CHAPTER VII. WATER RESOURCES DEVELOPMENT PLAN

CHAPTER VII. WATER RESOURCES DEVELOPMENT PLAN

7.1. Basic Concept of Plan Formulation

7.1.1. Target Years

The target year of the study is 2010. Also, the study team is requested to make recommendation regarding water resources development potential beyond 2010 up to 2030.

The study of course concerns those water resources which have been already developed and those which are to be developed soon by fixed plans. It also contains comprehensive development plan for the years 1987 (current) and 2000 (the target year of the already existing plans) based on the same policy regarding water balance.

7.1.2. Priority among Proposed Water Resources

The priority of development among the proposed water resources, especially storage water, have those which will produce maximum effect at minimum investment.

- A water resource should be newly developed about one year before the demand exceeds the supply.

- The implementations order should in principle follow the order of economy of "Unit Water Costs", except for the already existing projects.

- Small schemes should be given priority in case that the supply may exceed much the demand.
  appropriate small scale scheme will have a priority.

7.1.3. Optimum Dam Sizing

From the viewpoint of effective use of water resources on a stream, the dam size should be as large as possible within the engineering limits.

However each damsite has its proper tendency about rates of investment and effect, and if this fact is not taken into account, some of investment may turn futile in case that the size is too large and some of resources may be of no use if the size is too small.

Following is the manner of approach proposed in this study:

- On each proposed damsite, a relation curve between investment and effect (unit water cost curve) should be made.

- At the stage of selection of the damsite among those nominated on a stream, live storage capacity of a dam will represent the above-mentioned effect factor.

- At the next stage, probable water production of the dam will represent the effect on a selected damsite.

- Dam construction costs and operation/maintenance costs will be adopted as investment factors.

- On the unit water cost curve made as mentioned above, the appropriate dam size will be pointed out. Shape of curve describes a parabola having the minimum point of unit water cost of the dam.

An appropriate dam size should be close to this minimum point, while having as large capacity as possible. When the maximum size is limited by engineering technology, the technology limits should be given priority.

The purpose of this study is to establish a comprehensive development plan of various water resources for various users, so that the analysis by "unit water cost curve" could be more significant.

7.2. Assessment of Water Resources Development and Current Development Plan

7.2.1. Assessment of Water Resources Developed

For water supply to Islamabad/Rawalpindi at present, the developed and functioning facilities are all in the Soan basin. This is summarized in Table D-4-1 (Islamabad) and D-4-2 (Rawalpindi) of Appendix D.

Besides, the Khanpur dam was completed but its conduction main to the twin city was completed only up to the Nicholson Monument. The conduction main should be top priority scheme in order to meet acute water demand in the twin city. The Government of Pakistan considers the financial aid from the international organizations.

On the other hand, Taxila/Wah area has been also developed water resources for their water use. The development of water resources for this area is concentrated to groundwater and spring water in the Jhablat Kas basin. Water supply in this area is described in Table D-4-3 of Appendix D.

7.2.2. Assessment of Current Water Resources Development Plan up to the Year 2000

The current plans for Islamabad and Rawalpindi are as follows. Among these plans, some of these plans are already fixed and some are only early conception.

A. Current Plans of Islamabad

- Construction of the Khanpur Conduction and its Terminal Facilities

- Extension of the Existing Head Works (Shahdara, Nurpur etc.) (including rehabilitation works to keep facilities with originally projected capacities)

- Laying of 3rd conduction pipeline from the Simly dam and reopening of the Kurang Head Works.

- Installation of additional tubewells.

B. Current Plans for Rawalpindi

- Constructions of the Khanpur Conduction and its Terminal Facilities

- Extension of the Rawal Lake Filtration Plant

- Rehabilitation of the Hailay Water Works

- Installation of additional tubewells.

7.3. Construction Cost and Optimization

7.3.1. Construction Costs and Operation/Maintenance Costs

A. Basic Concept of Cost Analysis

Construction costs of the proposed facilities: storage dams, diversion dams and conveyance systems are estimated using unit prices as of January 1987.

Materials and labour costs are determined using the market costs and the next references.

- Schedule of Rates (Building and Roads) 1982
  (Government of Pakistan)

- Final Report for Feasibility Study on the Conduction of Water from Khanpur to Islamabad/Rawalpindi 1985
  (The Japan International Cooperation Agency)

a. Construction Costs of Storage Dams

Dam construction costs are estimated for the dam bodies, spillways and outlet works, which are the main components of dam construction.

The construction costs of dam bodies are estimated for each damsite by using rough dambody volumes and unit costs.

The construction costs of spillway and outlet works are determined using the component ratio of the costs for each work, considering the difficulties of each work.

Unit prices are determined using a rough break down and taking into account recently constructed dam projects in Pakistan.

b. Construction Costs of Diversion Dams and Conduction Mains

Construction cost of conduction mains is estimated by multipling unit cost per linear meter of a facility by its length.

The costs of pumping station is also estimated based on discharge wise and/or motor output wise unit cost in relation to the proposed capacity of the facility. Construction cost of diversion dam is calculated from the rough volumes of its dambody and appurtenant structures.

c. Operation/Maintenance Costs

Annual operation/maintenance costs after completion of construction are obtained by applying certain ratio to the construction costs, and electric power costs are added for pumping stations.

B. Construction Costs and Operation/Maintenance Costs of Proposed Facilities

Cost estimation has been carried out for storage dams, diversion dams and conduction mains based on the procedures and methodologies described above.

Table VII-3-1 shows the construction costs and operation/maintenance cost of the proposed facilities.

C. Unit Water Cost

As a factor of evaluation of proposed water resources facilities in the study either of simple structure or of system structures, the "unit water cost" will be defined as follows:

Unit Water Cost at the terminal point of facility/system = C/B

Where,

C : Total annual cost of the facility/system (M.Rs.)

$= Ic \times (AN + (1 + AN)^{Y}) / ((1 + AN)^{Y} - 1) + OM$

IC : Initial cost of the facility/system (M.Rs.)

AN : Annual interest from those investments. In the study, the rate of interest is assumed to be 5%.

Y : Economic life (years) of the facility/system which is assumed as follows for those respective structures:

Dam, Head Works and Intake	;	50 years
Conveyance facilities	;	40 "
Lifting facilities	;	20 "

OM : Annual operation/maintenance cost. (M.Rs.) It includes fuel and power expense.

B : Annual water production or conveyance of the facility/system. (MCM)

Unit water cost, therefore, can be calculated dividing total annual cost (C) by annual water production or conveyance (B).

7.3.2. Proposed Storage Dam Size

Figure VII-3-1 shows the sizing curves of the seven potential dams. Unit water cost increases rapidly corresponding to the increase in dam size when dam size is extremely large. The optimum size for any dam is the point of the lowest unit water cost at the highest possible water production.

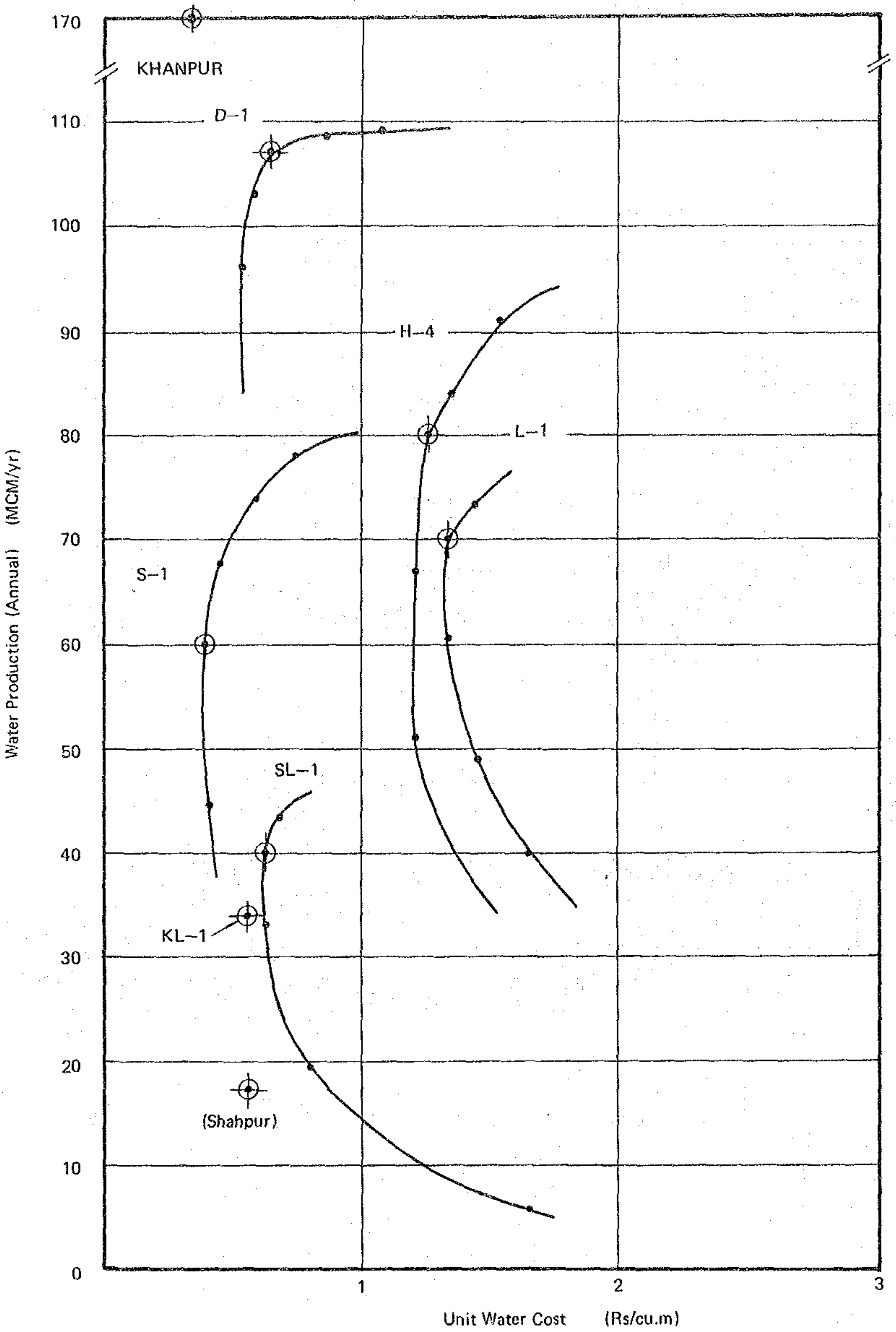
From Figure VII-3-1, there are two dam groups, one having comparatively low unit water costs (D-1, S-1, SL-1, KL-1 Dams and the Shahpur Heightening Scheme) and the other having relatively high unit costs (H-4 and L-1 Dams).

The former may be increased in size up to the limits of dam construction technology and compensation for land.

Table VII-3-1. Sizes and Costs of Proposed Facilities

Classification	Name	Location	Type	Size	Capacity	Production (Annual)	Initial (M.Rs.)	O/M Cost (M.Rs./Yr.)
Storage Dam	D-1	on Dor river near Rajola	Earthfill Dam	H=85.0, L=1590	60.0MCM	107MCM	1172.7	5.5
	H-4	on Haro river near Pina/Jabri	do	H=132.5, L=510	125.0	80	1689.3	7.1
	(Khanpur)	on Haro river, Khanpur	do	H=50.9, L=472+α	112.9	160	935(*1)	2.3(*1)
	(Simly)	on Soan river, Simly	do	H=80.2, L=308	24.7	34.7→52.8		
	(Rawal)	on Kurang river, Islamabad	Masonry Gravity Dam	H=40.7, L=213	53.0	37.9→39.9+α		
	S-1	on Soan river near Cherah	C. Gravity Dam	H=65.0, L=260+1750	66.0	60	381.5	2.5
	L-1	on Ling river near Dadhochai	Earthfill Dam	H=92.5, L=1570	91.0	70	1575.9	6.7
	KL-1	on Krung river near Lohi Bher	do	H=42.0, L=300+910	16.3	34	303.4	2.5
	SL-1	on Sil Kas near Dhok Shaban	do	H=55.5, L=420	62.0	40	415.5	2.5
	(K-2)	on Upper Kurang near Dohala	? (expected)	H= , L=	?	?		
	(Shahpur)	on Nandna Kas near Shahpur	Masonry Gravity Dam	H=30.6→32.6	40.0	17.3	60.0(*2)	2.5
Head Works (Intake)	Dw-1	on Dor river near Nikapah	Floating Weir	H=2.1, L=194.5	-	(107)	74.1	2.2
	Ki-2	on Khanpur Dam	Intake Tower		Max2.7m³/S	(67.1)	56.8	2.0
	Jw-1	on Jhablat Kas, Hassan Abdal	Floating Weir	H=1.9, L=80.0	-	70.8	27.2	2.0
	(Kurang)	on Kurang river near Bharakao				0.0→5.3		
	(Shahdara)	near Shahdara				2.9→4.0		
	(Nurpur)	near Nurpur				1.0→1.3		
(Spring)	(Saidpur)	in Saidpur	N.C.	N.C.	N.C.	1.2→1.1		
	(G.C.Old)	in National Park				3.2→2.9		
	(G.C.New)	in National Park				3.9→3.6		
	(G-10)	in Sector G-10				2.9→3.3		
	N.P-1	in National Park	Fixed Weir	(H=1.0, L=20.0)	-	?(expected)	(15.0	2.0)
	Sw-1	on Soan river near G.T. Bridge	do	(*3)				
	Sw-3	beside Soan river near Dahgal	Sump	ø800mm x 0.3km	-	6.4	1.1	-
Lift	Jp-1	on Jhablat Kas near H. Abdal	Volute Pump	ø600x1100kw x 4	Max2.7m³/S	(70.8)	116.1	13.3
	Np-1	near Shahpur Dam	do	400 500 4	1.2	(17.3)	73.3	7.1
	Kcp-1	at Sang Jani T. Plant	do	700 2000 6	5.0	(126.4)	193.5	40.2
	Kcp-2	ditto	do	700 1200 6	4.6	(114.8)	186.0	24.9
	SLp-1	at Dam SL-1	do	500 720 4	1.7	(40)	70.5	10.3
	Lp-1	at Dam L-1	do	700 780 4	2.8	(70)	111.5	10.9
	KLp-1	at Dam KL-1	do	400 160 4	1.0	(34)	50.5	3.8
	Swp-1	at Head Works Sw-1	do	(*3)				
	Sip-1	beside Soan river near Dahgal	do	350 55 2	0.5	(5.4)	33.0	2.3
Conduction	Dc-1	from Dw-1 to Khanpur Dam	Canal System	L=26.5km	5.0	(107)	225.8	2.3
	(Kc-2)	from Khanpur Dam to Nic. Monm.	do	19.4	11.1	(188.3)	108.7	1.1
	Kp-1	from Khanpur Dam to Nich. Monm.	Pipeline System	21.0, ø1500	2.7	(67.1)	476.7	4.8
	Kc-4	from Nich. Monm. to Sg.Jani T.P.	Canal System	1.0	7.8	(174.1)	119.6	1.2
	Kc-8	from Nich. Monm. to HRLBCA	do	0.5	1.0	(14.2)	4.8	0.5
	Kc-6	from Sg.Jani T.P. to S.Allahditta	Pipeline System	6.4, 1350x2	5.0	(126.4)	256.0	2.6
	Kc-5	from Sg.Jani T.P. to Tomar	do	16.5, 1350x2	4.6	(114.8)	406.9	4.1
	KZo-1	from Dam K2 to Islamabad	do		?	?		
	(Simc-1)	from Simly T.P. to Islamabad	do	27.8, 900x2	1.4→2.1	(34.7→52.8)		
	(Rc-1)	from Rawal T.P. to Rawalpindi	do	6.5, 1350	1.2→1.9	(29.8→37.2)		
	SLc-1	from SL-1 to Rawalpindi	do	5.5, 1100	1.6	(40)	77.0	0.8
	Sc-1	from S-1 to Pind Dara T.P.	do	11.5, 1350	2.4	(60)	71.3	0.7
	Rc-2	from Pind Dara T.P. to Rawalpindi	do	11.0, 1350x2	5.2	(130)	161.0	1.6
	Lc-1	from L-1 to Pind Data T.P.	do	12.5, 1000x2	2.8	(70)	280.0	2.8
	KLc-1	from KL-1 to Rawalpindi	do	3.7 900	1.0	(34)	34.8	0.3
	Rc-3	from SW-1 to Rawalpindi	do	(*3)				
	Jc-1	from Jhablat Kas to HRLBCA	do	8.2 1350	2.7	(70.8)	42.7	0.4
	Nc-1	from Shahpur Dam to HRLBCA	do	5.0 1100	1.2	(17.3)	22.0	0.2
Tube Wells	(T.W.-Wah)	in Wah/Taxila area				60-70(incl.Springs)		
	(T.W.-Islm)	in Islamabad area	Deep Well almost	ø = 8~12"	0 150m³/hr.	23.5→35.5		
	(T.W.-Rwl)	in Rawalpindi area		Dep=60-120m		35.6→49.5		
	T.W.-Arp	near Rakh Pind Ranjha				0.8→2.5		

Figure VII-3-1. Unit Water Cost and Water Production



From the technical point of view, there may not be much of a problem in increasing the sizes of the dams, but S-1 Dam will have a rapid increase in objects which will be submerged at Cherah Village located just upstream of the damsite.

As for KL-1 dam and Shahpur dam, their height is determined by considering the upper limits to compensate for lands, as shown in Appendix D.3.2.

Therefore, the dam sizes shown in Table VII-3-2 shall be recommended.

