JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

WATER AUTHORITY OF JORDAN
MINISTRY OF WATER AND IRRIGATION
THE HASHEMITE KINGDOM OF JORDAN

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT IN THE HASHEMITE KINGDOM OF JORDAN

FINAL REPORT

SUMMARY

JULY 1996

TOKYO ENGINEERING CONSULTANTS

IN ASSOCIATION WITH

NIPPON KOEI

JAPAN INTERNATIONAL COOPERATION AGENCY

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Exchange Rate
US$1=Jordanian Dinar 0.71
US$1=Japanese Yen 106
(as of October 1995)

PREFACE

In response to the request from the Government of the Hashemite Kingdom of Jordan, the Government of Japan decided to conduct the Study on the Improvement of the Water Supply System for the Zarqa District and entrusted the study to the Japan International Cooperation Agency (JICA).

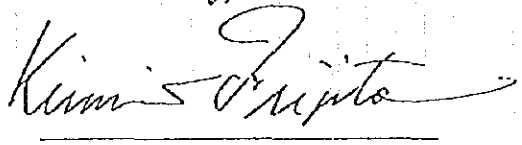
JICA sent to Jordan a study team headed by Mr. Kazufumi Momose of Tokyo Engineering Consultants Co., Ltd. associated with Nippon Koei Co., Ltd., several times between November 1995 to May 1996.

The team held discussions with the officials concerned of the Government of Jordan , and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Hashemite Kingdom of Jordan for their close cooperation extended to the team.

July, 1996



Kimio Fujita
President
Japan International Cooperation Agency

JULY, 1996

Mr. Kimio FUJITA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit herewith the Final Report entitled "The Study On The Improvement Of The Water Supply System For The Zarqa District In The Hashemite Kingdom Of Jordan".

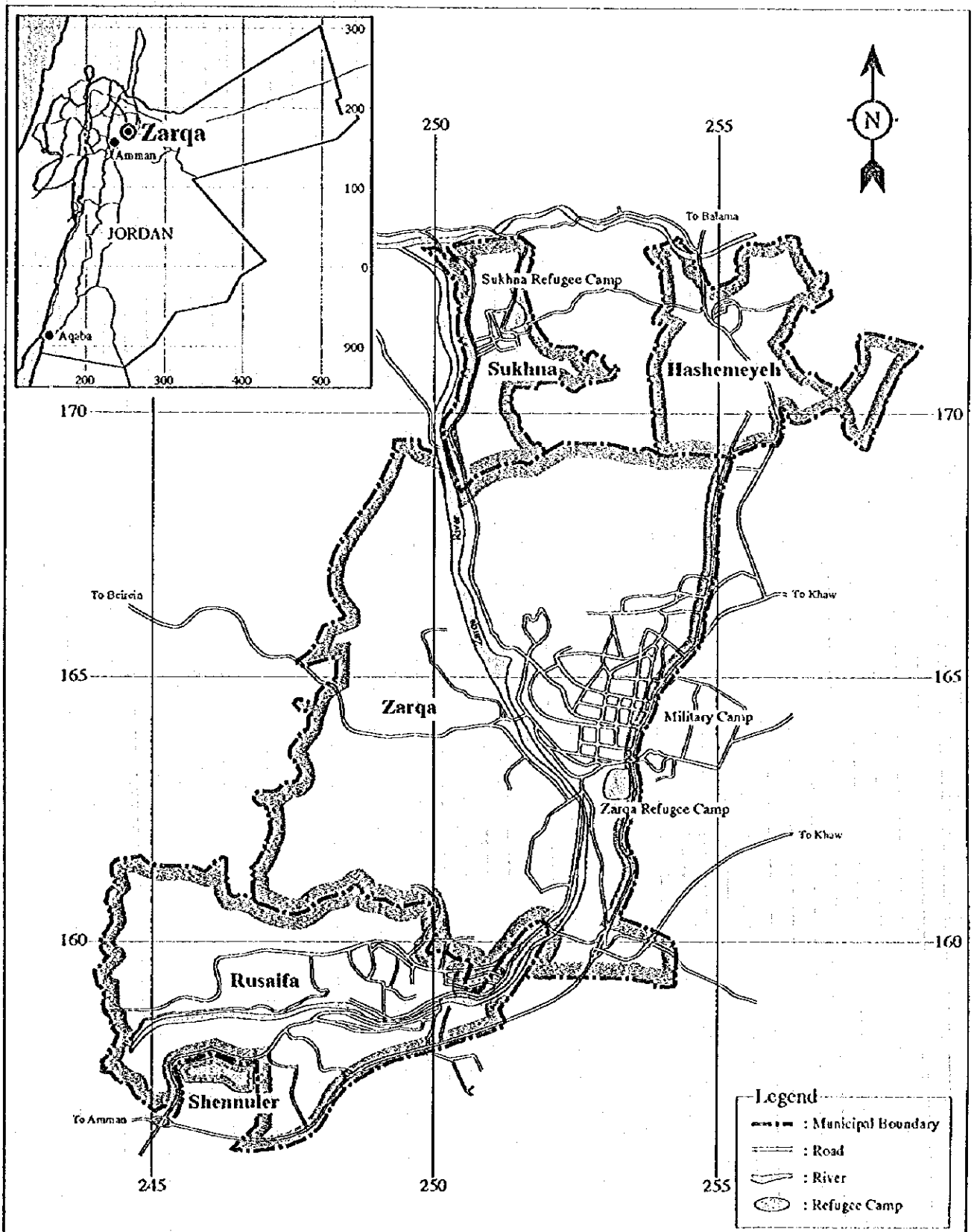
This report has been prepared by the Study Team in accordance with the contracts signed on October 1994, May 1995, October 1996 and May 1996 between the Japan International Cooperation Agency and the Joint Venture of Tokyo Engineering Consultants and Nippon Koei.

The report consists of the Summary in English and Japanese, the Main Report in English, the Supporting Report in English. The Summary summarizes the results of all studies and includes conclusions and recommendations. The Main Report contains the results of survey, analysis and explains about long-term development plan and short-term development plan.

All members of the Study Team wish to express grateful acknowledgment to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Health and Welfare, Embassy of Japan in Jordan and JICA Jordan office, and also to the officials of the Water Authority of Jordan for all assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the improvement of the water supply system for the Zarqa District.

Yours faithfully,

Kazufumi MOMOSE
Team Leader



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	LOCATION MAP OF STUDY AREA
JAPAN INTERNATIONAL COOPERATION AGENCY	

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

1. INTRODUCTION

Zarqa district, the Study Area, is situated 35km northeast of capital Amman and has been developed as an industrial city. In the Study Area water rationing has been practiced due to the limited availability of the water resources. It has been aggravated by high ratio of unaccounted-for water. The water resources shortages are prevailing not only in the Study Area but also in Jordan. The various majors are, therefore, being planned from the view point of the whole nation. Accordingly, the water resources issue is not dealt in this report. This report, instead, deals with the issues which are solved within the Study Area. They are;

- Reducing unaccounted-for water
- Rationalizing distribution system

2. PROJECTION OF POPULATION AND WATER DEMAND

The population of the Study Area is projected to increase to 739 thousands in 2005 and 938 thousands in 2015 with an annual growth rate of 2.4 to 3.2 %.

The average per capita consumption (on accounted-for water basis) in the Study Area is, at present, 52 lpcd, where water rationing is practiced. This would be, however, 70 lpcd if water is supplied continuously. For the future water consumption, another 20 lpcd is added in consideration of the future change in living standard, a way of life and likely decrease of household size. As a result, 90 lpcd is adopted as the target value for 2015.

To estimate demand, UFW within the system is added to consumption in the subscribers. The UFW ratio will decrease from 54% in 1994 to 30% in 2015, as meter reading and billing procedures (major reasons for UFW high ratio) as well as leakage control measures are strengthened and improved in the course of the project development. In estimating daily maximum water demand, a peak factor (Daily maximum/Daily average = 1.20), due to the seasonal and daily fluctuation is employed. As a result, the present demand of 97,000 m^3/day will increase to 145,000 m^3/day in 2015.

Water Demand

Year	1994	2000	2005	2010	2015
Population Served	534,700	644,800	739,200	832,300	938,500
Average per capita consumption (liter)	70	75	80	85	90
UFW ratio (%)	54	48	42	36	30
Maximum Daily Demand (m^3/day)	97,000	112,000	122,000	133,000	145,000

3. WATER BALANCE

Water sources available within the study area are allocated, taking into consideration of the water balance in whole country and will be allocated as well. Considering a) the water resources development projects such as the "dividend" of the Peace Treaty and the Disi Aquifer and b) water demand in the country, the following water resources will be allocated to the Study Area;

- Existing resources such as Azraq wells
- Converted resources which are now used for Amman

Considering the progress of the water resources development projects, the above resources will be used until 2005. However, after 2005, additional water resources need to be added to meet the water demand in the Study Area. The additional water resources will be located to the west of the Study Area while both the existing and the converted sources are located to the east of the Study Area. Accordingly, the transmission pipelines will change in direction in the year 2005.

4. WATER SUPPLY IMPROVEMENT PLAN

For formulating the long term development plan, the following development concept is applied in due consideration of the present problems;

1) More Efficient Use of Available Water
2) Improvement of Water Supply System
3) Re-use of Wells with Low Water Quality
4) System Expansion for Future

The facilities with the above concept is planned for the target year of 2015 with two staged implementation plan. For the first stage plan with a target year of 2005, feasibility study was conducted. The facilities are shown in Table and Figure. The project cost is 63 million US dollars for the first stage plan and is 22 million US dollars for second one.

5. ORGANIZATION AND OPERATION & MAINTENANCE

For the successful implementation of the Stage I Project, a Project Implementing Office (PIO), headed by a Project Manager (PM), is to be organized in WAJ Zarqa. The Project contains civil works for rehabilitation and expansion, which are considered slightly different in nature. It is therefore recommended that two teams, Rehabilitation team and Expansion team are organized under PM.

Rehabilitation of the deteriorated distribution and service mains are proposed to reduce UFW. More important measures to reduce UFW are strengthening of the leakage control organization to have active leakage control measures instead of the passive ones. Also, measures to reduce metering errors which is one of the major portion of the UFW, should be taken.

6. PROJECT EVALUATION

The estimated EIRR is 8.8%, which indicates that the project is economically justifiable. However, FIRR is negative due to low revenue associate with low tariff. To gain 5 % FIRR, the tariff needs to be doubled. In this case, ratio of the tariff against the household revenue will reach to approximately 1 % from the current 0.4 %. The 1 % is within the so-called tolerable ratio of 4 % and the tariff increase is within the allowable range.

Annual required fund for the project varies from US$ 2.0 million to US$ 15.8 million during the implementation period of 1998 - 2004.

WAJ has spent about JD 48.4 million or US$ 69.1 million annually on an average during the past 5 years. Compared with this figure, the estimated annual fund requirement for the project corresponds to 2.9 - 22.9% of the annual WAJ investment. The annual fund requirements is less than 20 % of WAJ investment except that of 2001 and is considered within the reasonable investment level of WAJ.

Further, substantial socio-economic impacts are expected from the implementation of the project. The improvement of the basic human needs through the alleviation of water shortage and rationing is considered a great benefit to the Study Area as well as the resulting regional development. Taking into account all the above the project is justified economically and socially and its early implementation is to be recommended.

7. ENVIRONMENTAL IMPACT ASSESSMENT

The following issues are concerned with the project implementation; 1. Resettlement, 2. Economic Activity (Impacts on existing tenant or lower income people), 3. Traffic and Public Facilities, 4. Archaeological Treasures and 5. Water Pollution

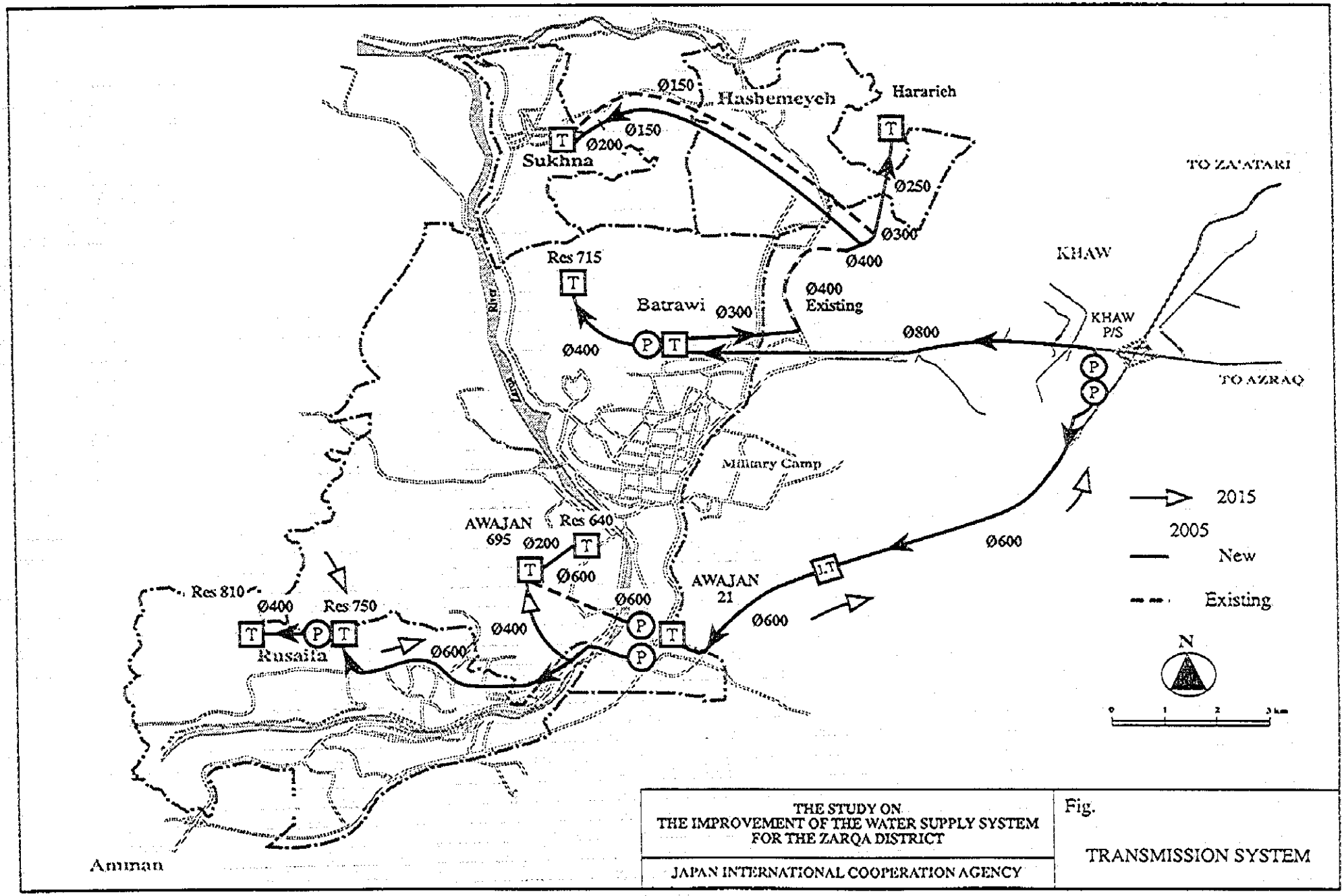
However, the impacts are minimized with the following measures;

1. The facilities are planned to avoid resettlement.
2. Lower income people does not reside the hilly areas which will be the major beneficially areas with the project implementation.
3. Sewerage facilities will be served by 2000.

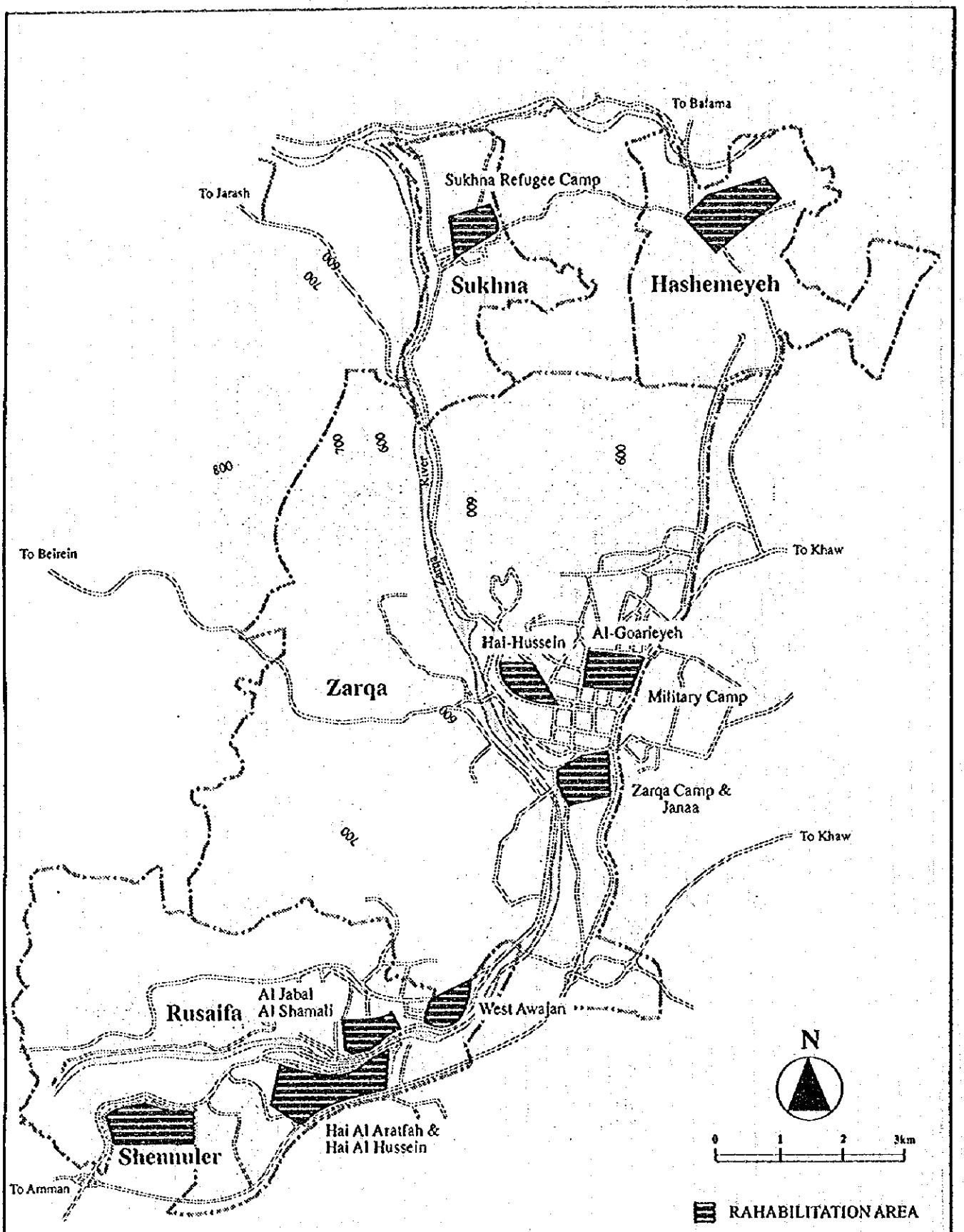
Table FACILITIES FOR THE STUDY

Target	Facility	Size
1) Reduction of UFW		
	Replacement of Distribution Pipe	150 mm X 17.4 km 100 mm X 75.0 km 50 mm X 13.1 km
	Replacement of Service Pipe and Meter	12,700 meters 20 mm X 140 km
	Creation of District Metering Area	25
2) Zoning System		
- Transmission Pipe	Khaw PS - Batrawi Res	800 mm X 7.9 km
	Batrawi Res - Res 715	400 mm X 2.2 km
	Batrawi Res - Hashemeyeh offtake	400 mm X 0.1 km 300 mm X 2.3 km
	Hashemeyeh offtake - Hararieh Res	250 mm X 1.9 km
	Hashemeyeh offtake - Sukhna Res	200 mm X 1.0 km 150 mm X 6.8 km
	Khaw PS - Awajan PS	600 mm X 12.2 km
	Awajan PS - Awajan 695 Res	600 mm X 0.3 km & Existing 600 mm
	Awajan PS - Awajan 635 Res	200 mm X 0.8 km
	Awajan PS - Rusaifa 750 Res	600 mm X 6.6 km
	Rusaifa 750 Res - Rusaifa 815 Res	400 mm X 1.8 km
- Pumping Station	Khaw Pump for Batrawi, Hararieh and Sukhna	9.7 m^3/min. X 77 m X 310 kW X 6
	Khaw Pump for Awajan PS	4.1 m^3/min. X 79 m X 110 kW X 5
	Batrawi Pump for Res 715	2.7 m^3/min. X 87 m X 75 kW X 4
	Awajan Pump for Awajan 695 Res	5.4 m^3/min. X 121 m X 220 kW X 5
	Awajan Pump for Rusaifa 750 Res	4.4 m^3/min. X 193 m X 290 kW X 6
	Rusaifa Pump for Rusaifa 815 Res	3.2 m^3/min. X 75 m X 75 kW X 4
- Reservoir	Batrawi 650 - Expansion	12,500 cubic meters
	Res 715 - New	4,000
	Hararieh Res - New	2,000
	Sukhna Res - New	1,000
	Awajan 695 Res - Expansion	5,500
	Awajan 635 Res - New	2,000
	Rusaifa 750 Res - New	10,000
	Rusaifa 815 Res - New	5,000
- Distribution Pipe	Rusaifa 815 - Schneler	4,600
	Rusaifa 750 - Rusaifa	1,700
	Being revised	
3) Utilization of Existing Wells		
- Collector Pipe	Zarqa well - Khaw PS	Existing (400 mm)
	Hashemeyeh - Khaw PS	250 mm X 5.7 km
	Awajan 23 well - Awajan PS	Existing
	Rusaifa valley wells - Awajan PS	500 mm X 2.9 km
- Pump	Zarqa well - Khaw PS	3.0 m^3/min. X 150 m X 150 kW X 1
	Hashemeyeh - Khaw PS	3.0 m^3/min. X 150 m X 150 kW X 1
	Rusaifa valley wells - Awajan PS	Existing
- Collector Tank	Awajan PS - New	5,000 m3
	Khaw PS	Existing (12,000m3)

