THE ISLAMIC REPUBLIC OF PAKISTAN
CAPITAL DEVELOPMENT AUTHORITY

FINAL REPORT
FOR
FEASIBILITY STUDY ON THE CONDUCTION OF WATER FROM KHANPUR TO ISLAMABAD/RAWALPINDI

EXECUTIVE SUMMARY

MARCH 1985

THE JAPAN INTERNATIONAL COOPERATION AGENCY

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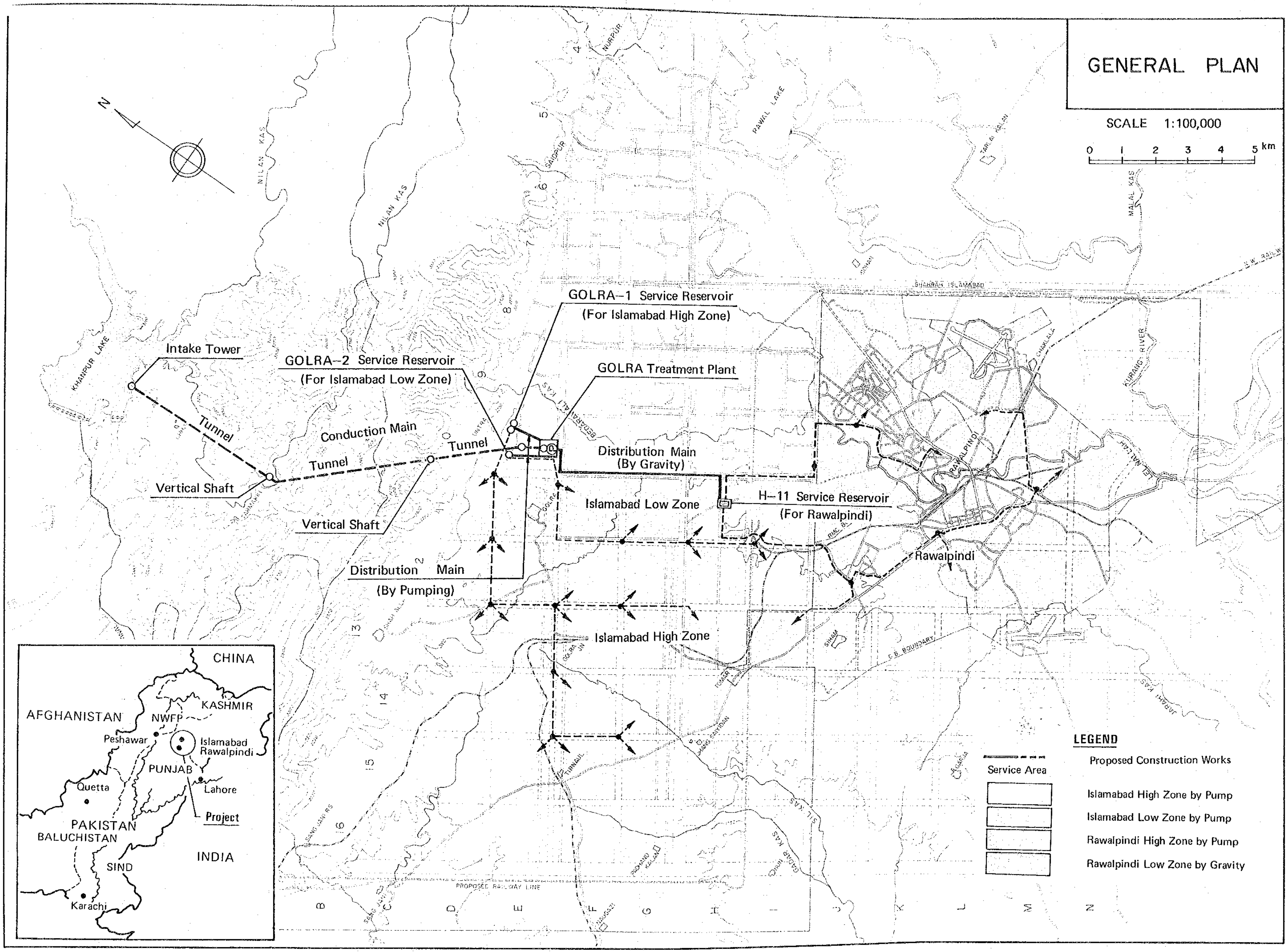

GENERAL PLAN
SCALE 1:100,000
0 1 2 3 4 5 km
Intake Tower
Tunnel
Vertical Shaft
Conduction Main
Tunnel
Tunnel
Vertical Shaft
GOLRA-2 Service Reservoir
(For Islamabad Low Zone)
GOLRA-1 Service Reservoir
(For Islamabad High Zone)
GOLRA Treatment Plant
Distribution Main
(By Gravity)
Distribution Main
(By Pumping)
H-11 Service Reservoir
(For Rawalpindi)
Islamabad Low Zone
Islamabad High Zone
Rawalpindi
RAWALPINDI
KHANPUR LAKE
RAWAL LAKE
NILAN KAS
KURANG RIVER
SIL KAS
SHAHRAH ISLAMABAD
CHINA
KASHMIR
AFGHANISTAN
NWFP
Peshawar
Islamabad
Rawalpindi
PUNJAB
Quetta
Lahore
Project
PAKISTAN
BALUCHISTAN
INDIA
SIND
Karachi
LEGEND
Proposed Construction Works
Service Area
Islamabad High Zone by Pump
Islamabad Low Zone by Pump
Rawalpindi High Zone by Pump
Rawalpindi Low Zone by Gravity

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I. INTRODUCTION

101. Report

The contents of the report consist of Executive Summary, Main Report and Appendixes. The report was compiled based on the field survey, review of data, information and existing reports related to the project, careful studies and series of discussion meeting between the governmental authorities concerned of Pakistan and the study team, and interim report which has been submitted to the Government of Pakistan dated November 3, 1984.

102. Scope of Work

The scope of study and major terms of reference are summarized as under;

- The study area will cover Khanpur reservoir including drainage area, water conduction routes from Khanpur Reservoir to Islamabad/Rawalpindi up to H.I. Principal road with raw water reservoir, water treatment plant, pumping station and service reservoirs, but excluding distribution system,

- To review the future water demand which will be projected by the year 2000 and conduct the water balance computation on the basis of water from the Khanpur Reservoir in consideration of the water demand for industrial area and farm land irrigation,

- To study the alternative plans for water conveyance systems including outlet works, pumping station, tunnelling, open channels, main pipeline, raw water

reservoir, treatment works and service reservoirs based on topographical and geological conditions, water demand studies, and economic assessments so as to obtain most adequate concepts and least cost water conveyance system for project formulation,

- To prepare layout plans and preliminary designs for the selected water conveyance system and related structures based on the comparative study mentioned above,

- To prepare implementation programmes of the project including construction plan and project organization, and cost estimate in consideration of foreign and local currency components,

- To carry out studies on organization and method of the post project operation and maintenance inclusive of estimate of operation and maintenance cost, and

- To evaluate and justify the project based on economic and financial analysis and sensitivity

103. Background of the Project

The construction of the new capital of the country was started in 1961 in accordance with a policy formulated by the Federal Government in 1958, and it was transferred from Karachi to Islamabad in 1968-69. These circumstances have given a substantial stimulus to the development of the old city, Rawalpindi, which is very close to Islamabad, and growth in all parts of Rawalpindi city has been accelerated since the early 1960's.

The Khanpur Reservoir which was constructed on the Haro river by WAPDA will supply 150 MLD (33.0 MGD) of water to Islamabad and 316 MLD (69.4 MGD) to Rawalpindi. Numbers of study have been carried out for conduction of water from Nicholson Monument, the terminal point of the Left Bank Canal, to Islamabad/Rawalpindi as well as for direct withdrawal from Khanpur reservoir and or existing canal through tunnels to the twin cities. A final plan, however, has not been so far adopted and a least cost alternative has still to be agreed/accepted.

In response to the request of the Government of the Islamic Republic of Pakistan, the Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programmes of the Government of Japan, carried out the feasibility study from July 1984 to February 1985 in close cooperation with the Capital Development Authority and the authorities concerned of the Government of Pakistan.

II. PROJECT AREA

201. Location

The Project Area, the twin cities of Islamabad and Rawalpindi, is situated in the north-eastern corner of the Potwar Plateau in the north of Punjab Province at the north latitude between 33°29' and 33°48', and the east longitude between 72°49' and 73°23'.

202. Climate

Being located at the southern foot of the Murree and Margala hills, the Capital Area is under relatively pleasant climate with cold winters and hot summers. There are two rainy periods a year; the summer monsoon originated from the east and winter rains caused by western disturbances. The annual rainfall ranges remarkably from season to season and from year to year amounting to 1,100 mm as an average in the past 30 years, of which about 60% concentrates during the monsoon season from July to September. The daily mean temperature varies from 32°C in June to 10°C in January with annual average of 21.5°C at Rawalpindi.

203. Topography and Geology

From the topographic and geological point of view, Islamabad/Rawalpindi area is divided into three zones, namely Margala hills, the foot zone of Murree hills and the flat zone.

Margala range of hills is composed of rather steep mountains spread easterly and westerly in the north of Islamabad/Rawalpindi area with an elevation ranging from 600

m to 1,200 m (2,000 - 4,000 ft). In the middle of the hills, Haro river traverses westwards. Geology of the Margala hills consists mainly of limestones with alternating marl and shale beds belonging to Jurassic to Eocene age. The strata are tightly folded and faulted resulting in complicated geological structures such as an overturned fold.

