

CHAPTER 6

SYSTEM OPERATIONS

6.1 Evaluating Hydro Capability

6.1.1 *Integrated Power System Operation*

Operation of the CEB power system has become complicated due to the multipurpose nature of its hydro system. The water releases of the Mahaweli reservoir system are also used for irrigation purposes. This cascade constitute of about 55% of the total installed capacity of the system. At present, medium term operation planning (i.e. monthly and annual) is carried out jointly by Water Management Secretariat of Mahaweli Authority of Sri Lanka and System Control Center of CEB to satisfy the pre-determined irrigation requirements in the Mahaweli basin Figure 6.1. The water thus released is made use for electricity generation by the power stations of the Mahaweli complex. The balance electricity demand is supplied by Laxapana complex Figure 6.2 and if required, by making additional releases from Mahaweli complex so that they would not jeopardize the future irrigation requirements and finally, by running the thermal plants.

6.1.2 *Seasonal Variation in Water Requirements*

Sri Lanka is situated in the large belt of monsoon climates in South Asia and hence the typical climate condition of Sri Lanka is characterized by the distribution of rainfall originating from the Southwest and Northeast monsoons. The monsoon season also defines the Sri Lankan hydrological year, which runs from October to September.

As a result of significant seasonal variations in rainfall and irrigation water requirements, system operations are subjected to marked seasonal variations with the highest requirements occurring in the *Yala* agricultural season which runs from April to September. In order to satisfy these requirements, local water supplies are augmented by diverting water from Mahaweli Ganga through the Polgolla diversion tunnel into the *Sudu Ganga* Figure 6.1.

KELANI RIVER

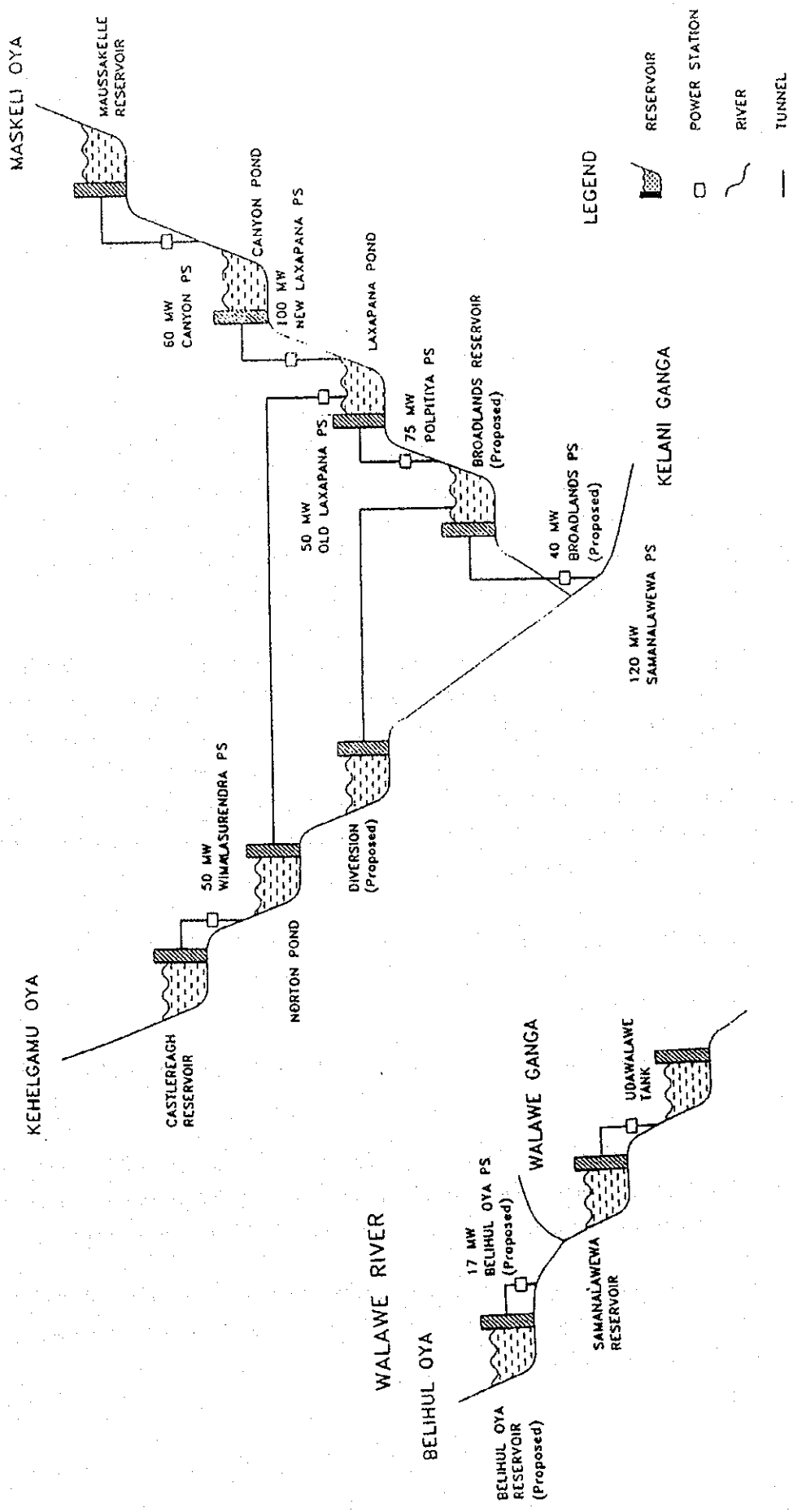


Figure 6.2 Reservoir Systems of Kelani and Walawe River Basins

CHAPTER 8

RESULTS

A number of computer simulations were conducted in arriving at the final least-cost plant sequence for the case with the Base-Load forecast. Subsequently, a number of sensitivity studies were conducted.

8.1 Discussion on the Base Case

The plant sequence and the resulting energy dispatch schedules for the base case are given in Table 8.1 and Table 8.9 respectively. Energy deficit and the loss of load probability (LOLP) in 1998 are 112 GWh and 8.3% (30 days) respectively. With the addition of 40 MW Diesel extension at Sapugaskanda and 51 MW KHD BOO plant in 1999, the energy deficit is reduced to 12 GWh and LOLP to 1%. The estimated energy deficits under different hydrological conditions are shown in Figure 8.1(a) and the expected loss of load probabilities are presented in Figure 8.1(b).

The plant sequence (Table 8.1) indicates the need for a 105 MW of Gas turbine plant in 2000 and a combined cycle plant of capacity 300 MW in 2001. The studies assumed that sites at Muthurajawela and Kelanitissa will be available to accommodate such thermal plants. First coal plant is expected to be commissioned in 2004. Note that the coal plant was constrained from coming into operation before year 2004 [due to the typical lead time required for such a plant]. The plan indicates the requirement for the installation of 1200 MW of coal, 300 MW of combined cycle and 315 MW of gas turbine capacities by the year 2010.

8.2 Other Scenarios Studied

8.2.1 Sensitivity to demand forecast

A set of least cost expansion plans was derived for the low and high demand forecasts as described in Chapter 4.

The **Low** growth scenario does not include any gas turbines upto 2004 whereas base case requires 105 MW of gas turbines, but the combined cycle capacity requirement is similar to that of the base case. The commissioning of the first coal plant is in the year 2004 again similar to the base case.

The **High** growth scenario requires very large thermal capacity in 1998-2004 with 140 MW gas turbine, 600 MW combined cycle. The full 900 MW of the Coal Power plant is to be developed and commissioned over 2005- 2008.

The Table below summarizes the plant sequence for the three demand forecasts upto the year 2004.

Year	Base Case	Low Demand Forecast	High Demand Forecast
2000	105 MW Gas Turbine	-	105 MW Gas Turbine
2001	300 MW Combined Cycle	300 MW Combined Cycle	300 MW Combined Cycle
2002	-	-	-
2003	-	-	300 MW Combined Cycle
2004	300 MW Coal	300 MW Coal	35 MW Gas Turbine

8.2.2 Sensitivity to Discount Rate

The discount rate of 10% used in the base case was reduced to 6% to examine the effects on the plan, particularly on capital intensive, low operating cost plants such as hydro and coal. The results are shown in Table 8.4. In the year 2005, only 35 MW of Gas Turbine is required compared to 105 MW in base case. The commissioning of the third 300 MW coal plant unit is advanced to 2007.

The plan was re-optimised for a discount rate of 12% and the results are shown in Table 8.5. In this plan, requirement of gas turbines is only 70 MW upto year 2004. Requirement of combined cycle and coal is similar to the base case.

8.2.3 Sensitivity to Fuel Prices

The light crude oil prices used for the base, high and low demand cases were based on 18.5 US\$/bbl in 1997 prices. The CIF price of coal at Trincomalee was taken as 44 US\$/MT and for the West coast as 47 US\$/MT. No price escalations were considered for the base case analysis. Sensitivity to fuel prices was analyzed using a high fuel price scenario with prices of crude oil and coal increased by 10% and 5% respectively.

The resulting plan (Table 8.6) shows that Gas Turbines are reduced to 35 MW in year 2000 compared to 105 MW in the Base Case. During the period 2000 -2010, the total gas turbine requirement has reduced to 140 MW in high fuel case compared to 315 MW in the base case while coal requirement has increased to 1500 MW compared to 1200 MW in base case.

8.2.4 Sensitivity to cost of Energy-Not-Served (ENS)

The base case was re-optimised with the cost of ENS set at 0.73 US\$/kWh against 0.31 US\$/kWh. The results are shown in Table 8.7. The resulting plant sequence is same as that of the base case. This shows that the plant expansion sequence is not very sensitive to cost of energy not served.

8.3 Comparison of Scenarios

Table 8.8 summarises the base case and the six different scenarios studied.

8.4 System Performance and Energy Balance (Base Case)

Energy dispatches for each hydrological condition and their weighted averages for the base demand case are shown in Table 8.9. The expected deficits (if any) are also shown in the same table.

Tables 8.10 and 8.11 show the respective annual Capacity and Energy Balance of the system if the base case expansion is implemented. Figure 8.2 is the graphical representation of the system expansion steps. Figure 8.3 shows the expected variation of hydro and thermal shares in generation, if the base case expansion sequence is implemented.

8.5 Investment Plan (Base Case)

Table 8.12 shows the expected investment plan for the base case. The graphical representation of the disbursements is shown in Figure 8.4.

8.6 Fuel Requirements (Base Case)

Table 8.13 shows the fuel requirements and fuel costs for the base demand case expansion sequence. The residual oil requirement increases from 194,000 MT in 1998 to a peak of 312,000 MT in 2000.

Table 8.1 Results of Generation Expansion Planning Studies - 1997

- BASE CASE -

YEAR	HYDRO ADDITIONS	THERMAL ADDITIONS	THERMAL RETIREMENTS	LOLP %
1998	-	-	-	8.266
1999	-	#40 MW Sapugaskanda Diesel Extension (KFW) #51 MW KHD plant (BOO) #100 MW GT part of 150MW Combined Cycle at Kelanitissa - OECF	-	1.002
2000	-	Gas Turbine 105 MW #Completion of 150 MW Combined Cycle at Kelanitissa (+ 50MW) - OECF	-	0.023
2001	-	Combined Cycle 300 MW	KPS Oil Steam 2*22 MW	0.039
2002	# Kukule 70 MW	-	-	0.080
2003	-	-	-	0.374
2004	-	Coal 300 MW West Coast	Sapugaskanda Diesel 2*18 MW	0.249
2005	-	Gas Turbine 105 MW	-	0.441
2006	-	Coal 300 MW West Coast	-	0.251
2007	-	-	-	0.920
2008	-	Coal 300 MW West Coast	Sapugaskanda Diesel 2*18 MW	0.820
2009	-	Coal 300 MW Trincomalee	-	0.660
2010	-	Gas Turbine 105 MW	-	1.229
2011	-	Coal 300 MW Trincomalee	-	1.112
2012	-	Gas Turbine 2*105 MW	-	1.400
Total	70 MW	2566 MW	116 MW	
Total PV Cost upto year 2017, 2392.7 million US\$ (141172.0 million Rs.)				

