NO.

BASIC DESIGN STUDY REPORT
ON THE PROJECT
FOR
IMPROVEMENT OF THE WATER SUPPLY SYSTEM
FOR THE ZARQA DISTRICT
IN THE HASHEMITE KINGDOM OF JORDAN

JUNE 2002

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO ENGINEERING CONSULTANTS CO., LTD.
NIPPON KOEI CO., LTD.

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PREFACE

In response to a request from the Government of the Hashemite Kingdom of Jordan, the Government of Japan decided to conduct a basic design study on the project for improvement of the water supply system for the Zarqa District and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Jordan a study teams from November 26 to December 29, 2001 and April 13 to 21, 2002.

The team held discussion with the officials concerned of the Government of Jordan, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Jordan in order to discuss a draft basic design, and as this result, the present report was finalized.

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

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

June 2002

川上隆朗

Takao Kawakami
President
Japan International Cooperation Agency

June 2002

Letter of Transmittal

We are pleased to submit to you the basic design study report on the project for improvement of the water supply system for the Zarqa District in the Hashemite Kingdom of Jordan.

This study was conducted by the joint venture between Tokyo Engineering Consultants Co., Ltd. and Nippon Koei Co., Ltd., under a contract to JICA, during the period from November 2001 to June 2002. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Jordan and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

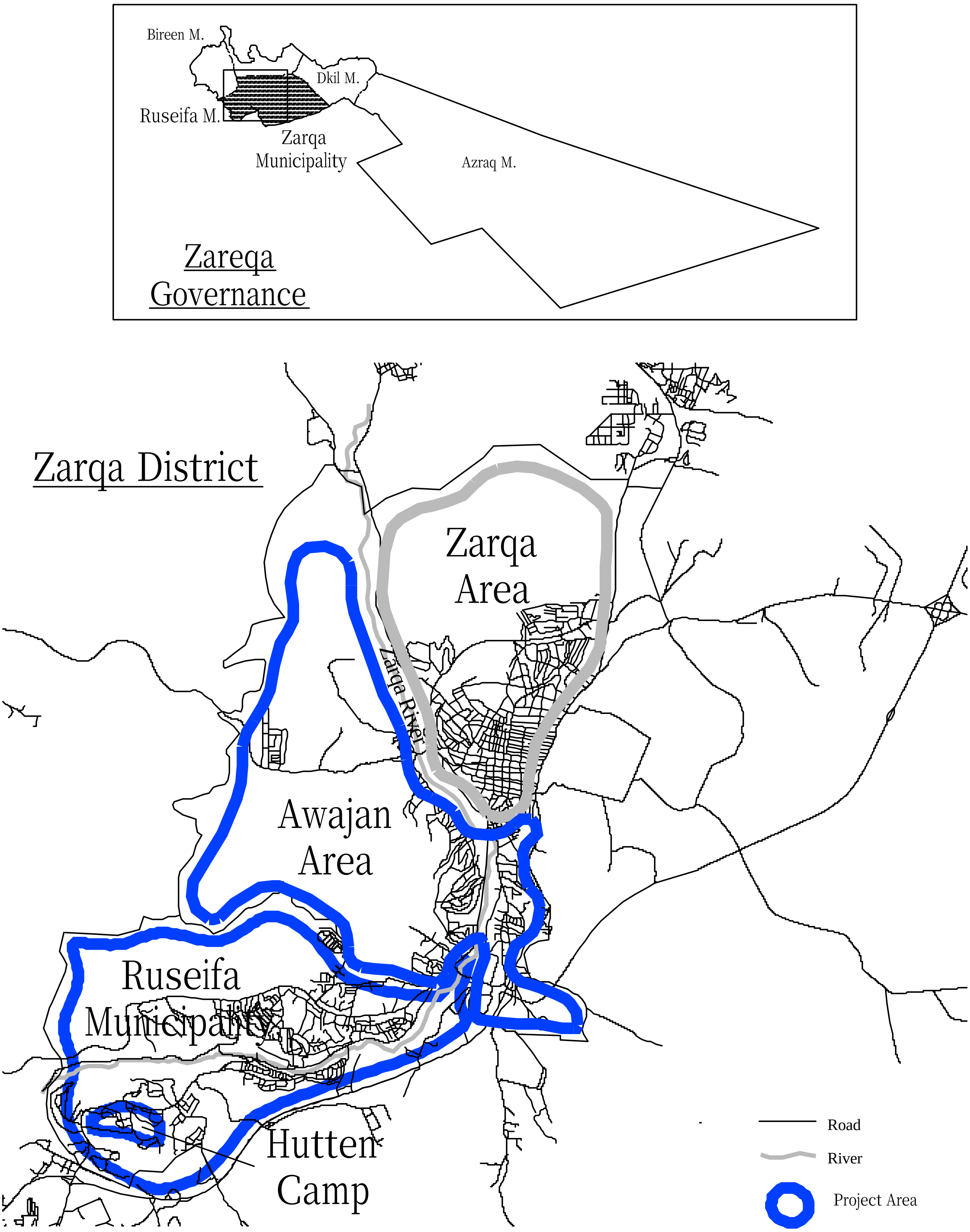
Very truly yours,

Kazufumi Momose

Project Manager,

Basic design study team on the project
for improvement of the water supply system
for the Zarqa District,

The joint venture between
Tokyo Engineering Consultants Co., Ltd. and
Nippon Koei Co., Ltd.



Location Map

Perspective View: Awajan High Reservoir

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Abbreviations

BOT	Build – operate – transfer
CIA	Central Intelligence Agency
CIDA	Canadian International Development Agency
DAC	Development Assistance Committee
DBO	Design – build – operate
DCIP	Ductile-cast iron pipe
DM	Deutsche Mark
EIB	European Investment Bank
EU	European Union
FS	feasibility study
GDP	Gross domestic product
GTZ	Gesellschaft für Technische Zusammenarbeit
HWL	high water level
IsDB	Islamic Development Bank
JD	Jordan Dinar
JICA	Japan International Cooperation Agency
JVA	Jordan Valley Authority
KfW	Kreditanstalt für Wiederaufbau
lpcd	litters per capita per day
LWL	low water level
MCM, mcm	million cubic meters
MCM/Y	million cubic meters per year
MP	mansterplan
MWI	Ministry of Water and Irrigation
NGO	Non-governmental organization
NO_3	Nitrate
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PC	Prestressed concrete
PMU	Project Management Unit
PS	Pumping station
PQ	Prequalification
PVC	Polyvinyl chloride
RC	Reinforced concrete
RES., Res.	Reservoir
TDS	Total dissolved solids
TVA	Tennessee Valley Authority
UFW	Unaccounted-for water
UNRWA	United Nations Relief and Works Agency
USAID	United States Agency for International Development
WAJ	Water Authority of Jordan

SUMMARY

Inadequate water management has been a problem of the Hashemite Kingdom of Jordan since its creation. Available water resource in Jordan is extremely small, as small as 200 m^3 per person per year against its world average of 7,700 m^3. This is less than a half of that in Israel, a neighboring country with the similar geographic conditions where recycled use of water is prevalent. Due to the shortage of water in Amman, the country's capital, in 1970's, remote groundwater wells were developed and put into operation, such as Azraq wellfield which is more than a hundred kilometers away. To address the need for the coordinated development and management of water resources at national level, Water Authority of Jordan (WAJ), a national water supply and sanitation services provider, was created in 1983 by merging numerous municipal water supply services under one unit and thus enabling coherent and efficient usage of the country's limited water resources.

Intending a comprehensive management of supply and demand of national water resources, rather than individual development schemes, a national water strategy was enacted in 1997, followed by undertaking of the Digital National Water Master Plan by the German technical cooperation and a study on nation-wide Water Resource Management by the Japanese technical cooperation through Japan International Cooperation Agency (JICA).

In addition to the scarce supply of water resources, the unaccounted-for water reached 59.4 percent in the national average in 1998. Actual water supply then comes down as little as approximately 70 liters per capita per day. Planned rationing of water is widely practiced, and therefore intermittent supply of approximately 30 hours per week is widespread. Residents are not only helped by individual cisterns to store water, but also obliged to buy expensive water from private venders.

To cope with these problems, WAJ formulated programs to reduce unaccounted-for water in major cities of Amman, Zarqa and others, and carried out rehabilitation of transmission pumps, transmission pipes, distribution reservoirs and networks with technical assistance from Germany through 1992 to 1995. The expanded rehabilitation projects in Amman are being carried out until 2004 with additional financial assistance from Italy, USA, etc. Japan, in recognition of the significance of stable Jordan in the Middle East Peace, and with request from the Jordanian Government to carry out a development study to reduce the unaccounted-for water in Zarqa area, undertook "the Study on the Improvement of the Water Supply System for the Zarqa District" through JICA from 1994 to 1996. In this study, recommendations were made to aim for equitable water supply and reduction of unaccounted-for water.

Zarqa area, the project area of the present basic design study, is the third largest city following Amman and Irbid. Zarqa is located at 20 km east of Amman and attributed with a high population growth, i.e., 3.8 to 3.9 percent per year, by in-migration of Palestinian refugees and those returned from jobs in the Middle Eastern countries. Being undulating terrain with limited flat land, inhabited plots have been expanding to slopes of hills at both sides of Zarqa river according to rapid increase of the population. Since distribution networks have been expanded following this tendency of housing development, networks in low areas are old and those in high areas are comparatively newer. Insufficient water pressure or discontinuation of supply takes place in high areas, while excessive distribution pressure and superannuated distribution pipes in low areas tend to cause leakage and breakage of pipes. To improve this situation, the Jordanian Government developed distribution networks in the areas not yet serviced and replaced superannuated pipes in the existing service areas with its own fund. It also requested Japan's grant aid to improve major transmission and distribution facilities that is intended to bring about the fair and equitable water supply and reduction of unaccounted-for water in the Zarqa district, which were recommended in the JICA study in 1996.

