7.3 IMPROVEMENT PLAN

7.3.1 Re-use of Existing Wells

The Zarqa wells cannot be used at present. Poor water quality exceeds not only the permissible limits but also the maximum allowable limits due to intrusion of the polluted surface water. There are three methods for reuse. The most fundamental method is removing the source of pollution by 1) continuing sewerage system development in the Study area and upstream in Amman and 2) strictly enforcing wastewater discharge standards for factories. A second method consists of providing treatment however conventional methods cannot remove TDS. Reverse osmosis or ion exchange methods are effective but expensive. The third and least costly method is blending with better quality water. This method is practiced now for water supplied to Hashemeyeh and Khaldieh.

We will assume that source control measures will be made and as a result, water quality will be improved. Nevertheless, for safety reasons, the improvement plan will also include blending water since the treatment option is prohibitively expensive.

The effect of blending is evaluated. The most serious concern is TDS. The values of TDS shown below are assumed to remain stable as a result of source controls. TDS values after blending depend on the quantity of water available for dilution. When water is blended in Batrawi reservoir, the supply point for the Zarqa area, the TDS will be 1,088 mg/l. On the other hand, if blending is carried out at Khaw pumping station, TDS will be 738 mg/l. The two values exceed the permissible limit of 500 mg/l but are well below 1,500 mg/l maximum allowable limit.

Case	Blending at BATRAWI		Blending at KHAW	
Water Source	TDS (mg/l) [1]	Quantity (l/s)	TDS (mg/l)	Quantity (l/s)
Khaw pumping station	700	415	700	2,450
Zarqa wells	1,750	145	1,750	145
Hashemeyeh wells	1,550	140	1,550	140
Total	1,088	700	738	2,735

[1] These figures are rounded-up for representing 1994 wet season from the water sampling program as well as WAJ record.

Blending at Batrawi costs less than blending at Khaw. This is because water from the two production wells must be pumped to Khaw for blending and then returned to the supply district. Despite the higher cost, blending at Khaw is proposed. because: 1) the water quantity sent back is relatively small, 2) TDS is much closer to the permissible limit and 3) water with the same TDS value can be distributed to all of Zarqa,

This proposal will also affect the quality of the water which is being sent to Amman. Water from Khaw is mixed at Ain Gazal station at Amman with water brought from other sources. The quality of this blended mix must also be evaluated.

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). TDS concentrations for the blend mix in Stage-1 (target year =2005) is expected to be as follows:

Water Source	TDS (mg/l)	Water Quantity (l/s)
Water from Khaw P/S	814	271
Awajan Well No.21 &22	1,150	59
Awajan Well No.23	1,030	72
Rusaifa Well Water	(500)	278
TDS Concentration	738	680

7.3.2 Zoning and Reservoir

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. Sukhna and Hashemeyeh are geographically independent and have a small demand. Hence, distribution to these two municipalities will continue from the independent reservoirs, receiving water from the Batrawi pumping station.

Zarqa municipality has developed at elevations between 600 m and 650 m on the right bank of the Zarqa river. The Batrawi reservoir has served as the supply point to Zarqa will continue this function. The Batrawi reservoir cannot serve the newly developed hilly areas where additional development has taken place and will continue. Therefore, a new reservoir is proposed to serve this "High Zarqa" zone. Water demand is much smaller than that of the existing "Low Zarqa" zone. As a result, water for the High Zarqa zone will be boosted from the Batrawi reservoir.

The demand in 2015 for the two Zarqa zones together with the other zones is presented in the following table:

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

The Awajan area is divided into high and low zones. The elevation (695 m) at the existing Awajan reservoir is too high to serve the central Awajan area. The Awajan reservoir will be used to serve only areas higher than 620 m. Areas lower than 620 will be served by a new reservoir located at 650 m. A section of the Awajan area near the highway will become part of the lower Zarqa zone.

Rusaifa has steep terrain; the lowest area is at the Zarqa river (600 m), climbing up steeply to 800 m on the north and south sides of the river. This area is currently served by lots of booster pumping stations and in some cases cannot be served due to high elevations and remote distances. During the initial phase of the study, Rusaifa was separated into four zones; north high, north low, south high and south low. However, site investigations indicated that such separation was not feasible due to the lack of appropriate sites for reservoirs in south Rusaifa which is heavily developed. Therefore, the storage requirements for the south high and south low zones are incorporated into north high and north low zones, respectively. New reservoirs will be constructed at 815 m and 750 m. The proposed zoning and command areas for the study area are shown in Fig. 7.4. Fig. 7.5 shows Zarqa zone and Fig.7.6 shows Rusaifa & Awajan zones especially.

The proposed zoning has several advantages;

1) Available pressures are relatively constant.
2) Available pressures are below the regulated pressures.
3) Leakage quantity is small because of the lower pressures.
4) Distribution can easily be controlled, therefore, more equal rationing becomes possible.

It will be necessary to lay transmission lines to interconnecting pumping stations and/or wells with the new reservoirs. The cost of these dedicated lines is considerably smaller than the above - mentioned advantages therefore the benefits outweigh the costs.

7.3.3 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. 7.7. 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..

(2) Transmission of Water to Each Zone

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.

Zone Name	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:

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

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

7.3.4 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:

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.

Reservoir Capacity

Zone Name	Reservoir Name	Required Capacity	Existing Capacity	Additional Capacity
Zarqa High	Res 716	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 operation and management improvements and the implementation of a rehabilitation and expansion program are required. The main reasons for high UFW related to operation and management are:

(1) Leakage of water;

(2) illegal connection and tampering water meter by subscriber; and

(3) meter reading error and insufficient bill collection procedure

7.4.1 Leakage Control Plan

Relatively high leakage rates are recorded in older distribution networks which were constructed in the 1960's and 1970's. WAJ Zarqa carries out repair works when leakage is found. This approach is rather passive. Positive leakage control on routine basis is necessary for the effective reduction 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.

	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

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. 7.8.
The expected construction period for each stage is :

Stage 1 Project: 1999 - 2004
Stage 2 Project: 2011 - 2014

7.5.2 Cost Estimate

Construction and operation & maintenance costs are estimated in this sub-section. Costs for works of this scale may vary significantly, depending on the bidding procedure, contract methods etc. Therefore, the following conditions are assumed;

1. All cost estimates use September, 1995 prices
2. All imported equipment and materials such as pumps and large-sized pipes are exempted from any tax and duties.
3. Construction work will be carried out by a selected contractor (s) through competitive bidding.
4. Physical contingencies applied to cost estimates are :
   Electric and mechanical equipment : 10 %
   Civil works : 10 %

5. The price contingency applied to cost estimates is 5.0 % per year..
6. Exchange rates are :
   US $ 1 : JD 0.70
   US $ 1 : Yen 100

Unit costs are used to determine the project cost for each of the following system components of the proposed system,

1. Pumping Stations
2. Transmission Pipes
3. Service Reservoirs at each zones
4. Distribution Pipes
5. Service Pipes(House connections)

The unit costs are based on other WAJ projects, consultation with local contractors, and quotations from pipe manufactures through local agents.

The estimated construction cost is US $ 85 million and is broken down as follows:

Estimated Project Costs

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

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 and Administration Cost	6,560	1,974	8,534
Physical Contingency	5,416	1,985	7,401
Total Project	63,000	22,000	85,000

7.6 Expected Economic Benefits and Evaluation

7.6.1 General

Economic evaluation of the project is based on calculating the Economic Internal Rates of Return (EIRR) on the basis of the estimated economic benefits and costs. The following principals and assumptions are made for estimating economic benefits and costs:

(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) costs and benefits are estimated on "incremental basis".
(4) only quantifiable benefits are included in the EIRR calculation though considerable non-quantified benefits are expected.

7.6.2 Economic Benefit

Through the implementation of the project, water availability in the Study Area will be considerably improved. This increase of available water is a major source of the economic benefit, which will contribute to enhance regional economic development and welfare of the residents in the following manners:

(1) The improved network will alleviate water shortage and rationing.
(2) The reduced rationing will improve sanitary and hygiene conditions, and generate health benefits in the Study Area. This benefit will be realized particularly in the lower income areas and will contribute to income distribution in the region.
(3) Cost savings for not obtaining water from tankers during periods of rationing is a direct benefit to the residents
(4) Industrial and commercial development will be facilitated, and the resulting increase in employment will enhance social welfare; and
(5) Property values will also increase due to the improved availability of safe drinking water.

Cost savings for WAJ Zarqa in operation and maintenance are also anticipated. The introduction of new distribution zoning and a more efficient distribution system will reduce electrical consumption and provide a substantial economic benefit.

Estimate of Quantifiable Benefit

For the economic calculation, only the benefit from increased water supply and OM cost savings are included as "quantifiable benefits". The benefits of water supply improvements are 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 (JD 0.52/m^3) in WAJ.

(2) The remaining portion of the increase in water supply is valued by applying the difference between the cost of supply from the water tankers (JD 1.42/m^3) and the cost of supply from WAJ (JD 0.52 / 0.46 = JD 1.13 /m^3).

7.6.3 Economic Evaluation

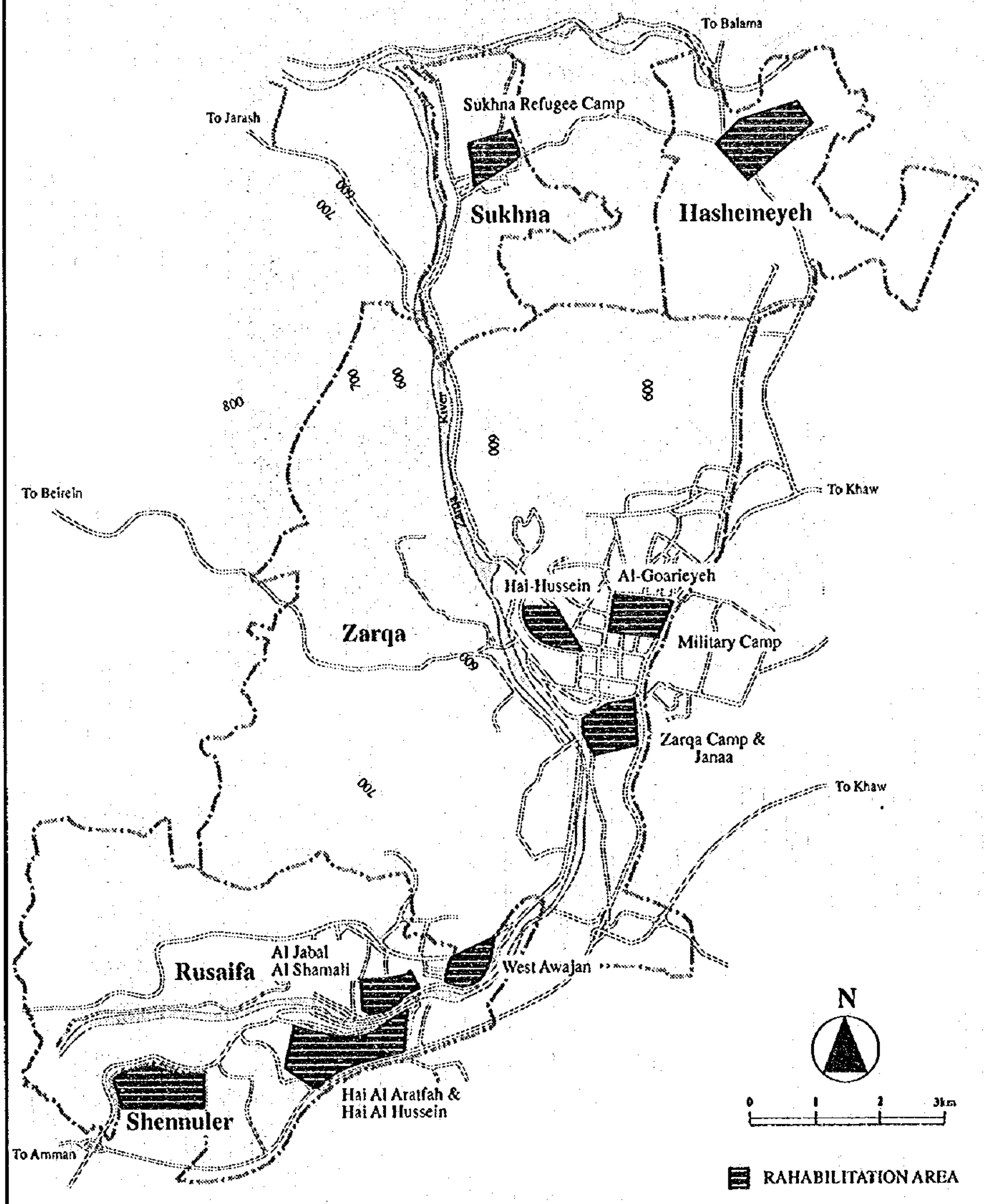
Economic evaluation of the project is made by calculating EIRR based on the estimated economic benefits, project costs and OM cost.

A sensitivity analysis for the following conditions confirms the project's feasibility.

(1) Project costs increase by 15%

(2) OM costs increase by 15%

(3) (1) + (2).



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

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.- 7.1

REHABILITATION AREA

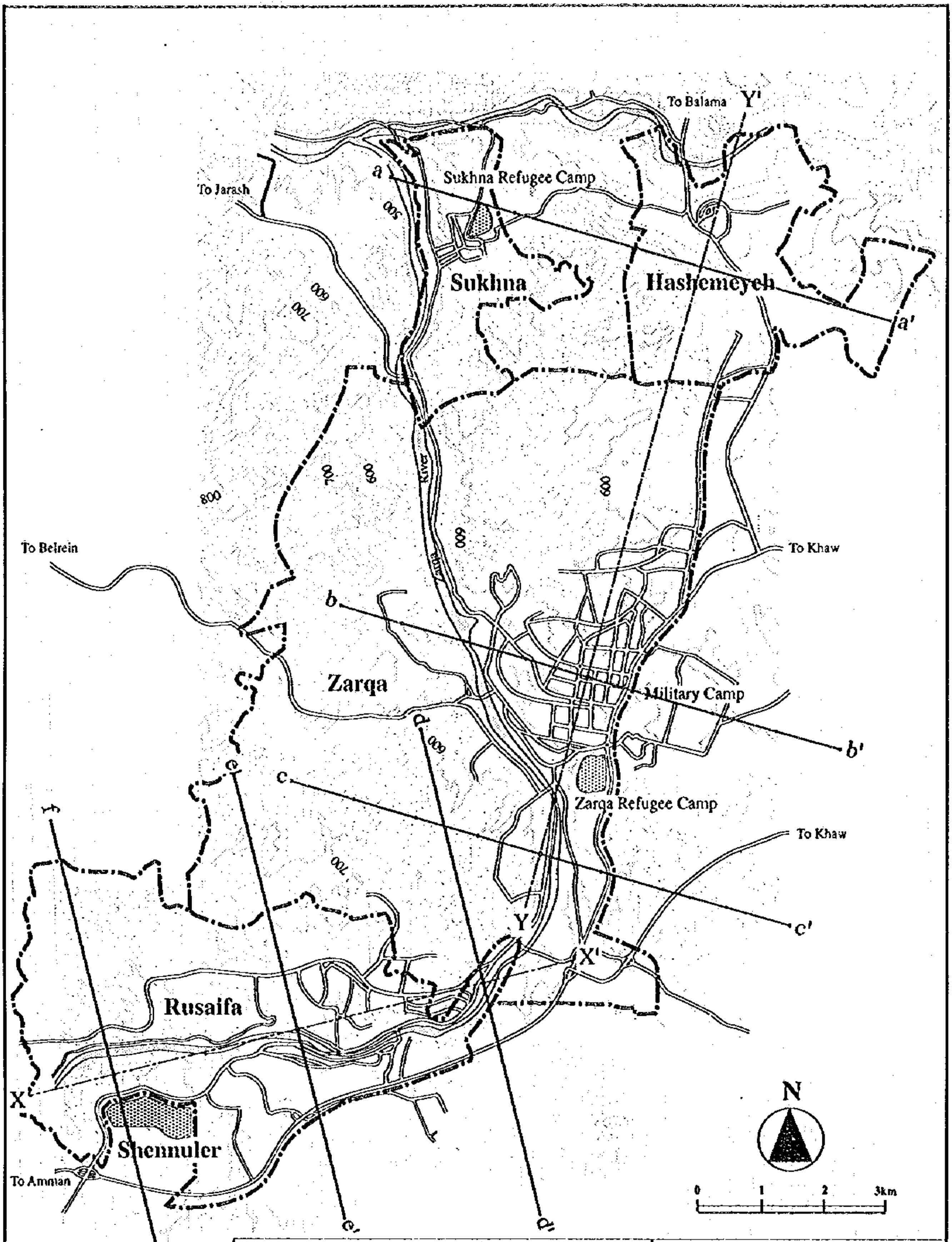


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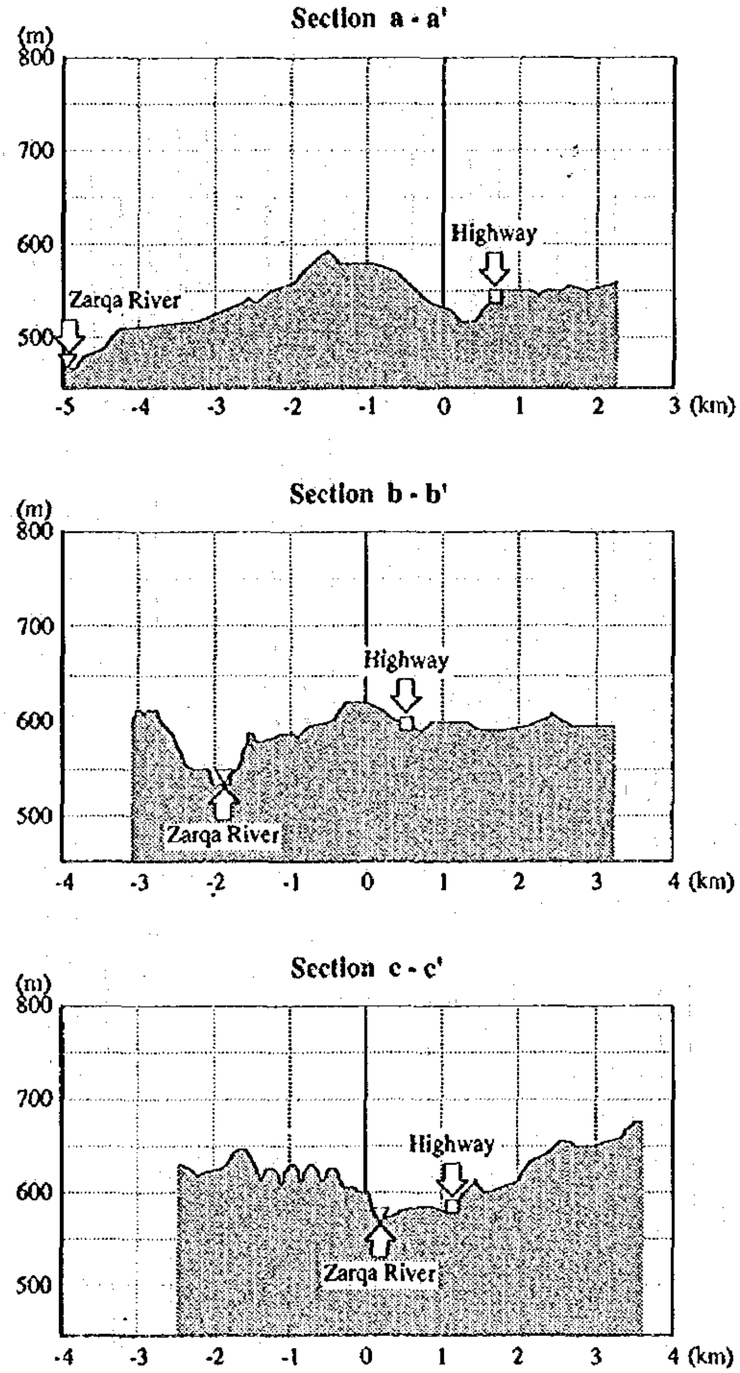
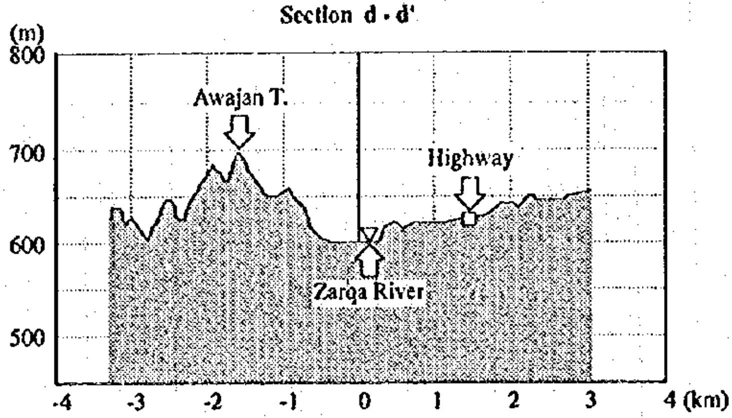
Fig. - 7.2

BASE LINE



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 7.3 (1) CROSS SECTION
JAPAN INTERNATIONAL COOPERATION AGENCY	

Section d - d'



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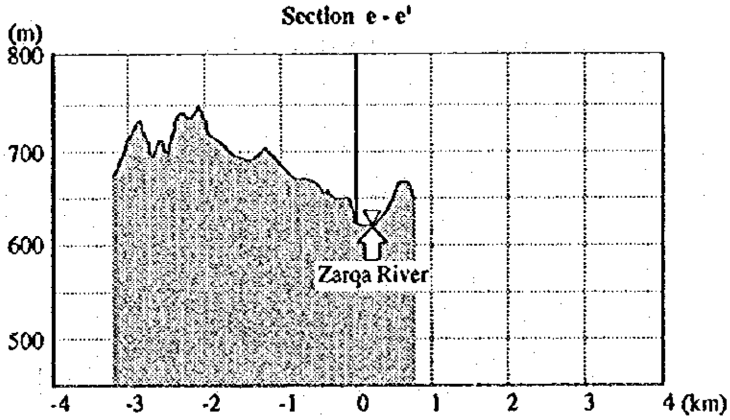

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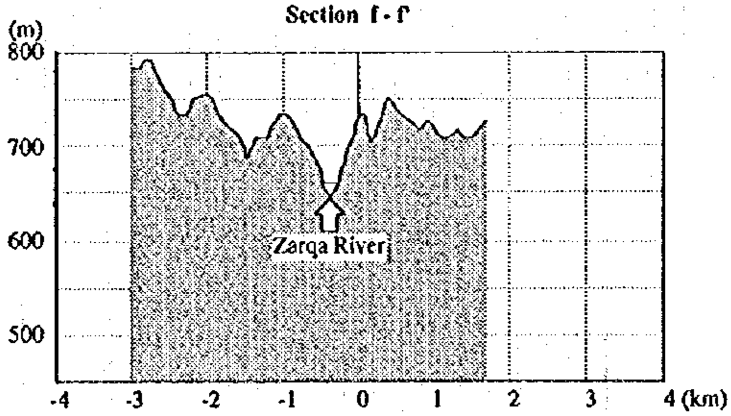

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 7.3 (2)
JAPAN INTERNATIONAL COOPERATION AGENCY	CROSS SECTION

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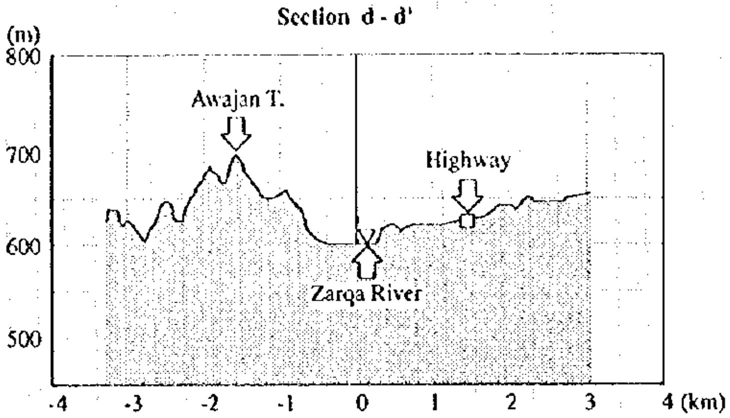

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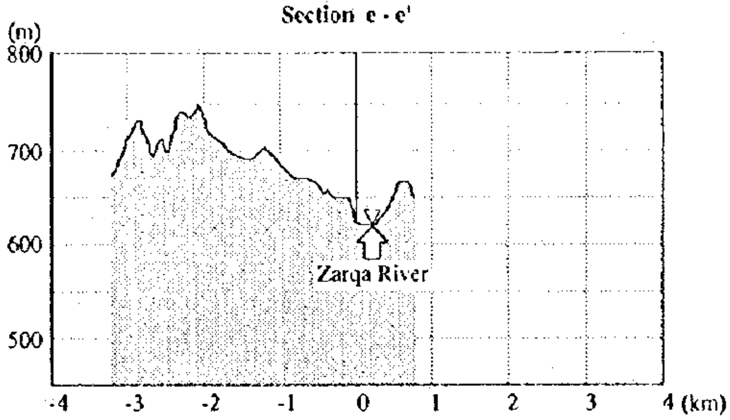