- Notes : (i) Discount rate 10%
(ii) # - Denotes committed plants
(iii) Exchange Rate 1 US\$ = SL Rs. 59.00
(iv) All Additions/Retirements are carried out at the beginning of year

Table 8.2 Results of Generation Expansion Planning Studies - 1997

- LOW DEMAND (7.1%) GROWTH -

YEAR	HYDRO ADDITIONS	THERMAL ADDITIONS	THERMAL RETIREMENTS	LOLP %
1998	-	-	-	5.862
1999	-	#40 MW Sapugaskanda Diesel Extension (KFW) #51 MW KHD plant (BOO) #100 MW GT part of 150MW Combined Cycle at Kelanitissa - OECF	-	0.470
2000	-	#Completion of 150 MW Combined Cycle at Kelanitissa (+ 50MW) - OECF	-	0.632
2001	-	Combined Cycle 300 MW	KPS Oil Steam 2*22 MW	0.043
2002	# Kukule 70 MW	-	-	0.068
2003	-	-	-	0.272
2004	-	Coal 300 MW West Coast	Sapugaskanda Diesel 2*18 MW	0.128
2005	-	Coal 300 MW West Coast	-	0.069
2006	-	Coal 300 MW West Coast	-	0.028
2007	-	-	-	0.112
2008	-	-	Sapugaskanda Diesel 2*18 MW	0.408
2009	-	-	-	1.163
2010	-	Gas Turbine 105 MW Gas Turbine 35 MW	-	1.355
2011	-	Coal 300 MW Trincomalee	-	0.901
2012	-	Gas Turbine 105 MW	-	1.401
Total	70 MW	1986 MW	116 MW	
Total PV Cost up to year 2017, 1800.7 million US\$ (106242.9 million Rs.)				

- Notes : (i) Discount rate 10%
(ii) # - Denotes committed plants
(iii) Exchange Rate 1 US\$ = SL Rs. 59.00
(iv) All Additions/Retirements are carried out at the beginning of year

Table 8.3 Results of Generation Expansion Planning Studies - 1997

- HIGH DEMAND (9.1%) GROWTH -

YEAR	HYDRO ADDITIONS	THERMAL ADDITIONS	THERMAL RETIREMENTS	LOLP %
1998	-	-	-	11.13
1999	-	#40 MW Sapugaskanda Diesel Extension (KFW) #51 MW KHD plant (BOO) #100 MW GT part of 150MW Combined Cycle at Kelanitissa - OECF	-	2.214
2000	-	Gas Turbine 105 MW #Completion of 150 MW Combined Cycle at Kelanitissa (+ 50MW) - OECF	-	0.368
2001	-	Combined Cycle 300 MW	KPS Oil Steam 2*22 MW	0.132
2002	# Kukule 70 MW	-	-	0.304
2003	-	Combined Cycle 300 MW	-	0.134
2004	-	Gas Turbine 35 MW	Sapugaskanda Diesel 2*18 MW	0.683
2005	-	Coal 300 MW West Coast	-	0.495
2006	-	Gas Turbine 105 MW	-	0.990
2007	-	Coal 300 MW West Coast	-	0.855
2008	-	Coal 300 MW West Coast	Sapugaskanda Diesel 2*18 MW	0.992
2009	-	Coal 300 MW Trincomalee	-	1.068
2010	-	Coal 300 MW Trincomalee	-	1.210
2011	-	Coal 300 MW Trincomalee	-	1.472
2012	-	Gas Turbine 3*105 MW	-	1.630
Total	70 MW	3201 MW	116 MW	
Total PV Cost up to year 2017, 2882.1 million US\$ (170043.7 million Rs.)				

- Notes : (i) Discount rate 10%
(ii) # - Denotes committed plants
(iii) Exchange Rate 1 US\$ = SL Rs. 59.00
(iv) All Additions/Retirements are carried out at the beginning of year

5.1.3 Broadlands Project

- **General**

This project is located on Kelani Ganga below, the existing Polpitiya Power station. This development comprises a diversion weir across the Maskeliya Oya, down stream of Polpitiya tailrace with water conveyed through a 3.5 km long tunnel on the left bank of the Kelani Ganga terminating in a 40 MW Power Station. The Kehelgamu Oya is proposed to be diverted to the pond formed by the weir across the Maskeliya Oya through a separate diversion which consists of a weir across the Kehelgamu Oya, intake structure and a tunnel.

- **Project Overview**

Province/ District	Sabaragamuwa/Kegalle/Central/N'Eliya
Catchment	Kelani
Catchment area	139 km ²
Reservoir Full Supply Level/ Storage	121 m MSL / 0.254 MCM
Min. Reservoir Operating Level/ Storage	111 m MSL / 0.014 MCM
Max Flood Level	122 m MSL
Normal / Minimum Tailwater Level	53 m / 52 m MSL

Main Features of Dam/Weir

Dam across Maskeliya Oya

Dam type	Concrete gravity
Dam Height / Crest length/ Volume	24 m / 100 m / 30600 m ³
Dam top elevation	124 m MSL
Spillway crest level	107 m MSL

Weir across Kehelgamu Oya

Dam type	Concrete gravity
Dam Height / Crest length/ Volume	13.5 m / 35 m / 5950 m ³
Dam top elevation	124.5 m MSL

Kehelgamuwa Oya Diversion Tunnel

Type	Concrete lined D shaped
Length / Diameter	840 m / 2.66 m
Discharge Capacity	20 m ³ /s for head diff. 3.5 m

Maskeliya Oya Water Conveyance System

Intake Tunnel

Type / Length / Diameter	Steel lined / 133 m / 5.4 m
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Cut-and-Cover Conduit

Type	Welded steel conduit with concrete backfill
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Length / Diameter 720 m / 5.4 m

Main Tunnel

Type Concrete lined horse-shoe
Length / Diameter 2708 m / 5.8 m

Penstock Tunnel

Type / Length / Diameter Steel lined / 130 m / 4.9 m

Penstock

Type Welded steel conduit
Length 92.0 m single & 23.0 m twin
Diameter 4.9 m single & 3.5 m twin

Type of Power Station Open air

Rated Head 59 m

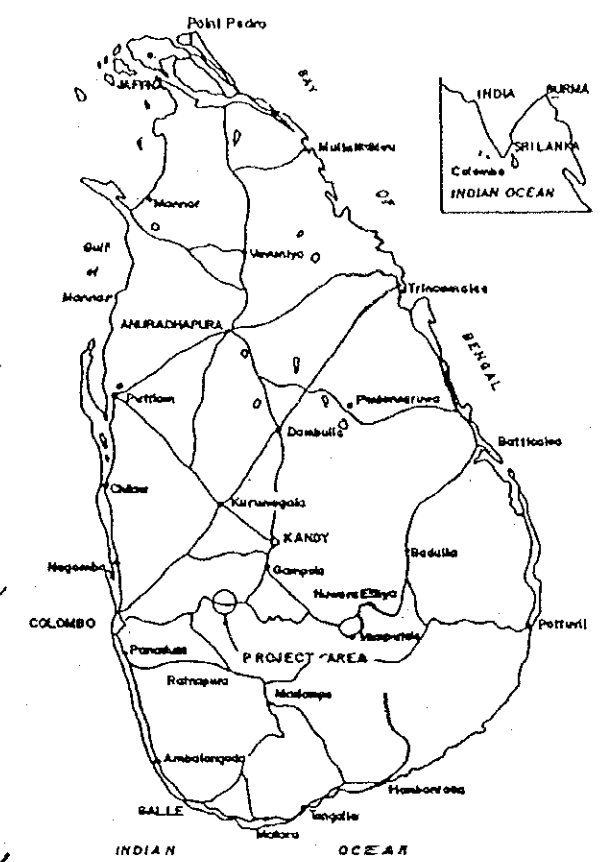
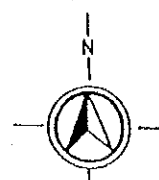
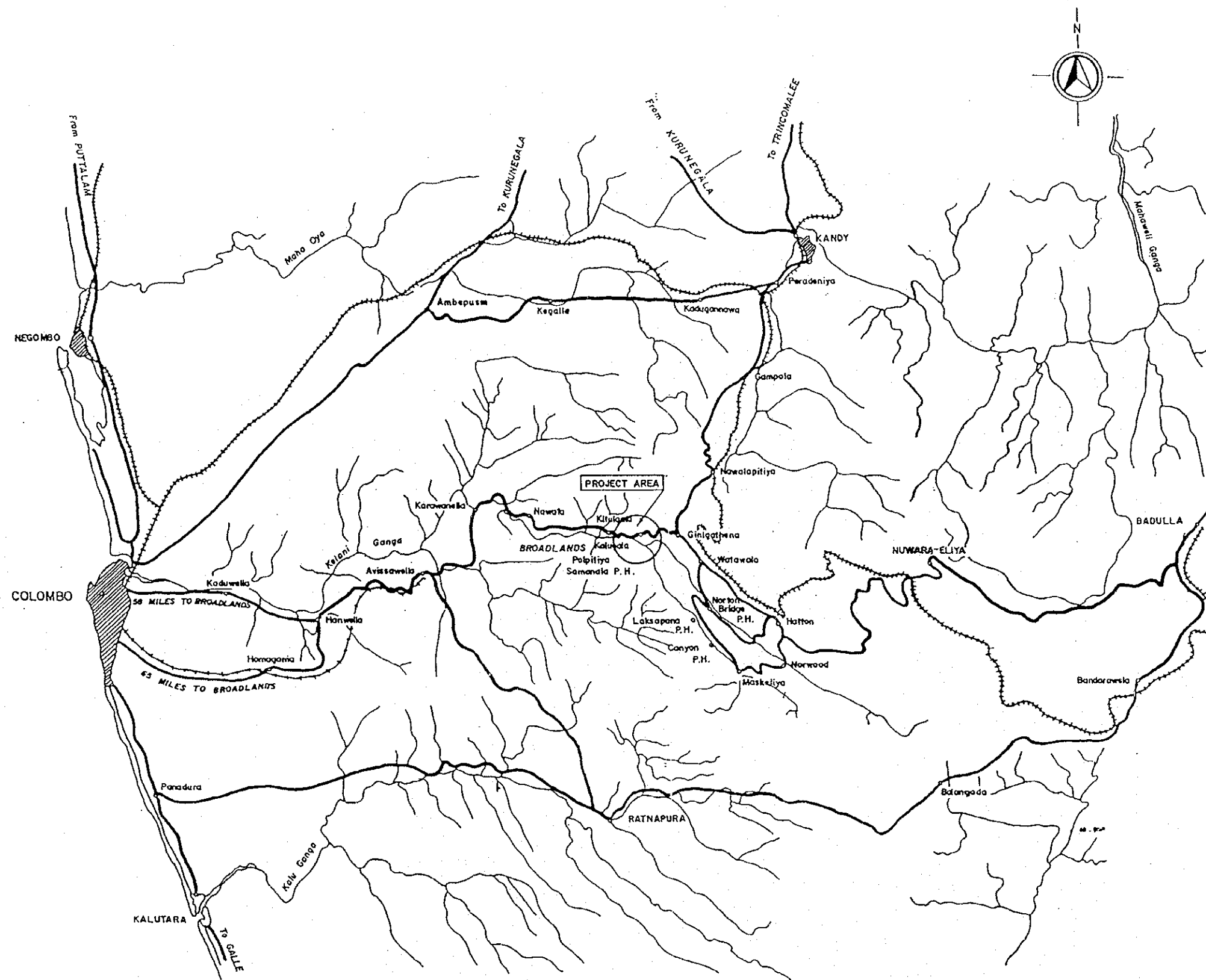
Turbines 2 Francis

Rated Turbine discharge 39.7 m³/s (per unit)

Plant Capacity 40 MW

Ave. Annual Generation 145 GWh

H.V. Feeder Line 132 kV to existing Polpitiya
Kolonnawa Line / 1.0 km



LEGEND

HIGHWAYS	
RAILWAYS	
RIVERS	

LOCATION MAP



DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA CEYLON ELECTRICITY BOARD	
BROADLANDS POWER PROJECT ACCESS FACILITIES TO PROJECT AREA	
CENTRAL ENGINEERING CONSULTANCY BUREAU COLOMBO - SRI LANKA	
DESIGNED BY: <i>[Signature]</i>	DATE: 03-07-84
DRAWN BY: P.J.M.A.	
CHECKED BY: C.J.A. APPROVED: <i>[Signature]</i>	025-FI-01
SUBMITTED BY: J.A.D.E.	
PASSED BY: S.F. GENERAL MANAGER	

