4.2 Initial Environmental Examination

4.2.1 Guidelines for Initial Environmental Examination

According to JICA's policy on environmental examination for international cooperation projects, IEE (or EIA as required) shall follow the environmental guidelines of the host country as far as possible, and if there are no guidelines available in that country or the guidelines are insufficient, JICA Environmental Consideration Guidelines (JICAECG) shall be adopted. Considering the present conditions in Jordan, IEE for this project shall mainly follow JICAECG, and meanwhile, the particular environmental issues in the Study Area shall be considered.

Based on JICAECG, 23 environmental elements which covers social environment, natural environment and hazards should be examined for a groundwater development project (Table 4.2.1).

4.2.2 Environmental Examination Matrix

An environmental examination matrix (EEM) is a useful tool for a brief screen of the impact of a project on the environment. Project activities to be involved in each of the alternative plans in both construction and operation phases are taken into considerations.

Table II-4.2.1 shows the EEM for this project in which all the environmental elements are screened with reference to each of the project activities.

(1) The environmental elements on which there is no negative impact from any of the project activities

Considering social environment, the project will not involve any problems of resettlement, area separation, water right or risk of disaster. As for public health, brackish groundwater desalination will provide an additional supply of high quality drinking water and an improvement in the sanitary conditions in the North part of Jordan. There is a positive impact on public health.

The project will serve a large area and the pipelines for water transfer will stretch along the Jordan Valley and to Amman. However, the scale of the project will not be so large as to affect topography and geography, to result in soil erosion, to cause impact to the ecological system (flora and fauna), nor to affect the weather in the related areas. The landscape will not be affected either.

Because no large construction is planned on the sea shore, the impact to the coast and sea area can also be ignored.

The process of brackish water desalination will not pollute the air nor give out offensive odor. Within the safe yield of the brackish groundwater aquifer (the maximum exploitable amount has been set as 70% of the total amount of water recharge), ground subsidence will not occur during long term groundwater abstraction.

(2) Environmental elements to which impacts of project activities should be further examined

In the construction phase of the desalination plants, brine evaporation pond and transfer pipelines, the impact on the following environmental elements cannot be ignored and need to be further examined.

- Economic activities
- Traffic and public facilities
- Archaeological treasures
- Solid waste
- Noise and vibration

In the operation phase of desalination plants, the impact on groundwater (water table and quality) should be examined.

Dealing with brine disposal in the operation phase, the impact on water and soil should be investigated especially for the evaporation pond and Wadi Ijarfa.

Finally, the problem of sewage increase by the improvement of water supply through this project will also be discussed.

4.2.3 Examinations of Selected Environmental Elements

(1) Impacts to Economic Activities

1) Agricultural land

In the Jordan Valley area, agriculture is the most important economic activity. Therefore, the impact of this project on agricultural land is the first item to examine.

Fig. II-4.2.1 and Fig. II-4.2.2 are the agricultural land classification maps of Deir Alla area and South Shuneh area. The land is classified into 6 classes according to the suitability of the soil for irrigated agriculture. The proposed sites of this project are plotted on these maps.

Desalination plants: Both the North and South sites are not on irrigated agricultural land.

Production well fields: In the two maps, the proposed production well fields include some irrigated land. However, wells will be scattered in the fields and each of them will need no more than 50 m^2 for construction. In fact, the 40 wells in the North and 60 wells in the South will not occupy large area. Besides, pieces of empty land are also scattered in the agricultural area. Therefore, the use of agricultural land can be avoided by a careful selection of the site for each well, as well as the raw water pipelines from the wells to the desalination plant.

Evaporation pond: The evaporation pond for the 6 MCM/year development plan in the North area will be constructed in the dissected terrain that can not be used for any agricultural purpose.

Pipelines: Most of the lengths of the common brine discharge line, the transfer pipeline between Deir Alla and South Shuneh, the transfer pipeline to National Park Pump Station and the brine transfer pipelines from the desalination plants to the common line and to the evaporation pond will be along the verges of the roads. In locations where these pipelines do go through agricultural areas, the route should be carefully selected to reduce the influence on crop lands.

2) Other economic activities

There are no industries nor business centers, markets and so on in the sites of the desalination plants and the production well fields. The impact of the project on these can therefore be ignored. The construction of the pipelines will not affect these economic activities either.

Table II-4.2.1 Environmental Examination Matrix

Project Activities			Environmental Elements	Hazards						Natural Environment								Social Environment								
				Offensive odor	Ground subsidence	Noise and vibration	Soil pollution	Water pollution	Air pollution	Landscape	Weather	Flora and Fauna	Coastal and sea area	Lake and rivers	Groundwater	Soil erosion	Topography/Geography	Risk of disaster	Solid waste	Public health	Water right	Archaeological treasures	Traffic/public facilities	Economic activities	Area separation	Resettlement
Desalination plants	North plant		Construction phase			O													O			O	O	O		
			Operation phase												O											
	South plant		Construction phase			O													O			O	O	O		
			Operation phase												O											
Brine disposal	North plant	Evaporation pond	Construction phase			O													O			O	O	O		
			Operation phase				O	O											O							
		Transfer line	Construction phase			O																O	O	O		
			Operation phase																							
	South plant		Wadi Ijarfa				O	O						O												
			Transfer																							
Common brine discharge line			Construction phase			O													O			O	O	O		
			Operation phase																							
Transfer pipeline between North and South plants			Construction phase			O													O			O	O	O		
			Operation phase																							
Transfer pipeline to National Park Pump Station			Construction phase			O													O			O	O	O		
			Operation phase																							

Shaded area: No impact is anticipated; Circle: Impact cannot be ignored and further examination is needed.

