III Part – 2 Pre-Feasibility Study

1. Reuse of Treated Wastewater from Existing Treatment Plants

1.1 Project Objectives

In the water resources management plan in Jordan, it is important to secure municipal water supply for the steadily increasing population and the water resources required for the growing socioeconomic sector, and it is inevitable to find a way to develop new water resources of non-conventional type. These non-conventional water resources are reuse of treated wastewater, desalination of brackish groundwater and seawater. It is important to make a detailed study of reuse of treated wastewater to be used for irrigation. As mentioned in Part II, it is estimated that the treated wastewater amount in 2020 will be more than 200 MCM/year with a share of 15% of the total water demand.

With this background, the pre-feasibility study on the reuse of treated wastewater from the five existing treatment plants without reuse plan will be made in this chapter.

1.2 Outline of the Projects

The study sites will be Abu Nuseir, Fuhis, Wadi Essir, Tefielah and Ma'an plants and the facilities such as small pumping stations and supply pipelines will be planned for reuse of treated wastewater. For the Ma'an treatment plant, the expansion of the treatment plant will also be planned because the wastewater influent amount would exceed the existing capacity by 2005. Fig. 1.2-1 shows the locations of the treatment plants.

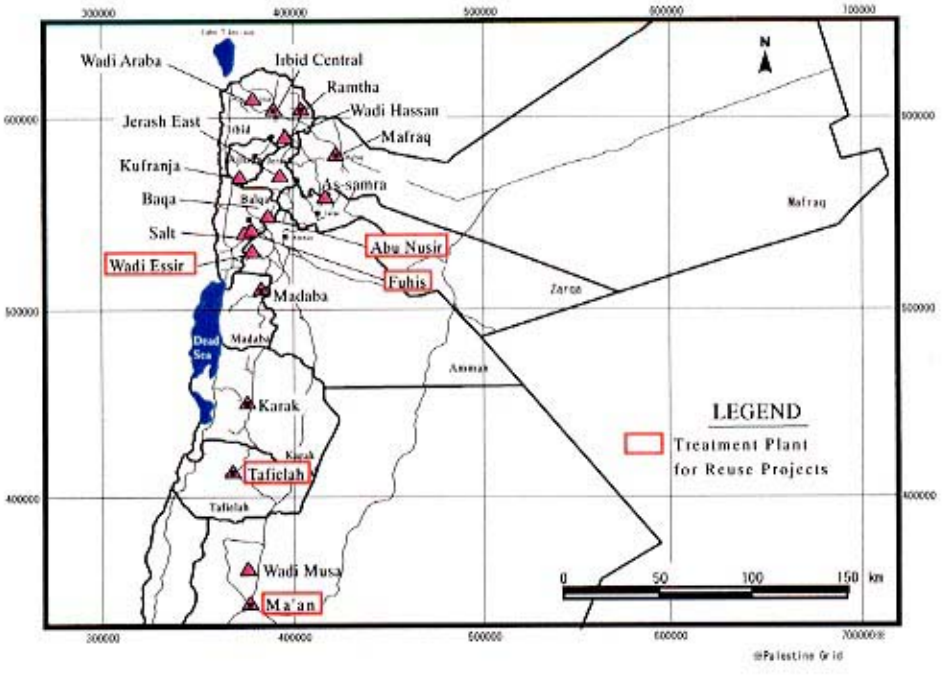

Fig. 1.1-1 Locations of the Wastewater Treatment Plants

(1) Reuse plan of the treated wastewater from the five existing treatment plants

The target year of this project will be scheduled for 2010, and the total annual quantity of treated water from the five existing plants is planned to be 3.9 MCM/a as shown in Table 1.2-1. Wadi Essir has suffered landslides in the past, and it is feared that there may be move in the future. Thus, it has been planned to combine the Wadi Essir project with the project for the Naur treatment plant located downstream and it will not be further considered here in.

Table 1.2-1 Reuse Plan of the Treated Wastewater from the Five Existing Treatment Plants

Treatment Plant	Governorate	Target population	Treated water quantity	Remarks
		Person	MCM/a	
Abu Nuseir	Amman	27,000	1.06	
Fuhis	Balqa	25,000	0.74	
Wadi Essir	Amman	16,000	(0.53)	* Combined with Naur
Tafielah	Tafielah	25,000	0.84	
Ma'an	Ma'an	27,000	0.76	Incl. treatment plant extension
Total		120,000	3.93	

The reuse facilities will be composed of pumping stations to convey the treated wastewater, reservoirs at the reuse points as shown in the example of the reuse facilities of Ma'an treatment plant in Fig. 1.2-2. The construction cost and operation & maintenance cost are shown in Table 1.2-2.

Table 1.2-2 Cost of construction, and operation/maintenance by planned site

Treatment Plant	Construction cost		Operation and maintenance cost		Unit costs for operation and maintenance	
	JD	USD	JD/year	USD/year	fls/m³	US Cent/m³
Abu Nuseir	227,068	158,950	4,326	3,028	4.1	0.28
Fuhis	141,680	99,180	4,000	2,800	5.4	0.38
Tafielah	434,275	303,990	5,080	3,556	9.7	0.68
Ma'an	373,428	261,400	9,918	6,943	11.4	0.80
Total	1,176,451	823,520				

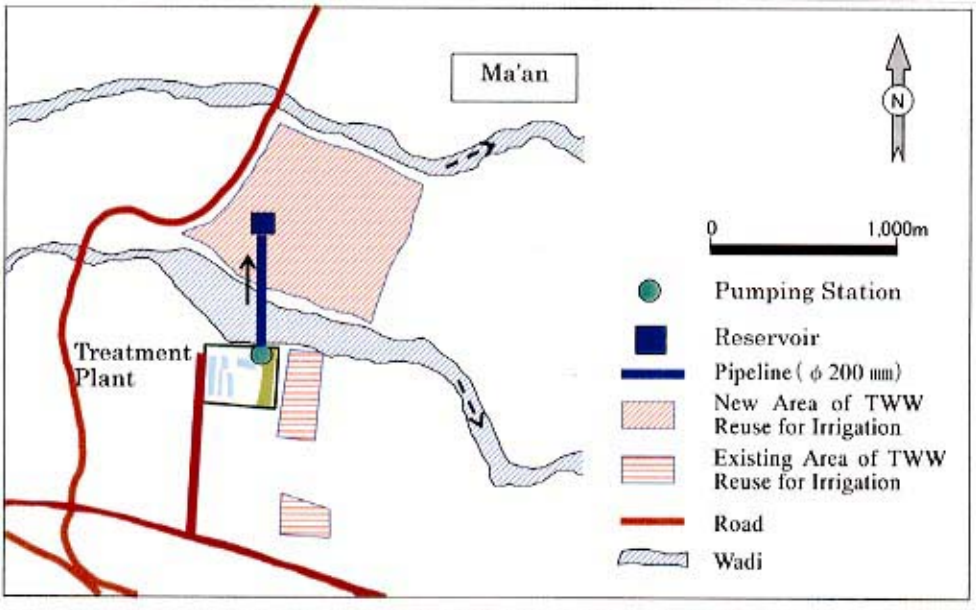

Fig. 1.2-2 Example of the Layout of the Reuse Facilities in Ma'an Treatment Plant

(2) Ma'an wastewater treatment plant expansion project

For the Ma'an wastewater treatment plant, it is foreseen that the capacity of existing treatment facilities will sufficient by 2005. Therefore, additional facilities with water treatment capacity for the target year of 2015 will be constructed in 2004. The extension land has been provided within the existing treatment plant. Table 1.2-3 shows the outline of the reuse project and Table 1.2-4 shows the project cost.

Table 1.2-3 Outline of the Ma'an Wastewater Treatment Plant Expansion Project

Anaerobic ponds	Unit	2015	Existing (2000)
Number of basins	-	4	2
Total surface	ha	0.690	0.320
Total volume	m^3	24,000	24,000 [2)]
Facultative ponds			
Number of basins	-	7	3
Total surface	ha	7.787	1.740
Total volume	m^3	93,450	43,500
Maturation ponds			
Number of basins			
in series	-	3	1
in parallel	-	1	1
Total surface	ha	1.483	0.750
Total volume	m^3	18,500	9,400

Table 1.2-4 Construction and Operation/Maintenance Costs

	2005	**2015**
Cost of extension of treatment facilities	JD 671,000	-
	USD 469,700	
Operation and maintenance cost (m^3/year)	JD 76,970	JD 95,300
	USD 53,880	USD 66,710

1.3 Project Evaluation

This project includes the extension project for the existing wastewater treatment plant at Ma'an, but in order to evaluate and verify "the appropriateness of reuse of wastewater for agriculture" the facilities extending from the outlet of the treatment plant to the farmland for reuse of treated water will be evaluated.

The expanded facilities for wastewater treatment must also be evaluated and results similar to those from other wastewater treatment projects should be obtained. (See the Main Report.)

(1) Position in the Water Resources Management Master Plan

The task of wastewater reuse involves the problems of water quality and transport costs. It will be economically appropriate to reuse the treated wastewater from the metropolitan area, along the Jordan Valley where the water can be conveyed by natural downstream flow. Therefore, it is an important issue to economically use the treated wastewater out of local treatment plants in their surrounding areas in the Upland region where the reduction of the groundwater abstraction is called for. In the Master Plan for water resources

management, it was estimated that the total quantity of treated wastewater in this region was approximately 45MCM/year, so that the reuse of wastewater in this region will have a large impact.

(2) Environmental impact assessment (EIA)

The environmental impact assessment (EIA) including the interview survey was made for both natural and social aspects. According to the results of EIA, it was inferred that the serious negative impacts on both natural and social aspects, which were groundwater contamination, salt accumulation in the soil, conflicts between the beneficiary groups and so on, would not be generated by the reuse projects of the treatment wastewater.