The requested project for the grant aid originally consisted of utilization of transmission route from Azraq wellfield through Khaw pumping station to Amman, which should be diverted to Awajan and Ruseifa areas through two newly constructed pumping stations.

Upon the request, JICA dispatched a basic design study team to the field in Jordan twice from November 26 to December 29, 2001 and April 13 to 21, 2002.

It was learned in the field study that “Dier Alla-Zai-Amman Water Project Stage II” under the German loan through KfW and “Zara and Ma’in Brackish Water Desalination Project” with the US assistance through USAID are to be completed by the target year of the present project (2005); thereby water demand in the neighboring Amman area is to be satisfied; and the surplus of water thus derived can be supplied to areas of the present project. This project then receives the surplus water from Amman through the existing transmission pipeline from Khaw pumping station to Amman in its reversed way, and transmits it to the project area by gravity. All pumping stations included in the original request, therefore, became unnecessary. A comparison of project components between the original request and the final basic design is shown in Table 1.

Table 1 Original Request and the Basic Design

Original Request	Basic Design
Transmission pipe Khaw PS – Awajan PS Awajan PS – Awajan High Res. Awajan High Res. – Awajan Low Res. Awajan PS – Ruseifa Low Res. Ruseifa Low Res. – Ruseifa High Res.	 Hutteen junction – Hutteen Res. Hutten Res. – Ruseifa High Res. Ruseifa High Res. – Ruseifa Low Res. Awajan High Res. – Awajan Low Res.
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Distribution reservoir Awajan PS Res. Awajan High Res. (expansion) Awajan Low Res. Ruseifa High Res. Ruseifa Low Res.	 Awajan High Res. (expansion) Awajan Low Res. Ruseifa High Res. Ruseifa Low Res.
Distribution main Awajan High Zone. Awajan Low Zone Ruseifa High Zone Ruseifa Low Zone	 Awajan High Zone. Awajan Low Zone Ruseifa High Zone Ruseifa Low Zone

In order to bring about benefits of the project earlier, technical cooperation through a “software components program” is proposed to help in designing the distribution sub-zones and transfer technology for operation of distribution control, both of which are to be carried out by the Jordanian side.

The following design policies are adopted in the basic design of the project:

a. Currently distributed volume seems to be suppressed due to insufficient supply from water source. Improved target should be set at 90 liters per capita per day in 2005, as allocated water increase. Similarly, target for hours of supply should be more than 96 hours per week in 2005 compared to the present supply of 10 to 36 hours.

b. To supply water fairly and equitably and reduce the leakage in the project area, uniform distribution pressure should be maintained by controlling volume and pressure within the defined distribution zones. A distribution reservoir, transmission line and distribution main are to be serviced in each zone. The reservoir capacity should be set at 8 hours, whereas transmission capacity should be set for the daily maximum and the distribution capacity should be enough to supply hourly maximum.

c. Yields of groundwater wells that are currently over-drafted should be reduced.

Targeted levels of water supply services are compared with the present levels in Table 2.

Table 2 Present and Planned Service Level

Service Index	Unit	2000	2005
Served Population	Person	342,100	413,300
Service Ratio	%	93%	98%
Service Hours	hr/week	10- 36	96
Service Pressure	bar	0 – 14	2.5 – 6
Service Area	—	Partially unserved	Expansion
Water Supply (daily average)	m^3/day	30,400	50,500
UFW Ratio	%	55	40
Leakage Ratio	%	31	25
Per-capita Consumption (daily average)	lpcd	67	90
Per-capita Consumption (daily maximum)	lpcd	89	122
Increase of Supply	m^3/day	—	20,100
Water Quality	—	Satisfactory	Satisfactory

Facilities to be constructed under the project are the following transmission pipelines, reservoirs and distribution mains:

Transmission pipeline

1	Hatten junction – Hutten reservoir	D 500 mm, L 1,112 m
2	Hutten reservoir – Ruseifa High reservoir	D 400 mm, L 4,822 m
3	Ruseifa High reservoir – Ruseifa Low reservoir	D 300 mm, L 1,535 m
4	Awajan High reservoir – Awajan Low reservoir	D 200 mm, L 1,285 m

Distribution reservoir

1	Ruseifa High reservoir	V 1,800 m^3, L20 m x W18 m x H5 m
2	Ruseifa Low reservoir	V 6,300 m^3, D 36.6 m, H 6 m
3	Awajan High reservoir (expansion)	V 6,300 m^3, D 36.6 m, H 6 m
4	Awajan Low reservoir	V 1,800 m^3, L20 m x W18 m x H5 m

Distribution main

1	Ruseifa High zone	D 200 mm, L 3,392 m
2	Reseifa Low zone	D 500 mm, L 1,695 m
3	Awajan High zone	D 600 mm, L 1,747 m
4	Awajan Low zone	D 400 mm, L 1,466 m

A technical assistance shall be implemented in the framework of "software component program." It is intended to support and ensure the Jordanian undertaking, which consists of delineation of distribution zones, daily distribution control, periodical replacement of superannuated pipes and maintenance of distribution networks. Through uplifting the capacity of operation and maintenance, benefits of the project to reduce the unaccounted-for water and distribute water equitably will be maximized. Major activities of the program include the following three approaches:

- Network mapping approach
- Network analysis approach
- Capacity improvement approach to control distribution

The necessary measures and obligations of the Jordanian side for the project are listed as follows:

a. Development of distribution network in Ruseifa area currently not yet serviced
b. Replacement of superannuated service pipes and water meters
c. Installation of control valves needed in delimitation of the distribution zones

d. Other obligations auxiliary to the work by Japanese side

The project will be implemented in two phases. Four months will be allocated for the detail design and 29 months for the construction.

Estimated cost for the Jordanian undertaking is 2.89 million JD.

The following direct and indirect effects (outputs) are expected by implementation of the project:

Direct effects:

a. The served population in Ruseifa and Awajan area will be increased from 340,000 persons at present to 410,000 persons in the target year 2005.
b. Hours of water supply will be increased to more than 4 days from the current 1 day a week, and hours of suspended supply will decrease largely.
c. By keeping appropriate distribution pressure, residents at higher places will be able to enjoy water supply for a longer hours and fair and equitable supply will be achieved. Thereby leakage due to breakage of distribution pipe will come down. This will lower the fraction of unaccounted-for water as well as reduce the repair cost.
d. Volume of supply will increase to more than 90 liters per capita per day from the current 70 liters. An improvement in health conditions is expected.
e. By utilizing the gravity flow without pumping, electric power cost will be largely reduced.

Indirect effects:

a. By improving the level of water supply service and therefore sanitation situation, cases of water-borne diseases such as typhoid and hepatitis A are expected to decrease.
b. Need to buy expensive water from private water venders will become less and infrequent. Stable life of citizens is ensured.
c. Citizens in the project area, particularly those in Ruseifa area including refugees and displaced people will be benefited. Improved water supply services to those vulnerable ones will contribute to the socio-political stability

For the efficient implementation of this project, the Jordanian side is required to install the well-balanced distribution facility and establish the suitable system of operation and maintenance. This project will be more smoothly and effectively implemented, provided that the following are ensured:

a. Water should be allocated by completion of "Dier Alla-Zai-Amman Water Project Stage II" under the German loan through KfW and "Zara and Ma'in Brackish Water Desalination Project" with the US assistance through USAID by 2005.
b. The distribution network should be developed and expanded suitably following the development of major facilities of transmission pipeline, distribution reservoirs and mains.
c. Delineation of distribution zones, distribution control and periodical replacement of superannuated pipes should be implemented in the expanded distribution network.

Basic Design Study on the Project for
Improvement of the Water Supply System for the Zarqa District
Final Report

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Chapter 1 Background of the Project

Chapter 1 Background of the Project

To reduce the unaccounted-for water in Zarqa area, Water Authority of Jordan (WAJ) implemented a project for rehabilitation of distribution networks from 1990 to 1993 at a project cost of 13 million JD. Major part of the rehabilitation work comprised replacement of distribution pipes and house connections that were installed before 1960's. Due to the inappropriate distribution pressure, however, expected objectives were not fully attained. WAJ became aware of the need to restructure the transmission and distribution networks, and requested Japan to undertake a development study. In response to the request, JICA carried out a development study on improvement of the water supply system for Zarqa district from 1994 to 1996. The study consisted of a master plan with target year of 2015 and a feasibility study on the first stage improvement program for the target year of 2005. The study pointed out the following:

- Difference in elevations in the service area reaches 300 m. As appropriate distribution control is not practiced, difference in distribution pressure is large. There are many leakages in the high pressure areas and discontinuation of supply happens frequently in the low pressure areas. As a result, the precious water is utilized ineffectively.

- As transmission pipes and booster pumps had been expanded without a reasonable master plan, distribution control could not be properly made. As a consequence, electric energy is ineffectively used. In addition, operation of pumps is very difficult and ineffective.

To reduce leakage and develop energy-efficient system, the study recommended the following:

a. Delineation of 8 distribution zones to keep distribution pressure in proper range in each area

b. Partitioning of each distribution zones into multiple district metering areas (sub-zones) to make distribution control easy

c. Restructuring of transmission systems including discontinuation of some part and new installation of distribution reservoirs to establish the energy-efficient system

d. Replacement of superannuated distribution pipes and inaccurate water meters, which are the causes of unaccounted-for water

e. Adoption of active leakage control program for the place of passive protection against leakage that had been practiced

f. Reorganization of effective and mobile leakage control team

g. Application of monetary incentives for employees engaged in the difficult leakage control activities

h. Promotion of leakage control program (dispatch of expert for leakage control)

i. Rehabilitation of groundwater wells

j. Programmed expansion of facilities in conformity with growth of demands

These programs were intended to reduce leakage, increase supply, enable equitable supply within the service area, and to pursue an energy-efficient operation system.

