BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR REHABILITATION
OF
WATER TREATMENT SYSTEM IN ISLAMABAD
IN
THE ISLAMIC REPUBLIC OF PAKISTAN

AUGUST 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Islamic Republic of Pakistan, the Government of Japan decided to conduct a basic design study on the *Project for Rehabilitation of Water Treatment System in Islamabad and entrusted the* study to the Japan International Cooperation Agency (JICA).

JICA sent to Pakistan a study team headed by Mr. Akihiro Mitarai, Resident Representative of JICA Pakistan Office, from February 25 to March 24, 1991.

The team held discussions with the officials concerned of the Government of Pakistan, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Pakistan in order to *discuss a draft report and the present report was prepared.*

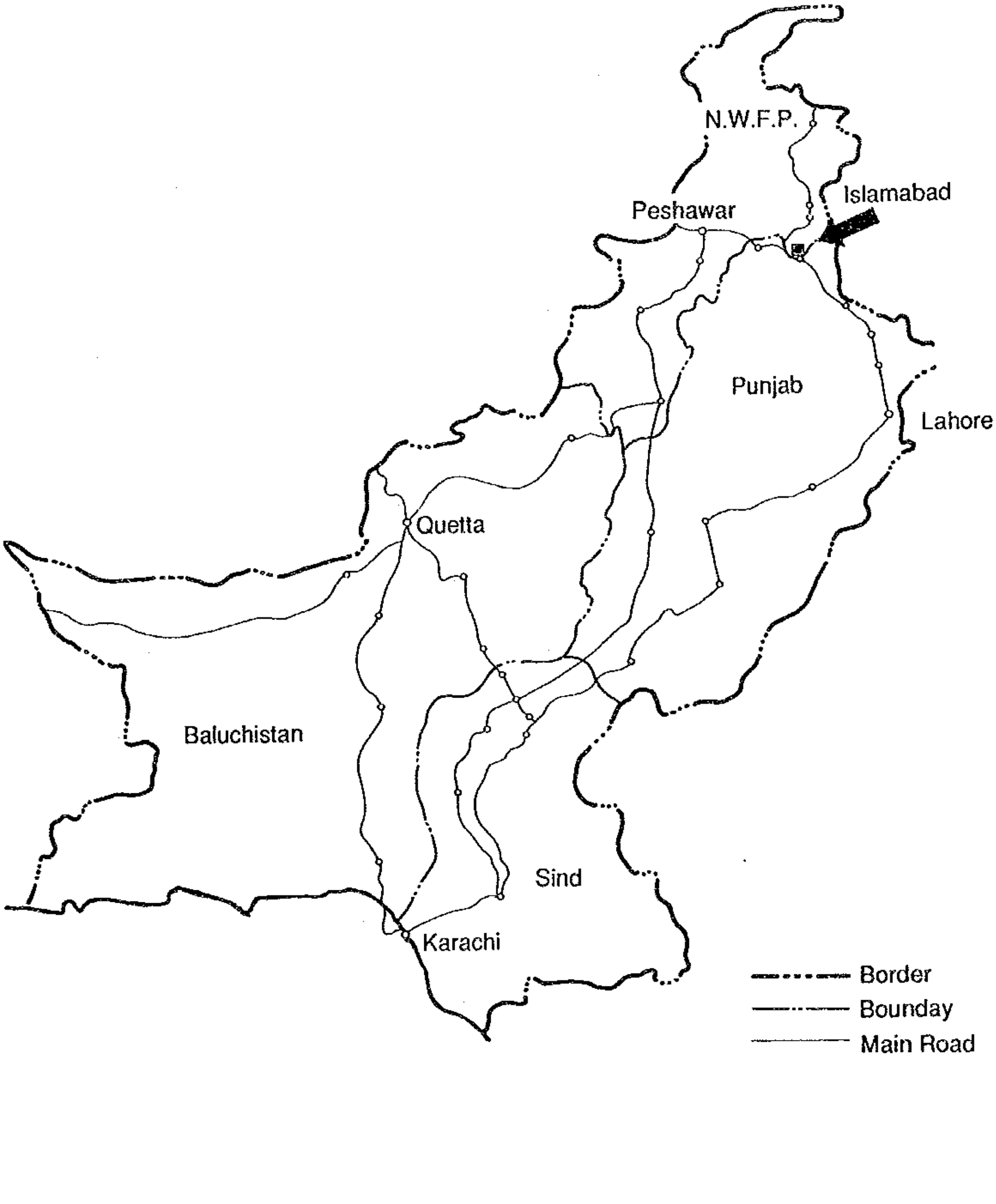
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan for their close cooperation extended to the teams.

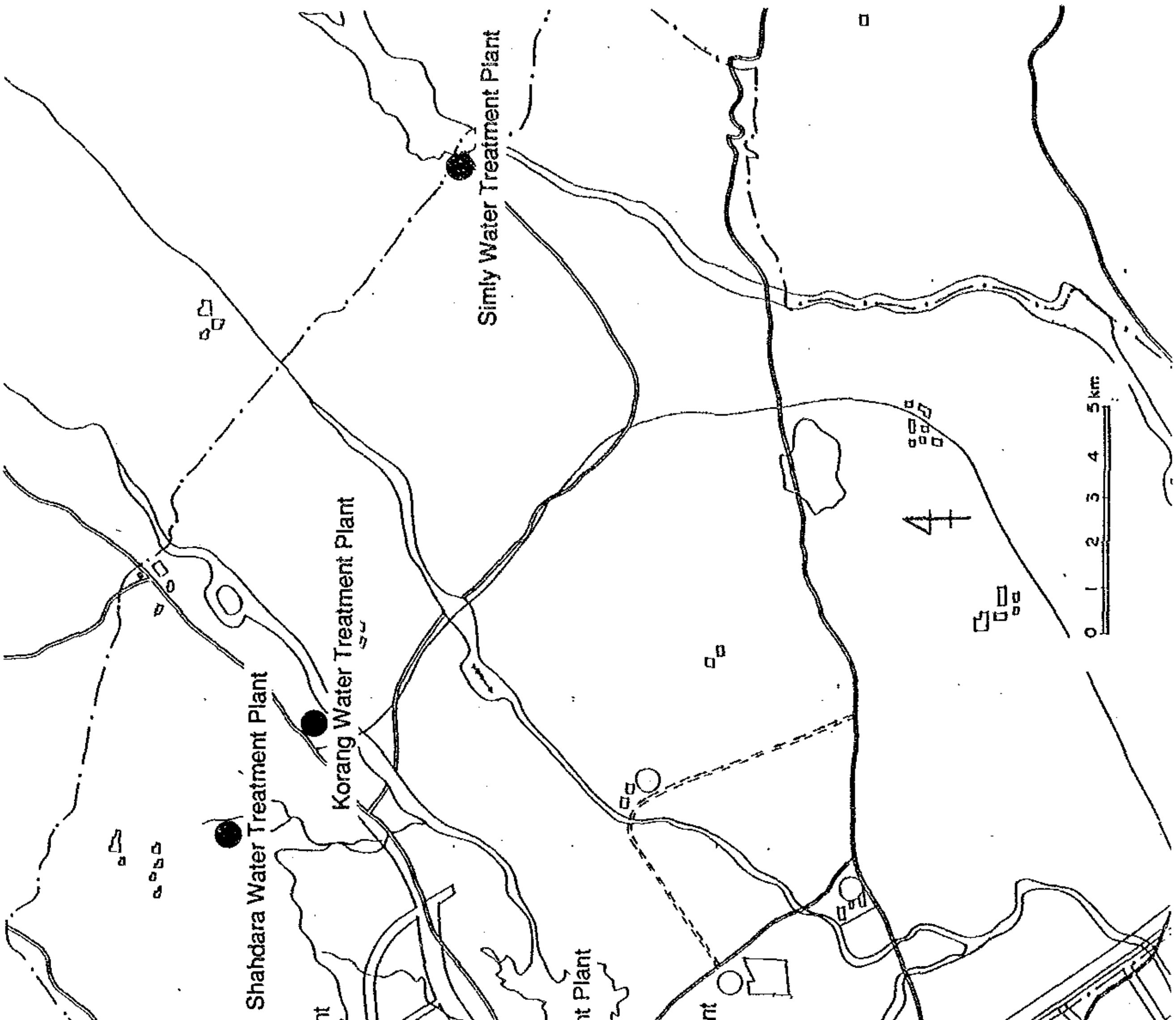
August 1991

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency



Location Map



Location of the Existing Water Treatment Plants

Summary

SUMMARY

Water supply system in Islamabad supplies water to the residents in the whole city area, population of 340,000, from eight water treatment plants (one of which has been not in operation since 1983) and tube wells. The total producing capacity is presently 227,000 m^3/day (49.7 MGD). Water supply from the water treatment plants covers 85 % of the total population and accounts 70 % of the total producing water.

For the future water supply, the Capital Development Authority (CDA), which is responsible for the water supply of the capital city, prepared the Water Supply Master Plan in 1988 aiming to maintain 100 % of service coverage so as to meet the objectives of the Seventh Five Year Plan. In the Master Plan, the population in the year 2000 is projected 621,000 and daily maximum demand and daily average demand are projected 453,000 m^3/day (99.7 MGD) and 362,000 m^3/day (79.7 MGD) respectively. Those demands will be covered by water supply from two new water treatment plants to be constructed, the existing eight plants and the existing tube wells. Two projects that construct new water treatment plants with total supply capacity of 164,000 m^3/day have been started with financing by the Overseas Economic Cooperation Fund, Japan. The total water supply capacity in the year 2000 is expected 391,000 m^3/day (85.9 MGD) and 42 % of which are to be covered by water supply from the existing eight water treatment plants.

As such, the existing water treatment plants play an important role in the present water supply operation in Islamabad and are expected to play an important role in the future, too. However, all the plants were constructed in 1963 through 1971 and many problems have been encountered in daily operations due to the aging of various facilities. They are causing a shortage in the water production amount and deterioration of the water quality of the treated water. Furthermore, such deterioration of the facilities could ever progress in the future and difficulties in achieving the Water Supply Master Plan is foreseen. To cope with these situations, CDA prepared the rehabilitation plan for the eight water treatment plants in 1989.

As a result of this background, the Government of Pakistan requested the project for the rehabilitation of water treatment system in Islamabad through Japan's grant aid program in accordance with a request of CDA. Responding to the request, the Government of Japan decided to implement the basic design study for the project. Japan International Cooperation Agency despatched a basic design study team to

Islamabad from February 25 to March 24, 1991 and a mission for the explanation of the Draft Final Report on the study from 2 July to 13 July, 1991.

As a result of the basic design study, the following facts have been confirmed:-

- The facilities in the existing plants are severely deteriorated. The present water treatment capacity is maintained by operation where the quality of the treated water is left being deteriorated.

- If the situation is not changed, not safe and not comfortable water is being supplied and the Water Supply Master Plan will not be accomplished due to the shortage of water supply from the existing plants.

- It is technically feasible to restore the water treatment capacity in terms of quantity and quality by the rehabilitation works for the existing plants.

The basic design of the project has been carried out based on the following policies:-

- To restore the water producing capacity to the original design capacity and to produce water of which quality satisfies the WHO guideline.

- To minimize size of the rehabilitation works by utilizing the existing structures and equipment as much as possible.

- To select such facility of which operation/maintenance meets the technical and financial conditions of the local.

- To meet the scheme of Japan's grant aid program.

The project is outlined as follow:-

<u>Outline of the Project</u>

Executing Agency :	Capital Development Authority (CDA)
Project Area :	Islamabad
Project Sites :	Simly water treatment plant Korang water treatment plant Golf Course water treatment plant R.L.1 water treatment plant

G-10 water treatment plant
Saidpur water treatment plant
Noorpur water treatment plant
Shahdara water treatment plant

Type of the Project : Rehabilitation of the existing plants

Purpose of rehabilitation : To improve water producing capacity to the original design capacity.

To supply clean (turbidity less than 5 degree) and safe (free from coliform bacteria) water.

Components of the Project : Replacement of water intake pumps (Golf Course and G-10 plants)

Improvement/repair of water intake facility (R.L.1 and Shahdara plants)

Improvement of coagulation/sedimentation facility (Simly, Korang, Golf Course, G-10, R.L.1 and Shahdara plants)

Improvement of operation valves of filtration basin (Simly, Golf Course, G-10, Saidpur, Noorpur and Shahdara plants)

Installation of rapid sand filtration (Golf Course and G-10 plants)

Improvement of chlorination facility (All water treatment plants)

Improvement of chemical dosing facility (All water treatment plants except Saidpur plant)

Installation of flow measuring device (All water treatment plants except Korang plant)

Replacement of distribution pumps (Korang, G-10 and R.L.1 plants)

Installation of pump operation panel (All water treatments plant except Simly plant)

Installation of water quality test kit (All water treatments plants)

The project implementation will be divided into two phases considering amounts of rehabilitation works that will spread over eight plants. Each phase is scheduled to be completed within four months for the detailed design and within twelve months for the construction including the period for manufacturing equipment. List of the water treatment plants to be rehabilitated in each phase is shown below:-

Phase 1: Simly, Korang and Shahdara Plants.

Phase 2: Golf Course, R.L.1, G-10, Saidpur and Noorpur Plants.

The cost to be borne by the Government of Pakistan is estimated at Rs 1.4 million.

After the implementation of the project, it is expected that the water producing capacity by the existing water treatment plants will increase by 20 % of the existing and clean and safe water, of which quality satisfies the WHO guideline, will be supplied to the consumers in Islamabad. The effects of the project are expected to contribute to the improvement of the living conditions of 300,000 population who presently receive the water from water treatment plants and to the stable water supply in the future.

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CHAPTER 1 INTRODUCTION

In August, 1990, the Government of the Islamic Republic of Pakistan made a request for Grant Aid assistance to the Government of Japan, for the Project for the rehabilitation of water treatment system in Islamabad. The Government of Japan decided to implement the Basic Design Study for the Project. Then Japan International Cooperation Agency (JICA) despatched a Basic Design Study Team, headed by Mr. Akihiro Mitarai, Resident Representative of JICA Pakistan Office.

The Study Team conducted the field surveys from February 25 to March 24, 1991 to identify the background and contents of the project and to collect the information necessary to conduct a basic design of the project. At same time, the Team had a series of discussion with the concerned officials of the Pakistani government to have a mutual understanding on the procedures of the Japan's Grant Aid Program and the scope of the project. The results of the discussions and the basic agreement were written up as the Minutes of Discussions and were signed by both parties.

The draft final report for the basic design study were prepared in Japan and JICA despatched a mission for the explanation of the Draft Report headed by Mr. Masashi Fujita, First Basic Design Study Division, Grant Aid Study and Design Department, JICA, to Pakistan to explain the report from July 2 to July 13, 1991. The mission had discussions with the concerned officials of the Pakistani government and the results of discussions were adopted as the Minutes of Discussions.

Upon returning to Japan, the Team conducted further studies and prepared this Final Report. The Report contains the background of the project, the outline of the project, basic design, project evaluation and conclusion, and some appendices.

The member lists of the study team, the schedule of the surveys, the member list of the concerning party of Pakistani side and the minutes of meetings are attached in appendices.

Chapter 2 Background of the Project

CHAPTER 2 BACKGROUND OF THE PROJECT

2-1 Background of the Project

2-1-1 General

The Government of Pakistan has carried out six Five Year Plans since the early 1950's and the Seventh Five Year Plan (1988-1993) is now being carried out. The Seventh Plan seeks to improve the quality of life and the living standards of the majority of the population. The improvement of the water supply coverage is one of the Quality of Life Indicators of the Plan, which is shown in Table 2-1. In term of urban water supply, the Plan has set targets to increase from 80 % in 1988 to 95 % in 1993, with 100 % coverage in the Metropolitan cities and 70 % in all other urban centers. The total capital requirements has been estimated at Rs 8 billion to accomplish these targets.

The present water supply coverage in Pakistan is estimated, as shown in Table 2-2, at 77 % in urban areas, 16 % in rural areas and 50 % in the entire Pakistan in 1986. Among 77 % in urban areas, 50 % of population are supplied water by service connection and 18 % are through public hydrant.

Table 2-1 Quality of Life Indicators in Seventh Five Year Plan

	1982-83	1987-88	1992-93
Literacy (%)	27.0	30.0	40.0
Primary Enrollment (%)			
Boys	68.5	79.5	89.0
Girls	35.5	45.7	70.0
Infant Mortality(age 0-1) per thousand	98.5	80.0	60.0
Life Expectancy (year)	58.6	61.0	63.0
Access to clean water			
% of total population	38.0	53.0	82.0
% of rural population	22.0	40.0	75.0
% of urban population	77.0	80.0	95.0
Access to Sewerage Facilities			
% of total population	16.0	23.0	44.0
% of rural population	4.0	10.0	30.0
% of urban population	48.0	52.0	70.0
Availability of Electricity (% of total population)	27.2	35.0	47.0
Availability of Telephones			
% of total population	4.1	6.7	13.6
% of rural population	3.2	5.2	10.8
% of urban population	0.9	1.5	2.8

Table 2-2 Water Supply Coverage for Urban Areas (1986)

Province	Projected Population (Thousand)	Population Served(x1000)			Population Served (%)		
		Service Connection	Public Taps	Total	Service Connection	Public Taps	Total
Punjab & Islamabad	15,065	8,515	1,410	9,925	56.5	9.4	65.9
Sind	9,557	6,016	2,843	8,859	62.9	29.8	92.7
NWFP	1,904	982	514	1,496	51.6	27.0	78.6
Baluchistan	912	541	251	792	59.3	27.5	86.8
Total	27,438	16,054	5,018	21,072	58.5	18.3	76.8

Source : Development of Optimal Standards for Water Supply Systems for Urban and Rural Area, Vol-I, 1987, Ministry of Planning and Development.