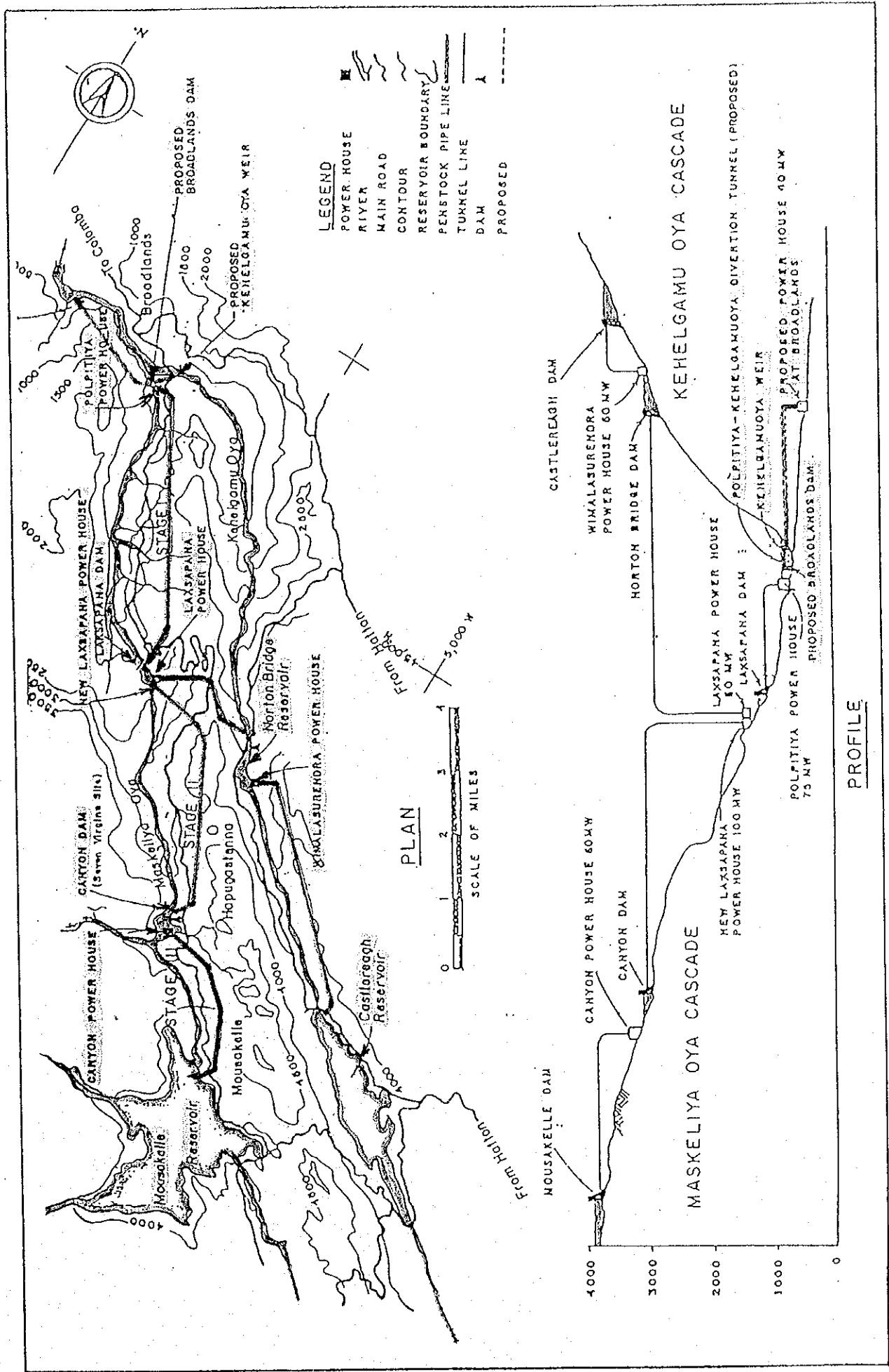
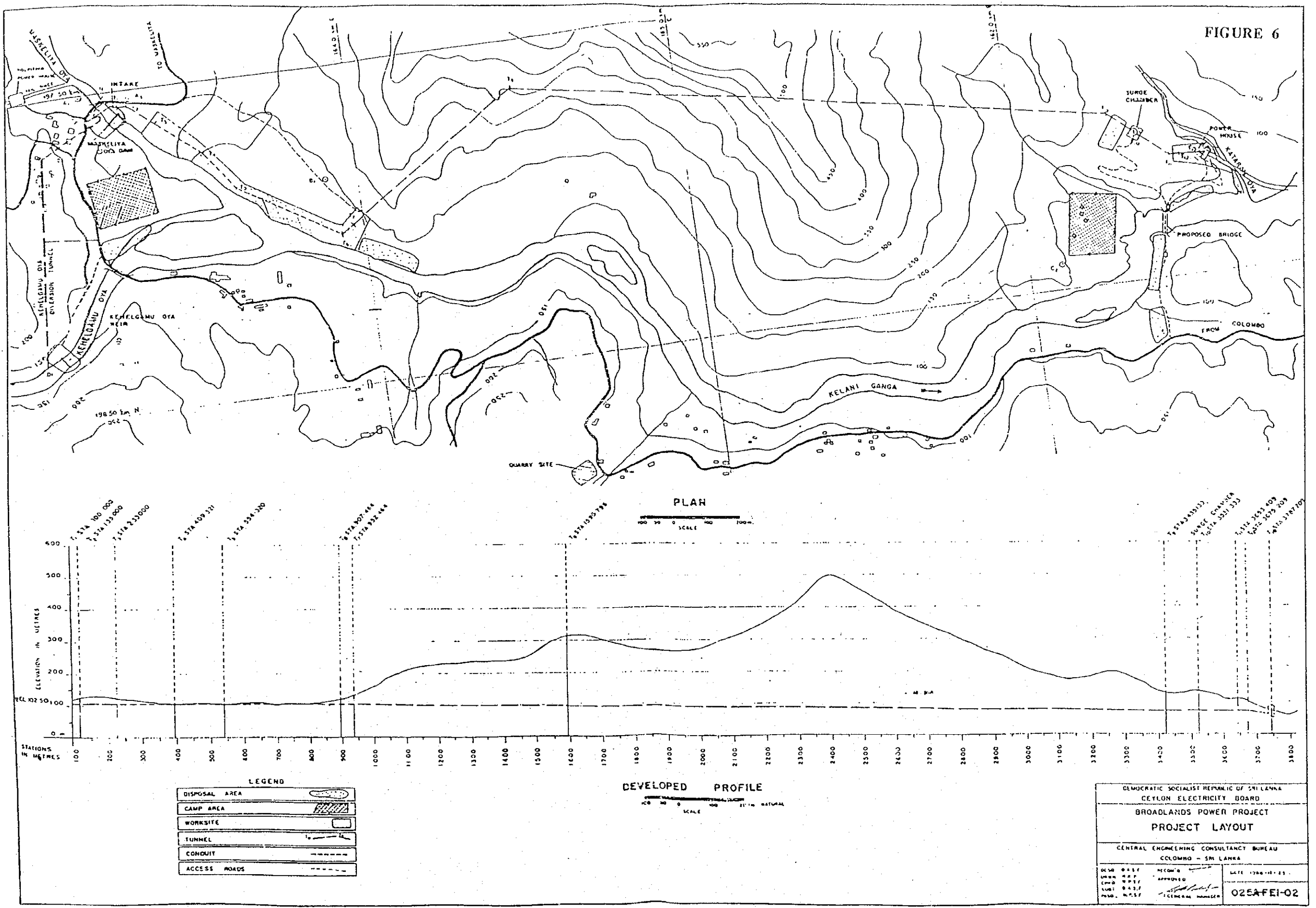


FIGURE 5 BROADLANDS PROJECT IN KEHELGAMU - MASKELIYA OYA COMPLEX

FIGURE 6



The Government of the Democratic
Socialist Republic of Sri Lanka

NATIONAL ENVIRONMENTAL ACTION PLAN

NEAP 1998 - 2001 VOLUME II

Sector Perspectives

Ministry of Forestry and Environment

file M4002.01.001
date 30 May 1998
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rev 3

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 Annex I:	 Abbreviations and Acronyms

NATIONAL ENVIRONMENTAL ACTION PLAN 1998 - 2001

VOLUME II : SECTOR PERSPECTIVES

EXECUTIVE SUMMARY

Volume II: Sector Perspectives, of the National Environmental Action Plan presents an analysis of the key issues relating to nine key sectors and the recommendations for addressing these issues. The nine sectors are: Environment and Health, Land, Water, Biological Resources, Built Environment, Industry, Coastal and Marine Resources, Energy, and Mineral Resources. This analysis is based on the findings of and review by the sector committees appointed by the then Ministry of Transport, Environment and Women's Affairs. The key recommendations are given below for each sector.

1. Land

- Formulate a land use policy which provides guidelines for identifying appropriate land use practices in development programs;
- Develop an institutional structure at national and sub-national levels for land use planning;
- Design and implement innovative economic and institutional incentives to encourage the practice of conservation oriented farming;
- Establish integrated natural resource management model projects in selected watersheds that involve local communities and local authorities;

2. Water Resources

- Create a single authority to guide and coordinate the activities of the institutions involved in water management;
- Obtain agreement on national principles for water allocation and implement them in major river basins;
- Introduce reforms to improve efficiency of water use;
- Implement a monitoring program for assessing the level of pollution in water bodies;
- Develop and implement a strategy for managing groundwater that addresses the issues of groundwater extraction and ground water pollution.

3. Biological Resources

- Prepare and implement a National Wildlife Strategy;
- Prepare and implement management plans for all protected areas through an approach involving community participation;
- Design and implement economic incentives to promote activities such as eco-tourism or nature tourism which will help to conserve and maintain national parks and other protected areas;
- Introduce incentives for establishing and maintaining mixed home-gardens with high species diversity.

4. Coastal and Marine Resources

- Implement the Coast Conservation Act and Fisheries and Aquatic Resources Development Act, placing emphasis on community participation;

- Promote the production and use of lime from limestone sources other than sea coral;
- Promote the identification of sources of sand other than river beds and sea beaches;
- Promote the use of sand substitutes by the construction industry;
- Develop and implement national strategies for sustainable culture and for harvesting from natural sources, of shrimp and ornamental fish for export.
- Design and implement a strategy for reducing marine pollution;
- Promote the development of environmentally sensitive tourism in coastal areas.

5. **Industry**

- Encourage location of high polluting industries in industrial estates;
- Strengthen capability of national and sub-national agencies to implement pollution control regulations more effectively;
- Promote the establishment of a fund financed by industry for private sector management of environmental pollution by industrial effluents;
- Promote private sector self regulation and motivation through measures such as environmental audits, ISO 14000-Environmental Management Systems and Environmental Entrepreneur of the year award;
- Assist the private sector in identifying sources of clean technology.
- Streamline the EIA process by promoting other processes such as strategic environmental assessment;

6. **Minerals**

- Design and implement a strategy for promoting sustainable sand mining from rivers and beaches;
- Set up a Fund for the rehabilitation of lands degraded during prospecting for gems (gem mining);
- Revise the Mines and Minerals Act to include environmental guidelines for the conduct of mining operations that would provide safeguards against environmental (especially land and water) degradation.

7. **Energy**

- Review energy policy and electricity generation plans to address environmental concerns;
- Conduct a feasibility study on use of alternative fuels for power generation, industry and transport;
- Improve efficiency of bio-mass utilization through use of fuel-wood gasifiers and energy efficient fuel-wood stoves;

8. **Built Environment**

- Provide institutional support to upgrade environmental conditions in low income urban settlements;
- Design and implement a Colombo Metropolitan Flood Control and Drainage Strategy;
- Develop and implement a National Solid Waste Management Strategy;
- Formulate and implement a Revised Clean Air 2000 Action Plan, focusing on environmentally sound public transport systems;

- Improve urban planning and zoning processes and effectively implement urban plans and zoning regulations.

9. Environment and Health

- Upgrade and focus activities of Public Health services;
- Review vector control programs to focus on cost effective preventive interventions;
- Reduce incidence of pesticide poisoning through promotion of integrated pest management, better education, and responsible marketing;
- Implement interventions to reduce air pollution and noise pollution;
- Introduce a National Sanitation Week to ensure that a coordinated participatory program is launched to provide toilets for all dwellings.

