Restoring Beira Lake

An Integrated Urban Environmental Planning Experience in Colombo, Sri Lanka

MEIP

Metropolitan Environmental Improvement Program

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An Integrated Urban Environmental Planning Experience in Colombo, Sri Lanka

Written by Leonard Dissanayake and Ravi Pereira for the **Metropolitan Environmental Improvement Program**

Aerial view of Beira Lake

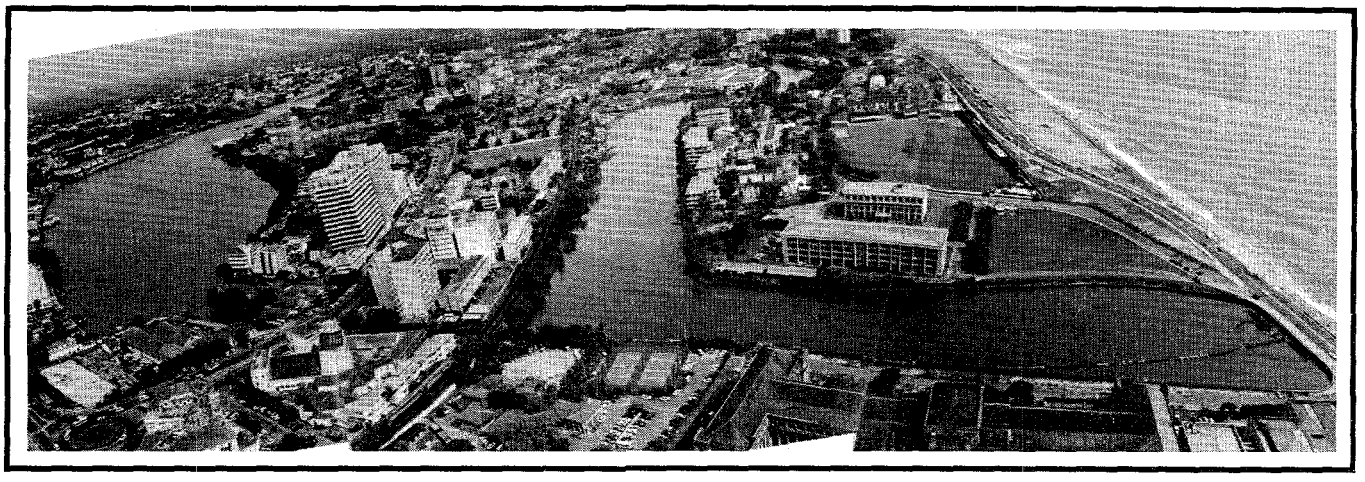

TABLE OF CONTENTS

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On a personal note, the authors would like to dedicate this publication to Hiranthi and Violet with love and respect.

Leonard Dissanayake and Ravi Pereira
Authors

FOREWORD

The World Bank-executed Metropolitan Environmental Improvement Program (MEIP) started work in 1990 in five Asian metropolitan areas -- Beijing, Bombay, Colombo, Jakarta, and Metro Manila -- with assistance from the United Nations Development Programme. In 1993, this intercountry program began its second phase and Kathmandu joined as the sixth MEIP city. In 1995, MEIP began work in Karachi, the Northern Economic Triangle of Vietnam, and in secondary cities in existing MEIP countries.

The MEIP mission is to assist urban areas tackle their rapidly growing environmental problems. The MEIP approach emphasizes the cross-sectoral nature of these problems and the failure of traditional, sectoral development strategies to adequately address urban environmental deterioration or the linkage between industrial and urban development.

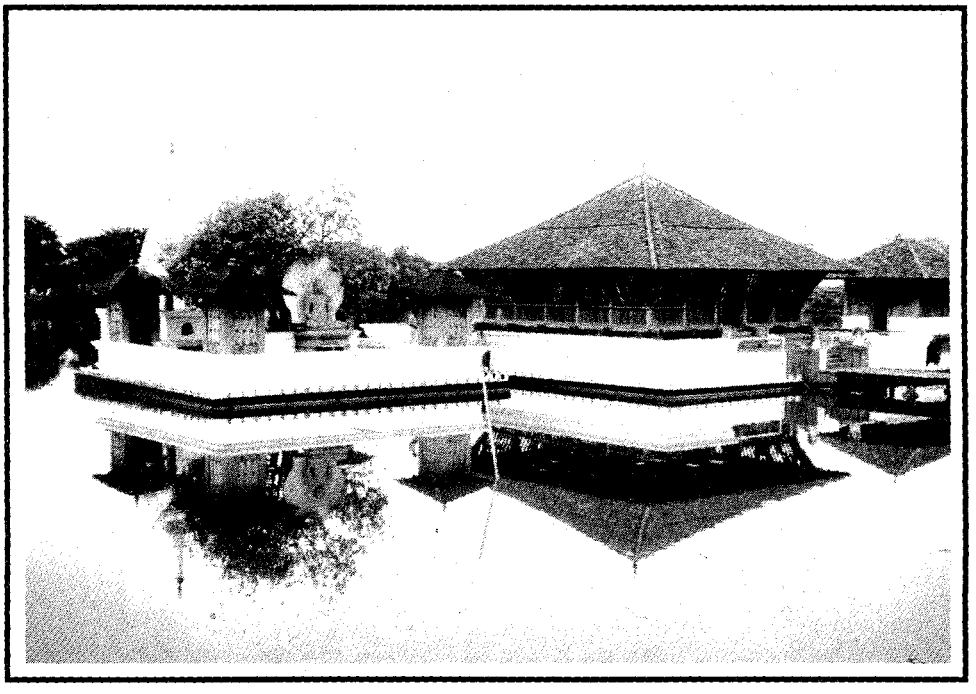
The work program in each city is therefore guided by Steering Committees and technical working groups that reflect the cross-sectoral, interagency nature of urban environmental issues. The policy and technical committees develop Environmental Management Strategies (EMS) and action plans for their metropolitan regions; incorporate environmental considerations into the work of economic and planning agencies; contribute to the strengthening of environmental protection institutions; and identify high priority environmental investments.

The MEIP city office serves as secretariat to the Steering Committee and is managed by a local environmental professional, the National Program Coordinator (NPC). The NPC coordinates all MEIP activities and is responsible for developing the environmental network of government, private sector, non-governmental organizations (NGOs), research institutions, and communities. MEIP supports workshops, demonstration projects, and community environmental actions, and links these growing environmental network efforts with government policy and investment initiatives.

A further focus is the exchange of experience and sharing of information among MEIP cities. This has been carried out through a series of intercountry workshops that review the city work programs, exchange useful experience, and develop intercountry projects.

MEIP has now established the city programs, set in motion a variety of city subprojects, and mobilized the intercountry exchange. MEIP publications are intended to share insights and experiences developed from the MEIP process and its projects. The MEIP city programs work independently, with each other, and with international partners to reverse urban environmental degradation and provide useful and replicable lessons in urban environmental management.

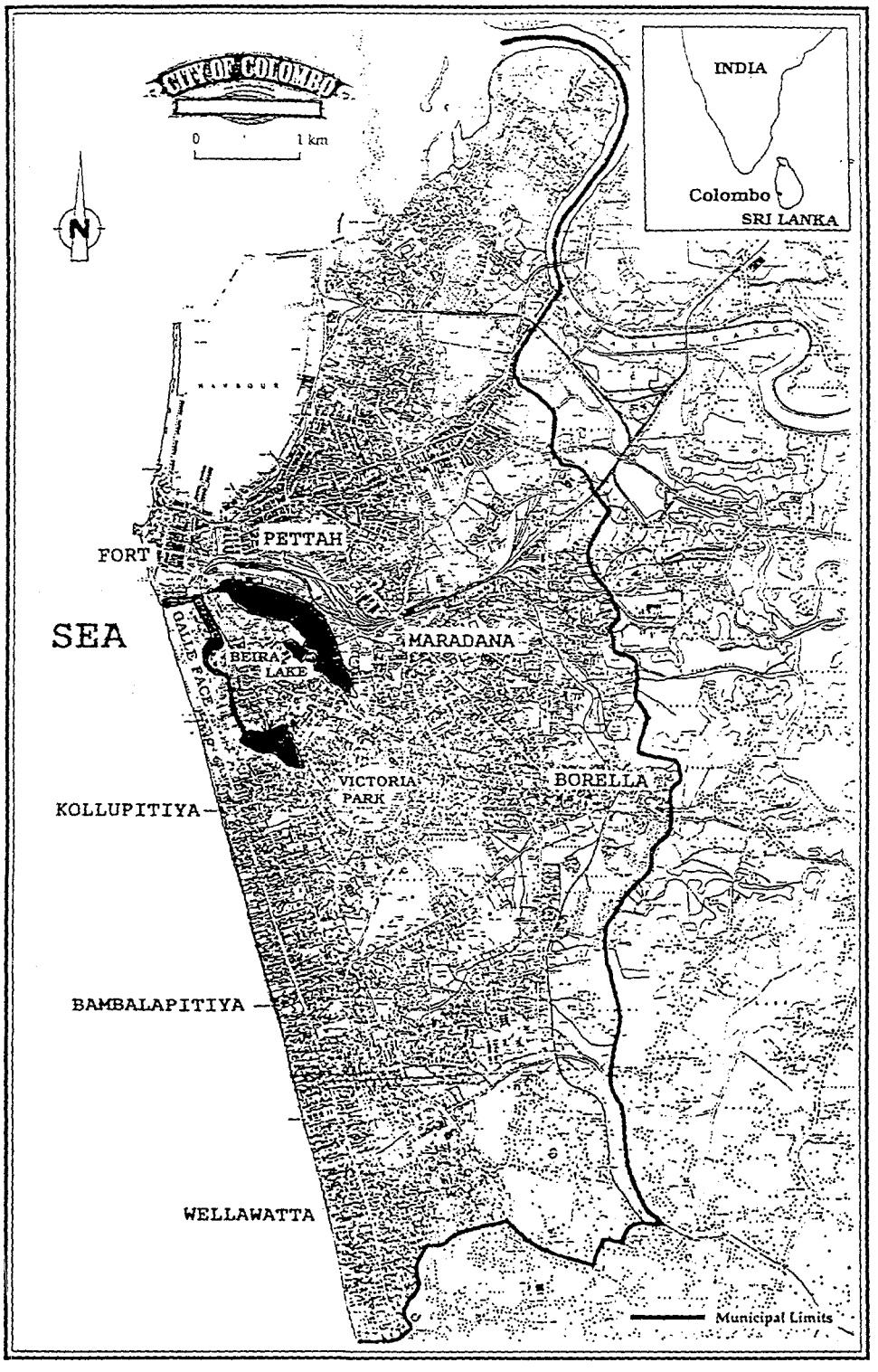
David G. Williams
Program Manager, MEIP



Beira Lake has played a rich role in Colombo's cultural heritage as evider by the pristine Temple in the South West Lake

Shanties along Beira's shores add to its polluted and smelly waters.

Figure 1. Beira Lake and City of Colombo



RESTORING A NEGLECTED RESOURCE

The City of Colombo is distinguished by a neglected, deteriorating but potentially magnificent resource, Beira Lake, which lies in the heart of this port City (**figure 1**). The lake has been in existence for nearly five centuries and once was a larger and deeper body of water which had strategic relevance to the ancient fort of Colombo. Long known as Colombo Lake, the origin of the name Beira is subject to different interpretations.

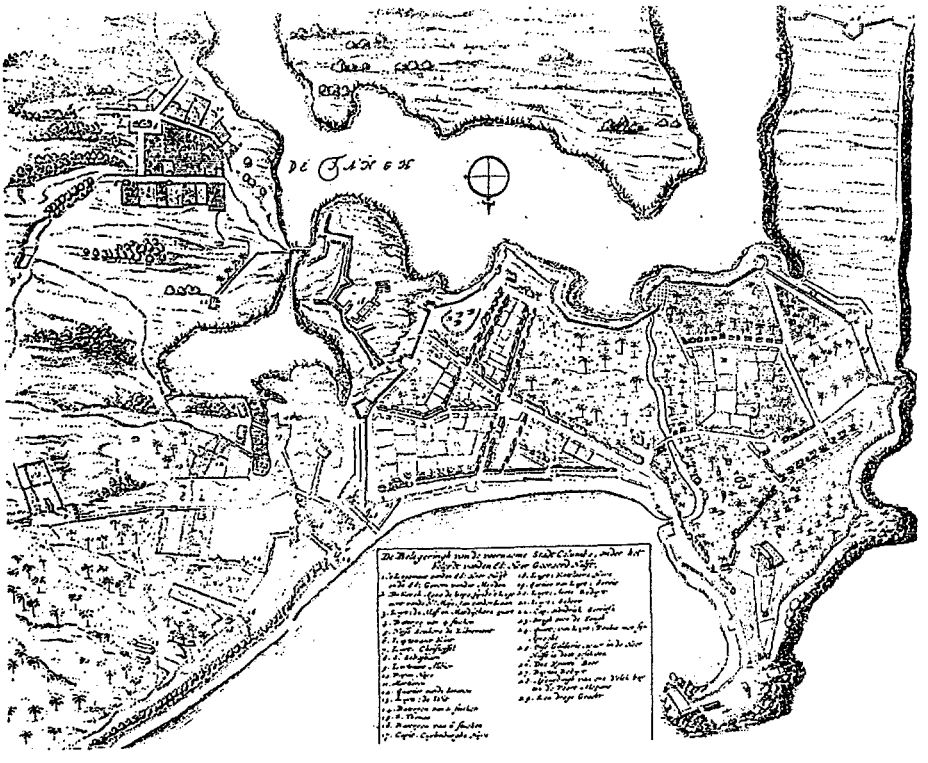
The name Beira appears for the first time in a map dating around 1927. Some believe that Beira Lake is named after a Portuguese engineer named Beiro who in 1554 dammed flowing water at the present Dam Street to form a lake. Others argue that the lake was named after a Dutch engineer named De Beer who constructed the moats and water defenses of the Colombo Fort around 1700. Still others are of the opinion that Beira was derived from "de beer" which denotes a place where the boats are berthed. Whatever the name origin, Beira Lake was identified in maps (**figure 2**) drawn during the Portuguese, Dutch and even in the early British periods only as the "Lake" or "Colombo Lake."

Despite the idyllic location and natural beauty, its potential has not been fully realized. Rather, over the years it has progressively become heavily silted and progressively polluted as a result of receiving both domestic and commercial waste.

This publication provides a record of the history of the lake, its gradual deterioration, previous efforts made to improve it and future lake restoration plans. The publication aims to raise the level of public knowledge and provide information to concerned citizens who wish to maintain a dialog with decision makers and participate in the lake's improvement. It also details some of the technical and policy aspects of a recent Beira Lake Restoration Study which provides a practical blueprint for action by public sector agencies and the private developers and landowners around the lake.

Finally, it offers an example of integrated planning and management of a natural environmental feature in an urban setting and an approach which could be applied in similar situations in Sri Lanka and other countries.

Figure 2. Map of Colombo showing Beira Lake (1672)



Box 1. How Colombo got its name

The name Colombo is believed to be a corruption of a local word. Some say it is derived from the Sinhala term for a mango (*amba*) leaf or a mango tree which grew in the City, but bore no fruit *Kola-amba*. Others prefer the derivation from the term *Kolon-tota* which translates into 'ferry at river kolon' [kolon being a former branch of the Kelani opening into the Harbor] and then to *Kalanbu* by the Moors or *Kolamba* [ferry, port or harbor] by the Sinhalese and its subsequent Anglicization.

COLOMBO CITY'S POLLUTED LANDMARK

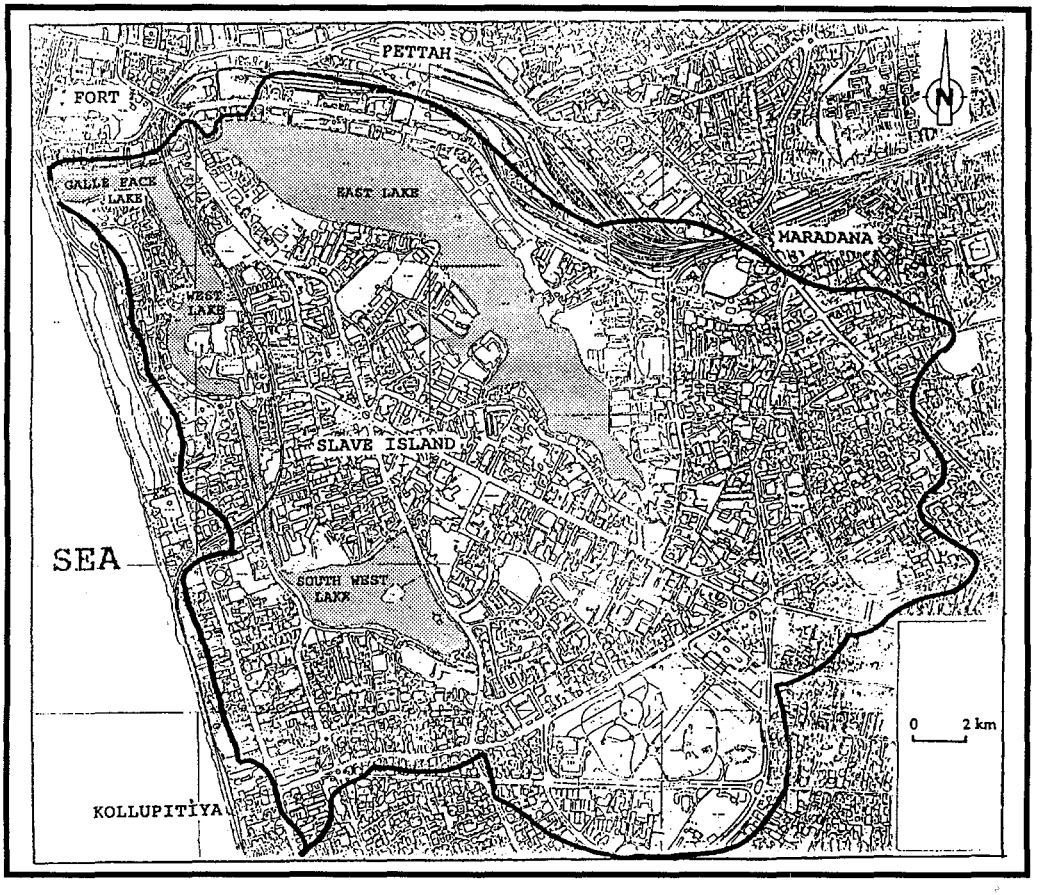
LAKE SETTING

At present Beira Lake is essentially a stagnant water body totally dependent on the run-off of its highly urbanized, mostly flat catchment which covers approximately 448 hectare. The maximum elevation within the catchment is 9.8 meters above mean sea level (MSL). The lake covers 65.4 hectares (162 acres) and has an average depth of 2.0 meters (6.5 feet). It comprises four main basins: the East Lake, the Galle Face Lake, the West Lake, and the South West Lake **(figure 3)**. The East Lake is the largest and deepest basin (43.2 hectare, maximum depth of 5.6 meters), while the other three basins are much smaller and shallower (total of 22.2 hectare, maximum depth of 3.4 meters). The water level of the lake is maintained at 1.8 meters above MSL by a semi-circular spillway at Galle Face Lake.