The foot zone of Murree hills is occupied mostly by the National Park Area with an elevation ranging from 540 m to 900 m (1,800 - 3,000 ft) forming steep and irregular valleys eroded by the Soan and Kurang rivers, which flow southeastwards, and intervening ridges. Geology of this zone is characterized by non-marine sandstone and mudstone of Miocene to Pleistocene age, and most part of the zone except the area along Soan river is composed of Miocene Strata which is called Murree Formation.

The flat zone expands over the Sectoral Area of Islamabad and Rawalpindi City, and in its most part consists of rolling table land sloping southwards with an elevation ranging from 480 m to 600 m (1,600 - 2,000 ft). The main geological units comprise Pleistocene to recent unconsolidated sediments which consist of alternating beds of clay and gravel. The most clay is silty clay and considered to be reworked loess. The Gravel layers embrace an available amount of groundwater. After eroding the upper layers of bedrock materials, river has cut the underlying foundation to a depth exceeding 200 m (650 ft), and old valleys thus formed are subsequently filled with alluvial deposits of unconsolidated sediments.

204. City Development Status of Islamabad and Rawalpindi

Islamabad, given the status of an independent district, is spread over an area of 906.5 sq.km and comprises Islamabad

Proper, Islamabad Park and Islamabad rural area. In accordance with the CDA plan, construction work of major buildings in administrative area and special building area such as the Presidency, Parliament Building, Ministry of Foreign Affairs, Government Hostel, State Bank of Pakistan and National Broadcasting House are almost completed. Residential area up to series 8 is almost completed and series 9 and 10 are now in progress. Special institutional and light industrial areas of series 8 and 9 are also in progress. The sectoral areas from series 11 are projected to be developed from 1984 on the basis of the CDA 15 Years Development Programme.

Rawalpindi is the headquarters of the Rawalpindi District. It is divided into two parts, namely, municipal corporation area and cantonment area by the Pakistan Railways' line and the sluggish stream Lei Nallha. The city undertook national importance in 1959, when shifting of the Federal Capital of Pakistan near Rawalpindi was decided. The construction of the Capital started in 1961 and it was actually shifted in 1968. In the intervening time from 1959 up to 1968, Rawalpindi remained as the interim capital of Pakistan. These brought substantial incentive into the development of Rawalpindi and growth in all parts of the city has been accelerated since the early 1960's. Development of the twin cities of Islamabad and Rawalpindi has now reached the point where the urban areas merge together in places.

205. Socio-economic Conditions of the Project Area

According to house visit inquiry surveys which were conducted by the study team, the household income is on an average Rs. 1,890 per month in the project areas encompassing both Islamabad and Rawalpindi. Area-wise, it is Rs. 3,937 in Islamabad, Rs. 1,495 in Rawalpindi city and Rs. 1,977 in

Rawalpindi cantonment. In terms of income brackets, it ranges as below.

Income (Rs/Month)	Proportion (percent)
Less than 500	4
500 - 1000	22
1000 - 2000	38
2000 - 3000	18
3000 - 4000	10
4000 - 5000	4
More than 5000	4

The labor force counted 274,489, of which 40.5% was comprised of government employees, 28.0% of self-employed people and 26.3% of non-governmental employees. In Islamabad government employees occupied the majority (58.8%) of labor force. The ratio of labor force to population was 27.5%, which is almost equal to both the averages of the Province of the Punjab in which the cities are located and the whole nation. Unemployment rate was 4.3%, which is a little higher than the provincial and national averages (3.2 and 3.1%).

The gross value added in 1981 works out to Rs. 4,553.9 million, which occupies 1.8% of the GDP in the same year. Per capita gross product of the cities is calculated at Rs. 4,558, which is by 53% higher than the national average (Rs. 2,979).

206. Population

The populations of Islamabad urban area and Rawalpindi municipal cooperation/cantonment in 1972, 1981 and 1984 are summarized as below;

Year	Islamabad		Rawalpindi	
	Population	A.G.R[1/]	Population	A.G.R.
1972	74,000	- %	598,000	- %
1981	144,000	7.7	795,000	3.2
1984	206,000	12.7	888,000	3.8

Note: 1/ A.G.R.; Annual growth rate of the population

207. Water Resources and Availability

Major water sources for water supply to the cities of Islamabad and Rawalpindi are surface water drained by the Haro, Kurang and Soan rivers. Supported by the storage function of the Khanpur, Rawal and Simly reservoirs, these rivers would contribute towards the existing achievement of perennial water supply accounting for 60% and 80% of the total requirements respectively for Islamabad and Rawalpindi for drinking and domestic uses, while surface water from small streams would cover 20% of total demand for Islamabad and groundwater including springs would account for the remaining 20% for both the cities.

A. Storage Dams

Originally the Khanpur Dam Project was approved in 1963 envisaging construction of 41.8 m (137 ft) high earth-fill dam and a canal system to irrigate 31,150 ha (77,000 acres) of agricultural land situated both on the left and right bank of the river, and the construction work was started in the beginning of 1967. Due to growing need for municipal and industrial water supply in the terrain, irrigation water in the vicinity of twin city of Islamabad and Rawalpindi, heavy industrial complexes at Taxila and Wah, the Project was revised in 1973 converting the primary objective of the scheme from irrigation to water supply. Consequently, the Khanpur Reservoir, which has 112 MCM live storage capacity, was designed with the raising of dam height to 50.9 m (167 ft), which is the maximum allowable from technical, geographic and geologic point of view, to supply 33.0 MGD of water to Islamabad and 69.37 MGD of water to Rawalpindi for domestic purposes, 28.5 MGD to the various industries at Wah and Taxila, and irrigation water with 55.2 MGD for 14,770 ha (36,470 acres) of culturable command area on both the Left

and Right Bank Canal. The yields from reservoir were estimated on the basis of a long period rainfall record at Murree and Rawalpindi. Since the average inflow involves flood runoff which is unavoidable to be spilled out, the Project, in consequence, allows frequent occasions of shortage of water of more than once in 2 years.

In the original plan of the Rawal dam the reservoir was proposed so as to provide 28.0 MGD of water to Rawalpindi and Cantonment, but the Project was revised due to the drought during the years 1972-73 with the conclusion that the supply of water be reduced to 21.0 MGD and the filtration plant was completed in 1979 with design capacity of 21.0 MGD. The Rawal Lake formed by the dam spreads over an area of 780 (3 sq.miles) and with 3.0 m (10 ft) high gates installed on the top of the spillway crest has a gross storage capacity of 58.6 MCM (47,500 acres ft) out of which 46.9 MCM or 38,000 acre ft is provided at present as the net live storage.

The Simly Dam Project is recognized as an essential constituent of bulk water supply scheme of Islamabad. In the original design of the Simly dam which has about 25 MCM live storage capacity, it has been mentioned that the normal conservation level of the reservoir will be raised from 2,295 ft to 2,315 ft level in order to increase the live storage of the reservoir after about 21 years of operation when almost all of the dead storage is lost due to sediment deposit. This will be done by providing three 7.62 m (25 ft) high gates, and may result in an additional live storage of 11.8 MCM (9,600 acre ft) obtainable. It has become realized that the installation of gates can be advantageously progressed in near future to raise the conservation level to 2,315 ft thereby increasing live storage by 11.8 MCM resulting in gain of a substantial safe yield from the catchment.

B. Rivers and Streams

Besides storage dams, seven head works have been planned and constructed at the foot of the Margala hills as well as in the vicinity of the Capital area in order to receive surface water from streams and supply treated water to Islamabad. According to the data on production of water prepared by CDA for the period of 11 years from 1974 up to 1984, seasonal fluctuation of water production appears to be small throughout a year. Average annual production in the last 11 years is about 40 MLD (8.7 MGD) in total.

C. Groundwater

The number and yield of the existing groundwater intake facilities in Islamabad and Rawalpindi as of August 1984 are tabulated as under. With exception of a few dug wells, majority of facilities are of tubewells and their locations, dimensions and yield are investigated in detail. Tubewells are distributed scattered mostly in the development areas of Islamabad and Rawalpindi, and in the National Park area along the Kurang river downstream of Rawal lake.

PRESENT GROUNDWATER PRODUCTION

Operating Agency	Water Source	No. of Wells	Production MGD	(MLD)
(Islamabad)				
CDA	National Park Area	19*	6.5	(29.6)
	Old Golf Course	3*	0.7	(3.2)
	New Golf Course	3	0.8	(3.6)
	Sectoral Area	35*	3.8	(17.3)
	Sub-Total	60*	11.8	(53.7)
(Rawalpindi)				
RMC		38	6.0	(27.3)
PHED	Sohan Camp	6	3.5	(15.9)
	Others	11	4.5	(20.5)
CB	CB	7	2.5	(11.4)
	MES (ARMY)	3	0.7	(3.2)
	MES (PAF)	3	0.7	(3.2)
	Sub-Total	68	17.9	(81.5)
Total		128	29.7	(135.2)

Note: *... Abandoned wells and long resting wells are not included.

208. Present Water Production and Demand

Islamabad water supply system produces clear water at nine major facilities. The day production capacity is now about 147 MLD (32.4 MGD). The existing water supply system of Rawalpindi produces water at seven sources including Rawal reservoir. The production capacity is about 187 MLD (41.0 MGD). Tubewells are actually forced to reduce their operation time into 8 to 16 hours due to drawdown of groundwater table in summer season.

