CHAPTER 3 GENERAL CONDITIONS OF PROJECT THE AREA

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3.1 Location of the Project Area

Kandy City, the project area, is located towards the center of the island of Sri Lanka. It is the central city of Kandy district, one of 24 districts in Sri Lanka. This city is located about 150 km east of Colombo City. There are two transport modes to Kandy City from Colombo, one by Hatianal Highway (A1 road) fully paved with asphalt and the other by train. It takes about 3 hours by car and about 2.5 hours by train to reach Kandy from Colombo.

3.2 Socio-economic Conditions

Kandy City ranks fifth in population in Sri Lanka. It has a rich natural environment, and in the past, was prosperous as the capital of the Sinhala Dynasty. This city has many historic remains and cultural facilities including the Royal Botanical Garden and Peradeniya University. Moreover, it is important as the center of Buddhism in Sri Lanka, and in the heart of the city, there is the magnificent Dalada Maligawa Temple, where the sacred Tooth Relic of Buddha is housed.

The main industry of Kandy City is agriculture. The major crops include tea, and tea estates occupy about 16% of the entire area of Kandy District. Kandy City is also a major itinerary of sight-seeing in Sri Lanka. Because of its fine climate and rich historic remains and the proximity to the other tourist spots such as Sigiriya and Nuwara Eliya, a large number of tourists and sight-seers visit this city through the year. Thus, it has well-appointed sight seeing facilities and modern hotels.

Kandy City has a population of about 110,000 (as of 1987), corresponding to about 10% of the population of Kandy District. Table- 3.1 shows the population changes of Kandy City. From this table, it is estimated that the annual rate of population increase from 1978 to 1987 was 2.3% (provided that the population data containing a floating population between 1982 and 1984 are ignored), and the population in year 2000 will reach 145,000. According to the statistics of 1981, 43% of the total working population was engaged in agriculture, 35% in the service industry and 11% in the handicraft industry.

According to the statistics of Kandy District, the total population is grouped into races with 75% Sinhala, 10.5% Moors, 9.4% Indian Tamils, and 5% Sri Lanka Tamils. By religion, 74% are Buddhist, 11% Muslim, 13% Hindu and 2% Catholic.

Table - 3.1 Population Changes of Kandy City

Year	Population	Remarks
1978	88,146	
1979	89,945	
1980	91,780	
1981	91,779	
1982	137,700*	Including floating population
1983	137,700*	Same as above
1984	137,700*	Including floating population
1985	106,918	
1986	106,478	
1987	108,288	

Source : Hearing survey at the Kandy City office

3.3 Natural Conditions

Kandy City is situated in the central plateau around 500 m above mean sea level. Table- 3.2 shows the rainfall and air temperature in Kandy City. Because of the high altitudes, the air temperature is about 3° C, on the average, lower than that in the plains with low altitudes, presenting a genial climate throughout the year. Kandy City has been developed on the right bank of Mahaweli River. It is located on the northern flank of Mount Hantane (altitude about 1,100 m) and Mount Matinapatana (altitude about 960 m) situated 4 to 5 km south of the city. The city spreads about 7 km both east to west and north to south. Since Mahaweli River protrudes largely towards the north and meanders, the city takes a triangle shape and is surrounded by the river except on the southern side. The area of the city is 28.5 km^2.

Table 3.2 Mean Rainfall and Mean Air Temperature in Kandy City

Month	Rainfall(mm)	Number of rainy days	Air temperature (degrees)
Jan.	79.6	9	23.6
Feb.	58.8	6	24.7
Mar.	80.8	10	25.9
Apr.	167.2	14	26.4
May.	178.8	15	26.3
Jun.	156.5	18	24.8
Jul.	126.8	16	24.5
Aug.	85.0	14	24.4
Sep.	160.6	15	24.4
Oct.	248.7	18	24.6
Nov.	299.2	19	24.2
Dec.	153.8	14	24.0
Total	1,795.8	168	----

* Monthly mean from 1977 to 1987 (Dep. of Meteorology)

Geologically, the bedrock in the vicinity of Kandy City consists of mixed layers generally of quartz, feldspar, gneiss, and other hard rocks, and their metamorphic rocks. Layers of bedrock are complicatedly altered under the influences of faults and folds observed existing all over the neighborhood. The reason for Mahaweli River to meander extremely in the vicinity of Kandy City is considered as the influences of the complicated structure of these bedrock. The surface layer consists of brown sandy soil mixed with clay, and is 1 m to 3 m thick depending on the location. Under the surface layer, there are layers of weathered rock, and their thickness is varying from a few meters to 50 m depending on the location under the influences of the folds of the bedrock.

3.4 Social Infrastructure

Kandy City, which was prosperous in the past as an important place in Sri Lanka, is well consolidated in its social infrastructure, and the people are enjoying the amenities of its urban environment in comparison with other local cities. In the city, electric and telephone lines are installed and the health and sanitation facilities are also well consolidated. Table- 3.3 describes major social amenities, city bureaus in charge, and the conditions in Kandy City.

Table- 3.3 Consolidated Conditions of Social Amenities in Kandy City

Social amenities	Bureau in charge	Contents
Electricity	Electricity Department	Electricity is bought from Ceylon Electric board (CEB) and supplied to 15,000 consumers and 4,200 street lamps.
Road	Works Department	A total length of roads about 150 km, paved with asphalt to 90 %.
Drains	Works Department	A total length of drainage conduits 73 km.
Solid Waste Management	Public Health Department	Sweeping of 131 km of road, Daily refuse collection 60 tons.
Disease Prevention	Public Health Department	Clean-up of natural water course 30 km to control of breeding of mosquitoes, and flies.
Water Supply	Water Works Department	Piping networks 90 km. Total number of connection is 10,000. 470 stand posts.

3.5 General Conditions on Construction Activities

(1) Construction Contractors

The construction contractors in Sri Lanka have some capabilities for work execution and have experience in construction of hotels, etc. As to engineers, there are some excellent engineers who studied abroad or graduated from local universities and institutes of technology. Around 1979 to 1980, many laborers went to work in the Middle and Near East, but few in recent years. Kandy City has no construction companies which have overall construction technologies, and therefore, for large scale construction works, contracts are generally awarded to the contractors in Colombo.

(2) Construction Materials

Sand and gravel are available in the country, but steel materials such as reinforcing bars must be imported. Moreover, there are only a few heavy construction machines which can be leased, and in many cases, it is difficult to obtain heavy construction machines other than those of universal-purpose types. Materials used for temporary works are generally wood, and the steel materials available for temporary works in large-scale work are very few.

CHAPTER 4 CONTENTS OF THE PROJECT

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4.1 Objective of the Project

The objective of the Project is to increase the capacity of the existing water supply facilities up to 7.5 MGD (34,100 m^3/day), which was the capacity at the time of 1983 expansion work, through rehabilitation works of the raw water intake and the treatment plant. The scope of the Project consists of execution of facilities improvements and repairing works, and provision of the necessary equipment for operation and maintenance of the water supply system. The implementation of the Project will contribute to improve the current water supply situation and future development in the city of Kandy.

4.2 Review of the Request

4.2.1 Scope of the Project

This project aims at improving especially both water intake facilities and treatment plants in the entire water supply system in the city of Kandy consisting of the water intake facilities, water treatment plants, and water distribution systems. The contents to be assessed in this study include countermeasures against sand sedimentation in the intake facilities, measures for increasing the treated water, and installation of equipment, materials and facilities. These aspects cannot be disregarded for an effective operation, maintenance and management system of water supply in the city of Kandy. In accordance with this objective, the functions, the degree of aging, the capabilities of the existing facilities and equipment shall be analyzed. Moreover an optimal facilities structure of an adequate and appropriate scale to meet the above mentioned objective shall be examined in this study.

4.2.2 Review of the Requested Contents

Before starting site investigations, the Study team had meetings with the authorities concerned on the Sri Lanka side, and confirmed the requirements which were described in clause 2-4-2 "Contents of the Request." Based on these requirements and the results derived from the site investigations of the current status of the existing facilities and equipment, the study shall be made with a purpose to recover the existing water treatment capability up to the level of 7.5

MGD, which was the original design level, through rehabilitation of both the water intake and treatment plants. The following are main issues in this study.

(1) Review of the Target Quantity of Water Supply

The water supply service areas of the Kandy water supply system cover the entire area in the city of Kandy and the adjacent areas of both Ampitiya and Tennekumbura. It is estimated that the 1987 population in the city of Kandy was about 108,200, and that in Ampitiya and Tennekumbura was 15,000. Given a population increase rate of 2.3% per annum, based on the data collected at Kandy Municipality, the future population in this area is estimated as shown in Table 4.1.

Table - 4.1 Future Population

Year	Kandy	Ampitiya and Tennekumbura	Total
1987	108,200	15,000	123,200
1990	115,900	16,000	131,900
1995	129,900	18,000	147,900
2000	145,500	20,100	165,600

The water demands in the future are calculated based on an assumption that 70% of the total population will be served by individual house connections with a water demand unit of 40 gallon per capita per day (gcd) and the remaining 30%, by stand posts with a water demand unit of 10 gcd. Further, assuming that 3 MGD in the year 1987 and 4 MGD in the year 2000 will be used up as water leakages from the water supply systems and as consumption in industrial use (assumption by the Regional Support Center of NWSDB in Kandy City), the water demands in these areas are estimated as shown in Fig. 4.1. Based on this, the target of 7.5 MGD in this project is equivalent to the demand level in 1991. The sum of the quantity of leakage and industrial use assumed herein accounts for as much as 78% of the residential demand which is thought to be a considerably high proportion. However, this water demand is fairly changeable, depending greatly on the assumptions made. Under the current situation, the Water Works Department of Kandy City has neither equipment to measure the quantity of water leaking nor detailed data on the water demand for industrial use. In the course of this project, such data shall be developed and accumulated for a more effective maintenance and management of the system in the future.

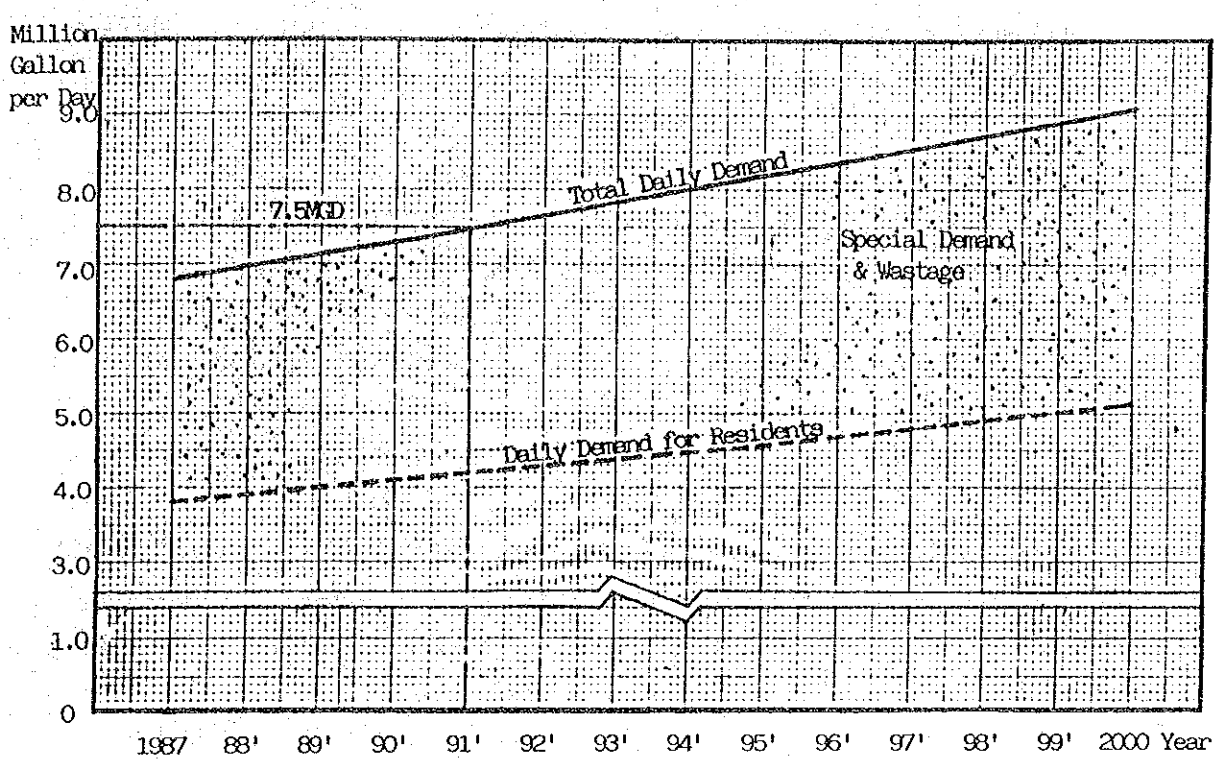


Fig. 4.1 Prediction of Water Demand

(2) Assessment of the Water Intake Facility

The request was preconditioned to use the same type of pumps continuously as the type of existing pumps. However, it is assessed that the use of the same type of pumps as the existing ones is not appropriate because of the reasons mentioned below. Instead, a grit chamber is recommended to be newly installed with the objective of eliminating the work of removing sand sediments from the intake facilities. This shall result in a 2-step pumping system consisting of the raw water intake pump and a water transfer pump which are to be installed with the grit chamber to transfer the water to the treatment plant.