INTRODUCTION

The second National Environmental Action Plan (NEAP) update 1998-2001 sets the agenda for the twenty first century. The NEAP is now presented in two volumes. Volume I presents a Strategy to pursue Sustainable Development. This volume identifies policies, institutional shifts and actions needed to meet the likely environmental challenges in the short and long term. Volume II: Sectoral Perspectives is an analysis of nine key sectors: environment and health, land, water, biological resources, built environment, industry, coastal and marine resources, energy, and mineral resources.

The main objective of the National Environmental Action Plan (NEAP) is to integrate environmental concerns into the development process. The National Environmental Action Plan is therefore both a product as well as a process. To be successful in this ambitious task, the NEAP had to create a forum in which the many conflicts and compromises in pursuing sustainable development can be discussed openly by the major stakeholders involved. The (former) Ministry of Transport, Environment and Women's Affairs initiated a committee approach to facilitate such a process. The conclusions reached and recommended actions agreed on were to be documented in the NEAP. They are presented in this volume.

Success in implementation depends on the support of the principal actors in the development process. These actors are the Finance Ministry, other key development Ministries, their supporting agencies, the private sector, the local community and the non governmental organizations. These agencies must feel that they "own" the final recommendations by being actively involved in their formulation.

In order to encourage the active participation of the concerned agencies, committees were appointed to study the environmental issues relating to the more important sectors.. They were chaired by the Secretaries and other senior officials of the key development Ministries. The Committees on Land, Industry and Fisheries were each chaired by the Secretary to the Ministry concerned. Other committees were chaired by officers at the level of Additional Secretary. The Committee on Poverty and Environment was chaired by the Director General of National Planning who represented the Ministry of Finance. The membership of these Committees, which included private sector and NGO representatives, is given in Annex 1.

The overall NEAP process was reviewed regularly by a high level NEAP Steering Committee chaired by the Secretary, Ministry of Environment and including chairpersons of all the sectoral Committees. The NEAP sectoral reviews were presented to this Steering Committee at a number of meetings. The NGO representatives at these meetings also made useful contributions.

The major sectoral concerns were subsequently discussed at a workshop. A significant change from the previous NEAP (1993) was the appointment of separate Committees for Environmental Health, Water, Built Environment and Poverty. All four areas were considered to have become far more important since the last NEAP so as to warrant separate discussions. It was felt that having separate sectors on biodiversity and forests reduces the opportunity to focus on Sri Lanka's rich freshwater and marine ecosystems. It was therefore decided to have just one Committee on Biodiversity that would handle all natural systems. The following nine sector Committees were finally agreed upon:

- Environmental Health
- Land
- Water
- Bio-diversity
- Built Environment
- Industry
- Coastal and Marine Resources
- Energy and Minerals
- Poverty and Environment

The sector papers prepared by the first seven Committees are presented in Volume II. Energy and Minerals are treated as two separate sectors in this volume even though they were studied by the same sector committee. The committee report itself is presented in two parts, one devoted to Energy and one to Minerals. An even stronger reason for treating Energy and Minerals as two separate sectors is that in Sri Lanka, unlike in many other countries, none of the sources of energy belong to the category of minerals as do crude oil, coal or radioactive ores. The recommendations of the Committee on Poverty and Environment were policy oriented and broad. It was therefore considered more appropriate to include them in Volume I.

The same Terms of Reference were issued to all the Committees by the Ministry of Environment in order to ensure consistency. However the interpretation of its Terms of Reference was left to each Committee. This naturally led to different formats being used for the different sector reports. The following common format has been used in revising the sector reports for inclusion in Volume II in order to make it a consistent and focused presentation:

- A broad overview focusing on strengths, weaknesses and threats, and opportunities of the sector,
- a detailed description of the key environmental issues and
- a series of key recommended actions.

The task ahead is how to effectively implement the actions recommended for each sector. In order to ensure effective implementation, a number of innovative institutional mechanisms have been proposed. These are outlined in Volume I. These include regular meetings of the NEAP Committees to review implementation, publication of the NEAP in all three languages and the creation of a strong unit within the Ministry of Environment to facilitate implementation.

5. INDUSTRY

a. Overview

The industrial sector has emerged as the country's most vibrant economic sector growing at the rate of 10 per cent per annum during 1995 - 1996. Industrial pollution is the one major drawback of the manufacturing sector. Such pollution is conspicuous because factories are point sources of pollution which are easily identified. They are therefore also easier to control. For this same reason public attention and environmental legislation are directed mainly at industry and tourism.

Strengths:

Manufacturing industry is growing rapidly and should therefore be able to generate funds and skills to reduce environmental damage. Industry contributed 23 percent to national GDP in 1996, and industrial products accounted for 75 percent of the total value of exports in 1996. Nearly 15 percent of employed persons were engaged in industry. Industrial development is supported by several strong institutions. The Ministry of Industrial Development facilitates industrial development by providing an environment that promotes such growth. It provides incentives, and also facilities like industrial estates and industrial parks. The Board of Investment (BOI) provides foreign investors with attractive fiscal incentives and facilities like Export Processing Zones (IPZs).

Strong environmental laws and institutions are in place to ensure that industrial development while economically productive does not harm the country's environment or its natural resources. Industrial consultant firms are being established to advise industry on pollution control and design and the manufacture of equipment for the purpose.

The following measures taken to control industrial pollution are showing success:

- The Environmental Protection Licensing (EPL) Scheme
- The Environmental Impact Assessment (EIA) procedures, and
- Locating polluting industries in industrial estates.

The proposed amendments to the NEA will require EPLs only for highly polluting industries.

Standards and tolerance limits have been set by the Standards Institution for effluents discharged:

- into inland surface waters;
- into irrigated agricultural land;
- into marine coastal waters;
- from rubber or textile factories into inland surface waters;
- from tanneries

Standards have been developed by CEA for emissions into the atmosphere and for noise. Manufacturing industry is supported by a number of strong institutions that have developed over the past few decades. The Ministry of Industrial Development concentrates on facilitating industrial development through the provision of incentives and the facilities like industrial establishment of industrial

Weaknesses and Threats:

Industrial effluent continues to pollute surface and ground water. Industrial pollution is particularly severe in the Colombo and Gampaha Districts where more than 70 percent of all registered industrial units are located (Central Bank, 1996). Particularly heavy concentrations of industrial units are located in the Moratuwa-Ratmalana and Ekala -Ja-Ela areas. Surface waters so affected include the Kelani River, Negombo Lagoon, Lunawa Lagoon and Bolgoda Lake where the fisheries are threatened. Spent wash from distilleries in the Kalutara district has affected ground water quality. Severe pollution is caused by the tanneries and the paper (pulp) mill. Most tanneries today use chromium compounds as the tanning agent. Electroplating is often done on a very small scale on shop verandas but involves the use of deadly poisonous chemicals like potassium cyanide. Vapours and particulate matter including asbestos fibres released into the atmosphere by industries pose a health hazard to people in the neighbourhood. The noise emitted by the operation of factory machinery can also cause serious disturbance to neighbours. Solid waste from factories can be a public nuisance.

Regulation by itself has proved inadequate to arrest industrial pollution. Problems relate to lack of incentives for compliance, lack of appropriate technology and the absence of a strategic phased program for compliance. Many industrialists have difficulty in obtaining technical assistance for pollution minimization in choice of technology/ technology assessment; in design and installation of equipment and in effecting changes in manufacturing procedures;

Industries face difficulties in adopting effective pollution control measures because of financial constraints, and the lack of technical skills and capabilities in operating such measures.

Opportunities:

Industry is now starting to take a more pro-active approach to environmental management, and the regulatory authorities are showing a greater willingness to appreciate the concerns of industry. Industry is now focussing on selecting low polluting technologies and installing pollution minimizing measures at the project design stage.

International assistance is available for efforts to reduce industrial pollution. Steps are being taken to establish with World Bank assistance common effluent treatment facilities in the Ratmalana and Ekala -JaEla areas where pollution levels are very high.

b. Issues

i) Industrial Estates Program

The government has made a policy decision to locate high polluting industries wherever possible within industrial estates provided with effluent disposal facilities. The Export Processing Zones (EPZs) of the Board of Investment (BOI) provide central effluent treatment facilities at their Katunayake and Biyagama Export Processing Zones. One private industrial estate also has treatment facilities. It is planned to set up treatment plants in Moratuwa-Ratmalana and Ekela-Ja-Ela where there is a very high concentration of industries.

Work on nine new industrial estates has begun (out of a total of 27 sites selected for establishing industrial estates). This includes an industrial estate of international standard at Seethawaka. The tanneries in all parts of the country will be moved to the industrial estate at Bata Atha. These are important steps, but the industrial estate program currently has some shortcomings. A consistent decision must be made as to which industries the industrial estate wants to attract. The payment of heavy subsidies by the state to some industrial estates undermines the incentives for the private sector to develop cost-effective estates. Finally there needs to be a consistent package of incentives to attract industry to locate away from the many advantages of Colombo.

ii) Difficulties faced by the private sector in obtaining clean technology

Assistance is available, often free of charge, to industrialists in the choice of low polluting technologies and the identification of their sources of supply. At the international level, UNIDO and UNEP, and ESCAP's Division of Environment at Bangkok and ESCAP's Asia and Pacific Centre for Transfer of Technology (APCTT) located in Delhi provide such information. Within Sri Lanka, CISIR, some Universities and a number of private sector organizations also now offer consultancy services.

There is also some assistance available on clean technology, which is cheaper and more efficient than end of pipeline treatment. The UNIDO/UNDP/CEA Industrial Pollution Reduction Program (IPRP) Project has been promoting good housekeeping in factories, training of trainers (industrial consultants), monitoring and demonstration projects on waste minimization and effluent treatment at the arrack distillery, Seeduwa and elsewhere.

However despite these developments, many industrialists wishing to implement pollution minimization measures find difficulty in obtaining the required technical assistance. They particularly need help in identifying low polluting technologies, in locating the suppliers of such technology and in selecting a cost-effective low polluting technology from among a number of alternatives.

The main problems are the nature of the developing environmental technology market in Sri Lanka, with the lack of regulation of contractors some of whom

are substandard. The industrialists, for their part, must provide accurate discharge data to the contractors. Price should not be the over-riding factor in the choice of technology. The availability of skills needed to maintain imported pollution control equipment is another factor to be considered.

iii) **Financial constraints to environmental compliance**

The cost of installing pollution control measures can be high in some sectors, although generally it is less than one per cent of the company's profits (IPS, 1995). Introducing pollution control equipment into existing factories pose problems of space, installation and high costs. The introduction of pollution control measures at the design stage of a project is much simpler and far less expensive than modifying either the plant or the manufacturing process in an already established factory where questions arise regarding space or the replacement of equipment that has already been installed.

The Pollution Control and Abatement Fund (PCAF) funded by the German Government through KFW provides funds at concessionary rates to industrialists for obtaining technical assistance and for meeting the costs of designing and installing pollution control measures. The Pollution Control and Abatement Fund (PCAF) offers financial assistance at concessionary rates and grants to industrial enterprises for waste minimization, recovery of resources and control and abatement of pollution. The PCAF consists of a non-repayable technical assistance grant and a low interest credit component. The PCAF will reimburse up to 75 percent of the cost of pollution control measures with an upper limit of Rs.600,000.. The fund is administered by the National Development Bank together with DFCC, Commercial Bank, Hatton National Bank and Sampath Bank.

The PCAF has proved very effective in enabling more than fifty firms to install waste treatment using Rs 200 million obtained from it. Industries who have received assistance are mostly agrobased (18 firms), followed by textiles and garments (12 firms), hotels (6 firms), metal / chemicals / plastics (6 firms), rubber and leather (6 firms) and wood and paper (3 firms). More recently a number of aquaculture farms have applied for funding. However while the fund is successful and has now been replenished, there are still a few procedural bottlenecks to be cleared.

There are also some schemes to help new firms afford pollution control including duty waivers and tax holidays for clean technology. These were announced in the 1995 budget and continued in 1996 and 1997.

While funds and assistance are available for environmental compliance, these are often not well publicized so not many firms know about them.

iv) **Regulatory structure and regulatory procedures**

The Central Environmental Authority has faced a difficult task responding to the growth of industry and public complaints of deteriorating environmental quality. It is now recognized that a more strategic reform is needed. This would seek to ensure that the main regulatory instruments - the Environmental Impact Assessment (EIA) and the Environmental Protection License (EPL) -

are used as effectively and constructively as possible to promote environmentally sound development.