To restructure the distribution system, the existing distribution network, pumping stations, reservoirs and water sources within and outside of the district were reviewed, and a program was formulated to delineate plural number of distribution zones in conformity with population distribution and elevation of the area. Transmission pumps, transmission pipelines and distribution reservoirs are the major facilities required for this delineation of zones.

Jordanian side implemented improvement projects in small scales according to the proposed programs in the JICA master plan.

a. Improvement of Khaw pumping station

Booster pumps for transmission to Amman and Zarqa were separated and a new pump house for Zarqa was constructed.

b. Improvement of Zarqa Low Distribution Zone

Construction of transmission system from Khaw pumping station to Zarqa area started in early 2002. This project consists of delineation of Zarqa High and Zarqa Low distribution zones and discontinuation of an inefficient booster pump station. As a part of this project, water treatment facilities were installed at Hashemeyeh well, which produced water with high TDS content. This project was carried out by Jordan's own fund.

c. Improvement of Ruseifa High Zone (south)

Distribution facilities in Hutten Refugee Camp, which is located in the south of Ruseifa High zone, was improved. This project was completed in 2001 as one of 6 projects for improvement of water supply systems in 6 refugee camps that were financed by KfW. It includes:

- Served population at the target year of 2025 is set at 105,218 persons compared to 36,218 persons in 1994. Supply of 106 liters per capita per day is targeted,
- Delineation of distribution sub-zones. To keep pressure in a range of 25 to 60 m, high sub-zone at altitudes of 734 to 762 m and low sub-zone at altitudes of 682 to 740 m were established,
- Installation of Ruseifa booster pump station with a reservoir of 500 m^3 for the place of three existing pump stations,
- Transmission line (dia. 300 mm, L 1,800 m) from the same pump station to Hutten reservoir,
- Hutten reservoir (10-hour retention, 4,000 m^3, LWL 772 m), elevated reservoir (200 m^3) and pump for elevated reservoir,
- Replacement of all distribution pipes (dia. 75 to 350 mm).

d. Improvement of Ruseifa High and Low Distribution Zones

Inhabitation into areas at the north of Yajuuz road was progressed after Gulf War. Expansion of water service to this area could not catch up with the growth of housing development without urban planning, and the area (3.9 km^2) now has population of 28,800 including unserved population of 9,000. To improve this situation by introducing zoning system, a conceptual and detailed design of distribution networks was completed in 2001. Expansion and replacement of distribution pipes are planned. This project is expected to be carried out with Jordan's own fund and consists of the following index and components:

- Served population at the target year 2025 is projected to be 64,000 persons against the present population of 29,659 in year 2000. Per-capita per-day supply is planned at 125 liters,
- In accordance with the JICA master plan, Ruseifa High zone (altitude: 725 – 800 m) and Low zone (675 – 725 m) are delineated,
- Distribution reservoirs with capacity of 12-hour retention time at each zone are planned,
- Ductile cast iron pipe for dia. 100 mm or bigger and high density polyethylene pipe for dia. 63 mm or smaller are used in accordance with WAJ standards,
- Newly installed pipe will include 3 km of steel pipe (dia. 400 mm), 15 km of ductile cast iron pipe (dia. 250 to 100 mm), 22 km of high density polyethylene pipe (dia. 63 mm) and 7 km of high density polyethylene pipe (dia. 32 mm).

e. Replacement of Superannuated Pipe

To replace the old pipe and expand the service area, Unaccouted-for Water Department of WAJ Zarqa office requested the budget of 2,946,150 JD (US$ 4.1 million). This project includes 146,220 m of distribution pipe with dia. 13 to 600 mm for the entire Zarqa area. Part of this project to be implemented in Ruseifa area includes 16,200 m of pipe with cost of 313,100 JD. Details of pipe and length are as follows:

Diameter (mm)	Total Length (m)	Length in Ruseifa area (m)
600	820	0
400	3,000	0
200	15,000	1,500
150	14,700	3,700
100	33,800	6,000
50	57,800	3,000
25	13,100	1,000
13	8,000	1,000

Components of the Requested Project

Components of the present project requested are major transmission and distribution facilities in four distribution zones (Awajan High, Awajan Low, Ruseifa High and Ruseifa Low). These four zones are among eight distribution zones proposed in the development study on improvement of the water supply system for Zarqa district.

Chapter 2 Contents of the Project

Chapter 2 Contents of the Project

2.1 Basic Concept of the Project

Zarqa Directorate of the Water Authority of Jordan (WAJ) practices planned rationing of water to districts in the service area due to insufficient supply much less than the demand. The Jordanian Government, therefore, requested Japan a development study on improvement of the water supply system to upgrade the level of water supply service and hence the living standards of the residents in Zarqa area.

Upon the request, Japan International Cooperation Agency (JICA) carried out a master planning and feasibility study from 1994 to 1996 aimed at appropriate water supply and reduction of unaccounted-for water. The study recommended, taking into account topographic conditions, delineation of four distribution zones to keep the distribution pressure uniform for easy distribution control, and renewal of deteriorated distribution network.

Increase in growth of population in the study area is almost four percent a year, and development of distribution network does not catch up with the growing demand. To improve this situation, the WAJ developed distribution networks in the areas not yet serviced and replaced superannuated pipes in the existing service areas with its own fund. It also requested Japan's grant aid to improve major transmission and distribution facilities to establish stable water supply.

In response to the request, JICA carried out a basic design study from November 26 to December 29, 2001 and April 13 to 21, 2002. It was learned in the study that "Dier Alla-Zai-Amman Water Project Stage II" under the German loan through KfW and "Zara and Ma'in Brackish Water Desalination Project" with the US assistance through USAID are to be completed by the target year of the present project (2005); thereby water demand in the neighboring Amman area is to be satisfied; and the surplus of water thus derived can be supplied to areas of the present project. This project then receives the surplus water from Amman through the existing transmission pipeline from Khaw pumping station to Amman in its reversed way, and transmit it to the project area by gravity. All pumping stations included in the original request, therefore, became unnecessary.

Under the project, the Jordanian side is expected to implement delimitation of the distribution zones by installing valves. WAJ anticipates technical supports on designing of zones and the distribution control in the zones by technical assistance under "*software component program*," and wishes to bring about a fair and equitable water supply as early as possible.

Comparison between Original Request and Basic Design

Original Request (June 1999)	Basic Design
Transmission pipe Khaw PS – Awajan PS Awajan PS – Awajan High Res. Awajan High Res. – Awajan Low Res. Awajan PS – Ruseifa Low Res. Ruseifa Low Res. – Ruseifa High Res.	Hutteen junction – Hutteen Res. – Ruseifa High Res. Hutteen Res. – Ruseifa High Res. Ruseifa High Res. – Ruseifa Low Res. Awajan High Res. – Awajan Low Res.
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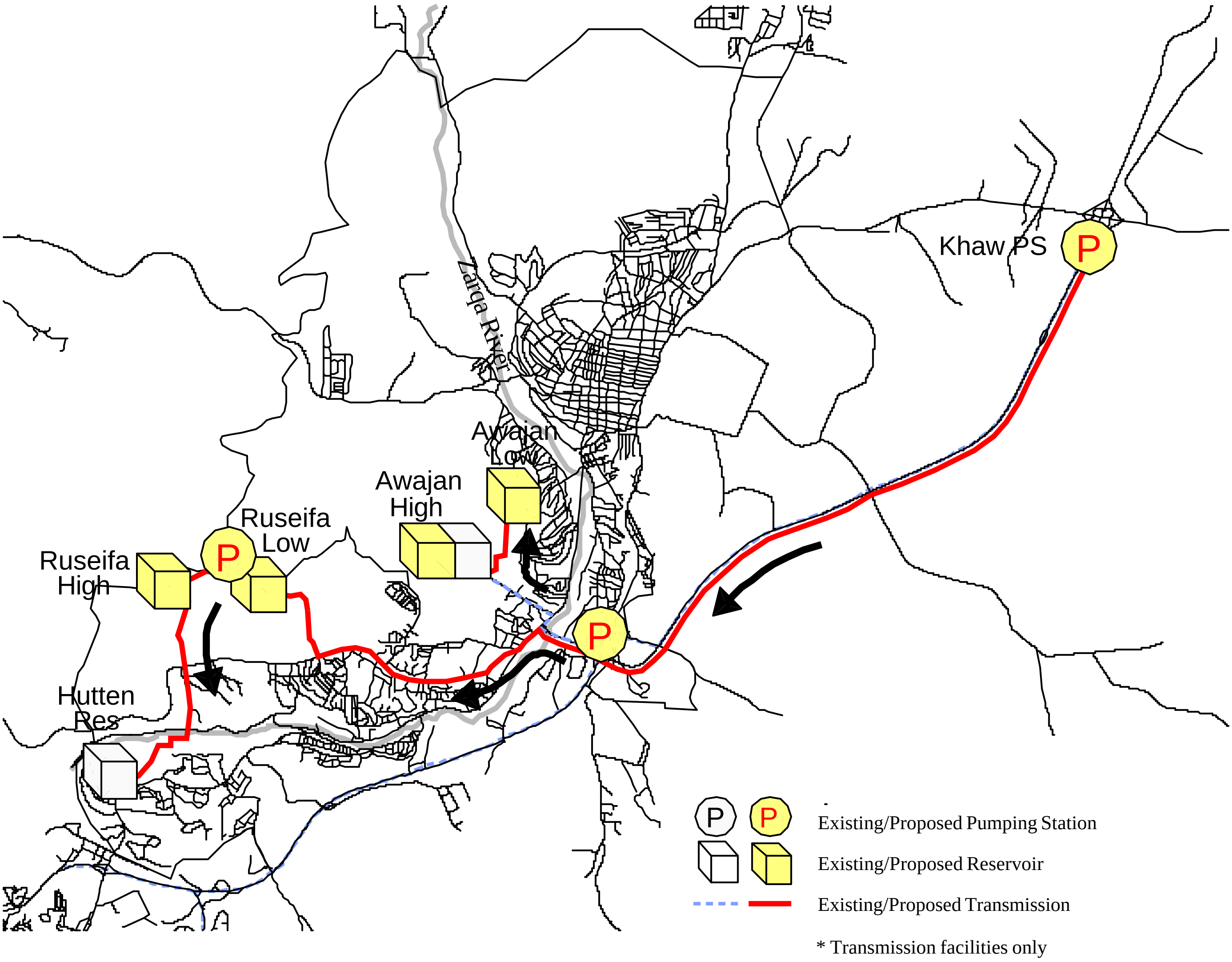
Distribution main From Awajan High res. From Awajan Low res. From Ruseifa High res. From Ruseifa Low res.	From Awajan High res. From Awajan Low res. From Ruseifa High res. From Ruseifa Low res.