Two locks, the San Sebastian and McCallum, allow management of the water level and give connections to the Kelani River and the Harbor, respectively **(figure 4)**. In the past San Sebastian Canal was the link between Beira Lake and an extensive network of canals and waterways developed by the Dutch which served to transport both goods and people and was part of the City's drainage system. No longer used for commercial transport, this network is now fragmented and in a state of disrepair.

The bulk of run-off into the lake is provided by rainfall, which is highly variable due to monsoonal effects. During the dry seasons the lake water level falls and produces conditions favorable to increased microbial and chemical activity, resulting in anaerobic gas production and unpleasant smells. The turbulence resulting from this gas production occasionally causes the re-suspension of the dark, bottom muds which results in portions of the lake turning black. In addition, released hydrogen sulfide adds to the stench emanating from its polluted waters.

Figure 3. Beira Lake Catchment Area



CHANGING PUBLIC PERCEPTIONS

The increasing pollution of Beira Lake has become a source of concern to the Government of Sri Lanka. The pollution has made bathing and water sports hazardous to the health of citizens and reduced the lake's capacity to support aquatic life. Consequently, the lake has lost its attraction to the residents who once enjoyed its vistas and has become a nuisance to people living and working around its shores. Beira Lake is becoming increasingly isolated and, lacking proper maintenance, a national eyesore.

Many factors contribute to Beira Lake's degradation including its almost total dependence on rainfall for replenishment, its stagnant condition, numerous outfalls discharging polluted waters, and locus for disposal of sewage and garbage. Moreover, the aesthetic appeal of the City is diminished due to periodic discoloration of the lake, unrestricted growth of algae and massive fish kills and bad odors. The almost complete apathy of

an uninformed public which has little idea of the potential value of this magnificent asset contributes to this decline.

Periodically, the public and the media voice their displeasure over this disheartening situation. The Chamber of Commerce expresses its concern that attendance at tea auctions may diminish as a result of the stench emanating from the lake during periodic fish kills. Criticism is leveled against the various authorities who are perceived as having responsibility for the lake. Newspaper articles on the subject often carry provocative headlines. A newspaper editorial comments that "what is abundantly clear is that many responsible authorities and agencies have negligently permitted pollution to escalate to very considerable proportions. The lack of that proverbial 'stitch in time' has necessitated not just nine stitches but nine hundred thousand as far as Beira Lake is concerned."

In the past, the administration of Beira Lake had been the responsibility of a single individual or agency **(box 2)**. Today, however, administrative response to public outcry about the lake has not been easy, as numerous government agencies have jurisdiction over the lake and its related activities; at best only *ad hoc* remedies can be undertaken. Furthermore, economic constraints, public apathy and lack of strong political will prevent the development and implementation of a comprehensive solution.

Box 2. Changing administration of Beira Lake

The Portuguese gained control of Colombo in 1565, with the fall of the Kotte Kingdom. The City, though nominally ruled by a Sinhala king, was in actual fact under the Portuguese Captain General.

During Dutch administration of Colombo and after the fall of the Dutch East India Company, the lake was in the hands of the governor and director of the Island and the Political Council, consisting of the Controller of Revenue, the "Dissawa" (District Chief) of Colombo, the Chief Military Officer, the Public Prosecutor and five other heads of principal departments.

During early British times, the administrative responsibility for the city was in the charge of a Crown Collector stationed in Madras. After 1833 the government agent of the Western Province administered the city until the Municipal Council was established in January 1866. With the development of the Colombo Harbor, the Beira was placed under the Colombo Port Commission (CPC), established in 1936 and given jurisdiction of the lake waters and six feet of its near shore area. With the abolition of the CPC in 1979, the Beira came under the purview of its successor, the Sri Lanka Ports Authority (SLPA).

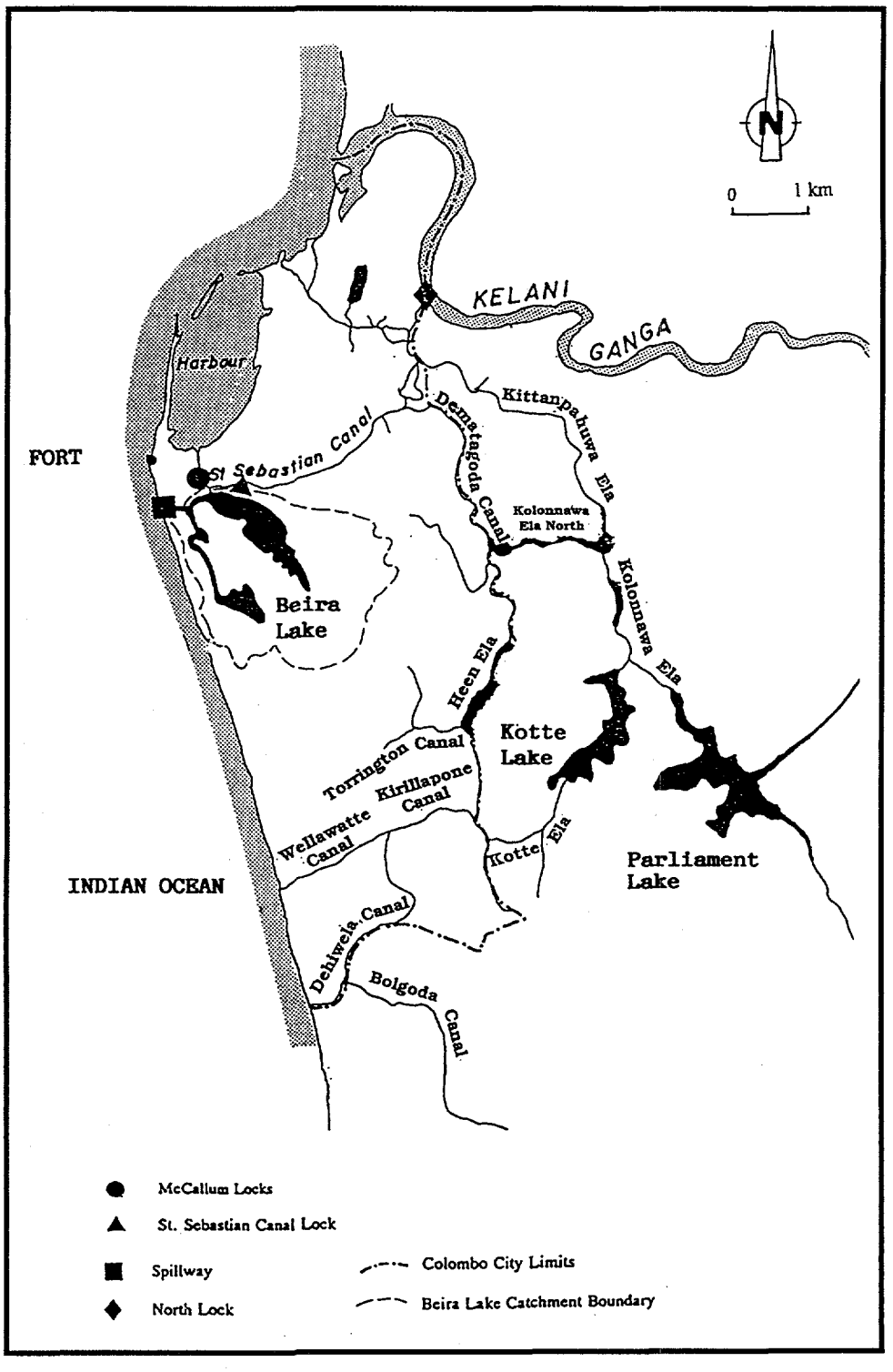


Figure 4. Beira Lake in relation to other water bodies in and around Colombo

IDENTIFYING A RESTORATION STRATEGY

Polluting of Beira Lake was first recorded in the last decade of the nineteenth century. Over the ensuing years sporadic efforts have been made towards its potential restoration. Many of these efforts, unfortunately, remained in the proposal stage, but a few were implemented including dredging, water level management, shoreline improvements, control of entering pollutants, and relocation of squatters from the banks. Extensive reclamation, which began in the early part of this century, reduced the area of the once sizable lake by more than half. This further diminished the carrying capacity of the lake and hindered restoration efforts.

The more recent 1990 initiatives led by the Metropolitan Environmental Improvement Program (MEIP) within the World Bank prompted the relevant government authorities to take concrete actions towards the sustainable restoration of the lake. Playing a pivotal role in this action, the National Environmental Steering Committee (NESC) coordinated the inputs, functions and responsibilities of the various sectoral agencies having jurisdiction over Beira Lake and its catchment. This culminated in a comprehensive feasibility study on restoring Beira Lake carried out jointly by the Urban Development Authority (UDA) and a Canadian consultancy firm with the financial assistance of the World Bank and the Canadian International Development Agency (CIDA). The Beira Lake Restoration Study (BLRS) was overseen and guided throughout its year-long duration by an intersectoral Beira Lake Restoration Coordination Committee (BLRCC). The feasibility study encompassed the lake's physical, biological and human environmental considerations and identified the lake's pollution sources and its water and nutrient budget.

Revealed in the study are the diverse extent of pollution in the different basins of the lake, the high nutrient content of its waters and toxic metal content of its sediments. The poor biological diversity in the lake's waters and the presence of indicator organisms confirming its advanced eutrophic condition are also disclosed in the study. In addition, the results established the mixed land use character of Beira Lake catchment and revealed that the State owned the majority of the lands immediately surrounding the lake.

The study made evident the extent of the lake-shore shanty dwellers, their impact on the lake and the fact that subsistence fishing was prevalent.

The study conclusively demonstrated that the major pollution source of the lake was the entry of sewage and sullage to the extensive storm-water network through unauthorized connections from households in the lake catchment area. The study also made an attempt to work out the lake's water and nutrient budget and tentatively identified phosphorus as the limiting nutrient which entered via the extensive storm-water network which delivers the lake's main source of water.

Finally, the study suggested a restoration strategy with an action plan to be implemented in two phases over a ten-year period. The total cost is estimated to be US$23.7 million. The restoration strategy has five major components which include: (i) reduction of pollutant loading from the catchment; (ii) in-lake restoration procedures; (iii) shoreline beautification and recreational facilities; (iv) land/catchment development and management program, and (v) a monitoring and enforcement program. Chapter 4 of this publication describes the strategy in more detail. The World Bank is financing the first phase of the recommended restoration strategy with a somewhat modified action plan as a component of the Colombo Environmental Improvement Project (CEIP) which was initially developed by MEIP.

Chapter Two

A POLITICAL AND SOCIAL HISTORY OF BEIRA LAKE

The origin and history of the man-made Beira Lake are inextricably entwined with that of the City of Colombo; furthermore, the lake also has an interesting geological history **(box 3).** Between the ninth and sixteenth centuries, Colombo was a small seaport used by Arab, Indian, Persian and Chinese sailing craft. When the maritime provinces of the Island, Sri Lanka, then known as Ceylon, came under successive occupation by the Portuguese, Dutch and finally the British, Colombo was their metropolis; and in 1815 when the Island finally capitulated, Colombo became the capital of the Island.

The Kelani, one of the Island's major rivers, flows into the sea at Colombo. Many centuries ago, apart from a port situated at the mouth of the Kelani River, much of what is Colombo today consisted of low, swampy marshlands subject to floods. It is believed that a Moorish trading settlement was set up in the early part of the eighth century by Arab traders engaged in the export of cinnamon, arecanuts, pearls, gems and elephants.

PORTUGUESE PERIOD (1505 - 1658)

The Portuguese discovered the Island in late 1505 and established a fortress in Colombo by 1518. Later, as a protective measure, they cut a ditch from the harbor to the sea to separate the fort from the mainland **(figure 5)**.

Seventeenth century records show that Beira Lake owes its origins to the period when the local ruler attacked the Portuguese Fort of Colombo in 1521. The Portuguese, in repulsing their attackers, dammed a brook passing through a stretch of swampy land which was a flood outlet of the Kelani river. This formed a lake which effectively protected the City of Colombo from land attacks and thus formed one of its chief defenses. It

Box 3. Geological History of Beira Lake

According to the distinguished Indian scientist D.N. Wadia, the geological history of Beira Lake is closely connected with that of the Kelani River estuary, the Lake being at one time a portion of that estuary. The Kelani mouth since then has migrated four miles to the north. Historic evidence points to the fact that from the start of the Holocene Period (11,000 years before present), Beira Lake has oscillated between fresh-water and salt-water no less than four times, most of this movement occurring within very recent geological times.

It appears that the present bed of Beira Lake is not the true bottom of the Lake. The original bedrock supporting the water-basin is 38 feet below spill-level in the deepest parts. The surface of the Lake now is 6 feet above mean sea-level. Between the old bottom and the present floor of the Lake, there occurs a belt of stratified deposits of about 30 feet maximum thickness, divisible into four well-marked horizons, indicating four different cycles in its history.

On the weathered uneven floor of gneiss, with an overlying sheet of sand, a marsh must have flourished for a period long enough to fill it with 7 feet of vegetable humus and forest debris. The ground was already subject to a slow subsidence of the coast, then a more pronounced sinking of the ground with consequent submergence of the marsh under the sea-water. This connection with the sea did not last long and a reversion to fresh-water and marshy conditions occurred. A second in-rush of the sea is suggested at a later date. This is the latest earth-movement. The two submergences could not have been less than 20-25 feet. No data is available to judge the amount of uplift that has taken place in the interval between these two submergences.

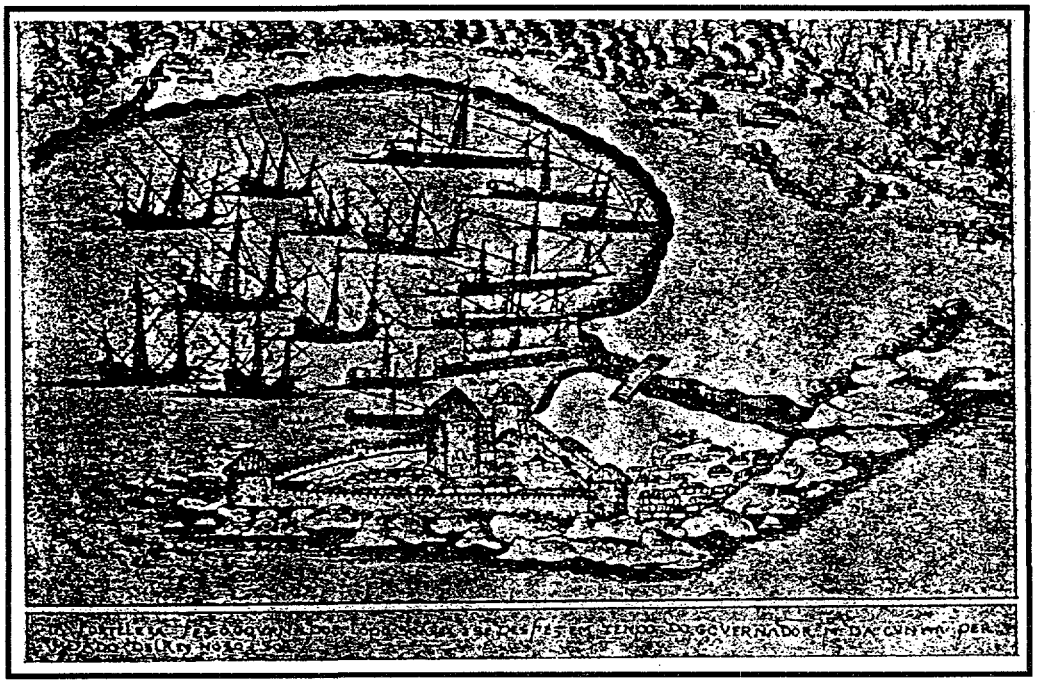


Figure 5. Early Portuguese map showing first fortress of Colombo (1518) which was situated on the narrow point which now forms the foot of the south-west breakwater. For greater safety it was cut off by a ditch and had no other entrance but by the ditch.

encircled more than half the city and gave protection to its southern and eastern areas, while the sea protected it to the north and west. The local populace, although unsuccessful in capturing the Fort of Colombo, somehow managed to drain the lake dry twice through canals, one of which is represented today by the San Sebastian Canal. The main gate out of the fort at that time was Queens Gate (or Poorte Reina) on the eastern flank of the fortress. This was later called Kaymans Gate named after the crocodiles (or "Kaaiman") who came to feed on the garbage cast out from the city.

DUTCH PERIOD (1658 -1796)

Arriving in 1602 for purposes of trade, the Dutch besieged Colombo Fort in 1655, and the lake became the scene of some of the bitterest encounters between the Portuguese and Dutch. The Portuguese made great use of the lake for the transport of material for the City's defense while the Dutch are reported to have launched vessels on the lake for the transport of soldiers and to breach the Portuguese defenses.

The battered Portuguese ramparts were temporarily replaced by a stockade extending to the edge of the lake. Later the defenses were withdrawn to higher ground a few hundred yards back. The low-lying ground outside was flooded and a broad expanse of the lake flowed in as far as Kaymans Gate **(figure 6)**. During the Dutch period, the lake was enlarged and connected with the Kelani river to the north and the Panadura river to the south by a navigable canal system **(figure 7)**.

BRITISH PERIOD (1797 - 1948)

The British commenced hostilities against the Dutch and by 1795 most of the maritime provinces of Ceylon had fallen. In 1815 Ceylon in its entirety fell into British hands. Colombo became the country's capital.

Painting a vivid picture of the lake as it was in the early half of the nineteenth century, the modern day scholar-historian R. L. Brohier drew on the contemporaneous writings of John Deschamps (a Royal Artillery officer who served in Ceylon from 1828 to 1837) among others. Brohier described a much larger Beira Lake, which was an ornament of the city and afforded an ideal opportunity for boating which resulted in the increase of small sailing vessels and row boats, pleasure barges and skiffs **(figure 8)**.