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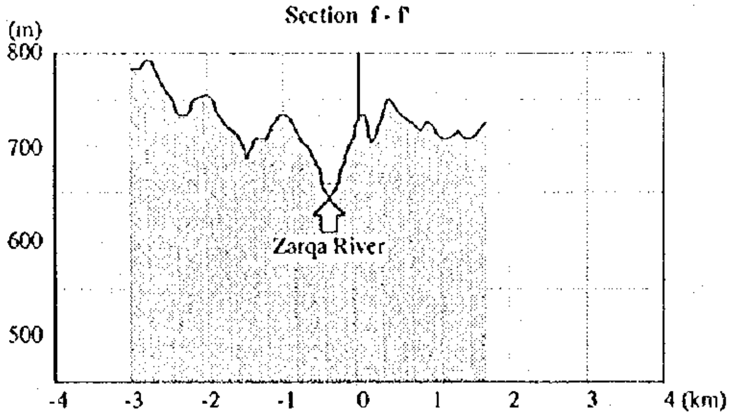
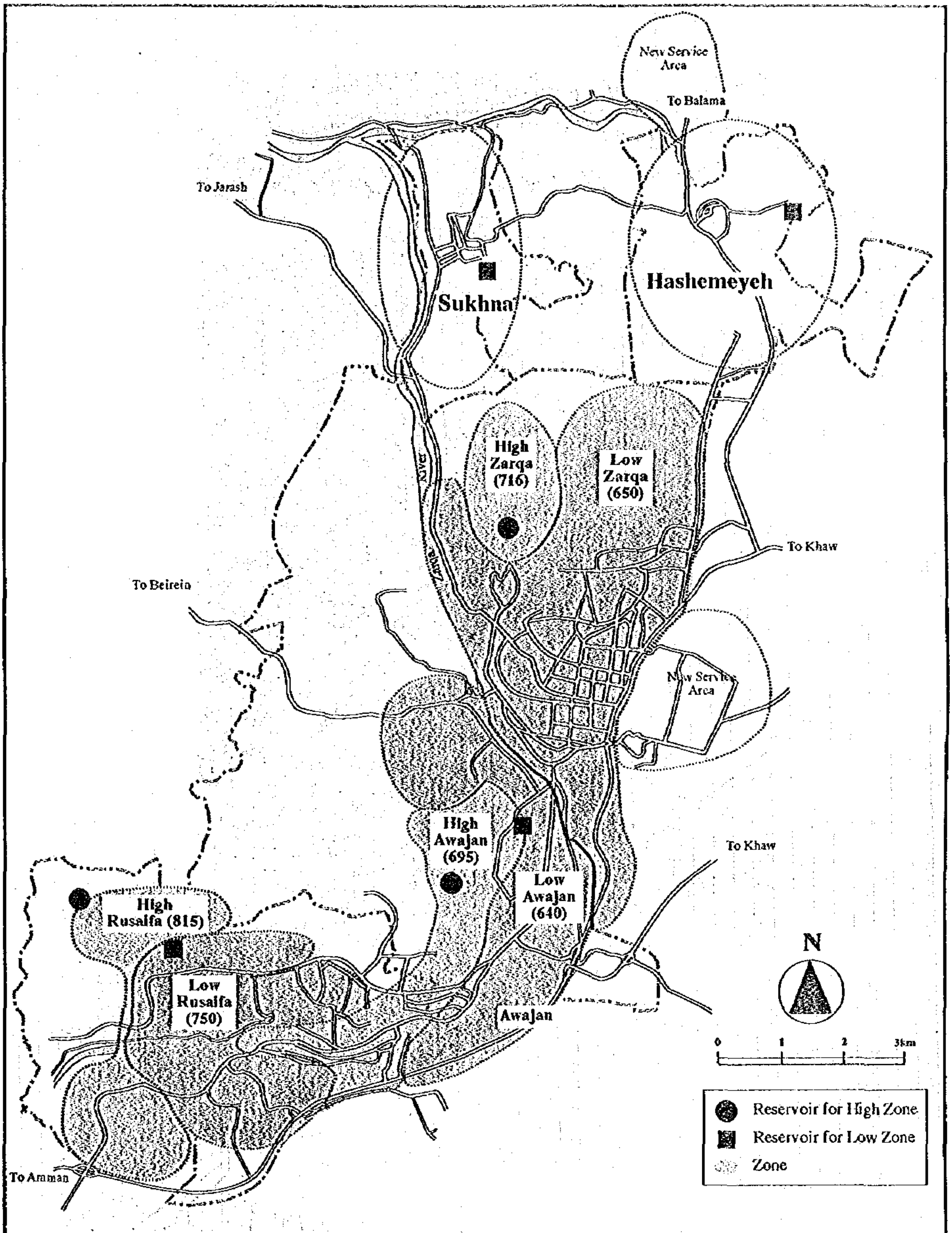
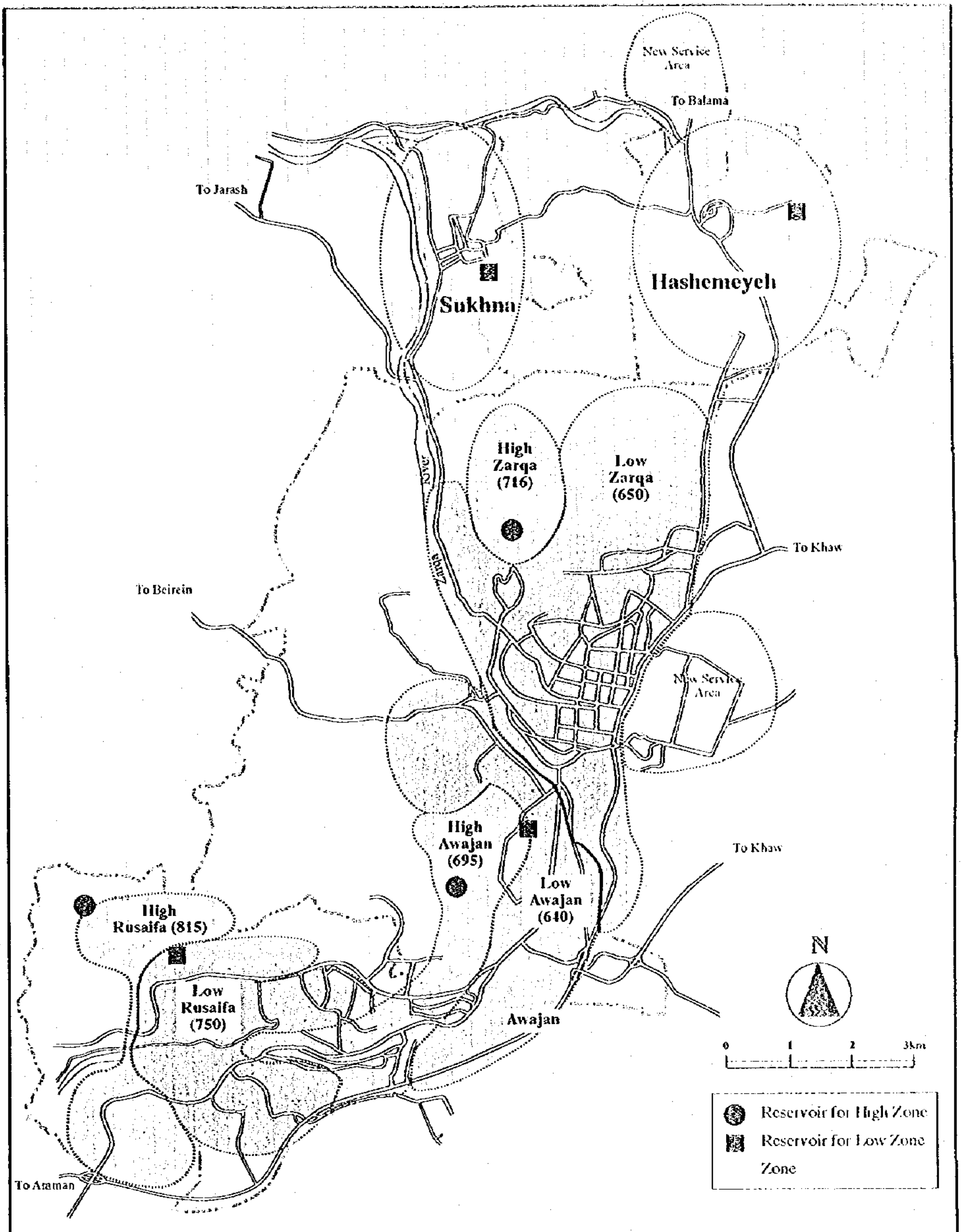


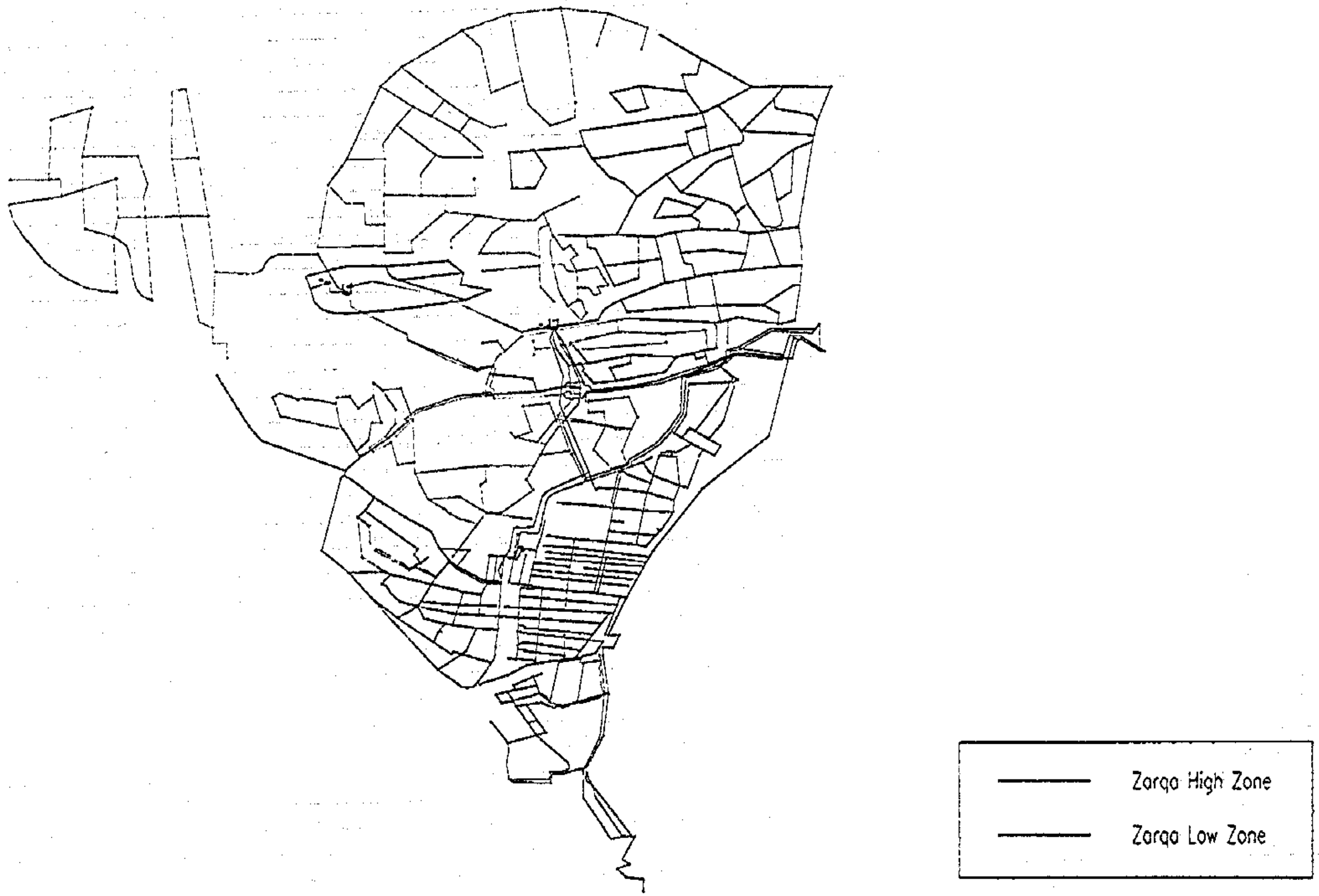
THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 7.3 (2)
JAPAN INTERNATIONAL COOPERATION AGENCY	CROSS SECTION



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 7.4
JAPAN INTERNATIONAL COOPERATION AGENCY	Zoning Map



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 7.4
JAPAN INTERNATIONAL COOPERATION AGENCY	Zoning Map



THE STUDY ON
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FOR THE ZARQA DISTRICT

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Fig.- 7.5

Zarqa Zone

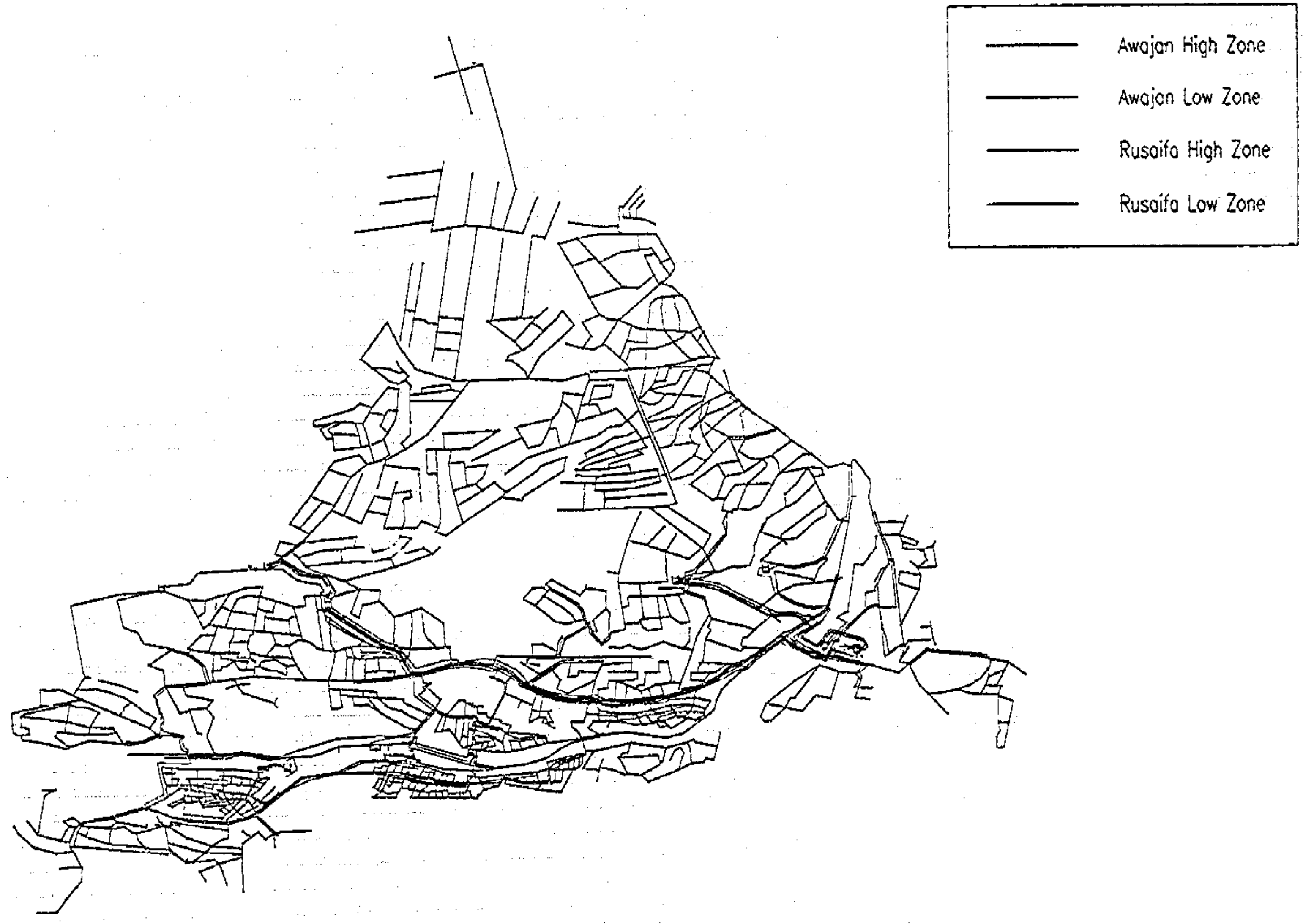

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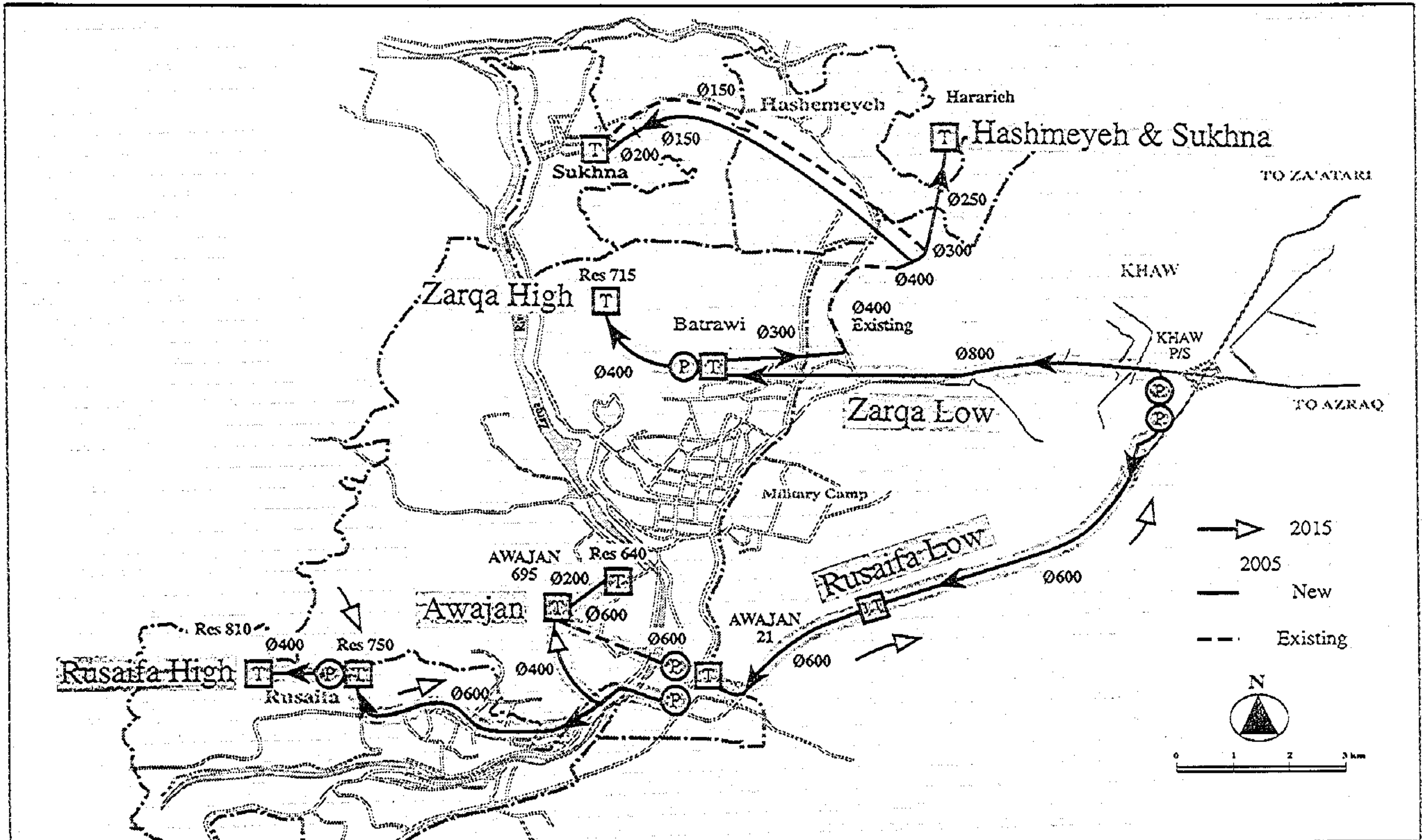
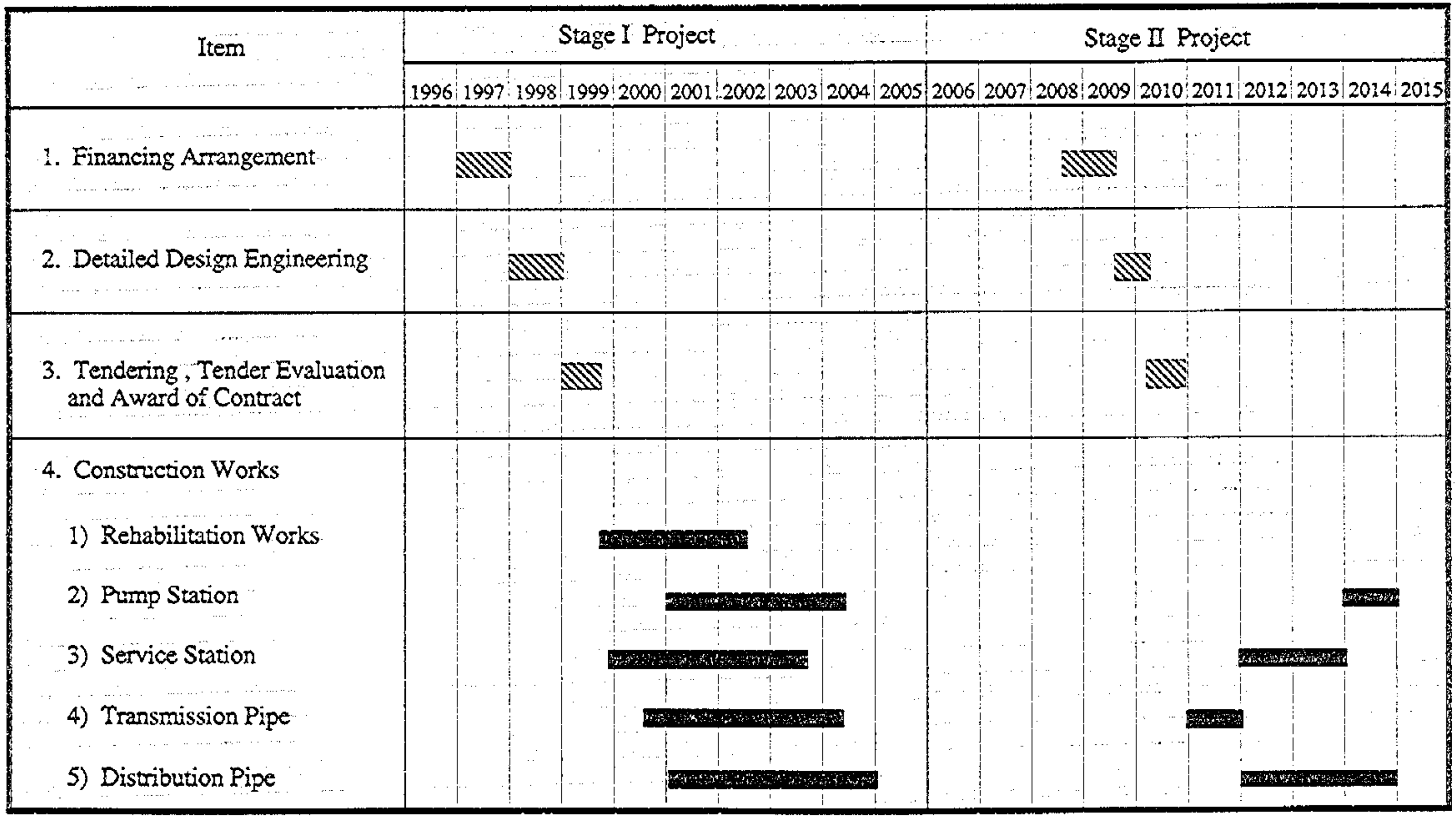
Fig.- 7.6

Rusaifa and Awajan Zones



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig.- 7.7
JAPAN INTERNATIONAL COOPERATION AGENCY	TRANSMISSION SYSTEM

Fig.- 7.8 IMPLEMENTATION SCHEDULE



VIII. INITIAL ENVIRONMENTAL EXAMINATION

VIII. INITIAL ENVIRONMENTAL EXAMINATION

8.1 GUIDELINES FOR INITIAL ENVIRONMENTAL EXAMINATION

8.1.1 Jordanian Environmental Regulations

Environmental policy is now being set by the Department of the Environment , under the Ministry of Municipal and Rural Affairs and Environment (MMRAE). Laws and regulations on environmental protection and environmental impact assessment (EIA) have not been put into effect on a national level in Jordan. However, the Jordanian Government is implementing a program to construct a legal framework for environmental management.

