The Study on Water Resources Management in The Hashemite Kingdom of Jordan

FINAL REPORT VOLUME X
SUMMARY REPORT

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II Part － 1 Water Resources Management Master Plan

1. Water Strategy and Water Policies in Jordan

The Water Resources Management Master Plan has been formulated under the umbrella of "Water Strategy" and "Water Policies" which are briefly summarized in this chapter.

(1) Water Strategy

The Government of Jordan formulated the "Economic & Social Development Plan 1998-2002" in 1997 and based on this National Plan "Jordan's Water Strategy" was also formulated in the same year. The Water Strategy defined the basic concept for the water resources development and management and its general contents were as follows.

- Sustainable utilization of the water resources and reduction of abstraction of renewable groundwater
- Promotion of utilization of treated wastewater reuse and brackish water
- Strengthening of public awareness on serious shortage conditions of limited water resources
- Promotion of participation of the private sector (promotion of privatization)
- Improvement of institutional system in order to ensure sustainable operation of the water related projects

The basic concept of the Water Strategy is to utilize the limited water resources in Jordan effectively as much as possible relying not only on the development of new water resources but also on appropriate management which aims for sustainable utilization of the limited water resources through the quantitative and qualitative conservation of the water resources, promotion of the public awareness and improvement of the existing legislative & institutional systems.

(2) Water Policies

Water policy papers have been issued during 1997 and 1998 for several water sectors. Water Policies described concrete concepts of the water resources management under the umbrella of the Water Strategy. The Water Policies were divided into four papers which were "Water Utility Policy", "Groundwater Management Policy", "Irrigation Water Policy" and "Wastewater Management Policy". The main contents of these papers are as follows:

<u>Water Utility Policy</u>

- Information systems related to water resources development & management shall be unified under the Ministry of Water and Irrigation
- The retail sectors of the water supply and wastewater treatment of WAJ shall be separated and privatized.

<u>Groundwater Management Policy</u>

- Priority of the groundwater allocation shall be given to Municipal, Industrial, and Touristic purposes
- The groundwater water allocation for forestry shall be given higher priority even though it is agricultural use.
- The groundwater monitoring system shall be strengthened for the conservation of the resource.

Irrigation Water Policy

- Existing water right for irrigation water shall not be used for other purposes without giving substitute water to agriculture.
- Although the extents of the activities and rights of the Jordan Valley Authority (JVA) shall not be changed, weight shall be shifted toward the touristic, industrial and commercial development in the future. In this shift, privatization of public entities and participation of the private sector shall be promoted.
- The tariff of irrigation water shall be increased to the level which at least enables to cover the sustainable maintenance and operation cost of the projects. To achieve these efforts to gain the understanding of the farmers shall be made through public awareness activities.
- Efforts shall be made to change to low water consumption crops.
- The PIM irrigation system, in which farmers shall be responsible for water conveyor to their own lands, shall be introduced.
- Wastewater shall be regarded as not waste but an important resource.

Wastewater Management Policy

- For the reuse of wastewater, treatment shall be upgraded to comply with WHO and FAO standards.
- The wastewater treatment shall be done giving the first priority on the protection of water contamination and health of the people.
- The public shall be made aware of the principal that the discharging side is responsible to bear the cost of the treatment.
- The usefulness of the treated wastewater reuse shall be advertised through public awareness.
- The tariff of the wastewater treatment shall be increased to the level which at least enables to cover the sustainable maintenance and operation cost of the projects.

2. Present Status of Water Sectors and Plans

Sectors related to the water in Jordan are tackling the problems of how to achieve the "Sustainable Development and Management of the Water Resources" (see I Introduction) under the conditions of increase in water demands due to the growth of the population and industrial activities and absolute shortage of the water resources. Several measures have been planned and implemented based on the Water Strategy and Water Policies with the cooperation of international organizations and donor countries.

2.1 Current Water Use in Jordan

The water use status in Jordan in 1999 was as shown in Figure 2.1-1 below:

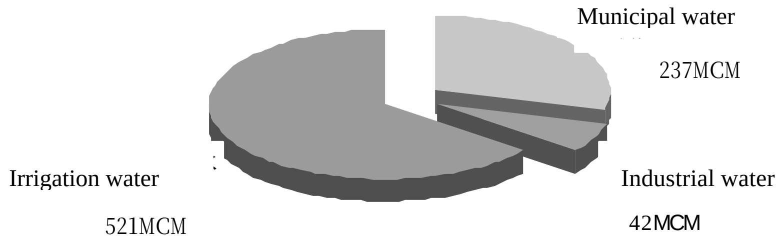


Fig. 2.1-1 Water Use of Jordan (1999)

The total quantity of water use in 1999 in Jordan was 800 MCM (million cubic meters) broken down as follows: irrigation water accounted for 65%, municipal water (including water for the tourism industry) 30% and industrial water 5%.

(1) Municipal water (including water for tourism and industry)

During the latest 4 years, the national municipal water supply was about 240MCM/year as shown in Table 2.1-1. The share of Amman Governorate in 1999 accounted for 37.2% of the total municipal water supply, Zarqa Governorate 13.4% and Irbid Governorate 12.7%. This means that the supply quantity to the three Governorates reached 63.3% of the total.

However, the total water supply quantity did not increase to meet the increase in the national population that grew at an average yearly rate of 3.3% for the same 4 years. The municipal water supply quantity per capita/day decreased from about 149 liters in 1996 to about 133 liters in 1999. The three Governorates of Aqaba, Mafraq and Ma'an had a high rate of unaccounted for water (UFW), resulting in the municipal water supply quantity per capita/day of over 200 liters.

According to the water information system (WIS) database of the Ministry of Water and Irrigation, the UFW rate including physical loss and administrative loss is estimated to be 55% to 60% of the water supplied in the year of 1998. Based on some studies by the UFW prevention department, the physical loss increased from 25% to 30% of the UFW.

Table 2.1-1 Municipal Water Supply by Governorate 1996 – 1999

(Unit:MCM/a)

Gover-norate	1996			1997			1998			1999		
	Municipal Water Supply	Popula-tion (1,000)	l/c/d	Municipal Water Supply	Popula-tion (1,000)	l/c/d	Municipal Water Supply	Popula-tion (1,000)	l/c/d	Municipal Water Supply	Popula-tion (1,000)	l/c/d
Amman	89.622	1,696	144.8	88.776	1,752	138.9	85.214	1,810	129	88.179	1,865	129.6
	37.0%	38.2%		37.0%	38.1%		35.3%	38.1%		37.2%	38.0%	
Zarqa	31.583	687	126	31.455	711	121.3	32.372	748	118.6	31.809	771	113.1
	13.0%	15.5%		13.1%	15.5%		13.4%	15.7%		13.4%	15.7%	
Mafraq	17.099	192	244.1	18.416	199	253.9	19.208	219	240.3	19.021	226	230.7
	7.1%	4.3%		7.7%	4.3%		8.0%	4.6%		8.0%	4.6%	
Irbid	31.972	802	109.2	29.641	835	97.2	30.532	848	98.6	30.055	874	94.2
	13.2%	18.1%		12.4%	18.2%		12.6%	17.8%		12.7%	17.8%	
Ajloun	3.482	101	94.1	3.705	105	96.8	3.946	106	102.5	3.029	109	76.3
	1.4%	2.3%		1.5%	2.3%		1.6%	2.2%		1.3%	2.2%	
Jerash	3.854	133	79.7	4.146	137	82.9	4.545	140	89.1	3.559	144	67.7
	1.6%	3.0%		1.7%	3.0%		1.9%	2.9%		1.5%	2.9%	
Balqa	19.172	301	174.3	18.867	307	168.5	19.149	312	168.1	17.920	321	152.8
	7.9%	6.8%		7.9%	6.7%		7.9%	6.6%		7.6%	6.6%	
Madaba	12.887	111	318.9	11.737	119	269.9	11.737	121	265.2	8.754	125	191.9
	5.3%	2.5%		4.9%	2.6%		4.9%	2.6%		3.7%	2.6%	
Karak	8.480	182	127.5	8.728	189	126.8	9.329	191	133.5	9.173	197	127.6
	3.5%	4.1%		3.6%	4.1%		3.9%	4.0%		3.9%	4.0%	
Ma'an	6.762	85	217.2	6.769	88	210	6.875	93	203.1	7.155	96	205.1
	2.8%	1.9%		2.8%	1.9%		2.8%	2.0%		3.0%	2.0%	
Tafielah	2.036	68	82.6	2.303	70	90.2	2.355	72	89	2.208	75	81.2
	0.8%	1.5%		1.0%	1.5%		1.0%	1.5%		0.9%	1.5%	
Aqaba	15.370	86	491.4	15.077	89	465.3	16.335	95	469.3	16.489	99	458.6
	6.3%	1.9%		6.3%	1.9%		6.8%	2.0%		6.9%	2.0%	
Total	242.319	4,444	149.4	239.864	4,600	142.9	241.597	4,756	139.2	237.349	4,900	132.7

Note: 1) Municipal water includes water for the tourism industry and industrial water for small- and medium-size businesses.
2) The figures include physical loss.
3) L/c/d: Litter/capita/day including physical loss

Source: WAJ/JICA

(2) Industrial water

Most industrial water for large-size businesses is supplied from groundwater sources and its supply quantity per year was between about 30 MCM and about 40 MCM in the years of 1993 to 1999. The demand for industrial water increased as shown in Table 2.1-2.

Table 2.1-2 Industrial Water Supply 1993 – 1999

(Unit:MCM/a)

Item/Year	1993	1994	1995	1996	1997	1998	1999
Industrial water supply	37	27	37	40	41	42	42
(UFW)	10%	10%	10%	10%	10%	10%	10%
(Actual supply)	33	24	33	36	37	38	38

Source: MWI

(3) Irrigation water

The sources of irrigation water are surface water, groundwater and treated wastewater. The irrigation water supply in 1999 was 521 MCM; of which surface water accounted for 37%, groundwater for 49% and treated wastewater for 14%. Groundwater sources are breakdown into 38% from the upland, 1% from the midland and 10% from Jordan Valley. Generally, the tendency for surface water and groundwater decrease and an increase treated wastewater is observed. The total water supply had been falling every year (see Table 2.1-3).

Table 2.1-3 Irrigation Water Supply 1993-1999

(Unit:MCM/a)

Item/Year	1993	1994	1995	1996	1997	1998	1999	
Surface Water Supply	341	302	259	253	266	224	195	37%
Groundwater Supply								
Upland	291	254	237	237	222	209	198	38%
Midland	3	3	3	4	4	4	5	1%
Jordan Rift Valley	53	58	52	56	44	46	53	10%
Total	347	315	292	297	270	259	256	49%
Wastewater Supply								
Upland	4	6	6	7	8	11	11	2%
Jordan Rift Valley	45	45	49	52	53	60	59	12%
Total	49	51	55	59	61	71	70	14%
Grand Total	737	668	606	609	597	554	521	100%

Note: including the leakage from the supply pipeline network
Source:MWI

2.2 Organizations in Water Sector and Financial Budget Status

There are three organizations directly related to the water sector: MWI (Ministry of Water and Irrigation), WAJ (Water Authority of Jordan) and JVA (Jordan Valley Authority). The simplified organization chart is shown in Fig.2.2-1.

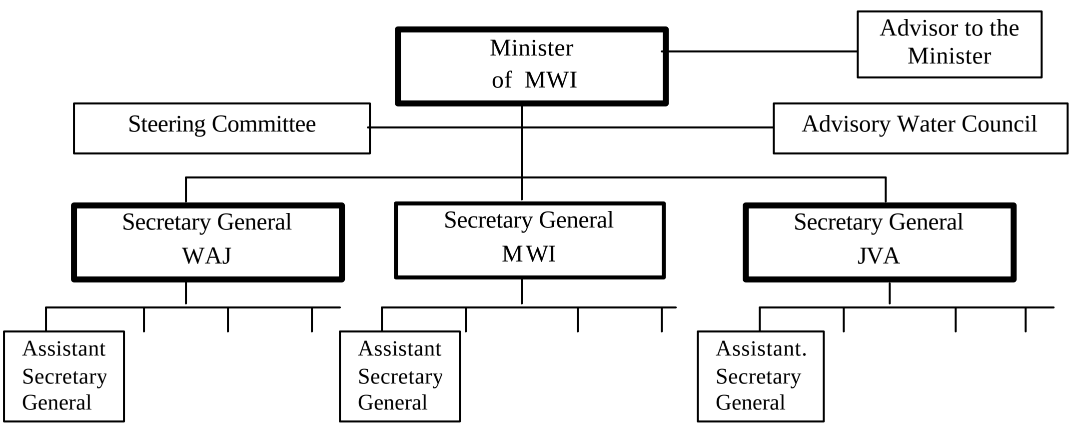


Fig.2.2-1 Simplified Organization Chart of the Sectors Related to Water Projects

Privatization including the participation of the private sector has been promoted among the governmental sectors related to water projects especially in WAJ. The PMU (Project Management Unit) has been established in 1996 in MWI and PMU has initiated activities for privatization. BOT and BOO systems have been introduced for the construction of facilities such as water conveyance & supply and wastewater treatment plant.

2.2.1 MWI

(1) Organization

In order to establish water resources management and integrate various policies under one entity, MWI was founded in 1992 under the Law No. 54/1992. Its main objective was to centralize the national management of substantially insufficient water resources to one Ministry in order to improve it. The water resources management regulated by multiple governmental agencies having services that are different from those of WAJ, JVA, Ministry of Agriculture and Ministry of Health was centralized to MWI. The MWI acquired the comprehensive function to distribute and regulate the water resources in Jordan and the responsible authority to settle any disputes raised between agriculturists and water supply authorities.

Three Secretary Generals of MWI, JVA and WAJ are posted directly under the Minister of Water and Irrigation. Under the secretary General of MWI headquarters, there are four organizational units: Legal Affairs and Water Resources Development Directorate, Financial and General Affairs Directorate, Project Directorate and Financial Directorate. The MWI proper has 35 regular workers at present.

(2) Financial budget status

MWI is one of the ministries of the Government of Jordan. The ministry's budget is drawn up for annual expenditures every year. As WAJ is subject to an independent accounting, the budgets are provided for the Ministry proper and JVA. The budget of the MWI proper for 1998 amounted to 199,000 JD (about US$284,000), or 0.01% of the gross budget for annual expenditures of the Government that was 2,058 million JD for the same year.

