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SRI LANKA LAND RECLAMATION
&
DEVELOPMENT CORPORATION

KERAWALAPITIYA RECLAMATION PROJECT

AS PART OF IMPLEMENTATION OF THE
MASTER PLAN FOR MUTHURAJAWELA AND NEGOMBO LAGOON

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

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KERAWALAPITIYA RECLAMATION PROJECT

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

CONTENTS

EXECUTIVE SUMMARY

Description of the Project

S.01 In Chapter 2, a description of the project is given. Chapt.2.1 summarizes the procedures of Master Planning of the Muthurajawela Marsh and Negombo Lagoon, including the selection of the Kerawalapitiya area for reclamation. It is emphasized that in this Master Plan study, for the first time in Sri Lanka, *prior to planning*, due consideration is given to conservation, sustainable resource uses and to resource users. The Master Plan has been adopted, the present landfill of 162 ha at the southern end of the marsh being part of the implementation of the plan.

S.02 Time schedules for civil engineering works and project implementation, together with responsibilities for implementation, are outlined. The envisaged development of the section of the marsh land after reclamation is briefly described.

S.03 Chapter 2.2 gives a justification of the project, referring to the need for land for urban expansion, the poor sanitary and health conditions in which squatter families live, the much reduced conservation values, and the general unsuitability of soils for agricultural production. It also outlines, that, in the absence of management, the on-going illegal settlements and resource uses will further deteriorate the marsh's environment and worsen the living conditions of marsh dwellers.

S.04 The methodology of hydraulic landfill using sand from the sea bottom, using a Trailing Suction Hopper Dredger and a temporary pipeline for the transport of sand/seawater mix to the fill site, is described in Chapt.2.3. It points out, that any disturbance or inconvenience resulting during the sand fill operation will be temporary, i.e. the operation is expected to be completed in a period of about six months.

S.05 In Chapt.2.4, alternatives for borrow site selection and method of landfill are discussed. Hydraulic offshore mining is considered a viable option from an economical, ecological and engineering point of view, provided dredging is carried out at sufficient distance offshore from the coast in order to avoid disruption of the longshore and onshore-offshore sediment drift which dictate the sediment budget of the coast. The selected borrow site will be 3 km offshore, well beyond the outer coastal sandstone reef, and dredging will take place at depths between 15 and 30 m, in shallow (2m deep) trenches parallel to the shoreline. An estimated 4.8 million m^3 of sand will be mined from an area of approximately 2.5 km^2. From a coastal conservation or sediment budget point of view, the selected borrow site would be acceptable.

S.06 The alternative of a land-based borrow site (lateritic soil) and using lorry transport is discussed in Chapt.2.4.1.2. The nearest borrow site would be Warakopola about 50 km from the landfill area. The cost of lorry transport of almost 5 million m^3 of earth over such distance would be very high, and would impose severe pressure on the existing road network, causing road damage, traffic congestion and higher accident risks.

S.07 The option of using peat from the marsh itself for the landfill is rejected for geotechnical reasons (low bearing capacity of peat, subsidence and oxidation of peat after exposure to the air), and because of the risk of acid and toxic aluminium formation after oxidation of pyrites in the potential acid sulphate soils under peat domes.

S.08 In Chapt.2.4.2, alternatives for delivery of sand to the intermediate aluminium station are discussed. Stockpiling of sand and subsequent lorry transport is rejected for reasons listed above. Stringent Colombo port regulations and restricted berthing facilities would impair delivery of sand to Colombo harbour. Piped transport from the booster station to the fill site appears to be the best option.

S.09 Alternatives for locating the pipeline are given in Chapt. 2.4.2.2. The pipeline should pass the sandstone reef without touching or damaging it. The onshore pipeline should preferably pass the beach north of Dickowita, where a pool is connected to the Hamilton canal. In this way, environmental and residential disturbance would be minimized.

S.10 Considering the alternatives for locating the stockpile of sand for subsequent fill of private allotments at relocation sites, the most economically and environmentally feasible option would be stockpiling on the landfill itself.

S.11 Alternatives for the location of the booster pump are discussed in Chapt.2.4.3. A location landwards of the shoreline near the Hamilton canal is recommended. Unacceptable noise levels during engine operation shall be avoided.

S.12 The disposal of salt water draining from the sand/sea water mix at the landfill is discussed in Chapt.2.4.4. A bund of 2.4 km length will be constructed along the northern boundary of the landfill, to prevent salt water intrusion in the adjacent northern section of the marsh. Towards the southern end, drainage water will be collected in existing drainage channels and in a collecting reservoir. Sluice gates will be installed to contain the drainage water before it is pumped. The recommended option is pumping the salt drainage water back into the sea.

Physical and Ecological Environment: Borrow Site

S.13 Chapt.3.1 describes the existing ecological and physical environment at the borrow site. Chapt.3.1.1 deals with the physical environment at the borrow site and gives a summary account of coastline morphology and dynamics. Sediment transport in the near-shore region is explained in general (3.1.1.2), and specifically for the coastline between Colombo and Negombo (3.1.1.3). Emphasis is put on the effects of extensive sand mining in the Kelani river mouth, which has negatively affected the sediment budget of this coastal stretch. Average coastal recession between 1956-1981 has been in the order of 2,3 m/y, with a maximum of 3.9 m/y over a stretch of 1100 m of beach.

S.14 The sea environment at the borrow site is described in 3.1.1.4. Special attention is given tidal movements and wave measurements carried out over recent years by the Lanka Hydraulic Institute and Coast Conservation Department. In 3.1.1.5, the sand deposits at the proposed borrow site are indicated.A 1988 assessment revealed sand deposits exceeding 10 million m^3.

S.15 The ecological resources at the borrow site are described in Chapt.3.1.2. The area does not contain sea grass beds but still represents an important biotope for marine-coastal organisms typical for the region. However, two factors have (and continue to) influenced the ecosystem. First, the use of trawl nets in the area which is causing continuous disturbance of the sea bed. Second, the massive seasonal discharge of silt from the Kelani River which remains in suspension for extended periods of time and which affects a coastal zone several kilometres wide extending north of the river mouth. It is concluded that the area is not a prime fishing ground (established fishing grounds are several kilometres further offshore), and that it is very unlikely that it contains unique habitats or rare or endangered biological species.

Physical and Ecological Environment: Landfill Site

S.16 Chapt.3.2.1 deals with the physical environment of the landfill site. The description is mainly based on the Environmental Profile study carried out in 1990/91 on which the Master Plan is based. Climate, geology and soils are described, the latter with particular emphasis on the predominant peat domes. The present drainage pattern is summarized, as well as seasonal variations in salinity levels. The estimated storage capacity of the marsh is about 11 million m^3, with a water level of 0.52 m and a maximum discharge of 12.5 m^3/s. The retention time is slightly more than 10 days. Sediment inflow (four sources) and transport is described. The calculated sediment load entering the marsh and lagoon is 50,000 m^3/y.

S.17 Chapt. 3.2.2 summarizes the ecological environment of the landfill site, mainly based on the findings of the Environmental Profile study. Vegetation cover and surviving faunal communities are described in some detail. For centuries, the area' hydrology, vegetation and wildlife have been subject to human interference, reason why the area can no longer be classified as pristine, although parts of it retain a certain degree of naturalness. No unique habitats and species are found in the proposed landfill site, which is the section of the marsh closest to Colombo.

Human Settlements and Community Health Situation

S.18 Based on a recent survey, i.e. Muthurajawela Relocation and Integrated Community Development Project (MURIC, 1993, Netherlands Embassy, Colombo) an assessment of the squatter population in the 162 ha landfill site is made (Chapt.3.2.3). A total of 330 housing units will be affected by the landfill project. The squatter families are grouped in four locations, Kudagahapitiya, Lankamatha, Avarakotuwa and Galagahaduwa. They make little use of the marsh's resources, most family incomes depend on employment in the nearby capital city.

S.19 Employment is found in the formal sector (25%), the informal sector (64%) and in self-employment (11%). Most are employed as manual labourers (64.5%), only 9.5% work as skilled labourers, where 11.7 % is involved as sales workers and 13.7% as fishermen. Only 0.6% is involved in agricultural production. High rates of unemployment and underemployment are noticeable, in particular among the young-educated population group.

S.20 Land and resource use in the marsh is limited to some home gardening, small-scale livestock keeping (pigs and hens) mat weaving using marsh sedges, and some fishing for private consumption in abandoned irrigation canals and some ponds. In general, soils are not suitable for agricultural cropping. Houses are in general make-shift dwellings and sanitary and waste disposal facilities, as well as adequate drinking water supply are absent. Seasonal flooding of houses and paths adds to the poor living conditions. Unauthorized settlement debarred the marsh dwellers from some of the standard services provided by the State.

S.21 Sewage and waste disposal in canals and ponds near dwellings, combined with pig rearing create high infection risks for serious water-related and water-borne diseases. The situation provides ample breeding sites for mosquitoes and other human disease vectors. Rats proliferate in the marsh. The general health situation of the marsh dwellers is significantly worse as compared to upland areas. A summary of the incidence of infectious diseases is given in chapt.3.2.4. A most serious disease is leptospirosis which is transmitted through water contaminated with rat and mice urine. Reportedly, considerable deaths due to kidney failure occurred in the Muthurajawela marsh over the last 15 years.

Possible Impacts at Borrow Site : Physical Impacts

S.22 Chapt.4.1 deals with possible environmental impacts at the borrow site. Impacts on physical resources are given in 4.1.1. They include impacts on the dredging site, along the transportation route and at the disposal site (the latter given in 4.2.1). Impacts at dredging sites are divided in area directly affected and areas affected by the results of dredging operations. The proposed dredging of sand in shallow, linear channels parallel to the shore, causes less impact making deep holes in the sea bottom. Considering the location of the borrow area (seaward of the outer reef, about 3 km from the shore) and the method of dredging (excavating shallow channels not exceeding 2 m, at about 15 m depth), the impact of dredging (increased turbidity) will be a transient phenomenon which will only last over a short period of time in a restricted area. In fact, during part of the year, natural turbidity is already high due to the suspended silt load from the Kelani river. These temporary disturbances cannot be avoided but can be much reduced by careful operation and prevention of spoils and leakages from the hopper-dredger and pipelines. Noise pollution at dredging site is not considered to be a problem.

S.23 The risk of subsidence of adjacent areas due to undermining, the possibility of causing subsoil failure, the alteration of local soil characteristics and changes in flow patterns with subsequent scouring or siltation in the dredged trench will also be minimized by the method of dredging. These destabilizing effects can be eliminated by limiting the depth of dredging, which is specified for this project not to exceed 2 m.

S.24 The possible impacts on the neighbouring coastline, i.e. beach drawdown, removal of natural beach protection (bars, reefs), changes in nearshore coastal processes (shoaling, refraction, damping) and disruption of longshore sediment drift (trapping sediment in dredged holes) are discussed, as well as the possible interception of shore-ward movement of sediments. It is emphasized that, given the fact that the coast in the area is already receding, such impacts *must not occur*. The location of the borrow site and the proposed dredging method warrant the expectation that the stability of the nearshore coastline will not be affected by the dredging operation. The borrow area does not act as an offshore bank and no interference will occur in particular because a sandstone reef is placed between the borrow site and the coastline.The waves break on the reef and dissipate it's energy.

S.25 The pipeline should not damage the sandstone reef and its location should not unduly disrupt the navigation of maritime traffic, which in the area are essentially fishing vessels. A dialogue with local fishermen is recommended.

S.26 Recommendations are given for beach crossing of the pipeline. Undue disruption of traffic and movements in the beach area, the Hamilton canal and adjacent public road should be avoided.

Possible Impacts at Borrow Site: Environmental Impacts

S.27 The removal of sand from the sea bottom will eliminate some 2.5 km^2 of benthic habitat. With time, the physical structure will be restored, but the restoration of bio-diversity at the mined site will take a longer time. Considering the relatively small size of the disturbed area, and given the vastness of similar ecosystem surrounding it, it can not be expected that any unique habitat or species will go extinct or will be seriously affected.

S.28 The increase in turbidity in the borrow are to a lesser extent, in neighbouring areas could locally lead to death or damage to gills and filtering organs (clogging) of certain species. This would mainly affect the less mobile species, most fish and shrimp species will probably move to less turbid areas before being affected.

S.29 The new technology of sand extraction from the sea bed allows to minimize turbidity increase. The effects on fisheries (fish moving away from the area)is expected to be minor. Restoration of the configuration of the sea bed and of the bio-diversity of the site will probably have taken place a few years after dredging. It is noted, that the productivity of the area has probably been reduced by seasonal discharge of large amounts of silt from the Kelani River, causing "natural" turbidity (at times likely exceeding turbidity brought about by dredging), and by the use of trawl nets disturbing the sea bottom and benthic communities containing essential food items for many pelagic and demersal species of commercial importance.

S.30 No established fishing grounds occur in the borrow area. These are found some 3 km away from the site.

Possible Impacts at Landfill Site : Physical Impacts

S.31 Potential physical impacts at the landfill site (Chapt.4.2.1) include changes in hydrology, drainage patterns, drainage capacity, surface water quality, and salt water intrusion in groundwater and adjacent areas. The most important impact will be the reduced storage capacity of the marsh, which would lead to higher water levels and less retention during floods. Based on a model study by the Irrigation Department, the reclamation of 162 ha would result in a decrease in maximum storage of 2.63% (50-years' return period), and maximum flood levels would increase by 5.35%. The maximum outflow would be reduced by 28.12%. Apart from these changes, there will be no major alteration in the overall drainage patterns in the Muthurajawela marsh during the wet and dry seasons. Gravity drainage from the filled up area will be possible, for which purpose drainage ditches will have to be constructed.

S.31 The salt water retention structures in the Hamilton canal should be repaired and made functional again.

S.32 The sea water entering the landfill area will increase salinity in adjacent areas. However, after the construction of the northern bund, salt water intrusion to the northern part of the marsh will no longer take place. In the southern end of the landfill salt drainage water will be collected in gated canals and reservoirs and will be pumped back into the sea. The landfill will not cause saline water intrusion in the fresh groundwater lenses in the dunes and near Bopitiya.

Possible Impacts at Landfill Site: Environmental Impacts

S.33 The landfill implies the loss of 162 ha of wetland, but the loss of natural flora and fauna will be minor, as the area is no longer in pristine condition because of centuries of human interference. The proposed site is of minor importance as a wildlife habitat and none of the recorded species depends uniquely on the areas' habitats for its survival. The fact that some large mammal species still occur is indicative to their resilience rather than reflecting habitat quality. The most common mammal species are disease transmitting species (rats). Although the area still provides habitat for numerous bird species, it would be exaggerated to say that the area is very important for the survival of any of these species. More important wildlife habitats are found in the transitional brackish water swamp and the Negombo lagoon and its fringing vegetation. This area is earmarked in the Master Plan as a Conservation Zone.

S.34 Further discussions on loss of biological and ecological resources is given in chapt.4.2.2.1. The landfill will also imply a loss of wetland functions, which include water storage and water regulation, buffering and filtering capacity, absorption and retention of pollutants and sediments. No quantitative assessment is possible. An estimated 5% reduction will is expected to occur.

S.35 Few impacts are expected from salt water seepage on flora and fauna in adjacent areas (4.2.2.2). The already occurring seasonal salinity intrusion during the dry season has lead to animal and plant communities tolerant to these conditions.

Possible Impacts at Landfill Site: Human Settlements

S.36 The impacts of relocating squatter families to relocation sites are dealt with in chapt.4.2.3. The immediate impact on their sources of income are negligible as the relocation sites are very close to the original site and transport and communication facilities are available at the new location. Thus, those employed as casual labour, skilled labour, fishermen or sales men will not be affected.

S.37 Negative impacts are related to loss of goods and benefits directly derived from the resources of the part of the marsh that will be filled. These include income from vegetable gardening, mat weaving, fishing in abandoned irrigation canals and ponds, and in some cases from homestead coconut and fruit trees. Sale of home-made products based on established relations with clients could be disrupted, but the communities near relocation sites would provide new markets for these products.

S.38 Initially, there could be some social disruption during the period the former marsh dwellers have to adapt to their new environment (which will be rather similar to their former living place). Some pressure on public facilities (schools) could occur because of the influx of new settlers, but this is not expected to be a serious problem.

S.39 An important positive effect will be the improvement of the health and sanitary conditions at relocation sites as compared to the marsh environment. See S.42.

S.40 Another positive effect that the resettled families will benefit from getting legal ownership of land to which they have expressed their willingness to move. This will lay a better foundation to successful future community development.

Possible Impacts at Landfill Site: Human Health

S.41 The potential health impacts related to the project are given in chapt.4.2.4. Most of these impacts can be avoided by preventive measures, as given in chapt.5.2.4.

S.42 The sanitary situation at the future relocation sites will be substantially better as compared to the living conditions in the marsh. Piped drinking water and septic latrines will be provided and the possibility of collective waste disposal exists. The landfill will eliminate large areas of potential breeding sites for human disease vectors and pest and disease transmitting animals.

Mitigating Measures : Physical resources Borrow Site

S.43 Chapt.5 lists the recommended mitigatory measures. Those pertaining to avoiding or minimizing negative impacts on physical resources are dealt with in chapt. 5.1.1. These include:

dredging:
- in shallow channels, parallel to the coast
- dredged channels not to exceed 2 m of depth
- channels to be contained within the boundaries of the selected borrow site
- dredging only in areas exceeding 12 m of depth

turbidity:
- prevent overflowing as much as possible
- no pumping overboard of lean mixture
- safe level filling
- using splash screens or hoses

transport:- pipeline to be clear of sandstone reef
- avoiding any damage to sandstone reefs
- solid anchoring of floating pipeline
- minimize disturbance of maritime traffic
- marking of pipeline with buoys, flags, lamps

pipeline crossing shoreline:
- should not cause obstruction of traffic and movements
- special provisions for crossing Hamilton canal and road
- guarantee unobstructed passage of 3½ t vessels

pipeline crossing land:
- minimize disturbance local residents
- minimize environmental damage
- inform communities timely to achieve cooperation

booster pump location:
- avoid unacceptable noise levels

Mitigatory Measures : Ecological Resources Borrow Site

S.44 Adherence to operation prescriptions listed in S.43 could reduce possible negative impacts on ecological resources at the borrow site and surroundings. Timing of the dredging operation to coincide with periods of high silt discharge from the Kelani river would further reduce turbidity impacts resulting from dredging (Chapt.5.1.2).

Mitigatory Measures: Physical Resources Landfill Site

S.45 The main problem is the prevention of the negative effects of sea water seepage affecting surface and groundwater resources and adjacent marsh areas, and the risk of flooding (Chapt.5.2.1). Proposed mitigatory measures include:

- rehabilitation of neglected drainage system
- rehabilitation of salt exclusion and drainage control structures
- proper siting of a retention bund, 2.4 km long, along the northern boundary of the landfill area to avoid salt water intrusion in the marsh area north of the fill site (part of the landfill project)
- design and construction of main drainage system (ditches, gates, culverts) in and around the fill area (part of the landfill project)
- rehabilitation of control gates in existing collecting channels receiving salt drainage water at the southern end of the landfill
- optional : construction of separate, gated drainage canal connected to a low bed storage pond at the southern end of the landfill area
- disposal of collected salt drainage water by means of pumping through a pipeline back into the sea
- the capacity of the drainage pump should be sufficient to allow for the evacuation of additional run off during heavy storms
- reliable power supply to the drainage pump allowing for operation when required

- control of water levels slightly below average sea level in the enclosed fill site (after completion of the northern bund), to prevent flooding.

S.46 The project also includes design and construction of 4 culverts/bridges to provide access to the filled area. The siting of these structures should be carefully studied.

Mitigatory Measures: Ecological Resources Landfill Site

S.47 These are summarized in Chapt.5.2.2 and pertain to similar issues as listed in S.45, adequate salt water disposal from the landfill site and flood prevention. Hence, the measures to be taken to avoid or minimize detrimental effects on ecological resources in areas adjacent to the fill site are similar to those listed under S.45.

S.48 The establishment of a Conservation Zone and a Bufferzone as outlined in the Master Plan, would be greatly enhanced the conservation of ecological resources in the Muthurajawela marsh-Negombo Lagoon wetland. A management plan for the Conservation Zone is now under preparation through the Wetlands Conservation Project of the Central Environmental Authority (WCP-CEA). Both the landfill and the establishment of the Conservation zone serve a similar purpose: to bring the presently not managed and degrading resources of the wetland under a management regime focused on sustainable use of the land and its resources, and conservation of important ecological functions and values.

Mitigatory Measures : Resettlement

S.49 Chapt.5.2.4 summarizes the planned relocation project as outlined in the MURIC report (8). Families to be resettled will be allocated 15 perches of land and relocation sites will be provided with communal piped water supply and latrines (septic tanks). The construction of houses is planned in phases, and supported by NHDA and MUPO, a local NGO. Overall coordination will be with SEDEC. The resettlement scheme is based on self-help. Landfill for housing and the construction of latrines and water supply is already nearing completion (SLLRDC). Additional filling of allotments will be the responsibility of families themselves, for which purpose a stockpile of sand will be deposited by the dredging contractor. A number of community development programmes, to be initiated after relocation, have already been identified. Families will receive Rs 3000 for compensation of incurred losses. The total cost for relocation amount to Rs 14.5 million.

S.50 In Chapt. 5.2.4, a list of measures is given to prevent health and sanitary problems at relocation sites.

Monitoring

S.51 Chapt.6 identifies issues which would require monitoring during project implementation. Where applicable, indicators and standards for monitoring are given. These issues include:

- The Dredging Operation
  In this case the borrow area is definitely identified and no deviation from the boundaries of the identified area is permissible. The depth of dredging should also not exceed 2 meters.

- Transportation of Sand
  The stability of the pipeline conveying the sea water/sand mix should be ensured by regular systematic checks.

- Landfill Operation
  One of the main concerns is the increase in water levels and changes in salinity in and around the lanfill area. These changes could be caused by normal behaviour of the existing system as well as by the landfill operation. Systematic monitoring is necessary.

- Nearshore Coastal Stability
  No direct impacts are expected due to the dredging operation, considering all the precautions that have been taken. However due to the fact that the stretch of coastline from Kelani river mouth to Negombo represents a fast eroding coastal stretch, monitoring of beach profiles will assist in detecting any new trends.

KERAWALAPITIYA RECLAMATION PROJECT

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

1. INTRODUCTION

1.1 Purpose of the EIA Report

1.1.1 Project History

Proposals for the development of the Muthurajawela marsh in a planned and proper manner are the result of a sequence of events that began probably in the year 1964, when a Cabinet Sub-Committee decided that paddy cultivation at Muthurajawela was no longer feasible. Such a decision was a major milestone in the history of this vast extent of land and water, as Muthurajawela had for ages been an extensive stretch of productive paddy land until a canal was constructed from the Negombo lagoon southward to the Kelani Ganga to improve access. This move however had a disastrous effect on paddy cultivation due to salt water intrusion via the lagoon. Despite substantial investments made to flush out the salt from Muthurajawela, by many parties even during the time of Dutch rule, all efforts failed to restore the once fertile soils, leaving it as it is today, an unmanaged stretch of marsh of extent about 3000 ha. contiguous with a lagoon of extent 3,500 ha, and many expanding urban settlements such as Negombo, Katunayake, Gampaha, Jaela, Kandana, Wattala, Hendala and also in very close proximity to the City of Colombo which is itself "bursting at the seams" due to its own population pressure. This situation has led to the setting up of many unauthorised settlements within the marsh itself.

As early as 1965, in its efforts to develop the City of Colombo, the 60,000 non-tax paying slum population was considered a problem. In 1966 the Department of Irrigation submitted a plan by Sessional Paper 21 for conversion of the Muthurajawela Marsh into a system of polders and residential areas mainly for relocation of low-income groups from Colombo City. To implement this landfill plan, the Colombo Low-lying Area Development Board (CLADB) was established together with other organizations. The plan was however deferred due to high costs. In the meantime the political climate prevailing in the country after 1978 led to the escalation of land prices in Colombo city. In 1982, the CLADB was upgraded as Sri Lanka Land Reclamation and Development Corporation (SLLR&DC). Under the many programmes instituted by the SLLR&DC, a proposal in 1985 for a pilot project of 250 ha. sandfill in the southern section of the marsh aroused much interest and controversy. This project was to be carried out in collaboration with a Dutch Engineering Company. By this time it appeared that the unauthorised settlers in the marsh were utilising it in good measure for many illegal activities and there was sufficient justification by the authority to issue eviction notices on all such unauthorised settlements. It was at this stage that Non-Government

Organizations which were already operating in the area came to the fore with a view to securing a just deal for these settlers. Janodhaya, a social facilitator group, with assistance from a Dutch religious movement, organized the settlers in the marsh to form the Muthurajawela United Peoples Organization (MUPO). At about the same time another NGO, the Justice and Peace Commission, carried out a socio-economic survey of the residents of the southern segment of the marsh. The study reveals that the marsh residents or in fact communities that have developed by way of cooperative activities and that the majority of the members of these communities are employed as labourers in the nearby urban centres. The study also revealed that there was little evidence of illegal activities. Representations made by this NGO aided by other organizations, resulted in the suspension of the eviction orders followed by a series of events such as:

- A planning study for MUPO by a team of students from Delft University of Technology, Netherlands

- Discussions between SLLR&DC, the Central Environment Authority (CEA), Coast Conservation Department (CCD) and the National Aquatic Resources Agency (NARA) all of whom were keen and interested parties in the future economic utilisation of the marsh and lagoon.

- The then Prime Minister (1988) who then overlooked the activities of CEA instructing the Greater Colombo Economic Commission (GCEC), since the marsh was situated within its area of jurisdiction, to prepare a plan for development of the Muthurajawela marsh.

- The new President in 1989 directing the GCEC to prepare a Master Plan for Muthurajawela, preceded by an Ecological Survey. The Netherlands Government agrees to provide experts and funds for the ecological survey.

- All development activities in Muthurajawela being frozen until the release and acceptance of the Master Plan.

1.1.2 Ecological Survey Studies and the Master Plan

The ecological study, which preceded the formulation of the Master Plan, was completed in 1991. The information pertaining to ecology was supplied by about 40 No. specialists from Government Agencies, Universities and NGOs.

The socio-economic survey that was needed to enhance the ecology study was carried out by GCEC staff in collaboration with government officials at local level who were most familiar with the inhabitants and the terrain. A review of development options summarised the land requirements for developments. This review too was done in a systematic way by enlisting the help of potential developers. The results of these 3 components of study resulted in the report - Environmental Profile of Muthurajawela and Negombo Lagoon - carried out for the GCEC by Euroconsult of the Netherlands with the assistance of numerous individuals, government agencies and NGOs.

This report reveals many aspects of the marsh and lagoon and by setting specific conditions for development, a Master Plan of Muthurajawela and Negombo Lagoon was developed and presented by Euroconsult of the Netherlands in May 1991. The Consultants were throughout guided by a steering committee headed by the Director General of the GCEC and a Working Group headed by the Director, Regional Development of the GCEC. The release of the Master Plan was preceded by a workshop consisting of participants from a wide spectrum of society and represented Government Departments, semi-government Boards, Corporations and Authorities, NGOs with interest in the areas of Environment, Wild Life and Nature Protection, Universities, People's Organizations, Private Voluntary Organizations, Politicians of the area and private individuals who had a knowledge of Muthurajawela and its environs.

The structural concept of the Master Plan was approved for implementation by the Cabinet of Ministers. Accordingly, a new Steering Committee was convened to supervise implementation under the Chairmanship of an Additional Secretary to the President in the Ministry of Policy Planning and Implementation. The main condition for implementation was that there was to be no deviation from the Master Plan.

Significance of the Muthurajawela Master Plan

This is the first time in Sri Lanka that a development and management plan is being implemented for a coastal wetland where the natural values including biodiversity and the interests of the existing resource users have been given serious consideration.Muthurajawela/Negombo Lagoon coastal wetland (Fig.2.1)is situated in a highly urbanised area and it's natural productivity is presently under dangerous threats stemming from existing and prospective resource use conflicts.(The successful implementation of the total Muthurajawela-Negombo Lagoon Master Plan which embodies a land use strategy for sustainable use of the resources of this wetland will constitute a reproducible model for management of 45 no. similar wetland systems in Sri Lanka).

Figure 1.1 indicates the development options and the areas earmarked for specific purposes. Basically the structure plan consists of a Conservation Zone (4900 ha) engulfing the entire lagoon and the marshes immediately contiguous and to the south of the lagoon. A Recreational Buffer Zone (405 ha), reclamation and development in the eastern part (650ha) and a capital intensive development area of 160 ha. further south of the Buffer Zone.

This 160 ha. extent of the marsh is in any case presently surrounded on the West, South and East by a high density resident urban population; and has always been subject to encroachment from the surrounding areas.

One of the important management strategies adopted, to ensure safe development of any area within the marsh is that any proposed development activity will be subject to an Environment Impact Assessment (EIA). This EIA is for the proposed Kerawalapitiya Reclamation Project which comprises hydraulic land filling of 160 ha. of marsh with sea sand from borrow areas which are located over 3 km offshore, into an area called

Kerawalapitiya located in the southern part of the Muthurajawela, involving pumping of about 4.8 million cubic meters of sand.

1.2 Extent and scope of the project

The project mainly comprises :

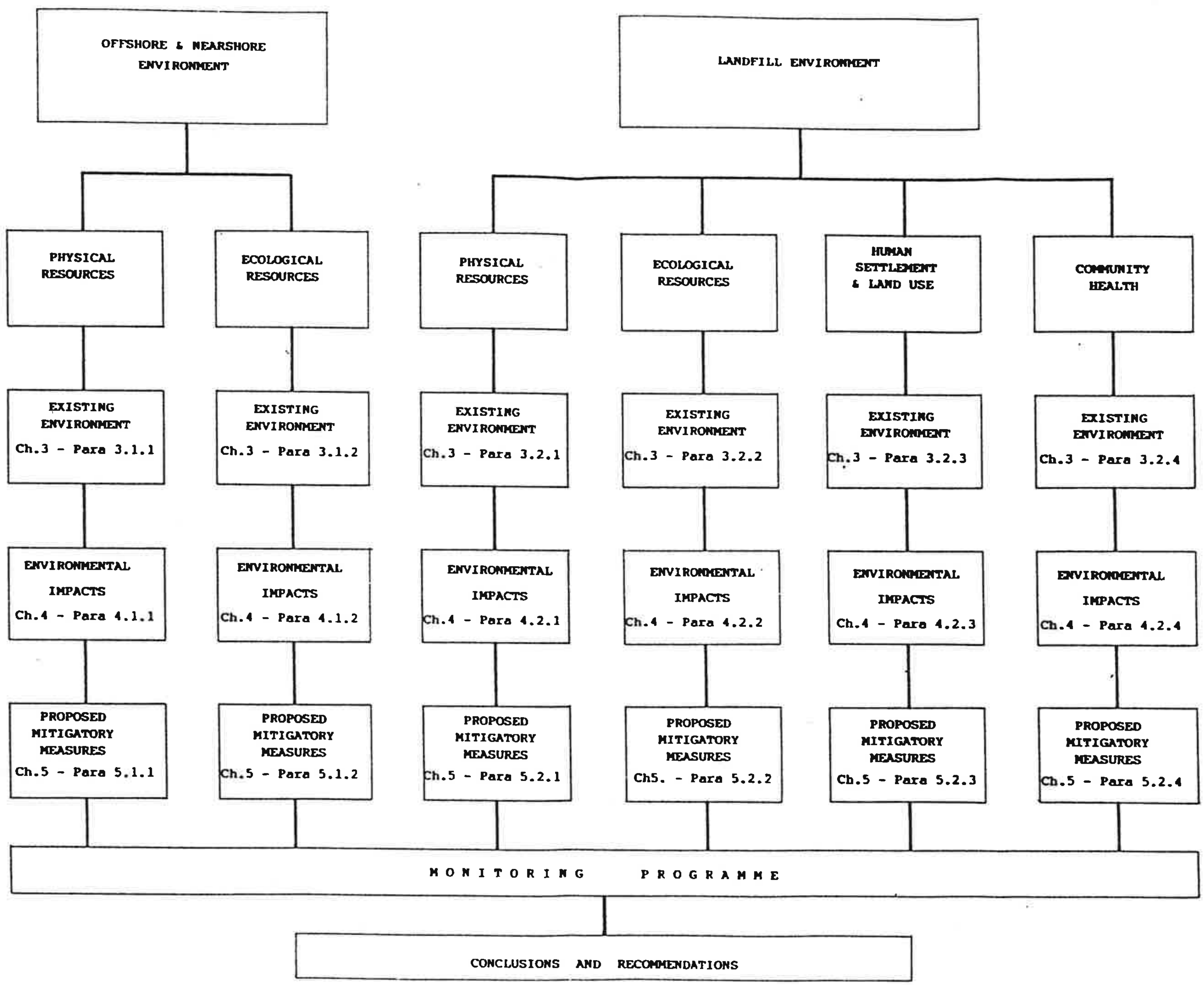
- Borrowing of approximately 4,800,000 m^3 of well graded medium to coarse sea sand as per the specifications and reclamation of an area of about 160 hectares to a finished level (post settlement level) of about 1.85 m above MSL.

- Design and construction of main drainage system in and around the fill area.

- Design and construction of 4 no. culverts/bridges to provide the main access to the fill area.

- The project to be completed within a period of about 12 months.

Table 1.1


OFFSHORE & NEARSHORE ENVIRONMENT
LANDFILL ENVIRONMENT
PHYSICAL RESOURCES
ECOLOGICAL RESOURCES
PHYSICAL RESOURCES
ECOLOGICAL RESOURCES
HUMAN SETTLEMENT & LAND USE
COMMUNITY HEALTH
EXISTING ENVIRONMENT Ch.3 - Para 3.1.1
EXISTING ENVIRONMENT Ch.3 - Para 3.1.2
EXISTING ENVIRONMENT Ch.3 - Para 3.2.1
EXISTING ENVIRONMENT Ch.3 - Para 3.2.2
EXISTING ENVIRONMENT Ch.3 - Para 3.2.3
EXISTING ENVIRONMENT Ch.3 - Para 3.2.4
ENVIRONMENTAL IMPACTS Ch.4 - Para 4.1.1
ENVIRONMENTAL IMPACTS Ch.4 - Para 4.1.2
ENVIRONMENTAL IMPACTS Ch.4 - Para 4.2.1
ENVIRONMENTAL IMPACTS Ch.4 - Para 4.2.2
ENVIRONMENTAL IMPACTS Ch.4 - Para 4.2.3
ENVIRONMENTAL IMPACTS Ch.4 - Para 4.2.4
PROPOSED MITIGATORY MEASURES Ch.5 - Para 5.1.1
PROPOSED MITIGATORY MEASURES Ch.5 - Para 5.1.2
PROPOSED MITIGATORY MEASURES Ch.5 - Para 5.2.1
PROPOSED MITIGATORY MEASURES Ch5. - Para 5.2.2
PROPOSED MITIGATORY MEASURES Ch.5 - Para 5.2.3
PROPOSED MITIGATORY MEASURES Ch.5 - Para 5.2.4
MONITORING PROGRAMME
CONCLUSIONS AND RECOMMENDATIONS

1.3 Brief outline of the contents of the report including methods and techniques

The format of the EIA report adheres closely to the format suggested in the Terms of Reference (TOR). However for the sake of clarity and considering the importance of the issues to be dealt with,the study has been directed towards examining two different environments viz;

(1) The offshore and nearshore environment and
(2) The landfill environment.

Under each major sub-heading,the aspects that have been dealt with are shown schematically in Table 1.1.

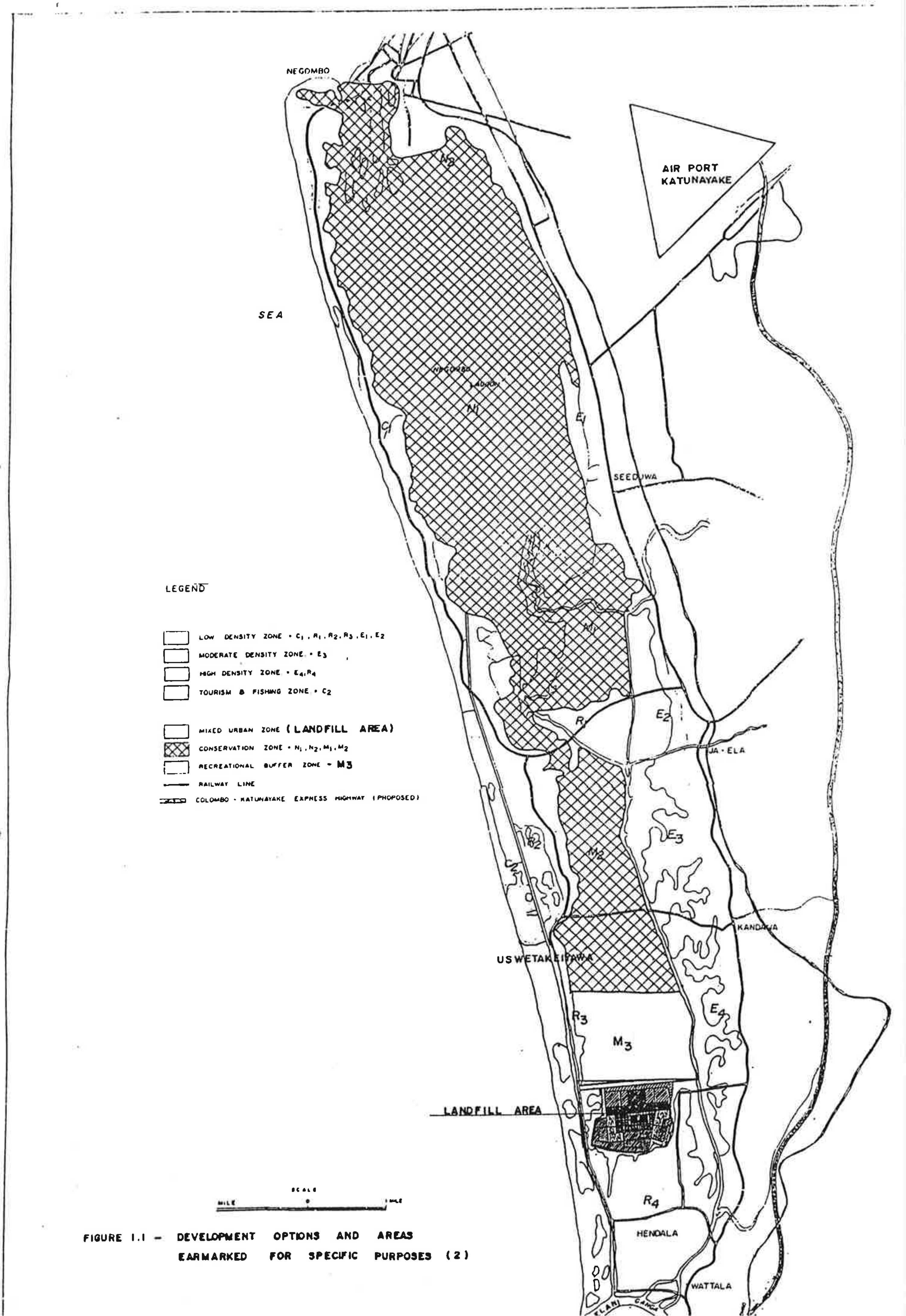


FIGURE 1.1 - DEVELOPMENT OPTIONS AND AREAS EARMARKED FOR SPECIFIC PURPOSES (2)

2. DESCRIPTION OF THE PROJECT

2.1 Nature Aims and Scope of the Project

2.1.1. Description of the major features, locations and layout of the project

* The Muthurajawela Marsh and the Negombo Lagoon situated 10-30 km North of Colombo (Fig.2.1) can be classified as interdependent ecological systems forming one contiguous wetland. The total area covers about 10,000 ha of which an area of about 3000 ha consists of undeveloped marshland (Fig.2.2). The lagoon measures around 3100 ha and the balance is made up by rivers, channels and other water bodies, a dune belt along the coast, the shore areas of the lagoon and some higher land along the eastern and southern periphery of the marsh.It is in these latter areas that most of the population is settled.

* The wetland represents a large area of brackish marshes, mangrove - swamps and fresh water marshes merging into an estuarine lagoon to the north - west. The lagoon opens to the sea at its northern end and receives fresh river water inflow from the Ja-ela and Dandugam Oya.

* Hydraulic structures such as channels, drains, bunds, sluices and culverts many of which are in a state of disrepair are found in abundance all over the marsh. These structures used essentially for drainage reflect various attempts made to combat flooding and the exclusion of salt water. Some areas of the marsh still hold reminders of the paddy fields that existed previously. These abandoned paddy fields now provide habitat some for wild life,i.e.birds.

* The Greater Colombo Economic Commission (GCEC) prepared a Master Plan for Muthurajawela and Negombo Lagoon (2). This Master Plan which was based upon an ecological survey was completed in June 1991 and forwarded to the Government of Sri Lanka.This was the first time in Sri Lanka that a development and management plan was implemented for a coastal wetland where the interests of the existing resource users have been given due consideration. It is expected that the successful implementation of the Muthurajawela - Negombo Lagoon Master Plan which incorporates a land use strategy for sustainable use of the resources of this wetland will constitute a reproducible model for the effective management of the wetland systems in Sri Lanka.

* The Master Plan was adopted for implementation and activities in this respect commenced in November, 1991 under the supervision and guidance of a steering committee. The implementation is proceeding in two stages of which the first stage is Programming and Feasibility Analysis (1991 - 1993) and the second stage is Project Operationalisation and Monitoring (1994 onwards).

* One of the projects that has already undergone feasibility analysis is sand filling of 162 ha of marsh land at Kerawalapitiya and the associated housing relocation and community development programme.

* The Kerawalapitiya Reclamation Project comprises hydraulic land filling with sea sand from borrow areas located over 3 km offshore into an area called Kerawalapitiya located in the southern part of the Muthurajawela Marsh (Fig. 2.3) It is the intention of the Sri Lanka Land Reclamation Development Corporation (SLLRDC) functioning under the Ministry of Housing and Construction of the Government of Sri Lanka (GOSL) to use this land for the purpose of urban development such as housing and industry after completion of further infrastructure provisions.

* The civil engineering works mainly comprise the following:

(i) Borrowing of approximately 4.8 million m^3 of well graded medium to coarse sea sand in accordance with the specifications and reclaiming an area of about 160 ha to a finished level (post settlement level) of about 1.85 m above MSL.

The sand required for the reclamation will be dredged using a Trailing Suction Hopper Dredger (TSHD) from an area the boundaries of which are defined below:

East:3 km from the shore

West:-30 m MSL Bathymetrical Contour Line
North:7° 05' N latitude

South:7°00' N latitude

The dredged sand to be pumped from the TSHD using an approximately 4 km long temporary pipeline laid from the sandstone reef to the reclamation site.

(ii) Design and construction of the pipeline (and the associated anchorages to support the pipeline) transporting the dredged sand to the respective locations within the site of reclamation.

(iii) Design and construction of the main drainage system in and around the fill area.

(iv) Design and construction of access facilities such as roads and culverts/bridges to the fill area.

* The Sri Lanka Land Reclamation and Development Corporation (SLLRDC) is implementing the Kerawalapitiya Reclamation Project together with a Housing Relocation and Community Development Programme for the families that would be displaced by the landfill. It is recognised that the implementation of the housing relocation and community development programme will be critical for the successful implementation of the entire Master Plan.SLLRDC is presently laying the groundwork for the housing relocation and community development programme for the 330 families which would be displaced by the sand fill project. It should be noted that a considerable squatter population exists in the area covered by the Master Plan for Muthurajawela and Negombo Lagoon (Fig. 2.4) and the 330 squatter families referred to are those affected

directly by the reclamation project. The housing relocation project will include the supply of housing and amenities. This programme will be accompanied by a community development programme of activities based upon a participatory approach.

* The target communities who will be included in the housing relocation and community development programme have been identified.Their families will be relocated from their present location in the marsh where the living conditions are unhealthy to a filled area at Awarakotuwa. Each family unit will be allocated 15 perches of land and a house with facilities for obtaining power supplyp together with piped water supply and sanitation facilities. Five perches of the allocated 15 perches will be filled by SLLRDC. Further assistance will be made available to the respective families by the SLLRDC to complete the filling of the balance 10 perches.