Present water consumptions of Islamabad and Rawalpindi are calculated from production status, served population and service standard as under.

Category	Islamabad MLD (MGD)	Rawalpindi MLD (MGD)
Domestic Use	37.9 (8.3)	49.8 (10.9)
Public Use	33.1 (7.3)	14.7 (3.2)
Commercial/Industrial	23.7 (5.2)	29.4 (6.5)
Military Use	-	15.9 (3.5)
Leakage/Wastage	47.3 (10.4)	62.6 (13.8)
Total	142.0 (31.2)	172.4 (37.9)

209. Existing Left Bank Canal

The Left Bank Canal has been constructed by WAPDA during years from 1973 to 1978 to convey Khanpur water for water supply to both the cities of Islamabad and Rawalpindi, for industrial water supply to POF (Wah) and PIDC (Taxila) and for irrigation to agricultural land extending on the left bank of the Haro river. Irrigation water is diverted from the canal between the points 0.0 km and 8.8 km, and the canal section downward is allocated for municipal and industrial waters allowing water diversion for PIDC at the point of 15.6 km. Downstream portions of the canal are assigned only for water supply.

Design capacity of the canal varies from 12.5 to 7.9 cu.m/sec (440 to 278 cusec). Since the canal passes undulating terrain of northwest foot of the Margala range of hills, many appurtenant structures such as tunnels, syphons and aqueducts are accompanied, and the canal is lined with concrete block on its all faces for about 80% of total length. The majority of canal portions is situated on the rock foundation with fine limestone and alternations of limestone and shale or marl. However, sedimentary loam has been found at the limited portions at the beginning point of the Left Bank Canal, outlet of the Mohra Muradu Tunnel and inlet of Margala Tunnel.

It is investigated that the Canal has been designed employing design procedures prepared for irrigation purposes and included many deep-cut portions without protection works of side slopes resulting in sediment inflows during heavy rains, and that operation and maintenance works are laborious. In addition, subsidence of canal bed due to piping of seepage water along a cross-drainage and traces of overflow at just upstream of a cross-regulator were inspected during field investigations.

210. Operation and Maintenance

In Islamabad operation and maintenance of water supply systems are performed by CDA, which at the same time executes the development of bulk water sources. In Rawalpindi, RMC (Rawalpindi Municipal Corporation) is in charge of the operation and maintenance of water supply systems for the city areas under its jurisdiction, while MES (Military Engineering Service) and CB (Cantonment Board) are in charge of the operation/maintenance for the cantonment areas under their jurisdiction. PHED (Public Health Engineering Department) of the Government of the Punjab is responsible for the development of bulk water sources in Rawalpindi. After they are developed, they are handed over to RMC and MES & CB.

211. Water Tariff System and Finance

The present water supply systems in the twin cities have inherent factors which tend to disrupt the efforts towards financial self-support in the water supply service of the organizations concerned. They are intermittent supply of water, prevalence of unmetered connections, losses of water through leakage/wastage and predominance of flat rate tariff system. All the above factors interrelate with each other,

creating a vicious circle situation. The existing flat rate tariff system must be totally abolished and a system where people are charged in accordance with the volume of water consumed has to be thoroughly applied if the water supply service is to be financially on a sound basis. Present water tariff systems are described as under.

Present Water Tariff

Unit: Rupees/1000 gallons

Classification	Rawalpindi			Islamabad
	RMC	MES	CB	
(1) Domestic or Public User				
- Metered Connection	2.5	1.2 (4)	4	3
- Unmetered Connection	F.R.	F.R.	F.R.	F.R. 1/
(2) Commercial or Industrial User				
- Metered Connection	5	- (6)	6	5
- Unmetered Connection	F.R.	F.R.	F.R.	F.R.

Note: 1/ F.R: Flat rates in Islamabad, MES and CB are on the monthly basis and differ according to the categories of users and categories and sizes of houses and buildings. The flat rates in RMC are on the annual basis.
2/. Figures without and with parentheses indicate unit prices for users belonging to the army and for citizens and public institutions respectively.

Financial positions of respective agencies on operation and maintenance in 1983 - 84 are summarized as under.

Unit: Million Rupees

	Item	Islamabad	Rawalpindi	
		CDA	RMC	MES+CB
(1)	O & M Cost	64.05	10.70	10.89
	Cost Shared for			
	- Electricity	40.8%	36.0%	32.5%
	- Depreciation	30.2%	22.0%	16.3%
	- Personnel	17.5%	33.4%	33.7%
	- Others	11.5%	8.6%	17.5%
(2)	Recovery Rate	14.0%	59.0%	9.4%

III. WATER DEMAND AND WATER RESOURCES

301. Population Projection and Served

Projected population of the twin cities in respective target years are estimated based on past population census, city development plan and utilizing most applicable method of population projection. The prospected populations for Islamabad and Rawalpindi are summarized as below;

Year	Islamabad		Rawalpindi	
	Total	Served	Total	Served
1984	206,000	195,000	888,000	622,000
1990	341,000	341,000	1,046,000	837,000
1995	480,000	480,000	1,167,000	992,000
2000	621,000	621,000	1,275,000	1,148,000

302. Water Demand

Water demand is defined as water consumption of various users and wastage/leakage of the supply system. The water consumptions are classified into four categories under the study such as Domestic, Public, Commercial and Industrial, and utility for Rawalpindi. Future water demands are prospected taking into account water supply service level, living standard, reduction of wastage/leakage losses, water tariff structures and human needs.

The domestic water consumption is classified into two to three classes by consumption level according to the house classification. Public consumers include such establishment as government offices, educational institutions, embassies, hospitals, mosques and parks. Future water consumptions for the public users are estimated on the basis of the increase in proportion to the served population growth, and urban area

development plans. Commercial and industrial consumers consist of mainly hotels, restaurants, factories and manufacturers. The consumptions to be proposed for this category are usually estimated with annual population growth rate and the GDP annual growth rates. The reduction of wastage/leakage losses is proposed to be about 20% in target year 2000. The summary of water demands for the twin cities is shown in Table S-1 and S-2.

303. Water Availability of Khanpur Reservoir

Regarding water demand of the Khanpur reservoir, seasonal variations of the projected water demand for urban water supply are considered to be 1.25 times of annual average for summer peak and 0.80 times of one for winter minimum. Rate of industrial water consumption is considered to be uniform throughout a year. Detailed study on irrigation water requirements has been conducted based on irrigation intensity, cropping schedule, crop water requirement, effective rainfall, and irrigation efficiency.

Water balance study of the Khanpur reservoir was undertaken combining every aspects of hydrology, such as inflow into the reservoir, water demand for municipal and industrial water supply and for irrigation, and water losses from the reservoir surface and bottom. The return period of drought is decided to be once in five years after discussion meeting has been held between WAPDA and CDA.

The computation was made for the period of 21 years from 1960 to 1980 with a ten-daily unit, employing a simple assumption that the surplus water in the reservoir above full water level during any ten-daily interval would be released through a spill during the corresponding ten-daily interval. Regarding water losses from the reservoir, deduction of 10%

from the available inflow was considered to be sufficient to account for both evaporation and seepage. In review of various cases of water balance study, size or capacity of the Khanpur reservoir would be sufficient to satisfy various water requirements. However, inflow is small in contrast with demand, and hence there are frequent occasions of relatively long period before the reservoir water level comes back to its full water level meaning that practically water shortage would occur in most years. A review of the study in terms of probability of shortage occurrence indicates that about 75% of the present water requirement would be optimal when the capacity of the reservoir and the rate of inflow are combined. With deduction of water demand to 75% of that presently projected, the Khanpur reservoir would provide full amount of water supply just to meet requirement even during a drought period of once in five years frequency.

304. Water Availability of Other Resources

Major water resources of the project area are Simly and Rawal reservoirs as well as Khanpur reservoir. The Simly reservoir under the existing condition of storage capacity would satisfy the scheduled amount of water supply even in five-year dry year, and after raising of the dam by installing three 25 ft high gates the reservoir would produce 38.4 MGD of firm yield, which is equivalent to 160% of the present requirement (24 MGD). The existing Rawal reservoir could provide scheduled amount of firm yield successfully throughout periods of once in five-year probability drought and still have some excess water such as 80% of presently programmed yield.

305. Water Balance in the Year 2000

The existing and proposed yields from surface and

groundwater are listed in Table S-3. The water balance of firm yields and demands by year taking into account the phasing plan of water resources development are illustrated in Figure S-1 and S-2.

IV. ALTERNATIVE PLAN

401. General Descriptions and Given Conditions

In order to verify least cost water conveyance systems of Khanpur water, the comprehensive comparison study was conducted based on data/information collected, review of existing study reports, detail field survey, strategies of urban water supply development and design criteria and results of series of discussion meeting with Pakistan Governmental authorities concerned. Design capacities of conduction main from the Khanpur reservoir are 150 MLD (33 MGD) for Islamabad and 316 MLD (69.37 MGD) for Rawalpindi as annual averaged water supply, respectively. Preliminary design of the facilities for each alternatives was carried out taking into account not only technical and economic aspects but also staged development plan of the water supply scheme. Economic justification of alternative plan was made on the basis of the EIRR (Economic Internal Rate of Return) which can be estimated from the project costs, operation/maintenance cost including replacement cost of equipments and benefits.