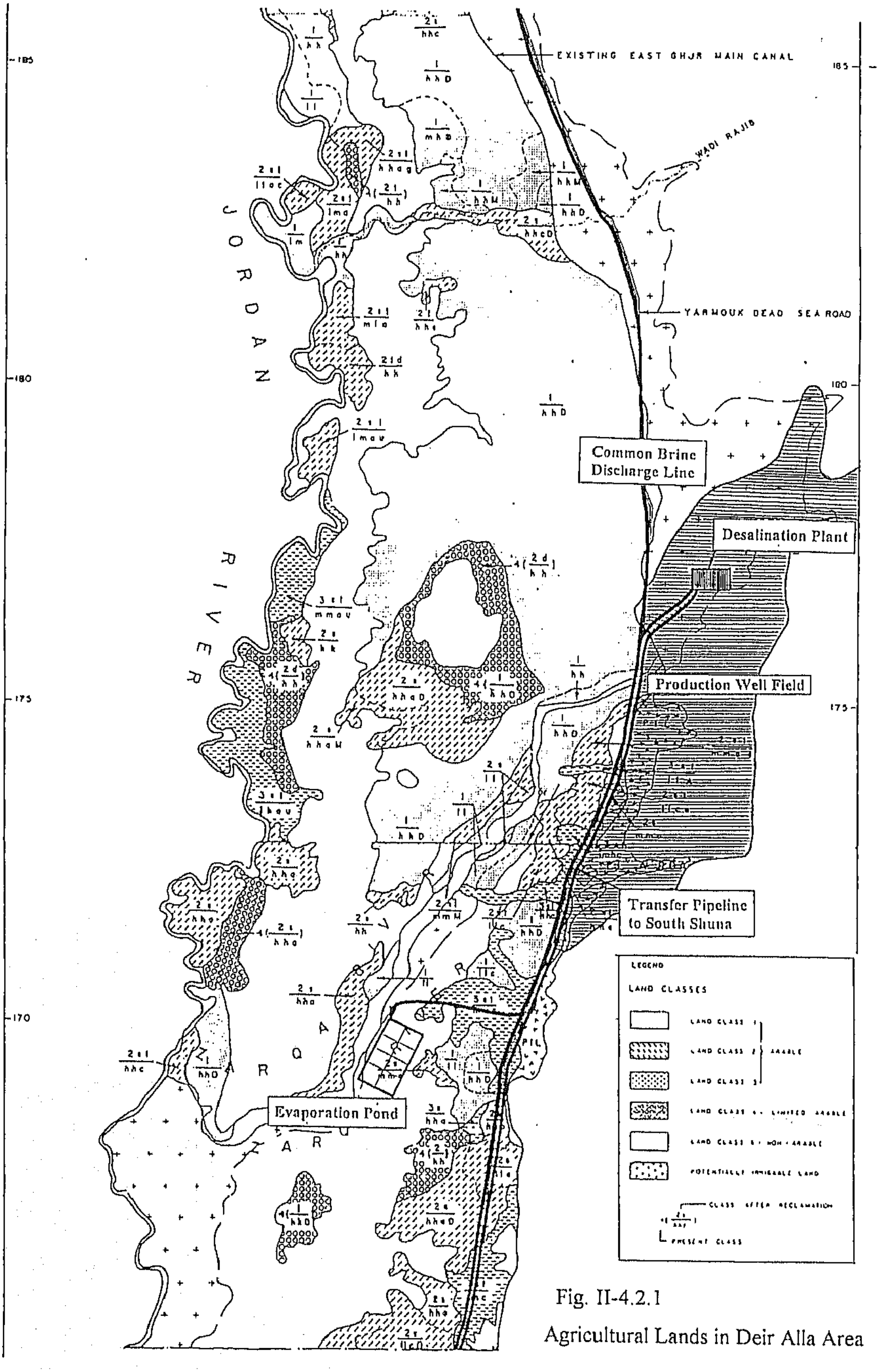


Fig. II-4.2.1

Agricultural Lands in Deir Alla Area

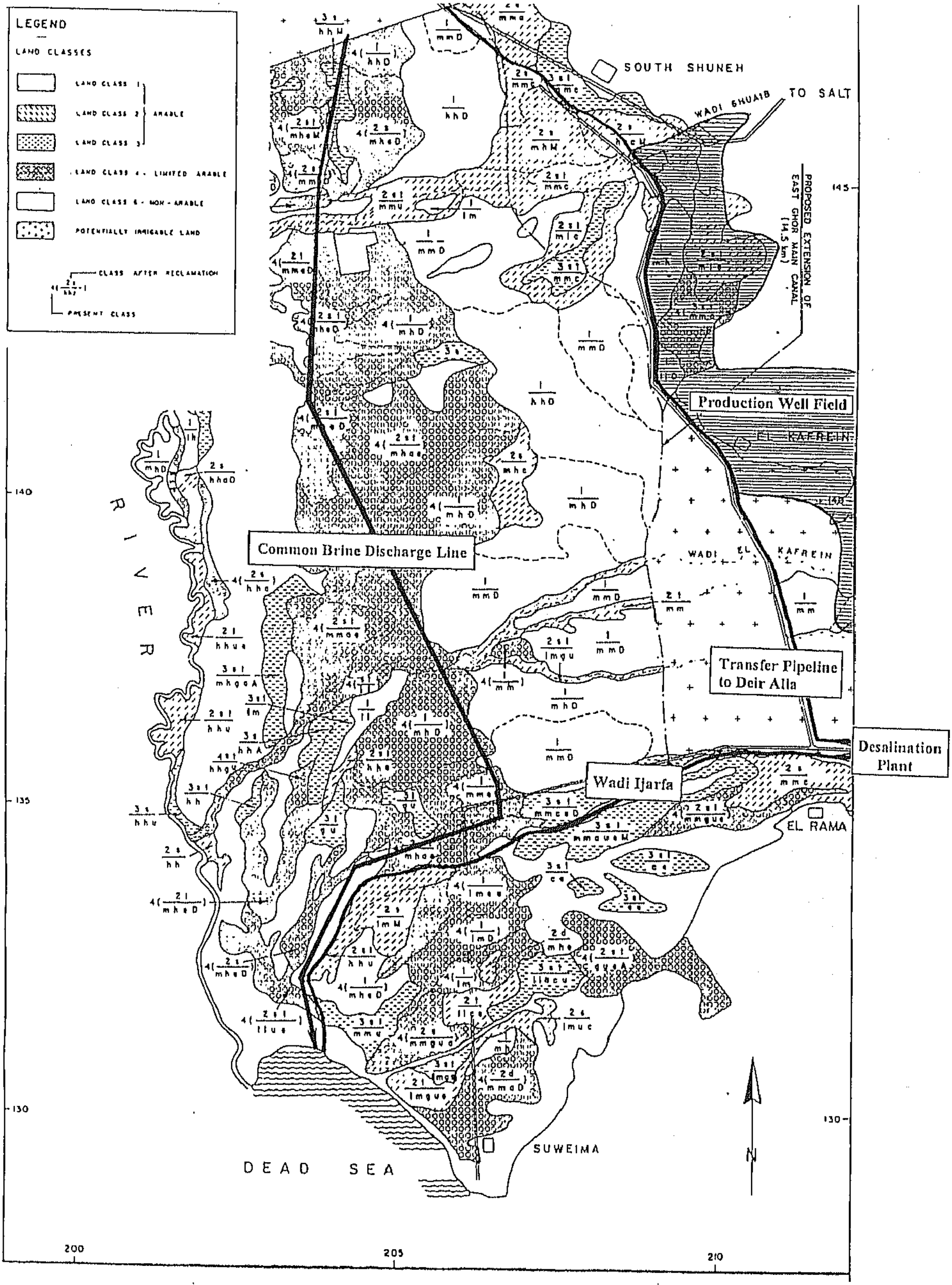


Fig. II-4.2.2 Agricultural Lands in Kaffrein Area

(2) Impacts on Traffic and Public Facilities

1) Traffic

Generally speaking, the construction work involved in this project is not very large scale in comparison with the other undergoing projects in Jordan Valley such as Karameh Dam project. The transportation for the work will not cause traffic problems. However, there will be several places where pipelines intersect the main roads, such as the brine transfer line across Road No.65 to the evaporation pond, the common brine discharge line and water transfer pipeline across Road No.40, and some intersections with the other roads. During the construction of the pipelines at these locations, temporary by-passes should be built to enable vehicles to use the road as usual.

2) The other public facilities

Public facilities, such as schools, kindergartens, hospitals and clinics, governmental buildings, banks in the related areas in Jordan Valley are concentrated in Deir Alla, Mu'addi, Karameh, Shuneh Nimrin and Kafrein. The desalination plants and production well fields are not near these towns. Therefore, the construction work will not affect these public facilities.

(3) Archaeological Treasures

According to the data provided by the Institute of Archaeology and Anthropology, Yarmouk University, in the Southern half of the Jordan Valley between Wadi Rajib and Dead Sea, there are 118 archaeological sites dating from the Neolithic/Chalcolithic period, through the Bronze, Iron, Persian, Hellenistic, Roman, Byzantine periods, to the Islamic period. The approximate locations of these archaeological sites are shown in Fig. II-4.2.3. Among them, the site names of those located in or near the project sites are as follows.

a) In the North production well field (9 sites)

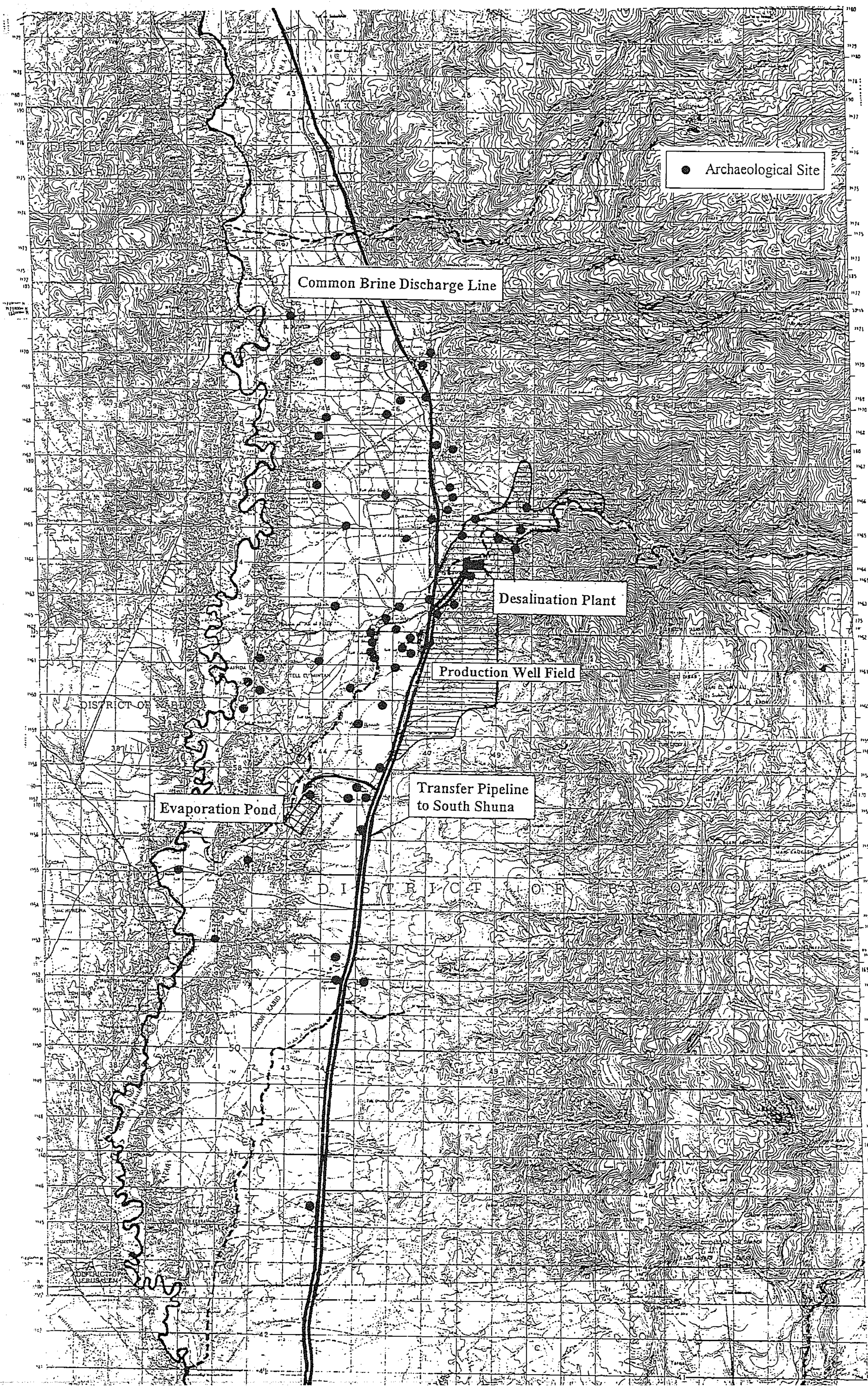
- Tell el-Hemmeh West
- Tell el-Hemmeh East
- er-Rweihah
- Ze'aze'iyyeh
- el-Hazromi
- el-Msattarah
- Abu Zeighan