2-1-2 Administration of Water Supply

The institutional structure of water supply sector in Pakistan consists of three levels; Federal, Provincial and Local levels.

At the Federal level, the ministries concerned to water supply activities are as shown in Table 2-3. Among them, the Environment and Urban Affairs Division (EUAD) of the Ministry of Housing and Works (MHW) and the Physical Planning and Housing Section (PP&H) of the Ministry of Planning and Development (MPD) are the main federal agencies with responsibility for the water supply sector. The EAUD is responsible for urban water supply, coordination at the federal level, liaison with provincial Governments and departments, review of investment projects submitted by Provincial Governments and monitoring of sector performance. The PP&H prepares the housing development, urban development and regional development in consultation with other sections. It is also responsible for technical review of all requests for capital assistance for urban water supply projects and is expected to coordinate the execution of national development plans in the fields of housing and urban development including water supply.

Table 2-3 Institutional Framework of Water Supply at the Federal Level

Ministry	Department / Section	Functions
Ministry of Housing and Works (MHW)	Environment and Urban Affairs Division(EUAD)	- -coordination at the federal level - liaison with Provincial Governments and departments - review of investment projects submitted by Provincial Governments monitoring of sector performance
Ministry of Planning and Development(MPD)	Planning and Development Division(PDD)	- preparation of annual and five-year plans
	Physical Planning and Housing Section(PP&H)	- preparation of urban development including water supply - technical review of all requests for capital assistance for urban water supply - coordination for the execution of national development plans which include water supply
Ministry of Economic Affairs (MEA)	Economic Affairs Department(EAD)	- finalizing all foreign contribution
Ministry of Health and Social Welfare (MHSW)	Health and Social Welfare Division(HSWD)	- -water quality surveillance - collecting and analysing epidemiological information
Ministry of Water and Power(MWP) Water and Power Development Authority(WAPDA)		- use of surface and ground water

The Provincial Governments, through their departments such as Planning and Development Department, Physical Planning and Housing Department, Local Government and Rural Development, Public Health Engineering Department, and various Boards and Authorities as shown in Table 2-4, participate in planning, funding, collection of revenue, and development of water supply, and even in operation and maintenance of some of these facilities.

The Local Governments are responsible, in law, for the operation of the water supply through local authority. However situation is complicated by the fact that certain functions of local authorities are taken away from them and placed under the jurisdiction of Development Authorities, which are directly responsible to the Provincial Governments as shown in Table 2-5.

Table 2-4 Institutional Framework of Water Supply at the Provincial Level

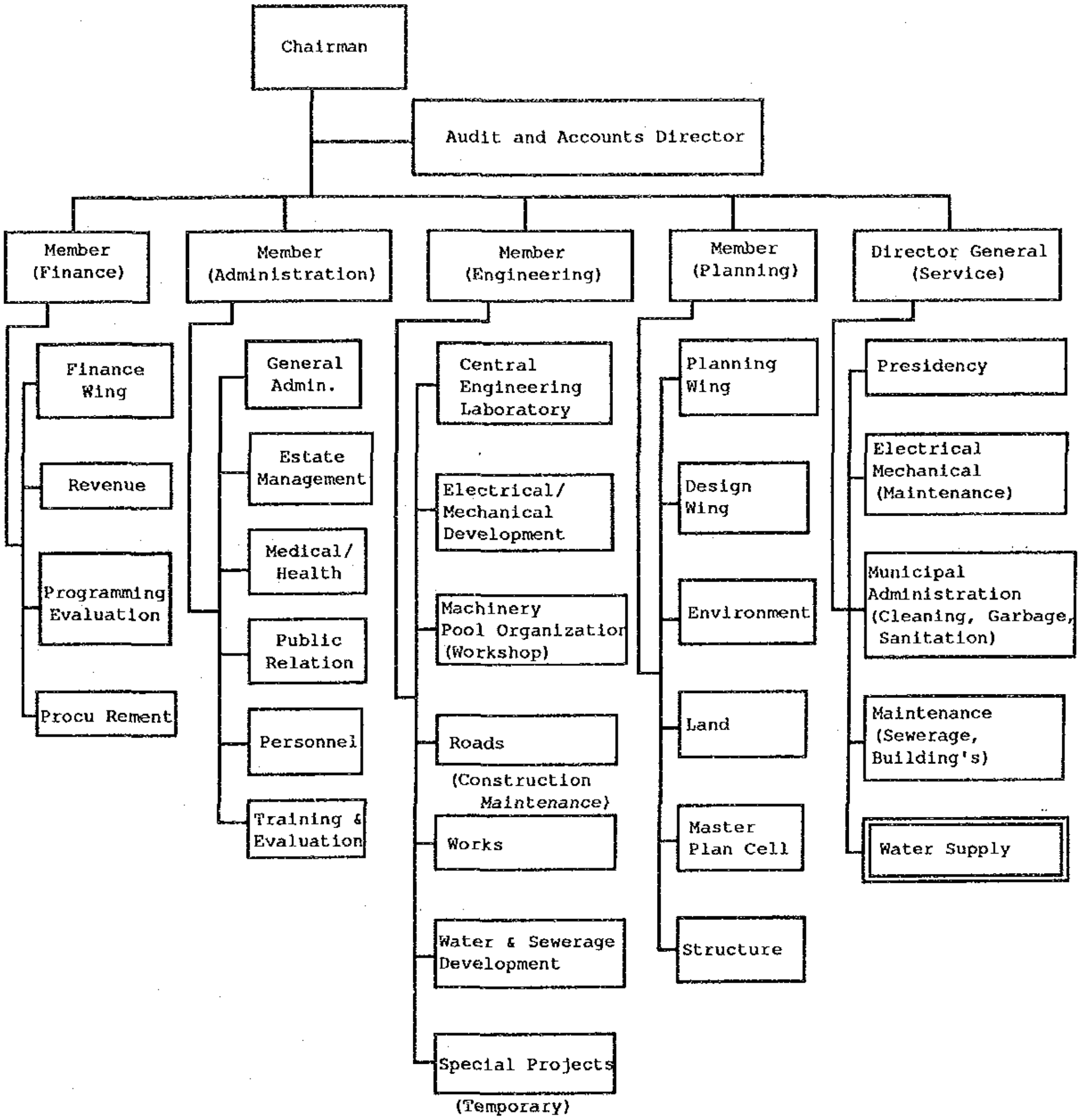
Department	Functions
Planning and Development Department(PDD)	-Coordination of development policies
Physical Planning and Housing Department(PPHD)	-Coordination of housing developments
Public Health Engineering Department(PHED)	-Execution of water supply projects
Local Government and Rural Development Department (LGRDD)	-Monitoring Local Governments and local developments -Supplying engineers,technicians to local authority.
Health Department(HD)	-Domestic and community hygiene -Monitoring drinking water quality

Islamabad has a unique urban management system responsible directly to the Federal Government. The Capital Development Authority (CDA) was created by the Capital Development Ordinance 1960, which is responsible to the Cabinet Division of the Federal Government. CDA develops, operates and maintains the water supply, sewerage and drainage systems of the Capital. The current organization chart of CDA is presented in Fig 2-1. Member of Engineering is responsible for development and construction of water supply and Director General of Service is responsible for the operations and maintenance of water supply through a Director of Water Supply. Director of Water supply would be responsible for the proposed project because it is of the rehabilitation of the existing water treatment plants.

Table 2-5 Institutions Active in the Water Supply in Punjab

Institution	Plan & Finance	Design & Execution	O&M	Monitor. Service	Inform. & Education
Local Authority	X	X	X	X	X
Special Municipal Agency	X	X	X	X	X
LGRDD	X	X	X		
PHED	X	X	X		
HPPD	X	X	X		
Health Dept.				X	X

Source : Urban Water supply and Sanitation Sector Study (ADB T,A, No 963-PAK), 1989



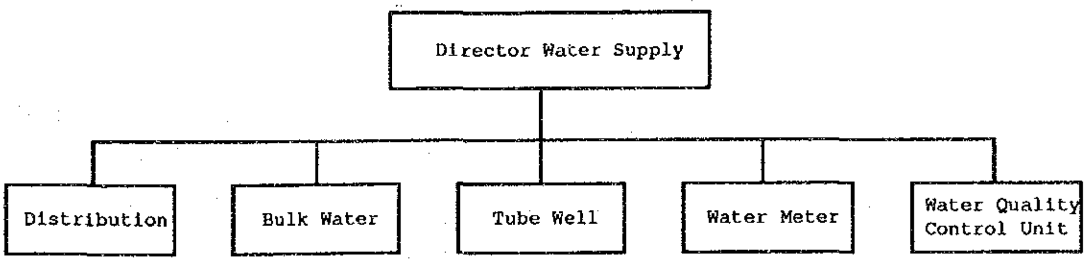


Fig. 2-1 Organization Chart of CDA

2-2 Outline of the Request

Water supply system in Islamabad supplies water to the residents in the whole city area, population of 340,000, from eight water treatment plants (one of which has been not in operation since 1983) and tube wells. The total producing capacity is presently 227,000 m^3/day (49.7 MGD). Water supply from the water treatment plants covers 85 % of the total populations and accounts 70 % of the total producing water.

For the future water supply, the Capital Development Authority (CDA), which is responsible for the water supply of the capital city, prepared the Water Supply Master Plan in 1988 aiming to maintain 100 % of service coverage so as to meet the objectives of the Seventh Five Year Plan. In the Master Plan, the population in the year 2000 is projected 621,000 and daily maximum demand and daily average demand are projected 453,000 m^3/day (99.7 MGD) and 362,000 m^3/day (79.7 MGD) respectively. Those demands will be covered by water supply from two new water treatment plants to be constructed, the existing eight plants and the existing tube wells. Two projects that construct new water treatment plants with 164,000 m^3/day of total supply capacity have been started with financing by the Overseas Economic Cooperation Fund, Japan. The total water supply capacity in the year 2000 is expected 391,000 m^3/day (85.9 MGD) and 42 % of which are to be covered by water supply from the existing eight water treatment plants.

As such, the existing water treatment plants play an important role in the present water supply operation in Islamabad and expected to play important role in the future, too. However, all the plants were constructed in 1963 through 1971 and many problems have been encountered in daily operations due to the aging of various facilities. They are causing a shortage in the water production amount and deterioration of the water quality of the treated water. Furthermore, such deterioration of the facilities could ever progress in the future and difficulties in achieving the Water Supply Master Plan is foreseen. To cope with these situations, CDA prepared the rehabilitation plan for the eight water treatment plants in 1989.

As a result of this background, the Government of Pakistan requested the project for the rehabilitation of water treatment system in Islamabad through Japan's grant aid program in accordance with a request of CDA. The request consists of the rehabilitation of the following eight water treatment plants by repairing, replacing and upgrading of the deteriorated facilities/equipment and installation of the necessary facilities as shown in Table 2-6:-

Simly Water Treatment Plant
Korang Water Treatment Plant
Golf Course Water Treatment Plant
G-10 Water Treatment Plant
R.L.1 Water Treatment Plant
Saidpur Water Treatment Plant
Noorpur Water Treatment Plant
Shahdara Water Treatment Plant

Table 2-6 Summary of the Request for Improvement

Facility/ Equipment	Plant name								Common
	Simly	Korang	Golf Course	G-10	R.L.1	Said-pur	Noor-pur	Shah-dara	
Water Intake									
Pump	-	b	b	-	-	-	-	-	
Removal of sand	-	-	-	-	-	-	d	b	
Flocculation/ Sedimentation									
Mixer/Flocculator	b	e	e	e	e	-	-	e	
Sludge Withdrawal	b	b/e	b/e	b/e	b/e	-	-	b	
Filtration									
Filter basin	-	e	e	e	e	-	-	-	
Valves	b/c	-	-	-	-	-	-	-	
Chemical dosing									
Metering pump	b	b	b	b	b	-	b	b	
Mixer	b	c	c	c	c	-	e	c	
Tank	d	d	d	d	d	-	d	d	
Chlorine Dosing									
Tank	e	e	e	e	e	-	-	e	
Chlorinator	b	b	b	b	b	c	c	b	
Instrumentation		e	e	e	e	e	e	e	
Electric		b	b	b	b	e	e	b	
Miscellaneous (Water Quality Test)		e	e	e	e	e	e	e	
Transmission pump		e		e	e				
Building		d	d		d	d	d	d	
Communication System									e
Laboratory									e
Maintenance Equip.									e

a:Removal b:Replacement c:Improvement d:Repair e:Installation

2-3 Present Conditions of Water Supply in Islamabad

2-3-1 Facility

Water supply system in Islamabad currently comprises of eight water treatment plants (one which has been stopped operation since 1983), tube wells, conduction mains, reservoirs and distribution networks. Location of each facility is presented in Fig. 2-2. Distribution network are spread over the city area as shown in Fig 2-3. The population in each distribution area is shown in Table 2-7 and the population of the distribution area of Simly plants (including water from the National Park Tube Wells) is 160,000, 45 % of the total.

Table 2-7 Water Supply and Population Served by Distribution System (1990)

Distribution System		Population (Persons)	(%)	Water amount ($1000m^3$/day)	(%)
Simly 7MG Reservoir	95,000				
5MG Reservoir	65,000	160,000	44.7	138.5**	61.7
(including National Park Tube Wells)					
Korang		Stopped in operation			
Golf Course		10,000	2.8	10.0	4.5
G-10		50,000	14.0	11.4	5.1
R.L.1		40,000	11.2	12.3	5.5
Saidpur		3,000	0.8	3.2	1.4
Noorpur		25,000*	-	3.0	1.3
Shahdara		15,000	4.2	11.4	5.1
Tube wells in H/I areas		80,000	22.3	34.6	15.4
TOTAL		358,000*	100	224.4	100

Note: Prepared by the data from CDA.

* : Distribution system for Noorpur Plant is eliminated from the total because it overlaps with the area of Simly distribution system.
The total population is different from the estimated population for 1990, 341,000.
This is because it is based on the number of the residences served.