2.1.2 Time Schedule of Development

The tentative time schedule for the project is given Table 2.1 below:

Table 2.1

	Activities	From	To
1.	Preliminaries		
	E.I.A.	Oct. '93	Jan. '94
	Contour Survey	Jan. '94	Mar. '94
	Soil Investigations	Jan. '94	May '94
	Study and Design (Main Drainages & Structures)	Jan. '94	May '94
2.	Land Filling		
	Land Filling (Mobilisation)	May '94	Sept.'94
	Land Filling (Dredging)	Oct. '94	May '95
	Land Filling (Full Design)	Nov. '94	July '95
3.	Other Civil Works		
	Excavation of drainage canals	Mar. '94	July '95
	Canal bank protection	Dec. '94	July '95
	Clearing existing drainage canals.	Feb. '94	June '95
	Renovation of existing structures	Apr. '94	Jan. '95
	Construction of new culverts/ Bridges.	Nov. '94	July '95

2.1.3 Contemplated expansion of the project and land use pattern subsequent to reclamation

* Because of its location in the Colombo Metropolitan Region there exists a strong demand for land of Muthurajawela for urban development. A rapidly growing population and employment opportunities in the area have contributed to these demands. Hence,urban development has to be given high priority in the management of Muthurajawela Marsh and the Negombo Lagoon. However, it must be noted that urban development has an inherent potential to be in conflict with the conservation of wetlands. Therefore, the permissible extent, location and design of future urban development have to be considered in great detail.

* The most limiting factors of Muthurajawela with respect to urban development are the presence of poor soil conditions and high water levels which demand land reclamation for almost any type of development activity. The average land level of the marsh is approximately 30 cm above MSL.

* The entire marsh is virtualy covered with a layer of peat with an average depth of about three meters. The strata below contain predominantly well bearing clayey and loam-sandy soils. The peat profile is highly irregular and borings have found depths of six meters and more. Of all common soil types, peat has the lowest bearing capacity and in combination with high groundwater levels creates a situation which is very unsuitable for construction of buildings, roads and similar infrastructure. Thus to permit such construction activities, either the water levels have to be lowered on a long term basis or the land level has to be raised by filling with coarse material. A combination of both methods is also possible.

* As identified earlier, urban development in marshy areas is in conflict with wetland conservation and this identifies the need for critical judgement with respect to the location, ground area and the type of proposed urban development. Based on the findings of the detailed environmental study described in the Environmental Profile of Muthurajawela and Negombo Lagoon (1), the Master Plan of Muthurajawela and Negombo Lagoon (2) has identified the reclamation of 162 ha of marsh land. The master plan which opted for a 162 ha landfill in the Southern end of the Muthurajawela marsh,was discussed and approved by Parliament in November 1991.The SLLRDC has proposed to adopt hydraulic landfill using sea sand as fill material for land reclamation in Muthurajawela. In view of the heavy and costly equipment required for this type of work, this approach is only valid for large-scale projects and the land area of 162 ha is able to achieve the economics of scale required to attain minimum unit costs.

* Considering the available land and the location of Muthurajawela in a fast growing metropolitan region, the Master Plan has identified that the areas to be zoned for reclamation could be made available for the development of widely ranging projects including:
    - housing
    - light industry, warehousing, transport and industrial services
    - large institutions such as hospitals, educational establishments, trade centers etc.

- regional or city parks, sports fields and facilities for other forms of recreation.

- public utilities such as treatment plants, electricity sub-stations.

* The Master Plan has identified that Muthurajawela could offer sites for institutions and industries now occupying larger areas of valuable land in the city of Colombo and which should desirably be relocated either for economic and environmental reasons or to decentralize employment opportunities to the urban periphery.

* The Master Plan has identified that the first group for which land in the area must be made available is the resident squatter population of Muthurajawela. It has been identified that in addition to the resettlement of squatter families, land should also be made available to the families who will lose their land or means of livelihood as a result of the restrictions imposed by nature conservation in other parts of the marsh. The second target group to be provided with residential accommodation in Muthurajawela would be the immigrant workers in the nearby industrial zones at Katunayake. These aspects of the Master Plan which refer to human resettlement are given high priority in the implementation of the Master Plan.

2.2 Justification of the Project

* The Kerawalapitiya Reclamation Project and its impact on the environment and on society should be examined with reference to the integrated management framework of the Master Plan for Muthurajawela and Negombo Lagoon.

* At present the wetland system is under intense population pressure for settlement. Colombo, the capital of Sri Lanka with a population exceeding one million is situated 13 km to the south. Negombo town with a population exceeding 80,000 is situated contiguous with the northern border of the Negombo Lagoon (Fig.2.5) . Five rapidly expanding urban centres are located along its eastern border. The population growth in the wetland is expected to double within the next decade. The unplanned settlement and the resulting consequences associated with such growth could contribute to the progressive destruction of the wetland system. Population growth in the Muthurajawela Marsh and in the channel segment of the Negombo Lagoon has occurred mainly because of immigration from contiguous urban centres. Non-availability of affordable land in the vicinity of Muthurajawela has been the principal cause of migration into the marsh. It is no doubt that unauthorised encroachment into the state-owned wetland would lead to major problems. Very little land or resource use is practised in the proposed landfill part of the marsh. Most squattor families make a livelihood by taking up a variety of jobs in Colombo.

* The Master Plan for Muthurajawela and Negombo Lagoon constitutes a strategy for resolving resource use conflicts for the region. The strategy was developed on the findings of an ecological survey presented in the Environmental Profile for Muthurajawela and Negombo Lagoon (1).

* The ecological survey revealed that despite centuries of human interference in the wetland, there exist significant natural values. However, in the absence of management of the wetland directed towards sustaining the natural productivity of the ecosystem, continuing unplanned activities will intensify and result in the eventual collapse of the eco-system. Some of the important areas which have been identified in the ecological survey are as follows:

* (i) Unauthorised housing in the Muthurajawela marsh and in the channel segment of the Negombo Lagoon has caused both social and hydraulic problems.

  House construction in the marsh has exposed the inhabitants to a variety of hazards. The most pressing problems faced by the inhabitants are, the absence of amenities, infrastructure, lack of safe drinking water, flooding, stability of the houses and associated health hazards. Unplanned settlements without sanitary provisions result in health hazards as it increases opportunities for breeding of disease carrying animals such as rats and mosquitos. There is above average incidence of fatal diseases such as leptospirosis, dengue and chronic enteric diseases.

  Housing expansion in the channel segment of Negombo Lagoon is posing restrictions on the water exchange and thereby causing a disruption to the natural hydrological and tidal linkages.

  (ii) The continuing deterioration of the drainage system has resulted in increased waterlogging and salt water intrusion into the marsh. During rainy seasons, the net inflow exceeds outflow resulting in elevation of the water level. Houses belonging to the majority of the residents in the marsh are subjected to regular flooding during the annual rainy season for a period of about a week.

  (iii) Soils in the marsh are marginally suitable orunsuitable for the cultivation of traditional crops such as rice and vegetables. At some locations coconut cultivation is profitable. However, this activity interferes with the flow of water.

  (iv) The marsh is an important habitat for numerous species of plants and animals but is not a unique habitat for any species. The sea grasses in the lagoon constitute the critical feeding and nursery area for the fish and crustacean stocks on which the lagoon fisherfolk depend for primary income.

  (v) The most important economic resources available in the wetland are the fish and crustacean stocks which provide the primary income for a minimum 3000 fishermen. The lagoon has a high productivity exceeding 150 kg/ha/year.

* The principal findings contained in the environmental profile thus provide sufficient evidence to the effect that in the absence of management aimed at sustainability of multiple uses, both the Muthurajawela Marsh and the Negombo Lagoon will eventually become degraded by population pressure and existing resource use conflicts. The drainage system of the marsh will continue to deteriorate and the flood hazard faced by the residents will persist. In order to improve the health and living conditions of the unauthorized residents of the marsh, there is a need to relocate them on higher ground (filled areas) to which cost effective infrastructure facilities and amenities can be supplied. It is evident that there exists a strong and urgent demand for well planned development of Muthurajawela and the Negombo Lagoon.

* It is important that the impact of the Kerawalapitiya Reclamation Project should be examined within the integrated management framework of the Master Plan for Muthurajawela and Negombo Lagoon. Based on the recommendations of the Master Plan and the findings of the Environmental Profile, the SLLRDC identified 162 ha at Kerawalapitiya as the permissible extent and location for land reclamation by hydraulic landfill.

* It is important to note that the determination of the extent of conservation and development was given detailed consideration in the preparation of the Master Plan. The proposed conservation and development model recommended for Muthurajawela and Negombo Lagoon (Fig. 2.6) was the outcome of a planning workshop held in April, 1991. The participants consisting of approximately fifty experts were provided with background information on the ecological significance of the wetland and on development opportunities and constraints of the marsh as documented in the Environmental Profile. In addition, two extreme options namely a maximum and a minimum development model were presented to the participants as a reference for the formulation of the most desirable option.

2.3 Methodology of Operation

* The sand to be extracted for the reclamation of Muthurajawela is from an area located at a minimum distance of 3 km offshore. This dredgred sand extracted from a depth of 15-30 m will be conveyed to Kerawalapitiya located in the southern part of the Muthurajawela Marsh. The quantity of sand to be extracted for the purpose of reclamation is approximately 4.8 million m^3. The extraction of sand from the borrow area will change the water depths in that area. The methodology adopted will limit the maximum deepening to 2 m.

* A trailing suction hopper dredger having a hopper capacity of approximately 6000 m^3 will be used for the extraction of sand. This dredger is of the self-propelled ocean-going type, the dredged material being raised by dredge pumps through dragarms connected to dragheads in contact with the ocean bed and discharged into hoppers built in the vessel. These types of dredgers are designed to operate in rough and open seas and have found to be the most suitable type for the extraction of sand from offshore.

* The dredged sand collected in the hoppers will be transferred to Muthurajawela Marsh through a system of temporary pipelines.

* In order to position the trailing suction hopper dredger for the purpose of carrying out pumping and shore operations, a temporary anchorage system comprising of 3 anchors each of approximately 10 tonnes connected by 50m chains to a sunken heavy weight will be used. Two chains linked to this heavy weight will be used to connect the floating pipeline and to moor the hopper dredger respectively(Fig.2.7). In order to prevent damage to the floating pipeline during adverse weather conditions, when the hopper is not connected to the pipeline, a separate stationary anchor will be provided.

* The dredged material from the hopper will be pumped first through a floating pipeline and then through a submerged pipeline to a booster station from where it will be pumped through an onshore pipeline to Kerawalapitiya. The main structures envisaged under this programme comprise a booster station and the onshore pipeline,which are all temporary construction.

* In the following sections the important aspects of the methodology of operation will be presented. Certain specific details, in particular those which are of importance in the comparison of alternative methods will be discussed at a later stage in sections 2.4.2,2.4.3 and 2.4.4.

* The floating pipeline consists of flexible (rubber) elements of 12 m each, watertight flanged together. The floating pipeline is connected to the submerged pipeline by a transition construction of flexible elements varying from full floating to sinking elements. The fully welded submerged pipeline forms the connection between the floating pipeline and the onshore pipeline. Through this system of pipelines the sand/water mixture is pumped to the site for deposition. In order to achieve this pumping operation it is necessary to have an extra booster station (pumping station) to supplement the existing capacity of the pumps. Since the booster station requires water for cooling of its engines,it has to be positioned at a suitable location satisfying this requirement.

* The diameter of the floating pipeline is 90 cm and the diameter of the submerged pipeline is 80 cm. The total length of these pipes is approximately 1570 m. The required power for the booster station is in the order of 2500 kW. The on-shore pipeline is 80 cm in diameter and has a maximum length of approximately 2500 m.

* During landfilling a sand/sea water mixture (approximately 20% sand, 80% water by volume) will be pumped into the marsh. The land filling will commence with the construction of the separation bund along the northern border of the fill. By this method drainage of water from the marsh towards the area north of the bund will be reduced to a minimum. However, during the construction of the bund a limited amount of sea water will be released to the existing channel network. As the land filling progresses after the completion of the northern bund, a larger quantity of sea water will have to be drained out of the land fill area. The sea water will be trapped in a low bed storage pond sited on the southern end from which drainage pumps will be used to pump the sea water back to sea via a temporary pipeline(Fig.2.8).

* With reference to the methodology of operation attention should be focussed on the presence of a sandstone reef parallel to the coast located offshore of Muthurajawela. Such reefs provide considerable protection to the shoreline by dissipating a part of the energy of the waves passing over them. Damage to such reefs could aggravate coastal erosion because of the exposure of the shoreline to more severe wave conditions in the absence of the protection afforded by the reef. Therefore, adequate care should be exercised with regard to the crossing of the reef by the pipeline.This issue has been taken note of in the operational design of the landfill.It should be done in such a way that the reef would not be subjected to any form of damage. The crossing could take place at a position where the reef is already interrupted. If not, the pipeline would have to pass over the reef, adequately supported by appropriate anchoring methods.

* The route of the onshore pipeline will have to be selected such that it causes minimum inconvenience and disturbances to the people, houses and property of that locality.

* It is important that the booster station shall be located in such a place that it will not interfere with the development programmes planned for certain areas by the Ministry of Fisheries and Aquatic resources (MFAR) and the Coast Conservation Department (CCD) which functions under the Ministry of Ports and Shipping (MPS).

* MFAR in association with the Ceylon Fishery Harbours Corporation (CFHC) has planned a fishing vessel repair complex at Dickowita and in addition, they also intend providing common amenities such as drinking water facilities, yard lighting and toilet systems to the fishing community of the area.

* The Asian Development Bank (ADB) is also funding a project through the MFAR for improved access to the Negombo Lagoon and is also investigating the possibility of establishing a fishery harbour at Morawela, located south of the lagoon outlet. Detailed hydraulic and engineering investigations and environmental studies have been recommended for these proposed projects. In addition the ADB has also agreed to provide funds to carry out coastal engineering studies at ten other locations of which Dickowita has been identified as one. The ADB proposes to commence the Negombo and Morawela Projects in 1994 extending over a period of approximately 21 months. The studies relating to Dickowita are scheduled to commence in 1995.

* It is also observed that the pipeline from the shoreline to Kerawalapitiya, the area of landfill, will be crossing the Hamilton Canal and the adjoining road. Suitable provisions will have to be taken to permit the unobstructed movement of 3 1/2 ton fishing vessels using the Hamilton Canal. Appropriate arrangements will also have to be made for the pipeline to cross the roadway adjacent to the canal.

* It is important to note that,in assessing the possible impacts of the proposed landfill,the whole operation will be completed within a period of approximately six months by adopting the proposed technology. Hence, whatever inconveniences that may arise will be limited to a short period of disturbance.

2.4 Evaluation of Alternatives

2.4.1. Borrow Site Selection

2.4.1.1 Ocean based borrow sites for the extraction of sand

- The extraction of sand from offshore regions for the purpose of artificial nourishment of beaches and reclamation of nearshore regions is an accepted practice which has been successfully implemented both in the developed and developing world. The extraction of sand as a mineral from the sea bed is in many cases more feasible than using fill material from inland sources. This is particularly relevant when a large quantity of material is required for the purpose of filling. The removal of materials on a large scale from inland borrow pits have had a greater impact on the environment than offshore mining. To a great extent the sand layers of the sea bottom are in dynamic equilibrium and the extraction of sand from a considerable distance offshore of the wave breaking zone does not have any impact on the nearshore sediment budget which is the vital parameter contributing towards the movement of sand in the shoreline regions.

- The contractor for the reclamation project at Kerawalapitiya has identified the proposed borrow region (Fig.2.3) after conducting investigations on the availability of borrow sand for the project. The sand search compaign carried out by Zanen Verstoep in April 1988 in the offshore regions of Colombo has established the availability of good quality coarse sand exceeding 10 million m^3 in the area referred to as the 'Borrow Area'.

- The alternatives that are available for the extraction of sea sand could be classified as follows:

  (1) extraction/dredging of sand from nearshore
  (2) extraction/dredging of sand in deeper areas beyond the proposed borrow area.
  (3) extraction/dredging from the navigation channel.

- In accordance to the regulations of the Coast Conservation Department sand mining is not permitted within the 5 fathom contour or 1000 meter seawards from the low water mark. Sand mining in the nearshore regions very close to the shoreline would have a severe impact on increasing erosion and hence cannot be considered as a viable alternative. Extraction ofsand from very deep areas and pumping to the shore is extremely costly and such an exercise will not be economically feasible due to high operational costs. The navigation channel is considered a restricted area and hence dredging cannot be carried out in the channel.

- For offshore sand mining to be a viable option from both an economical and engineering point of view it is important that dredging is carried out at a sufficient distance offshore from the shoreline such that it does not have an impact on the longshore drift and the onshore - offshore drift components of the coastal sediment budget for the given region. Research and practice in coastal engineering indicates that extraction of sand well beyond the wave breaking zone has no impact upon coastal erosion or accretion. Dredging experience has established that extraction of sand beyond the MSL - 15 m is safe from a coastal engineering point of view in that it would have no impact on nearshore processes contributing to coastal erosion or accretion. In view of the above observations the site chosen by the contractor for borrowing of sand is acceptable.

2.4.1.2 Land based borrow sites for the extraction of fill material

* Fill material from land based sources were also considered for the purpose of reclamation. It is noted that 4.8 million m3 of material is a large quantity of fill to be utilized in a project in Sri Lanka and to obtain such a quantity from land based sources without causing adverse impacts on the environment would be a difficult task. Two options with respect to land-based sources have been considered.

* The first option is the use of lateritic soils and gravel from inland sources close to Warakapola located about 50 km away. Existing industrial regulations prevent access to nearer sources. Besides the cost factor from borrowing from Warakapola, which would be an extremely expensive exercise, the transportation of earth from Warakapola will impose severe pressure on the existing road network, leading to road damage,traffic congestion and higher accident risks.It is expected that there will be a high level of air pollution due to dust and vehicle exhaust during the transportation process involving a large number of vehicles over a long period of time. Soil excavation and transportation of earth fill of this scale have not been carried out previously in Sri Lanka and it can be expected that residents along the road network will raise objections when the impacts of the transportation process are being felt.Further reference to problems on land-based transportatiton of fill material is outlined in Section 2.4.2.1.

* The second option is the use of peaty soil from the marsh itself. However, adequate quantities of material are not available in the marsh and furthermore peaty soil is not a suitable filling material,mainly because of its very low bearing capacity and because of the fact that peat exposed to the air is subject to substantial subsidence(30% in the case of Muthurajawela peat),and to oxidation. The removal of large quantity of material from the marsh could only be carried out by identifying specific areas after detailed investigations on possible environmental impacts. Therefore, primarily due to the inadequacy of supply and geotechnical reasons this option is not considered as a feasible option.

  It should also be noted that the removal of peat would also expose the underlying potential acid sulphate soils. This would lead to serious acidity problems, resulting from pyrite oxidation and the formation of sulphuric acid and soluble toxic aluminium ions, which would kill plants and most aquatic organisms for a long period after peat extraction.

2.4.2 Delivery of fill material (sea sand)

As identified in the previous Section land based sources are not recommended as fill material taking into account the non availability of such sources in large quantities and the environmental impacts associated with the acquisition of such sources and delivery to the site. Thus,the only source of material appropriate for this project is to obtain the sand from the proposed offshore borrow area.

2.4.2.1 Alternative methodology for delivery of fill material to the intermediate booster station

* It has been recommended that the dredged sand be pumped directly to the intermediate booster station from which it will be pumped to the site. There are two alternative methods available for this process. The first is for the sand to be stockpiled at a suitable location on the beach and then delivered to the site. The second is for the dredger to deliver the sand to the Colombo Port followed by the delivery of material to the site.

* According to the information supplied by the client, pumping ashore of the water/sand mixture to the proposed site can be achieved with the use of an extra booster station (pumping station) having a power capacity of the order of 2500 kW. If a booster station is to be used, the most convenient form of transportation of the dredged sand to the booster station would be by pumping using a suitable arrangement. In this respect the method recommended by the client to adopt a combination of floating and submerged pipelines is the most appropriate. On the other hand,when the dredged sand is to be stockpiled on the beach, the sand has to be delivered to the final destination by pumping or by the use of land transport. It is obvious that if the sand could be delivered directly to the site by pumping it serves no purpose to adopt an intermediatory stage of stockpiling on the beach. Stockpiling on the beach could result in the loss of a certain amount of dredged material prior to delivery to the site and causing increased turbidity of nearshore coastal waters. However, the lost sand will eventually contribute indirectly to the artificial nourishment of the eroding beach in that locality. If land transport is to be used for the transport of material which is either stockpiled on the beach or discharged at the port it will be necessary to plan a transportation strategy to deliver approximately 5 million m3 within about 30 weeks. This would demand a large fleet of heavy trucks working round the clock, a task which is extremely difficult to achieve in the overall context of the project with particular reference to the efficiency of the sandfilling process.

* The possibility of discharging the sand to the Colombo Port would cause considerable inconvenience to the smooth operation of the busy Port of Colombo. Stringent port regulations, restricted berthing facilities and existing demand on the port will impose severe restrictions. The transportation by land of the sand from the port to the site would impose greater problems than the transportation of the sand from a stockpile on the beach to the site. The delivery trucks will have to travel along one of the busiest traffic routes in Colombo causing considerable inconvenience to the regular users and an unfavourable impact on the environment. It should also be noted that when the dredged sand is to be delivered in the port, the sand will have to be pumped onto the trucks in small quantities, an operation not feasible in the context of this large project. The other alternative is to use a light duty quayside grab crane to fill the sand from the hopper. This approach is not feasible because the operation is carried out in a restricted area and the entire load cannot be retrieved by the process.It would be too time consuming and too costly an operation.

* Having reviewed the alternative strategies for the transportation of the dredged sand to the site, the method of delivery recommended by the client is the best option with respect to cost, safety, acceptable environmental impact within the prescribed time frame of the overall project.
The issue of stockpiling sand is further discussed in chap.4.

2.4.2.2 Alternatives for the siting of the proposed pipeline and the method of mooring and laying

* In laying the pipelines and moorings in the sea, in compliance with the Coast Conservation Act,it is prohibited to cause any damage to the sandstone reefs and to create gaps in the reefs. Any form of damage will increase the wave energy on the fragile shoreline resulting in increased erosion.

* In view of the above restrictions,there are two alternative methods available for the crossing of the reef. The first alternative is to lay the pipeline across an existing gap in the reef. In doing so sufficient care should be exercised to provide clearance for the fishing vessels which make use of the gap to travel to deep water. The second alternative is to cross the reef at any given location and in order to avoid damage to the reef the pipeline will have to be taken over the reef by a suitable mechanical arrangement. A floating pipeline with flexible elements ranging from full floating to sinking elements should be used in conjunction with proper anchoring methods to avoid damage to the reef.

* In considering the first alternative, it is observed that a gap in the reef exists at the Dickowita Anchorage and that it is possible to take the pipeline through this gap in the reef straight to the Dickowita beach and thereafter to the land fill area. However, the Dickowita Anchorage has been identified for further development through the ADB-funded fisheries project,scheduled to commence in the near future, which may cause a hindrance to the proposed reclamation project.

* An approach to overcome the above problem would be to lay the pipeline obliquely through the gap, leaving sufficient space and depth for the navigation of fishing crafts, and thereafter to continue the pipeline parallel to the beach and divert inland at a suitable location. By this method it would be possible to avoid the Dickowita Anchorage which has been identified for fisheries development.

* On the other hand if the second alternative is considered, i.e crossing the reef not at an existing gap but at another location, the pipeline could be directed straight across the shoreline to the proposed landfill.

* The onshore pipeline will have to be placed across the compounds of a few residences and the laying of the pipeline would also necessitate the felling of a few coconut trees. It may also be necessary to relocate a few residences depending on the path of the pipeline.

* A study of the aerial photographs of the area indicated the presence of a pool of water connected to the Hamilton Canal north of Dickowita. This may offer a satisfactory location to place the pipeline across the beach with least environmental impacts and much reduced residential disturbance.

* While reviewing the alternatives for the siting of the proposed pipeline and the method of mooring and laying it is of extreme importance to take every precaution to avoid any

form of damage to the reef while laying the pipeline. The pipeline should not in anyway act as a littoral barrier.A hazard which could have an adverse impact on the environment would be the development of possible leakages from the pipeline. The contractor is expected to carry out monitoring of the pipeline at regular intervals during installation and when the project is in progress.

2.4.2.3 Alternatives for the stockpiling of sand for community development

The contractor will be required to stockpile sand for filling marshy areas of allotments of resettled families.As to the location where a sand stockpile can be kept,three options can be considered:

(i) Stockpiling sand on the beach

The sand will dry out and truck transport of sand to the private resettlement allotment will be the only option. The amount of sand will also interfere with traffic and people movements in the beach area.

(ii) Keep a stock of sand under water near the shore.

Much sand will be lost by coastal drift and cutters will be required to transport the sand to the loading place. Required investments will be prohibitive and effects on coastal morphology will be serious.

(iii) Stockpiling sand on the landfill

This appears economically the most feasible option, causing no additional environmental impacts. Further, transport to private fill sites could be arranged by means of trucks.

2.4.3 Alternatives for the location and type of intermediate booster station

* From a technical view point there is limited choice with respect to the location of the booster station. In general the booster station should be located in a place where the efficiency of the pumping ashore is at its optimum level. In accordance with the capacity of the pump installed in the hopper dredger, the location of the booster station has to be between the Hamilton Canal and the shoreline. Taking into consideration the above facts there are three options available for the location of the booster station.

(1) Seawards of the shoreline
(2) Landwards of the shoreline on the beach
(3) Near the Hamilton Canal

* Due to the presence of rough seas experienced during the monsoon period, the installation of a booster station seawards of the shoreline would create considerable problems relating to the mooring of a floating installation. The presence of such a facility in this region could also have an impact on sediment movement along the coastline. Therefore the installation of the booster station landwards of the shoreline or near the Hamilton Canal is recommended.

* Since the booster station requires cooling water for its engines, this facility should be installed at a suitable location where fresh water is readily available. Another aspect which should be considered is the proximity of residences i.e. to avoid unacceptable noise levels during engine operation.

2.4.4 Proposed alternative methodology for pumping saline drainage water from the isolated fill area back into the sea.

* In order to retain the sand and prevent sea water seeping into the area north of Kerawalapitiya, an earth bund with side slopes ranging from 1:40 to 1:20 is to be constructed in the first instance. The landfill will thus commence with the construction of the separation bund along the northern border of the fill.

* This bund which is in the order of 2.4 km in length requires approximately 625,000 m^3 of sand. The source of supply of this sand is also from the dredger. Since the ratio of pumping is approximately 20% volume of sand to 80% volume of water, the sand is mixed with approximately 2.7 million m^3 of sea water. Of this volume of sea water approximately half will flow in the northern direction and the other half in the southern direction. The flow to the northern part will be intercepted and drained by the Mahabage Ela and the flow to the southern part will be intercepted and drained by the Kerawalapitiya Ela and Wedaralage Ela. The latter will be pumped off, or released by temporary opening of the sluices to the Hamilton Canal. This drainage of sea water in the northern and southern direction cannot be avoided until the bund is completed.Considering water salinity as a result of the tidal exchange of sea water in the Hamilton Canal, it can be expected that this volume of drainage will not impose adverse environmental effects,i.e.give rise to undue salinity increase in the Hamilton Canal.

* Once the sluice gates which control the drainage system are closed and with the northern bund has been completed, the water level in the enclosed area can be controlled through pumping. In this operation,the waterlevel will be maintained slightly below average sea level in order to avoid any risk of flooding.

* As the land filling progresses after the completion of the northern bund, a large amount of sea water will have to be drained out of the area. In order to trap the sea water,the construction of a low bed storage pond on the southern end has been proposed. (Fig.2.8). The drainage pumps at this location will be used to pump the sea water out of the area. Two alternatives are available for the pumping operation. The first option is to pump the sea water into the Hamilton Canal. The second option is to pump the sea water back to the sea.Considering the large amount of sea water that will be mixed with 4.8 million m^3 of sand fill,and,because the Hamilton Canal is connected to the existing channel network within the marsh,it is not desirable to discharge the sea water into the Hamilton Canal. This may cause problems relating to salt water intrusion leading to an ecological imbalance. Therefore,the second option is recommended and for this purpose a separate pipeline has to be installed to discharge the saline drainage back into the sea.

* During land filling the drainage of the sea water to the low bed pond is to be achieved through existing waterways.As these waterways are connected to the Hamilton Canal, there exists a possibility of saltwater intrusion into other areas. In order to prevent intrusion of salt water,it is recommended that a separate channel be provided on the southern periphery of the fill area and this channel should drain the sea water directly to the low bed storage pond without any connection to existing waterways.The sides of the channel should be properly lined to avoid erosion. On the other hand, if the existing waterways are to be used for draining water into the low bed storage pond, sufficient care should be exercised to prevent the intrusion of salt water by the interconnected channel network. For this purpose it would be necessary to study in detail the existing channel network and provide and/or rehabilitate control gates at locations where sea water could escape into the system.

* The pumps that are to be installed at the low bed storage pond will have to be maintained in excellent working condition,and,in addition the pumps should also be able to discharge any flood water which may accumulate due to heavy rainfall. Efficient standby electric power generators should be available during emergencies when the main electric power supply is interrupted. Such situations usually occur during heavy rainfall and stormy conditions.

2.4.5. Scheduling of the dredging operation

* It is important that the timing of the landfill operation will be such as to limit the effects of increased turbidity of coastal waters. When the dredging is in progress in offshore waters it is expected that turbidity at the site will increase and it is also likely that these effects will further increase during periods of high wave activity. The dispersion effects thus created will also increase the turbidity of water in the adjacent areas. It is in this context that the proper timing of the operation could minimise these impacts. From previous experiences with dredging projects it is quite common to find that there are many instances where the natural turbidity exceeds the levels caused by dredging for

considerable periods. The impact of turbidity effects can be reduced to a minimum if the operation is to take place during the period when the turbidity of nearshore coastal waters is already high due to increased sediment load from the Kelani River. During the rainy seasons the Kelani River discharges a heavy load of sediments contributing to increased turbidity in the nearshore coastal waters extending several kilometers from the river mouth. This phenomenon has been clearly observed from the air during low level flights. Turbidity considerations are also of particular importance in timing the disposal of salt water from the landfill area back to the sea.

2.5 Work Force

2.5.1 Labour Requirements - Design Construction

The estimated labour rquirement of local personnel will be as indicated at Table 2.2. :

Table 2.2

Activity	Effective Duration	Position	No. Required	Total Man Weeks
Design & Investigation	08 Weeks	Consultant	05	40
Installing pipeline	04 weeks	Drivers Submerged	03	12
"	04 weeks	Welders	15	60
"	04 weeks	Labour	15	60
Installing shore pipe line	02 weeks	Excavator operators	06	12
"	02 weeks	Crane Operators	02	05
"	02 weeks	Labour	07	14
Installing Booster Station	01 week	Excavator Operators	06	06
"	01 week	Crane Operator	02	02
"	01 week	Labour	07	07
Land filling/ Reclamation	30 weeks	Loader Operator	02	60
"	30 weeks	Bulldozer Operator	02	60

"	30 weeks	Excavator Operator	01	30
"	30 weeks	Pipeline Supervisor	01	30
"	30 weeks	Labour	20	600
Drainage Canals	40 weeks	Excavator Oeprators	02	80
"	40 weeks	Labour	20	800
Canal Bank Protection	20 weeks	Crane Operator	02	40
"	20 weeks	Specialist Plaiters	10	200
"	20 weeks	Labour	30	600
Culverts/ Bridges	20 weeks	Mixer Oeprator	01	20
"	20 weeks	Skilled Labour	10	200
"	20 weeks	Labour	30	600
Office	40 weeks	Car driver	06	240
"	40 weeks	Office Aide	04	160
"	40 weeks	Labour	06	240
Demolishing & Landscaping	04 weeks	Divers	03	12
"	04 weeks	Operators	08	32
"	04 weeks	Labour	19	76
	Estimated Total Man Weeks			4397

2.5.2 Labour Requirements During Operation

The completed project will produce a 160 HA extent of Land filled area that needs to settle further and will then be developed as a mixed urban zone. Until the final development process commences, the land fill area will be under the SLLR & DC and under the direct supervision of their Resident Engineer stationed at Uswetikeiyawa.

The maintenance duties at the land fill site are:

- Maintenance of Main Drainage Canals

- Maintenance of access culverts and bridges

- Maintenance of land fill surface

The annual labour requirement for these tasks are:-

Excavator Operators	- 08 man weeks
Skilled Labour	- 52 man weeks
Labour	- 104 man weeks

2.5.3 Availability of Labour

About 330 families from the Kerawalapitiya area are to be resettled at Awarakaluwa.Sociological surveys have revealed that 26% of the total population to be resettled are skilled while 43% are unskilled. About 30% of the total population are unemployed. Hence a good proportion of skilled and unskilled labour needed for the landfill project could be drawn from the resettled population. The balance labour can be obtained from other sources, e.g. Divers, heavy Machinery Operators, Welders etc.

2.5.4 Requirements of Construction Equipment and Cars

In order to carryout the landfill operation the fleet of machinery needed is given in Table 2.3 below:

Table 2.3

Type of Equipment	No. Required	Period Required
Loaders	2	30 weeks
Bulldozers	2	30 weeks
Excavators	1	30 weeks
Cars	6	40 weeks
Trailing Suction Hopper Dredger	1 No.	30 weeks

The Contractor is to be provided an area of marsh within the project area to be used by him as the office and yard. The equipment will be maintained by a team of skilled expatriate and local personnel and all precautions will be taken to ensure that the yard is kept neat and tidy without heavy oil spills and accumulation of dirt caused by the use of heavy construction machinery.

2.5.5 Facilities Required for the Work Force during Project - Construction

The project area is located in marshy land and during construction the concentration of the labour force will gradually move from the beach area close to Dickowita to the southern end of the Muthurajawela marsh. Considering the distances to the nearest township from the project area, it is very necessary that the Contractor provides many basic amenities to the work force during the construction period. The following facilities/amenities are necessary:-

- Changing rooms - 4 Nos.
- Bathrooms with temporary piped water supply facilities - 2 Nos.
- Canteen for 20 number people
- Potable water availability
- Transport to nearest township
- Temporary power supply
- First Aid Centre
- Transport to nearest Hospital for accident victims.
- All members to be covered by an appropriate Insurance Scheme.

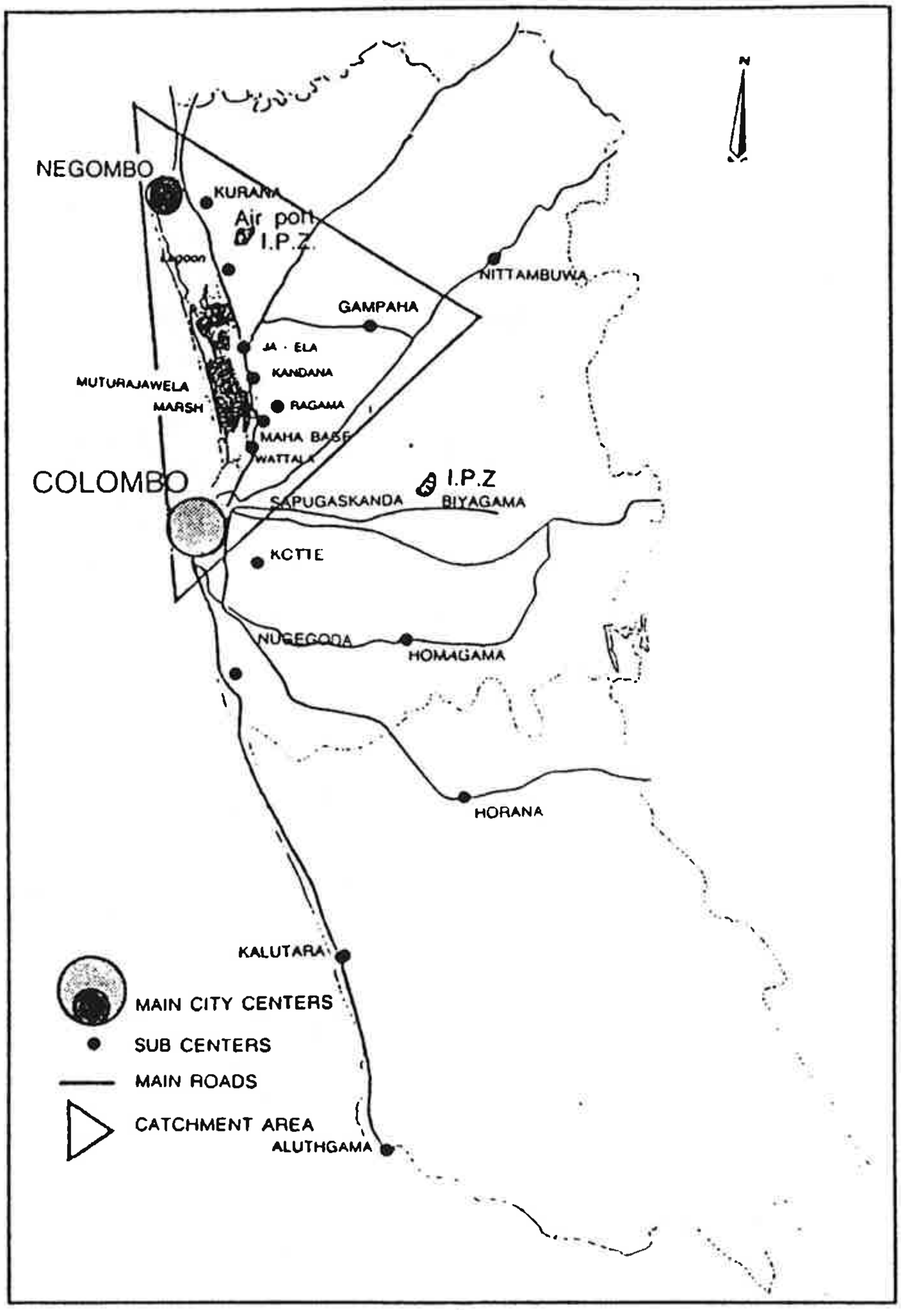


Figure 2.1
The Muthurajawela Marsh - Negombo Lagoon coastal wetland as a part of the Western Province (1)

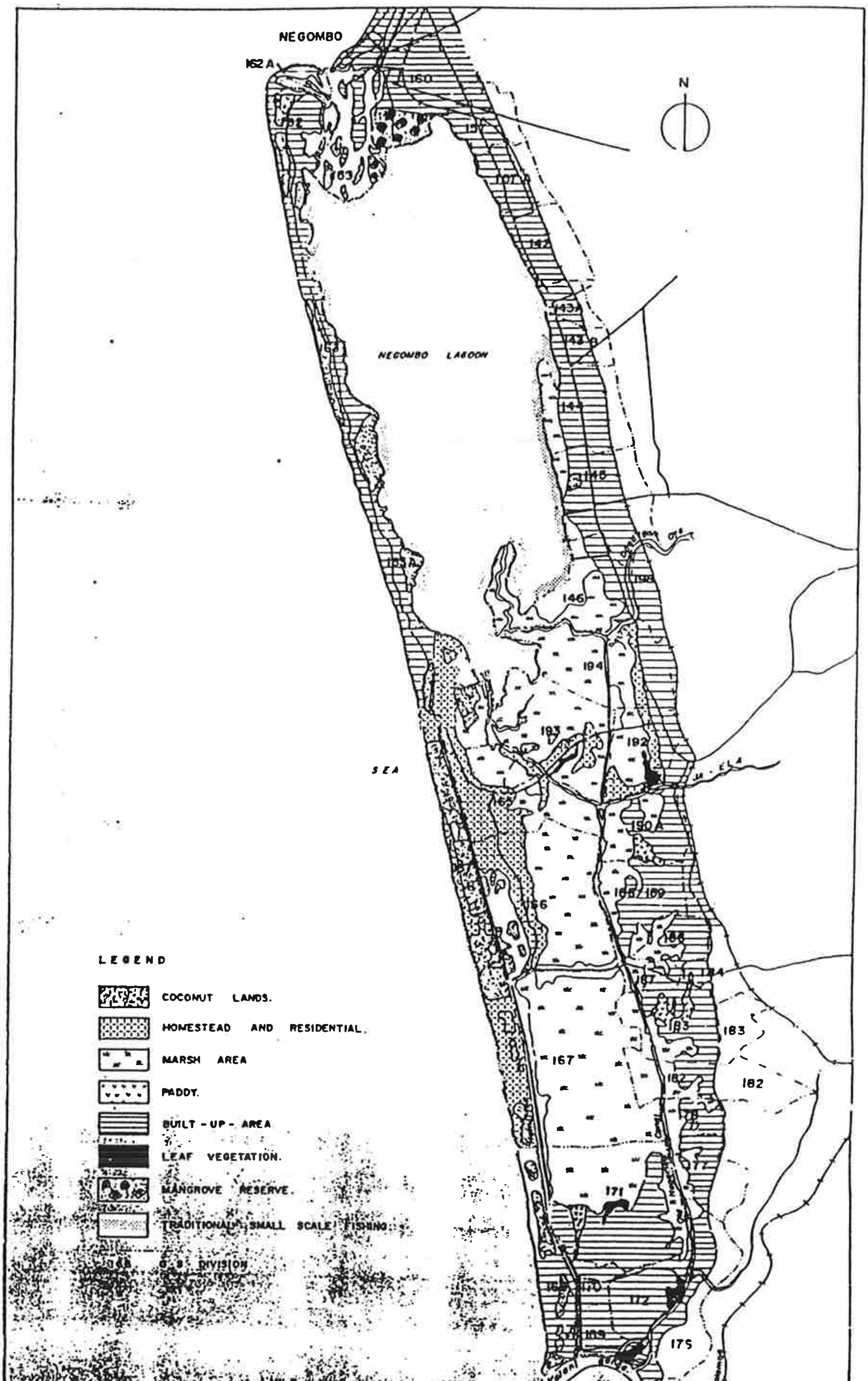


Figure 2.2
Present land use (2)