In May 1991, a 'National Environment Strategy for Jordan' was implemented and officially approved. Preparation of this Strategy involved 180 Jordanian specialists from various fields for more than 2 years under the financial support of USAID and technical assistance of the International Union for the Conservation of Nature and Natural Resources.

As the first step of the National Environment Strategy for Jordan, a draft of the Jordan Environment Act was prepared and submitted to the Minister of Municipal and Rural Affairs & the Environment in 1992. The Act is under the procedures of approval now, and its main contents are as follows.

(1)Establishment of the General Environment Corporation as a financially, technically and administratively independent organization to undertake all legal actions for the protection of the environment.
(2)Establishment of the Environment Protection Fund which will be financed by allowances from governmental budget, allocations from local organization, aids, donations and grants from international organizations and penalties due to the violation of environment rules and regulations.
(3)Provisions for environmental elements such as water, air, soil, flora and fauna, and pollutants.
(4)Environmental licensing.
(5)Liability for environmental pollution and insurance.
(6)Fines and penalties.

8.1.2 Japanese Environmental Guidelines

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.

8.2 ENVIRONMENTAL EXAMINATION MATRIX

8.2.1 Matrix Components

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

(1) Project activities

According to the development plan, construction / rehabilitation and operation of the following facilities are included in the project activities.

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

(2) Environmental elements

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

8.2.2. Environmental Impact Screening by EEM

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.

- 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 EXAMINATIONS OF SELECTED ENVIRONMENTAL ELEMENTS

8.3.1 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..

8.3.2 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.

8.3.3 Archaeological Treasures

According to the data from the Institute of Archaeology and Anthropology, there are about 300 archaeological sites. Most of these antiquities seems not so important compared to the cultural heritage on a national/international level. However, 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.

8.3.4 Solid Wastes, Noise and Vibration

According to the data from the Institute of Archaeology and Anthropology, there are about 300 archaeological sites. Most of these antiquities seems not so important compared to the cultural heritage on a national/international level. However, 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.

8.3.5 Sewage Increase due to the Improvement of Water Supply

At present, the water demand for domestic and industrial use is about 10 MCM / year. After the implementation of this project, the demand will increase to 31 MCM / year in 2015. Accordingly, the volume of sewage will increase by an equivalent amount.

In the Study Area, about 58% of the population are served by the public a sewer system. But, the remaining are using septic tanks. Increases in waste water might aggravate the water quality in the river and groundwater, effects of which will be further studied. In addition, groundwater from Zarqa which will be used for water supply has a high TDS. These high concentrations of TDS will not be reduced significantly before being discharged at the sewage treatment plant therefore water quality in the Zarqa river and the King Talal Dam may deteriorate with time.

Fig.- 8.1 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.

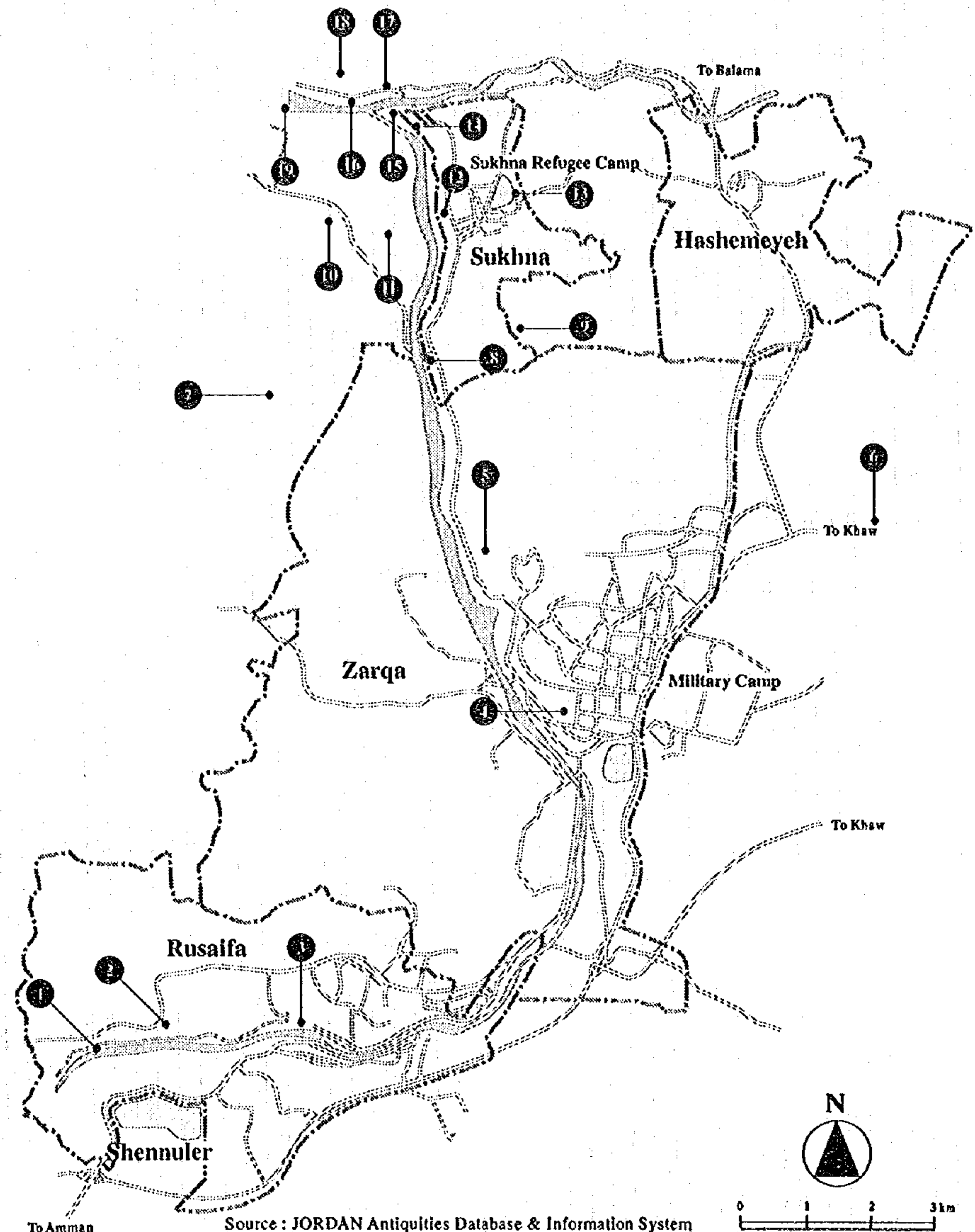
TABLE 8.1 LIST OF MAIN ANTIQUITIES IN THE STUDY AREA

NO.	SITE NAME	TYPE		
		PERIOD	USE	
1	ER-RESEIFAWI	UNSPECIFIED IRON AGE	03	SHERD/FLINT SCATTER (MAIN PRESENCE)
			25	OTHER/UNSPECIFIED STRUCURE OR WALL FOU
		EARLY BYZANTINE	01	SHERD/FLINT SCATTER
		UNSPECIFIED ISLAMIC	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	52	CISTERN
2	KHIRBET ER-RUSEIFA	EB IV (EB-MB)	01	SHERD/FLINT SCATTER
		UNSPECIFIED IRON AGE	01	SHERD/FLINT SCATTER
		UNSPECIFIED ROMAN	01	SHERD/FLINT SCATTER
		UNSPECIFIED BYZANTINE	01	SHERD/FLINT SCATTER
		UNSPECIFIED ISLAMIC	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	22	CAVE/SHELTER
			25	OTHER/UNSPECIFIED STRUCURE OR WALL FOU
3	RUSEIFAH	EB IV (EB-MB)	03	SHERD/FLINT SCATTER (MAIN PRESENCE)
		MB I (MB IIA)	01	SHERD/FLINT SCATTER
		UNSPECIFIED IRON AGE	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	12	FORTIFIED SETTLEMENT
4	QASR SHABIB (ZARQA)	UNSPECIFIED AYYUBID/MAMLUK	14	FORTRESS
			52	CISTERN
		UNSPECIFIED OTTOMAN	14	FORTRESS
			81	ARABIC INSCRIPTION
5	JREYYEH	EB II	01	SHERD/FLINT SCATTER
			13	POSSIBLY FORTIFIED SETTLEMENT
		EB III	01	SHERD/FLINT SCATTER
			13	POSSIBLY FORTIFIED SETTLEMENT
		EB IV (EB-MB)	01	SHERD/FLINT SCATTER
			13	POSSIBLY FORTIFIED SETTLEMENT
6	KHIRBET KHAU	UNSPECIFIED BYZANTINE	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	11	VILLAGE SITE (NO FORTIFICATIONS)
			22	CAVE/SHELTER
			52	CISTERN
			96	OTHER TYPE OF TOMB
7	KHIRBET ABU EZ-ZEIGI	PPNB	01	SHERD/FLINT SCATTER
		IRON IIA/B	01	SHERD/FLINT SCATTER
		IRON IIC	01	SHERD/FLINT SCATTER
		UNSPECIFIED ROMAN	01	SHERD/FLINT SCATTER
		UNSPECIFIED BYZANTINE	01	SHERD/FLINT SCATTER
		UNSPECIFIED AYYUBID/MAMLUK	01	SHERD/FLINT SCATTER
		UNSPECIFIED OTTOMAN	41	HAMLET/FARMSTEAD
		UNSPECIFIED PERIOD FLINTS	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD POTTERY	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	41	HAMLET/FARMSTEAD
			67	STONE FENCES/ENCLOSURES
			96	OTHER TYPE OF TOMB
8	KHIRBET ES-SEIL	UNSPECIFIED ROMAN	01	SHERD/FLINT SCATTER
		UNSPECIFIED BYZANTINE	01	SHERD/FLINT SCATTER
		UNSPECIFIED ISLAMIC	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	25	OTHER/UNSPECIFIED STRUCTURE OR WALL FO
9	KHIRBET MAKHUL	IRON IIA/B	01	SHERD/FLINT SCATTER
		IRON IIC	01	SHERD/FLINT SCATTER
		UMAYYAD	01	SHERD/FLINT SCATTER
			11	VILLAGE SITE (NO FORTIFICATIONS)
		ABBASID	01	SHERD/FLINT SCATTER
			11	VILLAGE SITE (NO FORTIFICATIONS)
		UNSPECIFIED AYYUBID/MAMLUK	01	SHERD/FLINT SCATTER
			11	VILLAGE SITE (NO FORTIFICATIONS)
10	KHIRBET EL-JAMUS	IRON I	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		IRON IIA/B	01	SHERD/FLINT SCATTER
			14	FORTRESS
		IRON IIC	01	SHERD/FLINT SCATTER
			14	FORTRESS
		LATE ROMAN	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		UNSPECIFIED BYZANTINE	01	SHERD/FLINT SCATTER
		UMAYYAD	01	SHERD/FLINT SCATTER
		UNSPECIFIED AYYUBID/MAMLUK	01	SHERD/FLINT SCATTER
			21	NOMADIC CAMP
			62	ANIMAL PEN
		UNSPECIFIED PERIOD POTTERY	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	52	CISTERN
11	JABAL ER-REHEIL	UPPER PALEOLITHIC	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		EB II	01	SHERD/FLINT SCATTER
			13	POSSIBLY FORTIFIED SETTLEMENT

TABLE 8.1 LIST OF MAIN ANTIQUITIES IN THE STUDY AREA

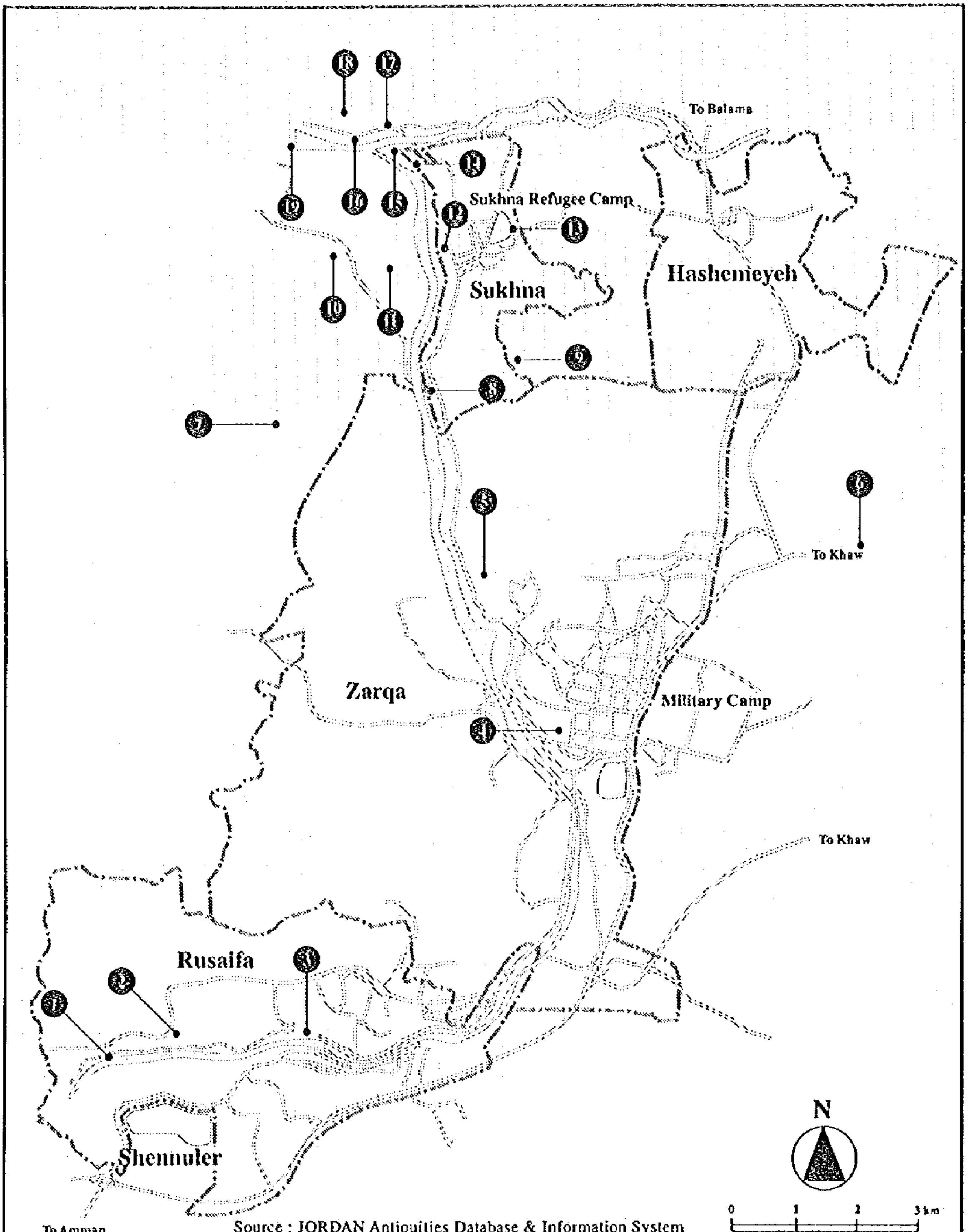
		EB IV (EB-MB)	01	SHERD/FLINT SCATTER
			13	POSSIBLY FORTIFIED SETTLEMENT
		UNSPECIFIED ROMAN	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		UNSPECIFIED BYZANTINE	01	SHERD/FLINT SCATTER
		UNSPECIFIED AYYUBID/MAMLUK	01	SHERD/FLINT SCATTER
			11	VILLAGE SITE (NO FORTIFICATIONS)
		UNSPECIFIED PERIOD FLINTS	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	22	CAVE/SHELTER
12	TELL ES-SUKHNEH	MB II/III (MB IIB/C)	03	SHERD/FLINT SCATTER (MAIN PRESENCE)
			06	MULTI-PERIOD STRATIFIED SITE (TELL OR KHI
		IRON I	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		IRON IIA/B	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		PERSIAN (IRON III)	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		EARLY NABATAEAN	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
			03	SHERD/FLINT SCATTER (MAIN PRESENCE)
		UNSPECIFIED ROMAN	01	SHERD/FLINT SCATTER
			06	MULTI-PERIOD STRATIFIED SITE (TELL OR KHI
		UNSPESIFIED BYZANTINE	01	SHERD/FLINT SCATTER
			06	MULTI-PERIOD STRATIFIED SITE (TELL OR KHI
		MODERN (1915-1950)	24	ISOLATED STRUCTURE/HOUSE
		UNSPECIFIED PERIOD POTTERY	01	SHERD/FLINT SCATTER
13	SUKHNE EAST	IRON IIA/B	01	SHERD/FLINT SCATTER
		IRON IIC	01	SHERD/FLINT SCATTER
		MODERN (1915-1950)	01	SHERD/FLINT SCATTER
			21	NOMADIC CAMP
14	ZAQM ESH-SHARQI	MIDDLE PALEOLITHIC	01	SHERD/FLINT SCATTER
		UNSPECIFIED PPN	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		UNSPECIFIED ROMAN	01	SHERD/FLINT SCATTER
		UNSPECIFIED BYZANTINE	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		ABBASID	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		MAMLUK	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD FLINTS	01	SHERD/FLINT SCATTER
15	KHIRBET ZAQM EL-GHU	LOWER PALEOLITHIC	01	SHERD/FLINT SCATTER
		UNSPECIFIED ROMAN	01	SHERD/FLINT SCATTER
		UNSPECIFIED BYZANTINE	01	SHERD/FLINT SCATTER
		MAMLUK	01	SHERD/FLINT SCATTER
		MODERN (1915-1950)	88	GRAVE
		UNSPECIFIED PERIOD FLINTS	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD POTTERY	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	25	OTHER/UNSPECIFIED STRUCTURE OR WALL FO
16	WAD'AH	PNA/YARMOUKIAN	03	SHERD/FLINT SCATTER (MAIN PRESENCE)
			11	VILLAGE SITE (NO FORTIFICATOINS)
		UNSPECIFIED BYZANTINE	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD POTTERY	01	SHERD/FLINT SCATTER
17	HASYA I	UNSPECIFIED CHALCOLITHIC	01	SHERD/FLINT SCATTER
			11	VILLAGE SITE (NO FORTIFICATIONS)
		EB I	01	SHERD/FLINT SCATTER
			11	VILLAGE SITE (NO FORTIFICATIONS)
		UNSPECIFIED BYZANTINE	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD POTTERY	01	SHERD/FLINT SCATTER
18	KHIRBET EL-WAD'AH	EB IV (EB-MB)	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		UNSPECIFIED LB	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		UNSPECIFIED IRON AGE	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		UNSPECIFIED ROMAN	02	SHERD/FLINT SCATTER (UNCERTAIN PRESENCE
		UNSPECIFIED BYZANTINE	11	VILLAGE SITE (NO FORTIFICATIONS)
		MAMLUK	11	VILLAGE SITE (NO FORTIFICATIONS)
			62	ANIMAL PEN
		MODERN (1915-1950)	62	ANIMAL PEN
		UNSPECIFIED PERIOD POTTERY	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	22	CAVE/SHELTER
			52	CISTERN
19	EL-NIMRAH	EB IV (EB-MB)	01	SHERD/FLINT SCATTER
		UNSPECIFIED IRON AGE	01	SHERD/FLINT SCATTER
		UNSPECIFIED ROMAN	01	SHERD/FLINT SCATTER
		UNSPECIFIED BYZANTINE	01	SHERD/FLINT SCATTER
		UNSPECIFIED ISLAMIC	01	SHERD/FLINT SCATTER
		UNSPECIFIED PERIOD STRUCTURE	24	ISOLATED STRUCTURE/HOUSE
			25	OHTER/UNSPECIFIED STRUCTURE OR WALL FO

Source: JORDAN Antiquities Database and Information System



Source : JORDAN Antiquities Database & Information System

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig - 8.2 MAIN ANTIQUITIES DISTRIBUTION IN ZARQA DIS.
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source : JORDAN Antiquities Database & Information System

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig - 8.2 MAIN ANTIQUITIES DISTRIBUTION IN ZARQA DIS.
JAPAN INTERNATIONAL COOPERATION AGENCY	

PART II FEASIBILITY STUDY

I. INTRODUCTION

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 master plan.

1.2 Study Area

Area and Population

The Study Area is Zarqa district, same as in the master plan. Zarqa District is situated 35 km northeast of the capital, Amman. Zarqa district includes the urban areas of Zarqa municipality, Rusaifa municipality, Hashemeyeh 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.

The size and population of the municipalities in the Study Area both in 1979 and 1994 are presented in the following table.

Area and Population

Study Area	Area (km^2)	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 partly to the returnees from the Gulf countries.

Topography and Climate

Zarqa district is concentrated around the Zarqa river which runs east through Rusaifa then turns north with Zarqa on its eastern side. Through Rusaifa the elevation of the river is around 650 m AND (above national datum) with properties on the north and south sides, having ground elevations rising to 815 m AND and 776 m AND respectively. As the river runs north its elevation drops to 525 m AND whilst central Zarqa rises to over 625 m AND to its east.

Located at the western fringes of the inland desert, the Study Area has an arid climate throughout the year. The annual rainfall ranges from 160 mm to 310 mm with virtually all of the rainfall between the months of October and April.

Public Health

The study area is generally well serviced by infrastructure for public hygiene. About 99 % of the households are serviced by WAJ domestic water supply system. (According to the household survey conducted by us in December 1994, 96 % of the households use WAJ pipe system, 3 % use WAJ water tanks and 1 % use wells). However, water rationing is required in some areas, particularly, during the summer season. The installation of roof tank/ground reservoir and purchasing domestic water from private water tankers is common practice. Public health is being affected by deteriorating water quality caused by waste water intrusion into the wells.

In Zarqa Governorate, about 58 % of the residents are connected to the public sewerage system and the remaining 42% use cess pools. This is a relatively high installation ratio compared to other developing countries. However, waste water volumes exceed the capacity of the treatment plant installed at As Samura by more than twice, which results in discharging partially-treated water into rivers which deteriorates the living environment in Zarqa. Sewerage effluent is also used for agricultural irrigation which and has contributed the deterioration of public health and hygiene.

Other unfavorable public hygiene & health aspects in the Study Area are rapid urbanization and industrialization. Increased traffic and discharges from major factories installed along Ruseifa - Zarqa municipalities cause air pollution and water contamination. According to our factory survey, some factories are dumping industrial wastes and sludge into the public sewer lines or directly into Zarqa river without proper treatment.

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

The land near the boundary of Rusaifa and Amman is allocated for liquid waste disposal. The liquid waste is collected by tankers with a capacity of 10m3 and dumped into a waste water pond for evaporation. However, contaminated water from the pond is occasionally flushed out into the tributary of the Zarqa river during the winter season..

Land Use

The present urban development in the Study Area can be grouped into the following three different development categories:

Residential development

Considering the rapid urbanization observed in the Study Area, the most important factor is residential development. Residential development started from the core of the municipalities such as Zarqa city and Rusaifa as well as Hashemeyeh and Sukhna. The development area has been expanding in the west to south direction from the core. New housing development is underway in Awajan, north of Zarqa and north Hashemeyeh. At present, there are ten on-going public housing projects in the Study Area, providing 5,307 plots / buildings for the estimated served population of 82,080.

Industrial development

The Study Area has been recognized as the most industrialized area in Jordan, and major industrial establishments such as a petroleum refinery plant and a thermal electricity power plant are concentrated around this area. In addition, most major industrial establishments are located in the Study Area, particularly along the Zarqa-Rusaifa corridor from the south of Zarqa to the east of Rusaifa. Recently, government agencies have been directing new industrial establishments to locate on upland areas to the south of Zarqa to facilitate access from the Amman-Zarqa highway.

Refugee camp development

Three Palestinian refugee camps are located in the Study Area, namely, the Shennuler camp, the Zarqa camp, and the Sukhna camp, each of which was established in 1968, 1948, and 1968, respectively. Population in the camps, except Shennuler camp, seem to have already reached saturation levels.

Present land use in the Study Area is prepared by the JICA Study Team. The composition of land use in the Study Area is presented below.

Present Land Use

Land Use	Area	Percentage
Residential Area	29.0 km^2	32.0 %
Mixed Area	11.2 km^2	12.4 %
Industrial Area	7.2 km^2	8.0 %
Agricultural Area	3.7 km^2	4.1 %
Public Area	1.9 km^2	2.1 %
Open Space Area	1.4 km^2	1.5 %
Refugee Camp	0.8 km^2	0.9 %
Vacant Land	35.3 km^2	39.0%
Total	90.5 km^2	100.0 %

1.3 Objective

The master plan identifies the following issues 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 Sources

1.4.1 Population Served

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.

Projected Population in the Study 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:

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 Sources

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.

Water Source And Quantity

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 totally from Khaw or Khaw and Rusaifa 4 in 2005.

II. PROJECT DESCRIPTION

2. PROJECT DESCRIPTION

Rehabilitation and expansion of the existing water supply system will be undertaken under the Stage I Project. This sub- section develops the design concepts and the preliminary design of the expanded facilities to determine the technical requirements and capacity of each facility.

The projects which were identified under the first stage program in the master plan and for this feasibility study, are presented in Table 2.1 and Fig. 2.1.