402. Staged Development Plan of Khanpur Water

The required urban water for the twin cities of Islamabad and Rawalpindi is presently provided from the Simly and Rawal reservoirs, stream flows and groundwater sources such as springs and tubewells. Khanpur reservoir has a proposed water supply capacity of 308 million cubic meter per year for multi-purpose demands and would contribute to meeting future water demands of twin cities in the target year 2000. The following three staged development plan of the project was made upto the target year 2000 through assessment of previous plan.

- Islamabad

Phase	Year	Production Capacity of Treated Water				Percent
		Average		Maximum		
		MLD	(MGD)	MLD	(MGD)	
1st	1986-1990	67.8	(14.9)	84.2	(18.5)	50
2nd	1991-1995	33.6	(7.4)	42.3	(9.3)	25
3rd	1996-2000	33.6	(7.4)	42.3	(9.3)	25
	Total	135.0	(29.7)	168.8	(37.1)	100

- Rawalpindi

Phase	Year	Production Capacity of Treated Water				Percent
		Average		Maximum		
		MLD	(MGD)	MLD	(MGD)	
1st	1986-1990	142.0	(31.2)	177.5	(39.0)	50
2nd	1991-1995	71.0	(15.6)	88.7	(19.5)	25
3rd	1996-2000	71.0	(15.6)	88.7	(19.5)	25
	Total	284.0	(62.4)	354.9	(78.0)	100

403. Alternative Plan

The three basic alternative plans on the water conduction main and appurtenant facilities have been proposed based on the result of field survey, review of study reports and design criteria.

Alternative I

- The major purpose of this plan is to make the fullest use of the existing left bank canals; multipurpose water conveyance canals for irrigation, industry and urban water, the downstream portion of which was constructed for exclusive use for urban water.

- The project could be completed in a short period so as to meet the urgent water needs in Rawalpindi.

- The proposed water conduction system starts from the end of the existing canals near Nicolson Monument, lifts water at Sang Jani, and terminates at the beneficiary areas.

Alternative II

- The major purpose of this plan is to make the better use of the existing multipurpose canals.

- As a result of the study, the route that takes water just downstream of Khanpur reservoir has been selected, which has a shorter length among several possible plans in the Alternative II.

- The conduction main conveys water by means of tunnel and pipeline, after lifting it at the left bank of Haro river, to the beneficiary areas via Shah Allah Ditta.

Alternative III

- The major purpose of this plan is to connect the beneficiary areas with Khanpur Reservoir by the shortest route of tunnel and pipeline.

- Potential water head can be conserved and as a result water can be conveyed by gravity to the beneficiary areas to a maximum extent.

- The conduction main directly diverts water at Khanpur reservoir to convey it to the beneficiary areas via Golra.

Each of the alternatives mentioned above was sub-divided into two to four, and eight alternatives in total were finally warranted for further studies.

404. Comparison of Alternatives

Construction and operation/maintenance cost summary and EIRR (Economic Internal Rate of Return) of each alternatives are shown as below and in Table S-4.

Figures S-3 shows schematic maps of the Alternatives.

Alternative	Construction Cost (Rs. Million)	O & M Cost per Year (Rs. Million)	EIRR (%)
I-A	2,055	72	6.88
I-B	1,977	69	6.97
I-C	1,917	68	7.05
II-A	2,070	74	6.69
II-B	2,021	70	6.83
II-C	1,971	63	7.02
II-D	2,012	63	6.98
III	1,726	47	7.56

Note: In computing EIRR costs of distribution networks were not incorporated in the project costs.

Sub-Alternative I-C and II-C have been selected from technical, economic and operational aspects as recommendable plan for Alternative I and II respectively. Final conclusions of the study are summarized as under.

- From technical point of view, all of Alternatives I, II and III are feasible.

- It will take five years under Alternative I and II to complete the first phase in which 50% utilization of Khanpur urban water is envisaged. Whereas, in case of Alternative III, it will take six years. However, this one year delay will not bring a serious problem for the staging plan for water supply.

- Operations of Left Bank Canals under Alternative I may raise technical problems for urban water supply, arising from the control of water diversion to irrigation and industry. In contrast, in Alternatives II and III, water is directly taken from the reservoir and, therefore, diversion operations for urban water supply will be easy.

- In Alternative III, out of the total amount of the water to be distributed to Rawalpindi area, about 78% would be served by gravity. It puts this alternative in an economically advantageous position in an indisputable manner.

- A clear grasp can be had of the situation where Alternative III is recommendable as the most optimum plan.

- It might be emphasized that annual recurring costs are the least under this alternative, which will lessen and relieve burdens on water supply organizations and on the users as well for the project life of half a century.

V. PROPOSED PROJECT

501. Objective of the Project

The main purpose of the project is to provide improved living conditions through stabilized water supply for people living in the project area. In addition to the above, the related objectives are to support growth of industries, commercial enterprises and institution such as school and hospitals etc. The major objectives and strategies of the project implementation are summarized as under.

i. The situation of Islamabad is that it is being developed and this water supply project is one of the important sector for new city development scheme because water supply scheme must go side by side with the development plan along with housing and road construction. Besides, the water demand increasing in Rawalpindi as a part of Metropolitan area is faced with serious problems the year round. Stabilized water supply for twin city of Islamabad and Rawalpindi, therefore, is obviously and urgently required. The Khanpur water supply project as a regional development scheme will contribute to meeting human needs of the people in the project area.

ii. Upgrading of service standard, such as house connection, stand post, commercial and industrial water supply is also fundamental requirements of the project target. Served population in Rawalpindi as of 1984 is about 70 percent of total population while it is almost 100% in Islamabad. Approximately 70% of total served population receives clear water from house connection system. The final goals of service standard of Rawalpindi in the year 2000 are proposed to provide water to 90% of total population with 90% house connection system.

iii. Another aim of the project is to assist the twin cities in improving water supply service to all the consumers through a net 420 MLD (92 MGD) increment of production, better control of distribution through wastage and leakage losses reduction and introducing household metering to monitor patterns of demand with a view to ultimately achieving more rational water use.

iv. The project will support and strengthen the new water supply entity in its effort to become operationally and financially viable by providing it management assistance to improve management information systems, accounting procedures and billing and collection by the computerization. The final targets of the aspect are to collect 100% water charges from consumers concerned and to reduce wastage losses.

502. Scope of the Project

The project scope is new construction of intake tower which will be made in the Khanpur reservoir, conduction main consisting of pressure and free flow tunnel with energy dissipating facility, Golra water treatment plant, pumping stations, service reservoirs and pipelines upto respective service reservoirs from clear water reservoir at water treatment plant and or pumping stations.

In addition to the construction of main facilities incorporated in this Project, distribution systems including distribution networks upto house connection will have to be implemented in parallel with main facilities implementation as associated project in order to realize quick benefit.

503. Project Component

The components of proposed project are summarized as under.

i. Raw Water Conveyance:

- Providing intake tower in the Khanpur reservoir with about 6.74 cu.m/sec maximum intake capacity;

- Provision of about 13.1 km long conduction main, including pressure tunnel of 824 m with breaking pressure basin, concrete culvert conduit of 106 m, free flow tunnel of 11,480 m, pipe conduit of 650 m, respectively.

ii. Water Treatment plant:

- Provision of about 522 MLD (115 MGD) production capacity at E-10 sector of Golra area.

iii. Pumping Station:

- Provision of Golra pumping station near water treatment plant to raise clear water to Islamabad high and low zone beneficial area;

- Provision of about 25 km 11 KV electrical transmission systems including substation.

iv. Distribution Main:

- Providing about 1.5 km long and 700 mm diameter of twin pipelines for high zone of Islamabad

- Providing about 1.6 km long and 800 mm diameter of pipeline for low zone of Islamabad

- Providing about 6.5 km long and 1,500 mm diameter of twin pipelines for Rawalpindi

v. Service Reservoir:

- Provision of PC type tank with 26,000 cu.m capacity for high zone of Islamabad.

- Provision of PC type tank with 16,600 cu.m capacity for low zone of Islamabad

- Provision of flat-slab type tank with 89,200 cu.m capacity for Rawalpindi

vi. Procurement:

Procurement of equipment on project implementation and operation and maintenance including vehicles and office equipment.

vii. Consulting Services

Assisting in project implementation, including geological investigation for tunnel works, preparation of detail design and tender documents as well as construction supervision.

504. Project Implementation

The whole project would be implemented over a 14 year period. Phase I project would start in 1987 with construction of intake tower and No.2 tunnels (11,480 m long) that need a construction period of five years, and complete in early 1992. At the same time all construction works of Phase I should be completed, so that Phase I water supply would start in the both cities of Islamabad and Rawalpindi. Construction works of Phase II and III would be started in 1992 and 1998 respectively so as to meet the water demand prospected in 1996 and 2001, respectively. Project implementation schedule is attached in Figure S-4.

505. Organization of Project Implementation

The Capital Development Authority (CDA), being the principal implementing agency, would be responsible for overall planning and coordination. Because of the involvement of the Project, special provision should be made for the coordination of their activities. A Project Coordination Committee, comprising representative from CDA, WAPDA, PHED, MES, RMC, CB, ID, POF and PIDC, would be established to coordinate their activities related to the Project.

The committee will concentrate on the planning and coordination of the construction programmes to be carried out by different agencies; in securing Government funds for financing these programmes; and in periodically reviewing their progress. Later the role of the committee will be expanded to include formation of plans for joint activities and adequate operation and maintenance of project works.