2.2.2 WAJ

(1) Organization

WAJ is responsible for the construction, operation and maintenance of water supply and sewage facilities and the national water resources management under the Minister of Water and Irrigation in accordance with the Law No. 18/1988. It formulates water supply and sewage policies and prepares water resources management plans. This organization has also the responsibility of supervising the water supply and sewage services being implemented. Five assistant secretary generals of Technical Support, Planning and Investment, Maintenance and Workshop, Financial Affairs and Administrative Sectors are posted under the WAJ Secretary General.

WAJ had 7,460 staff members as of 1998, of which 69% consists of regular workers and 31% irregular workers (see Table 2.2-1). The regular workers are decreasing from year to year while the irregular workers are increasing. This probably results from the restructuring of central and local organizations based on the organizational improvement plan established with CIDA's cooperation.

Table 2.2-1 Number of WAJ Staff Members

(Unit: person)

Item/year	1996	1997	1998
Regular	5,292	5,164	5,117 (69 %)
Irregular	2,139	2,250	2,343 (31%)
Total	7,431	7,414	7,460 (100%)

Source: WAJ

(2) Financial budget status

Of the three organizations directly related to the water sector, MWI and JVA are not controlled by the business accounting system, but the budgets for their annual expenditures are appropriated. The revenues from both agencies go into the national treasury. At present only WAJ operates its financial affairs in accordance with the business accounting scheme. The revenue and expenses statements of WAJ are shown in Table 2.2-2.

Table 2.2-2 Revenue and Expenses Statement of WAJ

(Unit：1,000JD)

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Revenue									
Water revenue	15,420	16,097	18,464	21,805	24,269	25,197	29,278	31,221	44,174
Revenue of water by tanks	191	241	185	244	333	347	438	468	402
Sewage and drainage revenue	982	1,581	3,381	4,325	4,516	4,876	5,371	5,632	9,081
Sewage tax	2,500	3,717	4,056	4,171	5,410	5,123	5,530	6,461	6,548
Contracts, maintenance and connection revenue	2,246	1,648	1,608	3,755	4,239	3,303	3,457	3,992	4,002
Meter maintenance fees	0	0	0	0	0	646	666	697	731
Interest receivable	385	531	128	133	48	15	6	20	33
Other revenue	0	0	0	0	0	6	46	43	10
Miscellaneous revenue	199	539	16	393	1,275	1,110	1,341	821	935
Total revenue	**21,922**	**24,354**	**27,840**	**34,824**	**40,090**	**40,623**	**46,133**	**49,354**	**65,914**
Expenses									
Wages and salaries	11,087	13,509	13,317	15,218	16,099	16,348	19,363	20,253	20,683
Operation and maintenance cost	13,166	16,605	19,057	19,017	25,188	29,765	30,639	32,869	33,733
General administration expenses	672	573	454	498	633	723	805	970	911
Depreciation expenses	15,379	21,680	22,332	24,388	27,586	29,454	32,986	35,993	38,950
Interest payable	3,869	7,490	11,839	12,044	15,782	16,188	17,560	15,399	16,927
Total expenses	**44,173**	**59,857**	**66,999**	**71,165**	**85,288**	**92,478**	**101,354**	**105,484**	**111,204**
Excess of expenses over Revenue	27,250	35,504	39,159	36,341	45,198	51,355	47,447	54,191	45,290
Differences in exchange rate	8,693	4,319	3,214	2,227	4,129	6,926	3,887	970	944
Previous years adjustments	0	-763	0	0	0	0	0	0	0
Deficit for the year	35,944	39,060	42,373	38,568	49,327	58,280	51,334	55,161	46,234
Prior years deficit	74,754	110,698	149,758	192,131	230,698	280,025	338,806	395,092	437,544
Accumulated deficit	**110,698**	**149,758**	**192,131**	**230,698**	**280,025**	**338,306**	**390,140**	**450,253**	**483,778**

Source：WAJ

Water Supply and Sewage Revenue (Unit: %)

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Water and sewerage revenue/ Total revenue	76	74	79	76	73	75	76	76	81
Sewage tax, contracts, Operation and maintenance cost and connection revenue/Total revenue	22	22	20	23	24	21	19	21	16
Total	97	96	99	98	97	96	96	97	97

Cost Recovery (Unit: %)

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Total revenue/operation and maintenance cost *	88	79	85	100	96	87	91	91	119
Total revenue/Total expenses	50	41	42	49	47	44	46	47	59

* Operation and maintenance cost: Wages and salaries + Operation and maintenance cost + general administration expenses

Share of operation and maintenance cost (Unit: %)

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998
Operation and maintenance cost/ Total expenses	56	51	49	49	49	51	50	51	50
Capital expenses/Total expenses	44	49	51	51	51	49	50	49	50
Total	100	100	100	100	100	100	100	100	100

As shown in Table 2.2-2, WAJ obtained the revenue of about 65.9 million JD in 1998, of which the water supply and sewage and drainage revenue accounted for 81% and the sewage tax, contract, maintenance and connection revenue 16%, the total of both revenues being 97%.

The total expenses in 1998 amounted to 111.2 million JD. Thus, the total expenses accounted for 59% of the total expenses. Comparing the operation and maintenance cost with the total revenue, the latter accounted for 119% of the former. This means that WAJ was successful in collection of the maintenance cost as far as 1998 is concerned. However, the capital expenses (depreciation expenses and interest payable) remain to be uncollected. It is concluded that the financial conditions of WAJ are still severe.

2.2.3 JVA

(1) Organization

JVA was founded in 1977 under the Law No. 18/1977, under which this agency acquired the prime authority to plan and implement water supply services in the Jordan Valley. Subsequently, JVA strengthened the management for the infrastructure development (including water, electricity, land and municipalities) in the Jordan Valley. Over many years, this Authority has taken the lead in the development of water supply facilities in the Jordan Valley and built up an advanced water management system.

Under the JVA Director General, six assistant secretary generals of Planning and Environment, Southern Ghors and Wadi Araba, Lands and Urban Development, Administration, Finance and Tenders, Northern and Middle Ghors, and Studies and Project are posted.

Of the total number of 2,094 staff members in 2000, 1,020 members were engaged in irrigation water supply as shown in table 2.2-3. Of 1,020 members, the regular workers accounted for 68% and irregular workers for 32%. The former is decreasing while the latter is increasing. This probably results from the restructuring of the central and local organization based on the organizational improvement plan.

Table 2.2-3 Number of JVA Staff

Item/Year	1998	1999	2000
Total staff	2,022	2,116	2,094
Irrigation water supply	955	1,029	1,020 (100%)
Regular	738	731	697 (68%)
Irregular	257	298	323 (32%)

(2) Financial budget status

JVA is one of the agencies of the Government of Jordan, for which the budget for annual expenditures is drawn up every year. The budget in 1998 for JVA amounted to 34,910,300 JD, which accounted for 1.7% of the gross budget for the annual expenditures for the same year.

3. Setting of Basic Conditions for the Formulation of the Master Plan

3.1 Setting the Frame Work for the Formulation of the Master Plan

Prior to the formulation of the Water Resources Management Master Plan, the basic framework for the future balance between demand and supply were considered by World Bank/MWI by September, 2000. The main policies for "Conservation of Water Environment" and "Recycling of the Water resources" are presented in this basic framework. The Water Resources Management Master Plan was formulated for the twelve governorates in Jordan according to the basic framework. The target years of the Master Plan were set for Short Term (2000-2005), Mid Term (2006-2010) and Long Term (2011-2020).

3.2 Basic Policies for the Formulation of the Development Master Plan

The water resources development should be promoted for the sustainable utilization of the limited water resources in developing both the conventional and non-conventional type water resources as described below.

(1) Conventional type water resources

Surface water, renewable groundwater, fossil fresh groundwater and peace water were considered as conventional type resources in the Study. For the surface water, its potential was used to the maximum extent. For the renewable groundwater, reduction of its abstraction was adopted throughout the country instead of additional development because it was under the over drafting condition. For the fossil fresh groundwater, the development amount was determined considering that the development period would be restricted to 50 years. For the peace water, it was considered that the water amount supplied from Israel would not be changed on the assumption that the peace treaty would remain in force.

(2) Non-conventional type water resources

Desalinated brackish groundwater, desalinated seawater and treated wastewater were considered as non-conventional type water resources. For the desalinated brackish groundwater, although huge potential was anticipated to exist along the east bank of the Dead Sea and Southern Jordan Valley, it was decided that its full scale development would be implemented after 2020 or would be preserved for the emergency cases in future because the desalination cost was still high. For the sea water desalination, the desalinated water was used only for the MIT purposes in Aqaba considering the high cost of water conveyance. For the treated wastewater, it was decided that the its reuse would be limited to the vicinities of the treatment plants and in Jordan Valley because it would not be economically feasible in case of the reuse in the Upland because of the high cost of water conveyance.

3.3 Policies for the Formulation of the Management Master Plan

3.3.1 Policies for the Demand Control by Sector

A strict demand control policy should be taken against the demands for municipal water including touristic, industrial and irrigation water because of restriction of available water resources. The basic policies for demand control are as follows:

(1) Municipal water

The increasing demand for municipal water resulting from the population growth (from 470 million in 1998 to 920 million in 2020, annual average growth rate: 3.03%) would be secured, but the consumption rate per capita would be maintained around the present level (about 100l/c/d to 150l/c/d excluding physical loss). The differences of the consumption rate per capita among the 12 Governorates would also be balanced by 2020. For this purpose, education of users to promote awareness of the social/economic value of water resources would be carried out.

(2) Industrial and touristic water

In consideration of the importance to the national economy of the touristic and industrial sectors, which accounted for 10% and 13% of the GNP (1998) respectively, the minimum possible water demand would be secured. In the demand projection, the major tourist and industrial development projects would be fully considered, which include the Dead Sea Touristic Development, the special economic districts and industrial development districts and oil shale developments.

(3) Irrigation water

Based on "Irrigation Water Policy" issued in 1998, the water for agriculture would not be reduced in the future. However, it is clear that the irrigation water could not be increased any more because of the increasing demand of municipal, industrial and touristic sectors. Concerning this problem, World Bank/MWI/JICA confirmed that the irrigation demand would be sustained at the present level in the future.

The abstraction of the renewable groundwater would be reduced in the Upland Area where the groundwater level decline and the water quality deterioration of the renewable groundwater have become prominent. In this case, it would be necessary to establish the policy of shifting the agricultural activities from the Upland to Jordan Valley. In addition, the treated wastewater would be used for irrigation in the Upland as a supplementary resource in order to maintain the irrigation water as much as possible.

3.3.2 Policy for the Water Resources Management

(1) Quantitative management

1) UFW (Unaccounted for Water) improvement plan

Rate of UFW reaches about 60% and the leakage from the water supply system (physical losses) is about 25% to 30%. The rehabilitation of the water supply system is in various stages of planning and implementation covering the whole of Jordan by MWI and financed by several donor countries such as USA, Germany and others. This project aims to reduce the physical losses to 15% by 2010. The Water Resources Management Master Plan would be formulated taking this project into consideration.

In addition, the national water supply control systemwould be considered for the purpose of the precise detection of UFW.

2) Water allocation and transportation plan

The available water resources and water demand in the 12 Governorates would be defined as numerical data and the water distribution would be suitable balanced among those Governorates permitting no excesses and shortages.
The existing agriculture using surface water for irrigation would be maintained in the future, but the agriculture using groundwater would be controlled in the terms of quantity of use in accordance with the groundwater reduction plan. The water resources available from new surface water developments would be allocated primarily to municipal water use with priority and the remaining quantity would be allocated to irrigation. The quantity of treated wastewater would be used for irrigation and industrial water as much as possible.

The inter-govenorate water conveyance would be planned after the final water allocation to twelve Governorates.

3) Reduction plan of the renewable groundwater abstraction

The safe yield of the renewable groundwater which is the sustainable development amount would be examined and evaluated based on the existing data and studies. The reduction plan of the renewable groundwater abstraction would be formulated in each Governorate based on the safe yield. The reduction plan would cover not only abstraction for the irrigation but also abstraction for MIT (Municipal, Industrial and Touristic) uses. For the formulation of the reduction plan, the reduction plan in Amman/Zarqa Basin recommended by USAID Study would be taken into consideration.

(2) Qualitative management

The water quality conservation in the national level would be considered on the basis of the existing water quality data analysis and water quality change simulation analysis on surface water and ground water from the MWI's WIS database. For the formulation of the water quality conservation plan, the national monitoring system of surface water and groundwater quality recommended by USAID Study (WQICP) would be taken into consideration.

(3) Institutional and legislative management

The improvement plans of the institutional and legislative system that are in progress within MWI would be reviewed in relation to this Water Resources Management Master Plan to make necessary improvements and additions. In particular, USAID and MWI have examined the reduction plan of renewable groundwater abstraction and the treated wastewater reuse plan. Though the agricultural organizations and legal/standard schemes were also proposed to implement these plans, these plans would be positively taken into consideration.

4. Water Demand Projection

4.1 Setting of Scenario for Demand Projection

The water demand projection which is the basic data for the formulation of the Water Resources Management Master Plan should be restricted considering the sustainable water resources development because of the severe water shortage in Jordan. Namely, the increase of the municipal water demand to be caused by the future population growth should be secured but the consumption rate per capita should be kept at minimum because of the limited water resources. For the agriculture, water demand of all development schemes can not be secured. In making the water demand projection, three scenarios were prepared taking above conditions into consideration.

These scenarios were related to municipal water, industrial water and touristic water as summarized in Table 4.1-1. Scenario 1 was the basic scenario that was established in the work made by the World Bank and MWI to study the basic water balance between water resources and water use in the national level from early 2000 to 2020, which the Study Team also participated in.