According to the results of the interview survey conducted on about 100 farmers in the vicinity of the five existing treatment plants of Abu Nuseir, Fuhis, Wadi Essir, Tafielah and Ma'an, it was also found that 90% to 100% of the farmers expressed willingness to use the treated wastewater for irrigation of the trees and fodders. However, almost all of the farmers were negative on the use of treated wastewater for vegetables.

As the reuse of the treated wastewater without dilution is not been widely practiced in Jordan and it is limited to a few areas in the vicinities of existing treatment plants, unpredictable problems such as disease and reduction of the crop productivity might happen. For anticipation and prevention of such problems, the monitoring and control of the treated wastewater quality should be carefully carried out by several organizations concerned.

(3) Economic and financial evaluation

a. Reuse projects of the treated wastewater

The pre-feasibility studies conducted in this Study assume a discount rate of economic evaluation to be 10% and that of financial evaluation 5%. This financial discount rate is rather lower than general loan-financed projects in Jordan. However, through the discussion with MWI, it has been found that since soft loans are available for the implementation of these basic social infrastructure projects, this borrowing condition is assumed in this Study.

The evaluation of this project is based on the following assumptions:

Currently, the agricultural water is not treated and only provided to the supply point of each farmland. Irrigation at the farmland is done by each farmer. On the other hand, in the wastewater reuse projects, treatment facilities and irrigation in the farmland are considered, and the costs for wastewater reuse actually include costs for these facilities. In order to compare the price of reuse water on the same basis as the current agricultural water price, thus, it is assumed that the cost for wastewater reuse does not include costs for treatment or irrigation.

In the economic analysis, the unit benefit is regarded as gross agricultural profit (142 fils/m^3) that can be generated from producing crops with the use of treated wastewater.

For the financial analysis, the implementation body is the WAJ, and its cash flow is analyzed with the revenues that come from user fees. The user fee is assumed 38 fils/m^3 in the project target year of 2010.

The current irrigated water price of 10 fils/m^3 is so low that it jeopardizes the financial viability of the projects. This price can barely cover the costs for operating and maintaining a facility, about 9 fils/m^3 per annum on average. At the current price level of irrigated water, obviously, it is not possible to repay the principal of the initial capital cost and the interests, and the cash flow records deficits every year throughout the project period, which makes it impossible to calculate an internal rate of return. Thus, the financial analysis hypothesizes a case where the price is gradually raised to 38 fils/m^3 in 2010, as proposed in the Master Plan. The proposed new price level is appropriate and payable for users in comparison with the gross agricultural profit and water prices currently charged for other purposes. The idea of raising the price follows the principle discussed in Part 1 that project costs should be recovered by charging user fees on direct beneficiaries. Even at this level, however, there is still a gap from the real economic value of treated wastewater, but the price is at least follows the rule of "pay-as-you-go."

With these technical, economic, and financial assumptions, the economic and financial evaluations have found that the four wastewater reuse projects in total register an EIRR of 12.1% and an FIRR of 6.4%, which clearly indicates the economic and financial feasibility of the projects as a group.

Analysis	Unit Benefit/Revenue		Internal Rate of Return (%)
Economic	Gross agricultural profit	142 fils/m^3	12.1
Financial	Irrigated water price	38 fils/m^3	6.4

b. Expansion project of Ma'an Treatment plant

This section explains project evaluation of expanding the Ma'an treatment plant, planned together with the wastewater reuse project. The assumptions for the analyses are described below:

The economic analysis presumes the unit benefit as an amount each household can afford to pay for the wastewater (368 fils/m^3). This concept is generally accepted by various international assistance organizations including the World Bank, and it is assumed within a range of 1 to 1.5% of the disposable household income. In this analysis, the Study team and MWI have adopted 2% on the ground that the household income will increase toward the year of 2010 as the economy grows.

The financial evaluation has been conducted by analyzing a cash flow of the implementation body, the WAJ. The project costs consist of construction cost for the expansion and cost for operating and maintaining the facility. The revenue comes from the collection of wastewater tariff from customers, 468 fils/m^3 in 2010, which has been derived from a preliminary evaluation. When the current tariff (147 fils/m^3) was kept, the project cash flow would remain in deficit throughout the project period, and a rate of return calculation would be impossible. In order to make the project feasible, as discussed in Chapter 8 of the Main Report, the current tariff needs to be raised to 468 fils/m^3 in 2010.

With these assumptions, the results of the evaluations show that the EIRR (4.6%) falls short of the threshold, whereas the FIRR (5.3%) goes beyond the capital opportunity cost.

Analysis	Unit Benefit/Revenue		IRR (%)
Economic	Affordability to pay (wastewater)	368 fils/m^3	4.5
Financial	Wastewater tariff	468 fils/m^3	5.3

There are two points that should be noted about the results of the above project evaluations. First, the EIRR is below the discount rate, and second, the wastewater tariff is set above the affordability amount.

One of the reasons that the results of the economic evaluation have not reached the threshold of 10% is that the initial capital cost is enormous, and that only counting the tangible benefits cannot justify the use of resources by the project. However, the project is expected to generate other significant intangible benefits as described below:

- Improvement of urban environment, especially the reduction of water-born diseases
- Prevention of contaminating the groundwater, which is one of the most important sources of potable water
- Creation of a new water source under the condition of absolute water shortage

Wastewater treatment projects, thus, serve public interests, and their implementation can be justified as they bring about intangible, but important benefits such as alleviating groundwater pollution and improving the sanitary environment.

The second point to note is that since the raised tariff for wastewater (468 fils/m^3) is beyond the affordability amount of the household (368 fils/m^3), the actual collection may be difficult to implement. As mentioned above, however, the role of the project is very important, and it must be implemented through some measure. A measure can be proposed to collect fees for both water and wastewater together because there is a margin in the amount a household can afford to pay for water (up to 4% of household income, 735 fils/m^3) in relation to the proposed general water tariff (382 fils/m^3). In this case, the amount charged for both water and wastewater is 850 fils/m^3, and the proportion in the average household income remains approximately 4.6%, which is kept lower than the affordability amount of a household for water and wastewater (1,103 fils/m^3).

It can be argued just and fair to ask the people to share the burden within the limit of their affordability, considering the severity of groundwater pollution in the country and the contribution of the wastewater treatment projects to this problem. In addition, since the tariffs for water and wastewater are already collected together, it should not be so difficult to implement this collection scheme.

Finally, if it is found difficult to raise the tariffs, it is necessary to secure other sources of fund, such as government subsidies, assistance from foreign countries, and so forth. Like the As Samra treatment plant, for instance, in pursuit for efficient operation and use of private capital, the BOT scheme can be considered as an option. In that case, however, a higher rate of return must be realized (about 10%), or some other governmental support would be required in addition to the revenues collected at the raised tariffs. Obviously, for the project to be financially viable and sustainable, sufficient revenues to support a good cash flow are absolutely necessary.

1.4 Implementation Schedule

Immediate implementation of the reuse schemes in the four existing treatment plants is possible because the all conditions required for the reuse have been prepared in these treatment plants. The staged implementation will also be possible for selected parts in the case of financial constraints. The implementation schedule of reuse schemes in the four existing treatment plants is shown in Table 1.4-1.

Table 1.4-1 Implementation Schedule of the Reuse Schemes in Four Existing Plants

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Abu Nuseir										
Fuhis										
Tafielah										
Ma'an (reuse)										
Ma'an (treatment plant)										

1.5 Problems and Issues

According to the results of the environmental impact assessment (EIA), it was inferred that serious negative impacts on both natural and social aspects which were groundwater contamination, salt accumulation in the soil, conflicts between the beneficiary groups and so on, would not be generated by the reuse projects of the treatment wastewater. As the reuse of the treated wastewater without dilution has not been widely practiced in Jordan, unpredictable problems might happen. Therefore, monitoring and control of the treated wastewater quality by the several organizations, appropriate appliance of the low and regulations for the reuse, disclosure of the information of the reuse and education to the farmers concerning the reuse should be done simultaneously.

As the expansion project of the Ma'an treatment plant will not be financially feasible under the current charge for wastewater collection and treatment (147fils/m^3), the charge should be raised to 468fils/m^3. However, though the charge of 468fils/m^3 exceeds the affordability to pay (2% of the household income,368 fils/m^3), it was recommended in the Master Plan that the gap between financially feasible charge and affordable charge (100 fils/m^3) should be filled by increasing the charge of the municipal water which is presently much lower than the charge of affordable to pay. In this case, the charge of both municipal water and wastewater should be collected in the lump. Though the raise in both charges must need the consent of the users, the education and explanation campaign to the people concerning the necessity of water supply and wastewater treatment projects, present financial conditions of both projects and necessity of the raise in both charges should be done in parallel with the implementation of the expansion project. If the raise of the charges will not be possible by any means, the subsidiaries should be supplied from the government for the implementation of the project.

It is better to use fresh water for leaching of the soil. However, suitable locations were not found to store and develop the fresh flood water in the vicinity of the sites of the reuse projects. Efforts to obtain the fresh water for leaching should be done in the implementation stage as much as possible.

1.6 Conclusion

a. Salt accumulation in the soil

The reuse of treated wastewater is an important task in water resources management. As soon as the conditions for implementation of these projects are prepared, they should be implemented one by one. However, the careful monitoring and control of the quality of the treated wastewater will be necessary for the implementation.