Table VII-3-2. Recommended Sizes of Potential Dams

Dam Name	Annual Production (MCM)	Effective Capacity (MCM)
D-1 (Rajoia)	107	60
H-4 (Pina)	80	125
S-1 (Cherah)	60	66
L-1 (Dadhochai)	70	91
KL-1 (Lohi Bher)	34	16.3
SL-1 (Dhok Shaban)	40	62
Shahpur Heightening	17.3	40

7.3.3. Diversion Dam and Water Intake Tower

The diversion facilities will be constructed across the Dor and Jhablat rivers, and their height was so determined in due consideration of the intake water velocity that the water flow should not transport fine particle sand. At the immediate upstream of the intake works, a flushing gate will be provided for eliminating sediment. The structure of the proposed intake facilities was designed with the concrete fixed weir type in stead of the gated weir type whose construction is very expensive in cost.

On the rivers Dor and Jhablat, the diversion dam should be of floating type because of the river bed with sand and gravel.

Furthermore, river bed protection works were designed in optimum length at the immediate downstream of the fixed weir. For the proposed Dor diversion dam, a sedimenting basin should be constructed at the downstream of the diversion works for easy operation and maintenance services of the facilities because the 26.5 km long canal is to be branched off from the diversion point.

The proposed new intake tower, which will serve to take from the Khanpur reservoir an additional amount of water available by development, will be constructed so that the Khanpur reservoir will remain filled with water and the works should be carried out with temporary close of the inlet at about 500 m east of the saddle-embankment on the left bank.

7.3.4. Pumping Station and Conduction Main

The plans for the conduction mains and the pumping stations have been worked out through in the confirmation by field investigation according to the topographic maps in the scale at 1:50,000 as the base maps.

The water lift pumps for municipal water supply will consist of four or six units including one stand-by unit, while those for irrigation with two or four units without any stand-by units.

The intake point for the irrigation area on the right bank of the Soan river shall be located at immediate downstream of the confluence with the Lei Nala flowing through the central part of Rawalpindi, and the conduit type will be employed for taking the filtrated water so as to avoid polluted urban sewerage.

The water resources developed by storage dams and diversion dams can be easily conveyed from the sources to their respective consuming areas by comparatively simple method because these water sources and consumers can be connected in simple and direct lines independently. In the Haro river system, however, various methods must be considered for water conveyance because of so intricated conditions.

In details, the amount of water increased by development will be taken out of the Khanpur reservoir through an intake tower proposed in the reservoir. There are basically two alternatives of conveyance method for the above.

i) The water should be released to a stream to flow down about six kilometers through the Haro river, and should be conveyed by the proposed new canal after re-intaking by newly constructed intake facilities, or

ii) Immediately after being taken out of the Khanpur reservoir, the water should be conveyed to the final destination through the pipeline to be newly provided in the Project.

There are problems of selection of the proposed two plans and of the use of the new water conveyance system for urban water or irrigation water.

A comparative study of the construction costs based on the preliminary design has revealed that the pipeline system as per (ii) alternative is advantageous when the discharge is less than 4 m^3/sec.

Since the existing left bank canal is concurrently used for the supply of urban water, industrial water and irrigation water. The newly developed irrigation water (1.0 m^3/sec) should flow down through the aforesaid left bank canal, while that of urban water (2.7 m^3/sec) should run through the proposed pipeline system.

The plan of specific utilization of the canal and pipeline will effectively serve for maintaining favorable the water quality and dispersing risks and troubles with the left bank canals in emergency like floodings.

7.3.5. Preliminary Design of Facilities

A. Storage Dams

a. General Features of Selected Dams

The general features of the seven selected dams which have the optimum sizes described in 7.3.2, are shown in Table VII-3-3, and their preliminary design drawings are shown in DWG.No.1 to 7 in Appendix D.

b. Engineering Considerations

Preliminary designs of storage dams are carried out based on the design criteria described in 6.1.4. This chapter describes the engineering considerations of the preliminary designs based on topographical, geological and soil mechanical reconnaissance.

i) Selection of Dam Type

The type of dam is selected in accordance with the topographical, geologic and hydrological conditions of the damsites. Such technical characteristics at dam foundation and distribution of construction materials are especially important factors for the selection of the dam type.

The results of the geological surveys and the construction materials for selected damsites are summarized in Table VII-3-4.

Table VII-3-3; General Features of Selected Dams

Number of Dam	D - 1	H - 4	S - 1	L - 1	SL - 1	KL - 1	Shahpur
Name of River	Dor River	Haro River	Soan River	Soan River	Soan River	Soan River	Haro River
Name of Tributary	-	-	-	Ling River	Sil River	Kurang River	Nandna Kas
Name of Dam	Rajoia	Pina	Cherah	Dadhochai	Dhok Shaban	Lohi Bher	Shahpur
Catchment Area * (sq.km)	292.3	498.5	341.1 (188.3)	285.0	237.6	558.8 (283.7)	203.9
Reservoir Area (sq.km)	2.9	4.2	6.1	8.4	6.5	4.7	8.6
Gross Storage (m.c.m)	74.62	144.94	82.95	116.65	83.38	41.80	47.28
Live Storage (m.c.m)	60.00	125.00	66.00	91.00	62.00	16.30	40.00
Dead Storage (m.c.m)	14.62	19.94	16.95	25.65	21.38	25.50	7.28
High Water Level (El.m)	1,017.0	869.0	591.5	554.5	473.0	480.0	449.58
Normal Water Level (do)	1,012.0	864.0	586.0	549.5	469.0	480.0	449.58
Low Water Level (do)	981.5	815.0	570.0	529.0	453.0	475.5	440.40
Type of Dam **	E	E	C&F	E	E	E	G (Heightening)
Dam Top Elevation (El.m)	1,020.0	872.5	594.0	557.5	475.5	482.0	450.8
Dam Height (m)	85.0	132.5	C;65.0 F;14.0	92.5	55.5	42.0, 18.0	30.59 32.61
Dam Length (m)	1,590	510	C;260 F;1750	1,570	420	300 + 910 = 1,210	256.0
Dam Volume (m.c.m)	5.469	7.477	C;0.236 F;0.453	7.360	1.943	0.797 + 0.506 = 1.306	-
Initial Cost (10^6Rs)	1,172.65	1,689.31	381.52	1,575.89	415.50	303.44	60.00
Annual O/M Cost (10^6Rs/Yr)	5.5	7.1	2.5	6.7	2.5	2.5	2.5
Water Production (m.c.m/yr)	107.0	80.0	60.0	70.0	40.0	34.0	17.25
Unit Water Cost (Rs/cu.m)	0.65	1.25	0.39	1.33	0.63	0.56	0.34

* ( ) ... Direct Catchment Area ** Type of Dam G; Concrete Gravity, E; Embankment, F; Embankment Flank

Table VII-3-4. Dam Foundation and Construction Materials

Dam	Foundation			Construction Materials			Remarks
	Lithology	Weathering	Overburden	Impervious	Pervious	Aggregate	
D-1	Bedrock : Mesozoic limestone Overburden: Partially cemented terrace gravel layer	Moderate	Terrace gravel more than 50 m River dep. less than 10 m	Terrace	Limestone River dep.	Limestone River dep.	
H-4	Bedrock : Mesozoic limestone Overburden: River dep. Terrace gr.	Moderate	River dep. 30-40 m Terrace gr. 20-30 m	Terrace (12 km)*	Limestone River dep.	Limestone River dep.	*Near Battal, left tributary of Dhund Haro
S-1	Bedrock : Tertiary Sandstone and some Shale layers	Fresh	Negligible	Alluvial dep.	Sandstone	Sandstone	
L-1	Bedrock : Tertiary Sandstone and Shale Overburden: Alluvial dep. River dep.	High	Alluvial dep. 0-5 m River dep. 0-5 m	Alluvial dep.	Sandstone (moderate)	Sandstone (12 km)*	*South-west of S-1
KL-1	Bedrock : Tertiary Sandstone and Shale Overburden: Alluvial dep. (Silt)	High	Alluvial dep. 0-20 m River dep. 0-5 m	Alluvial dep.	Sandstone (moderate)	Sandstone (12 km)*	*Near Rawal Lake
SL-1	Bedrock : Tertiary Sandstone and Shale Overburden: Alluvial dep. River dep.	High	Alluvial dep. 0-10 m	Alluvial dep.	Sandstone (moderate)	Limestone (4 km)*	*North of SL-1

Judging from the technical characteristics of dam foundations, only the S-1 damsite, comprised of Rawalpindi group sandstone and shale, has enough strength for the foundation of a concrete gravity dam.

The bedrock of the H-4 damsite consists of limestone and might have enough strength for a concrete gravity dam of moderate size, but an embankment dam would be more suitable when the existence of thick river deposits and terrace deposits is taken into account.

The foundations of other damsites consist of thick terrace deposits (the D-1 damsite) or highly sheared and weathered bedrock (the L-1, SL-1 and KL-1 damsites). These foundations are not strong enough for concrete gravity dams, but will support embankment type dams.

As for the construction materials, concrete aggregate and embankment materials, quality materials are expected to be available in the near vicinity of each of the proposed damsites. However, there are some materials for some damsites which must be brought from a distance of over 10 km.

ii) Foundation Treatment

The foundations of selected damsites can be classified into three groups by foundation treatment.

(1) Rock foundations (S-1, L-1, KL-1, SL-1)
(2) Pervious gravel foundations (D-1)
(3) Combinations of (1) and (2) (H-4)

Rock Foundations

Grouting is usually performed to seal fissures, joints and other cracks in the foundation rock and to improve their watertightness.

In the case of limestone layers, it is very important to select injection materials and perform injections gradually using coarse to fine materials.

As for soft rock foundations, injections using low pressures are adequate and do not destroy the foundation rock.

Pervious Gravel Foundations

If a sand or gravel layer in the foundation is not very thick and a sufficient impervious layer underlies it, the cut-off wall is designed to reach the impervious layer.

When there is a thick sand or gravel layer foundation, seepage may generally be controlled by providing an upstream impervious blanket to reduce the hydraulic gradient.

The blanket method is not a direct measure to insure the watertightness of pervious foundations, but an indirect measure to prevent high velocity and large quantity seepage through the foundation by reducing the hydraulic gradient.

iii) Types of Spillways

In this study ungated and overflow type spillways are used for the damsites proposed in 6.1.4.

It is necessary to use not only center overflow types but also side overflow types. This is decided upon consideration of the topographical conditions of each damsites.

B. Diversion Dams, Intake Towers and Conveyance Systems including Pumping Stations

All proposed facilities to be constructed are tabulated in Table VII-3-5.

a. Diversion Dam

The main functions of diversion dams are to intake surface water from rivers, to intake water released from upstreams dams and to stabilize stream flow for pumping-up.

In the study, diversion dams are planned to be constructed by one each on the Dor river and the Jhablat Kas. A few prospective sites are selected on the topographical map in the scale at 1 to 50,000 in consideration of selection criteria described in D.3.3. The detailed field investigation clarifies that a proposed site is at Nikapah 12.5 km east of Haripur on the Dor, at 4 km downstream of Hussan Abdal on the Jhablat Kas. An a floating type diversion dam is planned on the Dor and Jhablat Kas. Selection of the prospect site, geology and basic approach to structural design can be referred to D.2.2.

The intake point of the irrigation water to the Soan river right bank suburban areas of the Capital shall be located about 8.0 km downstream of the confluence with Lei Nala. It is recommended, however, that the percolation conduit system should be adopted for collecting infiltrating water due to heavy river water pollution by urban sewage.

Table VII-3-5. Specifications of Intake and Conveyance Facilities

Item	Type and Specification					River Basin
1. Diversion Dam						
Dw-1	Floating	H = 2.1^{m}	L = 194.5^{m}			Dor River
Jw-1	"	H = 1.9	L = 80.0			Jhablat Kas
2. Pumping Station						
Kcp-1	Volute Pump,	ø700^{mm}	x 2,000^{kw}	x 6^{unite}	discharge 5.0$^{cu.m/sec.}$	Sang Jani T.P.
Kcp-2	"	ø700	x 1,200	x 6	4.6	"
Lp - 1	"	ø700	x 780	x 4	2.8	Ring River
KLp-1	"	ø400	x 160	x 4	1.0	Kurang River
SLp-1	"	ø500	x 720	x 4	1.7	Sil Kas
Sip-1	"	ø350	x 55	x 2	0.5	Soan River
Np-1	"	ø400	x 500	x 4	1.2	Near Shahpur Dam
Jp-1	"	ø600	x 1,100	x 4	2.7	Jhablat Kas
3. Conduction Main						
Dc-1	Canal System,	L = 26.5^{km}			5.0	Dor River
Kp-1	Pipeline System,	L = 21.0^{km}	ø1,500^{mm}		2.7	Khanpur Riservor
Kc-4	Canal System,	L = 1.0^{km}			7.8	L.B.C.
Sc-1	Pipeline System,	L = 11.5^{km}	ø1,350^{mm}		2.4	Soan R. near Cherah
Lc-1	"	L = 12.5^{km}	ø1,000^{mm}x2		2.8	Ling River
Rc-2	"	L = 11.0^{km}	ø1,350^{mm}x2		5.2	Pind Dara T.P.
SLc-1	"	L = 5.5^{km}	ø1,100^{mm}		1.6	Sil Kas
KLc-1	"	L = 3.7^{km}	ø900^{mm}		1.0	Kurang River
Nc-1	"	L = 5.0^{km}	ø1,100^{mm}		1.2	Shahpur Dam
Jc-1	"	L = 8.2^{km}	ø1,350^{mm}		2.7	Jhablat Kas
Kc-8	Canal System,	L = 0.5^{km}			1.0	L.B.C.

b. Intake Tower

The water stored in the Khanpur reservoir is conveyed out through intake facilities provide at the right saddle. The intake capacity of the facilities is 15.57 cu.m (550 cu.sec), which is equal to the total capacity of water conveyance through the canals for the both banks.

Consequently, new intake facilities must be provided to meet the increased urban water and irrigation water requirements for the commanded areas to be developed.

The construction of the new intake works, however, will be technically intricated and trouble some as the works must be implemented with the reservoir storing water. And the new facilities will be provided at the inlet about 500 m east of the left saddle and the water taken out of the reservoir will be conveyed through 770 m long pressure tunnel to cross the ravine to the southern side. (Refer to the Feasibility Study Report on the Water Conduction from the Khanpur to Islamabad/Rawalpindi)

c. Pumping Station

Nine pumping stations will be constructed within proposed water supply areas, of which six is for supplying urban water to the Metropolitan area, three for supplying irrigation water.

(1) Type of Pump

The pumping heads higher than 30 m are mostly required for the Project. In view of the required discharge and head, double suction volute pump has been selected.

(2) Control Method

Considering operational and economic advantages as well as operation and maintenance, flow control is primarily based on the simplest method of control by charge of operating pump number and on-off control in terms of water level control in the discharge pool. Accordingly HWL and LWL are to be established in both suction and discharge pools, providing proper capacities which are determined as 30 minutes capacity of the maximum design discharge.

(3) Number of Pump Units

The number of pump units is determined in consideration of the following factors;

- For easy operation and maintenance, the number of pump units should be as small as possible and the equal capacity units should be adopted.

- The larger the delivery may be, the higher the pump efficiency, so that possibly larger units should be used.

- For those of urban water supply, at least one stand-by unit must be provided. If the total pump units are small, the stand-by will be costly. Stand-by pumps will not be installed for the irrigation pumps; however total interruption of pumping operation shall be avoided by any means with more than two units installed.

- The number of units should be determined so as to be operated effectively corresponding to seasonal water-load fluctuation. (Fluctuation rangs from 1.25 to 0.8 ordinarily in urban water supply).

As a conclusion, the number of the pump units for the urban water supply is recommended by four or six including one stand-by unit, while that for irrigation is four or two without using any stand-by units.

(4) Rising Main

The appropriate conveyance pipe diameter ranges between 800 m and 1,350 mm, and steel pipes or ductile iron pipes shall be employed for those portions where high hydraulic pressure works.

7.3.6. Accumulated Unit Water Cost

From the cost data of proposed facilities selected finally in previous clauses, each unit water cost and their compositions as of respective systems are listed up in Table VII-3-6 (AN=5%).

Table VII-3-6. Compositions of Unit Water Costs of Potential Resources

Facility Name	Dam D-1	H.W Dw-1	Cnl.Dc-1
Initial Cost M.Rs.	1173	74.1	225.8
Annual O/M Cost M.Rs.	5.5	2.2	2.3
Durable Years	50	50	40
Annual Cost M.Rs.	69.8	6.3	15.4
Water Production MCM/yr.	107		
Unit Water Cost Rs./m³	0.65	0.06	0.14
Ditto accumulated	0.65	0.71	0.85

	Dam H-4	+	Khanpur Dam
Initial Cost	1689		935
Annual O/M Cost	7.1		2.3
Durable Years	50		50
Annual Cost	99.7		53.5
Water Production	80		160
Unit Water Cost	1.25		0.33
Ditto accumulated	1.25		0.33

	Weighed average
Annual Cost	244.7
Water Production	347
Unit Water Cost	0.71
Ditto accumulated	0.71

	Cnl.Kc-2	Cnl.Kc-4
Initial Cost	108.7	119.6
Annual O/M Cost	1.09	1.20
Durable Years	40	40
Annual Cost	7.43	8.17
Water Production	222.2	174.1
Unit Water Cost	0.03	0.05
Ditto accumulated	0.74	0.79

	Intk.Kl-2	P.L Kp-1
Initial Cost	56.8	476.7
Annual O/M Cost	2.0	4.8
Durable Years	50	40
Annual Cost	5.11	32.6
Water Production	67.1	
Unit Water Cost	0.08	0.49
Ditto accumulated	0.79	1.28

	Weighed average
Annual Cost	223.4
Water Production	241.2
Unit Water Cost	0.93
Ditto accumulated	0.93 (3)

Note: These unit water-costs are for resources development and conveyance only. Water treatment costs are not included.