2.1 Design Concept

2.1.1 Pumps

1) Type of pump:
   - Selection of a multi-stage volute pump suitable for high lift
   - Installation of pump at lower position of suction water level for easy operation, omitting vacuum pump equipment
2) Number of pump:
   - installation of 4 to 5 duty pumps for the large scale pumping stations of Khaw and Awajan (see Figs. 2.2 to 2.3), transmitting constant flows and controlling pump operations with numbers for seasonal water demand
   - Installation of 3 duty pumps for the small scale pumping stations of Batrawi and Rusaifa
   - installation of 1 standby for each pump set
3) Control of pump operation:
   - Control based on water levels of service reservoir
   - Telemetry system for Khaw pumping station
4) Flow meter and control valve:
   - Installation of venturi type flow meters with indicator, recorder and integrator for controlling the transmission flow
   - Installation of butterfly type control valves for regulating the transmission flow
   - Monitoring of the flow rate in each pump station
5) Hoist crane:
   - Installation of hoist crane for each station for pump installation and repair
6) Header pipe:
   - Installation of steel header pipes on suction and delivery side of pumps
7) Building:
   - Reinforced concrete structure for columns and beams, and concrete block structure for wall

Table 2.1 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

8) Water hammer device:-Installation of water hammer devices for high-lift pumps in Awajan high zone and Rusaifa low zone pumping stations.

2.1.2 Pipe

1) Diameter: - 100 mm, 150 mm, 200 mm, 250 mm, 300 mm, 400 mm, 500 mm, 600 mm and 800 mm
2) Pipe material: - Ductile iron pipe with cement mortar lining and tar epoxy coating for transmission and distribution pipes
3) Joint: - Push-in type for pipes and thrust blocks for bends and tees
4) Air-valve and wash-out valve:
   - Installation of air-valve with quick exhaust type at the high points and wash-out valves at the appropriate points for washing of pipelines
5) River crossing: - River-bed crossing type
   - Steel pipe with cement mortar lining of electric arc welding joint and reinforced concrete covering of outside

2.1.3 Service Reservoir

1) Capacity: - 8 hours for daily maximum supply
2) Structure: - Reinforced concrete
3) Over flow and wash-out pipes:
   - Installation of over flow pipe in the reservoir
   - Installation of wash-out pipes
4) Float valve: - Installation of altitude valve for inlet pipe to regulate inflow by water level
5) Flow meter: - Installation of venturi type flow meter with recorder, indicator and integrator for measuring of distribution flow
   - Accommodating venturi tube in a reinforced concrete chamber and indicator and others in small house
6) Water level indicator:
   - Magnetic type indicator with float
   - Installation on the roof of reservoir

2.1.4 Chlorination System

Chlorination is usually provided at the reservoirs. There are eight reservoirs which makes the number and therefore the cost of chlorination large. In order to minimize the number, chlorination systems will be located at the Khaw and Awajan pumping stations since both stations will function as collecting centers of various sources of well water.

Lengthy transmission pipelines such as the Hashemeyeh and Sukhna lines will consume most of the residual chlorine, so that further chlorine will be added at the reservoirs to maintain minimum residual chlorine levels. Thus, small scale chlorination systems will be provided at the outlet of Batrawi reservoir to Hashemeyeh and Sukhna reservoirs.

1) Chlorinator:
- Vacuum injection type chlorinator which is no chlorine leakage and possible to dose the chlorine to higher point from the chlorinator
- 2 of chlorinator including 1-standby

2) Booster pumps:
- Installation of 2 pumps, 1-duty and 1-standby, to supply pressured water to the injector of chlorinator

3) Evaporator:
- Installation of an evaporator for use of 1,000 kg containers to increase chlorine evaporation during the cold season

4) Hoist crane:
- Installation of a hoist crane to change 1,000 kg chlorine containers

2.1.5 Distribution Network

1) Pipes and accessories:
- Conforming to transmission pipe specifications

2) Available head:
- minimum 30 m and maximum 90 m at the end of the distribution pipeline

2.2 Transmission System

The water demand in each service area by the year 2005 will not be much different than that of 2015. Therefore the system is planned to meet the water demand in 2015. However, the shortfall for the water demand in Awajan and Rusaifa areas is expected to be supplemented by Amman at Rusaifa low zone reservoir. Accordingly, the facilities to Awajan 21 PS and Rusaifa low zone reservoir are planned by the water demand in 2005.

A line profile survey was carried out along the transmission pipelines (and two major distribution lines), interconnecting pumping stations and reservoirs. The lines are shown in Fig. 2.4 and the results are attached to the Data Book.
A topographic survey was also made for the proposed reservoirs and pumping stations (see Fig. 2.5). Layout of pumping stations and reservoirs is shown in Figs. 2.6 to 2.13.

2.2.1 Zarqa Low Zone Reservoir (RES 650) from Khaw PS

Water required in Zarqa, Hashemeyeh and Sukhna zones is transmitted to Batrawi low zone service reservoir from Khaw PS. From Batrawi RES T-650, Water is pumped-up to Batrawi high zone reservoir (RES T-716) and flows by gravity to Hashemeyeh and Sukhna reservoirs, respectively. The pipeline is sized to meet transmission flows into the year 2015. From each reservoir, water is distributed to service areas by gravity flow. The longitudinal section and hydraulic gradient of the pipeline are shown on Fig. 2.14.

1) Planned transmission flow:

- Zarqa low zone	573 l/s (in 2015)
- Zarqa high zone	134 l/s (in 2015)
- Hashemeyeh and Sukhna zones	99 l/s (in 2015)
Total flow	806 l/s (in 2015)

2) Pipeline:
- ø 800 mm and 7,900 m long
- velocity, v = 1.60 m/s

3) pump:
- 4 duty units and 1 standby, total 5 units (1 unit is to be added in Stage 2)
- ø 300 x ø 250 x 9.7 m^3/min. x 77 m x 310 kW double suction type
- Pump house with 165 m^2 and electric room of 120 m^2 accommodating power distribution panel, switch gear panel and necessary panels, and monitoring room of 75 m^2

4) Chlorinator:
- 2 chlorinators (max. capacity of 6 kg/h)
- 1 evaporator with a capacity of 50 kg/hr
- 2 booster pumps

2.2.2 Batrawi High Zone Reservoir (T-716) from Batrawi PS

Batrawi reservoir T-716 is supplied with water by pumping up from Batrawi PS.
The longitudinal section and hydraulic gradient of the pipeline are shown on Fig. 2.15.

1) Planned flow: - 134 l/s (in 2015)

2) Pipeline: - ø 400 in diameter and 2,200 m long (v = 1.1 m/s)

3) Pump:
- 2 duty units in and 1 standby unit, total 3 units (1 unit is to be added in Stage 2)
- ø 150 x ø100 x 2.7 m^3/min. x 87 m x 75 m single suction type
- Pump house with 140 m2 including electrical room

2.2.3 Hashemeyeh (T-600) and Sukhna (T-580) Reservoirs from Batrawi PS

Hashemeyeh and Sukhna reservoirs (T-600 and T-580) are supplied with water by gravity flow from Batrawi low zone RES T-650. The existing 400 mm diameter pipeline between Zarqa PS and Hashemeyeh PS and the existing 150 mm diameter pipeline of from Hashemeyeh PS to Sukhna will be re-used as transmission lines. The longitudinal sections and hydraulic gradients of the pipelines are shown on Figs. 2.16 and 2.17.

Supplementary chlorination system is provided at the reservoirs to increase residual chlorine levels at both T-600 and T-580 reservoirs because of the lengthy transmission lines.

1) Planned flow:	- Hashemeyeh area		72 l/s (in 2015)
	- Sukhna area		27 l/s (in 2015)
	Total flow		99 l/s (in 2015)
2) Pipeline:	- To Hashemeyeh reservoir		
		ø 300 mm and 2,300 m long (v = 1.4 m/s)	
		ø 400 mm and 100 m long (v = 0.8 m/s)	
		Existing ø 400 mm and 4,700 m long	
		ø 250 mm and 1,900 m long (v = 1.5 m/s)	
	- To Sukhna	ø 200 mm and 1,000 m long (v = 0.9 m/s)	
		ø 150 mm and 6,800 m long (v = 0.8 m/s)	
		Existing ø 150 mm and 7,800 m long	
3) Chlorinator:	- 2 chlorinators (max. Capacity of 3 kg/h)		
	- 2 booster pumps		

2.2.4 Awajan 21 PS from Khaw PS

In accordance with the water demand increase in Zarqa, Hashemeyeh and Sukhna areas in future, the transmission flow to Awajan 21 PS will gradually decrease. After the year 2010, the water is to be transmitted to Awajan PS from Rusaifa low zone reservoir by gravity flow. Therefore, 600 mm in diameter of pipeline is employed to reduce the pump head.

The proposed pipeline will pass a hill of EL. + 660 m on the way to Awajan 21 PS. Pumping will be required to pass the hill. A junction tank will be built on the hill site to establish a free air conditions. This tank will also act as a service reservoir for an adjacent population area (refer to Appendix B). From the tank, water will be transmitted to Awajan PS by gravity flow. A longitudinal section and hydraulic gradient of the pipeline are shown on Fig. 2.18.

1) Planned flow: - 270 l/s (in 2005)
2) Pipeline: - ø 600 mm and 12,200 m long (v = 1.0 m/s)
3) Pumps: - 4 units in duty and 1 unit standby, total of 5 units

- ø 200 x ø 150 x 4.1 m^3/min. x 79 m x 110 kW
  single suction type
- Pump house with 135 m^2, electrical room 120 m^2 and monitoring room 75 m^2 (common use with Batrawi transmission pump

2.2.5 Awajan High and Low Zone Reservoirs (T-695 & -635) from Awajan 21 PS

The existing 600 mm in diameter pipeline from Awajan RES T-695 branching off the Khaw - Amman line will be used as a transmission pipeline. The water demand allotted in RES T-635 is about 17 % of the total demand for the Awajan area. It is proposed water be pumped-up to T-695 from Awajan PS and transmitted by gravity flow to T-635.

The flow pumped to T-695 is expected to reach a maximum in 2010. Supplementary water from Rusaifa RES T-750 will be directly conveyed to T-695 by gravity flow through a new pipeline which will be installed under the Stage 2 Project. Therefore, the system is planned to meet the 2010 demand.

Water from the existing Awajan Rusaifa wells is received at Awajan 21 PS for mixing to the water from Khaw PS. A chlorination system will be provided at the pump station to chlorinate well water.

The longitudinal section and hydraulic gradient of the pipeline are shown on Fig. 2.19.

1) Planned flow:
   - Awajan high zone 297 l/s (2010)
   - Awajan low zone 61 l/s (2010)

   Total flow 358 l/s (2010)
2) Pipelines:
   - ø 600 mm (v = 1.3 m/s) and 250 m long (to connection point of ø 600 mm existing pipeline from Khaw-Amman line)
   - ø 200 mm (v = 1.9 m/s) and 800 m long for transmission pipeline to RES T-635 from T-695)
3) Pumps:
   - 4 duty units and 1 standby unit
   - ø 250 x ø 200 x 5.4 m^3/min. x 121 m x 220 kW
     single suction type
   - Pump house with 180 m^2 and electrical room of 120 m^2 (common use of Rusaifa PS)
4) Chlorinator:
   - 2 chlorinators (max. Capacity 6 kg/h)
   - 1 evaporator with max. Capacity 50 kg/h
   - 2 booster pumps

2.2.6 Rusaifa Low Zone Reservoir (T-750) from Awajan 21 PS

Water required in Rusaifa area will be pumped-up to Rusaifa RES T-750 from Awajan 21 PS. A corresponding increase in the water demand for Zarqa and Awajan areas, after 2005, will result in a decrease in flows transmitted to Rusaifa. After 2005, water is expected to be supplied from Amman at RES T-750. The facilities are planned to met the water demand in 2005. In 2015 the water supplied from Amman will be conveyed to Awajan and Khaw PS by gravity flow. The longitudinal section and hydraulic gradient of the pipeline are shown on Fig. 2.20.

A small scale chlorination system will be provided in Stage 1(- 2005) to supplement the residual chlorine in RES T-810 due to the length of the distribution main to the Shennuler area. In Stage 2 (2006 - 2015), the system will be expanded to chlorinate the water supplied from Amman.

1)	Planned flow:	-	Rusaifa low zone	271 l/s (in 2005)
		-	Rusaifa high zone:	135 l/s (in 2005)
		-	Well water in Rusaifa area:	-36 l/s (in 2005)
			Total flow	370 l/s (in 2005)
2)	Pipeline:	-	ø 600 mm and 6,600 m long (v = 1.4 m/s)	
3)	Pump:	-	5 duty units and 1 standby, total 6 units	
		-	ø 200 x ø 150 x 4.4 m^3/min. x 193 m x 290 kW single suction type	
		-	Pump house with 210 m^2 and electric room of 120 m^2	
4)	Chlorinator:	-	2 chlorinators (max. Capacity of 3 kg/h)	
		-	2 booster pumps	

2.2.7 Rusaifa High Zone Reservoir (T-810) from Low Zone RES T-750

Rusaifa RES T-810 will be supplied with water by pumping up from Rusaifa PS or T-750 to supply the Rusaifa high zone and the Shennuler areas. The longitudinal section and hydraulic gradient of the pipeline are shown on Fig. 2.20.

1)	Planned flow:	-	160 l/s (in 2015)
2)	Pipeline:	-	ø 400 mm and 1,800 m long (v = 1.1 m/s)
3)	Pump:	-	2 duty units in and 1 standby unit , total 3 units (1 unit is to be added in Stage 2)
		-	ø 200 x ø 150 x 3.2 m3/min. x 75 m x 75 kW double suction type
		-	Pump house with 140 m^2 including electrical room

2.3 Collection System

2.3.1 Khaw PS from Hashemeyeh and Zarqa Wells

Water from both existing wells of Hashemeyeh and Zarqa is transmitted to Khaw PS for mixing with low TDS water from Khaw reservoir. The existing transmission pipelines is used for 400 mm in diameter and 8 km long as Zarqa line. On the other hand, Hashemeyeh line will be newly installed with 400 mm in diameter and 5,700 m long due to superannuated existing pipeline with 300 mm in diameter.

Direct pumping method by the well pumps is applied for both well fields to Khaw reservoir. Hashemeyeh No.5 well pump is to be replaced with new one because of shortfall of pump head. Other existing pumps, Nos. 2 and 3, have enough pump head of 150 m and more. Zarqa No. 14 and 14-a pumps are also replaced with new one because they are not used for long period so far due to high concentration of TDS in well water. The existing three pumps replaced will be strored as standby after overhaul. Pumps to be procured under the Project are as follows:

1) Planned flow: - Hashemeyeh well field 150 l/s (540 m3/h)
   - Zarqa well field 140 l/s (500 m3/h)
2) Pipeline: - New collection pipeline is added for Hashemeyeh well field
   - ø 400 mm and 5,700 m long
3) Pump: - Hashemeyeh well; ø 150 x 3.3 m3/min x 150 m x 150 kW x 1 set
   - Zarqa well; ø 200 x 4.2 m3/min. x 130 m x 160 kW x 2 sets

2.3.2 Awajan 21 PS from Rusaifa Valley Well

Rusaifa will transmit 1,000 m3/h (278 l/s) of well water to Amman in 2005. It is considered that the existing 400 mm diameter from Zarqa PS to Rusaifa will be partially used to avoid congestion of the main pipeline in the street and at the Zarqa river crossing. The flow will be reduced to 140 l/s by 2015. The existing pumping head will be sufficient from Awajan 21 PS because the pipeline is at a lower elevation and shorter than the one for Amman.

1) Planned flow: - 278 l/s (in 2005)
2) Pipeline: - Existing ø 400 mm and 1,900 m long (2.2 m/s)
   - New ø 500 mm and 2,900 m long (1.4 m/s)

Rehabilitation and extension facilities executed under Stage 1 Project are summarized on Tables 2.2 to 2.4 and plans of pump stations are shown on Figs. 2.11 and 2.12.

2.4 Distribution System

The whole service area is divided into five areas; Hashemeyeh, Sukhna, Zarqa, Awajan and Rusaifa, and furthermore, Zarqa, Awajan and Rusaifa areas are also divided in high and low zones due to the topographical condition. These areas and zones are individually established with service reservoirs and supplied by gravity flow with a minimum 30 m of water pressure at the end of distribution network.

2.4.1 Service Reservoir

The reservoir is sized for 8 hours capacity at daily maximum demand in 2015. Half the capacity of the reservoir will be constructed in Stage 1. The capacity, dimensions and water levels of each service reservoir are shown on the following table:

Zone Name	Reservoir Name	Demand in 2015 (m^3/d)	Required Capacity (m^3)	HWL (m)	LWL (m)	Dimension (m)	No. in Stage 1
Zarqa Low	R-650	49,500	12,500 (4,500)	+ 651	+ 644	25 x 18 x 7 (3,125 m^3)	2
Zarqa high	R-716	11,600	4,000	+ 720	+ 715	16.6 x 11 x 5.5 (1,000 m^3)	2
Hashemeyeh	R-600	6,300	2,000	+ 600	+ 595	20 x 10 x 5 (1,000 m^3)	1
Sukhna	R-580	2,400	1,000	+ 580	+ 575	10 x 10 x 5 (500 m^3)	1
Awajan low	R-635	5,700	2,000	+ 640	+ 635	18 x 11 x 5 (1000 m^3)	1
Awajan high	R-695	27,900	5,500 (4,500)	+ 698	+ 693	20 x 13.8 x 5 (1,375 m^3)	2
Rusaifa low	R-750	27,700	10,000	+ 757	+ 752	28 x 18 x 5 (2,500 m^3)	2
Rusaifa high	R-810	13,800	5,000	+815	+ 810	20 x 12.5 x 5 (1,250 m^3)	2

Note: ( ) shows the capacity of the existing reservoirs.

2.4.2 Other Reservoirs for Junction and Blending Well Water

1) Junction tank in Khaw - Awajan transmission system

The pipeline route from Khaw PS to Awajan 21 PS passes through hilly areas. A junction tank will be built at the highest point to control pump operations from the water level in the tank. Water will be transmitted from the tank to Awajan PS by gravity flow. The capacity and dimension of the tank are as follows:

- Capacity: 1 hours volume for the planned flow rate, 1,000 m3
- Dimension: 20 m x 10 m x 5 m x 1 unit

2) Awajan reservoir

Water from Awajan wells (130 l/s), and Rusaifa wells (278 l/s), will be collected at Awajan 21 PS where mixing with water from Khaw PS, will dilute TDS (Total dissolved solids). Water will be transmitted from the Awajan collection reservoir to the Awajan and Rusaifa service reservoirs by pumping. The capacity and dimensions of the reservoirs are as follows:

- Capacity: 2 hours capacity of the planned flow rate, 5,000 m3
- Dimension: 25 m x 20 m x 5 m x 2 units

2.4.3 Distribution Pipes

A zoned distribution system will be established in stage 1. Accordingly, most of the trunk mains from the service reservoir will be installed in Stage 1. The distribution network pipes in the newly developing areas will also be installed in Stages 1 and 2.

1) Zarqa service area

The Zarqa service area will be separated into high and low zones. The high zone is being developed and new distribution network pipes will be installed. The low zone covers the existing service area and the newly developed area now in progress. The new trunk mains will be installed from the reservoir in Stage 1. The following distribution pipes will also be installed in Stage 1.

Pipe Length in Zarqa Zones

Diameter	600	500	400	300	250	200	100	Total
low zone	2,800	300	500	100	300	6,400	17,200	27,600
high zone	0	700	700	0	900	600	24,700	27,600
Total	2,800	1,000	1,200	100	1,200	7,000	41,900	55,200

Unit: Diameter in mm, Pipe length in m

2) Awajan and Rusaifa service areas

Both service areas will be divided into two zones, high and low. According to the establishment of the zoning system, each zone has a service reservoir and distribution trunk mains which will be installed in Stage 1. Areas covered by each zone are as follows:

- Awajan low zone: the existing Awajan low area and new area being developed, below 599 m elevation
- Awajan high zone: the existing Awajan high area and new area being developed, and the existing Rusaifa low area, from 600 m to 660 m elevation
- Rusaifa low zone: the existing Rusaifa high area and new area being developed, from 661 m to 714 m elevation
- Rusaifa high zone: the existing Shennuler area and new area being developed, above 715 m in elevation

The following distribution pipes are planned to be installed in Stage 1.

Diameter	600	500	400	300	250	200	100	Total
Awajan								
low zone	-	-	1,000	2,100	-	1,900		5,000
high zone	-	-	-	-	300	2,600		2,900
Awajan Total	-	-	1,000	2,100	300	4,500	39,300	47,200
Rusaifa								
low zone	3,100	-	3,900	800	-	1,700		9,500
high zone	-	-	5,700	-	-	2,400		8,100
Rusaifa Total	3,100	-	9,600	800	-	4,100	39,300	56,900
Total	3,100	-	10,600	2,900	300	8,600	78,600	104,100

Unit: Diameter in mm, Pipe length in m

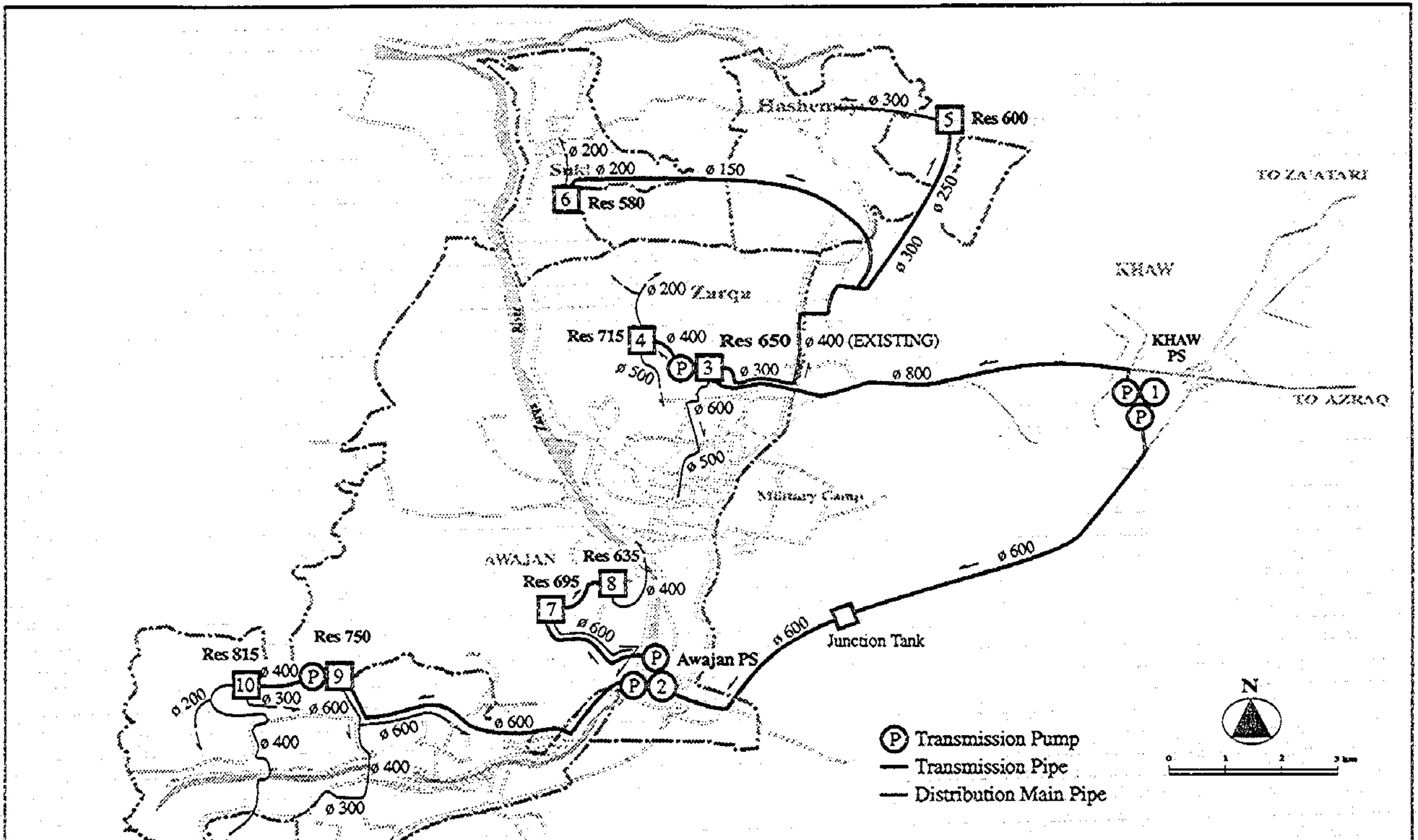
3) Hashemeyeh and Sukhna service areas

Water required for the Hashemeyeh and Sukhna areas will be transmitted from Batrawi service reservoir by gravity flow . Each area will be supplied by independent reservoir.

The following distribution pipes are planned to be installed in Stage 1.