PS: Pumping Station Res: Reservoir



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.
JAPAN INTERNATIONAL COOPERATION AGENCY	TRANSMISSION SYSTEM



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.-
JAPAN INTERNATIONAL COOPERATION AGENCY	REHABILITATION AREA

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SUMMARY

PART 1 LONG-TERM DEVELOPMENT PLAN

1 INTRODUCTION

This Report prepared by the JICA Study Team, compiles results of surveys and analyses carried out from November 1994 to March 1996. It contains 1) a long-term development plan of the water supply system in Zarqa District with a time horizon of 2015 and 2) a feasibility study of the Stage I project identified in the long-term development plan.

2. STUDY AREA

2.1 Natural Conditions

Zarqa district, the Study Area, is located 35km northeast of the national capital Amman. Development has occurred mostly along the Zarqa river and because of the flat area is small, it has also expanded towards the hilly areas on both sides of the river. Elevations range from 525 m to over 800 m.

There are many urban areas in the Study Area, namely the municipalities of Zarqa, Rusaifa, Hashemeyeh, Sukhna and the Shennuler refugee camp. The Study Area covers 90.5 km^2.

The areas and population of the Zarqa Governorate in the Study Area for 1979 and 1994 are presented in the following table.

Table S1 AREA AND POPULATION

Study Area	Area (km2)	1979	1994	Average Growth Rate (%)
Zarqa Municipality *1	58.9	219,344	344,524	3.06
Sukhna Municipality	5.6	4,390	9,764	5.47
Hashemeyeh Municipality	6.2	4,148	13,038	7.93
Rusaifa Municipality	18.9	49,885	131,130	6.65
Schnneler Camp	0.9	23,261	36,218	3.00
Study Area Total	90.5	301,028	534,674	3.90

Source: Department of Statistics
*1 Includes new Zarqa and Awajan
*2 High increase rate during 1979 - 1994 is due to the influx of Jordanians returning from the Gulf countries.

Water resources and their limited availability are a major concern not only in the Study Area but also in Jordan. The area is characterized by a dry arid climate. Rainfall is concentrated in the winter months, with the summer months generally receiving no rainfall. In addition, wide fluctuations in annual rainfall make water planning efforts very difficult. Intermittent streams, known as wadis, are common in the Study Area and constitute the major portion of surface water systems. These streams dry up during the summer months so that surface water is unavailable to the area. The primary water source for the Study Area is groundwater abstracted from the "Amman-Zarqa" and the "Azraq" basins which are the major groundwater production basins in Jordan.

2.2 Socio-Economic Conditions

2.2.1 National Economy

The gross domestic product (GDP) of Jordan was JD 3,882 million in 1993 at current price and the per-capita income is estimated at about JD 970 (US$1,385). The share of manufacturing sector is relatively small at 17 %. The share of the secondary industry including the manufacturing and construction sectors accounts for less than 30 %, while that of the services sectors accounts for 56 %.

In 1993, the Jordan government had a revenue of JD 1,368 million. The expenses were JD 1,341 million and the resulting budget surplus was JD 27 million. About JD 574 million was allocated in 1993, for capital expenditures which is equivalent to 14.8 % of GDP.

During the period of 1988 - 1991 consumer prices increased at a high rate of 16.4 % p.a. on an average. From 1991 to 1993, consumer prices leveled off at (4.4 % p.a. during 1991 - 1993) and this trend continues today. The currency exchange rate has been relatively stable at around US$ = JD 0.7 during the past 5 years.

A National Economic Development Plan was prepared for the target year of 1993 - 1997. The target set in the 5-year plan are as follows:

(1) The GDP (1991 constant price) will increase from JD 3,452 million in 1992 to JD 4,147 million in 1997 at an average growth rate of 6 % p.a.
(2) The population will increase at 3.2 % and the per-capita GDP (1991 constant price) will increase at an average growth rate of 2.7 %.
(3) The inflation rate will be controlled at 4 - 5 % p.a. to correct structural imbalance and to achieve fiscal and monetary stability.
(4) The unemployment rate will decrease to 9.6 % in 1997 (from the current

18 %).

2.2.2 Regional Economy

Rapid population growth is attributed to an influx of refugees from Palestine (particularly after 1948 and 1967) and migration from rural areas (since the military base was established). A more recent increase in population was caused by the influx of Jordanian returnees from neighboring Arabic Countries after the Gulf War (1990 - 1991).

The South part of Zarqa has been developed as an industrial city and attracted factory laborers from rural areas. In Rusaifa and Zarqa municipalities, about 45 major factories are operating, which include mining, dairy products, paper, iron and steel product, ceramic, breweries and distilleries. In Hashmeyeh two key industrial plants in the nation are operating, namely, a petroleum refinery plant and a thermal power plant.

There are no available statistics regarding regional production in Zarqa Governorate. But the Regional Gross Domestic Product (RGDP) is roughly estimated at around JD 590 million in 1993 based on population statistics.

The average number of members per family household is 7.1 in Zarqa. Based on the population of 534,674, about 75,300 households live in the Study Area.

Though detailed information on the economic activity of households in Zarqa or the Study area is not available, about 25 % of the residents are thought to be employed in the industrial and construction sectors, while about 70 % in the service sectors. The agricultural sector employs a very small percentage of the residents.

The average household income in 1992 was JD 4,003 per year in Zarqa Governorate, which is relatively lower than the Jordanian average (JD 4,607). Based on the average family size of 7.1 persons per household, the annual per-capita income is estimated at JD 559 in Zarqa.

About 50 % of the households earn an annual income ranging from JD 1,200 - 3,600 Figures for Zarqa and Jordan are the same. The percentage of households with incomes less than JD 1,200 is only 6 - 7 %, while those with incomes higher than JD 7,200 is 9 - 12 %.

Total household expenditures are estimated at JD 4,197 per year on an average in Zarqa Governorate. Out of the total, about 38 % of expenditures are allocated for food and beverages, 23 % for housing and 11 % for transportation. The amount allocated for fuel, electricity and water is only JD 200 (JD 16.7/month/h) or 5 % of the total expenditure.

2.3 Public Health And Hygiene

The study area is relatively well services by public hygiene infrastructure. About 99 % of the households are connected to the WAJ water supply system. About 58 % of the residents are serviced by the public sewerage system and the remaining 42% still use cess pools. The volume of sewage exceeds by a factor of two the capacity of the treatment plant installed at As Samara. This results in the discharge of partially treated wastewater into rivers which deteriorates the living environment in Zarqa.

Solid wastes from factories and households in the Study Area are collected by trucks and dumped at a designated disposal site for land reclamation located in Rusaifa, a few hundred meters east from the Zarqa - Amman Highway.

Liquid wastes are disposed on the land near the boundary of Rusaifa and Amman. The liquid waste is collected by tanker trucks with the capacity of $10m^3$ and dumped into a waste water pond for evaporation. Contaminated water from the pond may be flushed out into the tributary of the Zarqa river during winter season.

2.4 Urban Development And Land Use

The characteristics of land use in the Study Area are as follows:

(1) The steepest land located to the west of the Study Area is vacant. It dominates land use and represents 39% (35.3 ha) of the total land area.

(2) The residential area extends towards the north and southwest directions from Zarqa city. It is the second largest land use and has the second highest share of 32%.

(3) The mixed area, which is defined as high density residential mixed with commercial represents 12% of the total land area. This area is located mainly in Zarqa and Rusaifa along the highway.

(4) The industrial area is relatively large and represents 8% of the total land area. This area is located to the southeast of Zarqa, west of Rusaifa and south of Hashemeyeh.

(5) The agricultural area is relatively small and represents 4% of the total land area. It extends along the Zarqa river.

(6) The remaining area is divided by public and open space (bus stop, park, etc.) land uses and refugee camps which account for about 5% in total.

The composition of land use in the Study Area is presented in the following table.

Table S2 LAND USE

Major Land Use	Land Area	
Residential	29.0 km²	32.0 %
Mixed	11.2 km²	12.4 %
Industrial	7.2 km²	8.0 %
Agricultural	3.7 km²	4.1 %
Public	1.9 km²	2.1 %
Open Space	1.4 km²	1.5 %
Refugee Camp	0.8 km²	0.9 %
Vacant Land	35.3 km²	39.0%
Total	90.5 km²	100.0 %

3. PRESENT WATER USE

3.1 *Service Area And Population Served*

The service area is the same as the Study Area. Around 63,900 subscribers or 532,000 population are served in the Study Area. The service ratio in the Study Area was 99% in 1994.

3.2 Water Service Level

Water supply is not continuous and a rationing program is often implemented due to shortages. More than half of the households suffer from water shortages. Frequent rationing is practiced particularly in summer seasons in most of Rusaifa and in the northern fringe of Zarqa. This situation is aggravated by the rapid rise in the area's population. Many new properties are being built at in areas with elevations higher than existing service reservoirs. Consequently, many booster pumps are installed and these are prone to failure. Most households have water storage facilities (roof tanks and/or underground storage) to cope with the water rationing or intermittent supply.

3.3 Water Consumption

During the six year period from 1989 to 1994 the per capita water demand (water supplied) gradually increased from 97 to 126 lpcd (liters per capita per day). However, the per capita consumption based on "accounted-for water" stood at an almost constant value of 50 - 55 lpcd.

Table S3 PER CAPITA WATER CONSUMPTION IN DAILY AVERAGE BASE (ZARQA GOVERNORATE)

Year	Demand (lpcd)	Consumption (accounted for) (lpcd)	UFW* (lpcd)	UFW Ratio (%)
1989	97	50	47	49
1990	108	53	55	51
1991	117	56	61	52
1992	112	50	62	55
1993	119	55	64	54
1994	126	-	-	-

Source: WAJ Zarqa *UFW Un-Accounted For Water

This implies that the UFW ratio increased over the same period. In order to identify causes of this high ratio of UFW, a survey was conducted applying the Combined District and Waste Metering Method (CDWM) and the Meter Replacement Method (MRM). The results suggest that UFW is 15 - 30 % leakage mostly from smaller distribution and service mains and 20 - 30 % administrative losses related metering inaccuracies, meter tampering by subscriber and WAJ billing errors.

The above per capita consumption is suppressed because the supply could not meet the true demand. A household survey was conducted to determine the unsuppressed consumption. According to the survey for Zarqa where sufficient supply is available, the per capita consumption averaged 72 lpcd in the summer. During the winter season, per capita consumption drops to 57 lpcd. These two figures are considered to be the actual unsuppressed per capita consumption.

According to the 1994 water consumption data provided by WAJ, domestic water use is predominant, representing 98.3 % of the total consumption. According to the factory survey, water supplied by WAJ is used only for drinking purposes. Factories usually have their own wells for in-plant process water.

3.4 Quality Of Water Supplied

Except for salinity and total hardness results from laboratory testing conducted under the current study indicate that all sampled house tap water was within the 'maximum allowable level' set by the Jordanian Standard No. 285 for Drinking Water. High concentrations of salinity above the 'permissible level' of 1,500mg/l were observed in 80% of the samples. High values of total hardness were also recorded with ranging from 200mg/l in the Zarqa/

Hashemeyeh areas to 400mg/l in Rusaifa/Schenuller. The permissible level for hardness is 100mg/l. Residual chlorine levels were adequate in all house tap and roof tank samples.

4. EXISTING WATER SUPPLY SYSTEM

4.1 History

The water supply system in Zarqa District dates back to 1934 when the municipal council of Zarqa, then the responsible agency for water affairs, laid water pipelines to supply groundwater to the residents. In 1964, a first full-fledged expansion project was launched to meet increasing water demand due to the rapid growth of the industry and population in the area. Under this project, main existing facilities such as Zarqa wells No. 14, 14a, and 16, Zarqa booster pumping station, Batrawi tank and 16" mains were constructed and started operation in 1967.

However design capacities were not enough to keep pace with the remarkably high growth rate of the population. Expansion of the water supply system was inevitably carried out shortly thereafter, aiming at obtaining additional water sources from the Azraq wellfield and wellfields in Mafraq Governorate. Water transmission mains connecting Za'atari, Khaldieh and Hallabat wellfields to Khaw pumping station were completed in 1975 and those connecting Azraq well field to Khaw pumping station were completed in 1984. These facilities were constructed to mainly to meet the demands of Zarqa municipality and Amman. Rusaifa municipality, at the time when WAJ was established, was responsible for it's own water supply system. As a result Rusaifa did not have the resources to provide proper planning and the distribution system and was constructed in a piecemeal and ad-hoc manner.

4.2 Water Source and Transmission System

Zarqa district is divided into two separate water supply areas: Hashemeyeh and Sukhna to the north, and Zarqa and Rusaifa to the south. These are interconnected by the Khaw-Zarqa trunk main:

Water for the Hashemeyeh and Sukhna areas is taken from the Khaw-Zarqa trunk main and then boosted into the distribution system at Hashemeyeh booster station. Thereafter, there are separate feeds to the areas of Hashemeyeh and Sukhna. Both these areas have reservoirs which float on the system, namely Harairieh and Sukhna reservoirs.

Water from Khaw is boosted to a tank at the Zarqa pumping station. In addition, water from wells in Hashemeyeh is sent to the Zarqa pumping station where it is boosted into the Zarqa and Rusaifa distribution areas.

The remaining water for these areas comes from the following wells: Awajan 21, 22 and 23, Rusaifa 18, Rusaifa phosphate well, Al Basatin 1 and 1A, Hutteen 1 and 2 and the Murhib wells. Murhib water is boosted to the Awajan reservoir which floats on the system. Rusaifa well 18 boosts into an adjacent tank from where it is boosted into distribution. The remaining wells pump directly into distribution. There are additional booster pumps at Al Basatin and Rusaifa site 4. Water from Rusaifa well 4 is pumped to Amman and does not feed the area. In addition to the Awajan reservoir, there is a reservoir at Batrawi which in theory floats on the system but in practice is often dry.

Fig.- S1 shows the location of the wellfields, transmission lines and main distribution facilities scattered throughout Zarqa and Mafraq governorates. Fig.- S2 portrays the locations of main facilities such as pumping stations, tanks and reservoirs in Zarqa district. Further information on system alignment and water transmission is presented in Fig.- S3 which portrays a system flow chart of the existing water supply system.

During the period from 1990 and 1993, WAJ Zarqa executed a large scale rehabilitation and improvement works on the deteriorated pipe networks including installation of distribution mains, service mains and house connections. This intensive work covered most of Zarqa District, excluding Goariah and Hai Hussein, in the northern built-up area of Zarqa municipality. Investment costs, borne by the central government, exceeded 13 million JD. Despite these efforts, the distribution network, particularly in Ruseifa, is still weak.