There have been improvements to the CEA. These include delegating powers for EPL for low and medium polluters to the local authorities, updating the database on EPL issues, conducting training courses on the EIA process for regulators and developers and creating a separate unit for public complaints which have been rapidly increasing. Most of these reforms have so far been ad hoc. The effectiveness of the EPL and the EIA procedures now need to be assessed.

The CEA has administratively delegated some environmental functions to selected local authorities.

The EIA process is being reviewed to examine the potential for sectoral environmental assessment (SEA) which lays emphasis on anticipating and minimizing environmental damage. SEA is proactive unlike project EIA that only reacts to development proposals rather than anticipate them. Spatial planning in respect of a defined geographical area with a focus on resources management have been seen as imperfect first step towards SEA (Nanayakkara, 1997). Other planning efforts aimed at conserving the environment and natural resources include Master Planning, (Water Resources Master Plan, Water Resources Master Plan and Coastal Erosion Management Master Plan), Area Management (for Coastal Resources in Hikkaduwa and Rekawa), Spatial Planning and Zoning (for selected urban areas) and Land Use Planning.

Greater willingness is now shown towards taking a more strategic vision about what the role of the CEA and how best the private sector, local authorities and the public can help.

c. Recommendations

i) Increase private sector access to clean technology by establishing a Cleaner Production Center

The environmental engineering sector needs more training and funds for developing low cost pollution control equipment. A clearer institutional arrangement is also required, as many firms are sole suppliers of one type of equipment so it is difficult for industry to obtain an unbiased recommendation. One suggestion is that industry federations provide more information to their members. Another suggestion is to develop a "Cleaner Production Centre". This could either be a stand alone institution or be housed in an existing agency such as CISIR.

ii) Encourage locating or re-locating high polluting industries in industrial estates.

Government has taken the responsibility for providing the infrastructure necessary for the disposal of industrial pollutants in new industrial estates and in Industrial Processing Zones managed by the Board of Investment (BOI). This strategy is highlighted in a Cabinet Paper signed by the Ministers of Industry, Environment and Science and Technology. The 25 industrial estates now existing have many unoccupied sites, and few have high polluting industries. The policies and investments required to promote these estates include:

- Coordination of allocation of these estates and advertising to be improved with a Committee chaired by BOI given stronger legal backing (eg Industrial Estate Management Authority) to coordinate rational allocation and level playing field between private and public estates
- CEA to issue EIA and EPL to the entire industrial estate and exempt industries located in them from individual EIA or EPL.
- Tax and other incentives to be provided to industries locating in estates which are more advantageous than for industries locating outside estate
- Private sector to be encouraged to set up industrial estates by being granted the same concessions as the public sector.
- Public sector estates to be set up only after a clear survey of demand.
- Category A or high quality estates to be promoted for accommodating high polluting industries only.

iii) Government to take initiative in developing environmental infrastructure for existing industry

Liquid and solid waste disposal is a problem for industry. The construction of planned common treatment plants for Moratuwa and Ja-Ela is behind schedule. There is still no sanitary landfill site or hazardous waste disposal site in Sri Lanka. These projects must be given the highest priority because of the serious consequences for health. The main obstacles seems to be disagreement among the various stakeholders on long term viable mechanisms for financing construction and operation, and problems in site selection due to protests from people near the chosen site.

iv) Strengthen national and subnational agencies to implement pollution control regulations more effectively and with greater participation

- Identify clearly the areas where the local authority, private sector and public can be involved in CEA activities ;
- CEA to be reorganized to focus more on monitoring of EPL and EIA compliance;
- CEA to devolve some functions to local authorities, provide training and monitor progress;
- Regulations to be developed following greater consultation with the private sector, streamlining of regulatory burden and development of environmental dispute resolution mechanisms (eg Environmental Tribunal or Mediation Boards)

- Innovative mechanisms to be developed to promote EPL compliance including self-regulation by firms and use of public information . In Indonesia industries are assigned a publicly announced rating in terms of low, high and medium compliance. This procedure aims to generate public pressure for improved compliance;
- Working closely with the banking and finance sector to develop ways to encourage environmental concerns to be included.
- EPL process to focus on high polluting industries, with a load based license fee and be issued under oath in appropriate circumstances
- Selected activities to be contracted out to private sector on an experimental basis;
- Develop sectoral environmental assessment for key areas.

v) **Promote the establishment of a revolving fund for private sector environmental management financed by the private sector**

There are a number of schemes ongoing, primarily the Pollution Control and Abatement Fund for environmental investments by the private sector. However this fund is currently funded by donors and may therefore not be sustainable in the long run. The most effective source of funding is the private sector itself. This would also ensure that the private sector could use the money as it wishes. A revolving fund could be set up using the revenue generated from EPL license fees, environmental fines and other charges.

The scope of the fund could be broadened out from a narrow focus on pollution control. There are many new environmental products and services, which the private sector is developing, such as organic products or nature tourism. These ventures are new and often involve some risk. There may be a need to have access to low interest loans to develop these innovative environmental products.

vi) **Promote private sector self-regulation through environmental management systems, an Environmental Entrepreneur of the year award and environmental clearance by the Banking and Finance sectors.**

As the private sector develops, a more pro-active partnership is developing towards environmental management. This arises from greater awareness, realization of the marketing potential and pressure from domestic and international customers and shareholders. This should be taken advantage of to promote greater self-regulation by the private sector by environmental audits, ISO 14000 and other environmental management systems.

- vii) **Encourage Community participation in control of industrial pollution**
Local communities can make a significant contribution towards control of industrial pollution. Community groups can play an important role in conducting public awareness and education programs, carrying out surveys and research also assisting in the enforcement of environmental laws and regulations.
- viii) **Improve environmental dispute resolution mechanisms**
Many environmental disputes have led to protracted legal proceedings between the affected parties often under the Public Nuisance Ordinance. This has led to delayed settlements, and bitter legal and social conflicts. It would be more effective to have a more flexible dispute resolution mechanism. This would provide faster relief to aggrieved members of the public and a more predictable, technically competent mechanism for industrialists.

7. ENERGY

a. Overview

Sri Lanka's annual per capita energy consumption is 4 GJ, compared with 9GJ for India, 8GJ for Pakistan, 2GJ for Bangladesh and 1GJ for Nepal. This reflects the low level of industrial development achieved by Sri Lanka. Biomass provides about 70 percent of the total energy used; petroleum products account for about 25 percent and electricity about 5 per cent. The distribution of energy consumed in 1994 by source is given as follows: Petroleum products 25.3 percent; fuelwood 67.8 percent; Electricity 5.0 percent; and Others 1.9 percent (CEB, 1996). Liquid petroleum gas (LPG) contributed about 1 percent. out of the 1.9 percent credited to "Others". Domestic consumption accounts for about 65 percent of total energy consumption and industry for about 13 per cent. Transportation accounts for 13 per cent of energy used and 52percent of petroleum products.

Hydropower currently provides the bulk of the electricity used. About 51 per cent of households are provided with electricity. Of the total installed electrical power generating capacity of 1,564MW, 1,137 MW was hydro- and only 427 MW was thermal. Electricity demand is increasing by about 10 per cent per year. More thermal power generating plants are being installed or planned. The main energy users are the domestic, industrial and transport sectors.

Strengths:

Biomass supplies approximately 70 per cent of total energy consumed in Sri Lanka. It is used in most homes for cooking and in many industries. The large scale industrial uses of biomass include brick and tile manufacture, baking bread and manufacture of smoked sheet raw rubber.

Biomass for energy generation is projected to be available in sufficient quantities since wood and crop residues from home gardens and coconut and rubber plantations, and paddy husk will continue to be available and fuelwood continues to be an unpriced good in rural areas.

The Forestry Sector Master Plan updated in 1995 presents a projected fuelwood supply and demand scenario from 1995 to 2020. Total fuelwood consumption is projected to be 9.7 million tonnes in 2020, while the supply is expected to be 10.1 million tonnes if present practices continue and 10.6 million tonnes if the Master Plan recommendations are implemented.

Hydro-electricity the only other "indigenous" source of energy has in most years supplied between 80 and 98 percent of the electricity demand in the country. The use of hydroelectricity is non-polluting, hydro power reservoirs change the ecology of the area, and enhance its scenic beauty but they can also cause environmental damage. Biomass and hydroelectricity are both indigenous sources of energy.

Weaknesses and Threats:

The demand for energy is increasing. Electricity demand is increasing at a rate of about 10 per cent per annum.

The energy efficiency of the traditional open firewood hearth is less than 10 per cent. More energy efficient hearths have been designed in many countries but have never been able to supplant the traditional hearth.

Hydropower reservoirs are known to have some environmental costs. For example dam construction across the Mahaweli inundated some of the country's fertile land in the Dumbara valley.

The installation of more thermal power plants will lead to increased atmospheric pollution from the burning of petroleum fuels, coal and, even natural gas.

Loss of power during transmission and distribution is in the region of 17 per cent, which is comparatively high as achievable losses are thought to be around 12 per cent..

The number of motor vehicles especially motor bicycles vans, and their use in traffic congested conditions continues to increase. This increases emissions of gases and particulate matter.

Opportunities:

The rise of the private sector in the energy sector allows the government to insist on the use of clean technology in future BOT projects. A number of innovative methods are available for increasing the availability of biomass and the efficiency of its use. These include establishment of village woodlots and the use of stoves having higher fuel efficiency

- Manage growth of electricity demand through
 - promotion of energy conservation programs;
 - reduction of system losses, and
 - use of less power consuming equipment,
 - use of non-traditional sources of energy: wind, solar, biomass (paddy husk, saw dust, wood waste, etc.). and
 - recycling urban / municipal biodegradable wastes

b. Issues

i) Biomass

Biomass usage for energy generation involves:

- deforestation resulting in loss of habitat and reduced biodiversity as well as increased soil erosion, flash floods and droughts;
- atmospheric pollution by smoke (from burning biomass) components including particulate matter, carbon monoxide, carbon dioxide, oxides of nitrogen and carcinogens in tar residues.

Domestic use of biomass is expected to remain constant because increases due to population growth are counter balanced by greater use of efficient stoves and more affluent consumers switching to other sources of energy.

Commercial and industrial use of biomass is however reported to be increasing at the rate of 3 to 4 per cent per year. Though adequate supplies of biomass are projected for the next two decades, localized shortages can occur especially in urban and semi-urban areas.

ii) **Hydropower generation**

Nearly all the sites for large scale hydropower generation are being developed. Only a few sites identified as suitable for generating hydropower on a medium scale remain to be tapped.

iii) **Growth in fossil fuel energy**

Coal and oil based power plants and internal combustion engines release oxides of carbon, nitrogen and sulphur, as well as smoke containing particulate matter and carcinogens. Such plants also discharge hot water from their cooling systems into the sea or other water body. The negative environmental impacts associated with Coal-fired power plants: include environmental damage caused by unloading of coal, transporting of coal in lumps and pollution from coal ash.

iv) **Transport Policy**

The transport sector is responsible for most of the air pollution in the country and especially in the Greater Colombo and other urban areas. There is seemingly uncontrolled import of private vehicles, namely cars, vans and motorcycles and also of three wheel vehicles. The only restraining factors on their use are traffic congestion and limited parking facilities. If parking facilities are increased and road capacity enhanced by widening of existing roads, construction of new roads and traffic management measures, the volume of traffic and the exhaust emissions will increase.

c. **Recommendations**

i) **Overall Energy Sector**

Carry out an environmental assessment for the entire Energy Sector.
Encourage energy auditing.

ii) **Biomass promotion**

Encourage establishment of village woodlots where possible with private sector participation, and home gardens.

Intensify the promotion of fuel efficient stoves. Several designs of fuel efficient wood stoves have been designed and marketed. In rural areas where biomass is still unpriced, these stoves may be promoted for improving indoor air quality.

Develop collection, storage and processing of urban biodegradable wastes for bio-gas generation, and develop technologies for bio-gas storage and use.

- iii) **Hydropower generation**
Develop all available sites for hydropower generation. They should include the following sites identified by the CEB. Upper Kotmale; Broadlands; Gin Ganga; Belihul Oya; Moragolla.; Uma Oya; and Kukule. Effective environmental Safeguards should be provided in all cases.
- iv) **Thermal power**
Use thermal power technologies that cause minimum air pollution and use "cleaner" fuels such as low sulphur oils and coal.

In considering alternative technologies and alternative sites for coal and oil fired power generating plants, select cleaner fuel types, less environmental sensitive sites and technologies that will cause minimum environmental damage.