Diameter	300	250	200	150	100	Total
Hashemeyeh	900	-	900	-	3,600	5,400
Sukhna	-	-	800	-	3,200	4,000

Unit: Diameter in mm, Pipe length in m

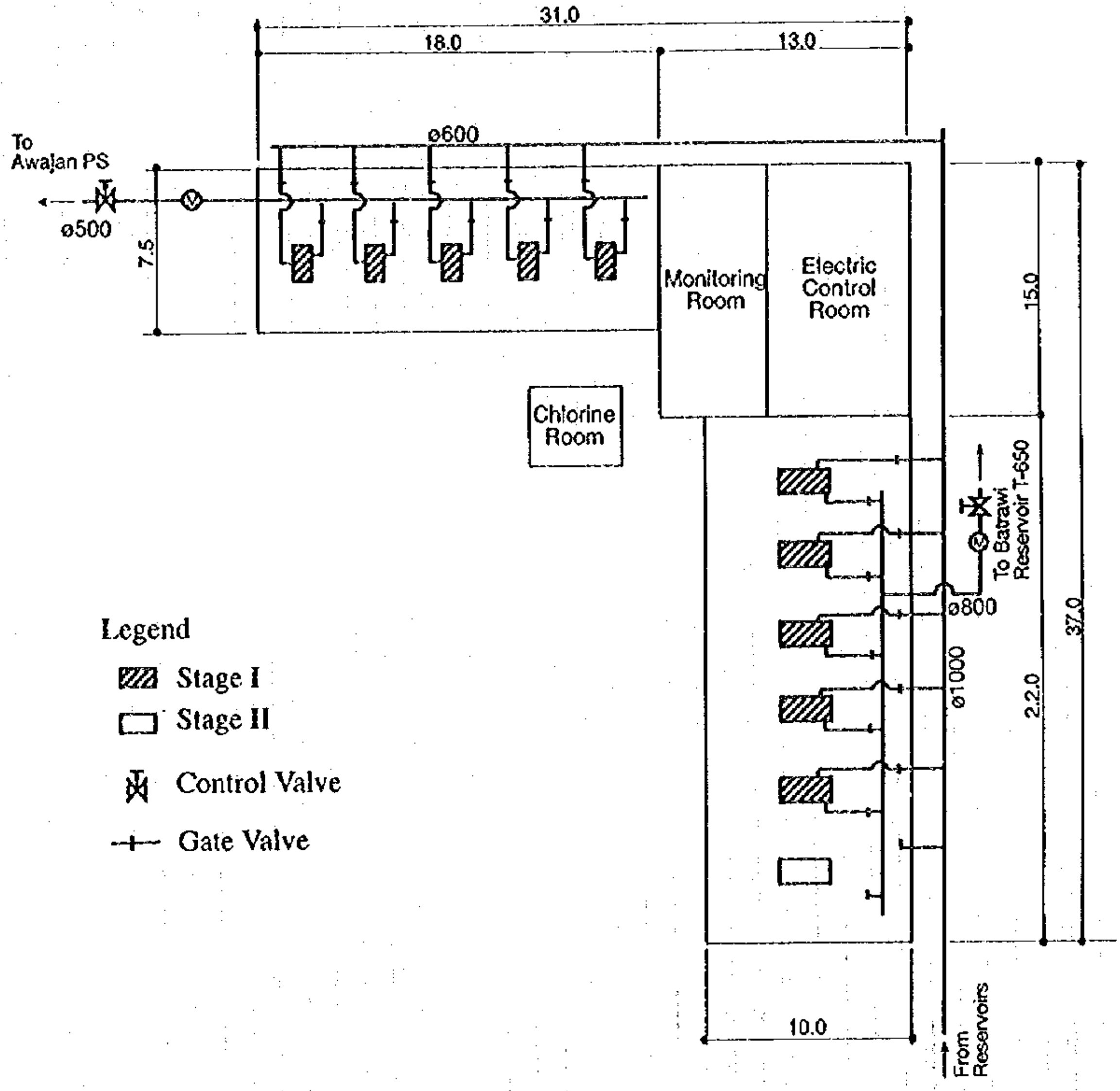


THE STUDY ON
THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM
FOR THE ZARQA DISTRICT

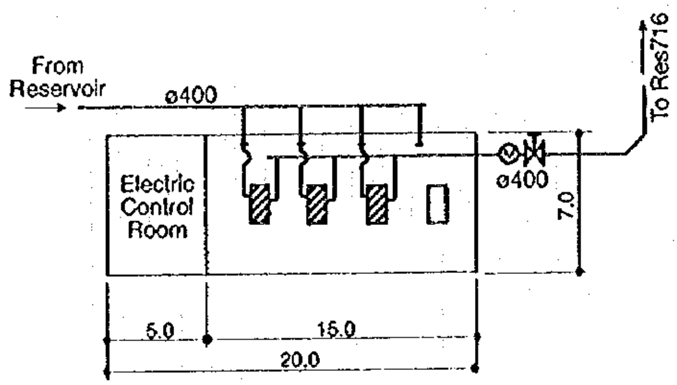
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. - 2.1
Transmission and Distribution Main Pipes

1. Khaw Pumping Station

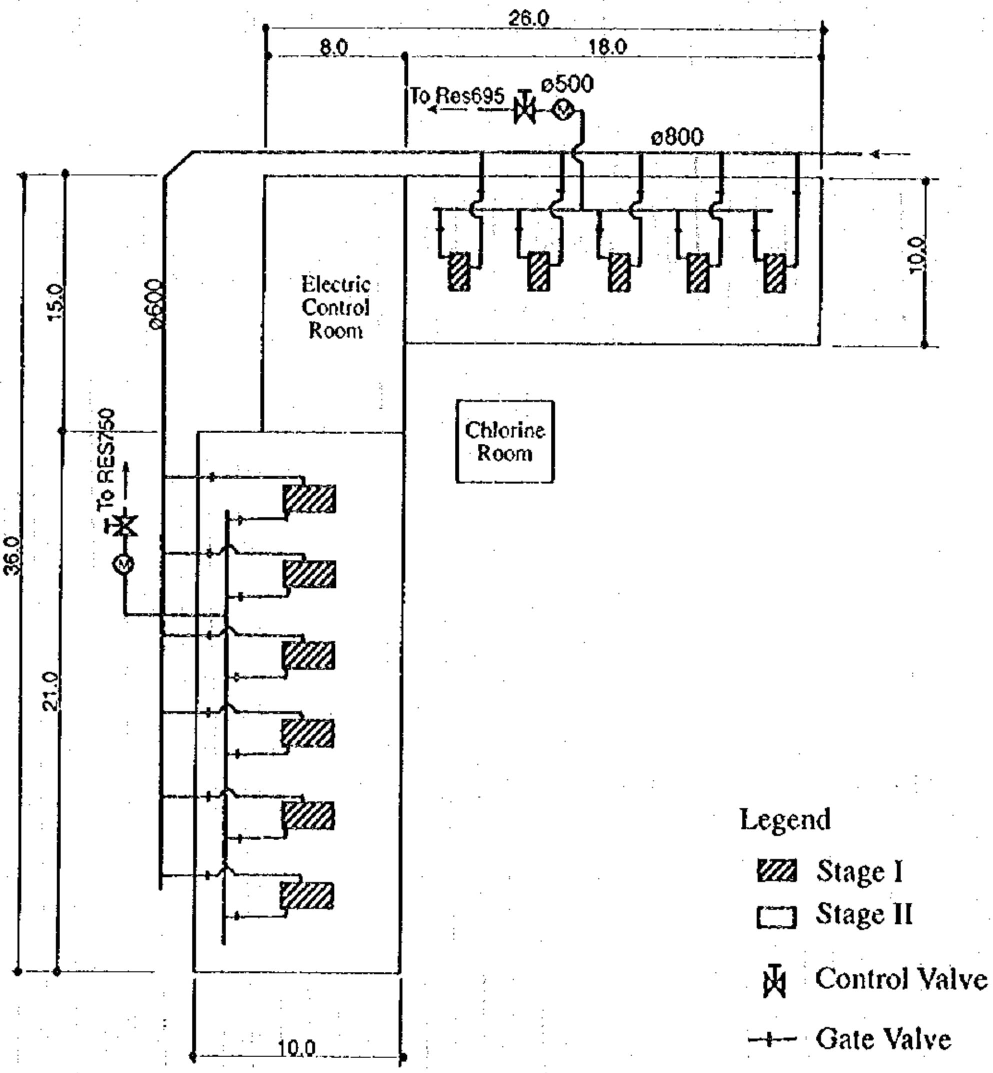


2. Batrawi Pumping Station

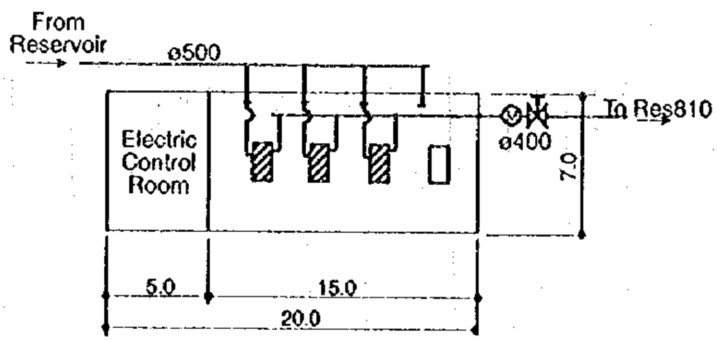


THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. - 2.2 KHAW AND BATRAWI PS
JAPAN INTERNATIONAL COOPERATION AGENCY	

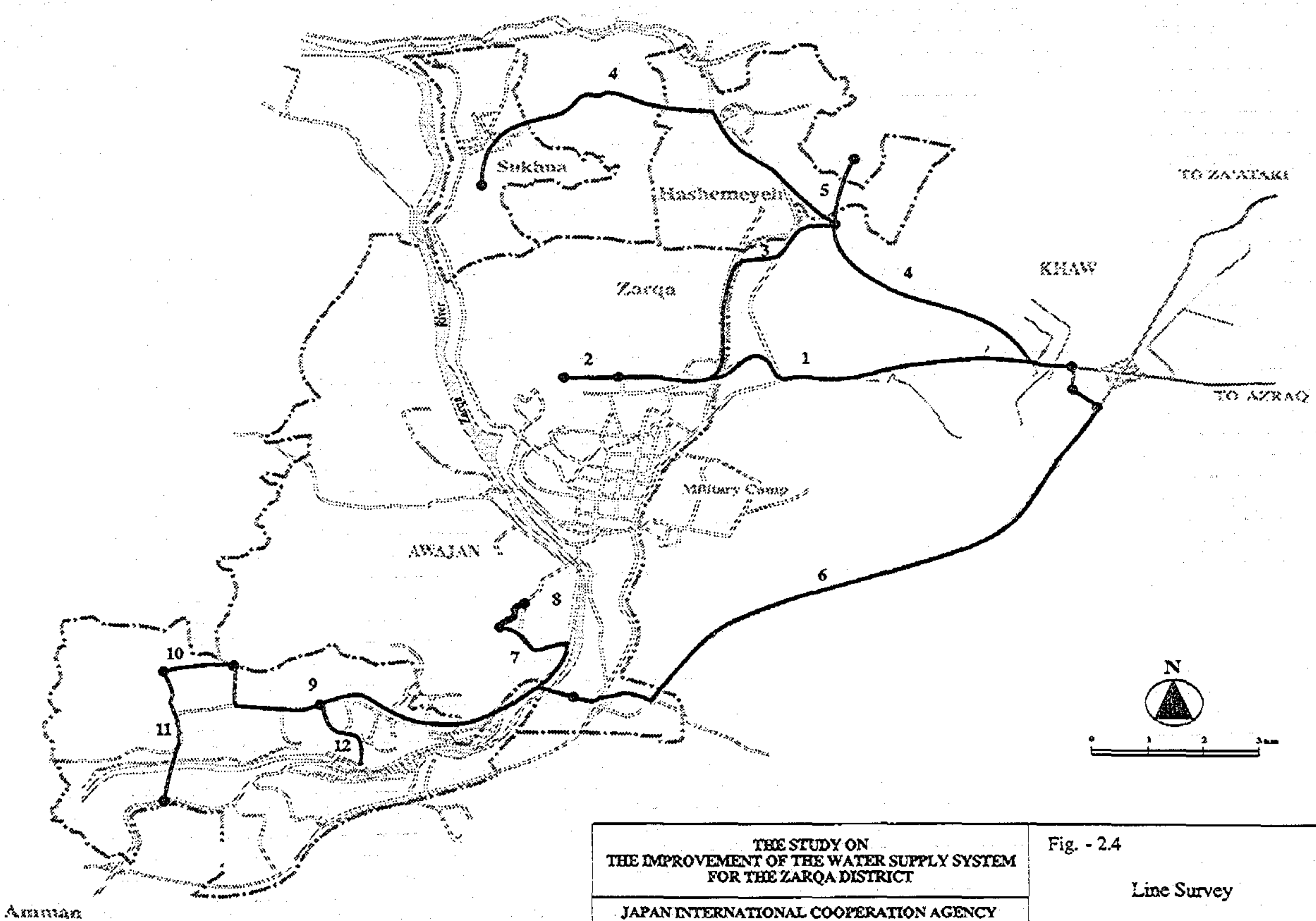
3. Awajan Pumping Station



4. Res750 Pumping Station



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. - 2.3 AWAJAN AND RES750 PS
JAPAN INTERNATIONAL COOPERATION AGENCY	

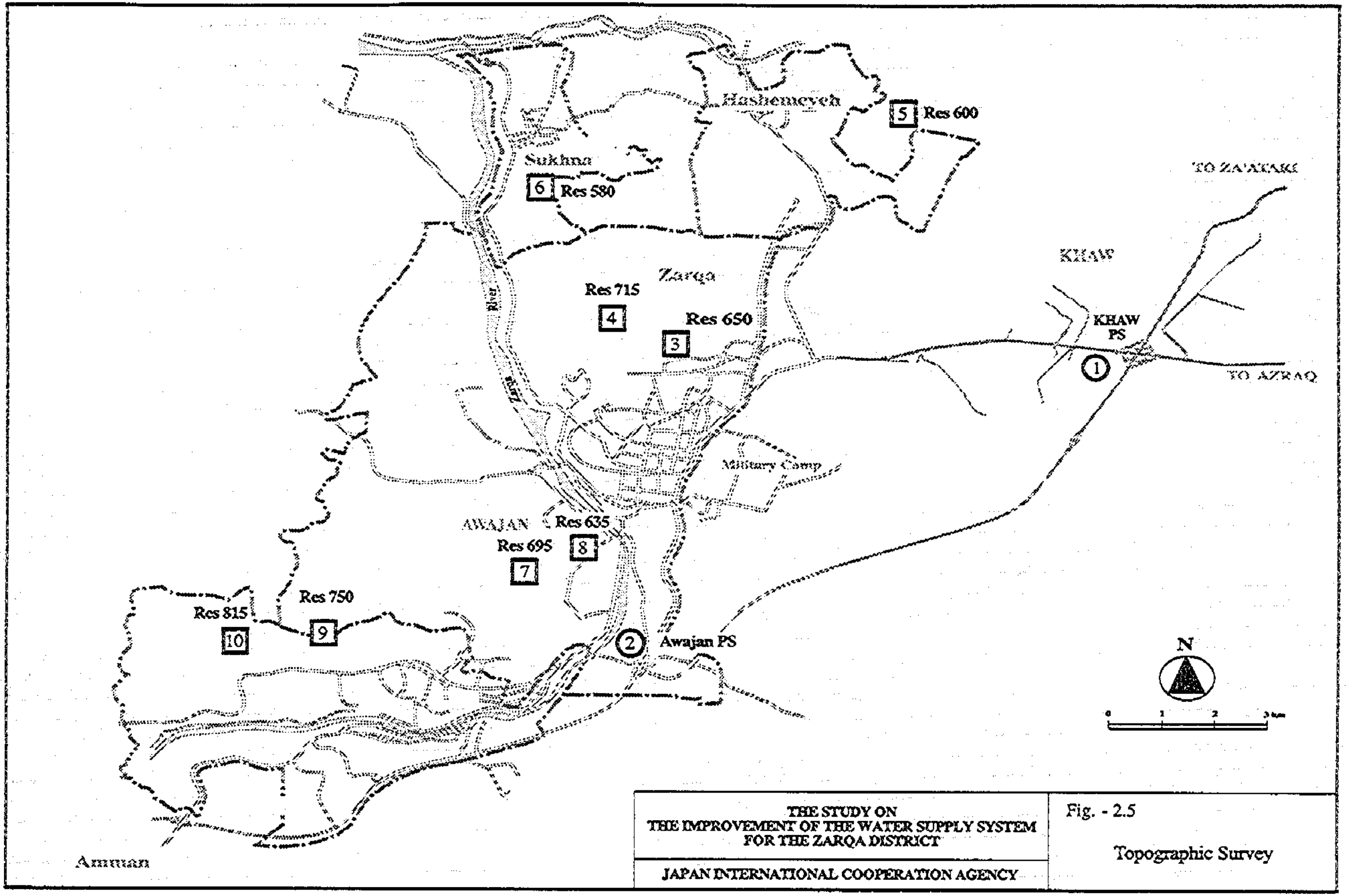


THE STUDY ON
THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM
FOR THE ZARQA DISTRICT

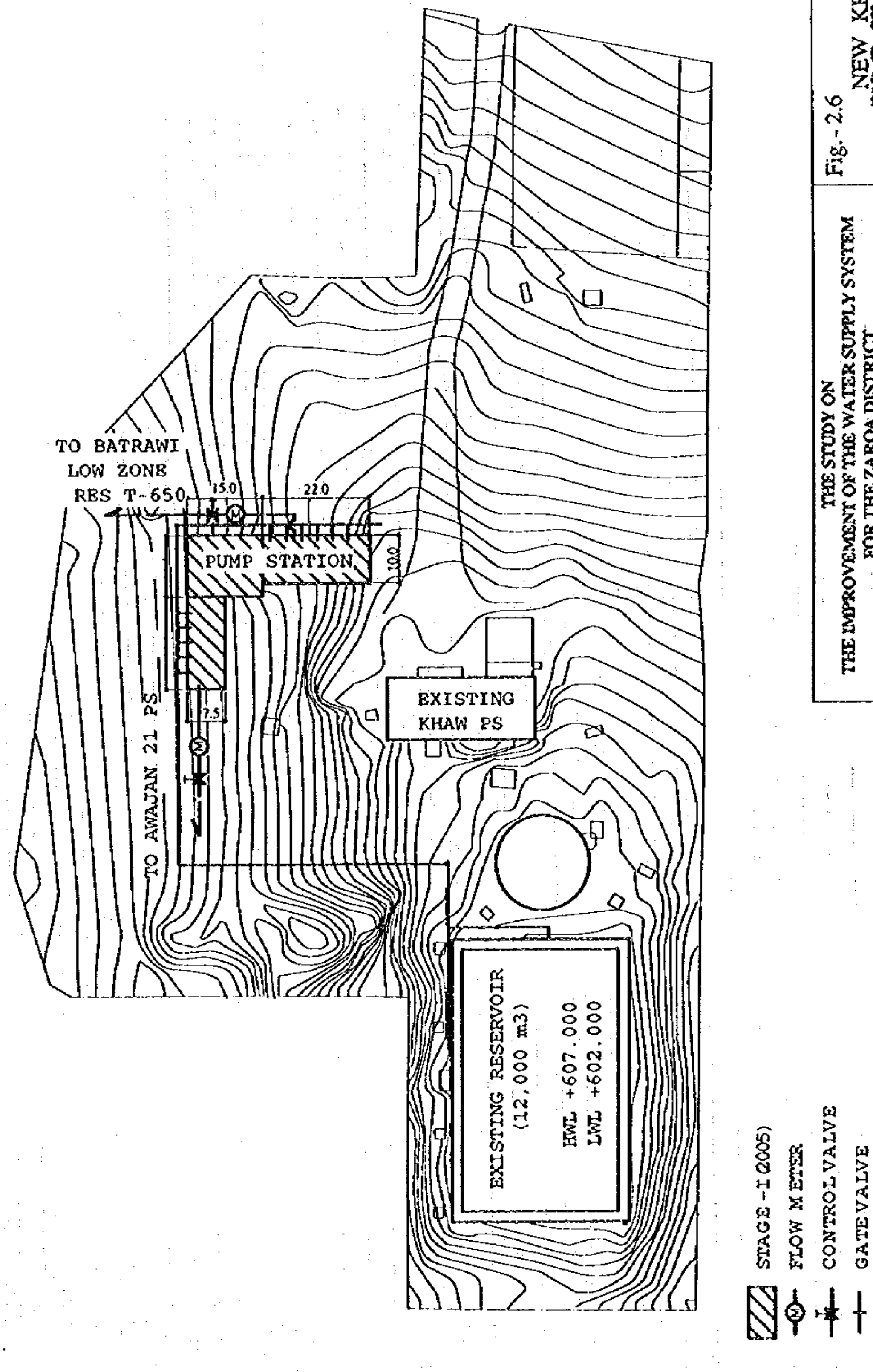
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. - 2.4

Line Survey



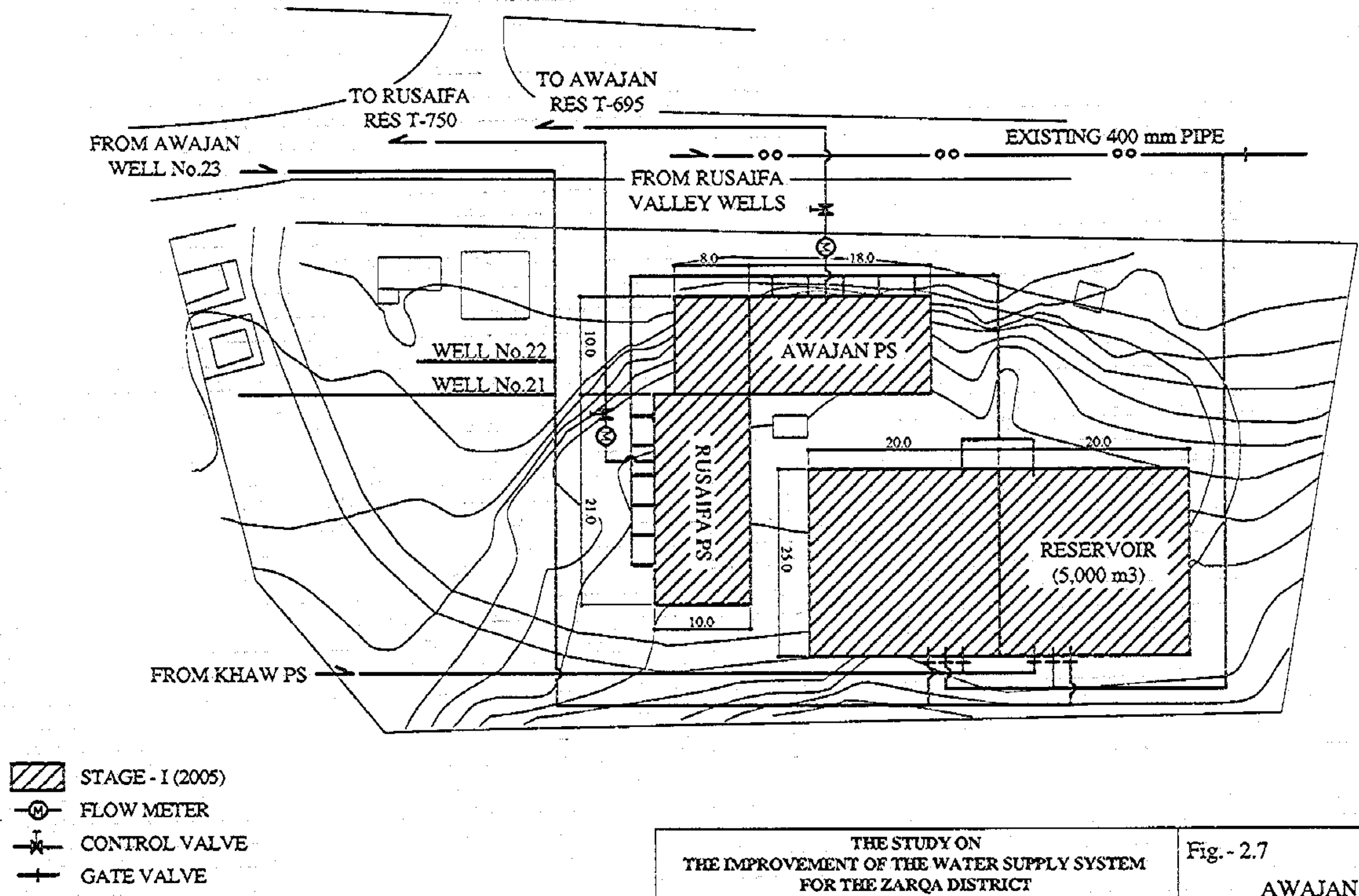
THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. - 2.5 Topographic Survey
JAPAN INTERNATIONAL COOPERATION AGENCY	