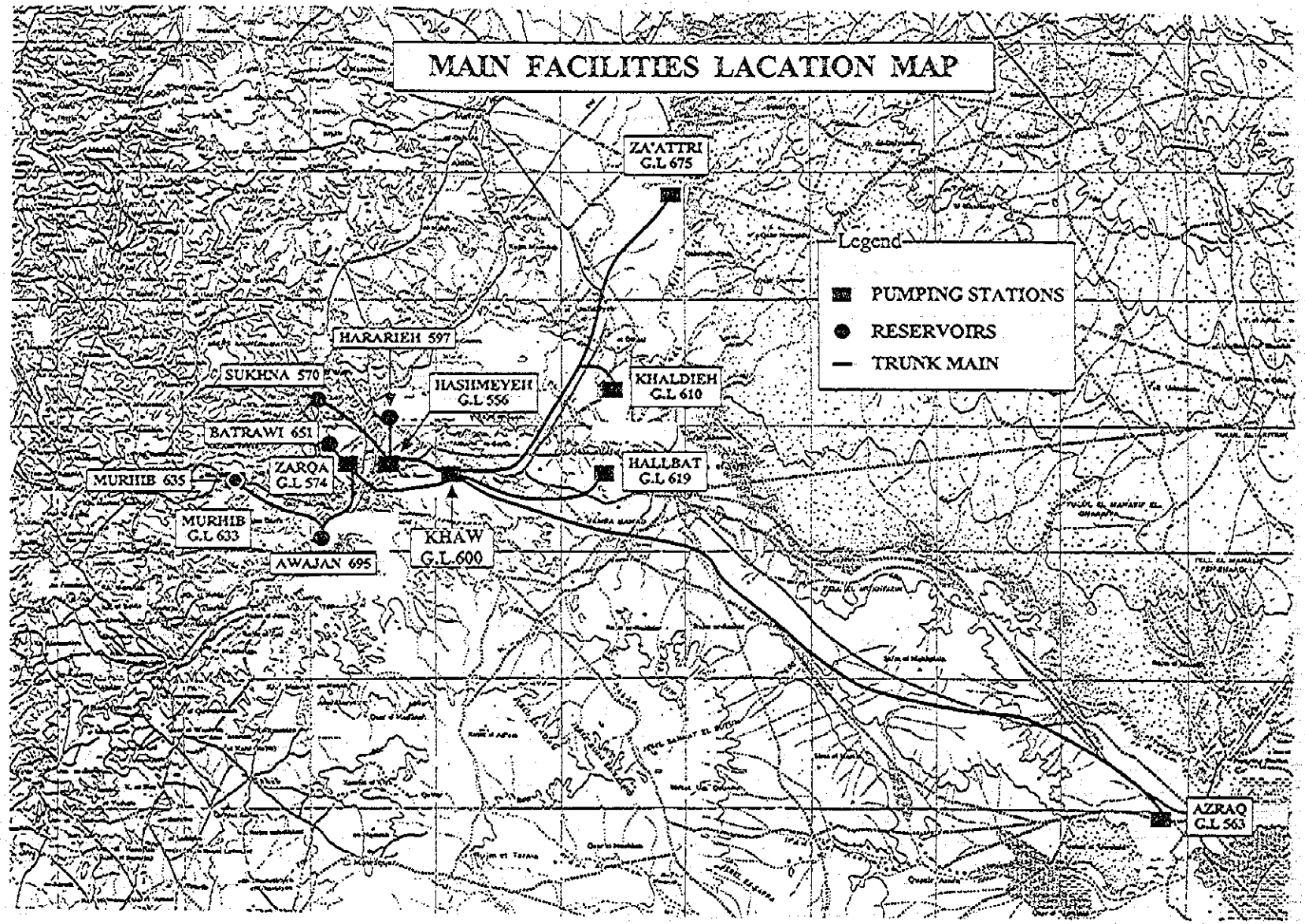
4.3 Distribution System

In 1994, total installed pipe length reached 327 km, excluding small diameter pipes 50mm or less, and all pipes in Sukhna and Hashemeyeh. This is equivalent to 0.6 metres per capita serviced and 21 litres of pipe storage volume per capita served. Both parameters clearly suggest insufficiency of the pipe network in terms of size and length (Similar size cities in Japan recorded 3.0 meters per capita and 103 litres per capita). Distribution pipelines installed to date have the following general characteristic:

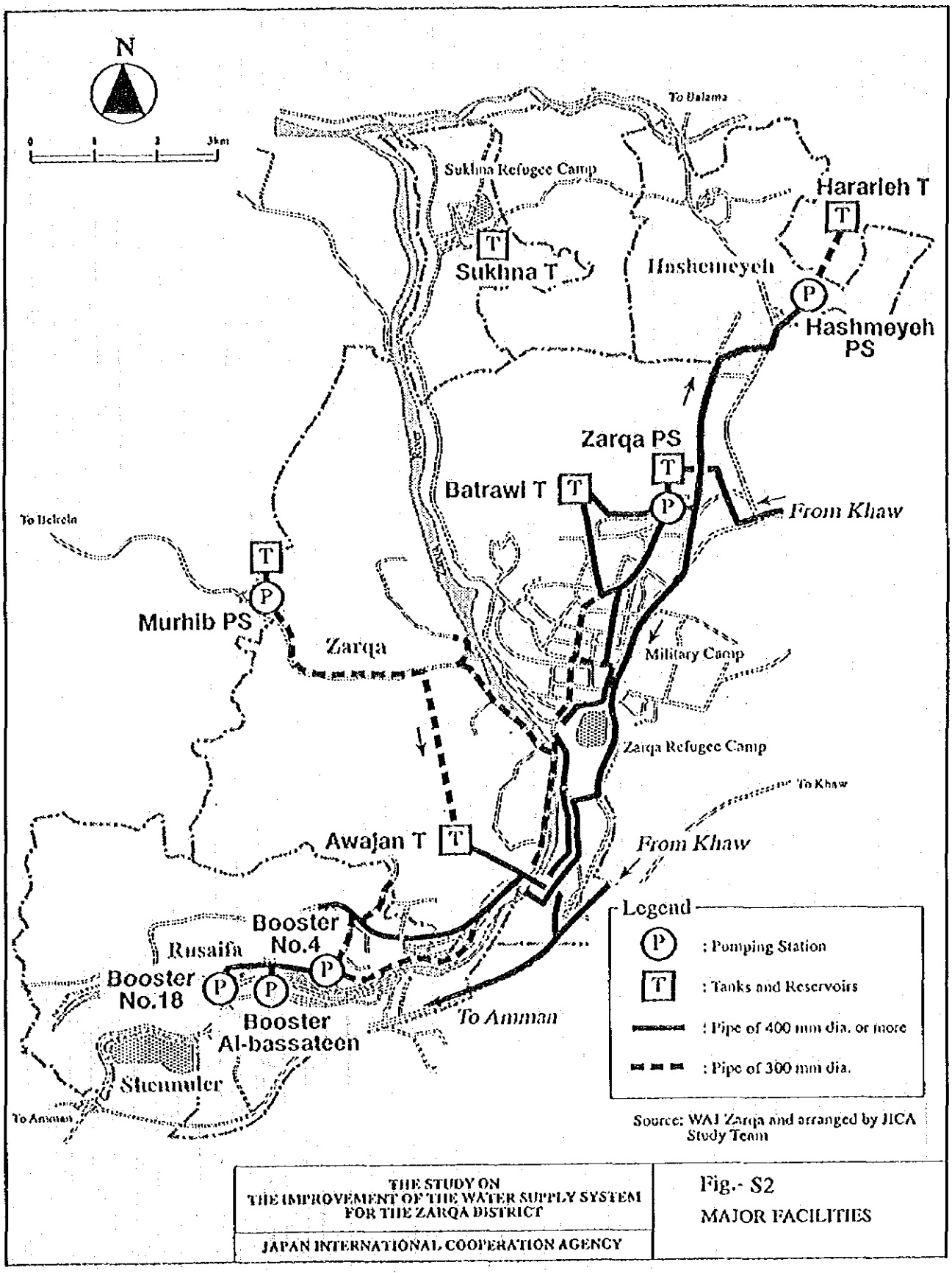
-Construction of the water supply system in the area has not kept pace with the rapid municipal development since 1960s mainly because of financial constraints. As a provisional measure, the water authority has installed relatively small diameter distribution mains.

-Topographic constraints have required rather high pumping heads. A misaligned and undersized distribution network has resulted in: 1) inefficient energy consumption, 2) high pressures in areas of lower elevation and 3) a large amount of leakage in the distribution pipe network.

The total storage capacity of the storage tanks which are operational 51,100 m^3, equivalent to 20 hours of water consumption in Zarqa District. Consumption meters are installed at all subscriber connections. Most of the meters are located in the customers' yards but sometimes can be found inside their houses which makes monitoring and maintenance by WAJ staff, difficult.

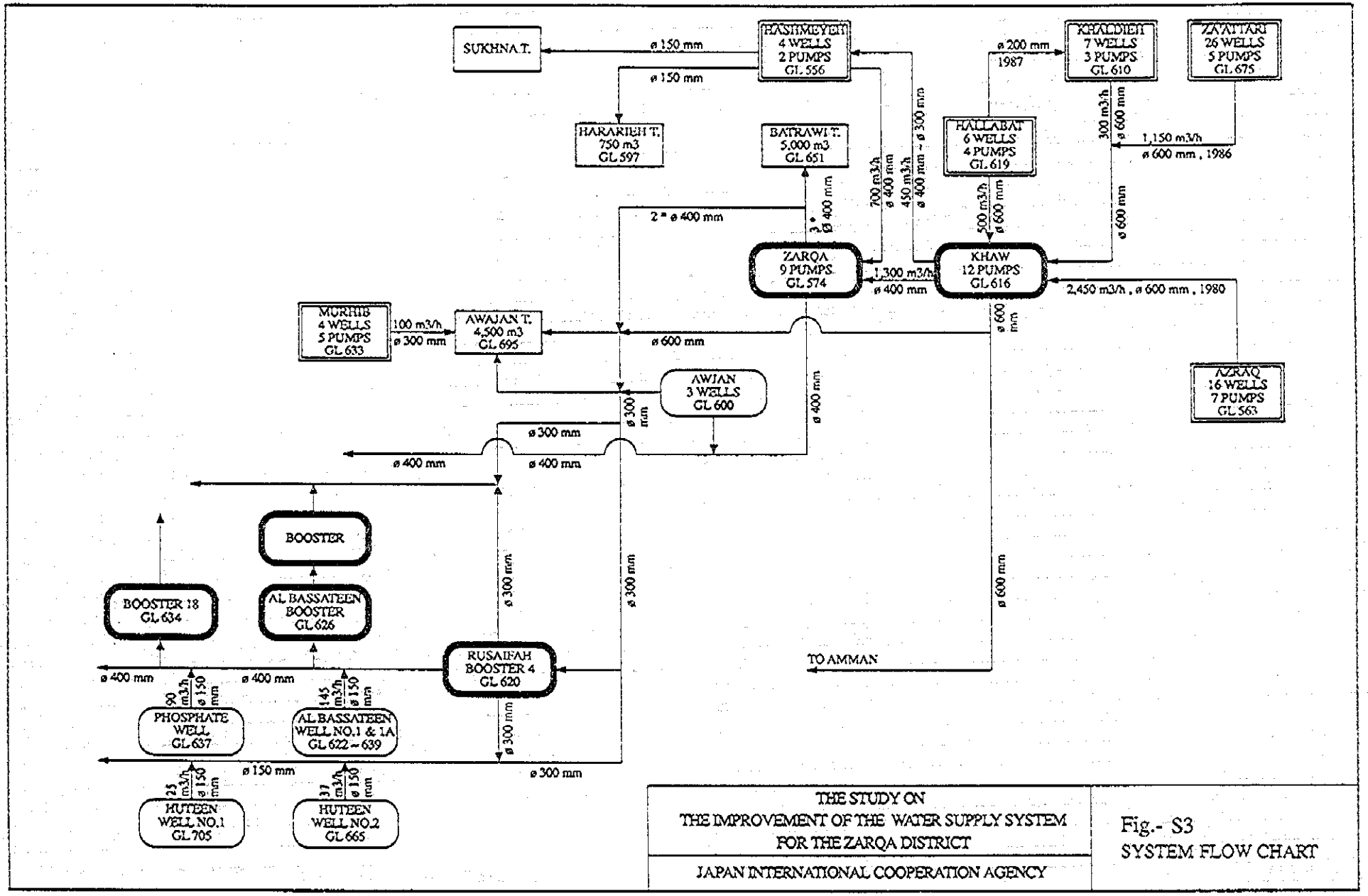


THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- S1 MAJOR FACILITIES IN ZARQA GOVER.
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: WAJ Zarqa and arranged by JICA Study Team

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- S2 MAJOR FACILITIES
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON
THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM
FOR THE ZARQA DISTRICT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.- S3
SYSTEM FLOW CHART

5. ORGANIZATION, OPERATION AND MAINTENANCE

5.1 Organization

WAJ Zarqa Governorate was established in 1985 as one of the governorate offices of WAJ and all the water administration was transferred from Zarqa Municipality. The total number of employees at WAJ Zarqa is about 607 or about 9 % of the WAJ total. There are five departments under WAJ Zarqa Governorate. The number of staff allocated to each department is as follows:

- Planning, studies & information department : 10
- Operation & maintenance department : 347
- Subscribers department : 87
- Administrative & finance department : 41
- Rusaifa water department : 122
- Total : 607

The number of the customers served by WAJ Zarqa is 73,830 households. The number of staff per 1,000 customers is 8.4 in WAJ Zarqa and 12.7 in WAJ. It can be concluded that the staff to customer ratio is relatively efficient in WAJ Zarqa.

5.2 Operation And Maintenance

5.2.1 Operational Organization and Staffing

In WAJ Zarqa, the "Operation and Maintenance Department, Zarqa" and the "Operation and Maintenance Section of Rusaifa Water Department", are in charge of operation and maintenance of the water supply system including wellfields, pumping stations, transmission and distribution pipe network. To assist them in achieving optimal and effective operation, the "Planning, Studies & Information Department" conducts laboratory and field testing for quality control and water resource monitoring.

5.2.2 System Operation and Maintenance

(1) Wellfields and Pumping Stations

Pumping stations are operated by the "Operation and Maintenance Department Zarqa" and "Rusaifa Water Department". The former operates 6 pumping stations in Azraq, Hallabat,

Khaw, Zarqa, Hashemeyeh and Murhib and the latter operates 4 pumping stations located in Rusaifa Municipality.

Khaw pumping station which collects groundwater from the Azraq, Hallabat, Za'atari and Khaldieh wellfields is operated in accordance with the agreement between WAJ Amman and Zarqa. This agreement which defines water allocation to each service area is usually updated yearly. According to the 1994 Agreement, a maximum of 1,700 m^3/h can be delivered to Zarqa District (Zarqa and Rusaifa municipalities), while Amman municipality and the Army camp in Zarqa receive up to a maximum of 2,200 m^3/h and 100 m^3/h, respectively.

There is also an allocation agreement between Zarqa and Rusaifa (1994). During the summer season when water demand increases and well yields are limited, water is allocated as follows: during almost five days of the week starting from 4:00 am Wednesday up to 21:00 pm Sunday, around 400 to 500 m^3/h of water is delivered to Rusaifa. In the remaining two days of the week, 1,000 m3/h from Zarqa is boosted to supply the northern hilly areas of Rusaifa.

(2) Water Treatment and Reservoir/Tank

WAJ does not practice periodical maintenance for cleaning, leak detection and repair. Operational staff and/or watchmen keep records on hourly fluctuation of water levels at most of the reservoirs/tanks except for the balancing tanks that float on the pipe network.

Except for chlorination water does not receive any treatment. Chlorine dosing is usually carried out at the reservoirs and tanks of major pumping stations.

(3) Transmission and Distribution Mains

Maintenance crews organized under the departments carry out passive leak repair. WAJ engineers explained that broken mains and leaks are usually repaired on the same day they are located depending on site conditions and nature of the leak.

(4) Other Facilities

(Customer Meters)
In the WAJ Zarqa office, the Customer Department has one meter calibration set and repairs on an average, 500 house meters yearly. The Rusaifa Water Department also has one meter calibration set and in 1994 calibrated 1000 meters.
(Water Tankers)

Two water tankers are operated each under Zarqa and Rusaifa offices. Since large scale repair of mechanical equipment such as pumps and vehicles is the responsibility of WAJ Headquarters. The Rusaifa and Zarqa offices retain only small tools and devices for leak repairs and pipe installation. Each office operates a sufficient number of vehicles for system operation and maintenance.

5.2.3 Procurement and Storage

Procurement is usually made by WAJ Headquarters upon request by WAJ Zarqa. WAJ Headquarters has standard specifications for all equipment and materials. Hence, their quality and quantity are kept at a certain level satisfactory to WAJ.

Small lengths of steel, ductile iron, and polyethylene pipes are stored in the yard near Zarqa Pumping Station. These materials are under the control of the Supply & Storage Section, of the Administration & Finance Department, Zarqa.

Bulk chemicals (chlorine tanks) are stored at warehouses in As-Samura and Amman. They are periodically delivered to the site when required. On average, chemicals on site last two weeks - to one month and are sufficient in quantity for normal operating conditions.

House meters are B-class, and meet ISO standards. The Subscribers Department of the WAJ Zarqa and Rusaifa Water Departments usually keep 2,000 and 500 meters respectively. The house meters are delivered from Amman Storehouse after sample calibration. Meters are considered sufficient in number and performance.

5.2.4 Workshop and Laboratory

There are two minor workshops, each in Zarqa and Rusaifa. They are used for meter calibration and repair. Full scale repair of pumps, flow meters and vehicles is done at the Amman Workshop.

Laboratory testing is carried out by the Water Resources & Laboratory Section, of the Planning, Studies & Information Department of WAJ Zarqa. The engineers and in-house staff take samples at major water supply facilities in Zarqa Governorate on a routine basis. The sampled water is brought into the Microbiological Laboratory in Amman. WAJ Zarqa engineers carry out all testing and analyses. These activities aim to 1) monitor trends and quality of the groundwater aquifer in the Governorate, and 2) ensure safety of the water quality based on the drinking water standard. Biological and physical parameters such as bacteria, fecal coliform, total coliform, pH, turbidity, residual chlorine are tested on a daily basis. Due to the slightly limited capacity of the Laboratory, an average of only 20 samples in a week are

brought in for testing. Chemical parameters such as fluoride, calcium, magnesium, TDS, nitrate, sodium, potassium, chloride, sulphate, carbonate, bicarbonate are examined once or twice a month according to the need. Analyses for heavy metals and trichlroethylene, are carried out once a year by WAJ. Parameters and frequency of the routine water testing are considered sound and favorable.

In addition, the Lab section carries out water sampling at all private wells for testing. Waste water from the major factories are also tested to monitor and control ground water contamination in Zarqa Governorate.

5.3 Meter Reading, Billing And Bill Collection

5.3.1 Meter Reading

Meter reading is carried out by WAJ meter readers every three months. There are 74,000 water subscribers in WAJ Zarqa Governorate, about 70% of which are in Zarqa and the remaining 30% in Rusaifa. The total number of collectors working in WAJ Governorate is 50 (35 in Zarqa and 15 in Rusaifa). The number of subscribers per collector varies from 500 to 2,000, depending on the density of the house connections.

5.3.2 Billing and Bill Collection

All the data for the preparation of bills is processed by computer in WAJ Zarqa. Water bills thus prepared are distributed to subscribers every three months. In general, 2-3 weeks are required for preparation and distribution of bills. As meter readers are familiar with local conditions, they are also engaged in bill collection. Bill collectors (or meter readers) are not periodically shifted to other areas.

According to regulations, subscribers should pay within 7 days after receiving the bill or else WAJ has the legal authority to cut off the service. However, this regulation is not applied strictly depending on the physical situation and its practical implications. Actually it takes about two weeks to collect the bill after distributing the bill.

There are three payment methods available to subscribers: 1) pay the collector, 2) bring cash to WAJ and 3) pay at the bank. Most of the subscribers in WAJ Zarqa (60-70%) are paying the collectors. The remaining customers bring cash to WAJ Zarqa. Payment at banks is used by a limited number of customers.

According to statistics in WAJ Zarqa the ratio of bills collected to bills issued in 1994 was 0.89, which indicates high recovery rate compared to that of other developing countries.

According to the information collected through UFW survey and from staff at WAJ Zarqa, the following problems need to be solved or improved:

1. many subscribers tend to mistreat water meters.
2. it takes 2 months or more for collecting bills including meter reading.
3. billing is quarterly instead of monthly.
4. bill collectors work as meter readers and bill collectors, and with no periodical shifting.

5.4 Financial Management

5.4.1 General

All the budgets of the local governorates are planned and controlled by WAJ Headquarters. Water bills are collected by the local governorates and remitted to and managed by the central office. Major expenses such as payroll of the employees and electricity are paid by the central office. The budget for additional investment and repair is also being controlled by the central office.

5.4.2 Tariff Structure

Applied tariff rates in Zarqa District both for water and sewerage are shown below. In January 1994 the water tariff for specific consumers was abolished. Tariffs for domestic consumers and such bulk consumer as commercial and industrial consumers are the same.