(1)-(5) are economical order by unit water-costs for urban supply

	HW.Jw-1	Lft.Jp-1	PL.Jc-1	Reg.Pnd.
Initial Cost	27.2	116.1	42.7	418.0
Annual O/M Cost	2.0	13.3	0.4	2.5
Durable Years	50	20	40	50
Annual Cost	3.49	22.6	2.89	25.4
Water Production	70.8			
Unit Water Cost	0.05	0.32	0.04	0.36
Ditto accumulated	0.05	0.37	0.41	0.77

	Dam S-1	P.L.Sc-1	P.L.Rc-2
Initial Cost	381.5	71.3	161.0
Annual O/M Cost	2.5	0.70	1.61
Durable Years	50	40	40
Annual Cost	23.4	4.86	11.0
Water Production	60		
Unit Water Cost	0.39	0.08	0.18
Ditto accumulated	0.39	0.47	0.65 (1)

	Weighed average	P.L.Rc-2
Initial Cost		161.0
Annual O/M Cost		1.61
Durable Years		40
Annual Cost	160.3	11.0
Water Production	130.0	
Unit Water Cost	1.23	0.08
Ditto accumulated	1.23	1.31 (5)

Dam K-2	P.L.K2c-1
(expected)	

	Shahpur H	Lift Np-1	P.L.Nc-1
Initial Cost	60.0	73.3	22.0
Annual O/M Cost	2.50	7.1	0.2
Durable Years	50	20	40
Annual Cost	5.79	13.0	1.48
Water Production	17.3		
Unit Water Cost	0.33	0.75	0.09
Ditto accumulated	0.33	1.08	1.17

	Dam L-1	Lift Lp-1	P.L.Lc-1
Initial Cost	1576	111.5	280.0
Annual O/M Cost	6.7	10.9	2.8
Durable Years	50	20	40
Annual Cost	93.1	19.8	19.1
Water Production	70		
Unit Water Cost	1.33	0.28	0.27
Ditto accumulated	1.33	1.61	1.88

	H.W.Sw-1	Lift Swp-1	P.L.Rc-3
Initial Cost	76.8	36.5	28.1
Annual O/M Cost	2.3	4.1	0.28
Durable Years	50	20	40
Annual Cost	6.51	7.03	1.92
Water Production	- (succeeded by KL-1)		
Unit Water Cost	-	-	-
Ditto accumulated	-	-	-

	Dam SL-1	Lift SLp-1	P.L.SLc-1
Initial Cost	415.5	70.5	77.0
Annual O/M Cost	2.5	10.3	0.8
Durable Years	50	20	40
Annual Cost	25.3	16.0	5.29
Water Production	40		
Unit Water Cost	0.63	0.40	0.13
Ditto accumulated	0.63	1.03	1.16 (4)

	Dam KL-1	Lift KLp-1	P.L.KLc-1
Initial Cost	303.4	50.5	34.8
Annual O/M Cost	2.5	3.8	0.35
Durable Years	50	20	40
Annual Cost	19.1	7.85	2.38
Water Production	34.0		
Unit Water Cost	0.56	0.23	0.07
Ditto accumulated	0.56	0.79	0.85 (2)

	H.W.Sw-3	Lift Sip-1	Cnl.Sic-1
Initial Cost	1.1	33.0	Existing
Annual O/M Cost		2.30	nil
Durable Years	50	20	40
Annual Cost	0.05	4.95	nil
Water Production	6.4		
Unit Water Cost	0.01	0.77	nil
Ditto accumulated	0.01	0.78	0.78

7.4. Recommended Plan of the Water Resources Development

7.4.1. Water Demand and Supply Balance in Target Years

For the these water demands of years 1987 (current) 2,000, 2010 and 2030, resources development of which the basic concept is mentioned in Chapter 7.1. is programmed in such manner and described in Table VII-4-1 to VII-4-4 and also in Figures VII-4-1.

Figure VII-4-2 indicates implementation schedule of respective proposed facilities construction in accordance with the supply and demand balance.

In order to realize these water balances, the following enforcements shall be most indispensable.

A. Indispensable Measures for the Year 2000

- Khanpur Conduction Project shall start very soon and finish by the end of 1991.

- Cherah (S-1) dam shall be studied, designed and commenced the works. Sil Kas (SL-1 or Dhok Shaban) dam shall be studied, designed and to be ready for construction.

- Programmed projects in the twin city such as extention scheme of existing facilities shall be performed without delay.

B. Indispensable Measures for the Year 2010

- KL-1 dam shall be completed by the end of 2005.

- Sil Kas (SL-1) dam shall start the construction and finished by the end of 2009.

- After the year of 2001, Rawalpindi which can be profitably supplied from S-1, KL-1, and SL-1 shall reduce the receipt water from Khanpur dam to about 57 percent of 58.7 MCM per year. The surplus water shall be delivered to Islamabad which may be in very need in these years. The distribution of such water is made at proposed Sang Jani filtration plant.

C. Indispensable Measures for the Year 2030

- Rajoia (D-1) dam, Nikapah (Dw-1) Head Works and Dor (Dc-1) Conduction shall be studied, designed and completed by the end of 2015.

- Pina (H-4) dam shall be studied, designed and completed by the end of 2019.

- Dadhochai (L-1) dam shall be studied, designed and completed by the end of 2025.

7.4.2. Chronological Development Plan

As explained in the previous clause, the order of implementations of facilities have been arranged according to the concept of priority mentioned in Chapter 7.1.2.

As contrasted with the chronological growth of the demand, it is shown in Figure VII-4-3.

Table VII-4-1 A Trial of Water Balance

(Target Year = 1987)

MCM/Year

Water Resources		Present Production as of 1987	Additional Production	Notes	Total Production as of 1987
1. Dor Basin	1.1. Storage Dam D-1	-			-
	1.2. Diversion Dam Dw-1	-		JICA KHANPUR	-
	Total	-		Report II-14 &	-
2. Haro Basin	2.1. Storage Dam H-4	-		A-II-88 88.2x	-
	2.2. Storage Dam Khanpur	66.8		(231.3/305.6)	66.8
	2.3. Tube Wells & Springs	40.9			40.9
	2.4. Diversion Dam Jw-1	-			-
	2.5. Storage Dam Shahpur	-			-
	Total	107.7			107.7
3. Soan Basin for Islamabad	3.1. Storage Dam Simly	34.7		Reported pro	34.7
	3.2. Storage Dam K-2	-		duction 1986	-
	3.3.1. Head Works N.P.-1	-			-
	3.3.2. Ditto Kurang	0		Suspended	0
	3.3.3. Ditto Six Others	15.1		see Tab.III-2-2	15.1
	3.4. Tube Wells Islamabad	23.5		Reported '86	23.5
	Total	73.3			73.3
4. Soan Basin for Rawalpindi	4.1. Storage Dam Rawal	35.0	29.8('86)+5.2(Irrig)		35.0
	4.2. Tube Wells Rawalpindi	35.6		Reported '86	35.6
	4.3. Diversion Dam Sw-1	-			-
	4.4. Storage Dam S-1	-			-
	4.5. Storage Dam L-1	-			-
	4.6. Storage Dam KL-1	-			-
	4.7. Storage Dam SL-1	-			-
	Total	70.6			70.6
5. Head Works (Pump) at Soan river		-			-
6. Tube Wells for New Int. Air port		-			-
Grand Total		251.6			251.6
Total of Storage Dams's Resources		136.5			136.5
Ditto of Diversion Dams (incl.Head W.)		15.1			15.1
Ditto of Tube Wells		100.0			100.0

←Dor Conduction

←Khanpur Conduction

Demand	(Users and their Dimentions)
	1. Khanpur Dam project
41.8	1.1. Right Bank Irrigation
25.0	1.2. Left Bank Irrig. (exist.)
32.7[1]	1.3. POF Wah
8.2[2]	1.4. PIDC Taxila(incl. H.R.F.)
107.7	Sub Total
-	2. Haro Left Area Irrigation
73.3	3. Urban Water Islamabad
65.4	4. Urban Water Rawalpindi
5.2	5. Rural Irrigation Islamabad (Rawal Dam Left Irrigation)
0[3]	6. Rawalpindi South Irrigation
-	7. New International Air Port

Note; 1) from Wah Spring, 2) from Tube Wells

3) Existing irrig. system has been damaged.

The Allowance;
Resources(251.6 MCM) - Demand(251.6 MCM) = 0

Table VII-4-2 A Trial of Water Balance

(Target Year = 2000)

MCM/Year

Water Resources		Presented Production as of 1987	Additional Production	Notes	Total Production as of 2000
1. Dor Basin	1.1. Storage Dam D-1	-	-		-
	1.2. Diversion Dam Dw-1	-	-		-
	Total	-	-		-
2. Haro Basin	2.1. Storage Dam H-4	-	-		-
	2.2. Storage Dam Khanpur	66.8	93.2		160.0
	2.3. Tube Wells & Springs	40.9	6.4		47.3
	2.4. Diversion Dam Jw-1	-	70.8		70.8
	2.5. Storage Dam Shahpur	-	-		-
	Total	107.7	170.4		278.1
3. Soan Basin for Islamabad	3.1. Storage Dam Simly	34.7	18.1		52.8
	3.2. Storage Dam K-2	-	-		-
	3.3.1. Head Works N.P.-1	-	-		-
	3.3.2. Ditto Kurang	0	5.3	Tab.III-2-2	5.3
	3.3.3. Ditto Six Others	15.1	1.1	Tab.III-2-2	16.2
	3.4. Tube Wells Islamabad	23.5	6.0	12.0/2	29.5
	Total	73.3	30.5	excl. 3.3 to	103.8
4. Soan Basin for Rawalpindi	4.1. Storage Dam Rawal	35.0	2.2	New G.C.,CDA	37.2
	4.2. Tube Wells Rawalpindi	35.6	7.0	20.4/2	42.6
	4.3. Diversion Dam Sw-1	-	-		-
	4.4. Storage Dam S-1	-	60.0		60.0
	4.5. Storage Dam L-1	-	-		-
	4.6. Storage Dam KL-1	-	-		-
	4.7. Storage Dam SL-1	-	-		-
	Total	70.6	69.2		139.8
5. Head Works (Pump) at Soan river		-	6.4		6.4
6. Tube Wells for New Int. Air port		-	0.8		0.8
Grand Total		251.6	277.3		528.9
Total of Storage Dams's Resources		136.5	173.5		310.0
Ditto of Diversion Dams (incl.Head W.)		15.1	83.6		98.7
Ditto of Tube Wells		100.0	20.2		120.2

←Dor Conduction ←Khanpur Conduction

Demand	(Users and their Dimentions)
	1. Khanpur Dam project
57.7	1.1. Right Bank Irrigation
33.9	1.2. Left Bank Irrig. (exist.)
24.8[1]	1.3. POF Wah (refer to Appe-
22.5[2]	1.4. PIDC Taxila ndix D.1.-)
138.9	Sub Total
·	2. Haro Left Area Irrigation
70.8	10,000ha x 7,077m³/ha/yr.
	3. Urban Water Islamabad
139.0	362,700 m³/day x 365 x 1.05
	4. Urban Water Rawalpindi
145.8	380,400 m³/day x 365 x 1.05
	5. Rural Irrigation Islamabad
xx.x	(Under individual study by JICA)
	6. Rawalpindi South Irrigation
6.4	900 ha x 7,077 m³/ha/yr.
	7. New International Air Port
0.8	0.5 MGD

Note; 1) from Wah Spring, 2) from Tube Wells

The Allowance;
Resources (528.9) - Demand (501.7) = 27.2 MCM

Table VII-4-3 A Trial of Water Balance

(Target Year = 2010)

Water Resources		Presented Production as of 2000	Additional Production	Notes	Total Production as of 2010
1. Dor Basin	1.1. Storage Dam D-1	-	-		-
	1.2. Diversion Dam Dw-1	-	-		-
	Total	-	-		-
2. Haro Basin	2.1. Storage Dam H-4	-	-		-
	2.2. Storage Dam Khanpur	160.0	-		160.0
	2.3. Tube Wells & Springs	47.3	-		47.3
	2.4. Diversion Dam Jw-1	70.8	-		70.8
	2.5. Storage Dam Shahpur	-	17.3	Heightening	17.3
	Total	278.1	17.3		295.4
3. Soan Basin for Islamabad	3.1. Storage Dam Simly	52.8	-		52.8
	3.2. Storage Dam K-2	?	?	Expected	?
	3.3.1. Head Works N.P.-1	?	?	Expected	?
	3.3.2. Ditto Kurang	5.3	-		5.3
	3.3.3. Ditto Six Others	16.2	-		16.2
	3.4. Tube Wells Islamabad	29.5	6.0	12.0/2	35.5
	Total	103.8	6.0		109.8
4. Soan Basin for Rawalpindi	4.1. Storage Dam Rawal	37.2	-		37.2
	4.2. Tube Wells Rawalpindi	42.6	7.0	14.0/2	49.6
	4.3. Diversion Dam Sw-1	-	-		-
	4.4. Storage Dam S-1	60.0	Succeeded by KL-1		60.0
	4.5. Storage Dam L-1	-	-		-
	4.6. Storage Dam KL-1	-	34.0	M-i→KL-1	34.0
	4.7. Storage Dam SL-1	-	40.0		40.0
	Total	139.8	81.0		220.8
5. Head Works (Pump) at Soan river		6.4	-		6.4
6. Tube Wells for New Int. Air port		0.8	0.9		1.7
Grand Total		528.3	105.2		634.1
Total of Storage Dams's Resources		310.0	91.3		401.3
Ditto of Diversion Dams (incl.Head W.)		98.7	-		98.7
Ditto of Tube Wells		120.2	13.9		134.1

←Dor Conduction

←Khanpur Conduction

MCM/Year

Demand	(Users and their Dimentions)
	1. Khanpur Dam project
57.7	1.1. Right Bank Irrigation
33.9	1.2. Left Bank Irrig. (exist.)
24.8 1)	1.3. POF Wah (refer to Appendix D.1.-)
22.5 2)	1.4. PIDC Taxila
138.9	Sub Total
	2. Haro Left Area Irrigation
88.1	16,100ha x 7,077m³/ha/yr. x 77.3% 3)
	3. Urban Water Islamabad
165.9	433,000 m³/day x 365 x 1.05
	4. Urban Water Rawalpindi
217.7	568,100 m³/day x 365 x 1.05
	5. Rural Irrigation Islamabad
xx.x	(Under individual study by JICA)
	6. Rawalpindi South Irrigation
6.4	900ha x 7,077m³/ha/yr. x 100%
	7. New International Air Port
1.7	1.0 MGD

Note; 1) from Wah Spring, 2) from Tube Wells
3) Remains are by Small S. Lift Irrig.

The Allowance;
Resources(634.1) - Demand(618.7) = 15.4 MCM

Table VII-4-4 A Trial of Water Balance

(Target Year = 2030)

MCM/Year

Water Resources		Presented Production as of 2010	Additional Production	Notes	Total Production as of
1. Dor Basin	1.1. Storage Dam D-1	-	107.0	incl. Dw-1	107.0
	1.2. Diversion Dam Dw-1	-	-		-
	Total	-	107.0		107.0
2. Haro Basin	2.1. Storage Dam H-4	-	80.0		80.0
	2.2. Storage Dam Khanpur	160.0	-		160.0
	2.3. Tube Wells & Springs	47.3	-		47.3
	2.4. Diversion Dam Jw-1	70.8	-		70.8
	2.5. Storage Dam Shahpur	17.3	-	Heightening	17.3
	Total	295.4	80.0		375.4
3. Soan Basin for Islamabad	3.1. Storage Dam Simly	52.8	-		52.8
	3.2. Storage Dam K-2	?	-	expected	?
	3.3.1. Head Works N.P.-1	?	-	expected	?
	3.3.2. Ditto Kurang	5.3	-		5.3
	3.3.3. Ditto Six Others	16.2	-		16.2
	3.4. Tube Wells Islamabad	35.5	-		35.5
	Total	107.8	-		107.8
4. Soan Basin for Rawalpindi	4.1. Storage Dam Rawal	37.2	-		37.2
	4.2. Tube Wells Rawalpindi	49.6	-		49.6
	4.3. Diversion Dam Sw-1	-	succeeded by KL-1		-
	4.4. Storage Dam S-1	60.0	-		60.0
	4.5. Storage Dam L-1	-	70.0		70.0
	4.6. Storage Dam KL-1	34.0	-	M-1→KL-1	34.0
	4.7. Storage Dam SL-1	40.0	-		40.0
	Total	220.8	70.0		290.8
5. Head Works (Pump) at Soan river		6.4	-		6.4
6. Tube Wells for New Int. Air port		1.7	0.8		2.5
Grand Total		634.1	257.8		871.9
Total of Storage Dams's Resources		401.3	257.0		658.3
Ditto of Diversion Dams (incl.Head W.)		98.7	-		98.7
Ditto of Tube Wells		134.1	0.8		134.9

←Dor Conduction

←Khanpur Conduction

Demand	(Users and their Dimentions)
	1. Khanpur Dam project
57.7	1.1. Right Bank Irrigation
33.9	1.2. Left Bank Irrig. (exist.)
24.8 [1]	1.3. Wah
22.5 [2]	1.4. Taxila
138.9	Sub Total
102.3	2. Haro Left Area Irrigation 16,100hax7,077m³/ha/yr.x89.8% [3]
215.8	3. Urban Water Islamabad 563,000m³/day x 365 x 1.05
379.1	4. Urban Water Rawalpindi 989,100m³/day x 365 x 1.05
xxx.x	5. Rural Irrigation Islamabad (Under individual study by JICA)
6.4	6. Rawalpindi South Irrigation 900ha x 7,077m³/ha/yr.x100%
2.5	7. New International Air Port 1.5 MGD

Note; 1) from Wah Spring, 2) from Tube Wells.
3) Remains are by Small S. Lift Irrig.