Take effective steps to reduce power losses during transmission and distribution.

- v) **Design and implement a Transport Policy**
The need for a transport policy that supports environmental conservation has been explained under "Issues". Such a policy should consider air pollution in particular. A mass transit railway system should also be considered.

The present implied policy of CARS FIRST should be replaced with an express policy of priority for public transport, bicycles and pedestrians. Lessons should be taken from Singapore's policies and programs for restraint in the ownership and use of private vehicles. Such restraint should be supported by positive steps to improve train and bus services. These steps should include both physical and fiscal measures. A start should be made on electrifying the suburban railways, reconsolidating the fragmented ownership and operation of buses, compensating bus operators for restrictions on fare increases and positive priority for buses on urban roads, including the location of bus terminals and bus stops in the interest of bus passengers.

- vi) **Renewable Energy Sources**
Encourage new and renewable sources of energy (wind, solar, biomass, etc.).

8. BUILT ENVIRONMENT

a. Overview

The urban population remains low at under 25 percent of the total population and growing at 1.3% a year (UDA, 1996). Most of the urban population is concentrated in the Western Province, Central Province and in the Jaffna Peninsula. However there are a growing number of semi-urban areas developing into towns. The urban population is expected to increase more rapidly in the future, reaching 40 per cent of the total population by 2030 (WHO, 1996).

Strengths:

Most urban households have access to water and sanitation and solid waste collection. Air pollution in Colombo remains at a relatively low level when compared with other Asian cities because of the stability of the atmosphere resulting from the city's proximity to the sea and the relatively low volume of vehicles (compared with many Asian cities) as a result of high import duties and low per capita income. A long tradition of urban planning and urban government and a well-laid out institutional structure, that extends from the technically skilled Urban Development Authority to political bodies such as municipal and urban councils, has helped maintain some environmental services.

Weaknesses and Threats:

The level of urbanization is expected to significantly increase as industrial growth continues at more than 5 percent a year. Various economic and institutional shortcomings have led to the spread of low income settlements. These shortcomings include the distorted land market and failures in the credit market, which restrict the poor from access to land and money to improve their homes. Already one third of the urban population in the Western Province live in low income settlements, which lack services provided to the other groups: They receive water from a standpipe or unprotected well. They have inadequate sewerage facilities and tend to discharge their sewage directly into canals and water bodies. There is no regular collection of solid waste from these settlements. Such settlements are overcrowded and create unpleasant surroundings, being affected by floods, noise and mosquitoes. Such conditions impose significant health and social costs on the residents and also adversely affect others through pollution of water. Water quality in the main urban water bodies is poor, while air pollution is evident from the content of particulate matter and sulfur in the atmosphere being well above WHO recommended levels.

Opportunities:

A number of innovative mechanisms have been adopted to upgrade urban settlements in response to this challenge, with a focus on self help schemes and community involvement. The Government is committed to providing basic urban services in order to improve the living conditions of low-income settlers. There is also a growing trend towards involving the private sector in providing urban environmental services, such as the planned Colombo sanitary landfill to

be built by the private sector. Even where services are provided by government agencies, finances are being generated to fund the provision of improved services by such means as the recent increase in water rates. will reduce Air pollution is expected to be lowered by early next century by discontinuing the use of leaded petrol, and by the reorganization of bus companies, which may lead to more fuel efficient vehicles operating on the roads.

b. Issues

i) Inadequate policies and investments to upgrade environment of low income urban settlements

People living in low income urban settlements suffer from many problems, due to poor environmental conditions such as poor drainage, lack of potable water and sanitation, vector borne diseases and other health problems. Lack of adequate sanitary facilities in low-income settlements also affects other urban residents. The Urban Development Authority (UDA) estimates that about 35 percent of the population or about 550,000 people in the Western Province live in such uncongenial areas. The UDA estimates that 52,000 families comprising about 312,000 people (representing 50 percent of the total city population) now live in low-income settlements within the Colombo Municipal Council (CMC) area. Of this number, 64,000 live in shanties (temporary structures on encroached land), 61,000 in slum gardens (old deteriorating houses other than tenements), 127,000 in slum tenements (rows of about 15 houses built originally for workmen), 23,000 in local authority workmen's quarters and 37,000 in relocated settlements ("nava-gamgoda" or new areas of state-sponsored resettlement).

Improving sanitation in low-income settlements is the most important intervention to reduce water pollution in Colombo. While industry produces some chemical and toxic pollution, the main cause of organic water pollution in Colombo (eg Beira, Lunawa and most canals) is raw sewage, mostly from low-income urban settlements. Even in a heavily industrialized area such as Ratmalana almost three times as much domestic waste is produced as industrial wastewater. Low-income settlements have inadequate sewerage facilities and tend to discharge straight into the canals and water bodies.

The key issues are to mobilize low-income settlements to generate better planning and management of their environment and to more effectively lobby government agencies for assistance. The main community institution are the Community Development Councils (CDCs), which were encouraged by the government to act as mediators within the local community. However while these CDCs were once beneficial, many are now dormant. The state institutions involved also need to participate more actively. The National Housing and Development Trust (NHDA) has taken some important steps to encourage community participation.

ii) **Absence of a National Waste Management Strategy**

It is estimated that more than 1,000 tonnes of solid waste are currently generated per day in the Colombo Municipal Region and this is expected to increase as consumption levels increase. Waste collection serves about 90 percent of households in the CMC, but much less in other Municipal Councils. Waste is currently disposed into about 15 open dumps without any environmental safeguards. Houses around such dumpsites suffer year around as a result of diseases (especially of children), water pollution, flooding and the use of protective measures such as fly spray.

A sanitary landfill is planned with an organic composting unit, but its commissioning has been delayed by protests from local area residents.

At present there is no hazardous waste ^{dumps} treatment facility, despite hazardous wastes being generated each year by hospitals ^{and industries}, mostly in the Colombo area.

A hazardous waste treatment system is now planned.

The planned landfill and hazardous waste treatment system by themselves are inadequate. Colombo city and the country need to have a National Waste Management Strategy. Currently waste disposal, recycling and composting are being carried out in a haphazard ad hoc manner.

iii) **Flooding in Colombo and other urban centers**

Flooding due to poor drainage is a major problem in Colombo, and increasingly so in other urban centers. Such floods affect households every year, but seem to be forgotten and ignored soon after they reside. However, millions of rupees are spent on compensation for flood victims, and on disease control. The causes are linked to the earlier problems of waste and low-income settlements as the drainage system is blocked by solid waste, illegal sewerage connection and canal bank erosion. However the single most important underlying cause is the filling of marshy land as a result of unplanned land development. While the Sri Lanka Land Reclamation Board has embarked on engineering solutions to the problem there is also a need to consider possible softer solutions such as controls on land filling. A transparent consultative process involving the local community should be followed in arriving at decisions.

iv) **Rising Levels of Air pollution**

Air pollution levels are high in some locations of the country especially in respect of particulate matter and sulfur which exceed the current ambient air quality standards and WHO recommended levels. Motor traffic is growing at about 07 percent a year, especially diesel powered vans, helped by the relatively low price of diesel. While steps have been taken to import unleaded petrol, and to process unleaded petrol following the rehabilitation of the Refinery, this should be introduced with a cross-subsidy as in most other countries.

c. **Recommendations**

i) **National Urbanisation Policy to be developed and implemented by Zoning and Development Plans for Local Authorities**

At present urbanisation is proceeding in a haphazard manner, Ribbon development along major roads leads to severe traffic congestion and lack of service facilities for the hinterland. A clear policy must developed on what type of urbanisation is required in Sri Lanka and what spatial planning and other strategies should be used to promote this. Although the Urban Development Authority has made some progress, only Colombo has a legally binding legally proclaimed development plan (since 1996)

ii) **Introduce policies and incentives to upgrade environmental conditions in urban settlements**

While some self-help schemes are ongoing or being planned to reduce these problems by upgrading low income settlements (UN Sustainable Cities Project and Clean Settlements Project), an overall policy framework and innovative investments are needed. One of the key issues is how to secure tenure. Many agencies such as the UDA and NHDA cannot work with residents of low-income settlements because they are encroachers. Past attempts at providing tenure have resulted in the occupants selling the land.

Possible approaches towards addressing the problem include the following:

- Develop and implement a strategic urban housing policy, particularly for low income settlements
- Ensure community participation in urban planning and infrastructure
- Encourage Community Development Councils, Municipal Councils and other local bodies to be pro-active in responding to community needs.
- Reform existing laws to increase supply of affordable rental accommodation
- Provide adequate compensation to displaced low income dwellers;
- Entrust public facilities like standpipes, wells and latrines to community management and self financing maintenance system.
- Provide loan schemes to pay for incremental home improvements

iii) **Prepare and implement a national solid waste management strategy**

Plans are being made to prepare a waste management strategy for the Colombo Region. Although waste management is a devolved subject, many local authorities often lack the technical skills and exposure to the many innovative approaches to waste management. The strategy should cover the roles of government agencies, the private sector and communities.

It should also focus on ways to finance improved solid waste management. At present the local authority pays for solid waste collection out of property taxes. As a result low-income settlements are often ignored in formal waste collection systems. The limited sums provided also mean that little money is available for effective waste disposal. In many developing and developed countries, the private sector has been encouraged to provide waste collection and disposal.

iv) **Prepare an Environmentally Sound Canal Development Programme, focusing on a Cost effective Drainage and Flood Control Strategy**

The canal system of Colombo and other cities remains one of Sri Lanka's most under valued resources. The canals serve both for drainage and flood control,

for absorbing and moving pollutants and are a potential recreational resource. There is an urgent system to revitalise the canal system. In the short term this would improve flood control, and reduce vector pests. In the longer term a clean canal system could provide a recreation facility and a clean and cheap transport system.

Flooding and poor drainage impose high costs on the Colombo region, but no clear management strategy has yet been developed. The Sri Lanka Reclamation and Development Board has taken some steps, but is itself only one of the stakeholders. There is also a need to examine the underlying causes of flooding and design soft solutions, such as more focused planning policies, to complement the current hard engineering approach.

v) **Revise Clean Air 2000 Air pollution strategy**

The Clean Air 2000 Action Plan was formulated in 1992 and endorsed by the Cabinet of Ministers. The Plan included 50 actions under seven major issues:

- vehicle inspection and maintenance,
- fuel reformulation,
- pricing and fleet mix,
- emission inventory and monitoring,
- standards setting, institutional setting and regulatory compliance,
- economic instruments and transportation planning and
- traffic management.

A National Task Force was appointed and chaired by the Secretary, Ministry of Environment. Only 4 of the original 50 actions had however been implemented fully by June 1996 owing to lack of funds, lack of institutional capacity and lack of infrastructure. The Plan needs to be critically reassessed and updated. With a new list of priorities, budgets and time frames. The updated action plan should also focus on economic instruments as attempts at regulation have largely failed, and also there should be greater integration with the transport institutions.

In the meantime a number of short-term policy measures can be taken to:

- Enforce no parking on all major arterial roads, with tax incentives to private sector to develop car parking space
- Encourage shift of more public offices to Sri Jayawardenepura
- Introduce unleaded petrol with a cross subsidy to encourage all vehicles to switch to it
- Introduce low sulfur diesel with a cross-subsidy
- Require an annual Motor Operation Test (MOT)
- Encourage conversion to alternative fuels
- Improve the public transport system, particularly the railway.

vi) **Urban Greenery Programme**

Urban greenery (parks, open spaces, live fences, trees etc.) is being rapidly lost through urbanisation and rising land prices. Urban greenery provides a source of free recreation, as well as a vital natural role in regulating air pollution and even micro-climates. Parks are often referred to as the "lungs of a city". There is a need to ensure that a minimum area of urban greenery is available in each local authority area. A first step would be identify the status of existing urban greenery areas and then develop guidelines for maintaining these areas.