Table 4.1-1 Summary of Water Demand Projection Scenarios

(Figures for plan target year 2020)

	Municipal Water	Industrial Water[*5*6]	Touristic water[*5*6]	MIT Total	Irrigation Demand[*7]
Scenario 1	Population: 9.18 million Predicted by MWI*[1] Water supply[*3]: 128 l/c/d	Increase rate: 4.2 – 1.1%/year[*4]	Increase rate: 5.0 – 2.5%/year	647MCM/a	630 MCM/a
	501 MCM/a	130MCM/a	16MCM/a		
Scenario 2	Population: 9.24 million Predicted by MWI*[1] Water supply[*3]: 150 l/c/d[*4]	Increase rate: 5.3 – 4.6%/year	Increase rate: 8.4 – 8.3%/year	777MCM/a	963 MCM/a
	587MCM/a	169MCM/a	21MCM/a		
Scenario 3	Population: 7.99 million Predicted by Statistics Bureau*[2] Water supply[*3]: 150 l/c/d[*4]	Increase rate: 2.9 – 2.9%/year	Increase rate: 5.5 – 3.0%/year	659MCM/a	630 MCM/a
	510MCM/a	132MCM/a	17MCM/a		

*1 Projection of the population used by MWI to formulate the projects.
*2 The figure used by the population projection agency (Department of Statistics) of the Government of Jordan (including the population control policy of the Government).
*3 Water supply is the quantity actually supplied to the consumers exclusive of physical loss.
*4 150l/c/d is the target value of municipal water supply that MWI set as its target demand.
*5 The increase rates of industrial water and touristic water represent the change during the plan period of 1998 to 2020.
*6 In addition to the regular increase, irregular increase is also considered based on the specific development projects.
*7 Water demand for the agriculture of Scenario 1 & 3 was residual water amount after securing the MIT demand

The demand projection was made on the basis of the basic items in these scenarios and calculated using the demand calculation module on the "Digital National Master Plan" that was newly developed in the Ministry of Water and Irrigation.

The average annual water consumption amount for agriculture from 1993 to 1998 is around 620MCM/a (see table 2.1-3) and it would be employed for Scenario 1 and 3 as "Policy Demand" which would not be largely changed in future according to the basic water balance prepared by World Bank/MWI in 2001. The water demand for the agriculture based on the agricultural development schemes of JVA and MOA (Ministry of Agriculture) would be employed for Scenario 2 as "Target Demand".

Fig.4.1-1 shows main characteristics of the three Scenarios mentioned above.

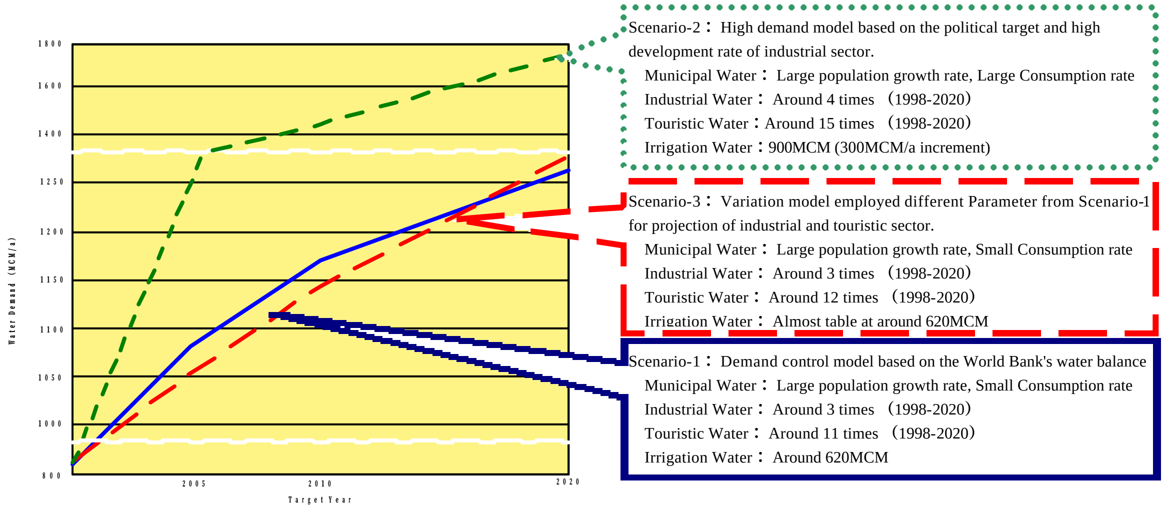
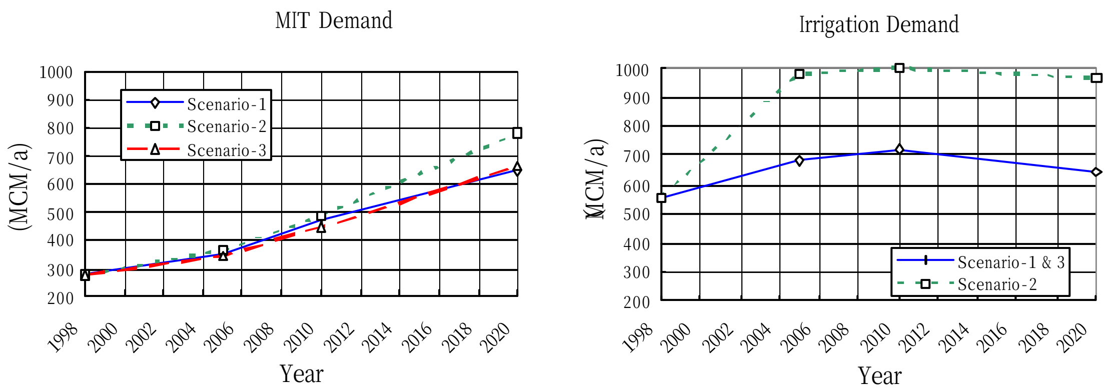


Fig. 4.1-1 Water Demand Projection by Each Scenario

Fig. 4.1-2 shows the water demand projection of MIT and agriculture. The water demand projection of Scenario 1 and 2 is estimated based on the concept that the water demand for agriculture would be basically constant without any large changes and the agriculture demand would be residual amount after securing the MIT demand in this case. For this reason, the water demand for agriculture will slightly increases from 2000 to 2005 because the water demand for MIT will be still low in this period but the water demand for agriculture will gradually decrease because of the increase of the MIT demand after 2005 and the water demand for agriculture will reach the level almost near to the present consumption amount by 2020. On the other hand, the slight decrease of the water demand for agriculture from 2010 to 2020 in Scenario 2 is caused by improvement of the irrigation efficiency in future and the irrigation area will be constant without reduction.



Note: The reasons for the increase by 2005 and the decrease after 2005 in Scenario 1 & 3 is due to the allocation of the residual water to the agriculture. The reasons for the decrease after 2005 in Scenario 2 is due to the improvement of the irrigation efficiency.

Fig. 4.1-2 Water Demand Projection of MIT and Agriculture

4.2 Municipal Water

(1) Population

The population by Governorate in Jordan in each of the target years of 2005, 2010, 2015 and 2020 was forecast in accordance with each of the three scenarios. The projections in Scenarios 1 and 2 were made jointly by MWI and the World Bank. Scenario 3 reflected the projection by the Department of Statistics (DOS).

As shown in Table 4.2-1, the first two scenarios predicted that the population of Jordan would nearly double in the 22 years period from 1998 to 2020. The predicted population in scenario 3 is lower than that in the other scenarios.

Table 4.2-1 Population Projection by Target Year and Scenario

Scenario		1998	2005	2010	2015	2020
Scenario 1 and Scenario 2	Population	4,756,000	5,980,000	6,970,000	8,040,000	9,180,000
	Annual average increase rate		3.3%	3.1%	2.9%	2.7%
Scenario 3	Population	4,756,000	5,710,000	6,450,000	7,220,000	7,990,000
	Annual average increase rate		2.6%	2.5%	2.3%	2.0%

(2) Water supply per capita/day

As shown in Table 4.2-2, the water supply per capita/day exclusive of physical loss (the actual quantity supplied to consumers) and the water supply per capita/day including physical loss were set by target year in the three scenarios. As shown in the table, the same water supply per capita/day was set in scenarios 2 and 3. The predicted unit water supply in scenario 1 was lower than in the other scenarios.

Table 4.2-2 Municipal Water Supply Projection per Unit by Target Year and Scenario

Scenario 1 (Unit: l/c/d)

Year	Municipal Water Supply per Unit		Physical Loss Rate
	Actual Consumption	Consumption with Physical Loss	(%)
1998	102	136	25
2005	101	126	20
2010	124	146	15
2015	130	153	15
2020	128	151	15

Scenarios 2 and 3 (Unit: l/c/d)

Year	Municipal Water Supply per Unit		Physical Loss Rate
	Actual Consumption	Consumption with Physical Loss	(%)
1998	102	136	25
2005	101	126	20
2010	124	146	15
2015	144	169	15
2020	150	176	15

The water supply per capita/day exclusive of physical loss in each target year was predicted with consideration of the gross developable water quantity, the population and the industrial irrigation water demand as estimated for each target year. The total water supply amount is equal to the maximum available water quantity for each target year. The physical loss rate was assumed to achieve the final level of 15% in 2010 on the basis of the study made by the UFW Prevention Department that had been recently set up within the MWI. The actual consumption in each target year in Table 1.3.1-3 was weighted average value of actual consumptions in the Governorates.

(3) Demand projection

The municipal water demand by Governorate was also predicted on the basis of the forecast population and the predicted water supply per capita/day including physical loss per target year and scenario. As shown in Table 1.3.1-4, the municipal water supply demand was predicted to be a little over 500 MCM in 2020 in scenario 1. This value is more than double as high as the demand in 1998. In scenario 2, the demand in the final target year was predicted to be a little less than 600 MCM, nearly 2.5 times the demand in 1998. In scenario 3, the predicted demand was about 510 MCM in 2020, at the medium level between both values in the other scenarios.

Table 4.2-3 Municipal Water Demand Projection by Target Year and Scenario

(Unit: MCM)

Scenario	1998	2005	2010	2015	2020	1998/2020 Factor
Scenario-1	237.06	272.67	367.51	445.12	501.26	2.1
Scenario-2	237.06	272.67	367.62	493.07	587.40	2.5
Scenario-3	237.06	260.36	340.65	443.39	510.05	2.2

Note: Including physical loss

4.3 Industrial Water

(1) Regular increase

The annual average increase rate of industrial water in scenario 1 adopted the rate based on the basic water balance predicted by MWI/World Bank/JICA. This increase rate was obtained in the way that the increase rate of industrial water demand predicted through the statistic processing of the gross industrial production for the past years in Jordan was suppressed in consideration of the reuse rate and use efficiency.

From the result of the questionnaire survey into the large-size industries, the current reuse rate (the rate of the use by industries to the gross use) was about 70%, while about 30% was discharged from the processing stage. In scenario 3, the increase rate of industrial water demand was determined based on the demand for the future production expansion plans in the industries as responses to the questionnaires.

Table 4.3-1 Industrial Water Demand Growth Rate by Scenario

Scenario	1998-2005	2005-2010	2010-2015	2015-2020
Scenario-1	4.2%	3.1%	2.1%	1.1%
Scenario-2	5.3%	4.6%	4.6%	4.6%
Scenario-3	2.9%	2.9%	2.9%	2.9%

(2) Irregular increase

In addition to the regular increase in industrial water demand, each scenario involved the drastic demand growth to the gross water supply of 60 MCM based on the Industrial Development Project, which have been prepared by Ministry of Planning (for example, the shale mining project in Karak Governorate).

(3) Demand projection

The industrial water demand by Governorate, target year and scenario was predicted based on the actual consumption of industrial water 1998 by Governorate, the regular increase rate per year for certain years, the existing industrial development projects and the projection of improvement of the industrial wastewater reuse rate.

Table 4.3-2 National Industrial Water Demand by Target Year and Scenario

(Unit: MCM)

Scenario	1998	2005	2010	2015	2020	1998/2020 Factor
Scenario-1	38.95	76.08	94.13	113.55	130.21	3.3
Scenario-2	38.95	80.07	101.57	133.94	168.66	4.3
Scenario-3	38.95	71.85	88.68	109.85	132.28	3.4

Note: Including physical loss

As shown in Table 4.3-2, the industrial water demand for the final target year of 2020 was predicted to be about 130 MCM in scenario 1, which was 3.3 times as high as in 1998. In scenario 2, the demand was predicted 169 MCM in the same year, an increase of 30% of the level in scenario 1. In scenario 3, the demand in the final target year was predicted to be 132 MCM, not so different from that in scenario 1.

4.4 Touristic Water

As the development of the tourism will be highly contribute for the acquisition of foreign currency, the higher priority should be given for the water allocation to the touristic sector. For the projection of the touristic water demand, regular increase which assumes demand increase by annual rate and irregular increase which assumes demand increase based on the specific touristic development schemes are were employed.

(1) Regular increase

Table 4.4-1 shows annual increase rate of the touristic water demand by scenario. The annual average increase rate of touristic water in scenario 1 was a value set by the World Bank and MWI. In scenario 2, the future increase rate of touristic water demand was calculated by statistic processing method (logarithmic regression method) based on the number of tourists that visited Jordan in the past years. In scenario 3, the different statistic processing method (natural number regression method) from the case in scenario 2 was employed to determine the increase rate.

Table 4.4-1 Annual Increase Rate of Touristic water Demand by Scenario

Scenario	1998-2005	2005-2010	2010-2015	2015-2020
Scenario-1	5.0%	5.0%	2.5%	2.5%
Scenario-2	8.4%	8.3%	8.3%	8.3%
Scenario-3	5.5%	4.3%	3.5%	3.0%

(2) Irregular increase

In addition to the regular increase rate of touristic water demand, each scenario involved a drastic demand growth to the gross water quantity of 15 MCM based on the existing tourist development projects (for example: the Dead Sea East Coast Infrastructure Development Project).

(3) Demand projection

The touristic water demand was predicted by Governorate, by target year and scenario based on the actual number of beds and water demand in 1998 by Governorate, the predicted physical loss rate by Governorate, the predicted average bed occupancy rate, the seasonal change in hotel bed availability rate, predicted increase rate by target year and the existing tourist development projects.

Table 4.4-2 National Touristic Water Demand by Target Year and Scenario

(Unit: MCM)

Scenario	1998	2005	2010	2015	2020	1998/2020 Factor
Scenario-1	1.44	6.92	11.40	16.08	16.42	11.4
Scenario-2	1.44	10.79	17.18	18.82	21.28	14.8
Scenario-3	1.44	10.38	16.12	16.55	16.99	11.8

Note: Including physical loss

As shown in Table 4.4-2, the touristic water demand in 2020 was predicted to increase to ca. 16.4 MCM, 11.4 times higher than in 1998 in scenario 1. In scenario 2, the demand was predicted to be ca. 21.3 MCM, an increase of 30% of that in scenario 1. In scenario 3, the final demand was predicted to remain ca. 17 MCM, not so different from that in scenario 1.