(a) The existing pumping well in which pumps are installed had many chippings and exposure of reinforcement due to repeated execution of repairs or replacement of pumps. It was assessed that reinforcement in the structure is inadequate.

(b) If the same type of pumps as the existing ones were installed, recurrence of same problems cannot be avoided due to sand contained in the raw water.

(c) Since the existing pumps have to send water continuously to the water treatment plant, it would not be possible to stop intake of water for long periods during construction work to change the pump well structure.

In accordance with the request, the facilities to be improved under this project are as follows:

i) High Water Intake

Since this structure was found to have neither been weathered nor damaged, it is considered that this can withstand the future use as well. The superannuated screen installed at the intake gate should be replaced.

ii) Pumps

Since the existing pumps were found to have been superannuated due to frequent repairs and wear by sand, it is assessed those will not withstand future use. For this reason, the existing pumping system is not recommended to be adopted for future use. Instead, a 2-step serial pumping system consisting of the raw water intake pumps and the water transfer pumps combined with a grit chamber is strongly recommended. In particular, abrasion resistance type pumps should be installed for the first step pumping, taking into consideration of the wear by sand contained in the river water.

iii) Mixer and Sand Remover

These kinds of equipment are provided to prevent sand from accumulating in the existing pumping well, but the mixer can hardly suspend and fluidize sand because the particle size of sand is considerably large. Therefore it is assessed that the mixer is not effective for this purpose. The sand remover is also unnecessary, as the sand will be removed in the newly installed grit chamber.

iv) Siphon Piping System

The present situation of the 1st-step siphon piping system

between the low water intake and the high water intake was not investigated, because it had been submerged during the survey period. In the 2nd-step siphon piping system between the high water intake and the pump well, water leakage was identified through this survey. The 2nd-step siphon piping system shall not be used, pursuant to the change in the water intake system. The vacuum pumps for the 1st-step siphon piping system shall remain for future use, but the existing vacuum pumps need to be replaced, because of their substantial reduction in capability due to aging.

v) Existing Pump House and Bridge

The pumping well located in the basement shall not be used, pursuant to the change in the water intake system. The existing bridge should be used in the future, because there will be a continual need for accessing to the High Water Intake. The steel members have partially been in a hazardous condition, and the wooden footboards are rotten. These should be replaced with gratings so as to withstand the future use.

(3) Assessment of the Water Treatment Facilities

The existing water treatment plant was expanded to 7.5 MGD capacity in 1983. Based on the results of the water quality tests, the facilities survey, and from the review of the report on the augmentation plan, the existing development programmes are appraised to be adequate. Therefore, the major problem of the existing Water Treatment Plant lies on the inoperability of the facilities due to superannuation of the equipment. Although improvements are drastically needed, no additional facilities need to be considered in this project. The rehabilitation to be implemented in this water treatment plant shall be as follows.

i) Rapid Mixer

The existing mixer now remains disconnected. As a result of the flocculation tests conducted at site, it was identified that the chemical dosing point should be changed to a post-stage of the desludging channel, and the location of installation of the mixer should be changed accordingly.

ii) Desludging Channel

Since the lower-part of the sludge collector is damaged, this part

should be repaired. In accordance with the change in the chemical dosing point, a partition should be installed at a post-stage of this desludging channel so that the down-stream part functions as a mixing tank.

iii) Pulsator

Since the vacuum pumps, desludging wells, water collection piping, tranquilizers are damaged or aging, they should be repaired or replaced.

iv) Filtration Facilities

The valves and equipment in the operating panel should be replaced.

v) Chemical Dosing Equipment

Since this equipment as a whole has been superannuated to a considerable extent, full replacement is recommended. Furthermore, a safety system shall be newly installed against chlorine gas leakage. A bleaching powder dosing equipment should also be installed as a back-up system of the chlorine dosing equipment.

vi) Backwashing Facilities of Filter

since the existing blowers and wash water feed pumps are working trouble-free, these should remain for future use.

vii) Others

The piping systems and other miscellaneous equipment, which have already been superannuated, shall be replaced.

(4) Assessment of the Water Distribution Facilities

The installation of the high lift pumps for conveyance treated water from the Treatment Plant to the R_2 reservoir is now in progress in accordance with the NWSDB's design and under their supervision, and this work is scheduled to be completed in June, 1989. Since this facility will be capable to cope sufficiently with the planned target level of 7.5 MGD after completion, the assessment of these facilities is excluded from the scope of this project.

(5) Assessment of the Testing Equipment and Associated Equipment

i) Equipment for Water Quality Test

The existing equipment is capable of testing three items only. Since facilities capable of conducting the physical and basic chemical tests are indispensable for water quality analysis, the necessary testing equipment should be provided.

ii) Workshop Equipment

There is no workshop facilities whatsoever available at present. In order to adequately maintain the water supply facilities in best operating conditions at all times, it is recommended that simple workshop machinery, gas cutting & welding equipment and tools which can be easily operated even by the local staff, should be provided.

iii) Vehicle and Equipment for Water Leakage Investigation

Although no statistics are available, the quantity of water leaking out of the existing water supply network systems is considered to be very high when the type and age of the laid pipes are taken into account. Unless countermeasures against such water leakage are taken when increasing the amount of water supply, it will be difficult to establish an effective water supply system. Although this project does not cover the countermeasures against water leakage, it is recommended that a vehicle equipped with a water leakage detector, other necessary equipment and tools should be provided through this project with the objective of ensuring a good system of operation and management by the Water Supply Department of Kandy City.

iv) Electric Transformer

The existing electric transformer has apparently not received adequate maintenance, and has become substantially dirty with insulation oil. It was identified that the capacity of the existing transformer was adequate for this project, but that the capacity of the secondary switch is insufficient. Through discussions with the Electricity Department of the Kandy City, it was confirmed that this switch could be replaced with a new one with sufficient capacity by the time of completion of ongoing construction work of the High Lift Pumps. In this project, therefore, it is proposed to keep the existing transformer in use, but to change the

insulation oil.

v) Diesel Engine Power Generator

No generator facilities exist at present. The electric power is supplied by the Electricity Department. As the current electric status of supply is very poor, stoppage of electric power lasting about 5 to 10 minutes, or sometimes a few hours, is a frequent occurrence. This inevitably forces the water supply to be shut down. A complete set of diesel engine electric power generator system shall, therefore, be newly installed in order to ensure a stable water supply.

vi) Buildings and Lighting Systems

Particularly, the existing lighting systems have greatly been superannuated. Some distress is also found on the buildings. Therefore, the buildings, lighting systems, window frames, and exteriors are recommended to be repaired.

vii) Installation of a Private Telephone Line

Since the existing private telephone line between the Water Intake Plant and the Treatment Plant is very old, telecommunication between these two plants is often disrupted. Since both the Water Intake Plant and the Treatment Plant have to be operated in collaboration, a private telephone line for communication between the two plants is indispensable even in this rehabilitation project. Therefore, laying of new communication cables for a water-feed monitoring and displaying system is recommended in order to facilitate the effective operation and management of the water supply system.

(6) Assessment of the Water Distribution Facilities

The total capacity of the existing reservoirs is 1,100,000 gallons, which is equivalent to the amount of water that could be treated for about 3.5 hours after completion of this project. The standards in Sri Lanka specify that the required capacity of the water reservoir should be 50% of the volume of daily water supply (equal to a 12-hour supply volume), in the case of 24 hour constant operation facilities. Thus, compared with this standard, the capacity of the existing reservoirs is extremely low, making the facilities uneconomical. Even though this rehabilitation project could successfully restore the target capacity of the water intake and the treatment plants, if the

water distribution facilities still remained with insufficient capacity, the entire water supply system may not function effectively. Although the construction of a reservoir is not requested in the scope of this project, it is recommended that water distribution facilities including Reservoirs should urgently be expanded in order to ensure more stable operation.

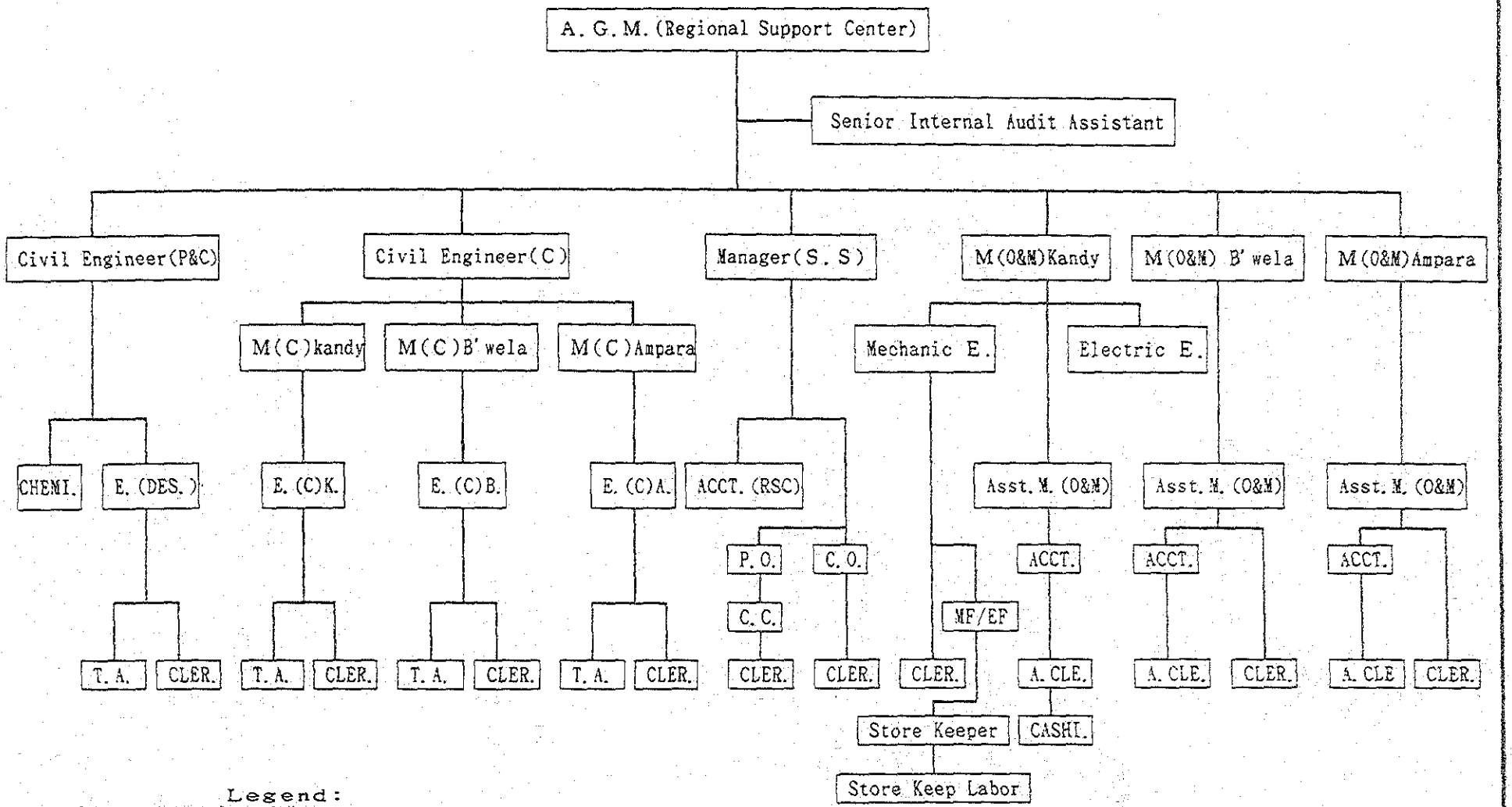
4.3 Contents of the Project

4.3.1 Executing Agency

NWSDB of Sri Lanka will be the executing agency for this project. NWSDB has already committed a tentative budget to execute this project in the coming fiscal year. The regional office of NWSDB located in the city of Kandy will be able to be in charge of the construction works of this project. The Kandy office is one of four Regional Support Centers of NWSDB throughout the country, whose organization is as shown in Fig. 4.2. Assigned under an Assistant General Manager (AGM), are about 30 specialists and other staff, and also 6 engineers in charge of the design, construction and management of the facilities. After completion of this project, NWSDB will hand over the improved facilities to the Kandy Municipality which is scheduled to continuously perform the management and operation of these facilities.

4.3.2 Summary of Facilities and Equipment

The contents of facilities to be rehabilitated and those of equipment to be provided under this project are summarized in Table 4.2.