** : Including water supply from National Park Tube Wells.

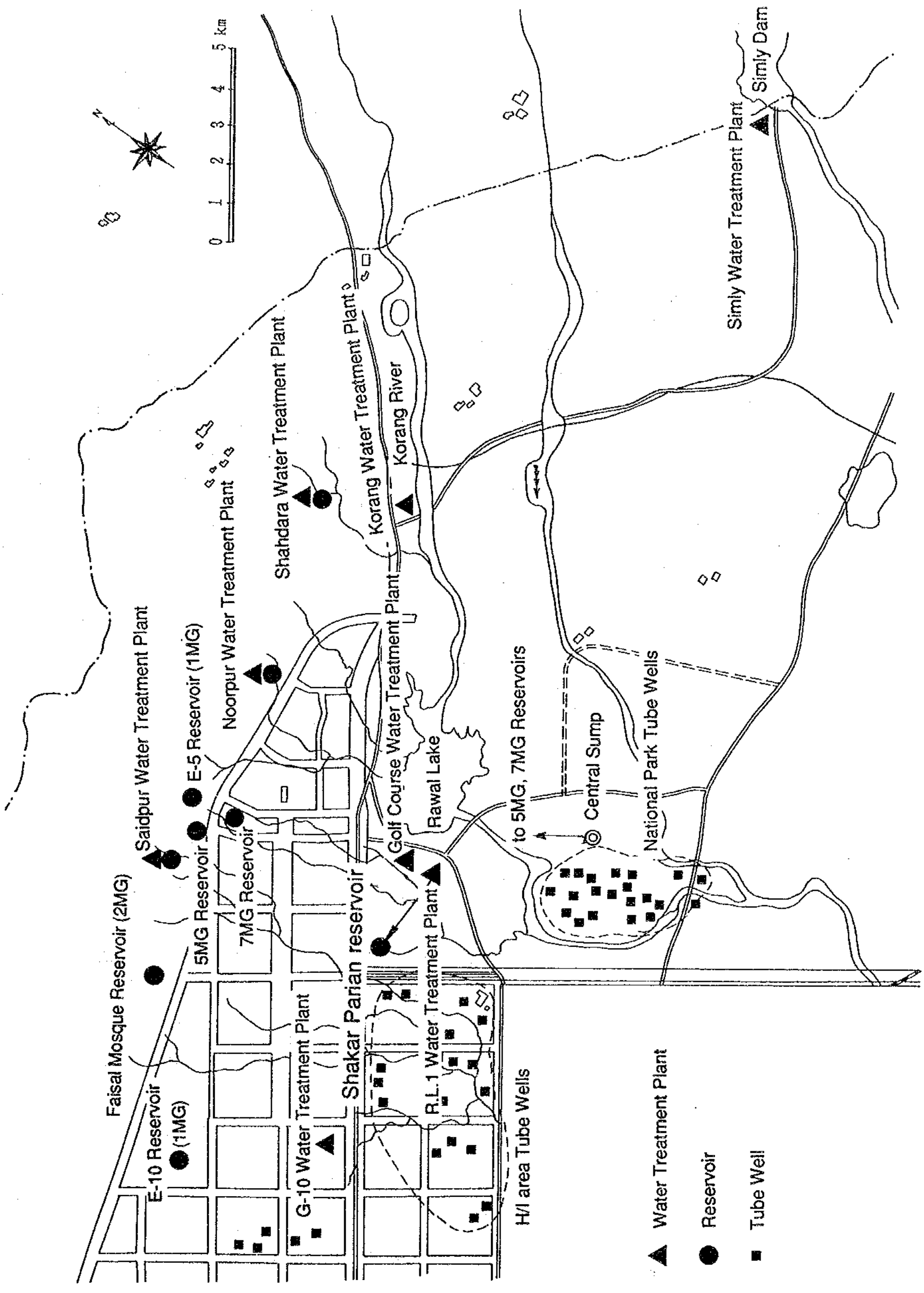


Fig 2-2 Location of Water Supply Facilities

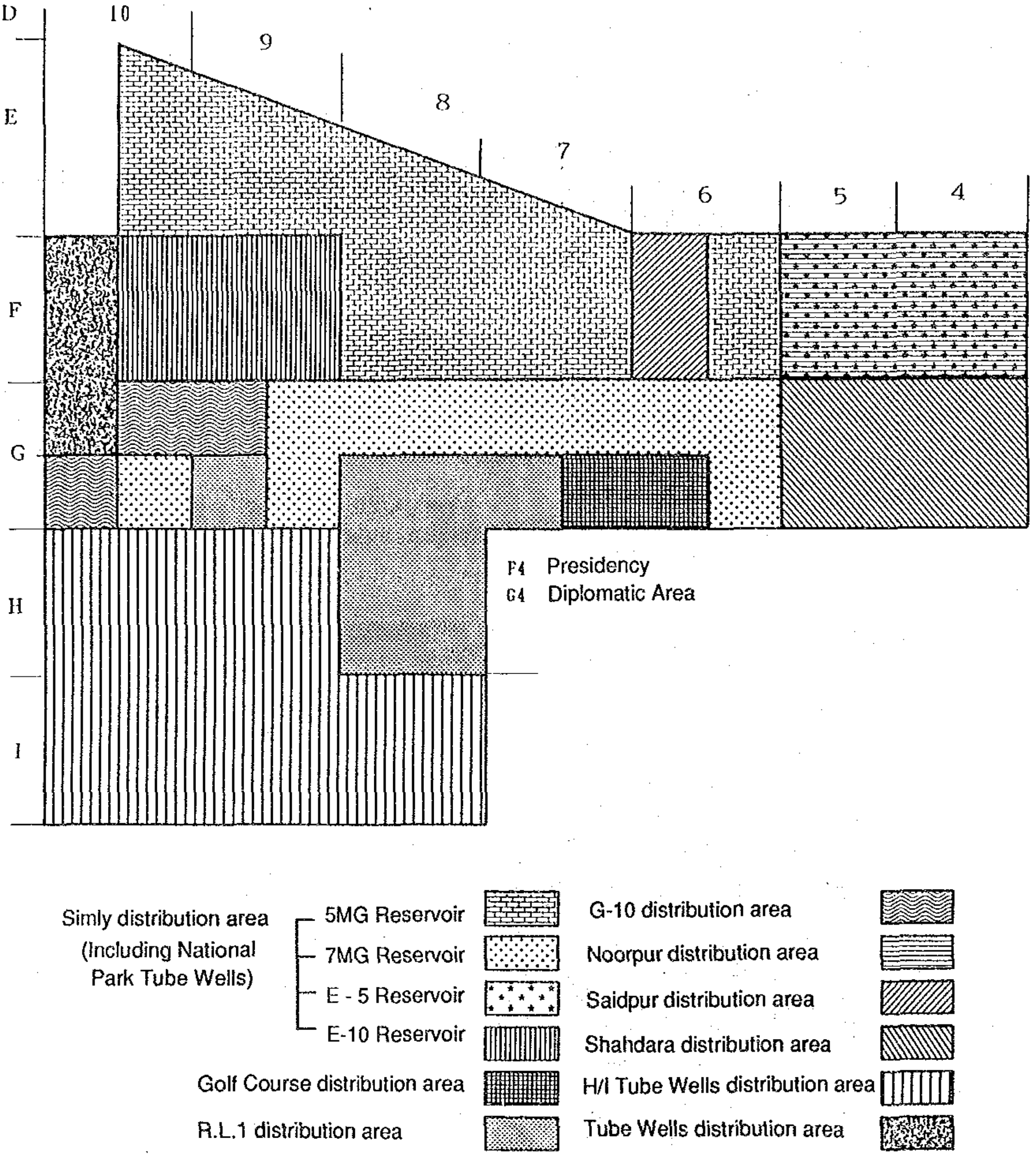


Fig. 2-3 Water Distribution System

2-3-2 Water Treatment Plants

Outlines of the existing water treatment plants are presented in Table 2-8 and they are classified into three groups by its filtration methods;

i)	Rapid filtration	Simly plant
ii)	Medium rate filtration	Korang, Golf Course, G-10, R.L.1 and Shahdara plants
iii)	Slow filtration	Saidpur and Noorpur plants.

Table 2-8 Outline of the Existing Plants

Water Treatment Plant	Design Capacity m3/d	(MGD)	Water Source	Water Intake	Purification Process	Chlori-nation*	Water Trans-mission
Simly	109,100	(24)	Simly Dam	Gravity Flow	Coagulation Sedimentation Rapid Sand Filtration	Pre/Post	Gravity Flow
(Korang)**	10,910	(2.4)	Korang River	Pumping	Coagulation Sedimentation MRSF***	Pre/Post	Pumping
Golf Course	11,400	(2.5)	Branch of Korang	Pumping	Coagulation Sedimentation MRSF***	Pre/Post	Pumping
G-10	9,100	(2.0)	Lai River	Pumping	Coagulation Sedimentation MRSF***	Pre/Post	Pumping
R.L.1	10,230	(2.25)	Rawal Lake	Pumping	Coagulation Sedimentation MRSF***	Pre/Post	Pumping
Saidpur	3,200	(0.7)	Branch of Lai	Gravity Flow	Sedimentation Slow Sand Filtration	Pre	Gravity Flow
Noorpur	3,200	(0.7)	Branch of Korang	Gravity Flow	Coagulation Sedimentation Slow Sand Filtration	Pre	Gravity Flow
Shahdara	7,300	(1.6)	Shahdara River	Gravity Flow	Coagulation Sedimentation MRSF***	Pre/Post	Gravity Flow

* : Indicating pre-chlorination, post-chlorination or both.

** : Stopped in operation.

*** : Medium Rate Sand Filtration, which is a filtration classified between the rapid and slow sand filtration.

This grouping agrees with the operation capacity. Simly employing rapid sand filtration has the biggest operation capacity among the all plants, producing 66 % of the total production. The plants employing medium rate sand filtration produce 7,000 to 11,000 m^3/day, which are medium size among the all and the plants with slow sand filtration are small plant producing 3,200 m^3/day.

For the water source, two plants, namely Simly and R.L.1, intake water from a dam lake and other plants intake water from river except Saidpur plant that intakes water from springs along the small stream.

Existing conditions of the plants are summarized in Tables 2-9-1 to 2-9-8.

Table 2-9-1 Operation Condition of Simly

Facility	Problems observed	Causes of Problems
Water Intake	*Excess inflow during high water level of Simly dam	*Malfunction of inflow valve and regulation valve
Sedimentation	*Incomplete flocculation *Carry-over of flocs	*Malfunction of flocculation *Out of control of dosing rate *Low performance of sludge pump *Leakage of sludge pipe *Malfunction of sludge scraper
Filtration	*Overflow from trough *High turbidity of treated water	*Failure of flow control *Incomplete backwash *Over load
Chemical dosing	*Dosing rate uncontrolable *Not uniform concentrations *Leakage from pipes	*Corrosion by chemicals *Loss of measuring device *Out of operation of mixer
Chlorination	*Freezing of cylinder outside *Emission of gas chlorine	*Corrosion *Malconnection *Malfunction of discharge valve
Instrumentation	*Unable to set up dosing rate	*Malfunction of flowmeters *Malfunction of head loss indicator
Electric	*untreated terminals *Malfunction of meters	
Others	*unable to isolate two treated water ponds	*Malfunction of isolating gates

Table 2-9-2 Operation Conditions of Korang

Facility	Problems observed	Causes of Problems
Sedimentation	*Incomplete flocculation	*Not enough mixing
	*Over accumulation of sludge	*Shortage in dosing rate
		*Shortage in size of sludge pipe
	*Inflow of rain water	*Low leveling
Chemical Dosing	*Dosing rate uncontrolable	*Loss of measuring device
Chlorination	*Loss of facility	
Instrumentation	*Unable to set up dosing rate	*loss of flowmeters
Electric		
Transmission pump	*Low efficiency	* aging

Table 2-9-3 Operation Conditions of Golf Course

Facility	Problems observed	Causes of Problems
Water Intake	*Not enough pump capacity	*Incompatibility in specification of pump
Sedimentation	*Incomplete flocculation	*Not enough mixing
	*Over accumulation of sludge	*Shortage in dosing rate
		*Shortage in size of sludge pipe
Filtration	*Clogging of filter bed	*Incomplete backwash
	*Mad ball	
Chemical Dosing	*Dosing rate uncontrolable	*Loss of measuring device
Chlorination	*Corrosion	*Leakage
Instrumentation	*Unable to set up dosing rate	*loss of flowmeters

Table 2-9-4 Operation Conditions of R.L.1

Facility	Problems observed	Causes of Problems
Water Intake	*Deterioration of raw water	*Contamination by wastewater and rain water
Sedimentation	*Incomplete flocculation	*Not enough mixing
	*Carry-over of flocs	*Shortage in dosing rate
		*Clogging of drain
		*leakage from basin
Filtration	*Clogging of filter bed	*Incomplete backwash
	*Mad ball	
Chemical Dosing	*Dosing rate uncontrolable	*Loss of measuring device
Chlorination	*Corrosion	*Leakage
Instrumentation	*Unable to set up dosing rate	*loss of flowmeters
Transmission pump	*Low efficiency	* aging

Table 2-9-5 Operation Conditions of G-10

Facility	Problems observed	Causes of Problems
Water Intake	*Fluctuation of intake flow *Deterioration of raw water	*Incompatibility in specification of pump *Contamination by wastewater
Sedimentation	*Incomplete flocculation *Over accumulation of sludge	*Not enough mixing *Shortage in dosing rate *Shortage in size of sludge pipe
Filtration	*Deteriorated water quality *Mad ball	*Incomplete backwash
Chemical Dosing	*Dosing rate uncontrolable	*Loss of measuring device
Chlorination	*Corrosion	*Leakage
Instrumentation	*difficulty in reading V-notch	*turbulent flow in measuring pit
Electric		
Transmission pump	*Low efficiency	* aging

Table 2-9-6 Operation Conditions of Saidpur

Facility	Problems observed	Causes of Problems
Filtration	*Low operationability in cleaning filter bed	*Damaged inflow gates
Chlorination	*Corrosion	*Leakage
Instrumentation	*Unable to set up dosing rate	*loss of flowmeters

Table 2-9-7 Operation Conditions of Noorpur

Facility	Problems observed	Causes of Problems
Water Intake	*Decreasing inflow rate	*Malfunction of inflow valve
Filtration	*Low operationability in cleaning filter bed	*Over size of bed
Chemical Dosing	*Dosing rate uncontrolable	*Loss of measuring device
Chlorination	*Corrosion	*Leakage
Instrumentation	*Unoperated V-notch	*turbulent flow in measuring pit

Table 2-9-8 Operation Conditions of Shahdara

Facility	Problems observed	Causes of Problems
Water Intake	*Inflow of sand	*Malfunction of sand settling pond
Sedimentation	*Incomplete flocculation *Carry-over of flocs	*Not enough mixing *Shortage in dosing rate *Clogging of drain
Filtration	*Deterioration of treated water quality	*Malfunction of inflow valves *Unable to backwash
Chemical Dosing	*Dosing rate uncontrolable	*Loss of measuring device
Chlorination	*Corrosion	*Leakage
Instrumentation	*Unoperated V-notch	*Loss of scale

2-3-3 Water Supply Conditions

The actual producing rate and the operation capacity in each plant are compared in Table 2-10. Since no flow measuring devices are in operation in every plants, data given as the actual rate in the table is based on the experiences of the operators. Table 2-11 shows the producing rate measured through the study. Those two data on the actual producing rate agree well with each other, thus data in Table 2-10 is considered to show the actual conditions. According to Table 2-10, the total operation capacity of seven plants in operation is 162,000 m^3/day and the actual producing rate is 137,000 m^3/day. The difference is considered because of decrease in producing rate by plant shut-down, suspension of filter operation due to backwashes, etc.

The total water supply in Islamabad is estimated 202,000 m^3/day by adding water from water treatment plant mentioned above and water from tube wells, 64,600 m3/day. The total water demands in 1990 has been estimated at 214,000 m^3/day in average, thus the present water supply lowers the demands. In the water distribution system in Islamabad, water is supplied intermittently (over 3 hour a day) to each consumer. Consumers store water for daily consumption in their storage tank. Sometimes they fail to fill up their tank with water during scheduled supplying time due to shortage of water supply.

For the water quality of the supplied water, turbidity that is an index for cleanliness of the water exceeds 5 degree, which is WHO guideline, more than 30 % of days in a year. Coliform bacteria that is an index of bacteriological safe has been observed to be positive in most water treatment plant. As such, water quality conditions are not considered to be good.

Table 2-10 The Actual and Design Capacity of Each Plant

($1000m^3$/day)

Water Treatment Plant	Producing Capacity**		Actual producing rate in 1990 *	
Simly	108.5	(23.8)	94.7	(20.0)
Golf Course	10.0	(2.2)	8.2	(1.8)
G-10	11.4	(2.5)	8.9	(2.0)
R.L.1	12.3	(2.7)	10.2	(2.2)
Saidpur	3.2	(0.7)	3.0	(0.65)
Noorpur	3.0	(0.65)	2.5	(0.56)
Shahdara	11.4	(2.5)	9.5	(2.1)
TOTAL	162	(35.7)	137	(30.0)

* : Based on the Data obtained in the survey.

** : Study Report Planning of Rehabilitation works for Islamabad Water Supply System, 1989, CDA

Table 2-11 Result of the Measurement of Treatment Capacity

Water treatment plant	Nominal Design Capacity (m^3/day)		Measurement (m^3/day)	Method of measurement
Simly	109,000	*2	101,400	Flow rate of open channel at the Outlet of Sedimentation basin
Korang	10,900			
Golf Course	11,400		7,700	Water depth at Distribution pond
G-10	9,100		12,700	V-notch at the Sedimentation basin
R.L.1	10,200		9,100	Water depth in the pump pit
Saidpur	3,200	*2	4,300	Flow rate of Flocculation channel
Noorpur	3,200	*2	3,100	Flow rate of Flocculation channel
Shahdara	7,300		10,500	Flow rate of Water intake channel
TOTAL	153,500	*1	148,800	

*1 Total except Korang

*2 Design capacity in the original design. Others are nominal capacity by CDA.

2-3-4 Future Plan

CDA prepared the Water Supply Master Plan for Islamabad with target year of 2000 in 1988 based on the Regional Study for Water Resources Development Potential for the Metropolitan Area of Islamabad-Rawalpindi by JICA. The Plan projects the water demands in Islamabad, 289,000 m^3/day of daily average in 1995 (400,000 m^3/day of daily maximum) and 362,000 m3/day in 2000 (453,000 m^3/day of daily maximum) as shown in Table 2-12. The plan also projects the total water supply 391,000 m^3/day by the following sources;

- New Simly water treatment Plant ....82,000 m^3/day
- Khanpur water treatment plant..............................82,000 m^3/day
- Existing tube wells...65,000 m^3/day
- Existing eight water treatment plants......................162,000 m^3/day

Table 2-12 Projected Water Demand

Year	Daily Average 1000m3/D (MGD)	Daily Maximum 1000m3/D (MGD)
1990	214(47.0)	264 (58)
1995	289 (63.5)	400 (69)
2000	362 (79.7)	453 (99.7)

Source : Study Report Planning of Rehabilitation Works for Islamabad Water Supply System, 1989, CDA

The projected water demands and supply are presented in Fig. 2-4. The plan proposed the construction of two water treatment plants to supply total 164,000 m^3/day. Those proposed construction projects have been realized as the Metropolitan Water Supply Project (Khanpur-I) and the Bulk Water Supply Phase-III (Simly) financed by OECF as shown in Table 2-13. The completion date of the projects are expected in 1994 and 1995, respectively. The expansion of the water supply capacity will be one year behind the planned increase in the figure.