Table S4 WATER AND SEWERAGE TARIFF

Block (3 months consumption)	Water Tariff JD/m3	Sewerage Tariff JD/m3
0 - 20 M^3	0.065	0.030
21 - 40 M^3	0.090	0.040
41 - 70 M^3	0.300	0.100
71 - 100 M^3	0.500	0.200
101 M^3 more	0.600	0.250

Source: Information Dept., WAJ

5.4.3 Financial Statement

(1) Financial Statements of WAJ Headquarters

Income statements for WAJ in 1994 indicate that the total revenue almost covered salaries and wages and O&M cost. However, depreciation cost and interest on loans could not be covered by the revenue. The deficit for the year reached JD 49.3 million which is larger than the annual income. Based on the actual water consumption in 1994, the revenue and the cost are analyzed as follows:

Table S5 REVENUE AND COST ANALYSIS
WAJ in 1994 (JD)

	Revenue/cost	Revenue/cost per m^3
1. WAJ Revenue		
1) Water Revenue	24,269,095	0.25
2) Water revenue plus sewerage revenue and sewerage tax	134,195,14	0.35
2. WAJ OM Cost		
1) O&M Cost excluding depreciation	41,919,786	0.43
2) OM. Cost plus depreciation	69,505,770	0.71
3) OM. Cost plus depreciation and interest	85,288,268	0.87

Note: Revenue/cost per m^3 are calculated on the basis of the water consumption (billing amount) of 97,888,825 m^3 in all WAJ.

As indicated above revenue from the sale of water is JD 0.25 /m3. Even if sewerage revenue and sewerage tax are added, the revenue only increases by 40% to JD 0.35/m3 which still does not cover OM cost of JD 0.43/m3. When depreciation is included, O&M accounts for 49% of total operating costs. If interest is included with depreciation then OM accounts for 40% of total operating expenditures.

Operational and Maintenance costs of WAJ during the past 3 years are summarized as follows:

Table S6 OPERATION AND MAINTENANCE COST

	1992		1993		1994	
Salary and Wages	13,316,713	(19.9)	15,218,277	(21.4)	16,099,444	(18.9)
Electricity	8,318,353	(12.4)	14,996,061	(21.1)	16,966,535	(19.9)
Repair and Others	11,192,675	(16.7)	4,518,724	(6.3)	8,853,807	(10.4)
Depreciation	22,332,096	(33.4)	24,388,270	(34.3)	27,585,984	(32.3)
Interests	11,838,784	(17.6)	12,043,867	(16.9)	15,782,498	(18.5)
Total	66,998,621	(100%)	71,165,199	(100%)	85,288,268	(100%)

About one fifth of the total OM costs are for salary and wages, while about 20% is for electricity. Depreciation shares about 30% showing a relatively high ratio, while 17-18% of the total cost was allocated to interest.

Investment in fixed assets is being financed by government contribution and long term loan. Annual income could not cover the depreciation cost and the annual deficit was finally offset by reducing WAJ's working capital. Net working capital has been decreasing since 1988 and reached JD 34 million in 1994, despite considerable contributions from the government.

(2) Financial Situation of WAJ Zarqa

Independent accounting systems have not been introduced in each WAJ governorate. Accounting remains a centralized function. Individual governorate balance sheets and income statements for WAJ Zarqa are not available. Based on information provided by WAJ Zarqa the annual budget is prepared by WAJ Headquarters, as presented in Table 5.1.

The expected total revenue of WAJ Zarqa in 1995 is about JD 4.0 million which consists of revenue from water (JD 3.1 million) and revenue from sewerage (JD 0.9 million). Total expenses are projected at JD 5.0 million excluding depreciation and interest costs. The resulting net revenue is estimated at minus JD 1.0 million (deficit).

On the basis of the assumed water consumption for 1995 (14,358,000 m^3), unit revenue and cost for WAJ Zarqa are calculated as follows:

Table S7 BUDGET FOR WAJ ZARQA, 1995

Item	JD
I. Revenue	
1. Water Revenue	
Water Charge	2,702,035
Connection Fee	250,286
Meter Charge	96,139
Repairing Fee & Others	62,295
(Sub - total)	(3,110,755)
2. Sewerage Revenue *	
Sewerage Charge	435,677
Connection Fee	416,000
Others	64,260
(Sub-total)	(914,937)
Total Revenue	4,025,692
II. Expenses **	
1. Salary and Wage	1,422,666
2. Electricity	3,007,107
3. Repair Cost and Fuel	457,053
4. Others	162,069
Total Expenses	5,048,895
III. Revenue minus Expenses	- 1,023,203

Source : WAJ Finance Directorate
* : Excludes sewerage tax to be collected by MOF
** : Excludes depreciation cost

Table S8 UNIT REVENUE AND EXPENSES

Item	Unit Rate
1) Water Revenue	JD 0.210 / m^3
2) Sewerage Revenue	JD 0.064 / m^3
3) Total Revenue	JD 0.280 / m^3
4) Total Expenses	JD 0.352 / m^3
5) Total Expenses plus Depreciation	JD 0.621 / m^3
6) Total Expenses plus Depreciation and Interest	JD 0.791 / m^3

From these figures, the following conclusive remarks can be made on the financial situation of WAJ Zarqa :

1. Total revenue covers about 80% of the total expenses excluding depreciation.
2. Since the total revenue is only 45% of the total expenses plus depreciation, substantial increases in revenue or cost reductions are a pre-requisite for the cost recovery.
3. If interest is included, present total revenue covers only 35% of the cost.

6 PROJECTION OF POPULATION AND WATER DEMAND

6.1 Future Urban Development Plan

A development scenario for the Study Area is formulated, in due consideration with the development constraints given below;

- Existence of the military camp located in Zarqa, which limits further development towards the east of Zarqa, and
- Steep land laid down around Zarqa, which limits further development towards the west and north of Zarqa.
- Existing industrial plants such as oil refinery and power plants in Hashemeyeh.

The residential and mixed residential area will expand to west, north-west directions and cover most of the relatively flat terrain area of the Study Area while the vacant land will decrease correspondingly. Then, future land use of the Study Area is projected, which is summarized below;

Table S9 FUTURE LAND USE OF THE STUDY AREA (2015)

Major Land Use	Area (Km^2)	
Existing Residential	29.0	(32.0 %)
Mixed	11.2	(12.4 %)
Future Residential	10.2	(11.3 %)
Industrial	8.0	(8.8 %)
Agricultural	3.4	(3.8 %)
Public	2.2	(2.4 %)
Open Space	1.6	(1.8 %)
Refugee Camp	0.8	(0.9 %)
Vacant Land	24.1	(26.6 %)
Total	90.5	(100.0 %)

6.2 Population Projection

The population of the Study Area increased at 3.9% p.a, during the period of 1979-1994. Excluding a returnees from the Gulf countries, estimated at around 60,000, natural population growth is estimated at 3.1% during this period. Another indicative figure for future population projection would be the planned population growth rate set up in "Economic and Social

Development Plan of Jordan, 1993 - 1997. The projected figure is 3.2% p.a. during the plan period.

Based on these figures, total population growth of the Study Area is estimated.

Period	Total Population Growth in the Study Area
1995 - 2000	3.2% p.a.
2000 - 2005	2.8% p.a.
2005 - 2015	2.4% p.a.

During 1995 - 2000, a little bit higher rate than the past trend is applied in due consideration of the socio - economic effect of the Peace Treaty. But the higher growth rate will decrease after the year of 2000 as household incomes increase and living standards improve.

Population projection for different municipalities is made on the basis of past trends with and growth rates estimated above. For the estimate of the future growth rate by municipality, the following assumptions are made:

- Past trend of high population growth observed in each municipality will slow down in the future.
- Higher population increase will continue in the surrounding lower density areas such as Sukhna, Hashemeyeh, and Rusaifa.
- Zarqa and Schenuller which have the highest population density in the Area will increase at relatively lower rate compared to other municipalities.

Table S10 PROJECTED POPULATION IN THE STUDY AREA

Municipality	1994	1994 - 2000	2000	2000 - 2005	2005	2005 - 2015	2015
Zarqa	344,524	2.8%	406,600	2.5%	460,000	2.3%	577,500
Sukhna	9.764	4.4%	12,600	3.9%	15,300	3.0%	20,600
Hashemeyeh	13,038	4.7%	17,200	4.0%	20,900	3.2%	28,600
Rusaifa	131,130	4.0%	165,900	3.3%	195,200	2.6%	252,300
Schenuller	36,218	2.7%	42,500	2.4%	47,900	2.2%	59,500
Study Area	534,674	3.2%	644,800	2.8%	739,300	2.4%	938,500

6.3 Water Demand Forecast

The average per capita consumption (on the basis of accounted-for water) in the Study Area is, at present, 52 lpcd, where water rationing is practiced. This consumption would, however, increase to 75 to 80 lpcd during dry periods and 70 lpcd during wet periods if water were supplied continuously.

For the future water consumption, another 10 -15 lpcd is added to allow for increased per capita consumption due to improved living standards and a likely decrease in household size. As a result, 90 lpcd is adopted as the target value for 2015.

To estimate demand, UFW within the system is added to subscriber consumption. It is assumed, that the UFW ratio will decrease from 54% in 1994 to 30% in 2015, as meter reading and billing procedures (major reasons for UFW high ratio) as well as leakage control measures are strengthened and improved in the course of the project development. In estimating daily maximum water demand, a peaking factor (Daily maximum/Daily average = 1.20), is used to account for the seasonal and daily fluctuation.

Taking the above factors into consideration, the present 183 lpcd on daily maximum basis will amount to 166 lpcd in 2005 and 154 lpcd in 2015. The daily maximum water demand of 97,000 m^3/day in 1994, will be increased to 145,000 m^3/day at 2015.

Table S11 DAILY AVERAGE AND MAXIMUM PER CAPITA CONSUMPTION (lpcd)

Year	1994	2000	2005	2010	2015
Average consumption	70	75	80	85	90
UFW ratio (%)	54	48	42	36	30
Average demand	151	144	138	133	129
Maximum demand	181	174	165	160	155

* Demand includes both consumption in subscribers and UFW in the system.

Table S12 WATER DEMAND

Year	1994	2000	2005	2010	2015
Population Served	534,700	644,800	739,200	832,300	938,500
Avg. Demand (m^3/day)	81,000	93,000	102,000	111,000	121,000
Max. Demand (m^3/day)	97,000	112,000	122,000	133,000	145,000

6.4 Water Balance

Water sources available within the Study Area are scarce. If appropriate measures for new water resource development are not advanced by the agencies concerned, the water shortage in the area will become more serious in the future.

The following table shows an estimated water balance, supposing that the present well fields continue to produce water and no additional water sources are available.

Table S13 WATER BALANCE WITHOUT ADDITIONAL SOURCES

(Daily Average Base) (MCM/year)

Year	1994	2000	2005	2010	2015
Annual Water Demand	29.6	33.9	37.2	40.5	44.2
Water Source Availability	21.9	21.9	21.9	21.9	21.9
Balance	-7.7	-12.0	-15.1	-18.6	-22.4

6.4.1 Current Water Source For Zarqa

Current water sources for the Zarqa water supply system are based on the water balance for the whole of Jordan. The population is concentrated mostly to the north of Jordan (population of which is 3.92 million while Jordan is 4.33 million in 1993). The current water balance for the northern region is as follows;

Table S14 CURRENT WATER BALANCE IN NORTH JORDAN

(MCM/year in 1993)

Governorate	Supply	Import	Export
Zarqa	25	15	19
Amman	* 101	** 46	0
Mafraq	13	0	19
Irbid	34	4	0
Balqa	19	3	0
(King Abdul Canal)	-	-	30
Total	192	68	68

* Import from South Jordan is included. ** Import from South Jordan is excluded.

The location of the water sources serving Zarqa is expected to change by the development of future water resources in Jordan. Projects resulting from the Peace Treaty, the Wadi Mujib

Lower basin and Disi will have a profound impact on the arrangement of the Zarqa water supply system.

6.4.2 Water Demand in Jordan

Determining the water demand is the first step to understanding the water balance in Jordan. Population in the north Jordan is projected below by using the same population growth rates applied in Zarqa.

Table S15 POPULATION PROJECTION IN NORTH JORDAN

(thousand person)

Governorate / year	Amman	Zarqa	Irbid	Mafraq	Balqa	Total	Growth rate
1995	1,803	688	1,006	179	207	3,883	3.20%
2000	2,111	805	1,178	210	242	4,545	3.20%
2005	2,424	924	1,352	241	278	5,218	2.80%
2010	2,729	1,040	1,522	271	313	5,875	2.40%
2015	3,073	1,171	1,714	305	352	6,615	2.40%

Based on the population projections, domestic water demands are projected for 2 possible scenarios: 1) a low consumption scenario where the per capita consumption will remain the same as the current level of 150 liters per day (including 58 % of unaccounted for water) and 2) a high consumption scenario of 180 liters per day.

Table S16 WATER DEMAND IN NORTH JORDAN

(MCM/year)

Governorate / year	Amman	Zarqa	Irbid	Mafraq	Balqa	Net Total	* Gross Total
Low case	**(150 lpcd)**						
1995	99	38	55	10	11	213	234
2000	116	44	64	11	13	249	274
2005	133	51	74	13	15	286	315
2010	149	57	83	15	17	322	354
2015	168	64	94	17	19	362	398
High case	**(180 lpcd)**						
1995	118	45	66	12	14	255	281
2000	139	53	77	14	16	299	329
2005	159	61	89	16	18	343	377
2010	179	68	100	18	21	386	425
2015	202	77	113	20	23	435	479

* includes 10% conveyance loss and 58% UFW ratio.

6.4.3 Water Resources Development in Jordan

If the water resources development proceed as shown below, water will be balanced between 2000 and 2010. However, after 2010, other water resources development will become necessary.

Table S17 WATER BALANCE BASED ON POSSIBLE WATER SOURCES

(MCM/year)

Water source / year	1995	2000	2005	2010	2015
Existing Supply	192	192	192	192	192
Mukheb	-	25	25	25	25
Fahel	-	8	8	8	8
Yarmouk River	-	30	80	80	80
Degnia Gate (Lake Tiberias)	-	20	20	20	20
Desalination from Israel	-	10	10	10	10
Wadi Muj Lower Basin	-	30	30	30	30
Disi	-	-	- (90)	90 (150)	90 (150)
Total Supply	192	315	365	455	455
Demand (Low - High)	234 to 281	274 to 329	315 to 377	354 to 425	398 to 479
Water Balance (Low - High)	-42 to -89	-14 to +41	-12 to +50	+30 to +86	-24 to +42

In the above cases it is assumed that 58% of high UFW in Jordan in 1993 will not change. However, rehabilitation of the distribution systems is also planned for the rest of Jordan as it is in this study. Although reduction of the UFW will take a long time, it is reasonable to expect that UFW will be reduced to 30% by 2010. The required demand will therefore be significantly lower at an estimated 298 MCM/year in 2010 and 335 MCM/year in 2015 for the high consumption scenario and 248MCM/year in 2010 and 279 MCM/year in 2015 for the lower consumption scenario.

Table S18 WATER BALANCE FOR UFW RATIO OF 30%

(MCM/year)

Year	1995	2010	2015
Total Supply	192	455	455
Demand (Low - High)	234 to 281	248 to 298	279 to 335
Water Balance (Low - High)	-42 to -89	+157 to +207	+120 to +176

It is reported that existing wells are producing at twice the safe yield limit. For both the high and low consumption case there will be a large positive water balance. Therefore it is advisable to reduce production yield of the overdrawn wells. Even when production is reduced to half, the water balance remains positive as shown below.

Table S19 WATER BALANCE FOR UFW RATIO OF 30%

(MCM/year)

Year	1995	2000	2005	2010	2015
Existing Supply	192	192	192	* 96	* 96
Mukheb	-	25	25	25	25
Fahel	-	8	8	8	8
Yarmouk River	-	30	80	80	80
Degnia Gate (Lake Tiberias)	-	20	20	20	20
Desalination from Israel	-	10	10	10	10
Wadi Mujib Lower Basin	-	30	30	30	30
Disi	-	-	# - (90)	90 (150)	90 (150)
Total Supply	192	315	365	359	359
Demand (Low - High)	234 to 281	274 to 329	315 to 377	248 to 298	279 to 335
Water Balance (Low - High)	-42 to -89	-14 to +41	-12 to +50	+61 to +111	+24 to +80

* Reduced to half of the existing supply.

\# Disi project is planned to yield 150 MCM/year at the second stage. However, from the viewpoint of water balance, it is not necessary.

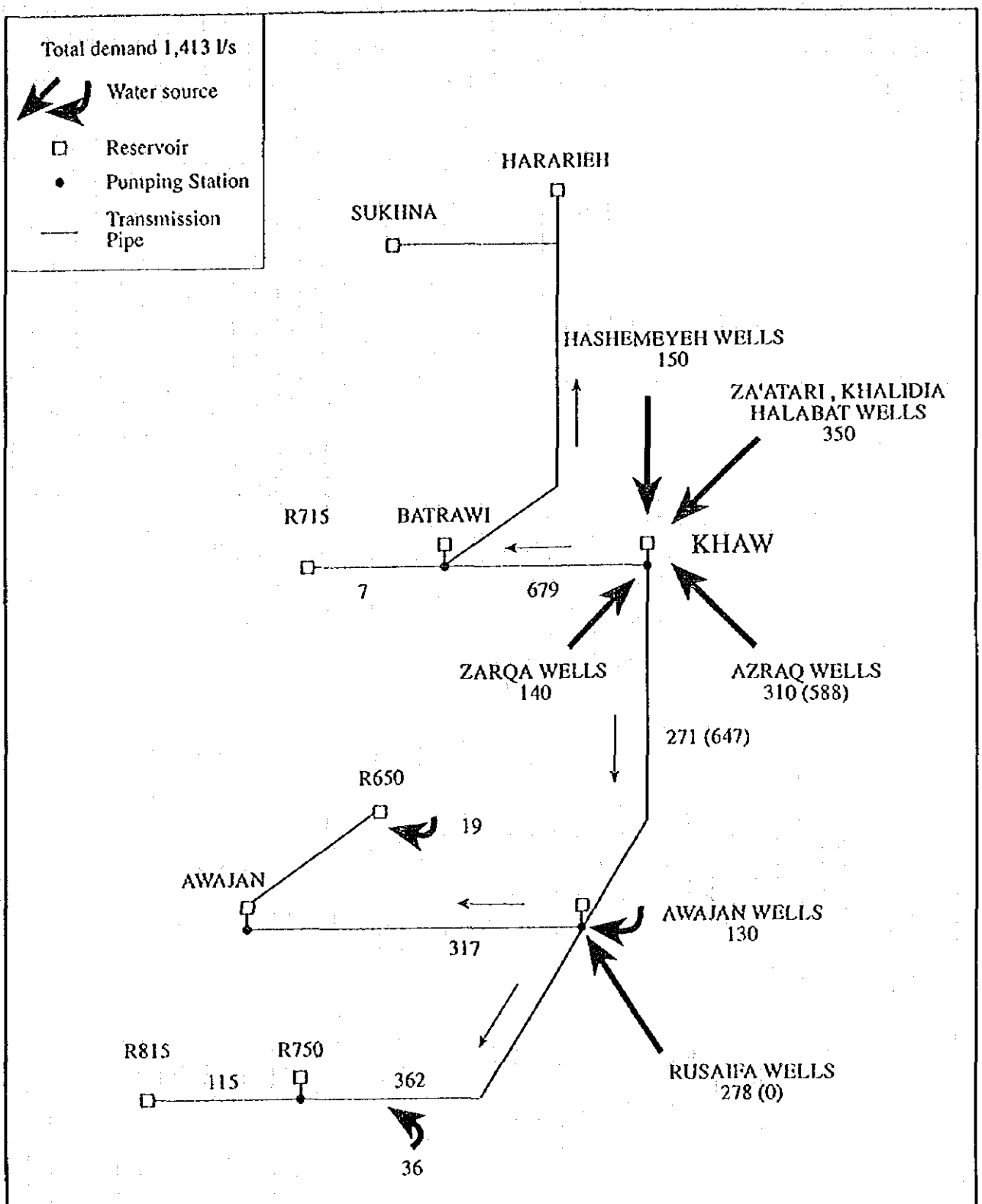
6.4.4 Future Water Source For Zarqa

From the preceding, until 2005 the quantity of water from existing sources will match the current use and the additional amount required to meet increased demands will come from the east, namely Azraq, Za'atari etc., reaching 938 l/s (30 MCM/year) in 2005. After 2006, the quantity from existing sources will be reduced by half and additional water will come from the west. The amount from the west will reach 741 l/s (24 MCM/year) in 2015. Water sources for the years 2005 and 2015 are shown in Figs.- S4 and S5, respectively.