Legend:

A. G. M.	: Assistant General Manager	E.	: Engineer
M.	: Manager	(C)	: Construction
(P)	: Planning	(O&M)	: Operation & Maintenance
(SS)	: Support Service	P. O.	: Personal Officer
(DES)	: Designing	C. C.	: Chief Clerk
C. O.	: Commercial Officer	MF/EF	: Mechanical Foreman / Electric Foreman
T. A.	: Technical Assistant		

Fig- 4.2 Organization Chart of NWSDB's Regional Support Center in Kandy

Table - 4.2 Summary of Facilities, Equipment and Materials

C : Current
R : Replacement
N : New

No.	Title	Spec/Size	Unit	Q'ty	C/R/N
1	**Water intake facilities**				
1.1	Low water intake				
	1. Structure		Unit	1	C
	2. Screen &lid		no.	1	R
1.2	Siphon pipe				
	1. Piping	500 mm	Set	1	C
1.3	High water intake				
	1. Structure		Unit	1	R
	2. Screen	1 cm mesh	Set	1	R
1.4	Water intake pump station				
	1. Structure	Reinforce concrete, 6 x 15 x 5 H m	Bldg	1	N
	2. Pump	Slurry pump of abrasion resistance 12.43 m^3/min x 18.5mh x 55 kw	Unit	3	N
	3. Vacuum pump	2.8 m^3/min x 5.5 kw	Unit	2	N
	4. Seal water pump	20 l/min x 30 m x 2.2 kw	Unit	2	N
	5. Aux. equip't., manual-operate crane, piping, etc.		Set	1	N
1.5	Grit chamber				
	1. Structure	RC-make 4 x 15.5 x 3.8 H m x 2 basins	Unit	1	N
	2. Pump well	RC-make 1.5 x 8 x 3.8 H m	Unit	1	N
	3. Gate, peripheral piping		Set	1	N
1.6	Water transfer pump station				
	1. Structure	RC-make	Bldg	1	N
	2. Pump	W-suction centrifugal pump 12.43 m^3/min x 20.8 H m x 55 kw	Unit	3	N
	3. Aux. equip't., piping, manual-operate crane, etc.		Set	1	N
1.7	Electrical equipment				
	1. Generator set	DEG 400 KVA, 400 V, 50 Hz	Unit	1	N
	2. Switch board & operating panel	Self-standing type, indoor	Set	1	N
	3. Receiving substation	11 KV/400 V, 630 KVA, oil-immersed transformer, etc.	Unit	1	C
	4. Building for generator	RC-make brick wall	Bldg	1	C
1.8	Existing pump room				
	1. Arrangement for office and/or work shop room		Unit	1	R
	2. Foot-bridge	Partial repairing	Unit	1	R

1.9	Transfer main pipe				
	1. Flow meter	Ultrasonic, 500 ø mm	Unit	1	N
	2. Connection to existing pipe line		Set	1	R
	3. Connecting cable	Underground signal cable up to water treatment plant	m	700	N
1.10	Completion of premises	Access road, fences, etc.	Set	1	R

2 Water treatment facilities

2.1	Inflow piping line				
	1. Flow meter	Ultrasonic, 500 o mm	Unit	1	N
	2. Drain piping	250 ø mm bypass piping	Set	1	R
2.2	Aerator				
	1. Structure	Use as now	Unit	1	C
2.3	Desludging channel				
	1. Structure	Use as now. Crack repair	Set	1	N
	2. Associated equipment				
	1. Sludge collector	Replacement of Lower-part only	Unit	1	R
	2. Scum skimmer	Manual pipe type	Unit	2	N
	3. Desludging related valve		Set	1	R
	4. Rapid mixer installation	Longitudinal, 1.5 kw	Unit	1	N
	5. Repair of gallery		Set	1	C
2.4	Pulsator				
	1. Structure	Use as now	Pond	4	C
	2. Associated equipment				
	1. Water channel partitioning plate	SUS-make	Set	1	R
	2. Piping, valves, etc.		Set	1	R
	3. Vacuum pump	5.4 m^3/min x 1,000 mm Aq x 3.7 kw	Unit	6	R
	4. Desludging pipe		Set	12	R
	5. Tranquilizer, Upper water collection piping		Lot	1	R
2.5	Filtration tank				
	1. Structure	Use as now	Pond	9	C
	2. Associated equipment				
	1. Various piping, valves, etc.		Set	1	R
	2. Adjustment & replenishment of filtration sand		Pond	9	R
	3. Water collection strainer		Lot	1	R
	4. Operation panel	Pneumatic operation desk type	Nos.	9	R
2.6	Filtered water tank				
	1. Structure	Use as now	Unit	1	C
2.7	Water distribution facilities				
	1. Structure	Use as now	Unit	1	C
	2. Associated equipment				
	1. Primrose pump	18 m3/hr x 10 H m x 3.7 kw	Unit	2	R

2. Water level gauge	Remote indication alarm type	Unit	1	N
3. Flow meter	Ultrasonic, 500 ø mm	Unit	1	N
2.8 Chemical dosing equipment				
1. Building structure	Use as now	Bldg	1	C
2. Associated equipment				
1. Lime mixer	Longitudinal, SUS 304 x 3.7 kw	Unit	2	R
2. Lime pump	50 l/min x 25 H m x 2.2 kw	Unit	2	R
3. Alum tank	2 x 3 x 1.6 m, 6.6 m^3	Set	1	C
4. Alum pump	10 l/min x 2 kg/cm^2 x 0.4 kw	Unit	2	R
5. Alum mixer	Portable, SUS 304, 1.5 kw	Unit	2	R
6. Chlorinator	6 kg/hr	Set	1	R
7. Chlorine neutralizer	Packing tower type, 5 m^3 tank	Set	1	N
8. Bleaching powder facility		Set	1	N
2.9 Electrical equipment				
1. Generator set	DEG 1,250 KVA, 400 v, 50 Hz	Unit	1	N
2. Bldg for generator set	RC-make	Bldg	1	N
3. Switchboard & operating panel	Self-standing type, indoor	Set	1	R
4. Electric instrumentation system	Monitoring panel	Set	1	R
5. Receiving substation	11 KVA receiving panel, 1,000 KVA oil-immersed transformer x 2, etc.	Unit	1	C
2.10 Others				
1. Replenishment of water quality testing equipment	As per Sri Lanka water quality standard	Set	1	N
2. Workshop equipment	For maintenance & inspecting the water intake & treatment plants	Set	1	N
3. Vehicle mounted w/water leakage investigation equipment	For inspecting & repairing the city water supply network	Unit	1	N
4. Building repair	Cracks, exteriors, windows, lighting systems, etc.	Lot	1	R
5. Renewing of private telephone line	Intake - treatment plant	Set	1	N
3.1 Appurtenant structure				
1. Embankment protection against scouring of river	stone-piching	Set	1	N

CHAPTER 5 BASIC DESIGN

CHAPTER 5 BASIC DESIGN

5.1 Basic Design Policy

For repairing and improving the facilities and equipment, the policies for the basic design were determined as follows in accordance with the contents of the project described in Chapter 4.

(1) The purpose of this project lies in recovering the water treatment capacity of 7.5 MGD (34,100 m^3/day) achieved in 1983 through the repairs and renovations. Basically, therefore, the original design system will not be widely changed, and the equipment in the existing facilities will be mainly replaced to achieve the recovery of capacity.

(2) Because these facilities are the sole source of water for the city of Kandy, construction will avoid interruption of water supply service for long periods as much as possible.

(3) Design for operation and control will be as simple as possible, providing simple operation, with energy-saving type systems, so that local maintenance and management costs will not be much increased.

(4) Each facility will adopt multiple systems of partially possible shutdown, through which the affects to be imposed on the entire system during a period of such work as maintenance, inspection, cleaning etc. or at an emergency, may be reduced as low as possible.

(5) For work, the locally available materials will be used as much as possible, and buildings, etc. will have the specifications under actuations in the country of Sri Lanka.

(6) The permissible stress of materials will comply with the standards as prescribed by the Japan Society of Civil Engineering , but they may be varied from time to time by considering the workability, etc. at site.

5.2 Review of Basic Design Conditions

5.2.1 Design Conditions

The design of facilities will be made in accordance with the following standards.

(1) design Criteria for Water Works Facilities, reviewed by the Ministry of Health and Welfare and Published by the Japan Water Works Association.

(2) Design manual on small community water supplies, NWSDB, 1982.

(3) Building basic structure design standards and interpretation, published by the Japan Building Association.

(4) Concrete standard manual published by the Japan Society of Civil Engineering.

(5) Other standards necessary for facilities design, etc.

5.2.2 Selection of Equipment and Materials

The equipment and materials manufactured locally are such basic building materials as cement, aggregates, etc., roof tiles, bricks, etc. It is an actuality that most of the machinery required for this project depends upon imports. The project will, therefore, procure locally such materials to be used for a grit chamber and pump houses. All other equipment and materials, pumps, valves etc., required for this project will be imported from Japan.

5.3 Basic Planning for the Facilities

5.3.1 Water Intake Facilities

Independent of the existing facilities, the water intake pump station and grit chamber will be constructed on a side slope of the river bank. A 2-step pumping system will be designed; to pump up the raw water into the grit chamber via the abrasion resistance type slurry pumps, and after sand removing, to transfer water up to the water treatment plant via the pumps.

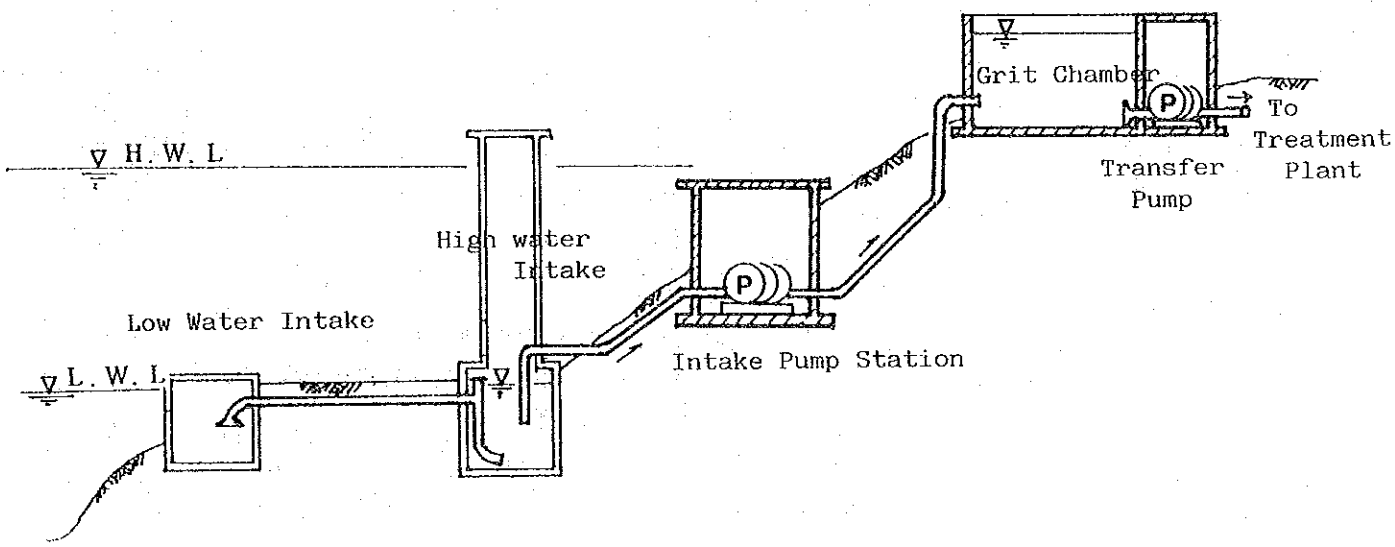


Fig. 5.1 Concept Drawing on Water Intake Facilities

The contents for improving the intake facilities will be as follows.

(1) Low Water Intake

The damaged cover and screen will be replaced.

(2) Siphon Piping

The vacuum system will be repaired.

(3) High Water Intake

The structure will be used as is. The screens will be replaced.

(4) Intake Pump Station

A new structure will be constructed. The structure and materials of the water intake pumps which will be newly installed must be withstandable to the inflow of silt and sand. They shall be easy to maintain and provide high suction head so that the intake pump station can be installed at a level higher than the river bed level as possible. Subsidiary equipment required for operating the intake pumps such as vacuum pumps, etc. will also be installed.

(5) Grit Chamber

This will be newly installed at a high location to prevent damage from flooding. The settled sand will be manually removed.

(6) Transfer Pumps

These pumps will be newly installed. The pump station will be installed adjacent to the grit chamber with the view of saving space.

(7) Electric Equipment

The existing receiving substation will be used as is. All other equipment including the switchboards will be replaced. A diesel engine generator and a room to house it will be installed for using during power failures.

(8) Existing Pump House

After dismantling the existing pumps, the space will be rearranged to be used as offices for the user's convenience. (However, the interior improvements will be the responsibility of the Sri Lanka side.)

The existing foot bridge whose steel members 7 or 8 meter distant away from the pump house are superannuated and this needs partial repairs. The existing wooden footboards of the bridge will also be replaced over the entire span with steel plates.

(9) Raw Water Pumping Main

The existing raw water pumping main between the water intake

and the treatment plants will be used as is. The connecting piping between the transfer pumps and the existing transmission pipe will be newly installed within the premises. A flowmeter for checking the water feed rate will be replaced.

5.3.2 Water Treatment Facilities

The main work for this facilities are to replace all damaged and /or obsolete machines, various valves and electric equipment.

(1) Water Inflow Piping System

The flowmeter will be replaced.

(2) Aerators

The structure will remain for use as is.

(3) Desludging Channel

The under-part of sludge collector, which is damaged, will be replaced. Piping type scum skimmer will be installed to remove scum. Automatic and manual valves for sludge extraction, which are damaged and superannuated, will be replaced. The post-stage of desludging channel will be partitioned and converted to a mixing tank.

(4) Pulsators

The structure will remain for use as is. The various damaged and superannuated valves, upper water collecting piping system, and vacuum pumps will all be replaced.

(5) Filtration Facilities

The various superannuated valves, siphon piping system and operating panels will be replaced or repaired. The existing backwash pumps and blowers will all remain for future use.

(6) Filtered Water Tank

The existing filtered water tank will remain for use as is.

(7) Water Distribution System

The pumps to Primerose Hill area will be replaced. The High Lift Pumps to R_2 reservoir are now being replaced by NWSDB, and they are beyond the scope of this project. The damaged flowmeter will be replaced.