Table 2-13 CDA's Projects by OECF Loan

Project	Cost(RS million)	Timing*	Major components	Remarks
Metropolitan Water Supply Project (Khanpur-I)	2922 (1726)**	90-94	Rehabilitation of the existing Construction of Reservoir and Conduction Tunnel Construction of New Water treatment plant (60mgd) Installation of Conduction Main (21.4Km)	18mgd for Islamabad
Bulk Water Supply phase-III(Simly)	1285 (793)**	90-95	Construction of New water treatment plant (18mgd) Installation of New Conduction Main (28Km)	

* : Proposed

** : ( )OECF Loan portion

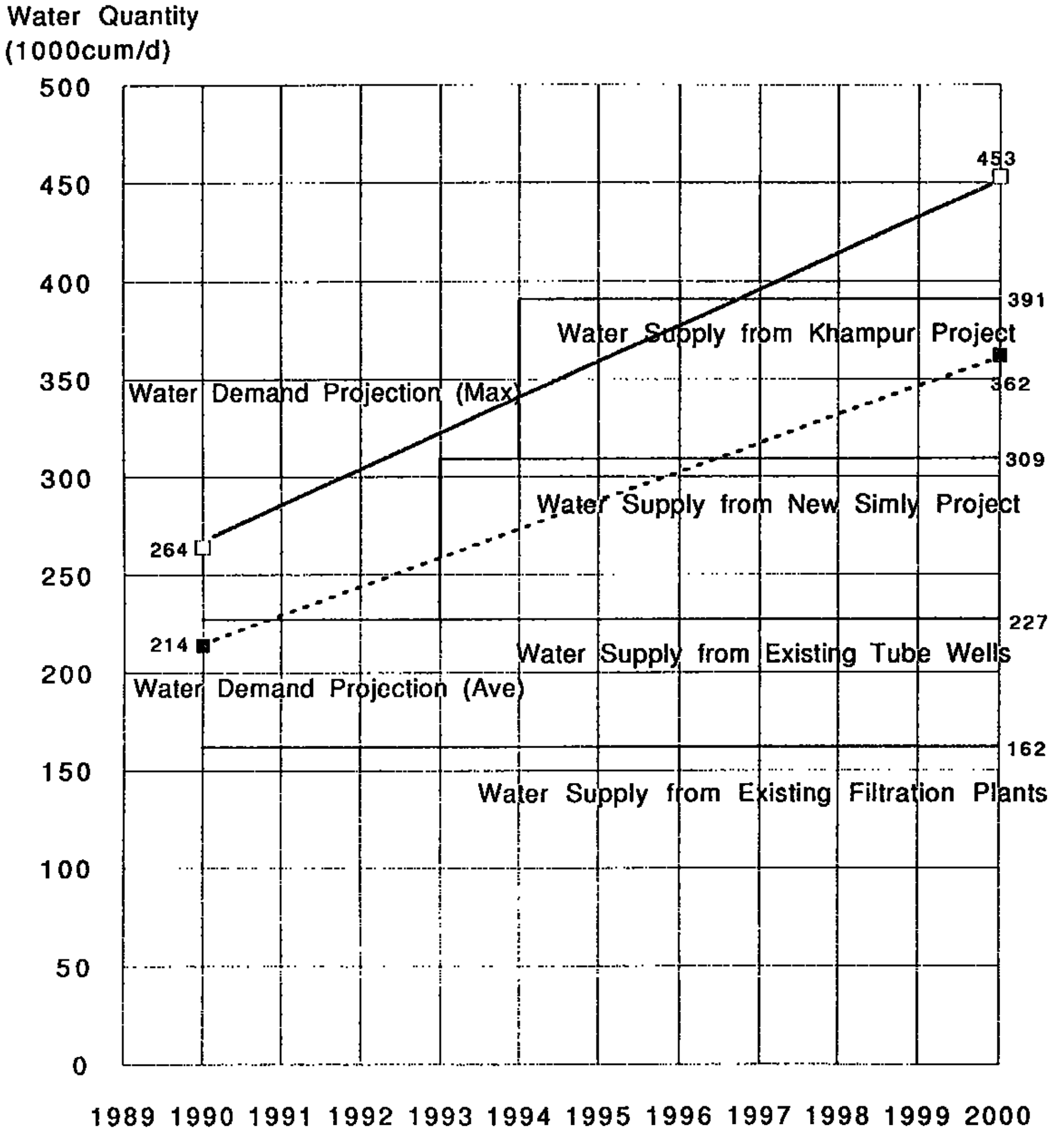


Fig. 2-4 Projection of Water Demand and Supply in Islamabad

Chapter 3 Outline of the Project

CHAPTER 3 OUTLINE OF THE PROJECT

3-1 Objectives

Present water supply system in Islamabad consists of eight water treatment plants, one of which has been stopped in operation since 1983, and tube wells, and supplies water to the whole city area with population of 340,000. Water distribution from the water treatment plants covers 85% of the total population. They are also expected to supply 42% of the projected water supply in the year 2000 in the Water Supply Master Plan, which CDA prepared to provide for the projected increase of water demand. As such, the existing water treatment plants play an important role in the present operation and are expected to play an important role in the future operation, too.

However, the present operation conditions of every water treatment plants have been severely deteriorated, causing shortage in water supply and failure in supplying safe water. They were constructed in 1963 through 1971 and most of their facilities are not in good operation due to the aging and/or ill maintenance works. It is presumed that there would be a difficulty in achieving a water supply target of the Water Supply Master Plan if the present conditions are left without improvement.

To solve the problems in the present water supply operation and secure the water supply in the future, CDA has proposed a plan for the rehabilitation of the existing water supply system in Islamabad. The objective of the Project is to rehabilitate the existing eight water treatment plants that are key facilities of the system, as a part of the proposed plan by CDA.

3-2 Study and Examination on the Request

3-2-1 Necessity and Appropriateness of the Project

CDA established the Water Supply Master Plan, which was aiming a stable water supply operation in the year 2000, following the water supply target in the Seventh Five Year Plan. In the Master Plan, daily average water demand in 2000 is projected 362,000m^3/d and the total water supply is planned 391,000m^3/d that comprises of i) 162,000 m^3/d from the existing water treatment plants, ii) 65,000 m^3/d from the existing tube wells, iii) 82,000 m^3/d by Bulk Water Supply for Islamabad phase-III and iv) 82,000 m^3/d by Metropolitan Water Supply Project (Khanpur-I). The latter two new projects are financed by the Overseas Economic Cooperation Fund, Japan and are under execution.

Present water supply system in Islamabad supplies water from seven water treatment plants and tube wells. Water supply from the water treatment plants covers 80% of the amounts and 85% of the population served.

The existing eight water treatment plants, one of which has been stopped in operation since 1983 due to shifting the equipment for repair or replacement to the other plants, were constructed in 1963 through 1971. They have been observed in bad condition due to excessive use over time and lack of spare parts. Malfunction, losses and damages are found in many equipments in every plants. Because of such deterioration of equipment, major water treatment process such as chemical dosing, filtration and chlorination can not be properly controlled, resulting in supplying high turbid and not safe water. Furthermore, it is suspected that the existing water treatment process in Gulf Course filtration plant, G-10 filtration plant and R.L.1 filtration plant may not be enough to purify their raw water that are polluted by domestic wastewater and/or livestock wastewater.

For the water quantity, the actual water supply from the water treatment plants, which is 137,000m^3/d, is equivalent to 85% of the nominal treatment capacity and slightly lower than the present demand. However, it is understood that this quantitative operation capacity is possible only by the operation where the quality of the treated water is left being deteriorated. If the operation where the necessary water quality is maintained is adopted, the capacity will be reduced by 30% to 40% of the actual capacity because amount of treating water must be reduced so as to ensure the nominal function of sedimentation basin and filtration basin.

Such deterioration of the treatment capacity is expected to ever progress along with the further aging of the facilities. Supposing that the capacity in 2000 would remain 60% of the actual, the water supply capacity from the existing treatment plants is estimated at 100,000m^3/d. This estimation shows that the total water supply in 2000 is 62,000m^3/d less than the planned and can not cater even daily average demand in 2000.

Therefore, the necessity of the Project can be justified from following view points;

i) the existing water treatment plants can not cater the existing demand and supplies not safe water to consumers, and

ii) the existing water treatment plant will not play the expected role in the Water Supply Master Plan.

Implementation of the Project will resolve the existing problems in water quantity and quality in the present water supply system of Islamabad and enable the accomplishment of the Water Supply Master Plan. This will contribute to the improvement of the living standards of the residents of Islamabad and meet the objectives of the Seventh Five Year Plan.

For there reasons, the implementation of the Project with grant aid from the Government of Japan is judged to be appropriate.

3-2-2 Technical Feasibility

As mentioned in the previous chapter, many equipment of the existing plants have been found to be lost and damaged and to require repairing and replacement, causing deterioration of the treating capacity. While they are supposed to resume their capacity by repairing and replacing the damaged or lost equipments in principle, technical feasibility has been studied in order to confirm that it is possible to obtain clear water (less than 5 degree of turbidity) and bacteriologically safe water (free from chloroform bacteria) as well as maintaining the level of treating capacity in the original design within the work scope to rehabilitate the existing facility.

A unique filtration method, which is classified in between rapid filtration and slow filtration by its filtration rate, is being adopted in five water treatment plants among the existing eight water treatment plants in Islamabad. Since no design criteria/standards for this method is available, its performance has been evaluated by invoking the theory for rapid filtration as shown in

Appendix-7. As a result of the study, the performances of the filtration in each plant have been evaluated as shown in Table 3-1 and it has been judged to change the existing system to rapid filtration in Golf Course and G-10 plants. In addition, other process such as sedimentation, water intake and so on have been also studied as mentioned below and all the plants have been judged to be technically feasible to improve the performance in terms of quality and quantity within the scope of the rehabilitation.

Table 3-1 Evaluation of the Medium Rate Filtration Methods

Plant Name	Feasibility to achieve the targets of the Rehabilitation
Korang	Possible by enforcement of coagulation and sedimentation process
Golf Course	Need to change to the rapid sand filtration
R.L.1	Possible by improving the raw water quality
G-10	Neel to change to the rapid sand filtration
Shahdara	Possible by improving settling pond

Note : Targets of the rehabilitaion are to restore the capacity to the original design and to obtain the water quality;less than 5 degree of turbidity and free from coliform bacteria.

(1) Simly water treatment plant

The plant intakes water from Simly dam and employs the rapid filtration system. As shown in Table 3-2, the raw water quality is considered to be suitable for the conventional rapid filtration.

The problems existing in the rapid filtration process are recognized as follow;

i) the coagulant dosing is not well controlled since neither raw water inlet rate is measured nor the metering pump for coagulant dosing is in operation,

ii) flocculation is not completed because of insufficient mixing due to damage of mixers,

iii) the suspended material are carried over to filtration process from sedimentation process because of low performance of sedimentation process due to over accumulated sludge, and

iv) the excessive solid loading to filtration process causes frequent backwashing, which results in decrease of the water production rate, and deterioration of the treated water quality.

Dosing rate of chlorine is not controlled since the treated water amount can not be measured. While the chlorination is conducted at two points in the system, i.e. pre-chlorination and post-chlorination, the pre-chlorination is not considered necessary because it hardly contains Ammonium and because its chlorine demand is very low .

As conclusion, it is judged to be possible to achieve the purposes of the rehabilitation, that is to treat water at the original design rate and to satisfy the water quality guideline by WHO, by implementing the following rehabilitation works;

i) to instal water flow measuring device,

ii) to replace flocculators,

iii) to replace sludge withdrawal pipes and pumps,

iv) to instal/replace valves in the filtration basin,

v) to restore chemical dosing equipment, and

vi) to replace chlorinator for post-chlorination and to stop pre-chlorination.

It was observed that there was no isolating gate in the clear water basins during site inspection. It is desirable to instal it so as to clean up the basins. However, the installation works will take at least 2 weeks accompanying a suspension of water supply. The installation of the gate are eliminated from the scope of the proposed rehabilitation works because the situation around the water supply in Islamabad does not allow the suspension of water supply from Simly plant lasting such a long period.

(2) Golf Course Water Treatment Plant

The plant intakes water by pumping from one of the branch rivers of Lai river, which runs through the city area of Islamabad, and employs coagulation /sedimentation and medium rate sand filtration. It was found in the survey that the actual water treating amount was 30% lower than the design treating amount as shown in Table 2-11. This is supposed because of decrease of the efficiency due to the following incompatibility in specifications of two intake pumps and to be solved by replacing them by new pumps with same capacity;

	Discharge Head	Discharge Capacity
Pump-A	70 feet	7.53 m^3/min
Pump-B	200 feet	2.71 m^3/min

(Note: Necessary capacity is 7.92 m^3/min.)

The treated water quality has been observed to be deteriorated due to the following reasons;

i) pollution of raw water due to discharges from urbanized area,

ii) sedimentation failure because of lack of mixers and sludge withdrawals, and

iii) incomplete back washing.

It will be possible to improve the treated water quality by employing a mechanical or gravity mixing and sludge withdrawal (pumps and or pipes) and replacing the existing filters by rapid filtration as shown in Table 3-1.

(3) Korang Water Treatment Plant.

This plant has been stopped in operation since 1983 and rehabilitation works are undergoing by CDA. Water is collected through infiltration gallery from the Korang river and the plant employs coagulation, sedimentation and the medium rate sand filtration process.

While not particular problem exists in the raw water quality shown in Table 3-2, an over loading of the filters is foreseen because sedimentation process would not function sufficiently due to lack of flocculator. This will be, however, improved by installing flocculator and sludge withdrawal equipment. It is judged that the objectives will be achieved by the existing intermediate sand filtration if the sedimentation process will be completed as shown in Table 3-1.

In addition, it is necessary to instal one new water distribution pump and to replace two existing distribution pumps.

(4) G-10 Water Treatment Plant.

The plant intakes water by pumping from Lai river and employs coagulation, sedimentation and medium rate sand filtration process.

The Lai river is one of the most polluted water sources because it runs through the residential area of Islamabad receiving domestic wastewater. The water contains Ammonium (0.3 mg/l in average) and high turbidity (42 degree in average) as shown in Table 3-2. The plant is producing insufficient quality of water due to incomplete sedimentation as well as the deteriorated raw water quality. Therefore, rehabilitation works will require a replacement of the existing intermediate filtration by the rapid sand filtration as shown Table 3-1 in addition to installing flocculator and sludge withdrawal equipment.

Pre-chlorination and post-chlorination are conducted in the present operation. Both chlorination are considered necessary in this plant from a result of chlorine demand test shown in Appendix-7, while pre-chlorination is not necessary in other plants.

Two water intake pumps, each of which capacity is 7.5 m^3/min, are being used to intake the amount of 6.5 m^3/min. Since this indicates a deterioration of the existing pump capacity, it is necessary to replace them. In addition, it is necessary to replace the existing distribution pumps.

(5) R.L.1 Water Treatment Plant

The water source of the plant is Rawal lake which is located on Korang river. The water is transmitted about 1 mile through the open channel from the lake to the pumping station form where the water is sent to the plant by gravity flow.

While no particular problem is found in the lake water, the raw water of the plant is severely polluted as shown in Table 3-2 because domestic and livestock wastewater inflow into the channel from residents located along the channel. However, this situation will be improved by changing to the piping transmission by gravity flow or pressurized flow in the section between the water intake point for the Rawalpindi Water Treatment Plant and the existing pumping station.

The purification process employs coagulation, sedimentation and medium rate sand filtration same as the other plants, having problems in coagulation and sedimentation due to the lack of flocculator and sludge withdrawal. Those will be improved by installing flocculator and sludge withdrawal equipment.

Therefore, it is judged that objectives of the rehabilitation can be achieved by changing the water intake method and enforcing the coagulation and sedimentation.In addition, it is necessary to replace the existing aged distribution pumps.

(6) Saidpur Water Treatment Plant

The plant intakes water from springs and employs slow sand filtration. The raw water is very clean as shown in Table 3-2 and there is no need to improve the major process.

Although the existing process employs the pre-chlorination, this should be changed to the post-chlorination. Slow sand filtration is a filtration in which biological films that develop on the surface of sand play major role of the purification. If the pre-chlorination is applied in the slow sand filtration, remaining chlorine would inhibit the purification function of the biological film or kill it.

In addition, it is necessary to replace the damaged gate valves in the filtration basins which make it difficult to drain out the water from the basins during the cleaning.

(7) Noorpur Water Treatment Plant

The plant intakes water from the upstream of the branch river of the Korang and employs the slow sand filtration. Since the raw water is very clean there is no particular need to improve the process.