- Tell 'Alla (Handaquq)
- el-Msattarah East

b) Near evaporation pond (1 site)
- el-Murabba'

c) In the South production well field (15 sites)
- Tell esh-Shuneh South (Nimrin)
- Tell el-Mahmuleh
- Tell esh-Sharab (el-Kufrein)
- esh-Sharab East
- en-Nassariyyat
- Abu Qaraf
- Tell et-Tahuneh
- Tell el-Hammam
- Tell Iktanu North
- er-Rashidiyyeh East
- Tell Wad'an
- Ketif es-Safi
- Tell Iktanu South
- Muthallath er-Rameh
- Azeimeh Reservoir

Before locating each well in the well fields and planning the desalination plants and evaporation pond, a detailed survey of these archaeological sites should be conducted with the coordination of Jordanian agencies or institutes for archaeological study and management, and measures should be taken to protect archaeological treasures from any negative impact from the construction work.


Archaeological Site
Common Brine Discharge Line
Desalination Plant
Production Well Field
Transfer Pipeline
to South Shuna
Evaporation Pond
DISTRICT OF NABLUS
DISTRICT OF BALQA
DISTRICT OF JERUSALEM

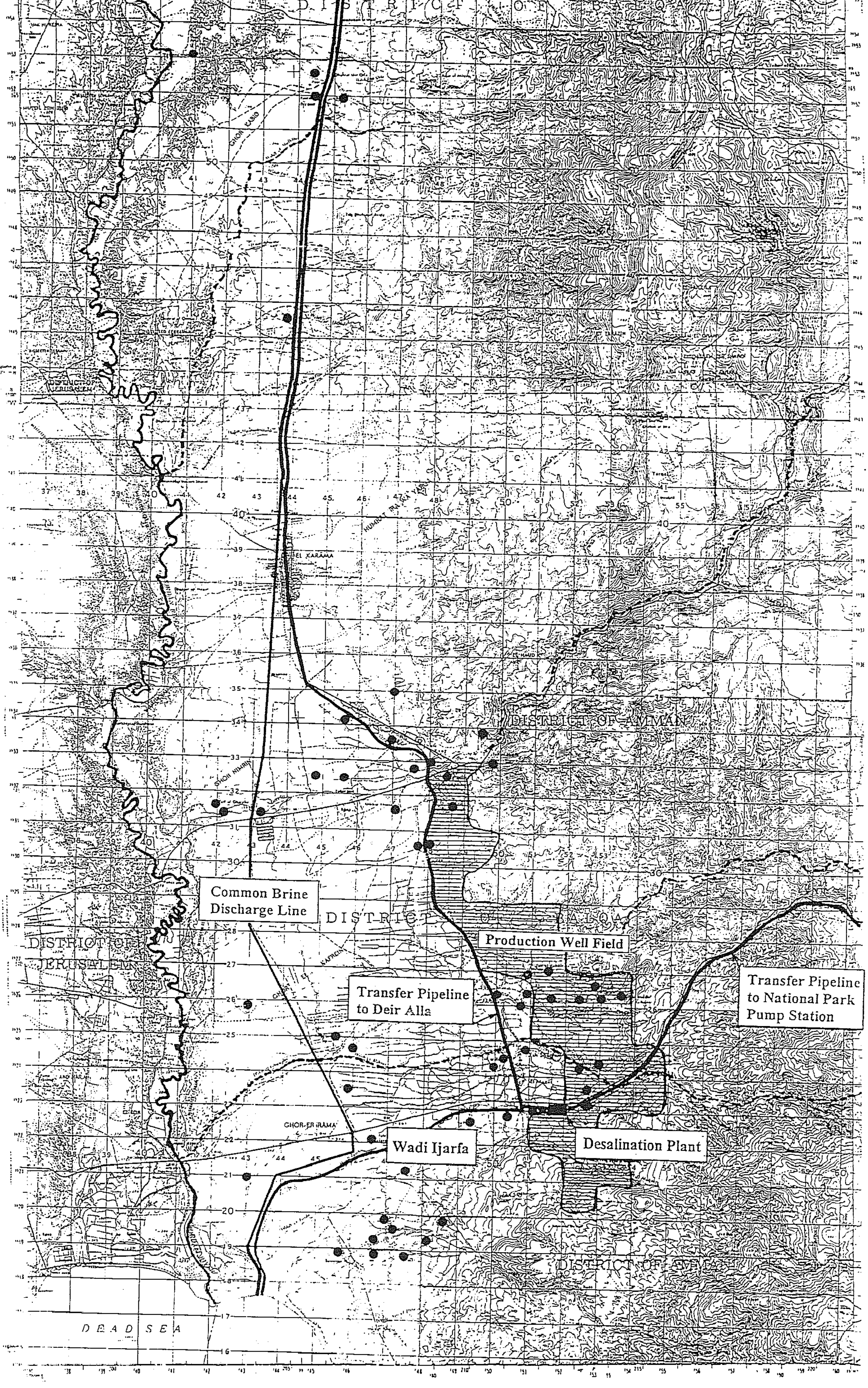


Fig. II-4.2.3 Archaeological Sites in Deir Alla and Kaffrein Areas

(4) Solid Wastes, Noise and Vibration

1) Disposal of solid wastes

Solid wastes will be mainly from the earth work of plant and pump station construction and from the excavation for pipeline construction. Because most of the wastes will be used as backfill, the amount to be disposed of will not be large. In Jordan Valley area, there are solid waste landfill sites in South Shuneh, Hisban and Karameh. Extra solid wastes from the construction site should be transported to these sites for final disposal.

2) Noise

In the construction phase of this project, the noise sources and the evaluated noise levels (30 m from the sources) will be as follows.

- Rock drill: 75 dB
- Air compressor: 75 dB
- Concrete blender: 75 dB
- Drilling machine: < 70 dB

The noise levels of the other machines to be used for construction are lower than the above mentioned values.

For well drilling and the construction of the desalination plants, evaporation pond, and booster pump stations on the water transfer pipelines, because the sites are far from towns and densely populated areas, the influence of noise to the surrounding area can be ignored. However, with reference to Japanese standards, the pipeline construction work in the town areas and residential areas should only be conducted in daytime.

In the operation phase of the whole project, noise levels will be negligible.

3) Vibration

The degree of the impact of vibration is similar to noise. No additional restriction is needed to the work.

(5) Impacts to Groundwater Aquifers

1) Water table of the Zerqa Aquifer

From the results of the hydrogeological analyses and groundwater simulation, the variation of groundwater table of the Zerqa Aquifer after long term development is estimated as follows. a) North (Deir Alla) area

- 6 MCM/year development

  Draw-down of water table: about 10 m

  Influence area: well field only

- 30 MCM/year development

  Draw-down of water table: about 50 m (maximum)

  Influence diameter (10 m draw-down): about 8 km

b) South (Kaffrein) area

- 6 MCM/year development

  Draw-down of water table: about 30 m

  Influence diameter (10 m draw-down): about 2 km

- 45 MCM/year development

  Draw-down of water table: 60 m

  Influence diameter (10 m draw-down): 20 km

In these areas, the water from the Zerqa Aquifer is not used for any other purpose. The draw-down of the water table will have no impact on the life and economic activities of the people there.

2) Water quality of Zerqa Aquifer

Table II-4.2.2 shows the historical data and analysis results of TDS by the JICA Study Team for the existing Hisban No.2 and Kaffrein No.7 wells which belong to the Zerqa Aquifer.