(8) Chemical Dosing Facilities

The obsolete chemical dosing pumps, mixers, chlorine dosing equipment and piping systems will be replaced. Bleaching powder dosing equipment will be newly installed as a backup system against an interruption in the supply of chlorine cylinders. A neutralization plant will also be installed as a safety measure against chlorine gas leakage. The alum dosing point will be changed from pre-stage to post-stage of the desludging channel.

(9) Electric Equipment

The existing power receiving facilities will remain for use subject to change of insulating oil. The aged switchboards, operating panels and cables will be replaced. A diesel engine generator and a room to house it will be installed as a measure against power failures.

(10) Others

Buildings, windows and exteriors will all be repaired for cracks, damage, etc. A private telephone line will be installed between the water intake and the treatment plant.

5.4 Basic Design of Facilities

5.4.1 Water Intake Facilities

(1) Design Conditions

(i) Water Intake Quantity

Water to be purified will be 34,100 m^3/day (7.5 MGD). Considering water consumption in the water treatment plant, such as for back washing for filter, etc., the water intake quantity will exceed by 5% the water to be purified as shown below.

34,100 m^3/day x 1.05 = 35,800 m^3/day = 24.86 m^3/min.

(ii) Low Water Level of River

Low water level of river is EL + 460.55 m (1,510 ft) MSL.

(2) Loss of Water Head via the Siphon Piping System

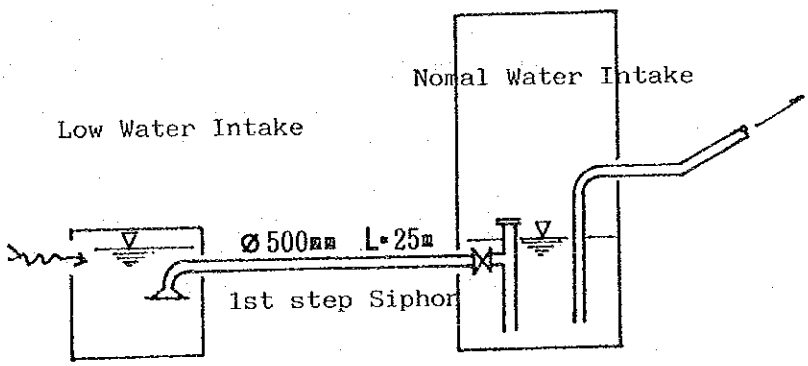


Fig. 5.2 concept Drawing on Piping

(i) Intake Loss

$$h_l = f_l \times v^2/2g$$

Where: h_l: Loss head (m)

f_l : Friction coefficient (= 0.06 from Weisbach)

g : Gravity acceleration (= 9.8 m/s^2)

v : In-pipe flow rate (m/sec) = Q/A = 2.11

Therefore, $h_1 = 0.06 \times 2.11^2/(2 \times 9.8) = 0.014$ m

(ii) Loss via Straight Piping

$h_2 = 10.666 \times Q^{1.85} \times C^{-1.85} \times D^{-4.87} \times L$

(from Hazen-Williams formula)

Where: h_2 : Loss head (m)

C : Coefficient (old cast iron pipe = 100)

D : Inside diameter of pipe (= 0.5 m)

Q : Flow rate (= 0.41 m^3/sec)

L : Length of piping (= 25 m)

Therefore, $h_2 = 0.292$

(iii) Loss via Bent Piping

$h_3 = 2$ pcs $\times f_2 \times v^2/2g$

$= 2 \times 0.17 \times 2.11^2/(2 \times 9.8) = 0.077$

(iv) Loss via Tee-type Piping

$h_4 = f_3 \times v^2/2g$

$= 1.1 \times 2.11^2/(2 \times 9.8) = 0.250$

(v) Loss via Sluice Valve

$h_5 = f_4 \times v^2/2g$

$= 0.04 \times 2.11^2/(2 \times 9.8) = 0.009$

(vi) Loss via Discharge

$h_6 = v^2/2g$

$= 2.11^2/(2 \times 9.8) = 0.227$

(vii) Total Loss

$$H = h_1 + h_2 + h_3 + h_4 + h_5 + h_6$$
$$= 0.014 + 0.292 + 0.077 + 0.250 + 0.009 + 0.227$$
$$= 0.869 \text{ m}$$

The required water quantity will be furnished by using the existing siphon piping system and adding a bell mouth at the inlet. The total loss water head will then be 0.87 m. And the planned low water level in the water intake tower will be EL + 459.5 m from the above calculation (460.55 - 0.87 = 459.68 m).

(3) Water Intake Pumps

(i) Number of Pumps

In the intake pumps, the time variation of pumping quantity is small. In view of the space limitations of the site and in order to facilitate easy maintenance, the type will be the same for all pumps given below.

Normally operated pumps = 2 pumps
Standby pump = 1 pump

(ii) Discharge Quantity

Since two pumps provide the water intake quantity of 35,800 m^3/day (24.86 m^3/min.), the discharge quantity per pump will be 12.43 m^3/min.

(iii) Head Calculation

a) Piping Route

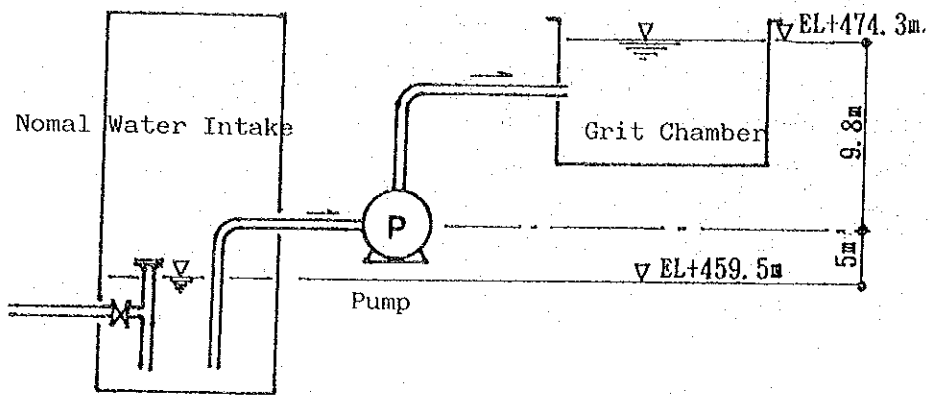


Fig. 5.3 Concept Drawing on Intake Pump

b) Total Head

$$H = ha + \square hp + he + Va^2/2g$$

Where: H : Total head (m)

ha : Actual height (m) = 14.8 m

□hp: difference in the pressure head acting on the water surface (m) = $(hp_2 - hp_1) = 0$

he : Various head losses via piping, valves, etc. (m) = 1.91

$Va^2/2g$: Discharge speed loss (m) = 0.14

Therefore, H = 16.85 m.

Considering a 10% allowance, the total head will be 18.5 m.

c) Net positive suction head (NPSH)

Available NPSH (Av)

NPSH (Av) = pa/r - Pv/r - hs - h_l

Where: Pa : Absolute atmospheric pressure = 9,740 kgf/m^2
(at 460 m altitude)
Pv : Saturated vapor pressure = 238.3 kgf/m^2
(water temperature at 20° C)
r : Specific gravity of water = 995.7 kgf/m^3
hs : Suction height = 5 m
h_l : Head loss via suction pipe = 0.67 m

Therefore, NPSH (Av) = 9.78 - 0.24 - 5 - 0.67
= 3.87 m

Required NPSH (Re)

In order to prevent pump cavitation in the pumps
NPSH (Av) > NPSH (Re)

Therefore, NPSH (Re) < 3.87 m

This means that in order to meet a suction head of 5 m, a pump having a performance of NPSH (Re) < 3.87 m is required.

(iv) Type and materials

As horizontal pumps with a structure to withstand the sand inflow will be adopted. Surface in contact with fluid, such as casing, impeller etc., will be made of material with high abrasion resistance against (silica) sand. This type of pump will also have a structure which facilitates replacement of wornout parts.

(v) Motors

$P = 0.163 \times Q \times H \times r \times (1+\alpha)/np \times nt$

Where : P : Output of motor (KW)

Q : Discharge quantity = 12.43 m^3/min.

H : Total head = 18.5 m

r : Specific gravity of water = 1

np: Efficiency of pump = 0.8

nt : Transfer efficiency = 1.0

â : Allowance = 0.1

Therefore, P = 51.5 KW, wherein the motor capacity will be 55 KW.

(vi) Vacuum Pumps and Seal Water Pumps

Before starting the water intake pumps, the pipe line at the suction side of the water intake pumps must be fully filled with water via the vacuum pump. This vacuum pump is also used as a vacuum pump for the siphon piping system between the low water intake and the high water intake. The seal water pumps will also be installed for supplying seal water to the water intake pumps.

(4) Grit Chamber

This will be installed to remove sand contained in the raw water. Two settling basins will be installed, to and from which the intake water will be pressure-pumped. The particle size of sand to be removed will be larger than 0.15 ø mm.

(i) Basin Shape

Basic shape = 4W x 11L x 3.3 mH x 2 basins

The water depth of 3.3 m will include a settled sand depth of 0.3 m.

(ii) Checking Average Velocity in the Basins

V = 24.9 m^3/min. (4 m x 3 m 2 basins) = 1.04 m/min.

= 1.7 cm/sec.

The velocity is normally designed to be less than v = 2 or 7 cm/sec. The foregoing results, therefore, meets this normal velocity.

(iii) Checking the Required Length of a Basin

$L = K \times (H \times V/U)$

Where : H : Effective water depth = 3 m

U : Settling velocity of sand = 1.5 cm/sec.
(at 0.15 ø mm in particle diameter)

V : Average velocity in basin = 1.7 m/sec.

K : Safety factor = 2

Therefore, $L = 2 \times (3 \times 1.7/1.5) = 6.8$ m

Since the length of a basin is 11 m, this is satisfactory.

(iv) Checking Capacity and Retention Time

a) Capacity

(Without considering the depth of 0.3 m allowed for settling of sand)

$4 \times 3 \times 11$ m $\times$ 2 basins = 264 m^3

b) Retention time

264 m^3 / 35,800 m^3/day = 10.6 min.

Hence, the normal designed retention time of 10 to 20 min. is met.

5) Water Transfer Pumps

(i) Number of Pumps

The number of water transfer pumps will be determined the same as the number of water intake pumps so as to provide easier operation and control, viz:

Normally operated pumps = 2 pumps

Standby pump = 1 pump

(ii) Discharge Quantity

The discharge quantity of this pump will be same as that of a water intake pump, i.e. 12.43 m^3/min. per pump. Since a low ON/OFF frequency of a water transfer pump is desirable during actual operation, the discharge quantity of a water intake pump will be set slightly higher than that of a water transfer pump, and the surplus will be drained though the overflow from the grit chamber.

(iii) Head

a) Piping Route

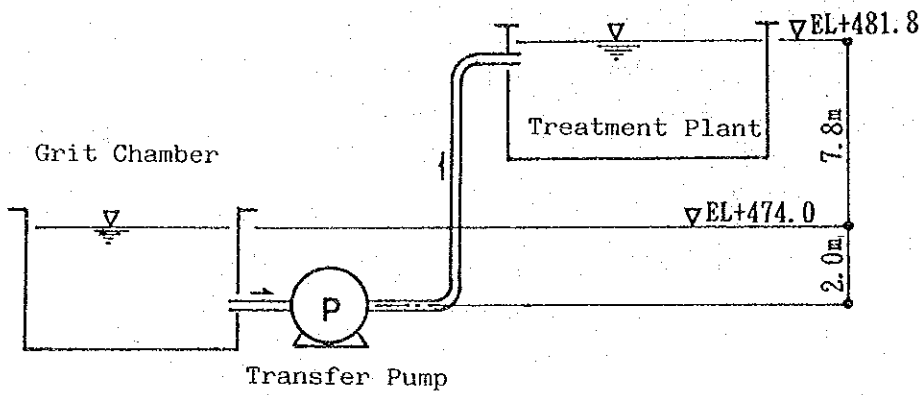


Fig. 5.4 Concept Drawing on Transfer Pump

b) Total Head

$H = ha + \square hp + he + Va^2/2g$

Where : H : Total head (m)

ha : Actual height = 7.8 m

□hp: Difference in pressure acting on water surfaces = 0 m

he : Various head losses via piping, valves, etc. = 10.92 m

$Va^2/2g$: Discharge speed loss = 0.23 m

Therefore, H = 18.95 m. 20.8 m is determined with an allowance.

(iv) Type and Materials

A horizontal pump which can be easily maintained will be adopted. The casing material is FC25, that for impeller is BC2 or equivalent.

(v) Motors

A totally-closed, external fan cooled, indoor type motor will be adopted.

$$P = 0.163 \times Q \times H \times r \times (1+å)/np \times nt$$

Where : P : Output of motor (KW)

Q : Discharge quantity = 12.43 m^3/min.

H : Total head = 20.8 m

r : Specific gravity of water = 1

np: Efficiency of pump = 0.85

nt : Transfer efficiency = 1.0

å : Allowance = 0.1

P = 54.5 KW, therefore, the motor capacity will be 55 KW.

5.4.2 Water Treatment Facilities

(1) Inflow Piping System

(i) The damaged flowmeter will be replaced with an ultrasonic type flowmeter (500 mm ø)

(ii) A 250 mm ø drain pipeline will be newly installed, as the discharge capacity of the existing drain pipeline is low. The destination of the new drain pipeline will be the drain ditch for filter backwash discharge.