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

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.-2.6
NEW KHAW
PUMP STATION

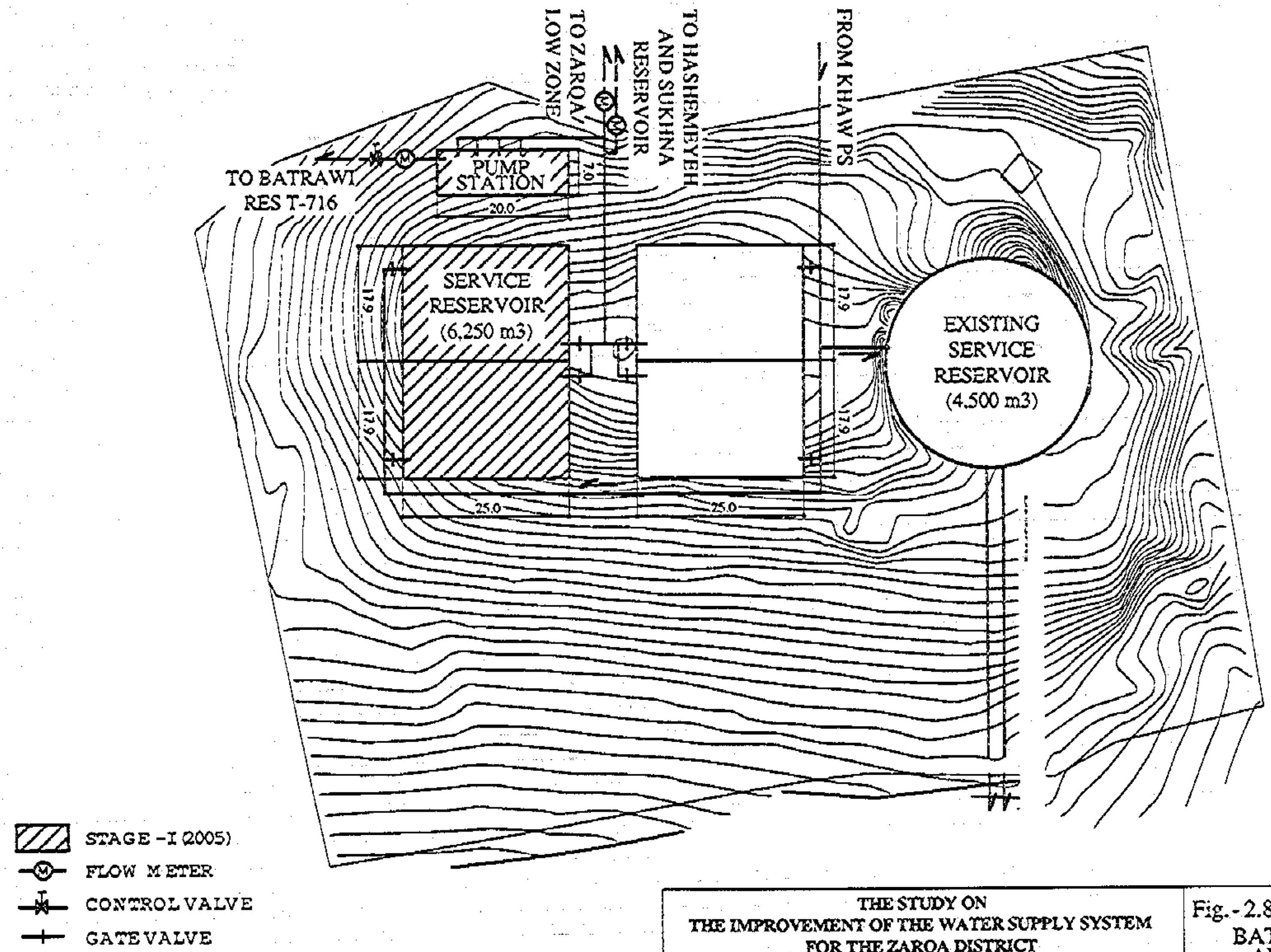


THE STUDY ON
THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM
FOR THE ZARQA DISTRICT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. - 2.7

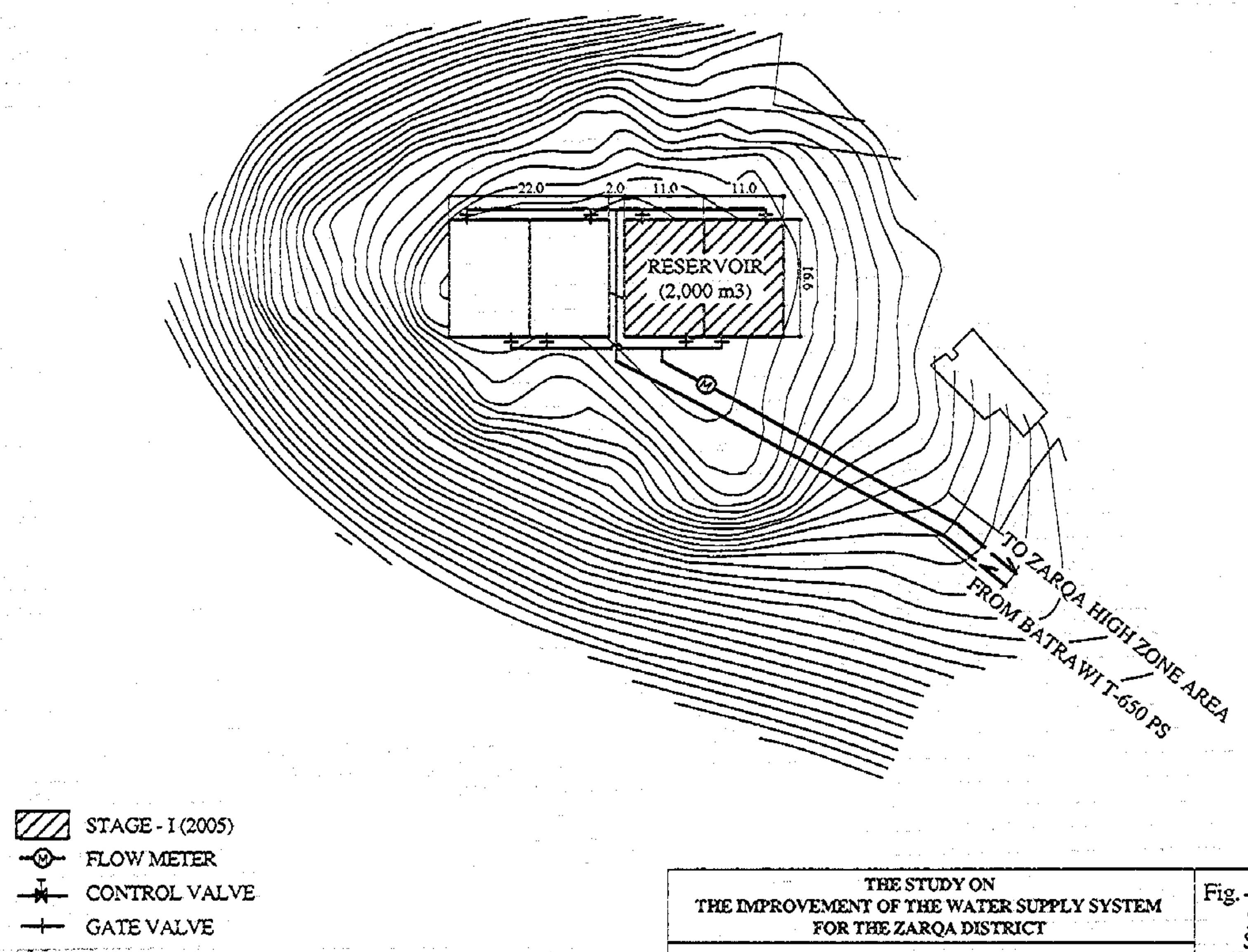
AWAJAN 21 PS



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

JAPAN INTERNATIONAL COOPERATION AGENCY

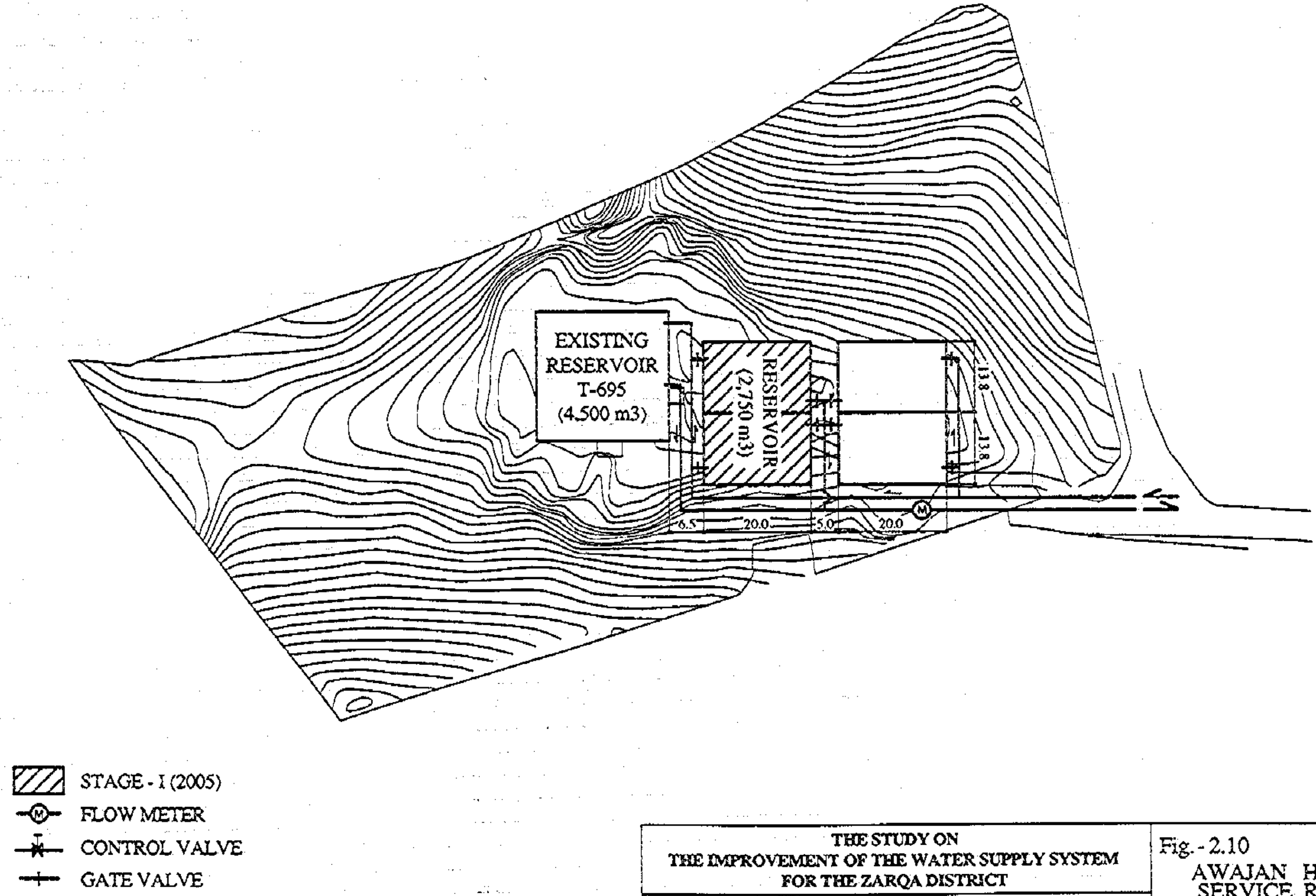
Fig.-2.8
BATRAWI RES T-650
AND HIGH ZONE
PUMP STATION



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

JAPAN INTERNATIONAL COOPERATION AGENCY

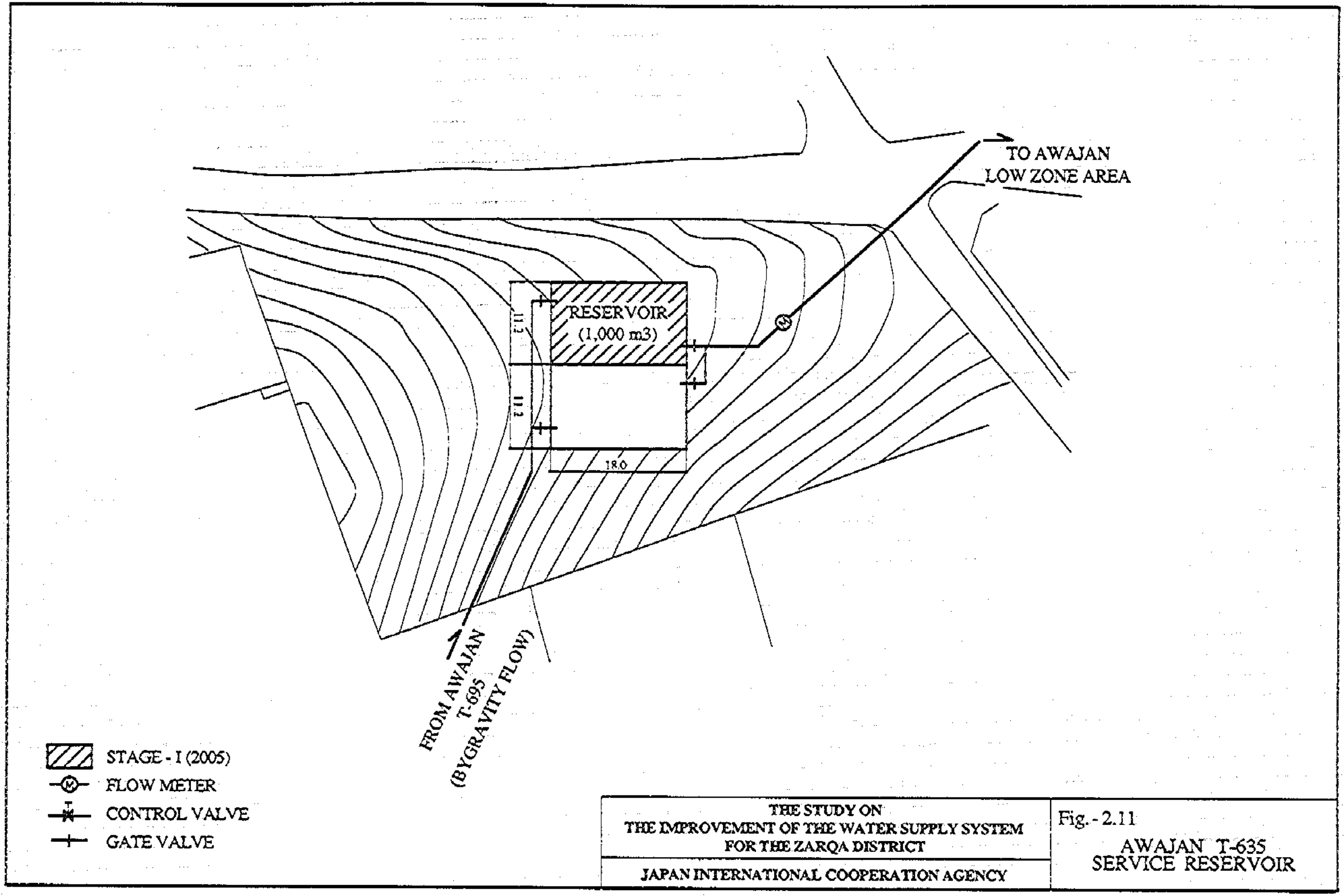
Fig. - 2.9
ZARQA HIGH ZONE
SERVICE RESERVOIR
(NEW BATRAWI T-716)



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

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. - 2.10
AWAJAN HIGH ZONE
SERVICE RESERVOIR
(T-695)

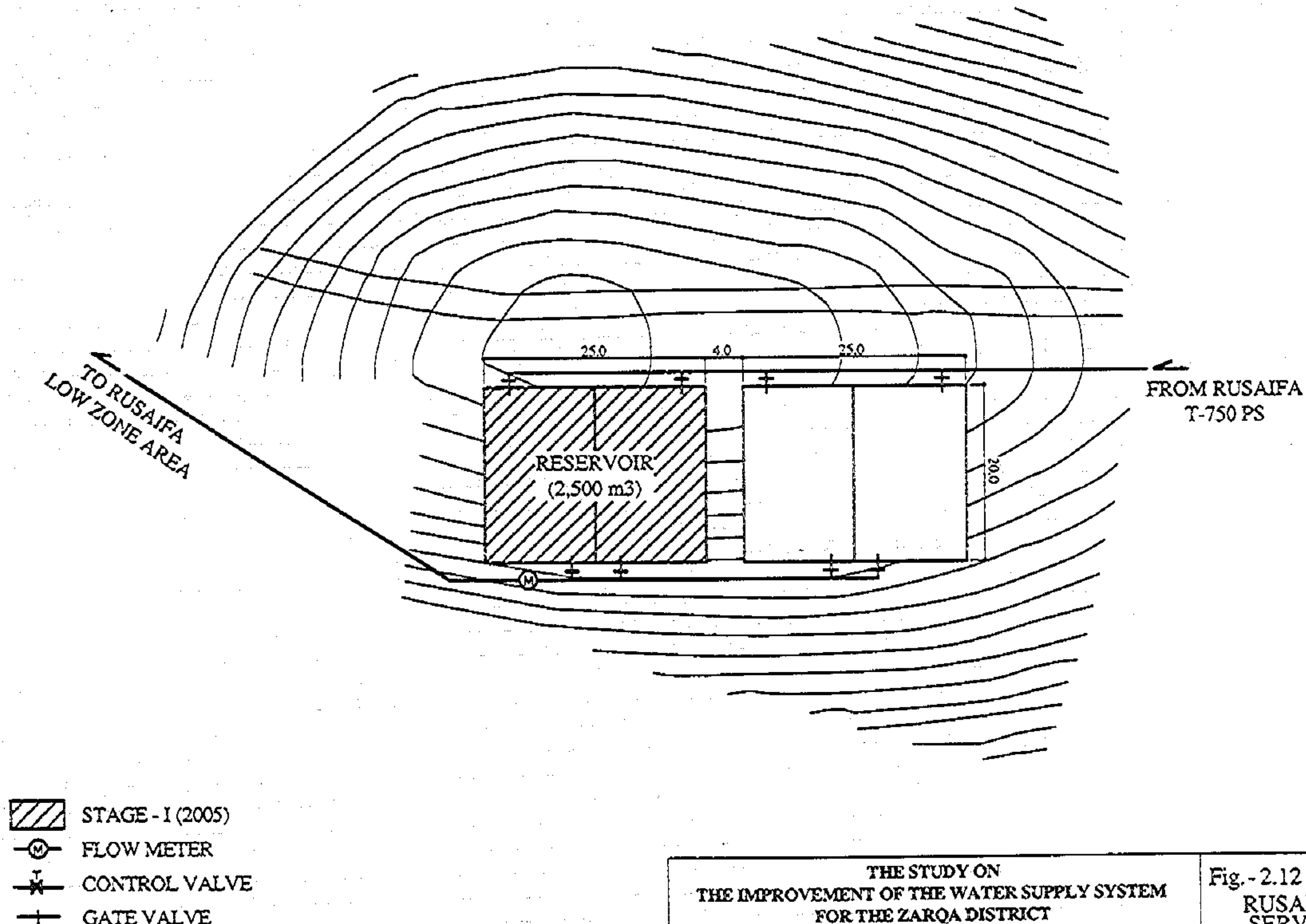


THE STUDY ON
THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM
FOR THE ZARQA DISTRICT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. - 2.11

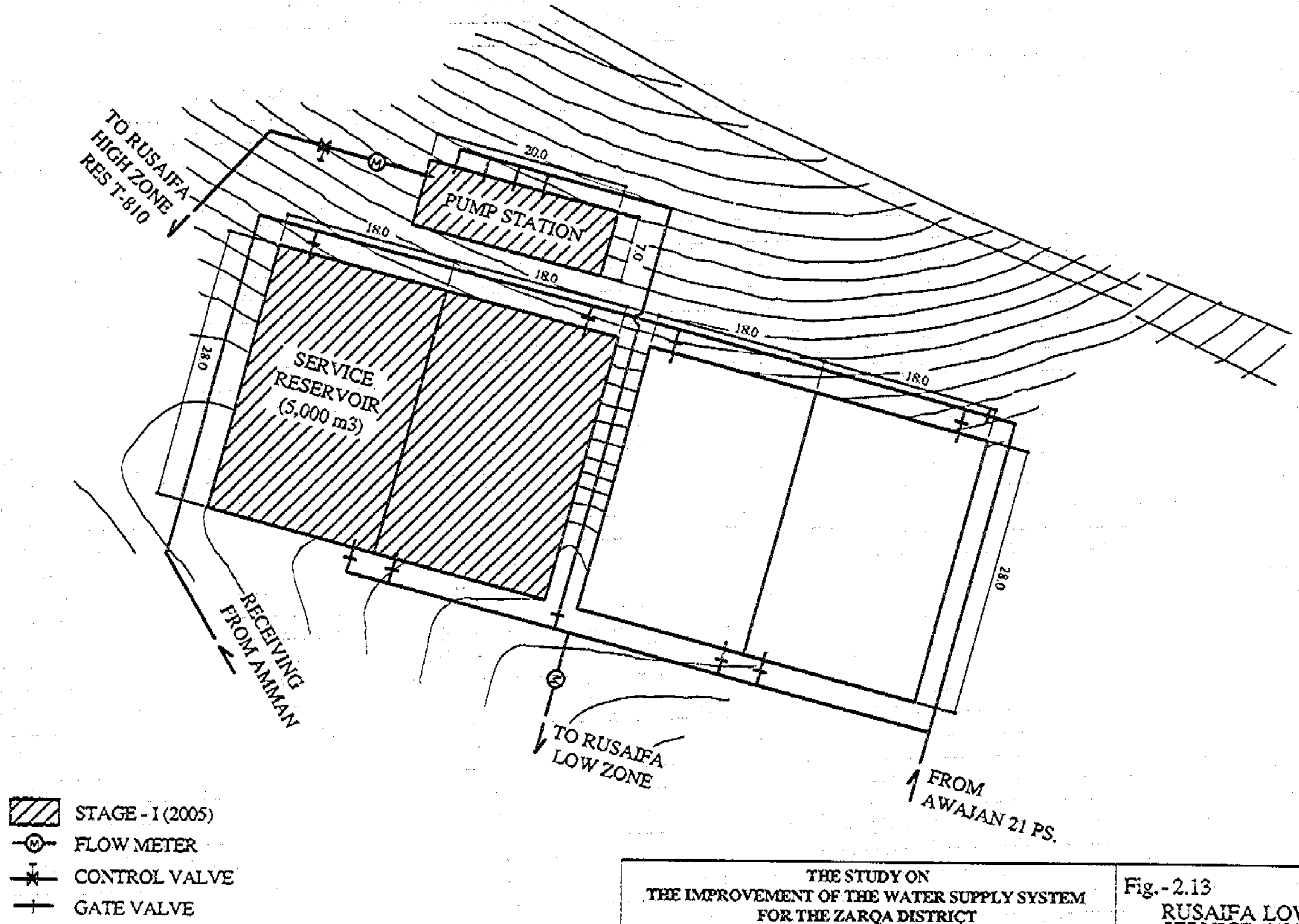
AWAJAN T-635
SERVICE RESERVOIR



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

JAPAN INTERNATIONAL COOPERATION AGENCY

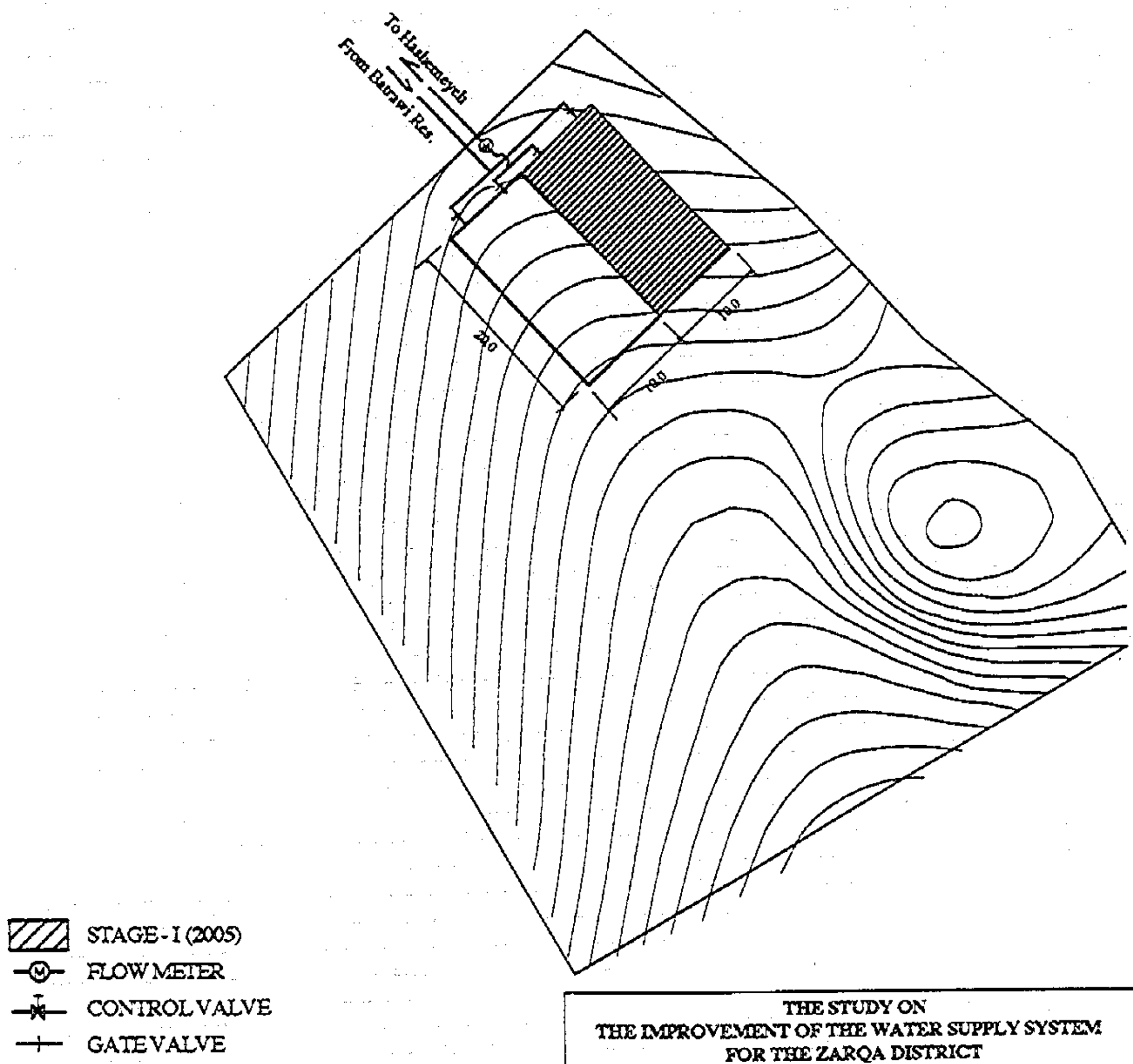
Fig. - 2.12
RUSAIFA HIGH ZONE
SERVICE RESERVOIR
(T-810)