Table-Tolerance for effluents from textile factories

Sl. No.	Determinant	Tolerance limit	Method of test (Ref: to publication in Clause 5)	Technique of the method
(1)	(2)	(3)	(4)	(5)
i)	pH value at ambient temperature	6.5 to 8.5	a	Electrometry by means of pH meter with a glass electrode (Reference method)
			b	Colorimetry
ii)	Temperature °C, max.	40	b	Thermometric Thermometer
iii)	Total suspended solids, mg/l, max.	50	a	Glass fibre filtration. 103 °C to 105 °C post washing residue
iv)	Biochemical oxygen demand(BOD), mg/l, max.	60	b	Incubation for 3 days ambient temperature incubation for 5 days at 20 °C (Reference method)
v)	Chemical oxygen demand(COD) mg/l, max.	250	a	Dichromate reflux
vi)	Oils and grease, mg/l, max.	10.0		Gravimetric, liquid extraction with trichlorotrifluoro ethane

Sl. No.	Determinant	Tolerance limit	Method of test (Ref: to publication in Clause 5)	Technique of the method
(1)	(2)	(3)	(4)	(5)
vii)	Phenolic compounds (as phenolic (H) mg/1,max.	1.0	a	colorimetry-chloro form extracts method
viii)	Sulfides,mg/1,max	2.0	a	Titrimetric-iodine method
ix)	Chromium total, mg/1,max.	2.0	a	Atomic absorption spectrophotometric method
x)	Hoxavalent chromium, mg/1,max	0.5	a	Colorimetry-diphenyl carbaside method
xi)	Copper, total mg/1, max.	3.0	a	Atomic absorption spectrophotometric method
xii)	Zinc total,mg/1, max.	5.0	a	Atomic absorption spectrophotometric method.
xiii)	Ammoniacal nitrogen, mg/1, max.	60	a	Nesslerization method
xiv)	Chloride (as u) mg/1, max	70	a	Titrimetry-Silver nitrate method (Perference method) Titrimetry-mercuric nitrate method

The temperature shall be measured at the site of sampling.

SIGIRI WEAVING MILL社 概要

同社は織布工場であるが、染色工場とガーメント工場と連繫している。原料として綿物用綿糸30％はパキスタン、織物用ポリエステル糸は台湾、ポリエステル65％、レーヨン35％の混紡糸はインドより、それぞれ輸入している。

(1) 織 物

バーマテックス製のレピア20台を保有し、整経はスイス、ベニンガー製の整経機を使用している。サイジングは外注し、製織を行っている。

操業時間は16時間（8時間 2交代制）で生地、先染の平織（資材）を生産している。織機の停台は少なく、良く動いていた。織上げ品は連繫の染色工場で染色加工を行い、一部輸出（3,000m/月）を除き、国内向けに出荷されている。

(2) 検 査

検査機を2台所有し、1台で検査を実施していたが、実際は実長測定（透過光線で見ると穴が発生しているものもあった）に使用しており、品質管理のための欠点チェックシートもなく、検査といえるものではなかった。

Employee	60×2 Shifts
Fibres	C,P / J,P
Amount of effluent	11,000 - 22,000 M3 / Day
Amount of Products	30,000 - 50,000 M2 / Day
Dyes	Dis. Rea. Pig.
Bleaching	Jig. H2O2
Waste water	Non
Width	50
Boiler	6 t / h × 1 set oil
	3 t / h × 2 sets

※ 聞き取り調査による。

SIGIRI WEAVING MILL LTD.



脱色工程外観



排水路1（脱色（中央）及び染色（左側）工程から）



排水路 2 (工場排水路)



排水路 3 (壁の向こうは敷地外 (そのまま川へ))

NAGINDAS INDUSTRIES社 概要

Employee	111
Fibres	C,N,P
Amount of effluent	40,000 M3 / Day
Amount of Products	60,000 M2 / Day
Dyes	Dis. Rea. acid.
Bleaching	Jig. H2O2
Waste water	Treated
Width	48
Boiler	0

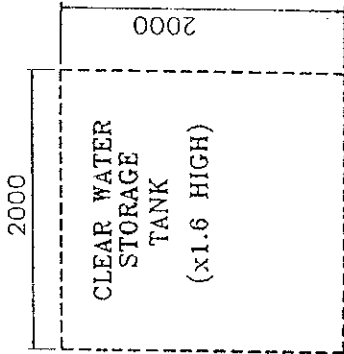
※ 聞き取り調査による。

NOTE

- ALL DIMENSIONS ARE IN mm.
- OVERALL SPACE REQD. FOR THE PLANT = 10.9mLx5.0mW.
- DRAIN TRENCHES TO BE COVER BY PRECAST SLAB BY CLIENT.

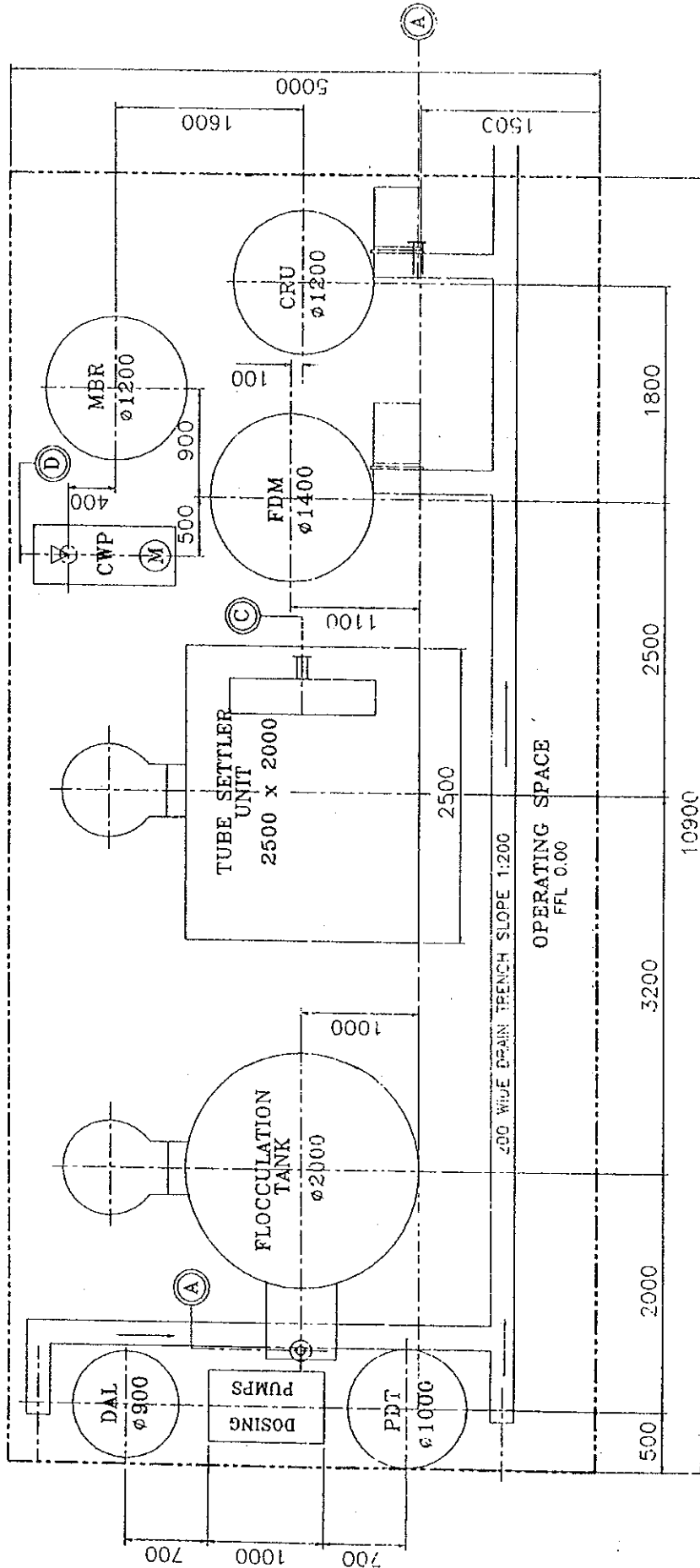
TERMINATION POINTS :

- A - RAW EFFLUENT INLET
- B - CRU OUTLET
- C - TSU OUTLET
- D - CWP PUMP SUCTION



LEGEND

- DAL ALUM DOSING TANK
- PDT CHEMICAL DOSING TANK
- CWP CLEAR WATER PUMP
- MBR BRINE MEASURING TANK
- CRU COLOUR REMOVAL UNIT
- FDM DUAL MEDIA FILTER



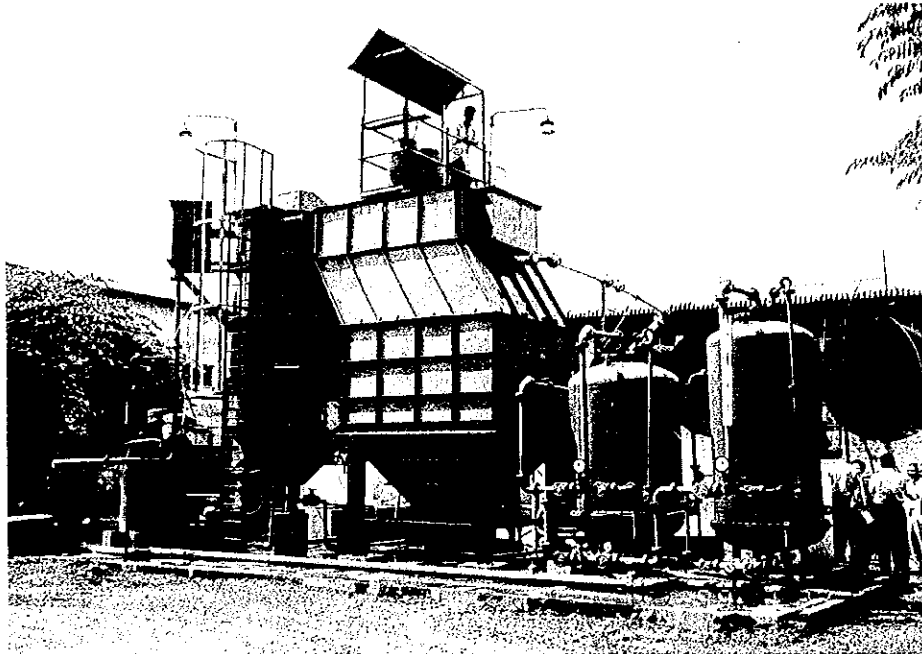
THIS DRG IS ISSUED FOR FABRICATION		THIS DRAWING IS EXCLUSIVELY OUR PROPERTY AND SHOULD NOT BE REPRODUCED OR EXHIBITED IN ANY WAY DETRIMENTAL TO OUR INTERESTS WITHOUT OUR WRITTEN CONSENT.		FILE NAME	SCH OF MTL APP. NO	CLIENTS CONSULTANTS	TITLE
REV	DATE			DRAWN	DESIGN	FOR CRS TERMINATOR - 25	
DATE				CHECKED	PROJECT	JOB NO. STD	
DATE				SCALE	TEST	DRG NO. 2.1 04707 / 1	
DATE					ASST	THERMAX LTD. WATER TREATMENT DIVISION PUNE.	