4.5 Irrigation Water Demand Projection

Regarding future irrigation water demand of this study, there were two demands considered. One is, for scenario-1 and scenario-3 based on the policy of the government that securing the current water supply of approximately 600 MCM/a, surplus water after the allocation for MIT (municipal, industrial and touristic) demands from the available water supply in the sustainable development scheme. Table 4.5-1 shows the results of water allocation to the irrigated agriculture decided in the water resources management plan in Chapter 6.

Table 4.5-1 Irrigation Water based on the Water Allocation

Unit: MCM/a

Governorate	2005	2010	2015	2020
Amman	42.1	41.9	40.8	39.1
Zarqa	65.2	60.0	58.1	53.8
Mafraq	50.5	44.7	41.3	36.4
Irbid	150.8	167.4	166.5	167.4
Ajulun	6.8	7.7	8.3	8.6
Jerash	11.9	11.8	11.3	11.1
Balqa	213.1	233.6	219.9	197.3
Madaba	8.1	8.9	9.2	9.5
Karak	67.8	72.6	71.9	72.4
Ma'an	46.4	26.9	23.8	13.4
Tafiela	11.6	11.4	11.4	11.5
Aqaba	19.6	16.2	7.2	9.2
Total	693.9	703.3	669.8	629.6

The other is, for scenario-2 based on the "Target Demand" fulfilling the maximum agricultural development schemes. JVA and MOA have their own agricultural development plans in Jordan Rift Valley and Up/Mid Land though water resources are not substantiated as water allocation. MWI computed future irrigation water demand using Digital National Master Plan Tool developed by GTZ/MWI and its results is summarized hereunder Table 4.5-2 with a huge demand of 963 MCM/a for the planning horizon of year 2020.

This demand can be considered as "Target Demand of Irrigation Water" and was taken into consideration in that of Scenario-2 (Target Demand Scenario).

Tabel 4.5-2 Target Irrigation Water Demand and Irrigated Areas in 12 Governorates

	Irrigated Area	Water Supply	Irrigated Area	Water Demand	Irrigated Area	Water Demand	Irrigated Area	Water Demand	Irrigated Area	Water Demand
	1,000Ha	MCM/a	1,000Ha	MCM/a	1,000Ha	MCM/a	1,000Ha	MCM/a	1,000Ha	MCM/a
Amman	6.8	37	6.8	55	6.8	55	6.8	55	6.8	54
Zarqa	10.6	60	10.6	98	10.6	97	10.6	94	10.6	93
Mafraq	16.9	55	16.9	122	16.9	122	16.9	121	16.9	120
Irbid	11.2	92	14.6	148	17.9	170	17.9	170	17.9	158
Ajulun	1.2	6	1.2	10	1.2	9	1.2	8	1.2	8
Jerash	2.6	12	2.6	24	2.6	23	2.6	22	2.6	20
Balqa	12.4		24.4	331	25.8	336	25.8	334	25.8	329
Madaba	0.8	7	0.8	4	0.8	4	0.8	4	0.8	4
Karak	8.2	60	9.3	64	9.4	63	9.4	62	9.4	60
Ma'an	10.6	53	10.6	86	10.6	85	10.6	84	10.6	83
Tafielah	1.8	5	1.8	18	1.8	18	1.8	17	1.8	16
Aqaba	1.9	18	2.3	20	2.3	20	2.3	20	2.3	20
Mid/High Land	59.6	292	59.6	486	59.6	479	59.6	471	59.6	459
JRV	25.4	258	42.3	495	47.0	523	47.0	520	47.0	505
Total	85.0	551	101.9	981	106.5	1,002	106.5	992	106.5	963

Source: Based on the agricultural development plans of JVA and MOA, MWI computed the irrigation water demand using GTZ/MWI demand modules. (Assumptions for the computation such as cropping areas, cropping patterns, irrigation methods, improvement of irrigation efficiency shall be referred to the Main Report)

5. Water Resources Development Plan

The target water resources to be developed in the Water Resources Management Master Plan are as follows:

Conventional Resources
- Surface water (see section 5.1)
- Renewable groundwater (see section 5.3.2)
- Fossil fresh groundwater (see section 5.3.3)

Non-conventional Resources
- Desalinated brackish groundwater (see section 5.3.4)
- Desalinated sea water (see section 5.4)
- Treated wastewater (see section 5.5)

- Peace water* (see section 5.2)

*: Peace water is classified as intermediate resource among conventional and non-conventional because it may include desalinated water. However, it will be regarded as conventional water in this report because conveyance of the desalinated water has not been started yet.

5.1 Surface Water (Conventional)

5.1.1 Hydrology and Climatology

Dry summer with average maximum annual temperatures of 38.8 ^{o}C occurs during April to October. On the other hand, in winter months from November till March, the average minimum annual temperature is 0.5 ^{o}C.

Seasonal uneven rainfall occurs during the period from October until mid May. Eighty (80) % of the annual rainfall takes place during December-March period. Average annual rainfall ranges between less than 25 mm in the eastern desert to approximately 600 mm over Ajloun heights.

Based on the rainfall distribution, Jordan can be classified into zones as shown in Table 5.1-1.

Table 5.1-1 Classification by Rainfall Distribution

Classified Zone	Annual Rainfall (mm/yr)	Catchment Area (km^2)	Area Ratio (%)	Rainfall Volume (AD1937 – 1998) (MCM)
Semi-humid	500 - 600	620	0.7	425
Semi-arid	300 - 500	2,950	3.3	1,170
Marginal	200 - 300	2,030	2.2	530
Arid	100 - 200	20,050	22.3	2,950
Desert	< 100	64,350	71.5	3,425
Total		**90,000**	**100.0**	**8,500**

Source: WIS database of MWI

The above-mentioned table indicates that 93% of the total area of Jordan is arid or desert land with an average annual rainfall of below 200 mm/yr. The annual average rainfall ranges between less than 50 mm/yr to about 600 mm/yr. The mountainous highlands along the Jordan Valley - Dead Sea - Wadi Araba depression receive the majority of total rainfall volume. The calculated long-term average annual quantity of rainfall over the whole country is around 8,500 MCM as shown in the table.

The annual rainfall has been under the long term average in these three years according to the observation records. On the other hand, as the general tendency of long term decrease in annual rainfall cannot be detected according to the observation much data obtained continuously for more than 50 years, it cannot be concluded that the recent decreasing tendency of the rainfall indicates global climatic change. However, it is reported that the rainfall in the Middle East Area may fall to 10% to 15% after 50 years (Hadley Center, UK). Therefore, the tendency of the climatic change should be carefully observed.

5.1.2 Surface Water Basins

The overall drainage system in Jordan consists of two main flow patterns. The first one drains rainfall towards the Jordan Rift Valley, through deeply incised wadis and rivers dissecting the Jordan Valley-Dead Sea escarpment, to ultimately discharge into the Dead Sea. The second one drains rainfall through those wadis that generally run eastwards from the western highlands towards the internal desert depressions and mudflats.

Based upon the prevailing topographic terrain, fifteen (15) catchment areas can be recognized in the country. Table 5.1-2 presents the major surface water basins and their main features in Jordan. Fig. 5.1-1 shows distribution of the surface water basins.

Table 5.1-2 Surface Water Resources in Jordan

No.	Surface Water Basin: Basin/Area			Surface Water Basin: Name		Symbol	Catchment Area (km^2)	Average Annual Rainfall (mm)	Estimated Runoff Coefficient (%)	Long-term (1937-1998) Rainfall Average (MCM/a)
①	Dead Sea Basin	Jordan River Sub-basin	Northern Areas	Yarmouk		AD	1,426	308	5.1	439
②				Amman-Zarqa		AL	3,739	248	2.9	926
③				Jordan Valley		AB	780	298	1.9	233
④				Jordan Valley Side Wadis	North	AE, AF, AG AH, AJ,AK	946	618	2.9	584
⑤					South	AM, AN, AP	736	398	3.4	293
⑥		Dead Sea Sub-basin	Central Areas	Mujib		CD	6,727	131	4.0	884
⑦				Hasa		CF	2,603	128	2.8	334
⑧				Dead Sea Side Wadis		C	1,508	192	2.5	290
⑨				North Wadi Araba		D	2,953	136	0.7	403
⑩	Eastern Desert Basin			Azraq		F	12,400	70	2.7	866
⑪				Hammad		H	18,047	114	0.7	2,050
⑫				Sirhan		J	15,733	28	1.9	445
⑬				Jafer		G	12,363	44	1.5	545
⑭	Southern Basins			South Wadi Araba		E	3,742	37	1.3	138
⑮				Southern Desert		K	6,296	16	1.0	102
Total							**90,000**			**8,532**

Note : All Basins are within Jordan Territory   Source : from WIS database

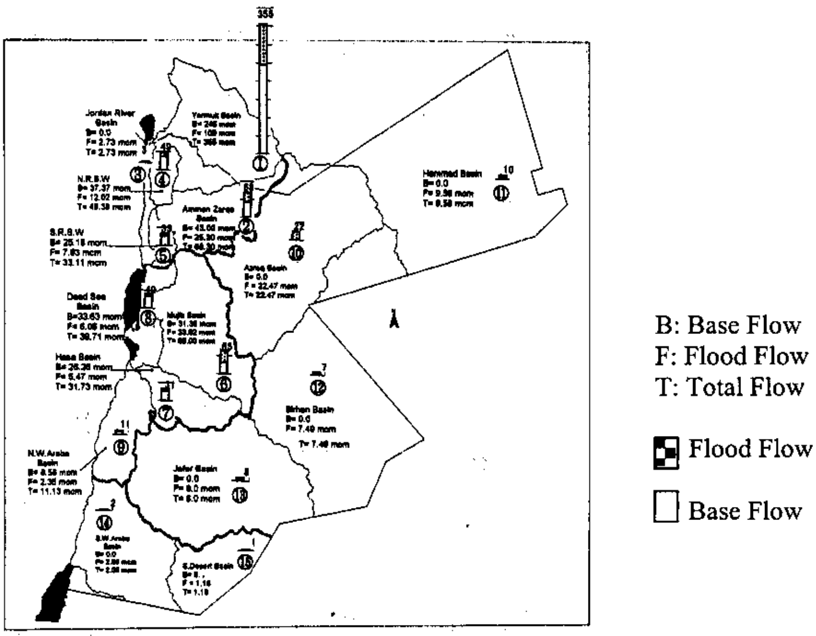


Fig. 5.1-1 Surface Water Basins

5.1.3 Surface Water Potential

Table 5.1-3 shows the long-term average annual surface water flow volumes (1937 to 1998) measured at the main gauging stations on the various rivers and wadis in the kingdom. Total surface water potential is estimated at around 707MCM/a including the flood flow as shown in table 5.1-3. The potential of the surface water is estimated around at 60% to 70% of the total flow considering the climatic and geographic conditions of Jordan.

Table 5.1-3 Long-term Surface Water Flow Amount by Governorate

Governorate	Base Flow (MCM/a)	Flood Flow (MCM/a)	Total Flow (MCM/a)
Amman	0.00	0.00	0.00
Zarqa	0.00	0.92	0.92
Mafraq	0.00	30.92	30.92
Irbid	278.38	122.62	401.00
Ajloun	4.99	1.22	6.11
Jerash	43.00	25.30	68.30
Balqa	25.18	7.92	33.10
Madaba	31.38	33.62	65.00
Karak	61.32	12.12	73.44
Ma'an	1.64	17.07	18.71
Tafielah	5.51	1.80	7.31
Aqaba	0.00	2.10	2.10
Total	451.40	255.51	706.91

Source : WIS database

As mentioned in section 5.1.1, the annual rainfall has been under the long term average in these three years. However, though the general tendency of decreasing of the annual rainfall cannot be detected according to the long term observation records, the future potential of the surface water was estimated without considering the global climatic change.

With respect to a drought year in a 20-year return period, it is estimated that the surface water potential may decrease to about 560MCM/a which is about 80% of normal season potential according to the analysis of the long term runoff observation data.

5.1.4 Present and Future Development of Surface Water

Twenty two (22) dams including small scaled embankments were constructed on wadis and rivers with a storage capacity of about 190MCM. The surface water developed by dams and intakes was 303MCM in 1998. Karameh dam and Wadi Arab Dam are regulation dams which store surplus surface water in winter season and release it for irrigation in the summer season.

Table 5.1-4 shows the existing development scheme for the surface water. The total incremental surface water potential can be expected to be 143MCM/a including water harvesting projects to be implemented in long term target year. Most projects will be completed before AD 2005 in short term target year. As the development amount of surface water is around 303MCM in 1998, it is expected that the total development amount will reach to 446MCM/a by 2020 after the completion of all the projects listed below.

Table 5.1-4 Existing and Planned Surface Water Development Projects

File No.	Project Name	Expected Completion Year		Development Amount (MCM/a)	Remarks
Existing Development Amount of Surface Water		-		303	see Table A2.1.5-1 in Supporting Report
Future Development Plan of Surface Water					
15	Tanur Dam	Short Term	2001	8	completed
13	Mujib Dam		2003	12	on-going, 23MCM/a which will be desalinated at Sweima is not included
14	Wala Dam		2002	5	on-going
26	Feedan Dam		2004	3	
62	Al Wahda Dam		2005	93	
18	Small Dams (Ibn Hamad, Karak, Meddien)	Mid Term	2008	7	
19	Water Harvesting, Badia Region	Long Term	(2011-2020)	15	
Total Incremental Water Amount				143	
Total Development Amount of Surface Water by 2020				446	

Source : Investment Program 2000 to 2010

Note: Total development amount of Wadi Mujib's surface water will be 42MCM/a including the development of the base flow and 12MCM of the total will be used without desalination and remaining 30MCM/a will be mixed with brackish water from Wadi Zarqa Ma'in and Zara Spring and desalinated at Sweima. The desalinated water (frash water) will be 23MCM/a and 7MCM/a will be discharged to Dead Sea as brain.