Facilities proposed in the original request is shown in Figure 2-1. Facilities in this basic design based on the amended request is shown in Figure 2-2. Global plan including transmission route from Amman is shown in Figure 2-3.

Figure 2-1 Facilities of Original Request



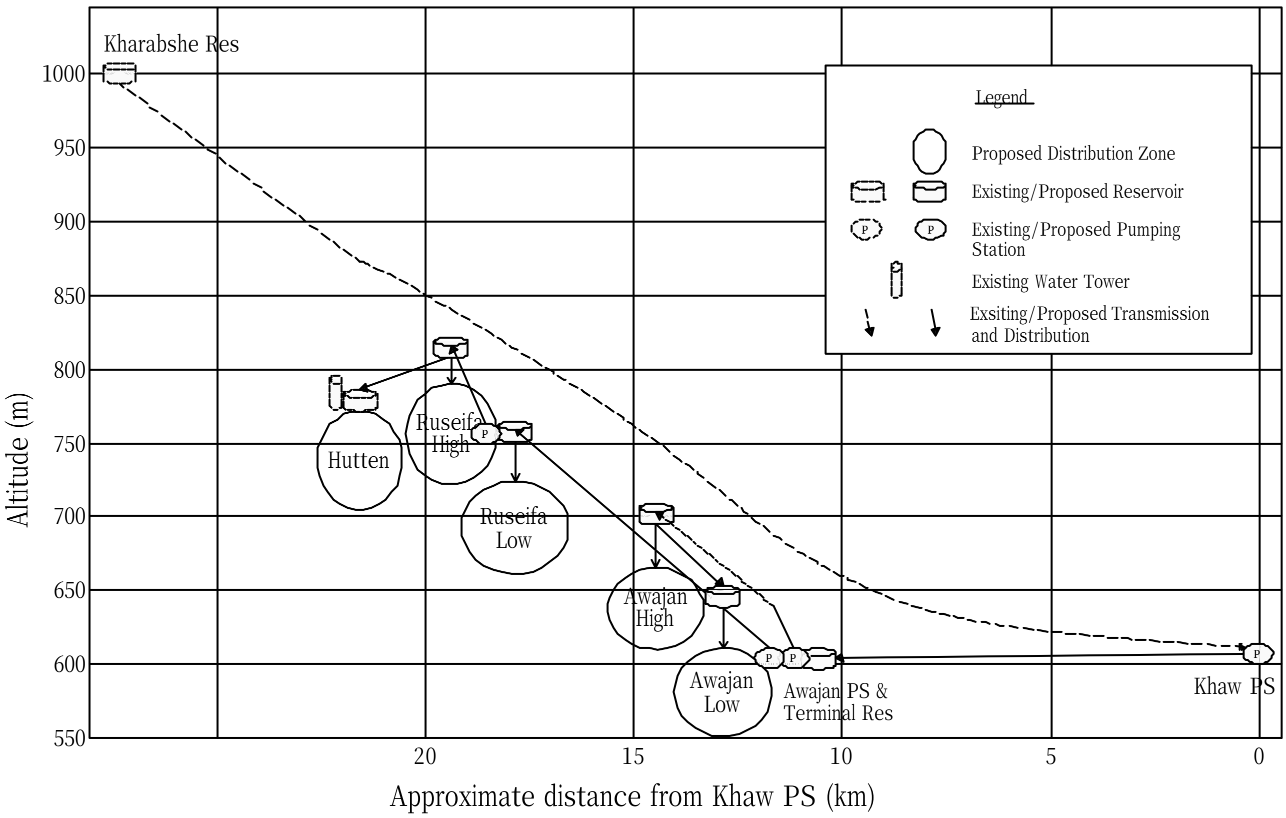
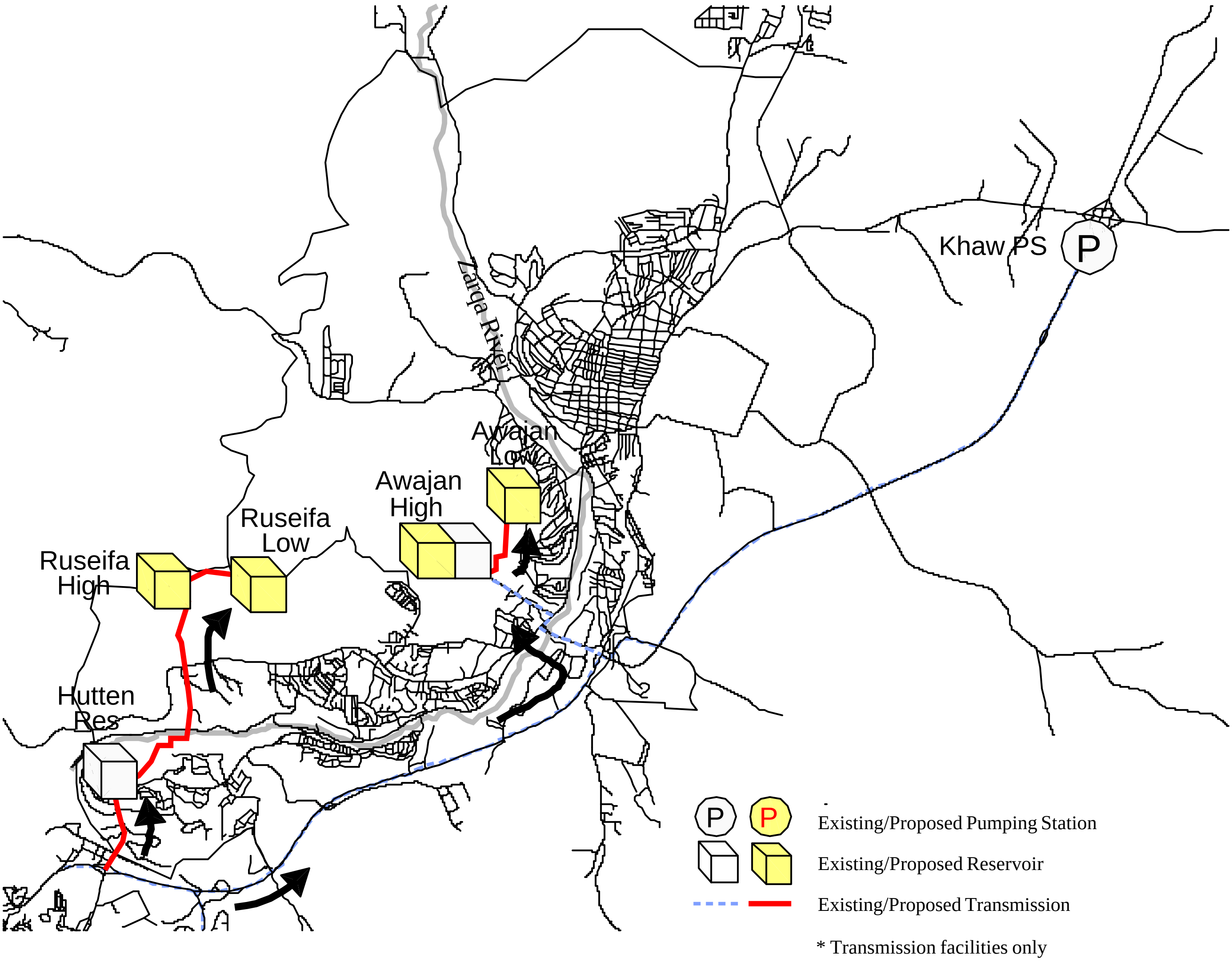