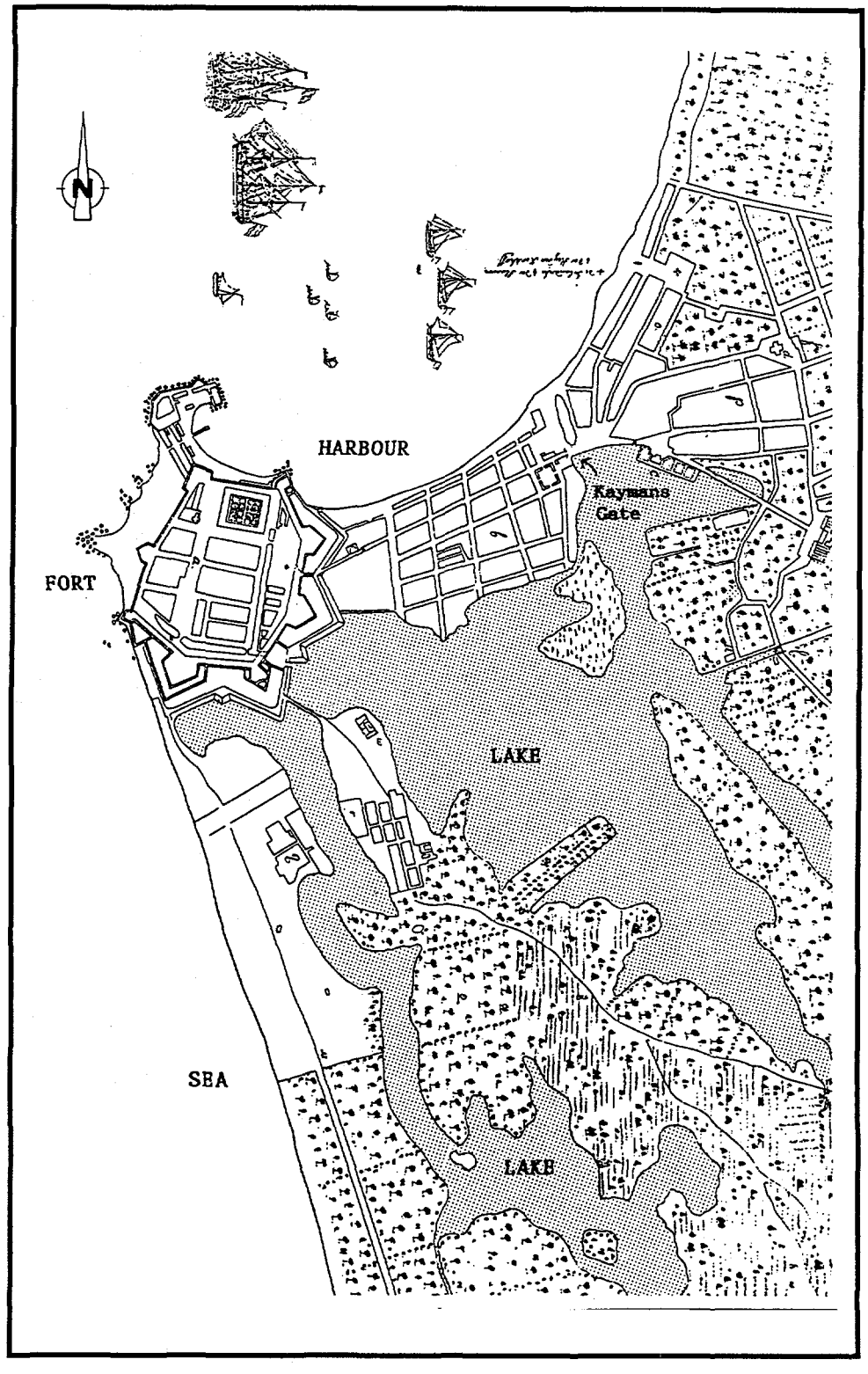


Figure 6.
The Lake and Fort
of Colombo
(1750)

Frequent and colorful regattas were held with enjoyment only hindered by an "inordinate growth of water weeds." Colombo residents living outside the fort dwelt on the high land by the margin of the sea, or on the verges of the many inlets of Beira Lake. Residents on the banks often boated to their work places in the fort. Their "villas" offered a gracious setting for their less fortunate friends living in the fort "to come across the lake, to partake of a hospitable dinner at four o'clock under charming circumstances and salubrious conditions." During the early British Period, the banks of Beira Lake were extensively used for parties and other recreational activities, and it is even reported that a festive ball was held in June 1815 to celebrate Napoleon's defeat. Beira Lake was both a center of commercial activity and a notable resort in the city.

In 1845, John Deschamps spoke of several small tributary streams feeding the "Lake of Colombo" which then extended four to five miles in a north-easterly direction from the fort. He wrote that the lake "communicates, by means of canals, with the Kalany Ganga [Kelani River], near the bridge of boats, and so with Negombo, northwards; with the lake of Bolgodde [Bolgoda], the Pantura [Panadura] river, or estuary, and thus with the Kalu Ganga near Caltura [Kalutara], southward, affording great facilities for internal communication, which might be most advantageously extended without much labor or expense."

There were many beautiful areas near the lake. An open space called "Racket Court" that existed up to the second decade of the twentieth century was bounded by the lake on one side and the harbor on the other. It was described as the "most charming of all places - with beautiful flowering plants and shady walks." In its location now stand the dilapidated buildings of the Chalmer's Granary.

The Beira featured prominently in the life of Colombo citizens. Most householders bought drinking water from "water-men" who transported water from wells in Captain's garden, a peninsula which jutted into Beira Lake opposite the pettah (now marked by the Historic Hindu Temple in the busy railway yard off Maradana). Washer-men, locally referred to as "dhobies," had a prescriptive claim to parts of Beira Lake **(figure 9)**.

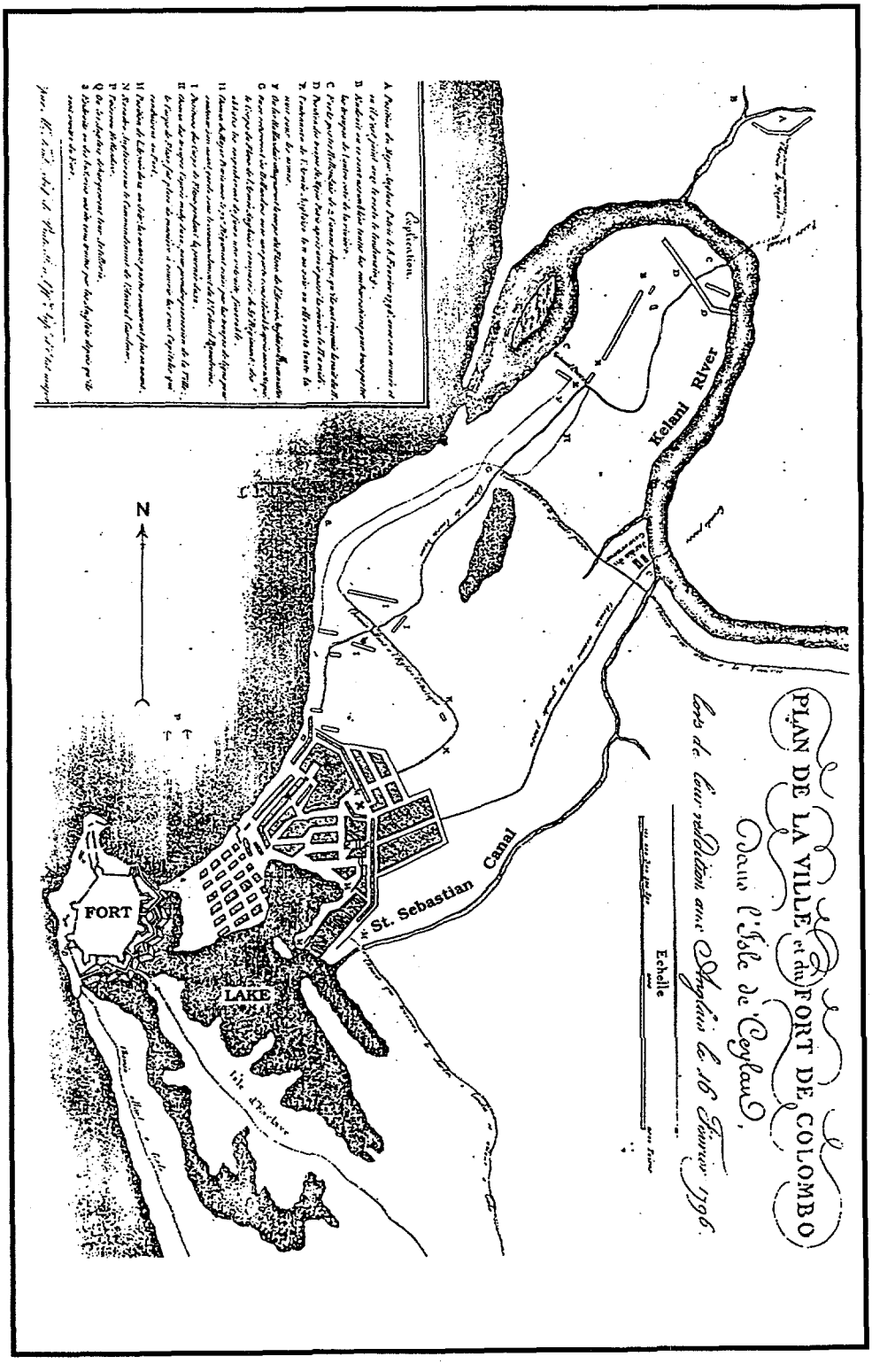


Figure 7.
Map of Colombo
(1796)

POST-INDEPENDENCE PERIOD

After Ceylon gained independence in 1948, considerable political and economic changes took place in the country. Following a period of State ownership of production, it is now moving towards an export-oriented free market economy which is increasingly becoming sensitized to environmental issues. Some of these have had impacts on Beira Lake.

As a result of increased port activities, the lake underwent further encroachment. Sections of East Lake were reclaimed to put up warehouses and the boatyard of the Port Commission. Some stretches of land on the banks of the lake were encroached upon by squatters. A few corners of the lake have become naturally filled up due to siltation. Two new roads have been developed, namely Perahera Mawatha in the 1970s and Navam Mawatha in the 1980s, along the southern and northern boundaries of the South West Lake.

Presently, Beira Lake supports several activities which include domestic and industrial uses. The Beira Lake offers berthing for repair and construction of boats and barges. Many of the old barges have ended up sinking and over a period of time their numbers in the East Lake became quite substantial and obstructions to boats plying the lake. In 1989 the number of sunken barges was reported to be 141. The Sri Lanka Port Authority (SLPA) has been progressively salvaging these barges and by 1993 only 21 remained. Subsistence fishing is performed by people from surrounding areas. The Colombo Rowing Club, located on the East Lake for nearly a century, still uses the lake for recreational and competitive rowing. Household garbage, laundry and waste water add to the pollution of the lake as people continue to dump garbage along the banks and in the water. In addition, the human polluter continues the regular use of the South West Lake to wash vehicles and bathe livestock, and periodically even as an elephant bath when religious processions are held at a nearby Buddhist temple.

Several establishments, however, exploit their location at or near the Beira for aesthetic purposes which are intrinsically non-polluting. These include some hotels, restaurants, clubs, private sector companies, as well as military and religious premises. During the last few years, Beira Lake has been patrolled by military boats for security purposes, especially since several defense forces buildings, including the Ministry of Defense, are located on

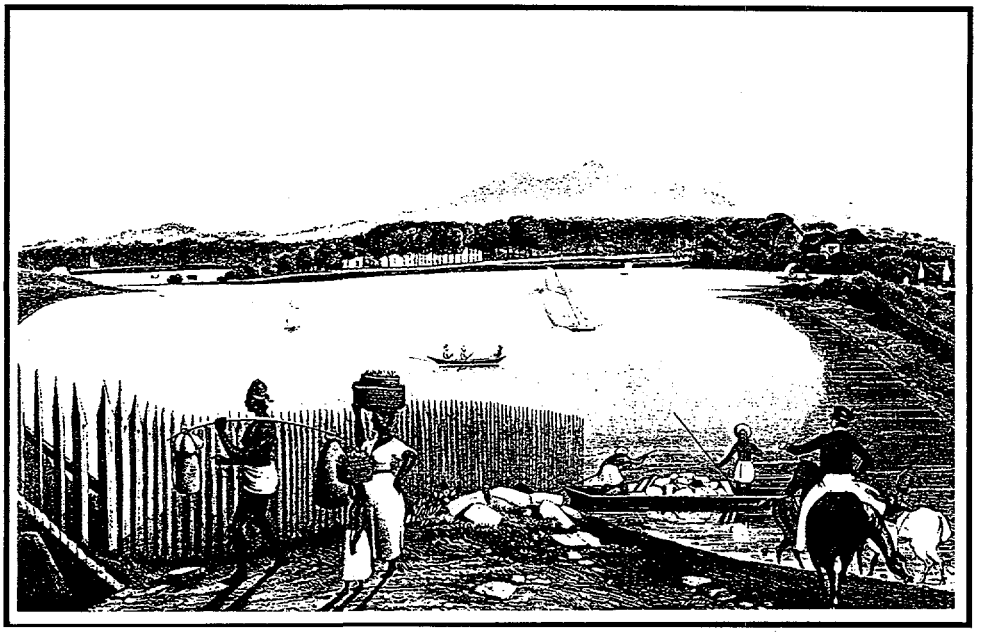


Figure 8. Artist view of Beira Lake from the Galle Face area (1845)

its shores. The lake also supports a variety of bird life which uses its waters and near-shore area as feeding and breeding grounds.

URBANIZATION AND DEVELOPMENT

During the Portuguese Period in Colombo, the foreign residents, who were mostly soldiers, lived within an area fortified by ramparts and gun batteries which covered most of today's fort and pettah areas. The residential quarter was the old town or "pettah," an Anglo-Indian term used during the British times meaning extramural suburb of a fortified city. The fort had a thick rampart with bastions at the angles. A portion of this fortification is visible today, preserved in the premises of the present Commercial Bank. Terms fort and pettah still survive, but their significance has all but been lost. Gradually within the ring of the fort's ramparts arose churches, colleges, hospitals, elegant villas occupied by high officials and smaller houses occupied by lesser bureaucrats. Historical accounts refer to a fortified city populated by some 2,400 families while on the outside there lived some 300 Portuguese who had intermarried with the local population.

During the Dutch siege against the Portuguese, the fortified city was virtually reduced to rubble by the Dutch cannonade. For practical purposes, the Dutch during their rule reduced the size of the original fortified city by a

third to approximately the size now occupied by the Colombo Fort. The fort was separated from the residential pettah. An engineer named Vyver converted the open space which separated fort and pettah into a pond by admitting water from the lake. The road from the pettah to the fort lay over a dam or causeway and is represented by a section of today's Main Street. The present Echelon Square, now the hub of the urban redevelopment of the fort area, was an open space during the Dutch Period, bounded on one side by the moated ramparts of the citadel and on the other by Beira Lake.

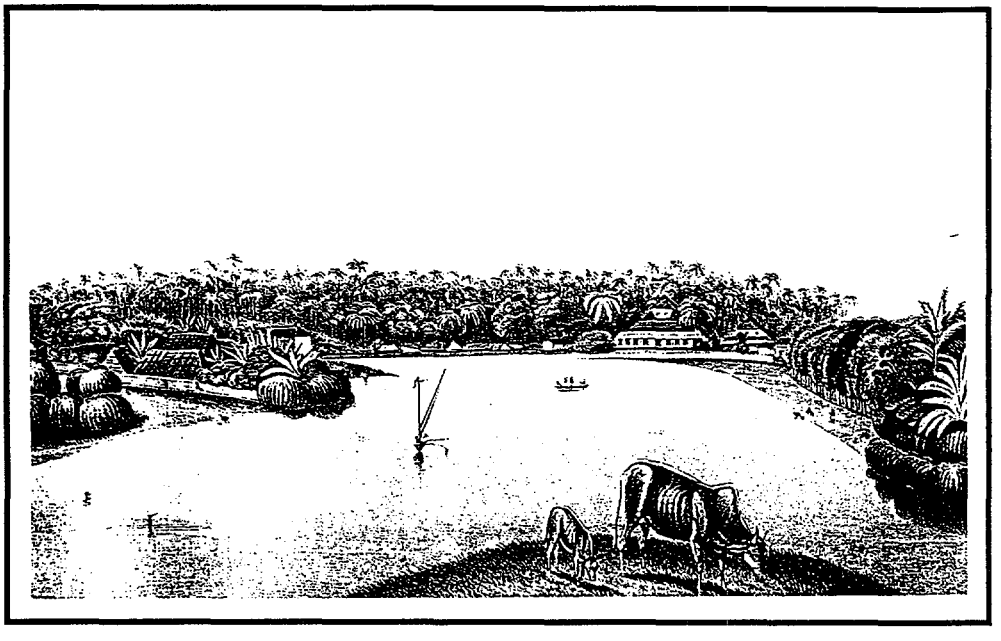
African slave labor, originally introduced to Ceylon by the Portuguese around 1630 from their settlement in Goa, was drawn on extensively by the Dutch when they set out to build the citadel of Colombo. The slaves were housed in lines of shanties outside the fort across the lake on a jagged peninsula which came to be mislabeled "Ije" on old maps meaning island. The area still known as "Slave Island" perpetuates this misnomer despite the fact that reclamation of the lake has wiped out its original topography **(figure 10)**.

Restricted space within the fort resulted in the population spreading into areas outside the fort with some of the most elegant homes situated on the banks of the lake. Describing the changing face of the fort area, British

Figure 9.
Dhobies (washermen) at work in the Beira lake (possibly in 1940s)

historian John Penry Lewis stated that "the railway has made great changes round the lake. The breakwaters have altered the appearance of the harbor. But, perhaps, the greatest change was caused by the removal of the ramparts round the fort. These were taken down and the moats filled by the Military authorities between 1869 and 1871." The British traders and agencies started establishing their offices and stores in the fort area of Colombo. Today these can still be identified within the fort area, especially around Beira Lake.

Figure 10. Artist view of Beira Lake and Slave Island from the Fort (1845)



In 1824 the population of Colombo totaled a mere 31,188, with 1,734 in the fort; 4,979 in the pettah, and 25,475 in the neighboring regions. By 1871 the total population increased to 98,843 and by 1881 it was up to 110,502 with a density of 11 persons per acre. In 1931, fifty years later, the population more than doubled to 284,155 with a density of 21 persons per acre. Another fifty years later, in 1981, Colombo City had a population of 585,776 with an average density of 63 persons per acre. In the absence of a recent census the population in 1995 is estimated as being over 615,000, with a density of around 67 persons per acre.

The Beira catchment area, 1,107 acres in extent, has an estimated residential population of approximately 62,278, giving a population density of 56 persons per acre. The immediate surroundings of the Beira (core area) with an area of approximately 287.5 acres has a residential population of 6,884

with a population density of 24 persons per acre. This density rises to 153 persons per acre when the daily working population is taken into account.

MISUSE AND POLLUTION IN MODERN COLOMBO

During the British occupation, the lake and canal systems were used mainly for navigation. Unfortunately, they were also subjected to gradual pollution by diversion of drainage and sewerage outlets into them. The effectiveness of the lake to serve as a natural outlet to the sea was reduced when the water level of the lake was raised to between 8 to 10 feet above MSL during the early part of the twentieth century. It was subsequently lowered around 1918 to its present level of about six feet above MSL and maintained at this level by a semi-circular spillway at the Galle Face Lake. These actions aggravated water stagnation and pollution problems. In addition, Beira Lake's carrying capacity has been reduced by reclamation and siltation, as a result of urban expansion.

Historical records indicate that the quality of water in the lake was good until the latter part of the nineteenth century. In 1845, John Deschamps described Beira Lake as a "fine piece of water supplied by several small tributary streams." In 1879, a botanist named Dr. Trimen observed that a great variety of water plants grew in the lake which indicated that the water was pure. The lake would have been one of the more pleasing amenities of the city. However, in 1891 Trimen reported that the lake was increasingly polluted as sewage passed into it.

The lake was neglected thereafter and as the population increased it became a menace to the health of the inhabitants, since much of the sewage of the city found its way into it. By the dawn of the twentieth century, the lake was described as a "cesspool," wherein plant life had "degenerated to the species 'algae' due to sewage contamination." In time, the water body came to be used more for drainage purposes than for transport, and with this change the canal system also finally fell into disuse and became badly silted and neglected.

Over a thousand outfalls opening into Beira Lake were identified in the National Aquatic Resources Agency (NARA) study of 1985. Many of the large diameter outfalls are storm drains. The greatest concentration of outfalls is to be found in the Galle Face Lake and the east bank of the East

Lake. It was noted that a significant number of outfalls were clogged with organic matter coming from waste water outlets which entered Beira without prior treatment. The discharged quantities varied from a trickle to about 0.5 cubic meter per second noted at a commercial establishment on its banks (Ceylon Cold Stores Ltd.). The squatter settlements along its banks have become a major source of pollution aggravated by the construction of temporary latrines opening into the lake. Further, soap used for bathing and toilet purposes introduces more pollution into the lake.