Chlorination and gates valves are same situations as mentioned in Saidpur Water Treatment Plant.

(8) Shahdara Water Treatment Plant.

The plant intakes water from Shahdara river that is one of the Korang branches and employs coagulation, Sedimentation and the medium rate sand filtration. The turbidity of the raw water is high, 40 degree, comparing the other raw waters as shown in Table 3-2. This is considered because the water quality is affected by the quarry site locating just upstream of the water intake point.

For this reason, there exists a settling pond between water intake point and the plant to remove suspended materials in water, Presently, the existing pond is not working efficiently due to such improper structures that there is no overflow plate and the outlet is located at the bottom of the pond. This will be improved by installing a overflow plate before the out let so as to overflow the surface water after settling sand particles. By this improving, as well as enforcement of the coagulation and sedimentation process same as other plants, it is judged to achieve the objectives of the rehabilitation.

Table 3-2 Raw water Quality of Each Plant

Plant Name	Turbidity(ppm)		pH	Alkalinity	NH_4-N	Iron	Coliform*
	Max	Ave		$CaCO_3$mg/l	(mg/l)	(mg/l)	Bacteria
Simly	135	27	7.8	100	N.D	N.D	+
G-10	600	42	7.6	173	0.3	N.D	+
Shahdara	600	40	7.7	135	0.1	N.D	+
R.L.1	500	45	7.9	102	0.5	N.D	+
Golf Course	600	40	7.6	163	0.2	N.D	+
Korang	300	27	7.9	210	0.1	N.D	+
Saidpur	8	5	7.6	194	N.D	N.D	+
Noorpur	400	11	7.7	131	N.D	N.D	+

Based on the data from CDA and measurements in this study.

* : No quantitative data is available. + shows positive result.

3-2-3 Implementation and Management Plan

Institutional system for the water supply in Islamabad has been mentioned in the previous chapter. In CDA there are two possible departments/sections that implement projects relating to the water supply facilities, that is, Water and Sewerage Development under the Member (Engineering) and Director Water Supply under the Director General (Service). For the proposed Project, Deputy Director Bulk Water Supply under the Director Water Supply would be assigned as a section in charge of the implementation since the Project is rehabilitation works of the existing water treatment plants, of which operation/maintenance they are responsible for. They are to operate the water treatment plants after the completion of the rehabilitation works.

CDA has long experiences in constructions, operation and maintenance of water supply system since 1962. They have constructed seven water treatment plants, many tube wells, reservoirs, pumping stations and water transmission and distribution pipe lines. The Deputy Director Bulk Water Supply has recently conducted the following modification/rehabilitation works relating to the water treatment plants;

i) Installation of an isolating valve in the water intake line of Simly water treatment plant.

ii) Expansion of Sedimentation basins in G-10 Water treatment Plant.

iii) Rehabilitation of Korang water treatment plant including relocation of water intake, replacement of water intake pipe line, repairing leakage of sedimentation basin, replacement of raw water inlet pipe and replacement of water collectors in filtration basins.

Judging from these experiences, they are considered to be capable to execute the proposed project.

For the operation and maintenance of facilities after completion of the project, particular changes from the present are not expected in principle since the project is a rehabilitation of the existing system. Daily work amounts at the plants is expected to increase slightly due to the enforcement of the operation of sedimentation and filtration. For instance, coagulant is to be dosed every day while presently only in rainy days, thus the preparation of the chemicals will be required everyday, operations of sludge withdrawal valves that are not operated in the present system will be required every day and the back washing of the filter beds are necessary everyday while it is presently once a few weeks. However, such increase in work amounts is not considered significant and they will be covered by the present organization shown in Fig 3-1.

The training of the operators of G-10 and Golf Course Plants would be required to operate the rapid sand filtration system that would be newly introduced to those plants. The training can be managed by CDA based on their operational experiences in Simly water treatment plant that presently employs the rapid sand filtration. This will cause a change in their operational method, but not cause an increase of the work amount.

While the enforcement of chemicals dosing in every plant and the installation of backwashing pumps in some plants are proposed in the rehabilitation plan, they are not to increase the operation cost because chemicals dosing rate can be well controlled by measuring the water flow rate and installing metering pump for chemicals and because power consumption can be reduced by applying high efficiency pumps. Consequently, the additional operation cost could not be required for the operation of the rehabilitated system. (Cost comparison between the actual and estimated is shown in the latter section.)

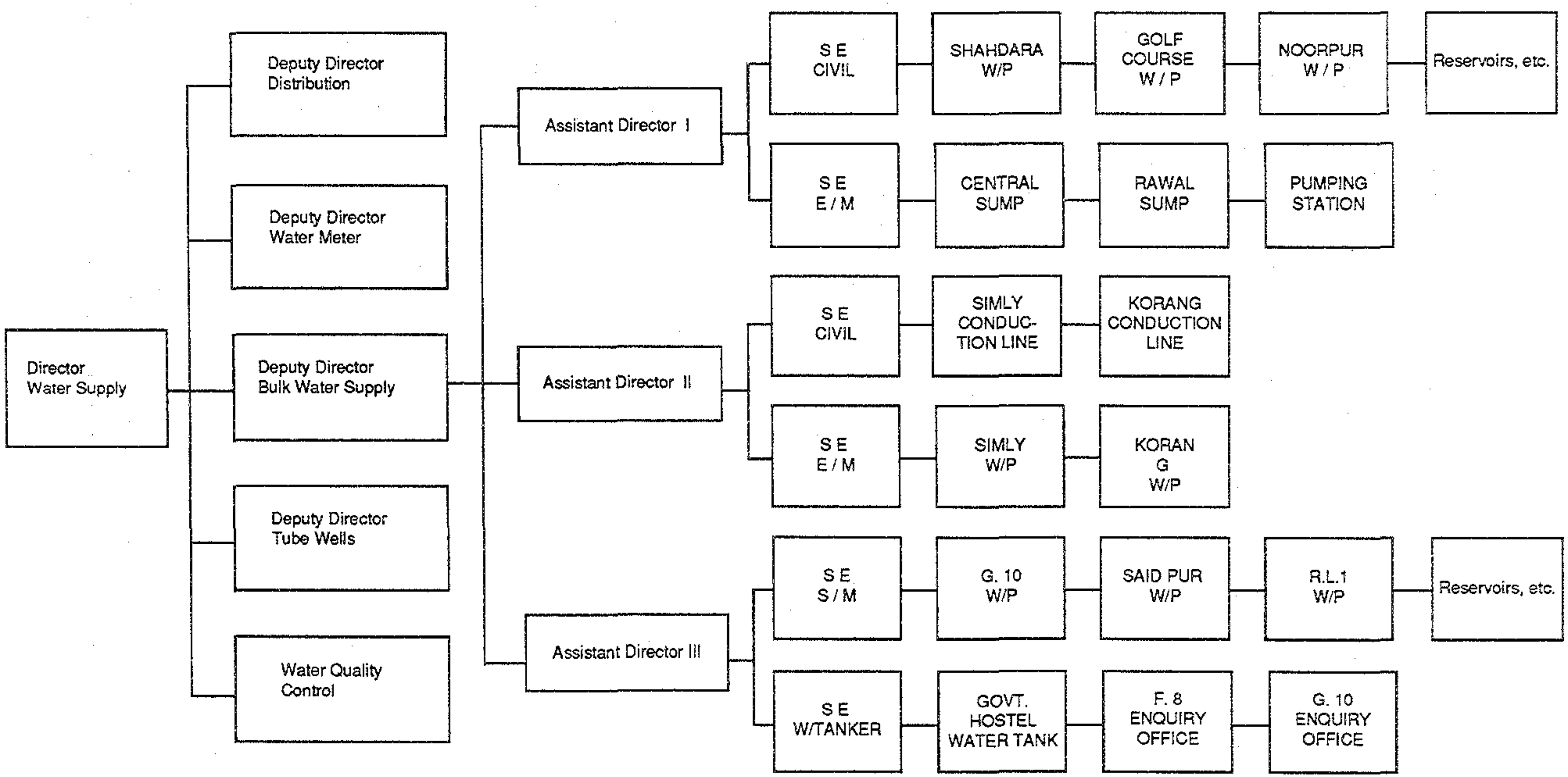


Fig. 3-1 Current Organization Chart of Water Supply Operation in CDA

3-2-4 Similar Projects and Projects financed by the Other Foreign Donors

The Water Master Plan with the target year 2000 was prepared in 1988 to maintain its water supply coverage, 100%, which is the national target in the Seventh Five Year Plan. To cope with the water demand in the year 2000, the Master Plan comprises of the following there major projects;

i) Bulk Water Supply to Islamabad-Phase III.

ii) Metropolitan Water Supply Project (Khanpur-I).

iii) Improvement of the Existing Water Supply System.

Two projects, i) and ii) are to construct new water supply systems of which water sources are Simly dam and khanpur dam and develop additional water of 164,000 m^3/day. Both projects have been approved as projects of the Seventh Five Year Plan and financed by the Overseas Economic Cooperation Fund(OECF), Japan.

The last iii) aims to restore, extend and last the capacity of water supply system by rehabilitating or improving the existing facilities such as water treatment plants, distribution net works, conduction pipe lines, etc. Concrete and overall plans for the project have not been prepared yet and the project now being requested, which is a rehabilitation of the existing water treatment plants, can be considered as a part of the project mentioned in iii).

As mentioned above, two projects are being financed by OECF, but there are no other projects related to the water supply in Islamabad, which have been committed or are planned to be financed by the foreign donors.

3-2-5 Basic Principle for Project Implementation

The appropriateness and necessity of the project, technical feasibility, the capability of the Pakistani side to implement the project have been confirmed as discussed in the above sections. In addition, the expected effects of the project meet the scheme of the Japan's Grant Aid Program.

Therefore, the implementation of the project under the Japanese Grant Aid Program has been concluded to be appropriate and the Basic Design for the project has been prepared based on the premise that the project will be implemented by the Japan's Grant Aid.

The project will provide proper facilities. However, it should be noted that stable water supply can be materialized only when proper facilities are operated and maintained properly. Thus it is required that CDA provides the proper operation and maintenance system to ensure the success of the project.

3-3 Outline of the Project

3-3-1 Project Implementation and its Organization

Since the project is of the rehabilitation of the existing water supply system, the Director Water Supply, who is responsible for the operation of the water supply system, will be assigned as a director responsible for the implementation of the project. There are five Deputy Directors under Director to support daily operation and maintenance of the water supply as shown in Fig 3-1 and the Deputy Director Bulk Water Supply is to be in charge of the implementation of the project as the project is related to the water treatment plants.

The facilities after the rehabilitation are to be operated by three sub-directors under the Deputy Director Bulk Water Supply, who are presently operating the existing plants.

3-3-2 Project Plan

As a result of examination, it has been concluded to conduct rehabilitation works for the facilities of the eight existing water treatment plants in Islamabad, to restore their treatment capacity to the original design capacity and to produce safe, clean water satisfies the water quality specified in the WHO guideline.

In the preparation of the rehabilitation plan, special consideration have been put on the utilization of the existing structures and equipment and designing the minimum scale facilities necessary to achieve the rehabilitation objects. Components of the rehabilitation works for each plant are shown in Table 3-3 and summarized as bellow;

- Replacement of intake pumps in two plants.
- Improvement/repair of intake facilities in two plants.
- Improvement of coagulation/sedimentation faculties in six plants.
- Improvement of operation valves of filtration basin in six plants.
- Modification from medium rate sand filter to rapid sand filter in two plants.
- Improvement of chemical dosing facilities in seven plants.
- Improvement of chlorination facilities in eight plants.
- Installation of flow measuring devices in seven plants.
- Replacement of the existing distribution pumps in three plant.
- Installation of operation panel for pump to ensure the normal operation in seven plants.
- Installation of the water quality test kit in eight plants.

Table 3-3 Summary of Improvement Plan

Facility / Equipment	Plant name							
	Simly	Korang	Golf-Course	G-10	R.L.1	Said-pur	Noor-pur	Shah-dara
Water Intake								
Pump	-	-	b	b	e	-	c	-
Removal of sand and sludge	-	-	-	-	-	-	-	c
Flocculation /Sedimentation								
Mixer/Flocculater	a.b	c	c	c	c	-	-	c
Sludge With drawl	b	e	e	e	e	-	-	b.c
Filtration								
Filter basin	-	-	c	c	-	-	-	-
Valves	b.c	-	c	c	-	b	b	-
Chemical dosing								
Measuring device	c	c	c	c	c	-	e	c
Mixer	b	c	c	c	c	-	e	c
Tank	d	e	e	e	e	-	e	e
Chlorine Dosing								
Tank	-	c	c	c	c	c	c	c
Chlorinator	b	b	b	b	b	c	c	b
Instrumentation	b	c	e	e	e	e	e	e
Distribution pump		b		b	b			
Electric	b	b	b	b	b	-	-	b
Miscellaneous (Water Quality Test)	d	e	e	e	e	e	e	e

a:Removal b:Replacement c:Improvement d:Repair e:Installation

3-3-3 Operation and Maintenance Plan

Since this project is to rehabilitate the existing facilities, there could be no particular change in operation methods of the facilities after completion of the project. Therefore, additional manpower is not necessary for the operation of the rehabilitated facility. However, it is required to enforce the operation management of chemical doing, sedimentation, filtration and chlorination to ensure the normal function of the facilities. Typical inspection and maintenance schedule for water treatment plant is shown in Table 3-4 for reference.

Table 3-4 Schedule for the Standard Inspection and Maintenance

Facility and Inspection Item	Daily	Weekly	Monthly	Yearly	Every 5 years
Civil Structures					
Leakage				x	
Metallic structures					
Corrosion				x	
Water Intake					
Sludge, debris accumulation	x				
Pumps, Motors					
Meter	x				
Lubrication oil		x			
Insulation				x	
Inpellar, Shaft					x
Valves, Gates					
Leakage			x		
Drain from pit		x			
Chemical Dosing					
Measuring	x				
Dosing pipe	x				
Debris in the solution tank		x			
Chlorination					
Leakage	x				
Water supply pressure	x				
Starting emergency fan		x			
Corrosion			x		
Instrumentation					
Indicator	x				
Wiring				x	
Electric					
Indicator	x				
Wiring			x		
Other Machines					
Action				x	
Corrosion					x
Conduction/transmission line					
Leakage	x				
Pressurized Pipe			x		
Underground Installation		x			

Note: This is an example of standard schedule. The actual schedule is to be prepared considering the actual facilities and operation conditions.

In addition, the training of the operators in G-10 and Golf Course Plants will be necessary because the filtration system in those plants would be changed from medium rate sand filtration to rapid sand filtration. Such training can be carried out by the on-site training by sending the operators of those plants to Simly plant where rapid sand filtration is presently in operation.

Operation cost for the rehabilitated facilities is estimated to remain at almost same level as the actual. The actual operation cost in 1990 and the estimated operation cost for the rehabilitated facilities are shown in Table 3-5 and Table 3-6 respectively. The comparison of two Tables indicates reduction of 15% from the actual, by decrease in chemical cost and electricity while chlorine cost will slightly increase. While electricity charge could in crease because of the installation of new intake and transmission pumps in R.L.1 and Korang plants and new backwash pumps in G-10 and Golf course plants, it is estimated still lower than the actual because new pumps are of high power efficiency type. The chemicals cost will increase in Golf Course, R.L.1 and Shahdara plant where chemical dosing is hardly conducted in the present operation. However, it will significantly decrease in Simly and G-10 plants, which are presently consuming most of chemicals used in seven plant operations. This is because dosing rate will be controlled by measuring water rate and installing metering pump, and suggests that chemical may be dosed more than necessary in the present operation.

Table 3-5 Actual Annual Operation Cost in 1990

(Unit:RS 1,000)

Water Treatment Plant	Salary	Electricity	Alum	Chlorine	Miscel-laneous	Total
Simly	4,000	2,980	9,950	820	58	17,808
Korang	2,700	170	-	-	-	2,870
Golf Course	2,800	4,900	220	260	57	8,237
R.L.1	1,500	13,200	360	260	57	15,377
G-10	2,200	18,300	1,100	260	57	21,917
Noorpur	1,100	130	150	100	57	1,537
Saidpur	1,000	170	-	40	57	1,267
Shahdara	2,700	150	220	200	57	3,327
TOTAL	18,000	40,000	12,000	2,000	400	72,340

Table 3-6 Estimated Annual Operation Cost

(Unit:RS 1,000)

Water Treatment plant	Salary	Electricity*2	Alum	Chlorine	Miscel-laneous	Total
Simly	4,000	2,300	7,350	1,830	58	15,538
Korang	2,700					2,700
		(4,200)	(550)	(250)	(57)	(7,757)
Golf Course	2,800	4,600	560	250	57	8,267
R.L.1	1,500	11,950	740	250	57	14,497
G-10	2,200	13,700	450	500	57	16,907
Noorpur	1,100	130	150	200	57	1,637
Saidpur	1,000	170	-	200	57	1,427
Shahdara	2,700	150	350	70	57	3,327
TOTAL *1	18,000	33,000	9,600	3,300	400	64,300

*1: Cost for Korang in ( ) is eliminated from the total to compare to the actual.