(2) Aerators

(i) Since the raw water contains no iron ions or manganese ions to be oxidized, and has no odor, etc. The existing aerator has little significance. The existing structure will remain for use as is.

(ii) The remaining damaged chemical dosing pipeline will be removed.

(3) Desludging Channel

(i) Scum which is not desirous in appearance may be generated on water surface, pursuant to the aeration in the pre-stage. Piping type scum skimmers will, therefore, be installed.

(ii) Both the lower collector mechanical structure and the valves for sludge extraction, which are not normally operated due to superannuated, will all be replaced.

(4) Mixing Tanks

(i) Purpose

In order to ensure the mixing between the dosed flocculant and raw water, post-stage of the desludging channel will be partitioned and converted to a mixing tank.

(ii) Capacity

Assuming a mixing time of two minutes for the water intake quantity of 35,800 m^3/day (24.86 m^3/min.), the required capacity will be as follows.

24.86 m^3/min. x 2 = 50 m^3

(iii) Others

a) Dimensions

4.3 W x 3.4 L x 3.4 effective depth (m)

(a partitioning of stainless steel plate will be located at 3.4 m from the existing baffle plate to make a mixing tank.)

b) One unit of rapid mixer will be newly installed.

c) Changes will be made so that both alum and line can be dosed into this mixing tank.

d) The lower sludge collecting ditches in the mixing tank will be filled with mortar to provide a flat bottom.

(5) Pulsators

(i) Quantity and Dimensions of the Existing Pulsators

Quantity : 4 units

Dimensions : 9.5 x 18 x 4 mH per pond

Capacity : 684 m^3/pond x 4 ponds = 2,736 m^2

Water Surface area : 171 m^2/ pond x 4 ponds = 684 m^2

(ii) Checking Treating Capacity

35,800 m^3 of water will be treated by 4 ponds per day.

a) Retention Time

2,736 m^3 / 35,800 m^3/day = 1.8 hours

Retention time is normally designed for 1.5 to 2.0 hours, which is met.

b) Up-ward Flow Velocity

Suppose that 85% of the total water surface area is effective, the up-ward flow velocity will be as follows.

$$35{,}800\ m^3/day\ /\ (684\ m^2\ x\ 0.85) = 61.6\ m/day = 42.7\ mm/min.$$

A normal up-ward flow velocity is 40 to 50 mm/min., which is met. Based on (a) and (b) above, the existing structure will remain for future use as is.

(iii) Pulsation Cycle

a) Assuming that water quantity rising in the vacuum tower is to be half of the water to be treated :

$$35{,}800\ m^3/day\ /\ 2 = 17{,}900\ m^3/day$$

b) Quantity of Water Pumped per Cycle

Assuming that existing vacuum tower is 1.5 m x 2 m and that the effective suction head is 0.6 m:

$$1.5\ x\ 2\ x\ 0.6\ m = 1.8\ m^3/cycle$$

c) Rising Frequency

$$17{,}900\ m^3/day\ /\ 4\ ponds\ /\ 1.8\ m/cycle = 2{,}486\ cycles/pond/day$$
$$= 35\ sec/cycle/pond$$

d) Cycle

The cycle will be 30 sec. for rising up and 5 sec. for discharging, amounting to a 35 sec/cycle.

(iv) Vacuum Pumps

A pump capable of raising 0.6 m/30 sec. water level in the vacuum tower will be selected.

$$T = A\ x\ P\ /\ 10\ x\ Q\ (2\ Ha - (Ha + 10 - 2p)\ log\ (p - Ha)/p)$$

Were : T : Operating time = 0.5 min.

A : Cross section area of vacuum tower = 3 m^2

P : Maximum degree of vacuum by vacuum pumps
= -1,000 mm Ag = -1 m

Ha : Rising of water level = 0.6 m

Q : Maximum air flow volume of vacuum pump : m^3/min.

Therefore, the calculation results in Q = 5.4 m^3/min. Based on the foregoing, the number of vacuum pumps to be replaced will be 5.4 m^3/min. x 1,000 mm Ag x 3.7 KW x 6 units. (two for standby)

(6) Filtration Facilities

(i) Quantity and Dimensions of the Existing Facilities

a) Quantity : 9 ponds

b) Dimensions : 7.35 x 3.53 x 1.7 mH per pond

c) Filtration area : 25.9 m^2/pond

(ii) Checking Filtration Velocity

a) 9 ponds Operating

35,800 m^3/day (25.9 m^2 x 9 ponds) = 154 m/day

b) 8 ponds Operating

35,800 m^3/day (25.9 m^2 x 8 ponds) = 173 m/day

According to facilities standards, the filtration velocity will range from 120 to 150 m/day. As this is exceeded, the water quality tends to be worsened slightly but it is considered to be permissible for practical use. The existing structure will, therefore, remain for use as is.

(iii) All superannuated valves, siphon pipes, operating panels and some part of water collecting strainers will be replaced.

(7) Filtered Water Tank

The existing filtered water tank will remain for future use.

(8) Water Distribution Facilities

(i) The High Lift Pumps to R_2 Reservoir and their associated panels will remain for future use, as they are now under replacement by NWSDB.

(ii) The existing pump for the Primerose Hill area will be replaced with a self-priming centrifugal pump with can be more easily maintained. Both the discharge quantity and head will remain the same as those of existing pumps, viz:

18.8 m^3/hr x 10 mH x 3.7 KW

(9) Alum Dosing Facilities

(i) Dosing Quantity

Based on the results of jar tests at site, the average value will be as follows;

30 ppm as $Al_2(SO_4)_3 18H_2O$

The average quantity per day will be:

30 ppm x 35,800 m^3/day = 1,074 kg/day (as $Al_2(SO_4)_3\ 18H_2O$)

Suppose that the dosing concentration is 20% as $Al_2(SO_4)_3 18H_2O$, the dosing quantity will be as follows:

1,074 kg/day / 0.2 = 5,370 kg/day

Based on the liquid's specific gravity of 1.1:

5,370 kg/day / 1.1 = About 5 m^3/day

(ii) Storage Tanks

The existing storage tank is 2 x 3 x 1.6 mH x 2 tanks.

Suppose that the clearance above the liquid is 0.3 m and that the dead space below the water is 0.2 m, the effective water depth will be

1.1 m, so that the effective tank volume will be 2 m x 3 m x 1.1 m = 6.6 m^3/tank. Therefore, the number of storage days per tank will be

6.6 m^3 / 5 m/day = 1.3 days.

(iii) Dissolving Work

Two storage tanks will alternatively be used every other day. The dissolving will be worked out as follows:

Once/every two days/tank x 2 tanks = Once everyday

The solid alum is packed in 50 kg/bags. Number of bags per dissolving work will be as follows:

1,080 kg/day x Once a day / 50 kg/bag = About 22 bags

(iv) Dosing Pumps

a) Type : Diaphragm or plunger type metering pump

b) Discharge quantity : 3.47 l/min. based on 5 m^3/day.
Discharge rate of 0 to 10 l/min will be adopted considering the increase of dosing rate .

c) Quantity : Two (2) pumps (one for standby)

(10) Lime Dosing Facilities

(i) Dosing Quantity

Based on the results of jar tests at site, the pre-lime dosing rate will be 25 ppm (as converted into powder hydrated lime) and the post-lime dosing rate for final adjustment of pH and for alkali replenishment will be 5 ppm (as converted into hydrated lime), amounting to 30 ppm. The average daily consumption will be as follows;

30 ppm x 35,800 m^3/day = 1,074 kg/day

Suppose that the dosing concentration is 10% (as converted into $Ca(OH)_2$), the dosing quantity will be as follows:

1,074 kg/day / 0.1 = 10,740 kg/day

Based on a specific gravity of the liquid = 1.06:

10,740 kg/day / 1.06 = About 10 m^3/day

(ii) Storage Tanks

The existing storage tank is 2.1 x 2.1 x 2.1 mH x 2 tanks. Suppose that the clearance above the liquid is 0.3 m and the dead space at the bottom is 0.6 m, the effective water depth will be 1.6 m, so that the effective tank volume will be 2.1 x 2.1 x 1.6 mH = 7 m^3/tank. Therefore, number of storage days per tank will be

7 m^3 / 10 m/day = 0.7 day.

(iii) Dissolving work

Two storage tanks will alternatively be used every half day. The dissolving will be worked out as follows:

Once/day/tank x 2 tanks = twice/day

The powder hydrated lime is packed in 25 kg/bags, so that

1,074 kg/day / Twice/day / 25 kg/bags = 22 bags

will be dosed per dissolving work.

(iv) Dosing Pumps

a) Dosing Method and Type

A circulation method will be adopted to prevent the piping system being clogged with hydrated lime slurry. A slurry pump will be adopted for this purpose.

b) Quantity : Two (2) pumps (one for standby)

c) Discharge quantity : 10 m^3/day = 6.9 l/min.

Considering an increase in the dosing quantity at high turbidity a circulation operation of 50 l/min. will be adopted.

(11) Chlorine Dosing Facilities

(i) Dosing Quantity

The pre-chlorination and post-chlorination dosing rates will both be 2 ppm. The dosing quantity will be as follows:

2 ppm x 35,800 m^3/day = 72 kg/day = 3 kg/hr

The daily consumption will be as follows:

72 kg/day x 2 = 144 kg/day

(ii) Storage Containers

A 1,000 kg cylinders (net chlorine quantity = 900 kg) will be used. The number of storage days will be:

900 kg/cylinder / 144 kg/day = 6.25 days/cylinder

(iii) Replacement of Chlorine Cylinders

The chlorine cylinders will be changed weekly without keeping standby cylinders.

(iv) Chlorine Dosing Equipment

This equipment consists of one chlorinator (common for pre-chlorination and post-chlorination) which can be connected directly to a cylinder and two each of flowmeters and ejectors. Spare equipment (one each of chlorinator, flowmeter and ejector) will be stored, instead of being installed at site.

(12) Bleaching Powder Dosing Facilities

(i) Purpose

This will be used in an emergency when the supply of chlorine

cylinders is suspended.

(ii) Dosing Quantity

Will be dosed only for post-chlorination at 2 ppm as effective chlorine. The chlorine consumption will be as follows:

2 ppm x 35,800 m^3/day = 72 kg/day (as chlorine)

The effective chlorine part of bleaching powder is 35%. The bleaching powder consumption will, therefore, be

72 kg/day / 0.35 = 206 kg/day.

Suppose that the dosing concentration is 10% (as converted into powder), based on the specific gravity of 1.08:

206 kg/day / 0.1 / 1.08 = About 2 m^3/day

(iii) Storage Tanks

1 m^3 x 2 tanks will be used.

Number of storage days : 0.5 day/tank x 2 tanks = 1 day

(iv) Dissolving Work

Two tanks will alternatively be used. The dissolving will be worked out as follows:

Once/day/tank x 2 tanks = Twice/day

The bleaching powder is contained in 50 kg cans.

206 kg/day / Twice/day / 50 kg/can = About 2 cans will be used per dissolving work.

(v) Dosing Pump

a) Type : Diaphragm or plunger type metering pump

b) Discharge quantity : 1.39 l/min. based on the daily consumption of 2 m^3, 0 to 4 l/min. for pump

c) Quantity : One (1) pump

(13) Chlorine Neutralization facilities

(i) Purpose

This will be used in an emergency when chlorine gas leaks from a chlorine cylinder, and is intended to neutralize the leaked chlorine gas by means of a neutralization tower of filling type.

(ii) Design Conditions

a) Neutralization capacity : 500 kg (as representing a half quantity of 1-ton cylinder)

b) Neutralization method : Scrubber method of filling tower type.

c) Neutralizer liquid : 15% caustic soda.

d) Concentration of chlorine after neutralization : 10 ppm or below

(iii) Air-exhaust Ventilator

$Q = V \times N/60$

Where : V : Room capacity = 3.5 x 15 x 4.5 m = 236 m^3

N : Ventilation frequency = 8 times/hr

Q : Ventilating air quantity (m^3/min.)

Q = 31 m^3/min., therefore 40 m^3/min. will be adopted.

(iv) Allowable Inlet Gas Concentration

$C = A / 60 \times 22.4 / B \times T / 273 \times 100 / Q$

Where : C : Allowable inlet gas concentration (%)

A : Neutralization velocity = 630 kg/hr

T : Absolute temperature = 303 (30 ° C)

Q : Ventilating air quantity = 40 m^3/min.

B : Molecular weight of chlorine = 70.9

Therefore, C = 9.2%

(v) Caustic Soda Storage Tank Capacity

$Cl_2 + 2NaOH \text{ --- } NaCl + NaClO + H_2O$

71 80

From the foregoing, the caustic soda quantity required to neutralize 500 kg of chlorine gas will be:

500 kg x 80 / 71 = 563 kg

Suppose that 15% caustic soda is stored and used up to 3% concentration, the initial requirement will be

563 kg x 10 / (15 - 3) x 1 / (1.17×10^3) = 4 m^3.

The storage tank capacity will, therefore, be 5 m^3.

5.4.3 Electric Facilities

1) Receiving Substation and Distribution Equipment

(i) Electric power to the treatment plants is supplied through the 11 KV power drawn into the receiving substations located at both the water intake and the water treatment plant after transformed to 400/230 V via a transformer. This electric power is also distributed to the neighboring private households, and is managed by the Electricity Department of Kandy City.