There is a lack of maintenance of the existing drainage system as well as outfall restrictions due to siltation. During periods of rain, storm water entering the lake carries with it pollutants derived from the catchment areas. It was noted that floating garbage and refuse tended to accumulate on the leeward side of the wind and much of this collected in the half-sunken barges which until recently obstructed most of the middle of the East Lake.

The southern end of the East Lake is an area where extensive dumping of refuse has taken place. This blocks a badly silted and marshy end of the lake. The shoe shaped cul-de-sac on the western flank of the East Lake is also badly silted and filled with refuse. The bottom mud of this area is totally anoxic, giving off bubbles of hydrogen sulfide with its characteristic odor of rotten eggs.

In addition to liquid waste, oil from several motor repair garages situated near its banks also finds its way into the Beira. Among the many outfalls that open into the lake are three which are major sources of pollutants. A large open drain which serves a good part of the Slave Island area falls into the West Lake near the railway bridge and brings in refuse and waste water mainly from slum area drains routinely used for toilet purposes. The East Lake is despoiled similarly by a major drain serving a significant portion of the catchment which brings in a variety of pollutants including untreated hospital wastes. Another enters the South West Lake at its western flank, often introducing sewage diverted from a nearby sewage pumping station during its regular maintenance periods.

PAST ATTEMPTS AT ENVIRONMENTAL IMPROVEMENT

Proposals were made and certain actions taken from time to time by the relevant authorities with regard to the lake and its surroundings. These mainly dealt with the reclamation, water management, shoreline development, navigation and pollution aspects of the lake.

LAKE DEVELOPMENT SCHEME

In 1904, Governor Sir Henry Blake appointed a committee to report on a number of proposals concerning the lake. One of these was to connect the lake to the harbor. The lake at the time had an area of about 400 acres (162 hectare) and a volume of 83 million cubic feet at maximum water level **(figure 11)**. The committee's report indicated that there would be no practical advantage to this proposal as the existing depth of the lake was such that the flow of water would be minimal and would require extensive dredging of the lake.

Blake's committee also endorsed a proposal for a development scheme involving reclamation of parts of the lake for building purposes and the construction of new roads. The cost of the development was to be partly recovered by the sale of the reclaimed land. Nevertheless, one member of the committee strongly dissented, saying that the proposed scheme not only favored private ownership of the foreshore area, enormously enhanced in value at public expense, but also practically excluded the public from the lake frontage altogether.

However, both the construction of the canal and the reclamation of the lake were initiated during the tenure of Governor Sir Henry McCallum (1907 - 1913), and despite the fact that some European firms said that their interests would be adversely affected, the majority welcomed the scheme. The

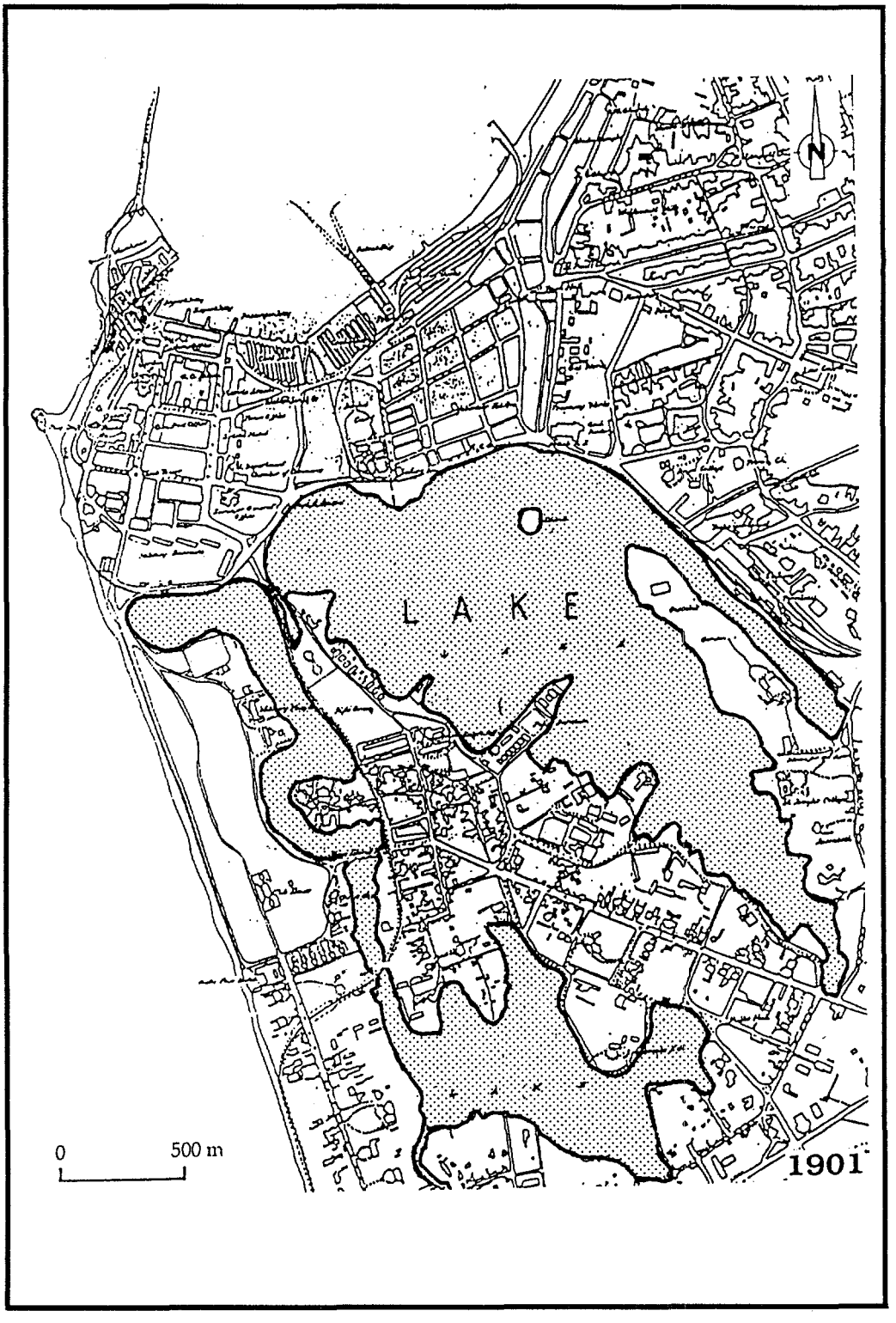


Figure 11. Map of Beira Lake in Colombo City (1901)

reclamation of the lake under this scheme, which was completed in 1921, considerably reduced the extent of the lake.

LOWERING THE WATER LEVEL

In the early part of the twentieth century, Beira Lake was isolated from direct access to the sea. The water surface of the lake was kept at a level varying from plus 8 to 10 feet MSL. With this isolation the city was deprived of its natural drainage outlets and thereafter began experiencing an ever increasing need for a coordinated system of soil and storm water drainage within the municipal limits. Around 1918, Beira Lake was partially lowered to plus six feet MSL and its bed was dredged. Some drainage relief was provided through the semi-circular spill at Galle Face because the outfall was reduced to plus six feet MSL.

GEDDES' PLAN

In his report, "Town Planning in Colombo" (1920), the eminent British town planner Sir Patrick Geddes emphasized the "Garden City" concept and also stressed the importance of the harbor and related facilities, recommending that these should largely determine the layout of the city.

Rather than reclaiming part of the lake to construct a new road, he proposed the creation of a fairly wide parkway linking Colombo's Victoria Park with the South West Beira Lake. He argued that the area of acquisition for the parkway was neither extensive nor very expensive, with an existing road running almost exactly through this proposed parkway to the lake. At that time the South West Lake basin was much more extensive than it is now with a looped section **(figure 12)**.

Offering a strong argument to prevent the reclamation and elimination of this looped section, Geddes observed:

at sunset especially, looking over the lake to the palm forest of the lake-side bungalows, this is by far the finest park view in Colombo, and only second to the totally different seascape of Galle Face. Hence I cannot too strongly emphasize the plea, that, though the great lake [i.e. East Lake] and the north of this one are now being completely commercialized [commercially developed], this one portion of the city's old beauty should be spared for the future. The economic return from spoiling this end of the lake can after all be but small, and the loss to the city is incomparably great.

Further, commenting on the water quality of the area, Geddes reported "I am told that the water in this loop is dirty. That, of course, one sees at the first glance, but also how to cleanse it." This he proposed by dredging the loop and by replacing the existing three or four little drains by a new one which would empty under the bridge at the mouth of the loop, where he felt it would do no harm and help to feed the fish. The whole strategy he believed would be far less costly than the new road proposed for the area under the Lake Development Scheme, and would preserve its beauty.

Unfortunately, many of Sir Patrick's proposals for Colombo could not be implemented, largely because of the lack of resources. As for the Beira, his vision was not to be a reality. The Loop was reclaimed and today is the site of two playgrounds and various buildings. The road proposed in the Lake Development Scheme became a reality and was called General's Lake Road (today Sir James Pieris Mawatha).

ABERCROMBIE'S PLAN

With the enactment of the Town and Country Planning Ordinance in 1946, the Colombo Municipal Council embarked on preparing a town planning scheme for the city. For this purpose, the services of another internationally recognized British town planner, Sir Patrick Abercrombie, were secured.

Abercrombie's Plan (1949) ambitiously covered the Colombo metropolitan region as a whole, but was not translated into detailed proposals. Consequently, it has had little effect on the nature and extent of Colombo's subsequent development. While Abercrombie's report made no specific proposals regarding Beira Lake, annexed to the report are the notes of a meeting held in May 1948 in connection with a proposed extension of the Port involving East Beira Lake.

In outlining the details of this proposal, the chairman of the Colombo Port Commission had described plans to provide deep water quays in the harbor with separate warehouses for export goods on the north bank of the East Beira Lake. He had pointed to the availability of excellent rail and road facilities which would facilitate transport and storage of export products (tea, rubber, copra, etc.) prior to their being transported across Beira Lake through a canal, to be loaded into ships in the harbor. This would ease delay and congestion in the port resulting from restricted warehouse space available in the harbor area.

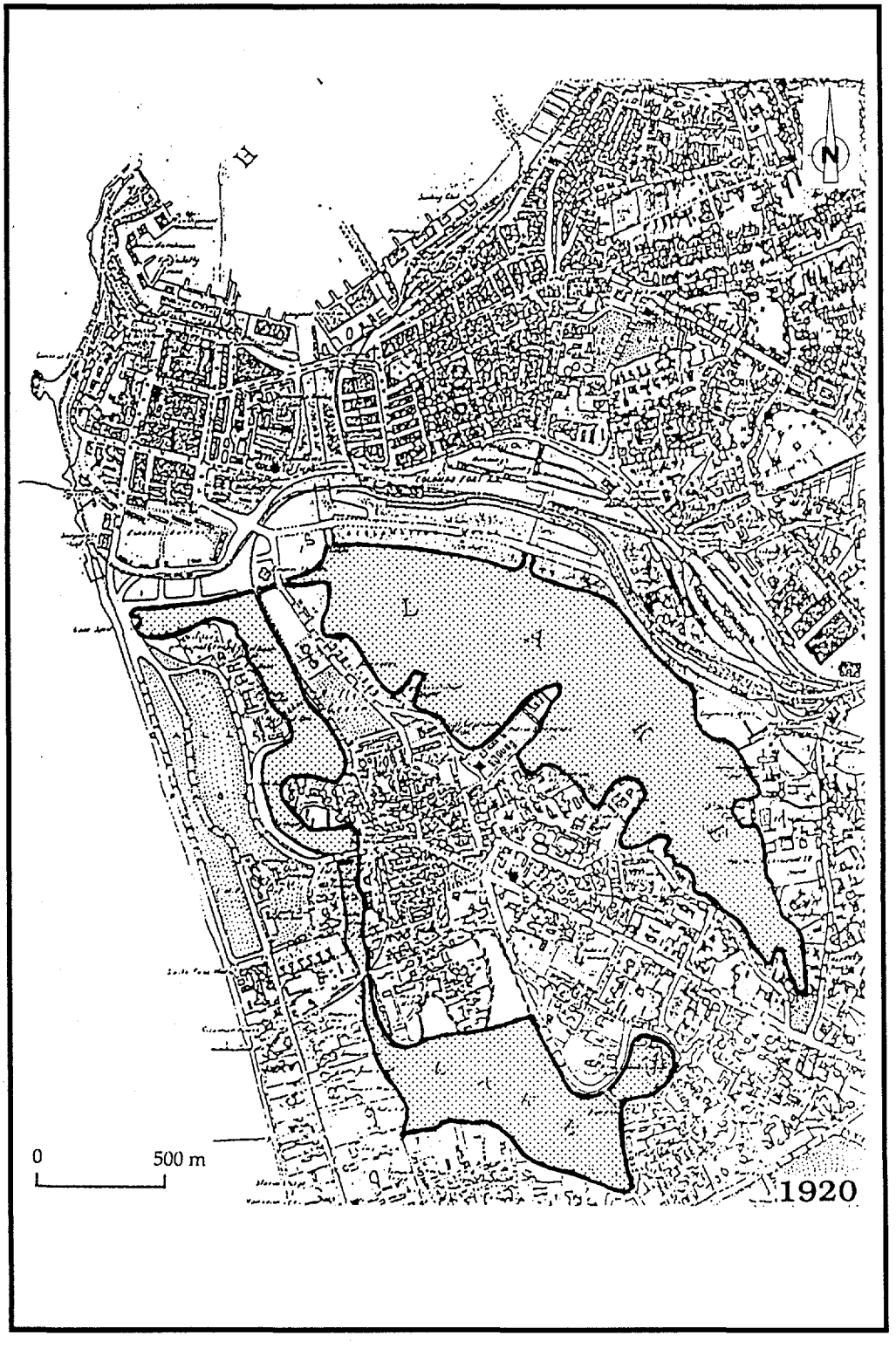


Figure 12.
Map of Beira Lake in Colombo City (1920)

The chairman also had suggested that if all the land on the north bank of Beira Lake was reserved for warehouses then the open land existing on the south bank of Beira Lake need not be built upon. The chairman also endorsed Abercrombie's suggestion that the south east bank of Beira Lake towards the Slave Island end could be reclaimed to provide additional land for commercial purposes. To a large extent, this scenario has been fulfilled. However, the open space envisioned by Abercrombie is today occupied by commercial buildings, the Hotel Renaissance and various government establishments.

UNDP -- Colombo Master Plan

In 1975, preparation of a Master Plan for the Greater Colombo area was undertaken by the Government with UNDP assistance. In Volume 2 of their Final Report (1978) the consultants referred to Beira Lake as a resource as well as an asset, one that was unfortunately long neglected.

Emphasizing its substantial tourism potential including its use for water sports, the consultants had prepared an action project for the utilization of the South West Beira Lake for this purpose. This included the creation of a mini-leisure park complete with sculpture court, island restaurant, children's play area, boathouse, fishing decks and swimming pool. However, there is no record of any follow up or implementation of this action project.

UDA -- Integrated Development Plan

In July 1977 a change of government resulted in dramatic changes including a policy shift from long-term planning to an emphasis on projects and a new attitude to urban development.

In order to promote integrated planning and implementation of economic, social and physical development of urban areas, the UDA was set up in 1978. One of its priority functions was to prepare a development plan for Colombo City together with the new set of planning and building regulations. This task was completed and formally approved by the Government in 1985.

The City of Colombo Development Plan identified Beira Lake as one of the most unexploited resources of the City and specified planning guidelines in respect of Beira Lake and its surroundings. It recommended the

encouragement of shops, offices, hotels, apartments and landscaping around the lake, and the shifting of existing warehouses.

The Plan also advocated prohibition of new warehousing, workshops and pollution of the lake. It also called for the conservation and preservation of the Beira environment and preparation of detailed plans for shoreline development. However, due to shortcomings in planning practices and the lack of direct and adequate intervention of the relevant government authorities, these objectives have not been satisfactorily realized.

NARA -- REPORT ON THE ECO-SYSTEM

In 1985, a subcommittee appointed by the Presidential Secretariat directed the NARA to investigate and report on the status of the lake and its environs. The NARA Report revealed that Beira Lake was a highly eutrophied, mostly shallow body of water (average depth 2 - 2.5 meters) which had restricted flow and limited potential for self cleansing. Investigation of the chemical and biological parameters confirmed the lake's eutrophic status and revealed that the lake waters had excessive populations of blue-green "algae" (cyanobacteria), high turbidity levels, and elevated values for chemical and biochemical oxygen demand (COD and BOD). The excessive fecal coliform contamination in the lake waters indicated significant amounts of sewage entering the lake. The report identified over a thousand outfalls of varying sizes which discharged effluent into the lake. Also identified were four squatter settlements on the banks which used the lake as an open toilet and garbage dump. Indiscriminate garbage dumping on the banks of the lake was excessively apparent. Beira Lake was found to support a thriving and varied bird population, in addition to a fish population. However, the deterioration of water quality periodically resulted in mass fish kills.

The report recommended, among other initiatives, the establishment of an Inter-agency Governmental Management Committee for Beira Lake to implement immediate short-term and long-term actions identified in the report. Although initial steps were taken towards implementing some recommended actions, they were neither sustained nor carried through into a concrete action plan.

BEIRA LAKE MONITORING COMMITTEE

Cognizant of the worsening situation in and around the lake and in response to increasing public concern, in August 1989 the President of Sri Lanka directed that a meeting of relevant government agencies be convened to review the condition of Beira Lake and discuss improvement measures. Subsequently, a technical committee appointed in December 1989 identified six projects for implementation. They included: (i) improvement and monitoring of water quality; (ii) control of pollutants entering the lake; (iii) dredging; (iv) resettling lakeshore shanty dwellers; (v) landscaping of lake reservation with development of recreational, transport and tourism activities, and (vi) employment generation. The project document, submitted by the technical committee in July 1990, had both short- and intermediate-term recommendations and their estimated costs.

The short-term actions included a physical clean up of the lake and its banks designed to maintain the water body in an acceptable condition. The intermediate measures were in two phases. Phase I included pumping water from the East Lake to the South West Lake using pipes and existing storm drains to overcome stagnation. Phase II involved pumping in water from the Kelani River through the dredged San Sebastian Canal, together with relocation of shanty dwellers and construction of "silt traps" at main storm water inlets to the lake.

However, apart from a few actions such as some public awareness activities and monitoring of 18 major and minor outfalls by the National Building Research Organization (NBRO), no further steps were taken to implement the measures outlined above, mainly due to financial constraints. The NBRO study nevertheless established for the first time the greater significance of domestic sewage outflow over industrial discharges into Beira Lake.

On January 1, 1991 a large number of dead fish were observed floating on Beira Lake. This perceived health hazard became such an issue that it prompted the President to direct a ministerial-level inquiry aimed at rectifying the problem. Based on the outcome of meetings held in this connection, the then Minister of Housing and Construction sought Cabinet approval to mobilize relief measures at an estimated cost of Rs.25 million (US$500,000), which was granted.

A Beira Lake Monitoring Committee (BLMC) was set up at the same time to monitor the progress of these activities. The Committee included heads of relevant institutions and was chaired by the Director General of the Central Environmental Authority (CEA). The program of work was based on the July 1990 project document cited above. Although the major items of phases I and II were completed by July 1991, the BLMC continued to function thereafter and coordinate the activities designed to improve the Beira Lake environment.