The Allowance:
Resources(891.9) - Demand(845.0) = 46.9 MCM

Figure VII-4-1. Schematic Flow of Proposed Water Supply

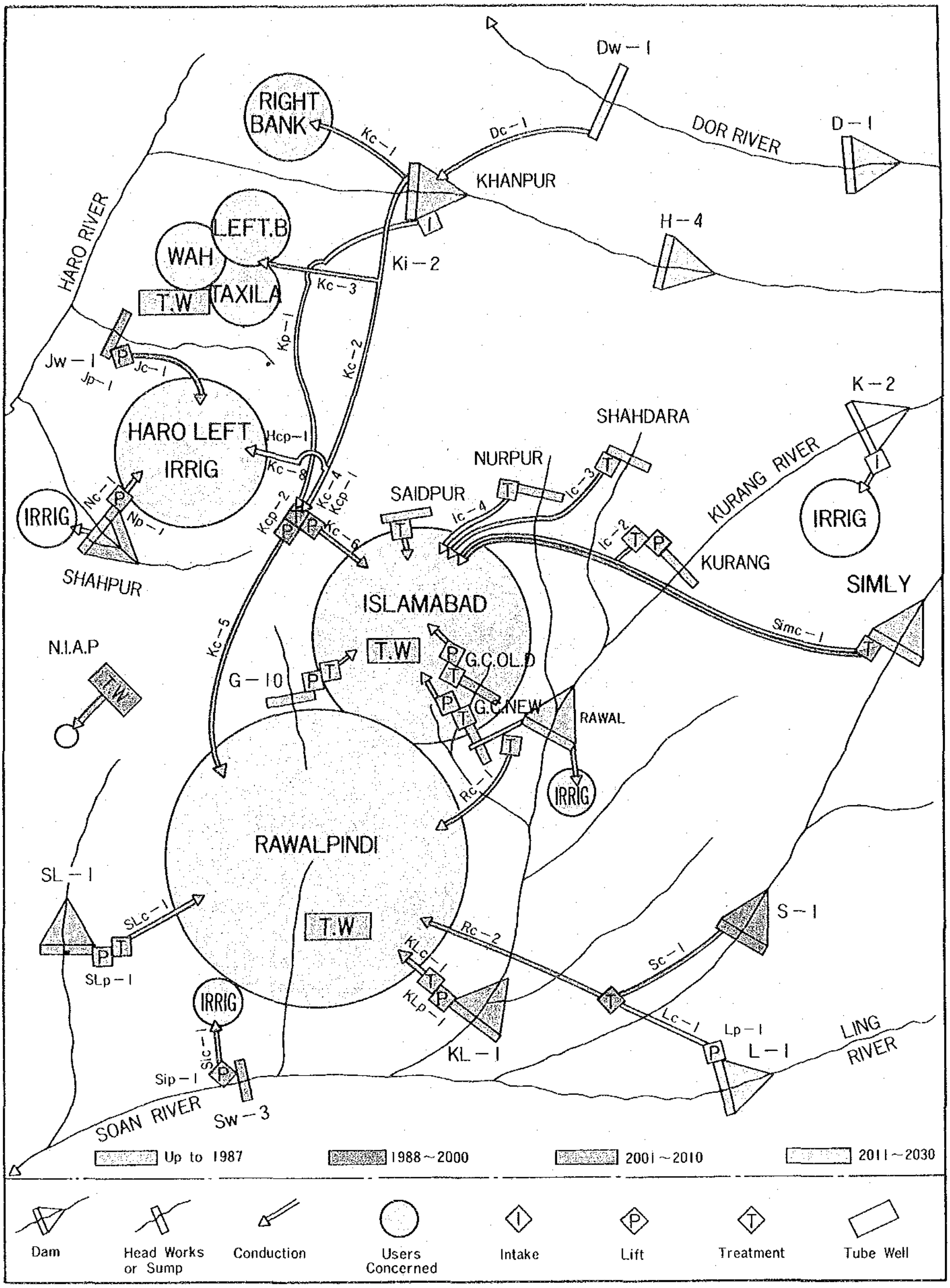


Figure VII-4-2. Development Scheme of Water Resources

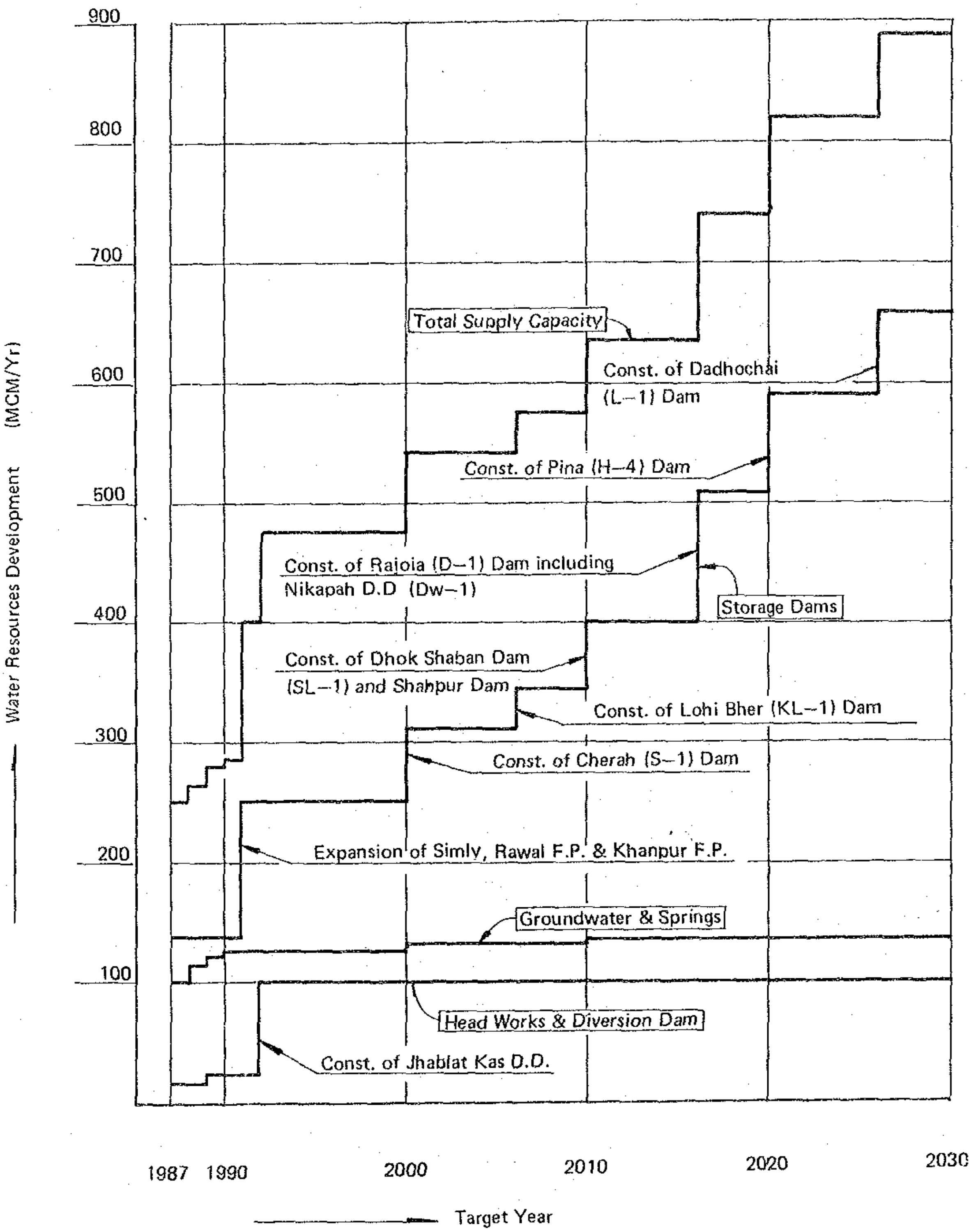
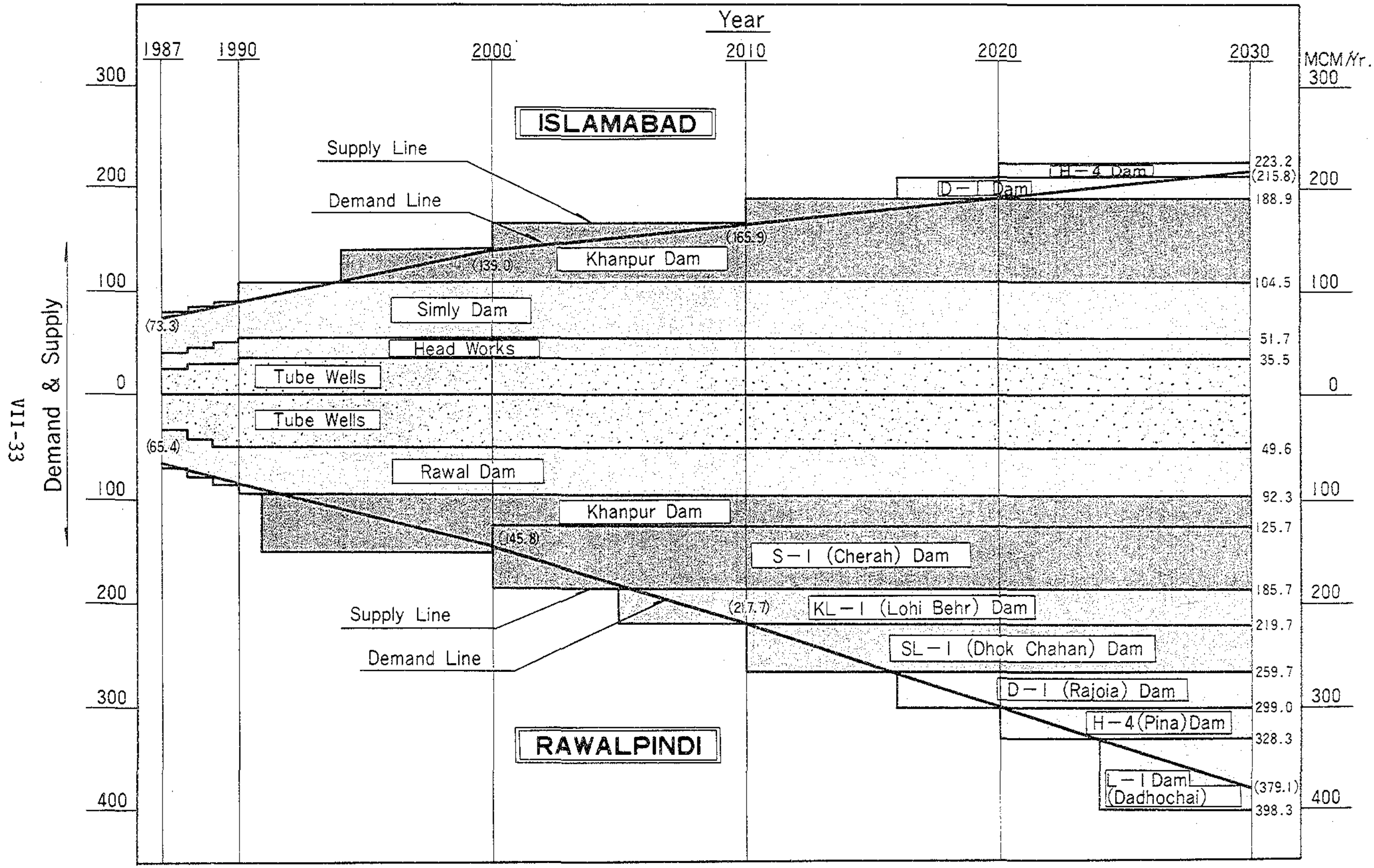


Figure VII-4-3. Chronological Growth of Water Demands and Supplies



7.4.3. Alternative Plans to the Restriction of Dor River and Kurang River

A. Alternative Plans to Dor Conduction

The study team was requested, against their proposal of Dor Transbasin Conduction in the first stage of the study, to investigate the alternative in case that the Dor river will not be available.

The proposal is to produce an amount as big as 107 MCM in annual average or about 16 percent of the total production of all the proposed resources (656 MCM). It is hard to find any other possibility than the Indus and the Jhelum lying on both western and northern borders of the study area.

However, if it is said that this necessity of alternative depends on the situation and possible water right of the Dor river which is pouring into the Indus upstream of the Tarbela dam, the alternatives of Indus and Jhelum also involve much problems. Therefore, they will be rough studied here only in technical manner.

Locations of these two alternatives are shown in Drawing No.8, 9 in Appendix D. Respective costs are roughly estimated as follows.

Costs for Construction and Operation/Máintenance

	Dor Canal		Jhelum Canal		Tarbela Canal	
	Construction Cost	O/M	Construction Cost	O/M	Construction Cost	O/M
Dam	1,173	5.5	-	-	-	-
Diversion Dam	131	3.9	-	-	-	-
Pumping Station	-	-	374	54	179	69
Canal	703	7.0	1,722	17	2,506	25
Total	2,007	16.4	2,096	71	2,685	94

B. Effective Utilization of Water Resources in Kurang River Basin

The study team has been requested to consider the optimum utilization of the Kurang river for the following two alternatives.

a. On the basis of existing production capacity of facilities of CDA, PHED and SDO (Irrigation).

b. On the basis of existing production and future extension proposals of CDA and PHED.

Although the water resources potential of the Upper Kurang river is being initially studied for irrigation scheme, it is very necessary to consider its comprehensive development so that any surplus water could be allocated for the Urban Water Supply.

Hence the production balance between (a)and (b) is only 11.4 MCM a year in an average which is within the allowance of the total water supply for the total demand of Islamabad in these target years 2010 and 2030, there may be not any serious drought even in case of (a).

CHAPTER VIII. IMPLEMENTATION PROGRAMMES

CHAPTER VIII. IMPLEMENTATION PROGRAMMES

8.1. Staged Development Plan of the Water Resources

As described in the previous chapter, the staged development plan of the water resources in the Metropolitan area should be established taking into account the water demand of respective sectors, economic stand- point of facility construction and other social infrastructures related. The project would be implemented over a 43-year period, starting in 1988 with the implementation of the first phase being followed by the second phase in 2001 and the third phase in 2011 to end in 2030. The phase-wise plans of water resources development can be summarized as follows.

(unit: MCM)

Target Year	Storage Dam	Diversion Dam	Tubewell	Total
1987 (Present)	136.5	15.1	99.3	250.9
2000 (1st phase)	173.5	83.6	29.4	286.5
2010 (2nd phase)	91.3	-	5.4	96.7
2020 (3rd phase)	257.0	-	0.8	257.8
Total	658.3	98.7	134.9	891.9
(Composition)	(73.8%)	(11.1%)	(15.1%)	(100.0%)

Around 100 MCM of the developed volume from tubewell sources as of 1987 includes 40 MCM of groundwater for both Wah and Taxila industrial complexes. Total volumes of 83.6 MCM from diversion dam in the year of 2000 consist of 77.2 MCM for irrigation water and 6.4 MCM for urban water supply.

As can be judged from the above table, most of the water resources to be developed are storage water from the main river and its tributaries. The shares of new storage water to those of total are about 81.4 percent. Technology of the dam planning and designing aspect as well as construction supervision in Pakistan is at a quite high level with many experiences, especially in Water and Power Development Authority. The schemes recommended in the report are rather on a preliminary study basis. The detailed investigations, survey, analysis and designing, therefore, should be carried out before the commencement of dam construction. The said comprehensive high technology shall be transferred from WAPDA to the implementing agencies concerned gradually based on the development time schedule.

Another important aspect to be considered is effective utilization of limited water resources. The allocation of river discharge in the Haro river basin, especially, is comparatively more complicated than in other river basins. The negotiation among beneficiaries concerned for the development scheme shall be done smoothly in accordance with the laws and regulations of the country and comprehensive plan on the water resources development availability.

8.2. Investment Cost

The total investment costs which consist of construction cost, land acquisition, office facility, administration/engineering, physical contingencies and the cost of terminal facility are estimated at Rs. 16,500 million, of which Rs. 5,340 million is for the first phase, Rs. 2,200 million for the second phase, Rs. 8,960 million for the third phase, respectively. The summary of required investment costs by phase is tabulated as follows.

Summary of Investment Cost

(unit: Rs. million)

Item	First Phase	Second Phase	Third Phase	Total
A. Major Facility	2,926.2	1,107.8	5,618.6	9,652.6
B. Land Acquisition	63.3	19.3	75.8	158.4
C. Office Facility	15.0	4.7	28.3	48.0
D. Engineering/Admin.	295.2	91.2	538.2	924.6
E. Phys. Contingency	329.3	122.0	625.1	1,076.4
Total	3,629.0	1,345.0	6,886.0	11,860.0
F. Terminal Facility				
- Urban Water	1,378.2	726.9	2,009.6	4,114.7
- Irrigation	328.7	123.6	60.3	512.6
- Airport Water	4.1	4.5	4.1	12.7
Total	1,711.0	855.0	2,074.0	4,640.0
Grand Total (A to F)	5,340.0	2,200.0	8,960.0	16,500.0

Also, the summary of required construction costs for water resources development facilities by source is tabulated as follows.