*2: 22,600 RS/1KW/year

3-4 Technical Cooperation

The project is of rehabilitation of the existing system. None of new facilities will be introduced by the project. The facilities after implementation of the project could be operated by the experiences and knowledges of operation of the existing system. Only in two plants, G-10 and Golf Course plants, filtration system would be modified from medium rate sand filtration to rapid sand filtration which might be new for the operators of those plants. They will need training for the operation of rapid sand filter and the training can be managed by CDA based on their experiences and knowledges accumulated trough the operation of Simly plant. Therefore, it can be concluded that the water treatment plants after implementation of the project can be managed by the present capability of CDA without providing any technical cooperation by the Government of Japan.

Meanwhile, the following operations, which should be reconsidered, have been observed during the site survey in the study:

i) Pre-chlorination in every plants: According to the chlorine demand test shown in Appendix-6, raw water of any plant except G-10 plant does not require pre-chlorination. At least in two plants, Saidpur and Noorpur plants where slow sand filtration is employed, the pre-chlorination must be stopped. Because remaining chlorine after pre-chlorination could inhibit or kill the biofilm that develops on the surface of the filter bed and play a major role of the purification by slow sand filtration.

ii) Low dosing rate of chemicals during high turbidity period of raw water: It has been found that chemical had not been dosed enough to coagulate high turbidity water. The reasons were given that excessive alum dosing causes decrease of pH value resulting in failure of coagulation and may be hazardous to human health. However, those are not agreeable because alkalinity of the raw water in every plant is high (more than 100 mg/l as $CaCO_3$) and has enough buffering capacity to prevent lowering of pH, and there is no report on the hazardousness of Alum to human health as far as in the water treatment engineering.

Such operation will be improved after the project. As the improvement in terms of facility has been taken into consideration and the improvement in terms of operation will be recommended by providing operation manuals. However, it is recommendable to provide a training for the theory and operation technic of water treatment engineering to develop a technical level of CDA. By encouraging the correct theory and technic through such training it is expected that the further stable operation of the water supply will be ensured.

Chapter 4 Basic Design

CHAPTER 4 BASIC DESIGN

4-1 Design Policies

The basic design is carried out based on the following design policies.

i) The scope of the improvement works are to be limited within the facilities/equipment in water treatment plant that presently have problems relating to the quantity and quality of the treated water.

ii) The existing structures and equipment are to be utilized as much as possible.

iii) The design capacity of each plant is to adopt the CDA's nominal capacity.

iv) Water quality for the treated water is to conform to the drinking water guideline of WHO and the drinking water criteria of the Japanese Water Supply Law.

v) The operational method is to employ on-site, manual type, except for the case where automatic operation is required for the safety reasons.

vi) The facilities/equipment are to be a type that is able to run continuously except the period of power shut-down.

vii) The metric system is to be adopted in all the design works, while the yard-pound system is attached if necessary.

viii) The standards for designing are to adopt Japan Industrial Standard(JIS), Standards of the Japan Manufacturer's Association(JEM) and Standard of Japan Electrotechnical Committee(JEC). British Standard (BS) and Deutsche (DIN) that are used in the existing facilities/equipment are to be adopted if necessary.

ix) The types of facilities and construction methods are to be selected so as to minimize the length of water cut period due to the execution of the project.

4-2 Studies on Design Conditions

4-2-1 Aims of the Improvement

The scope of the design is to improve the facilities/equipment in which some problems have been identified through this study as mentioned in the previous chapters. Targets of the improvement of each facilities/equipment are fixed as follow:

i) Water Intake

To ensure the intake capacity for necessary water amount and to reduce the pollutants loading to the purification process.

ii) Coagulation and Sedimentation

To improve the floc formation and to accelerate the sludge withdrawal so as to reduce the turbidity loading to filtration process.

iii) Filtration

To improve the backwashing process in order to extend backwash interval and to stabilize the treated water quality.

iv) Chemical Dosing

To control the dosing rate and the concentration of the chemical solution.

v) Chlorination

To provide a economical facility and to control dosing rate.

vi) Instrumentation

To measure inlet water amount or outlet water amount in order to monitor the operation rate and to control the chemical and chlorine dosing rate.

vii) Distribution

To ensure stable operation of distribution pumps.

viii) Electronic

To provide high energy efficiency type of pumps and motors.

ix) Others

To provide water test kit so as to monitor water quality necessary for the daily operation.

4-2-2 Methods of Improvement

The improvement is to be carried out by the following methods:

i) To dismantle the existing facilities/equipment.

ii) To replace the existing facilities/equipment by new ones with same specifications.

iii) To up-grade the existing facilities/equipment.

iv) To repair the existing facilities/equipment.

v) To install the additional facilities/equipment.

4-2-3 Facilities/Equipment to be Improved

The method of the improvement for each facilities/equipment is shown in Table 4-1.

Table 4-1 Purposes and Methods of the Improvement

Purposes of Improvement	Plant name							
	Simly	Korang	Golf Course	G-10	R.L.1	Said -pur	Noor-pur	Shah-dara
Water Intake								-
Stable water intake	-	-	b	b	e	-	c	-
Removal of sand and sludge	-	-	-	-	-	-	-	c
Flocculation /Sedimentation								
Flocculation	a.b	c	c	c	c	-	-	c
Sludge With-drawal	b	e	e	e	e	-	-	b.c
Filtration								
Reducing Turbidity	-	-	c	c	-	-	-	-
Back Wash	b.c	-	c	c	-	b	b	-
Chemical dosing								
Measuring rate	c	c	c	c	c	-	e	c
Solution Concentrations	b	c	c	c	c	-	e	c
Continuous dosing	d	e	e	e	e	-	e	e
Chlorine Dosing								
Handling	-	c	c	c	c	c	c	c
Dosing Rate	b	b	b	b	b	c	c	b
Instrumentation	b	c	e	e	e	e	e	e
Distribution pumps		b		b	b			
Electric	b	b	b	b	b	-	-	b
Miscellaneous	d	e	e	e	e	e	e	e
(Water Quality Test)								

a: Removal b: Replacement c: Improvement d: Repair e: Installation

4-3 Design Conditions

The following design condition are adopted in designing of the improvement.

4-3-1 General Conditions

Generally, the following environment conditions have been taken into consideration in the designing.

Ambient Temperature :	maximum	40°C
	mean	20°C
	minimum	5°C
Humidity :	maximum	100%
	mean	50%
	minimum	20%
Elevation :	760m(2,500 ft)	

4-3-2 Design Treating Capacity of the Plant

The capacity of each facility/equipment is to be designed based on the design treating capacity shown in Table 4-2.

4-3-3 Design Treated Water Quality

The design treated water quality is to conform the WHO guideline for drinking water and water quality criteria of Japanese Water Supply Law. The adopted design water quality is shown in Table 4-3.

Table 4-2 Design Water Quantity

Water Treatment Plant	Design capacity		Required Raw Water *1
	m^3/Day	(MGD)	m^3/Day
Simly	109,100	(24)	114,800
Korang	10,910	(2.4)	11,500
Golf Course	11,400	(2.5)	12,000
G-10	9,100	(2.0)	9,600
R.L.1	10,230	(2.25)	10,800
Saidpur	3,200	(0.7)	3,500
Noorpur	3,200	(0.7)	3,500
Shahdara	7,300	(1.6)	7,700
TOTAL	164,440	(36.15)	

*1: Water consumption in the plant is fixed at 5% considering sludge withdrawal

Table 4-3 Design Water Quality of Treated water

Title	Japanese Water Supply Law	WHO Guideline	Adopted Design Criteria
pH	5.8	6.2 - 8.5	5.8 - 8.6
Turbidity	less than 2°	less than 5°	less than 5°
Total solid	less than 500mg/l	less than 1000mg/l	less than 500mg/l
Permanganate Consumption	less than 10mg/l		less than 10mg/l
Nitrate and Nitrite Nitrogen	less than 10mg/l	-	less than 10mg/l
Coliform Bacteria	not detected	not detected	not detected
Iron	less than 0.3mg/l	less than 0.3mg/l	less than 0.3mg/l
Manganese	less than 0.3mg/l	less than 0.1mg/l	less than 0.3mg/l
Chloride	less than 200mg/l	less than 250mg/l	less than 200mg/l
Total Hardness (as $CaCO_3$)	less than 300mg/l	less than 500mg/l	less than 300mg/l

4-3-4 Power Receiving Capacity

Replacement and installation of electric equipment is to be designed within the capacity of the existing power receiving facility. The capacity of the existing power receiving facility in the plants, where major improvement works are expected, are shown in Table 4-4.

Table 4-4 Capacity of Existing Transformer

Water Treatment Plant	Water Intake Pumping Station	Treatment Plant
Simly	-	630KVA, 11KV/415V
Korang	200KVA,11KV/415V	630KVA, 11KV/415V
Golf Course		750KVA, 11KV/415V
G-10	400KVA,11KV/415V	630KVA, 11KV/415V
R.L.1	-	630KVA, 11KV/415V
Shahdara	-	100KVA, 11KV/415V

4-4 Basic Plan

4-4-1 System Design

(1) System to be designed

Improvement of the system is to be designed so as to utilize the existing structure and equipment as much as possible. The system to be designed are classified into tree types as shown Fig. 4-1.

(2) Water Levels

The facilities are to be designed according to the existing water level of each facility except in case where a new pump is installed or the existing pump capacity is improved. Details of water level of each plant are shown in the Basic Design Drawings.

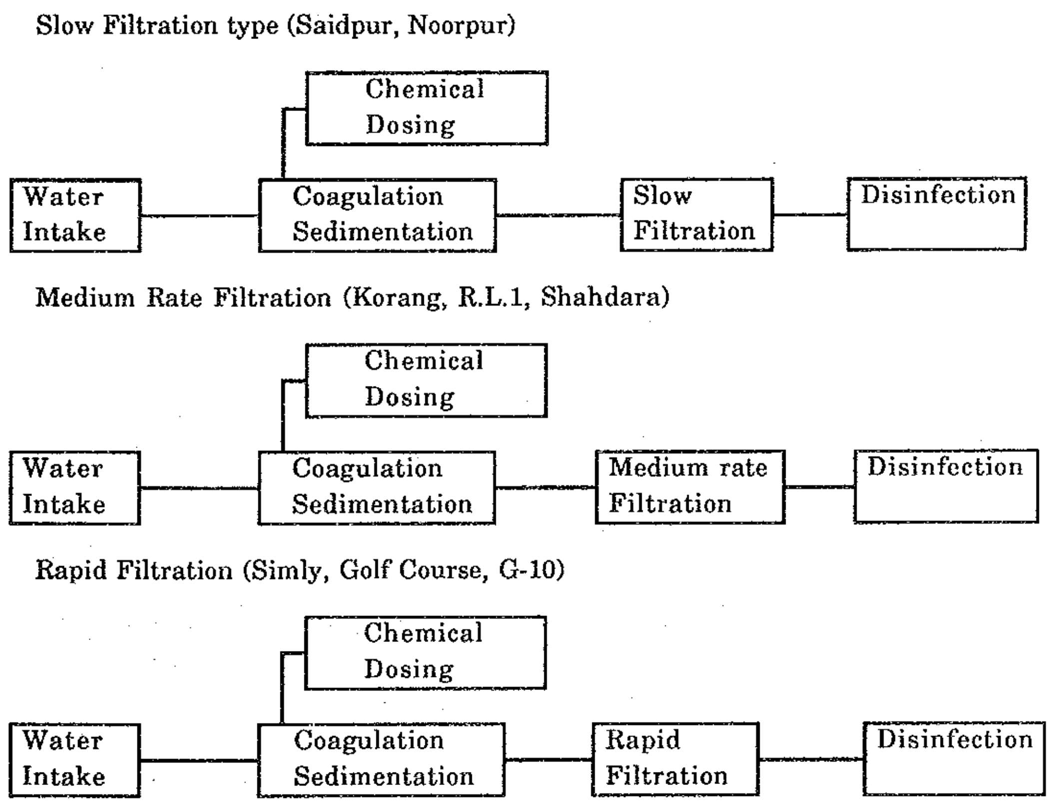


Fig 4-1 System to be Designed

4-4-2 Major Improvement and New Facilities/Equipment to be Designed

(1) Water Intake

Installation of intake and conduction facilities for R.L.1 water treatment plant, two types of conduction facility, gravity flow and pumping, have been compared as shown in Table 4-5. It has been judged to select gravity flow conduction.

(2) Coagulation and Sedimentation

(a)Agitation in Simly Water Treatment Plant

While there exists mechanical agitators in mixing basins of Simly Plant, the agitation intensity by inflow velocity has been calculated as below because it is considerably high velocity due to big difference of water levels between dam and mixing basin. As a result of the calculation, it has been judged that the agitation intensity by inflow velocity is enough to ensure the agitation, thus the existing mechanical agitation would not be necessary.

Calculation Conditions

Water Quantity: 114,800 m^3/day=1.33 m^3/sec

Volume of Agitation Basin: 25.9 m^3

Calculation

$G=(ß*v^2*Q/2/\mu/V)^{1/2}=(1000*2.6^2*1.33/2/1/10^{-3}25.9)^{1/2}$

where, ß: density of water(1000kg/m^3)

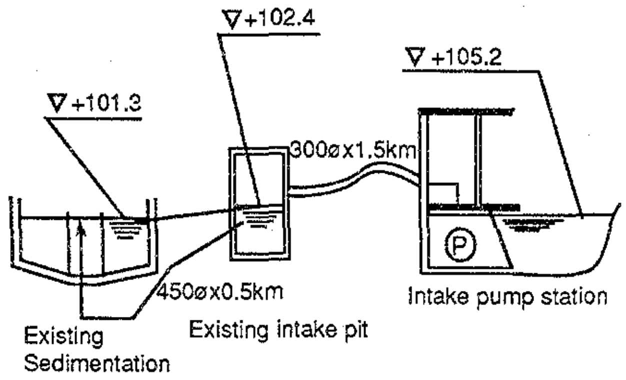
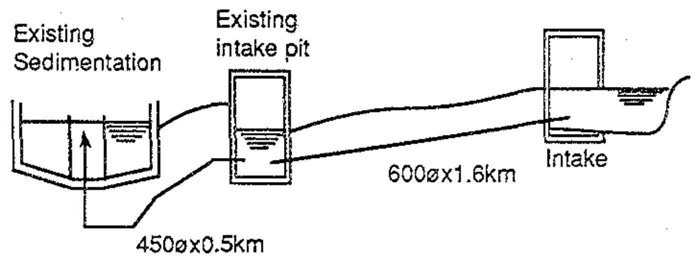
v: initial velocity of water flow ($1.33/\pi/0.8^2*4=2.6m^3$/sec)

μ: coefficient of viscosity of water (10^{-3}kg/cm/sec)

G: Agitation Intensity Index (1/sec)

(Note: Minimum G value necessary for agitation is known 100 1/sec.)

Table 4-5 Comparison and Study of Intake Facility

Description \ System	Pumping System	Gravity Flow System
1. System Outline		
2. Merit	(1) Discharge pipe diameter can be minimized by the use of the pump. (300mm) (2) Erection cost for the pipe is comparatively low (Freedom from ground elevation)	(1) Minimizes the necessary facilities without any electrical device and is simple to operate. (2) Can operate even in the case of an electrical failure.
3. Demerit	(1) The construction of a new pump station is necessary. (2) Operation and maintenance is complicated. (3) Can not be operated during power failures. (4) Running cost is high (electrical charge)	(1) The pipe diameter is large depending on the gravity flow (600mm)

System / Description	Pumping System	Gravity Flow System
4. Construction cost	100 (Mechanical works : 60 Electrical works : 10 Civil works : 30)	55 (Mechanical works : 0 Electrical works : 0 Civil works : 55)
5. Total cost for 10 years (Including operation cost)	100	46
6. Evaluation	While the civil works will be smaller than the gravity flow system, the construction cost is estimated higher than it. Operation and maintenance are also more complicated than it.	Construction and operation costs are cheaper than the pumping system. Operation is easier than the pumping system.

(b) Flocculator for Simly plant

The mixing intensity of the existing flocculators has been calculated as below and found to be sufficient. Therefore, same specifications are adopted for designing new flocculators.

<u>Mixing intensity</u>

$G=(102*p*g*n/V/\mu)^{1/2}$

where; p:Power output (0.15kw, slow run)

g:acceleration of gravity (9.8m/sec^2)

v: volume of flocculation basin (330m^3)

n: numbers of flocculator (4 no)

μ: coefficient of viscosity of water (1*10^{-3}kg/cm/sec)

$G=(102*0.15*9.8*4/330/1.0/10^{-3})^{1/2}=43$ 1/sec.

The calculated G value falls in the optimum range of G value for mixing intensity for flocculation, 10 to 75 1/sec.