Chapter Four

TOWARD AN INTEGRATED RESTORATION STRATEGY

MEIP LEAD INITIATIVE

A turning point towards a concerted effort at restoring Beira Lake was the establishment in 1989 of MEIP initiated by the World Bank, together with the UNDP. MEIP-Colombo was started in April 1990 at the invitation of the Government of Sri Lanka (GOSL) and was placed under the then Ministry of Policy Planning and Implementation. In July 1991, it was understood that the World Bank, through the International Development Agency (IDA), had made tentative provision for an investment operation for priorities identified under MEIP.

MEIP identified deterioration of surface and ground water quality as one of the priority issues of Colombo's environment. As the most significant water body in the City of Colombo, Beira Lake was assigned great importance for its restoration. The priorities of MEIP were to be implemented through the proposed CEIP which included restoration work on Beira Lake.

Prior to attempting the sustainable restoration of Beira Lake, a feasibility study was considered essential. Previously there had been no concerted attempt made to undertake a multi-disciplinary study aimed at identifying the causes and magnitude of the pollution and finding solutions with respect to the degradation of the lake. MEIP was able to obtain funds for this purpose from the Canadian International Development Agency (CIDA) and the Canadian Environmental Trust Fund (CETF) facility at the World Bank.

The Canadian consulting firm, Roche International, submitted a proposal to CIDA and the World Bank in November 1991. The Roche proposal was accepted and the necessary contracts/agreements between the concerned parties were signed by January 1993, with a contract value of about CAN$470,000. The proposed feasibility study was to become known as the

Beira Lake Restoration Study. The main objective of the BLRS was to examine the feasibility of different restoration options and formulate a long-term strategy for the lake. The main elements included improvement of the water quality, planned development of surrounding lands and viable management of the lake.

The BLRS was carried out in two stages. The first was a diagnostic analysis which reviewed the existing state of knowledge about the lake and determined the extent of environmental degradation, identified causes and reviewed short-term remedial action taken by the GOSL. This was followed by the establishment of environmental quality standards and the development of a least cost strategy to achieve the standards, including an action plan to implement the strategy.

In addition to the intersectoral initiatives on the lake pioneered by MEIP, there were isolated efforts made by both the public and private sectors towards improvement of the Beira Lake environment. For instance, the National Housing Development Authority (NHDA) took the initiative to conduct surveys of the squatter settlement areas on the lake shore and registered them by issuing "yellow cards" making them eligible for inclusion in future urban shelter programs. With the involvement of local municipal councilors, the settlers were mobilized into community development groups. In addition, there were actions taken by some institutions with vested interests in the lake to maintain the lake shore front in an attractive manner. Among these were the Colombo Rowing Club, the Renaissance and Oberoi Hotels, and the John Keels group of companies. Even the armed forces took steps to enhance the beauty of the shore, albeit restricted to the region bordering their officers' mess.

CONSULTATIVE GUIDANCE AND DIRECTION

National Environmental Steering Committee

An Inter-Ministerial NESC, comprising the secretaries of relevant ministries and the heads of concerned institutions, was established in January 1991 to coordinate major environmental initiatives and ensure the integration of environmental perspectives in development planning. The NESC provided policy guidance and direction to MEIP-Colombo.

Recognizing the funding constraints faced by the BLMC, the NESC gave high priority to the Beira Lake Restoration Project which enabled the GOSL to obtain substantial funds for studies and a subsequent investment program to finance the necessary civil and remedial works.

NESC decided in June 1992 that the UDA should function as the implementing agency for the Beira Lake Restoration Project and that CEA would function as a regulatory agency with responsibility to lay down standards and monitor the environmental measures taken. In response, the UDA established a coordinating body called the Beira Lake Restoration Coordinating Committee.

Beira Lake Restoration Coordinating Committee

The Beira Lake Restoration Coordinating Committee (BLRCC), established in August 1992 under the UDA Chairman, was comprised of the chief executive officers of Sri Lanka Land Reclamation and Development Corporation (SLLR&DC), Colombo Municipal Council (CMC), Sri Lanka Port Authority (SLPA), National Housing Development Authority (NHDA), CEA and MEIP-Colombo. Subsequently, in February 1993, NARA and National Water Supply and Drainage Board (NWS&DB) were also co-opted into the BLRCC. The BLRCC would debate and reach consensus on operational issues and refer to NESC for policy advice.

During its tenure, the committee dealt with a number of major issues.

- **Control industrial effluents entering the lake.** A major food processing and beverage company on Beira Lake was persuaded to divert its effluent into the sanitary sewer network and to install grease traps to its vehicle maintenance bays.

- **Ownership and maintenance of the lake.** The SLPA claimed ownership of the lake and a six-foot wide strip of its banks. The CMC maintained that if the lake was under their jurisdiction it would allow them to keep the banks and waters clean and clear of debris. The matter was not resolved but the SLLR&DC was contracted to keep the South West Lake and part of the West Lake clean and SLPA maintenance activities were confined to the rest of the lake.

- **Relocation of shanties bordering the lake.** A five acre block of land belonging to the Railway Department had been identified by the

NHDA from relocation purposes. The Railway Department was reluctant to release this land. NESC sought Cabinet approval for release of this land but due to the opposition by the Minister of Transport and Highways, the matter could not be resolved.

- **Temporary lowering of water level prior to rainy seasons.** This was a contentious issue with respect to management of the lake's water level. SLLR&DC was of the opinion that lowering of the water level by about two feet during the rainy seasons would offer some relief from flooding. The SLPA did not favor this course of action because of the fear of possible structural damages to buildings on the banks. However, a compromise was reached and partial lowering of the water by nine to twelve inches was successfully implemented;

- **Survey of illegal connections to storm water outfalls into Beira Lake.** Following an initial discussion of this work, the consultants' terms of reference were amended to take into account this survey which was determined would be a critical factor of the study. Subsequently five representative sub-catchment areas were thus analyzed by the consultants and the methodology established for a complete survey.

GETTING STARTED ON BEIRA LAKE RESTORATION STUDY

After the consultant's contract was finalized, UDA established a project office with one of its staff as the project manager. The project manager, who was also a land use planner, was part of a full-time, local counterpart study team together with a hydraulic engineer and water quality specialist.

The progress of the study, carried out in two stages, was reviewed by the BLRCC at its monthly meetings. The committee decided to obtain views and suggestions from the public with respect to restoring Beira Lake and maintaining its peripheral areas. Even though newspaper advertisements to this effect were published on April 7, 1993, in the leading Sinhala, Tamil and English newspapers, the response was very poor.

The team considered a proposal submitted to the UDA which suggested that sea water be pumped to the South West Lake to flush out the polluted water. With a view to getting expert opinion on this subject, a half-day workshop

Over 2,000 people live in squatter settlements along the banks of Beira Lake

on the subject "Beira Lake - Fresh or Saline Water" was held under the auspices of the Environmental Committee of the Sri Lanka Association for the Advancement of Science (SLAAS). This was attended by a cross section of scientists and members of the public. The majority of the participants, however, did not favor the saline option.

At the end of Stage I, the interim report was submitted and reviewed at a workshop held in Colombo. It was attended by the BLRCC members, representatives of the World Bank, MEIP, relevant government agencies, NGOs, universities and professional organizations. At this workshop, the feasibility of the three different restoration alternatives presented in the Interim Report were discussed and a consensus reached about one of the options presented. Based on this option, a comprehensive restoration strategy was developed and presented in the Final Report.

During the initial stages of the BLRS, the applicability of hydraulic numerical modeling in respect of Beira Lake was evaluated. Hydraulic numerical models are generally used to determine the general circulation pattern of a water body and evaluate the relative importance of water inflow and discharge in relation to the inputs of contaminants and their movements within the water body. However, considering that the Beira does not possess any natural feeder tributaries and since there is scarcely any

circulation in the lake, the consultants felt that the need for using a hydraulic numerical model was unnecessary.

Instead, the study team decided to use an empirical water quality model developed by H. J. Salas and P. Martino (*The Control of Eutrophication of Lakes and Reservoirs,* 1991) for tropical lakes. This type of model was better suited for the type of problems encountered in Beira Lake, since it permitted the evaluation of the lake's trophic level and of the relative contribution of the different pollution sources to the lake in terms of phosphorus loads. Contrary to the hydraulic model, the empirical water quality model considers both point and diffuse sources of pollution. It was agreed that diffuse sources of pollution represented an important proportion of the pollution load entering Beira Lake.

An important aspect that was unique to this study was the necessity to comply with certain security requirements. Defense Ministry clearance was an absolute requirement to conduct any surveys in and around Beira Lake, especially the Galle Face and West Lake areas which had been declared a high security zone. The approval was granted only for a specific day, during a specific time period and for specifically named persons on specific surveys (such as the collection of water samples from a boat). Even maps and aerial photographs of Beira Lake area were released only upon Defense Ministry clearance.

The SLPA boat was used for surveys of the lake, but securing of the boat was also not an easy task. Under these circumstances, obtaining the security clearance and arranging a boat for specific surveys at short notice (such as 24 hours after a heavy rainfall) was a challenge. However, the cordial and close relationship developed by the study team with the relevant agencies made logistics much easier.

There were ample opportunities for close interactions between the Canadian and Sri Lankan team members both in Sri Lanka (where the consultants visited frequently) and in Canada (where the Sri Lankan team members participated in technology know-how transfer). Even the time difference between Quebec and Colombo was effectively exploited to give what became an almost 24-hour working day for the team as a whole. The main events relating to the BLRS are chronologically summarized in **box 4.**

Box 5
Milestones of Beira Lake Restoration Study

July 1991 - draft Terms of Reference for the BLRS submitted.
November 1991 - Roche International, Canada ,submitted a study proposal to CIDA and the World Bank.
- Roche proposal accepted and three separate contracts/agreements entered into:

December 16, 1992 - between UDA and Roche.
January 4, 1993 - between CIDA and Roche.
January 15, 1993 - between World Bank and Roche.

December 1, 1992 - Official commencement of BLRS with the setting up of the project office at UDA.
December 7 - 17, 1992 - Inception mission by a three-member team of the Roche consultants.
February 2, 1993 - Presentation of draft inception report at BLRCC meeting.
February 9, 1993 - Inception report submitted to, and accepted by, BLRCC.
February 1993 - Visit by Canadian limnologist for one month to initiate and organize the environmental assessment of the lake.
February to June, 1993 - Environmental assessment of Beira Lake and its watershed carried out.
April 7, 1993 - Newspaper advertisement published to obtain public views and suggestions on restoring the Lake.
May 1993 - Visit of Canadian limnologist for two weeks to monitor progress of the study.
May 19, 1993 - Half-day workshop, "Beira Lake - Fresh or Saline Water," was held in Colombo under the auspices of the SLAAS.
May - June 1993 - Visit to Canada by project manager and hydraulic engineer for three weeks to work with Roche consultants on the Interim Report.
June 1993 - Submission of Progress Report to the World Bank.
July 1993 - Visit of four-member Canadian team to conduct a workshop in connection with Interim Report.
July 16, 1993 - Interim Report reviewed at a workshop held in Colombo.
September - October, 1993 - Visit to Canada of the water quality specialist for three weeks to work on the draft final report.
October 1993 - Visit by five-member Canadian team to conduct a workshop in connection with the draft final report.
October 18, 1993 - Workshop held in Colombo to review the draft final report.
December 1993 - Presentation of final report.
January 24, 1994 - Final report accepted by the BLRCC.
June 8, 1994 - The final report is honored with a Canadian Award for International Development (1994) presented at the 11th Annual CEA/CIA consultations in Hull, Canada.

Findings of Beira Lake Restoration Study

The results of the surveys and investigations carried out by the study team and the environmental assessment of Beira Lake, on which it was based, were documented in detail in the BLRS Final Report. The results are summarized in **boxes 5, 6, and 7** as follows:

Long-term Degradation of Water Quality	**1985**	**1992**
BOD_5	37.0 mg/L	70.0 mg/L
Orthophosphate	0.016 mg/L	2.388 mg/L
Turbidity	8.16	9.12

Average Water Quality Ranges in Major Outfalls	
BOD_5	129 - 179 mg/L
Suspended Solids	61 - 163 mg/L
Faecal Coliforms (no./100mL) [10^6]	0.2 - 180
Total Phosphorus	1.6 - 2.4

Mean Nutrient Values for Lake (1993)	
Total Phosphorus	1.52 mg/L
Total Nitrogen	13.74 mg/L

Core Sample Data
Core samples obtained indicate that the sediment layer is about 0.5 m thick except in the West Lake where it was 1.5 m

Box 5. Results of BLRS: Physical Environment

Physical Environment. The water quality of Beira Lake has so deteriorated with time that bathing or recreational activities involving prolonged water contact would be a health hazard. This is amply demonstrated by the testing results in **box 5**. This was complemented by an intensive monitoring program conducted during the study which further indicated that the water quality of the West and South West Lakes has deteriorated to a greater extent than that of the East and Galle Face Lakes. The studies also indicated that the organic pollution load entering the lake through the storm water network is very high.

Extremely high concentrations of nutrient (phosphorus and nitrogen) observed in Beira Lake is a clear indication that this body of water is at an advanced stage of eutrophication. The resulting microbial productivity leads to excessive generation of oxygen in the surface waters and its depletion in the lake bottom waters.

The conditions prevailing in the lake favor nutrient release from the sediments and increase the toxicity of some metals found in the water and sediments of Beira Lake. Concentrations of lead, zinc, copper, and iron are particularly high and sufficient to affect sensitive benthic organisms and resident fish species.

Box 6. Results of BLRS: Biological Environment

Reduction in Species Richness

- genera of algae in 1970 (14 green algae; 6 cyanobacteria)
- genera of algae in 1990 (5 green algae; 7 cyanobacteria)
- genera of algae in 1993 (0 green algae; 2 cyanobacteria)

Biological Environment. Investigation on the biological environment of Beira Lake covered five areas: phytoplankton, macrophytes, benthic organisms, ichthyofauna and avifauna. The number of plankton, benthic, and fish taxa present in Beira Lake has substantially decreased over the past decades. This reduction in the richness of the aquatic communities indicates the extent of Beira Lake water quality degradation. It is best exemplified by the change in the ratio of green algae to poisonous cyanobacteria over time **(box 6)**. By contrast, the terrestrial and aquatic flora show considerable richness.

The presence of cyanobacteria and their rapid growth as a thick surface mat has no doubt contributed to changing the characteristics of the water column. The extremely high level of primary productivity can cause large fluctuations in dissolved oxygen levels, create bad odors, change the pH of the water, and impede light penetration in the water column.

In 1954, twelve species of fish were reported for Beira Lake. The 1993 survey revealed only seven species of which the dominant one was *Tilapia*. Occasional severe reductions of oxygen levels and/or increase of ammonia concentrations may partly be the cause of the periodic fish kills observed in Beira Lake. The 1993 survey also indicated the presence of 22 species of birds in the near shore area of the lake.

Population	
Catchment area resident population	62,300
Core area resident population	6,800
Core area working population	4,400

Land Use: Catchment area	
Residential	26.0%
Institutional	18.5%
Commercial	15.0%
Utilities	8.0%
Roads and Reservations	14.0%
Others	18.5%

Box 7. Results of BLRS: Human Environment

Human Environment. The Beira Lake catchment area has a mixed land use character **(map 2)**. During the 1993 study, it was estimated that the total population of Beira Lake catchment area was approximately ten percent of the total residential population of the City of Colombo. Demographic and other data from the Beira lake area are given in **box 7**.

In Beira Lake core area, approximately 67 percent of the land mainly bordering the East Lake, the Galle Face Lake and the northern section of the West Lake are under government ownership where mostly public and semi-public institutions, defense establishments and warehouses are the predominant land uses **(figure 13)**. Five squatter settlements are located on the banks of the lake. There are 487 housing units for 573 families with a total population of 2,247 in these settlements.

After the liberalization of the economy in the country in 1977, Colombo experienced a marked increase in the construction of buildings; there has been a significant increase in such activities in the Beira Lake core area, too. Of the total premises surveyed in the core area, approximately 25 percent of the total floor space of existing buildings was added after 1978, most of it for commercial and institutional purposes.

Human activities on the lake include subsistence fishing which is exclusively carried out by a small community of fishermen mainly on the East Lake and involves up to 24 boats and around 50 fishermen. Other activities include recreational and competitive rowing and the use of mechanized boats for the activities of the SLPA as well as periodic patrols by security forces.

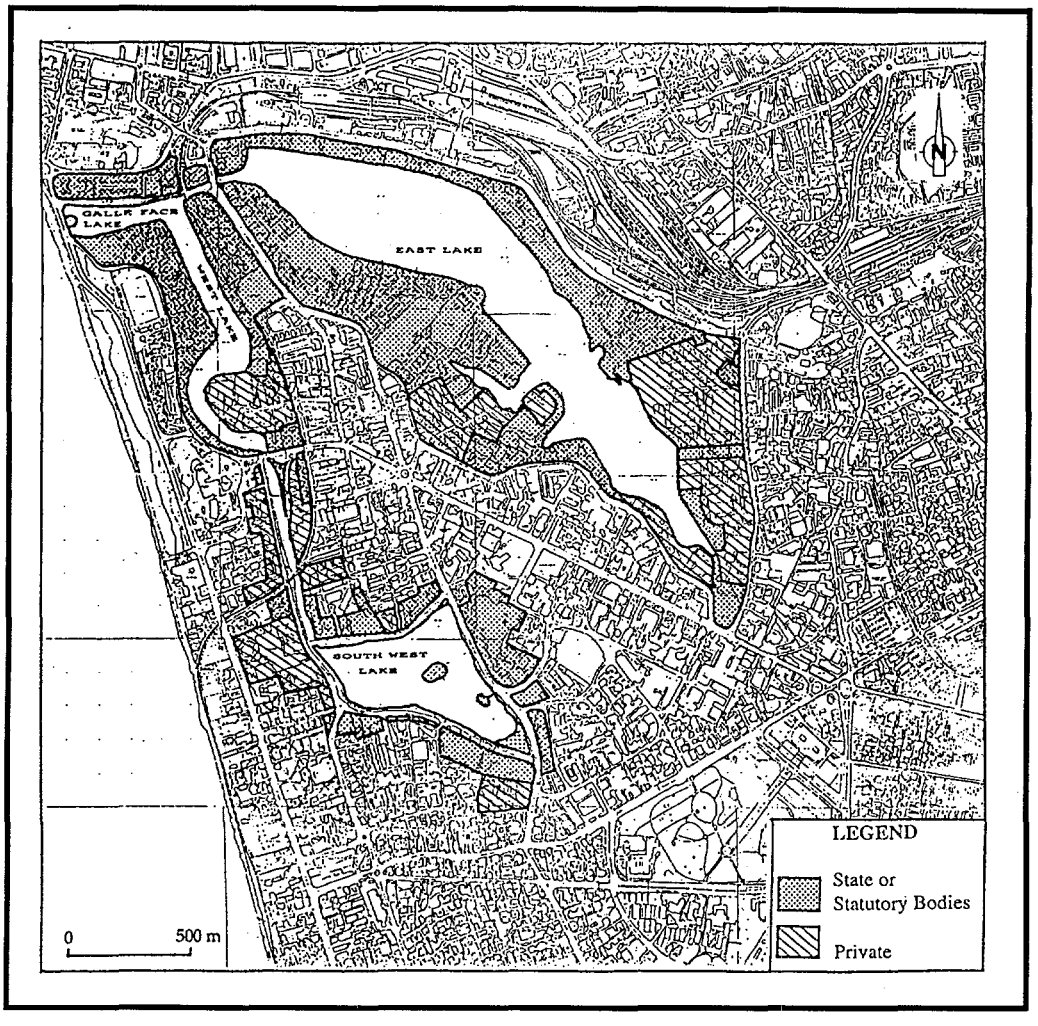


Figure 13. Ownership of lands in Beira Lake core area

Point/Non-Point Pollution Sources. Pollutant loads to the lake originate in the catchment either as point or non-point sources. ***Point source pollution*** represents pollution arising from a definite or discrete source, such as an industrial facility or sources that discharge water through a pipe or a similar outlet.