Fig 2-2 Facilities of Amended Request



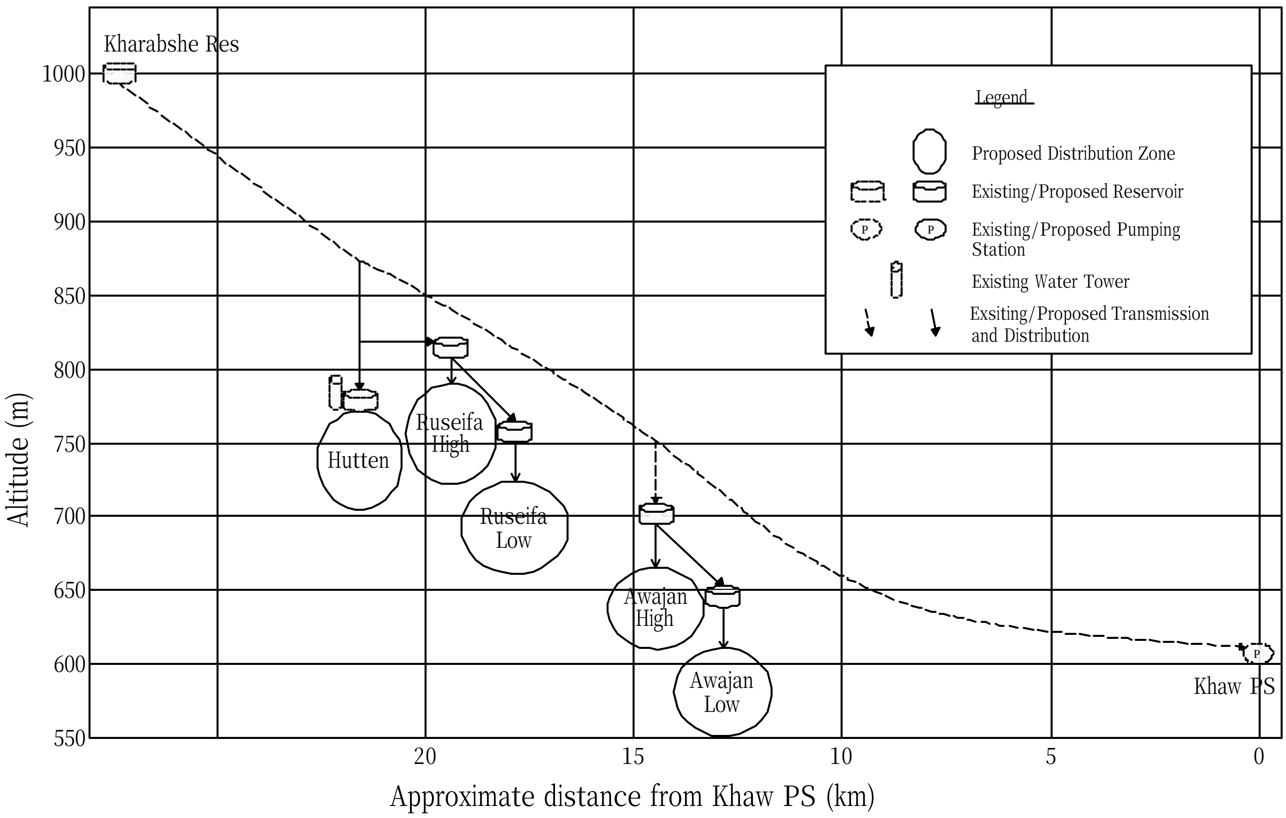
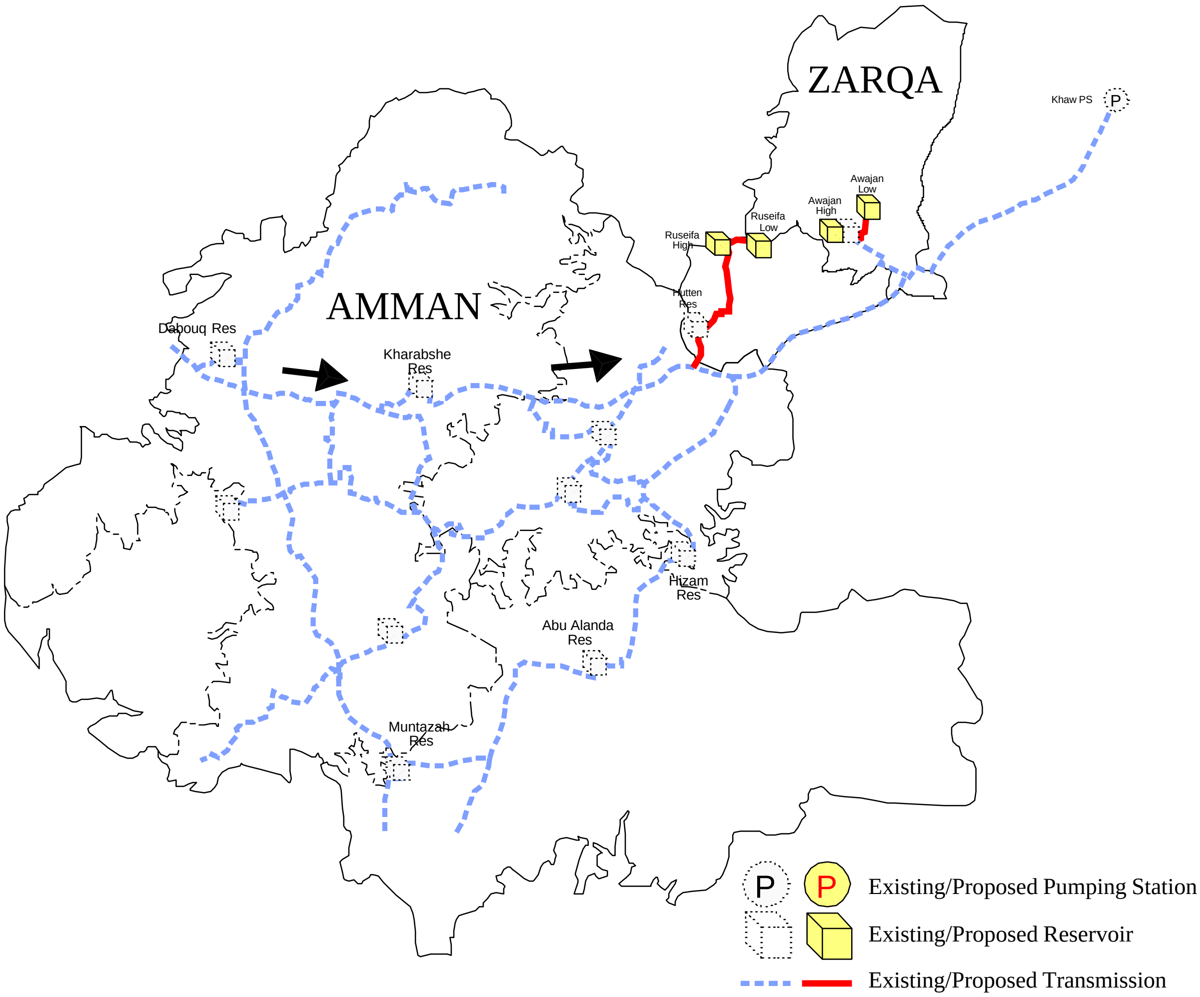


Figure 2-3 Transmission Route from AMMAN



2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

To make facilities and equipment of the basic design suitable to the conditions of Jordan and WAJ, the implementing agency, design policy is elaborated and summarized below.

(1) Scope of Basic Design

1) Project area

Project area consists of Ruseifa city (including Hutten refugee camp) and Awajan area in Zarqa city in the Zarqa governorate.

2) Planned facilities

The following facilities are planned to improve water supply condition in the project area:

a) New facilities: transmission pipes, distribution reservoirs and their auxiliaries, distribution main pipes from reservoirs to the existing distribution pipes
b) Rehabilitation and improvement: replacement of superannuated distribution pipes, water meters and service pipes
c) Expansion of service area: installation of distribution and service pipes

3) Split of work

a) Japanese side: transmission pipes, distribution reservoirs and their auxiliaries, distribution main pipes from reservoirs to the existing distribution pipes
b) Jordanian side: installation of valves to delineate distribution zones, replacement of superannuated distribution pipes, water meters and service pipes; and installation of distribution and service pipes in the expanded service area

4) Software component program

The following software component program will be implemented by the Japanese side to maximize the project benefit.

a) Program to control transmission/distribution flow rate and distribution pressure
b) Assistance in planning and delimitating of distribution zones
c) Assistance in programming and implementation of water rationing
d) Assistance in network mapping system for optimum water distribution management

(2) Target Year

Target year of this project shall be 2005. Nevertheless, water demand projection is estimated up to 2015.

(3) Level of Water Supply Services

Present service level (2000) and planned service level (2005) are shown in Table 2-1.

Table 2-1 Present and Planned Service Level

Service Index	Unit	2000	2005
Population	person	366,100	421,700
Served Population	person	342,100	413,300
Unserved Population	person	24,000	7,400
Service Ratio	%	93%	98%
Service Hour	hr/week	10- 36	96
Service Pressure	bar	0 – 14	2.5 – 6
Service Area	–	–	Expansion
Water Supply (Daily Average)	m^3/day		50,500
UFW Ratio	%		40
Leakage Ratio	%		25
Per Capita Consumption (Daily Average)	lpcd		90
Service Water Quality	–	Satisfy DW Std	Satisfy DW Std

1) Population projection

Population censuses were carried out in 1979 and 1994. As new census has not been carried out since 1994, accurate population is not known. Department of Statistics estimates own figures of population. In addition, population projection in Zarqa governorate is not made. Therefore, population projection in the Study on the Improvement of the Water Supply System for the Zarqa District (JICA study, 1996) has been adopted for this Basic Design Study. Some minor modification has been done for each census unit projection by applying saturated population density (700 persons/ha). Projected population is shown in Table 2-2.

Table 2-2 Population Projections in Zarqa District

Area	Projected Population					Density in 2015
	1994	2000	2005	2010	2015	Persons/ha
Zarqa	340,261	401,600	454,400	509,100	570,400	97
Ruseifa	134,495	170,200	200,200	227,600	258,800	137
Hashemeyeh	13,936	18,400	22,400	26,200	30,700	50
Sukhna	9,764	12,600	15,300	17,700	20,500	37
Hutten	36,218	42,500	47,900	53,400	59,500	649
Total	534,674	645,300	740,200	834,000	939,900	104
	Annual Population Growth Rate (%)					
Zarqa		2.8	2.5	2.3	2.3	
Ruseifa		4.0	3.3	2.6	2.6	
Hutten		2.7	2.4	2.2	2.2	

Note: Projection of Ruseifa area after 2005 is moderate in view to the national average growth of 3 percent.