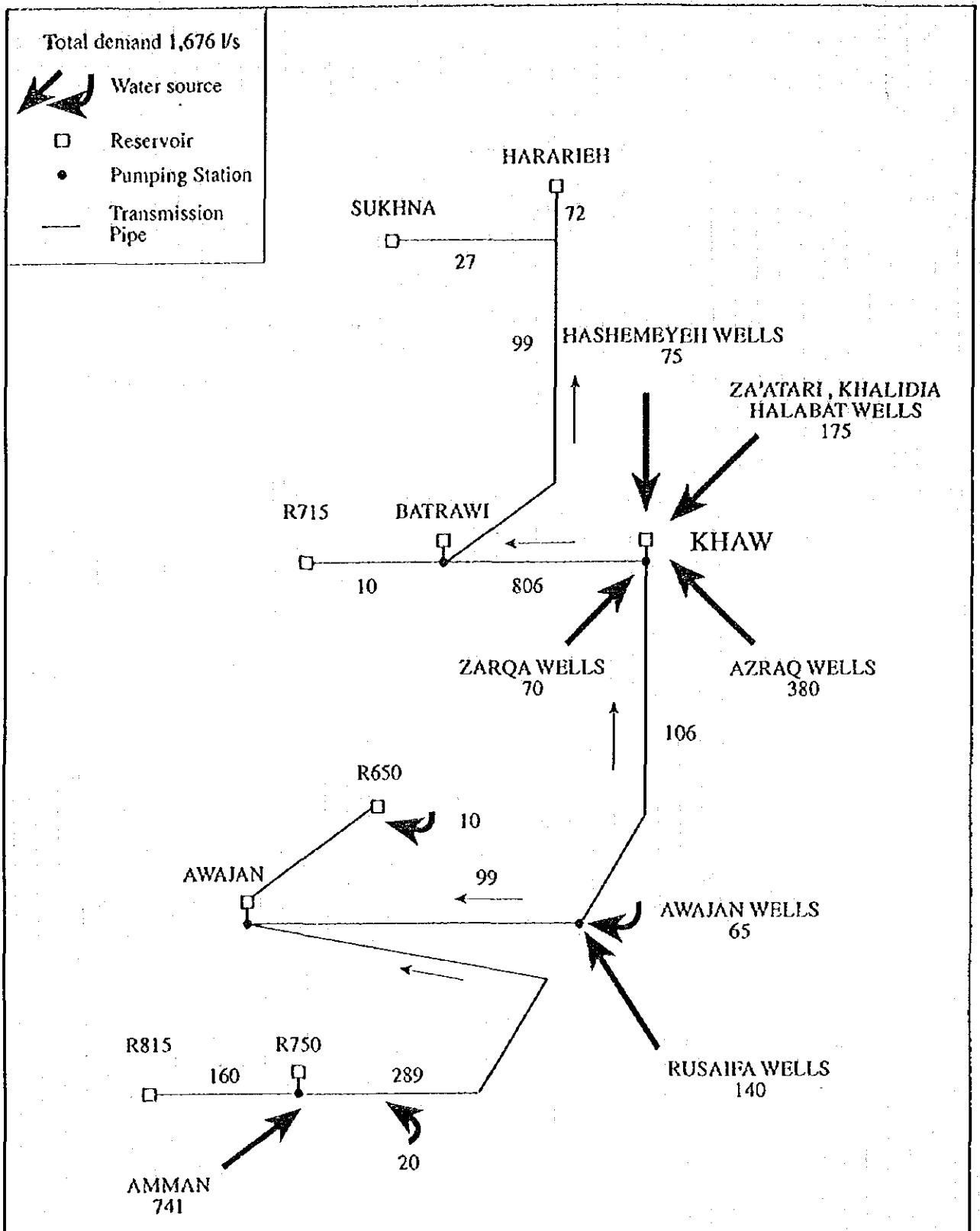
Table S20 WATER SOURCES AND QUALITY FOR ZARQA

Water Source / Year	1995 (l/s)	2005 (l/s)	2015 (l/s)
Khaw (Za'atari, Khaldia, Halabat and Azraq)	* 340	# 938 (660)	555
Zarqa	140	140	70
Hashemeyeh	150	150	75
Awajan	130	130	65
Murhib	19	19	10
Wells in Rusaifa (Phosphate, Hutteen, Bassateen, Rusaifa 18)	36	36	20
Rusaifa valley wells	-	# - (278)	140
Unspecified New Source from West Side	-	-	741
Total	815	1,413	1,676

* Current yield is 1,110 l/s and the remaining is sent to Amman.
# 938 is required either from Khaw totally or Khaw & Rusaifa valley wells in 2015.



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. S4 WATER FLOW 2005
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. S5 WATER FLOW 2015
JAPAN INTERNATIONAL COOPERATION AGENCY	

7. WATER SUPPLY IMPROVEMENT PLAN

7.1 Development Concept

Present water supply conditions in the Study Area lag far behind the need. Per capita consumption is at a low level of 52 lpcd. 30 % of the subscribers feel dissatisfied with water supply services provided by WAJ because of regular rationing in 70 % of the service area, high concentration of TDS and frequent meter reading errors.

WAJ Zarqa is facing the following problems;

1) High UFW (including leakage) ratio
2) Shortage of water resources
3) Inadequate distribution system
4) Low quality of existing water resources

For formulating the long term development plan, the following development concept is applied in due consideration of the present conditions;

1) More Efficient Use of Available Water
2) Improvement of Water Supply System
3) Re-use of Wells with low Water Quality
4) System Expansion for Future

(1) More Efficient Use of Available Water

More efficient and effective use of available water is sought since available rechargeable water resources are quite limited in the country. It is planned to reduce the high UFW ratio to the level of 30% by 2015 through the implementation of a rehabilitation program and routine leakage control activities.

(2) Improvement of Water Supply System

The existing water supply system is not well laid out because extension and expansion have were made in response to a rapidly increasing demand without overall planning and coordination during the past decades. Inefficient layout of pumping stations and distribution network is a typical.

to make the water supply system more efficient, reorganization of the distribution system is planned including;

1) introduction of a new zoning system
2) separation of distribution pipes from transmission pipe; and
3) optimization of pumping station layout including boosters, and reservoirs.

(3) Re-use of Wells

Resuming operations at wells which are out of operation due to the deteriorated water quality, will help ease the severe water shortage in Zarqa district. The critical quality parameters are TDS and NO_3. Water quality can be improved with appropriate treatment, however, removal of TDS requires the costly RO method. Blending with better quality water is proposed to minimize costs since these wells will again stop production when new resources are provided to Zarqa.

(4) System Expansion for Future

The improvement plan will see to the expansion of the system to prepare for future demand increases. Preparation of the expansion plan will require consideration of the location of the water sources which will be changing over the planning period.

7.2 Rehabilitation Plan

(1) Transmission and Distribution Pipe Network

The older and smaller diameter service mains are leaking. They were mostly laid in 1960s and 1970s and have been left without proper maintenance and repair since then.

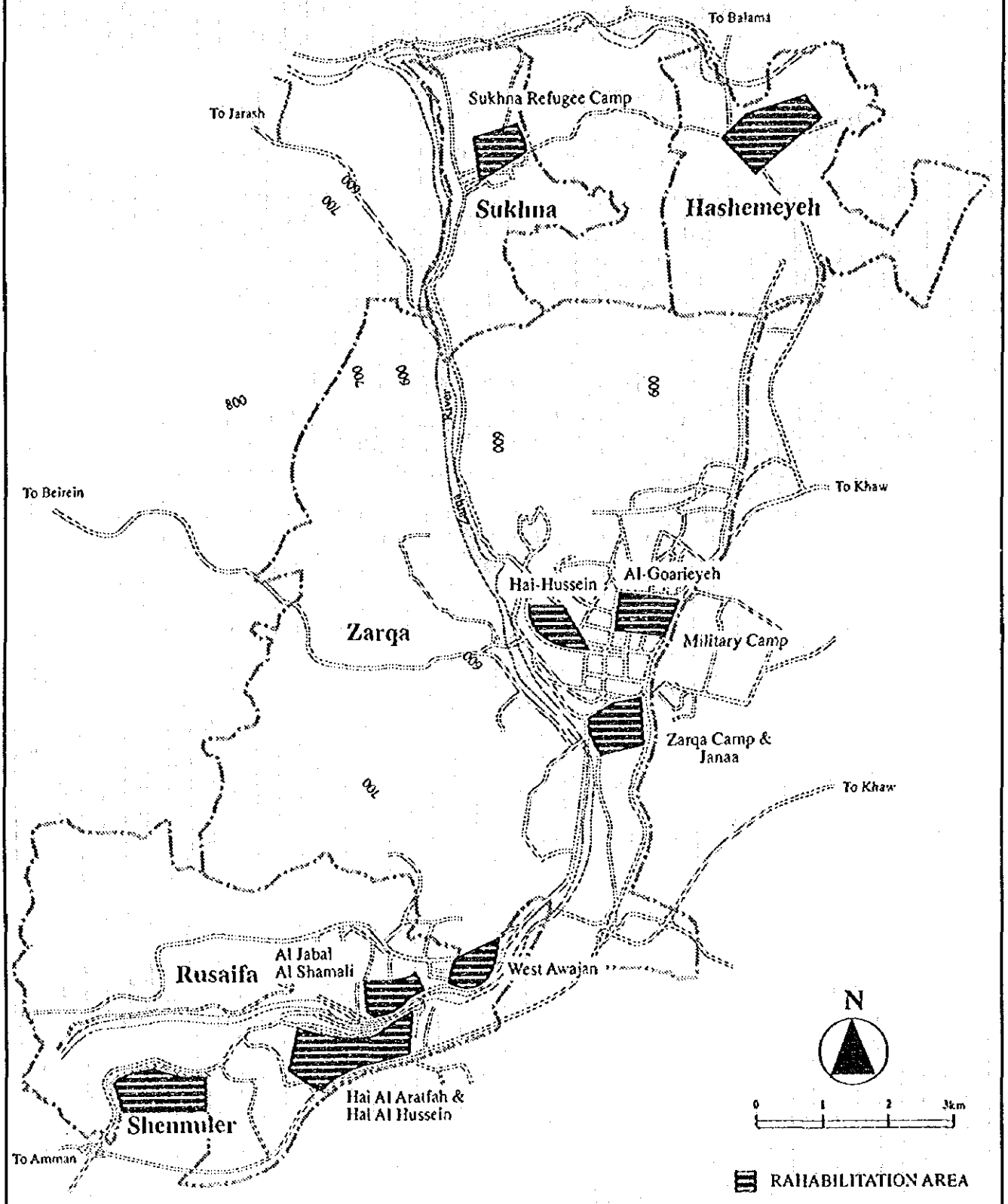
In case where the leakage ratio is high, replacement with new corrosion-resistant ductile iron pipe is usually more economical than repair. For pipeline assessment, a leakage ratio of 30%, was set as a the threshold for pipe replacement.

From the results of the UFW survey and the available information on pipeline rehabilitation carried out by WAJ Zarqa, areas and pipes (mostly black steel) are selected for rehabilitation as presented in Fig.- S6 and summarized below. They were all installed in 1960s and have never been rehabilitated.

Table S21 SCOPE OF PIPE REHABILITATION

Name of Area	Area (km^2) or Nos of Subscribers	150 mm DIP Pipe Length (m)	100 mm DIP Pipe Length (m)	63 mm polyethylene Pipe Length (m)
Al Goarieyeh[1]	0.6 km^2	2,800 m	1,100 m	-
Hai Hussein	0.5 km^2	3,000 m	900 m	-
Zarqa Camp & Janaa	2,300 subscribers	1,100 m	7,800 m	-
Sukhna	800 subscribers[2]	-	2,800 m	4,700 m[3]
Hashemeyeh	1,700 subscribers[2]	3,900 m	9,100 m	8,400 m[3]
West Awajan	2,000 subscribers	-	12,550 m	-
Al Jabal Al Shamali	3,000 subscribers	-	18,250 m	-
Hai Al Aratfah & Hai Al Hussein[3]	2,900 subscribers	-	18,100 m	-
Shennufer	0.9 km^2	6,600 m	4,400 m	-
Total		17,400 m	75,000 m	13,100 m

1) It contains ø150mm in Abu Abdeh Street and Al Jazair Street and ø100mm in Al Ordon Street.
2) It was assumed that around 70% of the total subscribers are residing in old municipal center in Sukhna and Hashemeyeh.
3) It contains ø100mm black steel mains in Prince Hasan Street and Al Bokhari Street.
4) In smaller municipalities of Sukhna and Hashemeyeh, diameter of the existing distribution mains is 100mm. Therefore, 50mm service mains are considered appropriate.



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.- S6 REHABILITATION AREA

(2) House Connections

House connections have been replaced intensively by WAJ since 1990. But there are still a number of old deteriorated service pipelines left without repair. These older service pipelines are mainly 3/4" diameter galvanized steel. They are the main source of leakage. Therefore, replacement of old connections which were laid in 1960s is also included.

Table S22 NOS. AND LENGTH OF HOUSE CONNECTIONS FOR REPLACEMENT

Area	Number of Customer Meters	Length of Service Pipelines**
Sukhna	800	32mm x 12km*
Hashemeyeh	1,700	32mm x 26km*
West Awajan	2,000	32mm x 20km
Zarqa Camp & Janaa	2,300	32mm x 23km
Al Jabal Al Shamali	3,000	32mm x 30km
Hai Al Aratfah & Hai Al Hussein	2,900	32mm x 29km
Total	12,700	32mm x 140km

* Average service pipeline length per connection, 10m, was used for the estimates except for Sukhna and Hashemeyeh where 15 m was applied.

7.3 Improvement Plan

(1) Re-use of Existing Wells

The Zarqa wells cannot be used at present because water quality parameters exceed not only the permissible limits but also the maximum allowable limits due to the intrusion of polluted surface water.

The effect of blending at Khaw pumping station is evaluated. The most serious concern is TDS and it is assumed that existing values of 750 mg/l will remain unchanged in the future. TDS values will exceed the 500 mg/l permissible limit but are below the 1,500 mg/l maximum allowable limit.

Similarly, it is proposed to blend water from Awajan wells with water from Rusaifa valley wells (in 2005 and 2015) and from Khaw pumping station (in 2005).

(2) Zoning

Ground elevations in the Study Area range from 500 m in Sukhna to 800 m in north Rusaifa. The Study Area stretches approximately 20 km from Sukhna, the lowest point, to Rusaifa, the highest point. Given this range in topographical conditions, distribution of water to the Study Area from one supply point is obviously not economical. Considering the elevation and distance, the Study Area is divided into 8 zones as shown in Fig.- S7.

Although it will be necessary to lay transmission lines exclusively dedicated to connecting pumping station and/or wells with reservoirs, the cost is insignificant compared to the considerable advantages mentioned previously.

Table S23 ZONING

Zone Name	Demand (l/s) in 2015	Reservoir Name	Altitude at the reservoir (m)	Altitude for Served Area (m)
Zarqa Low	573	Batrawi (addition)	652	560 - 625
Zarqa High	134	Res 715 (new)	715	620 - 700
Sukhna	27	Sukhna (addition)	574	500 - 535
Hashemeyeh	72	Hararieh (new)	608	550 - 565
Awajan Low	66	Res 640 (new)	640	550 - 610
Awajan High	323	Awajan (addition)	695	610 - 660
Rusaifa Low	321	Res 750 (new)	755	660 - 720
Rusaifa High	160	Res 810 (new)	810	720 - 770
Total	1,676			500 - 770

(3) Layout of Pumping Station and Transmission Line

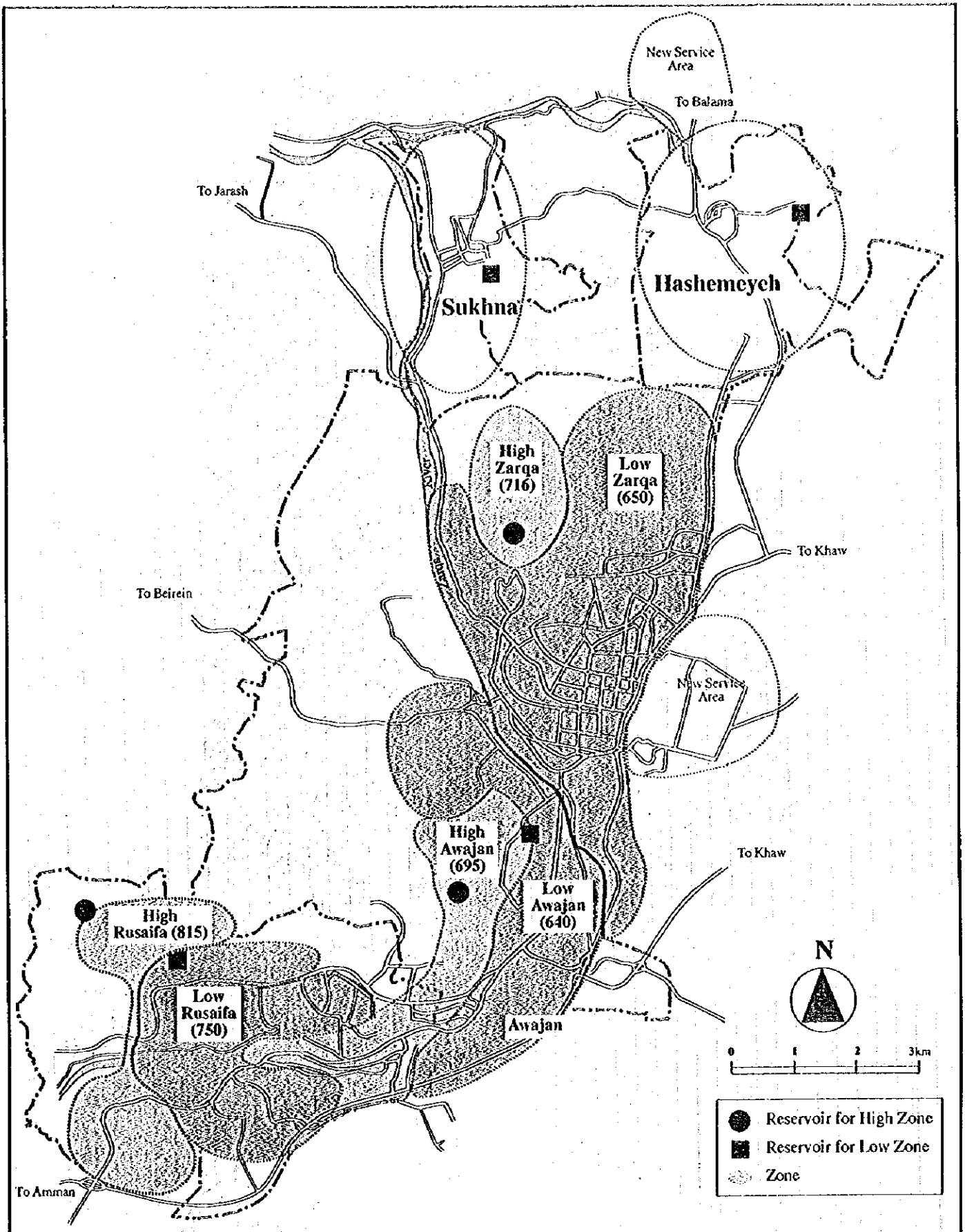
(1) Water Source

The configuration of pumping stations and transmission lines is based on the location of the water sources supplying Zarqa which will change over the planning period.