Table II-4.2.2 TDS of Zerqa Aquifer Wells

(Unit: mg/L)

Hisban No. 2		Kaffrein No. 7	
Mar. 1984	4095	Dec. 1983	5760
Apr. 1994	4055	Apr. 1994	5508
Sep. 1994	4121	Sep. 1994	5590

It can be seen that for more than 10 years from the time when the wells were drilled, the water quality has not changed at all. The water quality of the Zerqa Aquifer is thought to be stable.

An assumption has been drawn from the hydrogeological study that stagnation of water in saliferous strata results in water salification, and the salinity of water relates to its flow rate in the aquifer. Within the influence area of the brackish groundwater development, the flow rate of water in the aquifer will increase but not decrease. Therefore, water quality deterioration will not happen.

3) Water table of shallow aquifer

On top of the Zerqa Aquifer, there is the Kurnub sandstone aquifer which is a fresh water resource in some of the Jordan Valley area.

In the North area near Deir Alla, the Kurnub Aquifer does not exist. Therefore, no influence is anticipated on this aquifer after the long term development of the Zerqa Aquifer. In the South area near Kaffrein, a development of 6 MCM/year of the Zerqa Aquifer may result in a draw-down of the Kurnub Aquifer of 4 m at the well field with an influence diameter of 10 km (2 m draw-down), and that of 45 MCM/year may result in a draw-down of 20 m at the well field with an influence diameter of 5 to 10 km (10 m draw-down).

Within the influence area are the Kaffrein and Rawda Well Fields for drinking water production. However, among these wells only Kaffrein Well No.2 reaches the Kurnub Aquifer, and the others are shallow wells in the upper sand and gravel aquifers on which the influence from the Zerqa Aquifer is negligible. On the other hand, under the 45 MCM/year development condition, brackish groundwater desalination will be the main source of water supply in this area, and the present condition of over-abstraction of water from these shallow aquifer wells will be completely changed.

4) Water quality of shallow aquifer

A tendency of increase in the salinity of the Kurnub Aquifer is noticeable. This is believed to be the result of leakage of the brackish groundwater from the Zerqa Aquifer. The development of brackish groundwater will result in a decrease of the piezometric surface of the Zerqa Aquifer in some areas. This may reduce the upward leakage of water to the shallow aquifers but not increase it. No negative impact on the water quality of the shallow aquifers is therefore anticipated.

(6) Water and Soil Pollution by Brine Disposal

1) Brine discharge pipeline to The Dead Sea

The Dead Sea is the most saline water in the world. Its salinity is 323.94 g/L as TDS, with an ion composition as shown in Table II-4.2.3.

With its extremely high salinity, the Dead Sea is the most suitable place for final disposal of the brine from the desalination plants (with a TDS of 25 to 37.5 g/L). The discharge of brine to the Dead Sea will not affect its water quality in any sense.

To avoid misuse of brine and to prevent soil pollution during brine transfer, a closed pipeline, not an open channel, should be constructed for the whole system.

Table II-4.2.3 The Chemistry of The Dead Sea Water

(In percent of cations or anions)

Ion	Na	K	Ca	Mg	Cl	SO_4	HCO_3	Br
%	37.8	6.3	17.0	38.9	96.73	0.34	0.13	2.78

Source: Ibrahim Ahmad Ali Al-Sbaeay, The Dead Sea Water Geochemistry, 1987

2) Evaporation pond

An evaporation pond is proposed for brine disposal for the 6 MCM/year development in the Deir Alla area. Because its site is in the dissected terrain, and its bottom and sides will be sealed, soil and water pollution will not happen in the surrounding area.

3) Wadi Ijarfa

Wadi Ijarfa flows directly to The Dead Sea and is dry in most seasons. The distance from the proposed site of the desalination plant to The Dead Sea though the wadi is about 12.5 km and the bottom of the wadi descends from -190 m to -400 m. An average gradient of 16.8% is calculated. Therefore, the discharged brine can flow through the steep water course to The Dead Sea rapidly.

Because the wadi is deep and there is no farm land near its banks, brine discharge will not cause soil pollution. However, in order to protect the water quality in the shallow groundwater aquifer, it is recommended that a pipeline should be constructed for discharging brine directly to

The Dead Sea, especially for the development of 45 MCM/year brackish groundwater in Kaffrein area.

(7) Sewage Increase due to the Improvement of Water Supply through this Project

1) Jordan Valley area

At present, the amount of water supply for domestic and industrial use is about 10 MCM/year. After the implementation of this project, there will be an increase of 5 MCM/year (the immediate results of 6 MCM/year development) to 16 MCM/year (the results of 30 MCM/year development in Deir Alla or 45 MCM/year in Kaffrein area) in water supply. Accordingly, the volume of sewage will increase by an equivalent amount.

In the Jordan Valley area, sewer systems are not well built and there is only one wastewater treatment plant in Kufrinjeh with a design capacity of 1800 m^3/day. The environment is deteriorating in some areas due to arbitrary disposal of sewage. To improve the present condition and to prevent further pollution, it is recommended that projects for sewer system improvement be implemented step by step along with brackish groundwater development.

2) Greater Amman area

As a result of the 30 MCM/year development in Deir Alla, 45 MCM/year in Kaffrein, or 75 MCM/year in both areas, 8 ~ 44 MCM/year of water will be transferred to Amman and the water supply will be much improved.

In the metropolitan area of Amman, about 90% of the population are served with a sewer system. Sewage is transferred to As Samura Wastewater Treatment Plant where stabilization ponds are utilized to achieve secondary treatment of up to a design capacity of 68000 m^3/day. However, the actual load of the plant in 1993 was as high as 124,000 m^3/day. In the whole Greater Amman area including Amman and Zarqa Governorates, the percentage of population served by sewer systems is 80%. It can be seen that improvement of the sewer system is also needed along with brackish groundwater development.

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5. Project Evaluation

5.1 Project Cost

The construction costs of the 5 alternative projects are shown in Table II-5.1.1. The principles of cost estimation are as follows.

a) Production wells

- Practical cost for test wells drilling in this Study was referred.
- The prices of materials were based on the practical purchasing prices in Jordan.
- The cost for construction work was at the local level based on the information provided by WAJ.

b) RO equipment

- International standard prices and the practical price level of existing projects were referred.
- Calculation results by IDA (International Desalination Association) Brackish Water Desalting Costs Program were referred.
- Particular conditions of this project, such as the required pre-treatment process according to the brackish groundwater quality, were considered, and the costs for such equipment were respectively calculated.

c) Brine discharge equipment

- The prices of materials were based on the local level.
- The cost for construction work was at the local level based on the information provided by WAJ.

d) Electricity supply equipment

- The cost of electricity generating equipment was based on the consultant's experiences according to the required capacity.
- The cost for the other electricity supply equipment was at the local level based on the information provided by WAJ.

e) Water transfer trunk line

- The prices of materials were based on the purchasing prices in Jordan.
- The practical costs for pipe line constructions in some existing projects in Jordan were referred.
- Local cost for construction work was referred based on the information provided by WAJ.

Table II-5.1.1 Construction Cost of Alternative Projects ('000 JD)

	Plan-A		Plan-B		Plan-C		Plan-D		Plan-E	
	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local
I. Production Wells	**8,408**	**685**	**1,426**	**241**	**12,433**	**1,307**	**1,372**	**295**	**20,841**	**1,992**
a. Well Construction	1,716	484	832	235	2600	733	832	235	4,316	1,217
b. Well Pump	4224	176			6467	200			10,691	376
c. Collection Pipes	2468	25	594	6	3366	374	540	60	5,834	399
II. RO Desalination Plant	**24,003**	**13,133**	**6,107**	**2,953**	**32,787**	**17,366**	**6,511**	**3,206**	**56,790**	**30,499**
(1) Equipment	21,542	467	5,518	107	29,636	633	5,524	107	51,178	1,100
a. Machinery	17,775	467	4,451	107	24,569	633	4,457	107	42,344	1,100
b. Electrical & Instrumental	3,767		1,067		5,067		1,067		8,834	
(2) Material	1,306	1,266	332	313	1,611	1,533	730	566	2,917	2,799
a. Machinery	773	933	199	233	944	1,133	197	233	1,717	2,066
b. Electrical & Instrumental	533	333	133	80	667	400	533	333	1,200	733
(3) Construction Work	1,155	11,400	257	2,533	1,540	15,200	257	2,533	2,695	26,600
a. Mechanical	855		190		1,140		190		1,995	
b. Electrical & Instrumental	300		67		400		67		700	
c. Civil		11,400		2,533		15,200		2,533		26,600
III. Brine Discharge Line Construction	**12,000**		**1,153**		**2,167**		**33**		**14,167**	
IV. Electricity Power Supply	**3,653**		**860**		**8,207**		**613**		**11,860**	
V. Water Supply System	**10,618**	**2,349**	**4,933**	**1,333**	**27,860**	**9,189**	**4,666**	**1,600**	**38,478**	**11,538**
(1) Equipment	3,374		533		2,880		533		6,254	
a. Pump	1,587		333		1,587		333		3,174	
b. Electrical	1,787		200		1,293		200		3,080	
(2) Material	3,524	2,349	2,000	1,333	11,540	7,696	2,000	1,333	15,064	10,045
(3) Construction Work	3,720		2,400		13,440	1,493	2,133	267	17,160	1,493
a. Mechanical			300				300			
b. Piping	3,720		1,833				1,833		3,720	
c. Civil			267		13,440	1,493		267	13,440	1,493
VI. Design & Supervise	**5,055**		**1,288**		**7,316**		**1,256**		**12,371**	
Subtotal	*63,737*	*16,167*	*15,767*	*4,527*	*90,770*	*27,862*	*14,451*	*5,101*	*154,507*	*44,029*
	79,904		*20,294*		*118,632*		*19,552*		*198,536*	
Contingency* (10%)	7,990		2,029		11,863		1,955		19,854	
Total	*87,894*		*22,323*		*130,495*		*21,507*		*218,390*	

* Including physical contingency, price contingency and interest for working capital in the first year of construction.