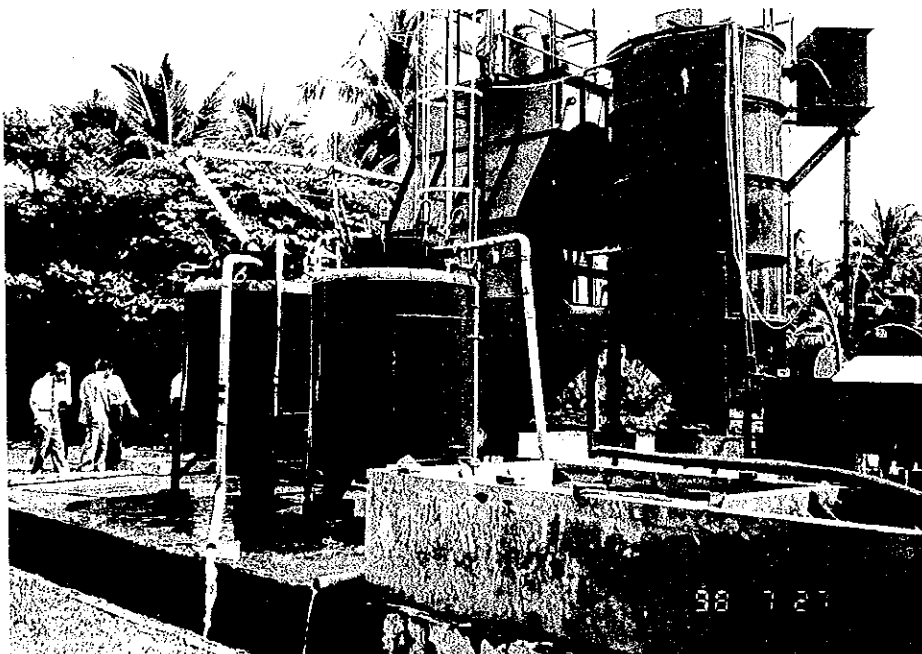
染色工程外観



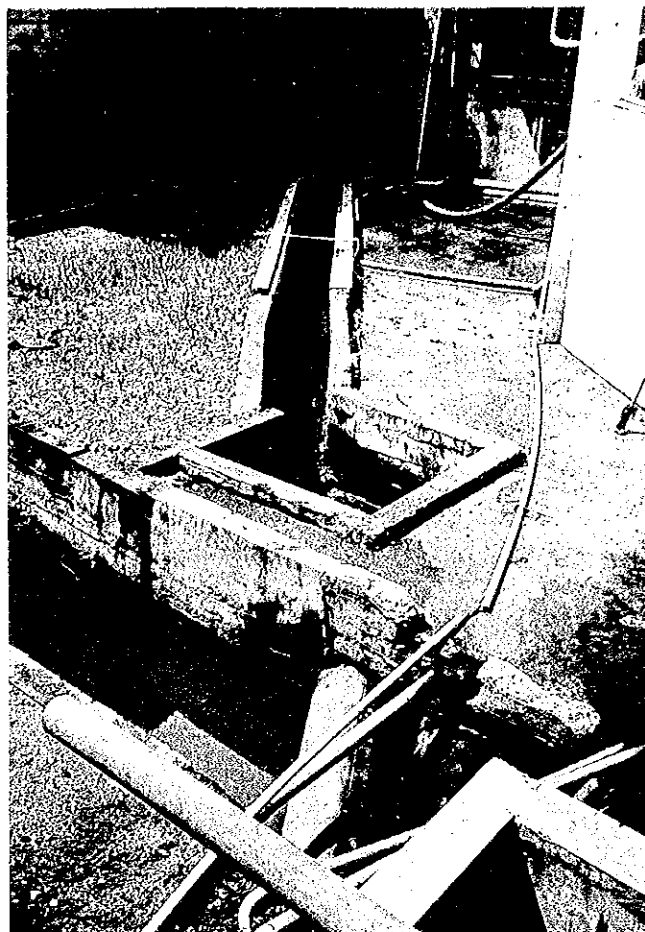
染色工程からの排水



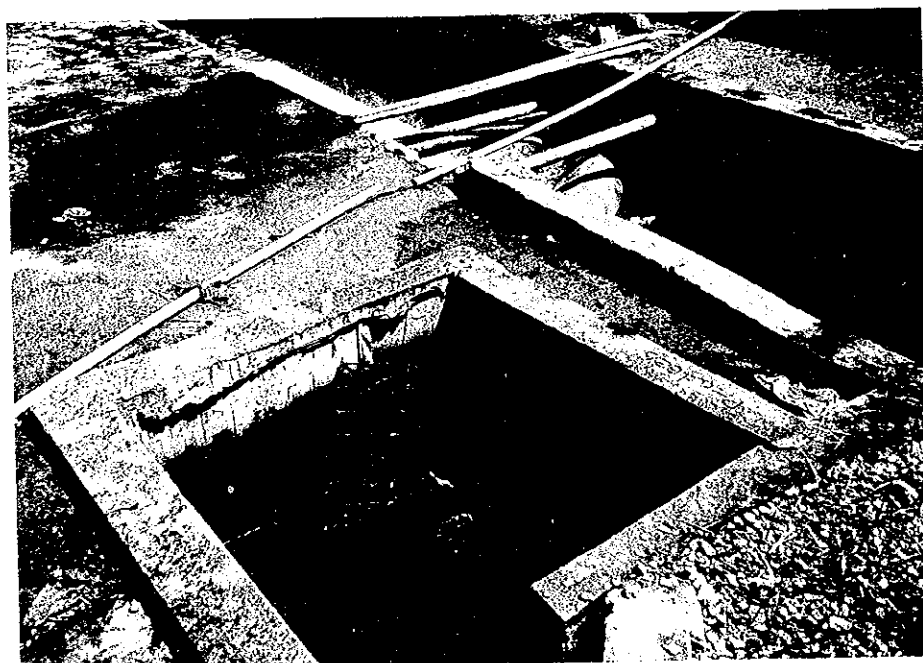
排水処理プラント外観1
(ヒアリングから：装置はインド製、総額3.5ミリオンルピー、
基礎工事から1年で完成)



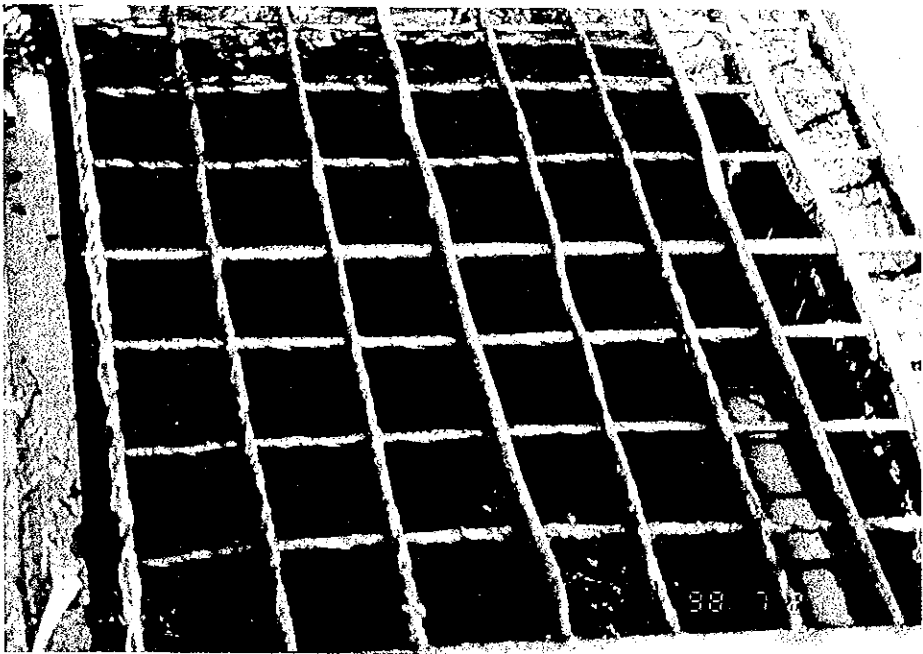
排水処理プラント外観2



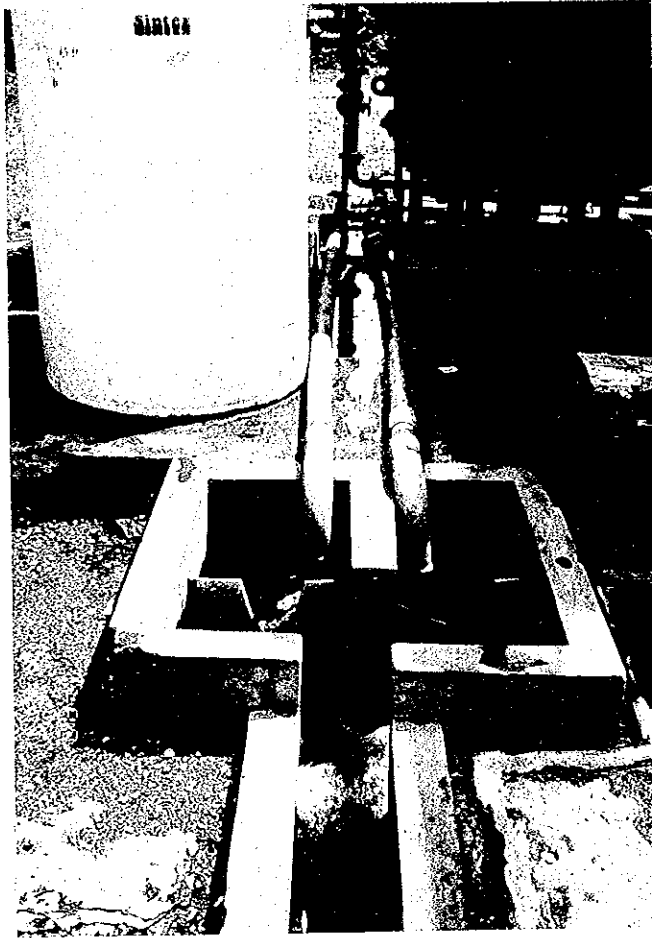
工場排水路（奥：処理前、手前：処理後）



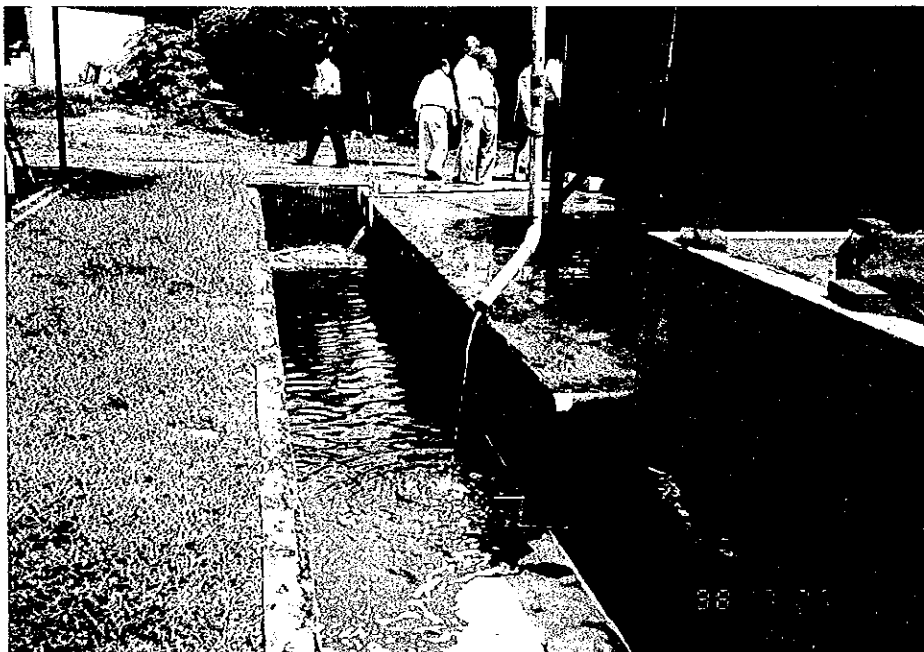
工場排水ます（処理前）



排水貯水槽



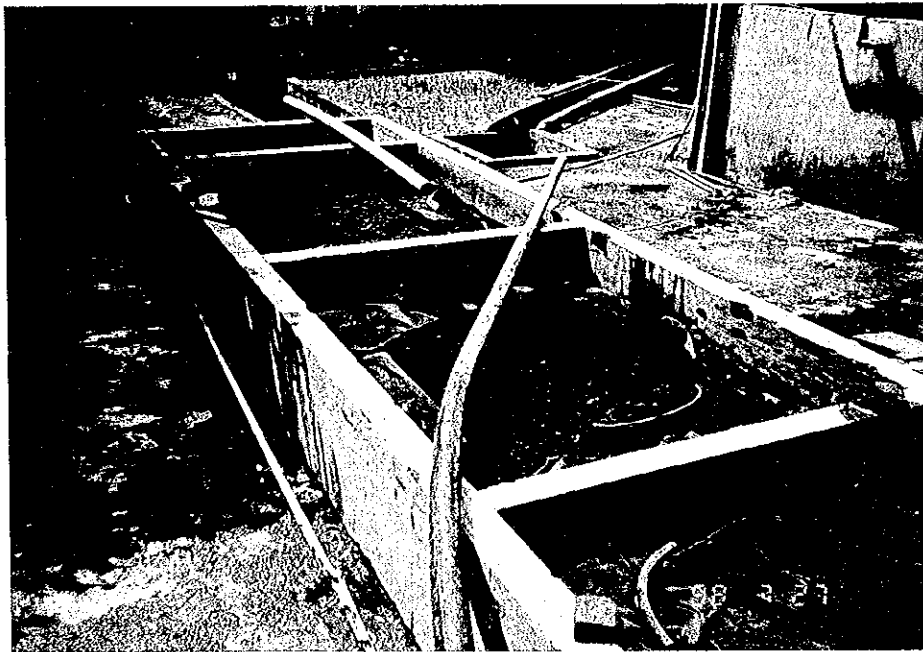
排水（処理後）



排水路（処理後）



排水路（壁の向こうは敷地外（そのまま川へ））



汚泥貯蔵地

JICA