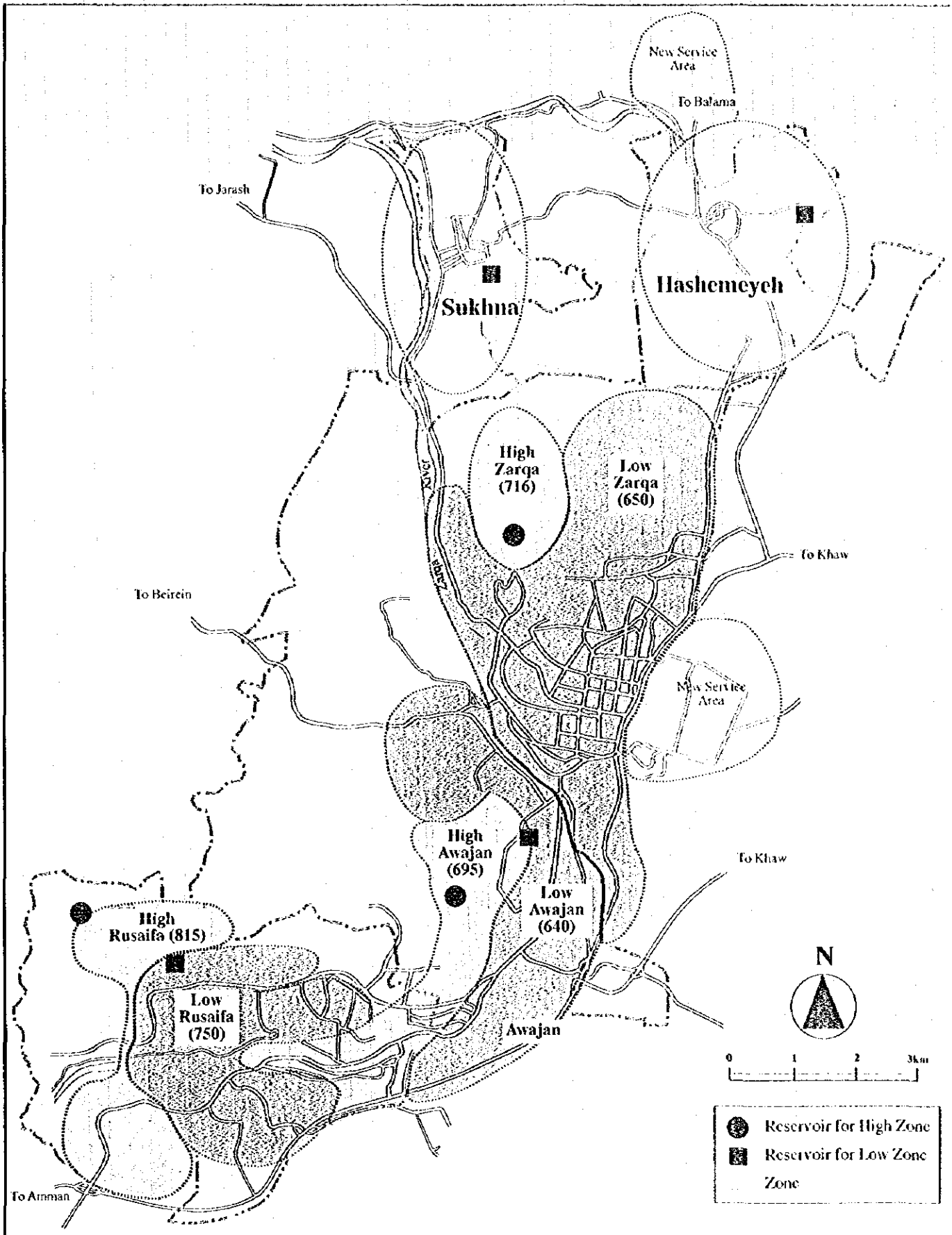
Water from Hashemeyeh and Zarqa wells will be sent to the Khaw pumping station. Similarly, water from Awajan wells will be blended with water from Khaw in the newly constructed Awajan pumping station. Water from the Rusaifa valley wells will be sent to the Awajan pumping station.

Water from small wells in the Study Area such as Phosphate, Hutteen, Bassateen, Rusaifa 18 and Murhib wells will also be directly injected into the distribution system.

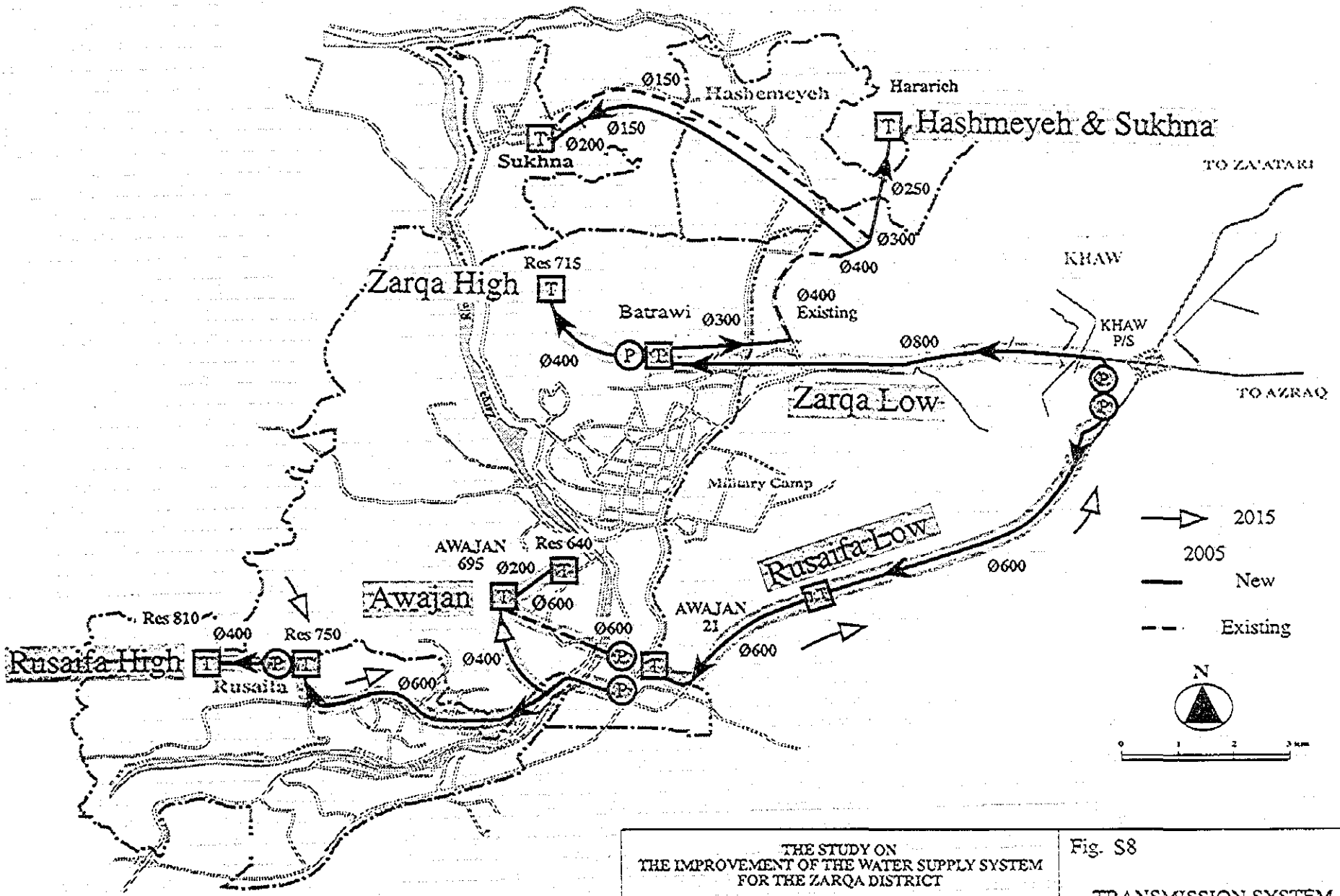
The layout for the years 2005 and 2015 is shown in Fig.- S8. Flow between Khaw pumping station through Awajan pumping stations and the RES 750 in Rusaifa will reverse in the years 2005 and 2015. Directions in other transmission lines do not change.



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.- S7 Zoning Map



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig.- S7 Zoning Map



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. S8
JAPAN INTERNATIONAL COOPERATION AGENCY	TRANSMISSION SYSTEM

(2) Transmission of Water to Distribution Zones

Water will be transmitted to the following distribution zones:

1) Hashemeyeh and Sukhna Zones
2) Zarqa High and Low Zones
3) Awajan High and Low Zones
4) Rusaifa High and Low Zones

Operation and maintenance can be facilitated by minimizing the number of pumping station. However, minimizing pumping stations is obviously not economical in the Study Area since elevations range from 600 m to over 800 m and most of the demand is concentrated in the low-elevation areas. Therefore, two large pumping stations (Khaw and Awajan) and two small booster pumping stations (Batrawi and RES750) are proposed as shown in Table below.

Table S24 PROPOSED PUMPING STATIONS

Zone	In 2005	In 2015
Zarqa High	Boost from Batrawi (Zarqa Low)	
Zarqa Low	Pump from Khaw P/S	
Sukhna	Gravity from Batrawi	
Hashemeyeh	Gravity from Batrawi	
Awajan High	Pump from Awajan P/S	Gravity from Rusaifa Low
Awajan Low	Gravity from Awajan High	
Rusaifa High	Boost from RES750 (Rusaifa Low)	
Rusaifa Low	Pump from Awajan P/S	From Amman side

In the above layout, Zarqa pumping station no longer functions as a booster station. Water from the Khaw pumping station to which Azraq, Hallabat, Khaldieh and Za'atari water is conveyed, is presently pumped to the older Zarqa pumping station. The elevation at the Khaw pumping station is higher than at the Zarqa pumping station by about 30 m. Therefore, the largest supply point of Zarqa pumping station which is in the Zarqa wells, are at present merely re-boosting water to Batrawi reservoir. This unnecessary pumping can be avoided for energy saving. For year 2015, water is better conveyed by gravity from Rusaifa 750 reservoir to Zarqa pumping station instead of through Khaw pumping station. However, its transmission line is difficult to be laid in the central Zarqa area. Therefore, the above layout is proposed even though it is hydraulically inferior.

In general it is better to maximize the use of existing facilities to minimize investment costs. Pipes usually have a longer service than pumps (10 to 15 years). Therefore, efforts were made to utilize the existing Khaw - Amman pipeline. However, WAJ indicated a preference to have this line rehabilitated and we have accordingly prepared a plan to meet this requirement.

The best alignment option is the shortest route with an altitude lower than the required hydraulic profile. This alignment is along the existing Khaw - Amman line to the Awajan offtake and further along Yajouz road to Rusaifa.

Facilities are sized against the maximum daily demand as follows:

Table S25 PROPOSED PUMP FACILITIES

From	To	Unit Flow (m^3/min.)	Head (m)	Unit Power (kW)	Number (set) *
Khaw	Batrawi Res	9.7	77	310	6
Batrawi	Res 715 (Zarqa High)	2.7	87	75	4
Khaw	Awajan PS	4.1	97	132	5
Awajan	Res 750	4.4	221	290	6
Res750	Res 815(Rusaifa High)	3.2	71	75	4
Awajan	Res 695	5.4	122	220	5

* Including one standby

Table S26 PROPOSED TRANSMISSION FACILITIES

	Diameter (mm)	Length (m)
1. Khaw - Batrawi	800	7,900
2. Batrawi - Res 715	400	2,200
3. Khaw - Junction Tank	500	8,100
4. Junction Tank - Awajan P/S	400	4,100
5. Awajan P/S - Awajan 695	Existing (600)	2,000
6. Awajan 695 - Res 640	200	800
7. Awajan P/S - Res 750	500	6,600
8. Res 750 - Res 810	400	1,800
9. Batrawi - Hashemeyeh	400	100
	300	2,300
	250	1,900
10. Hashemeyeh - Sukhna	150	6,800
	200	1,000
11. Hashemeyeh - Khaw (for blending)	400	5,700
12. Zarqa - Khaw (for blending)	Existing (400)	8,000
13. Rusaifa valley - Awajan PS (for blending)	500	2,900

(4) Distribution System

(1) Pipe

Once the transmission system is planned, then the distribution system is designed.

Almost every customer is equipped with a roof tank and these will likely be in use even in 2015. Therefore, the available head in a 4 story house is 10 to 15 m. A head loss of 15 m is added for the size and length of the service lines which are typically 50 mm or 25 mm. Facilities are not sized against the maximum hourly demand. Instead, they are sized for the average hourly demand because of the existence of roof tanks. Based on the above conditions, a hydraulic network analysis was conducted to determine the size of the facilities. The proposed distribution pipes are shown as follows:

Table S27 PROPOSED DISTRIBUTION PIPE

Diameter (mm)	Length (m)
600	9,300
500	600
400	9,300
300	6,900
200	6,600
150	13,400
100	9,100

(2) Reservoir

Reservoir capacity is sized to balance diurnal fluctuation. It is usually sized for 6 to 8 hours in Japan. Recently, Japanese standards were upgraded to allow additional water storage for emergency situations like major pump failures. In Jordan, where houses have rooftop storage tanks, the storage requirement can be shortened to 8 hours. Total capacity in all reservoirs are, therefore, about 50,000 m^3 (=145,800 m^3/day x 8 hours). This figure is allocated to each zone according to the demand.

Table S28 RESERVOIR CAPACITY

Zone Name	Reservoir Name	Required Capacity	Existing Capacity	Additional Capacity
Zarqa High	Res 715	4,000	-	4,000
Zarqa Low	Batrawi 695	17,000	4,500	12,500
Sukhna	Sukhna	1,000	* -	1,000
Hashemeyeh	Hararieh	2,000	* -	2,000
Awajan High	Awajan 695	10,000	4,500	5,500
Awajan Low	Res 640	2,000	-	2,000
Rusaifa High	Res 815	5,000	-	5,000
Rusaifa Low	Res 750	10,000	-	10,000
Total		51,000	9,000	42,000

* Existing reservoirs will not be used due to low elevations.

7.4 Operation and Maintenance Plan

Reduction of present high UFW is urgently required in order to ensure an adequate supply of water. To reduce UFW, a number of operational and management within WAJ Zarqa must be reinforced.

7.4.1 Leakage Control Plan

The repair works that WAJ Zarqa are carrying out, are rather passive ones. A more active control program is necessary for the effective reduction of the leakage from the pipe network.

The proposed plan is to organize a leakage control team directly under the Administration of WAJ Zarqa. The team would consist of 3 leakage detection sub-teams, 6 repair sub-teams, one design and recording sub-team and one equipment control sub-team. This team would be headed by a leakage control manager and the unit would have the following staffing levels.

Table S29 LEAKAGE CONTROL STAFFING

	Sub - Team	No. of Sub - Team	Technicians	Staff & Clerks	Workers
1	Leakage Detection	3	3	3	6
2	Leakage Repair	6	6	6	30
3	Design & Recording	1	2	4	0
4	Equipment Control	1	1	3	0
	Total	14	12	16	36

A direct sounding method would be used for leakage detection and supplemented by installing flow meters at strategic points to provide district metering in an effort to identify priority areas.

7.4.2 Legal Enforcement and Protective Measures

In 1994, 146 illegal connections were identified. Their cost in lost revenue to WAJ was JD 13,000. This appears to be only the tip of the iceberg. To prevent illegal connections, the proposed leakage control team is expected to collaborate closely with the Subscriber Department.

Tampering with water meters seems to be another major cause for high UFW. To prevent this, it is recommended that subscribers meters be relocated from inside house to the yard and installed inside a sealed meter box. Legal enforcement should include high fines and penalties.

7.4.3 Improvement of Meter Reading and Bill Collection Procedure

Meter reading errors is a serious source of customer complaints in the Study Area. To cope with this, recruitment and training of qualified meter readers who can judge meter performance is urgently required.

For more efficient meter reading, the following improvements are required:

(1) Prepare subscriber location maps with an adequate scale of 1:1,000.
(2) Simplify present billing zones.
(3) Lease contract for meter reading and billing
(4) Periodical shift meter readers to other billing zones.

At present, it takes 2 months or more to collect bills including meter reading. This process can be shortened by introducing monthly billing to large consumers. Accordingly, a bill collection team should be organized in the Subscribers Department especially for large consumers to issue monthly billing and collect payments. To shorten the time for bill collection, payment through the bank is recommended with some incentives for paying on time. Through introduction of this payment method, meter readers can concentrate their time on meter reading.

7.4.4 Strengthening of OM Organization

Operation and maintenance works at WAJ Zarqa are being conducted relatively well under the present institutional framework. However, due to rapid and random urban development without planning during the recent decades, the water supply facilities are not being systematically installed, which makes it more difficult to introduce operational and maintenance efficiencies.

WAJ Zarqa is now facing the following problems:

(1) lack of equipment for repair and maintenance works.
(2) lack of qualified technicians and manpower
(3) poor regulation and control of urban development, and lack of coordination with other agencies concerned.

Mitigating the first problem requires an inventory survey of existing machines, equipment and materials with identification of their location. Based on this inventory list, a basic inventory management system can be introduced.

Solving the manpower problem, requires recruiting and training qualified technicians for electric and mechanical works. Training programs should also be designed to meet the needs of existing staff. Recruitment of leakage control engineers seems an urgent priority

Financial management needs to be strengthened in WAJ Zarqa. A cost accounting system should be established in order to plan and manage cost disbursement. The decentralization of WAJ is now being planned with special emphasis on the cost accounting and assets management functions.

The lack of integrated planning is the most important but difficult problem to tackle, since WAJ is not responsible for the land use and its development. Better coordination with the related government agencies can be achieved by establishing an inter-agency planning committee with regulatory authority to oversee urban development .

7.5 Implementation Plan And Cost Estimate

7.5.1 Implementation Plan

The improvement project will be implemented in two stages:

Stage 1: With a target year of 2005, the Stage 1 Project plans to implement rehabilitation works, installation of trunk mains with associated pumps and reservoirs and rationalization of pipe network

The "Urgent Project" is to be implemented with a target year of 2000.

Stage 2: With a target year of 2015, Stage 2 Project plans to implement expansion of the necessary facilities such as pumps, reservoirs and pipe network.

To improve the present crucial water shortage in the Study Area, the "Urgent Project" will be implemented within the framework of stage 1.

The implementation schedule for Stage 1 and Stage 2 is prepared bearing in mind that water supply for the target year is realized 2-3 years in advance as presented in Fig.- S9.