<u>Power output of Flocculate</u>

Diameters of the existing mixing paddle are as follow;

1st stage ø 3.3m,
2nd stage ø 2.8m,
3rd stage ø 2.3m,
4th stage ø 1.8m.

By supposing that the peripheral velocity is maximum, 80cm/sec, and minimum, 20cm/sec and that the turn-down ratio is 1/4, the power of resistance against a paddle is calculated as follow:

$R=CD*1/2/g*ß*v^2*s$

where CD:coefficient of resistance(1.8)

g:acceleration of gravity(9.8m/sec^2)

ß:density of water (1000kg/m^3)

v:relative velocity(0.75*peripheral m/sec)

s:area of paddle(5m*0.15m=0.75m^2).

Thus, the peripheral velocity and the resistances of each paddle are calculated as below:

	Peripheral velocity (m/sec)		Resistance (kg)	
	max	min	max	min
1st stage paddle	0.72	0.18	20	10
2nd stage paddle	0.61	0.15	14	7
3rd stage paddle	0.50	0.13	10	5
4th stage paddle	0.39	0.10	6	3

Then, power output, P, is

$P=R*v/102/\mu*2.$

where; μ is mechanical efficiency of transmission(0.486).

For the maximum peripheral velocity,

$\Sigma p=2/102/0.486*(20*0.72+14*0.61+10*0.5+6*0.39)=1.5kw.$

Thus, the necessary power output of the flocculator for the maximum peripheral velocity is judged to be 1.5 kw.

In addition, for the minimum peripheral velocity,

$\Sigma P=0.15kw.$

Thus the necessary power output for the minimum peripheral velocity is judged to be 0.15kw.

(c) Mixing and Coagulation Facilities for Korang, Golf Course, G-10 and R.L.1 plants

As a result of the comparison of two mixing methods, that is, gravity flow mixing and mechanical mixing, as shown in Table 4-6, the gravity flow mixing method has been selected from view points of operation cost and operation /maintenance.

The specifications of these facilities have been determined by considering the mixing and flocculation efficiency based on G value. Example of calculation for Korang plant is shown below:

Mixing

Supposing,

Inlet pipe diameter=0.3mm,

Flow velocity in the pipe=1.8m/sec,

$G=(ß*v^2*Q/2/\mu/V)^{1/2}$.

ß:density of water ($1000kg/m^3$)

v:flow velocity in pipe (1.8m/sec)

Q:Water quantity ($0.126m^3/sec$)

μ:Coefficient of water ($10^{-3}kg/m/sec$)

V:volume of mixing ($0.25m^3$)

$G=(10^3*1.8^2*0.126/2/10^{-3}/0.25)^{1/2}=$
$900^1/sec > 100^1/sec$.

Thus, it is concluded that the necessary mixing would be obtained by using inlet pipe with diameter of 300mm.

Coagulation

$G=(p*Q*H*g/v/\mu/)^{1/2}$, then, $H=(G^2*v*\mu/p/Q/g)$

where, G:50sec^{-1}(10 to 75 ^{1}/sec)

v:volume of basin($\pi*9.8^2/4*3.21=242m^3$)

μ:coefficient of water(10^{-3}kg/m/sec)

p:density of water(1000kg/m^3)

Q:water quantity(0.126m^3/sec)

g:acceleration of gravity(9.8/sec^2)

thus,

$H=(50^2*242*10^{-3}/10^3/0.126/9.8)=0.49=0.5m$.

Therefore, necessary difference in water levels would be more than 0.5m and necessary diameter of the outer pipe is determined to be 0.6m by the following calculation:

Necessary cross section=$(\pi*0.3^2/4)^{1/2}+0.21=0.28m^2$

D=0.6m

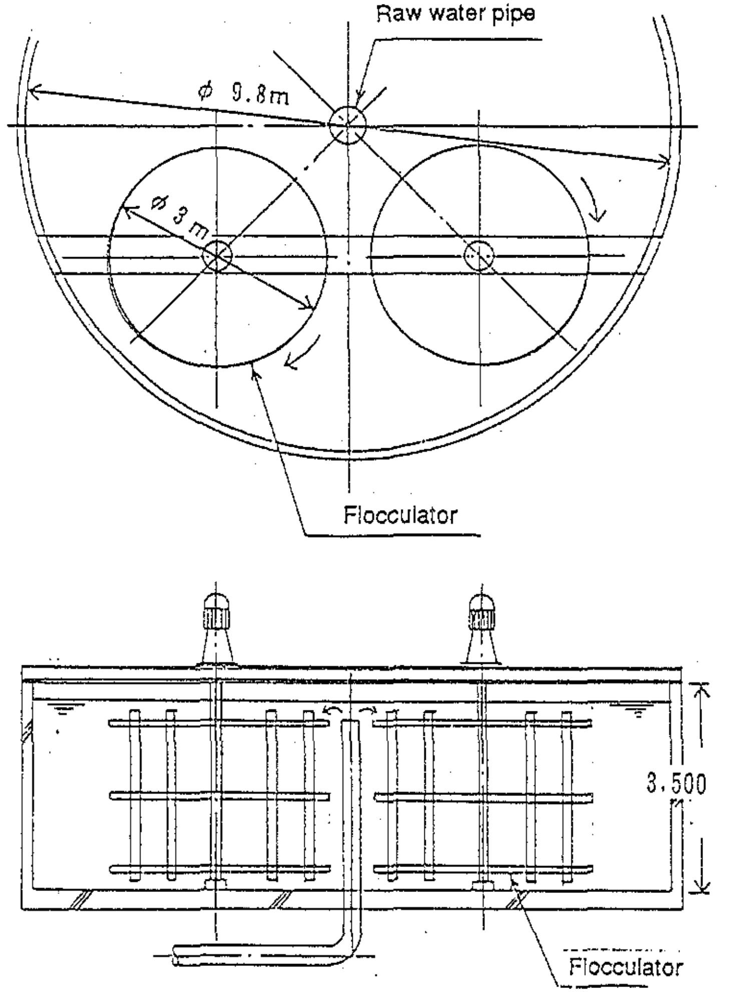
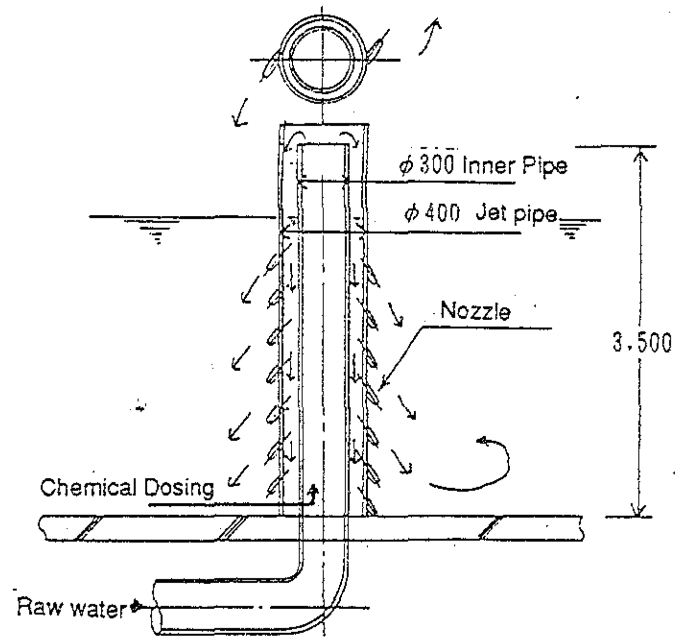
where $0.21m^2=0.126m^{3/sec}/0.6m^{/sec}$.

Retention time in coagulation basin, T, is supposing,

effective volume=$\pi*9.8^2/4*3.21=242m^3$

T=242*24*60/109000=32min.

Table 4-6 Comparison and Study of Coagulation and Sedimentation

System / Description	Mechanical Flocculator	Jet-Nozzle (Gravity flow)
1. System Outline		

System / Description	Mechanical Flocculator	Jet-Nozzle
2. Principle	The flocculator will give a energy to the mixed water and it will promote the growth of floc.	The growth of floc will utilize the potential energy under the gravity flow from the inner pipe to the jet pipe.
3. Feature	The flocculator can be controlled by the reducer and it will be operated by the water quolity conditions.	All operation is under the gravity flow of water and free from the maintenance trouble.
4. G-Value	10 - 75 (Normal Value is 50)	50 (Calculation is shown attached sheet)
5. Construction Cost	800 (4sets of flocculator and 1 complete set of control panel)	100 (1 set of Jet-Nozzle)
6. Evaluation	○	◎ Satisfactory The construction cost is cheap and the maintenance works are easy.

(3) Filtration

(a) Filtration operation for Simly plant

Three types of filtration operation valves, such as hydraulic control, electric control and pneumatic control, have been compared as shown in Table 4-7 and pneumatic control system has been selected from view points of availability, cost and operation/maintenance.

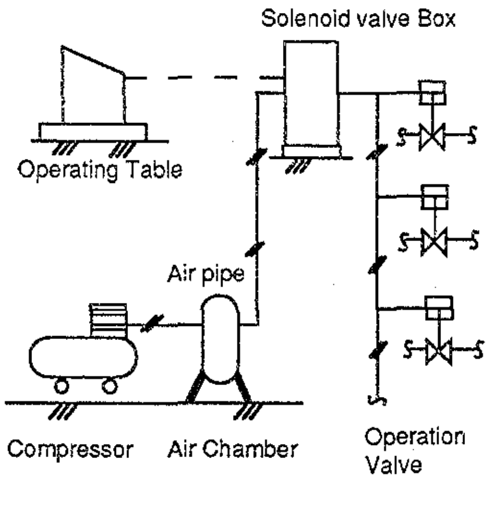
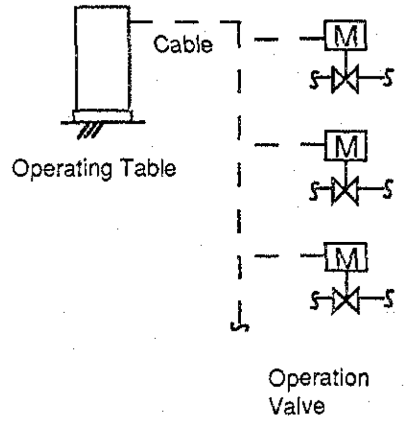
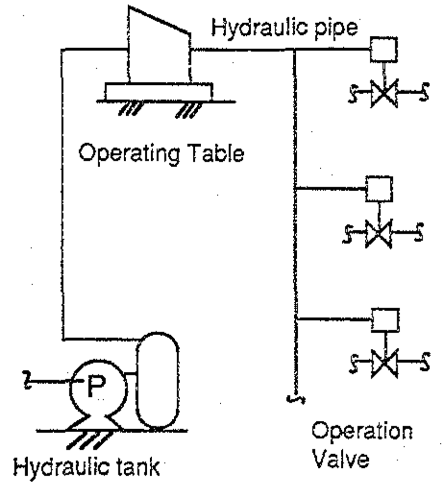
(b) Filtration System (Golf Course and G-10 Water treatment Plants)

In the previous discussion, it has been concluded to change the existing filtration system in two plants to rapid sand filtration. Considering the existing system, following three methods are considered to be possible; i)concrete made rapid sand filtration by modification of the existing basins, ii)installation of new steel made rapid sand filter abandoning the existing basin, and iii)modification of the existing system to the slow sand filter and installation of the steel made rapid sand filter to supplement a shortage of the capacity of the modified slow sand filter. Comparison has been made as shown in Table 4-8 and concrete made rapid sand filtration has been selected taking into consideration the cost and O&M.

The following design criteria for the rapid sand filtration are adopted based on the Japanese Guideline:

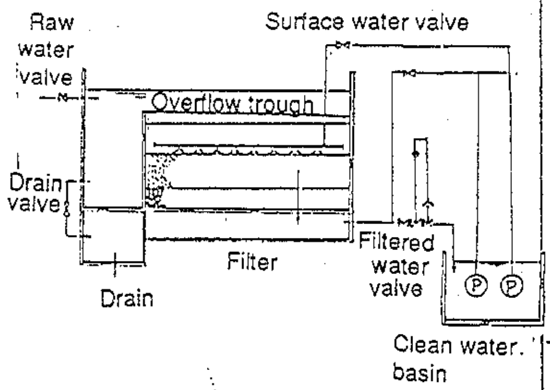
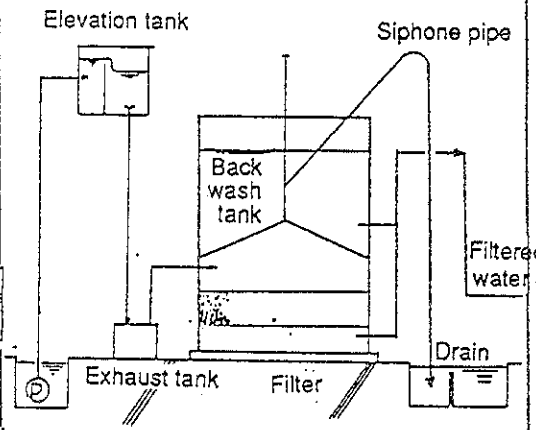
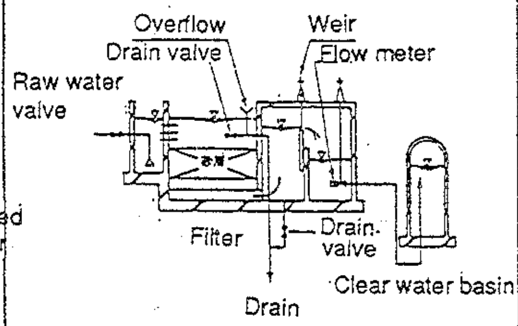
i)	Filtration Rate	120m/day
ii)	Backwash interval	over 24 hours
iii)	Backwashing method	Surface wash and backwash by water
iv)	Type of operation	Manual on site
v)	Backwashing Water Amount	Less than 5% of treated amount
vi)	Type of Water collection	Perforated Pipe

Table 4-7 Comparison of the Operation of the Filtration in Simly Water Treatment Plant

	Pneumatic Operation	Motor Driven operation	Hydraulic operation
1. System Outline			
2. Power Source	Compressed Air	Electricity	Hydraulic water
3. Feature	The construction cost is cheap depending on the system which is consisting with a power source unit and several operation valve.	The construction cost is costly depending on the quantity of valve control unit which is fitted with each operation valve.	Same as Pneumatic operation system.

	Pneumatic Operation	Motor Driven Operation	Hydraulic operation
4. Operation and Maintenance	Slightly complicated due to many components.	Maintenance is very easy for few compornents.	Same as Pneumatic operation system.
5. Procurement	available in Japan	same as pneumatic system	not available in Japan or local.
Delivery	Within 4 months	Within 6 months	Within 6 months
Reliance of the Delivery	○	○	×
6. Construction Cost	60	100	80
7. Evaluation	◎ Satisfactory The construction cost is cheap and delivery time would be reliable.	○	×

Table 4-8 Comparison of the Filtration System

<table>
<tr><th>System / Description</th><th>Concrete Made Rapid Sand Filter (Modification of existing)</th><th>Steel Made Rapid Sand Filter (New facility)</th><th>Slow Sand Filter + Steel Made Rapid Sand Filter</th></tr>
<tr><td>1. System Outline (Tipical model)</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>2. Principle</td><td>The settling water enters the filter bed by the raw water valve and the filtration process take place by gravity.
The filtered water then flows into the filtered water chamber through the filtered water valve and controller.
When the loss head of the filter increases, the raw water and filtered water valve are closed then the drain, the surface wash and the back wash valves are opened for the washing process. After the washing the surface wash and the back wash valve are closed. Then the filtration process can start.</td><td>The settling water enters the filter bed from a high elevation tank by gravity.
The filtered water is stored in the wash water tank then flows into the clean water tank. When the water in the siphon pipe increases by the loss head of the filter, the back wash system is automatically operated by the siphon phenomenon.
The back wash process is stopped by the vacuum breaker.</td><td>The settling water enters the filter bed by the raw water valve by gravity for filtration.
The filtered water is measured by a flow meter.
When the head loss of filter increases the variable weir ensures a constant flow.
The flow regulating device can not function unless the filter media is changed when more than 10mm of surface sand has accumlated.</td></tr>
</table>

System / Description	Concrete Made Rapid Sand Filter (Modification of existing)	Steel Made Rapid Sand Filter (New facility)	Slow Sand filter + Steel Made Rapid Sand Filter
3. Filtlation rate	120 - 150 m/day	120 - 150 m/day	Slow sand filter : 4 to 5 m/day Rapid sand filter : 120 - 150 m/day
4. Treated Efficiency	This system, when it is combined with chemical dosing and sedieentation process, is effective for high turbidity of raw water conditions.	Same as the concrete made rapied sand filter.	The rapid sand filter is installed to the shortage capacity of slow sand filter.
5. Maintenance	Since the operation method is all manually, while it uses many valves, operation failuar would be less because they are all manual driven.	(1) The system is non valve type and the wash water process is automatically operation. (2) System component is minimized. (3) Any failure in vacuum breaker causes process shutdown.	The combined operations to be slow and rapied sand filter are complecated operation and maintenance. Some maintenance works for changing of filter media are very complicated.
6. Water Supply during the Construction	decrease	not decrease	not decrease

System / Description	Concrete Made Rapid Sand Filter (Modification of existing)	Steel Made Rapid Sand Filter (New facility)	Slow Sand filter + Steel Made Rapid Sand Filter
7. Construction Period	8 months (To be modified existing filter step by step.)	8 months (To be operated existing filter.)	6 months (Same as steel made rapied sand filter)
8. Construction Cost Ratio (In case of Golf Course)	100 Contents (Mechanical works 50 Electrical works 5 Civil works 45)	180 Contents (Mechanical works 150 Electrical works 5 Civil works 25)	100 Contents (Mechanical works 100 Electrical works 5 Civil works 15)
9. Evaluation	Satisfactory The operation method is simple and the process is the most suitable for the water quality conditions.		