According to the results of EIA, the salinity of the treated wastewater ranged from 1.52ds/m to 2.05ds/m. The leaching requirement was estimated using a maximum salinity of 2.05ds/m (at Ma'an treatment plant) in EIA. In this case, the leaching requirements are 5% to 7%, 11%, 26% and 10% to 52% for barley & wheat, date palm, alfalfa and vegetables respectively. The leaching requirement is also subject to change according to the irrigation methods as the drip irrigation requires much less leaching compared with the furrow irrigation. In addition, the leaching requirement also changes according to the soil properties. Therefore, the leaching requirement will be examined after the selection of crops and irrigation method. As the high salinity groundwater is occasionally used for the Upland irrigation, the salt accumulation in the soil shall be prevented if the normal leaching procedures employed in the Upland irrigation will be applied for the irrigation by the treated wastewater. Although it is obvious that the fresh water is much better for the leaching, the leaching might be done using the treated wastewater because of the difficulties to get the fresh water as mentioned in section 1.3.

b. Influence to farmers' health and growth of plant

According to the EIA results, the fecal coliform was found in the treated wastewater from four treatment plants excepting Huhis and nematodes were found in Abu-Nuseir treatment plant according to the environmental assessment conducted in the Study. It is very dangerous for the health of the farmers to use such treated wastewater. Therefore, the treated wastewater must be sterilized for the reuse purposes by chrolination and other processes. Even in the case of using the sterilized treated wastewater, the sprinkler irrigation must not be applied because the farmers will be exposed to it.

For the harmful substances to the plants such as Na, Cl, B, and heavy metals, the treated wastewater from the five existing treatment plants met the irrigation water standards of FAO. However, the treated wastewater is not as good as surface water as shown in the fact that the concentration of Se in the treated wastewater from the Huhis treatment plant was near to the permissible limit according to the EIA results. The quality of the treated wastewater will be changed according to the urban development in future.

For the reasons mentioned above, a monitoring system should be established to monitor farmers' health conditions, growing conditions of the plants, harmful substances in the treated wastewater for both of farmers' health and growth of the plants, salt accumulation in the soil and so on. For the items of wastewater quality monitoring, SAR (sodium absorption ratio), Cl, Na, heavy metals, total nitrogen, total phosphate, nematodes and fical coliform are recommended.

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2. Wadi Zarqa Treatment Plant

2.1 Project Objectives

The wastewater treatment in the Amman Metropolitan Area is concentrated on As-Samra Treatment Plant at present, which is operating at the substantially higher quantity of treated wastewater than the originally planned quantity. As a result, incompletely treated wastewater is discharged in the Zarqa River, causing a serious environmental problem. To solve this problem, the Master Plan for wastewater treatment in the metropolitan area was formulated in 1997 under the cooperation of USAID. This M/P divided the metropolitan area into two east and west water collection areas. First of all, As Samra treatment plant would be improved and subsequently the new Wadi Zarqa treatment plant would be constructed. As the As Samra treatment plant project will be entrusted to private contractors on the BOT basis under the funding of USAID, the selection of contractors is in progress at present.

On the other hand, the Wadi Zarqa treatment plant construction project has to be completed by 2005, but there is no prospect for its completion because of lack of funds at present. Therefore, its completion will be delayed until around 2007 at the earliest. To compel the future implementation of this project, it is necessary to update the Master Plan and re-define the contents of plan taking into account the influence on the Wadi Zarqa treatment plant that the change of the wastewater quantity along with the progress of the detailed plan of the As Samra treatment plant will give.

Following the construction of the As Samra wastewater treatment plant, the main collection network and treatment facilities necessary for wastewater treatment in the west part of the metropolitan area after 2010 will be newly contracted.

2.2 Outline of the Project

The outline of the construction project of Wadi Zarqa Treatment Plant is shown in Table 2.2-1.

Table 2.2-1 Outline of the Construction Project of Wadi Zarqa Treatment Plant

Collection Area	3 areas of Russeifa, Zarqa and Hashimiyya
Population	1,188,000
Wastewater inflow quantity	113,000 m^3/day (41.4 MCM/year)
Treatment capacity	150,000 m^3/day
Planned construction site	Approx. 20km downstream along the Zarqa River from As Samra treatment plant
Treatment method	Actived sludge method

The location of Wadi Zarqa treatment plant is shown in Fig. 2.2-1.

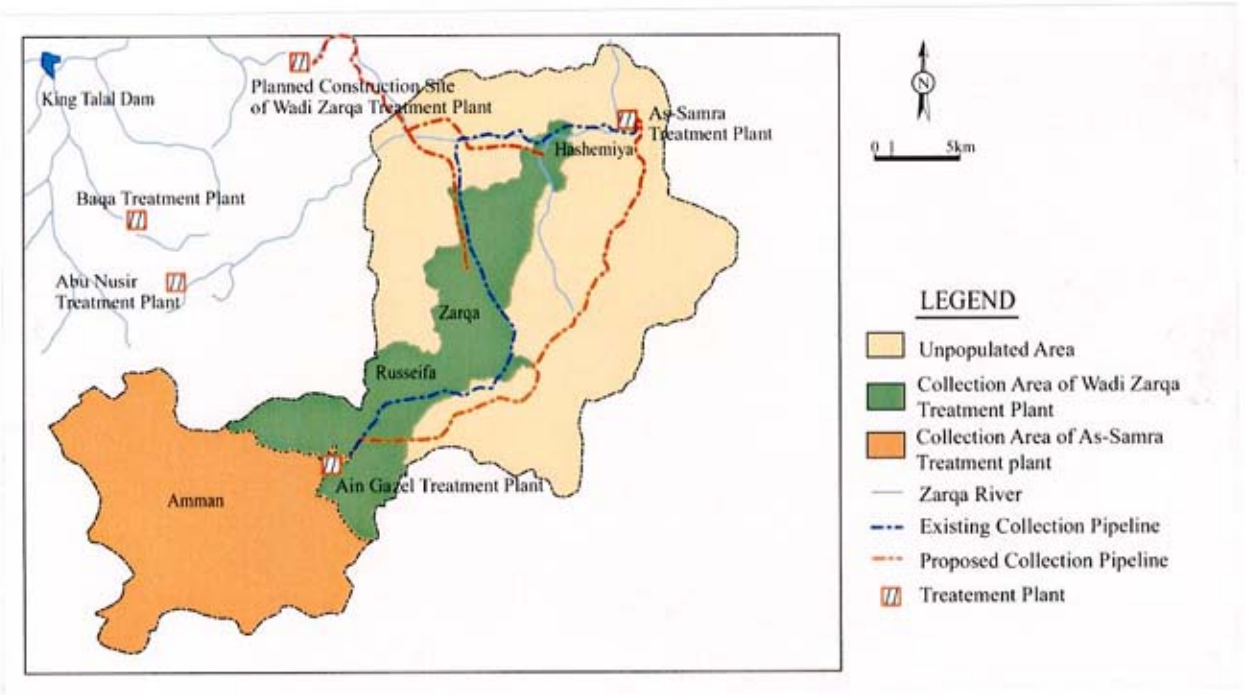

Fig. 2.2-1 Location of Wadi Zarqa Treatment Plant

A population of 1,730,000 and service ratio of approximately 100 % are expected in 2020 and wastewater inflow at that time will be 178,000 m^3/day as shown in Table 2.2-2.

Table 2.2-2 Projection of Wastewater Flows and Pollutant Load of Wadi Zarqa Treatment Plant

	Unit	2005	2010	2015	2020
Population	c	976,217	1,187,717	1,438,106	1,732,916
Connected (sewerage)	c	976,217	1,187,717	1,438,106	1,732,916
Not connected (sewerage)	c	0	0	0	0
Wastewater production					
Tariq and Marka	m^3/d	11,493	14,538	18,274	22,830
Russeifa	m^3/d	25,713	32,913	41,824	52,776
West Zarqa	m^3/d	28,260	36,173	45,968	58,004
East Zarqa and Hashimiyya	m^3/d	18,441	23,547	29,856	37,597
Sukhna	m^3/d	1,276	1,633	2,076	2,619
Industrial wastewater	m^3/d	4,500	4,500	4,500	4,500
Total	m^3/d	89,683	113,305	142,498	178,326
	m^3/month	2,690,489	3,399,140	4,274,942	5,349,772
	MCM	32.7	41.4	52.0	65.1
Pollutional load					
Poll. load (dom.demand)	kgBOD_5/d	63,454	77,202	93,477	112,640
Poll. load (industries)	kgBOD_5/d	550	550	550	550
Total load	kgBOD_5/d	64,004	77,752	94,027	113,190
Concentration	mgBOD_5/l	714	686	660	635

Treatment process of activated sludge which will be also employed in the expansion project of As-Samra treatment plant is proposed as shown in the figure below.

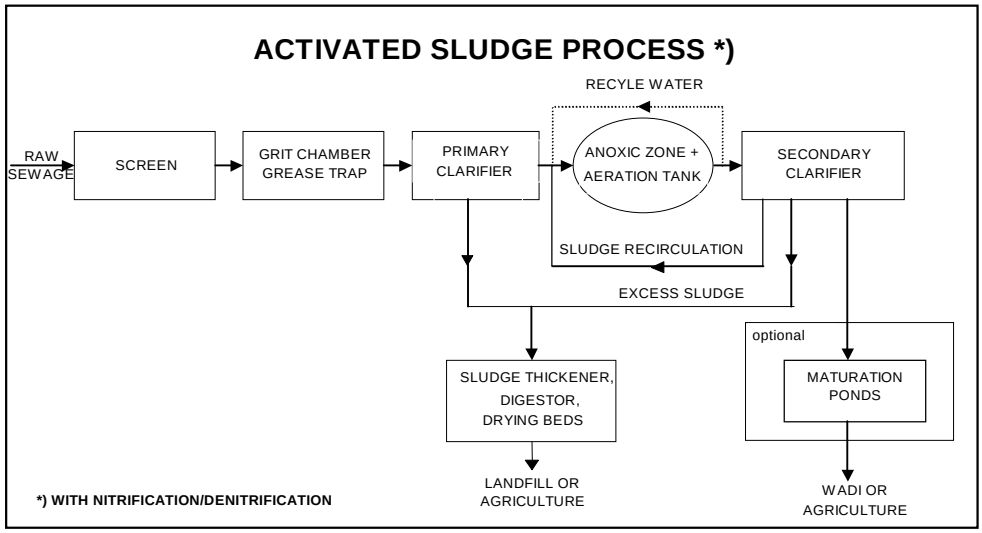

Fig. 2.2-2 Proposed Process of Wadi Zarqa wastewater treatment plant

2.3 Project Evaluation

(1) Position in the Water Resources Management Master Plan

These wastewater treatment projects are based on the Master Plan (1997) for comprehensive municipal wastewater collection and treatment in Amman metropolitan area. Two collection areas of As Samra and Wadi Zarqa are set. In the As Samra treatment plant construction project under the Master Plan, the construction of the collection piping network and the water supply system are in progress, but the treatment plant itself will have to be completed in 2007.