7.5.2 Cost Estimate

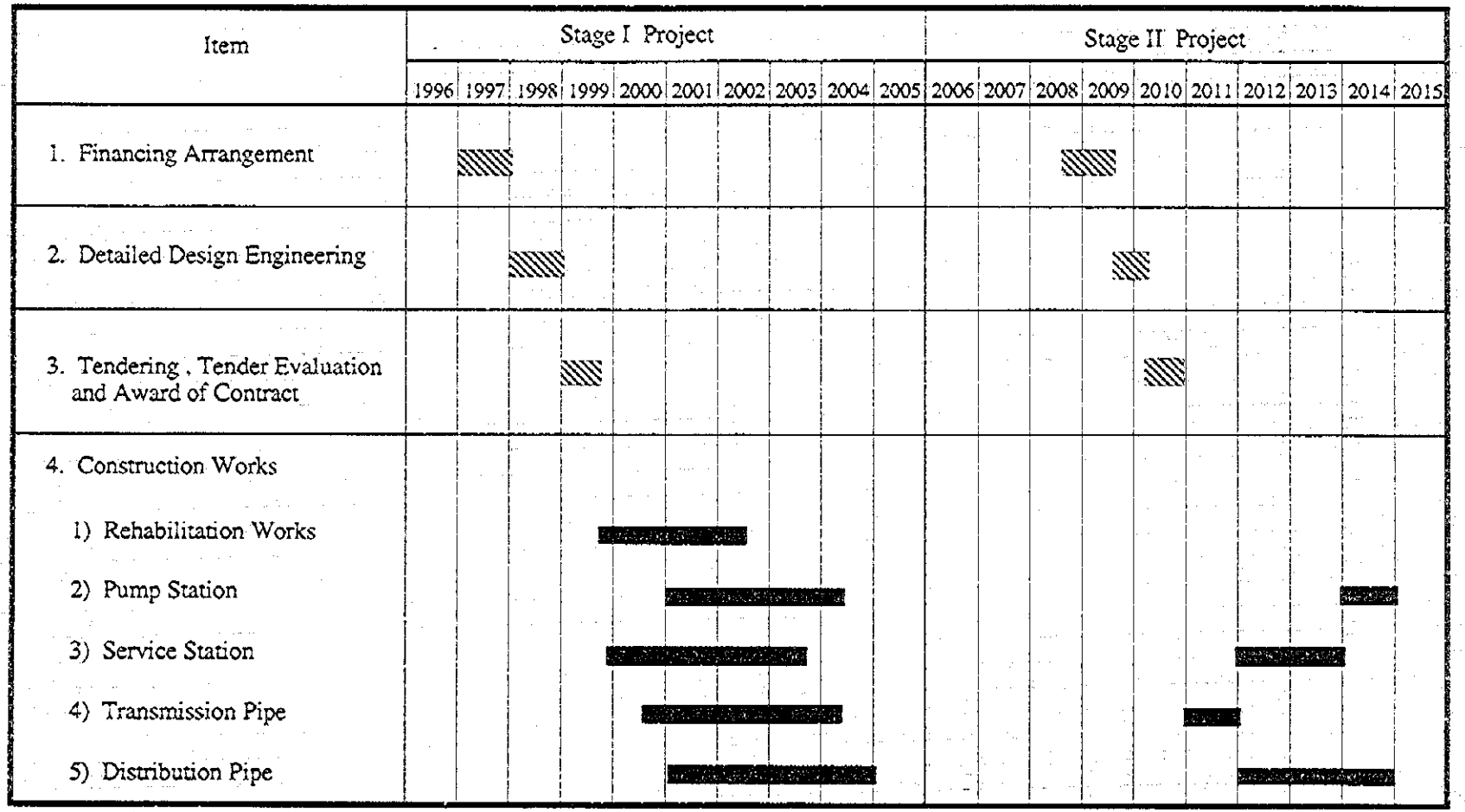
The estimated project costs are US$ 85 million as broken down below

Table S30 ESTIMATED PROJECT COSTS

(Unit: US$ 1,000)

Items	Stage - 1	Stage - 2	Total
Rehabilitation Works	9,767	-	9,767
Land Acquisition	330	-	330
Construction Works			
- Transmission Pumps	4,684	5,991	10,675
- Transmission Pipes	15,935	341	16,276
- Service Reservoirs	3,862	3,007	6,869
- Distribution Pipes	16,446	8,702	25,148
Sub-total	51,024	18,041	69,065
Engineering Costs and Administration Costs	6,560	1,974	8,534
Physical Contingency	5,416	1,985	7,401
Total Project Costs	63,000	22,000	85,000

Fig.- S10 IMPLEMENTATION SCHEDULE



8. INITIAL ENVIRONMENTAL EXAMINATION

8.1 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. In Jordan, a draft of the Jordan Environment Act was prepared and submitted to the Minister of Municipal and Rural Affairs & the Environment in 1992 as the first step of the National Environment Strategy for Jordan. However, the Act is currently following the review and approval process.

In the absence of suitable guidelines, JICA Environmental Guidelines (JICAEG) are adopted.

Based on JICAEG, the major environmental elements to be examined for water supply projects are as follows:

(1) Social environment.
(2) Natural environment.
(3) Pollution.

8.2 Environmental Examination Matrix

An environmental examination matrix (EEM) is a useful tool for a brief screening of a project's environmental impact. The components of the matrix include project activities and the above environmental elements.

Construction/rehabilitation and operation of the following facilities are included in the project activities.

- Pumping stations
- Reservoirs or water tanks
- Transmission and distribution pipes

Table 8.1 shows the EEM for this project. All the environmental elements are screened with reference to each of the project activities.

As indicated in the table, in the construction phase of the pumping stations, reservoirs/ water tanks and transmission/distribution pipes, the impact on the following environmental elements cannot be ignored and need to be examined further.

Fig.- S10 ENVIRONMENTAL EXAMINATION MATRIX

Projects Activities	Environmental Elements	Pollution						Natural Environment							Social Environment								
		Offensive odor	Ground subsidence	Noise and vibration	Soil pollution	Water pollution	Air pollution	Landscape	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
Pumping Stations	Construction phase			○												○			○	○	○		
	Operation phase																						
Reservoirs / Water Tanks	Construction phase			○												○			○	○	○		○
	Operation phase																						
Transmission / Distribution	Construction / rehabilitation			○												○			○	○	○		
	Operation phase					○					○												

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

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

In the operation phase of the project, the problem of increased sewage volumes will be evaluated.

8.3 Examination of Selected Environmental Elements

(1) Impacts to Economic Activities

Improvement or expansion of the water supply system will intensify land use and may increase the land values which could in turn squeeze out existing tenants or lower income households.

(2) Impacts on Traffic and Public Facilities

Construction work in this project is small scale. However, most of the transmission and distribution pipes are located under existing roadways. During the construction, traffic regulation or in some case construction of temporary detour roads will be required.

(3) Archaeological Treasures

According to the data from the Institute of Archaeology and Anthropology, there are about 300 archaeological sites. Before planning the pumping stations and reservoirs/ tanks, a detailed survey of these archaeological sites should be conducted with the coordination of Jordanian agencies or institutes for archaeological study and management. Appropriate measures should be taken to protect archaeological treasures from any negative impact from the construction work.

(4) Solid Wastes, Noise and Vibration

Solid wastes will be generated mainly from the earth works for pumping stations and reservoirs and from the excavation for pipeline construction. However, most of the wastes will be used as backfill. Excess solid wastes from the construction site will be transported to the surrounding landfill area.

During the construction of this project, the noise from such machines as air compressor and concrete blender could reach levels of 70-75 dB, which should not cause any serious problems if conducted during day time. Once constructed, noise levels from the operating facilities will be negligible.

Vibration will have a very small impact since the major facilities will be constructed on rock foundation.

(5) Sewage Increase due to the Improvement of Water Supply

In the Study Area, about 58% of the population is serviced by the public sewage collection system. Those who are not serviced rely on septic tanks. Increases in sewage volumes could aggravate the water quality of river and the groundwater. These effects will be further studied

PART II FEASIBILITY STUDY

1. INTRODUCTION

1.1 Background

Following the formulation of the long-term (master plan) plan, we have conducted the feasibility study for the first stage program with a target year of 2005. The first stage program is one of the two "staged" programs proposed in the Long Term Development Plan.

1.2 Study Area

The Study Area is Zarqa district, same as in the Long Term Development Plan. Zarqa District is situated 35 km northeast of the capital, Amman. It includes the urban areas of Zarqa municipality, Rusaifa municipality, Hashemeych municipality, Sukhna municipality and Shennuler refugee camp. The Study Area covers 90.5 km^2.

The population of the Study Area was 534,674 in 1994 and grew at 3.9 % per year on average during 1979 - 1994.

1.3 Objective

In the master plan, the following issues were identified to be resolved;

- High UFW (including leakage) ratio,
- Inadequate distribution system
- Shortage of water resources, and
- Low quality of existing water resources.

1.3.1 Reduction of UFW

Scarcity of water resources will continue to be an important constraint to the development of water supply systems throughout Jordan at least until the target year 2005. This constraint also controls the development of the water supply system in Zarqa. Large efforts have been made to solve the problem of scarce water resources including: 1) developing additional water resources, 2) rationalizing water allocation among the domestic (municipal and industrial) and the agricultural sectors, 3) rationalizing water usage within the domestic sector etc.

The development of new water resources has been slow because hydrological potential is small and high marginal cost. The peace treaty between Israel and Jordan in October 1994 has paved the way for additional water resources. Various studies are underway to determine how to best utilize the new water resources. Water shortages will not be eliminated within this century even projects to develop new water resources could be started now since project implementation will usually take approximately 5 years. Water shortages might begin to be alleviated by 2005 judging from the various studies now in progress.

Even with new sources of water, shortages may continue to be a problem depending upon how the produced water is utilized effectively and efficiently within the distribution systems. If the current level of UFW ratio of more than 50 % is not decreased, it can be said that new water resources are being developed only to be wasted. Recognizing the importance of UFW, WAJ has been expanding rehabilitation programs for various cities including Zarqa, aiming at reducing UFW ratio although the most important but tedious active leakage control measures have not yet been exercised regularly. Leakage control measures are the only solution to mitigate water shortages until additional water resources are allocated to the Zarqa water supply system sometime by the target year 2005.

1.3.2 Zoning System

To supplement the above leakage control measures, a zoning system will be implemented to the Zarqa water supply distribution system in order to :1) avoid excessive water pressure which is one of the causes of leakage and 2) distribute water equally to each part of the Study Area. Equal distribution is important because additional water might not be available by the target year. In order to facilitate the zoning system, trunk facilities such as transmission lines, pumping stations and service reservoirs will be provided.

1.3.3 Utilization of Existing Wells

Efforts are made to use the existing wells within the Study Area as much as possible. Unfortunately, water quality in these wells is not good due to their proximity to the upper aquifer system. Hence, blending with the better quality water from outside the Study Area is proposed although this will require long-distance transportation of the raw water to the blending stations.

1.4 Water Demand And Water Source

1.4.1 Population Served

The population and the water demand of the Study Area are estimated for the years 2005, 2015 in the master plan.

One of the unique features of the Zarqa distribution system is that the location of the water sources will gradually change due to the scarce water resources. At present water resources come from within the Study Area and from the east. Gradually, from around 2005 additional water will come from the west. Therefore, the layout of the distribution system needs to be configured to accommodate this change. This is why projections for the year 2005 are also included.

Table S31 PROJECTED POPULATION IN THE AREA

(Person)

Municipality /Year	1994	2000	2005	2015
Zarqa	344,524	406,600	460,000	577,500
Sukhna	9,764	12,600	15,300	20,600
Hashemeyeh	13,038	17,200	20,900	28,600
Rusaifa	131,130	165,900	195,200	252,300
Shennuller Camp	36,218	42,500	47,900	59,500
Total	534,674	644,800	739,300	938,500

Source: JICA Study Team

1.4.2 Water Demand

The present unsuppressed per capita consumption 70 lpcd (dry period) will uniformly increase to the target values of 75 lpcd in 2000, 80 lpcd in 2005, 85 lpcd in 2010 and 90 lpcd in 2015. The table below presents results of annual water demand forecast:

Table S32 WATER DEMAND

Year		1994	2000	2005	2010	2015
Population *		534,674	644,800	739,200	832,300	938,500
Accounted-for-Water	(m^3/day)	37,400	48,400	59,100	70,700	84,500
	(lpcd)	70	75	80	85	90
Unaccounted-for Water	(m^3/day)	43,900	44,700	42,800	39,800	36,200
	(%)	54%	48%	42%	36%	30%
Average Water Consumption	(m^3/day)	81,000	93,000	102,000	111,000	121,000
	(lpcd)	151	144	138	133	129
Peak Factor (daily max./daily ave.)		1.20	1.20	1.20	1.20	1.20
Maximum Water Consumption	(m^3/day)	97,000	112,000	122,000	133,000	145,000
	(lpcd)	181	174	165	160	155
Annual Water Consumption	(MCM/ year)	29.6	33.9	37.2	40.5	44.2

1.4.3 Water Source

Water sources currently used for Zarqa are classified into three groups:

1) Own resources such as Zarqa, Hashemeyeh and Awajan wells which are produced and consumed in Zarqa.
2) Imported resources such as Za'atari wells which are produced in Mafraq and used in Mafraq, Irbid, Zarqa and Amman.
3) Common resources such as Azraq, Halabat and Khaldia wells which are produced in Zarqa and consumed in Zarqa and Amman.

The above water sources are in shortage even at present. If appropriate measures for new water resource development are not advanced, the water shortage in the Study Area will soon become more serious.

WAJ has been planning for additional water resources development to meet the demand for the capital Amman and the whole country. These additional water resources are expected to come from the west and south and their location will influence the future arrangement of the Zarqa water supply system.

These additional water resources will probably not be available until the early 2000's. When they do become available, it is assumed that part of the water resources from Azraq, Za'atari etc. to the east , which is now sent to Amman, will be diverted to Zarqa, providing up to 938 l/s (30 MCM/year) in 2005.

After the target year of 2005, further water sources will become available. Based on the water balance for the whole of Jordan, available water resources will be adequate and existing sources can reduce their production by half in order to avoid depletion. Therefore, exported resources such as Ruseifa valley wells will be dedicated to the exclusive use Zarqa. Additional water will come from the west. The amount from the west will reach 741 l/s (24 MCM/year) in 2015.

Table S33 WATER SOURCE AND QUALITY

Year / Water Source	1995 (l/s)	2005 (l/s)	2015 (l/s)
Khaw (Za'atari, Khaldia, Halabat and Azraq)	* 340	# 938 (660)	555
Zarqa	140	140	70
Hashemeyeh	150	150	75
Awajan	130	130	65
Murhib	19	19	10
Wells in Rusaifa (Phosphate, Hutteen, Bassateen, Rusaifa 18)	36	36	20
Rusaifa valley wells	-	# - (278)	140
Unspecified New Source from West Side	-	-	741
Total	815	1,413	1,676

* Current yield is 1,110 l/s and the remaining is sent to Amman.
# 938 is required either totally from Khaw or Khaw and Rusaifa 4 in 2005.

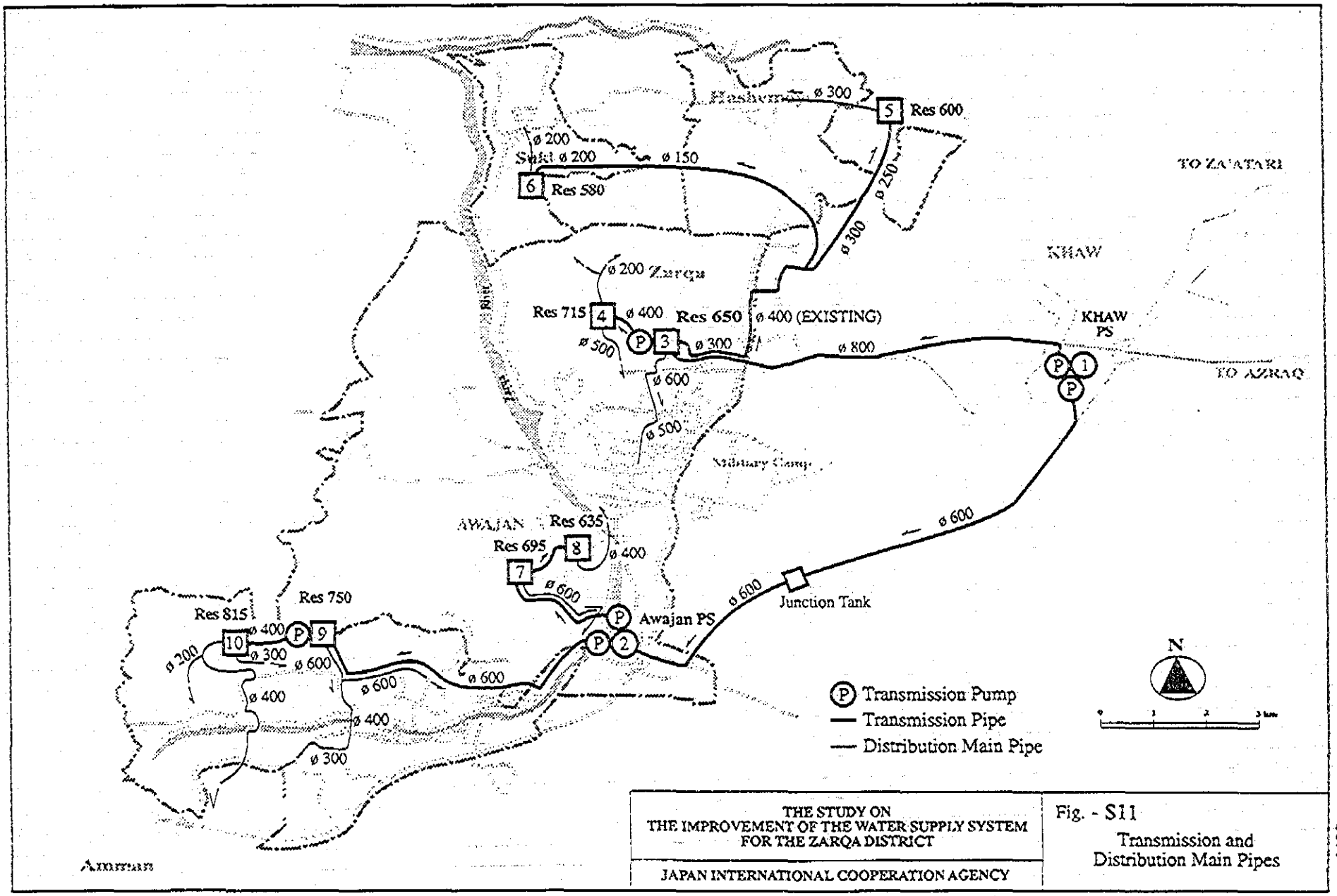
2. PROJECT DESCRIPTION

The projects identified in this feasibility study and outlined in the Long Term Development Plan as the first stage program are presented in Table S34 and Fig.- S11.