Construction Cost for Water Resources Development Facilities by Source

(unit: Rs. million)

Items	F/C	L/C	Total
1. Storage Dams	2,350.0	3,197.7	5,547.7
2. Head Works	83.8	75.3	159.1
3. Conductions	1,023.8	1,586.4	2,610.2
4. Lifts	436.3	398.1	834.4
5. Expansion Works	324.8	176.4	501.2
Total	4,218.7	5,433.9	9,652.6

8.3. Organizational Setup for Project Implementation

8.3.1. Basic Concept on the Organizational Setup of the Project

Implementation programmes of water resources development in the Metropolitan area are based upon an extra long-term concept with intermediate and ultimate target years set at 2010 and 2030, respectively. The development of the Metropolitan areas is expected to be increasingly stepped up in line with such a concept. At the same time, the administrative functions of Islamabad will necessarily be broadened and enhanced in parallel with such a development, including utilization and management of developed facilities.

In this connection, it will not be long before the need arises to consider the adjoining city of Rawalpindi functionally a part of the Metropolis or the Metropolis itself.

The water resources development for urban beneficiaries of the twin cities will center on the construction of dam for the storage of surface water. Such a development is, at the same time, inseparably interconnected with other kinds and purposes of water utilization and it is thus considered to be imperative that an integrated implementation organ for the coordination and adjustment of various conflicting factors will be established.

In this light the expected urban functions of Islamabad and Rawalpindi in the said target years will be studied on the premise that the twin cities will be merged into a single capital city in accordance with the request of the Pakistan Government.

8.3.2. Organization for Project Implementation

At present bulk water supply projects in Islamabad and Rawalpindi are executed by CDA and PHED, respectively. However, if the development of such large storage dams, as described in 8.1. of this chapter, is to be implemented, appropriate reorganization of related administrative organs and sufficient acquisition of competent engineers are indispensable as primary conditions.

WAPDA, which is one of the governmental authority under the Ministry of Water and Power, partook partially or wholly in the planning, designing and supervision of the construction of the three existing dams (Simly, Rawal and Khanpur), because domestic law and regulations dictated it and also they required advanced technology.

Urban water supply facilities include conduction facilities leading to filtration plants, and distribution systems besides water resources facilities. It is essential at the initial stage to draw up a construction plan that will enable those facilities to organically function as a single entity. With this in view, it would be necessary to examine an organization in the shape of a comprehensive organ encompassing operation and maintenance of constructed facilities or, further, a reorganization of urban water departments based on a "Greater Islamabad" concept.

The said reorganization will be executed stage by stage (up to 1990, 2000, 2010) taking into consideration the federal policies and urban development plan and its development progress for the Metropolitan area.

1) First Phase (up to 1990)

As described in the previous chapter, the Khanpur bulk water supply project is a joint construction programme of twin cities of Islamabad and Rawalpindi. Existing execution agencies of bulk water supply are CDA for Islamabad and PHED for Rawalpindi and they have their own expansion programmes of the Simly and Rawal filtration plants, respectively.

In parallel with the implementation of these expansion programmes, the Khanpur Bulk Water Supply Project Office will be newly established under Member Engineering of Capital Development Authority. It will perform planning, designing and construction supervision of the Khanpur Bulk Water Supply Project.

2) Second Phase (up to 2000)

Metropolitan Bulk Water Development Office directly under the control of CDA Chairman will be newly established (reorganized from Khanpur Bulk Water Supply Office) to perform planning, designing and construction supervision of the proposed dams (S-1, KL-1, SL-1 and heightening of the Shahpur dam) to be developed in and around the Metropolitan areas. It will be an organization independent and different from the existing one (first phase organization), and also it will absorb and incorporate development projects of other sources (tubewells and head works).

3) Third Phase (up to 2010)

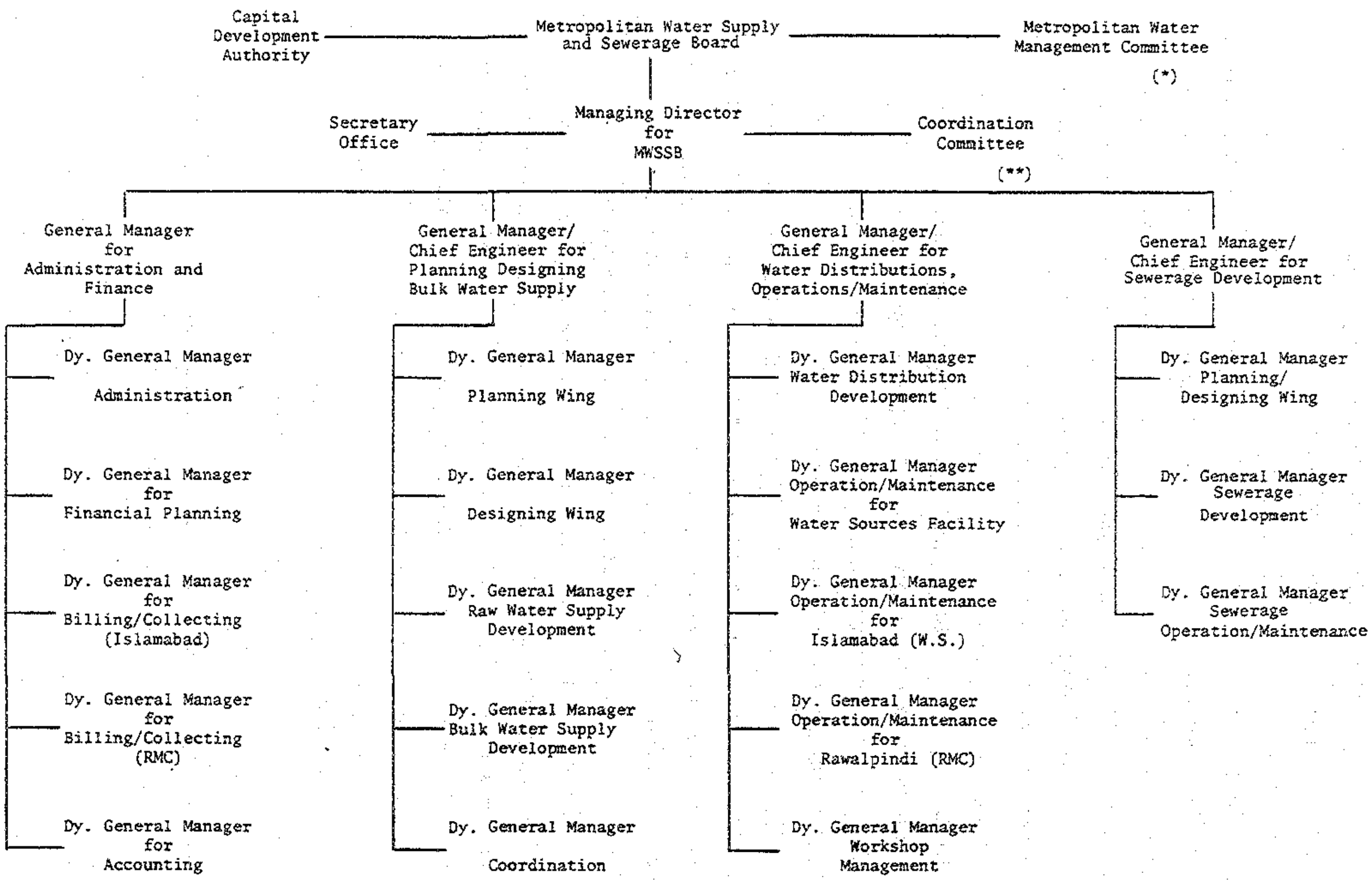
An independent organization technologically, financially and administratively capable of executing all projects related to water supply and sewerage will be established as a consummation of reorganizations in the preceding phases. It may be named Metropolitan Water Supply and Sewerage Board (MESSB). As shown in Figure VIII-3-1, Managing Director tops this organization, who appoints four General Managers under him. They manage the respective fields of administration/finance, planning/designing and bulk water supply, water distribution and operation/maintenance (Islamabad and RMC in Rawalpindi only) and sewerage facility development.

The existing organizational set-ups for water supply and sewerage in both Karachi and Lahore, which have revolved over many years resemble the proposed organizational set-up. It is proposed that the envisaged organizational set-up under the Project be expanded/elevated through gradual processes and that particular emphasis be placed on the development/acquisition of sufficient number of competent personnel and the elevation of technology in every related field.

MWSSB will be organizationally placed directly under the Chairman of CDA, but at the same time it will be independent from CDA in respect of finance, personnel, technology and project implementation. If such a situation is to be realized, consolidation of financial basis will be a prerequisite along with organizational expansion. Such a consolidation shall be accomplished by the end of the second phase.

In developing water resources for the Metropolitan areas the needs will arise for adjustments/coordinations among various interested parties, divisions and ministries. To facilitate the execution and management of projects Metropolitan Water Management Committee will be established as the supreme advisory and decision-making organ. This committee, besides performing the said function, will make deliberations and decision-making on such important matters as budgetary plan, financial/investment/borrowing plans, various development plans and execution of water supply and sewerage projects. Furthermore, Coordination Committee will be established under the Managing Director of MWSSB as an organ in charge of multi-purpose dams, coordination with administrative organs in Rawalpindi Cantonment, adjustments of interest among various related beneficiaries and consultations on project execution.

Figure VIII-3-1. Proposed Organization of MWSSB (Third Phase)



(*) Member of MWMC: Ministry (Division) of Planning/Development
Ministry of Water/Power
Ministry of Health
Ministry of Finance
Ministry of Agriculture/Food
Ministry of Defence
Ministry of Industry
CDA and WAPDA
Government of Punjab
Government of NWFP

(**) Member of CC: Ministry of P&D
Ministry of Water and Power
Ministry of Health
Ministry of Defence
Ministry of Industry
CDA
Government of Punjab
Government of NWFP

8.4. Special Aspects to be Improved on Operation and Maintenance

8.4.1. Sediment Control

The amount of sediment discharge to a river will be increased depending on the topography, geological features, foliage characteristics, land use and so on in the river basin.

With the development of reservoir dams the control of sediment discharge has become a major problem. Looking at reservoirs there is a close connection between the size of their storage capacities and the number of years they have been imbedded by sediment and the length of their lives.

Concerning the reservoir sedimentation problem, it is said that "prevention is the best cure". When sediment accumulates in a reservoir its removal is generally difficult and costly. A watershed management scheme for the prevention of sedimentation should, from the point of view of the environment, be implemented taking into account the amount of sediment discharged. The amount of sediment discharged is an indicator of a measure's effectiveness.

The main details of currently implemented or planned watershed management programs in the three catchment areas have been brought together under the following headings.

1) Forest Plantation
2) Forest and Fruit Nurseries
3) Soil and Water Conservation
4) Pasture Management

The followings are considered to be the main problems, from the point of view of the progress status of the watershed management programs and conditions in the areas concerned, in the implementation of the programs.

The main components relating to sediment discharge in the basins are as follows;

(i) The progress of terracing, which was proposed as a measure to prevent the discharge of sediment from the agricultural areas, has been slowed down because of the absence of farmers from their lands.

(ii) Along with the immediate implementation of soil relating works and protective construction at the sites of collapses and land slides the excavation (illegal extraction) of aggregate at quarry site should be regulated and wasted lands replenished.

(iii) The trend is for sediment yield and discharge per unit area to become larger from the urbanized areas which accompany the construction of housing areas than from agricultural areas. Therefore, it is necessary to regulate the expansion of urban and agricultural areas.

(iv) For denuded lands without surface covering sodding work and mulching to breed effective vegetation should be employed and surface covering provided. Erosion of the land due to water and wind progresses when vegetation is lacking. The land should be covered with bushes, various trees, grasses or vegetation to prevent erosion due to rain. This will increase infiltration into the ground and decrease runoff.

The following items are related to sedimentation in reservoirs and the monitoring of sediment runoff.

(i) The establishment of monitoring facilities for precipitation, river discharge, suspended sediment load, and water quality.

(ii) The analysis of observation results.

(iii) Knowledge of sediment conditions.

The results of the above investigations will be analyzed to facilitate the planning and implementation of more appropriate measures.

The following are suggestions concerning the management of sedimentation:

(1) Continuous Planning

It is necessary that plans for afforestation and soil conservation in a watershed management scheme is prepared in steps, that each step is carried out continuously and over a long period of time, and that each step is expanded.

(2) Monitoring and Evaluation

There is a close connection between the hydrological characteristics of a basin and sediment yield, transportation and accumulation. These are thought to be the main factors determining a basin's hydrological characteristics. Discharge observation and analysis of the data obtained are necessary to shed light on how to reduce sedimentation.

Watershed management programs are implemented for the purpose of preventing sediment discharge. Sediment yield is considered to be a scale by which to measure the effectiveness of the works implemented. A program may be evaluated using the relationship between the amount of work done in the catchment area and the amount of sediment discharged.

In order to know how much sediment is discharged it is necessary to establish gauging stations and collect rainfall, discharge and sediment accumulation data. This is then analyzed and the watershed management program may then be evaluated to assure a dam's functioning.

A monitoring system flow chart is shown in Figure VIII-4-1 and a study of monitoring and sedimentation is shown in Table VIII-4-1.

Along with a monitoring system, the use of Landsat data will make it possible to obtain a wide variety of information on sedimentation, sediment discharge, topography, geological features, and changes in foliage, etc. This data will prove valuable in the planning of a watershed management program.

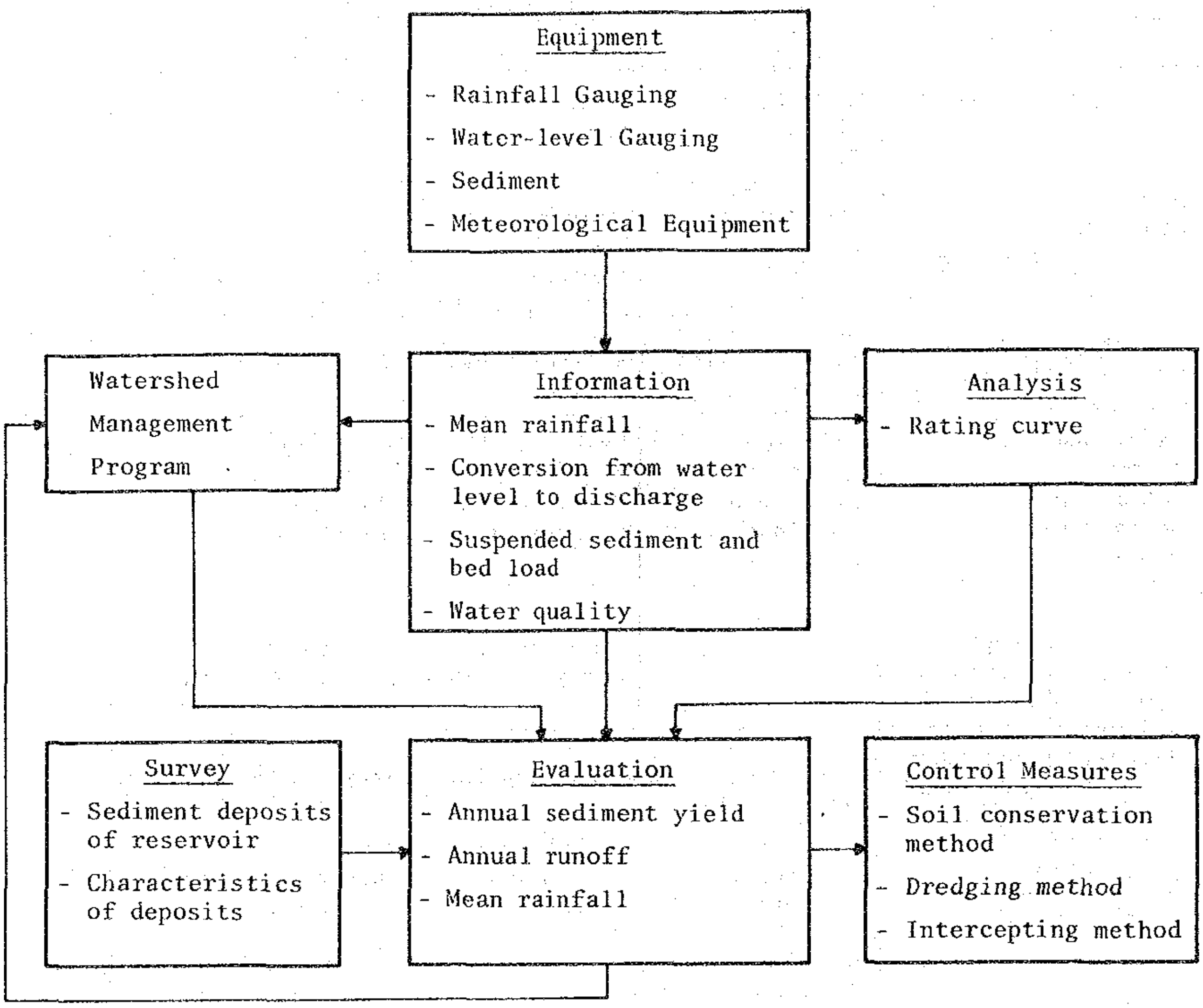
(3) Sediment Removal

The method used to remove sediment depends on the distribution state of sediment in a reservoir. Before planning is done it is necessary to conduct a sedimentation study. In selecting a method, feasibility, effectiveness and construction costs need to be considered and the most feasible method employed.