Surface water flow amount in Jordan is estimated at around 707MCM/a as shown in Table 5.1-3. Total development amount of surface water including long term projects is around 446MCM/a as shown in Table 5.1-4. However, the total development amount shown in table 5.1-4 dose not include the Wadi Mujib surface water of 30 MCM/a which will be mixed with brackish water from Wadi Zarqa Ma'in and Zara Spring and will be desalinated at Sweima. This amount is counted for the brackish groundwater development described in section 5.3. The total development amount of the surface water will be 476MCM/a by adding the Wadi Mujib surface water of 30 MCM/a to be desalinated and it will occupy at 68% of total flow. It is assumed that it is almost the maximum limit for safe development of the surface water resources because of the climatic, economical and geographic constraints as mentioned in section 5.1.3. Therefore, the further large scaled development of surface water may not be possible and this is the optimum development amount of the surface water in terms of "Sustainable Water Resources Development". Although the renewable groundwater abstraction will reduce the base flow, the reduction of the base flow will remain small because the safe yield of the renewable groundwater is estimated around 55% of the total recharge.

5.1.5 Surface water Potential by Governorate

The developable surface water potential by Governorate can be finalized in Table 5.1-5 taking the future projects into consideration. "Peace Water", "Groundwater" and "Treated Wastewater" are not included in this table.

As shown in Table 5.1-5, the surface water development will be mainly done in Irbid Governorate because the Yarmouk River belongs to this Governorate.

Table 5.1-5 Summary of Development Amount of Surface Water by Governorates

Gover -norate	Present Develop. Amount (1998) (MCM/a)	Future Incremental Development Amount (MCM/a)			Total Delopment Amount by 2020 (MCM/a)	Planned Future Projects and others
		Short Term (2000～2005)	Mid Term (2006～2010)	Long term (2011～2020)		
Amman	7	0	0	3	10	after 2010, Water Harvesting in Badia Region , 3MCM/a
Zarqa	16	0	0	2	18	-after 2010, Water Harvesting in Badia Region, 2MCM/a
Mafraq	2	0	0	7	9	-after 2010, Water Harvesting in Badia Region, 7MCM/a
Irbid	149	93	0	0	242	-2005, Wehda Dam (JRV), 93MCM/a
Ajloun	11	0	0	0	11	
Jerash	20	0	0	0	20	
Balqa	27	0	0	0	27	
Madaba	5	5	0	0	10	-2001, Wala Dam (JRV), 5MCM/a
Karak	54	20	7	0	81	-2001, Al-Tanur Dam (JRV), 8MCM/a -2002, Mujib Dam (JRV), 12MCM/a -2008, Small Dams (UP), 7MCM/a
Ma'an	4	0	0	3	7	-after 2010, Water Harvesting in Badia Region (UP), 3MCM/a
Tafielah	7	3	0	0	10	-2004, Al-Feedan Dam (JRV), 3MCM/a
Aqaba	1	0	0	0	1	
Total	303	121	7	15	446	
Total Amount by Target Year		424	431	446	446	

Source : Information from MWI and JVA, Investment Program 2000 to 2010

Note : JRV (Jordan Rift Valley) is defined as the areas below 300m in elevation.

The locations of the main existing dams and planned dams are shown in Fig. 5.1-2. The development amount of the surface water by Governorate is shown in page 3 of the attachments at the end of this report.

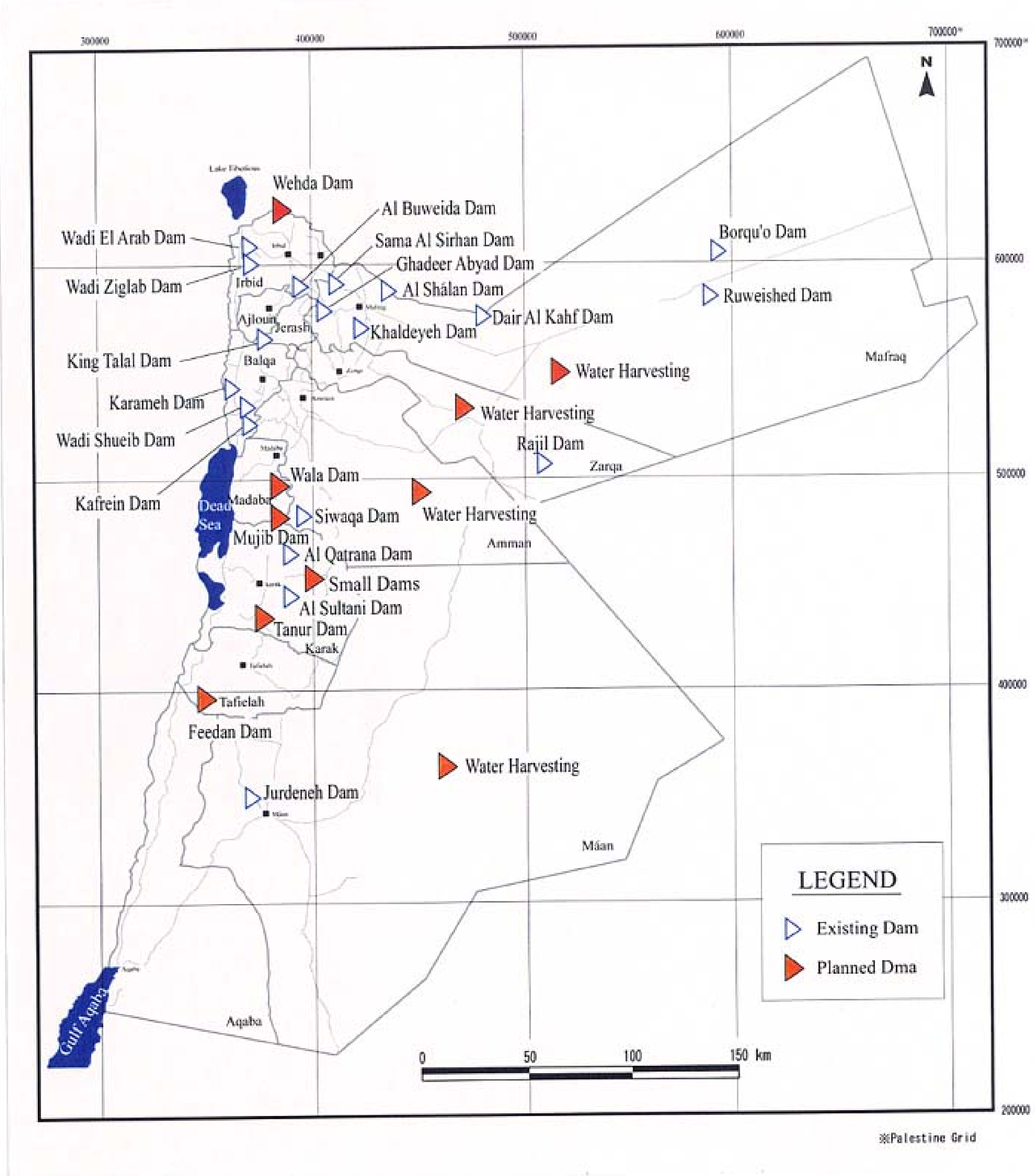


Fig. 5.1-2 Locations of the Main Existing Dams and Planned Dams

5.2 Peace Water (Conventional)

The Peace water is the water resource conveyed from Israel to Jordan based on the Peace Treaty concluded in 1994.

The Peace Water is presently taken from the Tiberious Lake and conveyed to King Abdullah Canal. The amount of the Peace water was 33MCM in 1998. The Peace Water is scheduled to be increased up to 60MCM/a by 2005 according to the Peace Treaty. The desalinated brackish spring water was scheduled to be conveyed to Jordan in the initial plan as shown by its project name "Desalination Conveyor to Urban Jordan". However, the surface water of the Tiberious lake is presently given to Jordan instead of the desalinated water because of the delay of construction of the desalination plant in Israel.

In addition to the project described above, the peace water project named "Storage on Jordan River and Side Wadis" is under planning based on the Peace Treaty. About 30MCM/a of surface water will be developed by constructing small dams in the Jordan River and side wadis and conveyed to Jordan. This project is scheduled to be completed by 2010.

As mentioned above, it is agreed that the total amount of the Peace Water will be 90MCM/a by 2010. All of the Peace Water is scheduled to be conveyed to Irbid Governorate and it will be further transferred to other governorates from there. Table 5.2-1 summarizes the development amount of the Peace Water.

Table 5.2-1 Development Amount of Peace Water

Gover-norate	Existing Development Amount (1998) (MCM/a)	Future Incremental Development Amount (MCM/a)			Total Delopment Amount by 2020 (MCM/a)	Planned Future Projects and others
		Short Term (2000～2005)	Mid Term (2006～2010)	Long Term (2011～2020)		
Irbid	33	27	0	0	60	Desalination Conveyor to Urban Jordan、60MCM/a、2005
Irbid	0	0	30	0	30	Storage on Jordan River and Side Wadis、30MCM/a、2010
Total	33	27	30	0	90	
Development Amount by Target Year		60	90	90	90	

Source: Investment Program 2000 to 2010

5.3 Groundwater

5.3.1 Hydrogeology

Based on the various hydrogeological investigations carried out, the following are the major aquifer systems in Jordan:

- The Upper Aquifer System, Quaternary – Tertiary Aquifers (All, Ba, B5, B4)
- The Middle Aquifer System, Carbonate Rocks Aquifers (A7/B2)
- The Lower Aquifer System, Sandy Faces Aquifers (K, Z, R)

Fig 5.3-1 shows the simplified hydrogeological map of Jordan.

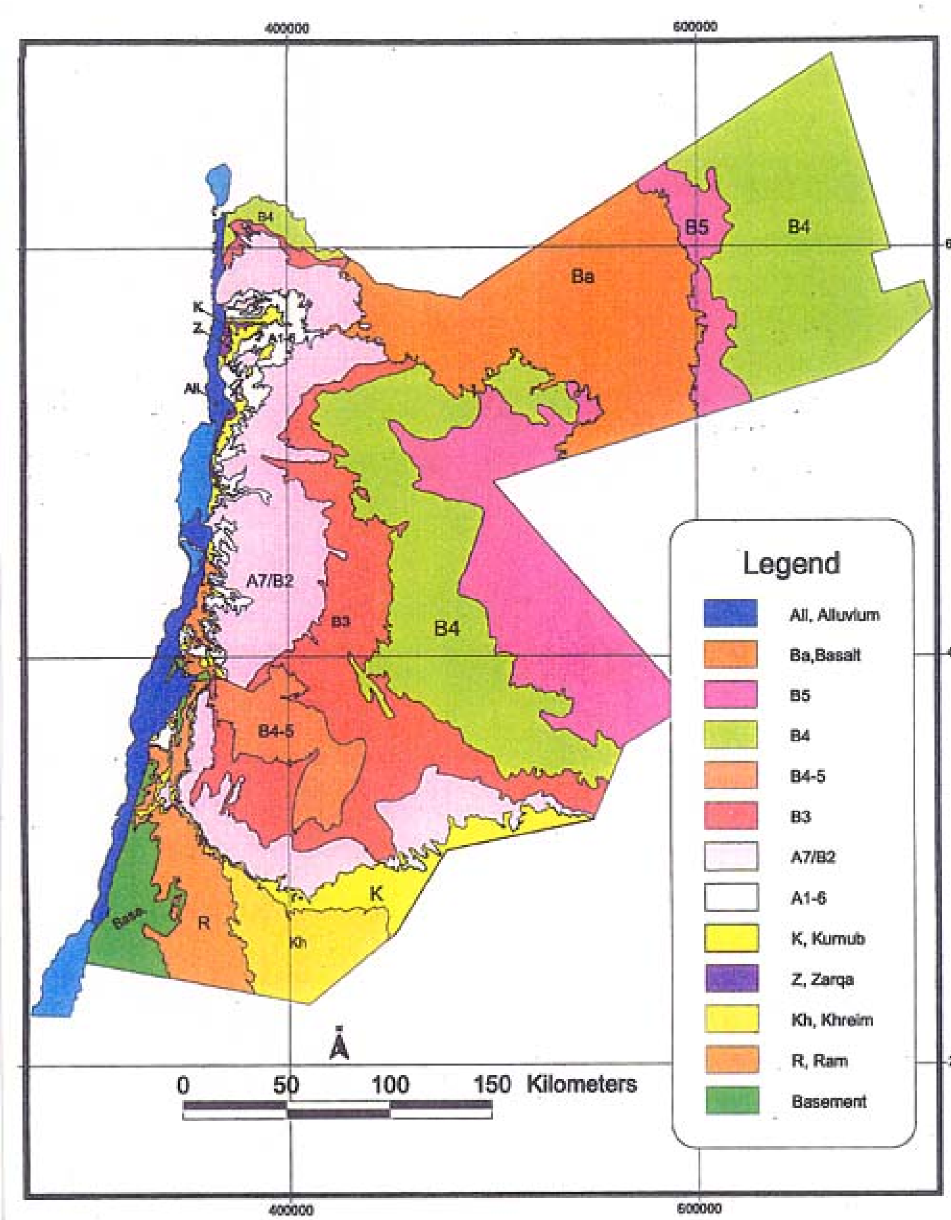


Fig 5.3-1 Simplified Hydrogeological Map of Jordan (from WIS)

5.3.2 Renewable Groundwater (Conventional)

(1) Aquifer system and groundwater basins

Based on the renewable groundwater divides configuration as anticipated by the various investigations, twelve major groundwater basins were defined (see Fig.5.3-2) on which the main renewable groundwater flow pattern within the upper aquifer system is shown.