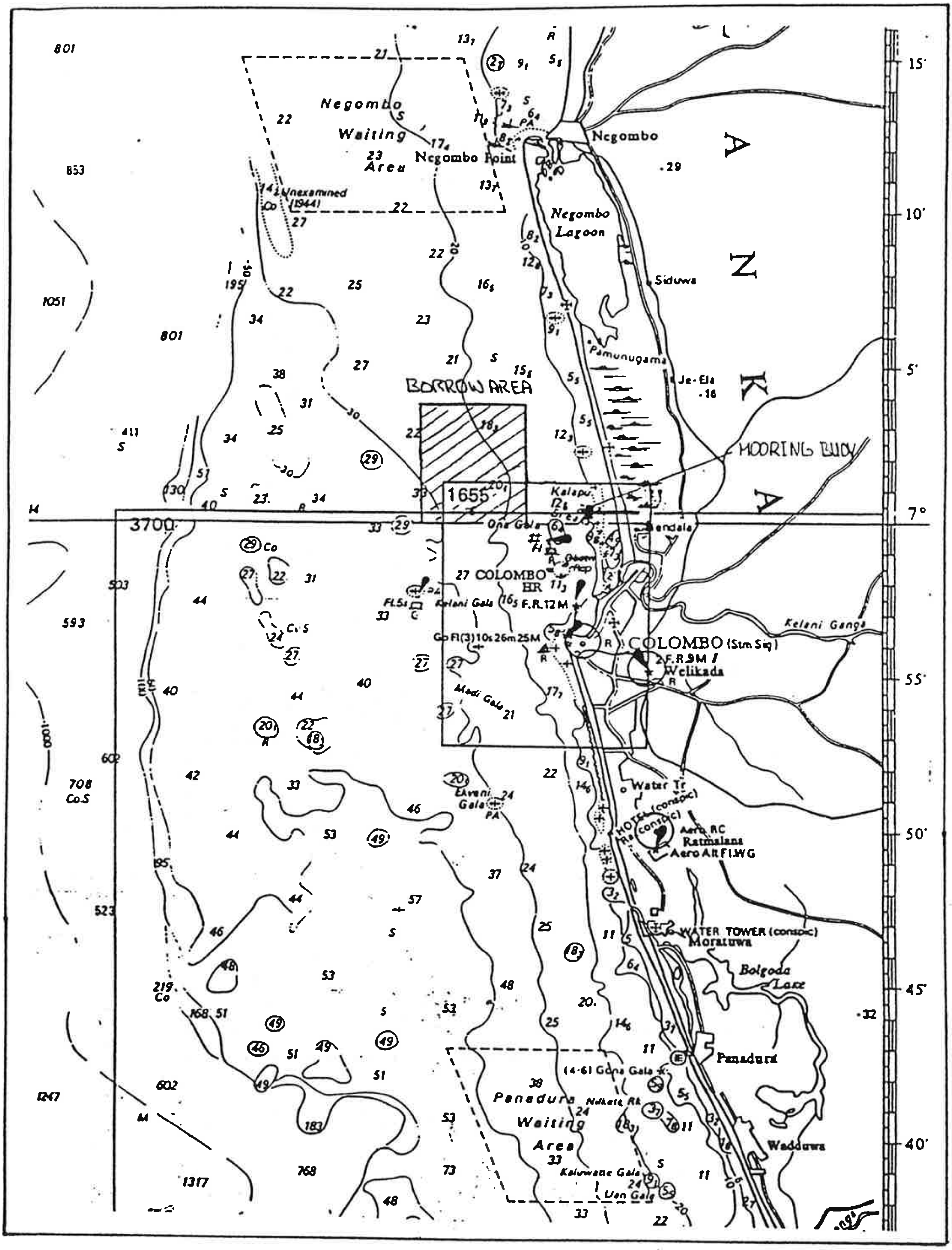


Figure 2.3
Proposed borrow area for offshore dredging

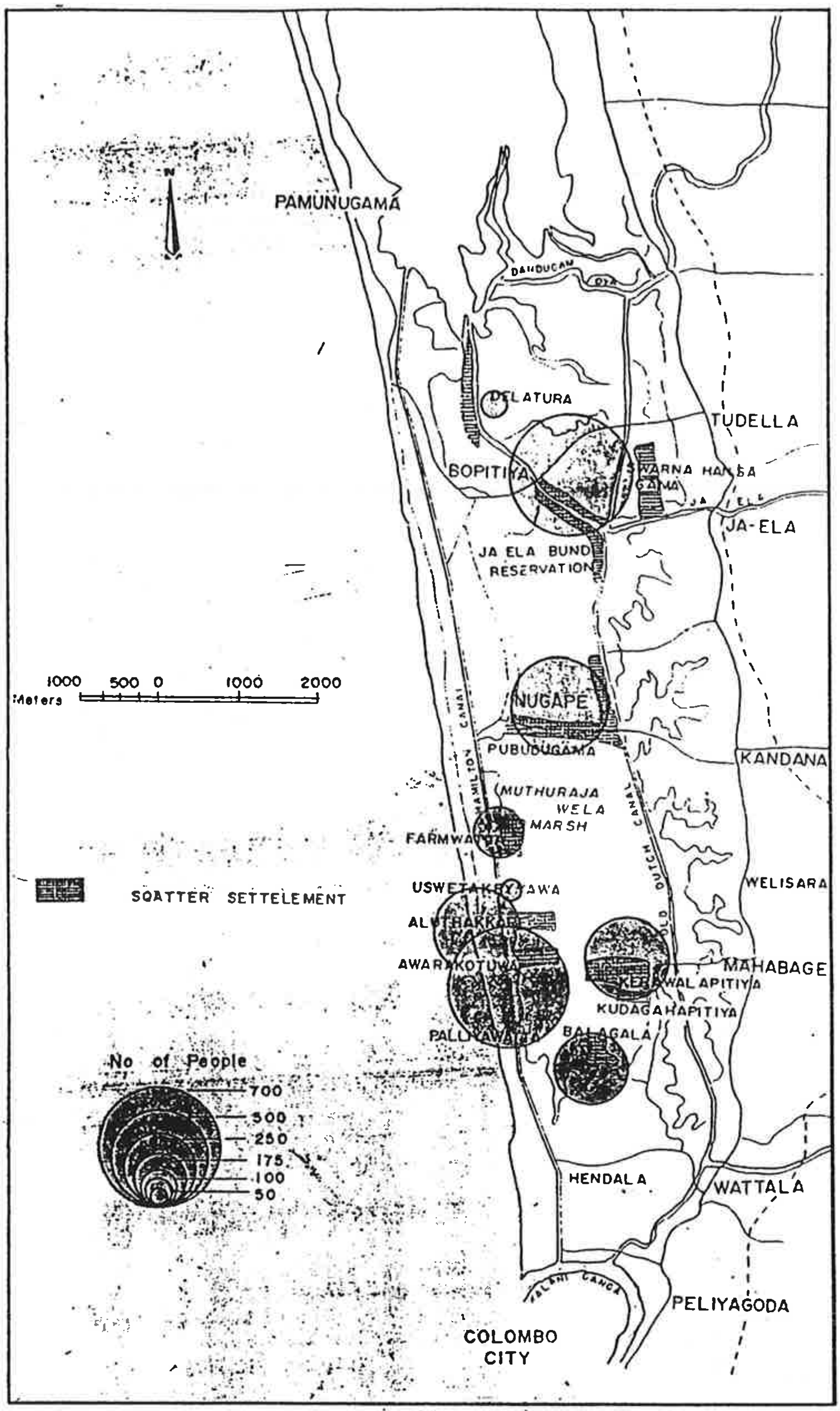


Figure 2.4
Distribution of squatter settlements in the Muthurajawela Marsh (2)

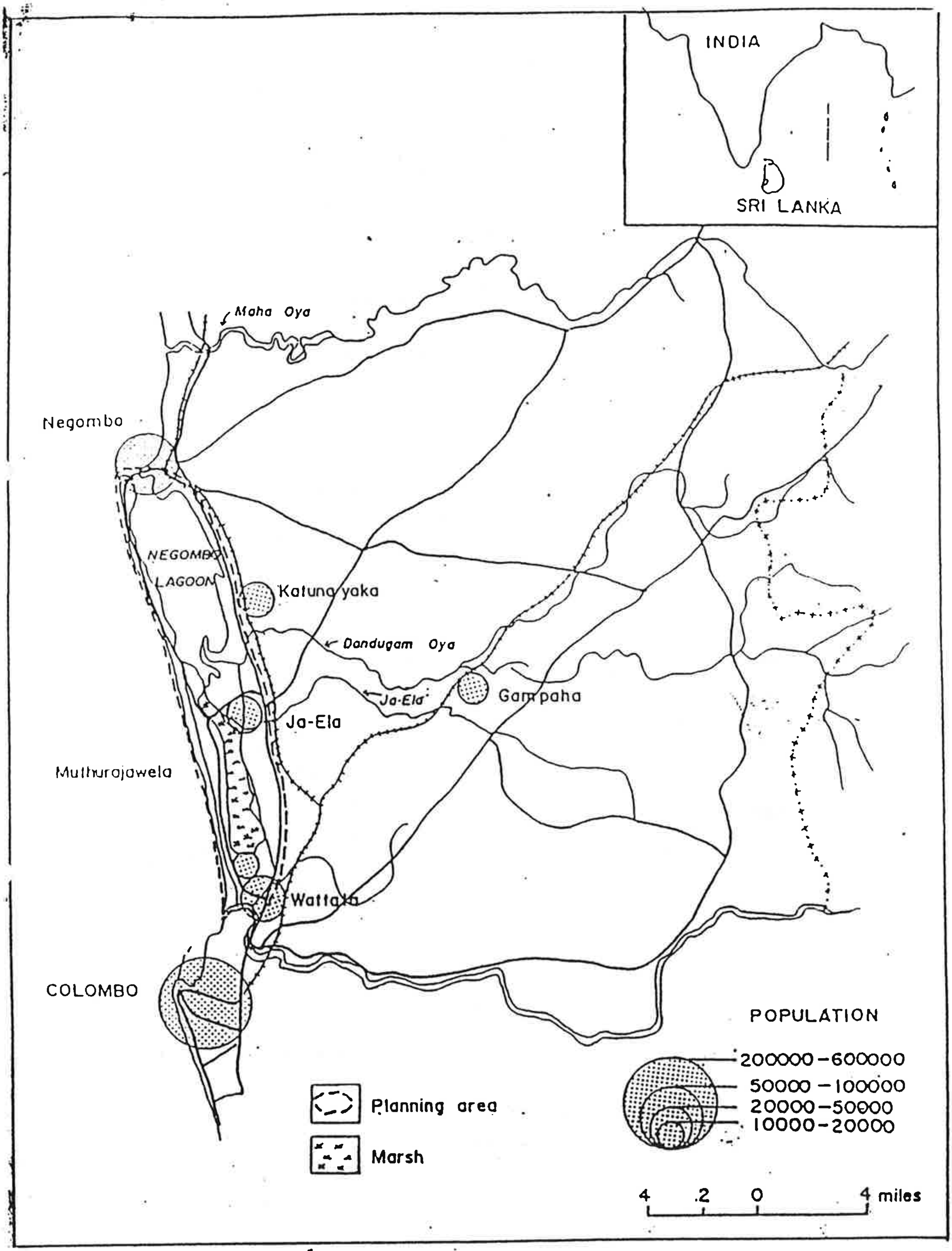


Figure 2.5
Population in cities close to the Muthurajawela Marsh -Negombo Lagoon coastal wetland (7)

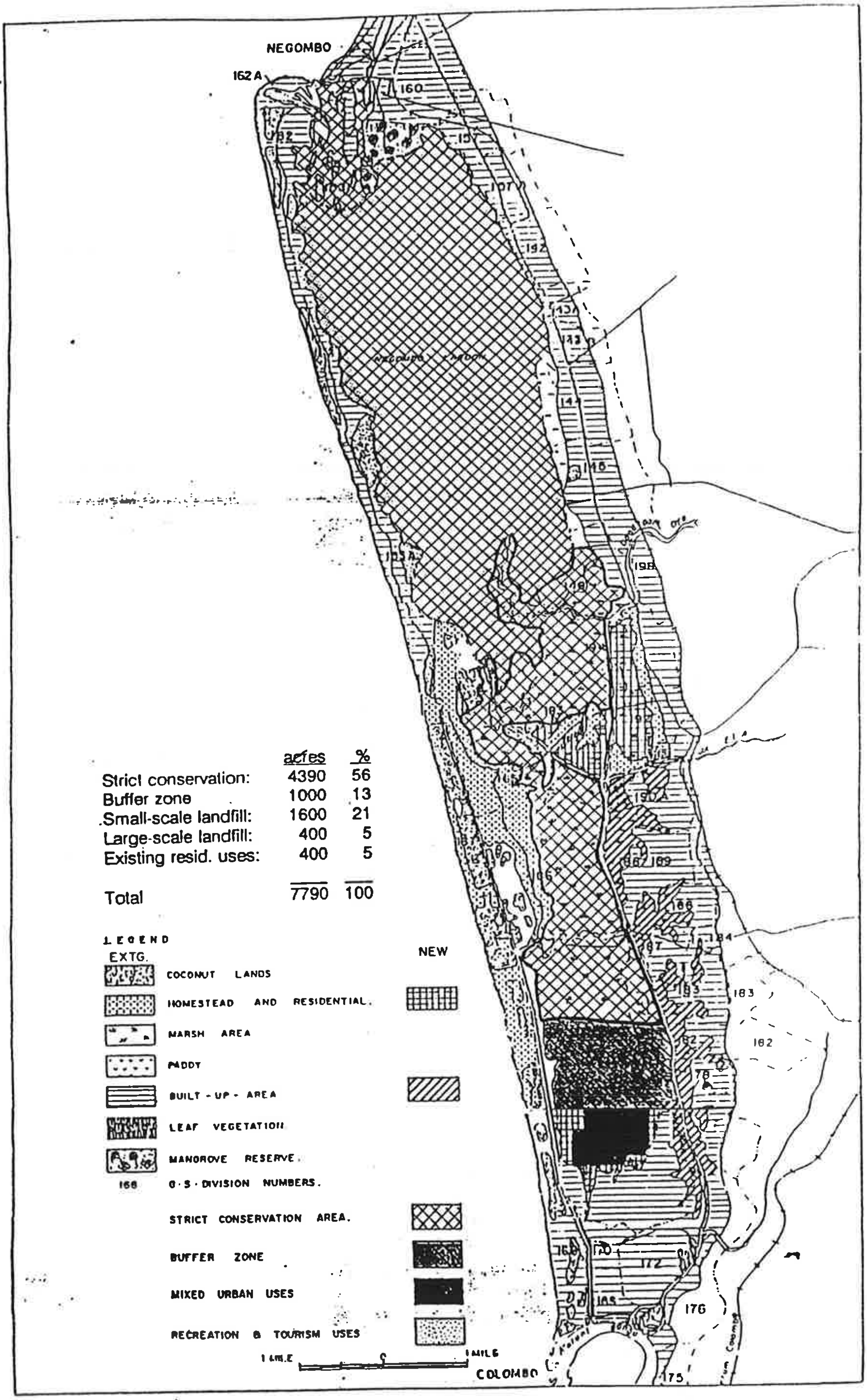
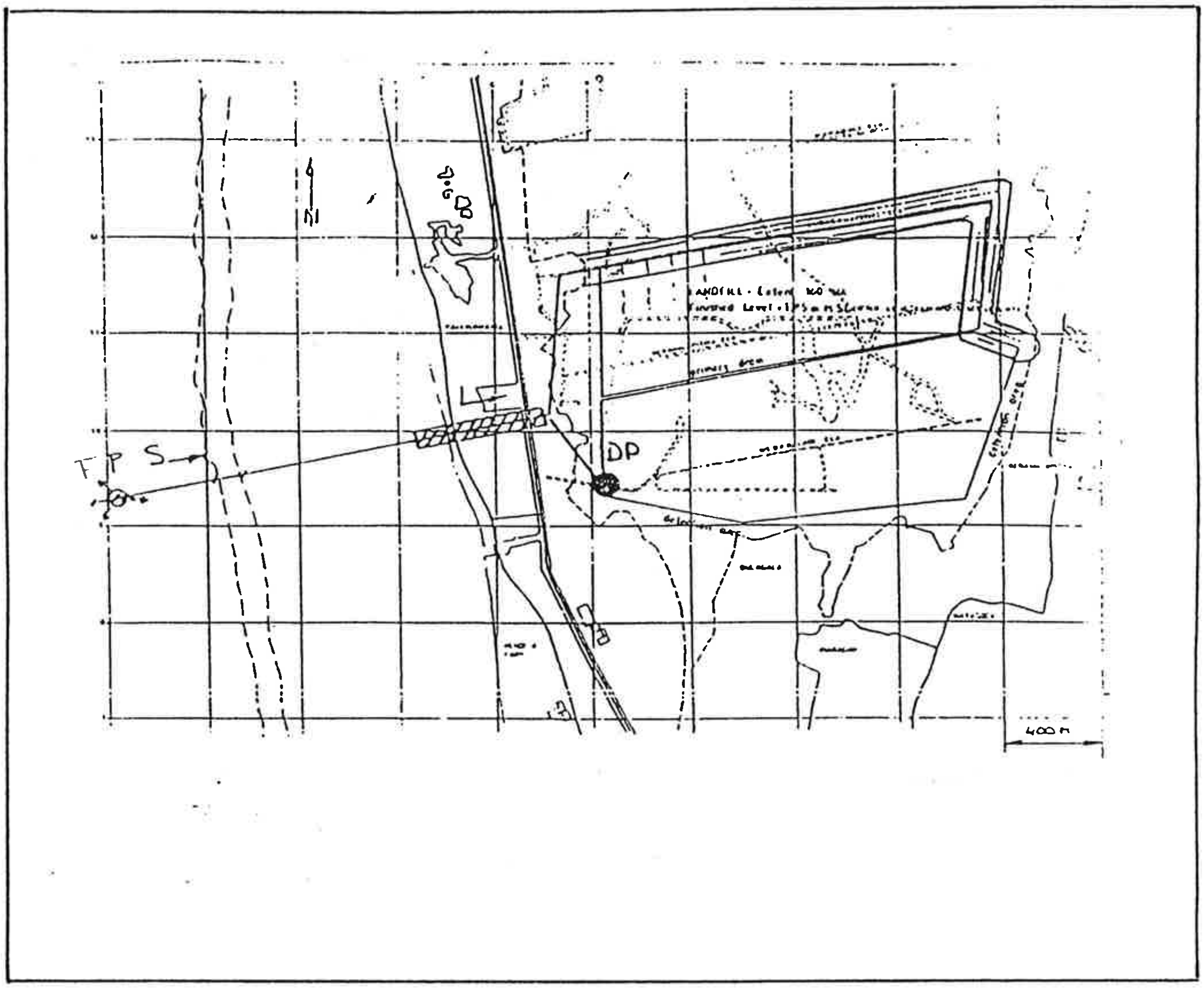


Figure 2.6
Proposed conservation and development model (2)



F: Floating Pipeline
P: Mooring Facility / Mooring Buoy
S: Submerged Pipeline
L: Shore Pipeline

Area for Booster station

The Northern Bund

DP : Drainage Pump

Figure 2.8
Details of the Offshore/Onshore pipeline and the Northern Bund in the landfill area.

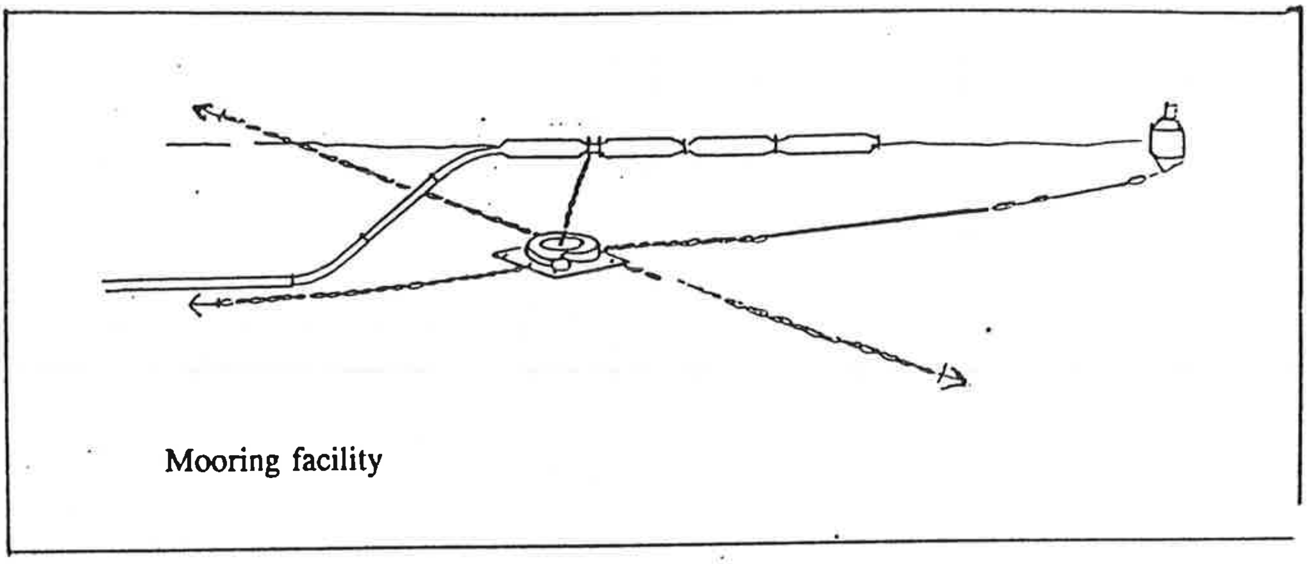


Figure 2.7
Mooring facility

3. EXISTING ENVIRONMENT AND SITE DESCRIPTION

3.1 Offshore and Nearshore Environment

3.1.1 Physical Resources

3.1.1.1 Coastline of Sri Lanka

The entire coastline of Sri Lanka, approximately 1600 km in length, is surrounded by the Indian Ocean. The narrow and very shallow Palk Strait separates it from the Indian sub-continent. The open coast is fringed by a narrow (3-30 km) and shallow continental shelf (edge at 15 - 90 m).

The coastline is subjected to wave action generated by the southwest and northeast monsoons, and by swells from southerly directions. They move sediments to the northwestern, northern and eastern parts of the coast forming relatively wide coastal plains with beaches. The other coastal sections are characterised by bays and headlands. Along the coastline numerous lagoons and marshes can be found behind sandy coastal barriers. The coastline of Sri Lanka is far from stable. A recent survey of the entire coastline (3) revealed that 40 - 55% of the coastline is eroding at an average rate of 0.30 - 0.45 m/y. Relatively severe erosion occurs along the southern, south-western and western parts of the coastline, including the dunal ridge separating the Muthurajawela marsh and the Negombo lagoon from the sea.

3.1.1.2 Sediment transportation in nearshore regions

A beach is rarely static. Sediments respond continually to the action of waves, nearshore currents and winds, and also to changes in the mean water level resulting from the tide. If an equilibrium of any kind exists at a section of a beach, resulting in short term or long term stability, it is usually a dynamic equilibrium in which the supply and the removal of sediments is balanced over a specific period of time. The movement of coastal sediments by waves and currents is known as *littoral transport*. It may be described in terms of two components *onshore/offshore transport* which takes place more or less perpendicular to the shoreline, and *longshore transport* which occurs parallel to the shoreline. These two phenomena dictate the sediment budget for a given coastal unit, the study of which providing an understanding of its' overall stability.

Onshore - offshore transport is primarily a function of beach slope, sediment particle size, wave height and wave period. It is caused by water motion at the seabed due to the passage of each wave. Sediment is moved if the water motion has sufficient velocity to detach particles of specific size on the seabed, and if the beach is not too steep. The threshold velocity for movement of the most easily moved particles is around 0.15 m/sec, whilst that for movement of a coarse beach sand of around 2 mm diameter is about 0.30 m /sec. It has been shown from wave dynamics studies that particle movement can occur even at considerable depths during extended wave periods.

Longshore transport is a result of the turbulence caused by the breaking wave, which initiates the sediment motion and transports it in the direction of the wave. The movement along the shoreline is due to the component of wave direction which is parallel to the shoreline and the alongshore current generated by the breaking wave. Since wave direction and energy vary throughout the year, the direction and amount of longhshore transport also vary. However, over the year or a number of years, there usually is a net drift in one direction. In order to calculate the seasonal or net annual longshore drift, detailed wave records for the shore under consideration and accurate surveys of the beach and seabed are required. It is important to note that longshore littoral tranport does not extend very much beyond the wave breaking zone. The detailed current pattern in the surf zone is complex. It is influenced by the extreme variability of wave patterns, the beach slope and coastline topography. Fig. 3.1.1 illustrates a typical situation of the current pattern in the nearhshore region. In the presence of plunging breakers on a flat beach, the longshore currents tend to display a strong meandering pattern with cellular eddies. On steep beaches and in the presence of plunging breakers the longshore current tends to be without significant cellular movements.

In most coastal zones there are also unidirectional currents. These may be oceanic or tidal in nature and hence, may vary seasonally, tidally or both. The presence of river estuaries discharging a large quantitiy of freshwater will also influence the nearshore current pattern. This is relevant to the offshore and nearshore regions under investigation in view of the presence of the Kelani estuary located a few km to the south. Depending on the current velocities, the currents on their own strength may not be capable of moving sediment unless it is already in suspension. In areas when wave action is the predominant cause of sediment motion, bed particles are usually 0.2 mm and upwards. In such situations unidirectional currents will have an impact when the current strengths are in the order of about 0.5 m/sec. Fig: 3.1.2 illustrates critical erosion and sediment boundaries for different types of bed materials. This plot of flow velocity vs grain size identifies important aspects relating to the erosion, transport and sedimentation of a wide range of materials.

Fig: 3.1.3 represents the movement of sediment around Sri Lanka. The materials supplied to a given coastal area from the adjacent area by rivers and eroding cliffs are transported by the action of currents and waves. Tidal currents and wave - induced currents, as discussed earlier, are dominant in the nearshore area and cause the movement of a large amount of sediments. The onshore/offshore movement of sand by waves together with the alongshore movement causes sediments to move along the shoreline in large quantities. These processes can transport sediments over large distances around headlands and coastal structures such as groynes that are built perpendicular to the beach and extend beyond the average breaker line.

Various types of sediment losses take place from shorelines. Sediment losses to the deep sea as sediment can be considered as permanent loss because this sediment will not be available for beach nourishment within time spans considered in coastal management. These losses are substantial, as indicated in Table 3.1(13). The onshore/offshore movement of sediment occurs due to changes in wave action or changes in the water level caused by tides. Fig: 3.1.4 illustrates the important sequences of a storm attack on a beach.

3.1.1.3 Coastline from Colombo to Negombo

With reference to the location of the proposed borrow area it is necessary to concentrate on the coastal stretch from Colombo to Maha Oya outfall. It has been reported (4) that this stretch, where the littoral forces are high, has a negative sediment balance, i.e. it is subject to a strong net drift of sand from south to the north causing a net loss of coast over the last few decades. This stretch has been identified as a progressively eroding shoreline (Fig. 3.1.5).

The harbour of Colombo, between Galbokka Point and Mutwal (2.6 km) is protected by breakwaters. A fishery harbour is located in Mutwal. From there, a relative unstable curved beach exists to the mouth of the Kelani Ganga with Crow Island located behind.

The coast north of the Kelani Ganga is protected by groynes and revetments over a distance of about one kilometer. A recession exists behind the Pegasus Reef. Thereafter the coast runs almost straight to Pamunugama and after a slight bend it extends to Pitipana in a convex manner. Beach rock exists along the entire coast from Pegasus Reef to Pitipana, extending northward into the sea as a rocky reef over a distance of about 6 km. A similar reef, but somewhat lower, exists along a stretch of about 7 km in front of the coast from Mutwal Point northward (Fig. 3.1.5).

A sandy coastal barrier with dunes separates the sea from the Muthurajawela marsh south of Pamunugama, and Negombo Lagoon between Pamunugama and Negombo. Dandugama Oya and Ja Ela discharge into the Negombo Lagoon at its southern end and is the reason why the sediment transported by those rivers does not influence the coast as most of it accumulates in the lagoon. Figures 3.1.5 and 3.1.6 illustrate Coast and Landforms from Colombo to Negombo.

The geological history of the area indicates a general recession of the coast. The appearance of beach rock on the beach is identified as a sign of recent erosion because it has been formed within the sand body of the beach ridge (1). In the stretch north of Dickowita, near the Pegasus Reef Hotel the coast has even receded behind the beach ridge. Fig. 3.1.7 illustrates some characteristic cross sections of the coasts. The reefs off the southern 8 km of the coast between Colombo and Pitipana appear in these profiles. Clearly the coast becomes steeper towards the north.

An important feature of the area is the opening created in the sandstone reef to facilitate navigation of fishing vessels. This unplanned activity has no doubt caused damage to the coastline by permitting greater wave activity on the shoreline. Furthermore, due to the extensive sand mining in the Kelani Ganga, there is not sufficient river-borne sand to nourish this beach segment. These two factors have played a major contributory role towards increasing coastal erosion of the area. Observations of coastal recession along the southern part of this coastal stretch (5) revealed an average erosion rate of 2.3 m/year, with a local maximum of 3.9 m/year, over a beach length of 1100 m between 1956 and 1981.

3.1.1.4 Ocean Environment

In this section attention is primarily focused on the tides and waves in order to appreciate the ocean environment in the vicinity of Colombo. Tidal records are available over a long period and a clear idea of the tidal environment is known. Wave height and period measurements have been undertaken by the Colombo Port authorities and information is available since 1980. However, continuous measurements have been undertaken only since 1988.

The tides observed at Colombo are characteristic for the entire western coast of Sri Lanka. They are weak, semi-diurnal having a mean tidal range of 0.35 m, with 0.2 m during neap tide and 0.6 to 0.7 m during spring tides. Storms may cause a limited set up on the narrow continental shelf, resulting in an additional rise of 0.3 m in extreme cases.

A wave measurement programme for the collection of wave data for the Colombo Port has been carried out on behalf of the Sri Lanka Ports Authority (SLPA) since 1980 by Lanka Hydraulic Institute Ltd (LHI) and the Coast Conservation Department (CCD). Although the programme of instrumental wave recording commenced in 1980, the total number of wave records available up to March 1991 was 9,414, an equivalent of 3 1/2 years of continuous recording based on a rate of 8 records per day. Continuous wave data were available only from January 1988 onwards. A two-year wave height measuring programme was commissioned in April 1991 in order to expand the Colombo Wave Data Base. The wave parameters have been recorded by a wave rider system at a location north of Colombo at a water depth of 16 m. With the completion of recording in March 1993, the Colombo Wave Data Base has been expanded with over five years of continuous wave data. The following information is a summary of the data presented in reports (10, 11, and 12) issued by Lanka Hydraulic Institute Ltd (LHI).

It is useful to note that the highest and second highest significant wave heights throughout the wave measuring programme (1980-1993) have been recorded during the South West monsoon periods of 1991 and 1992 respectively.

With reference to the data collected between April 1991 to March 1993 it is observed that during the two South West monsoons of the period under consideration, strong wave conditions prevailed, as compared to wave records of the past.

In the South West monsoon period of 1992 a maximum significant wave height H_s of 4.61 m has been recorded during the month of June, although this maximum did not last for a long period. In the South West monsoon period of 1992, a maximum H_s of 3.55 m (which could be considered as stormy weather) has been recorded during the month of July which lasted for 2 1/2 days. The minimum H_s during the two years was recorded during November 1991 (inter-monsoonal period) and its magnitude was 0.19 m.

There is a remarkable difference between the maximum and minimum values of the zero crossing wave periods (T_z). The maximum T_z of 10.96 seconds was recorded in June 1991 and a minimum T_z of 2.81 sec was recorded in February 1992. It has been noted that there is no well - defined pattern in the seasonal variation of maximum and minimum values of T_z. This indicates the existence of varying wave climates, such as pure swell waves, pure wind waves and combinations of swell and wind waves in many months of the year.

From the scatter diagram of H_s vs T_z, it can be seen that H_s over 2m were associated with T_z values between 5 s and 10 sec while H_s below 2 m were associated with T_z values between 2 sec and 10 sec. A relatively large scatter is observed in the diagram of H_s vs T_p, where T_p is the peak wave period defined as the inverse of the frequency which shows the highest energy in the wave energy spectrum. The T_p values were fairly independent of H_s values. The range of T_p was between 2 s and 22 s. These data can be used to compute the velocity regime of the seabed.

By analysing the stormy event in 1991, which occurred on 2nd June at 03 hours, it was noted that 85% of energy was concentrated in the wave periods ranging from 8 sec to 16 sec. This leads to the conclusion that the storm had originated far away from Sri Lanka and coastal water experienced only the secondary effect due to wave propagation.

It is important to note that wave height measurements are presently carried out off the coast of Henda in deep waters by the Coast Conservation Department (CCD) with the assistance of the Gern Government.There is no doubt that this information would be extremely useful for monitoring purp in relation to the Kerawalapitiya Reclamation Project.

3.1.1.5 Sand deposits at proposed borrow site

It is essential that sand mining from offshore sea beds does not lead to an imbalance of the sand budget in the coastal zone. Also, deepening of the seabed should not lead to destabilisation of the nearshore coastal profile, as this could induce an increase in coastal recession.

Previous studies (1) indicate the existence of primary, secondary and tertiary offshore sandstone reefs at depths of -2, -6 and -10 m MSL, at distances of 500 m, 900 m and 1500m respectively. These reefs are important coastal barriers forming an integral part of coastline dynamics. Sand extraction from the sea bed should be located to the seaward side beyond these barriers at sufficent depth. Minimal extraction depth is 12 m, minimal distance from the shore is 3 km. The planned landfill operation has complied to these requirements. The proposed borrow site is situated at 15 m depth exceeding 3 km from the shore.

Sand deposits in the proposed borrow site have been assessed in 1988 by Zanen & Verstoep, and SLLR&DC. These surveys revealed that sand deposits in the proposed sites are amply available, exceeding 10 million m^3.This information is available with the SLLRDC.

3.1.2 Ecological Resources at Borrow Site

The borrow site is situated more than 3 km offshore beyond a sandstone reef, at a depth exceeding 15m(average). This borrow area will be about 2.5 km^2 in area. The sand mining operation will remove a maximum 2 meter deep layers of sand in narrow trenches parallel to the shoreline, from a depth of 15-30m. In jurisdictional terms, the borrow area is situated within the limits of Sri Lanka's Territorial Sea.

The sea bottom substrate at the site consists mainly of medium coarse sands (particle size between 0.2 and 0.5 mm). No seagrass beds have been observed in the area. High turbidity prevails for most of the year, in particular during the rainy seasons when vast amounts of silt from the eroding catchments enter the sea south of the borrow area. This sediment fans out widely for several kilometers from the river mouth and is transported in a northern direction by coastal currents.

In contrast to the pronounced abundance of polychaetes (sea-worms) in the infaunal samples, the dominance in the epifaunal samples are shared equally among the crustaceans (shrimps, crabs), sea-worms, bivalves mussels etc. and brittle stars. When these four groups are compared on the basis of diversity, crustaceans invariably have the largest number of species followed by the polychaetes and bivalves.

Generally the sea benthos shows a decrease in animal life with increasing depth of water and distance from the land. The abundance of food, controls density and biomass at the sea bottom. Oxygen concentration, sediment type, turbidity and temperature also dictate biomass in shallow coastal waters.

Sources of food fall into two broad categories; either it is produced in the relatively narrow, lighted, upper water layer and conveyed into the deeper sea, or it is generated in situ at the sea bottom. Deposit feeders ingest particles from the sediment surface, or ingest mouthfuls of sediment from lower levels. Annelids (worms) are the characteristic deposit feeders, but many bivalves, gastropods (sea snails, slugs, sea hares), and crustaceans also live in this way.

On land and in the shallow marine regions reproduction is usually coupled with some cyclical and often seasonal phenomenon such as day length, temperature, or rainfall. This synchrony allows the adult portion of the population to be ready for reproduction at the same time, and the resulting young or larvae are usually present when feeding conditions are best.

The production of carbohydrate, the primary source of food for the ocean occurs within the relatively narrow, upper water layers. For this energy requiring process sunlight is essential. If the sediment load of the upper layers increases, this will result in a decrease in light penetration. Consequently, the primary production of the sea decreases. The bottom-living organisms, depend for their food supply to a large degree on the upper water layers (euphotic zone). If the primary production of the upper layers are disturbed, this will reduce the food available to the benthic community.

The organisms that utilize the primary carbon source, dead organic matter do so in one of the following three ways; they either filter particles that are in suspension in water just above the sediment, browse on particles at the sediment surface, or ingest particles that have been deposited on or in the sediments. The feeding mechanisms of each of these groups of animals will be affected by an increased sediment load in the water.

The survival of animals burrowing deep into anaerobic sea bed layers is conditioned by their ability to irrigate (or ventilate) their burrows with a supply of well-oxygenated water from the surface. If the sediment load of the water increases, the risk that these burrows will be closed through the depositing particles increases.

The area is used, to a certain extent, by coastal fishermen. The catch method is using trawl nets sweeping the sea bottom. Shrimp (pennaeid species) constitute the main catch, a minor part being demersal (bottom - feeding) fish species. Pelagic fish species (feeding in the sea water mass) include mullet (Liza ssp.) Detritus feeding sea bottom fauna (eg. polychaete worms, crabs) and infaunal detritus, serve as feed for various species of shrimp and fish.

It should however be realized that no established fishing grounds exist in the proposed borrow site. Important fishing grounds are at least 1.5km further seaward from the site.

Two factors indicate that the area in which the borrow site is situated is no longer in prime habitat condition:

i) the prevailing water turbidity caused by river sediment limits species variety and density, because of reduced light penetration, and consequently, lower primary production, and because of clogging of respiratory organs and reduced visibility.

ii) the prevailing use of trawl nets leading to frequent disruption and destruction of sea bed communities, causing turbidity causing further impacts - see (i).

Considering these impacts on the sea bottom at the proposed borrow site, it can be concluded that it is most unlikely that the area is of great importance to coastal fisheries production. It is also very unlikely that the area contains unique habitats, rare or endangered species, or economically important marine resources, i.e. considering the small size of the borrow site as compared to the vastness of the coastal ecosystem of which it forms part.

Fish and shrimp species harvested in the fishing grounds include:

Herring(amblygaster sirm),SardineSaidinella longiceps),Skip jack(Katsuwonus pelanis),Indian mackeral(Rastrelliger kanagurta),Spanish mackeral(Scomberomorous commersoni),Yellow Fin Tuna(Thunnus albecares),Mackeral tuna(Euthynnus affinis),Spotted Spanish Mackeral(Indocybium guttatum),ponyfish(Leiognathus spp.),and shrimps,i.e.Peneus indicus and P.monodon.

3.2 Landfill Area Environmen

3.2.1 Physical Environment

3.2.1.1 Topography

The Muthurajawela marsh in Kerawalapitiya area is bounded by Mahabage Ela to the North, Hamilton Canal to the West, Dutch Canal to the East and Hendala Road to the South.

The present level of the marsh is 0.3 meters m.s.l., while the proposed level after reclamation is 1.85 meters m.s.l.

3.2.1.2 Climate and meteorology

Meteorological Status

The climate of Muthurajawela is influenced predominantly by the South West Monsoon. It lies in a part of the Wet Zone which receives 2000-2500 mm of rainfall per year. There are two periods of heavy rainfall immediately preceding and following the monsoon period lasting from mid May to September.

Evaporation exceeds rainfall in January, February and March. In all other months there is an excess of rainfall. The highest mean daily maximum temperature of 31.5 °.C occurs in April and the lowest mean daily minimum of 22.3 °. C in January.

The main wind directions as recorded by the meteorological Department at 8.30 hours are N to NW from November through February and mainly SW during the rest of the year. At 17.30 hours the winds are NE from November through February, E in April and March, and mainly SW during the rest of the year. Monthly and annual levels of precipitation (1937-1989), evaporation, and evapo-transportation (Penman) at Colombo are given in Table 3.2.1

The figures in Table 3.2.1 indicate that there is a deficit in January, February and March and that the effective rainfall is minimal in July and August. Consequently Evapo-transpiration of the vegetional cover leads to a deficit in July and August. The mean monthly run-off of the Attanagalu Oya and the Kelani Ganga have been derived from observations made during the 6 year period 1956-1961 and the 11 year period 1975-1985 respectively. The main elements of the water balances of the Muthurajawela marsh (between Ja-ela and Hendala), as derived from the general data have also been given in Table 3.2.1.

Along the west coast cyclonic storms can be expected once in eight years while a severe storm can be expected once every 25 years.

Rainfall Pattern

The Muthurajawela area lies in a part of the Wet Zone of Sri Lanka which receives 2000-

2500 mm rainfall per year (Fig 3.2.1).

The South West Monsoons in Sri Lanka are characterized by two periods of heavy rainfall immediately preceding and following the monsoons period which lasts from mid May to September. For analysis of rainfall, data from the Colombo Observatory have been utilised, as this station is the closest to the Muthurajawela area with uninterrupted data over a long period.

For a 200 year return period, daily maximum rainfall can be as high as 340 mm, maximum rainfall in two consecutive days 470 mm, in three consecutive days 526 mm, and in 4 consecutive days 588 mm. Annual mean rainfall at Colombo during the present century amounted to:

1909 - 1930 : 2,240 ± 458 mm
1931 - 1961 : 2,374 ± 319 mm
1961 - 1989 : 2,383 ± 547 mm

Further analyses show a slightly declining trend in rainfall over the years 1962-1984

Evaporation and Humidity

The monthly average rainfall, evaporation and relative humidity recorded at the Colombo Observatory during the period 1964-1989 are compared in Fig 3.2.2.

The evaporation exceeds rainfall only in January, February and March. In all other months there is an excess of rainfall, the highest in May and October, and the lowest in August.

Temperature

Mean daily maximum, minimum and average temperatures, recorded over the period 1961-1980 in Colombo, are presented in Fig 3.2.3.

The highest mean daily maximum of 31.5 °C occurs in April and the lowest mean daily minimum of 22.3°C. in January. The highest maximum temperature and lowest minimum temperature recorded at the Colombo Observatory between 1910 and 1989 was 36.2°C on 23 February 1915 and 15.2°C on 4 January 1950 respectively. The highest day temperatures generally occur between 12.00 and 15.00 hours and the lowest between 05.00 and 06.00 hours.

Wind Pattern

Over 25 years of wind data of the Colombo Observatory for the two daily times (08.30 and 17.30 hours) are given in Fig. 3.2.4

and 17.30 hours) are given in Fig. 3.2.4

The maximum wind speed recorded at 08.30 hours local time is 15.3 km/h in March and the minimum is 5.3 km/h in April.

The main wind directions are at 8.30 hours N to NW from November through February, and mainly SW during the rest of the year. At 18.30 hours the winds are NE from November through February, E in April and March, and mainly SW during the rest of the year.

An analysis of the number of cyclonic storms reaching the West coast indicate that two important ones were registered during the 1881-1989 period i.e. in December 1912 and the cyclone in Chilaw in October 1967. Although no trend or periodicity of occurrence of cyclones is apparent over the mentioned period, the frequency of cyclonic storms can be set at one in eight years, with one of greater intensity, once in 25 years.

3.2.1.3 Geology

Geological Structure

The Muthurajawela marsh developed over the last 6000 years from the Pleistocene landscape that existed after the last glacial period. During the last century the sea level rose at a rate of about 1.2 mm per year. The rise of the sea level caused the coast to transgress over the continental shelf leaving reefs consisting of beach rock at depths varying from 10 m to 25 m.Fig.3.2.5 indicates the geological evolution of Muthurajawela Marsh.
As long as there is poor drainage the marsh will survive but the present trends show a considerable reduction or even ceasing of the accumulation of peat in the marsh which may lead to its vertical growth lagging behind the rise of the sea level.

Figures 3.2.6 and 3.2.7 provide more useful information on the variation of mean sea level during the last 10,000 years and a schematic cross section of the coastal area in the vicinity of Muthurajawela.Fig. 3.2.8 also depicts the stages in the geological history of the Muthurajawela Marsh-Negombo Lagoon.

Classification of Peat Strata

Peat formation started in the southern part of the lagoon during the period of low sea levels, probably around 6000 years BP . Three strata of peat can be identified, from top to bottom:

a) Reed and sedge type peat:

Consisting mainly of grass and sedge debris, together with debris from other marsh vegetation. This type of peat is light and spongy and has a fibrous and matted appearance.

b) Shrub and tree type peat:

Composed mainly of clearly recognizable remains of trees and shrubs, and being of a compact, hard texture.

c) Humus-type Peat;
Very different from the other (younger) peat types. It consists of fully decomposed, no longer recognizable plant materials.

The inclusion of marine, elements in the older sediment layer, the presence of pyrite in the deeper clayey deposits, the high sulphur content of most of the peat, particularly in the middle peat layer, and the occurrence of shells and other remains of sea organisms in the peat confirm that an abrupt and fast transition from forests to the present day marsh vegetation had taken place. Fig.3.2.9

However, during the last thousand years, the southern marsh area had been free of salt water influences, that is to say, until human intervention such as the construction of irrigation and drainage canals which caused seepage, infiltration and in-flow of salt water.

The abundance of metals in the Muthurajawela peat has been studied by Dissanayake (14). Their presence appears to be closely associated with the clay particles.

The low pH of the peat bog has aided in the conversion of the metals to free ions which are absorbed onto the clay complex. The bottom horizon with high clay content therefore, contains the highest amounts of these metal ions.

3.2.1.4 Soil

Soil Profile

According to the analysis of the existing borelog information the soil layers were described as follows:

(a) Surface clayey soil (GV):
The thickness of this layer is in general 0.30 m. The average water content of this brown and plastic soil is 70% to 80% and the organic matter content is low, 10% in general. The compressibility and permeability are less than those of peat.

(b) Soft Peaty Clay (PC):

The thickness of this layer is 0.30 to 8.40 m with an average of 0.60 to 1.0 m. It is grey to grey brown in colour. The average organic matter content is about 20%, water content is 95% in general and 151% maximum. It is plastic (sometimes plastic-flow) and may be rolled into fine strips. It has very low strength and low permeability. Its shrinkage is around 1/6.

(c) Peat (Pt):
The thickness of this layer varies from 0.30 to 9.20 m and the average is 1.9 to 2.30 m. The peat is brown to black in colour, having a bad odour. The sulphur content is 1.6 to 8.3%. The peat is mainly composed of remains of partly decomposed plants, in which roots, stalks and leaves are still distinguishable. The organic matter content is high, ranging from 30% to 80% in general. The water content is also very high, 352% in average and a maximum of 550%. Some types of peat have the form of cow dung, while others take the form of sponge.

It is not plastic and cannot be rolled into strips by hand. It's strength is low. It has a high compressibility and good permeability and the shrinkage is about 1/3 after being exposed to the atmosphere.

(d) Sand Layer(S):
This layer includes silt, fine and coarse sand. According to findings from boreholes penetrating the sand layer, it has been found that the average thickness is 2.20 m, the maximum 3.50m and minimum 0.9m. Coarse sand and fine sand are pure white and consists mainly of quartz with a fairly homogenous texture.

(e) Red Clay (C):
This layer generally 1.20m to 1.80m thick, and 3.60m maximum, is composed of weathered granite gneiss mixed with ferruginous cumularspharoliths. In part of the red clay, schistosity is evident. In general, these soils are hard and plastic, and have a low compressibility and permeability.