Table VIII-4-1. Monitoring and Survey of Sedimentation

<table>
<tr><th colspan="2"></th><th>RAWAL</th><th>SIMLY</th><th>KHANPUR</th><th>PRIORITY</th></tr>
<tr><td rowspan="2">Rainfall gauging station</td><td>Existing</td><td>60 Bari Kangran
651 Rawal dam</td><td>533 Murree</td><td>62 Barkot
383 Khanpur</td><td rowspan="2">2</td></tr>
<tr><td>Proposed</td><td>3 stations newly</td><td>2 stations newly</td><td>5 stations newly</td></tr>
<tr><td rowspan="2">Water level gauging stations</td><td>Existing</td><td>KRGO 2.
Chhattar
KRGO 1.
Bari Kangran</td><td>SONO 1.
Chaniot</td><td>Khanpur</td><td rowspan="2">2</td></tr>
<tr><td>Proposed</td><td>1 station newly</td><td>1 station newly</td><td>Haro R. 1 station
Nilan K. 1 station</td></tr>
<tr><td colspan="2">Suspended sediment observed and test</td><td>Near by water level gauging station</td><td>Same as Rawal</td><td>Same as Rawal</td><td>2</td></tr>
<tr><td colspan="2">Water Quality</td><td>- do -</td><td>- do -</td><td>- do -</td><td>3</td></tr>
<tr><td colspan="2">Watershed Management Program</td><td>Need to be continued with maintenance</td><td>Continuation of program</td><td>As soon as possible</td><td>1</td></tr>
<tr><td rowspan="2">Survey of sediment deposits</td><td>Hydro-graphic survey of reservoir</td><td>——</td><td colspan="2">Complete survey of reservoir (Longitudinal and cross-section)</td><td>2</td></tr>
<tr><td>Characteristics of deposits</td><td colspan="3">Boring or trenching, sampling, testing (Density and gradation)</td><td>3</td></tr>
<tr><td colspan="2">Apply to removal</td><td>Dredging method</td><td>Dredging method</td><td>Dry excavation method</td><td>4</td></tr>
<tr><td colspan="2">Survey of applied method</td><td colspan="2">1. Disposal area
2. Transfer distance
3. Field test
- friction loss
- critical velocity
- abrasion of pipe</td><td>1. Disposal area
2. Access road
3. Field test
- workability</td><td>5</td></tr>
</table>

Figure VIII-4-1. Monitoring System



8.4.2. Recommendation on the Future Operation/Maintenance for the Existing Dams (Rawal, Simly and Khanpur)

A. Present Status on the Operation/Maintenance of the Existing Dams

The three existing dams were constructed in adjacent river basins and have functioned as independent dam projects for the purpose of urban water supply and or irrigation to each beneficiary. The dams have not functioned as one of the dam series which have been proposed in this Report for the water resources development for the Metropolitan area of Islamabad/Rawalpindi.

The organizations of each beneficiary are complicatedly consisted of several organizations. For instance, the Khanpur Dam has been constructed to provide water to Islamabad and Rawalpindi for domestic purposes, to the various industries at Wah and Taxila for industrial purposes and to culturable command areas of both the Left and Right Bank Canal for irrigation purposes.

Generally speaking, the operation of reservoirs is carried out in order to satisfy the purposes of the projects, such as water supply, hydro-electric generation and flood control, etc.

Because the three dams have only the purposes of water supply, the operation of intake gates and spillway gates is required for the operation of the reservoirs.

Intake gates are operated in accordance with the operation rules based on seasonal water demand flunctuations. They are operated manually because the size of intake gates is rather small and daily changing of gate openings and the operation to correspond to inflow discharge into the reservoir are not required. For these reasons, the overall catchment area hydrological data collection systems have not been prepared.

Spillway gates are operated in accordance with the operation rules corresponding only to fluctuations in reservoir water level.

Data collecting systems which would enable inflow discharge into a reservoir to be forecast are lacking as mentioned previously.

The hoists of spillway gates are both automatic and manually operated, but auxiliary power systems, such as engine generators in the case of electric failure, are not provided at present.

The maintenance of dam facilities is carried out in order to secure the functions of facilities necessary for satisfying the purpose of the dam projects. The facilities to be maintained are dambodies, spillways, intake structures, outlet works and mechanical equipments, etc. Besides these facilities, the prevention measures for securing the storage capacities and the water qualities, described in 8.4.1, are to be considered.

Maintenance works are mainly consisted of daily patrol, routine inspection, special inspection, monitoring and remedial works for dambodies and appurtenant structures.

Maintenance of the three dams is appropriately carried out corresponding to the types of dams and the passage of time after completion.

B. Assessment of the Present Operation/Maintenance System

It is recommended that the three existing dams be provided with modernized dam operation/control systems including hydrological gauging stations with telemetering systems, dam data processing systems and discharge warning systems in the final stage, and that the present gate operation rules shall be improved to include the rules relating to inflow discharge into the reservoir.

The major reasons for these recommendations are summarized as follows;

- To utilize water resources effectively by reducing undesirable spillage during moderate intensity floods through the integrated operation of dam series including the dams newly proposed in this study.
- To obtain data useful to the dam discharge warning system which are expected to be greatly required in near future at downstream of dam.
- To obtain data useful to judge the fluctuations of water demands at each beneficiary, especially during rainy seasons.
- To secure the safe operation of spillway gates by preventing rapid increases in reservoir water level by forecasting inflow discharge into the reservoir during extraordinary floods which will have flashy flows with high peaks of short duration.

C. Improvement Schedule of Dam Operation/Control System

The three existing dams are expected to function not only as individual dams, but also as one of the most important parts of dam series necessary for water resources development to serve the Metropolitan area.

The schedule for the improvement of dam operation/control systems should follow the schedule for the water resources development programs.

Table VIII-4-2 shows the items to be improved and schedules of dam operation/control systems of the existing dams.

(1) *First Stage (Up to 1990)*

The year of 2000 is considered to be the target year for the extension program of the three existing dams. The said dams will function as individual water supply dams up to this year. Therefore, a modernization of dam operation/control systems is not necessarily required.

But, the safe operation of spillway gates is indispensable to the safety of dam itself.

1990 shall be the target year for improvements taking the safety of the dams into consideration.

(2) Second Stage (Up to 2000)

The extension program for the three existing dams will be completed by the year 2000. The construction of the proposed dam series will then be commenced.

After the year 2000 the existing dams will play important parts in the dam series for water resources development. They shall be provided the modernized dam operation/control systems so that water resources developed may be utilized effectively.

Such modernized systems shall also be provided for the proposed new dam series.

(3) Third Stage (Up to 2010)

The eight dams including the three existing dams will be completed by the year 2010, contributing to water supply for the Metropolitan area.

Around this year several dam series in a same river basin will be completed and necessity of dam series operation will be emphasized.

The Central Dam Operation/Control Office will integrate all informations on dam operation/control for the related river basins. They shall be established under the supervision of the Integrated Organization described in 8.3 at proper locations in the river basins.

The Central Dam Operation/Control Office which integrate concerned dams, will be established in the following two river basins.

Haro & Dor river basin	:	Khanpur, D-1, H-4, Shahpur
Soan river basin	:	Rawal, Simly, S-1, L-1, KL-1, SL-1

At this stage the forecasting of rainfall in the catchment area concerned will become a very important factor in the effective utilization of water resources.

It is recommended that the hydrological data collection systems be connected with the existing hydrological transmission networks established by such organizations as WAPDA and Pakistan Meteorological Department (PMD), and be utilized either for efficient utilization of water resources, or for flood forecasting and warning in conjunction with the Federal Flood Commission (FFC).

Table VIII-4-2. Improvement Schedule of Dam Operation/Control System

		1st Stage (Upto 1990)	2nd Stage (Upto 2000)	3rd Stage (Upto 2010)
Hydrological Data Col-lecting System	. Rain Gauge	Manual Type	Automatic Record Type (Tilting Rain Gauge)	Radar rain Gauge System
	. Water Level Gauge (Discharge)	Water Staff Gauge	Automatic Record Type (Float Type Water Level Gauge)	
	. Trans-mission	Telephone	Telemetering System	
Dam Data Processing System		Manually	Electronic Computer System	
Discharge Warning System		Near the Damsite by Siren	Siren/Speaker by Telemetering System	
Gate Operating Facilities		Spillway; engine generator	All gates to be mobilized and engine generator	
Dam Operation/Control Office		Existing Dam Office	New Dam Operation/Control Office	Connection to Central Dam Operation/Control Office

CHAPTER IX. EVALUATION OF THE WATER RESOURCES DEVELOPMENT PLAN

CHAPTER IX. EVALUATION OF THE WATER RESOURCES DEVELOPMENT PLAN

This is the master plan study of a multi-project consisting of seven major components which is estimated to require the initial cost of Rs. 16,500 million and spans the implementation period of over forty years.

Financial analysis will be necessary as well as useful to grasp the overall picture on the viability of the Master Plan from the standpoint of actual project implementation as related to the executing organization.

Assessing the viability of the Plan piece by piece by separating each component will lead one to an erroneous conclusion that some components are viable, while others are not, thereby disrupting the notion of the Plan as one entity.

Furthermore, the Study Team deems it most important for water authorities which will directly get in touch with the implementation and operation/maintenance of the Project to place themselves financially on a sound basis in light of a problematic financial status of the existing Metropolitan water supply authorities. The fact that the Project is a water supply project and as such involves basic human needs does not justify a lack of financial discipline on the part of the authorities concerned. Especially, it is estimated that over forty percent of the initial cost will be met through external loans and it is essential that the authorities concerned will have clear-cut basic policies and eventually set their houses in order in pursuance of them to induce or convince international or foreign lenders into loan agreements in a smooth, favorable manner.

In line with the above concept, the Study Team tried to provide basic guidelines on such financial matters as water tariffs, ability to pay of households as percentage of their income, the standard

FIRR and relending terms on which the Government will provide capital to the water authorities.

9.1. Project Benefits

The benefits to be brought forth by the realization of the Project can be divided into urban water benefits and irrigation benefits in accordance with the ultimate usages of developed water resources. These two kinds of benefits are further divided into financial benefits and economic benefits.

Financial benefits of urban water take the form of the income to be received by the organizations in charge of construction and operation/maintenance of the facilities for water resources development and water supply in exchange for the supply service of urban water. Financial benefits of irrigation are an incremental income for the farming beneficiaries, deriving from a greater agricultural/livestock produce. Economic benefits are the benefits to be brought forth by the supply of urban and irrigation water which are assessed in terms of national economy.

The facilities to be constructed under the Project do not include distribution and other facilities for urban water as well as channel and other facilities for irrigation. However, benefits of the Project will be realized only when the above facilities are constructed. Therefore, in project evaluation it is necessary to estimate the initial and operation/maintenance costs of those terminal facilities and incorporate them into project costs.

9.1.1. Urban Water

A. Financial Benefits

Financial benefits of urban water depend on the water rates water supply authorities will impose on beneficiaries per unit quantity of consumption. Such water rates must be determined in the most appropriate manner by assessing both beneficiaries' paying ability and financial position of water supply authorities.

Assuming that the price of the urban water to be supplied under the Project is Rs.2.53 per 1,000 lit. (Rs.11.50 per 1,000 gal.), then households will pay Rs.2.09 per 1,000 lit. (Rs.9.50 per 1,000 gal.) on the premise that the price for commercial/industrial users is twice as high as that for domestic/public users. In such circumstances households will allot 2.5 percent of their income for water payment. Upon these conditions financial internal rate of return (FIRR) is calculated at 5.2 percent.

The value of 2.5 percent as the ratio of water payment to income in home economy is considered to be one of the most appropriate standard values: It is within the maximum limit of 5 percent recommended by World Bank and also within the realistic and reasonable limit of 3 percent. According to the same bank, water supply projects seldom have internal rates of return equal to or greater than 6 to 8 percent. It would not be reasonable, nor realistic to apply long-term interest rate of 14 percent in the country to water supply projects as the acceptable FIRR, as such projects are highly social in nature, involving basic human needs. 5.2 percent is considered to be one of the most appropriate standard values of FIRR for water supply authorities.

It is thus decided that financial benefits of urban water to be supplied under the Project will be Rs.2.53 per 1,000 lit. (Rs. 11.50 per 1,000 gal.) as of 1987. Unit benefits will grow in future in parallel with the growth of beneficiaries' income.

B. Economic Benefits

Economic benefits of urban water are not calculated on the basis of unit cost of production. They are basically determined by beneficiaries' willingness to pay for unit quantity of consumption. Such a willingness to pay can be regarded as an expression of intrinsic values or benefits beneficiaries attach to the urban water. The greatest and foremost benefit among them is a reduction of diseases to be brought about by the introduction of clean water. The second benefit is a saving of the time that is spent every day in fetching water from rivers, ponds, etc. There are other benefits like the benefit to derive from the use of water for fire-fighting. If these individual benefits were expressed in quantitative or money terms, it would provide the most accurate picture of economic benefits of urban water.

But it is difficult in reality and thus beneficiaries' willingness to pay is substituted as an all inclusive expression of those benefits.

According to socio-economic surveys conducted by the Study Team, the beneficiaries in the Metropolitan areas are on average willing to pay Rs.1.77 per 1,000 lit. (Rs.8.05 per 1,000 gal.).

Table IX-1-1. Willingness to Pay

(unit: Rs./1,000 lit. (Rs./1,000 gal.))

1. User	Domestic	Public	Commercial/ Industrial	Average
2. Willingness to Pay	1.44 (6.55)	1.77 (8.05)	2.61 (11.87)	1.77 (8.05)

Source: EC-1

User wise willingness to pay are shown in Table IX-1-1.

Domestic users are willing to pay Rs.1.44 per 1,000 lit. (Rs.6.55 per 1,000 gal.). It means that they will spend 1.7 percent of their income as water payment. It is assumed that their willingness to pay will grow in future in parallel with the growth of their income. This will also be applied to other users.

9.1.2. Irrigation Water

A. Financial Benefits

It is expected that agriculture in the beneficiary areas will witness a remarkable growth of income through the elevation of cropping intensity, improvement of cropping pattern, increase of production per unit cropped area, etc. when irrigation water is supplied to those areas under the Project.

Table IX-1-2. Financial Benefits of Irrigation

(unit: Rs. million)

Item	Gross Income	Net Income
1. "Without" Situation	73.51	27.67
2. "With" Situation	548.48	207.94
3. "With" - "Without"	474.97	180.27

Source: EC-1

It is estimated that when irrigation water of 120.3 MCM is supplied per annum to the service areas of 17,000 ha under the Project, cropping intensity in the areas will go up from the present 111 percent to 140 percent, the present cropping pattern where wheat and other grains are dominant will be transformed into the pattern that gives priority to high income crops such as vegetables, orchards, sugarcane and fodder, and unit production of crops will shoot up two to four fold. As a result, as shown in Table IX-1-2, annual gross income from agriculture in the areas will grow by Rs.474.97 million (646%) and in parallel with it annual net income will grow by Rs.180.27 million (651%).

In short, the annual financial benefits of irrigation under the Project will be Rs.180.27 million. It means that annual financial benefits per farming household will be Rs.16,886. Also, financial benefits per 1,000 lit.(1,000 gal.) of irrigation water will be Rs.1.50 (Rs.6.82).

B. Economic Benefits

Sometimes it happens as a result of conversion processes that significant difference arises between actual output prices/input costs and economic counterparts depending on the presence/amount of agricultural subsidies, economic environment exemplified by unemployment rate, etc., weight/importance of imports in inputs and so forth. In such cases, ultimate economic benefits from irrigation may significantly differ from financial ones.

However, the factors that will significantly change financial benefits are considered under the present circumstances to be non-existent. Actually, there is no significant difference between the agricultural prices adopted by the Study Team and corresponding world prices. Moreover, there is an inherent limitation on the depth of analysis for this study in that it is a master plan study and not a feasibility study.

Because of the above reasons, so far as irrigation is concerned, economic benefits are considered to be equal to financial benefits.

9.1.3. Airport Water

The New International Airport, the user of the urban water to be supplied belongs to public institutions and accordingly in accordance with the custom in the country financial benefits of the urban water for the user are assumed to be the same with those for the domestic user, i.e. Rs.2.09 per 1,000 lit. (Rs.9.50 per 1,000 gal.). Unit financial benefits are assumed to grow in future in parallel with the growth of the user's income.

Economic benefits of the airport water are assumed to be equal to the willingness to pay of Metropolitan public beneficiaries, i.e. Rs.1.77 per 1,000 lit. (Rs.8.05 per 1,000 gal.). Unit economic benefits are assumed to grow in future in parallel with the growth of the user's income.

9.2. Water Tariff

9.2.1. Water Tariff for Urban Water

It is assumed that under the Project the charges for the consumption of urban water by the beneficiaries will be collected under a single and complete quantity rate system.

The total average unit rate of urban water will be Rs.2.53 per 1,000 lit. (Rs.11.50 per 1,000 gal.) as of 1987. User wise, on domestic/public users Rs.2.09 per 1,000 lit (Rs.9.50 per 1,000 gal.) and on commercial/industrial users Rs.4.18 per 1,000 lit. (Rs.19.00 per 1,000 gal.) will be imposed. Household income is estimated to grow at an average annual rate of around 3 percent in future in parallel with the growth of the economy. Water rate for domestic users, i.e. households will grow at an average annual rate of around 2 percent in parallel with the growth of household income on the premise that water payment is 2.5 percent of household income. Water rates for other users are assumed to grow in a similar way as the growth of domestic water rate.

What is described above is total and user wise average rates of urban water. The Study Team would like to emphasize here that as urban water is one of basic human needs establishment of an elaborate tariff based on the quantity of consumption is called for especially for domestic users. At present Metropolitan households on average consume 32.54 m^3 of urban water per month. If minimum requirement of urban water per capita per day is assumed to be 20 to 50 lit., requirement per household per month works out at 4.37 to 10.92 m^3 as average number of household members is 7.28. It is recommended that extremely low rates will be imposed up to this range, but once it is exceeded rates will be progressively raised. But, the tariff will be so structured that average rate for the total quantity of urban water to be consumed by domestic users will be as mentioned above. To make such a tariff statistics on the number of households by monthly quantity of consumption is required.