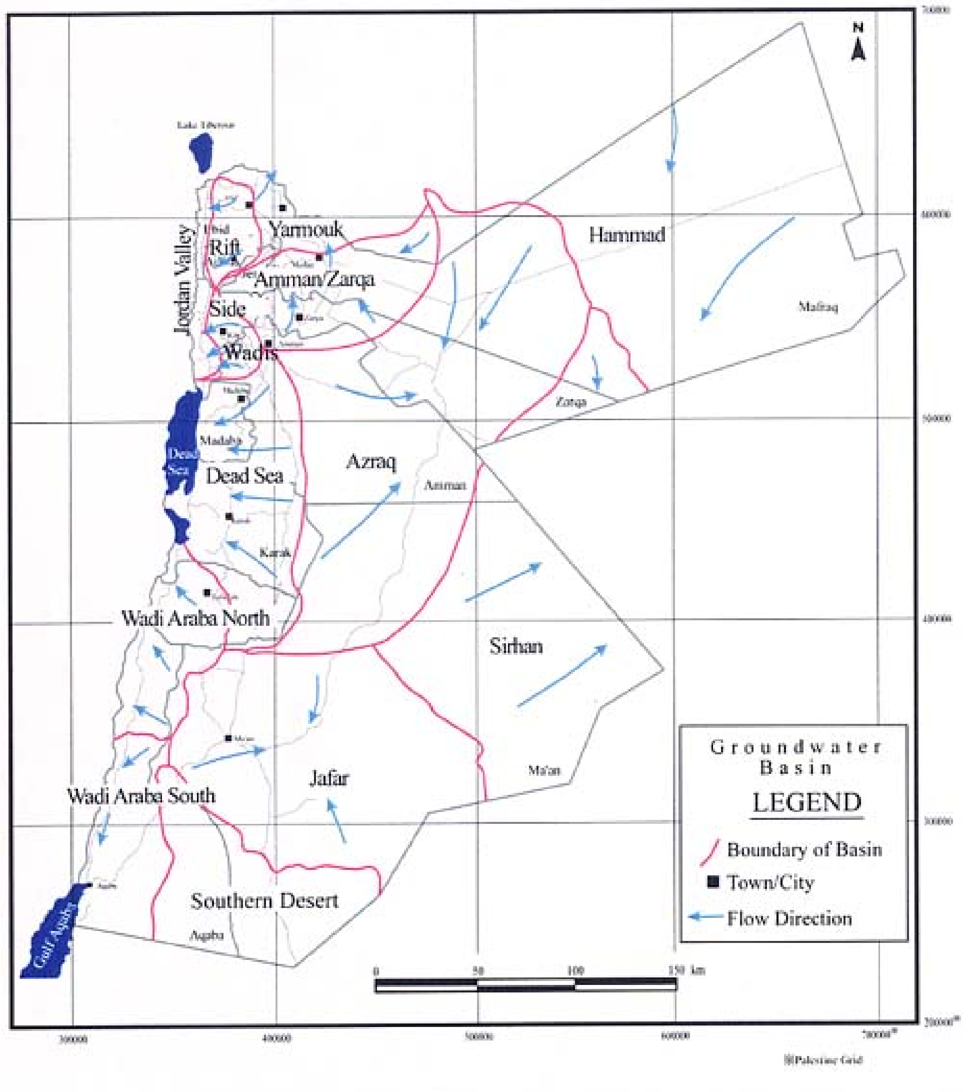


Fig. 5.3-2 General Flow System and Renewable Groundwater Basins in Jordan

(2) Renewable Groundwater Potential

Table 5.3-1 presents a summary of the renewable groundwater resources situation as computed by most of the previous investigations carried out in Jordan. Firstly, the renewable groundwater Safe yield was estimated by groundwater basin based on the existing reports and studies. The safe yield means the possible maximum development amount which allows the sustainable development without exhaustion of the aquifers. Secondary, the safe yield of the renewable groundwater was allocated to each governorate by area ratio of the groundwater basins to each governorate because the Water Resources Management Master Plan should be formulated by governorate basis in this Study.

Table 5.3-1 Safe Yield of the Renewable Groundwater by Governorate

Governorate	Groundwater Basin: Yarmouk	Amman-Zarqa	Azraq	Jordan Valley	Rift Side Wadis	Dead Sea	Wadi Araba North	Wadi Araba South	Jafer	Southern Deserts	Sirhan	Hammad	Total
Amman		12 (14%)	6[a]		2 (13%)	14 (24%)							***34***
Zarqa		17 (19%)	24[b]		6 (41%)								***47***
Mafraq	20 (50%)	48 (55%)									1 (8%)	8 (100%)	***77***
Irbid	18 (45%)			8 (38%)	3 (19%)								***29***
Ajloun					2 (13%)								***2***
Jerash	2 (5%)	6 (7%)											***8***
Balqa		4 (5%)		13 (61%)	2 (14%)								***19***
Madaba						9 (15%)							***9***
Karak						16 (35%)							***16***
Ma'an						3 (6%)	1 (14%)		6 (100%)	<1 (57%)	4 (92%)		***14***
Tafielah						11 (20%)	1 (35%)						***12***
Aqaba							2 (47%)	6 (100%)		<1 (43%)			***8***
Total	40	87	30	21	15	53	4	6	6	<1	5	8	***275***

The safe yield of the renewable groundwater is estimated 271MCM/a to 286MCM/a in whole of Jordan (refer to Table 2.2.2-1 of the Main Report). Therefore, 275MCM/a is employed for total safe yield of the renewable groundwater in whole of Jordan in this Study in accordance with the estimation of World Bank. It is judged that development amount of 275MCM/a may satisfy "Sustainable Water Resources Development" for the renewable groundwater.

(3) Necessary reduction amount of the renewable groundwater abstraction

The balance between the safe yield of renewable groundwater and present renewable groundwater abstraction amount is shown in Table 5.3-2. Their distribution is shown in page 4 of the attachments at the end of the report. It is quite obvious that the present abstraction amount of renewable groundwater alarmingly exceeds the safe yield. The declining tendency of the groundwater level has been clearly identified in almost all the governorates. Therefore, it is concluded that the groundwater abstraction must be reduced to its safe yield (around 40% reduction) in order to achieve "Sustainable Water Resources Development and Management".

Table5.3-2 Safe Yield, Actual Abstraction Amount and Necessary Minimum Reduction Amount of the Renewable Groundwater by Governorate

Governorate	Safe Yield (MCM/a)	a) Abstraction Amount in 1998 (MCM/a)	b) Necessary Minimum Reduction Amount (MCM/a)	Reduction Ratio (b/a, %)
Amman	34	62	28	45
Zarqa	47	89	42	47
Mafraq	77	91	14	15
Irbid	29	46	17	37
Ajloun	2	2	0	0
Jerash	8	4	0 (+4)	0
Balqa	19	47	28	60
Madaba	9	14	5	36
Karak	16	29	13	45
Ma'an	14	23	9	39
Tafielah	12	3	0 (+9)	0
Aqaba	8	6	0 (+2)	0
Total	**275**	**416***	**156**	**38**

Note : The safe yield of the renewable groundwater is divided into governorates based on the distribution rate of the groundwater basin area in the governorates. This Table does not include abstraction from R/D aquifer.
*: 416MCM/a dose not contain all abstraction, so, round figure of 420MCM/a is employed..

5.3.3 Fossil Fresh Groundwater (Conventional)

(1) Aquifer system and groundwater basins

The major aquifer of the fossil fresh groundwater in Jordan is what is locally known as Ram Group Aquifer (R/D) and it is of fossil origin (10-30 thousand years old). The fossil fresh groundwater does not receive recharge from the present rainfall and travels long distance without restriction of the groundwater basins. R/D aquifer is mainly exploited in the Disi-Mudawara Basin because the aquifer is located at shallower depth. The water quality is normally good and salinity ranges between 200mg/lit and 300mg/lit.

(2) Potential of the fossil fresh groundwater

It is expected that an annual abstraction of about 125MCM in Jordanian territory can be sustained for a period of 50 years according to the previous studies in Disi-Mudawara Area. On the other hand, another study conducted in 1995 (Qa Disi Aquifer Study) has indicated that 155MCM/a to 225MCM/a would be available for 40 to 100 years. Based on these existing studies, it is anticipated that more than 125MCM/a of fossil fresh groundwater could be developed for 50 years. The distribution of the potential of the fossil fresh groundwater is shown in page 5 of the attachments at the end of this report.

(3) Remaining potential of the fossil fresh groundwater

As stated before, the estimated potential of the fossil fresh groundwater in the R/D aquifer ranges from 125MCM/a to 225MCM/a for period of 40 years to 100years. The present abstraction amount from the R/D aquifer is estimated at around 70MCM/a in 1998. Therefore, it is considered that the fossil fresh groundwater of more than 55MCM/a are presently retained for future. However, this estimation was made under the assumption that the development of R/D aquifer in Saudi Arabia would not be further expanded.

(4) Development plan of the fossil fresh groundwater

The project named "Disi Amman Conveyor" is one of the development project of the fossil fresh groundwater. This project consists of the fossil fresh groundwater development in Disi-Mudawara area and the its conveyance from Disi to Amman. In addition, the fossil fresh groundwater development project is on-going in Lajoun area located in Karak Governorate, where 10MCM/a of the fossil fresh groundwater is developed and conveyed to Amman.

Table 5.3-3 shows planned and on-going development projects of the fossil fresh groundwater.

Table 5.3-3 Development Projects of the Fossil Fresh Groundwater

Gover-norate	Existing Development Amount (1998) (MCM/a)	Future Incremental Development Amount (MCM/a)			Total Delopment Amount by 2020 (MCM/a)	Planned Future Projects and others
		Short Term (2000~2005)	Mid Term (2006~2010)	Long Term (2011~2020)		
Karak	0	(11) *	0	0	(11) *	Lajoun Wells *, 11MCM/a, on-going
Ma'an, Aqaba	70	-5**	27	38	130	Disi Amman Conveyor, 130M/a, 2006~2020, selection of the contractor
Total	70	-5**	27	38	130	
Development Amount by Target Year		65**	92	130	130	

source: Investment Program 2000-2010
*: As the potential of the Lajoun well has not been clarified, the amount will not been counted in the Master Plan
**: Abstraction will be temporal lily reduced due to the reduction of the agricultural use

The potential of the fossil fresh groundwater has not been sufficiently determined in the Lajoun Area, and was regarded as the supplementary resource for the case of emergency in the Water Resources Management Master Plan.

The locations of the fossil fresh groundwater projects are shown in Fig.-5.3-3.

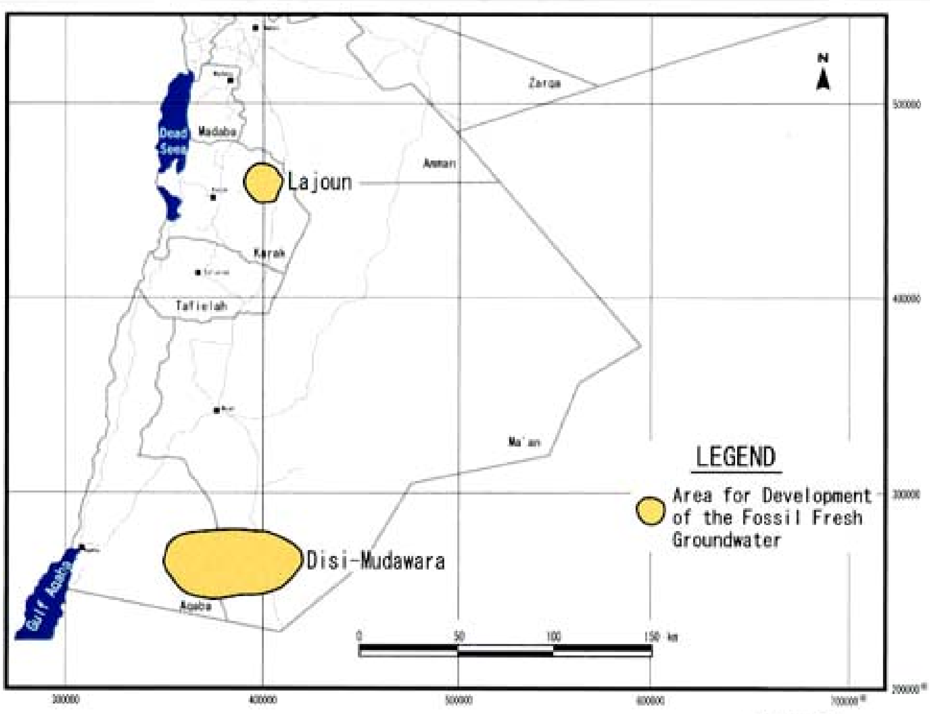


Fig. 5.3-3 Location of the Fossil Fresh Groundwater Development Projects

5.3.4 Brackish Groundwater Desalination (Non-conventional)

The brackish groundwater including brackish spring water is the sole water resource remaining almost undeveloped in Jordan. However, previous studies on brackish groundwater are limited. Therefore, the potential of the brackish groundwater is preliminarily evaluated based on the existing reports incorporating the up-dated information.

(1) Basin and aquifers

Previous investigations have indicated that the brackish groundwater potential occurs mainly in the Lower Aquifer systems (sandy facies aquifer). The brackish groundwater flow is not controlled by the renewable groundwater basins because it is mostly fossil origin. The Upper and Middle Aquifers system (alluvium, basalt and carbonates), contains substantial volumes of renewable and nonrenewable brackish groundwater but of limited spatial extent within Jordan.

(2) Brackish groundwater potential

The brackish groundwater can be largely classified into "Renewable" and "Nonrenewable". Furthermore, the nonrenewable brackish groundwater can be divided into " Flowing" and "Stagnant" conditions. The salinity of the brackish groundwater widely ranges from 1,000 mg/lit to more than 10,000 mg/lit in TDS.

The brackish groundwater potential based on the classification mentioned above, in the whole Jordan may be summarized in Table 5.3-4.

Table 5.3-4 Brackish Groundwater Potential of whole of Jordan

Type of Brackish Groundwater	Potential	Remarks
a. Renewable	55MCM/a to 60MCM/a	Almost over-drafted
b. Nonrenewable/Flowing	265MCM/a to 300MCM/a	Promising
c. Nonrenewable/Stagnant	24billion cubic meter*	Mining Development

* 10% of the total storage amount

The nonrenewable/flowing brackish groundwater (b) which is supposed to be promising in Table 5.3-4 is flowing into the Dead Sea and Jordan Valley. Therefore, it is inferred that these areas are the potential sites for the brackish groundwater development. The distribution of the potential of the brackish groundwater is shown in page 6 of the attachments at the end of this report.

(3) Brackish groundwater development project

"Mujib-Zara and Zarqa Ma'in Saline Water Treatment, Conveyance to Amman Project" is under study in 2001 sponsored by USAID. This project is to utilize the water from Wadi Mujib, brackish springs and side wadis in Zara/Zarqa Ma'in area in the Dead Sea Escarpment. These waters will be collected and desalinated at Sweima. The desalinated water will be conveyed to Amman from Sweima.