Soil types and Classification

The Muthurajawela marsh contains several types of soils ranging from very poorly drained organic soil to poorly drained mineral alluvial soils. Most of the soils contain sulphur at levels that could become toxic to most agricultural crops. A large portion of the marsh is subject to tidal influence which raises the soluble salt content to levels that adversely affect crops (Table 3.2.2).

Soil classification in Sri Lanka is based on the soil taxonomy of the United States.

The soil types present at Muthurajawela are classified into 3 basic types, all of which are acid sulphate soils or potentially acid sulphate soil.

The predominant soil of Muthurajawela consists of poorly drained organic soil (bog soils), dark brown to black in colour and overlying waterlogged mineral subsoils. All these sub soils contain pyrites (compounds of iron and sulphur) to the extent that they classify as potential acid sulphate soils. The bog soils bordering the Negombo Lagoon and those situated on the western segment of the main marsh become saline because of tidal influence

Table 3.2.2 describes the properties of bog soil(Organic Soil) of Muthurajawela.

The second major constituent of Muthurajawela are the mineral soils with large amounts of organic matter, but in quantities insufficient to classify them as bog soils. They have properties of both bog and mineral soils, with low levels of organic matter. These soils also contain sufficient pyrites to classify them as potential acid sulphate soils.

The third major Group consists of soils formed of inorganic material (minerals) with a thin layer of organic material (humus) at the surface. These soils have been deposited mainly by rivers and floods and are therefore classified as alluvial soils, i.e. humic alluvial gley soils, because they are water-logged and poorly drained. These too are potentially acid sulphate soils because of high pyrite content.

Ref. Fig.3.2.10,it is evident from the land suitability classification for selected agricultural land use types that the soils of Muthurajawela are not suitable, or only marginally suitable for most crops such as rice and vegetables.

Soil Characteristics

The characteristics of the soil have been deduced by considering borehole data collected from the marshlands of Muthurajawela, Peliyagoda, Bloemendhal, Orugodawatta, Maligawatte and Attidiya.

In general it was observed that in virgin marshland, the subsoil consists of the distinct horizons, the upper horizon is predominantly organic in nature (peat, or peaty clay) and the following horizon basically a transported sandy profile with varying admixture of silt and clay sized particles. The organic soil may be broadly divided into three basic groups, namely, coarse fibrous, fine fibrous peat. Amorphous granular peat was generally observed in the second horizon. Organic matter increases substantially and the fibrous character of the soil is lost. This is generally referred to locally as 'Humus Peat'.

Due to the predominantly fibrous constitution of the organic matter, peat has a sponge - like nature associated with very high moisture content, very high void ratio and high shrinkage (subsidence) after drying.

3.2.1.5 Hydrology ,

Hydrology of the Area

The Muthurajawela marsh receives water from direct rainfall, run-off from the Dandugam Oya, from local catchments like surrounding higher grounds, and probably occasionally during floods, from the Kalu Oya and Kelani Ganga. There is loss of water from the area by evaporation of open water and evapo-transpiration of the vegetation. Very poor drainage accompanied with rainfall and inflow exceeding losses to the atmosphere in the wet season, and vice versa in the dry season. There is a net outflow from the area. The marsh acts as a source of fresh water to its surroundings, especially to the tidal delta and the lagoon.

The water level in the marsh, and probably also the marsh itself is slightly higher in the centre than along its fringes. Water levels vary with the seasons, but the retention time is long enough to leave the area inundated, or saturated, during the year.

Hydrological units are given in Table 3.2.3

The estimated sea level rise is 1.2 mm/year over the last 100 years.

Tidal characteristics over the last 100 years are given in Table 3.2.4.

Present Drainage Patterns

The marsh area covers about 35 km^2, and fresh water enters the area from the Attanagalu Oya (Dandugam Oya and Ja-ela) 1.5 km^3/y and from direct precipitation 0.2 km^3/y. Occasional inflows can occur from the Kalu Oya and the Kelani Ganga during exceptional floods.

Evaporation and evapo-transpiration remove about 0.15 km^3 annually. The balance flows to the sea mainly via the outlet of the Negombo lagoon and for a lesser part through the Hamilton Canal into the mouth of the Kelani Ganga. The inflow of saline water from the sea is estimated at 1.1 km^3 per year through the inlet of the lagoon and a considerably lower quantity through the Hamilton Canal.

The Jayasuriya road cuts the main marsh into two parts except the bridge across the old Dutch Canal. Both parts receive water from higher grounds to the east and south and from the higher area around Bopitiya village. Agriculture along this eastern fringe may receive water from the marsh during dry periods.

The western boundary of the marsh is formed by the bund road along the Hamilton Canal between Hendala and Bopitiya, about 10 km long and 0.4 - 1.0m above m.s.l. Seven sluices with malfunctioning control gates cross this bund as well as numerous small culverts. These form the main drainage of the marsh between Ja-ela and Hendala towards the Hamilton canal. They are connected to the 28 canals crossing the marsh in east-west direction. They are all in open connection with the Old Dutch canal which drains towards the Kelani Ganga at its southern end. The extensive drainage system includes numerous more or less deteriorated canals and low bunds with roads and paths. Most of these structures, however, including low parts of the Hamilton Canal bund, are inundated during floods. Then a more or less continuous sheet of water flows towards the Hamilton Canal.
Fig.3.2.11 schematically explains the flow patterns that occur during the dry and wey seasons.

The Hamilton Canal, 14.5 km long, further conveys the water towards the Kelani Ganga mouth and to the Negombo Lagoon.

Salinity Variations

Salinity is low in the entire area during the wet seasons. Salt penetrates from the sea through the lagoon into the northern part of the area, and in the south-western part through the Hamilton Canal during the dry season. Evaporation increases salinity levels in some places. High salinities of 5 ppt were observed in the south-western half of the Muthurajawela area during the 1989-1990 dry season. Salinity exceeded 15 ppt in the north eastern part (1).

Surface Water Quality

The water in Muthurajawela marsh is generally acidic. Water quality is summarised in Table 3.2.5 and Fig.3.2.12.

Higher heavy metals concentrations were detected in the marsh which may be the result of acidic conditions facilitating their release from sediment into the water. However, more refined analysis using atomic absorption spectrophotometry is necessary in order to determine the pattern more precisely.

The faecal coliform and total coliform levels were unacceptably high at all locations where defecation occurred.

In the marsh, water in canals and pools in the vicinity of the squatter houses are used for washing and bathing and could transmit intestinal diseases. Note that no faecal coliform occurs at Nugape, where no squatter settlements are found. The high levels of chromium at this location is most likely associated with solid waste dumping.Fig 3.2.13 shows some solid waste dumping sites in the marsh area.

Sewage enters the area from the river, from industrial and touristic facilities along the lagoon border and from settlements around and in the area.

Storage Capacity

The distribution of the land according to its present elevation in the Muthurajawela marsh is:

0 - 0.1 m	6.0 km^2
0.1 - 0.2 m	15.6 km^2
0.2 - 0.5 m	1.4 km^2
0.5 - 0.8 m	2.0 km^2
0.8 - 1.1 m	1.0 km^2
Total	26.0 km^2

The maximum storage in the marsh area is about 11 million m^3, with a water level of 0.52 m and maximum discharge 12.5 m^3/s. The retention time is slightly more than 10 days.

A rainfall /run-off model developed by Dharmasena has simulated the effects of flood with return periods of 50,100 and 200 years.The results are given in Fig.3.2.14 and 3.2.15.The retention times appear to be 8.5 to 7 days.These retention times are too short to bridge rainless periods in a dry season. Before drainage conditions were improved, retention times must have been at least five to ten times as long as at present. Thus, in the past, the marsh remained wet during most of the dry season.

Quality of Groundwater

The quality of the groundwater indicate layers of fresh water levels fed by rains in the dunes and in the sandy area around Bopitiya. Acid water emerges from the marsh and spreads into other waters. The same water probably carries useful nutrients as well as pollutants which enter the groundwater from a variety of sources including squatters settlements, villages, touristic facilities, agriculture, industry etc.

3.2.1.6 Sediment Transport

The sediment balance for the entire marsh lagoon is given in Fig 3.2.16.The inflow and outflow of sediment follow the same pattern as the water flow, except that there can be deposition and erosion at different locations.

The inflow of sediment into the system is the result of:

- Sediment transport through the Dandugan Oya and Ja-ela rivers.

- Sediment from local catchments on the eastern and southern fringe of the area.

- Sediment carried by the Hamiltom Canal from local catchments and from the Kelani Ganga during flooding.

- Tidal inflow into the lagoon.

The outflow of sediment is essentially the sediment carried away through the lagoon mouth from lagoon to sea.

The sediment balance has been estimated as follows:

Annual Sediment load from Dandugan Oya and Ja-Ela (DJ)	147,000 t/year
Annual sediment load from Hamilton Canal (HC)	62,000 t/year
Annual Sediment Load from sea into Lagoon during high tides (SL)	60,000 t/year
Annual Sediment Load from Lagoon to Sea (LS)	190,000 t/year

Hence the estimated sediment load deposited in the lagoon and marsh can be expressed as =

DJ+HC+SL-LS = 79,000 t/year or 50,000 m^3/y.

If this quantity would be deposited in the lagoon, the sedimentation rate in the lagoon would be about 1.5mm/year. In reality, deposition of part of this sediment, takes place in the marsh, especially during periods of flooding. Similarly, sediments eroded in the lagoon, probably by wave action, are redeposited in the same water body.

Suspended sediment in the lagoon is estimated at 50g/m^3 during the wet season, which corresponds to a total of 200 t of sediment being suspended in the water of the lagoon at any one moment.

3.2.2 The Present Ecological Environment of the Fill Site

3.2.2.1 Background

The Asian Wetland Directory(16) lists the ecologically most important wetlands of Asia. Among these is the Muthurajawela marsh. The wetland consists of the Muthurajawela marsh and the Negombo lagoon, covering 6500 ha together situated along the western coast of Sri Lanka. The wetlands of Muthurajawela can be divided into the marsh proper, the more saline zone between the marsh proper and the lagoon and the lagoon itself. As any other marsh - lagoon system, river runoff and precipitation provide the lagoon with freshwater. The Dandugam Oya, the lower segment of the Attangalu Oya, which has a catchment area of 72,800 ha, flows into the Negombo lagoon. Unfortunately this catchment area has now very little forest cover and is subject to accelerated erosion, which has contributed to increased sedimentation of the lagoon. It has been determined that the annual sediment load trapped within the Negombo lagoon is about 50,000 t (1). As a consequence, the delta of the Dandugam Oya has grown from 44 ha to 92 ha in a period of 25 years.The Dandugam Oya discharges at the junction of the lagoon and the marsh.

At the lagoon mouth, deltas and channels have been formed. Accumulation of sediment in the northern part of the lagoon has contributed to the expansion of shoals, which reduce the tidal exchange between the lagoon and the sea. Landfill and housing expansion in the already narrow segments of the channels further threatens this essential tidal exchange.

The marsh receives freshwater from the AttanugaluOya (Dandugam Oya and Ja-Ela) from the surrounding higher grounds, through precipitation (2000 mm/y) and occasionally from floods from Kelani Ganga and Kalu Oya. Water is removed through transpiration and evapo- transpiration. Natural drainage is extremely slow, in fact some channels that have been created in the past are now overgrown with vegetation. With the rain and inflow exceeding the outflow primarily during the wet season there is a surplus of water. The marsh therefore acts as a source of freshwater to the surroundings.

The salinity is generally low in most areas during the wet season but increases in the dry season when salt penetrates into the northern part through the lagoon and in the south-western part through the Hamilton canal. High salinities have been recorded in the past: 5 ppt in the south-western half, and 15 ppt in the north-eastern part.

3.2.2.2 Vegetation

The vegetation types of Muturajawela as it exists today can be divided into three categories:

- the vegetation of the marsh proper.
- the vegetation of the transition zone between the marsh proper and the lagoon.
- the lagoon

The marsh vegetation of the proposed landfill site

The marsh substrate remains moist to saturated throughout the year. Certain areas are waterlogged for at least part of the year. The type of vegetation in the marsh is determined by its substrate condition. Most areas of the marsh are covered with combinations of grasses and sedges belonging to the family Poaceae and Cyperaceae and cattails belonging to the family Typhaceae. Occasionally there are patches of fern, Acrostichum aureum, and in more open places Hydrocera triflora occurs. The composition of the plantcover however changes gradually from south to north as a result of changing salinity combined with substrate condition.

Among the woody plant species that have been recently introduced into the area is wel atha, Annona glabra L. This most aggressive woody species establishes everywhere on bank gradients and it indicates the first step towards a more dryland plant association on higher better drained lands. Also common are species such as bowitia, Osbeckia aspera and wetakeyiya, Pandanus odoratissimus. The coastal vegetation on and behind the dune ridge has disappeared since most of this has been converted to coconut groves. On the sea side the dune ridge is still locally protected by trailing plants, such as the grass, Spinifex spp. and Ipomoea pes-caprae.

The aquatic vegetation

Plant species composition in abandoned paddy fields, ponds, canals and channels depends upon the level of eutrophication, the degree of salinity and water depth. In the southern part of the old Dutch canal, which is now very shallow, grasses (Panicum repens, Ischaemum rugosum) and sedges (Carex indica) predominate. Where the nutrient content is high invasion of dense growths of noxious weeds has taken place, i.e. the fern Salvinia molesta, or duck weed, Lemna spp..Salvinia is not found in places such as the Hamilton canal where salinity is high. The cover of emergent plants in the Hamilton canal is generally low since most of the canal banks have been stabilised by masonry. Less eutrophic waters are inhabited by the water lillies and Nymphoides spp., and the east-west running drainage channels contain water weeds such as Hydrilla verticulata and Aponogeton crispus (Kekatiya). The bottom-rooted floating plant species of ponds and water courses include water lillies and the noxious aquatic weed, the water hyacinth (Eichhornia crassipes).

The open canal waters are usually very rich in phytoplankton and algae which are essential food elements of the many higher aquatic organisms.

Some plant species of the marsh have medicinal value, others provide material for cottage industry, are used as fuel wood and as food plants for humans as well as animals. Many marsh plants serve as food for aquatic herbivorous birds and herbivorous fishes. Many species of grasses and sedges and water lillies produce an abundance of seeds, the favourite food items of certain species of duck. The aquatic fauna maintained by the marsh vegetation in turn provides food for a variety of fish-eating birds (herons, egrets, cormorants, etc.) and carnivorous fishes.

None of the plant species within project site are endemic and none are confined to the proposed landfill site.The profiles of vegetation along irrigation channels and the drainage channels of Muthurajawela are shown in Fig.3.2.17 and Fig.3.2.18.Fig.3.2.19 reveals the vegetation profile along the Dutch Canal.

3.2.2.3 Fauna

Mammals

Within the Muthurajawela marsh a total of 34 species of mammals have been recorded. Among these species two species are endemic to Sri Lanka, the Ceylon fruit bat, Rousettes seminudes and the toque macaque, Macaca sinica. Six species which are threatened include, the painted bat Kerivoula picta, the slender Loris, Loris tardigradus, the otter, Lutra lutra, the fishing cat, Felis viverrina and the rusty spotted cat, F. rubiginosa as well as the mouse deer, Tragulus meminna.

The mammals come under various forms of local threats. The black naped hare, Lepus nigricollis and the porcupine, Hystrix indica are intensively hunted for food. The otter's habitat is rapidly diminishing due to filling up of the canal system.For none of these species the landfill area is an essential habitat, because of disturbance and habitat modification.

The conservation of almost all of the threatened species is dependent on the protection of sizeable habitats including forest cover of Muthurajawela. For a healthy population of Felis ssp. an area between 1000 and 2000 ha is considered as a minimum habitat size. If this is met, then the other threatened sps. such as Rousettes seminudes, Kerivoula picta, Loris tardigradus, Macaca sinica and Tragulus meminna will also profit. The Master Plan identifies the northern part of the marsh bordering the lagoon for this purpose.

Birds

Wetlands are important feeding, resting, roosting and nesting grounds for a variety of bird species. Hence it is not surprising that a large number of resident as well as migrant species have been recorded from the Muthurajawela - Negombo lagoon wetlands. A total of 126 resident species have been identified.The breeding locations of some of the resident birds of the Muthurajawela Marsh-Negombo Lagoon wetland are shown in Fig.3.2.20.However, none of them is endemic. Nevertheless there are 4 threatened species: the reef heron (Egretta gularis schistacea), the grey- headed fish eagle (Ichthyophaga ichthyaetus plumberceps), the blue breasted banded rail (Gallirallus striatus) and the black-capped kingfisher (Halcyon pileata). These threatened species due to their dietary preferences, are confined to the northern segment of the marsh in the vicinity of the lagoon.

The habitat preference of the various bird species is determined by, among other factors, the availability of food. The canals and other waterways attract fish-eating bird species. The undisturbed marsh area with its dense population of insects attracts the insectivorous and omnivorous birds such as warblers, prinias, swallows and shrikes. The cultivated areas are preferred by fruit-eating species such as bulbuls, mynahs and the barbets. Nectar feeders such as the sunbirds are common throughout the whole of the marsh and the mangrove areas.

Marshy areas and mudflats are frequented by plovers, whimbrels, sandpipers which probe into the ground for burrowing worms and larvae. The coots, moorhens, and jacanas which feed on the aquatic vegetation of the wetlands are also found. The openbill stork (Anastomus oscitans) is found in the Bopitiya and Uswetakeiyawa marshlands and is especially adapted for feeding on molluscs and aquatic snails.

The most important habitats for the residential as well as the migratory species, based on the feeding and breeding habits, reveals that the northern part of the Negombo lagoon (Mangrove islands, open waters and sea grass beds), the lagoon/swamp transition area and Muthurajawela central region (Bopitiya and Uswetakeiyawa area) are of crucial importance to the avifauna. The latter two areas have been earmarked in the Master Plan (2) as Conservation Zone.The distribution of migrant birds in the Muthurajawela Marsh-Negombo Lagoon wetland is represented in Fig.3.2.21

The Reptiles

37 reptilian species have been identified in the Muthurajawela area. Among them are 7 threatened species ; two skinks (Mabuya macularia and Lankascincus fallax), two freshwater terrapins (Melanochelys trijuga and Lissemys punctata), the estuarine crocodile (Crocodylus porosus), the green garden lizard (Calotes calotes), and the lizard, Typhlina bramina.

Among those mentioned above the estuarine crocodile, is the most endangered since its breeding grounds are greatly reduced in Sri Lanka. The conditions suitable for its breeding are available within the Muthurajawela marshes and the breeding grounds are located within the central to the northern region, not in the proposed landfill site. The main threat against the crocodile sps. is the local community: some marsh inhabitants kill them for flesh and skin.

Among the snake species the two very rare species identified are the sea snakes in the lagoon area, i.e. Guenther's roughside (Aspidura guentheri) and Gerada prevostiana. Python molurus and the Sri Lankan pipe snake (cylindrophis maculatus) have also been found.

Amphibians

Some 15 amphibian species from five families have been identified in Muthurajawela; Ranidae, Bufonidae, Rhacophoridae and Microhylidae. The Ranidae (frogs) generally prefer Muthurajawla's aquatic habitats: the larger frogs (Rana hexadactyla and R. tigerina) dominate open waters with floating vegetation. Rana cyanophlyctis and R. limnocharis occupy the shallow heavily vegetated pools. Rana temporalis is found primarily in the reed marshes, especially along the canals. The Tomopterna breviceps on the other hand is a burrowing frog, breeding in rainfilled ditches and in mud holes along the road.

The toads, Bufo melanostictus and Bufo stomaticus are generally found on high grounds not in more or less disturbed sites close to human settlements.

The Rhacophoridae (tree frogs) naturally have an arboreal habitat. Rhacophorus (Polypedates) maculatus and Rhacophorus (Polpedates) cruciger are found throughout the area. Both these species build foamy nests, attached to foliage hanging over water. When there eggs hatch the tiny larve fall into the water. where they spend their larval stage.

Two threatened species were identified in the Muthurajawela marsh: Atukorale's dwarf toad (Bufo atukoralei) and the greater hourglass tree frog (Rhacophorus (Polpedates) cruciger). The B. atukoralei however is found even on the roadside ditches and canals along the road side occupying the same habitat as the burrowing frog, R. breviceps. Rana (Polpedates) cruciger is found throughout the areas, but is less often seen because of its more cryptic behaviour.

Fish

Muthurajawela is an important fish habitat not simply because of its extent but because of the presence of its variety of interconnected biotopes: pools, canals, rivers and the southern part of the Negombo Lagoon. Among the freshwater species found are the striped snakehead (Ophiocephalus striatus), the stinging catfish (Heteropneustes fossilis), the three-spot gourami (Trichogaster pectoralis), the climbing perch (Anabas testudineus), the silver barb (Puntius vittatus), an introduced tilapia (Sarotherodon mossambicus) and the pearl spot (Etroplus suratensis). The most common species found in the canal are Aplocheilus dayi, the silver barb, the pearl spot, (E. maculatus), and Panchax panchax.

The fish species found in the Hamilton canal include salt water dispersant species such as the common glassfish (Ambassis ssp), Oligolepis acutipennis, the minnow (Panchax melastigma), the silver biddy (Gerres abbreviatus), the pearl spot and the scat (Scatophagus argus).

No important commercial fishing of the species mentioned is taking place in the proposed landfill site. Some fishing is carried out mainly for private consumption.
Generalised distribution of fish species in Muthurajawela Marsh according to density is given in Fig.3.2.22. Fig.3.2.23 represents some of the important fishes of the Muthurajawela-Negombo Lagoon.

Invertebrates

Aquatic invertebrates

Zooplankton of the Muthurajawela is composed of the cycloid copepods, naupli larvae, rotifers, cladocerans, juvenile fish and larval prawns. These zooplankton species are important firstly, because they are the source of food for fish, shell fish and some birds, and secondly because the larvae of commercially important fish and shrimp species are part of the zooplankton community.

Copepods are the most abundant, but their distribution varies with salinity. The most important fish species of the marsh, the Ambassis dayi depends on these copepods as their primary source of food.
The generalised distribution and abundance of zooplanktons in the Muthurajawela Marsh is shown in Fig.3.2.24
The most important freshwater and brackish water macro- invertebrates include crustaceans, molluscs, worms and insects.

Among the crustacean species of Muthurajawela the small estuarine shrimp, Metapenaeus dobsoni and the larger white shrimp, Penaeus indicus occur in the northern part of the marshes and in the lagoon. The giant prawn, Macrobrachium rosenbergii are found in the Dandugam Oya, Ja-Ela and the Dutch canal. The mangrove crab, Scylla serrata is found as far south as the Uswetikaiyawa. The crab Neosernatium malabarium occurs on the banks of Kerawalapitiya and midway in the Hamilton canal.

Generally, most of the freshwater crustaceans occur in places with little water flow and where little bathing and washing takes place.

Among the insect species found in the Muthurajawela marsh are the dragon flies and mayflies, the diving beetle (Cybister confusus) and the creeping water bug (Holeocaris bengalensis).

The molluscan fauna of the Muthurajawela include the snails Pila globosa, which is an important source of food for the open-bill stork.

Terrestrial Invertebrates

67 species of butterflies have been recorded from Muthurajawela, and these include nine endemic sub-species. One species, the blue momon (Papilio polmnestor parinda) is listed as a threatened species. The butterfly species of Muthurajawela include 28 migratory species, the migratory season being March - April and October - December.
Of the eight species of Danidae present in the Muthurajawela marsh four are endemic: Danaus similis expromta, Euploea phaenareta corus, E. core asela and E. sylvester montana. Among these, the largest E. phaenareta, is restricted to the southwestern coastal belt. This butterfly which is rare elsewhere, is found throughout the Muturajawela marsh.

Of the Nymphalidae 17 species are found in the area including the endemic Vanessa canace haronica. The Lycaenidae are present with 14 species and the Pieridae with nine. Nine species of the swallow-tails including three endemics are found: Atrophaneura aristolochiae ceylonocus, Chilasa clytia lankeswarwa, and the threatened blue mormon. Of the brown skippers, six species are recorded.

Some 34 species of dragon flies are recorded from the area, including 8 endemics; two chlorocyphids (Libellago adami and L. greeni), three protoneurids (Elattoneura bigemmata, E. caesia and Prodasineura sita), two platystictids (Drepanosticta walli and D. nietneri) and one coenagrionid (Mortonagrion ceylonicum).

Most of the dragon flies were found in marshy waters with heavy aquatic vegetation, the lagoon being a less preferred habitat. Dragon flies control insect pests, their larvae feed generally on small aquatic fauna including insect larvae, and adults prey on adult insects.

3.2.2.4 The past impacts on the Muthurajawela-Negombo Wetland system

The history of Muthurajawela tells a fascinating story of how human interventions have accelerated the degradation of valuable natural resources. During the reign of King Vira Parakrama Bahu, the Muturajawela marshes were fertile paddy fields. In an attempt to improve transportation facilities to promote trade the King built a canal that connected the Negombo lagoon with the Kelani Ganga. As a result of this, salt water entered into the fertile paddyland thereby destroying the paddy cultivation in that area for ever. Many attempts were made during and after the colonial regime to rehabilitate the paddy lands, yet every attempt was unsuccessful. The construction of Ja-Ela canal was one of the major attempts to flush salt water from that area.

With the abandonment of Muturajawela as cultivatable land, squatters have moved in. The families now living in this area are again altering it through the utilisation of the land for having, sewage and waste disposal, home gardens, fuel wood, mat weaving (sedges), etc.The type of natural vegetation which sprung up in these poorly drained typical marsh wetand areas was determined by the hydrological regime,water quality and quality of the substrate. Consequently,the vegetation of Muthurajawela marsh is not prestine;it has undergone several changes in the past and this process still continues. Nevertheless, over large areas the vegetation survives in varying stages of naturalness. Past introductions and extermination of certain plants including woody species and aquatic plants, have further altered the vegetation, in particular in the proposed landfill site closest to the capital city.

3.2.3 Human Settlements and Landuse

For the first time in Sri Lanka, wetland squatters will be relocated in the framework of the implementation of a master plan for regional development, i.e.the Muthurajawela Master Plan. More specifically, in support of the conservation of other segments of the Muthurajawela marsh and the adjoining Negombo lagoon, the Master Plan identified a landfill of the 162 ha Kerawelapitiya section of the marsh, from which a number of squatter families will have to be relocated. Over the last few years, this section of the marsh, situated in commuting distance from the capital city, had already been identified as a potential area for urban expansion (housing, public amenities, industry). Since 1978, when the price of residential land in the metropolitan Colombo area escalated, the pressure to develop the state lands in the Muthurajawela marsh for urban expansion further increased.

In 1969, when the development of Urban Corridors started, many middle and upper income groups settled in the upland areas of Ja-Ela, Kandana Wattala and Hendala. As a consequence of prohibitive land prices in the urban areas contiguous with the marsh, encroachment in the marsh increased sharply from 1980. Attracted by employment opportunities, poor landless migrants from rural areas settled illegally in the marsh. This gave rise to a conflict of interest between the state and the landless poor. Pertaining to the proposed landfill, the issue to be resolved is: resuming control of state land by developing it in a manner that is acceptable to affected parties.

In compliance to the Master Plan, SLLRDC proposed sandfilling of the southern segment (162 ha) of the Muthurajawela marsh where unauthorized squatter communities had already established themselves. Hence, a conflict emerged between sandfilling and land development and marsh residents. The issue requiring adequate solution is the relocation of squatter families from the landfill area of the marsh by way of mutually acceptable packages of relocation commitments.

Present settlements in the proposed landfill area

A total of 330 housing units will be affected by the landfill project (SLLRDC-survey, 1992, MUPO, pers.comm.). However, the number of affected families is reportedly slightly higher (8). These squatter families are more or less grouped into four locations: Kudagahapitiya, Lankamatha, Avarakotuwa and Galagahaduwa, the latter sometimes referred to as Wederalage Ela.

It is important to realise that most of these squatters depend only to a very limited extent on the marsh's resources. These are not communities in the sense that they depend for their livelihood on local resources. Living near the capital city, their social and economic interactions extend mostly well beyond their "community". In fact, most family incomes depend on employment of family members in the nearby city.

A recent survey on the length of stay of 288 out of 330 housing units revealed that 27% of the squatters have been in the area for more than 10 years. The longest length of stay was 20 years, and about 48% have been in the area for 5-10 years. Others have arrived within the last 5 years (8).

Most settlers originate from either "spill over" from neighbouring areas (Galagahaduwa and part of Lankamatha communities), and from outside areas mainly in the Gampaha district (Kudagahapitiya and Avarakotuwa). Only 8% of the settlers have immigrated from outside the Gampaha district (2). Thus, most people who have settled in the area for a considerable length of time have extended kinship linkages in the area. This holds especially for the predominantly catholic (98%) communities of Galagahaduwa and Lankamatha. Settlers in Kudagahapitiya are predominantly Sinhala buddhist, another buddhist community is found in northern Avarakotuwa. Living in a predominantly catholic environment, these buddhist communities tend to follow their own way of life.

Employment is found in the formal sector (25%), the informal sector (64%) and in self-employment (11%). The last two categories pertain to a large variety of activities in Colombo city: casual labour, petty trade, and provision of various types of services. Included in these categories are many females contributing to household income through home-based activities. The breakdown of employment categories for the whole population in the marsh given below (1) probably also applies to the Kerawalapitiya area:

Manual labourers	64.5%
Skilled labourers	9.5%
Sales workers	11.7%
Agricultural	0.6%
Fishermen	13.7%

These figures point to the importance of casual labour on a daily wage basis, which could be even higher in the southern end of the marsh closest to Colombo where the landfill area is situated. The figures are also indicative to high rates of unemployment and underemployment. The Environmental Profile study puts the unemployment rate for the whole population in the marsh at 61.9%, of which 43% are unemployed females. A total of 65% of the unemployed are in the 15-29 age group, while 78% of the total unemployed have primary and secondary education, which is in line with the national unemployment situation, i.e. high unemployment under the young-educated population groups.

Land and resource uses

In general, the use of resources in the marsh itself is of minor importance. Home gardening (vegetables) is practised on a small scale using slightly raised beds (25 cm), made from excavated peat and fertilized with animal manure. Small-scale livestock keeping (pigs and hens) and fishing in abandoned irrigation canals (both for private consumption), mat weaving using sedges grown in the marsh, also provide for some additional income. Income from fisheries becomes more important towards the northern end of the marsh. The marsh lands are unsuitable for large-scale agricultural cropping, the main problems being poor soils (peat), acidity (acid sulphate soils), salinity intrusion during the dry season, flooding and waterlogging. Water quality in the marsh in general not suitable for drinking water, because of acidity, salinity and contamination with pathogens.

In places, squatter houses have been built on slightly raised mounds made from excavated peat. Some of the homestead ponds created in this way are used for fish breeding, but this activity is of minor importance because of water acidity and salinity. Abandoned irrigation canals are also used for bathing, washing and for sewage and waste disposal.

Clearly, the squatter families in the marsh are not farmers. In fact, the migration into the swamp could be linked to the general movement away from agriculture as a means of living, a tendency commonly seen in the Gampaha district.

Sanitation and health situation

Most dwellings are make-shift, temporary structures, usually built on raised mounds surrounded by pools of stagnant water. Adequate water supply, sanitary and waste disposal facilities are absent. Clearly, such a situation is not conducive to healthy living. Unauthorized settlement debarred the marsh dwellers from some of the services provided by the state.

During the rainy season, many houses are flooded and have to be vacated temporarily. Sewage and waste disposal in canals and ponds, combined with pig rearing create serious infection risks of water-related and water-borne diseases. Stagnant, polluted water bodies provide ample breeding sites for mosquito's and other disease vectors. Not surprisingly, the general health situation among marsh dwellers is significantly worse as compared to upland areas. Most serious infections include Dengue Haemorrhagic Fever (in particular dangerous to children), intestinal infections, and leptospirosis, a bacterial infection which caused over 500 deaths through kidney failure among residents of the Muthurajawela marsh during the past 15 years. The pathogen is transmitted by way of rat urine entering water with which residents regularly come in contact. The poor condition of houses and garbage and sewage disposal has resulted in high populations of rats near squatter houses.

The health situation and the incidence of common diseases is reported in the Environmental Profile study (1) and is summarized in chapter 3.2.4.

Kerawalapitiya comes under the Hendala Medical Officer of MOH, which has 5 Public Health Inspectors and 28 midwives. These offices suffer from a general lack of funds and means which makes them less effective. Usually, in such situation, people at the bottom of the social ladder, such as those living in the marsh, suffer most. Relocation of the people living in the marsh could improve their access to public health facilities.

Two dispensaries are available for the marsh dwellers within 5 km from the settlements. Pamunuwa is the closest hospital and Ragama hospital is about 13 km away from the settlements.

Drinking water supply is inadequate. Most settlers have to walk on average for about half on hour to get proper drinking water from wells or standpipes which have recently been constructed at the periphery of the marsh. However, most water supply comes from local, unprotected dug wells. The water quality in these wells is poor, having a peaty taste and bad smell, or being acidified or saline and contaminated with a variety of pathogens which enter the wells during periods of flooding.

Income

Data on family income are difficult to obtain. A recent survey (8) indicates that 25% of the households have an income below Rs 1000 per month, 65% make between Rs 1000 and Rs 2000 per month, and around 10% earn more than Rs 2000 per month. Food stamps receivers (issued to those earning less than Rs 750 per month) in Avarakotuwa amount to 34.9%, and to 30.7% in Kudagahapitiya (1). The different levels of income are to a certain extent reflected in the type o dwellings, and are the result of the type of employment and the diversification of income sources.

Education

The Environmental Profile study (1) and the Master Plan (2) indicate that almost 50% of the population of school-going age and above had acquired education up to primary and secondary levels, while about 10% had even completed schooling up to the General Certificate of Education (Ordinary Level) stage. The percentage of the population not attending schools is 10% and illiteracy among adults is 10%. There is a relatively well-developed network of schools in the area, which is partly due to the long-time involvement in education of the Catholic church, and partly because of the government efforts in educational development in the region.

Dickowita Primary School is closest to the area. The school conducts classes up to year 11. Children walk to the school through the (sometimes flooded) marsh.

In spite of this favourable situation, only a small portion of the population has reached higher educational levels.

3.2.4 Community Health

Introduction to the present scenario

The Kerawalapitiya Reclamation Project involves burrowing 4.8 million cubic meters of sea sand by offshore mining and reclaiming 162 hectares of marsh land in an area called Kerawalapitiya located in the southern part of the Muthurajawela marsh. The reclaimed land will be used for urban development such as housing and industry.

The project is situated in a densely populated suburban area north of Kelani river bordering Colombo City. The area comes under the Gampaha district and is located in the Wattala Medical Officer of Health (MOH) area. The estimated midyear population of the area was 112993 in 1992.

The MOH Wattala and his staff are responsible for all disease surveillance and control activities in the area. The available medical care services include a 63 bed government hospital manned by one medical officer and two assistants, several private practitioners both western and Ayurveda.

This study will focus on,

1. Disease situation in an around project area
2. Changes in the disease situation likely to occur as a result of the project.
3. Measures recommended to promote favourable health impacts and minimise likely adverse health impacts of the project.

Data for the study was obtained from the Medical statistician and Epidemiology Unit of the Ministry of Health and by interviewing the MOH Wattala and his staff.

Disease situation in and around project area

The three leading causes of hospitalization in Gampaha district in 1991 were ill defined conditions, respiratory diseases and traumatic injuries. These diseases are of multifactorial origin and too general for consideration in a study of this nature. In this study specific mosquito borne, water related and water borne diseases reported from the area will be considered. The spread of these diseases could be directly influenced by urban development. If well-planned, landfill that will eliminate potential breeding sites of human disease vectors could have a positive influence by reducing the incidence of vector forms diseases. The incidence of these diseases during the first six months of this year as reported by the MOH is given in table 1. the real incidence of these diseases is much higher as all treated cases are not notified to the MOH.

Table 3.2.6

Selected infectious diseases in Wattala MOH area
January to June 1993

	J	F	M	A	M	J	Total
Mosquito borne							
Japanese Encephalitis	-	-	01	-	-	-	01
Dengue Haemorrhagia fever	-	-	-	-	-	-	00
Filaria	11	04	03	03	05	04	30
Malaria	08	07	20	04	03	-	42
Water related							
Leptospirosis	-	-	-	-	-	-	00
Water borne							
Dysentery	07	-	01	03	02	01	14
Infection hepatitis	03	01	04	05	03	-	16
Typhoid fever	02	01	-	01	-	-	04
Cholera	-	-	-	-	-	-	00

Source MOH Wattala

Japanese Encephalitis (JE) one death has been reported this year due to JE. Earlier studies have reported intense JE activity in the area. JE is an arbovirus infection. The main disease vector is culex tritaeniorhynchus, a mosquito that breeds abundantly in marshy land. Pigs act as amplifier hosts sustaining viral multiplication and high viraemia for long periods.

Dengue Haemorrhagia Fever (DHF) This is an arboviral infection transmitted by mosquitoes of the genus Aedes. These mosquitoes are container breeders living and multiplying in collections of water in tins, tyres, polythene bags etc. Medical Research Institute (MRI) surveys have revealed much dengue fever infection in the area.

Filaria is endemic in the area. The MOH has reported 30 cases in the first 6 months of this year. Culex quinquefasciatus the vector that transmits Bancroftian Filariasis was the predominant species of mosquito found indoors in the area. This mosquito breeds abundantly in collections of stagnant water.

Malaria 42 cases of Malaria have been reported during six months of this year. The principal malaria vector mosquito Anopheles culicifacies has not been observed in the area. However, transmission of malaria within this area has been suggested probably through other anopheline species found in the area.

Leptospirosis This appears to be widespread in the area. MRI records show that outbreaks of epidemic proportion have occurred in 1986, 1987, 1988 and 1989. In 1991, an outbreak including one death was reported in adjoining MOH area Mahara. This outbreak occurred among a group a people that engaged in cleaning a stagnant water canal. Leptospirosis is a water related disease transferred to humans through the urine of infected rats and mice.

Dysentery, Infectious Hepatitis and Typhoid Fever are common diseases in the area. These infections are spread by consuming water and food contaminated with faeces . If has been observed that after introduction of pipeborne water in the area there has been a drop in the incidence of these diseases.

Cholera During the last Cholera outbreak in the city of Colombo and northern suburbs in 1992, Wattala MOH reported 3 cases and adjoining MOH area Kelaniya reported 22 cases. The disease spread among families living in the banks of Kelani river where basic housing conditions, potable water supply and sanitary toilet facilities were inadequate.