(ii) Classification of Scope

Up to low voltage switchboard OCB : Sri Lanka side

After low voltage switchboard : Japanese side

(iii) Cabling system to each piece of equipment will be as follows:

a) Power and lighting feeders : 3 ø 4 W 400/230 V

b) Pumps and fans : 3 ø 3 W 400 V

c) Lighting and outlets : 1 ø 2 W 230 V

2) Water Intake Plant

(i) Switchboards and operating panels for pumps, etc. will be newly be installed, while the existing panels will be removed.

(ii) Necessary lighting and outlets will all be installed.

(iii) A complete set of 400 KVA diesel engine electric power generator will be installed as a power supply facilities for lighting and operating of facilities during an emergency.

(iv) One flowmeter will be installed in the water transfer pipeline to measure the water quality.

(v) Both the operating conditions and troubles in the water intake plant will be displayed on the monitoring panels in the water treatment plant for the purpose of monitoring thereof.

3) Water Treatment Plant

(i) Control panels will be installed in the operation room and chemical building, respectively, to supply electric power to each equipment and lighting system.

(ii) A monitoring panel will be installed in the operation room to monitor the operating condition.

(iii) The lighting fixtures and outlets will all be repaired or replaced, as required.

(iv) A complete set of 1,250 KVA diesel engine electric power generator will be installed as a power supply for lighting and operating facilities during an emergency.

(v) The operating and control panels for pulsators, filters, etc. will be repaired or replaced, as required.

5.4.4 Appurtenant Works

(1) Embankment Protection Against Scouring

The water intake pump station is a structure to be constructed on the slope of embankment of River Mahaweli which is the longest river in Sri Lanka. In addition to that the stricture being stable, the ground around the structure disturbed by the construction work also needs to be protected against scouring during a flood. Stone pitching shall be done around the structure as the protection against scouring.

This work shall cover a 10 m distance from the upstream end of the adjacent High Water Intake in the upstream direction, and 10 m distance from the downstream end of the pumping station in the downstream direction. Further, stone pitching shall be done to a height so that its shoulder shall reach the intersection of the slope and the pump house's wall of road side.

5.4.5 Basic Design Drawing

Following drawings are attached together at the end of this report.

1) Hydraulic profile
2) Flow sheet of water intake plant
3) Flow sheet of treatment plant
4) Plan of intake plant
5) Layout of treatment plant
6) Section of treatment plant
7) Grit chamber & Transfer pump station
8) Intake pump station
9) Generator room, Intake plant
10) Generator room, Treatment plant
11) Electricity sequence

5.5 Planning of Equipment and Materials

(1) Replenishment of Water Quality Testing Equipment

Capabilities of the existing water testing equipment are now limited to the testing of only three items; namely turbidity, pH and residual chlorine, and the required reagents also tend to be in short supply. The Sri Lanka potable water standards specify that the testing equipment should essentially be capable of, at least once a day, checking four (4) physical test items and fifteen (15) basic chemical test items in the case of city water works serving for more than 100,000 people. Fortunately, as some specialists are assigned in charge of testing the water quality at all times, the testing equipment, which are not available now, should necessarily be added.

Recommended equipment are shown as below.

1. Water quality testing set complete with reagent set for physical and chemical quality tests ---------- 1 set

2. Laboratory instrument and auxiliary ---------- 1 set

(2) Workshop Equipment

No workshop equipment of any kind exist not. In order to maintain the facilities satisfactorily and to keep them in a good operating condition, it is recommended to have simple machining, gas cutting welding equipment and tools. The skill level of workers was appraised high enough to manufacture simple spare parts and tools with manual grinders, etc. If better equipment and tools are available, it is expected that the local maintenance capability will be radically improved.

Recommended equipment are shown as below.

1. Machine tools ---------- 1 set
2. Electric tools ---------- 1 set
3. Material handling tools ---------- 1 set
4. Measuring tools ---------- 1 set
5. Cutting tools ---------- 1 set

(3) A vehicle for Water Leakage Investigation

Practically no statistics on the quantity of water leakage in the Kandy Water Supply System are available. As there is no investigation equipment of this nature available now. A report published recently on the status of water supply in Sri Lanka pointed out that about a half of the total quantity of water supplied is lost due to leakage. If the degree of aging since construction is considered, the same can be assumed for the city of Kandy. However, this study does not cover the countermeasures against water leakage from the piping systems. If the countermeasures are taken in parallel with this project, the effectiveness of this project may be expanded remarkably. It is, therefore, recommended that a vehicle mounted with a water leakage detector and the necessary equipment and tools should be provided in this project. Consequently, this will contribute to strengthen the future operational system and management capability of the Water Supply Department of Kandy City.

Recommendable equipment are shown as below.

1. Vehicle, van type	1 no.
2. Water leakage detector	2 sets
3. Tools	1 set

CHAPTER 6 PLANNING FOR PROJECT EXECUTION

CHAPTER 6 PLANNING OF THE PROJECT EXECUTION

6.1 Project Execution System

The National Water Supply and Drainage Board (NWSDB) is the responsible agency for the project execution on the Sri Lanka side. The supreme responsible individual is the Chairman of the NWSDB. As for the local work execution of this project, the Regional Support Center of NWSDB in the Kandy City shall take the responsibility. During after conclusion of Exchange of Notes with the Government of Sri Lanka and the Government of Japan until the completion of the construction work, the NWSDB is concretely authorized to execute the activities as follows.

(1) Accomplishment of construction work of entire facilities related to this project.
(2) To contract with a consultant and a contractor.
(3) To approve the construction work.
(4) To bid and to review the tenders.
(5) To approve the payments.
(6) to manage the entirety of contracted work.
(7) To accept the completed work.
(8) to coordinate and adjust thereof with the government of Sri Lanka.

For the purpose of executing this project smoothly, the following procedure shall be taken by the organizations concerned, included Japanese side, respectively.

Immediately upon conclusion of Exchange of Note, a consultant agreement shall be concluded with the NWSDB of Sri Lanka and a Japanese Consultant firm. Then the consultant shall start the detailed design through close discussions on the matters relevant to the design with the NWSDB and the Water Works Department of Kandy Municipality. Simultaneously, the NWSDB shall execute the clearing of premises and preparation work, etc. The detailed design shall be carried out both in Sri Lanka and in Japan, and submitted to the NWSDB for approval before bidding. The official bid announcement shall be made in the name of the Government of Sri Lanka on the leading Japanese daily newspapers associated with construction and economy. The official bid documents shall be distributed to all prospective tenderers at the consultant's head office where they shall be publicly opened by a representative of the Government of Sri Lanka. The consultant shall thereafter assist the Government in evaluating bidders and drafting the contract.

After concluding an agreement on the construction work of this project, the project manager shall visit Sri Lanka to instruct the contractor on the work, and complete all necessary proceedings, including conducting of meetings and confirming relevant matters in process planning.

Upon commencing the work, one site resident manager shall always reside at the site to manage the work, to report the status of work progress periodically to the authorities related with the Government of Sri Lanka, and to attempt when necessary at adjusting opinions and reaching understanding among all concerns involved in this project. In addition to the foregoing, specialist personnel assigned on shout-term shall make spot checks in meeting the work progress. In carrying out the work, the natural, religious, customary and systematic features of Sri Lanka shall be taken into sufficient consideration, and the skill levels of local workers shall be clearly identified, prior to the management of the work execution. In the planning of work execution, the processes shall be examined in detail based on the local available technology and capabilities, and on the time required for transporting the equipment and materials procured in Japan to the site.

6.2 Divisions Responsible for Project Execution

The contents of this project shall be as described in Chapter 5. Since this project is to be accomplished with the cooperation between the governments of Japan and the Government of Sri Lanka, the responsible execution divisions between these two shall be as listed in Table 6.1 below.

Table- 6.1 Responsible Divisions of this Project Execution

Works to be undertaken	Japan	Sri Lanka
1. application for and acquisition of licenses, etc. required for works related to the execution outside the project facilities		○
2. Securing, free provision and clearing of land for a temporary base camp (2,000 m^2)		○
3. Securing of access road up to the temporary base camp		○
4. Laying of electrical cabling (230 V) and water supply system up to the temporary base camp		○
5. Furnishing of primary terminals for temporary power supply for works (400 V)		○
6. Clearing of premises and relocation of plants, fences, etc. before commencing the work		○
7. Construction of water intake facilities and clearing of premises after construction	○	
8. Internal renovation work of the existing water intake pump room for conversion into offices, etc.		○
9. Rehabilitation work for water treatment plant	○	
10. Installation of power generator set and improvement works of existing electric equipment	○	
11. Changing the capacity of the switch board on the secondary side of the electric power transformer		○

6.3 Planning of Project Execution

This project shall be carried out by the foregoing project execution systems and within the foregoing scope of work. The summary of the project execution plan shall be as follows.

6.3.1 Detail Design

Before executing this project, it is necessary to carry out the following works including topographical surveys, geological investigations, detail design and bidding related work.

(1) Surveys and Investigations

(a) Plane and leveling surveys, and establishing of bench marks within the premises of water intake and treatment plants for the purpose of constructing of the facilities based on the basic design.

(b) Geological investigation for the major facilities that are to be constructed in the premises of water intake and treatment plants.

(2) Preparation of Detailed Design and Bidding-related Documents

(a) Approval of the Project Pudget Based on the Basic Design

(b) Preparation of Design Drawings for Bidding

(c) Preparation of Bidding-related Documents

6.3.2 Planning of Work Execution and Management

The work of this project shall be executed in two phases, considering the duration required for the execution of work estimated based on the scale and quantity of work, with due consideration given to the weather, social conditions, etc. of the project area, in addition to the terms permissible in the grant aid system. The work to be done in each phase shall be as follows.

(1) First phase work : Rehabilitation work of water treatment plant

(2) Second phase work : Rehabilitation work of water intake facility

The reason why the rehabilitation work of the water treatment plant takes precedence to the other as above, is because the work has to be executed parallelly with the operation of the existing plant, and this results in a complicated process, thus requiring more time for the work. Further, since the water intake facility can be rehabilitated independently from the existing facilities, it may result in a shorter work term. During the period after completion of the first phase works until completion of the second phase works, the equipment operation manuals, etc. can also be prepared, while necessary adjustments could also be made to the facilities of the water treatment plant by actually operating them. This period may also be used for guiding and training the local staff on the operation of equipment.

6.3.3 Planning of Transporting Equipment and Materials

The ocean transportation from Japan up to the port of Colombo usually takes about half a month. Considering the lead times for requisitioning business, ship's offshore waiting, customs clearance and inland transportation, the transportation period from Japan up to Kandy City, the project area, is estimated to one and a half (1.5) months.

For the inland transportation from the port of Colombo up to the site in Kandy City, the Colombo/Kandy Highway shall be used. This road is one of the major roads in Sri Lanka, full length of which is paved, and allows traffic of large heavy vehicles. The time required between Colombo and Kandy is about 3 hours.

6.4 Execution Schedule and Estimated Project Cost

After conclusion of Exchange of Notes on the first phase work, a consultant agreement shall immediately be concluded with the Government of Sri Lanka. Prior to the agreement with contractor, various works such as detailed design, preparation of specifications, bidding, evaluation of the bid documents shall be scheduled, and the period for them is estimated at about 5 months. After conclusion of contractor agreement, it is scheduled for 12 months including procurement of

equipment and materials, and execution of the construction works.

For the second phase work, after conclusion of the Exchange of Notes, the duration shall be two 2.5 months from the preparation of the detail design up to entering into a contract with the contractor. The period of work execution is scheduled as 12 months allowing for the lead time required for procurement of equipment and materials. The work execution schedule summarizing all the foregoing shall be as shown in Fig.- 6.1 .

The works to be executed by the Government of Sri Lanka are described in chapter 6.2, and the preliminary cost for them is estimated at about Rupee 500 thousand.