In addition to the project mentioned above, two other projects for the brackish groundwater development were planned in the Water Resources Management Master Plan. One is "Brackish Groundwater Desalination Project in Hisban/Kafrein Area" which was proposed in JICA Study in 1995. The second is "Brackish Groundwater

Desalination Project in Lajoun Area" which is proposed in this Study because there might be some potential of the brackish groundwater according to the recent study on fossil fresh groundwater in Lajoun area.

The outline of the brackish groundwater development projects is shown in Table 5.3-5 and their locations are shown in Fig.5.3-4.

Table 5.3-5 Outlines of the Brackish Groundwater Development Projects

Gover-norate	Existing Development Amount (1998) (MCM/a)	Future Incremental Development Amount (MCM/a)			Total Delopment Amount by 2020 (MCM/a)	Planned Future Projects and others
		Short Term (2000～2005)	Mid Term (2006～2010)	Long Term (2011～2020)		
Karak	0	0	13	23	36	Proposed by JICA, 2006 to 2020, to be used for domestic industrial demand (Oil Shale Project)
Balqa	0	20[1)]*	20[1)]*	9[2)]	49	1) Wadi Zarqa Ma'in/Zara Spring, F/S done by USAID, 40MCM/a ncludes 23MCM from Wadi Mujib surface Water 2) Hisban/Kafrein, Proposed by JICA, 2020, to be conveyed to Amman area
Total	0	20	33	32	85	
Development Amount by Target Year		20	53	85	85	

Source: F/S Report of Mujib-Zara/Ma'in Saline Water Treatment, Conveyance to Amman Project and JICA Plan
*: Only desalinated water amount including the surface water conveyed from Wadi Mujib

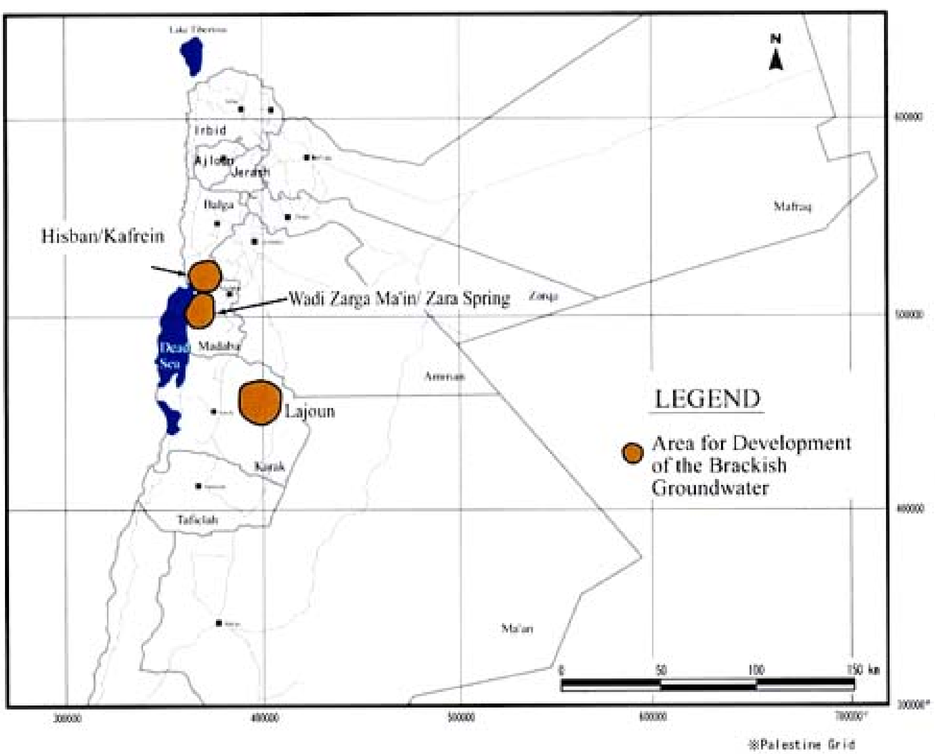


Fig. 5.3-4 Locations of the Brackish Groundwater Development Projects

5.4 Sea Water Desalination (Non-conventional)

The desalination of the sea water has not been done yet in Jordan. The desalination of the sea water will be done only to satisfy the future MIT demands of Aqaba City and conveyance of the desalinated water to other areas will not be considered as mentioned in chapter 3. The feasibility study on sea water desalination project has been already conducted by USAID.

Despite the potential of the sea water which is basically infinite, the water production and usage of the desalinated sea water is limited only for MIT purposes because of the high cost of the desalination process. The outline of Sea Water Desalination Project for Aqaba is summarized in Table 5.4-1 and location of the project is shown in Fig.-5.4-1.

Table 5.4-1 Outline of Sea Water Desalination Project for Aqaba

Item	Phase 1 (to be completed by 2005)	Phase 2 (to be completed by 2010)
1. Production	5MCM/a	12MCM/a (17MCM/a in total)
2. System	RO, brain discharged to the Aqaba Bay	RO, brain discharged to the Aqaba Bay
3. Construction Cost	27Million JD (about 39 million US$)	55Million JD (about 79 million US$)
4.Operation/maintenance Cost	1.5Million JD/year, (about 2.1 Million US$/year)	4.6Million JD/year, (about 2.1 Million US$/year)
5. Desalination Cost	976fils/m^3 (about 1.4US$/m^3)	

Source: F/S report of Sea Water Desalination Project for Aqaba and examination of JICA Study Team

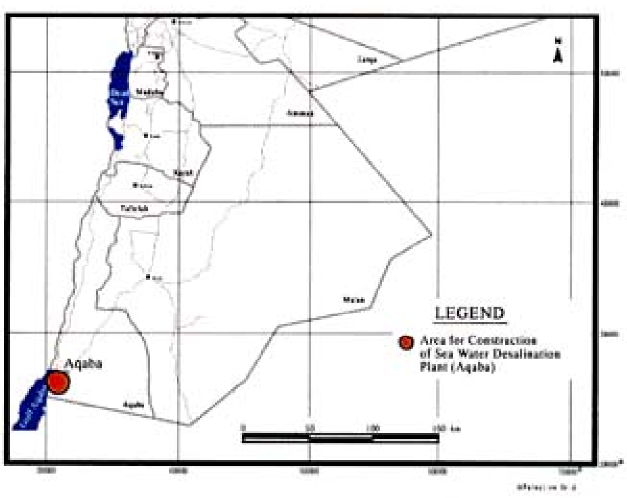


Fig. 5.4-1 Location of the Sea Water Desalination Project for Aqaba

Table 5.4.-2 shows the production amount of the desalinated sea water at Aqaba.

Table 5.4-2 Production Amount of the Desalinated Sea Water at Aqaba

Gover-norate	Existing Development Amount (1998) (MCM/a)	Future Incremental Development Amount (MCM/a)			Total Delopment Amount by 2020 (MCM/a)	Planned Future Projects and others
		Short Term (2000~2005)	Mid Term (2006~2010)	Long Term (2011~2020)		
Aqaba	0	5	0	12	17	Desalination Project for Aqaba, 2005 and 2015
Development Amount by Target Year		5	5	17	17	

Source: F/S Report of Sea Water Desalination for Aqaba and JICA Master Plan

5.5 Reuse of Treated Wastewater (Non-conventional)

5.5.1 Existing Wastewater Treatment Plants

(1) Existing treatment plants and coverage rate

In total 19 public wastewater treatment plants are in operation in 2001. Fig. 5.5-1 shows the locations of these plants together with planned ones within the 12 Governorates of Jordan. Six treatment plants (including the biggest one in As Samra for Greater Amman) rely on extensive treatment technology using anaerobic pond, facultative pond and maturation pond systems. At one plant (Wadi Essir) artificial aeration is provided in aerated ponds instead of the facultative (non-aerated) ponds. Intensive treatment technology is applied in 10 plants. These plants are based on activated sludge or trickling filter method or a combination of both.

The coverage of population living within the service areas of the existing plants ranges between about 45 and 95 %. The average of 82 % is relatively high due to 90 % coverage of As Samra Treatment Plant serving Greater Amman, where 70 % of the total population of towns with sewerage systems is living.

During the last 10 years the influent of the treatment plants has increased by 100 % due to increased coverage of service and due to the new construction and expansion of sewerage systems and plants. Presently, about 218,000 m^3/d or 80 MCM/a of wastewater are treated.

(2) Quality of the treated wastewater

Generally, the quality of wastewater is strongly influenced by the low values of per capita water consumption. This influences particularly the salinity and the content of organic matter – the BOD_5-load – leading to high contents of both parameters in raw sewage e.g. up to 1,500 mg BOD_5/l. High values of BOD_5-concentration (often underestimated at the design stage) leads in some cases to biological overloading of the treatment plants, even if these are operated below the hydraulic design capacity. Concerning the salinity, the observed effects are similar and even more important for the plant's effluent, if the wastewater is treated by a pond system of high evaporation rates.

The average salinity (measured as total dissolved solids, TDS) of municipal drinking water is some 580 mg/l. The TDS in the effluent of the treatment plants ranges between 700 and 1,200 mg/l (effluent of As Samra pond system).

According to the Jordanian Standard JS 893/1995 the maximum BOD_5-content of treatments plants' effluent into wadis and catchment areas should not exceed 50 mg/l. Based on this water quality requirement 9 of the 17 treatment plants do not fulfill the requirements of the standards. For 6 of the plants the BOD_5-concentration of the effluent exceeds even 100 mg/l. Four of these plants are stabilization pond systems. However, in this context it has to be mentioned that the effluent BOD_5 of the pond system plants is to a certain extent influenced by the organic matter of algae grown particularly in the maturation ponds.

(3) Constraint for reuse of treated wastewater

The treated wastewater from the As-Samra TP flows into the King Talal Reservoir and is diluted in the reservoir with surface water. The diluted treated wastewater is released to flow into the Jordan Valley and reused for irrigation. Other reuse of the treated wastewater is very limited in Jordan and some small scale irrigation is being done using the treated wastewater in the vicinity of the limited treatment plants. It can be said that the reuse of the treated wastewater for irrigation purpose without dilution has not been diffused yet. JVA is presently carrying out the irrigation project which includes the reuse of the treated wastewater for irrigation without dilution with the technical cooperation of GTZ. This project is scheduled to be completed in 2003.

For the problem of the salt accumulation accompanying the reuse of the treated wastewater, Serious problems are expected if the conventional irrigation method including the leaching is employed because the salinity of the present irrigation water (500mg/lit to 1,000mg/lit in TDS) does not greatly differ from the salinity of the treated wastewater (700mg/lit to 1,200mg/lit in TDS). However, the unpredictable problems such as diseases that may be caused by pathogenic organs or viruses in the treated wastewater may occur. Therefore, careful monitoring is needed in the reuse of the treated wastewater.

(4) Sludge control

As far as sludge management is concerned in most of the cases applied treatment and disposal methods are unsatisfactory. The practice of sludge disposal may have serious harm to the natural environment. In particular this is true for the disposal of liquid, non-stabilized sludge on dumping grounds (e.g. in Al Akeder, Jorf Darawesh and Lagoun). The fresh sludge disposed in liquid form at the dumping grounds may infiltrate into the groundwater table and pollute considerably the local water resources used for drinking purposes.

5.5.2 Present Reuse of Treated Wastewater

With respect to the quality criteria for treated domestic wastewater according to Jordanian Standard 893/1995 none of the effluent fulfills the standards for unrestricted use for irrigation. Generally, the limiting water quality parameter is the content of fecal coliform count. At several treatment plants the effluent approaches the limit of 1,000 fecal coliforms for unrestricted use, but a stable microbiological water quality is not recognizable.

Presently, in total more than 100,000 donum are irrigated by treated effluent of the existing treatment plants. Total annual treated effluent quantity reused for irrigation is roughly estimated to be 50 MCM/a, whereby this volume is applied to

- 15 MCM for restricted irrigation and
- 35 MCM for unrestricted irrigation (in Jordan Valley after blending with freshwater).

Irrigation by treated wastewater is practiced at agricultural land close to the treatment plants (inside or in the vicinity of the plant) and downstream of the plants along the wadis serving as receiving water for the effluents. These areas comprise about 15,700 donum of cereal, fodder, forest trees and fruits are irrigated.

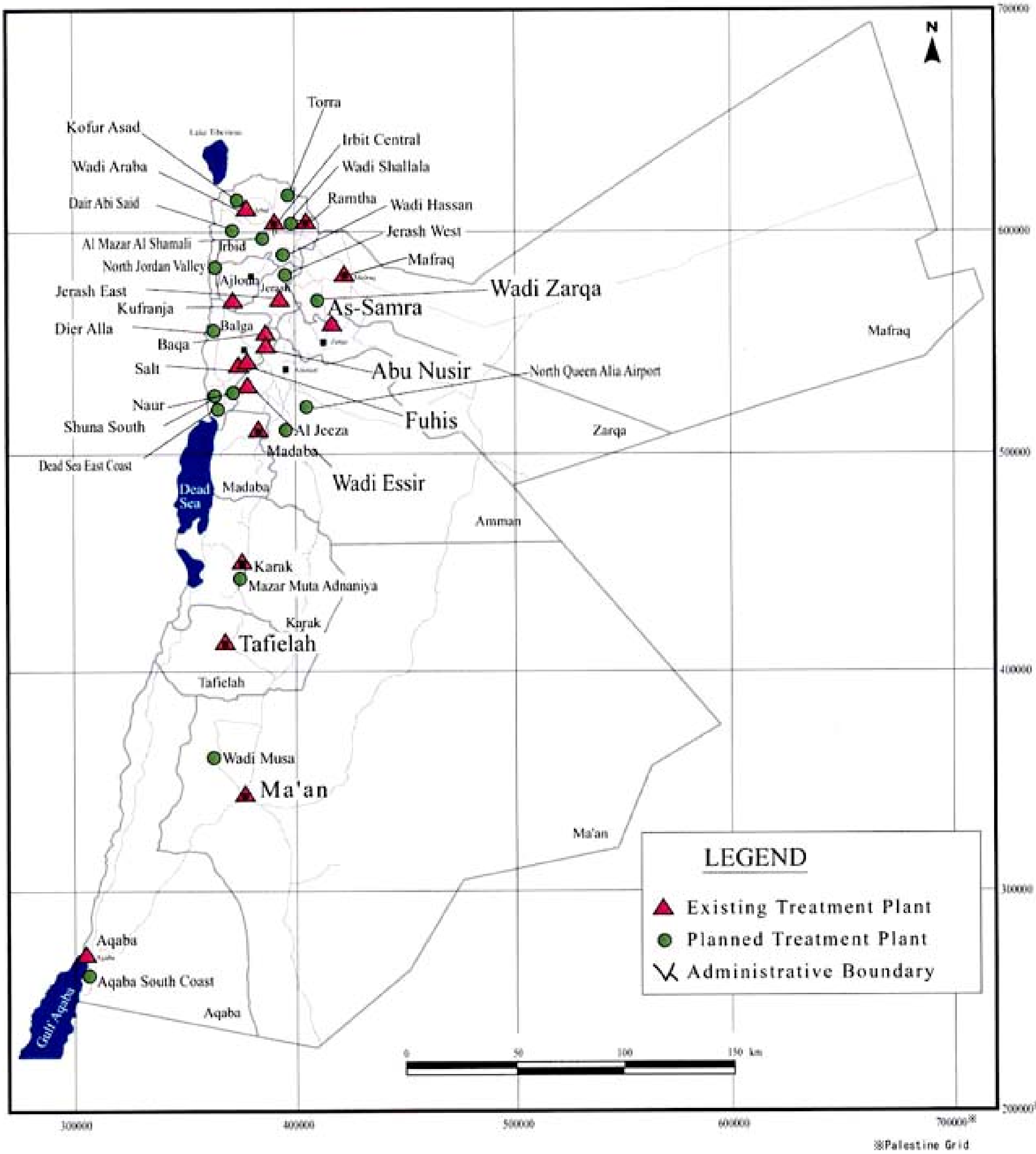


Fig. 5.5-1 Locations of Existing and Planned Treatment Plants

5.5.3 Proposed Wastewater Treatment Plants

Various studies were prepared on behalf of the Ministry for Water and Irrigation and WAJ dealing with the expansion/rehabilitation of existing treatment plants and the construction of new ones. Fig. 5.5-1 shows the location of the existing and proposed treatment plants.