5.2 Operation and Maintenance Cost

The costs for the operation and Maintenance of the project are shown in Table II-5.2.1.

Table II-5.2.1 Operation and Maintenance Cost of Alternative Projects

('000 JD)

Item	Plan-A	Plan-B	Plan-C	Plan-D	Plan-E
I. Desalination Plant	5,610	1,096	7,897	972	13,507
(1) Electricity	2,061	318	2,947	252	5,008
(2) RO membrane replacement	584	120	875	120	1,459
(3) Chemicals and consumable	2,556	509.5	3,477	451.5	6,033
a. H_2SO_4	1,603	310	2,392	310	3,995
b. NaClO	704	141	262	34	966
c. $FeCl_3$	0	0	383	49	383
d. Inhibitor	63	12	95	12	158
e. SBS ($NaHSO_3$)	31	6	46	6	77
f. NaOH	108	31	229	31	337
g. Citric acid	9.5	2	15	2	25
h. Safety filter	37.5	7.5	55	7.5	93
(4) Labor	86	76	112	76	198
(5) Maintenance	323	72	485.5	72	809
II. Water supply system	1,323	115	4,568	115	5,891
(1) Electricity	1,236	99.3	4,198	99.3	5,434
(2) Labor	0	0	0	0	0
(3) Maintenance	86.7	16	370	16	457
Total	*6,933*	*1,211*	*12,465*	*1,087*	*19,397*

Calculations of these costs are based on the following principles.

a) Electricity

- The current electricity price of 0.03 JD/Kwh for WAJ's water supply was used.

b) RO membrane replacement

- The price of RO membrane modules was set on the international base.
- An annual replacement of 20% membrane modules was considered.

c) Chemicals

- Consumption of chemicals was estimated according to the consultant's experience and the raw water quality.
- Both local purchasing prices and international standard prices were referred in setting the unit prices of chemicals.

d) Labor

- Present salary of labors in Jordan was referred.

e) Maintenance

- Annual maintenance cost was estimated according the equipment level and the consultant's experience.

5.3 Water Production Cost

Water production cost of desalination plan is calculated. The results are compared with that of Disi/Mudawarra project. (See Table II-5.3.1.)

- Capital cost means initial construction costs except for electricity power supply. Electricity power supply cost is depreciated and included in the O&M cost as an electricity price.
- Adjusted capital cost includes the replacement cost of machines and equipment in a middle of project period in addition to the initial construction cost. The replacement cost is evaluated at a present price.
- Adjusted capital cost is used to calculate to the annuity of 3 %-interest loan during the 25 year repayment period.
- Operation and maintenance cost covers an operation of desalination plant and water supply mains.

Plan A and Plan C are a full scale development of desalination in different locations; Deir Alla and Kafrain. Plan C requires a larger (adjusted) capital cost than Plan A because of the greater size of water production and the installment of new pipeline to Amman[9]. Plan C also needs a relatively larger O&M cost than Plan A. Plan B and Plan D are a pilot scale project for desalination before the full scale development. Plan D needs a slightly smaller capital cost than Plan B, because of its advantage of brine disposal to Dead Sea. Plan E is a combination of Plan A and Plan C, but saves the installment of water supply main between Deir Alla and Kafrain. The size of water production in Plan E exceeds that of Disi/Mudawarra project. Its capital investment stays below the Disi/Mudawarra project although its O&M cost is four times bigger than that of Disi/Mudawarra project.

- Water production cost of desalination project ranges between 0.522 JD/m^3 to 0.600 JD/m^3. It never achieves the current production cost of WAJ water. Desalination projects will probably require the government contribution or grant for their implementation. The government contribution or grant will ease a burden of capital cost and subsequently will reduce the water production cost.

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[9] Plan A assumes the use of existing Deir Alla/ Amman pipeline to transport a desalinated water to Amman.

Table II-5.3.1 Comparison of Water Production Cost

Items	A	B	C	D	E	Disi
Water Production (MCM)	24	5	36	5	60	50
Capital Cost (MJD)*	87.89	22.32	130.49	21.51	218.39	245.51
Adjusted Capital Cost (MJD)**	109.40	26.86	159.06	26.56	268.46	n.a.
O&M Cost (MJD)	6.93	1.21	12.47	1.09	19.40	5.59
Water Cost (JD/m3)						
Capital Cost***	0.262	0.308	0.254	0.305	0.257	0.282
O&M Cost	0.289	0.242	0.346	0.217	0.323	0.112
Total	0.551	0.551	0.600	0.522	0.580	0.394

Note 1: Capital cost does not include the capital cost for electricity power supply because electricity price each year is assumed to have already taken into account the depreciation of necessary equipment.

Note 2: Capital cost is adjusted by capital replacement cost during the project period.

Note 3: Calculation of water cost assumes a 3%-interest loan of which repayment period is 25 years.
The loan condition (low interest) in this analysis is in favor of the project of heavy initial investment such as Disi project.
If the government contribution or grant is introduced, capital cost will be substantially reduced.

- Among the desalination plans, Plan D is of smallest water production cost; 0.521 JD/m^3. This is because of several advantages that include proxy of brine disposal to Dead Sea and no water conveyance system for Amman necessary.
- However, the water production cost of Plan D stays higher than that of Disi/Mudawarra project.

In Jordan, electricity is supplied at a very low price because of free oil import from Iraq. Jordan Electric Authority (JEA) supplies electricity for water pumping at 30 fils/Kwh. The unit water production cost shown in Table II-5.3.1 was calculated on the basis of this low electricity price .

Because the electricity cost shares a large portion of the O & M cost for RO desalination, an increase of electricity cost will result in an increase of the unit water production cost. Although JEA calculates an economic cost (31.6 fils/Kwh) that is not much different from the current electricity price for water pumping, the electricity cost will be higher if an international price of oil is considered.

Table II-5.3.2 shows the unit water production cost calculated under an assumption that the electricity price is adjusted to 50 fils/Kwh. The resulted water production costs of the 5 alternative plans will increase from 0.522-0.600 JD/m^3 to 0.569-0.732 JD/m^3 as the electricity price increases from 30 fils/Kwh to 50 fils/Kwh.

Table II-5.3.2 Unit Water Production Cost at an Electricity Price of 50 fils/Kwh

	Plan				
	A	B	C	D	E
O & M Cost (MJD/yr.)	9.13	1.49	17.23	1.32	26.36
Water Cost (JD/m^3)					
Capital Cost	0.262	0.308	0.245	0.305	0.257
O & M Cost	0.380	0.298	0.479	0.264	0.439
Total	0.642	0.606	0.732	0.569	0.696

5.4 Existing Water Resource Development Plans

This analysis expects 45 MCM of the Peace Treaty Water available by the year 2000. Disi/Mudawarra project will bring an additional 75 MCM of fresh water probably by the year 2000. The brackish groundwater desalination in the study area will start by the pilot scale (5 MCM) project, and is expected between the first Peace Treaty Water (30 MCM) and the second Peace Treaty Water (15 MCM) or Disi/Mudawarra (75 MCM). Additional Disi/Mudawarra (25 MCM).

Full scale development of brackish groundwater desalination, and saline spring desalination around the east bank of Jordan Valley will be put in force probably after the year 2003. Unity Dam is the most difficult project because of a tri-lateral settlement regarding the water use of Yarmouk River.

The study area is permanently in short of water supply even if all water resource development projects are implemented.