(2) Environmental impact evaluation

In review of the environmental impact evaluation under the Master Plan, the initial environmental impact evaluation was implemented. No particularly remarkable environmental impacts were found, but some slight impacts were observed. At the time of construction, the study of historic spots and archeological relics has to be made on a large scale. For other problems such as increase in traffic and construction waste, the measures for reduction of those can be taken. In the operation and maintenance of the plant facilities, it is important to consider the impacts of treated wastewater on the pollution of surface water and reuse of it for irrigation and it is necessary to secure any appropriate treatment system to remove those impacts.

(3) Economic and financial evaluation

It was made clear in the process of constructing the As Samra treatment plant that the project could not be financially viable under the current wastewater pricing system. Hence it was found necessary to take additional measures such as public financial support

to the construction costs and adoption of efficient operation and maintenance by contracting out to the private sector. Likewise, the construction of the Wadi Zarqa wastewater treatment plant facilities cannot be financially realized under the current tariff system. Financial viability requires some other measures to secure funding sources such as drastically raising wastewater tariffs in order to cover the initial capital costs and recurrent costs.

The project evaluation has made the following assumptions:

Economic benefit is the amount an average household can afford to pay for wastewater (368 fils/m^3), just as discussed in the previous chapter.

The financial analysis presupposes that the current wastewater tariff will be gradually raised from 147 fils/m^3 now to 468 fils/m^3 in 2010. The implementation body is the WAJ. Its revenue source is the collection of wastewater tariffs, and its expenditure consists of construction cost for the expansion and costs for operating and maintaining the facility. A cash flow analysis is conducted from these data.

The results of the analysis show that the EIRR is lower than 10%. However, taking into consideration positive intangible benefits of improving the sanitation and groundwater pollution in the country, the justification for the project is sufficiently high, and the project can be said economically worth implementing.

Analysis	Unit Benefit/Revenue		IRR (%)	Remarks
Economic	Affordability to pay (wastewater)	368 fils/m^3	6.5	Additional qualitative benefits should be considered.
Financial	Wastewater tariff	468 fils/m^3	7.4	-

The financial analysis concludes that the FIRR calculated from the project cash flow goes over the capital opportunity cost and warrants financial viability of the project. The tariff is higher than the affordability amount, but as it serves significant public interests, similar measures and considerations mentioned in Section 1.3 (Ma'an treatment plant) are necessary.

2.4 Implementation Plan

The expansion project of As-Samra treatment plant is scheduled to be completed by 2005 with financing by USAID. The construction of Wadi Zarqa treatment plant including the financing will be implemented in 2003 taking into consideration the implementation schedule of As-Samra treatment plant. The investment cost shown in Table 2.2-2 includes the construction of the collection system of sewage.

Table 2.2-2 Implementation Schedule of the Construction of Wadi Zarqa Treatment Plant

Treatment Plant	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
As-Samra										
Wadi Zarqa			JD 124,500,000 (about US$177,900,000)							

2.5 Problems and Issues

The issues remaining for the construction of Wadi Zarqa treatment plant is to secure the finance. The financial plan should be formulated considering the grant element from the Government or donors which has been applied to the As-Samra project and increase of the tariff of the wastewater treatment.

Because the construction project of the Wadi Zarqa treatment plant will not be financially feasible under the present wastewater charge as same with the case of the Ma'an treatment plant expansion projects described in Section 1.3, (3), b, the raise of the charges of both municipal water and wastewater will be premise for the implementation of the project. Though the raise in both charges must need the consent of the users, the education and explanation campaign to the people concerning the necessity of water supply and wastewater treatment projects, present financial conditions of both projects and necessity of the raise in both charges should be done in parallel with the implementation of the project. If the raise of the charges will not be possible by any means, the subsidiaries should be supplied from the government for the implementation of the project.

The detailed study and design will be needed to be done for the implementation of the project based on the results of the Study done by USAID in 1997 and the results of this pre-F/S Study. In case that the project will be implemented under the BOT system, the detailed study and design will be done by the contractor.

2.6 Conclusion

These projects for wastewater treatment in the Amman Metropolitan Area are based on the policy of protecting the city environment and they are technically the most appropriate implementation plans as specified in the Master Plan. In addition, the treated wastewater from Wadi Zarqa treatment plant is scheduled to be reused for irrigation and industrial purposes in order to augment the limited water resources in Jordan.

3. National Water Control Center

3.1 Project Objectives

The effective use of water resources is the basic policy of the water resources management project, in which it is planned that about 10% of the water sources can be secured. To achieve this plan, various measures including reduction of unaccounted for water (UFW), higher efficiency in use of irrigation water, education of residents for water saving and development of the water supply and distribution system are in the planning and implementation stages. The Ministry of Water and Irrigation (MWI) has formulated and is implementing concrete work plans with the cooperation of international assistance organizations. Of these work plans, the water supply and distribution system is still in the stage of database development at the Ministry's headquarters, in which the flow monitoring and control scheme at the most important development sites and consumption areas is wanting. The UFW rate of over 50% in 1998 nationwide has been pointed out in the UFW reduction countermeasure proposed by JICA's long-term dispatched expert posted within the MWI. It is important to develop the national water supply network system.

3.2 Outline of the Project

The national water control system consists of the Main Control Center to manage the development, flow and distribution of the water resources that are conveyed to the Governorates throughout Jordan and the Sub-Center to manage the local water sources and distribution pipeline networks as shown in Table 3.2-1 and Fig.3.2-1.

Table 3.2-1 Outline of the National Water Control Center

Item/Center	Main Control Center	Sub-Center
Location	Ministry of Water and Irrigation, Amman	WAJ (Water Authority of Jordan) branches at 12 Governorates
Monitoring and measuring sites	34 sites in whole of Jordan	114 sites of main water sources and distribution pipeline networks
Remarks	In the basin of the King Abdullah Canal, the total flow control system has been completed at JVA, which will be integrated into the Amman Main Control Center.	

The project will be planned for implementation in two phases: Phase-I (Main Control Center and Sub-Centers at four Governorates) and Phase-II (Sub-Centers at eight Governorates). The preliminary construction cost estimate of Phase-I is 7.314 MJD as shown in Table 3.2-2.

Table 3.2-2 Construction and Operation/Maintenance Cost of the National Water Control Center

Facilities		Construction Cost (1,000JD,1000US$)	Operation/Maintenance Cost (1,000JD, 1,000US$/year) in 2005	Operation/Maintenance Cost (1,000JD, 1,000US$/year) in 2010
Phase-I	Main Control Center and Sub-Centers at four Governorates	JD7,314 (US$10,488)	JD687 (US$981)	JD687 (US$981)
Phase-II	Sub-Centers at eight Governorates	JD6,066 (US$8,655)	- -	JD1,032 (US$1,474)
Total		JD13,380 (US$19,114)	JD687 (US$981)	JD1,719 US$2,455

Note: Phase I Sub-Centers-------Amman, Irbid, Zarqa, Mafraq
Phase II Sub-Centers-----Ajlun, Jerash, Balqa, Madaba, Karak, Tafielah, Ma'an, Aqaba

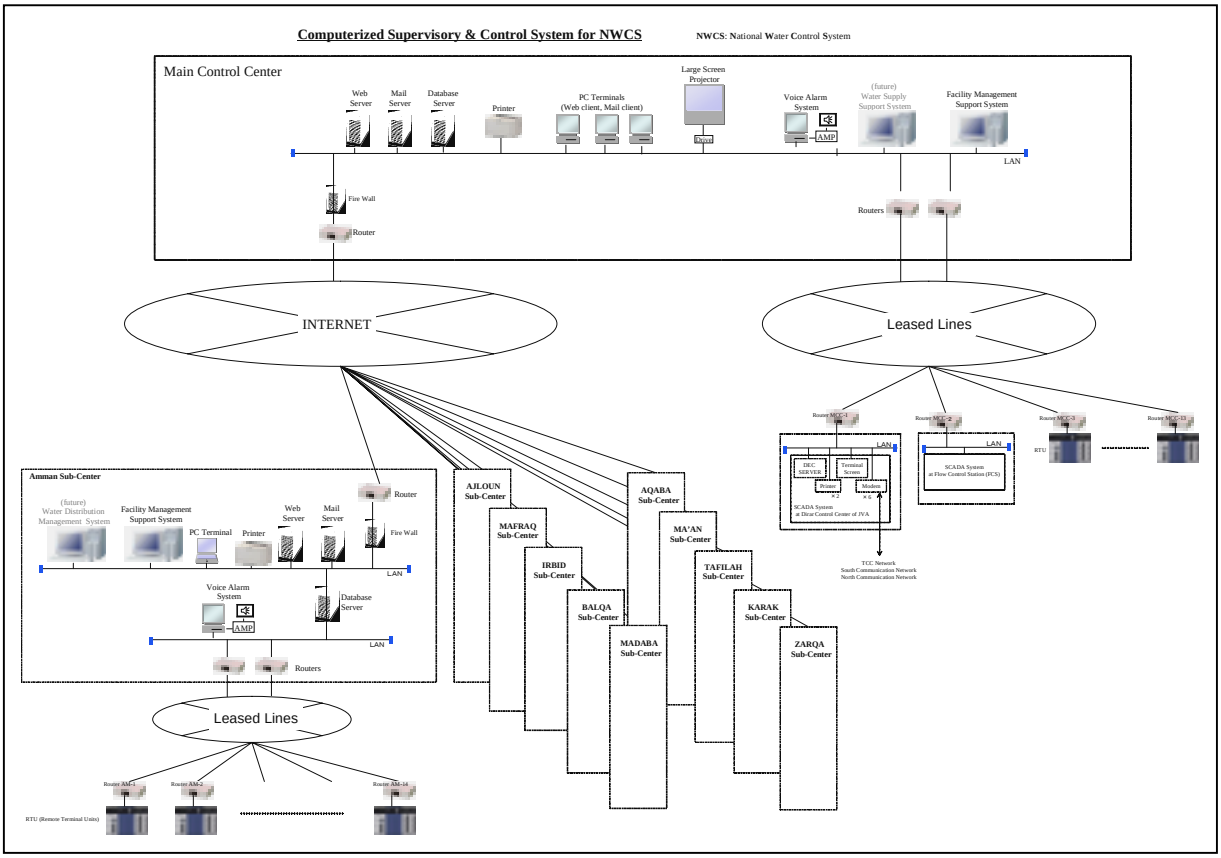

Fig. 3.1.1-1 Conceptual Drawing of National Water Control Center

3.3 Project Evaluation

(1) Position in the Water Resources Management Master Plan

The UFW countermeasures include measures against physical loss (water leakages) by rehabilitation of the distribution pipeline networks and measures against administration loss by flow control. In Jordan the physical loss and the administration loss are nearly the same rate, and this information is the basic data for the WIS (Water Information System) installed in the MWI.