At present for 9 of the 19 existing treatment plants specific planning work for rehabilitation, upgrading and expansion is under preparation. The plants of Wadi Hassan and Wadi Mousa were completed in early 2001. In addition the construction of 17 new plants is proposed during a period of 10 to 12 years. After completion of all planned measures the total number of treatment plants will increase to 36. In several of the newly planned treatment plants sand filtration is proposed as tertiary treatment instead of maturation ponds to meet irrigation water quality.

Installed treatment capacity of existing treatment pants (including the plants under construction) after completion of all upgrading and expansion measures will be increased to some 394,000 m³/d, while this capacity of additional planned plants will be about 262,000 m³/d leading to a total capacity of about 656,000 m³/d.

5.5.4 Future Treated Wastewater Quantity

Three scenarios were developed to estimate the future water demand (refer to chapter 3). Scenario 1 described here, follows the MOWI/World Bank assumptions with respect to population growth rates and specific water demands. Resulting development of total, connected and non-connected population as well as wastewater quantities are summarized in Table 5.5-1. As shown in the table, it is estimated that the wastewater effluent will reach to around 250MCM/a by 2020. The distribution of the treated wastewater production amount by target year in Scenario-1 is shown in page 7 of the attachments at the end of this report.

Table 5.5-1 Future Development of Wastewater Treatment

	Unit	2000	2005	2010	2015	2020
Scenario-1						
Connected population	mio. inh	2.47	3.63	4.65	5.49	6.29
Connected pop.related to Jord. population	%	49	61	67	69	69
Wastewater effluent of treatment plants	MCM/a	64	112	177	220	246
Scinario-2						
Connected population	mio. inh	2.47	3.63	4.65	5.49	6.29
Connected pop.related to Jord. population	%	49	61	67	69	69
Wastewater effluent of treatment plants	MCM/a	64	108	177	232	285
Scinario-3						
Connected population	mio. inh	2.44	3.47	4.26	4.88	5.40
Connected pop.related to Jord. population	%	49	61	66	68	68
Wastewater effluent of treatment plants	MCM/a	63	103	162	207	246

Source: Prediction of the Study Team

5.5.5 Future Effluent Reuse

Following the proposed future reuse schemes, related quantities were determined. Principally, "five destinations or disposal paths" of treatment plant's effluent were distinguished:

① **Category-1: Not (or only partly) used**

This "destination" means that most of the effluent quantities may not be reused, because e.g. appropriate agricultural areas for irrigation are not available in the vicinity of the plant. Only a minor portion of the effluents are reused e.g. within the treatment plant's area. Due to low quantity, big distance to potential reuse areas or required high power cost it is not economic to reuse these quantities. The effluent discharged into the receiving water will infiltrate and evaporate along the flow path and is therefore not available for substitution of freshwater presently used for irrigation.

② **Category-2: Reuse in Upland/Midland**

- **Reuse of effluent of As Samra in the Upland/Midland**

Within the frame of the "Jordan Water Resource Policy Support" project it the reuse of a portion of the effluent of the new As Samra Treatment Plant for agricultural irrigation purposes in the Upland (northeast of the treatment plant) is studied.

- **Local reuse in the Upland/Midland**

It is proposed to reuse locally (in the vicinity of the plant) the effluent of several treatment plants in the uplands/midlands. In addition to the presently existing ones (e.g. at Madaba, Mafraq and Ramtha) additional plants will be provided with reuse facilities.

③ **Category-3: Reuse for industrial purposes**

According to the "Jordan Water Resource Policy Support" project it is proposed to reuse a portion of the effluent from the new wastewater treatment plant of As Samra for industrial purpose. Major reusing industries will be in the area of Greater Amman, Zarqa and Russeifa including new thermal power plant (proposed location close to As Samra) for cooling processes. In addition it is proposed that the industrial complexes in Irbid and Aqaba will reuse a certain amount of treated effluent as shown in Table 5.5-2.

Table 5.5-2 Reuse Plan of Treated Wastewater for Industrial Purpose

(in MCM/a)

	2000	2005	2010	2015	2020
Amman/Zarqa	0	15	15	15	20
Irbid	0	0	5	5	5
Aqaba	0	0	0	5	5
Total	0	15	20	25	30

Source: Plan of the Study Team

④ **Category-4: Reuse in Jordan Valley for agricultural purposes**

- **Northern Jordan Valley**

A pipe around the Wadi Arab Dam to the Jordan Valley discharges treated wastewater of Central Irbid and Wadi Arab Treatment Plants. In addition, effluent of the Kufranja Wastewater Treatment Plant is flowing presently through the Wadi Kufranja to the Jordan Valley. All related effluent of the mentioned plants is available for agricultural reuse in the Northern Jordan Valley and contribute therefore to the quantity disposable for substitution of freshwater presently used for irrigation.

- **Southern Jordan Valley**

Treated wastewater discharged in the Wadi Zarqa, Wadi Shua'ab and Wadi Kafrein will be available as irrigation water in the Southern Jordan Valley. Certainly, the flow through Wadi Zarqa and King Talal Reservoir originating of As Samra, Wadi Zarqa, Jerash and Baqa WWTPs dominates the other discharge quantities. This effluent will contribute to substitution of freshwater presently used for irrigation in the Southern Jordan Valley.

- **Local reuse in the Jordan Valley**

All irrigation facilities for local reuse of treated wastewater in the Jordan Valley have to be newly constructed. In total the effluent of 6 treatment plants (e.g. Kofur Asad, Shuna South, Dair Ala) will be locally reused in the future.

⑤ **Category-5: Reuse in Aqaba**

Two schemes are proposed for Aqaba: Wastewater of the Aqaba Treatment Plant will be reused for agricultural purposes north of the plant's location. Effluent of the Treatment Plant Aqaba South Coast will be reused for irrigation of green areas.

With the concept described above the quantities available for substitution of freshwater for irrigation purposes were determined. Table 5.5-3 summarizes the local availability of treated wastewater and related quantities.

In this context it has to be mentioned that wastewater quantities as presented in Table 5.5-3 are determined under purely quantitative aspects i.e. taking into account planned development of infrastructure with respect to sewerage and sewage treatment only. It has to be considered that the effluents of the treatment plants have to comply with quality standards to be reusable for agricultural irrigation and/or industrial purpose. Therefore, the treated effluent quantities as shown in Table 5.5-3 may not be available in total for substitution of freshwater in irrigation, if the quality of treated wastewater will not be acceptable with regard to related Jordanian Standard 893/1995. As shown in the table, the reuse amount of the treated wastewater is expected to reach to more than 240MCM/a by 2020. Accordingly, almost all of the treated wastewater will be reused (compare with Table 5.5-1).

Table 5.5-3 Major Areas of Treated Effluent's Reuse

.	Available treated wastewater/effluent (MCM/a)				
	2000	2005	2010	2015	2020
Scenario 1					
1. Not (or only partly) used	4,4	0,0	1,1	1,3	1,5
2. For reuse in Up/Midland for irrigation	7,3	30,0	41,4	55,5	60,7
3. For reuse for industrial purposes Amman/Zarqa	0,0	15,0	15,0	15,0	20,0
4. For reuse to Jordan Valley (without Aqaba)	50,2	63,2	109,5	141,7	156,9
5. For agricultural reuse in Aqaba	1,9	4,0	5,0	1,0	1,8
Total	63,8	112,2	172,0	214,6	240,8
Scenario 2					
1. Not (or only partly) used	4.4	0	1.1	1.5	1.7
2. For reuse in Upland/Midland for irrigation	2.3	20.0	31.4	44.7	53.1
3. For reuse for industrial purpose (Amman/Zarqa)	0	15.0	15.0	15.0	20.0
4. For reuse to Jordan Valley (without Aqaba)	55.2	73.2	124.2	173.6	202.5
5. For reuse in Aqaba	1.9	4.0	5.0	6.6	7.7
Total	63.8	112.2	176.7	241.3	285.1
Scenario 3					
1. Not (or only partly) used	4.3	0	1.0	1.3	1.5
2. For reuse in Upland/Midland for irrigation	2.3	19.0	29.1	40.2	46.2
3. For reuse for industrial purpose (Amman/Zarqa)	0	15.0	15.0	15.0	20.0
4. For reuse to Jordan Valley (without Aqaba)	54.6	69.3	111.7	152.0	170.6
5. For reuse in Aqaba	1.9	3.8	4.7	5.9	6.7
Total	63.1	107.2	161.5	214.5	245.1

Source: Plan of the Study Team

5.6 Problems and Issues on Water Resources Development Plan

(1) Global climatic change

As mentioned in section 5.1.1, the annual rainfall has been under the long term average in these three years. However, though the general tendency of decreasing of the annual rainfall cannot be detected according to the long term observation records, the future potential of the surface water was estimated without considering the global climatic change.

However, if the tendency of decrease of rainfall caused by the global climatic change will appear to be real, the potential of both surface water and groundwater must be re-evaluated and accordingly the Water Resources Management Master Plan must be totally revised based on the new potential. Therefore, the tendency of the climatic change should be carefully observed.

(2) Cooperation for regional water development

1) Surface water development of the Yarmouk River

The most important water resource development project is the Wehda Dam construction project in the Water Resources Management Master Plan. Wehda Dam is planned to be constructed in the Yarmouk River by 2005 and 93MCM/a of surface water will be developed by the project. The 93MCM/a occupies 55% of the total incremental amount of the surface water (169MCM/a) to be developed from 2000 to 2020.

However, it is reported that the planned development amount may not be achieved because the base flow of the Yarmouk River is decreasing due to the extensive water development in the upper stream area of the Yarmouk River with in the Syrian Territory. As the water to be developed by the Wehda Dam will be quite important for Jordan as mentioned before, the rightful shares of water resource of the Yarmouk River should be negotiated with the Syrian side.

2) Peace water from Israel

"Storage on Jordan River and Side Wadis" is one of the peace water projects and it is under the planning. About 30MCM/a of surface water will be developed by constructing small dams in the Jordan River and side wadis and conveyed to Jordan. This project is scheduled to be completed by 2010. This project is regarded as one of the important water resources development projects in the Water Resources Management Master Plan because its development amount is much larger than other surface water projects excepting the Wehda Dam construction project.

However, the detailed study has not been done on this project and the actual development amount and project's feasibility are not clear. Therefore, the comprehensive study on this projects should be implemented at an early stage.

(3) Sustainable development/management of water resources

1) Brackish groundwater development

The brackish groundwater is the sole water resource remaining almost undeveloped in Jordan and it is regarded as an important water resource in the Water Resources Management Master Plan.

However, previous studies on brackish groundwater are very limited. Therefore, the comprehensive study should be carried out concerning the potential of the brackish groundwater in all of Jordan at an early stage.

2) Reuse of the treated wastewater

The treated wastewater without dilution cannot be used for unrestricted crops and its usage would be restricted for trees and fodder. The treated wastewater is a very important resource under the severe conditions of water deficit in Jordan and its reuse for irrigation must be promoted as mentioned above.

However, the reuse of the treated wastewater without dilution has not been widely practiced in Jordan and it is limited to only a few areas in the vicinities of existing treatment plants. There are concerns that unpredictable problems might happen. It is supposed that such problems relate to diseases (Bio-hazard) to be caused by pathogenic organ, fecal coliform, nematodes and so on or damages to the plant to be caused by harmful substances in the treated wastewater, or salt accumulation in the soil.

For anticipation and prevention of such problems, the mutual monitoring and control of the treated wastewater quality by several organizations, proper application of the related laws and regulations and public awareness/education campaigns aimed at farmers concerning the reuse are essential for the implementation of the reuse project of the treated wastewater. "Adaptive Management" which aims to change the plan according to circumstances detected through monitoring should be employed for the reuse of the treated wastewater.

Concerning these procedures, the institutional and legislative system has been formulated for the reuse and large scale reuse projects have been implemented in Israel. In the report issued by Water Management Authority of Israel in 1995, about 200MCM of the treated wastewater was reused. In Tunisia, the reuse of the treated wastewater is also highlighted as one of the important water management policies in that country's water resources management plan 1995-2010 (from the seminar report held in Amman in 1999). Therefore, the reuse of the treated wastewater should be implemented taking the experiences of other countries into consideration.

In addition, JVA is presently carrying out the irrigation project (BWP) which includes the reuse of treated wastewater for irrigation without dilution. The results of this project should be taken into consideration for the reuse of the treated wastewater.