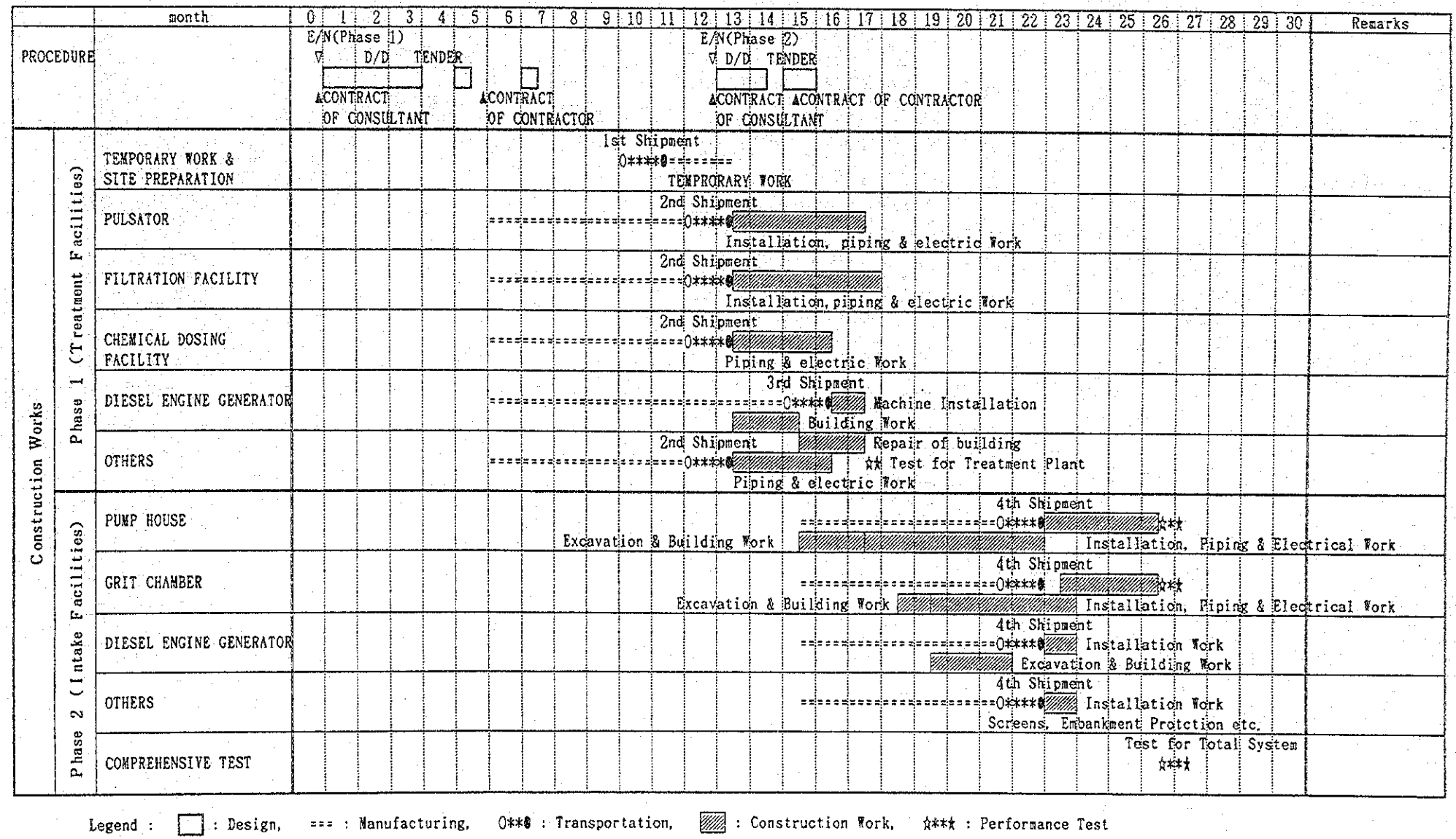


Fig- 6.1 Project Implementation Schedule

CHAPTER 7 PLANNING FOR OPERATION AND MAINTENANCE

CHAPTER 7 PLANNING OF OPERATION AND MAINTENANCE

7.1 Operation and Maintenance System

After completion of work, the various facilities in this project shall be transferred in ownership from the NWSDB to Kandy City, whose Water Works Department shall carry out the operation, maintenance and control of such facilities. The total water supply capacity after rehabilitation by this project shall be 7.5 MGD, which has already been experienced by the department at the time of augmentation of the facilities in 1983. The currently existing systems remain unchanged from that time. The major differences between the existing facilities expanded in 1983 and those after completion of this project are:

(1) that the water intake facility adopts a 2-step pumping system with water pumped from the intake upto the grit chamber in the first step and therefrom upto the treatment plant in the second-step

(2) that the scale of high lift pumps feeding from the water treatment plant up to the R_2 reservoir, now under construction, is to be expanded; and

(3) that a set of diesel engine electric power generator is to be installed both each at the water intake and treatment plants, respectively.

Based on the foregoing, it appears preferable to increase the personnel by one machine operator, by one electrical engineer, and by one water quality inspection engineer in addition to the current manpower assigned to the head works, if the operation, maintenance and control of future facilities are taken into consideration. The number of staff for the head works section of Water Works department of Kandy City will, therefore, be recommended as shown in Table- 7.1.

At present, however, the water supply department has assigned personnel in charge of daily operation and repairs. The staff in the Regional Support Center of NWSDB in Kandy City assist in technical fields such as planning design, repairs, work execution, maintenance, etc. Although NWSDB has the intention of covering these facilities under its direct management, including the operation and maintenance, Kandy City strongly opposes it. The foregoing system is required for providing a stable water supply service to the citizens, irrespectively of who the competent authority of these facilities is. Under the present circumstances, the

facilities are scheduled to be operated and maintained by Water Works Department of Kandy City. If the department is to maintain its own management, the technical upgrading of each competent staff becomes essential. If this is impossible, the question of transferring the jurisdiction of facilities to the NWSDB would continue to be pending even in the future.

Table- 7.1 Recommended Staff for Head Works Section

No.	Job Title	Current	Planned
1.	Technical officer	1	1
2.	Minor supervisor	1	1
3.	Mechanical supervisor	1	2
4.	Shift supervisor	3	3
5.	Driver mechanics	3	3
6.	Pump operator	2	2
7.	Filter operator	1	1
8.	Laboratory technician	3	4
9.	Electrician	1	2
10.	Labour	10	10
	Total	26	29

7.2 Operation and Maintenance Cost

The 1987 actual records collected at the Water Works Department of Kandy City show the approximate expenditure for the total water supply quantity of 9,237,000 m^3/year, as follows.

Table- 7.2 Actural Expenditure in 1987

No.	Item	Rs. 1,000	% to Total
1.	Labour cost	3,144	17.0
2.	Electricity	11,204	60.7
3.	Chemicals	793	4.3
4.	Fuel	322	1.7
5.	Repairs	1,220	6.6
6.	Others	1,773	9.7
	Total	18,456	100.0

After completion of this project, pursuant to increases in the facilities, personnel and the quantity of water supply, an increase in expenditure can also be assumed. The expenditure after completion of this project, is estimated as follows base on the foregoing, and subjected to the following conditions.

(1) Factors Deemed to Increase Spending

(a)	Personnel increase	3	persons
(b)	Increase in power consumption	475	KW
(c)	Installation of DEGs	2	sets
(d)	Increase in water supply quantity	2,363,000	m^3/year

(2) Electricity Cost

Electricity cost shall be estimated based on the actual records of the Water Supply Departmentfrom January to September in 1988, taking into consideration that it was revised in January of the same year.

(3) Labour Cost

Since the unit price of labour has been raised about 60% from the previous year's level in 1988, this shall be considered for this estimation.

(4) Repair Cost

It is expected that the repair cost for the Head Works section shall be greatly minimized after completion of this Project, therefore, this factor shall also be considered.

(5) The actual records of 1987 were used directly for the other factors in the following table, as they are not significant.

Note 1) An increase in the power consumption is as follows.

	Water intake facility	Treatment plant & High Lift Pump	Total
Current	90 KW x 3 units = 270 KW	200 KW x 3 units = 600 KW	870 KW
Planned	55 KW x 4 units = 220 KW (Water intake P : 2 units Transfer P : 2 units)	370 KW x 3 units = 1,125 KW (Work now under progress)	1,345 KW

*) Difference between now & planned 1,345 - 870 = 475 KW

Note 2) Quantity of water supply

Even if the capacity of the water supply facilities are restored to 7.5 MGD, a full-time operation will not be possible because of insufficient capacity of the existing reservoirs. The actual quantity of water supply is estimated at about 7 MGD. Therefore, annual water supply quantity will be about 11,600,000 m^3 as shown below.

(7.0 MGD x 365 day x 4,546 m^3/MG = 11,615,000 m^3)

Increased quantity of annual water supply will be estimated at about 2,363,000 m^3. In this case, mean operational time of the facilities will be estimated around 22 hours per day.

On the basis of the assumptions mentioned above, the annual operational cost of the water supply system is estimated as shown below.

Table- 7.3 Expenditure after completion of facilities

No.	Item	Rs. 1,000	% to Total
1.	Labour cost	5,030	16.4
2.	Electricity	22,171	72.4
3.	Chemicals	996	3.3
4.	Fuel	405	1.3
5.	Repairs	239	0.8
6.	Others	1,773	5.8
	Total	30,614	100.0 %

The foregoing estimate results in a 65.9 % increase in expenditure from the 1987 actual record after completion of the facilities. This is attributed to a substantial increase in the electrical cost accounted in the total expenditure. This increase in the power consumption is attributed to an increase in the power consumption of the high lift water pumps, now under construction in the water treatment plant, which is not within the scope of this Project.

On the other hand, the income will also increase pursuant to an increase in the quantity of water supplied. The assumptions for estimate shall be as follows.

(1) Suppose the water supply revenue is 1.5 times the present, based on the fact that the water supply fee has been raised to about 1.5 times in 1988.

(2) The ratio of the collection of the water supply fee to the quantity of water supplied remains as in actual records.

On the basis of the foregoing assumptions, the revenue is estimated as follows:

(Rs. 8,382,000 (1987 actual revenue) / 9,237,000 m^3 (1987 actual water supply quantity) x 9,237,000 (planned water supply quantity) + 2,363,000 $m^{3)}$ x 1.5 = Rs. 15,789,000

This is equivalent to 52 % of the annual operation and maintenance cost estimated above. Although the Financial Balance on Water Supply in 1988 has not been published yet, this figure can be assumed to fall down to around 40% from actual level of 49% in 1987. This result shows that the figure will be gained upto 52% after completion of this project, however it is still insufficient. In order to attempt at an increase in the future water supply profit ratio, there still remains a large number of improvement to be made, such as installation of meters, countermeasures against water leakage from the piping networks, improving the collection of fees, etc.

CHAPTER 8 EVALUATION OF THE PROJECT

CHAPTER 8. EVALUATION OF THE PROJECT

This rehabilitation project intends to restore the capacity of water intake and treatment plants in the city of Kandy to the level of 7.5 MGD (34,100 m^3/day), which was the 1983 design level. It consists of repair, rehabilitation, replacement and/or provision of new facilities.

The existing facilities except for the standby water treatment plant, are now being operated for only a few hours a day throughout the year, and are the sole facilities to supply of water for 110,000 citizens in the city of Kandy at present. However, it has already been more than a quarter century since its completion, and aging of the facilities has recently become conspicuous. The major problem of the water intake facility is due to sand intrusion from the Mahaweli River. This frequently interrupts the water supply service, thereby greatly influencing the lives of the citizens. To operate and maintain these aged facilities, the Water Supply Department of Kandy City bears the great burden of removing the sand sedimentation as part of its daily work. Despite all efforts, the existing water supply capability is only about 23,000 m^3/day.

The Project aims at restoring a stable water supply system with a supply capacity of 7.5 MGD, while eliminating problems such as those mentioned above. After completing the Project, it will be possible to provide quality water for the citizens and thereby improve their lives. As well as these direct effects, some indirect effects to be brought about by the Project cannot be overlooked in terms of stabilization of the people's lives and the Project's social impact.

The design principle for the Project was based on an appreciation of the experiences of the Water Supply Department who have been operating the existing facilities over a long period, and taking into account their capabilities in operation and maintenance. Major changes in the design of the existing facilities should be avoided. Both automation and electronic instrumentation, which have recently been implemented in Japan, have also been minimized. Should operation and maintenance capabilities be continuously strengthened, the target water treatment quantity of 7.5 MGD, could be able to be stably provided over a long period in the future as well.

This project for improvement of the water supply system in the city of Kandy is expected to be urgently implemented. This will contribute not only to lighten the burden of sand removal work in the wells and eliminate the problem of frequent suspension of the water supply, but also to improve public sanitation and the people's livelihood, which is one of the major goals of the Government of Sri Lanka. Provided with a grant aid from the Government of Japan, the Project would be able to be successfully and speedily implemented.

CHAPTER 9 CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

This project involves improvement measures for dealing with aging of water intake and treatment plants and for solving the various problems due to sand intrusion occurring in the existing water supply facilities. A system to enable the normal operation of the water supply network is crucial in water supply planning and in ensuring a stable water supply in terms of both quantity and quality. Because of this, the implementation of this rehabilitation project is indispensable for the country of Sri Lanka and also for the city of Kandy. In this sense, the earliest possible implementation is strongly desired.

The city of Kandy, which had once enjoyed great prosperity as a capital of the Sinhala Dynasty, is positioned at an important place in the central region of Sri Lanka. This city is also a center for gathering and distributing tea, one of the major export products of Sri Lanka, and a nucleus of the tourism industry whose importance for earning foreign exchange has recently been increasing. As described in Chapter 8, "Evaluation of the Project", the implementation of this project is not only expected to bring many positive effects on the society, but also is indispensable for the expected growth of Kandy.

It can also be concluded that this is an appropriate project to receive grant aid from the Government of Japan. In order to realize the smooth implementation and adequate management, operation and maintenance of this project, there are the following recommendations :

9.2 Recommendations

(1) Expansion of Reservoir

Including the major reservoir (R_2) of 800,000 gallons, the existing water reservoirs have a total water storage capacity of 110,000 gallons, which covers only a 3.5 hour water supply. At least a capacity equivalent to the daily water supply for 8 to 9 hours is required. Even though the water intake and treatment plants are rehabilitated in this project, unless the water supply reservoir capacity is increased, the situation of interruptions of the water

supply service could not be significantly mitigated. Given a water reservoir with a sufficient capacity, the water receiving tanks now installed at individual houses may also become unnecessary. This will provide quality water for the people and reduce the chance of generating waterborne epidemics. Providing the capacity required shall be equivalent to 8 hour water supply of 7.5 MGD, it shall be needed to construct a reservoir with capacity of 1.4 million gallon. In accordance with a strong request from Kandy City, the NWSDB has already commenced to study on the new reservoir. Although the city had own lands around the existing R_2 reservoir and R_3 reservoir, the former is on a steep slope of an adjacent hill and the latter is too high to convey enough water by the existing pumping system. The study has to be executed taking not only economical point of view but also adjustability to the existing system into consideration. Moreover, there are not dependable topographic maps and geological survey data for these possible sites at present. Therefore, it is recommended to carry out the study precisely based on these data collected in the future.