Table S34 FACILITIES FOR THE STUDY

Target	Facility	Size
1) Reduction of UFW		
	Replacement of Distribution Pipe	150 mm X 17.4 km
		100 mm X 75.0 km
		50 mm X 13.1 km
	Replacement of Service Pipe and Meter	12,700 meters
		20 mm X 140 km
	Creation of District Metering Area	25
2) Zoning System		
- Transmission Pipe	Khaw PS - Batrawi Res	800 mm X 7.9 km
	Batrawi Res - Res 715	400 mm X 2.2 km
	Batrawi Res - Hashemeyeh offtake	400 mm X 0.1 km
		300 mm X 2.3 km
	Hashemeyeh offtake - Hararieh Res	250 mm X 1.9 km
	Hashemeyeh offtake - Sukhna Res	200 mm X 1.0 km
		150 mm X 6.8 km
	Khaw PS - Awajan PS	600 mm X 12.2 km
	Awajan PS - Awajan 695 Res	600 mm X 0.3 km & Existing 600 mm
	Awajan PS - Awajan 635 Res	200 mm X 0.8 km
	Awajan PS - Rusaifa 750 Res	600 mm X 6.6 km
	Rusaifa 750 Res - Rusaifa 815 Res	400 mm X 1.8 km
- Pumping Station	Khaw Pump for Batrawi, Hararieh and Sukhna	9.7 m^3/min. X 77 m X 310 kW X 6
	Khaw Pump for Awajan PS	4.1 m^3/min. X 79 m X 110 kW X 5
	Batrawi Pump for Res 715	2.7 m^3/min. X 87 m X 75 kW X 4
	Awajan Pump for Awajan 695 Res	5.4 m^3/min. X 121 m X 220 kW X 5
	Awajan Pump for Rusaifa 750 Res	4.4 m^3/min. X 193 m X 290 kW X 6
	Rusaifa Pump for Rusaifa 815 Res	3.2 m^3/min. X 75 m X 75 kW X 4
- Reservoir	Batrawi 650 - Expansion	12,500 cubic meters
	Res 715 - New	4,000
	Hararieh Res - New	2,000
	Sukhna Res - New	1,000
	Awajan 695 Res - Expansion	5,500
	Awajan 635 Res - New	2,000
	Rusaifa 750 Res - New	10,000
	Rusaifa 815 Res - New	5,000
- Distribution Pipe	Rusaifa 815 - Schneler	4,600
	Rusaifa 750 - Rusaifa	1,700
	Being revised	
3) Utilization of Existing Wells		
- Collector Pipe	Zarqa well - Khaw PS	Existing (400 mm)
	Hashemeyeh - Khaw PS	250 mm X 5.7 km
	Awajan 23 well - Awajan PS	Existing
	Rusaifa valley wells - Awajan PS	500 mm X 2.9 km
- Pump	Zarqa well - Khaw PS	3.0 m^3/min. X 150 m X 150 kW X 1
	Hashemeyeh - Khaw PS	3.0 m^3/min. X 150 m X 150 kW X 1
	Rusaifa valley wells - Awajan PS	Existing
- Collector Tank	Awajan PS - New	5,000 m3
	Khaw PS	Existing (12,000m3)

PS: Pumping Station Res: Reservoir



THE STUDY ON
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FOR THE ZARQA DISTRICT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. - S11
Transmission and
Distribution Main Pipes

SUM

3. ORGANIZATION AND OPERATION & MAINTENANCE

3.1 Project Implementing Organization

For the successful implementation of the Stage I Project, a Project Implementing Office (PIO), headed by a Project Manager (PM), will be organized under the Secretary General for Project of WAJ.

The Project contains civil works for rehabilitation and expansion, which are considered slightly different in nature. It is therefore recommended that two teams, Rehabilitation team and Expansion team be organized under PM. Each team consists of staff and engineers for inspection, design and construction administration. They will be mobilized from WAJ Zarqa and/or WAJ head office.

For assisting with design and construction supervision, engineering consultants will be employed throughout the detailed design to construction stage.

Contractors selected through international/local tender, will be involved in the construction works under the supervision of PIO with the assistance of consultants.
The organization for project implementation is presented in Fig.- S12.

3.2 Operation of The Completed Facilities

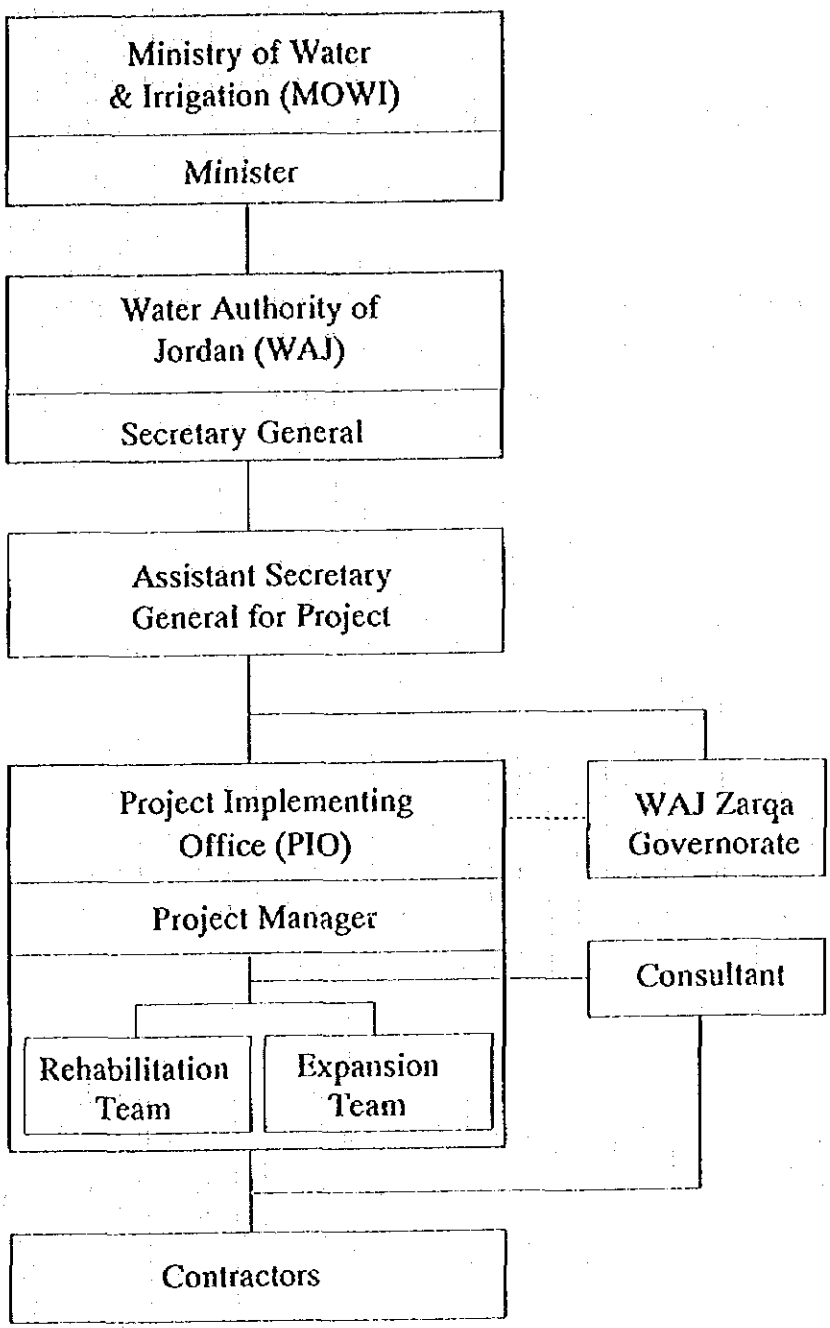
Without proper operation and maintenance all efforts made at the planning, design and construction stages to achieve cost efficiency and maximize effectiveness of the designed facilities will be in vain. Therefore careful attention is given to all WAJ. operational aspects.

As described in the Part I Long-term Development Plan, WAJ Zarqa has a very limited number of qualified engineers and experts. However, WAJ Zarqa staff have acquired a certain level of skills and technology particularly in the field of operation and control of pumps/valves through the long term operation of the existing water supply system.

Fortunately, facilities proposed under Stage I Project will not require many special skills for operation. The required skill sets will be similar to those already used for operating and maintaining the existing system which consists of pumping stations, several reservoirs and pipe network.

Staffing levels required are estimated below:

PROJECT IMPLEMENTING ORGANIZATION



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. - S12 Project Implementing Organization

Table S35 NUMBER OF STAFF REQUIRED FOR PUMP OPERATION

	Superintendent	Mechanical	Electrical	Total
Khaw	1	2 x 3 shifts	1 x 3 shifts	10
Batrawi	-	1 x 3 shifts	1 x 3 shifts	6
Awajan	1	2 x 3 shifts	1 x 3 shifts	10
Rusaifa	-	1 x 3 shifts	1 x 3 shifts	6
Total	2	18	12	32 pers.

From the above table, it is recommended to recruit qualified staff particularly in the field of electrical and mechanical engineering and provide appropriate training.

A telemetered supervisory system is proposed for monitoring pumping stations, reservoirs and pipe network. This new system may not require any special skills. Logged data such as flow rate and water levels at the reservoirs will be read and transmitted to a central station (Khaw PS) where relevant data will be displayed on a monitoring panel. This system will reduce the required number of operational staff particularly at reservoirs.

The requirement for operational staff will be further reduced by abandoning Zarqa pumping station and several small booster stations, and establishing continuous water supply throughout the service area

3.3 Leakage Control And District Metering

3.3.1 Leakage Control Measures

WAJ's current practice for leakage control is characterized as passive one. Upon leakage found, a survey crew organized under Operation and Maintenance Department repairs the leak with limited equipment and materials. Active leakage control is the most urgent and recommendable measures to reduce the unaccounted-for water.

WAJ Zarqa has a considerable lack of skills and equipment for leakage control. To overcome this situation, a leakage control team will be organized under the Administration of WAJ Zarqa. The team will conduct active leakage control on a routine basis. Its proposed organization, staff levels, equipment requirements and a tentative survey scheme is drawn up and described as follows:

(1) Organization

The team, headed by one leakage control manager, will be responsible for leak control activities in the whole service area of Zarqa District. The team will consists of 3 leakage control sub-

teams, 6 leakage repair sub-teams, one design and recording sub-team and one equipment control sub-team with the following number of staffs and technicians:

Table S 36 LEAKAGE CONROL ORGANIZATION

Sub-Team	No. of Sub-Team	Technicians	Staff and Clerk	Worker
Leakage Detection	3	3	3	6
Leakage Repair	6	6	6	30
Design and Recording	1	2	4	0
Equipment Control	1	1	3	0
Total	11	12	16	36

(2) Materials and Equipment

Survey equipment currently available at WAJ Zarqa includes several sets of portable ultrasonic flow meters, pipe locators, leak detectors, leak noise correlators, etc. which were used under the current study. They should have a useful life of 5 - 7 years at least. Therefore, it is more urgent to be provide materials specifically required for leak repair such as pipe cutters, couplings, leak repair bands, boring (tapping) machines for branching, branching saddles and survey vehicles. All of the above will be purchased under the Stage I Project.

(3) Operation Scheme

Leak detection will be practiced twice a week by WAJ staff during night shifts. Work will progress at the maximum rate of 1- 2 km pipe length/night. Hence, 300 km (= 50 weeks x 3 teams x twice x 1 km) of distribution pipe will be surveyed in one year. It should take 2 years to cover the whole service area. At least three cycles of leak detection will be required to achieve the target UFW ratio (30 - 40%). Although initial leakage control activities may be completed in 6 years, it is recommended that WAJ exercise leak detection on a continuous basis and periodically review it's activities to plan the scope of future leakage control programs.

(4) Others

Mobilization of staff is urgently required to organize the leakage control team. Technology for leakage control will be gained through training.

3.3.2 District Metering

To supplement the above plan, metered districts will be established in the service area. Objectives of district metering are to measure inflow rates and fluctuations in the designated areas, to carry out step testing periodically and to obtain the basic data and information required for determining priority areas for leakage control.

To this end, demarcation and number of the district metering areas are provisionally determined mainly from the configuration of the existing pipe network and topographical features of the area. A total of 25 meter districts will be formed in the eight (8) distribution zones of the service area.

District metering will require the installation of flow meters on the inlet mains to each area. The flow meters will be of the mechanical type with an indication of the integrated flow rate. Meter readings will be taken at the same time of the day by WAJ staff every three months at least and preferably every month.

The accuracy of the flow meters used for district metering is obviously important. Portable ultrasonic flow meters may be helpful for calibration. Annual calibration is recommended.

The measurements obtained should be used to determine the total quantity of water entering the meter areas. For each area, comparison of this quantity with WAJ consumption records may provide useful information on where leakage/UFW are dominantly taking place. This information will be most useful in developing leakage control policies for Zarqa District.

In order to collate this data with customer meter reading records, current metering and billing zones established by WAJ Zarqa will be rearranged to match the metered districts.

3.4 Improved Accounting System

To improve operating efficiency, WAJ is planning to decentralize. Most of the functions carried out by WAJ Zarqa are now under the control of WAJ headquarters. With respect to financial matters, all the bills collected by WAJ Zarqa are remitted to headquarters and managed there. All WAJ Zarqa budgets are also controlled by headquarters.

WAJ Zarqa only controls minor cost items such as wages for daily workers, local transportation costs, equipment and spare parts less than the designated amount (max. JD 500). Most of the operating costs including salaries of staff, electricity, chlorine, machinery, equipment, etc. are being procured or paid for by headquarters. Under the circumstances, cost accounting cannot be introduced, which causes less efficient operations at WAJ Zarqa. Facilitation of decentralization scheme is urgently required in order to introduce cost accounting in WAJ Zarqa.

4. COST ESTIMATES

The project cost for Stage 1 is estimated as follows and is broken down into foreign and local currency components at the price level of September 1995:

Table S37 PROJECT COSTS FOR STAGE 1

(Unit:US$ 1,000, 1US$=0.7JD)

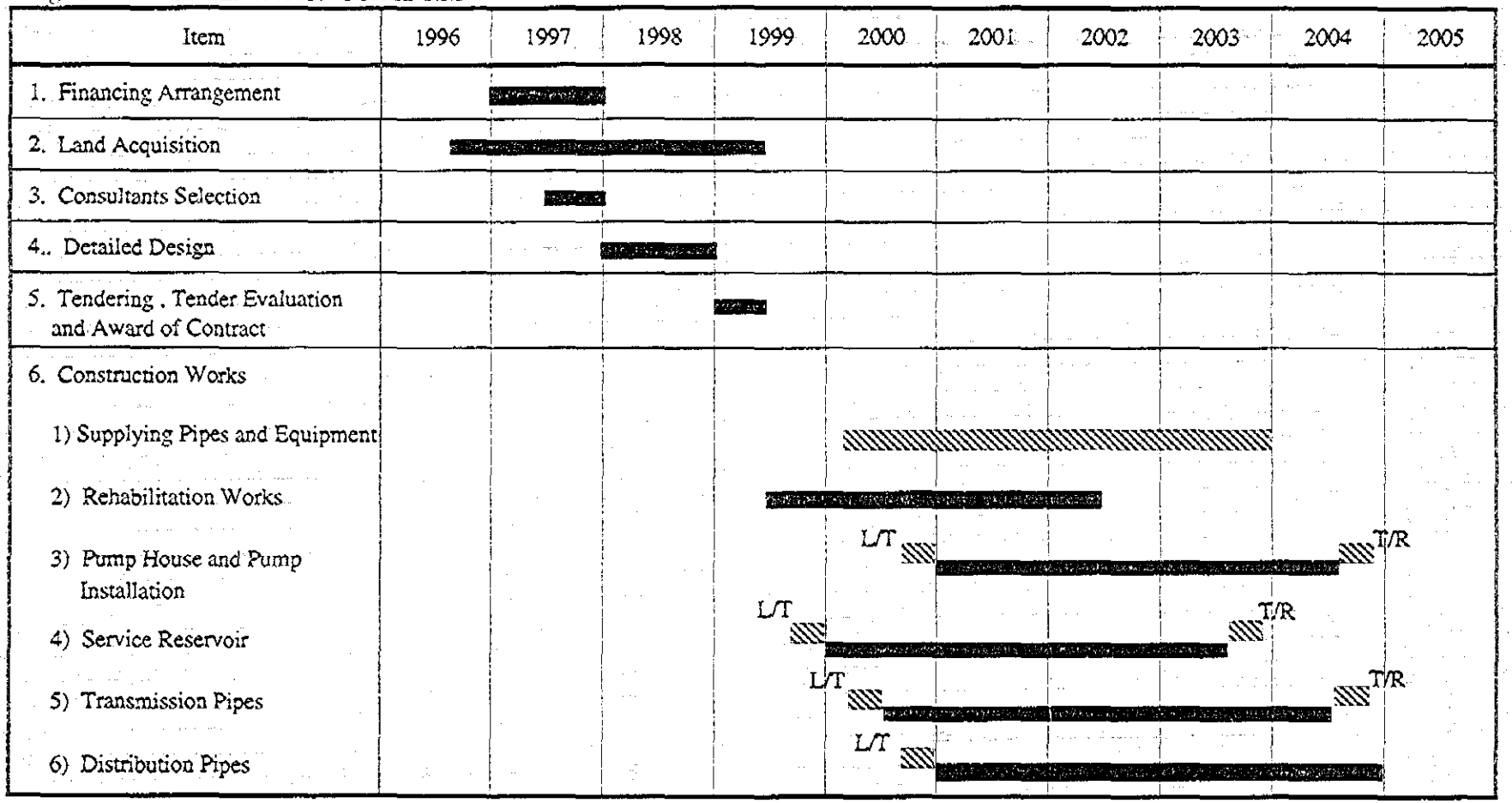
Items	F/C	L/C	Costs
Rehabilitation Works	8,870	897	9,767
Land Acquisition	-	330	330
Construction Works			
- Transmission Pumps	3,241	1,443	4,684
- Transmission Pipes	10,698	5,237	15,935
- Service Reservoirs	1,545	2,317	3,862
- Distribution pipes	10,903	5,543	16,446
Sub-total	26,387	14,540	40,927
Engineering and Administration	5,510	1,050	6,560
Physical Contingency	3,833	1,583	5,416
Total Project	44,600	18,400	63,000

5. IMPLEMENTATION SCHEDULE

The implementation of the present project is carefully planned and arranged for the purpose of satisfactory execution taking into consideration the present conditions for the on-going projects, including contractors, procurement of construction materials and labor force the manner of procurement of water supply equipment and materials and the manner of construction.

The implementation schedule is shown on FIG.- S13.

Fig.- S13 IMPLEMENTATION SCHEDULE



L/T: Local Tendering, T/R: Test Running

6. PROJECT EVALUATION

6.1 Economic Evaluation

Economic evaluation of the project is made by calculating the Economic Internal Rate of Return (EIRR) on the basis of the estimated economic benefit and economic cost. For the estimate of the economic benefit and cost the following principles or assumptions are made:

1) Economic benefit is estimated based on the "with and without project principle".
2) All costs and benefits are expressed in constant price and exclude taxes and duties.
3) Cost and benefit are estimated on "incremental basis".
4) Only quantifiable benefits are included in the EIRR calculation though considerable nonquantified benefits are expected.

Economic Benefit

Upon the implementation of the project, available water for consumption in the Study Area will increase considerably partly through reduction of UFW and partly through network expansion. This increase of available water is a major source of the economic benefit, which will contribute to enhance regional economy and welfare of the residents.

Benefit of water supply increase is estimated by using the following methods:

1) Increase in water supply through improvement of UFW is the net increase of water supply without any incremental cost in water resources. This net increase is, therefore, valued at the marginal production cost of water*[1] .
2) Remaining portion of the water supply increase is valued by estimating the difference between the economic cost of water production by tanker*[2] and the marginal production cost*[1].

This estimated economic benefit for the increased water supply is US$8.03 million in 2005.

Economic Cost

The estimated construction cost is converted to the economic cost by applying the shadow exchange rate*[3] to the local cost components. The estimated economic cost is US$ 61.340 million.

The incremental operation and maintenance cost after implementing Stage I project is also estimated on the basis of with-project and without-project condition as presented below.

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*[1] : JD 0.52/m^3 or US$ 0.74/m^3, estimate of WAJ
*[2] : JD 1.12/m^3 or US$ 1.60/m^3, estimate of WAJ Zarqa
*[3] : Shadow exchange rate is estimated at US$=JD0.77 by IBRD