(2) Initial environmental examination

The project facilities include installation of equipment such as flow meters, pressure gauges and communications equipment and establishment of the supervision rooms at the Main Control Center and the Sub-Centers. These facilities have little impact on the environment.

(3) Economic and financial evaluation

By installing the Center and controlling the flow volume, the UFW can be identified and analyzed, and water resources can be efficiently and effectively distributed. However, it is actually very difficult to quantify effects of the flow control. Thus, the evaluation makes the following assumptions:

A hypothetical case is considered where the planned control facilities would reduce the UFW by 1% (about 1.7 MCM). The UFW consists of administration losses, meaning that water is actually used, but the tariffs are not collected, and physical losses, or water leaking from the pipeline networks. These two types of loss account for almost equal portions in the total UFW. In the economic analysis, since the administration losses are resources actually used, only the physical losses are regarded as economic benefits. Thus, it hypothesizes a case where 0.5% (about 0.85 MCM) of the DFW can be reduced through the project. On the other hand, since revenues can be realized from reducing both types of loss, the financial analysis presumes a case where 1% of the DFW can be successfully reduced.

Economic benefit is regarded as the affordability-to-pay amount of water (4% of household income), or 735 fils/m^3. Although this Study conducted interview surveys to investigate an amount a household would be willing to pay for water, the reliability of data and results were low. Similar to the case of wastewater, therefore, the affordability amount has been taken as economic benefit of water projects.

In the financial analysis, the WAJ is the implementation body, and in order to examine the feasibility of the investment in providing a new Control Center, the project revenue is defined as the amount of the reduced DFW multiplied by water tariff. The current average tariff for municipal water of 341 fils/m^3 is raised every year until it reaches 407 fils/m^3 in 2010, which is also the planned price level of the Master Plan. As mentioned in Chapter 8 of the Main Report, with revenues collected at the current water tariff (national average, 341 fils/m^3), only 59% of the total project costs for the water supply projects planned in the country can be recovered, and the projects as a group cannot be financially realized. The industrial water tariff is also raised from 1,000 fils/m^3 to 1,194 fils/m^3. These amounts of water tariff are appropriate, compared to the affordability amount of households (735 fils/m^3) and for the gross industrial income (2,740 fils/m^3).

As a result of economic and financial analyses, the National Water Control Center Project registers an EIRR of 13% and an FIRR of 10%, which supports the viability of the project.

Analysis	Unit Benefit/Revenue		IRR (%)
Economic	Affordability to pay (water)	735 fils/m^3	13.0
	Gross industrial profit	2,740 fils/m^3	
Financial	Water charge (national average)	407 fils/m^3	10.0
	Industrial water tariff	1,194 fils/m^3	

3.4 Implementation Plan

The project will be implemented in two phases: Phase-I (Main Control Center and Sub-Centers at four Governorates in the metropolitan area) and Phase-II (Sub-Centers at remaining eight Governorates).

Table3.4-1 Implementation Schedule of the National Water Control Center Construction

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Phase I			•••••							
Main Control Center				▬▬						
Phase II						•••••				
Sub-Center							▬▬	▬▬		

••••• Detailed design ▬▬ Construction

3.5 Problems and Issues

This project called for the introduction of advanced technology and it will therefore be necessary to provide, training for maintaining the accuracy of the flow meter, and a maintenance of the control system. In addition, the education of the stuff members concerning the operation and maintenance will be also indispensable. The training and technical transfer should be done through the operation of the Phase I facilities and the system of operation and maintenance should be completed in Phase I for the implementation of the Phase II project.

The data to be obtained from the National Water Control center should be stored in WIS of MWI and integrated with other data such as water resources development and water quality data in WIS database.

3.6 Conclusion

The accurate flow control is the basic measure for UFW reduction. Technically, the personnel and maintenance plans including flow meter maintenance are important, and it is also important that the project will be started from the water supply control by the Main Control Center, which will be followed by the construction of Sub-Centers when the entire system configuration is fully designed to be feasible.

4. Municipal Water Network Rehabilitation

4.1 Project Objectives

The effective use of water resources is the basic measure for water resources management. For improvement of UFW which exceeds 50%, the physical loss in the municipal distribution pipeline network and the distribution system are subject to continuous improvement by the initiative of the new organization PMU. In the north region of Jordan, the rehabilitation plan is being formulated and implemented by PMU under the cooperation of international assistance organizations, but there are no implementation plans in five areas in the south region.

Thus, the pre-feasibility study will be made for these areas in order to reduce the physical losses by the rehabilitation of the existing water supply system.

4.2 Outline of the Project

These areas are South Amman, Madaba, Karak, Tafielah and Ma'an (see Fig. 4.2-1).

The rehabilitation project will focus on the urban areas of the study areas. Mainly, the improvement of the water supply system, replacement of obsolete distribution pipes and replacement of the water pipes in each household will be planned for physical loss reduction. Table 4.2-1 shows the current situation of water supply of the target areas and Table 4.2-2 shows the expected reduction ratio of the physical losses.

Table 4.2-1 Current Situation of Water Supply in the Target Areas (Year 2000)

Study area	Project area (km^2)	No. of subscribers in 2000 (nos.)	No. of house connections in 2000 (nos.)	Water supplied in 2000 (m^3/year)
South Amman	128.0	6,660	4,000	1,802,500
Madaba	5.0	8,235	5,800	2,995,900
Karak	4.0	4,500	3,200	1,593,000
Tafielah	5.0	6,776	5,400	1,906,400
Ma'an	8.9	5,600	4,500	1,529,400

Table 4.2-2 Expected Reduction of Physical Losses in 2010 for the Study Area

Study area	Water supplied in 2000 (m^3/year)	Pct. to whole Gov. (%)	Water supplied in 2010 (m^3/year)	**Physical loss without project ①** (2010) (m^3/year)	Physical loss with project ② (2010) (m^3/year)	Expected reduction of physical loss ① - ② (2010) (m^3/year)
South Amman	1,802,500	2.0	2,936,000	880,800	440,400	440,400
Madaba	2,995,900	53.7	4,026,200	1,207,900	603,950	603,950
Karak	1,593,000	17.3	2,140,900	642,300	321,150	321,150
Tafielah	1,906,400	79.0	2,562,000	640,500	384,300	256,200
Ma'an	1,529,400	20.3	2,207,200	662,200	331,100	331,100
Total	9,827,200	—	13,872,300	4,033,700	2,080,900	1,952,800

The rehabilitation work in each planned area consists of not only the physical loss reduction by replacement of low-quality/obsolete distribution pipes in distribution pipeline networks and improved connections to households, but also of the system rehabilitation to basically improve the water transport with high-pressure pumps that is a main cause of water leakages in Jordan. Cost of this project is shown in Table 4.2-3.

Table 4.2-3 Preliminary Cost Estimate of Rehabilitation Works

Study area	Construction Cost (JD)		Total (JD)	O/M Cost (JD)
	Rehabilitation	System Impr.		
South Amman	3,219,000	1,025,000	4,244,000	49,900
Madaba	865,000	0	865,000	3,400
Karak	484,000	250,000	735,000	2,800
Tafielah	1,050,000	0	1,050,000	4,200
Ma'an	952,000	0	952,000	3,800
Total	6,570,000 (US$9,386,000)	1,275,000 (US$1,821,000)	7,845,000 (US$11,207,000)	64,100 (US$91,600)