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

JAPAN INTERNATIONAL COOPERATION AGENCY

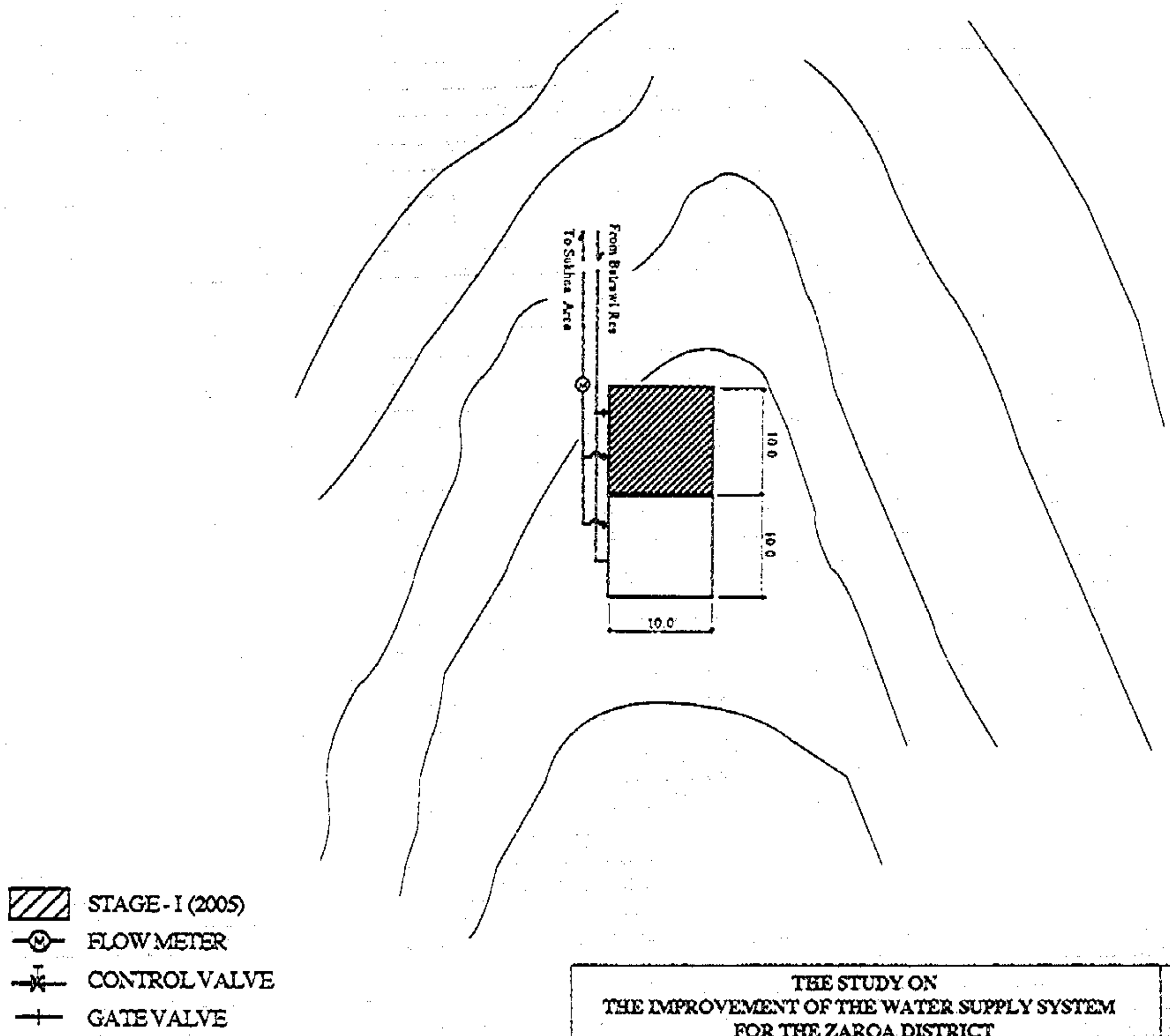
Fig. - 2.13
RUSAIFA LOW ZONE
SERVICE RESERVOIR
AND PUMP STATION



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

JAPAN INTERNATIONAL COOPERATION AGENCY

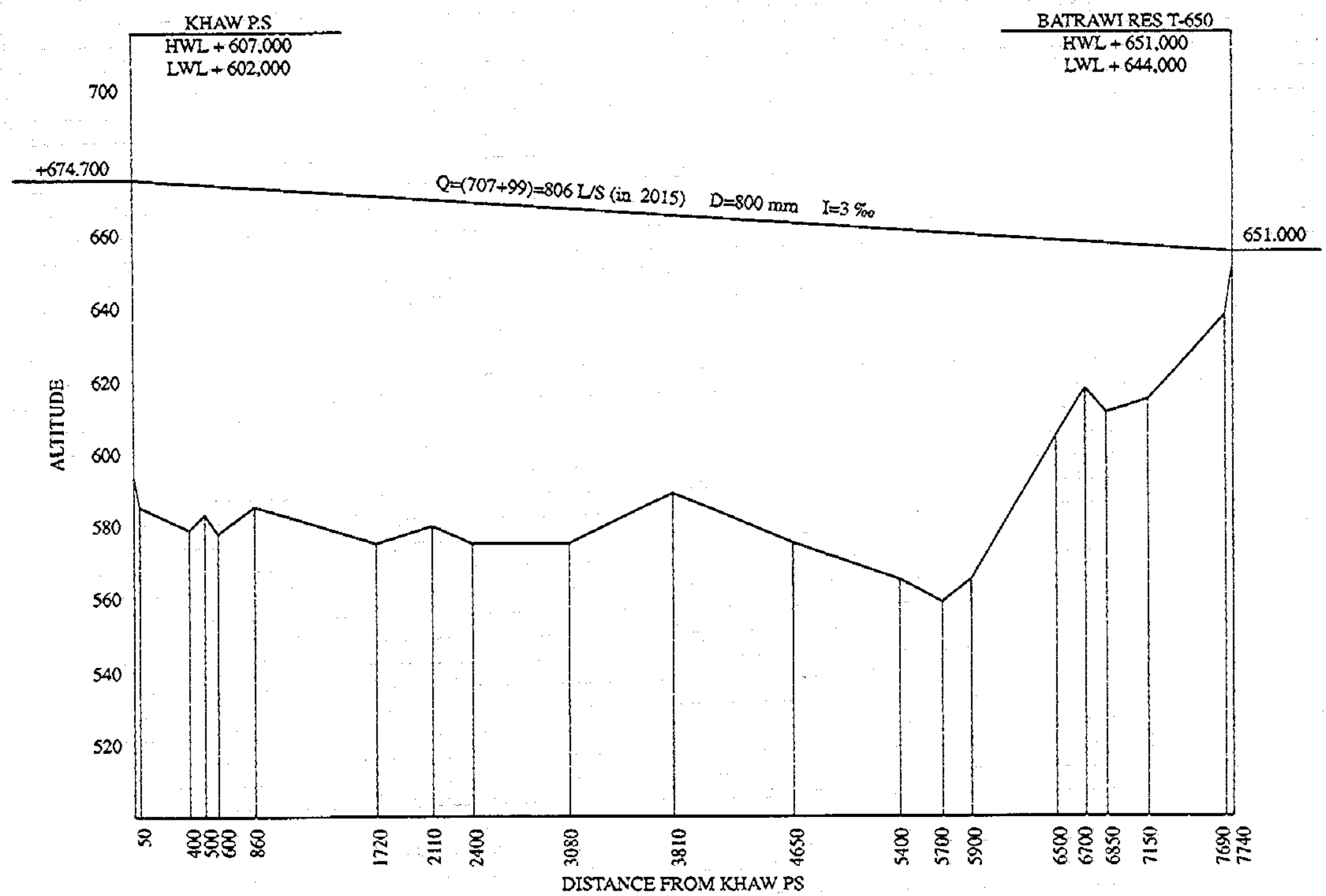
Fig.-2.14
HASHEMEYEH
SERVICE RESERVOIR



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

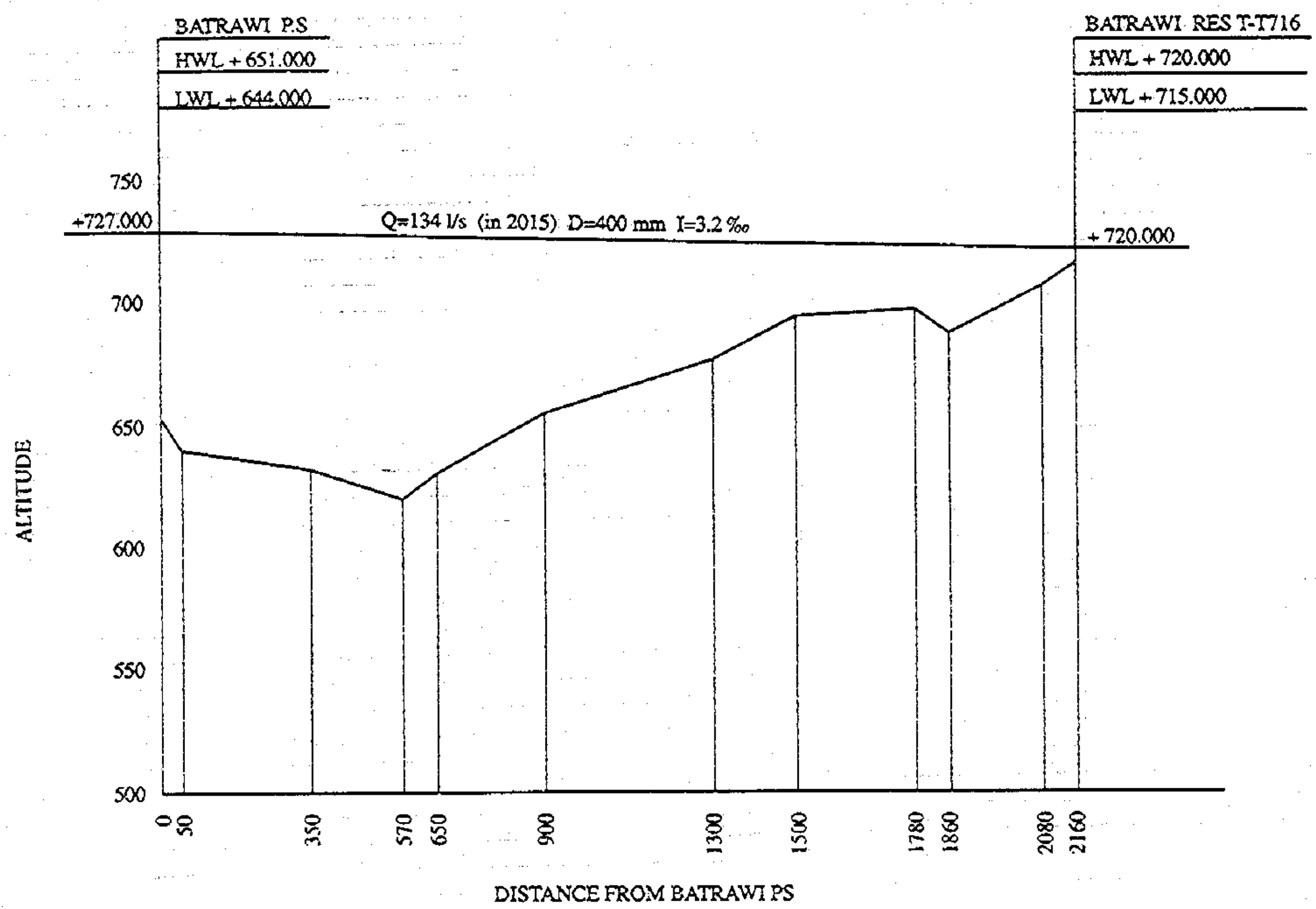
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.-2.15
SUKHNA
SERVICE RESERVOIR



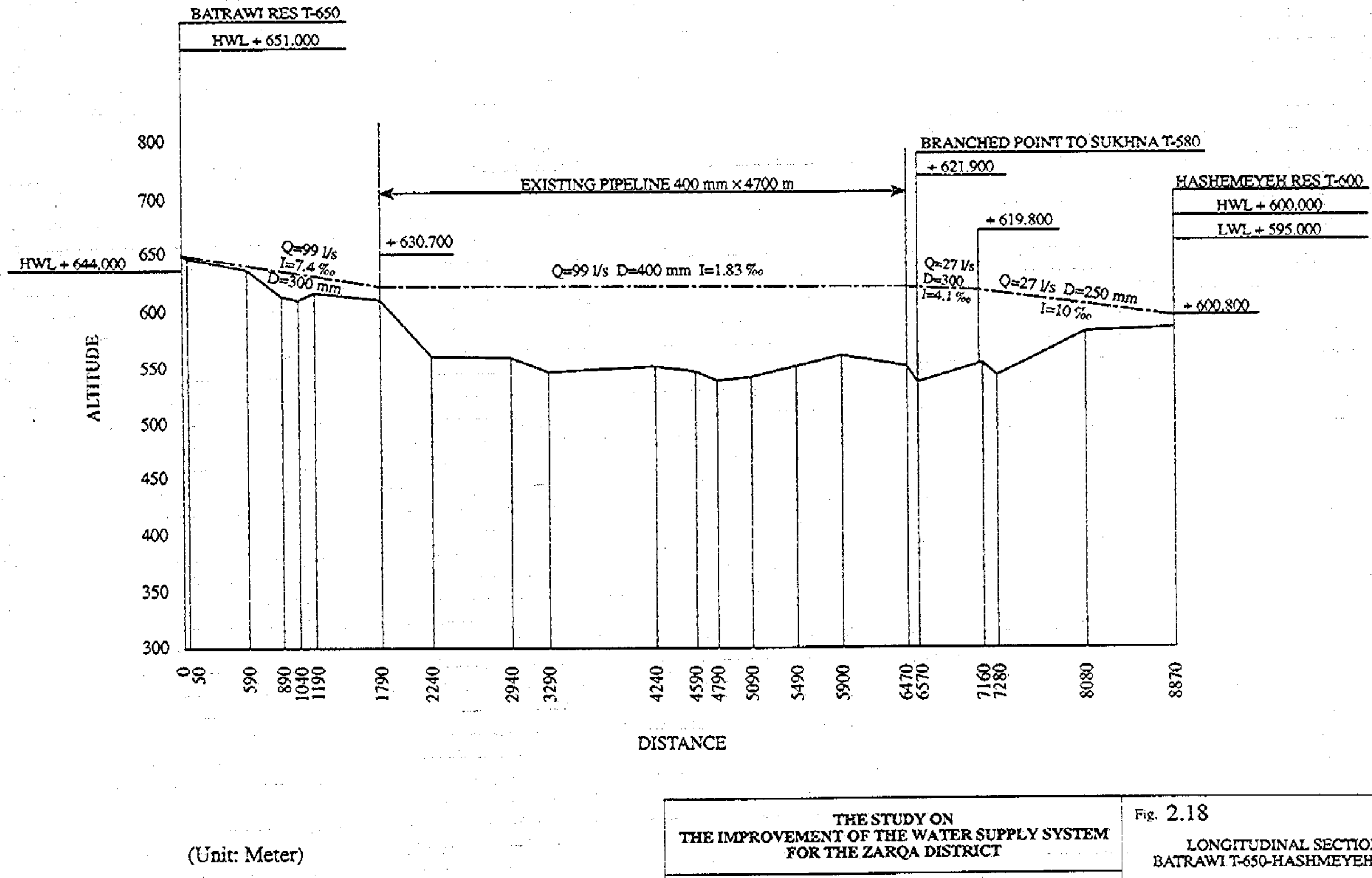
(Unit: Meter)

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. 2.16 LONGITUDINAL SECTION KHAW PS - BATRAWI RES T-650
JAPAN INTERNATIONAL COOPERATION AGENCY	

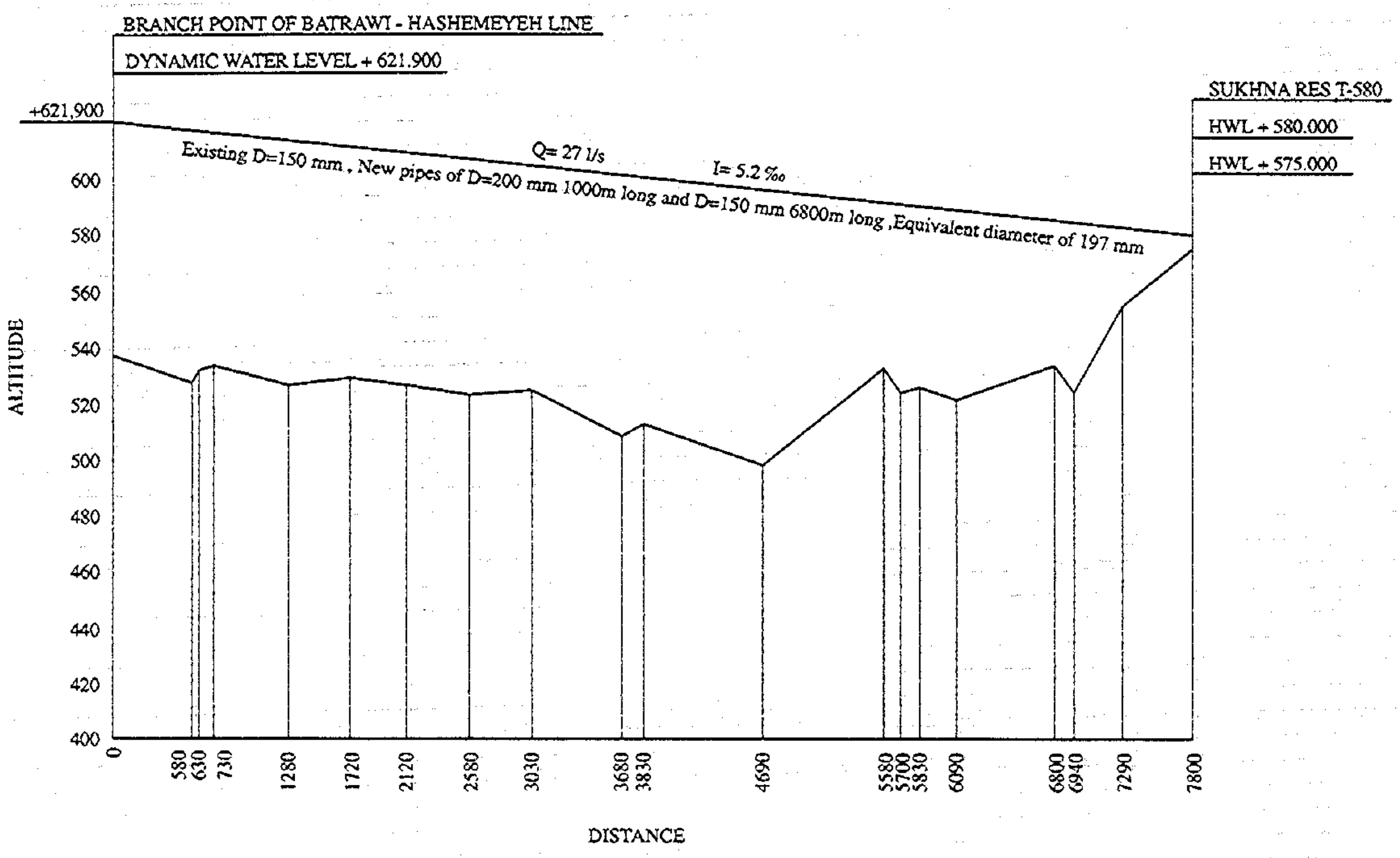


(Unit: Meter)

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. 2.17 LONGITUDINAL SECTION BATRAWI PS - RES T- 715
JAPAN INTERNATIONAL COOPERATION AGENCY	

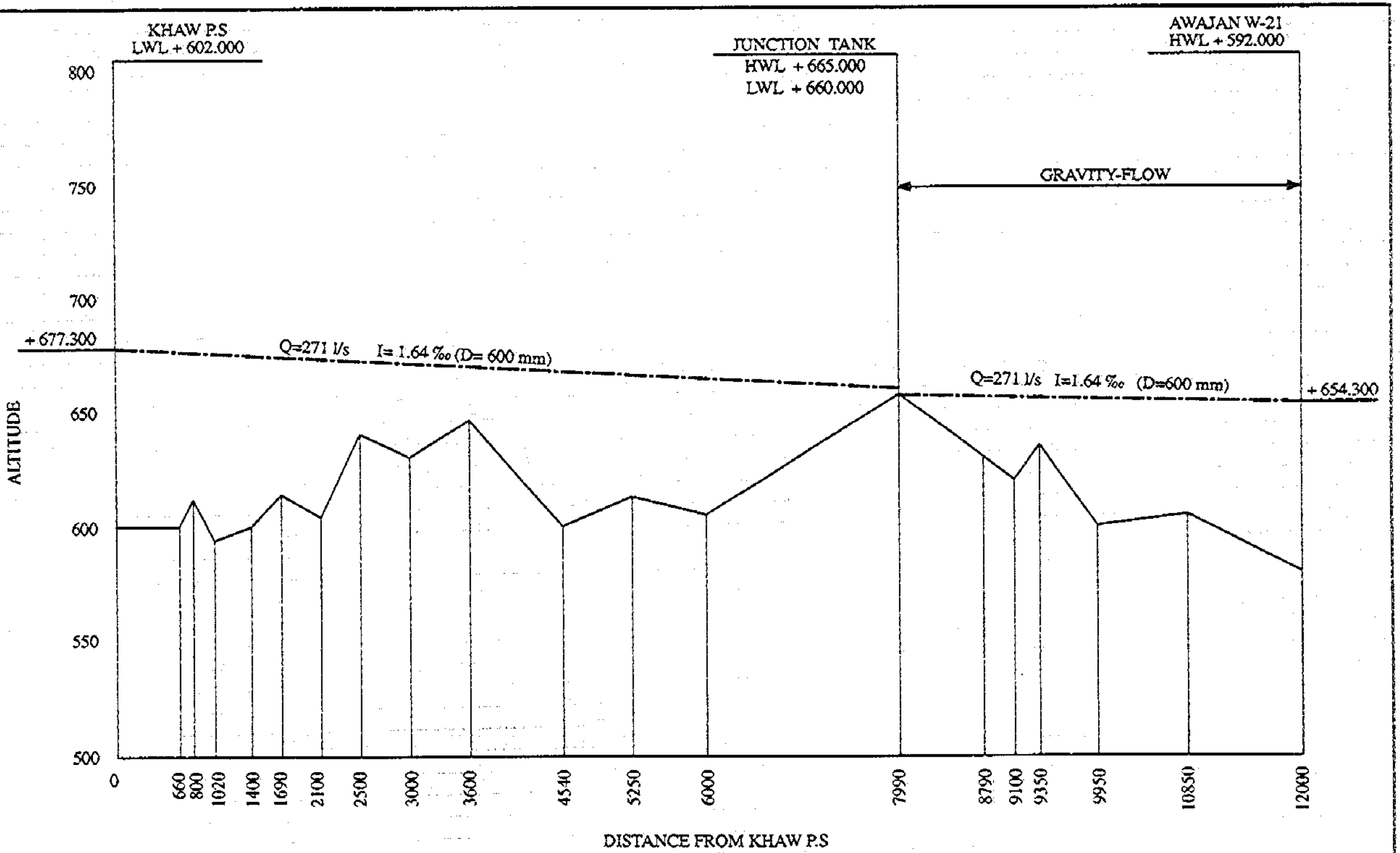


THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. 2.18 LONGITUDINAL SECTION BATRAWI T-650-HASHMEYEH T-600
JAPAN INTERNATIONAL COOPERATION AGENCY	