- Peace Treaty Water (30 MCM)

  The Peace Treaty between Jordan and Israel was ratified and becomes effective in November 1994. The Treaty settled the water issues of both countries by bringing the new water sources to Jordan as well as to Israel. Peace Treaty Water that is expected to be available very soon is probably 30 MCM. This amount of sweet water will be brought by the reduction of summer and winter pumping of Israel from the Yarmouk River, and off-summer diversion from Tiberias.

- Brackish Groundwater Desalination (5 MCM)

  Brackish groundwater desalination at a scale of 5 MCM per year assumes the Plan D that will be developed in Kafrain and will supply water to the Jordan Valley. The project consists of 5 MCM desalination plant and storage reservoir, and water supply main that conveys the water from Kafrain to Deir Alla. The capital cost is estimated to be JD 21.51 million, and an annual operation and maintenance cost including the replacement of membrane will be JD 1.09 million.

- Peace Treaty Water (15 MCM)

  Second Peace Treaty Water will be brought in the study area probably in a mid-term period. The amount of drinkable water from this scheme will be 15 MCM, and will be brought through the construction of dams in Adassiya, the Yarmouk, and the Jordan.

- Disi/Mudawarra Groundwater (75 MCM and 25 MCM)

  Disi/Mudawarra groundwater project extracts around 100 MCM per year of groundwater from Disi aquifer at the locations near to Disi and near to Mudawarra. Extracted water will be conveyed over the distance more than 350 km to Amman. The conveyance facility will be a system of storage reservoirs, pumping stations and transmission pipelines which include sections operating under pumped pressure, gravity flow and inverted siphon flow. The required capital investment at a scale of 50 MCM per year is estimated to be JD 245.51 million and annual running cost is to be JD 5.59 million.

- Brackish Groundwater Desalination (55 MCM)

  Brackish groundwater desalination at a full scale is 55 MCM per year, and assumed to be developed in both Deir Alla and Kafrain. Development in Deir Alla requires a large investment on the common waste disposal line and development in Kafrain needs a construction of new pipeline to Amman. As a result, the full scale development of brackish groundwater desalination needs around JD 197 million of capital investment and around JD 19.4 million of O&M cost.

- Saline Springs Desalination (40 MCM)

Large volume of saline spring water discharge is reported. It is estimated around 40 MCM per year of drinkable water if desalinated. The period of development is probably dependent upon the success of brackish groundwater desalination at a pilot scale (5 MCM).

- Unity Dam (40 MCM)

This project is most unknown, and its possibility is dependent upon the tri-lateral settlement regarding the water use of the Yarmouk River. This project will yield 225 MCM of water from which 100 MCM of drinkable water becomes available to the study area.

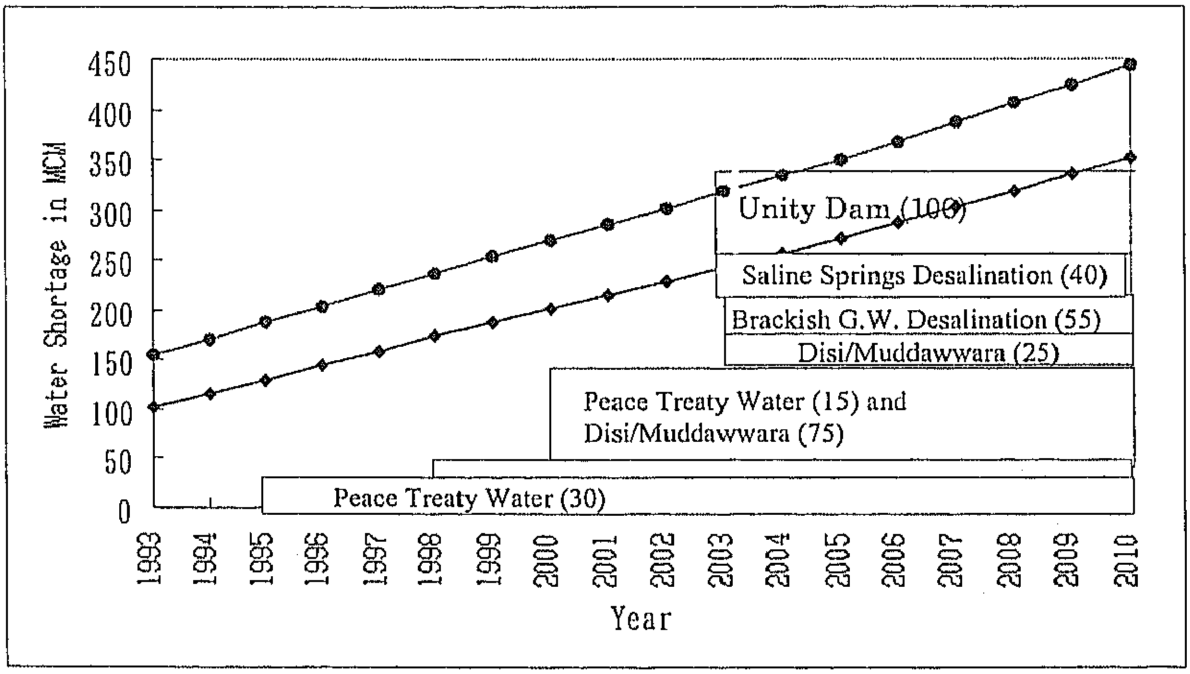


Figure II-5.4.1 Existing Water Resource Development in the Study Area

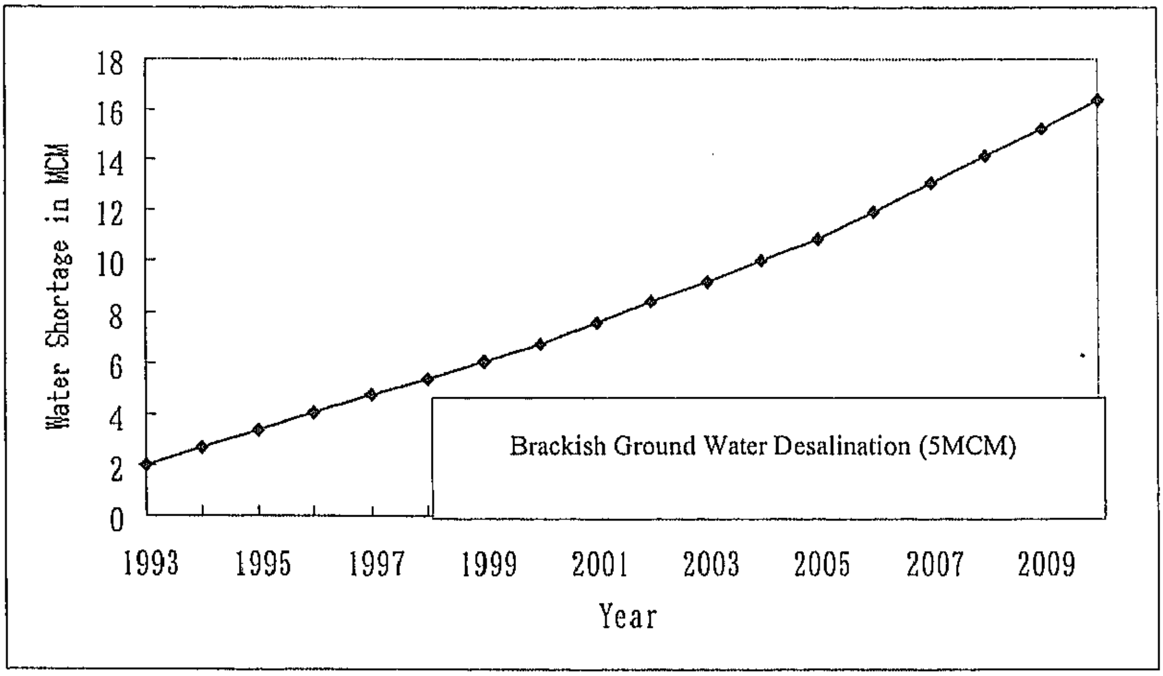


Figure II-5.4.2 Existing Water Resource Development in the Jordan Valley

5.5 Economic and Financial Analysis

5.5.1 Project Benefit (see Table II-5.5.1)

Primal project benefit of brackish groundwater desalination, Plan A through E is to ease a water shortage in the Jordan Valley, and to make possible the higher standard of water consumption. Plan A and Plan C will bring the water to the Upland as well as to the Jordan Valley through the conveyance system of desalinated water to Amman. Because the production of water by desalination will serve as a base supply throughout the year, a summer drought in the Jordan Valley and the Upland will be surely relieved. This will particularly improve the health standard of Jordan.

Plan A alone is effective to conserve the irrigable water of King Abudlla Canal through the reduction of canal intake to industrial use in the Jordan Valley and to municipal use in Amman. Implementation of Plan C and Plan D will result in the further development of industry in the Jordan Valley including the tourism development in the east coast of Dead Sea. Plan B and Plan D will serve as a pilot project of desalination that opens the possibility of full scale development of desalination such as Plan A and Plan C.