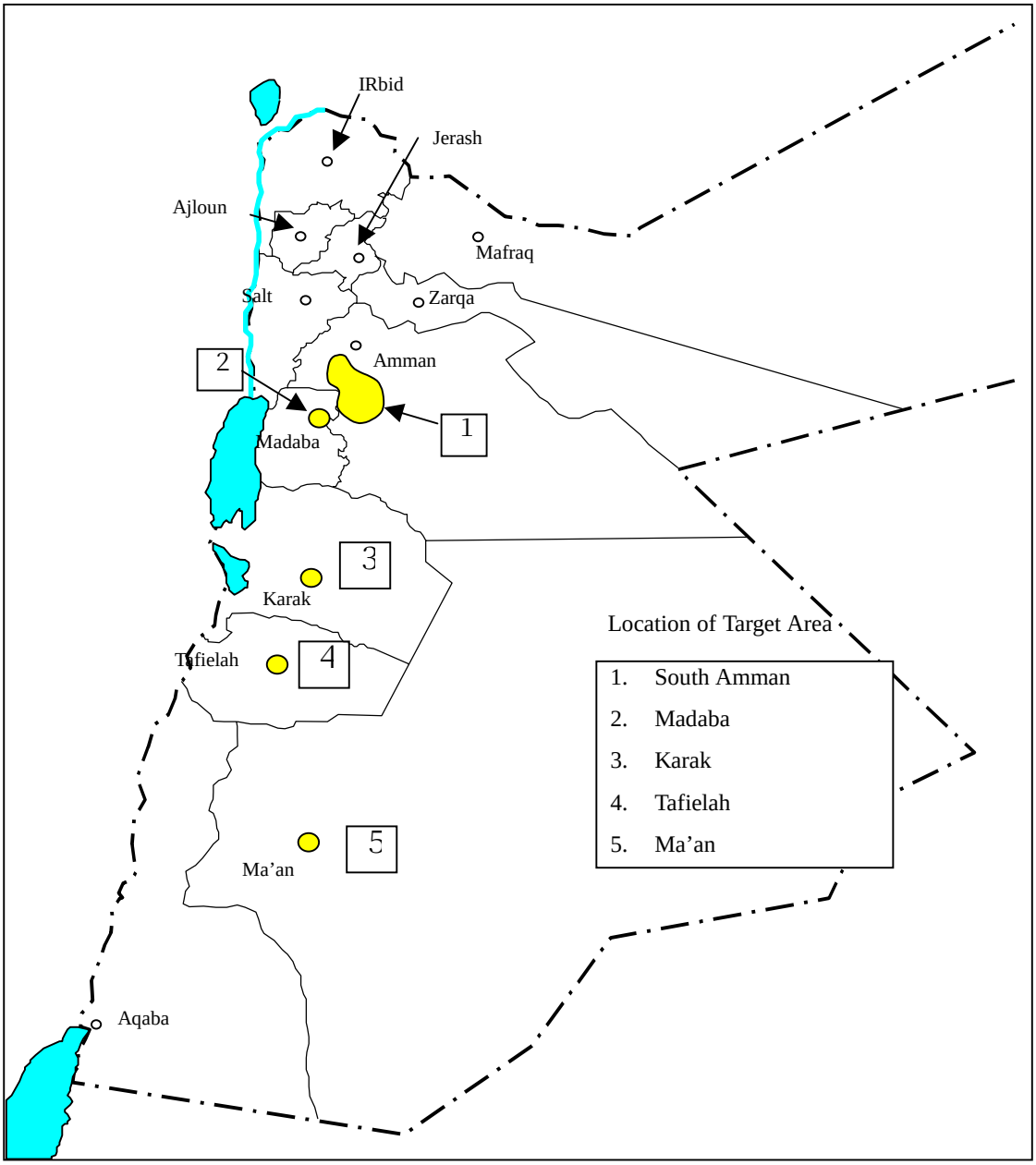

Fig 4.2-1 Location Map of Target areas for Distribution Network Rehabilitation

4.3 Project Evaluation

(1) Position in Water Resources Management Master Plan

The rehabilitation of distribution pipeline networks and the physical loss reduction are the basic measures for UFW reduction. Progress has been made in the cities in the metropolitan area, but from now on it is necessary to formulate and implement a rehabilitation plan for the local cities in the south region. In the local cities, the water supply quantities are lower than in the metropolitan area, but the UFW rate is apt to be higher than the national average and the rehabilitation work there is as important as that in the metropolitan area.

(2) Initial environmental examination

In the areas where the initial environmental impact evaluation was made, no remarkable environmental impact was foreseen except for the impact on the natural environment during the work period, because the distribution pipes to be rehabilitated are mainly embedded pipes.

(3) Economic and financial evaluation

In conducting economic and financial evaluation, the following assumptions have been made:

In the economic analysis, the unit benefit is an increase in the volume of water supply resulted from reducing the water loss as a result of the rehabilitation works. This water volume is multiplied by the average of the affordability amount of the household for water (735 fils/m^3) and the gross industrial profit (2,740 fils/m^3).

In the financial analysis, the implementation body is the WAJ, and a return of the investment in the rehabilitation works is defined as the revenue accrued as a result of reducing the UFW multiplied by the water tariff. The tariff in 2010 is 351 fils/m^3, (the average tariff rate for local cities as the projects are located outside Amman) and the industrial water tariff. They have derived from a preliminary financial analysis of all the planned rehabilitation works for their effects of reducing the UWF in relation to the water tariff. That is, when the current water tariff was continued, the EIRR would be economically feasible 18%, but the FIRR is 4%, and the projects as a whole would not be financially realized. Water supply projects are major activities for the MWI, and the deficit operation of this project may bring about negative financial impact on the Ministry per se. Therefore, raising the water tariff is considered essential for sound financial management of water supply projects. The raised tariff remains within the affordability range for the households.

Under these economic and financial assumptions, the five projects examined as a whole shows an EIRR of 17.2% and an FIRR of 6.3%, which implies economic and financial feasibility of the projects as a group.

Analysis	Unit Benefit/Revenue		IRR (%)
Economic	Affordability to pay (water)	735 fils/m^3	17.2
	Gross industrial profit	2,740 fils/m^3	
Financial	Water tariff (local average)	351 fils/m^3	6.3
	Industrial water tariff	1,194 fils/m^3	

Specifically, four projects except the South Amman project turns out to be both

financially and economically feasible with the FIRRs and EIRRs higher than their respective discount rates or capital opportunity costs (5% and 10%, receptively). In particular, both Madaba and Karak projects are excellent with remarkably high FIRRs and EIRRs and markedly low water prices. The water prices here mean a cost price that can cover the total project costs including an initial capital and recurrent costs. As scale merit, the water price is kept lower with a larger volume of water supplied. In South Amman, the volume of water to be supplied is little in comparison with the total length of pipelines, and for this reason, it was once excluded from the rehabilitation project for the metropolitan area. In this pre-feasibility study, the water price becomes inevitably very high, and the rehabilitation project for this area proves to be financially difficult. When the five projects are combined, the projects as a whole show satisfactory FIRR and EIRR for the given discount rates. In addition, the water price (334 fils/m^3) is lower than the proposed average price (351 fils/m^3). With regard to financial indices, both profitability and liquidity are excellent, showing that the five projects as a whole have a high financial sustainability.

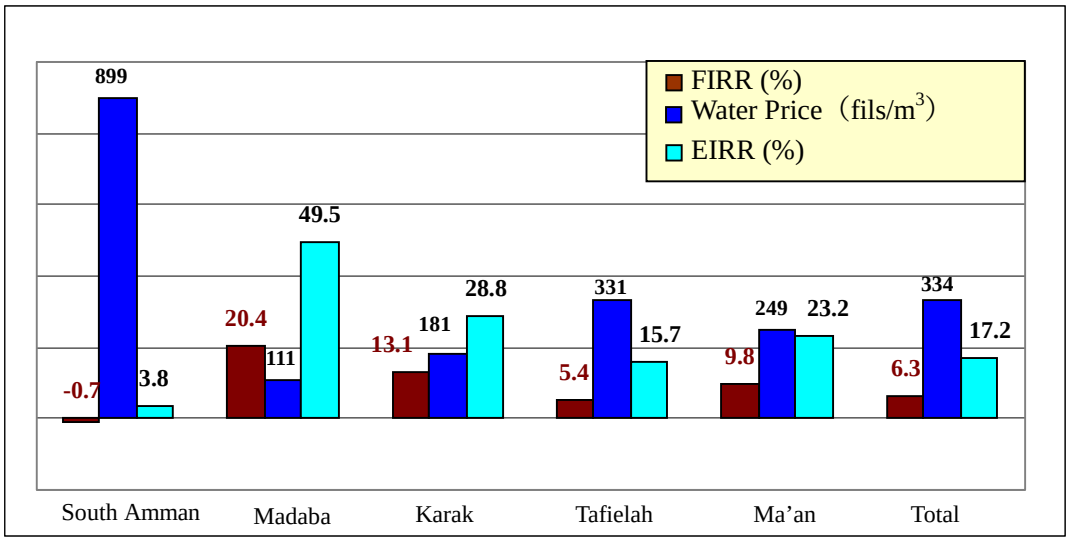

Fig. 4.3-1 Results of the Economic and Financial Analysis on the Rehabilitation Projects

4.4 Implementation Plan

Due to the limited existing data concerning the water supply system in the five target areas, the study on the water supply system should be done prior to the detailed design.

Table 4.4-1 Implementation Schedule of the Rehabilitation Projects

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
UFW study										
System rehabilitation		South Amman 1.03MJD (US$1.47Mil.)					Karak 0.25MJD (US$0.36Mil.)			
Piping work				Five Target Areas 3.22MJD (US$4.60Mil.)						

4.5 Problems and Issues

The pre-Feasibility Study on the rehabilitation of the existing water supply system, which mainly consists of improvement of the supply system, replacement of old pipes and water meters and so on, was conducted for the reduction of UFW in five target areas. However, the occupation ratio of the physical loss in the total UFW is not so large in these areas and the administration losses which are water theft, illegal use of municipal water for irrigation purpose, illegal connection to the main pipes and others occupy a large part of the UFW. Accordingly, rehabilitation alone cannot satisfactorily reduce the UFW and its investment effectiveness will necessarily become low (especially in South Amman, FIRR: negative, EIRR: only 3.8%).

Therefore, comprehensive measures against the UFW including those other than the rehabilitation such as the improvement of the institutional/legislative/social system should be done in the five target areas in parallel with the implementation of the rehabilitation works.

As the present charge of the municipal water cannot make the water supply project financially feasible, the rehabilitation projects of the existing water supply system were planned on the premise that the municipal water charge would be raised by 12% in order to get the financial feasibility of the projects. Though the raise in charge must need the consent of the users, the education and explanation campaign to the people concerning the necessity of water supply projects, present financial conditions of the water supply project and necessity of the raise in charges for the sustainable management should be done in parallel with the implementation of the rehabilitation project. If the raise of the charge will not be possible by any means, the subsidiaries should be supplied from the government for the implementation of the project.