(Unit: Meter)

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. 2.19 LONGITUDINAL SECTION BATRAWI RES T-650 - SUKHNA RES T-580
JAPAN INTERNATIONAL COOPERATION AGENCY	

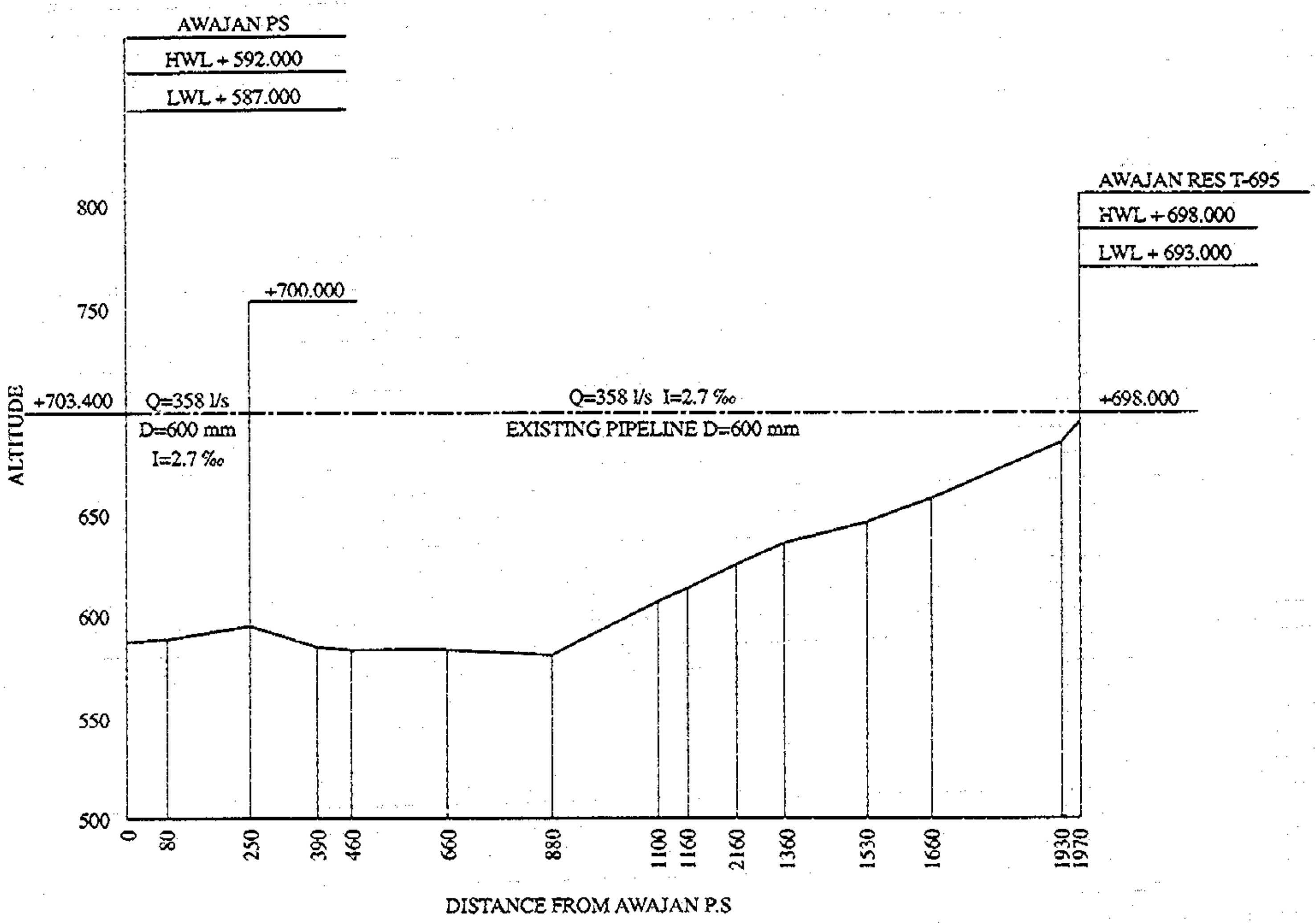


(Unit: Meter)

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

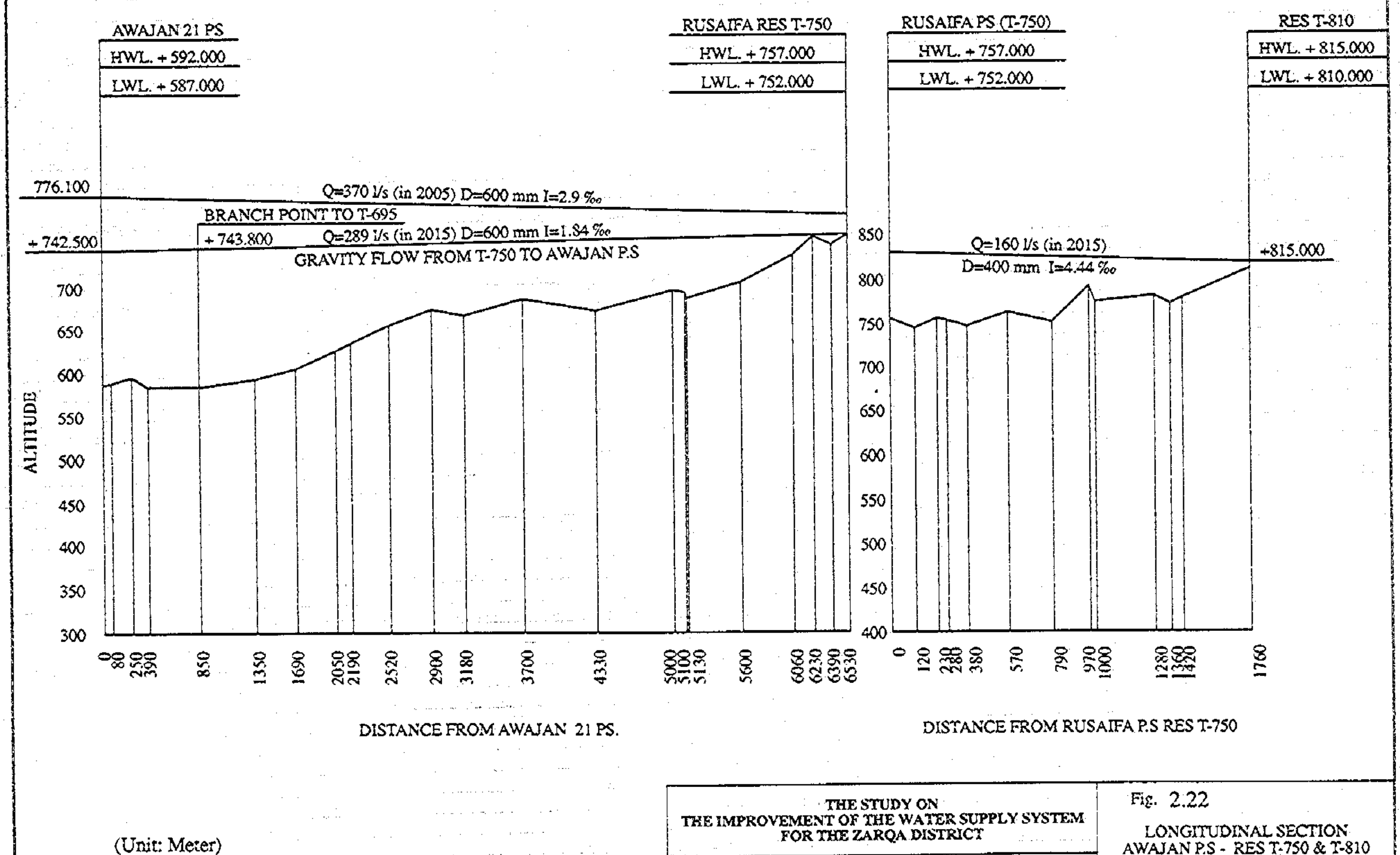
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.20
LONGITUDINAL SECTION
KHAW P.S TO AWAJAN P.S



(Unit: Meter)

THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. 2.21 LONGTITUDINAL SECTION AWAJAN 21 PS - AWAJAN RES T-695
JAPAN INTERNATIONAL COOPERATION AGENCY	



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

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.22

LONGITUDINAL SECTION
AWAJAN P.S - RES T-750 & T-810

III. ORGANIZATION AND OPERATION/MANAGEMENT

3. ORGANIZATION AND OPERATION/ MANAGEMENT

This section highlights four salient issues related to the operation and organization of the Stage I Project: 1) organization for project implementation, 2) operation and maintenance of the completed facilities, 3) leakage control and district metering and 4) accounting.

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 Assistant Secretary General for Project 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 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. 3.1.

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. In principle, they will be shifted from existing staffing resources in the Operation & Maintenance Department.

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:.

Sub-Team	No. of Sub-Team	Technician	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

Major activities of each sub-team are described below;

Leakage Detection Sub-team (LD)

Three sub-teams (LD) will be responsible for leak detection of pipelines located in Zarqa North, Zarqa South and Rusaifa. They will conduct direct sounding along the existing pipelines on a routine basis. All information on the exact location of leaks detected, diameter of pipes, pipe materials used, and pipe depth will be reported immediately to the Leakage Repair and Design & Recording sub-teams.

Leakage Repair Sub-team (LR)

Each of the two LRs will work under one LD. Upon request by the LD, the LR sub-team will carry out a preliminary survey at leak points and prepare the design for leak repair in cooperation with the Design & Recording sub-team to specify bills of quantities for leakage repair. When any interruption in service is required, necessary procedures to obtain public understanding and cooperation shall be taken under direction of the leakage control manager. Bills of quantities will be reported to the Equipment Control sub-team. Upon receipt of the materials and equipment, LR will carry out leak repair. Because of the nature & volume of the work, pipe replacement might be more economical than the leak repair. In some cases it may be more practical to tender the work to contractors.

Design & Recording Sub-team (DR)

The DR is responsible for the design of pipeline repair and will prepare bills of quantities, as-built drawing and update system maps based on information given by the LD and LR. All drawings will be computerized for easy reference and update.

Equipment Control Sub-team (EC)

This sub-team is responsible for purchase, provision and control of survey equipment and materials including preparation of budget for the approval of the leakage control manager.

(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 acquired through years of experiences at the site or through on-the-job training. Accordingly, it is considered efficient to assign several pipeline engineers/technicians under the leak control leader/expert for on-the-job 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 as presented in Fig.- 3.2. 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.

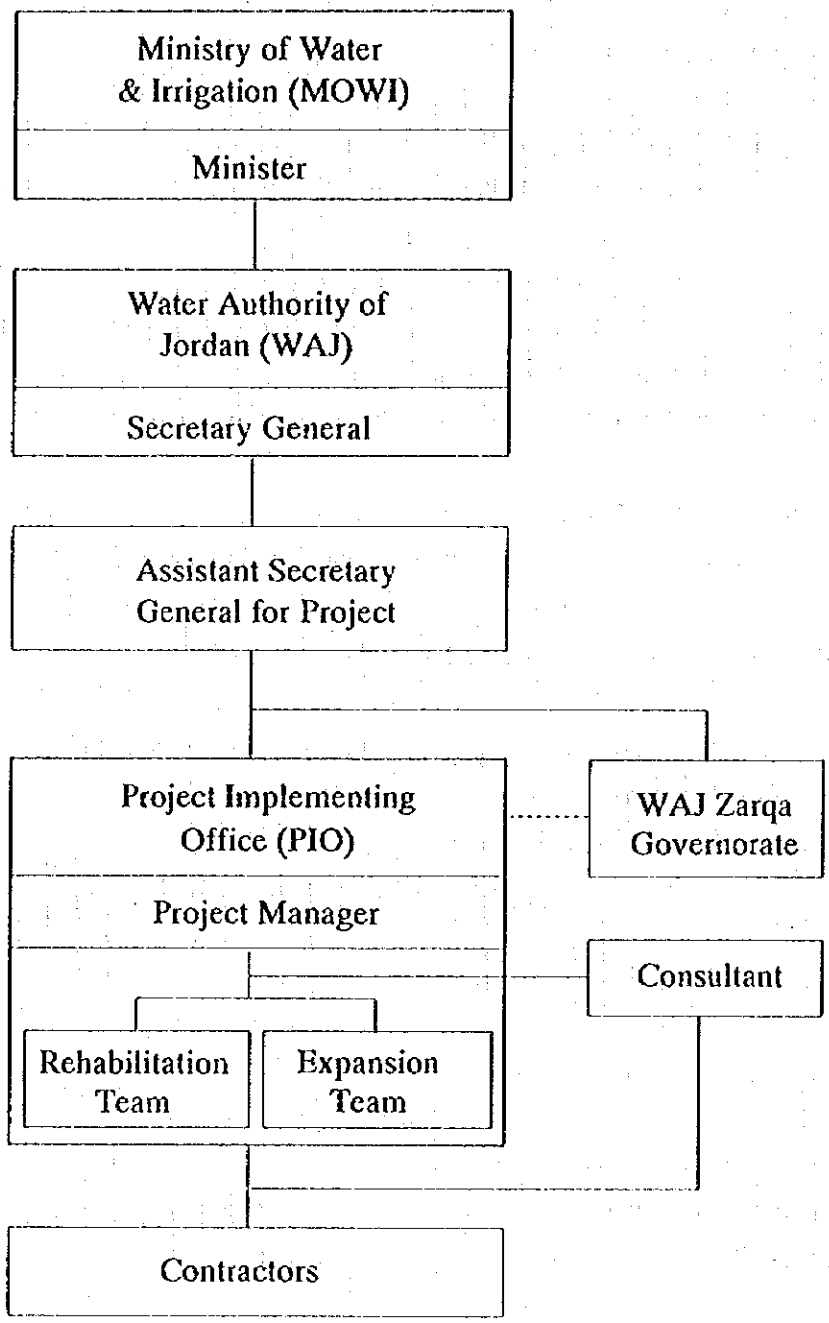
In order to collate this data with customer meter reading records, current metering and billing zones established by WAJ Zarqa will be rearranged to match the metered districts.

3.4 Improved Accounting System

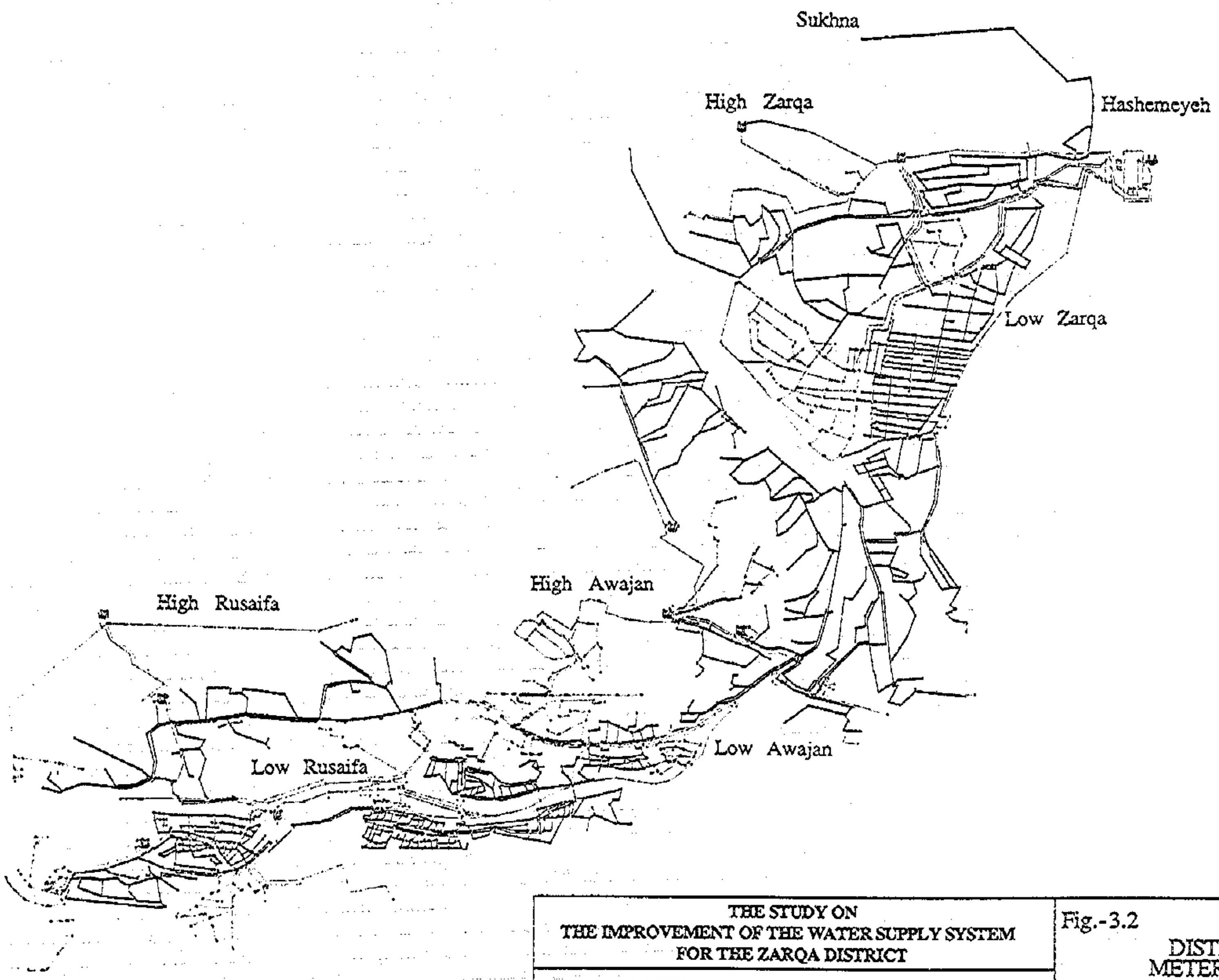
To improve operating efficiency, WAJ is planning to decentralize. Most of the functions carried out by WAJ Zarqa are now under the control of WAJ headquarters. With respect to financial matters, all the bills collected by WAJ Zarqa are remitted to headquarters and managed there. All WAJ Zarqa budgets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

PROJECT IMPLEMENTING ORGANIZATION



THE STUDY ON THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM FOR THE ZARQA DISTRICT	Fig. - 3.1
JAPAN INTERNATIONAL COOPERATION AGENCY	Project Implementing Organization



THE STUDY ON
THE IMPROVEMENT OF THE WATER SUPPLY SYSTEM
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Fig.-3.2

DISTRICT METERAREA

IV. COST ESTIMATE

4. COST ESTIMATES

The project cost for Stage 1 is estimated as follows, broken down into Foreign and Local Currency Components at the price level of September 1995:

Foreign currency portion (F/C)	US$ 44,600,000	(70.8 %)
Local currency portion (L/C)	US$ 18,400,000	(29.2 %)
Total	US$ 63,000,000	(100 %)

The costs are composed of rehabilitation works costs, land acquisition costs, construction costs, administration and engineering costs and physical contingency costs. The foreign currency portion includes the costs in CIF price of equipment and materials to be imported and the local currency portion includes the costs of labor, equipment and materials procured locally, custom clearance costs and transportation costs of imported equipment and materials.

Basic conditions and assumptions for the cost estimates are described below:

- unit prices of pump equipment and pipe materials are based on the quotations obtained from local agents
- unit prices of labor and equipment and materials for civil engineering works are based on current prices as of September 1995
- unit prices for service reservoir and pump house are based on the quotations obtained by from local consultants
- engineering and administration costs are estimated for required engineering services such as detailed design engineering and field survey /soil investigation costs and construction supervision, and WAJ administration costs for the project execution
- the exchange rates used reflect the prevailing exchange rates as of September 1995. The exchange rates used in the cost estimates are as follows:

  US$ 1.0 = JD 0.7 = Yen 100 (JD: Jordan Dinar)
- the import taxes and duties on the construction equipment and materials to be imported are excluded

Summary of the project costs are shown on Tables 4.1 and the breakdown is attached in Table 4.2.

Table 4.1 SUMMARY OF PROJECT COSTS FOR STAGE 1

(Unit:US$ 1,000)

Items	F/C	L/C	Costs
Rehabilitation Works	8,870	897	9,767
Land Acquisition Cost	-	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 Costs and Administration Costs	5,510	1,050	6,560
Physical Contingency	3,833	1,583	5,416
Total Project Costs	44,600	18,400	63,000

Table 4.2 PROJECT COST ESTIMATES FOR STAGE 1

(Unit : US$ 1,000)

Particular	Description	Quantity	Unit	Amount	F/C	L/C
1. Rehabilitation Works						
1) Custom meter replacement	13mm	12,700	m	381	343	38
2) Service pipes replacement	20 mm PE	140,000	m	2394	2155	239
	50 mm PE	13,100	m	317	285	32
3) Distribution pipe replacement	DIP 100 mm	75,000	m	4500	4050	450
	DIP 150 mm	17,400	m	1375	1237	137
Sub-total				8967	8070	897
4) Leakage detector and other equipment		1	LS	800	800	0
Total of Rehabilitation woks				**9767**	**8870**	**897**
2. Land Acquisition Costs						
1) Land for reservoir sites		11,550	m2	330		
Total of Land Costs				**330**	**0**	**330**
3. Transmission Pumps						
1) Pump equipment	to Batrawi 310 kW	5	sets	295	250	44
	to Awajan 21 132 kW	5	sets	145	123	22
	to RES 716 75 kW	2	sets	33	28	5
	to Awaj. RES 695 220 kW	5	sets	220	187	33
	to Rusa. RES 750 290 kW	6	sets	348	296	52
	to Rusa, RES 810 75 kW	2	sets	33	28	5
	Zarqa/Hashem well pump	2	sets	66	56	10
Sub-total				1140	969	171
2) Flywheel equipment		11	nr	165	140	25
3) Electrical equipment		1	LS	857	728	129
4) Header pipes, flow meters, control valves, chain hoists etc.		1	LS	913	776	137
5) Pump houses	RC	1	LS	871	0	871
6) Miscellaneous works		1	LS	738	627	111
Total of Transmission Pumps				**4684**	**3241**	**1443**
4. Transmission Pipes						
1) Transmission pipe works	DIP 800 mm	7,900	m	4234	2964	1270
	DIP 600 mm	19,100	m	6131	4292	1839
	DIP 500 mm	2,900	m	780	546	234
	DIP 400 mm	9,800	m	2166	1516	650

Particular	Description	Quantity	Unit	Amount	F/C	L/C
	DIP 300 mm	2,300	m	361	253	108
	DIP 250 mm	1,900	m	241	169	72
	DIP 200 mm	1,800	m	180	126	54
	DIP 150 mm	6,800	m	537	376	161
Sub-total				14630	10242	4388
2) One-way surge tank	capacity of 360 m3	6	nr	648	259	389
3) Miscellaneous works		1	LS	657	197	460
Total of Transmission Pipes				**15935**	**10698**	**5237**
5. Service Reservoirs						
1) Service reservoirs	Hashemeyeh	1,000	m3	170	68	102
	Sukhna	500	m3	85	34	51
	Zarqa low zone	6,250	m3	838	335	503
	Zarqa high zone	2,000	m3	340	136	204
	Awajan low zone	1,000	m3	170	68	102
	Awajan high zone	2,750	m3	377	151	226
	Rusaifa low zone	5,000	m3	685	274	411
	Rusaifa high zone	2,500	m3	343	137	206
2) Junction tank in transmission				0	0	0
route Khaw-Awajan		1,000	m3	170	68	102
3) Reservoir in Awajan 21 PS		5,000	m3	685	274	411
Total of Service Reservoirs				**3862**	**1545**	**2317**
6. Distribution Pipes						
1) Distribution pipe works	DIP 600 mm	5,900	m	1894	1326	568
	DIP 500 mm	1,000	m	269	188	81
	DIP 400 mm	11,800	m	2608	1825	782
	DIP 300 mm	3,900	m	612	429	184
	DIP 250 mm	1,500	m	194	135	58
	DIP 200 mm	17,300	m	1730	1211	519
	DIP 100 mm	126,900	m	7614	5330	2284
Sub-total		168,300		14921	10444	4476
2) Miscellaneous works		1	LS	1,525	458	1067
Total of Distribution Pipe Works				**16446**	**10902**	**5543**
7. Engineering and Administration Costs		1	LS	**6,560**	**5510**	**1050**
8. Physical Contingency				**5,416**	3833	1,583
TOTAL PROJECT COSTS				**63,000**	44,600	18,400