The 1985 NARA study revealed that more than a thousand outfalls from the catchment open into Beira Lake. The storm sewer network in the catchment is shown in **(map 1).** The 1993 BLRS survey monitored six major outfalls. The observed values confirmed that the organic pollution contributed by the storm-water network was very high.

The storm-water entering the lake is made up of run-off waters, waste-waters (sullage) and sewage. Storm-water drains receive waste waters from different sources (laundries, water stand-posts, vehicle service and repair shops, etc.) within the catchment. In addition, run-off, rain water passing through uncollected, scattered garbage piles bring nutrients, silt and organic matter into the drains. Further, wash water containing oil and grease from service stations and vehicle repair shops located in the Beira Lake catchment may also flow into the storm-water drains. During the dry season, there is limited flow in many of the storm-water drains, and this results in the building up of a significant amounts of organic matter and silt. During the rainy season this material is flushed into Beira Lake, contributing a considerable portion of the pollutant load.

Many premises located in the core area of Beira Lake still dispose their waste waters directly into the lake. Overflow of and percolation through ineffective soakage pits close to the lake possibly contributes to the nutrient load entering the lake. Another significant source of pollution is the waste water from the Colombo General Hospital that enters a major storm-water drain which eventually discharges into the Beira. Other possible sources include armed forces facilities and even major hotels which border the lake.

Sewage enters the storm-water system and, subsequently, Beira Lake through overflows from the sewer system, from unauthorized connections of sewer lines to the storm-water network and from overflowing septic tanks in the catchment. The sewage that reaches Beira Lake contributes to the high concentration of fecal coliforms observed in the lake.

Fortunately, no major sources of industrial effluent were identified in the catchment of Beira Lake since most industries located in the catchment are connected to the municipal sewer system. Only one major industry, Ceylon Cold Stores Limited, (a food and beverage producer) which borders the lake, discharges its effluent directly into the Beira.

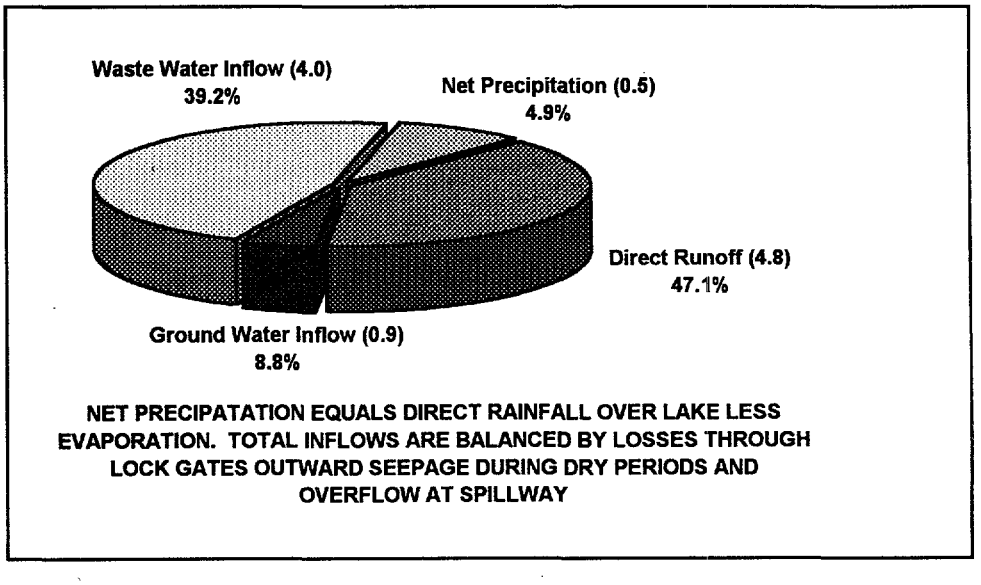
Non-point source pollution originate from silt, nutrients, organic matter, and other pollutant loads that are distributed over the catchment and are transported to the lake, either directly through run-off waters or through the ground-water system. Nutrients can also enter the lake from atmospheric fallout. This phenomenon, which is usually characteristic of urban areas, is a result of combustion emissions.

The repeated encroachment of the lake shores by squatter settlement communities has contributed to the reduction of the lake surface area and the degradation of the water quality. These populations use the lake for different purposes that contribute to its degradation. Among other things, the lake is used as an open sewer, a garbage disposal site and even as a landfill. The lake is used as a landfill at several locations where residents encroach upon the waters and enlarge their property by filling the lake with different materials.

Beira Lake Water and Nutrient Budget. Rainfall (directly or indirectly) represents the only natural source of water to Beira Lake. The overall average ***water budget*** of Beira Lake was established by considering the mean overall flow of all the contributing factors such as direct run-off, ground water infiltration (seepage), unauthorized sewer lines, evaporation, natural water retention and lake water management practices **(figure 14)**

The Beira Lake receives about 5.7 million cubic meters per year from the catchment area (14,48.21 hectare) composed of direct runoff (which contributes 4.8 million cubic meters per year) and to groundwater infiltration into the lake from the catchment (seepage which contributes the remaining 0.9 million cubic meters). Waste waters originating from unauthorized sewer lines are being discharged into the storm sewer network that leads to

Figure 14.
Annual water inflow into Beira Lake
(x million cubic meters per year)



the lake. Although discharge measurements taken at a few outfalls show great spatial and temporal variability, it was estimated that some 4.0 million cubic meters per year of water reach the lake on an annual basis. Net precipitation on the lake accounts for about 0.5 million cubic meters per year. Water loss from seepage through the lake bed, operation of the lock gates and industrial uses represents a water depletion of only 0.149 million cubic meters per year. It can be assumed that the excess water coming into the lake is lost through the semi-circular spillway (major) and leakage through both McCallum and St. Sebastian lock gates (minor).

Taking into consideration the uncertainties and assumptions previously mentioned, and excluding the outflow due to general water management, the overall mean water budget of Beira Lake can roughly be estimated between 9.95 and 10.05 million cubic meters per year.

Primary productivity is affected by ***nutrient availability***. According to the limiting nutrient concept, productivity will be determined by the abundance (and availability) of the substance that in relation to needs of the organism is least abundant in the environment. Nitrogen and phosphorus are the usual candidates. Thus, the reference figure for the ratio of total nitrogen to total phosphorus greater than 9.0 was used as an indication of phosphorus limitation in this study.

Based on the available information, it appears that 97 percent of the phosphorus load comes from the catchment via the storm-water network. Annually, the phosphorus loading of Beira Lake is estimated at approximately 9,500 kilograms of phosphorus.

RESTORATION STRATEGY

Objectives of the Strategy

To realize the goals of the proposed restoration strategy, obtainable, environmental quality objectives were identified with respect to water, sanitation, aquatic fauna and aesthetic standards, especially with regard to potential uses of the restored lake. Target environmental quality objectives designed to achieve these goals for both short-term (less than 5 years) and long-term (5 - 10 years) periods were determined **(figure 15)**.

Figure 15. Target Environmental Quality Objectives

	Short term *(< 5 tears)*	**Long term** *(5-10 years)*
Sanitary		
Fecal coliforms	50% reduction in storm sewer network. 50% reduction in the Lake	100% reduction in storm sewer network[a]. 100% reduction in the Lake[b]
BOD	70% reduction in storm sewer network -	85% reduction in storm sewer network; 6 mg/L in the Lake
Fish and Aquatic Life		
Ammonia	-	0.2 mg/L
Dissolved Oxygen	-	Concentrations should not fall below 4mg/L (daily minimum)
Aesthetic		
Chlorophyll-a	0.10 mg/L	0.08 mg/L
Total Phosphorus (as "P")	0.750 mg/L	0.15 mg/L
Total Kjeldahl Nitrogen (as "N")	-	6.1 mg/L
Transparency	50 cm	80 cm
Suspended Solids	45 mg/L	25 mg/L

[a] The proposed water quality objectives are yearly average concentrations (with the exception of dissolved oxygen). Because of the presence of extremely high fecal coliform concentrations.
[b] The fecal coliforms objectives should aim towards a 100% reduction, although in practice, there will still be a residual presence of fecal coliforms.

Central to the long-term success and the achievement of these goals is the reduction of pollutant loadings from the catchment. The goals of the proposed Restoration Strategy are:

- to control and reverse environmental degradation of the lake;
- to improve the sanitary condition of the lake in order to reduce the risk of health hazards to those persons carrying out activities involving limited water contact;
- to remedy the problem of periodic bad smells;
- to control nuisance algae;
- to provide water conditions capable of supporting living healthy aquatic communities;

- to improve the aesthetic quality of the built environment and conserve the natural environment of the lake and its shoreline;

- to provide and improve the recreational and public use potential of the lake for the local and tourist population;

- to provide opportunities for multi-use development and promote optimum utilization of lands and increase the commercial potential of the lake shore; and

- to create economic and employment generating activities especially for the local population.

Three Options Considered, One Selected

Based on the investigation carried out, and taking into account the views expressed during numerous discussions and consultations with local experts, the BLRS team selected a series of practical interventions, from a range of available restoration techniques, which could be successful in improving the condition of Beira Lake. These were chosen to ensure that the actions could be implemented at relatively low cost. Although some interventions were considered, such as the interception and/or treatment of the incoming effluent from storm-water drains, they were discarded due to lack of sufficient space; high cost of required infrastructure, and the fact that they would eliminate neither the causes nor the sources of pollution.

Instead, it was decided to trace all unauthorized sewer and sullage connections made to storm water drains in the lake catchment area. These would then be disconnected and diverted to existing or new municipal sewer lines. In some instances, pre-treatment of effluent would be required before final disposal into the sanitary sewer network.

Three restoration options were then developed and presented in the BLRS Interim Report and discussed at the workshop held in Colombo on July 16, 1993 (**figure 16**). All three options had three features in common, namely reduction of pollutant loadings to lake, dredging and bio-manipulation (such as the use of algae-eating fish). Two of the options involved dilution of the lake waters using water either from the Kelani Ganga or from the ocean. These were suggested as a means of increasing the water renewal of the lake

and thus, achieving a dilution of the pollutants present in the lake. However these were not favored by the participants.

Figure 16. Restoration Options Considered

OPTION 1	OPTION 2	OPTION 3
Reduction of pollutant loadings	Reduction of pollutant loadings	Reduction of pollutant loadings
Dredging	Dredging	Dredging
Filtration of algae	Dilution with freshwater	dilution with seawater
Stocking of algae-eating fish	Stocking of algae-eating fish	Stocking of algae-eating fish

The preferred ***Option 1*** recommended removal of algae through filtration and had the advantage of not requiring the use of external sources of water (central to the other two options) to rehabilitate the lake, which is of prime importance in Colombo where freshwater supplies are limited and required for human consumption. Option 1 was then incorporated with suitable modifications and developed into a restoration strategy with five main components, each consisting of a set of interventions to be implemented in a phased program with specific objectives as detailed in the following section. The cost of implementing the proposed restoration activities was estimated at approximately Rs.1,200 million (US$24 million).

In ***Option 2***, water collected from the upstream section of the Kelani (Ambatale) would have to be carried and pumped into Beira Lake through a water main, thus avoiding the use of polluted downstream waters. This option was discarded on a number of counts. Among the reasons for this is its prohibitive cost (since all water leaving Ambatale is purified and laying a new main would have been uneconomical) and the ecological impacts that it would have had both on the river (such as saline intrusion due to decreased flow caused by abstraction of larger water volumes) and the lake (introduction of large volumes of chlorinated water). Added to this is the fact that the Kelani can hardly cope with servicing the increased demand of fresh water for the city's water supply. ***Option 3***, which was rejected, consisted of pumping seawater into the most polluted sections of the Beira, namely the South West Lake, the West Lake and Galle Face Lake and constructing a dike to prevent saline intrusion into the East Lake. Thus one portion of the lake would be saline and the other fresh. This option was rejected because of the effects it would have had on existing ecosystems of

the lake and the adverse impacts it would have had on the groundwater table and possibly the foundations of buildings in the vicinity of the lake.

COMPONENTS OF THE RESTORATION STRATEGY

Reducing Entry of Pollutants

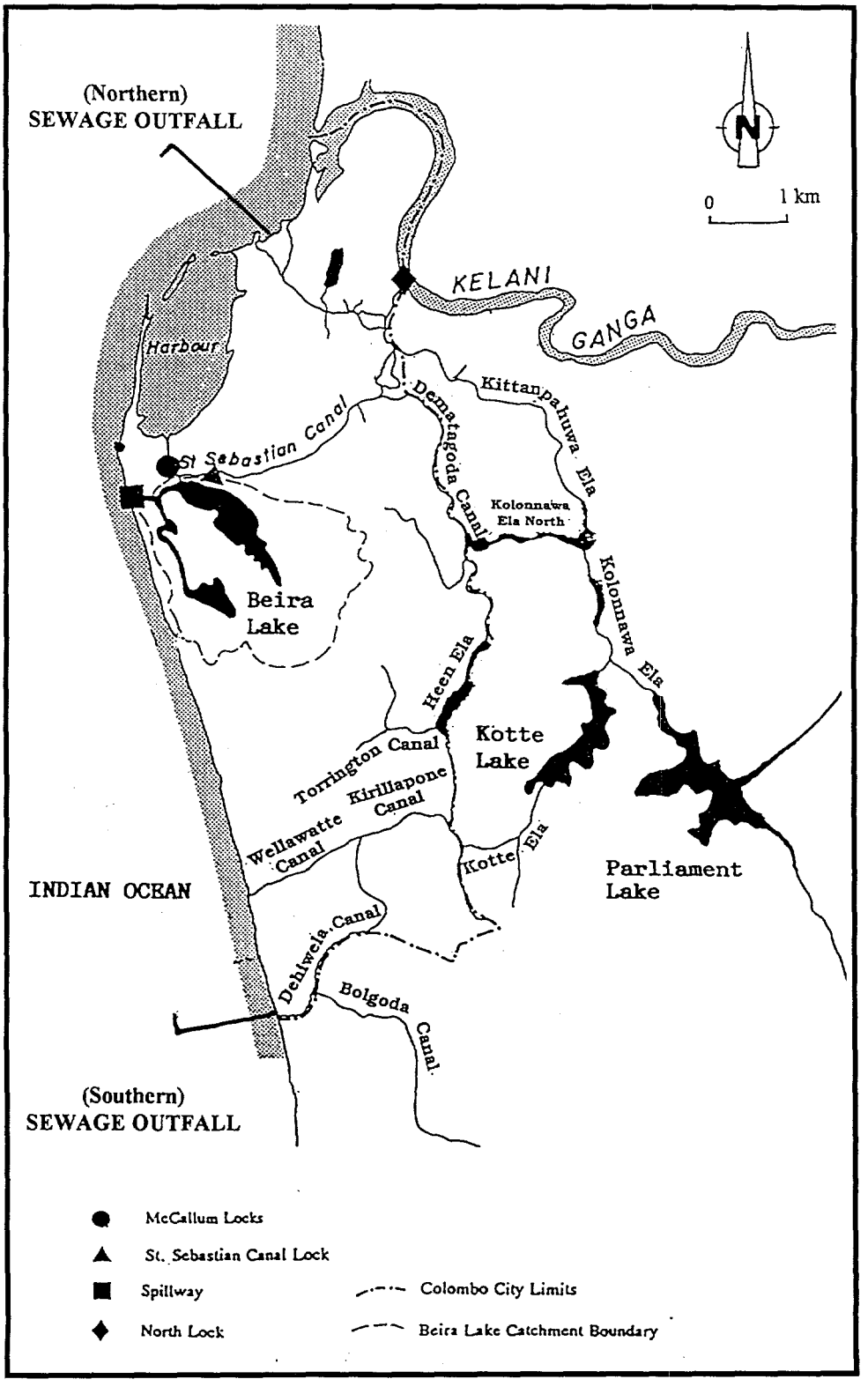
Central to the successful and sustainable restoration of the lake is the reduction of pollutant loads entering it from the catchment. This can only be achieved by a concerted attack on several fronts.

Disconnection of Unauthorized Sewer Lines. The NBRO survey proved conclusively that the storm-water network brings sewage into the lake. It was assumed that this was a result of unauthorized connections of sewage lines to the storm-water network. A field survey was carried out to validate this assumption by a CMC engineer who studied the storm-water network of five major outfalls, draining 7 out of the 24 sub-catchment areas. The survey showed conclusively that this was indeed the case, and by extrapolation of the results to the entire catchment, it was estimated that there were some 7,254 unauthorized connections.

Required interventions are identification and disconnection of all unauthorized sewage and sullage connections, including public water stand-post outlets and redirection of waste waters to the sanitary sewer network.

Reduction of Frequency of Sanitary Sewer Overflows. Colombo's sewer network is over ninety years old and at present its capacity is inadequate and in need of rehabilitation. The ultimate disposal of sewage, which takes place with only primary treatment, is through two 1,500 millimeter ocean outfalls -- a northern one off Mutwal which is 2,053 meters long, and a southern one off Wellawatte which is 1,394 meters long **(figure 17)**. The network has occasional overflow connections to the storm-water network. This is to prevent the backing up of sewers in the event of their failure during periodic pump house maintenance and the overloading of the sewerage system during excessive rainfall. However, because of small gradients in the sewerage system, excessive silting, and the frequent maintenance required to this aging system and pump houses, such overflows are becoming increasingly frequent. This probably contributes far more pollutants than all the individual unauthorized connections. The required

Figure 17. Northern and southern sewage outfalls



interventions involve plugging up the overflow connections, de-silting the network serving the catchment and rehabilitating the existing pump stations.

Reduction of Industrial Effluent Loadings. Only one major food processing plant has any outfalls into Beira Lake. This industry has already diverted its most polluting outfalls into the sanitary sewer network and has installed grease traps. The intervention required involves monitoring closely the effluent of this industry and the installation of more effective oil and grease separators. The other major source of pollutants is the General Hospital which discharges its waste water into a major storm-water drain [Norris Canal] which ends up in Beira Lake. This could be remedied by diverting all waste water into the sanitary sewer system.

Connection of Septic Tanks and Soakage Pits to Sanitary Sewer System. Not all of Beira Lake perimeter is served by a sanitary sewer network; one example is part of the East Lake perimeter. These areas are served by septic tanks and soakage pits which often overflow and discharge their effluents, either directly into or so close to the lake that the pollutants do not degrade before reaching the water. The intervention recommended here is the development of a new sewer network to serve these areas with a new or upgraded pump station facilities designed to accommodate the increased flows.