(4) **Chemical Dosing Facilities in Seven Plants except Saidpur Plant.**

New chemical dosing facility are installed in every plants. Fallowing conditions are applied for the design.

Chemicals

Alum (15% as Al_2O_3) is to be used as a coagulant. Concentration of alum solution is 10%.

Dosing rate

The dosing rate (r) is calculated by the following equations;

for raw water from dam ; $r=5+2T^{1/2}$ and

for raw water from river ; $r=5+T^{1/2}$,

where T is turbidity(degree).

Dosing amount

Dosing amount (R) is calculated by the following equation;

$R=Q*r*100/10*10^{-3}$

Q:Amount of treated water(m^3/hr).

Dosing rate and amount are shown in Table 4-9.

Table 4-9 Chemical Dosing Rate and Amount

Plant Name	Treated Water (m^3/D)		Dosing Rate (ppm) Min	Mean	Max	Dosing Amount (l/hr) Min	Mean	Max
Simly	*1	114,800	5	15	28	239	716	1,339
G-10	*2	9,600	5	11	29	20	44	116
Korang	*2	11,500	5	10	22	24	48	105
Golf Course	*2	12,500	5	11	29	25	55	145
R.L.1	*1	10,800	5	18	50	23	81	225
Shahdara	*2	7,700	5	11	29	16	35	93
Noorpur	*2	3,500	5	8	25	7	12	36

*1 Dosing rate = $5 + 2T^{1/2}$

*2 Dosing rate = $5 + T^{1/2}$

Type of dosing

Dosing by gravity flow and pumping injection have been compared as shown in Table 4-10 and gravity flow is selected from view points of cost and maintenance.

(5) Chlorination

New chlorination facilities are to be installed in every plants. The following conditions are applied for the design.

Chlorine

-liquid chlorine;

effective chlorine:95% up

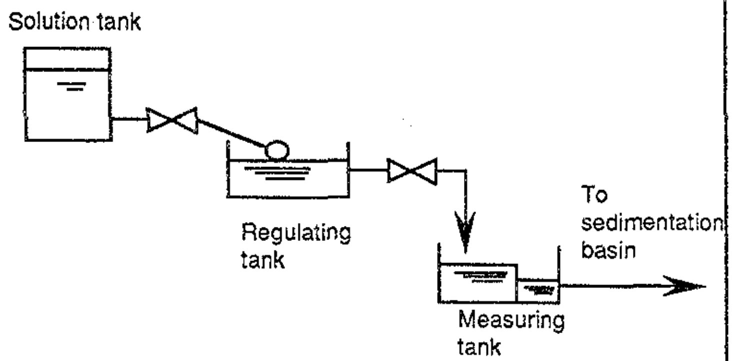
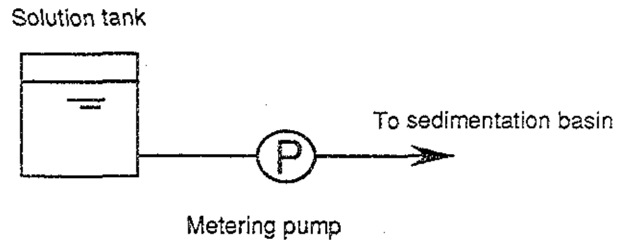
cylinder:1000kg, 250kg and 50kg

evaporating capacity: 8kg/cylinder for 1000kg
3kg/cylinder for 250kg
2kg/cylinder for 50kg

Dosing rate (r)

Dosing rate has been determined based on results of chlorine demand test shown in appendix-6.

Table 4-10 Comparison and Study of the Chemical Dosing System

System / Description	Gravity Dosing System	Metering pump System
1. System Outline		
2. Merit	The structure of each device is simple and its operation is easy.	The dosing rate is accurate depending on stroke and rotary process of diaphragm type metering pump.
3. Demerit	(1) The measuring tank is necessary to every dosing point. (2) The regulating tank is necessary.	(1) The metering pump is necessary for every dosing points. (2) In case of low dosing rate, the metering pump may clog by chemical slurry.

System / Description	Gravity Dosing System	Metering pump System
4. Maintenance	(1) Since the system has a few simple mechanical parts without electrical process, the operation and maintenance is easy. (2) The washing works in each tank is regularly required to drain slurry.	(1) The structure of metering pump is more complicated than centrifugal pump and metering pump should be put in overhaul every years. (2) The maintenance works are complicated for many pump parts.
5. Construction Cost	100	170
6. Procurement	Main parts or device are available in locally. It is available within short time in Japan.	The metering pump must be procured in Japan or third countries. Delivery time will be 2 or 3 months.
7. Evaluation	◎ Satisfactory The maintenance is very easy because the system components are very simple. The construction cost is cheap.	○

Dosing Amount (R)

-Gas chlorine

$$R(kg/hr)=Q*r*10^{-3}$$

where Q:treated water amount(m^3/hr)

r: Dosing rate

The determined dosing amount for each plant are shown in Table 4-11.

Table 4-11 Chlorine Dosing Rate and Amount

Plant Name		Treated Water (m^3/D)	Dosing Rate Mean	(ppm) Max	Dosing Amount Mean	(kg/hr) Max
Simly		109,100	2.5	5	11.4	22.8
G-10	pre	9,600	3.0	4	1.2	1.6
	post	9,100	1.5	3	0.6	1.2
Korang		11,500	2	4	1.0	2.0
Golf Course		12,000	2	4	1.0	2.0
R.L.1		10,800	2	4	0.9	1.8
Shahdara		7,700	2	4	0.6	1.2
Noorpur		3,500	1.5	3	0.23	0.46
Saidpur		3,500	1.5	3	0.23	0.46

(d) Types of dosing

The facilities of chlorination comprises of the following equipment:

Gas chlorine

Chlorine Cylinder,(250kg, 1000kg or 50kg)
Cylinder Suspending equipment
Chlorine injector
Water supply pump(if necessary)
Chlorine pipe
Solution pipe

(6) Instrumentation

Water amount measuring facilities are to be installed or replaced in every plants. Details of the facilities are shown in Table 4-12.

Table 4-12 Type of Flow Measuring Devices

Plant Name	Water to be measured	Quantity	Flow Rate (m^3/day)	Type
Simly	Raw Water	1	114,800	Ultra-Sonic
	Treated Water	12	10,450	Orifice
Korang	Sedimented Water	1	11,500	Weir
Golf Course	Sedimented Water	1	12,000	Weir
G - 10	Sedimented Water	1	9,600	Weir
R.L.1	Sedimented Water	1	10,800	Partial Flume
Saidpur	Raw Water	1	3,500	Weir
Noorpur	Sedimented Water	1	3,500	Weir
Shahdara	Sedimented Water	1	7,700	Weir

4-4-3 Design of Replacement of Major Existing Facilities

(1) Water intake

(a) Water intake pumps for Golf Course and G-10 plants

Major specifications are;

Golf Course	2 vertical centrifugal pumps		
		discharge capacity	8.3m^3/min
		Discharge head	22m
G-10	3 Vertical centrifugal pumps		
		discharge capacity	3.5m^3/min
		discharge head	30m.

(b) Conduction channel and Sand setting pond for Shahdara plant

Sand removal is to be installed in the conduction channel and sand settling pond is to be improved by increasing a height of over flow weir.

(2) **Coagulation and sedimentation of Simply plant.**

Following sludge withdrawal pump is to be installed;

Movable type sludge withdrawal pump	4 no
discharge capacity	$1m^3$/min
discharge head	10m
accessary	scraper.

(3) **Filtration for Simly, Saidpur, Noorpur, Shahdara Plants**

Simly plant

All operation valves in the pipe gallery are to be replaced by the following valves:

Raw water valve	400mmØ Electric gate valve	12
Drain valve	650mmØ Pneumatic lat valve	12
Treated Water valve	300mmØ Pneumatic butterfly valve	12
Air valve	250mmØ Pneumatic butterfly valve	12
Backwash valve	250mmØ Pneumatic butterfly valve	12

Saidpur and Noorpur plants

Inlet gates of filtration basin are to be replaced.

Shahdara plant

Inlet valve of filtration valves are to be replaced.(250mmØ, manual,6)

(4) Chemical dosing for Simly Plant

The existing chemical dosing facilities are to be replaced by the following equipment.

Crate board	wooden	3
Mixer	vertical paddle(3.7kw)	3
Measuring device	Rotameter	1
Pipes	PVC 50mm/25mm	1set
Chemical Lifting device	Whist(500kg)	1
Pallet for chemical stock	Wooden(500kg)	16

(5) Chlorination for Simly Plant

The existing chlorination facilities are to be replaced by the following equipment:

Cylinder lifting device	2ton*5mH	1
Cylinder suspension	1Ton	1
Dentillating fan	Pressurized fan	3
Chlorine injector	Solution feed	2
Repair of floor		1set
Pipes		1set

(6) Distribution pumps in Korang, G-10, and R.L.1 plant

The existing pumps are to be replaced as follow;

Korang :	Centrifugal pump	3
	Discharge	4.6 m^3/min
	Head	91.5m
G-10 :	Centrifugal pump	3
	Discharge	3.2 m^3/min
	Head	105m
R.L.1 :	Centrifugal pump	3
	Discharge	3.6 m^3/min
	Head	107m

(7) Electric for all plants

All the control panels in this project is to be designed based on the following specifications:

Source power: AC 415 V, 3 phases, 4 wires, 50 Hz

Standards: JIS, JEM, JEC, IEC or equivalent

Starting method: Star-delta type (Over 22kW of motor output)

Out side panel to be provided by space heater.

Power control panel inclosed, self standing type.

4-4-4 Summary of the Facility Design

The details of the improvement works of the facilities in each plant are summarized in Table 4-13-1 to 4-13-8.

Table 4-13-1 Schedule of Improvement Works for Simly Plant

Facility	Equipment	Quantity	Improvement
Water Intake	-		
Coagulation &	Agitator	1	removal
Sedimentation	Flocculator	16	replace
	Wheel of scraper	8	replace
	Rubber plate of scraper	4	replace
	Sludge pump	4	replace
	Overflow weir plate	4	replace
Filtration	Flow regulator	12	replace
	Operation valves	12	replace
	Operation panel	12	replace
	Filtration media	12	supplement
	Instrument air compressor	1	install
Chemical dosing	Alum tank	3	repair
	Crate board	3	replace
	Mixer	3	replace
	Measuring device	3	replace
	Piping and valves	1 set	replace
	Chemical lifting	1 set	replace
	Pallet	16	replace
Chlorination	Cylinder bed	6	install
	Injector	1	replace
	Piping valves	1	replace
	Lifting device	1	replace
	Ventilating fan	3	replace
	Emergency tool kit	1	install
	Floor	1	repair
Instrumentation	Raw water flow meter	1	replace
	Head loss meter	1	replace
	Treated water flow meter	1	install
Electric	Control panel for flocculator	16	replace
	Control panel for instrument air compressor	1	install
	Chemical dosing control panel	1	install
	Wiring	1	repair
Others	In-plant water supply	1	repair
	Floor drain pump	1	replace
	Piping for backwash	1	repair
	Water quality test kit	1	install

Table 4-13-2 Schedule of Improvement Works for Korang Plant

Facility	Equipment	Quantity	Improvement
Water Intake	-		
Coagulation &	Agitator and coagulator	1	upgrade
Sedimentation	Hand scraper	5	install
	Rain water drain	1	install
	Piping	1	repair
Filtration			
Chemical dosing	Alum tank	1	repair
	Measuring device	1	install
	Piping and valves	1	replace
	Mixing rod	2	install
Chlorination	Injector	1	install
	Pump	1	install
	Piping valves	1	replace
	Lifting device	1	install
	Emergency tool kit	1	install
Instrumentation			
Electric	Control panel for pump	1	install
	Distribution pump panel	3	install
Others	distribution pump	3	replace
	Rain water drain pipe	1	repair
	Water quality test kit	1	install

Table 4-13-3 Schedule of Improvement Works for Golf Course Plant

Facility	Equipment	Quantity	Improvement
Water Intake	Water intake pump	2	replace
Coagulation &	Agitator and coagulator	1	upgrade
Sedimentation	Hand scraper	5	install
Filtration	Rapid filtration	1 set	modification
Chemical dosing	Alum tank	1	repair
	Measuring device	1	install
	Piping and valves	1	repair
	Mixing rod	2	install
Chlorination	Injector	1	replace
	Water pump	1	replace
	Lifting device	1	install
	Emergency tool kit	1	install
Instrumentation	Measuring device for treated water	1	install
Electric	Water intake pump panel	1	install
	Filtration pump panel	1	install
	Chlorine water pump panel	1	install
Others	Water quality test kit	1	install

Table 4-13-4 Schedule of Improvement Works for G-10 Plant

Facility	Equipment	Quantity	Improvement
Water Intake	Water intake pump	3	replace
Coagulation &	Agitator and coagulator	1	upgrade
Sedimentation	Coagulator hand scraper	5	install
Filtration	Rapid filtration	1 set	modification
Chemical dosing	Alum tank	1	repair
	Measuring device	1	install
	Piping and valves	1	repair
	Mixing rod	2	install
Chlorination	Injector	1	replace
	Water pump	1	replace
	Lifting device	1	install
	Emergency tool kit	1	install
Instrumentation	Measuring device for treated water	1	install
Electric	Water intake pump paned	1	install
	Distribution pump panel	3	instal
	Filtration pump panel	1	install
	Chlorine water pump panel	1	install
Water Transmission	Distribution pump	3	replace
Others	Water quality test kit	1	install

Table 4-13-5 Schedule of Improvement Works for R.L.1 Plant

Facility	Equipment	Quantity	Improvement
Water Intake	Water intake pipe line	1	install
Coagulation &	Agitator and coagulator	1	upgrade
Sedimentation	Coagulator hand scraper	5	install
	wall of basin		repair
Filtration			
Chemical dosing	Alum tank	1	repair
	Measuring device	1	install
	Piping and valves	1	repair
	Mixing rod	2	install
Chlorination	Injector	1	replace
	Water pump	1	replace
	Lifting device	1	install
	Emergency tool kit	1	install
Instrumentation	Measuring device for treated water	1	install
Electric	Water intake pump paned	1	install
	Chlorine water pump panel	1	install
	Distribution pump panel	3	instal
Water transmission	*Distribution pump*	3	replace
Others	Water quality test kit	1	install

Table 4-13-6 Schedule of Improvement Works for Saidpur Plant

Facility	Equipment	Quantity	Improvement
Water Intake	-		
Coagulation & Sedimentation	Raw water gate	1	repair
Filtration	Inlet gate	2	replace
Chemical dosing	Alum dosing	1 set	install
Chlorination	Chlorine dosing devices	1 set	install
Instrumentation	Measuring device for raw water	1	install
Electric	Chlorine water pump panel	1	install
Others	Water quality test kit	1	install

Table 4-13-7 Schedule of Improvement Works for Noorpur Plant

Facility	Equipment	Quantity	Improvement
Water Intake	-		
Coagulation & Sedimentation	Arriving well	1	repair
Filtration	Inlet gate	2	replace
Chemical dosing	Alum dosing	1 set	install
Chlorination	Chlorine dosing devices	1 set	install
Instrumentation	Measuring device for raw water	1	install
Electric	Alum water pump panel	1	install
	Chlorine water pump panel	1	install
Others	Water quality test kit	1	install

Table 4-13-8 Schedule of Improvement Works for Shahdara Plant

Facility	Equipment	Quantity	Improvement
Water Intake	Water intake channel	1	repair
	Sand settling pond		repair
Coagulation &	Agitator and coagulator	1	upgrade
Sedimentation	Hand scraper	5	install
	Sludge valve	1	replace
Filtration	Inlet valve	5	replace
Chemical dosing	Alum tank	1	repair
	Measuring device	1	install
	Piping and valves	1	repair
	Mixing rod	2	install
Chlorination	Injector	1	replace
	Water pump	1	replace
	Lifting device	1	install
	Emergency tool kit	1	install
Instrumentation	Measuring device for treated water	1	install
	Water level of reservoir	1	replace
Electric	Chlorine water pump panel	1	install
Others	Water quality test kit	1	install