2) Unserved population and service ratio

The unserved population is also estimated. According to Water Supply Project for Parts of Ruseifa Municipality (2000), the unserved population is estimated as 9,000 at the northern hilly area of Ruseifa city. Considering this, the BD team has estimated that the unserved population of Ruseifa district is 15,000 in year 2000.

The unserved population of Awajan district is estimated as 9,000 in 2000 from the unserved area. In the Hutten refugee's camp, since the distribution pipes are improved recently, the service rate is almost 100 percent.

The service ratio in 2000 is 93 percent; since unserved population estimated is 24,000, and served population is 342,100.

3) Daily per capita consumption

According to the study result of the JICA study team (1996), daily per capita consumption in 1995 was 75 – 80 liters in summer and 70 liters in winter. On the other hand, the data from UFW survey, which JICA leakage expert conducted, leads to 69 liters. Thus, daily average per capita consumption in 2000 would be 70 liters. This is the minimum amount for daily life.

Demand projection is estimated considering following data of various studies and projects:

- 90 L: Planned per capita consumption in Zarqa in 2015, JICA, 1996
- 101 L: Estimated per capita consumption in Amman city in 1994
- 130 L: Planned per capital consumption in Hydraulic Analysis of Greater Amman Water Supply System, 1997
- 115 L: Water Supply Project for Parts of Ruseifa Municipality, 2000
- 100 L: Stage IV-Hutten Camp, Community Infrastructure Program
- 130 L: Per capita consumption generally applied in Jordan
- 130/144 L (Lower/higher estimation scenario in 2015): The Study on Water Resources Management (JICA, 2001)

A per capita consumption of 130 liter is adopted in Amman city. It is anticipated that the amount of water consumption of Zarqa district is lower than that of Amman city. On the other hand, JICA study team adopts the minimum value of 90 liters excluding the unaccounted-for water. Considering such a situation, Table 2-3 shows planned per capita consumption by every five years from 2000 to 2015.

4) Leakage rate

Though there is no accurate data of leakage rate of present water supply facilities, the present leakage rate is set as 31 % based on the results shown below. In this project, the decrease of leakage rate is predicted due to replacement of existing old pipes as indicated in Table 2-3.

- In the Hydraulic Analysis of Greater Amman Water Supply System, 1997, present leakage rate is estimated as 30 %, and aimed to reduce it to 15 %.
- According to the leakage survey of JICA study team (1996) in Zarqa district, the average leakage rate was 31 %.

5) Daily maximum coefficient

Various data for the daily maximum coefficient are indicated below. Under the rationed water supply situation at present, the accurate daily maximum coefficient cannot be estimated. In general, the higher is the service population, the smaller is the coefficient. Or the coefficient is larger in the place where the daily temperature difference is high. In Zarqa district, similarly in Amman area, the temperature difference is high, daily maximum coefficient is estimated high. In Jordan, the coefficient of 1.5 is adopted for planning the facilities. In this project, 1.3 shall be applied to improve the present value of 1.2 that is suppressed and to avoid unnecessarily bigger facilities.

- 1.1: Analysis of well production fluctuation in Zarqa
- 1.2: Analysis of yearly transfer rate fluctuation to Ruseifa
- 1.2: JICA study (1996)
- 1.16/1.11: Fluctuation of total water supply in Amman city (1994/1995)
- More than 1.5: Hydraulic Analysis of Greater Amman Water Supply System
- 1.5: Water Supply Project for Parts of Ruseifa Municipality (2000)
- 1.5: Stage IV-Hutten Camp, Community Infrastructure Program

Table 2-3 Planned Parameters

Year	2000	2005	2010	2015
Per capita consumption (lpcd)	70	90	100	110
Leakage rate (%)	31	25	20	15
Daily maximum coefficient	1.3	1.3	1.3	1.3

6) Water Demand Projection

Water demand projection in the Zarqa district is indicated in Table 2-4, and that in the project area is shown in Table 2-5.

Table 2-4 Water Demand Projection in Zarqa District

Year	2000	2005	2010	2015
Total Population	645,255	740,123	833,988	939,852
Daily average water demand (m^3/day)	65,100	88,700	104,300	121,300
Daily average water demand (Million m^3/year)	23.76	32.38	38.07	44.24
Daily maximum water demand (m^3/day)	84,600	115,500	136,000	158,000
Daily maximum water demand (Million m^3/year)	30.88	42.16	49.64	57.67

Table 2-5 Water Demand Projection in Ruseifa and Awajan Area

Year	2000	2005	2010	2015
Total Population	366,100	421,700	476,900	541,000
Daily average water demand (m^3/day)	37,100	50,500	596,00	69,900
Daily maximum water demand (m^3/day)	47,900	65,900	77,700	90,900

7) Service hours:
In districts in the project area water is supplied for more or less one day a week. Four-day supply shall be targeted in the year 2005.

8) Supply pressure:
The project area consists mostly of residential area with the prevalence of detached houses and four-story apartment buildings. Adequate pressure to supply water without pumping to four or five-story apartment buildings, i.e., 2.5kgf/cm^2 (25 m) shall be applied.

9) Quality of water:
Some water sources in the project area do not satisfy the TDS and NO_3 criteria of the Jordanian drinking water standards. These sources shall be mixed with good sources to satisfy the standards. In addition, enough chlorine shall be dosed to keep residual chlorine at the level of 0.2-1.0 mg/l as stipulated in the standards.

(4) Source of Water

(1) Present and future water source for Amman and Zarqa

Sources of water supply in Amman and Zarqa are mostly groundwater wells. As the demand has increased in recent years, wells have become overdraft, and remarkable lowerings of water table are observed. The lowering rate in some wells reaches 10 meters per year (m/y). Higher lowering rates are observed particularly in Ruseifa area.

Deterioration in water quality is also remarkable. Increase of salt content and NO_3 concentration is widely observed in Jordan, especially in Amman - Zarqa basin. In some areas, electric conductivity and NO_3

concentration exceeded the national drinking water standards. To reverse this deterioration, some simulation results show, yields should be reduced by 40% in the national average.

The Jordanian Government is developing new water sources as well as planning to reuse treated wastewater, while groundwater yields are planned to be reduced by almost a half. Among recently developed, on-going, and planned projects, the following water source development projects may affect the situation in 2005 and the succeeding years:

- Corridor wells are located northeast of Hallabat wellfield. These wells are operational from July 2001. Water from these wells is mixed with water from Hallabat pumping station and transmitted to Khaw pumping station. Their total production capacity is 10 MCM/y.

- Lajoun wells in Karak governorate are under construction. After completion in summer of 2002, these wells are expected to produce 15 MCM/y water.

  Zai system expansion: This is an expansion of raw water main and transmission main under "Dier Alla-Zai-Amman Water Project Stage II" under the German loan through KfW. Zai system was created in 1985 by an assistance from the US, and an only water treatment plant utilizing surface water in Jordan. Surface water from Tiberias lake and Yarmouk river through King Abdulle canal is taken at the Dier Alla intake at an altitude of 210 m below the sea level, pumped to Zai water treatment plant at altitude of almost 900 m above the sea level through the pumping head of 1,200 m. Nominal capacity of Zai system was 125,000 m^3/d. To restore the capacity that was aggravated by aging of raw water pumping facilities, the Japan's grant aid was requested to rehabilitate and expand the raw water pumps and to expand the Zai treatment plant. Through two-phased project for improvement of water supply system to the Greater Amman from 1997 to 2001, rehabilitation and expansion of raw water main and pumps, and expansion of Zai treatment plant (to 250,000 m^3/d) was undertaken by the Japan's grant aid. However, Germany funded "Dier Alla-Zai-Amman Water Project Stage II," which was to supply water to the plant and to convey water from the plant to Amman was not yet completed. This project is expected to be completed by July 2003 as the award of contract was made in December 2001 with the construction period of 18 months. After completion of this project, production capacity of Zai system will be expanded from 45 MCM/y to 90 MCM/y, and therefore, water transfer from Zarqa to Amman can be discontinued.

- Desalinated brackish groundwater (DBGW): This is "Zara and Ma'in Brackish Water Desalination Project" funded by USAID. In this project, surface water and spring water on the east coast of Dead Sea are collected, desalinated and transmitted to Amman. As of April 2002, prequalification of contractors was finished. Construction period is expected from December 2002 to December 2004. This project will supply 45 MCM/y treated water to Amman.

- Disi fossil groundwater will be transferred from the south of Jordan to Amman through 320 km pipeline. Prequalificaition of contractors was completed in January 2002, and operation of this project is expected to start in 2006. BOT contract will be applied for the implementation of the project. Expected production is 100-150 MCM/y. Enough water will be available in Jordan after the completion of this project, which will allow to change national water allocation pattern. The water withdrawal rate from over exploited eastern wells can then be reduced to the safe level.

Considering the availability of the above new water sources, water allocation in Amman is projected as in Table 2-6. Available volume from Zai system, DBGW and Disi is net value after reducing local consumption from production. As for demands in Amman and Zarqa, JICA study on Water Resources Management (2001) was applied. Table 2-6 shows that demand in Amman will be satisfied after 2005 and more than 40 MCM/y surplus water will be available for Zarqa and other cities.