Plan E is a combination of Plans A and C, and will have the benefits of both of them.

Those benefits above will be partially monetarized through the water sales of the Water Authority. The revenue will be used to pay off the capital investment and to support the plant operation.

5.5.2 Possible Financial Sources (inconclusive)

Possible financial sources are inconclusively explored. Detail term of loan condition should be examined when the project proceeds more to implementation. For the financial analysis such as FIRR and Balance Sheet Analyses, the terms of Overseas Economic Cooperation Fund (OECF) loan and local long term loan are employed.

Table II-5.5.1 Socio-Economic Benefit of the Project

Supply Area	Plan A	Plan B	Plan C	Plan D	Plan E
Jordan Valley	(Tangible) • Ease a water supply cut • Higher water consumption • Conserve the industrial water for irrigation	• Ease a water supply cut • Higher water consumption	• Ease a water supply cut • Higher water consumption	• Ease a water supply cut • Higher water consumption	A+C
	(Intangible) • Higher health standard • Industrial development potential	• Higher health standard	• Higher health standard • Tourism development potential • Industrial development potential	• Higher health standard • Tourism development potential	A+C
Upland	(Tangible) • Ease a water shortage in Amman	None	• Ease a water shortage in Amman	None	A+C
	(Intangible) • Higher development opportunity • Higher health standard	None	• Higher development opportunity • Higher health standard	None	A+C

Table II-5.5.2 Possible Financial Sources (inconclusive)

Financial Sources	Interest Rate (%)	Grace Period (yr.)	Repayment Period (yr.)	Condition
(Japan)				
OECF Loans	3.00	10	20	Total foreign portion or 75% of total project cost.
Japan Exim Bank	4.90	0	10	85 % of equipment value, MITI* trade insurance required.
(the U.S.)				
US Exim Bank	7.00	3	12	85 % of equipment value.
Commertial Bank	6.75	5	10	10 % of equipment value.
(Local)				
Long term loan	3 - 4	3 - 5	20	

* MITI: Ministry of International Training and Industry

5.5.3 Financial Analysis (FIRR)

(1) Assumptions

- Current price level of water is maintained.

  Average price of drinkable water in Jordan is 0.400 JD/m^3, and is assumed to be maintained throughout the analysis.

- Unaccounted-for water is assumed to be improved.

  Current unaccounted-for water is 54 %[10], and is assumed to be improved upto 25 % during the next 10 years.

- Current level of government subsidy is assumed.

  WAJ produced a drinkable water at 0.307 JD/m^3 in 1992, and caused a 0.186 JD/m^3 of production loss. This loss was subsidized by the Government. The analysis assumed the same amount of subsidy at a unit production cost.

(2) FIRR

Financial internal rate of return (FIRR) is calculated. It is an approximate calculation that does not take into account the interest payment of loan scheme.

None of plans becomes determined under the current assumptions. This is because of large negative balance in net. An increase of sales revenues (+50 %) or subsidy (+100 %) will bring the positive FIRR, but their margins are still small. (See Table II-5.5.3.)

[10] Out of 54%, 20% is expected to be an inevitable loss of conveyance network.

Table II-5.5.3 Financial Internal Rate of Return and Its Sensitivity

	Plans				
FIRR	A	B	C	D	E
Base case*	nil.	nil.	nil.	nil.	nil.
Sales revenue 50% up	4.57%	1.88%	3.04%	2.66%	2.91%
Subsidy 100% up	5.65%	2.65%	4.23%	3.41%	4.12%
Required Subsidy (MJD/yr.)	8.9	1.9	13.4	1.9	22.3
Current Subsidy of WAJ**(MJD/yr.)			37.8		

Note*: Base case assumes the current position of water sales in terms of price and subsidy.

Note**: Current subsidy of WAJ is a two year avarage in 1992 and 1993.

The results imply that the desalination projects could require the substantial amount of government contribution or grant under the current price or sales revenue level. If we assume the level of subsidy that brings positive FIRR, the required amount of government subsidy will be JD 1.86 million to JD 22.32 million that is equivalent to 5 % to 59 % of current subsidy received in WAJ.

5.5.4 Balance Sheet Analysis of Priority Project (Plan D)

(1) Assumptions

The balance sheet analysis is undertaken in order to probe into the financial position of the priority project (Plan D).

Government Subsidy

- Current government subsidy level for water production (186 fils/m^3) is assumed.

Finance (See Table II-5.5.4)

- Foreign portion of project cost is to be financed by foreign long term loan.
- Local portion of project cost is to be financed by local long term loan.
- Operation and maintenance cost in the first year is to be financed by short term loan.

Plant Replacement

- Plant equipment and machines are assumed to be amortized within 15 years, and to be replaced in the 15th year.
- Plant building is assumed to be amortized within 25 years, and not to be replaced during the project period.

Table II-5.5.4 Financial Assumption for Balance Sheet Analysis

Project cost	Loan ('000JD)	Type	Term
Foreign portion	15,896	foreign, long	3%, 10 yr. grace, 25 yr. repayment
Local portion	5,611	local, long	3.5%, 4 yr. grace 20 yr. repayment
1st yr. O & M cost	1,461	local, short	5%, single yr.

(2) Results (See Table II-5.5.5 and Figure 5.5.1)

- Total income never exceeds total expenditure during the project period.

Although the current level of government subsidy is assumed, the total income does not cover the whole expenditure. Depreciation cost shares the substantial part of the total expenditure.

- Total liability stays at a high level throughout the project period. Additional loan will be required at the year of replacement.
- Operating cash stays at a low level, and will be substantially low when the replacement of plant equipment is needed. The cash level and liability level will never balance.
- By any means, the priority project of brackish groundwater desalination needs a large volume of financial contribution or grant from the government. Otherwise, the project will not be sustained.

(3) Contribution Element

Contribution element such as an intra-government contribution or inter-government grant to the project is assumed, and the change of financial position of the priority project is studied. (See Figure II-5.5.2.) The financial position has substantially improved as in the following manner:

- Government subsidy is reduced to half of the current subsidy level.
- Although the net income stays negative throughout the project period, the cash level will increase every year. The cash level and liability level will eventually balance in the 8th year.
- A sum of total liability and own fund stays at a low level, and diminishes in the 22nd year.
- Cash will be accumulated so that the replacement cost is covered by its own cash.
- As a result, the project will be sustained throughout the project period.

Table II-5.5.5 Balance Sheet Analysis ('000JD)

	YEAR	0	1	2	5	10	15	25
Production(MCM/year)		0	5	5	5	5	5	5
I. Income Statement								
Water Sales(note#1)		0	1,600	1,600	1,600	1,600	1,600	1,600
Government Subsidy		0	930	930	930	930	930	930
Total Income		0	2,530	2,530	2,530	2,530	2,530	2,530
O&M Cost(note#2)		0	1,087	1,087	1,087	1,087	1,087	1,087
Depreciation(note#3)	Plants	0	514	514	514	514	514	514
	Buildings	0	552	552	552	552	552	552
	Total Dep.	0	1,066	1,066	1,066	1,066	1,066	1,066
Loan Interest	L-Term:Foreign	0	477	477	477	465	346	107
	L-Term:Local	0	196	196	182	133	166	87
	S-Term	0	51	0	0	0	0	0
	Total Interests	0	724	673	659	598	512	194
Total Expenditures		0	2,877	2,826	2,812	2,751	2,665	2,347
Surplus/Deficit		0	-347	-296	-282	-221	-135	183

Table II-5.5.5 Continued ('000JD)

		YEAR	0	1	2	5	10	15	25
II. Balance Sheet									
	Invest.(Plants)	Book Value	7,717	7,717	7,717	7,717	7,717	7,717	7,717
		Accumulated Dep.	0	514	1,029	2,572	5,145	0	5,140
		Net Book Value	7,717	7,203	6,688	5,145	2,572	7,717	2,577
	Invest.(Buildings)	Book Value	13,790	13,790	13,790	13,790	13,790	13,790	13,790
		Accumulated Dep.	0	552	1,103	2,758	5,516	8,274	13,790
		Net Book Value	13,790	13,238	12,687	11,032	8,274	5,516	0
	Total Fixed Assets		21,507	20,441	19,375	16,177	10,846	13,233	2,577
	Cash		1,461	517	1,195	2,966	5,034	1,318	1,118
	Account Receivables.(note#4)		0	201	293	290	106	95	121
	Total Cur. Assets		1,461	719	1,488	3,256	5,140	1,413	1,239
	Total Assets		22,968	21,160	20,863	19,433	15,986	14,646	3,816
	Long-Term Foreign Loans(note#5)		15,896	15,896	15,896	15,896	15,101	11,127	3,179
	Long-Term Local Loans(note#8)		5,611	5,611	5,611	5,050	3,647	6,961	2,192
	Short-Term Loans(note#6)		1,461	0	0	0	0	0	0
	Total Liabilities		22,968	21,507	21,507	20,946	18,748	18,088	5,371
	Government Contribution(note#7)		0	0	0	0	0	0	0
	Accumulated Surplus/Deficit		0	-347	-644	-1,513	-2,762	-3,442	-3,519
	Net Own Funds		0	-347	-644	-1,513	-2,762	-3,442	-3,519
	Total Liabilities & Own Funds		22,968	21,160	20,863	19,433	15,986	14,646	1,852
III. Cash Flow			-22,968	719	770	784	845	-6,786	1,249