	Unit	A	B	C	Total
		Maggona	Colombo	Negombo	Chilaw
<u>Past</u> (1850)					
River supply	m³/y	550,000	400,000	200,000	1,150,000
Beach mining	"	0	0	0	0
Boundary - S	"	0	50,000	50,000	200,000
- N	"	-100,000	-100,000	-100,000	
Off shore loss	"	-450,000	-350,000	-150,000	-950,000
Sea level rise	"	0	0	0	0
Recession Vol.	"	0	0	0	0
" Area	ha/y	0	0	0	0
" Rate	m/y	0	0	0	0
<u>Recent</u> (1960)					
River supply	m³/y	550,000	400,000	200,000	1,150,000
Beach mining	"	0	0	0	
Boundary - S	"	0	0	50,000	-250,000
- N	"	-100,000	-100,000	-100,000	
Off shore loss	"	-450,000	-350,000	-150,000	-950,000
Sea level rise	"	-60,000	-110,000	-270,000	-440,000
Recession Vol.	"	-60,000	-160,000	-270,000	-490,000
" Area	ha/y	0.5	1.6	3.4	5.5
" Rate	m/y	0.1	0.5	0.8	0.45
<u>Present</u> (1990)					
River supply	m³/y	410,000	160,000	90,000	660,000
Beach mining	"	-100,000	0	0	-100,000
Boundary - S	"	0	0	50,000	-250,000
- N	"	-100,000	-100,000	-100,000	
Off shore loss	"	-450,000	-350,000	-150,000	-950,000
Sea level rise	"	-60,000	-110,000	-270,000	-440,000
Recession Vol.	"	-300,000	-400,000	-380,000	-1,080,000
" Area	ha/y	2.4	4.0	4.8	11.2
" Rate	m/y	0.5	1.3	1.1	0.9
<u>Future</u>					
River supply (10%)	m³/y	50,000	40,000	20,000	110,000
Beach mining	"	-100,000	0	0	-100,000
Boundary - S	"	0	0	50,000	-250,000
- N	"	-100,000	-100,000	-100,000	
Off shore loss	"	-450,000	-350,000	-150,000	-950,000
Sea level rise	"	-60,000	-110,000	-270,000	-440,000
Recession Vol.	"	-660,000	-520,000	-450,000	-1,630,000
" Area	ha/y	5.3	5.2	5.6	16.1
" Rate	m/y	1.1	1.7	1.2	1.3

Table 3.1.1 Sand Balances of the coast (13)

TABLE 3.2.1 - MAIN CLIMATOLOGICAL AND HYDROLOGICAL CHARACTERISTICS (1)

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept	Oct	Nov	Dec	Yr	Unit
Climate														
- Temperature														
Daily maxi.	30	31	31	31	31	30	30	29	29	29	30	30	30	0C
Daily mini.	22	22	23	24	26	25	25	25	25	24	23	24	24	
- Rain	75	75	110	225	360	200	125	110	190	365	350	180	2360	mm
- Evaporation (E)	110	115	130	110	100	110	105	100	110	100	90	100	1280	mm
- R - E	-35	-40	-20	145	260	90	20	10	80	265	225	80	1080	mm
- Wind														m/s
Direction SW	6	8	19	36	58	62	59	62	60	40	15	6	36	
W	8	20	25	22	19	24	30	26	25	25	20	9	21	
NW	21	25	16	19	4	4	5	5	6	12	19	20	12	
N	19	8	5	2	2	0	0	0	0	3	12	20	6	
NE	35	25	14	6	2	0	0	0	0	4	17	34	12	
Others,calm	11	14	21	15	15	10	6	7	9	16	17	11	13	
.Av. meanspeed	2	1.5	2	2.5	2.5	2.5	2	1.5	1.5	2	2	2		m/s
Waves :														
. Direction SW	1			7			35			14		18		m/s
W	4			16			29			24		19		
NW	10			18			9			15		12		
.Height HI	4.1			3.4			6.3			4.0		5.8		m
H10	2.8			1.3			4.2			2.7		3.5		m
H50	1.6			1.3			2.5			1.5		1.8		m
Tides :														
. Max.M.W.S	0.53	0.58	0.64	0.64	0.60	0.50	0.47	0.44	0.42	0.42	0.45	0.49	0.52	m
. Mean S.L	-0.03	-0.03	-.0.01	0.05	0.08	0.13	0.08	0	-0.08	-0.10	-0.08	-0.05	0	m
Vegetation :														
- Evapo (T) Transp.	145	150	175	160	165	140	150	140	140	135	135	140	1775	mm
- R-T	-70	-75	-65	95	195	60	-25	-30	50	230	180	40	585	mm
- Rice (2 crops)	300	225	150	225	525	450	375	225	-	150	225	150	3000	mm
Lagoon :														
- Attanagalu	40	25	50	130	175	185	115	60	100	100	215	130	1325	$10^6 m^3$
- Rain	3	3	5	9	15	8	5	5	8	15	13	8	97	$10^6 m^3$
- Evaporation	-4	-4	-5	-4	-3	-4	-3	-3	-4	-3	-3	-3	-44	$10^6 m^3$
- Balance	39	24	50	135	187	188	117	62	104	112	225	135	1378	$10^6 m^3$
- Salinity	22	30	27	20	10	7	13	21	20	18	2	20	18	kg/m^3
- Inflow sea	160	170	150	90	45	50	100	140	115	104	110	90	1225	$10^6 m^3$
Marsh (N+S) :														
- Rain	2.4	2.4	3.5	8.2	11.5	6.4	4.0	3.5	6.1	11.7	10.1	5.8	75.6	$10^6 m^3$
- Evapo-tr	-2.7	-2.8	-3.1	-.2.7	-2.4	-2.7	-2.5	-2.4	-2.7	-2.4	-2.1	-2.4	-30.9	106m3
- Balance	-0.3	-0.4	0.4	5.5	9.1	3.7	1.5	1.1	3.4	9.3	8.0	3.4	44.7	$10^6 m^3$
Kelani Ganga	200	150	200	340	560	830	650	410	460	690	880	375	5745	$10^6 m^3$

TABLE 3.2.2 THE PROPERTIES OF BOG SOIL (ORGANIC SOIL) OF MUTHURAJAWELA (1)

Organic carbon content	18-54% generally the surface layers consist of highly decomposed or partially decomposed plant material mixed with peat, medium to strongly acidic (pH 4.5-6.0) when most in the field state. On drying extremely acid condition develop because of oxidation of sulphate forming sulphuric acid and subsequent formation of jarosite crystals which gives a yellow mottled appearance to the soil
Soluble salt content	High where brackish water influence occurs. Salt content is high bordering Negombo Lagoon and Hamilton Canal, and bordering the Dutch Canal.
Cation exchange capacity (CEC)	Very high on a soil weight basis, however, because of the low bulk density of the soil it decreases on a volume basis. Base saturation is 40-60% with the dominant cation being calcium. The exchange sodium percentage is low indicating that the soil has not become sodic although exposed to sodium.
Nitrogen	Varies between 0.2-1.5% with a carbon/Nitrogen ratio of 20:80. This ratio being wide, the nitrogen is not available.
Phosphorous	Very low, traces to 100 parts per 1000 ml.
Potasium	Exchangeable content very low, 0.06 - 1 milli equivalent per 100 g soil.
Iron	High 1-7% with most of the iron being bound with sulpher as pyrites. However, soluble iron also is high and at a level that is toxic to rice and causes "bronzing".
Sulphur	High 2-6%, with most occurring as pyrite.
Specific Density	Varies between 1.4 and 1.9. Bulk density varies with state of shrink/swelling. At high field moisture content, reaching 1000% on a weight basis, bulk density is about 0.19/ml i.e. the soil swells on saturation. At lower moisture level, about 200% bulk density is about 0.4 g/ml demonstrating shrinkage to quarter volume.
Erodability	Very high because of low specific density. During floods the low density material detaches form subsoil and floats away.
Bearing capacity	Very low at high moisture content thereby making it impossible to work the soil with animals or machinery for agriculture purpose . (also see A-4)
Agriculture potential	low to extremely low

Hydrological units (sq. km) consisting the Muthurajawela marsh-Negombo Lagoon wetland

UNITS	HIGH GROUND	LOW LAGOON /MARSH	TOTAL
1 Lagoon	7	35	42
2 Delta,swamp N. of Ja Ela	2	12	14
3 Marsh N: Ja Ela to Jayasooriya road	6	8	14
4 Marsh 5: Jayasooriya road - Hendala	10	11	21
5 West from Hamilton Canal	5	4	9
TOTAL	30	70	100

Table 3.2.3 Hydrological units (sq.km) consisting the Muthurajawela marsh-Negombo Lagoon wetland (1)

Constants			Characteristics	
Sa	H=9.5cm;	k=308°	Highest astr. tide	0.5 m
Ssa	4.1cm	111	MHWS	0.3 m
M2	17.6cm	50	MHWN	0.1 m
S2	11.9cm	95	MSL	0 m
K1	7.3cm	33	MLWS	-0.1 m
01	2.9cm	62	MLWS	-0.3 m
			Lowest astr. tide	-0.5 m

Table 3.2.4

The seasonal variation of mean sea level and the highest spring high waters per month are given in Table 3 with respect to present mean sea level. (1)

Table 3.2.5 Minimum andmaximum values recorded for selected water quality indicators. (1)

INDICATORS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
pH at 25C	9.1 5.4	8.4 5.8	7.1 5.5	6.8 5.6	8.1 6.4	8.6 7.1	7.9 7.1	8.2 7.1	9.2 7.8	8.1 7.6	6.8 6.2	6.8 8.1	7.0 8.4	7.1 8.2	7.0 8.3	8.8 8.1	7.1 8.1	8.8 8.1	8.5 8.1	8.5 5.8	7.2 5.8	8.2 5.6
Turbidity (NIU)	30 6.0	28 3.0	15 2.0	36 2.0	24 3.0	13 3.0	20 3.0	15 4.0	15 2.0	25 3.0	25 7.0	12.0 4.0	7.0 3.0	26.0 4.0	8.0 2.0	26.0 2.0	20.0 3.0	33.0 3.0	41.0 10.0	30.0 6.0	7.0 3.0	97.0 9.0
Condctivity (ms/cm)	0.35 0.04	0.22 0.06	<.04	<.26	38.8 11.9	32 31.7	22.2	26.6	30	25.9	0.17	1.08	1.1	0.79	4.0	2.8	1.58	1.38	0.39	0.2	0.2	0.5
Salinity (g/1)	<5.85	<5.85	<5.85	<5.85	40 13.0	35	43	43	37	29	5.85	<5.85	<5.85	<5.85	14.2	<5.85	<5.85	<5.85	<5.85	<5.85	<5.85	<5.85
Total Coliforms per ml		.	.	.	4510	6000	11200	8010	5200	3200	2100	11200	18000	6500	23000	26000	25000	6000	24000	15000	20000	15000
Fecal Coliforms per 100 m/l	.	.	.	.	1500 Nil	2510 1500 90	2500 Nil	3500 50	150 73	1200 750	1250 200	6000 600 60	1100 Nil 110	4000 Nil	3000 450 70	8000 1080	4700 5000 200	4000 850	30 1500 20	500 170	3840 500 50	300 3000 40
BOD 3 days at 30C	40 11	22 18	25 15	20 16	35 6	38 10	40 18	24 18	40 7	40 10	50 20	48 11	32 10	53 32	30 8	50 30	40 10	50 10	80 20	32 10	40 12	50 35
Total Phosphat mg/1	0.58 0.18	0.51 0.21	1.14 0.05	0.58 0.22	0.56 0.06	0.24 0.03	0.28 0.01	0.35 0.02	1.98 0.02	1.03 0.04	0.61 0.29	0.70 0.09	0.58 0.11	0.56 0.51	1.02 0.04	1.21 0.6	2.15 0.11	1.78 0.02	1.29 0.09	3.44 0.11	1.23 0.05	0.96 0.02
Zinc m/1	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.12	0.04	<0.01	0.01	<0.01	0.01	0.01	0.15 0.02	0.01	0.11	0.1	0.01	0.02
Chromium m/1	<0.01	<0.01	0.62 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1	0.86 0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper mg/1	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.03	0.02	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.01	0.02	0.01	<0.01	<0.01	0.01	0.01
Amonia mg/1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nitrate Mg/1	0.26 0.12	<0.01	0.41 0.05	0.24	0.10	0.12	0.06	0.11	0.40	0.10	0.05	0.15	0.21 0.04	0.18 0.05	0.11	0.10 0.05	0.12	0.03	0.12	0.10	0.10	0.01
Nitrite mg/1	0.003	0.002	0.001	0.003	0.002	0.001	0.002	0.003	0.001	0.001	0.002	0.001	0.002	0.002	0.001	<0.001	0.002	0.003	0.002	0.001	0.001	0.002
Cadmium mg/1	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.03	<0.01	0.02	0.01	0.01	0.01	0.01	<0.01	<0.01	<0.01
Mercury mg/1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

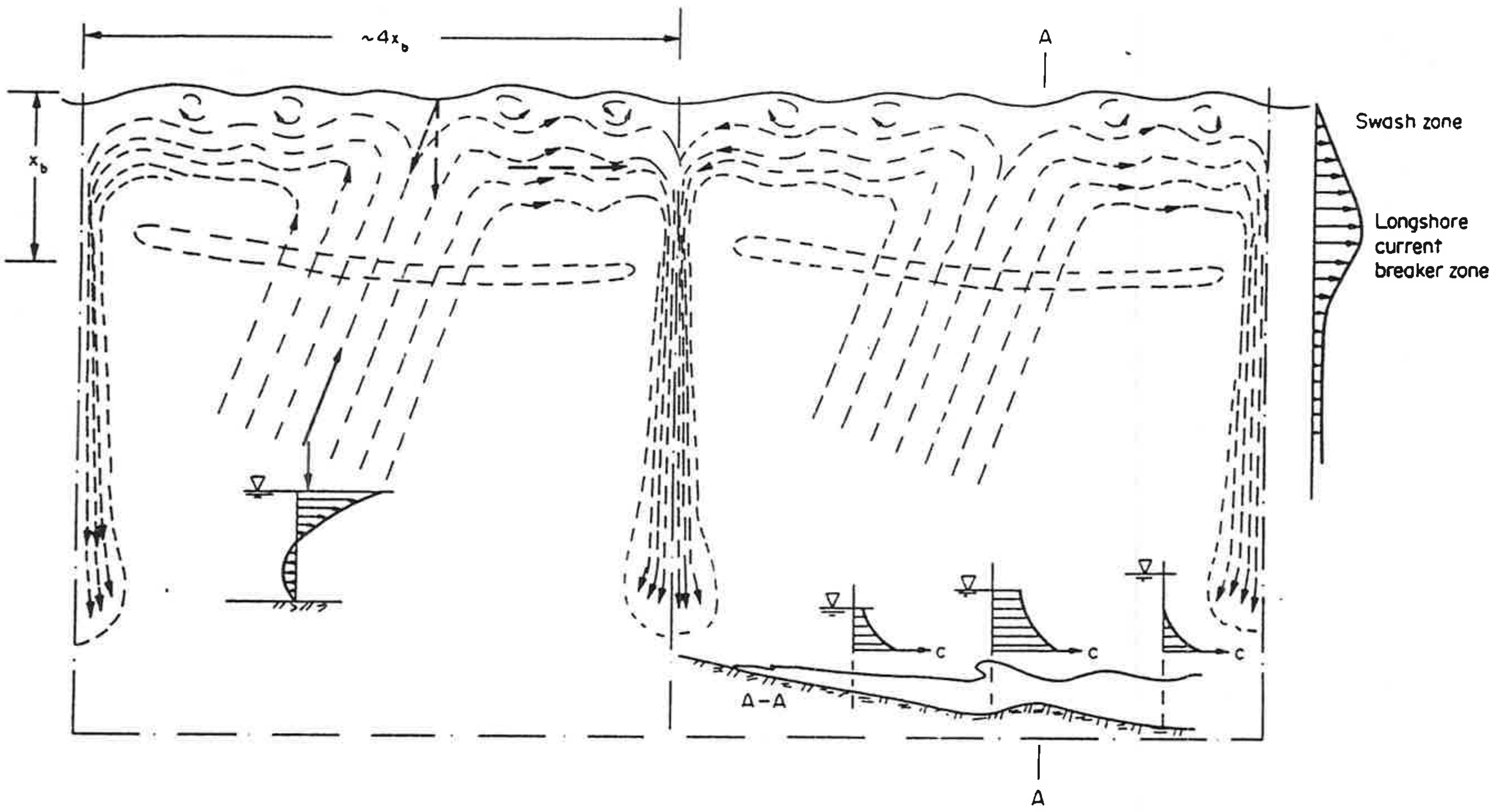


Figure 3.1.1
Schematic illustration of current patterns
in nearshore regions.

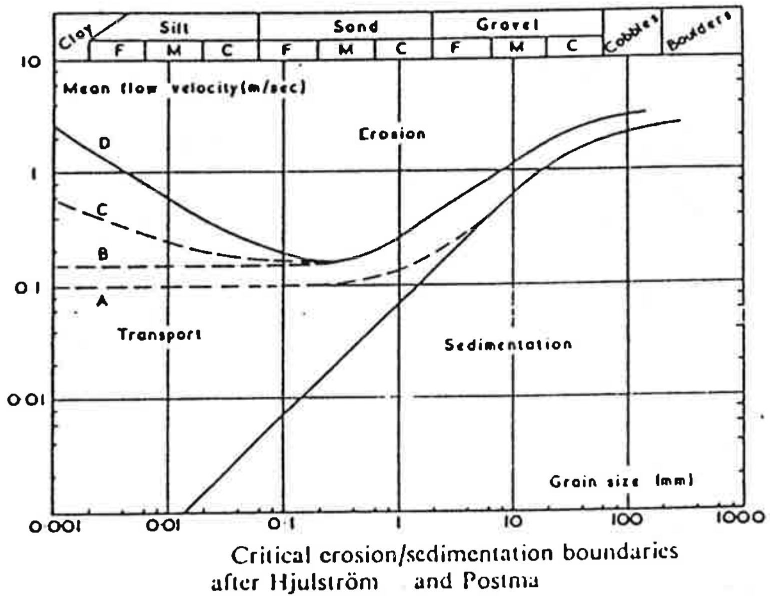


Figure 3.1.2
Critical erosion and sediment boundaries for different types of bed materials (9)

Figure 3.1.3
Sediment movement around Sri Lanka (4)

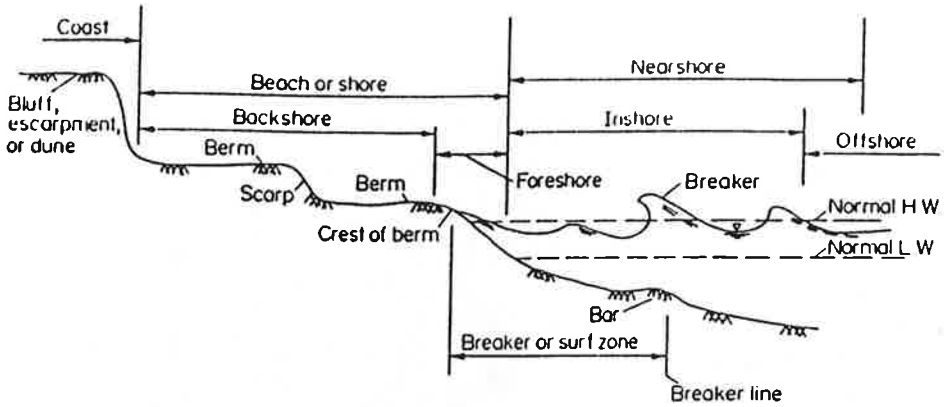
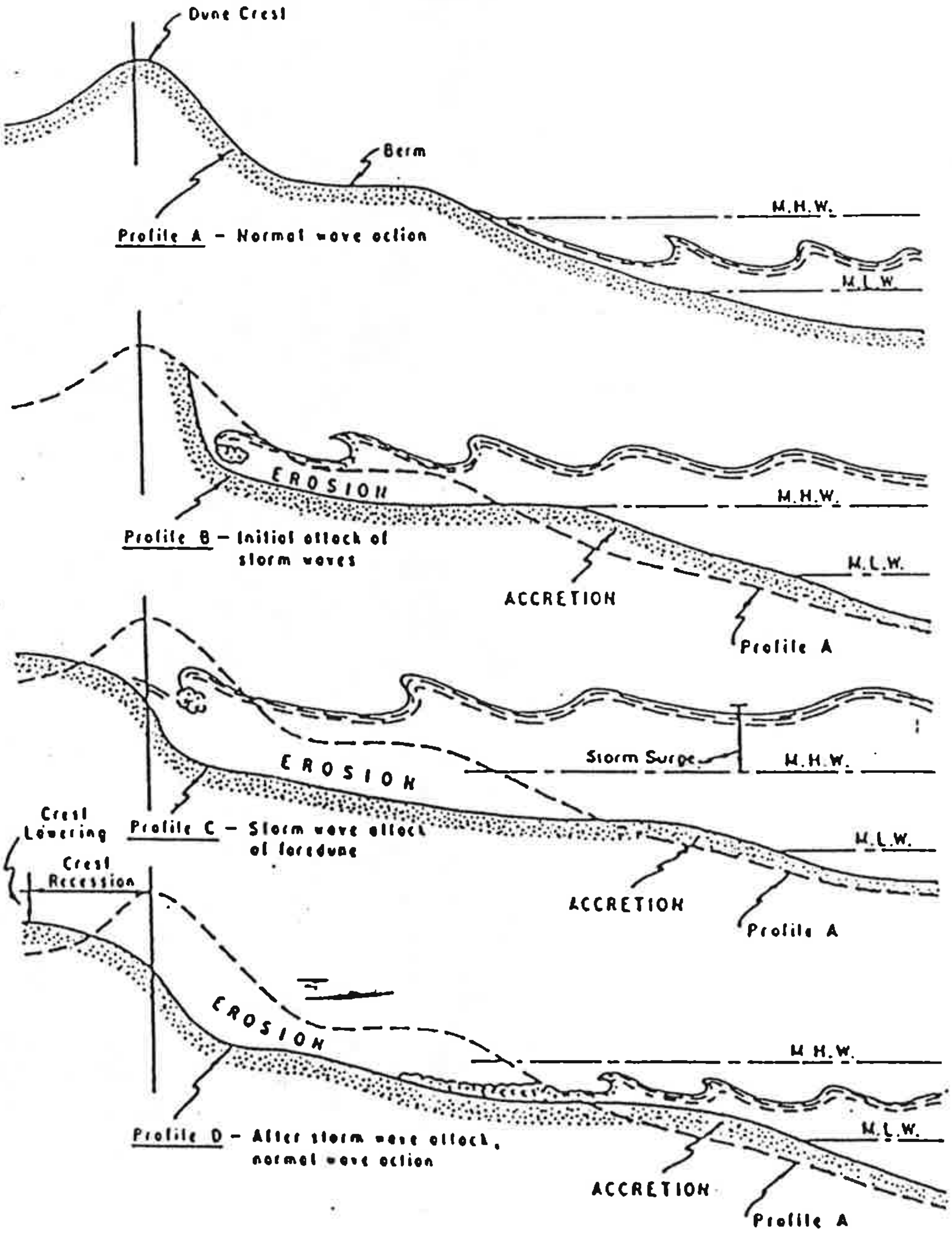
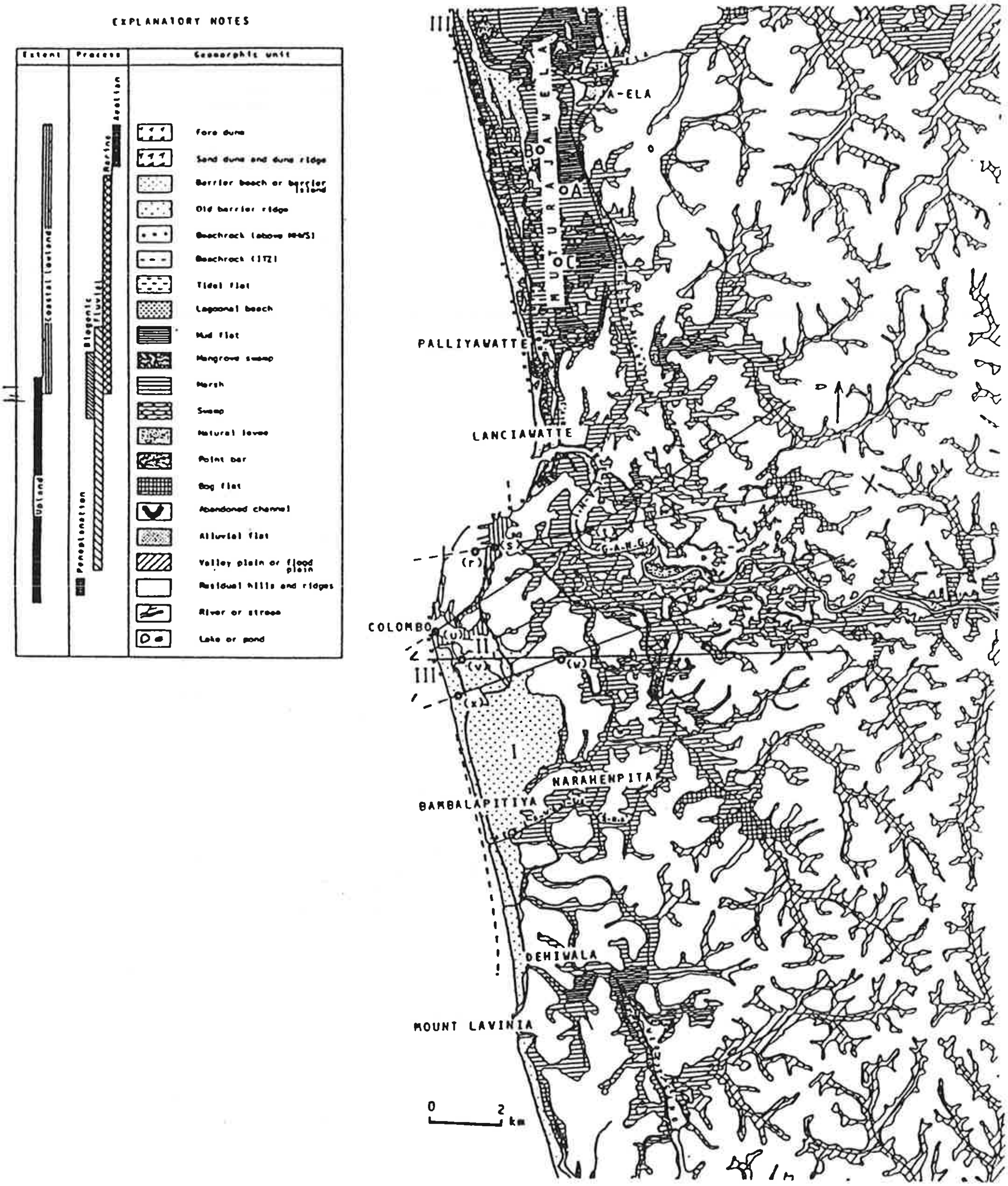


Illustration of terminology in use to describe parts of coastal zone.



Result of Storm on a Beach.

Figure 3.1.4
Definition of nearshore parameters and illustration of important sequences of a storm attack.



<u>Figure 3.1.5</u>
Coast and Landforms in the Colombo area (6)

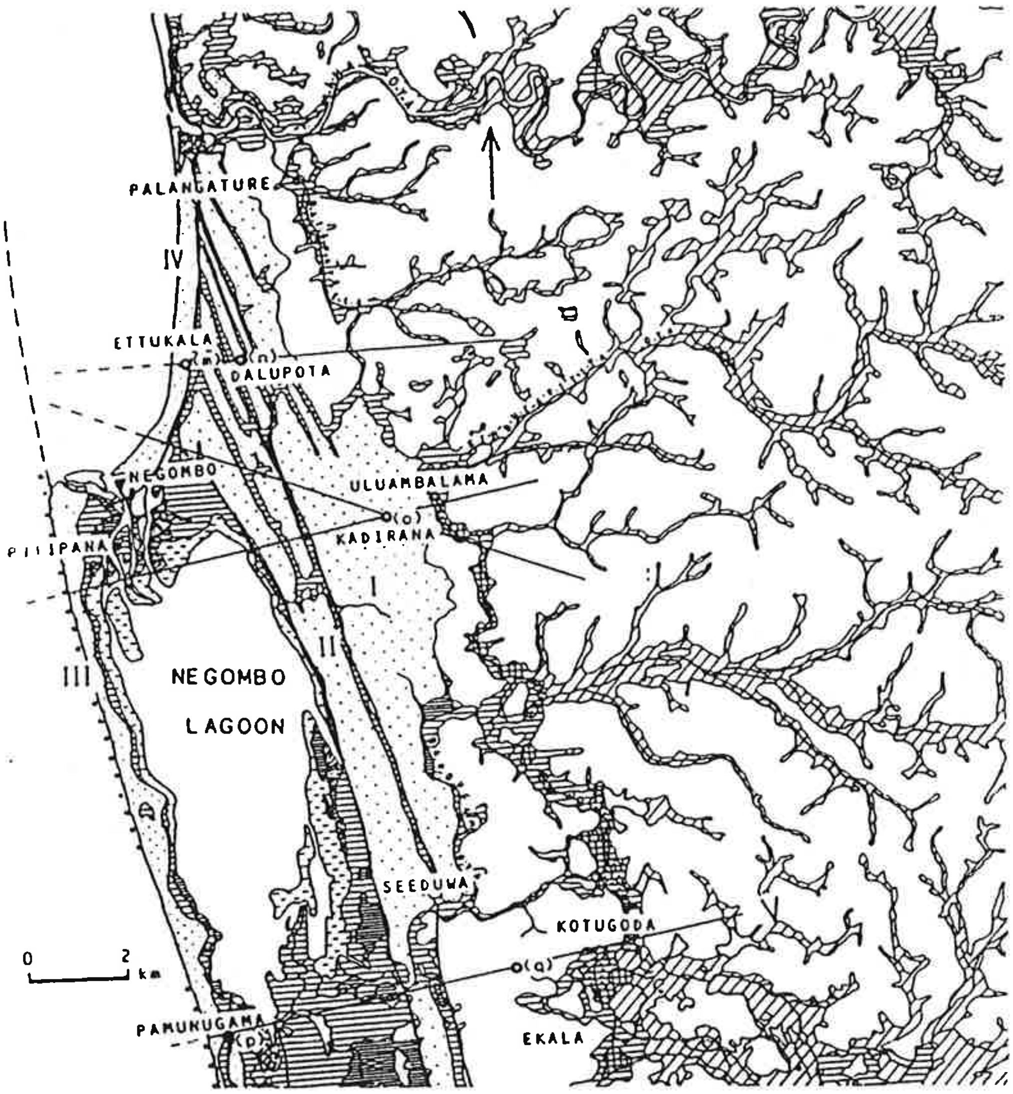
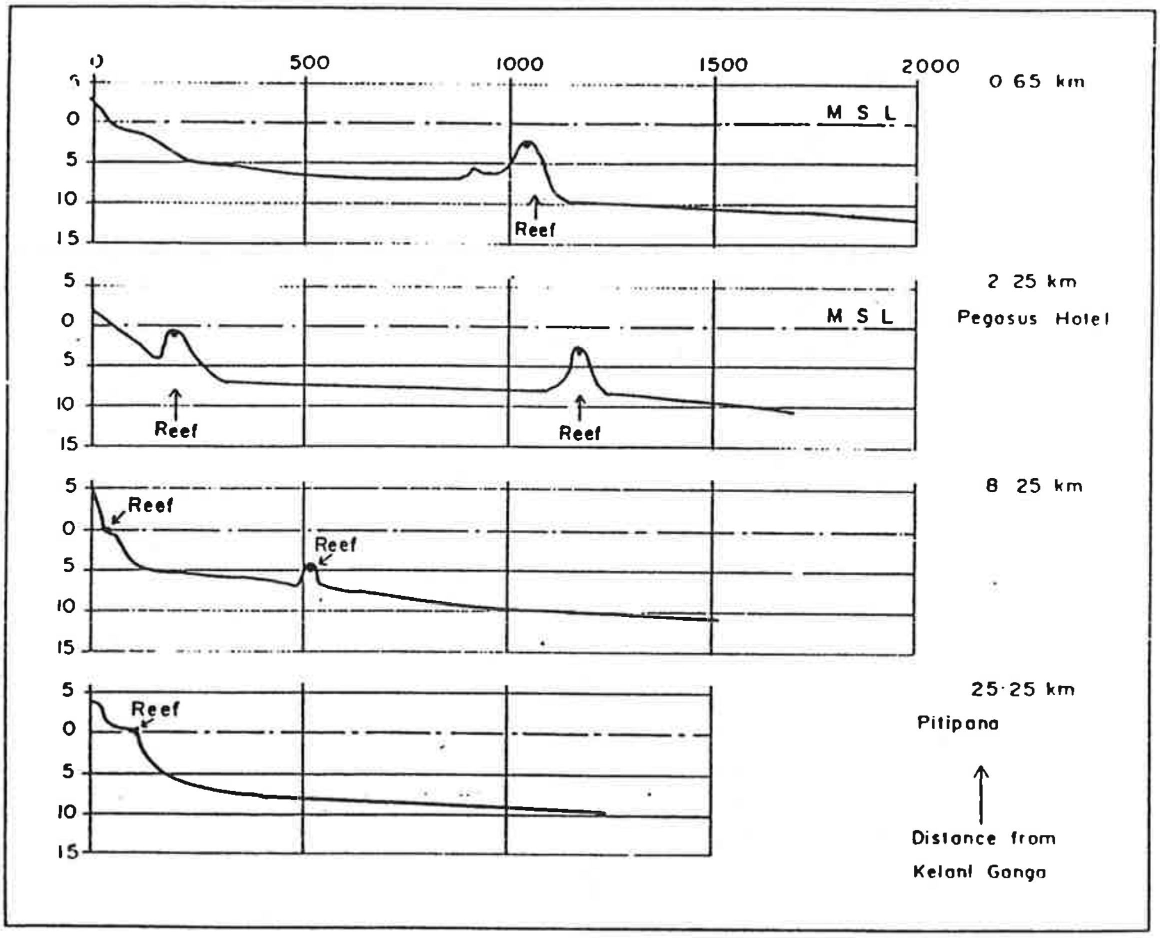


Figure 3.1.6
Coast and Landforms in the Negombo area (6)



Some cross sections of the coast

Figure 3.1.7
Characteristics of cross sections of the coast from Kelani Outfall to Pitipana

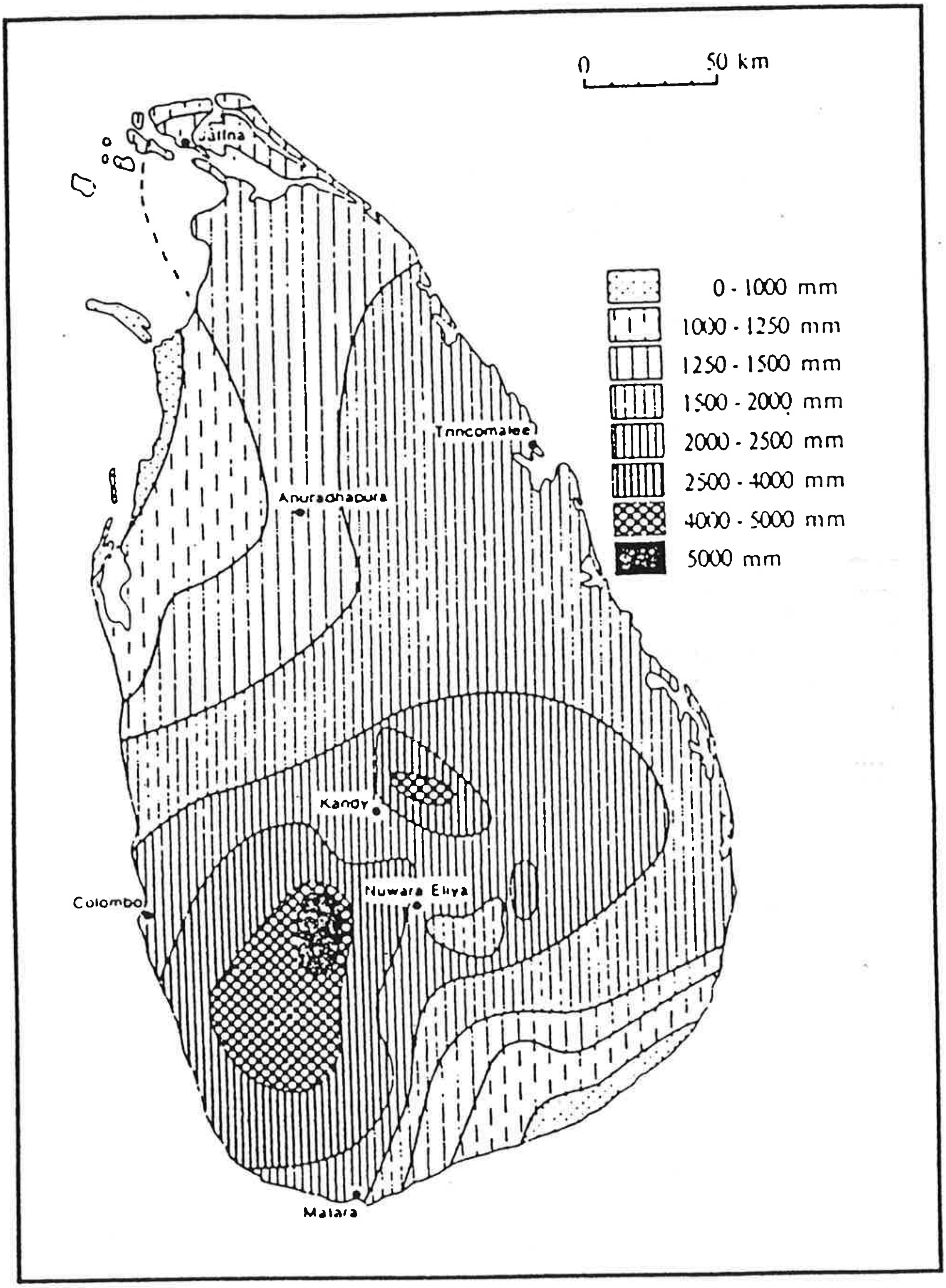


Fig.3.2.1 Average annual rainfall in Sri Lanka (1)

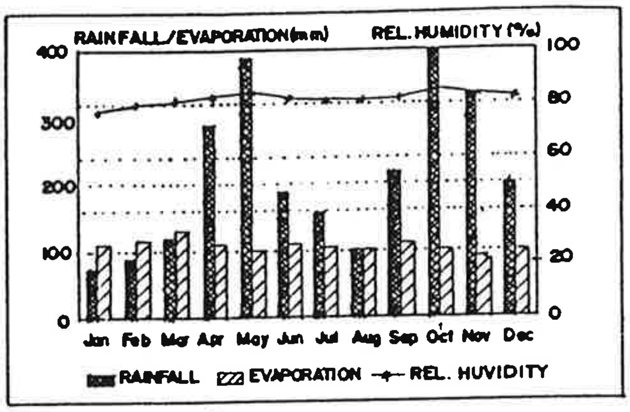


Figure 3.2.2

Monthly rainfull, evaporation (mm) and relative humidity (%) at Colombo Observatory (1964-1989) (1)

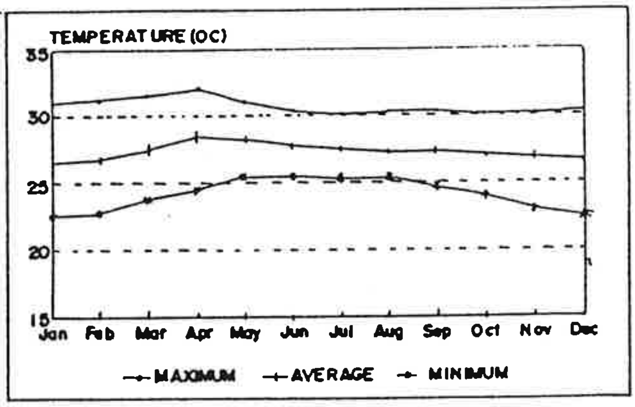


Figure 3.2.3

Mean monthly maximum, minimum and average temperature at Colombo Observatory (1961- 1980) (1)

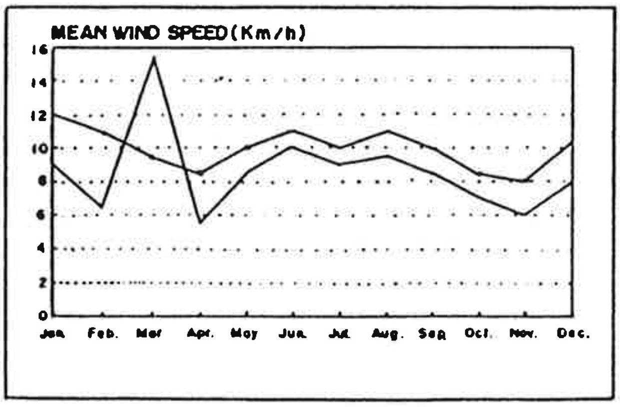


Figure 3.2.4

MEAN MONTHLY WIND SPEED (km/h) AT COLOMBO OBSERVATION (1)

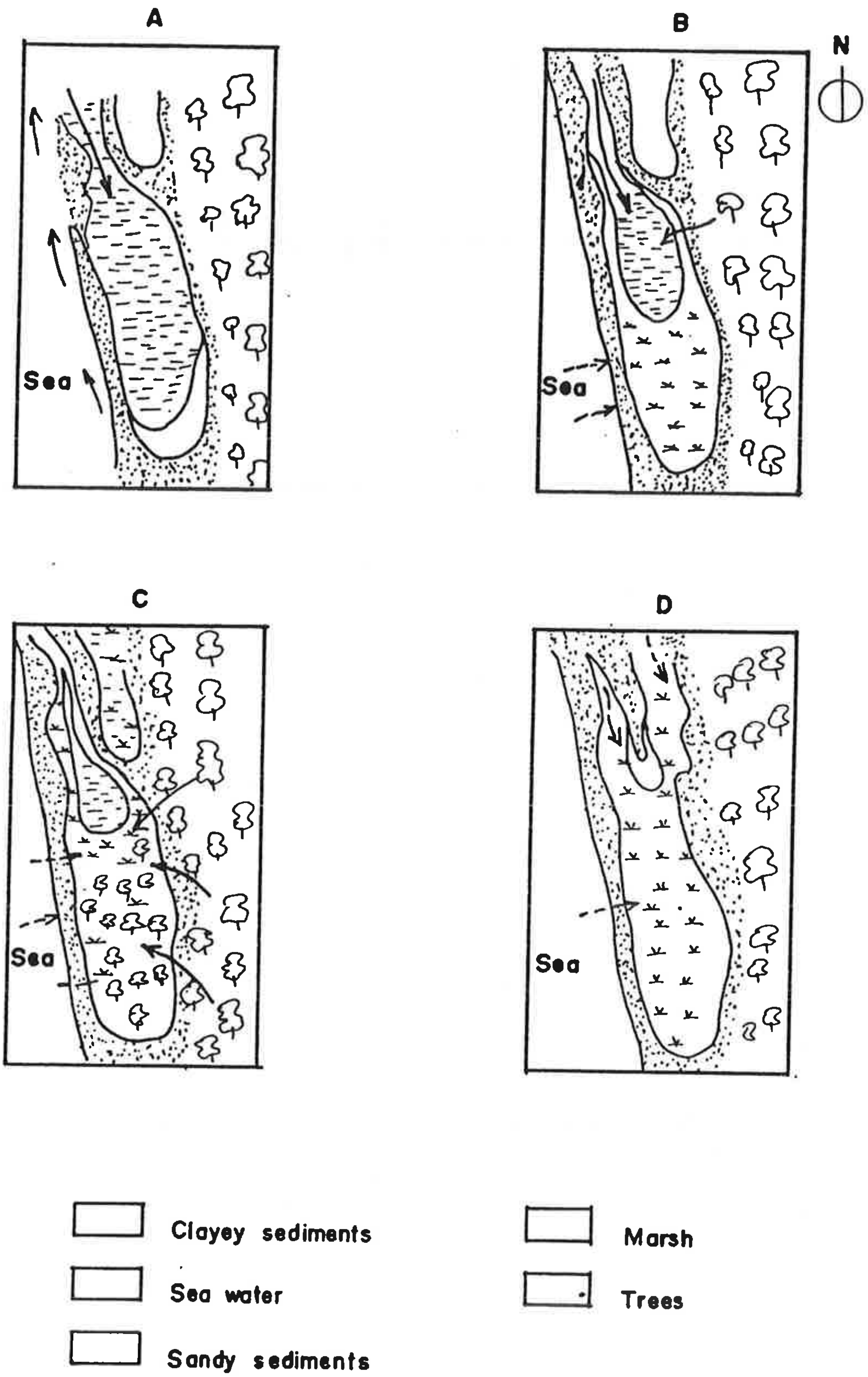


Figure. 3.2.5.

GEOLOGICAL EVOLUTION OF MUTHURAJAWELA MARSH (I)

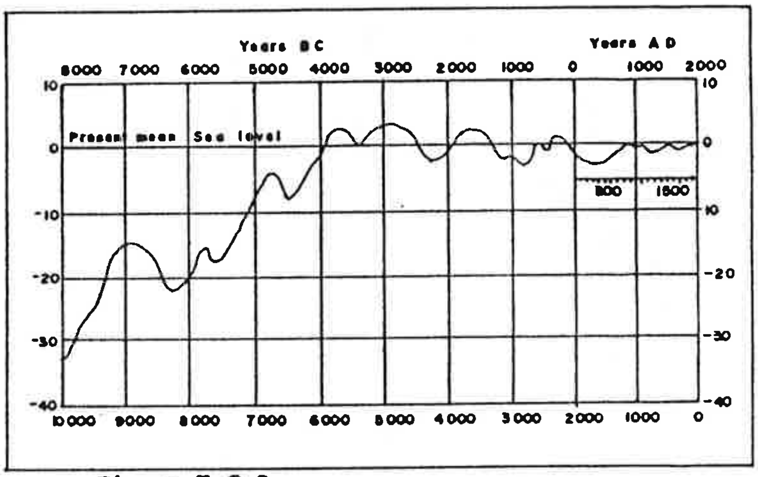


Figure 3.2.6
Variation of mean sea level during the last (1)
10,000 years.