Improvement to Solid Waste Management. According to the CMC, the annual solid waste generation by residents in the catchment is approximately 24 million kilograms per year. Many problems related to disposal and management of solid waste (such as the lack of serviceable vehicles and equipment, reduced frequency of collection, lack of garbage containers, inappropriate and damaged temporary collection sites) result in garbage being scattered throughout the catchment. In addition, Colombo's municipal garbage disposal site, which is an open dump, is quickly reaching its capacity. Among the interventions suggested are the upgrading of the fleet of trucks, increased frequency of collection, improved temporary collection sites and containers, and suitable final disposal of the garbage.

Street Cleaning. This aspect was considered as a result of experiences gained from the Great Lakes basin of North America where it had been demonstrated that street sweeping proved to be a relevant remedial measure to control urban non-point sources of pollution. The suggested interventions

include increasing both the number of street sweepers and the frequency of cleaning with the provision of better equipment to improve the efficiency.

Upgrading of Squatter Settlements. The number of inhabitants in squatter settlements in Beira Lake margins has been estimated at 2,347. Discharge of raw sewage directly into the lake, from open latrines in close proximity to their dwellings, contributes to the overall fecal contamination of the water. Although it is by no means the largest overall contributor, its localized nature would constitute a health hazard to the inhabitants, especially the children who often swim in the vicinity. As a measure of improving the situation of these individuals, a proposal has been made to relocate the squatter dwellers to an area within the catchment itself where they would be given rehabilitated housing facilities.

Public Awareness Program. Lack of public awareness and apathy towards environmental conservation and protection is possibly a major factor contributing to the continuing degradation of the lake. Any sustainable restoration effort would have to galvanize the public into active participation to ensure the maintenance of the restored lake. The study suggested a public awareness program directed exclusively at Beira Lake and consisting of three phases. Phase I would convey the goals of the restoration program and would be implemented through billboards, posters, stickers and media coverage. Phase II would identify target groups/affected communities and orient them towards preserving the water body through awareness of the importance of the Beira, the need to restore and maintain it. Phase III would involve local participation in preserving the restored lake.

Engineering Studies. The Study recommended that before engineering works are undertaken, studies should be done (i) to quantify and determine the extent of siltation and need to de-silt the sanitary sewer network, (ii) to identify unauthorized sewer and water stand-post connections to the storm water network, (iii) study the contributions made by hospitals and industry, and (iv) to evaluate the adequacy of the existing pumping stations and identify the points where the sewer system overflows into the storm water system.

In-Lake Restoration Techniques

These interventions would accelerate the restoration process and control nuisance algae once pollutant loadings to the Lake are significantly reduced.

A variety of alternatives available for the restoration of eutrophic lakes were considered with regard to their applicability to Beira Lake.

Beira Lake is a hypertrophic, shallow, tropical lake whose waters do not show a permanent stratification. A thick layer of sediments rich in nutrients and organic matter is present at the bottom of the lake. These physico-chemical characteristics appear incompatible with those necessary for the effectiveness of several restoration procedures aimed at controlling nuisance algae. More specifically, phosphorus precipitation, sediment inactivation, hypo-limnetic aeration or withdrawal, and artificial circulation have thus been discarded from the array of restoration techniques potentially applicable to lake systems.

Phosphorus precipitation would require an immense amount of alum, and the stability of the flocculated material overlaying and inactivating the sediment would be jeopardized by factors which cause turbulence (e.g. winds, emanation of methane, etc.). Similarly, artificial circulation of bottom waters may displace the loose sediment and result in negative effects such as an increase of the BOD and COD leading to oxygen depletion. The shallowness of the lake is also associated with a lack of permanent thermal stratification, and the absence of a true hypo-limnion which effectively prevents the application of both hypo-limnetic aeration and withdrawal. Moreover, these last two techniques are not commonly used and are still at an experimental stage.

Three in-lake restoration procedures have been retained for their potential effectiveness and their applicability to Beira Lake: dredging of sediments, filtration of algae, and the stocking of algae-eating fish.

Dredging. The most enriched layers of the lake sediments could be removed by dredging which would thereby reduce nutrient release from the bottom sediments and result in lower in-lake nutrient concentrations and reduction in algal "blooms." Prior to this, the removal of surface debris and any remaining sunken barges would have to be undertaken.

The coring studies undertaken indicated that the top layer of sediments and the organic clay layer beneath must be removed to limit or eliminate the above problems. Estimates of the total volume of material to be dredged is approximately 600,000 cubic meters. Disposal of dredged material would be at sea subject to the necessary environmental safeguards.

Filtration of Algae. Removal of algae would constitute another way to remove lake nutrients which have become incorporated in the algal biomass. Of the available technologies for removing cyanobacteria, the drainage table method was deemed most suitable. Here the algae-loaded liquid would be pumped slowly onto a continuously moving canvas filter belt. The algal biomass that collects on the belt would be scraped off and disposed of. The entire unit would be fitted on a barge which would also have a generator to power the unit and detachable containers to receive the biomass removed from the water. Preliminary experiments carried out during the study showed that a one-stage (50 micron) filter would remove approximately 50 percent of the suspended solids and with it 50 percent of the total phosphorus in the water. It is expected that approximately 10 tons of dried algal sludge would be extracted each year at a pumping rate of 100 cubic meters per hour.

Stocking of Algae Eating Fish. The use of algae-eating fish as potential biological control agents constitutes a relatively inexpensive partial solution to the problem of algal "blooms." Introduction of *Oreochromis* fingerlings which are herbivorous may help to control nuisance algae while enhancing the fishery potential of the lake.

Shoreline Beautification & Recreational Facilities

An evaluation of the existing problems, needs and potential of this urban water body and its verges, in respect of landscape and recreational potential, led to proposals for:

- maximum use of the water surface for recreation and passenger transport without conflict and management problems; and

- redevelopment of surrounding lands according to a comprehensive urban design including visual integration of the lake into the fabric of the City and providing necessary public open spaces.

Recommended water-based activities include a mix of water buses, group pleasure boating, rowing and canoeing, with pedalos in one small bay. The study also recommended the creation of a typically urban waterfront, catering for optimum pedestrian access and intensive use, while including maximum possible compatible vegetation. The planting concept requires the establishment of a luxuriant tropical vegetation character which would contribute substantially towards a "green lung" for the City while providing

shade, coolness, dust reduction and beautification and helping to decrease pollutant inflow to the lake.

Also suggested was the creation of linear parks varying from 6 to 12 meters in width and wider nodal parks including recreation facilities with landmark and focal feature buildings at the water's edge or on the water at carefully chosen locations. Small bays would be preserved to add interest and cater for smaller scale water recreation activities (e.g. pedalos).

The study proposed that following the dredging operations, unstable banks be stabilized, mostly by gabion structures, while selected small coves would have "pebble and boulder beaches" or "natural banks." It has been recommended that a plant nursery equipped with suitable vehicles and machinery be set up in advance of restoration work on a priority basis to meet the forecasted need for appropriate plant material (especially semi-mature trees) and to undertake actual planting and initial maintenance. At the same time, clearing of the shoreline, temporary fencing and cleaning of the areas earmarked for linear and nodal parks would be needed.

Land use zoning

Present Development Plan. The physical developments and the management of land uses in the Beira Lake catchment are guided by the City of Colombo Development Plan (1985) of the UDA. According to this plan, the lands in the Beira Lake catchment area generally fall under four land use zoning categories: Primary Residential, Mixed Residential, Commercial, and Public and Semi-Public, while some lands are designated for specific uses.

The type of uses that are permitted as well as the activities that are prohibited in different land use zones are defined in the Development Plan. It also indicates the permissible building densities, in terms of Floor Area Ratio (FAR), for sites in different areas. The Development Plan has also specified some planning guidelines for Beira Lake and its surroundings. However, the objectives of the Development Plan in respect of the land use characteristics and environmental improvement around Beira Lake has not been fully realized through present planning practices and also due to the lack of direct and adequate intervention on the part of the government authorities concerned.

Unauthorized development in properties abutting the lake generally negates the planned objective of achieving and maintaining a pleasant environment. Encroachment of the water body has taken place by the squatter settlers and by established property owners and legal occupants around the lake, in spite of the 20-feet-wide lake reservation stipulation in the UDA Development Plan and the SLPA claim for the ownership of a 6 feet-wide strip of land along the border of Beira Lake. Implementation of planning guidelines regarding the prohibition of warehouses, workshops, etc. around Beira Lake is not possible within the context of the present development control practices, since such activities are permissible to a limited extent in the areas designated as mixed residential and commercial zones. Therefore, it was found necessary to identify specifically both desirable and undesirable types of uses, with a view to encourage compatible uses, and determine the appropriate intensity of development allowable for different areas of the Beira Lake surroundings.

Development Potentials and Desired Uses. It was noted that the catchment area of Beira Lake, especially the immediate surroundings of the East Lake possess an extremely high potential for commercial, residential, recreational, cultural and tourism-oriented development of high environmental quality. Accordingly, the following activities have been identified as the most desirable uses around Beira Lake. Based on this list, and having evaluated the compatibility of the existing activities of the premises around the lake, the study team formulated a conceptual development plan for the Beira Lake Core Area.

Commercial: retail shops, departmental stores, super markets, offices banking institutions, consumer service establishments, professional service establishments, business services (e.g. airline offices);

Residential: luxury apartments; residential hotels; high density, middle-income housing;

Cultural and Recreational: cultural centers, gymnasium/games centers, exhibition centers, cineplexes, clubs/bars and restaurants, parks and playgrounds, promenades, floating restaurants, art galleries and museums, community centers for socio-cultural activities, outdoor recreational spaces with special emphasis on water sports;

Others: environment friendly activities (even factories). Utilities such as car parks to facilitate the above uses.

Undesirable uses. The following are the activities identified as undesirable uses not only from an environmental point of view, but also considering their inability for optimal economic utilization of lands.

Industries and Workshops: Manufacturing industries and workshops producing effluents and wastes, automobile repair workshops and service stations. Boat building and repairs, beverage factories;

Others: Stores and warehouses, container yards, agriculture and livestock farming, wholesale trade, high security establishments.

Proposed Plan In the proposed Development Plan, the core area is divided into different sections of blocks under the "Dominant" land use categories: commercial, residential, cultural and recreational, mixed development of desired uses, parks and playgrounds, and areas designated for specific uses

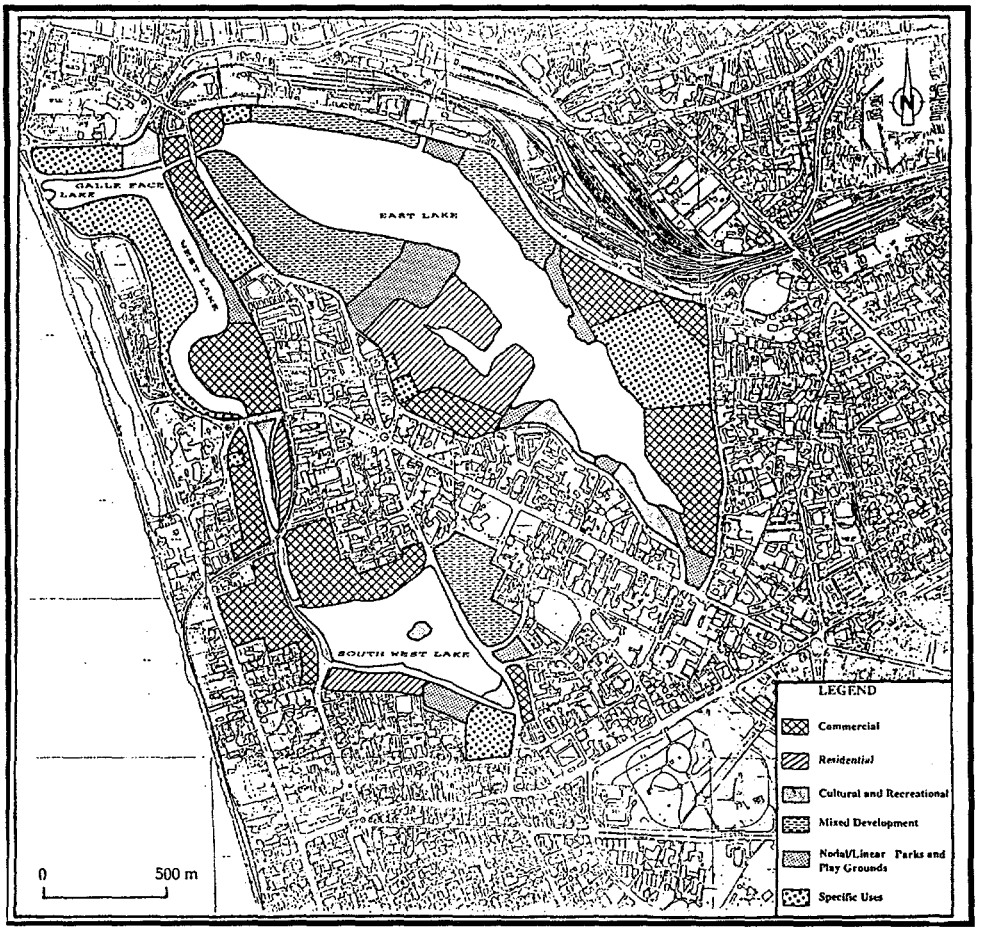


Figure 18. Proposed zoning plan for the Beira lake core area

(figure 18). This classifications has been made taking into consideration such factors as: land ownership, land values, property sizes, status of existing developments, demand for development, traffic circulation patterns, and need for better environmental quality standards. In addition to the land use specifications, the proposed plan also defines planning guidelines for building densities, land subdivisions, plot coverage, building line setback from the lake, and urban design practices in respect of each area category of the development plan.

Lake Management

Management of the Lake Water Level. The operation of the McCallum lock gates is under the supervision of the SLPA. The lock gates are used for the transport of small boats and barges from the congested port facilities to the SLPA boat repair facilities on the Beira Lake shoreline. Presently, the McCallum lock gates are used on the average about 15 times per month.

The water losses result from (a) an increased operation of the McCallum lock gates, (b) evaporation on the lake surface, (c) seepage through the aged lock gates, (d) seepage through the lake's bottom and (e) industrial and commercial uses. These may contribute to lower water levels and deteriorate the lake's water quality during the dry seasons, when evaporation reaches its highest values, rainfall is minimal, and the water table is at its lowest.

The reduction of water-borne pollutant loadings from the storm-water network will reduce the water inflow to the lake. The impact of this reduction on the water budget of the lake was studied in order to determine if it would result in an important draw-down of the lake's water level during the dry seasons. Calculations revealed that this would cause the lowering of the water level by about 0.35 meter.

Flood Control. The BLRS team also considered the possible use of Beira Lake for flood control as requested by SLLR&DC, since the Colombo North area is subject to periodic flooding during the rainy season. In order to prevent such flooding, the SLLR&DC had proposed the rehabilitation of the San Sebastian Canal, including the San Sebastian lock gates, and to direct the excess water towards Beira Lake. This solution would also involve some modifications to the existing structure of the semi-circular spillway in order to accommodate the excess flow.

However, considering the poor water quality of the San Sebastian Canal, the study team was of the opinion that directing water from the Canal into the Beira would have an adverse impact on the water quality of the East Beira Lake and thus would jeopardize the restoration efforts put into the least polluted section of Beira Lake. Flood waters carry significant amounts of suspended solids, nutrients and organic matter. Until the water quality of the San Sebastian Canal is improved, the use of Beira Lake for flood control was not recommended unless its use is limited to extreme cases or in emergency situations.

Institutional Arrangements for Project Implementation

One of the institutional problems that was identified during the Beira Lake Restoration Study was the multiplicity of government organizations that have their own limited and specific responsibilities over a given activity or area of Beira Lake, its shoreline and catchment.

The multiplicity of organizations which take responsibility for the lake and its catchment has led to a situation where no single organization is responsible for the lake and catchment as a whole, and where the specific concerns and interests of the various organizations sometimes differs with those of lake preservation. The study team found that the interventions proposed to reduce pollutant loadings would fall under the purview of the following institutions according to their current responsibilities:

- **UDA**: Coordination and implementation
- **CMC**: Disconnection of unauthorized sewer lines; improvement to solid waste management; street cleaning; reduction of the frequency of the sanitary sewer system overflows; connection of the septic tanks and soakage pits to the sanitary sewer system
- **NHDA**: Upgrading squatter settlements
- **SLPA**: Maintenance of the lake
- **SLLR&DC**: Assisting SLPA in the maintenance of the South West Lake
- **CEA**: Reduction of industrial effluent loadings
- **NWS&DB**: Necessary coordination in the Implementation of the Greater Colombo Waste-water and Sanitation Master Plan

The study team proposed that the restoration and the development of Beira Lake's potential should be coordinated by one organization that would have the overall responsibility of restoring and preserving the lake and its catchment. This is because it is more efficient to assign overall management of related environmental programs to a single agency than to have separate governmental units dealing with each problem as it arises. By having one entity responsible for the restoration, development and preservation of Beira Lake and its catchment, the public will have one clearly identified and readily accessible body to voice their concerns and opinions.

Monitoring Program and Enforcement

Monitoring Program. Given the Lake's present condition, it will take several years, after the sources of pollution are controlled, to produce observable results. In order to assess the impact of the phase I interventions, a monitoring program will be implemented throughout the project duration and continue after the physical completion of project supported engineering works. The objectives of the monitoring program are threefold: (i) to quantify the improvement of water quality in storm water outfalls discharging into the lake, (ii) to monitor the lake's water quality, and (iii) to establish a temporal representation of the lake's condition to enable assessment of additional interventions which may accelerate its restoration.

If properly designed, the results of such a program would indicate the success or failure of the restoration efforts attempted. Water quality monitoring of selected ***storm-water outfalls*** would give a representation of the status of the lake. The parameters to be monitored would include total phosphorus, total nitrogen, COD, BOD_5, total suspended solids, fecal coliforms and flow rate. Water samples would be collected at the six outfalls once every three months throughout the duration of the engineering works during the dry season at the same hour and on the same day of the week.

This program would measure the ***lake's water quality*** improvement during the implementation of the restoration strategy and enable additional interventions to be initiated, if required. Thus it would serve as a management tool in the implementation of the restoration strategy. Water samples would be taken at mid-water column depth and be carried out once every three months at the nine sampling stations used by the NBRO during the 1993 BLRS program. The following parameters would be monitored:

total phosphorus, total nitrogen, COD, BOD_5, total suspended solids, fecal coliforms and chlorophyll-a.

Following the completion of phase I restoration work, the water samples will be collected and analyzed once a year against an expanded list of parameters covering physical, chemical and biological aspects of the lake. These would include: Physical (temperature, turbidity, transparency, suspended solids, odor); General Chemical (pH, conductivity, hardness, BOD_5, COD, dissolved oxygen); Inorganics (total nitrogen, nitrate, nitrite, ammonium, total phosphorus, orthophosphate, and the following heavy metals: iron, cadmium, chromium, nickel, lead, zinc, copper and mercury); Organics (oil and grease); and Biological (chlorophyll-a, fecal coliforms). In addition, an oxygen, temperature & pH vs. depth profile of the water column would be carried out twice a year (once each during wet and dry seasons).

Diversity and variety of aquatic biology can be used as ***indicator organisms*** of improving water quality and consequently serve as a measure of the "health" of the lake. This would involve determining the species composition of the phytoplankton communities once every two years at sampling stations in the East and South-West Lake. Increased diversification from almost exclusively cyanobacteria to a more mixed plankton community including diatoms would indicate improving "health" of the lake.