506. Project Cost

The total project cost in August 1984 prices, including physical contingencies and price escalation, is estimated at Rs. 2,900 million, of which Rs. 1,925 million is for Phase I project, Rs. 558 million for Phase II project and Rs. 417 million for Phase III project. The foreign exchange component for the total project is Rs. 1,171.5 million, or 40% of the total cost.

Engineering and administration costs amount to Rs. 183.2 million for detailed investigation, detail design, and supervision and administration of the project. Physical contingencies of 10% have been added to all estimated costs. Price increased were estimated by applying the annual rates of price escalation of 10% for local costs and 6% for foreign costs.

Summary of the project cost is described as under and indicated in Table S-5 and S-6.

Unit: Rs. Million

Phase	Foreign	Local	Total	Foreign %
Phase-1				
- Civil work	430.1	515.7	945.8	45.5
- Non-civil Work	101.6	103.4	205.0	49.6
- Contingency	263.9	510.3	774.2	34.1
Sub-total	795.6	1,129.4	1,925.0	41.3
Phase-2				
- Civil Work	107.0	116.0	223.0	48.0
- Non-civil Work	14.2	8.1	22.3	63.7
- Contingency	106.9	205.8	312.7	34.2
Sub-total	228.1	329.9	558.0	40.9
Phase-3				
- Civil Work	51.3	57.0	108.3	47.4
- Non-civil Work	6.9	5.1	12.0	57.5
- Contingency	89.6	207.1	296.7	30.2
Sub-total	147.8	269.2	417.0	35.4
Whole Phase				
- Civil Work	588.4	688.7	1,277.1	46.1
- Non-civil Work	122.7	116.6	239.3	51.3
- Contingency	460.4	923.2	1,383.6	33.3
Total	1,171.5	1,728.5	2,900.0	40.4

507. Operation and Maintenance

Operation and maintenance works of the Khanpur water supply project shall be considered comprehensively from viewpoints of budgetary and financial managements, function of existing organizations, policy of future metropolitan area development, modernization and efficiency of their activities.

The organizations which are illustrated in Figure S-5 are proposed to operate and maintain the existing and planned facilities in the most effective and efficient manner based on regional scope and perspective encompassing both Islamabad and Rawalpindi areas.

Major functions and responsibilities of the boards and committees are described as below:

The Water Management Board on the Khanpur water shall be empowered to decide on water allocation of Khanpur water for respective consumers, to direct revision for seasonal fluctuation of water requirement and priority of water release from Khanpur reservoir during drought period, to decide on water charge revision if required and other political matters concerning Khanpur water.

Under the supervision of the water management board, Regional Water Supply System Operation and Maintenance Board (RWSSB) shall be empowered to decide on treated water allocation and adjustment for common use water supply system between Islamabad and Rawalpindi, to decide on water charges and tariff system for respective consumers, to deliberate and evaluate annual operation and maintenance budget, to evaluate operation and maintenance activities on the water supply systems.

The Water Supply System Coordinating Committee on the Khanpur Water (CCKW) is established to undertake the following activities.

- To prepare annual operation and maintenance programmes on the Khanpur water
- To prepare annual water supply programmes including seasonal requirements

- To decide on and arrange detailed water release plan for each consumer based on the direction of Water Management Board on Khanpur water on the revision of water allocation and release schedules
- To evaluate annual operation and maintenance cost of raw water and treated water including repairing works for common use facilities
- To prepare annual and periodical assessment reports which will be directed by the Boards
- To function as working group for the Boards

VI. PROJECT JUSTIFICATION

601. Project Benefit

Water is a prerequisite for living things. For human life urban water is vital because of its intrinsic utilities: we need it for drinking, cooking, bathing, washing, draining and other uses.

Similarly, urban water is indispensable for manufacturing, service, commercial and other industries as raw materials and other similar uses and purposes.

To measure these utilities in economic terms, house visit inquiry investigations were conducted by the Study Team. The result is that domestic and commercial/industrial users who are satisfied with the present water charges are willing to pay Rs. 6.80 and Rs. 5.62 per thousand gallons of water respectively. This, further, boils down to the weighted average value of Rs. 6.49 per thousand gallons of water.

To calculate the total yearly economic value of the Khanpur water, the volume of the water to be consumed in a certain future year is multiplied by this unitary economic value of water.

602. Water Rate and Tariff

A household in the Project areas on the average earns Rs. 1,890 per month. It monthly consumes 4.2 thousand gallons of water on the average. If the water rate of Rs. 9.0 per thousand gallons is adopted, it will spend Rs. 37.8 per month as a water bill payment, which corresponds to 2% of its monthly income. In other words, water charge under the

proposed rate is well within the paying ability of a household.

The proposed water tariff is based on this average water rate and is so structured that up to a certain volume of water to be consumed unitary charge is low, and from there on unitary charge progressively goes up in parallel with the rise of water consumption.

603. Economic Evaluation

Summary of Economic Evaluation

Item		Values
Cost Recovery Period		24 years
at 0% Discount Rate	Benefits	Rs. 19,658 Million
	Cost	Rs. 6,410 Million
	NPW	Rs. 13,248 Million
	B/C Ratio	3.07
EIRR		6.2%

As shown in the above table, from the standpoint of national economy the Project goes solvent just in the middle of project life, accumulating net benefits amounting to Rs. 13 billion in the end. The benefits will be ultimately three times more than the costs and EIRR is calculated at 6.2%.

This level of EIRR is a standard one for a project in the water supply sector, and as such the Project is primarily judged feasible. One point that is critically important is the magnitude and dimension of intangible benefits to be expected from the Project.

If one considers millions of people in the beneficiary areas to be saved from the sorrows of diseases and deaths as

well as from the drudgery of unending daily water fetching in the generations to come, which is not properly represented in the EIRR value, and also far-reaching socio-economic effects such as the creation of healthier and more productive people and the development of commerce and industries culminating in accelerated growth and expansion of the economy in and around the project areas, which can be beyond the realm of EIRR, one cannot but conclude that the Project is definitely feasible.

604. Financial Benefits and Costs

Benefits are calculated by multiplying the volume of water to be consumed by water rate. The average rate will be Rs. 9.0 per thousand gallons. From 1992 to 1995 30.4 to 35.9 MGD, from 1996 to 2000 48.6 to 59.0 MGD and from 2001 on 70.9 to 73.9 MGD will be consumed. It is assumed that the rates of conveyance, treatment and distribution losses are 5%, 5% and 20% respectively.

Raw water will be purchased from WAPDA at the rate of Rs. 2.77 per thousand gallons. The volume of water to be supplied will be 51.185 MGD from 1992 to 1995, 76.778 MGD from 1996 to 2000 and 102.370 MGD from 2001 on.

The capital for the construction of Khanpur water conduction facilities will be invested during the construction period of 1985 to 2000. It will be borrowed from external and domestic sources. Lending terms for foreign exchange component will be 5% annual rate of interest and the payback period of 30 years with 10 years grace period. Terms for local currency component will be 11% annual rate of interest and the payback period of 25 years with 5 years grace period. Financial costs arise in the form of principal and interest to be repaid to the lenders.

The costs for the maintenance and operation of the facilities concerned will arise from 1992 when water will start to be supplied, recurring over the whole period of project life.

605. Financial Evaluation

Summary of Financial Evaluation

Item		Values
Cost Recovery Period		36 years
at 0% Discount Rate	Benefits	Rs. 27,260 Million
	Cost	Rs. 17,040 Million
	NPW	Rs. 10,219 Million
	B/C Ratio	1.60
FIRR		6.6%

The water rate of Rs. 9.0 per thousand gallons is theoretically at the least within the paying ability of consumers. The proposed lending terms are standard ones except for the annual interest rate of 11% for local component, which is by 3% lower than the prevailing one. Aspects of cashflow are not marked: cost recovery period is 36 years and B/C ratio is 1.60. This is because the water supply service is essentially for the welfare of the people and thus based on a no profit, no loss principle. The FIRR value of 6.6% is reserved basically to alleviate financial losses in the first half of project life.

606. Sensitivity Analysis

A. Sensitivity Analysis in Economic Evaluation

Summary of Sensitivity Analysis in Economic Evaluation

No.	Cases	Instances	EIRR(%)	Instances	EIRR(%)
1.	Completion Delay of Phase I	A. 1 Year Delay	6.1	B. 2 Year Delay	6.0
2.	Overrun of Construction Costs	A. 10%	5.9	B. 20%	5.7
3.	Demand Shortage	A. 10%	5.6	B. 20%	4.9
4.	Combination of 1, 2 and 3	A. 1.A 2.A 3.A	5.3	B. 1.B 2.B 3.B	4.3

Sensitivity analysis Case No.4 is the sum total of the preceding cases. Computation resulted in the EIRR values of 5.3% and 4.3% for the first and second instances, respectively as shown in the above table. If things go bad as in the two instances, the feasibility of the Project will be strongly affected, though not to the extent that it is rendered nil. Besides, it is improbable that things will turn out altogether adverse and negative.

B. Sensitivity Analysis in Financial Evaluation

Summary of Sensitivity Analysis in Financial Evaluation

No.	Water Rate/000 Gal. (Rs.)	Annual Interest Rate (%) FC	LC	FIRR (%)
1	9	5	14	4.1
2	10.5	5	14	6.5
3	8	4	9	6.8
4	6.5	1	7	6.6

In performing sensitivity analysis repayment and grace periods for both foreign and local components were left unchanged.