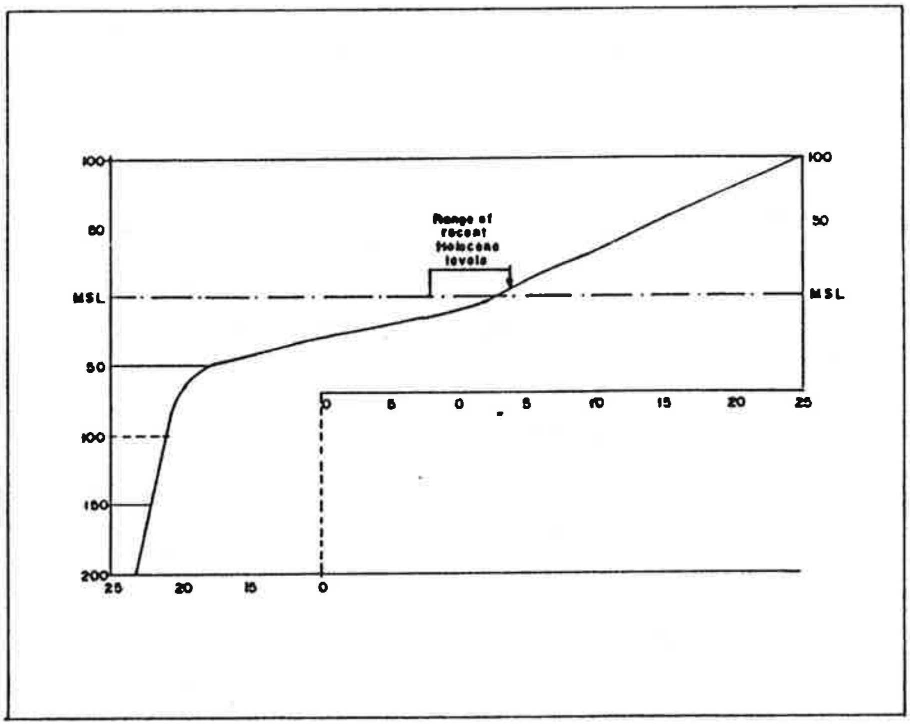


Figure 3.2.7
Schematic cross section
of the coastal area in the
vicinity of Muthurajawela. (1)

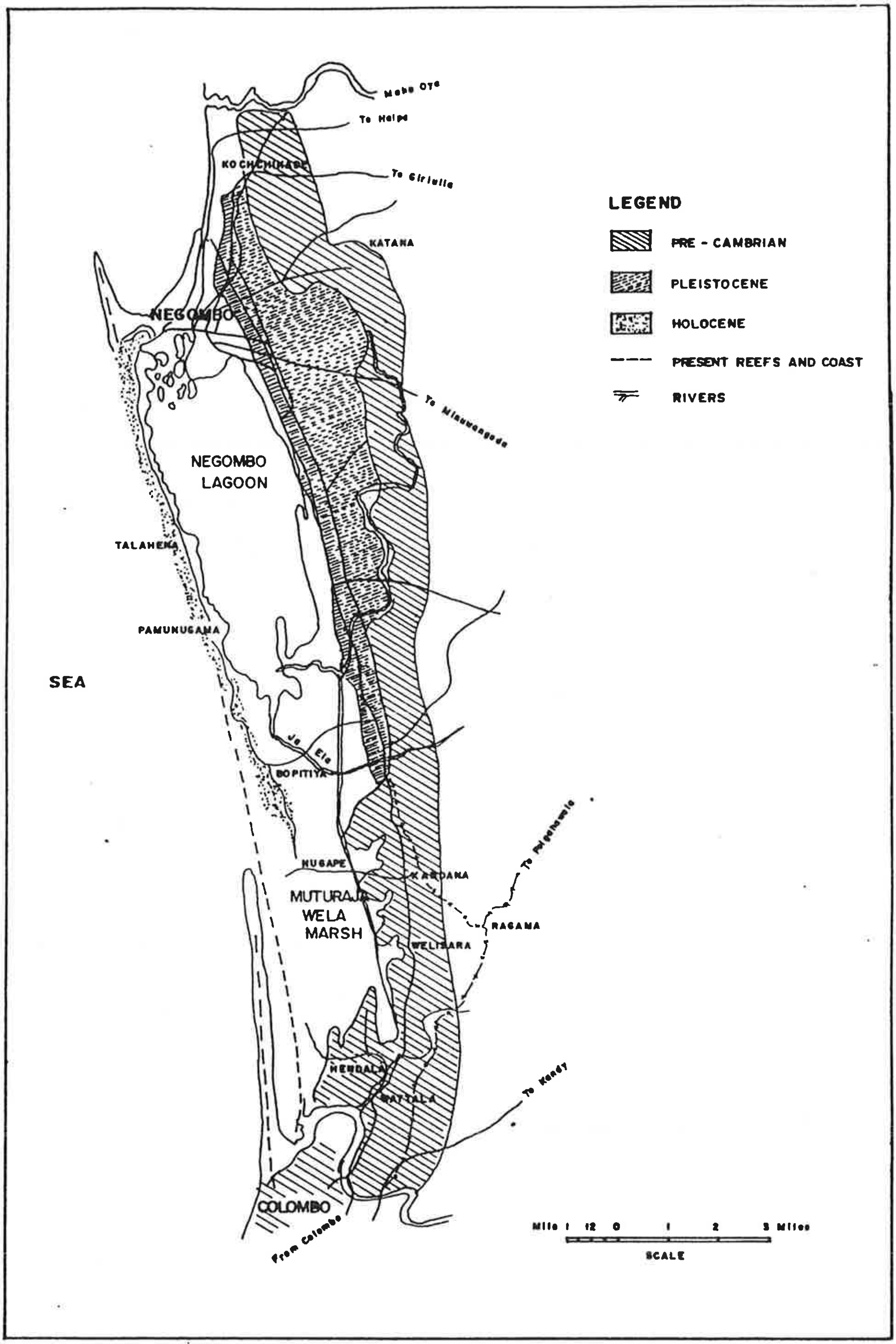


Figure 3.2.8

Stages in the geological history of the Muthurajawela marsh - Negombo Lagoon area (I)

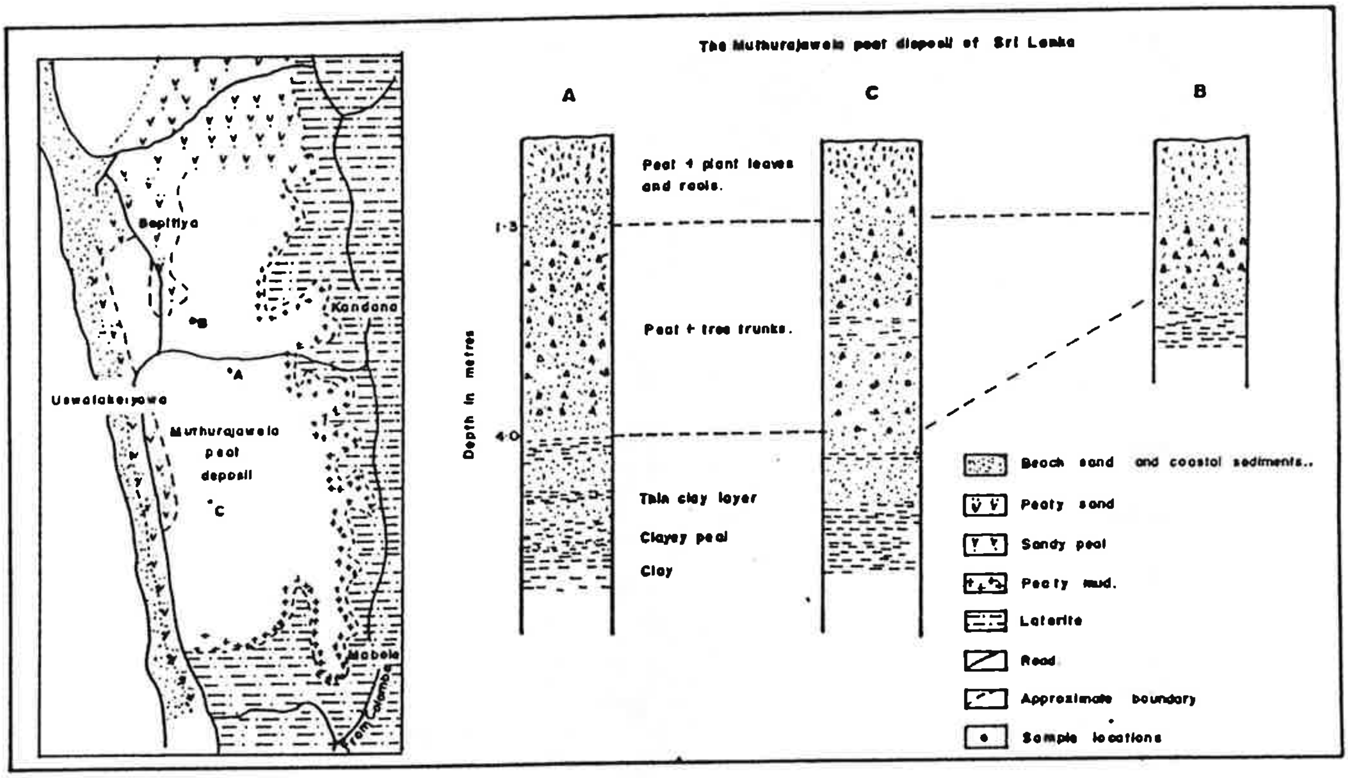


Figure 3.2.9.

THE GEOLOGY OF THE MUTHURAJAWELA MARSH AND ITS PEAT DEPOSITS A, B, AND C DENOTE THE LOCATIONS OF BORE HOLES FOR DEPTH PROFILES (1)

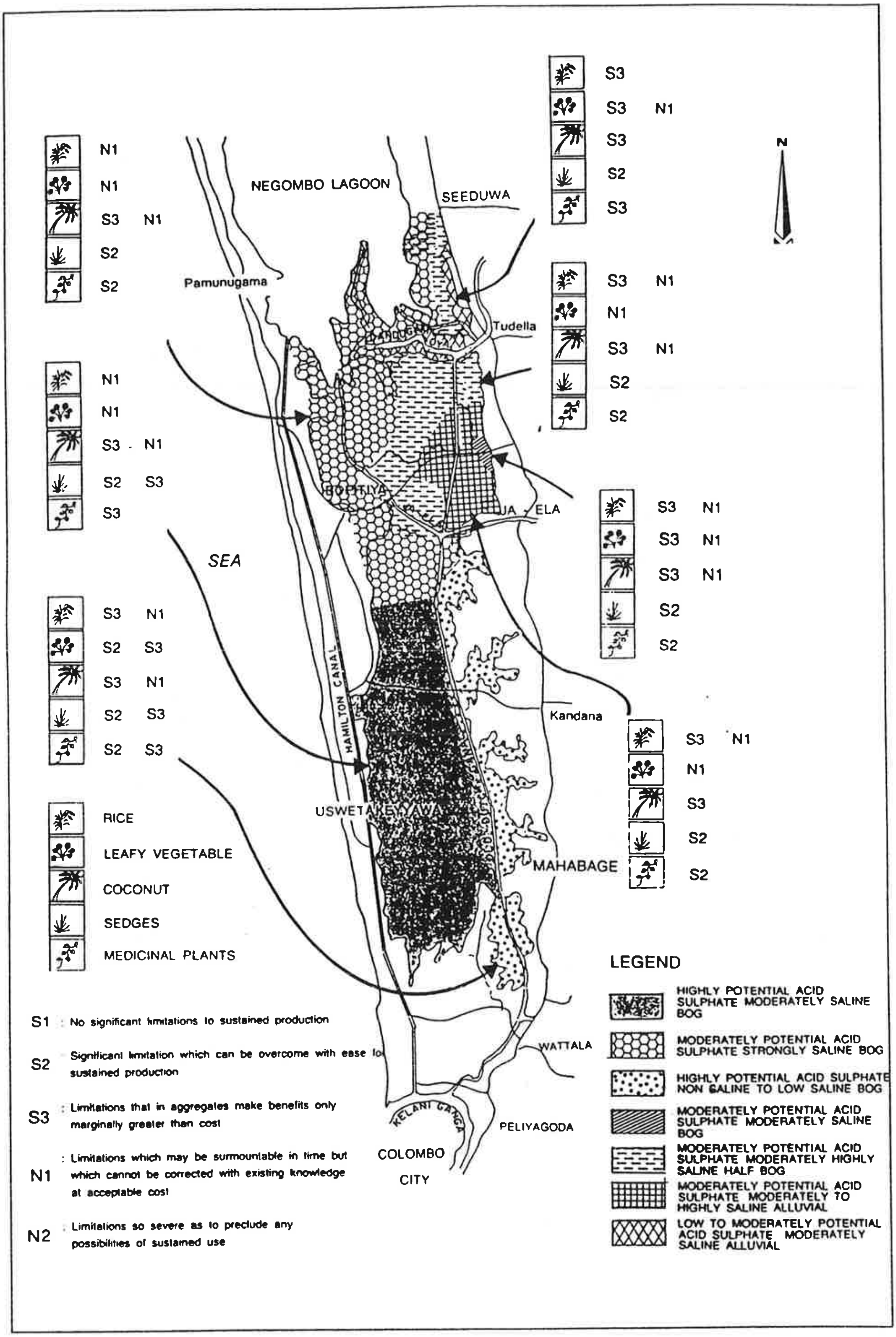


Fig.3.2.10 Land suitability classification of soil in the Muthurajawela marsh (1)

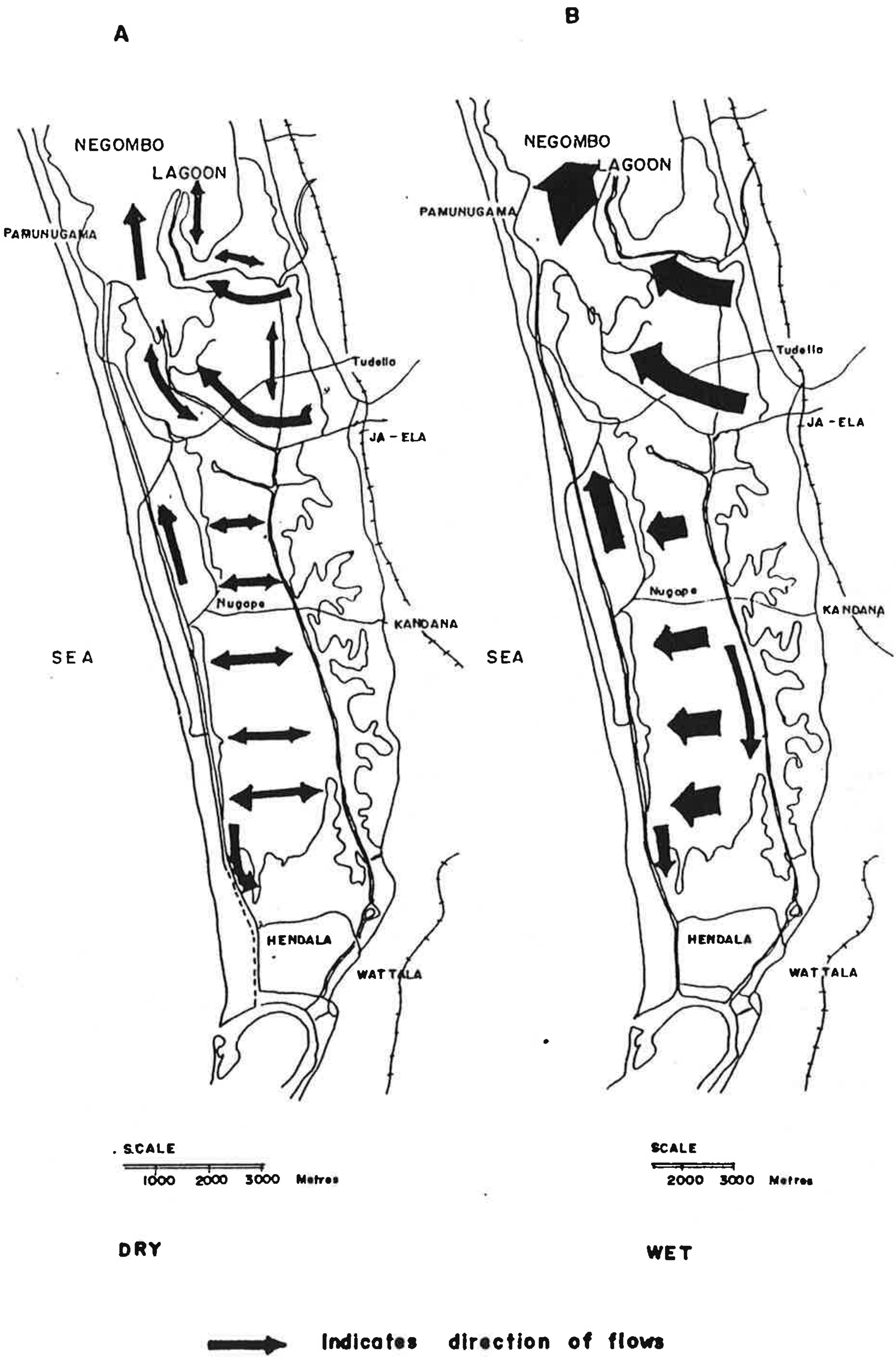


Figure. 3.2.11.

Water flow pattern in Muthurajawela during the dry and wet seasons (1)

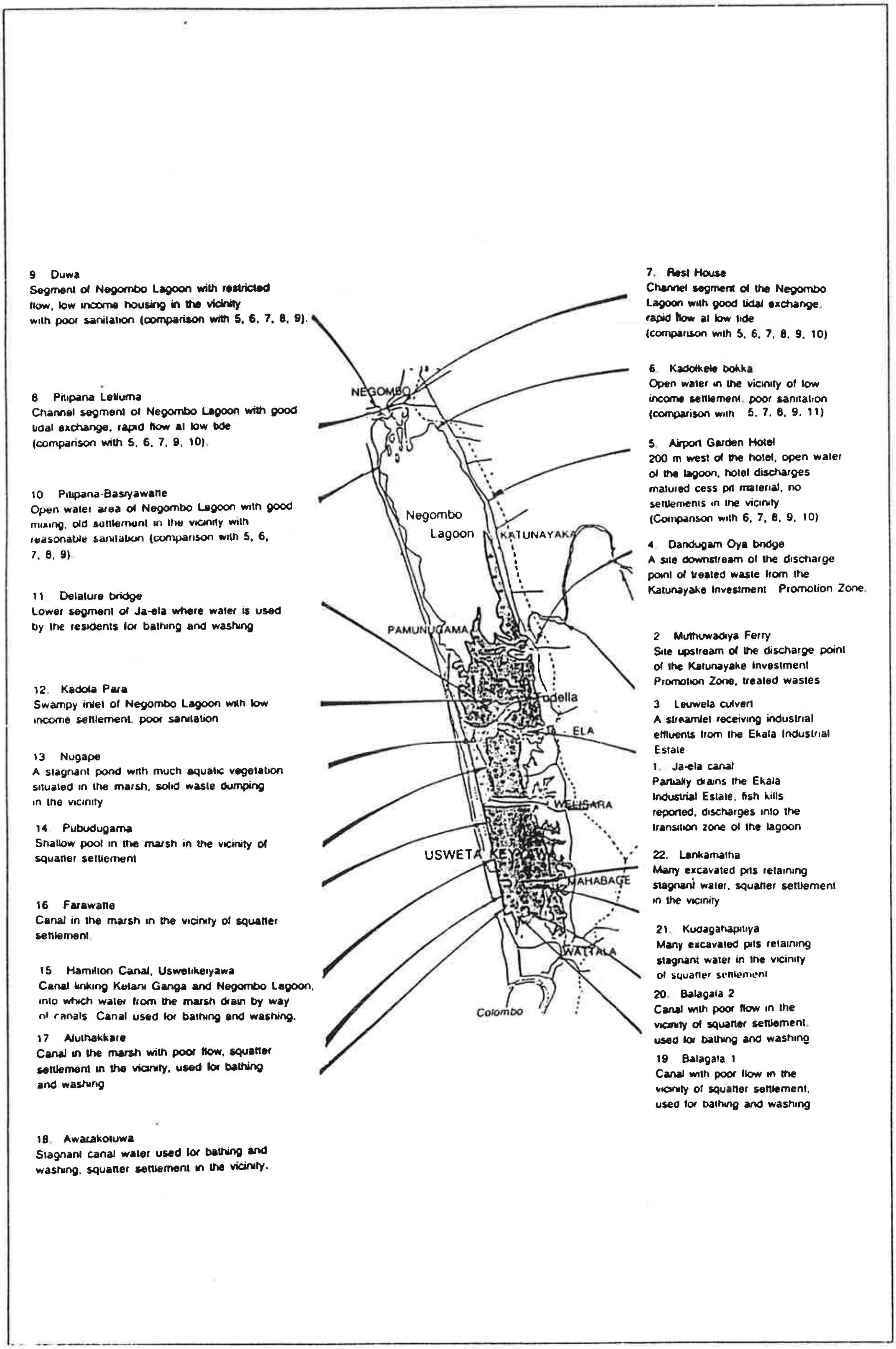


Fig.3.2.12 Sampling Stations in the study area for water quality and reason for their selection (1)

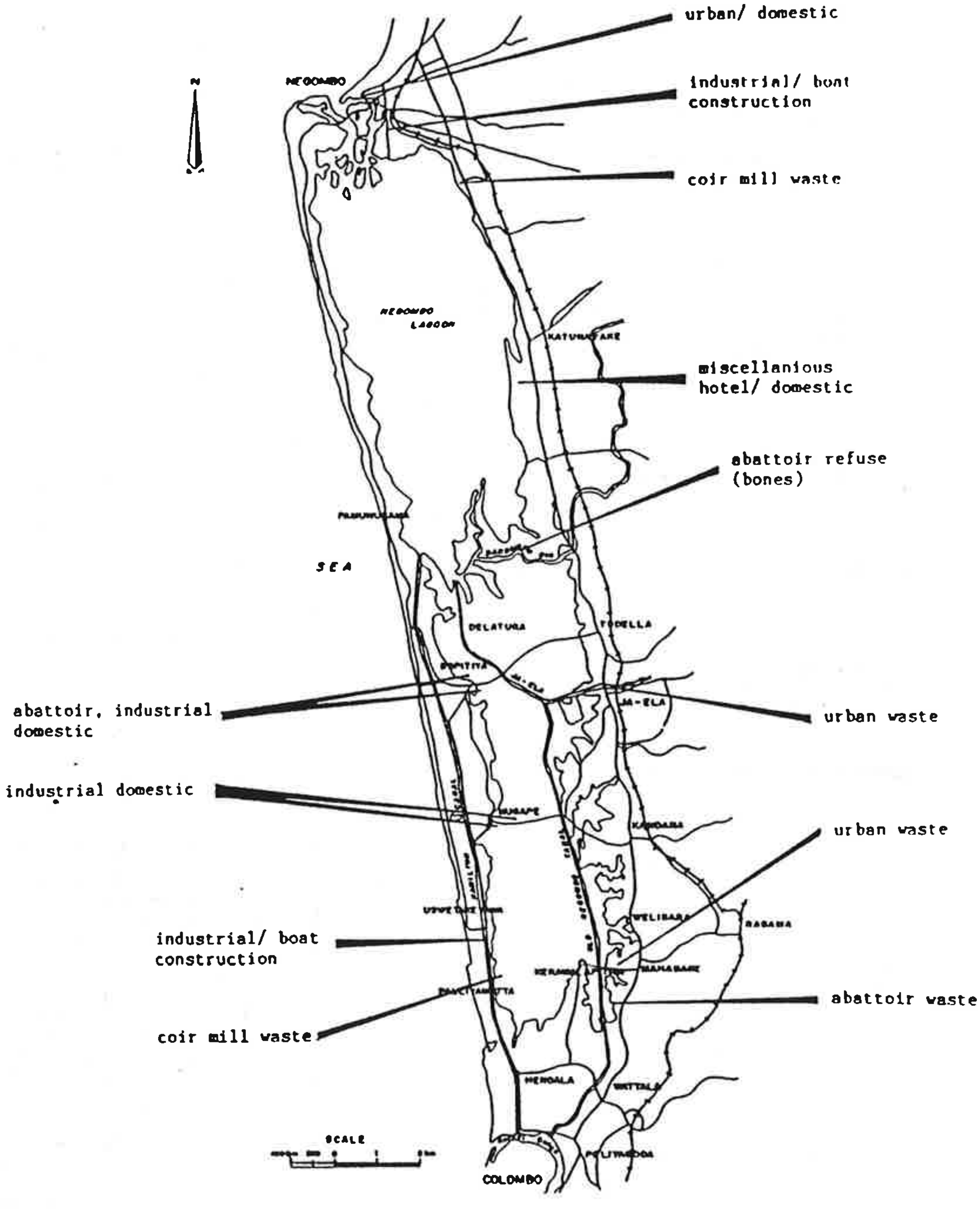


Fig. 3.2.13 *Solid waste dumping sites in the study area* (1)

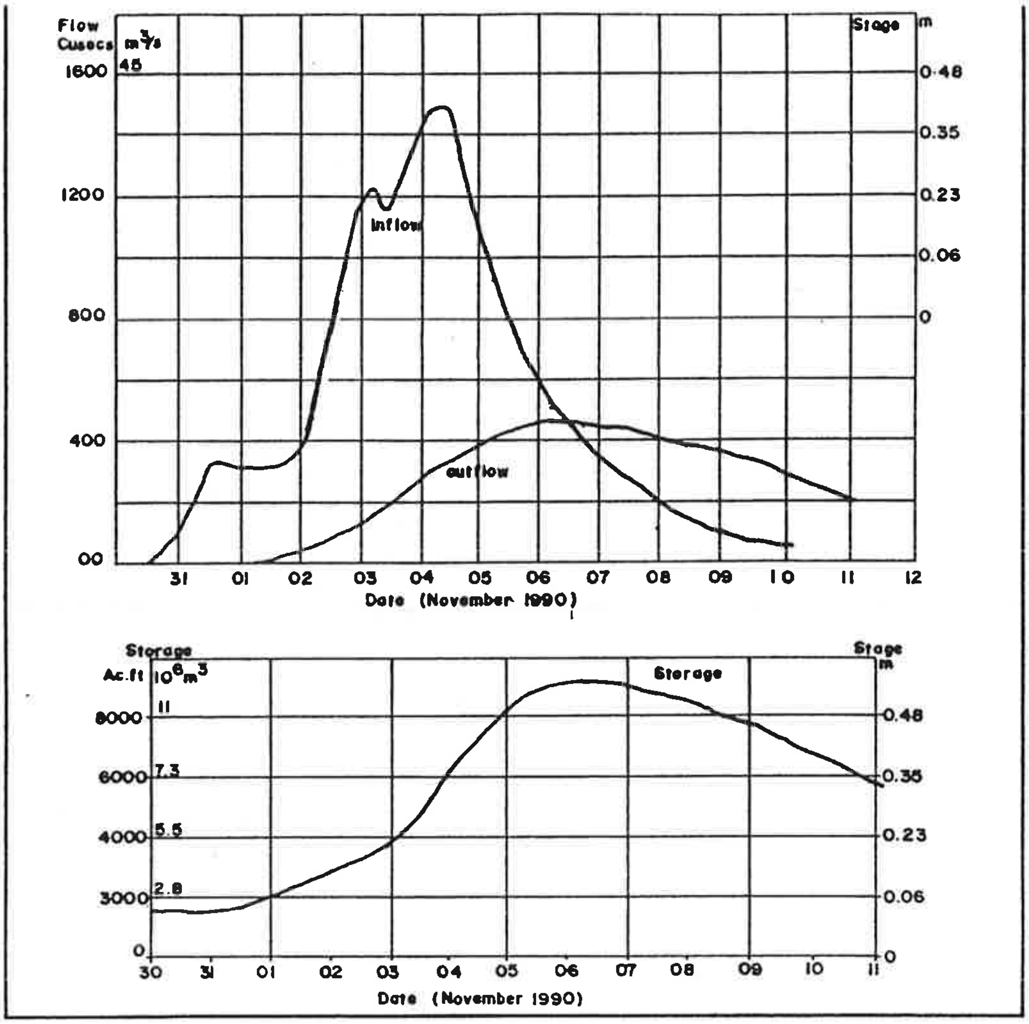


Figure 3.2.14
Simulation of Storage and drainage in the Muthurajawela marsh during the flood in November 1990 (Dharmasena, 1990) (I)

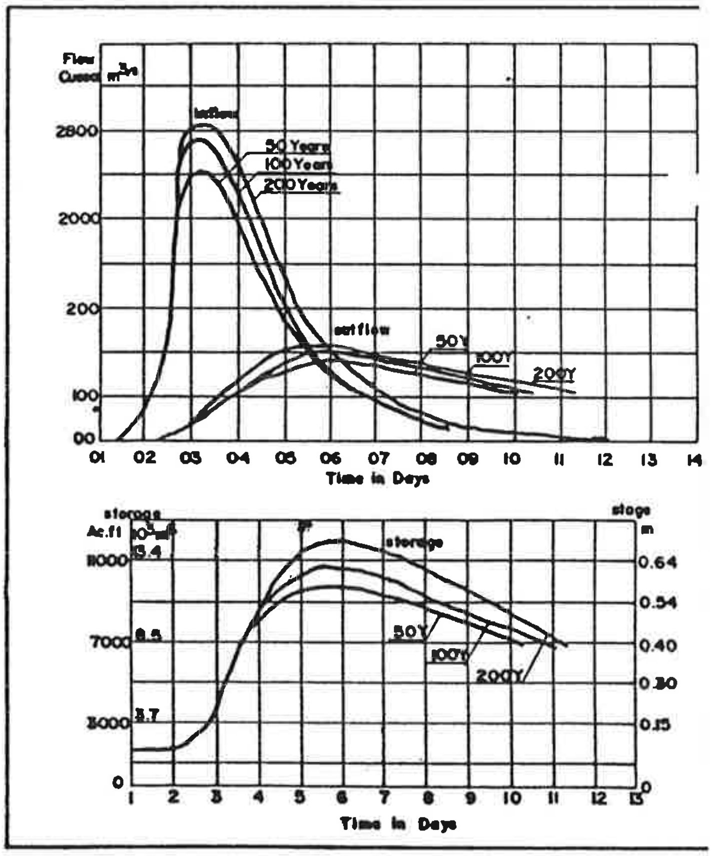


Figure 3.2.15
Simulation of storage and drainage in the Muthurajawela marsh for flood return periods of 50,100 and 200 years (Dharmasena 1990) (I)

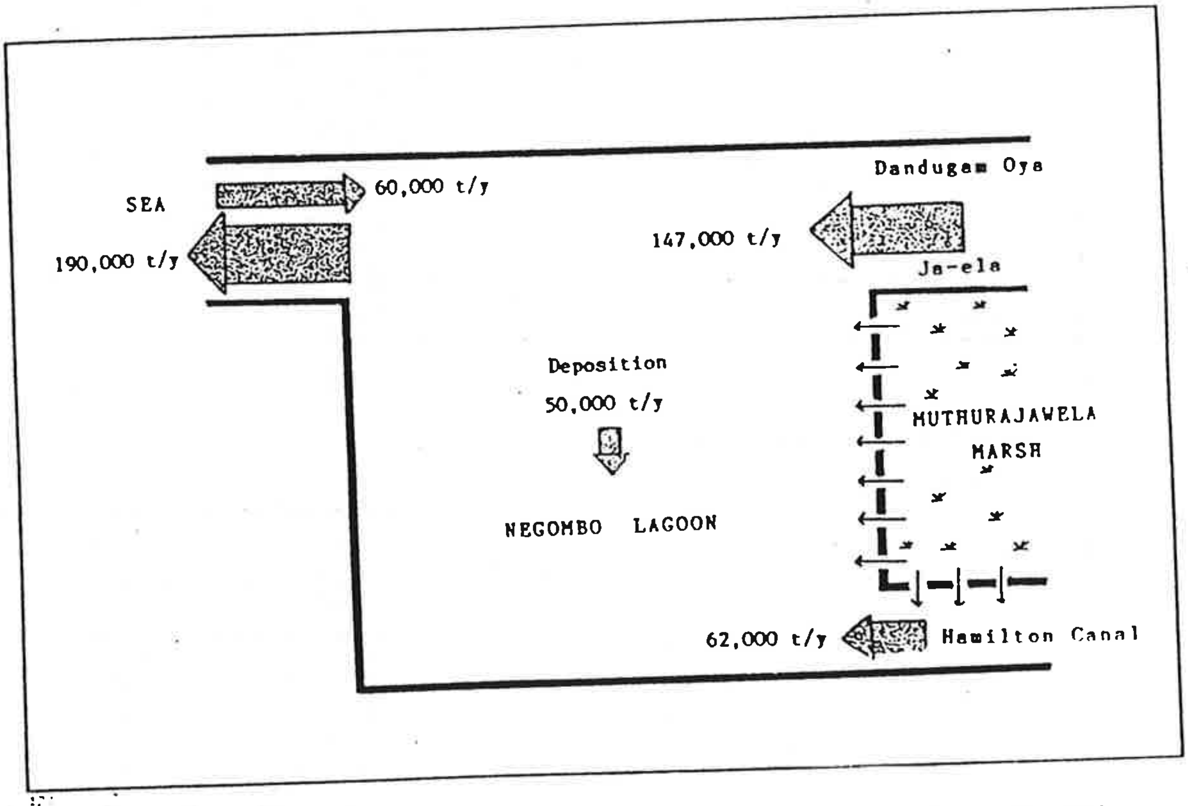


Fig.3.2.16 Sediment transport and deposition in Negombo Lagoon (1)

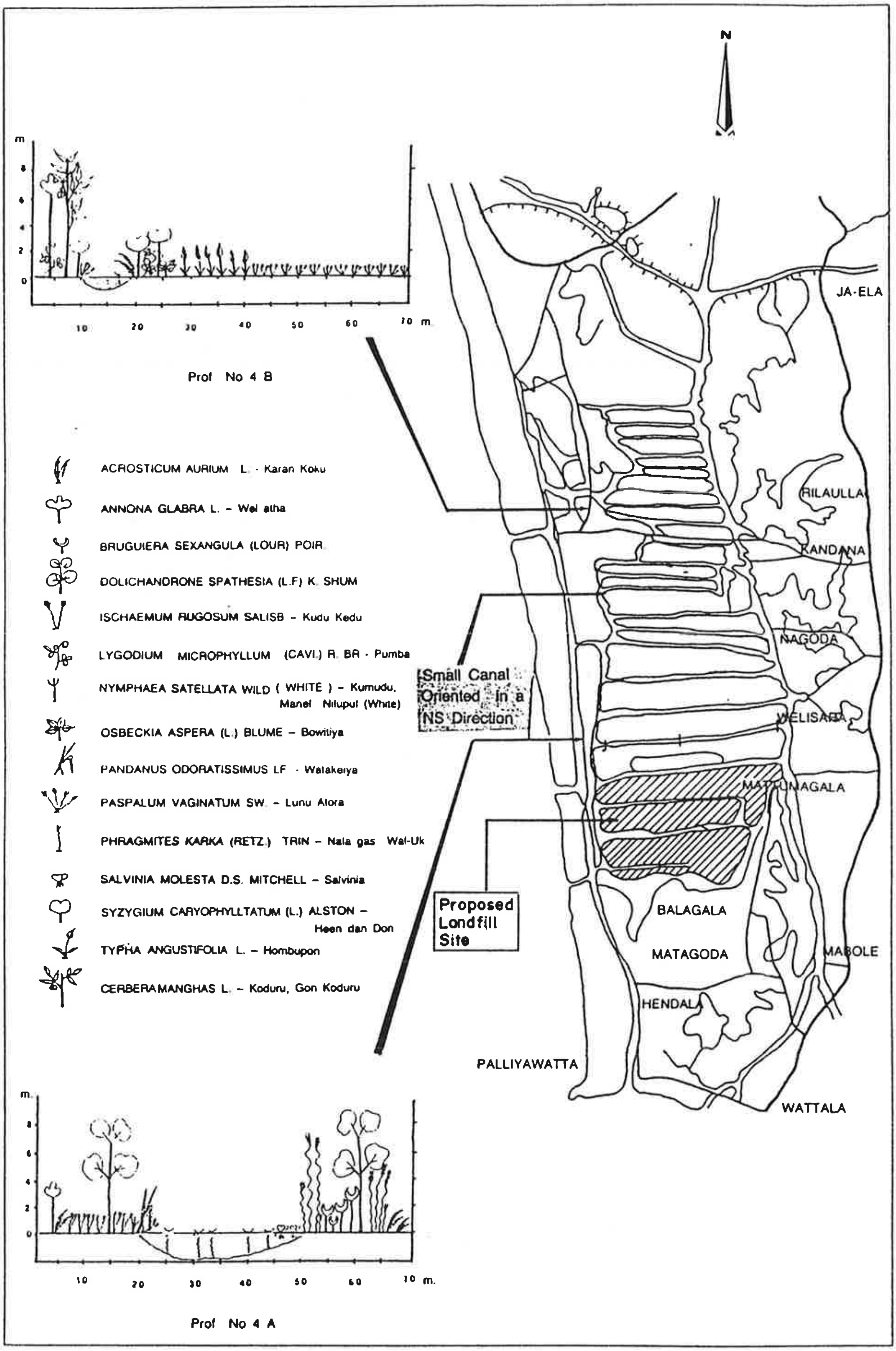


Fig.3.2.17 Profiles of vegetation along irrigation channels at Muthurajawela (Herat, 1990)

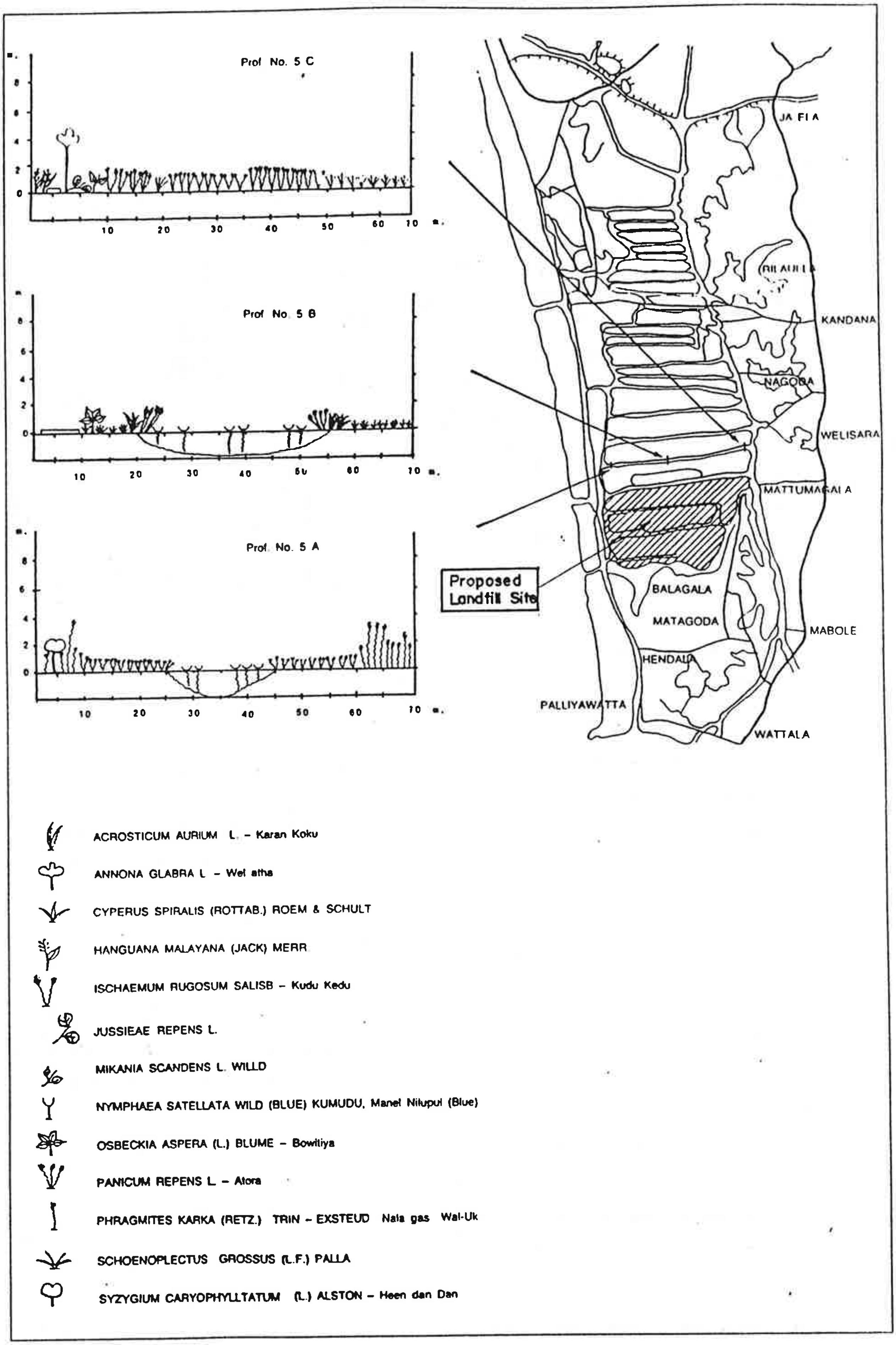


Fig. 3.2.18 Profiles of vegetation along drainage channels at Muthurajawela (Herat, 1990)

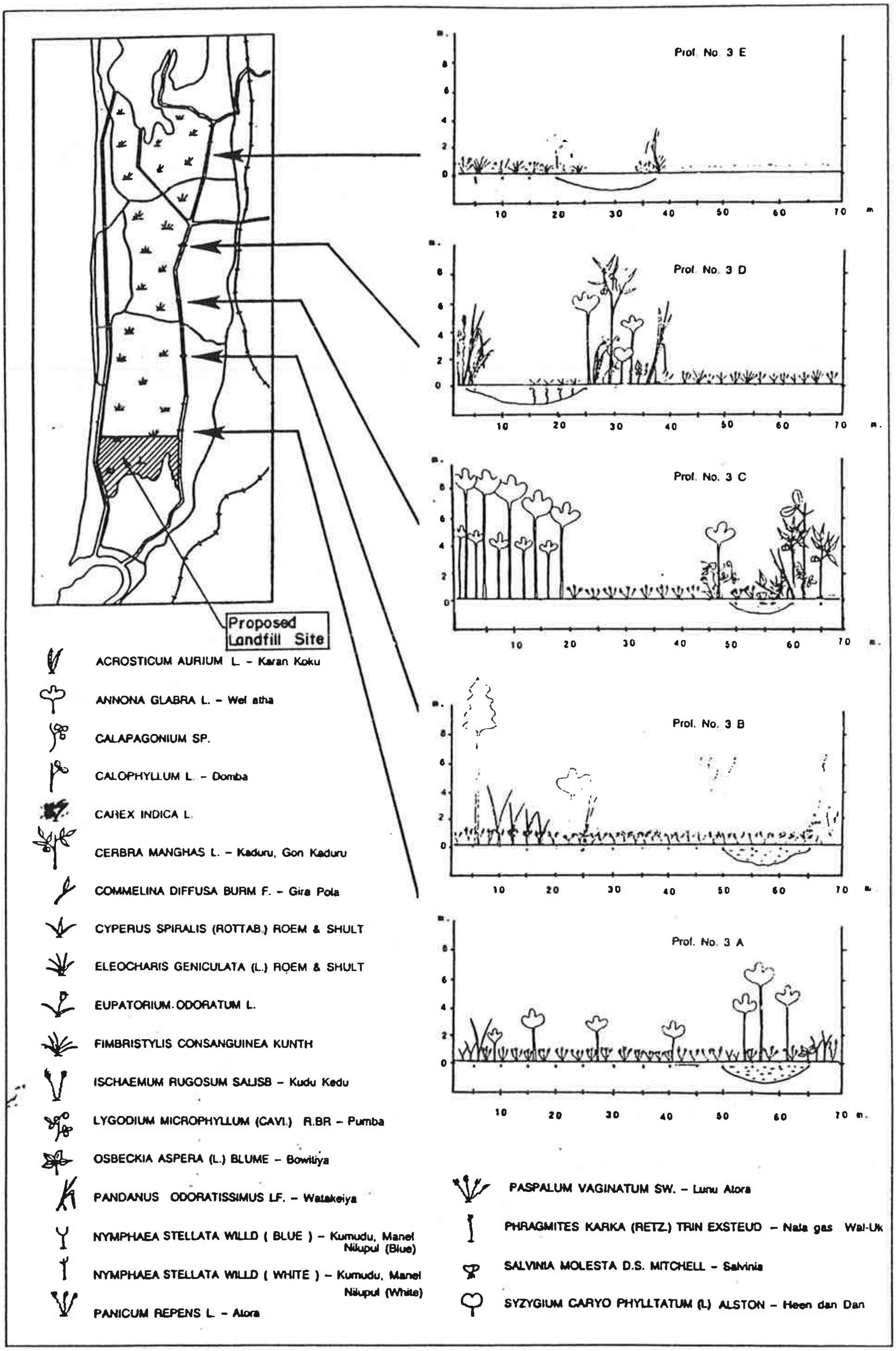


Fig.3.2.19 Profiles of vegetation along the Dutch Canal, Muthurajawela, (Herat, 1990)

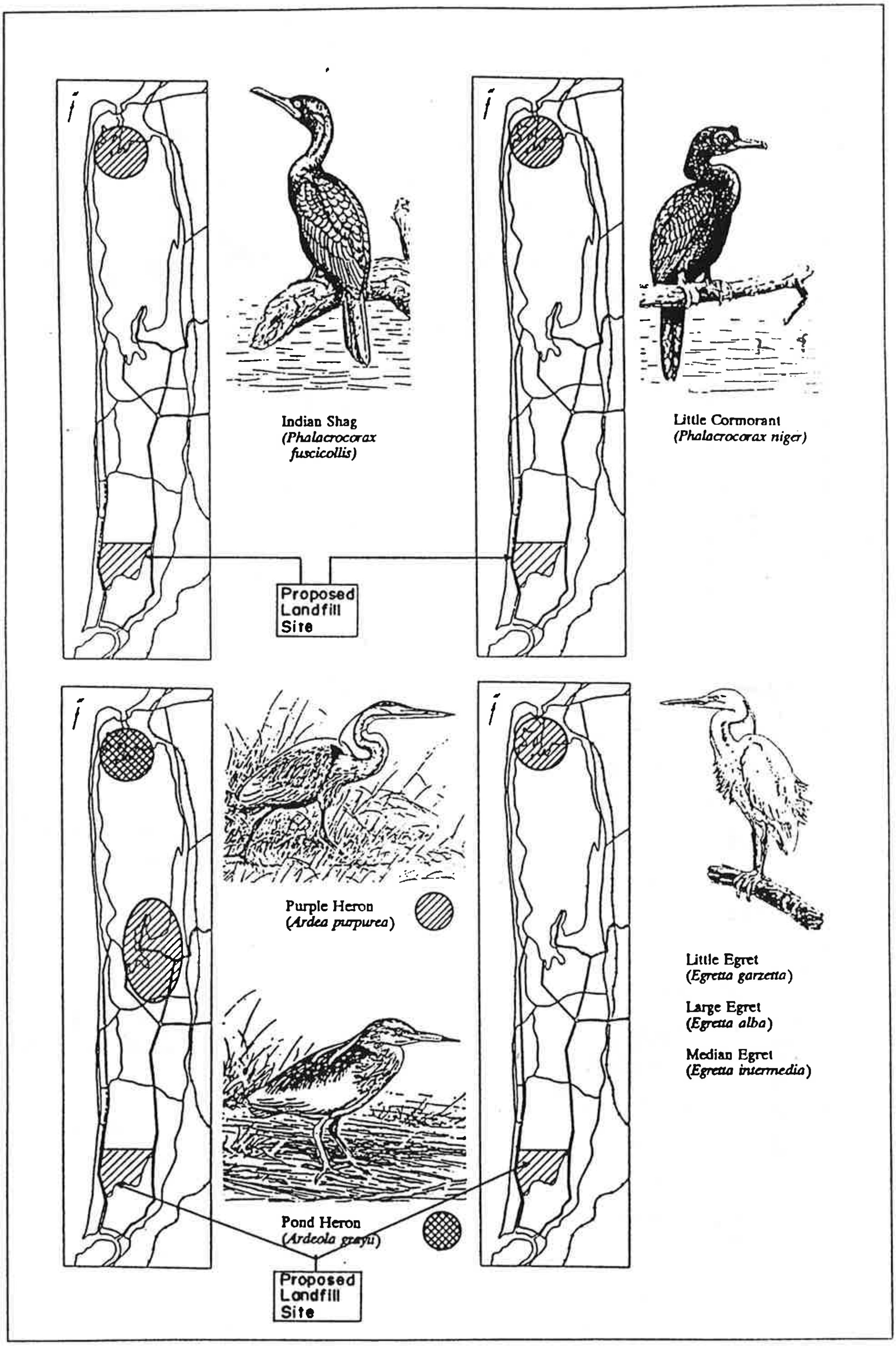
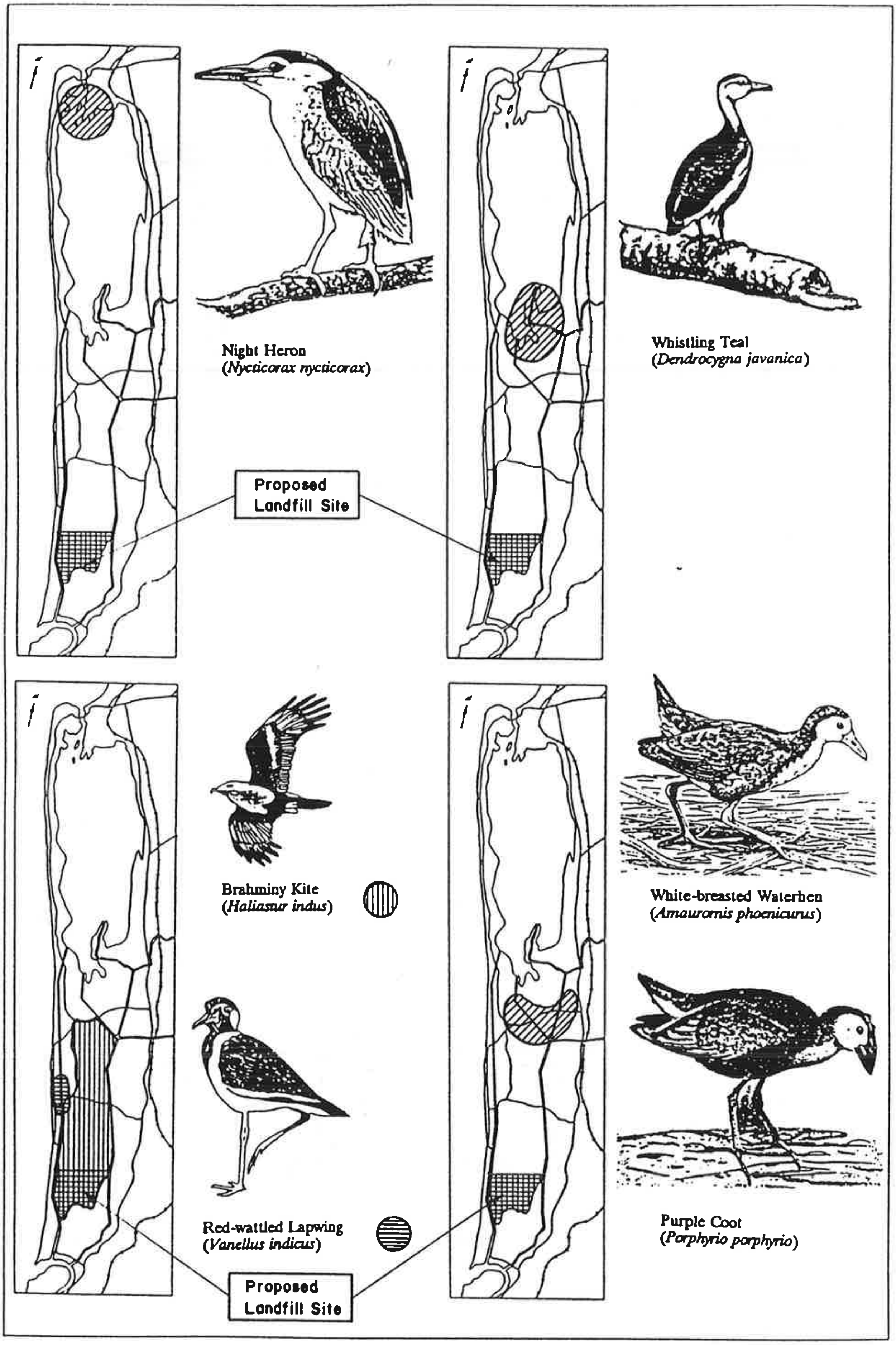