9.2.2. Water Tariff for Irrigation Water

As already described the irrigation water to be developed under the Project will bring forth the benefits of Rs.1.50 per 1,000 lit. (Rs.6.82 per 1,000 gal.). There arises a problem that out of that amount how much the authorities should collect from farmers. Analysis reveals that out of Rs.1.50 Rs.0.37 is made up of operation and maintenance cost. And the rest is consisted of investment cost and profit. The Study Team proposes that farmers bear the cost corresponding to 80 percent of O/M cost, i.e. they pay Rs.0.30 per 1,000 lit. (Rs.1.36 per 1,000 gal.) and the remaining Rs.1.20 per 1,000 lit. (Rs.5.46 per 1,000 gal.) be shouldered by the Federal Government in the form of subsidy.

Average annual water requirement and gross income per farming household are estimated at 11,268 m^3 and Rs.56,375, respectively. Consequently, a farming household will on average spend Rs.3,365 or 6.0 percent of its income per annum as water payment upon the above premise.

9.3. Project Evaluation

It is estimated that under the Project annual end demand for water amounting to 551.0 MCM will newly arise during the period 1988 to 2030, and to cope with it initial and O/M costs related to water resources development facilities amounting to Rs.11,860.0 million and Rs.189.0 million, respectively will be required.

Furthermore, it is preliminarily estimated that initial and O/M costs related to distribution and other facilities amounting to Rs.4,640.0 million and Rs.162.6 million, respectively will be required.

Project life is assumed to be 50 years, ranging from 1988 to 2037. Project implementation period is assumed to be 43 years, starting in 1988 and ending in 2030.

Financial evaluation is an analysis from the standpoint of water authorities. Whereas, economic evaluation is an analysis from the viewpoint of national economy.

When initial costs for water resources development facilities and the same costs for distribution and other facilities are converted into economic values by subtracting transfer payment such as customs duty and taxes from them, one gets Rs.8,865.8 million and Rs.3,859.6 million (preliminary estimate), respectively. Their respective conversion factors are 74.75 percent and 83.18 percent. Conversion operations were not performed on O/M cost.

Evaluations are done by target year and by beneficiary. That is to say, financial and economic evaluations are conducted for a project with the target year of 2010, a project with the target year of 2030, an urban water supply project, an irrigation water supply project and an airport water supply project.

On the ground already mentioned, the Study Team proposes the value of 5 percent as the standard FIRR for a water supply project. As the economic opportunity cost of capital the Team adopts the value of 12 percent which Planning Commission in the country recommends.

9.3.1. Financial Evaluation

A. Evaluations by Target Year

a. Target Year: 2010

Demand for urban, irrigation and airport water in the intermediate target year of 2010 under the Project is estimated to add up to 334.9 MCM.
To meet it initial cost of Rs.7,540.0 million and O/M cost of Rs.233.1 million will be required as shown below.

Table IX-3-1. Project Cost, Target Year: 2010

(unit: Rs. million)

Item	Initial Cost	O/M Cost
Water Resources Development	4,974.0	144.2
Distribution & Others (Preliminary Estimates)	2,566.0	88.9
Total	7,540.0	233.1

Source: EC-1

Financial analysis reveals that the project has the FIRR of 5.0 percent. It is equal to the standard FIRR and shows that this project, incorporating water supply sector as a major component can be said to be feasible upon the above-mentioned premises on benefits.

b. Target Year: 2030

The ultimate target year for the Project is 2030. Therefore, the ultimate financial justification of the Project is done for this case.

The combined demand for urban, irrigation and airport water in 2030 under the Project is estimated at 551.0 MCM.

To meet it initial cost of Rs.16,500.0 million and O/M cost of Rs.351.6 million will be required as shown below.

Table IX-3-2. Project Cost, Target Year: 2030

(unit: Rs. million)

Item	Initial Cost	O/M Cost
Water Resources Development	11,860.0	189.0
Distribution & Others (Preliminary Estimates)	4,640.0	162.6
Total	16,500.0	351.6

Source: EC-1

Financial analysis reveals that the Project has the FIRR of 5.4 percent. It is higher than the standard FIRR of 5 percent by 0.4 percent and shows that the Project, incorporating water supply sector as a major component has a sufficient viability upon the above-mentioned premises on benefits.

B. Evaluation by Beneficiary

Demand for urban, irrigation and airport water in 2030 under the Project is estimated at 428.2 MCM, 120.3 MCM and 2.5 MCM, respectively. To meet it the respective initial costs of Rs.14,989.3 million, Rs.1,493.6 million and Rs.17.1 million, and the respective O/M costs of Rs.305.6 million, Rs.44.9 million and Rs.1.1 million will be required as shown below.

Table IX-3-3. Project Cost by User

(unit: Rs. million)

Item	Citizens	Farmers	Airport
1. Initial Cost			
1) Water Resources Development	10,874.7	980.9	4.4
2) Distribution & Others (Preliminary Estimates)	4,114.6	512.7	12.7
3) Total	14,989.3	1,493.6	17.1
2. O/M Cost			
1) Water Resources Development	155.4	33.0	0.6
2) Distribution & Others (Preliminary Estimates)	150.2	11.9	0.5
Total	305.6	44.9	1.1

Source: EC-1

Financial analysis reveals that urban, irrigation and airport water supply projects have the respective FIRR's of 5.2, 6.3 and 19.0 percent.

The urban water supply project occupies a dominant position in the Project and consequently has an FIRR similar to that of the whole project. It is almost equal to the standard value of 5 percent and shows that the project is feasible if aforementioned premises are applied to benefits. The irrigation water supply project has an FIRR by 7.7 percent below the long-term lending rate of 14 percent in the country. However, the project is vital for the ever-growing future population in the Metropolitan areas in that it will supply them with ample fresh vegetables and fruits, thereby promoting and ensuring their nutritional balance and health. Consequently, it is ultimately judged to be financially feasible. This project has an FIRR greater than that of the urban water supply project and therefore it has a higher priority than the latter from the standpoint of financial analysis. The FIRR of airport water supply project is by 5 percent higher than the long-term lending rate in the country. The beneficiary is to engage in an international business and its profitability is considered to be high and as such the above value can be regarded as reasonable.

9.3.2. Economic Evaluation

A. Evaluations by Target Year

a. Target Year: 2010

Demand for urban, irrigation and airport water in the intermediate target year of 2010 under the Project is estimated to add up to 334.9 MCM.

To meet it initial cost of Rs.5,997.2 million and O/M cost of Rs.233.1 million in economic terms will be required as shown below.

Table IX-3-4. Economic Project Cost, Target Year: 2010

(unit: Rs. million)

Item	Initial Cost	O/M Cost
1. Water Resources Development	3,862.8	144.2
2. Distribution & Others (Preliminary Estimates)	2,134.4	88.9
3. Total	5,997.2	233.1

Source: EC-1

Economic analysis reveals that this project has the economic internal rate of return (EIRR) of 3.8 percent. It is lower than the opportunity cost of capital of 12 percent by 8.2 percent. However, because of the reasons enumerated in b. this project is judged to be economically feasible.

b. Target Year: 2030

The ultimate target year for the Project is 2030. Therefore, the ultimate economic justification of the Project is done for this case.

The combined demand for urban, irrigation and airport water in 2030 under the Project is estimated at 551.0 MCM. To meet it initial cost of Rs.12,725.4 million and O/M cost of Rs.351.6 million in economic terms will be required as shown below.

Table IX-3-5. Economic Project Cost, Target Year: 2030

(unit: Rs. million)

Item	Initial Cost	O/M Cost
1. Water Resources Development	8,865.8	189.0
2. Distribution & Others (Preliminary Estimates)	3,859.6	162.6
3. Total	12,725.4	351.6

Source: EC-1

Economic analysis reveals that the Project has the EIRR of 4.2 percent. It is lower than the opportunity cost of capital of 12 percent by 7.8 percent. However, as already described, it is rare that a water supply project has an internal rate of return equal to or more than 6 percent. Also, it is difficult to directly quantify economic benefits and when beneficiaries' willingness to pay is substituted for them, it tends to be lower than the real level. Furthermore, a water supply project involves basic human need and can not be left undone if people are to lead hygienic, healthy and modern lives. For these reasons the Project, incorporating water supply sector as a major component is judged to be economically feasible.

B. Evaluations by Beneficiary

Demand for urban, irrigation and airport water in 2030 under the Project is estimated at 428.2 MCM, 120.3 MCM and 2.5 MCM, respectively.

To meet it the respective initial costs of Rs.11,530.6 million, Rs.1,180.6 million and Rs.14.2 million, and the respective O/M costs of Rs.305.6 million, Rs.44.9 million and Rs.1.1 million in economic terms will be required as shown below.

Table IX-3-6. Economic Project Cost by User

(unit: Rs. million)

Item	Citizens	Farmers	Airport
1. Initial Cost			
1) Water Resources Development	8,108.0	754.2	3.6
2) Distribution & Others (Preliminary Estimates)	3,422.6	426.4	10.6
Total	11,530.6	1,180.6	14.2
2. O/M Cost			
1) Water Resources Development	155.4	33.0	0.6
2) Distribution & Others (Preliminary Estimates)	150.2	11.9	0.5
Total	305.6	44.9	1.1

Source: EC-1

Economic analysis reveals that urban, irrigation and airport water supply projects have the respective EIRR's of 3.7 percent, 8.1 percent and 16.0 percent.

The urban water supply project occupies a dominant position in the Project and consequently has an EIRR not too different from that of the whole project. It is lower than the opportunity cost of capital by 8.3 percent. However, for the reasons already described, the project is judged to be economically feasible. The EIRR of the irrigation water supply project is by 3.9 points lower than the opportunity cost of capital. However, because of its highly social nature as described in 9.3.1, the project is judged to be economically feasible. The EIRR of the airport water supply project is higher than the opportunity cost of capital by 2 percent. Therefore, it is economically feasible without any additional explanation.

9.4. Financial Support

9.4.1. Development Budget of Water Sector and Initial Cost

The gross domestic product (GDP) of Pakistan in 1985-86 was Rs.527,792 million at market prices. The Annual Development Programme (ADP), which is the development budget of Pakistan was Rs.39,398 million in the same year. Consequently, ADP as percentage of GDP comes to 7.5 percent. Out of the total amount of ADP, Rs.5,197 million or 13.2 percent was appropriated for water sector. At Federal level the appropriation for the same sector was Rs.4,001 million. Developing countries on average allocate 4 to 5 percent of national budget for the development of water sector. When one thinks of it, one gets aware of a great extent of the emphasis the country places on the development of this sector.

The average ratio of ADP to GDP for the last 7 years from 1979-80 to 1985-86 was 8.2 percent. Also, during the last 10 years from 1976-77 to 1985-86 water sector on average accounted for 10.4 percent of ADP. In other words, the country has consistently pursued the policy of "high priority to water sector" in the past.

On conditions that the above relationships continue in the future and the average annual growth rate of GDP during the project implementation period 1988 to 2030 is 4.88 percent the cumulative amount of water sector development budget for the same period works out at Rs.715,289 million. At Federal level it is roughly estimated at Rs.550,678 million. On the other hand, initial cost for the water resources development project during the same period is estimated at Rs.11,860.0 million. Also, initial cost for the construction of distribution and other facilities is preliminarily estimated at Rs.4,640.0 million. They add up to Rs.16,500.0. Thus, the share of the total initial cost in the corresponding water sector development budget works out at 3.0 percent.

Population and GDP of the Project Region as the administrative region encompassing beneficiary areas in 1981 occupied 4.3 percent and 4.5 percent of national population and GDP, respectively. The above share is, therefore, considered to be reasonable and realistic. Thus, the Project is judged to be an undertaking the country can sufficiently cater for in budgetary/financial terms.

9.4.2. Financing Terms for Executing Agency

So far the Federal Government has provided CDA with financial resources for the development of bulk water resources in the shape of grants. It is only a quarter of a century since the capital of the country was moved to Islamabad and under such circumstances it is appropriate as well as necessary that the financing terms for the development of the capital should be as soft as possible. However, it is proposed that under the Project where the ultimate target year is set at 2030 a centralized execution and O/M organization for water resources development, water supply and irrigation unifying Islamabad and Rawalpindi will be established at an appropriate time. And, it is reasonable as well as normal to assume that such an organization will be ultimately managed on self-financing basis.

The Government of the Punjab at times finances a water supply project of a city under its jurisdiction at the interest rate of 11 to 14 percent. Long-term lending rate in the country is estimated at 14 percent, and if a project is to be financially oriented such interest rate will be unavoidable. However, a water supply project involves basic human need and can not be left undone if people are to enjoy hygienic, healthy and modern lives. Actually, World Bank says out of its consultation experiences that such a project rarely has an internal rate of return equal to or exceeding 6 percent.

Analysis reveals that when the urban water supply project under the Project has the FIRR of 5.2 percent, water payment as percentage of household income will be 2.5 percent. Practically, the maximum limit of the ability to pay for water of a household is considered to be 3 percent of its income. Therefore, under the above FIRR households can reasonably and realistically bear water cost.

The Study Team thus proposes that the Federal Government will provide the executing agency of the Project with the development funds at the annual interest rate of 5 percent or less.

9.5. Recommendation

In case the beneficiaries are resistant to or reluctant for the payment of water charges as recommended by the Study Team and also in case billing and collection are not perfect the water authorities will tend to immediately go into the red. Besides, for the first one decade or two the authorities will be financially negative even if the above conditions are met.

Therefore, it is preferable that the Federal Government will provide the water authorities with the development funds at the interest rate of less than 5%, or if adoption of such a rate is inevitable the Government will assist the said authorities with subsidies enough to compensate for the loss as it arises.

This recommendation shall be applied especially in the initial years of project implementation and it shall be withdrawn when and if the water authorities financially stand on their own feet.

Table IX-3-7. Code Table for Cost Benefit Flow

Code		Meaning
1.	CC1	Investment cost for development and supply of urban water
2.	CC2	Investment cost for development and supply of irrigation water
3.	CC3	Investment cost for development and supply of airport water
4.	OM1	O/M cost for development and supply of urban water
5.	OM2	O/M cost for development and supply of irrigation water
6.	OM3	O/M cost for development and supply of airport water
7.	BF1	Benefits accruing from supply of urban water
8.	BF2	Benefits accruing from supply of irrigation water
9.	BF3	Benefits accruing from supply of airport water
10.	SCC	Investment cost for development and supply of urban, irrigation and airport water
11.	SOM	O/M cost for development and supply of urban, irrigation and airport water
12.	SBF	Benefits accruing from supply of urban, irrigation and airport water

Note:

1) Investment cost includes initial and replacement cost for water resources development and distribution.

2) O/M cost includes O/M cost for water resources development and distribution.