4.6 Conclusion

(1) South Amman

It is essential to conduct the detailed study on the entire UFW which includes administration prior to the implementation of the rehabilitation works and after that it will also be essential to formulate the comprehensive plan for the reduction of the UFW based on the study in the South Amman area. The efficiency of the rehabilitation works should again be examined based on the study.

(2) Four cities in the south region

The study areas for rehabilitation of the water supply system were screened. As a result, the work items of the pre-feasibility study including mainly the measures for physical loss reduction, meter improvement and system rehabilitation were determined to be highly appropriate. Thus, the UFW study and work plan including the maintenance system after rehabilitation should be positively promoted.

5. Wehda – Irbid Water Supply System

5.1 Project Objectives

The Wehda dam project, for which construction has officially started, makes the most of the flood flow from the Yarmouk River as the last water source for large-scale development of surface water (This project is in the stage in which the PQ has been announced for selection of contractors and start of the work is expected in 2002.). This project will allow the use of surface water of 93 MCM/a. According to the existing plan, part of the quantity will be allocated to the municipal water for Irbid City. For the water resources management plan, 40 MCM will be needed in 2010 to accomplish the reduction program of renewable groundwater abstraction in the north region. It was also concluded that the water transportation from the Wehda dam to Amman through Mafraq would be required to resolve the problem of water shortage in the Metropolitan Area in 2020 (the existing pipeline between Irbid and Zarqa will be used for the transportation). The dam construction and water supply projects have been planned many years ago. In 1979, JVA made feasibility study on the water supply and treatment facilities. However, as the basic conditions such as water quality of the river water and transportation amount have changed, the existing F/S will be reviewed.

5.2 Outline of the Project

(1) Outline of Wehda Dam

The outline of the Wehda Dam construction project and the water system construction project from Wehda dam are as follows:

Table 5.2-1 Outline of Wehda dam

Dam height/length	142 m/700 m
Storage Capacity	195MCM
Development Amount	93MCM/a
Construction funds	Arab Fund, Islamic Bank, Abudabi Fund, Total sum of 150 MJD (US$214Mil.)
Scheduled Completion Year	2005

(2) Outline of water treatment plant and water supply system

After the intake from the dam the surface water will be treated in the vicinity of the dam site. The treated water will be conveyed to the existing distribution reservoir located in Irbid City. In addition, a branch distribution reservoir will be installed at Beit Ras on the way of the distribution route (see Fig. 5.2-1, Fig. 5.2-2 and Fig. 5.2-3). The outline of the water treatment plant and the water supply system are shown in Table 5.2-2.

Table 5.2-2 Outline of Water Treatment Plant and Water Supply System

Capacity of the water treatment plant	22 MCM/year, 60,000m^3/day (2005) 40 MCM/year, 11,000 m^3/day (2010)
Capacity of the transfer pump	22 MCM/year, 60,000 m^3/day (2005) 40 MCM/year, 11,000 m^3/day (2010)
Pipe diameter	1,100 mm
Length of the pipeline	23.2 km
Lifting head	350 m
Construction costs preliminarily estimates	Water treatment facilities 13.5 MJD (2005) Water treatment facilities 13.5 MJD (2010) Water supply facilities 17.2 MJD (2005) Water supply facilities 1.4 MJD (2010)