Fig.3.2.20 Breeding locations of resident birds in the Muthurajawela marsh Negambo Lagoon Wetland (De Silva, 1990)



Contd.. Fig.3.2.20 Breeding locations of resident birds in the Muthurajawela Marsh - Negambo lagoon wetland. (De Silva, 1990)

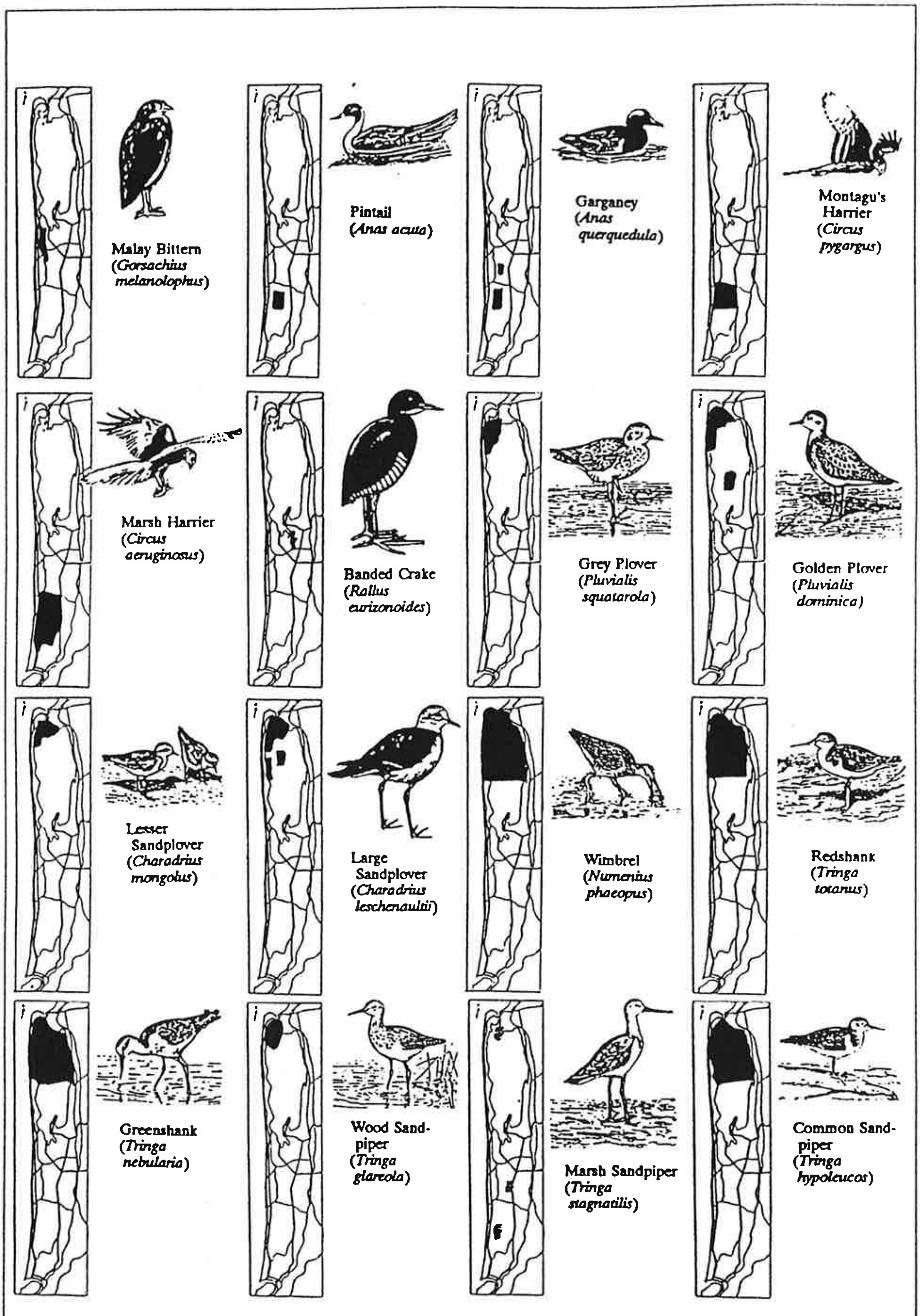


Fig.3.2.21 Distribution of migrant birds in the Muthurajawela marsh - Negambo lagoon wetland (De Silva 1990)

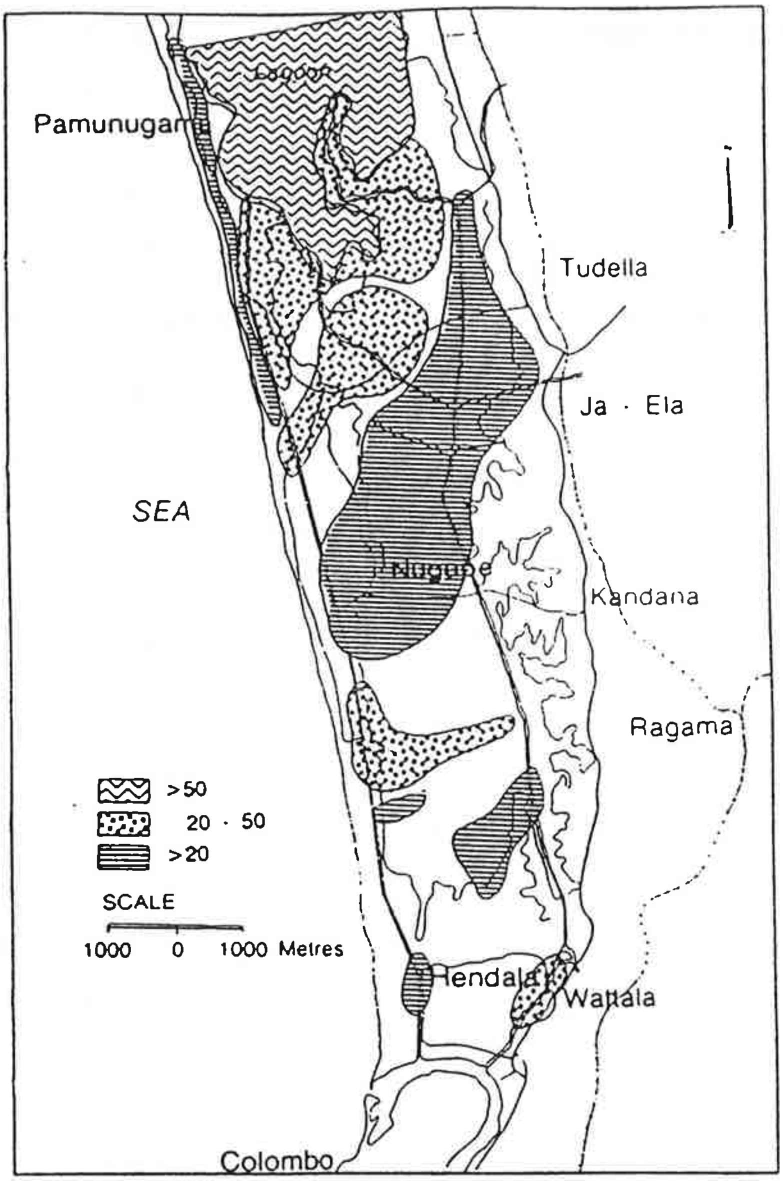
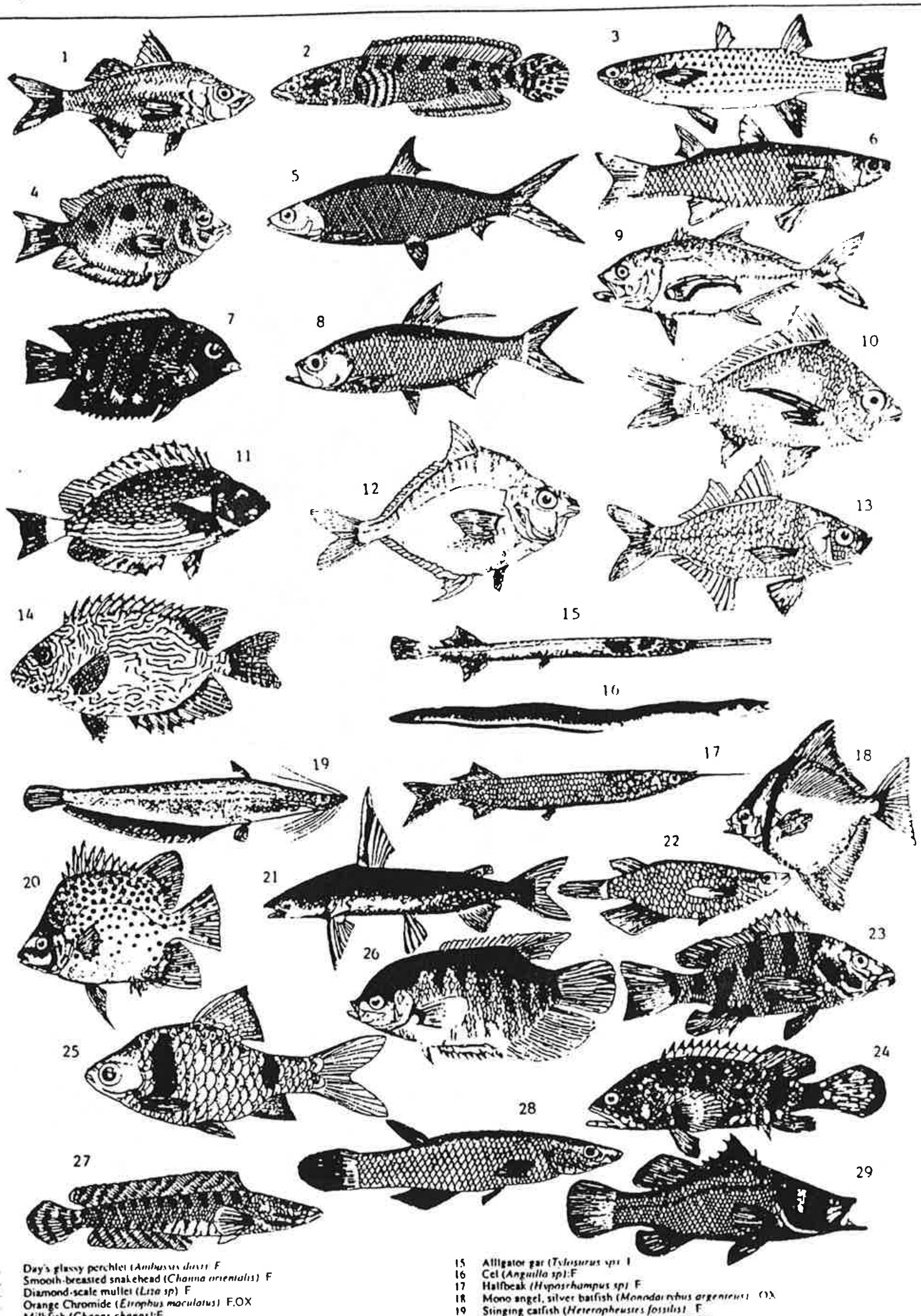


Fig.3.2.22 Generalized distribution of fish species in Muthurajawela marsh according to density



1. Day's glassy perchlet (*Ambassis dussi*) F
2. Smooth-breasted snakehead (*Channa orientalis*) F
3. Diamond-scale mullet (*Liza sp*) F
4. Orange Chromide (*Etrophus maculatus*) F,OX
5. Milkfish (*Chanos chanos*):F
6. Grey Mullet (*Mugil cephalus*) F
7. Pearl Spot, green chromide (*Etropus suratensis*) F
8. Tarpon (*Megalops cyprinoides*) F
9. Trevally (*Caranx sp*) F
10. Silver biddy (*Gerres oyena*) F
11. Rabbit fish (*Siganus jorvus*) F
12. Pony fish (*Leiognathus sp*) F
13. Commerson's glassy perchlet (*Ambassis commersonii*) F
14. Rabbit fish (*Siganus vermiculatus*) F
15. Alligator gar (*Tylosurus sp*) F
16. Cel (*Anguilla sp*):F
17. Halfbeak (*Hyposrhampus sp*) F
18. Mono angel, silver batfish (*Monodactylus argenteus*) OX
19. Stinging catfish (*Heteropheustes fossilis*) F
20. Spotted butterfish (*Scatophagus argus*) F,OX
21. Estuarine cat fish (*Tachysurus sp*) F
22. Estuarine top-monnow (*Panchax melastigma*)
23. Grouper (*Epinephalus spp*) F, AX
24. Grouper (*Epinephalus spp*) F, AX
25. Cummings two-banded barb (*Barbus cummingsi*) OX
26. Gouramy (*Osphronemus goramy*) F
27. Striped snakehead (*Ophiocephalus striatus*) F
28. Topminnow (*Panchax panchax*)
29. Sea bass (*Lates calcarifer*) F AX

F: Food Fish; OX: Ornamental Fish export AX: Aquaculture Seed Fish export

Fig.3.2.23 Some important fishes of the Muthurajawela marsh-Negambo lagoon wetland

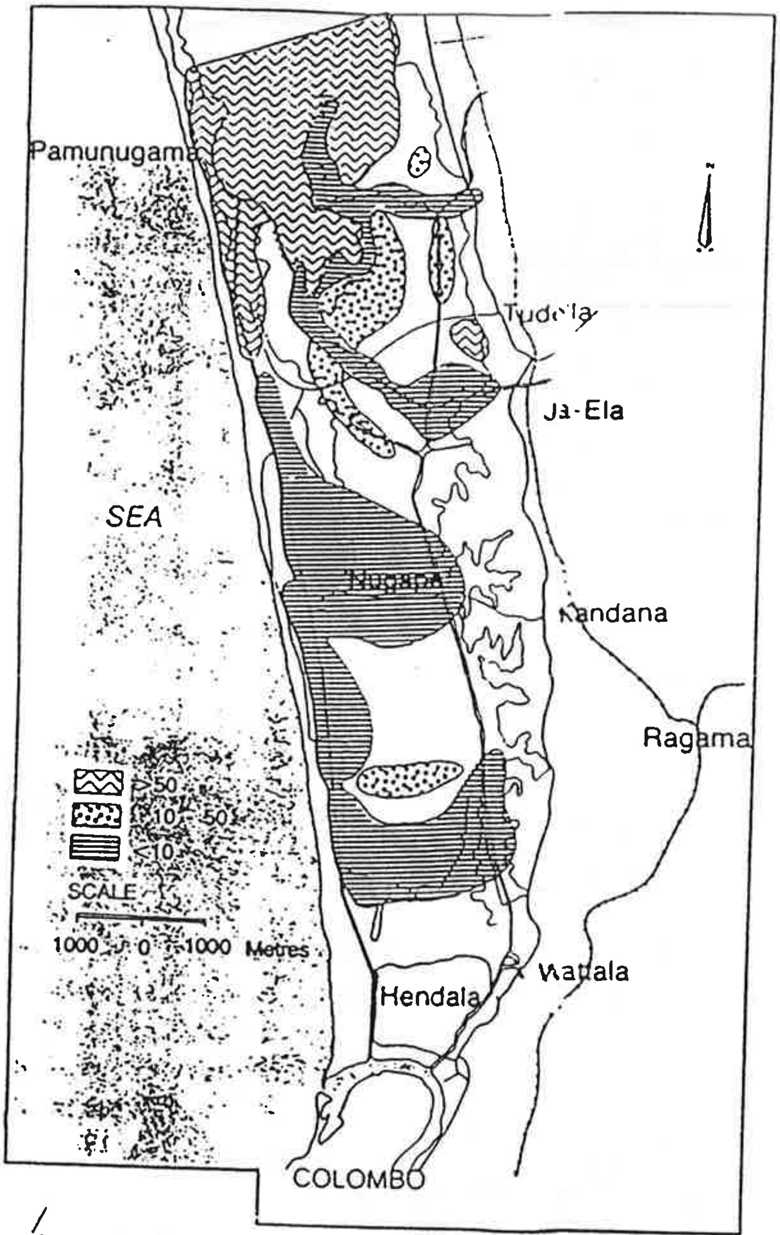


Fig.3.2.24 Generalized distribution and abundance of zooplankton in the Muthurajawela marsh (Pinto,1990)

4. DESCRIPTION OF ENVIRONMENTAL IMPACTS

4.1 Offshore and Nearshore Environment

4.1.1 Impact on Physical Resources

4.1.1.1 Areas and types of impacts

In the recent past with the increasing awareness of the need for a balance between urban development and environmental protection, the reclamation of marshy land by dredged material has been critically evaluated. With regard to these projects the dredging industry has been subjected to a critical review, in particular, on the environmental impact of its operations.

This section reviews most of the likely environmental impacts that might occur during, or as a consequence of dredging operations. The proposed measures to minimize these impacts will be identified in the next Chapter.

With respect to dredging operations for the Kerawalapitiya Reclamation Project there are three main areas of interest namely, the dredging site, the transportation route and the disposal site. Each of these areas may be further subdivided in terms of proximity and consequences as given below.

(1) The dredging site
- (a) areas affected directly by dredging operations
- (b) areas affected by the results of dredging operations

(2) The transportation route
- (a) areas affected by means of transport
- (b) areas affected by loss of spoil

(3) The disposal site
- (a) areas affected by the action of dumping the dredged material.

This section will review the impacts relating to the dredging site (burrow area) and the transportation route. The impacts relating to the disposal site (land fill area) will be considered separately under the impacts relating to the land fill environment (section 4.2.1).

The above three-fold categorization is important for two reasons. Firstly it permits to detect and eliminate undesirable impacts in a systematic manner. For example, the impacts due to the action of dredging or disposal may be overcome by changing the type of dredger or the method of disposal. However, impacts related to the location of the burrow area, volume of dredging and location of the disposal area cannot be overcome without substantial alteration to the job specification. Secondly, it permits a convenient way of classifying the types of impact that dredging will impose on the environment. Hence from the above categorization and the related approach towards the assessment of environmental impacts it is evident that certain aspects of the overall project should be investigated in detail at the design stage as opposed to a few days prior to the commencement of the project. These aspects include the environmental consequences of dredging, transportation of dredged material and on this occasion the disposal at the land fill site.

4.1.1.2 The dredging site

a) Areas affected directly by dredging operations

These impacts pertain to problems caused by the movement of the dredger during its operations and the forces applied by the dredger to the environment. The impacts due to the movement of the dredger around the dredging site and associated risks are considered in this section.

Regardless of whether the dredging operation is undertaken by means of a bucket, dragline or hydraulic dredge, the primary result is the creation of deep holes or linear channels and temporary suspension of clouds of sedimentary materials.

The sand used as the base material for the reclamation at Kerawelapititya is extracted from a borrow area at a distance more than 3.0 km offshore, which implies that the extraction will not interfere with the nearshore sediment movement processes. The dredging methodology will limit the maximum sea bed deepening to 2.0 m in a uniform manner in the form of linear channels as opposed to isolated deep holes. This will minimize the risk of creating a large deep subterrain pit which could lead to any form of instability and possible collapse of stable nearshore profiles. In this respect, dredging operations which generate linear shallow channels are more acceptable than those operations which create deep holes.

Dredging operations can cause accidental damage to underwater cables and pipes, if any present, and this aspect should be checked in advance.

The impact on water and soil quality as affected by dredging operations can be defined with reference to the chemical and biological state of the water and soil, the turbidity, or amount of suspended solids in the water, the dynamic characteristics of the water (currents, turbulence etc) and their effect on marine life and the physical state of the soil.

Turbidity is the most obvious effect of dredging on the quality of water. Increased turbidity caused by the agitation, raising and overflow of dredged material is likely to have an adverse impact on the environment. It can cause clogging of fish gills which leads to suffocation and it can also clog the membranes of filter-feeding organisms. By reducing the amount of sunlight penetration into the water it can also slow down photosynthetic activity of plant life.

When the dredging is in progress in offshore waters, it is natural that the turbidity of that region will increase and it is also likely that these effects will increase further during periods of high wave activity. The dispersion effects thus created will also increase the turbidity of water in the adjacent areas. When the impact of turbidity is assessed it should be compared with the level and frequency of turbidity caused by storms and natural phenomena at the site. The river Kelani discharges a heavy load of sediments to the sea thus generating considerable turbidity in the nearshore regions. During the rainy seasons this effect of increased turbidity, as a result of the discharge of sediments, has been observed in the nearshore regions extending several kilometers from the river mouth. From previous experiences on dredging it is quite common to find that for considerable periods, the natural turbidity exceeds the levels caused by dredging.

With respect to the Kerawalapitiya Reclamation Project, the burrow area is located at a distance of more than 3.0 km offshore and hence the nearshore regions will not be directly affected by increased turbidity. It is a transient phenomenon which will affect the environment during the dredging operation. The conditions would improve steadily after the dredging operation is complete. The methodology of the operation itself will control the impacts. Turbidity may also be caused by water draining from hoppers or containment areas. Although this can be serious it is easily controlled. Propellor wash may also cause the suspension of bottom sediments. These disturbances caused by the dredging action cannot be avoided. However, by proper management of the operation the likely adverse impacts can be reduced.

An important secondary impact of any form of dredging operation is the disturbance associated with the different activities. These impacts include the noise of the dredging operation, vibrations, the smell of dredged spoil in the hoppers, particularly when polluted or gaseous, the general disturbance due to dredging operations which could cause loss of both flora and fauna and would cause specific harmful effects on fishing grounds, if they exist. Since the dredging operations are carried out in deep sea between depths of 15 and 30 m at a distance more than 3 km, these disturbances arising from the dredging operations will not affect the nearest local community living on the shoreline. However the impact on the fish species will be considered separately in section 4.1.2.

b) Areas affected by the results of the dredging operations

Many areas can be affected both directly and indirectly by the results of dredging. These impacts primarily include all environmental effects of excavating material by dredging.

Impacts on the immediate neighbourhood

Some of the physical impacts affected directly by the results of dredging operations are

- the possibility of the subsidence of adjacent areas due to undermining
- the possibility of causing subsoil failure by the removal of a surcharge of soil
- the alteration of local soil characteristics by the continuous dredging of coarse or fine soils.
- the change in the local flow pattern together with associated scouring or siltation in the dredged trench.

Here again the impacts can be minimised by the methodology of the dredging operation. Most of the above destabilizing impacts can be eliminated by limiting the depth of dredging to a minimum. In this respect the specified depth of extraction of 1.5 m to 2.0 m would prevent likely adverse effects resulting from the above physical impacts.

Impacts on the neighbouring coastline

One of the areas which is identified as affected indirectly by the results of offshore dredging is the stability of the nearshore coastline. This aspect is of vital environmental importance and should be given detailed consideration.

Some of the physcial impacts relating to nearshore coastline stability affected indirectly by the results of dredging operations are

- the possibility of beach drawdown which is the movement of material seawards due to the removal of offshore deposits.

- the removal of natural coast protection by the dredging of an offshore bank or bar leading to consequent erosion of the coastline.

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- the change in nearshore coastal processes (shoaling, refraction, damping) caused by the change in sea bed contours due to dredging and the consequent erosion or deposition of material caused by change of wave height and direction.

- the possible effect of the dredging area acting as a littoral sink and preventing littoral material from moving alongshore causing erosion on the downdrift side.

- interception of shoreward moving sediments through the impact on current and wave action pattern.

Most shorelines which are relatively stable have attained a delicate dynamic equilibrium between the material coming into the coastal unit and that leaving the same unit. The fragility of this balance should be clearly understood and it should be appreciated that even a small change in one of the processes controlling sediment movement may produce very undesirable results.

If abstraction occurs too near a beach, its dynamic equilibrium can be affected. The shifting of material into excavated areas from a neighbouring beach can induce erosion of varying degree along a considerable stretch of shoreline.

If dredging activities transform seabed topography nearshore wave processes such as wave refraction patterns will be altered. These modify the angle of wave approach to the shoreline resulting in a change of the longshore current. As this current has a significant influence on sediment transport along the shoreline, its alteration will contribute to a change in the sediment budget leading to erosion or deposition.

The removal of natural coast protection by the dredging of an offshore bank could cause severe erosion problems. Offshore banks partially protect adjacent shorelines by dissipating wave energy by depth limited wave breaking or by damping through seabed friction.

Through its impact on current and wave propagation processes, dredging can interfere with the delivery of offhore sediments to the shoreline, thus contributing to erosion or re-distribution of material closer to the shoreline.

A study of the shoreline profile, the selected location of the borrow area, and the methodology of operation for the Kerawalapitya Project provides sufficient evidence to the fact that nearshore coastline stability will not be affected by the proposed dredging operations. Since the dredging operations will be carried out in the deep sea between depths of 15 and 30 m at a distance exceeding 3 km from the shoreline, this activitiy will in no way affect the littoral transport which only extends a short distance beyond the wave breaker zone. In this context the dredging operation will not contribute to erosion or deposition of the shoreline. The methodology of the dredging operation whereby depths of extraction are limited to 1.5 m - 2.0 m in the form of linear channels will not cause any significant change in the nearshore processes which could have an impact on shoreline stability. The borrow area for this project does not act as an offshore bank and hence the problems associated with the loss of offshore banks are not applicable.

One of the important aspects which should be noted is the presence of offshore sandstone reefs (Fig: 3.1.7) which provides considerable protection to the shoreline. The waves break on this reef and a considerable amount of energy is dissipated as a result of this process. In this respect the reef also provides a form of protection to the shoreline from any activity carried out offshore of the reef.

4.1.1.3 The transportation route

a) Areas affected by means of transport

Detailed aspects of the method of transportation were discussed under Methodology of Operation (section 2.3) and Evaluation of Alternatives (Section 2.4.b, 2.4.c and 2.4.d). In these sections attention was focused on both the delivery of sand to the landfill area and the discharge of seawater back to sea.

The transportation is essentially carried out by a system of pipelines, supported by a booster pump. The pipelines which commence at a point beyond the reef will cover a distance which includes the nearshore coastal waters, reef crossing, the beach crossing (including adjacent private land), Hamilton Canal crossing and road crossing.

The pipelines of diameters 90 cm (floating pipeline) and 80 cm (onshore pipeline) will be placed over a total distance of approximately 4000 m (sea and land). In the areas in which the pipeline is placed in nearshore coastal waters it is important to ensure that the pipeline will not affect maritime traffic which in this area is essentially fishing vessels. For this purpose it is recommended to establish a dialogue with the fishermen of the area in order to appreciate their views.

Relevant details regarding the reef crossing were discussed in Sections 2.3 and 2.4.b.(ii). It is very important to ensure that the reef will not be subjected to any form of damage because it could aggravate coastal erosion by the exposure of the shoreline to more severe wave energy as a result of any damage. The natural reef acts as an offshore submerged breakwater and dissipates a part of the incident wave energy. The fragile stability of the shoreline north of Kelani River outfall is very much dependent on the presence of the reef.

With regard to the beach crossing it is recommended that the pipeline is placed underground as opposed to laying it on the beach. The important aspect is that the pipeline if laid on the beach should not act as a littoral barrier or should not in any way obstruct the along-shore sediment drift. When crossing private land adjacent to the shoreline disturbance of people and property should be minimized. In particular, attention should be focused on acceptable noise levels, considering the fact that a booster pump will be located in that vicinity. It is important to minimise the disturbances to the local community.

When crossing the Hamilton Canal suitable provisions will have to be made to a reasonable height on both sides of the canal to permit the unobstructed movement of 3 1/2 ton fishing vessels using the Hamilton Canal. Appropriate arrangement will also have to be made for the pipeline to cross the adjacent roadway. The pipeline could be maintained at the elevated state as recommended for the canal crossing or the pipeline will have to be placed underground.

b) areas affected by the loss of spoil

These impacts include the turbidity caused by leakage of spoil from hoppers and floating pipelines and damage caused by leakage from land based lines. Sufficient care should be exercised to prevent leakage and overflow from the hoppers as well as to ensure that all pipes are well connected thus providing no opportunity for any leakage. It would be necessary to adopt a monitoring programme to ensure that all pipelines are kept in good working order.

4.1.2 Impacts of sand excavation on sea bottom fauna

The removal of sea sand from the coastal sea bottom would lead to the destruction of a portion of the benthic habitat, which include the physical substrate as well as the organisms which live in it. In time, the physical substrate will be restored but regeneration of species diversity would take a longer time. Not only the excavated area will be affected, also the immediate surrounding could be subject to temporary impacts, for instance, by increased turbidity. These disturbances would disrupt biotic community at the sea bottom, the severity of which depending upon the duration and magnitude of the disturbance. In this respect, considering the small size of the borrow site as compared to the vastness of the surrounding similar ecosystem, and the short period of disturbance, the proposed sea sand mining would cause minor disturbances.

The ocean bottom predominantly consists of unconsolidated sediments. The particles of the bottom sediments are of diverse origin, mineral (soil particles) and biological (detritus and excreta).

The disturbance of sea bottom fauna depends upon the extent to which the turbidity of the water increases, i.e. the number of sediment particles in suspension. Among the sediment particles the very fine sand, silt and the clay particles would create most problems since they tend to remain suspended in water for a comparatively longer length of time.

The increase in the number of sand particles could damage or clog the delicate structures of the organisms, such as their gills, which would decrease the oxygen intake. If the damage to the gills are severe this would lead to the death of the organism within a short period of time. If damage to the gills are not severe the rest of the gills may function to compensate for the loss. However lesions may develop in the damaged gills as well as any other parts of the body which are damaged by the sand particles, which could also cause death of the organisms with time.

The new methodologies which are utilized in sea sand extraction, as in this project, are geared to minimize the disturbances such as increase in turbulence. If the techniques allow for a minimum increase in the turbidity levels, then though these impacts will still occur in the immediate surrounding at a lesser magnitude it will not have an impact on the distant regions. The increased sediment load in a given region for days will drive away the pelagic fish species from that area. If this occur the fishery industry will be affected. However there are no established fishing grounds within the borrow area. According to the fishermen of the area the important fishing grounds are at least 1.5 km. away from the borrow site.

It is highly unlikely that sand excavation will lead to major disturbances of sea bed communities and coastal productivity. This opinion is based on three facts:

i) the very small size of the borrow-area, as compared to the vastness of similar ecosystems nearby;

ii) the existing turbidity of the water caused by massive silt discharge of the Kelani river (in particular suspended particles most likely to clog gills and filtering organisms;

iii) the occasional use of trawl nets which cause continuous disturbance of the sea bottom, also increasing turbidity at these levels.

If no other disturbances occur in this region, such as further extraction of sea sand, it can be concluded that once the extraction of sand is completed the disturbances caused will be repaired in a short period of time. Long shore drift and wave action will fill in the shallow trenches and biotic communities will re-establish themselves on the substrate. After a few years the benthic community will reestablish itself, provided no further disturbances at the borrow area take place.

The sea water, draining from the sand- fill site will be pumped back into the sea. The amount of turbulence will depend upon the velocity at which it will be discharged into the sea. Since the discharging point is within the fishing grounds, the turbulence should be kept to a minimum. The impacts of turbidity increase caused by drainage water from the landfill can be greatly reduced by allowing for sedimentation before pumping.

4.2 Landfill Area Environment

4.2.1 Impact on Physical Resources

The main requirement for a healthy marsh is restricted drainage so that its surface remains wet throughout the year.Economic development in the marsh during the last two centuries have increased the drainage capacity halting the accumulation of biomass,thus,restricting the development of the marsh.Promoting the vertical growth of the marsh is also desirable to keep up with the rising sea levels.

Housing and industry development in the marsh requires good drainage which in turn destroys the marsh ecosystem.This is the paradox of development of a marsh.Restoration of the marsh (or a part of it) would require almost complete impoundment to reduce its drainage as well as improve its capacity to regulate floods.Impoundment could help by absorbing the excess water from the drainage system during the wet season and releasing it during the drier periods.

The drainage of Dandugam Oya,Ja-ela and Kalu Oya maintains the balance in the Muthurajawela marsh and the Negombo lagoon.An intervention in any part of this system will affect the whole system.The larger the intervention the more serious the impact.The management of the combined basins should be coordinated with the water management in the Muthurajawela marsh and Negombo lagoon areas.In other words, the hydrological systems of the Muthurajawela marsh and Negombo lagoon and the Dandugam Oya, Ja-ela and Kalu Oya should be considered as one system.

(a) Changes in the hydrological patterns of the area

The changes in the hydrological patterns in the Muthurajawela marsh will not be affected drastically due to the proposed reclamation of land. Direct changes will be due to intervention in the catchment of Dandugama Oya, Ja-Ela and Kalu Oya. Deforestation in the catchment will cause a more rapid flow of water into the Dandugama Oya, Ja-Ela and Kalu Oya drainage system. Initially, the sediment transport by this drainage system will increase due to construction activities associated with urbanization. Increased urbanization will also facilitate rapid flows by increasing the impervious areas of the catchment.

(b) Changes in the drainage patterns

The implementation of the reclamation project will not affect the general pattern of drainage with the water flowing along the Hamilton canal towards the Kelani river and Negombo lagoon during the dry season. During the wet season the added flow will also be conveyed along the old Dutch canal towards the Kelani Ganga (Fig. 3.2.11).

The immediate impact of reclamation of land in the Kerawalapitiya area of the marsh will be a reduction of it's retention capacity. This reduced storage will lead to higher water levels and less retention during flood flows. Lower outflows will result from the increase in distance the water has to travel along the Hamilton and the old Dutch canals to reach the Kelani Ganga. The findings of the model study carried out by the Irrigation Department (Dharmasena (14)), to simulate the impacts of reclamation of the Muthurajawela area, support this theory (Table 4.2.1).

Table 4.2.1

Comparison of the flows and storage in the marsh with and without the sandfill.

Return Period (yrs)	50	100	200
Max inflow (cum/s)	70.3	77.7	85
A. Without Sandfill			
Max storage (cum)	11.4	13.8	14.5
Max Level,MSL,(m)	0.56	0.61	0.66
Max Outflow (cum/s)	19.20	21.7	24.,5
B. With sandfill			
Max storage (cum)	11.10	12.20	13.5
Max Level (MSL)(m)	0.59	0.63	0.69
Max Outflow (cum/s)	13.80	17.30	22.0

According to Table 4.2.1, for a return period of 50 years, due to the sandfill the maximum storage is expected to decrease by 2.63%, Maximum flood level is expected to increase by 5.35% and the Maximum outflow is expected to decrease by 28.12%

Apart from the changes in the water levels, retention capacity and outflow, there will be no major changes in the overall drainage patterns in Muthurajawela marsh during the wet and dry seasons. The greater part of the proposed project area is elevated below +25 cm MSL. Adequate drainage by gravity at low tide levels is possible only for areas lying above 50 cm MSL. Gravity drainage which is not possible from the project area at present will be facilitated from the post settlement elevation of the sand fill. The provision of drainage canals to replace those canals which will be buried by the sand fill, ditches in the filled-up area, will improve gravity drainage.

(c) Change in the drainage capacity of Hamilton Canal and ways of enlarging it's discharge capacity.

The Hamilton canal plays an important role in the draining of the Muthurajawela marsh as described in earlier sections. After land reclamation the drainage flow during floods will be reduced. This is due to the lengthening of the flow path of the drainage water to the Kelani Ganga.

The salt exclusion structures which are components of the Hamilton canal, but which now have been neglected, will have to be made functional again. An alternative to enlarging the canal capacity would be to shorten the path of flow to the sea. This could be achieved by constructing a canal connecting the Hamilton canal to the sea at a suitable location on the southern sector of the canal. This would enable the water to be discharged into the sea directly and not via the Kelani Ganga. However, from a coastal conservation point

of view,this could impose major problems on the nearshore sediment balance.This may also necessitate the construction of groyne type of structures to keep the outlet open,which in turn will have an impact on the beach development. If the discharge rate is not sufficient to reduce prolonged flooding then this will have to be augmented by a pumping station at the same location as the link canal.
These facilities should be designed and used in a manner as not to disrupt the interlinked flow of water and nutrients between the marsh and the lagoon.

In addition, dredging of the Hamilton canal and the removal of bottlenecks will also improve the drainage capacity of the canal.

(d) Changes in surface water quality

Hydraulic land fill with sand sucked from the sea bed entails large quantities of salt water being sprayed into the area to be reclaimed. This will lead to an increase in salinity in the surrounding area. Thus, the salinity in the marsh area will be increased in the short term.

The proposed project area consists of acid sulphate soil or potential acid sulphate soils. During the process of depositing the sand fill, the soil underneath will compact squeezing out a quantum of water. Although this quantity of water will be relatively small, with little influence on the water balance of the area, the water will be acidic and may be contaminated with heavy metal and other pollutants.

Pollutants already enter the Muthurajawela marsh - Negombo lagoon system from within (eg. squatters, industry and tourist facilities) and from the drainage system of Dandugama Oya, Ja-Ela and Kalu Oya. The reclamation of land and the subsequent urbanization will cause an increase in the level of pollutants in the surface water. The impact of pollutants, ranging from faecal coliform from housing, to dumping of industrial waste depends on the pollutant and the condition and the volume of the receiving water. Adequate provision for sanitation and waste disposal can greatly reduce the pollution problem.

(e) Salt water intrusion into the ground water table and adjacent area.

The exploitable groundwater in this area is restricted to lenses of fresh water fed by the rain in the dunes and the sandy areas around Bopitiya. The proposed reclamation in the southern part of the Muthurajawela marsh will not affect these localized fresh water lenses. Little is known of the groundwater underneath the marsh except that it is already saline. Salt water penetrates into the north-eastern part of the area and into the Dandugama Oya and Ja- Ela and in the south-western part through the Hamilton canal. Salt water intrusion into the marsh - lagoon ecosystem is more pronounced during periods of dry weather.

Considering current and planned developments in the catchment area feeding the marsh - lagoon ecosystem accentuating the occurrence of extreme events (more high and low flows) more salt water intrusion into the marsh is likely. The rehabilitation of the neglected salt exclusion structures and drainage canals will act in reverse to facilitate salt water intrusion unless properly maintained and operated.

4.2.2 <u>Impacts on Ecological Resources</u>

4.2.2.1 Loss of a portion of the wetland

The proposed landfill will imply the loss of 162 ha. of wetland ecosystems. Loss of flora and fauna resources, however, will be negligible, because the proposed landfill site, being closest to the capital city, is no longer in positive condition because of centuries of human influence. The vegetation has been altered by various human uses and impacts, and especially through introduction of exotic plant species which tend to encroach upon indigenous species (i.e. Annona glabra).

The proposed landfill site is also of minor inportance as wildlife habitat. None of the recorded species depends uniquely on this area's habitats for its survival. Given the small size of the landfill area, and the fact that structure and composition of the vegetation cover has drastically altered the habitat, very small populations of species mentioned in chapter 3.2.2. occur. The fact that some of these species may still survive in the area indicates the resilience of these species rather than habitat suitability. In fact, the populations of noxious pest species and disease-transmitting species greatly outnumber the populations of any of the other wildlife species.

The threatened mammal species listed for the Mathurajawela marsh, i.e. the Ceylon fruit bat, the toque macaque, the painted bat, the slender loris, the otter, the mouse deer, the fishing cat and the rusty spotted cat find much better quality and protected habitat elsewhere in the country.Within the Muthurajawela marsh, their best habitat is found in the transition swamp area between the marsh and the lagoon, with fringing mangrove forests. This zone has been earmarked for conservation according to the Master Plan.

The area still provides habitat for birds but it would be exaggerated to say that the 162 ha. are very important in this respect. None of the listed species depends uniquely on this part of the marsh.More important bird habitats are found in the transition zone to the north and in the Negombo lagoon and its fringing vegetation.

For two of the four bird species listed as threatened in Sri Lanka (i.e. the fish eagle and the reef heron), the proposed landfill site is not a preferred habitat. Small numbers of the other two threatened species (the black capped kingfisher and the flue-breasted banded quail)may still occur, but these species find more suitable habitat elsewhere in the marsh and in other parts of the country.

Of the repitilian species the monitor lizard is ubiquitous in the entire area including built-up-areas. The estuarine crocodile prefers brackish water environment which is confined to the northern sector of the marsh and lagoon. More of the other reptilian species depends uniquely on the habitats in the proposed landfill site. The population of pythons may have increased because of the proliferation of rats resulting from human waste dumping.

The distribution pattern of fish species reveal much higher species richness and densities, in the northern sections of the marsh and the lagoon. Undoubtedly, the 162 ha. landfill will cause a loss of fish habitat but these losses will neither cause extermination or drastic decline in numbers of any particular species, nor will it result in serious income losses.

It will however, cause some loss of valuable protein resources for the marsh dwellers for which compensation will have to be paid through the relocation programme. On the other hand, it can be expected that households relocated at sites at the periphery of the marsh will continue to harvest fish for private consumption from marsh areas adjacent to the landfill site.

Once the 162 ha at the end of the marsh has been filled with sand, the wetland functions of this area will be lost. These functions include: water storage and regulation capacity, buffering and filtereing capacity, absorption and retention of pollutants and sediments. It is impossible to give quantitative estimates of these effects. As a general approximation, it can be estimated, given the size of the proposed landfill, that some these functions such as watere storage capacity , will decline by about 5%. Adequate provisions will have to be made for the loss of storage capacity and disposal of excess drainage water to prevent water-logging and flooding in areas adjacent to the landfill site.