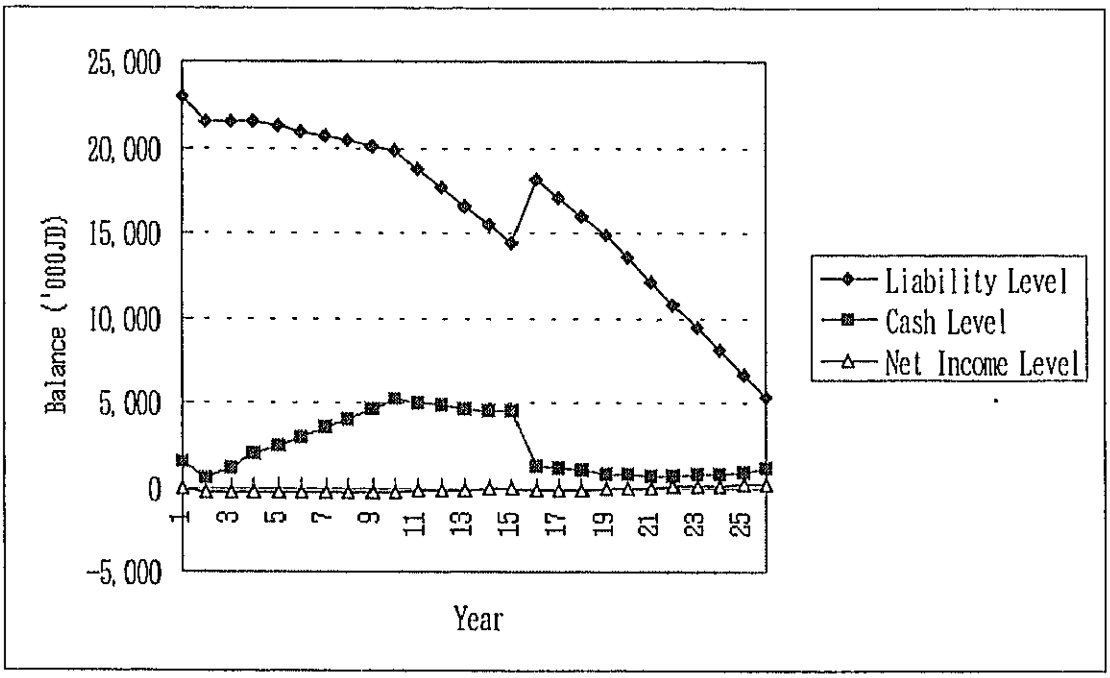


Figure II-5.5.1　Financial Position of Priority Project (Plan D)

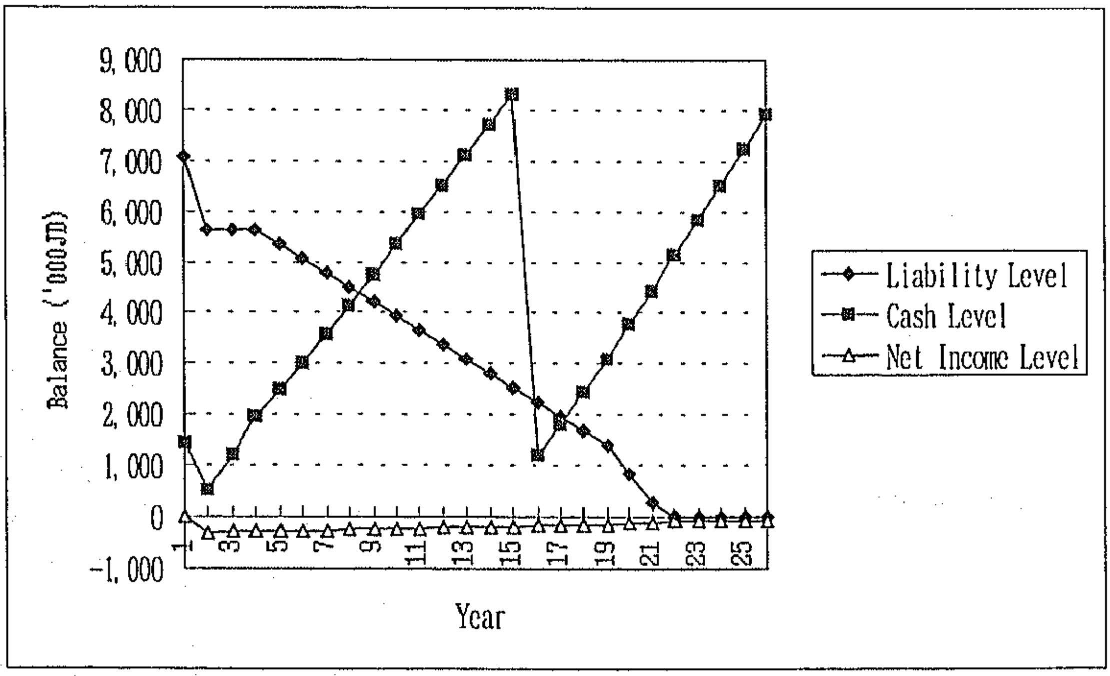
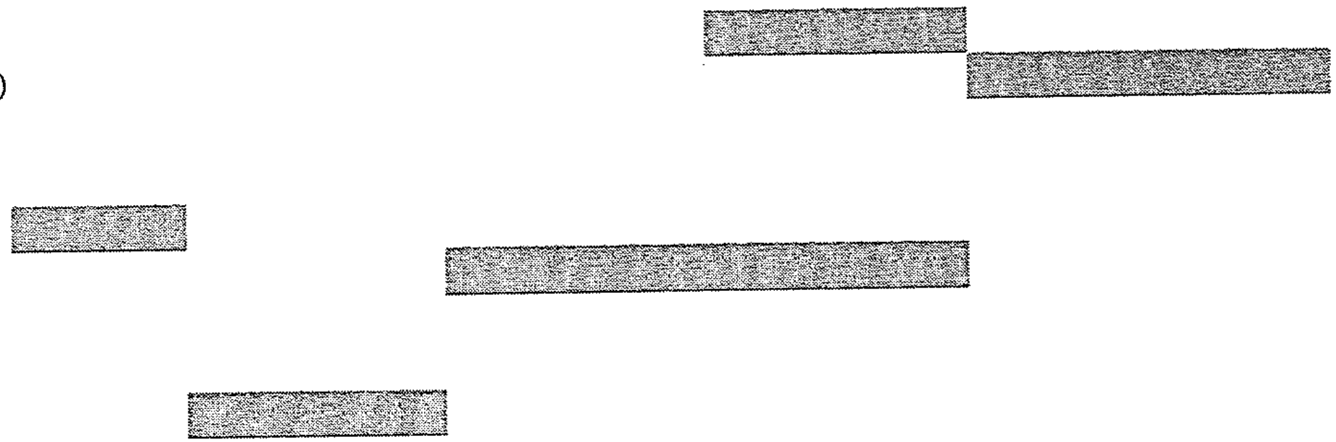


Figure II-5.5.2 Financial Position of Priority Project with Grant Element and Reduced Government Subsidy (-50%)

Table II-5.5.6 Development Strategy of Brackish Groundwater Desalination

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
(Deir Alla)															
Common Waste Water Line															
24 MCM/yr. Desalination (Plan A)															
(Kafrain)															
5 MCM/yr. Desali. (Plan D)															
31 MCM/yr. Desali. (Plan C)															
(Disi)															
75 MCM/yr. extraction															
Attained Water Supply (MCM)			5	5	5	80	80	80	80	80	80	111	111	111	111
Required Capital (MJD)	10.8	10.8	81.8	81.8	81.8	18.2	18.2	18.2	66.2	66.2	66.2	14.6	14.6	14.6	14.6
O&M Cost (MJD)	0	0	1.1	1.1	1.1	6.7	6.7	6.7	6.7	6.7	6.7	18.1	18.1	18.1	18.1
Water Production Cost (JD/m3)*			0.52	0.52	0.52	0.40	0.40	0.40	0.40	0.40	0.40	0.46	0.46	0.46	0.46



Note* : Current water production cost in WAJ is 0.307 JD/m3. If the grant element is introduced, water production cost of desalination as well as required capital will be reduced.

Source: JICA Study Team.