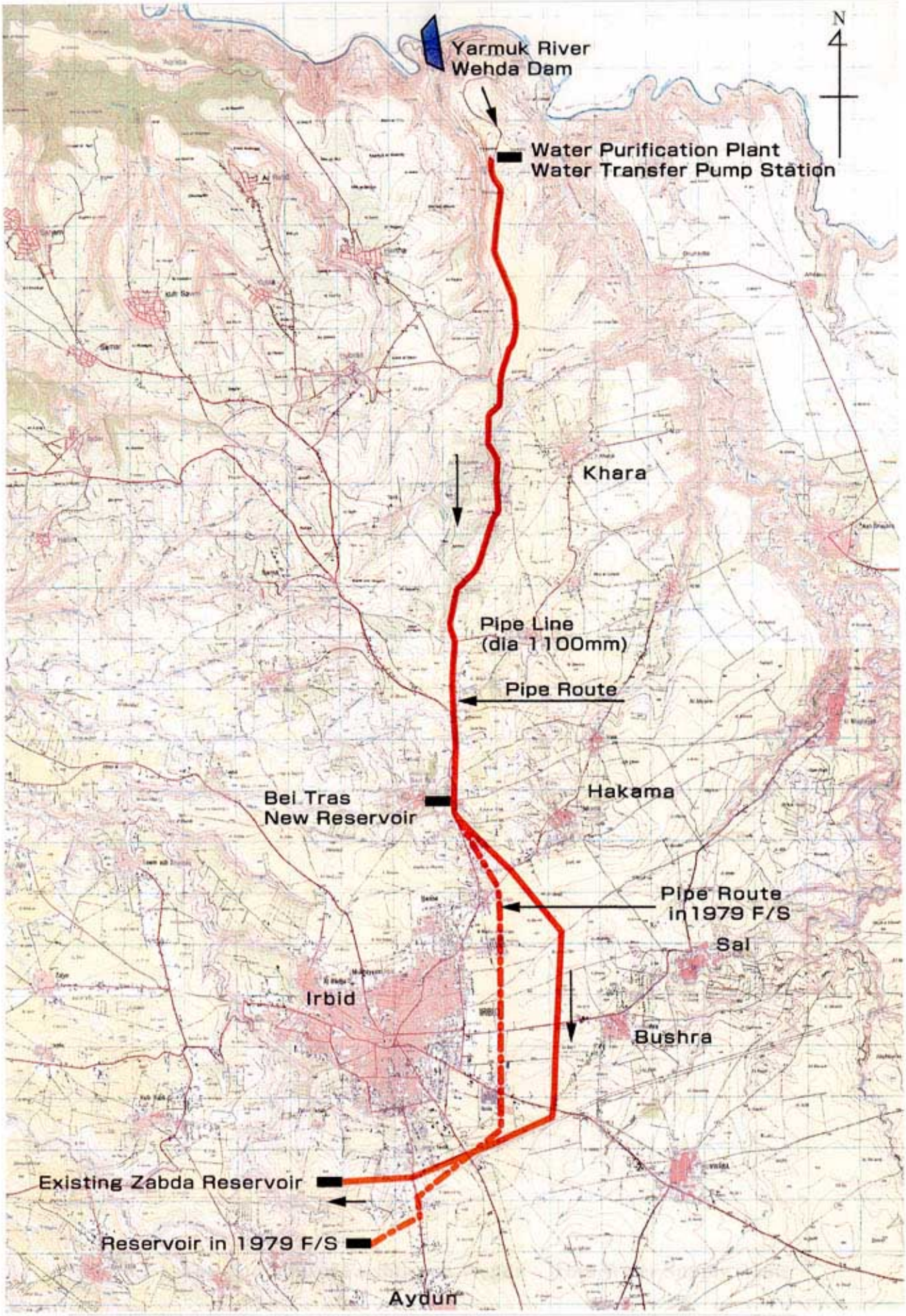

Fig. 5.2-1 Location Map of Facilities on Wehda – Irbid Water Supply Route

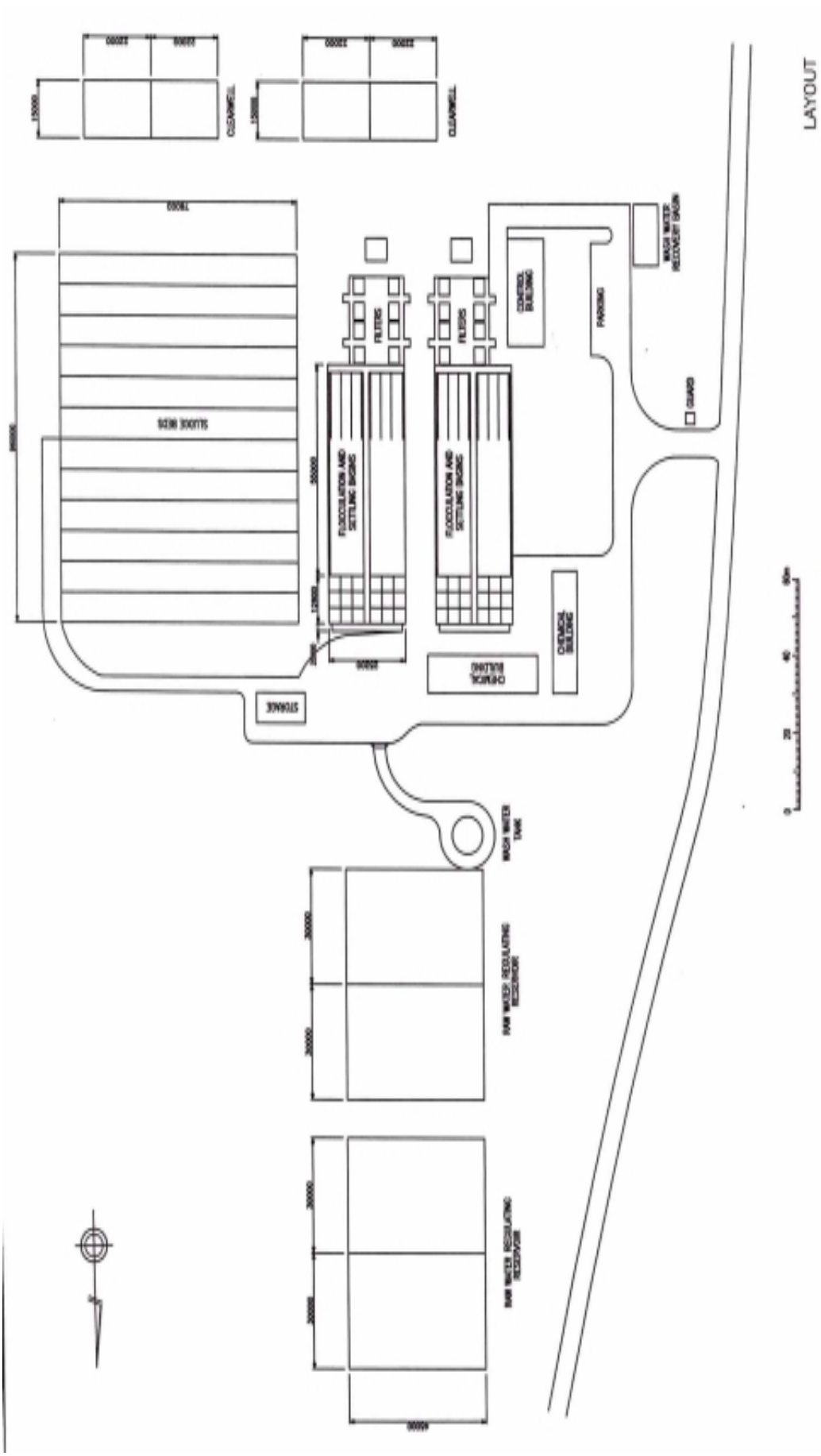

Fig. 5.2-2 Layout of the Water Treatment Plant

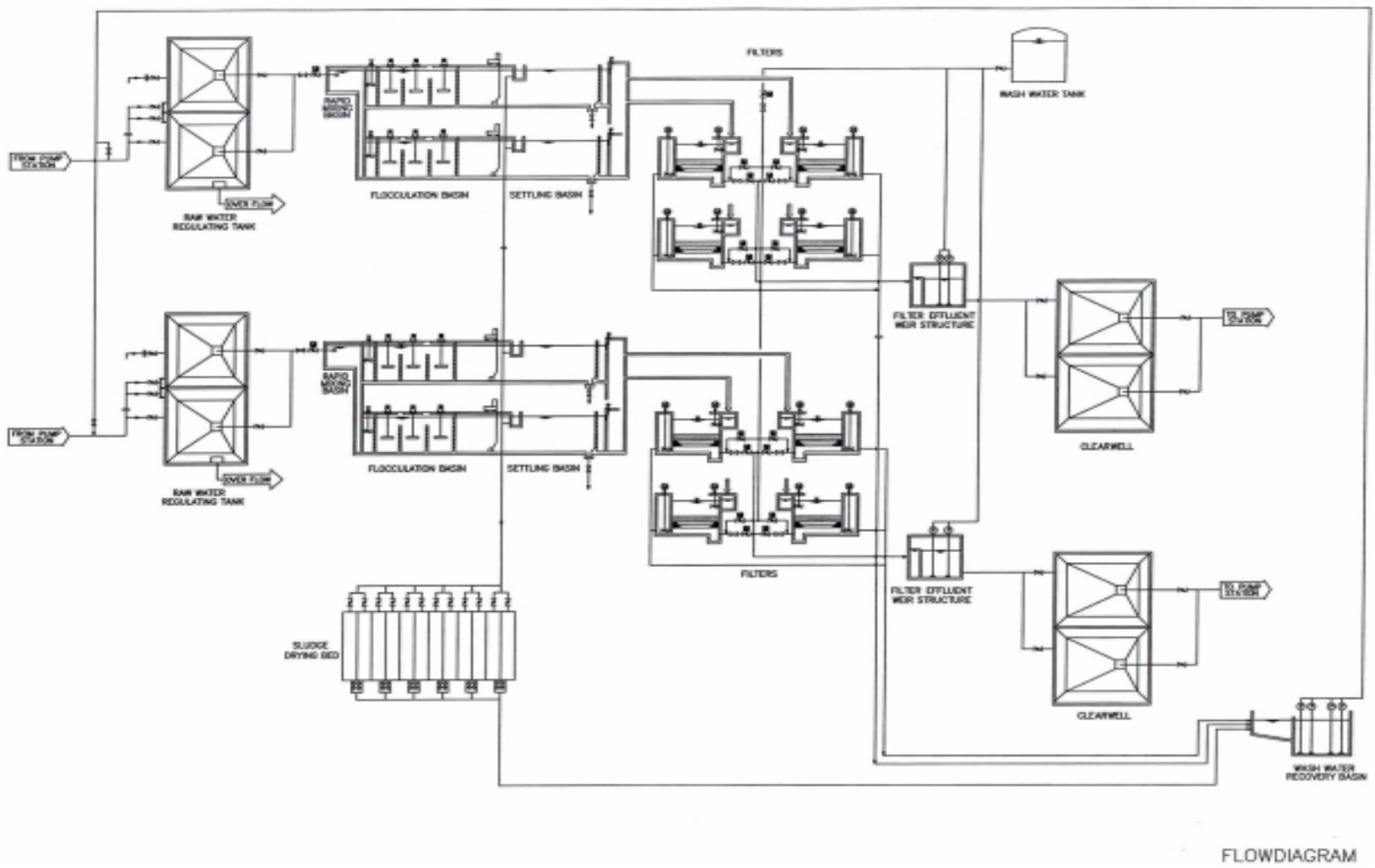

Fig. 5.2-3 Flow Diagram of the Water Treatment Plant

5.3 Project Evaluation

(1) Position in the Water Resources Management Master Plan

The water supply project has the following two important points. First it provides a needed alternative water source to the groundwater reduction because the groundwater as one of the main water resources in the environs of Irbid City has suffered from excessive water abstraction which led to an environmental problem. Secondly it is necessary to supply water via Irbid because the King Abdullah Canal and Deir Alla pumping station systems will have reached their specified capacity in 2020.

(2) Initial environmental examination

In the initial environmental impact evaluation, no significant environmental impact was foreseen except that on natural environment during the work period because the water supply facilities use embedded pipes.

The water treatment plant and water intake facilities should also be considered in framework of the environmental program in the dam construction project.

(3) Economic and financial evaluation

The economic and financial evaluations are based on the following assumptions:

In the economic analysis, the unit benefit is the amount an average household can afford to pay for water, (735 fils/m^3), and the total benefits are calculated by multiplying this amount with the total volume of water supplied.

In the financial analysis, the implementation body is the WAJ. Its annual project revenue is the multiplication of the water tariff (local average: 351 fils/m^3 in 2010) by the total volume of water supplied. The reason for raising the tariff is, as mentioned earlier, that a preliminary analysis has shown that with the current water tariff continued, the project planned in the country would not be financially feasible (4%). Therefore, raising water tariff is considered essential for the sound financial management of water supply projects as well as the Rehabilitation Project in Chapter 4. The financial analysis assumes to raise the water tariff (a local average of 351 fils/m^3 in 2010 since the projects are located outside Amman) and the industrial water tariff.

The project costs include development and operation costs related to the construction of the dam in addition to the costs for construction and operation and maintenance of the water treatment and supply facilities themselves. Specifically, based on the information of the unit project cost of the dam per unit water volume (93MCM/year in total), the project costs are estimated by calculating the costs attributable to this particular project to treat and supply the projected water volume (22MCM in 2005 and 40MCM in 2010).

With the above assumptions, the economic and financial evaluations of the Wehda-Irbid water supply system have concluded that an EIRR is 20.3%, showing a high economic viability, but an FIRR of 4.5% falls short of the capital opportunity cost of 5%.

Analysis	Unit Benefit/Revenue		IRR (%)	Remarks
Economic	Affordability to pay (water)	735 fils/m^3	20.3	
Financial	Water tariff (local average)	351 fils/m^3	4.5	Including costs related to the dam lowers FIRR below the discount rate.

The project costs include development and operation costs related to the construction of the dam in addition to the costs for construction and operation and maintenance of the water treatment and supply facilities themselves. In other words, since the total project cost includes dam-related costs in addition to treatment and supply costs, it is much larger than that of a standard water resource development project that usually do not require large-scale works such as dam construction. This is why the results of the analyses show that the FIRR is lower than 5%, but since the financial viability of the water projects as a whole examined in Chapter 8 is warranted, this particular project can be also financially realized.

5.4 Implementation Plan

The construction of the facilities will be done in two stages according to the progressive increment of the developed surface water. The construction of Wehda Dam will be undertaken by JVA. On the other hand, construction of the water treatment plant and water supply system will be done by WAJ.

Table 5.4-1 Implementation Schedule of Construction of the Water Treatment Plant and Water Supply System

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Wehda Dam construction		━━	━━	━━	━━					
Phase 1 work										
			Treatment Plant 13.5MJD, (US$19.3Mil.)							
			Pumping Station/Pipeline 17.2MJD (US$24.6Mil.)							
Phase 2 work								━━	━━	━━
								Treatment Plant 13.5MJD (US$19.3Mil.)		
								Pumping Station/Pipeline 1.4MJD (US$2.0Mil.)		

5.5 Problems and Issues

It was found in this pre-Feasibility Study that the previous feasibility study done in1979 does not match the present conditions and should be totally reviewed and revised because the basic conditions for the design of facilities such as raw water quality, water demand, developable resource amount, system of water transportation from Wehda dam, location of the treatment plant and so on have been greatly changed. The full scale feasibility study will be needed in future in accordance with the progress of the Wehda dam construction project.

The construction project of Wehda-Irbid water supply system was planned on the premise that the municipal water charge would be raised 12% in order to maintain the financial

feasibility of the project. Though the raise in charge must need the consent of the users, the education and explanation campaign to the people concerning the necessity of water supply projects, present financial conditions of the water supply project and necessity of the raise in charges for the sustainable management should be done in parallel with the implementation of the project. If the raise of the charge will not be possible by any means, the subsidiaries should be supplied from the government for the implementation of the project.

5.6 Conclusion

For the transportation of water from the Wehda dam to the Amman Metropolitan Area in the Upland which is the main water consuming area in Jordan, it is concluded that the water transportation through Irbid has more advantages because the lifting head is lower in case of the Wehda - Irbid – Amman transportation route compared with the route through King Abdullah Canal – Dier Alla pumping station – Zai treatment plant – Amman.

For the use of surface water from the Yarmouk River, the high lift pumping facilities and a treatment plant to remove suspended solids will be required.