4.2.2.2. Impact of salt water in sand/sea water mix

The sea water/sand mix (20% sand, 80% seawater)which will be sprayed on the fill site would increase the salt content of soil and water at the fill site which could have negative impacts on neighbouring areas. Some of these impacts may be due to the lateral leaching of the salt into the surrounding area. Since flora and fauna in these areas have adapted to a low salinity environment, this would lead to an imbalance of the physiological mecchanisms in some species. If no measures are taken, this could in the long run lead to local extermination or out migration of certain species which cannot adapt to the new environmental conditions.

The salt would penetrate rapidly into the peaty soil due to the soft and saturated nature of the substrata. During the heavy rains most of the salt would be washed off into the waterways, unless it is collected in retention ditches or canals. If the salt content of the run off is too high, this may affect freshwatere fish species, as the Ophiocephalus striatus, Heteropreustes fossilis, Trichogaster pectoralis, Anabas testudineus, Puntius vittatus, Sarotherodou mossambicuss and Etrophus suratensis, which cannot tolerate high salt content . Therefore, increased water salinity in these areas could cause the death of these species in case migration to nearby fresh water habitats is impossible.

Precautionary measures will be taken in order to avoid the seepage of salt into the neighbouring areas, which would affect on-going land uses, soil and water resources and flora and fauna, See section 5.2.2.

The filling will be done after the monsoon, thereby reducing the washing off of salt into the waterways during heavy rains. Furthermore, sea water accumulating at the fill site will be contained and will be rapidly pumped back into the sea thereby preventing or minimizing the salt penetration into the deep layers of the soil. A sand bund will also be constructed north of the fill site, between the fill site and the surrounding. This will prevent the lateral leaching of the salts into the remaining marsh areas.

The construction of this bund with a length of 2.4km will require a total volume of 625,000 m^3 sand. This amount is pumped to the site together with 2,700,000 m^3 of sea water. Approximately half of this amount will flow in the northern direction, the other half in southern direction. The northern flow will be captured and drained by the Mahabage Ela, which is the northern limit of the landfill area. The southern flow will be captured by Kerawalapitiya Ela and Wedaralage Eḷa and will be pumped off.

Before the construction of the bund has been completed, there will be some impact of saline water in small areas adjacent to the fill site. This impact will be limited as the completion of the bund will not take more than 1 month.

4.2.3 Impacts on Human Settlements

The resettlement of squatter families from the proposed landfill site (230 housing units) to a new location at the periphery of the marsh will entail some negative impacts but these will be largely compensated by the expected direct and potential positive effects. However, it is imperative that adequate compensation is provided to affected families for the losses and inconvenience caused by resettlement. Furthermore, existing facilities of 100 housing units will be upgraded at their present location.

Of primary concern in relocating people is the possible impact on their sources of income. In the present case, the relocation sites are very close to the original site and transport and communication facilities are available at the new locations. Thus, those employed as casual labour, sales workers and fishermen will not be affected. The principal impact will be on those means of livelihood that are home-based. Usually these are activities in which the female population plays an important role.

Negative impacts

These are mainly related to losses of goods and benefits the squatter families derived from direct use of the marsh' resources as listed in chapter 3.2.3. These losses include income and products from vegetable gardening, mat weaving, fishing in abandoned irrigation canals and ponds, and in some cases, from homestead coconut and fruit trees. It is not expected that income losses will occur because of job losses, as the relocation site is very close to the landfill area.

Income from home-based activities like mat weaving for sale or other forms of petty trade depend to a large extent on the establishment of relations with clients close to the place of living. Relocation could disrupt these relations, but on the other hand, the communities neighbouring the relocation sites would provide new markets for these products.

Initially, there will be some social disruption. Many marsh dwellers have been living freely in widely spaced dwellings in the marsh environment for many years. Resettlement to closely spaced houses at relocation sites would require adaptation to the new situation. However, it is expected that the general improvement of the living conditions at the relocation sites will facilitate this adaptation process.

What could also happen after resettlement is increased pressure on public facilities near the relocation sites, i.e. schools, dispensaries etc. Considering the relatively small number of resettlers, it is not expected that serious problems of this nature will arise. However, some upgrading of public facilities may be required, which could be part of the planned community development schemes.

Positive impacts

A major improvement of the health situation will be achieved at relocation sites. The living conditions in general will also be improved and a start can be made with community development programmes. These improvements will be brought about through:

- elimination of polluted and pathogen-infested surface water, which, in the marsh area, constituted a major source of human disease infections; other health aspects are dealt with in chapters 4.2.4 and 5.2.4.;

- elimination of breeding sites for animal carriers of human disease vectors (mosquito's, rats);
- improvement of drinking water supply by provision of piped water;
- reduced risk of flooding at elevated relocation sites;
- provision of toilets and septic tanks at relocation sites;
- opportunities to establish community-supported adequate waste disposal facilities;
- easier access to public facilities, such as schools, dispensaries, hospitals, public transport;
- opportunities for the implementation of community development programmes, as already planned;
- integration of resettled families and stabilization of communities;
- land ownership and the possibility to establish home gardens on part of the allotments.

While living in the marsh, the people were referred to as squatters as they were legally not authorized to occupy state lands. Socially, squatters are landless people encroaching upon urban centres. The government, being aware of the squatter problem, tries to regulate land tenure and ownership of these population groups. In urban areas, this implies the regularization of ownership of land to be used mainly for housing. In this context, the planned relocation will allow the government to regulate legal ownership of the land in the new settlement area. Thus, the resettled families will benefit from a significant improvement in their living conditions, mainly because they will get legal ownership of land to which they have expressed their willingness to move. This will lay a better foundation for successful long-term community development. The regularization of the tenure status of the land on which they live, combined with the improved sanitary and health situation, are very important preconditions for the improvement of the living standards of these communities.

4.2.4 Community Health - Changes in the disease situation likely to occur as a result of the project

The likely environmental problems and potential health effects of project activities are given in Table 4.2.2:

Table 4.2.2

Potential health effects of project activities

Activity		Likely Environmental Problem	Potential Health Effect
1.	Relocation of marsh dwellers in partially filled marsh land.	Pollution of drainage canals marshes, increased Mosquito breeding.	Filaria Japanese encephalitis Dengue.
		Domestic waste dumping increased rat and fly breeding.	Leptospirosis Intestinal infectious diseases.
2.	Site clearing, filling constr-uction of roads and embankments.	Inadequacy of natural drainage channels, obstruction of water ways formation of stagnant water pools increased mosquito breeding.	Filaria Japanese encephalitis Dengue Malaria
3.	Health hazards of project workers, canal cleaning.	Contact with water contaminated with rat urine.	Leptospirosis
	Earth moving	Contact with moving machinery	Accidental Injuries.
	Offshore mining	Exposure to intense sunlight, slippery surfaces, Deep sea	Skin ailments Accidental injuries Drowning.

4.	Development of reclaimed land for housing and industry		
	Domestic and industrial waste disposal	land, water, air pollution	Water borne diseases Helminth Infestation Chemical and Metal toxicity Cancer Respiratory Diseases.
	Transport Industrial Operations	moving vehicles moving machinery	Accidents

If well-planned,landfill that will eliminate potential breeding sites of human disease vectors could have a positive influence by reducing the incidence of vector forms diseases

The above environmental problems and potential health effects are preventable. Measures recommended for their prevention are set out in the section 5.2.4.

5. PROPOSED MITIGATORY MEASURES

5.1 Offshore and Nearshore Environment

5.1.1 Proposed Mitigatory Measures - Methodology of Operation and Physical Resources

5.1.1.1 Conservation of Wetland Systems

The Kerawalapitiya Reclamation Project and its impact on the environment and on society should be examined with reference to the integrated management framework of the Master Plan for Muthurajawela and Negombo lagoon. The principal findings contained in the Environmental Profile provide sufficient evidence to the effect that in the absence of management aimed at sustainability of multiple uses, both the Muthurajawela Marsh and the Negombo Lagoon will eventually become degraded by population pressure and existing resource use conflicts. The existing environment will continue to deteriorate causing further problems to the unauthorised residents of the marsh. It is evident that there exists a strong and urgent demand for planned development of the Muthurajawela Marsh and in this respect the proposed project should be viewed as the first phase of engineering and environmental management of a deteriorating wetland system. Hence the project itself can be identified as a mitigatory measure to prevent further deterioration and to conserve a threatened wetland system. It also incorporates the relocation of unauthorised residents to an unacceptable location at which they will be exposed to improved living conditions.

5.1.1.2 Implementation of Mitigatory Measures

In the implementation of the project it is important to evaluate the methodology of operation, in particular the construction activities to identify possible environmental damages and associated risks. The objective is to identify the mitigatory measures required during the progress of the project to protect against short term and long term environmental damage. These mitigatory measures have to be implemented by the contractor under the supervision of the client.

5.1.1.3 Dredging of sand

Nearshore coastal processes and Coastal erosion With reference to the methodology of operation it is important to ensure that the extraction of sand is carried out within the identified region, located atleast 3 km offshore from the shoreline, where the extraction will in no way affect the nearshore coastal processes or the nearshore sediment budget which governs coastal erosion. It is recommended that the depth of dredging is limited to 2 m below the existing seabed level at depths equal or exceeding 12 m, existing seabed level at depths equal or exceeding 12 m, the extraction would not generate hydraulic and geotechnical problems. The methodology of the operation should be such that the dredging be carried out in the form of uniform linear channels along the sea bed within the rectangular boundaries of the borrow region as opposed to the extraction by creating scattered deep holes on the sea bed.

Turbidity

Turbidity is a reasonably quantifiable phenomenon which may be important in certain situations. The effect of dredging - induced turbidity on the eco-system is not always detrimental, it is directly linked to the production rate of the dredger. The turbidity generated by the dredger must be seen in relation to the turbidity which results from natural causes including extreme events.

The proposed methodology of the sue of trailing suction hopper dredgers limits the impact of turbidity. Turbidity reduction or prevention can be achieved further by eliminating some of the reasons for the generation of turbidity. The following are recommended procedures.

Prevent overflowing; prevent overflowing as much as possible by using high transport densities. No lean mixture overboard pumping; the same considerations apply as above.Safe level filling; in order to prevent spillage while sailing loaded, the hopper or barge must not be completely filled to the maximum filling level.Splash screen or hoses; techniques which will permit the dredged material to fall into the barge without causing a splash-over of mixture.

5.1.1.4 Transportation of dredged material

The dredged sand collected in the hoppers is to be transported to the Muthurajawela Marsh through a system of temporary pipelines, commencing offshore of the reef.

Reef crossing

Precautionary measures should be adopted for the reef crossing of the pipeline to ensure that no damage is caused to the reef. Appropriate anchoring methods should,be adopted for the floating pipeline to ensure that the system can withstand the anticipated wave climate under monsoon conditions. In particular specific attention should be focused on the reef crossing to provide stable anchorage to any pipeline which crosses over the reef. The anchorage should not permit the pipeline to come into contact with the reef under any circumstances. If an existing opening of the reef is to be made use of for the reef crossing, the pipeline should be placed closer to sea bed to ensure that fishing vessel could travel through the opening without the pipeline causing any form of obstruction or hazards.

Shoreline crossing

For the shoreline crossing of the pipeline it is important to ensure that the pipeline does not act in any way as a littoral barrier. For this purpose the pipeline should remain submerged or the pipelines should be anchored in such a manner to permit the alongshore littoral transport to permit the alongshore littoral transport which is comparatively high in this region.

Navigational hazard

In order to prevent likely collisions between fishing vessels and the pipeline it is recommended to install warning signals and to inform those engaged in fishing, the specific area through which the pipeline is laid.

Land crossing

The land crossing of pipeline should be achieved such that it causes least disturbance to the local residents and minimum damage to the environment. The contractor should be made aware of the proposed development programme in the fisheries sector to be implemented in the vicinity of Dickowita. This will assist the contractor in the final selection of the path of the pipeline.

In locating the booster pump attention should be focused on the likely disturbance to the residents as a result noise and this aspect should be considered jointly with the land crossing of the pipeline. The booster pump should be located such that it will impose minimum disturbance to the resident with regard to noise emitting from the machinery.

Hamilton Canal Crossing

For the Hamilton Canal crossing it is recommended that the pipeline be placed elevated with the use of suitable abutments in order to permit unobstructed movement of 3 1/2 ton fishing vessels. If the canal crossing is to be achieved by the pipeline being placed at the canal bed it is necessary to maintain the required clearance (based on drift) for the movement of the fishing vessels.

Road crossing

For the road crossing it is recommended that the pipeline be placed elevated as recommended for the Hamilton Canal crossing or placed underground by appropriate methods. If the pipeline is placed at an elevation sufficient clearance should be made available for vehicular traffic including container traffic.

5.1.2 Mitigatory measures to protect ecological resources at borrow site.

The measures to be taken to minimise disturbance and damage of biotic communities at the borrow site include:

- careful execution of the dredging operation aoutlined in chapter 2.
- avoiding spoils and leakages causing unnecessary turbidity increase.
- limiting sand mining to shallow trenches parallelto the shore.
- allowing drainage water from the landfill siteto settle before pumping it back into the sea. dherence to these measures is likely to avoid serious impacts on the ecological resources.In fact,the present turbidity of the water during most of the year,caused by the silt load of the Kelani river,is higher what modern dredging in clear coastal waters would bring about. Timing of the dredging operation in such a way that it would coincide with periods of high silt discharge from the Kelani river would further reduce turbidity impacts resulting from dredging.

5.2 Landfill Environment

5.2.1. Proposed Mitigatory Measures - Physical Resources

Drainage of sea water

In the landfill operation it is important to ensure that the sea water contained in the sand/water mix does not seep into the neighbouring regions and be drained out of the project site at the earliest opportunity.This will prevent any form of adverse environmental impact resulting from the large influx of sea water

It is recommended that the large volume of sea water in the sand/water mix be drained out of the landfill site by pumping back to the sea by a system of pipelines.It is specifically recommended that the sea water should not be discharged to the Hamilton Canal because this large influx of sea water could cause an environmental imbalance with respect to increased salinity levels in the region.

Intrusion of sea water to areas north of Kerawalapitiya

It is recommended that the northern bund be constructed along the northern border of the project site to prevent sea water seeping into the area north of Kerawalapitiya.The high elevations along the other regions of the border will prevent initial seepage onto neighbouring regions.During the construction of the northern bund a limitd amount of sea water will flow into the existing canal system.

Discharge of sea water back to the ocean

After the completion of the northern bund and once the sluice gates which control the drainage system are closed,it is recommended that the water level in the enclosed areabe controlled fully by pumping out the sea water back to the sea.In order to implement this pumping programme effectively it is recommended to trap the sea water by the use of a low bed storage pond on the southern end of the site.The drainage pumps at this location should pump the sea water out of the areas.

During the landfilling the drainage of the sea water to the low bed pond could be achieved by the existing waterways or by the construction of a separate channel.If the existing waterways are to be used,there exist a possibility of salt water intrusion into neighbouring areas because the waterways are heavily interconnected.Hence it is necessary to study the existing channel network in detail and provide control gates at locations where sea water could escape into the system. A more effective mitigatory measure would be to construct a separate channel on the southern periphery of the fill area to direct the sea water to the low bed storage pond to be pumped back to the sea.

Water levels in the landfill.

The proposed reclamation projectwill result in an area of high ground at the Kerawalapitiya end of the Muthurajawela marsh bordering dry land, an area where human influences are already noticeable.The impact of this reclamation would be, reduced water storage capacity, increased levels and reduced outflow.
These impacts can be mitigated by rehabilitating the badly neglected drainage system and the associated structures in an attempt to achieve the hydrological conditions of the marsh before land reclamation.

It is recommended that during the landfill operation the water level in the project area be maintained slightly below average sea level in order to avoid any risk of flooding.It is recommended that the capacity of the pumps to be used for the pumping of the sea water back to the ocean should be such that it could accomodate additional discharge which could arise from heavy rainfall over the project area. Measures should be taken for proper maintenance and checking procedures to ensure the reliability of the power supply. One of the effective ways of providing an alternative power supply is by the use of a standby generator.

When improving drainage of the marsh to mitigate the impact of reclamation, conditions for a healthy marsh must be maintained by the proper operation of the rehabilitated drainage control structures. During the construction phase infrastructure development eg. roads and buildings, should give consideration to drainage patterns within the construction area.Adequate structures (culverts,drains and bridges) should be included in the design of works to guarantee drainage of surface water and maintenance of natural flow patterns within the reclaimed area.

Salt water intrusion into the existing system

During periods of low flow saline intrusion (combined with high sea and tidal levels), along the Hamilton canal and from the Negombo lagoon will be common. The adverse impact of excessive intrusion of salinity can be mitigated by the efficient operation of the salt exclusion structures which will have to be rehabilitated.

Urban Development

Urban development requires a sufficient height difference in the ground water table and the surface level to prevent the water from rising above the surface level during heavy rainfall. When open canals are constructed in the reclaimed area these should be designed to have flows that are necessary to maintain the minimum required height between the ground water level and the surface. Efficient drainage of the project area is also necessary to provide an adequate bearing capacity for the development of housing and industry.
Inadequate disposal of sewage and industrial effluent in the reclaimed area will require special precautions in order to preserve the ecosystems filtering and productive functions. The sand fill will allow sewage and effluent to seep into the marsh if a sewage system is not provided. This impact can be mitigated by a sewage treatment facility where the sewage is treated to an acceptable standard before releasing to the marsh. An alternative method of disposal would entail a closed system where the sewage and effluent is collected for treatment.

To reduce the negative impacts of reclamation the waste disposal in the already existing settlements could be improved. Part of the financial resources generated by the proposed reclamation and the subsequent development of land could be diverted to improve the sewage disposal facilities of the existing settlements. This would reduce the overall impact of pollutants on the marsh.

Inspite of all the efforts to mitigate the adverse impacts of planned reclamation on the Muthurajawela marsh and Negombo lagoon unplanned activities continue to strain this ecosystem. The site selected for reclamation borders dry land in an area where human influences are already noticeable. As such it is highly unlikely that this reclamation project would entail major losses and disruption of ecological values.

5.2.2 <u>Mitigatory measures to protect ecological resources</u>

The Muthurajawela Master Plan

Wetlands have been misused in the past simply because they were considered as wastelands. In an attempt to protect the wetlands' biological diversity, scenic or landscape beauty, historical or cultural values, scientific values or uniqueness, master plans are now being developed for a number of wetlands. These plans are based on ecological surveys, therefore they focussing on the protection of the areas' high biological diversity and ecological function. The Muthurajawela Master plan was prepared in 1991. Prior to the preparation of the Master plan an environmental profile was established. During this study the fauna and flora of the Muthurajawela marsh and the Negombo Lagoon were considered and based on their distribution patterns, allocations were made for various developmental processes. A zoning plan was proposed which included the present landfill for urban expansion. This plan was accepted for implementation.

The mitigatory measures necessary to preserve ecological resources are the following:

- establishment of a Conservation Zone
- adequate drainage to avoid flooding or water logging in areas adjacent to the landfill
- adequate disposal of salt water from the sand/sea water mix during landfilling.

5.2.2.1 Establishment of Conservation Zone

The transitional marsh area linking the Muthurajawela marsh with the Negombo lagoon has been proposed as a Conservation Zone in the Master Plan (2), which has been accepted. A management plan for this zone is now under preparation through the Wetlands Conservation Project (WCP/CEA). Once this zone has been given Protected Area status and structures have been established for its management in cooperation with peripheral communities, the conservation of flora and fauna, and the ecosystem functions of the marsh acid lagoon will be greatly enhanced.

5.2.2.2 Drainage

The need for adequate drainage of the area during and after the landfill, in order to avoid flooding and water logging problems in adjacent areas, has been included in the landfill implementation project. Further detail is given in the Hydrology section of this report (Chapt. 3.2.1, 4.2.1 and 5.2.1)

5.2.2.3 Salt Water Evacuation

Precautions will be tyaken to avoid salt water leaching and drainage into adjacent areas, which would affect on-going land uses, soil and water reservoirs, and flora and fauna.

As explained in Chap. 4.2.2.2, the correct timing of the filling (dry season) could reduce the salinization risk. Pumping of sea water draining from the landfill area, collected in canals specifically identified for this purpose as part of the landfill project. Pumping back into the sea would be the most appropriate solution. It is not recommended to pump or sluice the salt water back into the Hamilton canal, an option which had been suggested considering the already high salinity level of the canal water during the dry season. This would most likely be rejected by certain public and government groups, and by local inhabitants.

The landfill will start with the construction of a bund, 2.4 km in length, along the northern limits of the fill site. A volume of approx. 625,000 m^3 of sand will be required for this purpose, which will be mixed with some 2.7 million m^3 of sea water, half of which will flow to the north and will be collected in the Mahabage Ela, the other half will flow to the south and will be captured by the Kerawelapitiya Ela and Wedaralage Ela. Once the bund has been complete, it will prevent further salt water flow in northerly direction. The area will then have virtually controllable water levels (pumping), and the water level will be maintained at a few centimeters below m.s.l. in order to avoid any risk of flooding.

Drainage pumps will be installed to pump off the drainage water. When the northern bund and the door openings to the divers drainage systems are closed, the required drainage capacity (rainwater discharge plus transport water discharge) is calculated at 2.3 m^3/s. The run-off water from adjacent areas is then expected to be bypassed.

The operation of the drainage pumps requires alertness, in the case of sudden rain, and reliability. For this purpose, two well attended and maintained drainage pumps will be installed with reliable power supply.

5.2.3 Human settlements

A most critical element that will contribute to the successful implementation of Master Plan is relocation and development of squatter communities now illegally residing in the marsh. All communities have expressed willingness to be relocated as this will result in their coming into ownership of land for housing, in improvement of their living conditions and in opportunities for development of stabilized communities. The resettlement of people now residing in Kerawalapitiya proposed landfill area will serve as a model for other communities residing within the conservation zone of the marsh and in the outlet area of the Negombo lagoon.

In keeping with the decision of the Cabinet Sub-Committee on Foreign Investment, SLLRDC has taken the responsibility for laying the groundwork for relocation by preparing the land for plot allocation to the resettled families. The relocation site will be provided with electricity, sanitation facilities (toilets with septic tanks), piped water supply and drainage provisions. The relocation sites are former swamp areas filled with lateritec soil at the periphery of the proposed Kerawalapitiya landfill, hence very close to the original abodes of the resettlers. House construction on the relocation site will be by way of a self-help programme. The housing programme will be accompanied by a community development programme based on participatory approach, mediated by non-governmental and peoples' organizations. Hydraulic sandfilling of the 162 ha of the Kerawalapitiya area will follow relocation.

Families will be allocated 15 perches (0.0375 ha) of land, of which the housing site will be elevated with laterite, the remainder to be filled in by the owner himself, for which purpose a stockpile of sand will be kept. The relocation sites are located at Awarakotuwa, Galagahaduwa and Balagala (Fig 2.4). The allotment allows for the establishment of homestead gardens for vegetable cultivation, fruit trees and other crops.

Details of a resettlement plan for the Awarakotuwe site have been worked out (8). The project consists of three phases:

- Phase 1- relocation of the people to the new site
- Phase 2- construction of houses and infrastructure
- Phase 3- starting long-term community development programmes.

Phase 1 - Relocation

The preparation of the land and relocation will be controlled by SLLRDC. It includes clearing of the land, construction of roads, filling up of housing sites, construction of water supply and stand pipes, collective latrines. The main costs will be borne by SLLRDC.

The 25 ha (250x1000m) resettlement site is situated along the Hamilton canal. The southern 15 ha will be used for relocation of the families. Road construction and landfill (laterite) for house construction has been completed. The remainder of the landfill of allotments will be carried out in the second phase, by SLLRDC and by the families themselves . For this purpose a stockpile of sand will be established near the relocation site by the contractor of the large Kerawalapitiya landfill.

Legal documents will be issued to families stating the deed land title based on certain conditions such as respecting plot boundaries. The community will also be prepared for relocation through workshops and the formation of community councils. The National Housing Development Authority (NHDA) will be responsible for this task, as well as for the mobilization and removal of the population to the new site. MUPO (Muthurajawela People's Organization, an NGO with longstanding experience in community development in the area) will assist NHDA in this task on a voluntary basis.

Total costs Phase 1: Rs 795,000, including Rs 3000 paid per family as a compensation for loss of income.

Phase 2- Construction of Houses and Infrastructure

After the landfill of allotments has been completed and basic facilities have been provided, the family starts to build its own temporary wooden house, using the materials of the old house. The construction of the foundation of the new house requires a stabilized soil which is best achieved after a period with rainfall. The construction of permanent housing will also be on a self-help basis with NHDA and MUPO being the leading partners. It is noteworthy that about 150 families of the resettled group already participate in MUPO activities. NHDA and MUPO will closely cooperate, the former having a more specific role to play with those families who are not organised under MUPO. NHDA will organise these families in Community Development Councils and will organise the house building process. It can provide technical assistance and advice in house design, material costs, etc.

Special attention should be given to location and quality of permanent latrines. These should be of solid construction and sited at places where they could be easily linked up with future permanent sewage disposal systems.

The costs for construction of a core house with latrine, including materials and skilled labour, is estimated to amount to about Rs 40,000 per house. NHDA should work out packages of technical options to this amount. Total costs for Phase 2 are estimated at Rs 9,200,000 (1993-prices). Funds have to be channelled through the Socio-Economic Development Centre (SEDEC), which is an organization linked to the Catholic Bishop's Conference involved in development activities through parishes as well as through NGO's. It has links with MUPO and has working experience with NHDA. It is expected that SEDEC will act as a coordinator in this phase.

The disbursement of funds have been worked out in five instalments corresponding to construction phases. MUPO will organise the input of volunteers and family members during the construction phase.

Phase 3 - Long-term Community Development

It is expected that the implementation of Phase 2 through a self-help approach will create a proper basis for ensuing community development efforts. MUPO and SEDEC, both familiar with community development based on strengthening initiatives and beneficiaries, will have an important role to play during this phase. The relocation study (8) suggests a number of activities, mainly based on MUPO's experience in the area. These include "minibanks", based on monetary savings, an initiative appealing mainly to women; health related activities, focusing on health education; and lobbying. None of these can be classified as income-generating community development activities, but they can be very important in the stabilization process of the resettled community. Rightfully, these programmes put emphasis on the role of women, being the main actors in such programmes as personal health care and "minibanks".

Awareness building for environmental management and protection is another activity which needs to be pursued. The Wetlands Conservation Project, in compliance to the Master Plan, is in the process of preparing a Management Plan for the Conservation Zone of the wetland. This management plan, prepared under the aegis of the Central Environmental Authority, will be implemented by way of community participation. Obviously, there should be a linkage between community development efforts in the present project and the implementation of the conservation management plan. The conservation and perpetuation of the wetland production function, as well as its buffering function, are essential for large numbers of people depending on the marsh and lagoon ecosystem for their living. This also is the key objective of the Master Plan.

The total costs of the relocation scheme, including costs for NHDA/MUPO-technical assistance (Rs 900,000), costs for SEDEC as a coordinating agency (Rs 144,000), provisions for loan and grants for house construction (Rs 3,060,000) and "miscellaneous" (Rs 401,000) amount to Rs 14.5 million, equivalent to Nf 557,692.

Further detail on the relocation scheme is given in the report of "The Muthurajawela Relocation and Integrated Community Development Project (MURIC)", (1993), available from the Netherlands Embassy, Colombo.

5.2.4. Community Health - Measures recommended to promote favourable health impacts and minimise likely adverse health impacts

5.2.4.1 Relocation of marsh dwellers

(1). Housing units to ensure adequate floor space 6-8 sq.m. per occupant. Screening of houses to be considered if feasible.

(2). Safe and adequate water supply, preferably supplied through house connections or at least through standpipes in the immediate vicinity of houses.

(3). Sanitary means of disposal of excreta through the provision of a proper sewerage system or by means of on site low cost excreta disposal latrines. The disease problems are not related to landfill as such, and with adequate sanitary provisions sewage, waste and effluent disposal the incidence of these diseases could be greatly reduced.

(4). Sanitary means of storage, collection and disposal of refuse and other domestic waste. Standpipes and toilets with concreted septic tanks are being reinstalled at relocation sites.

(5). Adequate rainwater drainage in the surrounding area.

(6). "Green buffer" zone to separate settlement from marsh.

(7). Separate domestic animals from areas of human habitation.

(8). Discourage pig breeding.

(9). Immunize children against Japanese encephalitis and use of prophylactic drugs for filaria, malaria.

(10). Health education to maintain healthy living conditions and life styles.

5.2.4.2 Site clearing, filling, construction of roads, embankments

(1). Clean and clear existing drainage channels prior to commencing landfill.

(2). Expand the capacity of existing drainage channels to take the extra water load created by marsh filling.

(3). Avoid blocking existing drainage channels by road and embankment construction.

(4). Avoid accumulation of waste and effluent in drainage water storage canals, ponds. Close these areas where necessary, which would also facilitate subsequent piped discharge back into the sea.

5.2.4.3 Occupational health and safety of project workers

(1). Protect lower limbs from direct contact with polluted water during canal cleaning operations by use of suitable footwear.

(2). Educate workers on correct handling of earth moving equipment. Provide safety clothing and enforce strict safety rules for handling materials and machinery.

(3). Cordon off worksites to prevent entry of children and interested onlookers.

(4). Avoid prolonged direct exposure to sunlight. Loose fitting clothing of light coloured absorbent fabric is recommended.

(5). Maintain clean dry floors, stairs, walkways etc., to prevent injuries due to slipping.

(6). Provide rescue buoys and life jackets to those working in deep sea surroundings.

(7). Provide use of prophylactic drugs

(8). Organize first-aid unit at operation site

5.2.4.4 An overall strategy be adopted to prevent health hazards resulting from urban development by

(1). Consulting MOH and his staff prior to building roads, drainage systems, latrines, houses and industrial plants.

(2). Providing needed resources for the MOH to carry out periodic sanitary inspections and monitoring the environment for industrial pollutants.

(3). Involving local people in planning and implementing disease vector control programmes through the Pradeshiya Sabha Gramodaya Mandalayas and Voluntary Organisations.

(4). Ensuring that the responsibility for taking measures to minimize health impacts is shared by the different organizations such as NHDA, LRDC, MUPO which are involved in the relocation project under the overall co-ordination of SEDEC in consultation with MOH Wattala.

The above information was collected with the assistance of:

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6. MONITORING PROGRAMME

6.1 Monitoring Programme and its Implementation

For the successful implementation of mitigatory measures it is important to adopt a well formulated monitoring programme. Such a programme will not only provide considerable assistance in the implementation of mitigatory measures but will also assist in detecting likely adverse conditions which may arise due to the combined effect of different impacts associated with the project.

In relation to the Kerewalapitiya Reclamation Project the monitoring programme has to be implemented by the client in consultation with the contractor and with the assistance of specific government organizations, for example, the Coast Conservation Department. Since the impacts relate to the methodology of operation, physical resources, ecological resources, human settlement and land use and community health of both the offshore / nearshore environment and the landfill environment, it is recommended that the client appoints a monitoring committee. This committee will assist the client in implementing the monitoring programme which will commence prior to the landfill operation and extending upto a specific period after the completion of the operation.

6.2 Dredging Operation

It is important to monitor that the offshore sand extraction is strictly limited to the borrow area identified by the client and on which information was made available to the team who conducted the EIA. Monitoring should also be carried out to ensure that the depth of dredging does not exceed 2 m below the existing sea bed level and that the dredging is carried out in the form of uniform linear channels (as opposed to deep holes) within the specified boundaries of the borrow area.

Increase in turbidity at the site of dredging should be monitored prior to the commencement of the dredging operation and while the operation is in progress.

6.3 Transportation of Sand

The physical condition of the entire pipeline should be monitored regularly to detect the development of possible leakages from the pipeline or any form of damage which could lead to leakage. This monitoring should be carried out during the installation of the pipeline and while the project is in progress.

It is important to monitor that the sandstone reef is in no way affected by the pipeline crossing even under adverse weather conditions.

The noise levels of the booster pumps, if located within close proximity to residences, should be monitored to prevent excessive disturbances.

6.4 Landfill Operation

The salinity levels which will increase due to the sea water in the sand/water mixture and the water levels in the landfill area are two important parameters that have to be monitored.

Prior to the commencement of the landfill operation it is recommended to monitor the salinity levels in the Hamilton Canal and in the waterways bordering the landfill site. Since the salinity levels are very much dependent on the extent of salt water intrusion, these levels will vary during a calendar month depending on the tidal characteristics which is the driving force.

During the construction of the northern bund a limited quantity of sea water will be discharged into the existing waterways and it is recommended to monitor the salinity levels and water levels in the Hamilton Canal and waterways in the vicinity of the bund.

During the landfill operation the sea water will be discharged back to the sea. It is recommended that the salinity levels in the Hamilton Canal and the waterways bordering the landfill be monitored. It is recommended that the water levels in the landfill be monitored to ensure that these levels are maintained at the prescribed level and to detect any possible threat of flooding.

The project necessitates the upgrading of salt water control structures to prevent the intrusion of sea water into neighboring areas. The working conditions of these structures and there hydraulic efficiency in preventing intrusion should be monitored.

The monitoring of the performance of pump equipment located at the low bed storage pond is considered important. The monitoring should ensure that the pump equipment and stand by power generators are maintained in good working condition in order to function smoothly under adverse conditions.

Sandfill operations will result in the subsidence of the existing peat layer. The subsidence should be monitored and after the completion of the operation to ensure that the settlement is in accordance with the design of the landfill and that the final level will be maintained at 1.85 meters above MSL.

After completing the sandfill operation it is important to monitor the water levels in the landfill , in areas adjoining the landfill and in the canal system bordering the landfill (Including the Hamilton Canal) to ensure that the drainage system of the landfill is functioning efficiently without causing flooding of the landfill and neighboring areas.

6.5 Nearshore Coastal Stability

Although the extraction of sand from a distance exceeding 3 km and at a depth greater than 12 meters would in no way have an impact on the sediment budget of the coastline under consideration , it is recommended that the coastline be monitored during the landfill operation and for a period at least 6 months after the completion of the project. Monitoring in this respect will refer the obtaining beach profiles at specific intervals along the beach at regular intervals.

Although the sand extraction from the deep sea would not have an impact on the coastline, it should be noted that this stretch of coastline from Kelani river mouth upto Negombo represents a fast eroding coastal stretch. Therefore any change in the parameters affecting the sediment budget could lead to increased erosion. Furthermore this stretch of coastline is also vulnerable to storm ware attack which can change the beach profile. The monitoring of beach profiles will assist in detecting any new trend in the erosion/accumulation pattern which could be further examined by the Coast Conservation Department.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 ECONOMIC ANALYSIS

7.1.1 Introduction

In keeping with the TOR the conclusions and recommendations have been incorporated with the benefit-cost analysis(Economic Analysis)
However the advantages and disadvantages of a large scale sand fill project on an ever degrading unmanaged area affected by serious population and land pressure,cannot be strictly guided by an economic analysis alone.Several external factors such as environmental,socio-cultural and demographic considerations etc. will also play a vital role in influencing project viability.

There is bound to be public scepticism over aproject such as a large scale operation on an impoverished environment. As a precaution it is bounden to prove that a large scale operation with heavy expenditure naturally results in equally large scale benefits both quantifiable and unquantifiable. An economic analysis therefore should be a combination of cost benefit analysis, multi-criteria analysis, decision analysis etc.It has to be borne in mind that cost of mitigating has also to be considered and this factor is usually overwhelmed by the large economic gains achieved through appreciation of value or capitalization and social benefits accrued through the project.

The capital expenditure estimated to achieve the sand fill of 162 ha is the first large investment on a degrading marsh to provide for rehabilitation and a management system which economically would transform the area and facilitate the full realization of its comparative advantage.

It has been stated that though the land area to be filled viz 162 ha is only 5 percent of the total marsh the proposed operation of large scale sand fill has been decided, as at this level it would achieve economies of scale at minimum unit costs.

From an economic perspective, the benefit arising from the sand filling has to be maximised by a careful selection of the type of uses of the filled area.The uses should reflect the actual demand of the area avoiding environmental degradation whilst maximising the income derivable.

When consideration is given to absence of any serious impacts from sand mining, and sand transport, on coastal erosion and on fish resources from the operation, which are environmentally serious issues, the impact is concentrated on the ecological and ecosystem dependent on the site. Even these effects are marginalised due to the degraded condition of the unmanaged system which has transformed into a breeding ground of various water and insect borne diseases.

The sand fillling not only controls the likely catastrophic conditions but also enhances the economic value.

In the above circumstances the economic social gains outclass the expenses incurred in sand filling.However efforts should be made to prevent any environmental degradation by the various new uses of the reclaimed land avoiding the most common occurences like untreated waste and waste water, effluent accumulation, etc and through proper management of the newly created environment.

The cost effective use of newly reclaimed land is therefore much more important in providing direct support for economic and social development.

The allocation has to be well balanced between productive purposes and others (residence). In terms of uses though different combinations and permutations could be provided in filling the site there appears to be no better alternative.

In the circumstance the benefits of the project have to be maximised by the best possible user criteria.

In evaluating the cost of the project to the society,the Dutch Government has committed to supply 57.5 million Dutch Guilders of which 40% will be direct aid.It therefore appears that part of the project cost is subsidised and development on this basis is the most desirable for a developing economy and this aspect moderates the impact created by costs.

7.2 General Background

The economic evaluation of the large scale sandfill project at Kerawalapitiya cannot be accomplished in isolation without reference to the main parameters brought out in the Master Plan for Muthurajawela and Negombo Lagoon.

	Acres	Hectares	Percentage
1/ Strict Conservation	4390	1777	56
2/Buffer Zone	1000	405	13
3/Small Scale Landfill	1600	648	21
4/Large Scale Landfill	400	162	5
5/Existing Residential	400	162	5
	7790	3154	100

It is apparent that even if direct benefits and costs can be separately identified,indirect benefits and costs cover the wide geographical area.The inherent difficulty in computing a pro-rata analysis therefore has to be appreciated.

7.3 Flood control buffer

In the examination of the physical features of the area, the marsh is increasingly threatened by the sea due to the possibility of sea water penetrationassisted by two main factors:

a)The present elevation of the marsh being 0.0 M.S.L.

b)The Kelani Ganga estuary being deepened by sand mining and the river bed lying below sea level.

This influence is particularly relevant to the southern part of the marsh which is the project area considered in the study.The site therefore contributed to the ecosystem by acting as a flood control buffer.This particular advantage has been partly man-made consequent to sand mining of the Kelani Ganga - which however could be prevented with certain amount of economic loss to the sand miners.There is an attempt through persuasion to preclude them from mining due to environmemtal reasons and therefore if mining is stopped,there is no opportunity cost.It's a regularisation of the natural equilibrium.

As an area of flood control the area has a unique value.With the sand filling this value is reduced and it has been deduced that the flood level will increase from 0.56 to 0.59 meters.This necessitates the construction of a ring channel around the site
and dredging of the existing cross canals.
In these circumstances,the loss as a flood control buffer,of the ecosystem can partly be quantified.As regards sea water penetration during the operation,this will be mitigated by constructing a bund at the northern boundary of the fill area,and by providing adequate pumping facility within this area for the collected saline water to be pumpedback into the sea.This will be recorded as being part of the operation cost.

7.4 Measuring improvement of soil condition.

Though attempts have been made in the 1950's,emulating the sinhalese kings,to cultivate the marsh,with considerable outlay on infrastructure improvement,they failed due to years of degradation of soil with penetration of sea water.Sand filling and increase in the elevation of the area pre-empts such influences and would contribute to the improvement of the soil.Sand filling therefore reverses the trend which otherwise would continue.The improvement in the soil and the value it generates is directly proportional to the uses made of the soil. The cost of soil improvement and benefits derived could be quantified.

7.5 Improvement in Tourist Income.

The improvement of the physical features in the area and consequent changes in the environment are bound to have a permanent impact on tourism.The Pegasus Hotel,now under the management of a German company,would obviously lead to the arrival of more German and other North European tourists. A degraded marsh and an equally polluted waterway(Hamilton Canal) cannot be considered in the best interest of tourism development.

It is doubtful to imagine whether the tourists had closely watched the natural world of the marsh ecology making any payment.Therefore the opportunity loss to tourism consequent to filling is minimal.It may be stated that the absence of access and proper management could have constrained even the most enthusiastic of tourists,touring the site.It is however observed that the boats are being hired to tour the Hamilton Canal as well as the sea front.

With the proposed change of the physical environment,the use of the canal would be intensive and more hiring of boats could be expected.

This situation is bound to expand dramatically with the creation of a golf course and/or other recreational facilities in the adjoining buffer zone area.

7.6 The resettlement of low-income families.

The SLLR&DC is compelled to shelter the low-income families, particularly those living on canal banks,and degraded environment.This particular project provides for the resettlement of nearly 330 families living in dire conditions in the marsh.In fulfilling this obligation the SLLR&DC wil be realising two objectives in one project.

In fact the community development perspective and the phased changes of the area towards free market millieu enhanced it's potential value for funding by the Dutch Government amounting to a commitment of 57.5 million Dutch Guilders of which nearly 40% is a grant.

7.7 Economic impact on fishing.

To ascertain the impact on fishing during the period of dredging,it is necessary to consider the recorded catches per month for the Negombo district and derive an approximate estimate for the 300 fishermen regularly using the borrow area region as an open roadstead in their fishing itineraries and actual fishing by those who use the traditional crafts.

It was observed that out of about 250 fishing crafts,nearly 75 are 3.5 tonners which have the capacity to fish in both seasons and further away from the borrow area.The remaining 175 are traditional crafts which cannot do fishing during both seasons but have to confine their fishing activities only during the calm North-East monsoon period.Most of the fishermen were of the opinion that the dredging operation should be conducted during the NE monsoon,when the sea is calm.This means that the mostly affected

group will be the majority who own traditional crafts,who fish in and around the borrow area.
If a modest estimate is taken ,each traditional craft would go fishing nearly 22 days per month and the likely catch per boat would be an average of 10 kilos.Assuming that they mainly concentrate on the high priced crustaceans,the income derived is as follows:

22x175x10x500 = Rs.192,500/= per month.

This is equivalent to a total income for a 8 month period per year of Rs.1,540,000/=.The actual temporary loss in income due to the dredging activities would be a fraction of this value.
This also excludes the yields of the 3.5 tonne multi/day boats which will circumvent the likely income losses.

A broader perspective could be obtained from the recorded catches for the Negombo District(1989):
Coastal . . . . .12,524 Tons
Deep Sea . . . . 341 Tons
The monthly distribution is as follows

Month	Catch in Tons
Jan	790
Feb	510
Mar	870
Apr	575
May	806
Jun	1372
Jul	1157
Aug	1626
Sep	1673
Oct	1400
Nov	673
Dec	1072

The yearly income in 1989 has been estimated at Rs.411/= excluding income derived from brackish waters(Lagoon Fishing).
Hence the incidental loss in income to the traditional craft owners will be amply compensated for by the permanent benefits that would accrue to the community by the landfill project.

7.8 Concluding remarks.

* This report presents the Environmental Impact Assessment (EIA) for the Kerawalapitiya Reclamation Project which is a part of the implementation of the Master Plan for Muthurajawela and Negombo Lagoon. The Master Plan was built upon the findings of a detailed environmental study discussed in the Environmental Profile of Muthurajawela and Negombo Lagoon (1). This is the first time in Sri Lanka that development and management plan was implemented for a coastal wetland where the interests of the existing resource users have been given due consideration.

* The Environmental Impact Assessment (EIA) was conducted in accordance with the recommendations stipulated in the Terms of Reference (TOR). In approaching the Environmental Impact Assessment, the project area was classified into two areas namely, the offshore and nearshore environment and the landfill environment as outlined in Table 1.1. The dredging site and a part of the transportation route were classified under the offshore and nearshore environment. The remaining part of the transportation route and the proposed reclamation site were classified under the landfill environment. The project is described in detail in Chapter 2. Description of the existing environment (Chapter 3), environmental impacts (Chapter 4), Mitigatory measures (Chapter 5) have been presented with respect to physical resources, ecological resources, human settlement and land use and community health. These areas have been covered with due consideration to the guidelines specified in the Terms of Reference. Relevant monitoring programmes have been identified in Chapter 6.

* From the Environmental Impact Assessment it is concluded that the reclamation of 162 ha. extent of marsh at Kerawalapitiya, as recommended in the Master Plan for Muthurajawela and Negombo Lagoon which was approved by the Government in 1991, could be successfully implemented provided that the recommended mitigatory measures are implemented in association with the proposed monitoring programme.