In addition a systematic monitoring program of the fish communities and checking for heavy metals (mercury, chromium, cadmium, copper, lead, zinc, arsenic, nickel) in the flesh of commercial-size fish could also be carried out annually once phase I restoration works are completed.

Enforcement. While public awareness is crucial for long-term control of pollution, in some cases, enforcement is the only way to control pollution where prevention has failed. While there are adequate laws to monitor and control pollution in Sri Lanka, effective implementation of these laws is a problem. This is due to a variety of reasons not the least of them being the lack of personnel and resources. The area around the Beira would have to be declared a special project area under UDA law and special regulations will have to be formulated. Thus, illegal reclamation of the lake and the dumping of garbage on its shores would have to be severely punished. A special team drawn from relevant state agencies would regularly inspect and

monitor water and environmental pollution of the area. Periodic verification of unauthorized connections to storm-sewer network should be done in the catchment and violators should be prosecuted. A special service force would patrol the lake ensuring the security of the area and prevent encroachment, littering, dumping, vandalism, and settling of new squatter settlements in the nearshore area.

ACTION PLAN FOR A CLEAN BEIRA LAKE

According to the BLRS, the five components of the proposed Restoration Strategy were translated into an Action Plan to be implemented over a ten-year period in two phases (phase I - year one to four; phase II - years five to ten). A combination of technical, social and institutional interventions were suggested as follows:

Component 1: Reduction of Pollutant Loadings into the Lake addressed pollution entering the lake from its catchment. Interventions included the engineering works required to improve or rehabilitate the existing sewerage system in the catchment; reduction of industrial effluent; improvement to street cleaning and solid waste management and upgrading squatter settlements. Further, to make these interventions effective, carrying out of an environmental public awareness program was also proposed. These interventions were to be implemented during phase I of the restoration program.

Component 2: In-Lake Restoration Procedures involved dredging, filtration of algae and the stocking of algae-eating fish aimed at accelerating the rehabilitation of the lake and controlling nuisance algae. These actions were to begin during phase I and continue through phase II.

Component 3: Shoreline Beautification and Development of Recreational Facilities dealt with cleaning the shoreline, stabilizing banks, appropriate landscaping, creating parks, walkways and developing recreational facilities aiming at opening the lake shore to the public. These elements of the restoration program were to be implemented throughout both phases.

Component 4: Lake/Catchment Development and Management Program covered the institutional responses necessary to ensure proper management and maintenance of the lake once restored, together with

appropriate and compatible development of the lake surroundings. These aspects were to take place mainly during phase I.

Component 5: Monitoring Program and Enforcement aimed at providing the necessary tools to monitor the progress of the restoration and enforce the regulations required to ensure sustainability of the restored lake. These activities were to begin during phase I and continue as required.

Significant improvement of the water quality in Beira Lake is expected to be observed during years 4-6 of the action plan, after which the water quality would slowly improve further and reach an equilibrium. Most recreational and tourist facilities would be provided for during phase II of component 3. However, the actual implementation of the above action plan is being carried out with some modifications, necessitated by fiscal and practical constraints.

Public awareness of Beira's potential will help in its restoration goals

IMPLEMENTATION OF PHASE I OF ACTION PLAN

The environmental initiatives begun by MEIP resulted in GOSL seeking funding from IDA, the soft loan window of the World Bank, to implement some of the initiatives. The result of this was the development of the Colombo Environmental Improvement Project (CEIP) which became effective in December 1995. The total cost of CEIP is US$49 million, of which US$13 million has been assigned to effect improvements to Beira Lake by implementing the priority actions in the BLRS Action Plan.

UDA has been charged with the role of implementing the plan and project components **(figure 19)**. The priority package includes the following in component 1:

- Interception of unauthorized waste-water outlets now discharging to the storm drainage system and connecting them to the existing sewerage system (components 1.1 and 1.4);

- Reduction of sewerage overflows through cleaning sewer lines, rehabilitating pumping stations and adding a sewer line on the northwest bank of the East Lake (components 1.2, 1.3 and 1.5).

The following activities relating to components 1, 3 and 5 will be part of the technical assistance package to UDA financed through CEIP:

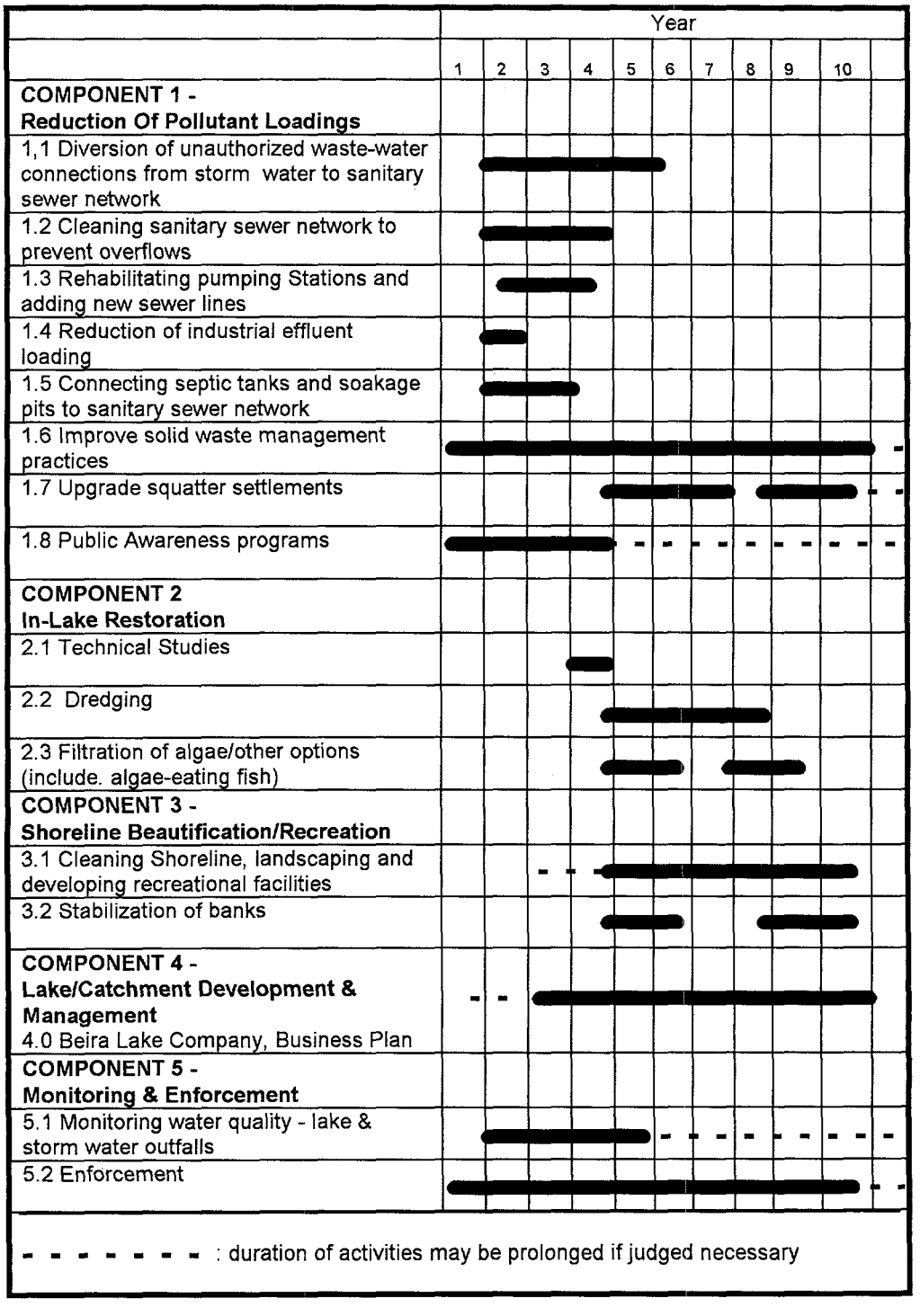
- Carrying out an environmental public awareness program;

- Formulation of further restoration measures for the lake such as technical studies for future in-lake restoration activities, and

- Implementation of a program to monitor the water quality of storm-water outfalls opening into the lake and the lake itself.

It should be mentioned that the improvements to solid waste management in the Beira catchment proposed under component 1 of the BLRS Action Plan will be addressed under the proposed Municipal Solid Waste Management Project for Colombo, also being funded under the CEIP.

Figure 19. Beira Lake Restoration Action Plan, Proposed Implementation Schedule



COST RECOVERY

The improvement and development of Beira Lake should not be a burden on the public budget, in view of the low-income level of Sri Lanka, and the fact that private interests will benefit from the lake improvement. Most of the improvement costs are, therefore, intended to be recovered in a variety of ways, related to those who pollute the lake and who benefit from its improvement. The types of cost recovery are described below, related to the components in **figure 19**.

User fees. The costs related to improving the sewerage system and collection (components 1.1, 1.2, 1.3 and 1.5) would be paid by sewerage connection charges to polluters and a general surcharge related to overall improvements of the sewerage system. Solid waste management would be covered through local property tax increases or a separate fee (component 1.6). The upgrading of squatter settlements would be fully or partially recovered from the residents, based on their ability to pay through sale of titled plots or lease charges.

Regulation. Private industries (component 1.4) would be required to institute pollution control at their own cost, or face heavy penalties.

Commercial enterprise. The BLRS also conducted a cost benefit analysis which explored methods by which cost recovery of the investment on the lake restoration could be realized. This was based on the premise that there would be a demand for commercial, rather than residential, occupation of the restored lake shore area by those who would be willing to pay a premium for this privilege, thus contributing to the recovery of costs. Commercial establishments would also have a greater ability, and a vested interest, to pay towards the continuous maintenance of the lake compared to households. In addition, a restored lake with proper public access would contribute to improving the quality of life of its numerous users. The cost benefit analysis concluded that the project would prove to be financially viable based on the largest component of marginal benefit, the increase in land value due to restoration.

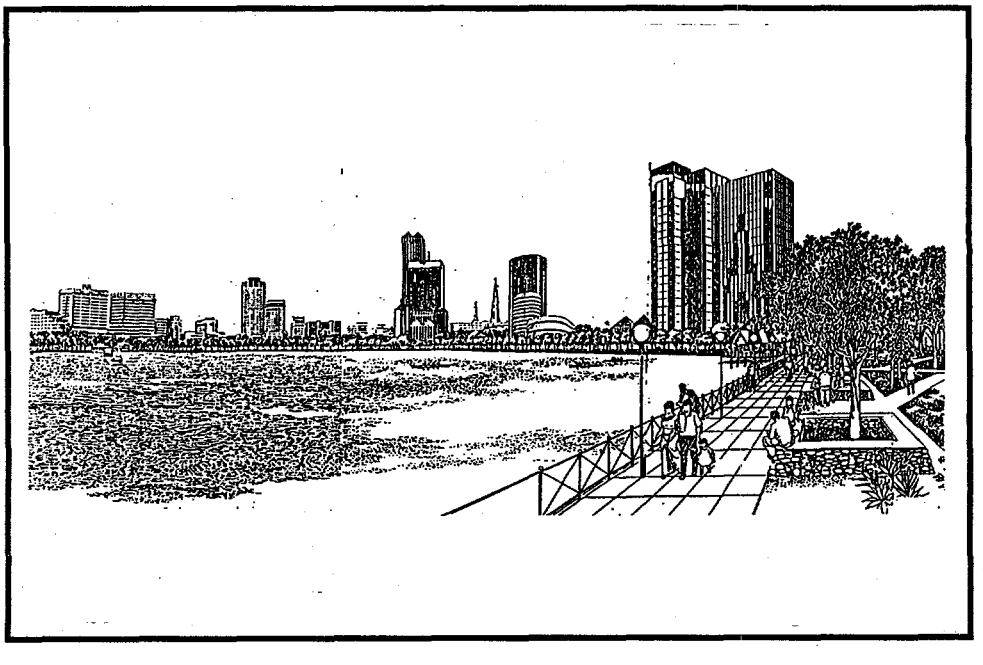
Equity financing. With regards to the other main components, In-lake Restoration (component 2.0), Shoreline Beautification/Recreation (component 3.0) and Lake Catchment Development & Management (component 4), these benefits accrue primarily to the landowners and

developers around the lake and should be supported by them. Therefore, it was proposed that the vehicle for management and development of the lake surroundings should be a public-private partnership of government agencies and the private sector in a joint venture tentatively named the Beira Lake Company (BLC). This development corporation could raise equity on the financial markets, and tax its members for the costs of development and operations.

Subsequently, the restoration project would have long-term social and economic benefits by generating new employment, sustaining the know-how and appreciation of the unpolluted sites; and reducing some maintenance and community health-related costs, adding also the unquantified benefits of an aesthetic environment that improves quality of life for all who would use this improved area of Colombo.

During the project preparation phase of CEIP, formulation of a business and development plan was initiated by the UDA and the necessary consultancy services were obtained for its preparation. The business plan would serve as a basis for structuring the BLC as a joint venture and to produce information necessary to seek private sector participation. The Scope of Work of the Business Plan is summarized in **box 8.** The plan is expected to be completed early in 1996.

Proposed development of the shoreline along the East Lake



1. Identifying lands to be planned and developed under the purview of Beira Lake Company (BLC).
2. Preparing a Master Plan for land development.
3. Reviewing existing laws and regulations to promote and stimulate investments and development relevant to the Project tasks and the BLC.
4. Recommending revisions and improvements as necessary to existing laws and regulations to ensure maintenance of restored condition of the Lake.
5. Establishing the Market Feasibility of the Development Proposals and opportunities for growth.
6. Determining the optimum structuring of BLC.
7. Preparing proposals for the establishment, organization and structuring of BLC
8. Investigation and identification of possible sources of private capital.
9. Preparation of a project schedule.
10. Preparation of a brochure to present the Business Plan to prospective entrepreneurs
11. In addition:
    (a) Recommending a strategy for rehabilitation of shanty dwellers and Role of BLC in the task.
    (b) Identifying employment opportunities created through BLC

Box 8.
Scope of work for Beira Lake Company

IMPLEMENTATION OF PHASE II OF ACTION PLAN

The success of phase I activities and the proper functioning of the Beira Lake Company are expected to lead to the implementation of the other activities suggested in the BLRS Action Plan. These will include dredging, mechanical or biological actions to clean the lake and control algae (as per the studies to be carried out in phase 1 under the CEIP), shoreline beautification and development of recreational facilities, development of the surrounding lands and necessary enforcement measures.

ACHIEVING A SUSTAINABLE ASSET FOR COLOMBO

The concept and overall objective of the proposed development strategy is to integrate the restored lake into the city where the lake will act as a catalyst for comprehensive development of appropriate, compatible and desirable uses of the living, working, traveling, marketing, shopping, entertainment, socio-cultural and recreational activities of the people in a functionally more efficient and aesthetically more pleasing environment.

Owing to the neglected and unpleasant status of Beira Lake as highlighted in the previous chapters, the full potential of the lake as an aesthetic, ecological and economic resource for Colombo City has not been realized. As discuss in Chapter Three, previous restoration efforts were unsuccessful. These failures can be attributed to addressing the physical problems in only a partial manner, and to the inadequate capacity of existing government organizations to monitor and implement pollution control regulations and to properly operate and maintain the sewerage, drainage and solid waste collection systems.

One of the objectives of the current Beira Lake Restoration Project is, therefore, to find and implement viable solutions for a sustainable restoration of the lake. The present approach to restore the lake is one that recognizes the importance of this body of water as a valuable asset and combines its restoration with a long-term opportunity for growth and development. This development, in turn, is one that guarantees sustainability of the restoration works by allowing for the generation of revenue. Such an approach would ultimately result in the upgrading of the living conditions of all inhabitants of the City of Colombo.

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LIST OF ABBREVIATIONS

BLC	Beira Lake Company
BLMC	Beira Lake Monitoring Committee
BLRCC	Beira Lake Restoration Coordinating Committee
BLRS	Beira Lake Restoration Study
BOD	Biochemical Oxygen Demand (BOD_5 -five days BOD)
CEA	Central Environmental Authority
CEIP	Colombo Environmental Improvement Project
CETF	Canadian Environmental Trust Fund
CIDA	Canadian International Development Agency
CMC	Colombo Municipal Council
COD	Chemical Oxygen Demand
CPC	Colombo Port Council
EMS	Environmental Management Strategy
FAR	Floor Area Ratio
GOSL	Government of Sri Lanka
ha	hectare (= 2.47 acres)
IDA	International Development Agency of the World Bank
MEIP	Metropolitan Environmental Improvement Program
MSL	Mean Sea Level
NARA	National Aquatic Resources Agency
NBRO	National Building Research Organization
NESC	National Environmental Steering Committee
NGO	Non Governmental Organization
NHDA	National Housing Development Authority
NPC	National Program Coordinator
NWS&DB	National Water Supply and Drainage Board
Rs	Rupee (1 US$ = Rs 50)
SLAAS	Sri Lanka Association for the Advancement of Science
SLLR&DC	Sri Lanka Land Reclamation and Development Corporation
SLPA	Sri Lanka Ports Authority
UDA	Urban Development Authority
UNDP	United Nations Development Program

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RESIDENTIAL	House Hold Units	Detached / Semi Detached	Hp
		Flats & Apartments	Fl
	Residential Hotels		RH
	Transient Lodgings & Guest Houses		GH
	Hostels & Group Quarters		QR
	Mixed Residential		MR
	Other Residential	Slums & Shanties	Ss
MANUFACTURING INDUSTRIES			I
		Automobile Repair Workshops	So
TRANSPORT, & UTILITIES	Transport	Rail Roads & Railway Yards	RL
		Railway Stations	Rt
		Automobile Parking	AP
	Utilities	Stores & Warehouses	St
		Service Stations	Ss
		Cemeteries & Crematoriums	Cb
		Utilities (general)	Ut
COMMERCIAL	Retail Trade		
COMMERCIAL BANKING & ALLIED	Banking Institutions		CB
	Personal (Consumer) Service and Professional Service Establishments		Cp
CULTURAL ENTERTAINMENT & RECREATIONAL			CE
	Cultural Activities & Nature Exhibition		CL
	Amusement Cinema Houses & Video Centres		AM
	Clubs, Bars & Restaurants		Rs
	Parks & Playgrounds	Parks	P
		Public Playgrounds	PP
INSTITUTIONAL (Public & Semi-Public)			IN
	Educational, Training, Scientific & Research Institutions		El
		Schools	Es
		Universities	Eu
		Libraries	El
	Health Institutions		H
		General Hospitals	Hg
		Nursing Homes	Hn
	Religious Institutions	Temples	Rt
		Churches	Rc
		Mosques	Rm
	Community Organizations		CM
	Administrative Organizations	State	As
		Embassies	Ae
		Post Offices	Po
VACANT & NON URBAN USES	Unused Land Area	Undeveloped or Unimproved Land	OP
	Vacant Buildings		VB
	Building Construction & Demolition Site		BC
	Water Areas		W
	Beach		B
OTHER	Defence Uses	Army Uses Airforce Uses	

Beira Lake's catchment boundary

1 Sub-catchment number and boundary

Source : BLRS Survey, 1993

Existing land uses in the Beira Lake catchment

Project No : 15016
Date : December, 1993
Scale 1 : 10 000
0 50 100 200m

Base Plan Source : NORPLAN, A/S OSLO, NORWAY, 1993

By Courtesy of ROCHE INTERNATIONAL

Map 2