In Case 1 the annual rate of interest on local component is presupposed to be full 14%, and FIRR works out to 4.1%.

This value itself is not to be argued about. The problem is the cashflow. Negative incremental benefits exceeding Rs. 200 million appear consecutively for 13 years. It cannot but put financial strains on the water supply organization.

The objective of the second analysis is to find out the water rate that will produce the FIRR value of 6% to 7% under the same lending terms as in the first case. The result is that water rate of Rs. 10.5 per thousand gallons produces the FIRR of 6.5%. In other words, if the terms on local component is not attenuated, the beneficiaries will have to pay Rs. 1.5 more to make up for it.

In the third case, under the given water rate of Rs. 8.0, the interest rates on both components that will produce the FIRR of 6% to 7% have been sought. It has been found that if the water rate is cut by Rs. 1, interest rate on foreign exchange and local currency portions shall be cut by 1% and 2% respectively to retain the value of FIRR.

Lastly, it is clarified that if the water rate is further cut down to Rs. 6.5, interest rates on FC and LC must be lowered to 1% and 7% respectively to have the FIRR value of 6.6%.

VII. CONCLUSION AND RECOMMENDATION

701. Conclusion

The recommended alternative, in which the water conduction facilities consist of intake tower, pressure and free flow tunnel, water treatment plant, pumping station, service reservoir and pipeline, is technically feasible. In the alternative, about 78% of the total amount of the water to be distributed to Rawalpindi area would be served by gravity.

The operation and maintenance of the facilities will also be technically facile and economically unburdensome compared with other alternatives.

The EIRR level of 6.2% is a standard one for a project in the water supply sector, and as such the Project is primarily judged feasible. One point that is critically important is the magnitude and dimension of intangible benefits to be expected from the Project.

If one considers millions of people in the beneficiary areas to be saved from the sorrows of diseases and deaths as well as from the drudgery of unending daily water fetching in the generations to come, which is not properly represented in the EIRR value, and also far-reaching socio-economic effects such as the creation of healthier and more productive people and the development of commerce and industries culminating in accelerated growth and expansion of the economy in and around the project areas, which can be beyond the realm of EIRR, one cannot but conclude that the Project is definitely feasible.

The proposed water rate of Rs. 9.0 per thousand gallons is theoretically at the least within the paying ability of consumers. The proposed lending rates on investment capital are 5% for foreign exchange component and 11% for local currency component. The latter is by 3% lower than the prevailing rate. Aspects of cashflow are not marked because the water supply service is essentially for the welfare of the people and thus based on a no profit, no loss principle. The FIRR value of 6.6% is reserved basically to alleviate financial losses in the first half of project life.

702. Recommendations

A. Survey and Investigation

The following topographic survey/mapping and geological survey shall be undertaken prior to and or during detailed design stage by the project execution agencies of Pakistan and consultants. The survey items and quantities are discussed in Appendix C and the summary is described as under.

- The mapping with scale 1:5,000 shall be made for 13 km along the proposed tunnel route.
- Topographical survey and mapping for major facilities shall be made with scale 1:500 to 1:1000.
- Seismic survey, drilling, permeability test, geological and hydro-geological reconnaissance and rock test shall be executed to clarify conditions of rock mass and groundwater along the proposed tunnel route.
- Geological survey such as drilling, standard penetration test and physical soil test for major facilities shall be executed during detailed design stage.

B. An effective countermeasure to the shortage of water in the Khanpur Dam during a drought period of once in five years frequency must be given a foremost priority for future examination.

C. To realize a sound management of water supply service thus leading the Project to a successful undertaking, the development and reinforcement of distribution networks and meter systems shall be pushed to the extent possible, and also the establishment of water tariff systems and the elevation of cost recovery rate shall be attained.

D. The gap of a few percent between the prevailing bank rates and the proposed lending rates on investment capital shall be filled by the subsidies from the central government.

TABLE S-1 PROJECTED POPULATION AND WATER DEMAND OF ISLAMABAD

Item / Year	1984	1990	1995	2000
Total Population	206,000 1/	341,000	480,000	621,000
Population Served	195,000 1/	341,000	480,000	621,000
Service Ratio (%)	100	100	100	100
Water Demand				Unit : MLD (MGD)
Domestic Use	37.9(8 .3)	72.0(15.8)	107.7(23.7)	146.6(32.2)
Public Use	33.1(7 .3)	45.2(9.9)	61.2(13.4)	77.5(17.0)
C/I Use 2/	23.7(5 .2)	36.9(8.1)	50.8(11.2)	66.1(14.5)
Leakage/Wastage	47.3(10.4)	59.9(13.2)	69.4(15.2)	72.5(16.0)
(%) 3/	(33)	(28)	(24)	(20)
Total	142.0(31.2)	214.0(47.0)	289.1(63.5)	362.7(79.7)
Average Day Demand	142.0(31.2)	214.0(47.0)	289.1(63.5)	362.7(79.7)
Maximum Day Demand	177.5(39.0)	267.5(58.8)	361.3(79.4)	453.2(99.6)
Dayly Per Capita Demand				Unit : l (gal)
Domestic Use	194(43)	211(46)	224(49)	236(52)
Total	728(160)	628(138)	602(132)	584(128)

Note : 1/ excluding population of Golra and Nurpur Shahan.
2/ C/I Use : Commercial and Industrial Use.
3/ Percentage of leakage/wastage to demand.

TABLE S-2 PROJECTED POPULATION AND WATER DEMAND OF RAWALPINDI

Item / Year	1984	1990	1995	2000
Total Population	888,000	1,046,000	1,167,000	1,275,000
Population Served	622,000	837,000	992,000	1,148,000
Service Ration (%)	70	80	85	90
Water Deman				Unit : MLD (MGD)
Domestic Use	67.9(14.9)	108.2(23.8)	146.8(32.3)	192.6(42.3)
Public Use	16.5(3.6)	20.1(4.4)	22.7(5.0)	25.3(5.6)
C/I Use 1/	28.6(6.3)	37.7(8.3)	46.1(10.1)	55.2(12.1)
Military Use	15.9(3.5)	24.6(5.4)	29.7(6.5)	34.9(7.7)
Leakage/Wastage	72.5(15.9)	81.7(18.0)	81.8(18.0)	77.0(16.9)
(%) 2/	(36)	(30)	(25)	(20)
Total	201.4(44.2)	272.3(59.9)	327.1(71.9)	385.0(84.6)
Average Day Demand	201.4(44.2)	272.3(59.9)	327.1(71.9)	385.0(84.6)
Maximum Day Demand	251.8(55.3)	340.4(74.8)	408.9(89.9)	481.3(105.8)
Daily Per Capita Demand				Unit : l (gal)
Domestic Use	109(24)	129(28)	148(33)	168(37)
Total	324(71)	325(71)	330(73)	335(74)

Note : 1/ C/I Use : Commercial and Industrial Use
2/ Percentage of leakage/wastage to demand

TABLE S-3 EXISTING AND PROPOSED YIELD OF WATER
(Average per day)

Water Source	Present[2/]	2000 A.D	Remarks
Islamabad			
Shahdara H.W[4/]	1.4	1.4	
Nurpur H.W	0.5	0.5	
Saidpur H.W	0.6	0.6	
Golf Course (Old)	2.1	2.1	
- do - (New)	1.7	1.7	
G-10 H.W	1.9	3.8	by the end of 1986
Kurang H.W.	-	3.2	by the end of 1986
Tube Wells in National Park Area	6.4	10.4	
Tube Wells in Sectoral Area	3.0	9.0	
Sub-total	17.6	32.7	
Rawalpindi			
Sohan Camp T.W[5/]	2.8	2.8	
PHED T.W	3.6	3.6	
RMC T.W	4.8	4.8	
CB T.W	2.0	4.4	in a few years
MES (Army) T.W	0.6	0.6	
MES (PAF T.W	0.5	0.5	
Sub-total	14.3	16.7	
Total	31.9	49.4	

Notes:
1/ Unit in MGD.
2/ As of July, 1984.
3/ Production of water from storage dams are excluded.
4/ H.W.: Head works
5/ T.W.: Tube wells
6/ Firm yield from surface water is estimated based on the actual achievement of water production, taking the lowest value observed in the past 5 years.
7/ Firm yield from groundwater is taken as 80% of average production, taking into account the reduction of production in dry summer period.

TABLE S-4 CONSTRUCTION COSTS OF ALTERNATIVES

(Unit: Rs. Million)

Item	Alternative							
	I-A	I-B	I-C	II-A	II-B	II-C	II-D	III
1. Raw water reservoir	95.0	95.0	95.0	109.9	57.7	-	-	-
2. Feeder facilities	27.4	27.4	27.4	28.1	9.4	34.4	12.5	44.5
3. Tunnel	-	-	-	52.8	134.2	119.0	111.9	320.7
4. Water treatment	442.2	442.2	442.2	541.4	541.4	541.4	541.4	397.7
5. Pumping Station	218.1	263.5	263.0	266.4	267.4	239.9	287.9	146.3
6. Pipeline	791.6	723.4	697.1	589.3	534.1	564.3	582.6	402.9
7. Service reservoir	232.5	182.3	157.4	232.5	232.5	232.5	232.5	189.4
8. Electric works	61.3	64.0	60.6	61.6	60.4	60.6	60.2	67.8
Sub-total	1,868.1	1,797.7	1,742.6	1,882.1	1,837.0	1,792.2	1,829.2	1,569.2
9. Physical contingencies	186.8	179.7	174.2	188.2	183.7	179.2	182.9	156.9
Total	2,054.9	1,997.4	1,916.8	2,070.3	2,020.7	1,971.4	2,012.1	1,726.1

Note: Differences in colum Sub-total are due to rounding.