Table 2-6 Water Allocation in Amman (MCM/y)

Sources	1995	2005	2010	2015
External wells (From Za'atari and Mafraq)	27	0	0	0
Zai	32	81	58	58
Local wells	33	23	23	23
Madaba	0	0	0	0
Desalinated Brackish Groundwater (DBGW)	0	40	45	45
Disi Fossil Groundwater	0	0	67	88
Export to outside	5	0	0	0
Total Resources Available in Amman	87	144	193	214
Demand in Amman (JICA study, 2001)	—	101	138	171
Excess Water in Amman	—	43	55	43

Water supply will exceed the demand in 2005 due to development of new water sources by Zai system expansion, DBGW and Disi fossil water. Accordingly in 2005, water transfer through Khaw pumping station to Amman can be discontinued and the abstraction rate from the local wells can be reduced by a half. Table 2-7 shows that deficit of supply in Zarqa without considering water sources of Zai system, DBGW, and Disi water will be 13.9 MCM/y in 2005, 28.3 MCM/y in 2010 and 31.0 MCM/y in 2015. On the other hand, surplus of water supply in Amman will be 43.0 MCM/y in 2005, 55.0 MCM/y in 2010 and 43.0 MCM/y in 2015 as shown in Table 2-6 and can meet the deficit in Zarqa.

Table 2-7 Water Allocation in Zarqa (MCM/y)

Sources	1998	2005	2010	2015
External wells (From Za'atari and Mafraq)	13.0	6.5	6.5	6.5
External surface water 1	0	0.7	0.7	0.7
External surface water 2 (Waheda dam)	0	0	0	10.0
Local wells	38.6	19.3	19.3	19.3
Total Sources	51.6	26.5	26.5	36.5
To Amman	17.6	0	0	0
To Jerash, Mafraq	1.5	1.5	1.5	1.5
Available Sources in Zarqa	32.5	25.0	25.0	35.0
Water Demand in Zarqa (JICA study, 2001)	32.5	38.9	53.3	66.0
Deficit Amount in Zarqa	0	13.9	28.3	31.0
Excess Amount in Amman (Table 2-6)	—	43.0	55.0	43.0

(2) Source for Zarqa with reduction of groundwater yield

WAJ has a plan to reduce the abstraction of water from wells after 2004 as water resources from Amman increase. The plan to reduce abstraction water by 50 % from wells has been agreed between WAJ and the study team. The following table shows sources available to Zarqa:

Table 2-8 Water Sources for Zarqa District in 2000 and after 2004
(Except water sources from Amman)
Unit：million m^3/year (MCM/y)

Year	2000	2005	2010	2015
Water Sources in Zarqa Governorate	36.65	18.77	18.77	18.77
Water Sources from out of Zarqa Governorate	15.85	10.98	10.98	10.98
Total Water Sources for Zarqa District	52.50	29.74	29.74	29.74
Export from Zarqa District and Local Consumption				
To Amman	18.70	0.00	0.00	0.00
To Jerash	0.39	0.40	0.40	0.40
To Mafraq	0.22	0.25	0.25	0.25
To Azraq	1.41	1.50	1.50	1.50
Total	20.72	2.15	2.15	2.15
Available Water to Zarqa District	31.78	27.59	27.59	27.59

As described above, the surplus water of Amman area will be available for Zarqa area, thus the water sources of Zarqa area will be sufficient as indicated in Table 2-9.

Table 2-9 Available Amount of Water in Zarqa area
Unit：Million m^3/year (m^3/day)

Water Resources	2005	2010	2015
Available water sources from Amman (from Table 2-7)	43 (118,000)	55 (151,000)	43 (118,000)
Available water sources within Zarqa area (from Table 2-8)	27.6 (75,600)	27.6 (75,600)	27.6 (75,600)
(out of which, sources within Project area)	(2.6) (7,200)	(2.6) (7,200)	(2.6) (7,200)
Total	70.6 (193,600)	82.6 (226,600)	70.6 (193,600)

Accordingly, transmission to Amman through Khaw pumping station can be discontinued by the year 2005. Upon completion of the project, transmission from Amman to the project area by gravity flow will be started.

Details of allocation of water from Amman system are attached in Appendix 5.

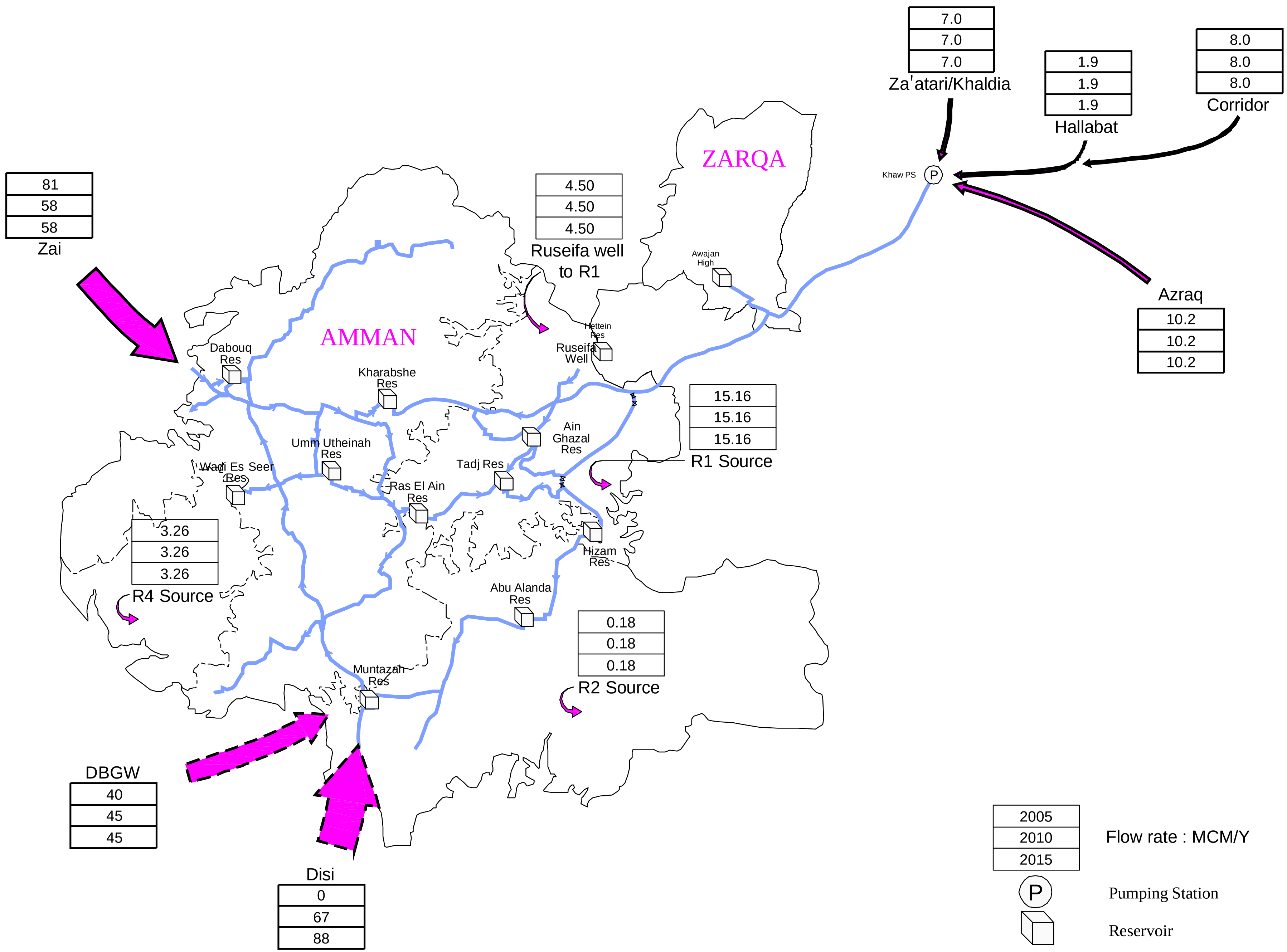


Figure 2-4 Water Source

(5) Design Basis

1) Service Reservoir: 8-hour retention time

Service reservoir has following functions in general.

- To absorb the flow difference between constant inlet water amount from transmission mains and the diurnal demand fluctuation,
- Backup for the accident and draught water flow,
- To reserve water for fire fighting.

In Jordan, rationed water supply is common because of the shortage of water. Hence, in addition to the back-up function, reserving water is the most important function of the service reservoir.

According to the flow pattern analysis in Awajan and Ruseifa, reservoir capacity corresponding to absorption of flow fluctuation is 4-7 hours. This value is under the condition that demand is suppressed, that is, peak flow at daytime is cut. If supply satisfies demand, required retention time becomes higher.

Reservoir capacity in the project area and Amman city is as follows. In Jordan, retention time of 12 hours is widely applied. Considering economy, however, this project applies approximately 8 hours capacity at year 2005, which will be 6 hrs (half the capacity of 12 hours retention) in year 2015.

2) Hourly maximum coefficient :1.5

As the hourly maximum coefficient of 1.5 is applied in Jordan, 1.5 is also applied for this project.

3) Distribution Pressure :2.5 bar – 6.0 bar

According to WAJ's guidelines, distribution pressure is 2.5 bar – 6.0 bar. Same procedure will be followed in this project.

4) Flow formula

Hazen-Williams Formula is applied for friction loss calculation.

$$H = 10.666\, C^{-1.85}\, D^{-4.87}\, Q^{1.85} \cdot L$$

H: friction loss (m)
Q: flow rate (m^3/sec)
D: diameter of pipe (m)
L: length of pipe (m)
C: Hazen-Williams Coefficient

(6) Effective utilization of the existing facilities

On the contrary to the present flow direction from Khaw pumping station to Amman, flow direction will be changed from Amman to Zarqa in this project from year 2005. Existing transmission pipe between Khaw pumping station and Amman will be utilized as transmission line from Amman.