(2) Improvement of Financial Status

In order to improve the financial status of the water supply in Kandy city, it is recommended that the Water Works Department makes efforts to raise the current rates of water charges and install water meters on the existing pipe network.

(3) Establishment of an Operation and Maintenance Organization

One of the problems of the management organization is deemed to be the limited availability of intermediate engineers who are interpositioned between the managerial class and general workers. In particular, the number of mechanical and electrical engineers is limited. It is indispensable to provide a wide variety of educational and training programmes to foster engineers who can become the nuclei of technical transfer.

(4) Perspective on Future Water Supply and Demand

Generally, the developing countries are being influenced by a recent depression in the agricultural sector, due to the tendency for concentration of the population into urban areas. This is the case in Sri Lanka as well. The population of the city of Kandy is anticipated to increase in the future to a considerable extent, because of its central urban function. Therefore, a long-term perspective on the balance between water supply and demand is necessary for establishing a comprehensive development plan involving the development of water resources, water treatment and supply facilities.

(5) Establishment of Execution System

In order to execute this project in an effective manner, thoughtful preparatory work in the relevant agencies of the central government and close coordination between NWSDB and the Kandy Municipality are required.

ANNEX

Annex 1. MINUTES OF DISCUSSION (BASIC DESIGN STUDY)

MINUTES OF DISCUSSIONS
ON
THE PROJECT
FOR
REHABILITATION OF KANDY WATER SUPPLY SCHEME
IN
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

In response to the request made by the Government of the Democratic Socialist Republic of Sri Lanka for Rehabilitation Project of Kandy Water Supply Scheme (hereinafter referred to as "the Project"), the Government of Japan decided to conduct a Basic Design Study on the Project and entrusted the Study to the Japan International Cooperation Agency (JICA). JICA sent to the Democratic Socialist Republic of Sri Lanka the Basic Design Study Team headed by Dr. Hidenori Aya, Professor of Musashi Institute of Technology from September 29th to October 26th, 1988.

The team had a series of discussions on the Project with the officials concerned of the Government of the Democratic Socialist Republic of Sri Lanka headed by Mr. T.B. Madugalle, Chairman of the National Water Supply and Drainage Board and conducted a field survey in Kandy city.

As a result of the discussion, both parties agreed to recommend to their respective Governments the major points of understanding reached between them, attached herewith, should be examined toward the realization of the Project.

Colombo, October 7, 1988

Dr. HIDENORI AYA
Leader
Basic Design Study Team JICA

Mr. Tikiri Banda Madugalle
Chairman
The National Water Supply
and Drainage Board

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ANNEX II

The following arrangements are requested to be taken by the Government of the Democratic Socialist Republic of Sri Lanka.

1. To secure necessary lands for the Project, and to clear, fill and level the sites as needed before the start of the construction works.

2. To provide facilities for distribution of electricity, and other incidental facilities outside or within the site if necessary.

3. To construct access roads to the sites when necessary.

4. To provide data and information to a Japanese consultant and a contractor necessary for the detailed engineering services and construction.

5. To ensure prompt unloading, tax payment, customs clearance, and prompt internal transportation therein of the products purchased under the grant.

6. To exempt Japanese national from customs duties, internal taxes and other fiscal levies which may be imposed in Sri Lanka with respect to the supply of the products and services under the verified contracts of the Project.

7. To provide and accord necessary permissions, licences and other authorizations required for the execution of the Project.

8. To maintain and use properly and effectively the facilities constructed under the grant, and to arrange the budget for maintenance and operation.

9. To bear all expenses, other than those to be borne by the grant, necessary for the execution of the Project.

ANNEX I

The following items are requested by the Government of the Democratic Socialist Republic of Sri Lanka as grant aid assistance.

1. Water Intake facilities
   (1) Water intake pump
   (2) Mixer
   (3) Silt removing device
   (4) Siphon Pipe
   (5) Screen

2. Treatment Plant
   (1) Rapid mixer
   (2) De-sludging channel
   (3) "Pulsator" type clarifier
   (4) Filter
   (5) Alum dosing facilities
   (6) Chemical dosing facilities
   (7) Chlorination
   (8) Filter washing facilities

3. Distribution Equipment
   (1) Water distribution pump

4. Others
   (1) Laboratory Equipment
   (2) Workshop Equipment
   (3) Vehicle
   (4) Transformer
   (5) Receiving Panel
   (6) Lighting
   (7) Telephone between the intake and the treatment plant
   (8) Existing building

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ATTACHMENT

1. The objective of the Project is to rehabilitate the Kandy Water Supply Scheme with the aim to restore its original capacity of 34,000m³/day (7.5MGD) through rehabilitation works from the raw water intake up to/and the treatment plant.

2. The responsible and coordinating agency for the Project is the National Water Supply and Drainage Board.

3. The Team will convey to the Government of Japan the desire of the Government of the Democratic Socialist Republic of Sri Lanka that the former takes necessary measures to cooperate in implementing the Project and bears the cost of the items requested by the latter shown in Annex I within the scope of Japanese economic cooperation program in grant form.

4. The Government of the Democratic Socialist Republic of Sri Lanka will take necessary measures listed in Annex II under the condition that the grant aid assistance by the Government of Japan is extended to the Project.

5. Both parties confirmed that the Team explained Japan's grant aid program and the Sri Lanka side has understood it.

Annex 2. MINUTES OF DISCUSSION
(DRAFT FINAL REPORT)

MINUTES OF DISCUSSIONS
ON
THE DRAFT FINAL REPORT OF THE BASIC DESIGN
ON
THE PROJECT
FOR
REHABILITATION
OF
KANDY WATER SUPPLY SCHEME
IN
THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

In response to the request made by the Government of Sri Lanka, the Government of Japan decided to conduct a basic design study on the Project for Rehabilitation of Kandy Water Supply Scheme (herein after referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Sri Lanka a study team from September 29 to October 27, 1988.

As a result of the study, JICA prepared a draft report of the Basic Design and dispatched a mission, headed by Dr. Hidenori Aya, Professor of Musashi Institute of Technology, to explain and discuss about it from January 23 to February 3, 1989.

The team had a series of discussions on the Project with the officials concerned of the Government of Sri Lanka headed by Mr. A. P. Chandraratne, General Manager of the National Water Supply and Drainage Board, Ministry of Local Government, Housing and Construction.

After clarifying its contents, both parties had agreed to recommend to their respective governments that the major points of understanding reached between them, attache herewith, should be examined towards the realization of the Project.

January 27, 1989

Mr. ALAHAKOON. P. CHANDRARATNE
Genaral Manager
the National Water Supply and
Drainage Board

Dr. HIDENORI AYA
Team Leader
Draft Report Team
of Basic Design Study, JICA

Major points of understandings

1. The Sri Lanka side agreed in principle to the basic design proposed in the Draft Final Report.

2. The Sri Lanka side requested that the estimation on the operation and maintenance cost of the new system described in the draft final report will be revised on the basis of most recent cost data on electricity, labor etc. The Japanese side agreed it on condition that the Sri Lanka side shall provide the related data by February 1, 1989.

3. The Sri Lanka side requested that a justification on the selection of 2-step pumping system in the intake site will be described in the report. The Japanese side agreed that it will be added as an annex in the final report of the Project.

4. The study team expressed its concern that the capacity of the existing service reservoirs were rather small for normal water supply system. Expansion of it is essential for the effective and economical operation of the system improved by the Project. The Sri Lanka side agreed on this.

5. Sri Lanka side informed that electrical equipment installed under this Project shall be in compliance with the Ceylon Electricity Board (CEB) standards or its equivalent. Japanese side agreed on this.

6. The Sri Lanka side understood the system of Japan's Grant Aid Program and confirmed the measure to be taken by Sri Lanka side towards the realization of the Project as agreed upon in the "Minute of Discussions" dated October 27, 1988.

7. The final report (10 copies written in English) on the Project will be submitted to Sri Lanka in the end March 1989.

Annex 3. MEMBER OF THE STUDY TEAM

Speciality	Name	Position
Team Leader	: Hidenori AYA	: Professor, Musashi Institute of Technology.
Project Coordination	: Tsutomu IWASAKI	: First Basic Study Division, Grant Aid Planning and Survey Dep., JICA
Water Supply Planning	: Haruaki IKEDA	: Kyowa Engineering Consultants Co.
Electric Planning	: Mitsuro TACHIMOTO	: Kyowa Engineering Consultants Co.
Water Quality Test, Equipment Planning	: Masayuki TAGUCHI	: Kyowa Engineering Consultants Co.

Annex 4. LIST OF PERSONNEL CONTACTED

(1) Ministry of Local Government, Housing & Construction

Mr. R. Paskaralingam;	Secretary
Mr. N. D. Peiris;	Additional Secretary (Tech)

(2) National Water Supply & Drainage Board

Head Office

Mr. T. B. Madugalle;	Chairman
Mr. A. P. Chandraratne;	General Manager
Mr. H. Pinidiya;	Deputy General Manager(Planning)
Mr. G. M. O. Fernando;	Deputy General Manager (O/M)
Mr. S. K. H. Perera;	Asst. General Manager
Mr. K. G. Dayananda;	Chief Engineer (Planning)
Mr. R. H. Ruvinis;	Engineer(Planning)
Mr. D. D. N. Padmasiri;	Chief of Laboratory Service
Mr. H. Karunatilake;	Engineer
Mr. H. Gunasekara;	Engineer

Treatment Plant for Colombo Area

Mr. H. G. Tillakaratne;	Manager (Production), Great Colombo
Mr. Y. S. Silva;	Officer-in-charge (Ambatale)
Mr. N. M. S. Kalinga;	Mechanical Engineer (Ambatale)
Mr. K. Arachchige;	Officer-in-charge (Kalatuwawa)
Mr. K. T. Gunadasa;	Officer-in-charge (Labugama)

Regional Support Center, in Kandy city

Mr. S. R. J. R. Senanayake;	Asst. General Manager
Mr. B. W. R. Balasuriya;	Chief Engineer (Planning)
Mr. R. M. Danapala;	Chief Engineer (Construction)
Mr. K. G. Dayaratne;	Chief Engineer (O/M)
Mr. L. L. A. Peiris;	Manager

(3) Kandy Municipality Council

Mr. T. Ratnayake;	Mayor of KANDY
Mr. H. P. Gunasinghe;	Water Works Engineer
Mr. J. M. P. Karandawatte	Officer-in-charge (Treatment Plant)
Mr. Rajapaksha;	Asst. Officer
Mr. Dayaratne;	Asst. Officer
Mr. K. H. Perera;	Electrical Engineer

(4) Ministry of Finance & Planning, External Resources Department

Mr. S. Weerapana;	Asst. Director

(5) Embassy of JAPAN

Mr. Yasuya HAMAMOTO	Ambassador Extraordinary and Plenipotentiary
Mr. Toshihisa TAKATA	Counsellor
Dr. Yuichiro HIRANO	First Secretary
Mr. Kazuhiko MARUYAMA	First Secretary

(6) Japan International Cooperation Agency, Sri Lanka Office

Mr. Jiro HASHIGUCHI	Resident Representative
Mr. Hiroshi NINO	Assistant Resident Representative

Annex 5. ITINERARY OF THE STUDY TEAM

	Date	Itinerary	Dr. Aya Mr. Iwasaki	Water Supply Engineer	Electric Engineer	Water Quality & System Engineer
1	29/ 9(Th)	Lv. NRT~Ar. CLB				
2	30/ 9(Fr)	CLB	Meeting With the Embassy of JAPN, JICA, MLGHC, NWSD			
3	1/10(Sa)	CLB to KND	Survey of Treatment Facilities			
4	2/ (Su)	KND	Planning of Detailed Survey			
5	3/ (Mo)	KND	Discussion with Kandy Municipality, Inspection of the Facilities			
6	4/ (Tu)	KND to CLB	Meeting with NWSDB, Preparation for Minutes			
7	5/ (We)	CLB	Meeting on Inception Report, Minutes with NWSDB & MIGHG			
8	6/ (Th)	CLB	Inspection of Treatment Plants, Kalatuwawa, Labugama, Ambatale			
9	7/ (Fr)	CLB	Signing of the Minutes of Discussion			
10	8/ (Sa)	CLB	Team Meeting			
11	9/ (Su)	CLB	Planning on Field Servey			
12	10/ (Mo)	CLB	Meeting with Secretary of MLGHC			
13	11/ (Tu)	Transportation	CLB to SGP	CLB to KND		
14	12/ (We)	KND	SGP to NRT	Site survey		
15	13~21( )	KND		- do -		
24	22/ (Sa)	KND to CLB		Data Summarizing		
25	23/ (Su)	CLB		Holiday		
26	24/ (Mo)	CLB		(Full moon day) Data Summarizing		
27	25/ (Tu)	Transportation		CLB to SGP		Data Arrangement
28	26/ (We)	- do -		SGP to NRT		NWSDB Meeting, to JPN
29	27/ (Th)	- do -				-- Arriving at NRT

Abbr.: MLGHC; Ministry of Local Government, Housing and Construction

NWSD ; National Water Supply and Drainage Board

CLB ; Colombo KND ; Kandy SGP ; Singapore NRT ; Narita