TABLE S-5 COST SUMMARY (1)

	Item	Local	Foreign	Total	Foreign
		---- Rs. Million ------			(%)
1.	Conduction main	249.7	177.8	427.5	42
2.	Water treatment plant	190.3	184.9	375.2	49
3.	Pumping station	51.6	54.1	105.7	51
4.	Distribution main	70.5	70.5	141.0	50
5.	Service reservoir	112.8	77.8	190.6	41
6.	Electric works	13.8	23.3	37.1	63
	Sub-total (1∿6)	688.7	588.4	1,277.1	46
7.	Project office	12.0	-	12.0	-
8.	Land acquisition	35.6	-	35.6	-
9.	Office equipment	2.2	6.3	8.5	74
10.	Engineering	31.2	116.4	147.6	79
11.	Administration	35.6	-	35.6	-
	Sub-total (7∿11)	116.6	122.7	239.3	51
	Base Cost (1∿11)	805.3	711.1	1,516.4	47
12.	Physical contingency	80.5	71.1	151.6	
13.	Price escalation	842.7	389.3	1,232.0	
	Total Cost	1,728.5	1,171.5	2,900.0	40

TABLE S-6 COST SUMMARY (2)

(Unit: Rs. Million)

	Item	Phase I	Phase II	Phase III	Total
1.	Conduction main	427.5	-	-	427.5
2.	Water treatment plant	196.1	101.2	77.9	375.2
3.	Pumping station	89.4	10.4	5.9	105.7
4.	Distribution main	76.0	65.0	-	141.0
5.	Service reservoir	124.6	43.0	23.0	190.6
6.	Electric works	32.2	3.4	1.5	37.1
	Sub-total (1∿6)	945.8	223.0	108.3	1,277.1
7.	Project office	12.0	-	-	12.0
8.	Land acquisition	35.6	-	-	35.6
9.	Office equipment	8.5	-	-	8.5
10.	Engineering	121.1	17.8	8.7	147.6
11.	Administration	27.8	4.5	3.3	35.6
	Sub-total (7∿11)	205.0	22.3	12.0	239.3
	Base Cost (1∿11)	1,150.8	245.3	120.3	1,516.4
12.	Physical contingency	115.1	24.5	12.0	151.6
13.	Price escalation	659.1	288.2	284.7	1,232.0
	Total Cost	1,925.0	558.0	417.0	2,900.0

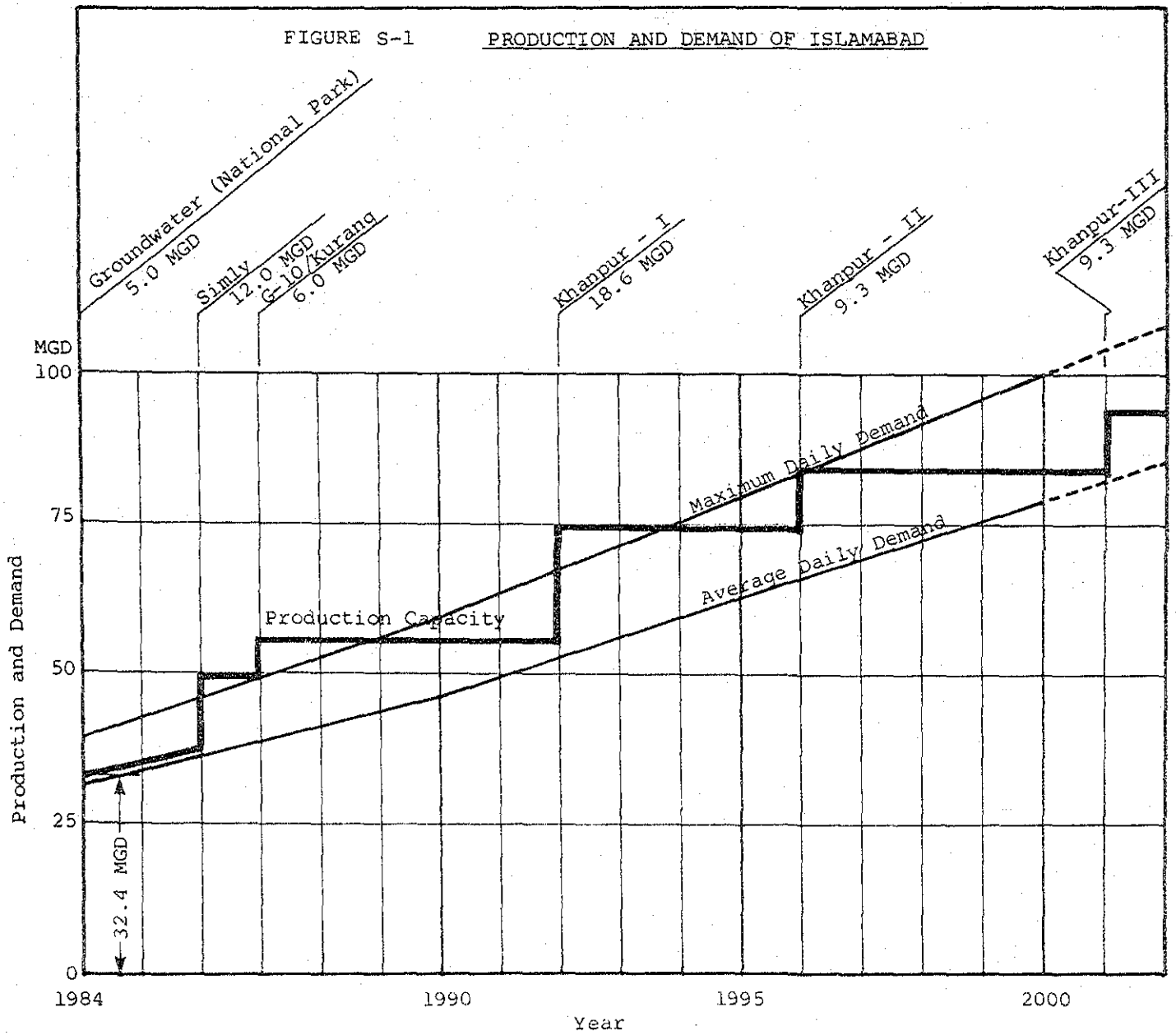
FIGURE S-1 PRODUCTION AND DEMAND OF ISLAMABAD
Groundwater (National Park)
5.0 MGD
Simly
12.0 MGD
G-10/Kurang
6.0 MGD
Khanpur - I
18.6 MGD
Khanpur - II
9.3 MGD
Khanpur-III
9.3 MGD
MGD
100
75
50
25
0
Maximum Daily Demand
Average Daily Demand
Production Capacity
32.4 MGD
Production and Demand
1984
1990
1995
2000
Year