Table IX-3-8. Cost Benefit Flow for Financial Analysis
- Target Year: 2030 -

Unit: Rs. Million

YEAR	NO.	CCI	CC2	CC3	OMI	OM2	OM3	BF1	BF2	BF3	SCC	SOM	SBF
1988	1	178.5	0.0	0.0	3.5	0.0	0.0	10.6	0.0	0.0	178.5	3.5	10.6
1989	2	605.7	0.0	0.0	8.6	0.0	0.0	21.5	0.0	0.0	605.7	8.6	21.5
1990	3	682.4	33.4	0.0	14.4	1.4	0.0	32.7	0.0	0.0	715.8	15.8	32.7
1991	4	440.1	37.4	0.0	20.5	3.9	0.0	55.2	0.0	0.0	477.5	24.4	55.2
1992	5	140.8	0.0	0.0	88.0	5.0	0.0	78.6	6.7	0.0	140.8	93.0	85.3
1993	6	140.8	0.0	0.0	92.0	5.0	0.0	103.0	8.6	0.0	140.8	97.0	111.6
1994	7	264.6	0.0	0.0	96.5	5.0	0.0	128.3	9.6	0.0	264.6	101.5	137.9
1995	8	407.2	0.0	0.0	102.0	5.0	0.0	154.6	9.6	0.0	407.2	107.0	164.2
1996	9	328.2	109.8	0.7	107.2	6.9	0.0	181.8	9.6	0.0	438.7	114.1	191.4
1997	10	222.8	200.3	0.7	116.1	9.0	0.1	210.0	9.6	0.0	423.8	125.2	219.6
1998	11	222.8	257.2	2.0	124.3	13.3	0.2	239.2	9.6	0.0	482.0	137.8	248.8
1999	12	270.6	281.0	2.0	133.1	20.3	0.3	269.4	9.6	0.0	553.6	153.7	279.0
2000	13	390.1	216.1	0.0	142.5	27.8	0.3	300.6	83.9	1.5	606.2	170.6	386.0
2001	14	233.1	78.0	0.0	144.8	33.2	0.3	330.0	105.1	1.7	311.1	178.3	436.9
2002	15	289.0	119.9	0.0	147.2	37.4	0.3	360.5	115.8	1.9	408.9	184.9	478.2
2003	16	308.0	89.4	0.0	152.8	41.3	0.3	392.1	115.8	2.1	397.4	194.4	510.1
2004	17	249.5	0.0	0.7	156.7	42.9	0.3	424.9	146.1	2.3	250.2	199.9	573.4
2005	18	118.8	0.0	0.8	170.1	42.9	0.4	458.8	154.8	2.5	119.6	213.4	616.2
2006	19	308.2	0.0	1.1	175.1	42.9	0.5	493.8	159.1	2.8	309.3	218.5	655.8
2007	20	654.9	0.0	1.1	181.3	42.9	0.6	530.0	159.1	3.0	656.0	224.8	692.3
2008	21	821.2	0.0	1.1	187.9	42.9	0.6	567.4	159.1	3.3	822.3	231.4	729.9
2009	22	858.6	0.0	1.1	194.8	42.9	0.7	605.9	159.1	3.6	859.7	238.4	768.7
2010	23	660.5	14.9	0.0	202.0	42.9	0.7	645.7	159.1	3.8	675.4	245.6	808.7
2011	24	165.5	18.1	0.0	208.8	42.9	0.7	686.3	159.1	4.1	183.6	252.4	849.6
2012	25	73.5	0.0	0.0	211.3	42.9	0.7	728.1	159.1	4.3	73.5	254.9	891.6
2013	26	215.0	0.0	0.0	214.3	42.9	0.7	771.0	159.1	4.5	215.0	257.9	934.7
2014	27	417.3	0.0	0.0	217.8	42.9	0.7	815.2	159.1	4.6	417.3	261.4	979.0
2015	28	538.6	0.0	0.0	221.3	42.9	0.7	860.5	159.1	4.8	538.6	264.9	1,024.5
2016	29	538.6	0.0	0.6	224.9	42.9	0.7	907.0	159.1	5.0	539.2	268.5	1,071.2
2017	30	417.3	0.0	0.6	228.4	42.9	0.7	954.7	159.1	5.2	417.9	272.0	1,119.1
2018	31	336.3	27.9	0.0	231.9	42.9	0.7	1,003.6	159.1	5.4	364.2	275.5	1,168.2
2019	32	214.1	53.4	0.6	236.4	42.9	0.7	1,053.7	159.1	5.6	268.1	280.0	1,218.5
2020	33	420.4	34.8	0.7	240.1	42.9	0.8	1,105.0	159.1	5.8	455.9	283.8	1,270.0
2021	34	584.8	17.6	0.4	244.4	42.9	0.9	1,158.6	159.1	6.2	602.8	288.2	1,324.0
2022	35	697.4	33.7	0.4	249.2	42.9	0.9	1,213.6	159.1	6.4	731.5	293.0	1,379.2
2023	36	647.3	22.0	0.4	254.2	42.9	0.9	1,269.8	159.1	6.6	669.7	298.0	1,435.6
2024	37	514.9	35.0	1.0	259.5	43.8	0.9	1,327.4	159.1	6.8	550.9	304.2	1,493.4
2025	38	163.8	35.5	1.1	275.6	44.8	1.0	1,386.3	159.1	7.0	200.4	321.4	1,552.5
2026	39	201.9	0.0	0.4	281.6	44.9	1.0	1,446.5	174.0	7.2	202.3	327.5	1,627.9
2027	40	278.2	0.0	0.4	287.6	44.9	1.0	1,508.1	178.3	7.5	278.6	333.5	1,694.0
2028	41	396.1	0.0	0.4	293.6	44.9	1.0	1,571.1	180.4	7.7	396.5	339.5	1,759.3
2029	42	685.1	0.0	0.4	299.6	44.9	1.0	1,635.4	180.4	7.9	685.5	345.5	1,823.8
2030	43	709.6	29.4	0.0	305.6	44.9	1.1	1,701.1	180.4	8.2	739.0	351.6	1,889.8
2031	44	281.7	32.6	0.0	305.6	44.9	1.1	1,701.1	180.4	8.4	314.3	351.6	1,890.0
2032	45	0.0	0.0	0.0	305.6	44.9	1.1	1,701.1	180.4	8.4	0.0	351.6	1,890.0
2033	46	0.0	0.0	0.0	305.6	44.9	1.1	1,701.1	180.4	8.4	0.0	351.6	1,890.0
2034	47	17.1	0.0	0.0	305.6	44.9	1.1	1,701.1	180.4	8.4	17.1	351.6	1,890.0
2035	48	69.0	0.0	0.0	305.6	44.9	1.1	1,701.1	180.4	8.4	69.0	351.6	1,890.0
2036	49	65.7	0.0	0.0	305.6	44.9	1.1	1,701.1	180.4	8.4	65.7	351.6	1,890.0
2037	50	0.0	0.0	0.0	305.6	44.9	1.1	9,550.4	434.7	14.1	0.0	351.6	9,999.3

Table IX-3-9. Cost Benefit Flow for Economic Analysis
- Target Year: 2030 -

Unit: Rs. Million

YEAR	NO.	CC1	CC2	CC3	OM1	OM2	OM3	BF1	BF2	BF3	SCC	SOM	SBF
1988	1	136.7	0.0	0.0	3.5	0.0	0.0	7.3	0.0	0.0	136.7	3.5	7.3
1989	2	452.1	0.0	0.0	8.6	0.0	0.0	14.8	0.0	0.0	452.1	8.6	14.8
1990	3	504.9	24.7	0.0	14.4	1.4	0.0	22.5	0.0	0.0	529.6	15.8	22.5
1991	4	327.9	27.3	0.0	20.5	3.9	0.0	38.0	0.0	0.0	355.2	24.4	38.0
1992	5	115.6	0.0	0.0	88.0	5.0	0.0	54.1	6.7	0.0	115.6	93.0	60.8
1993	6	115.6	0.0	0.0	92.0	5.0	0.0	70.9	8.6	0.0	115.6	97.0	79.6
1994	7	213.5	0.0	0.0	96.5	5.0	0.0	88.4	9.6	0.0	213.5	101.5	98.0
1995	8	336.1	0.0	0.0	102.0	5.0	0.0	106.5	9.6	0.0	336.1	107.0	116.1
1996	9	275.6	90.7	0.7	107.2	6.9	0.0	125.2	9.6	0.0	367.0	114.1	134.8
1997	10	185.3	164.8	0.7	116.1	9.0	0.1	144.6	9.6	0.0	350.8	125.2	154.2
1998	11	185.3	205.9	2.0	124.3	13.3	0.2	164.8	9.6	0.0	393.2	137.8	174.4
1999	12	218.6	221.5	2.0	133.1	20.3	0.3	185.5	9.6	0.0	442.1	153.7	195.1
2000	13	301.7	172.4	0.0	142.5	27.8	0.3	207.0	83.9	1.2	474.1	170.6	292.2
2001	14	165.0	58.7	0.0	144.8	33.2	0.3	227.3	105.1	1.4	223.7	178.3	333.9
2002	15	206.1	87.8	0.0	147.2	37.4	0.3	248.3	115.8	1.5	293.9	184.9	365.7
2003	16	220.5	66.6	0.0	152.8	41.3	0.3	270.1	115.8	1.7	287.1	194.4	387.6
2004	17	177.8	0.0	0.7	156.7	42.9	0.3	292.6	146.1	1.9	178.5	199.9	440.7
2005	18	102.0	0.0	0.8	170.1	42.9	0.4	316.0	154.8	2.1	102.8	213.4	472.9
2006	19	243.2	0.0	1.1	175.1	42.9	0.5	340.1	159.1	2.3	244.3	218.5	501.6
2007	20	492.8	0.0	1.1	181.3	42.9	0.6	365.0	159.1	2.5	493.9	224.8	526.7
2008	21	616.5	0.0	1.1	187.9	42.9	0.6	390.8	159.1	2.7	617.6	231.4	552.7
2009	22	639.7	0.0	1.1	194.8	42.9	0.7	417.3	159.1	2.9	640.8	238.4	579.4
2010	23	492.2	9.7	0.0	202.0	42.9	0.7	444.7	159.1	3.2	501.9	245.6	607.0
2011	24	123.9	11.9	0.0	208.8	42.9	0.7	472.6	159.1	3.4	135.8	252.4	635.3
2012	25	61.1	0.0	0.0	211.3	42.9	0.7	501.4	159.1	3.6	61.1	254.9	664.2
2013	26	163.8	0.0	0.0	214.3	42.9	0.7	531.0	159.1	3.7	163.8	257.9	693.9
2014	27	310.1	0.0	0.0	217.8	42.9	0.7	561.4	159.1	3.8	310.1	261.4	724.5
2015	28	398.0	0.0	0.0	221.3	42.9	0.7	592.6	159.1	4.0	398.0	264.9	755.8
2016	29	398.0	0.0	0.6	224.9	42.9	0.7	624.6	159.1	4.1	398.6	268.5	788.0
2017	30	310.1	0.0	0.6	228.4	42.9	0.7	657.5	159.1	4.3	310.7	272.0	821.0
2018	31	251.5	18.3	0.0	231.9	42.9	0.7	691.2	159.1	4.5	269.8	275.5	854.8
2019	32	162.0	35.0	0.6	236.4	42.9	0.7	725.7	159.1	4.6	197.6	280.0	889.5
2020	33	309.7	22.8	0.7	240.1	42.9	0.8	761.0	159.1	4.8	333.2	283.8	925.0
2021	34	424.8	11.5	0.4	244.4	42.9	0.9	798.0	159.1	5.1	436.7	288.2	962.3
2022	35	498.6	22.1	0.4	249.2	42.9	0.9	835.8	159.1	5.3	521.1	293.0	1,000.3
2023	36	473.7	14.4	0.4	254.2	42.9	0.9	874.5	159.1	5.5	488.5	298.0	1,039.2
2024	37	385.4	29.5	1.0	259.5	43.8	0.9	914.2	159.1	5.6	415.9	304.2	1,079.0
2025	38	136.2	30.0	1.1	275.6	44.8	1.0	954.8	159.1	5.8	167.3	321.4	1,119.8
2026	39	161.2	0.0	0.4	281.6	44.9	1.0	996.2	174.0	6.0	161.6	327.5	1,176.4
2027	40	211.2	0.0	0.4	287.6	44.9	1.0	1,038.7	178.3	6.2	211.6	333.5	1,223.2
2028	41	297.7	0.0	0.4	293.6	44.9	1.0	1,082.0	180.4	6.4	298.1	339.5	1,268.9
2029	42	510.2	0.0	0.4	299.6	44.9	1.0	1,126.3	180.4	6.6	510.6	345.5	1,313.4
2030	43	528.4	21.9	0.0	305.6	44.9	1.1	1,171.6	180.4	6.8	550.3	351.6	1,358.8
2031	44	205.6	24.0	0.0	305.6	44.9	1.1	1,171.6	180.4	7.0	229.6	351.6	1,359.1
2032	45	0.0	0.0	0.0	305.6	44.9	1.1	1,171.6	180.4	7.0	0.0	351.6	1,359.1
2033	46	0.0	0.0	0.0	305.6	44.9	1.1	1,171.6	180.4	7.0	0.0	351.6	1,359.1
2034	47	17.1	0.0	0.0	305.6	44.9	1.1	1,171.6	180.4	7.0	17.1	351.6	1,359.1
2035	48	69.0	0.0	0.0	305.6	44.9	1.1	1,171.6	180.4	7.0	69.0	351.6	1,359.1
2036	49	65.7	0.0	0.0	305.6	44.9	1.1	1,171.6	180.4	7.0	65.7	351.6	1,359.1
2037	50	0.0	0.0	0.0	305.6	44.9	1.1	7,125.3	373.1	12.7	0.0	351.6	7,511.2

CHAPTER X. CONCLUSION AND RECOMMENDATION

CHAPTER X. CONCLUSION AND RECOMMENDATION

1. The water resources development plans proposed in this report are based on the projected population and water demand at the target year of 2010 and 2030. Islamabad metropolis is expanding as the new capital of Pakistan in accordance with the federal government policy and CDA's development plan, so that the water resources development plans should be implemented following the revision of national policy or urban development plan as well as that of urban water supply scheme.

2. The urban water supply area covers both Islamabad area where a new capital is under construction and Rawalpindi area which is an old city. The both areas have different development history, but will develop their administrative functions complementary to each other in future.

   As development progresses, the urban development plan covering two cities will be comprehensively formulated and revised as required. Consequently, urban water supply scheme should adjust itself to the revision.

3. The irrigation development plan on the proposed area should be undertaken in due consideration of farmer's needs, prospect of suburban agriculture, its profitability and economics.

   On implementing the plan, elaborate study on the existing water rights and prior intake methods should be made with the authorities concerned.

4. For surface water resources development, hydrological data should be regularly observed at the proposed dam sites and intake points. For groundwater development, on the other hand, the water level and yield in the existing wells should be

continuously gauged in order to evaluate available yield and influence of new wells on the existing wells.

5. Judging from such natural features as topography, meteorology and geology, and expected function and scale of the capital, water resources for urban water will be developed mainly by dams reserving surface water. Groundwater, spring and lifting schemes (especially for irrigation purpose) are other potential water resources for alternatives.

   Groundwater, especially, should be utilized as provisional water resource or water resource alternative for extraordinary drought year appearing once in more than 10 years.

   In wet year, therefore, surface water should be efficiently utilized for saving groundwater resources.

6. The groundwater investigations performed in this study only delineate an outline of the hydrogeological conditions of the study area. It has not been made clear in this study that even the present groundwater abstraction amount is optimum or not because of the lack of data. For the reasons mentioned above, further studies should proceed for more accurate estimation of the area's groundwater development potential based on more detailed and reliable data. Such data would include long-term hydrographs of the groundwater tables.

7. Basic approach to water resources development is to undertake higher priority schemes which have less disadvantages from technical and economic points of view.

   Detailed water resources development plan should be formulated within the framework allowable, examining compensation for the existing water rights, evaluating effects on the rights and coordinating various development plans in the same basin.

8. D-1 and H-4 dams related to the Khanpur dam are multi-purpose dams, requiring not only large sum of investment, but also understandings and consensus from various consumers.

Water allocation of the Khanpur dam should be revised when necessary by evaluating present water use, potential of other water resources and their economics.

9. As for water use plan of the Kurang river basin, optimum water allocation should be formulated by elaborately examining present urban water supply and the on-going irrigation development project (covering 6,600 ha).

10. Technically and economically appropriate watershed management schemes should be formulated by evaluating the characteristics of river basin.

Intensive administrative guidance should be exerted to implement the schemes, examining countermeasures and regulations on water pollution.

11. It will not be far away before the urban development plan can not function without uniting two cities into one administration.

Expansion of the development will increase administrative tasks in CDA. Taking it into consideration that the Khanpur conduction project is needed to be implemented by joint venture by the both cities, the construction and O/M of water supply facilities should be administered by the united organization in future.

Intricate urban water system in the both cities should be phased out into a single organization. The reformed organization will promote engineers who can deal with construction of large-scale dams and urban water system.

12. As water resource development progresses and urban water supply system expands, operation and maintenance works will extend to wide area and become intricate.

Since the multi-purpose dam and single-purpose dam co-exist having different water use patterns in various consumers, water utilization and operation plan of dams should be formulated on a long-term basis in due consideration of technical innovation and coordination with medium-term plan.

13. The Metropolitan population to be served with urban water in the ultimate target year of 2030 is estimated at 3,267,000. And per capita demand in the same year is forecast to be 475 lit. Consequently, the annual total demand for urban water works out at 566.4 MCM. Furthermore, irrigation water of 120.3 MCM to serve the farming areas of 17,000 ha lying adjacent to the Metropolis and urban water of 2.5 MCM to serve the New International Airport will be required under the Project.

14. The construction cost for the development of water resources to meet the above demands is estimated at Rs. 9,652.6 million. Out of it, Rs. 4,218.7 million or 43.7 percent will be catered for by foreign exchange component, and the remaining Rs. 5,433.9 million or 56.3 percent will be met by local currency. Along with it, the cost for land acquisition, office facilities, engineering/administration and physical contingencies is preliminarily estimated at Rs. 2,207.4 million. Furthermore, the cost for terminal facilities is preliminarily calculated at Rs. 4,640.0 million. Thus, the total investment cost necessary to meet water requirements under the Project works out at Rs. 16,500.0 million.

15. The project has the EIRR of 4.2 percent. It is by 7.8 percent lower than the opportunity cost of capital at 12 percent in the country. However, the Project will provide urban water to the ever-growing Metropolitan population and also irrigation water to the adjacent areas for the period of half a century.

The urban water is essential and indispensable for the future Metropolitan citizens to enjoy hygienic, healthy and modern lives, and irrigated farmlands will supply them with ample fresh vegetables and fruits, thereby promoting and maintaining their nutritional balance and health. That is to say, the Project is a fundamentally social undertaking, concerning itself with basic human needs. The Project is thus judged to be economically feasible.

16. Under the FIRR of 5.4 percent water supply authorities can formulate a water tariff under which metropolitan households will spend 2.5 percent of their income on water. The percentage is within the maximum limit of ability to pay at 5 percent and also within the practical limit at 3 percent.

A higher FIRR is likely to put undue stresses on beneficiaries' home economy. While the long-term interest rate in the country is 14 percent, it is not reasonable, nor realistic to apply such a value in assessing the financial feasibility of a project with a highly social meaning and importance. Because of its crucial implications in the welfare of the future Metropolitan households, the Project is judged to be feasible at the FIRR of 5.4 percent.

17. It is preliminarily estimated that the Federal Government will have enough budgetary means to finance the Project, judging from the budgetary scale yearly growing in parallel with the national economy and a fair share water sector enjoys in budgetary allocations.

The Federal Government is strongly recommended to provide the executing agency of the Project with the necessary development funds at the annual interest rate of 5 percent or less on the above mentioned ground.

18. Urban water is an economic commodity, and it is at the same time one of basic human needs. The accommodation of these two sides can be attained through a water tariff structure where charges will be nominal up to the limit of a basic consumption, but beyond it they will progressively go up. Formulation and adoption of such a structure is highly recommended to reconcile Islamic teaching with modern economics.

19. For proper management of the urban water supply system, self-financing basis should be set up by introducing optimum water tariff system as well as levying the tariff compatible with Islamic belief.

The water tariff system will be set up by coordinating such programs as raising of consumers' consciousness, provision of service facilities and prevention of water leakage.

Increase of the consumers' income will improve their living condition as well as their payable amount for water, but a sufficient financial support from the federal government is indispensable at the same time.

20. These recommended projects should be phased on long-term basis. In order to meet acute urban water demand at the present moment, construction of water treatment plants and distribution facilities connected to the Khanpur dam and expansion of both Simly and Rawal water treatment plants should be commenced as early as possible.

JICA