FIGURE S-2 PRODUCTION AND DEMAND OF RAWALPINDI

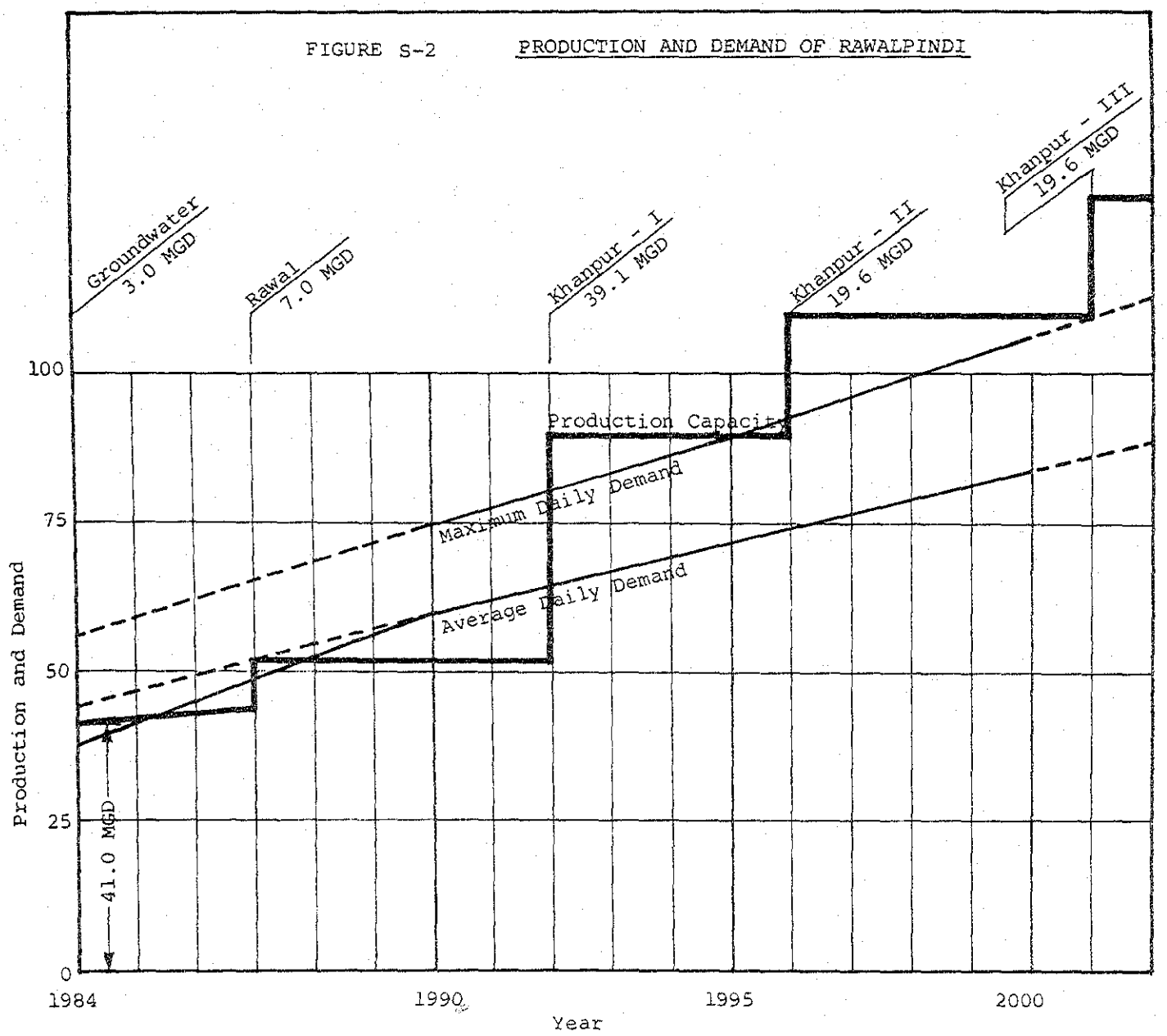

FIGURE S-3 SCHEMATIC MAP OF KHANPUR WATER CONDUCTION SYSTEM

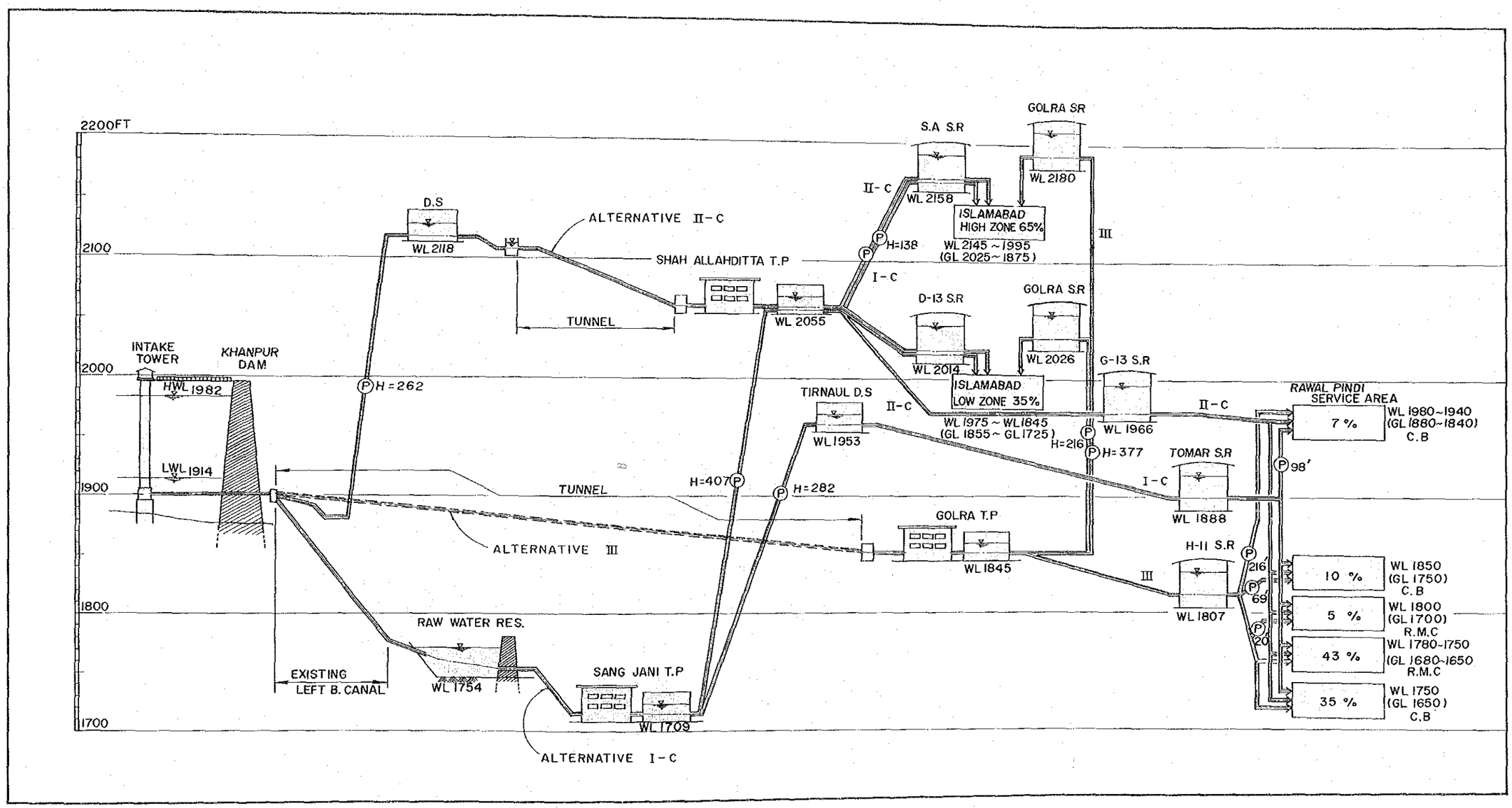

FIGURE S-4 IMPLEMENTATION SCHEDULE

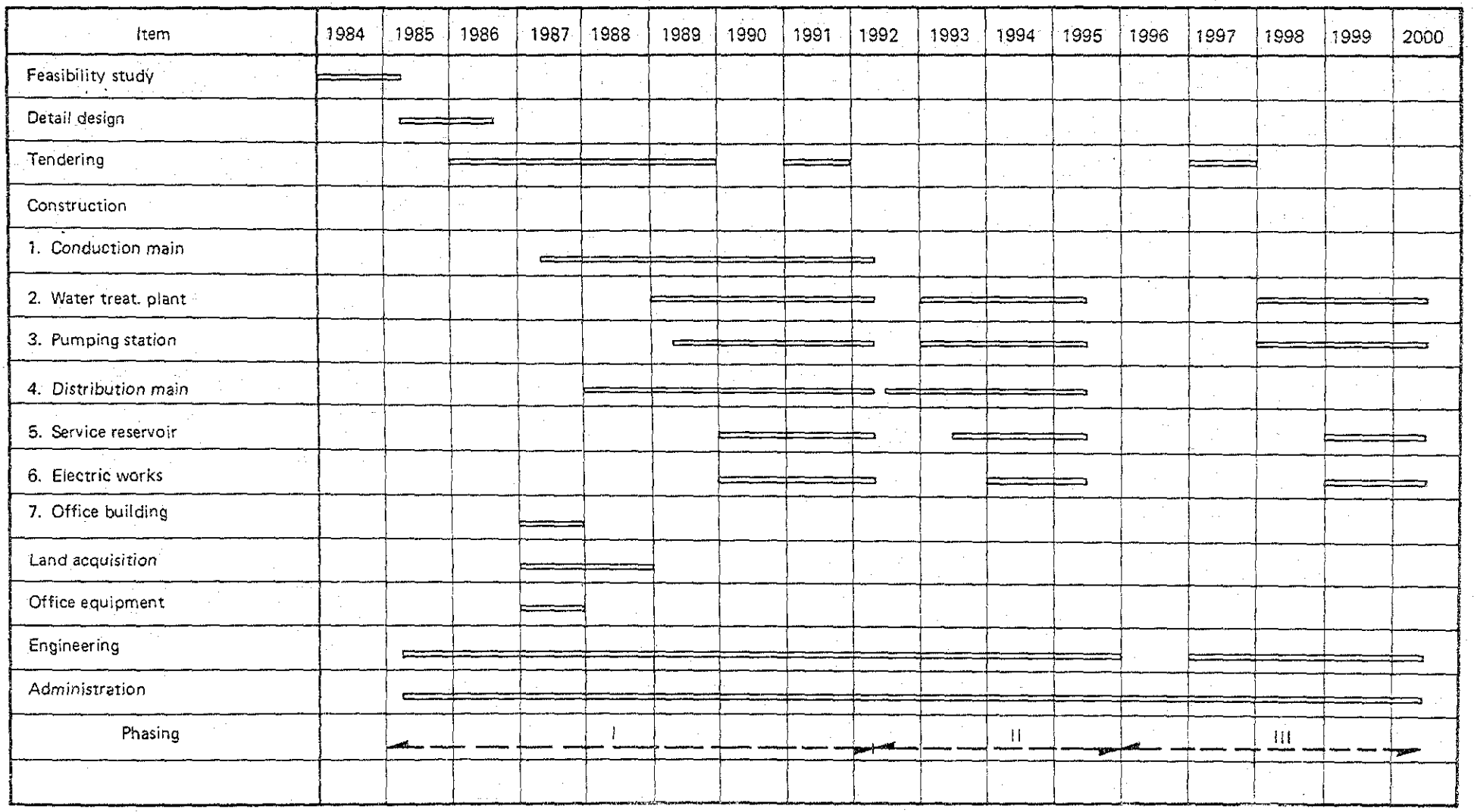

FIGURE S-5 PROPOSED ORGANIZATION CHART OF WATER SUPPLY SYSTEM OPERATION AND MAINTENANCE