(7) Design Concept

1) Design concept for natural condition

a. Temperature

As average temperature in summer season from May to September is 34-35°C, placing concrete should be done carefully. Temperature of reinforcement bars under the sunshine can be higher than 50°C. If concrete is placed in such condition, it may cause crack due to big temperature difference between bars and concrete. Thus, in summer, concrete should preferably be placed in the evening. Proper curing should be exercised in concrete works, especially if the concrete is placed in the daytime under sun.

b. Rainfall

Winter season from December to February is also rainy season. Average annual rainfall in the past 35 years is as small as 140 mm. Rainfall intensity is not so big, however, rain continues for relatively long time. Snow also falls two or three times in a year. It accumulated about 30 cm last year. Rainfall, which may affect outdoor concreting work, is 33 days a year as average of recent three years in Zai water treatment plant area.

c. Wind

In summer dry wind blows from south and west, and in winter wet wind blows from north. Wind is not so strong, so no special attention is required for the construction.

d. Earthquake

There are no design standards for earthquake in Jordan. Earthquake factor of 0.2 is applied in the project for improvement of water supply system to Greater Amman phase II (construction work for Zai water treatment plant and other facilities), which was executed by Japan's grant aid scheme. In this project, earthquake factor of 0.2 will also be applied for reservoirs, etc.

e. Daylight

Reservoirs should be designed not to cause the problem for the right of sunlight and to match with circumstances.

2) Design concept considering socio-economic conditions

Population in the project area is rapidly growing as the area includes industrial zones and returnees are increasing after the Gulf War in 1990. Expansion of distribution network has been done following population increase. As the topography of the area is undulating, many faults in the distribution networks are often encountered. They are water stoppage at the higher altitudes due to low water pressure, water leakage at the lower altitudes due to higher pressure, only one or two day supply in a week at certain zones, etc.

To improve such water supply conditions, delimitation of distribution zones for adequate pressure balance is planned.

3) Design concept considering special circumstances related to construction, procurement, etc.

Tax is exempted as the project is implemented by the Japanese grant aid. However, when the Japanese contractor executes the job, registration as foreign contractor with the Ministry of Industry and Trade, and permission by this ministry are required.

4) Design concept considering utilization of local contractors

A general constructors law in Jordan is Construction Contractors Law /Law No.13 of 1983. Local contractors are registered in the construction category with classifications of the first to the third classes. As local contractors have executed the domestic job jointly with foreign contractors since 1970s, maximum utilization of the local contractors can be expected.

5) Concept for construction, procurement and construction period

a. Construction method

Main construction works for the project are installation of transmission pipes, construction of distribution reservoirs and installation of distribution mains.

i) Installation of transmission pipes

As pipe routes are busy traffic area like shoulder of expressways, main roads in the city and roads in the densely populated area, care should be taken for the safety and existing infrastructures. As soil is calcareous and hard, the minimum earth covering of 1 meter should be applied. As groundwater level is low, neither countermeasures for ground water seepage nor sheathing will be required.

Specific resistivity test was done on 6 points along the transmission pipe routes to check the corrosivity of soil. The test was conducted according to British Standards (BS1377-Part 9: Method of test for soils for civil engineering purposes). On every point, specific resistivity was checked at 1m, 2m and 3m depth. Test results are as follows.

Test Results of Specific Resistivity

Location	Specific Resistivity (O-cm)		Location	Specific Resistivity (O-cm)	
P1	1m	4460	P4	1m	2450
	2m	7540		2m	12560
	3m	4900		3m	25620
P2	1m	130	P5	1m	1380
	2m	1000		2m	6780
	3m	4900		3m	19220
P3	1m	630	P6	1m	380
	2m	1130		2m	880
	3m	6030		3m	5650

According to American Standards (ANSI/AWWA C 105 / A21.5-82), specific resistivity, pH, oxidation-reduction potential, water content and sulfides are the evaluation factors of soil corrosivity. If total points are more than 10, countermeasures for corrosion should be applied. For example, comparison of American Standard and British Standard (BS7361-Part 1:Cathodic protection, Code of practice for land and marine applications) for specific resistivity is shown in the following table.

AWWA		BS	
Specific Resistivity (O-cm)	Points	Specific Resistivity (O-cm)	Evaluation
700>	10	1000>	Extensively Corrosive
700~1000	8	1000~5000	Surely Corrosive
1000~1200	5	5000~10000	Easily Corrosive
1200~1500	2	10000<	Occasionally Corrosive
1500~2000	1		
2000<	0		

No electric corrosion is expected, as the direct current electric train is not run along the pipeline routes. Considering above test result and evaluation criteria, corrosive soil is sparsely distributed. Corrosion protection such as polyethylene sleeve around the pipe shall not be applied, as is practiced in the pipe laying works in and around the project areas.

ii) Reservoirs

Two types of reservoir structures, i.e., prestressed concrete structure (circular) and reinforced concrete structure (rectangular) are assumed due to size of reservoirs. Structures are selected in view of economy, limitation of space, etc.

b. Procurement method

i) Local procurement

Cement, aggregate, reinforcing steel bar, plywood for formwork, PVC pipe, concrete pipe, general steel pipe, steel plate, etc. are available in the local market.

ii) Third country procurement

Pipes of large diameter are not manufactured in Jordan and therefore will be procured from Japan or European countries considering location of Jordan. Repair and after-sales services of equipment procured from the third country can be done through local agents.

c. Construction period

i) Order of Implementation

This project consists of laying of 9 km transmission pipe and 8 km distribution pipe, construction of 4 distribution reservoirs, and the auxiliary control equipment for flow, pressure and level of water. During the construction of distribution reservoirs, two reservoirs should be constructed first and then the other two should be constructed to utilize temporary materials, engineers, labors and equipments efficiently.

Transmission pipe laying work consisting of ductile cast iron pipes (500mm, 400mm, 300mm, and 200mm dia.) shall be made in 4 sites. Distribution mains (200mm, 400mm, 500mm, and 600mm) shall be laid in 4 sites. Multiple numbers of work groups shall implement these pipe laying works simultaneously in the same period.

ii) Implementation Condition

① Basis for formation of scale/group of facilities and machinery

In this plan, consideration of special method of construction such as high-strength concrete, special method of prestressed concrete, special measures for earthwork while laying pipes along the important trunk road is required. This will also need specialized equipment and machines. Since construction sites are located at different places, independent construction of facilities such as pipes and reservoirs can be done parallely. This will require coordination among the project sites. All these aspects shall be examined and most efficient and appropriate combination of equipment, work amount and supply quantity will be worked out.

* Concrete plant

In the Zarqa suburbs, there is a ready mix concrete batching plant, which can supply the concrete of a required quantity and quality. This plant and agitator trucks shall be utilized. Due to steep slopes, a freight of agitator truck is restricted. A concrete freight and placing plan shall be formulated taking into consideration geological conditions of freight routes.

* Strain apparatus for prestressed concrete

The model of the jack for prestressing will be selected corresponding to the standard of PC strands, PC steel calculated from structure calculation, and the number of use determined in accordance with the group composition and work capability which are specified by "The Standard of Estimation for Circular Prestressed Concrete Structure."

* Scaffolding and supporting work

Since the quantity of the scaffolding and supporting material used for four sites of water reservoirs is the largest, the materials needed for the simultaneous construction of two water reservoirs (Ruseifa high and Ruseifa low) shall be prepared. After completion of the first two, then these materials shall be diverted to the other two sites (Awajan high and Awajan low).

② Calculation of Working Days

* Working hours

In this plan, working hours are set up with 8 hours as the following bases.

Working hours	9 hours	8:00AM－5:00PM
Rest hour	1 hour	
Actual working hours	8 hours	

However, during the Ramadan (Fast month) (about 28 days), working hours will be:

Working hours	6 hours 8:00AM－2:00PM
Rest hour	0 hour
Actual working hours	6 hours

If it is converted into days during the Ramadan holidays, considering the decreased working efficiency, the number of the day will be as follows,

(Ramadan holiday – Friday of during Ramadan (fast month) x working hours of Ramadan (fast month) / Normal working hours = (28day – 4day) x 6 hours / 8 hours = 6 days

* Annual working days

In Jordan, Friday is a holiday. There are 16 public holidays as follows. In case a Friday and a public holiday come together, the following day shall be a replacement holiday.

Holidays in Jordan in year 2001

Name of the Holiday	Date
NEW YEARS DAY	1/1
KING ABDUILLAH'S BIRTHDAY	1/30
HAJI HOLIDAYS	2/20-25
LABOURS DAY	5/1
INDEPENDENCE DAY	5/25
PROPHET MOHAMED BIRTHDAY	5/24
ISRAMIC NEW YEAR	5/15
ARMY DAY	6/10
AL-ESRA'A & AL-ME'RAJ	10/4
THE LATE KING HUSSEIEN7S BIRTHDAY	11/14
RAMADN HOIDAYS	12/2-5
Total	18 days

The unworkable days by rain and snow are calculated as follows when annual rain days are assumed to be 24 days (two days/(month)).

Annual rain days 24 day x {1-(Friday 52 + decrease of working day during Ramadan (fast month) 6 + public holiday 18) / (annual day 365)

As mentioned above, an annual working day is estimated as follows.

Fridays	52 days
Decreased working day during Ramadn holidays	06 days
Public holidays	18 days
The unworkable days by rain and snow	19 days
Total	95 days

Annual working days = 365 – 95 = 270 days

* Average monthly working days

Average monthly working days become 270 / 12= 22.5 days.

③ Calculation for machine capacity

The work capacity of machines, such as a breaker, excavator, bulldozer, dump truck, crane, and a roller is calculated in accordance with "The Standard of Estimation, Ministry of Land Infrastructure and Transport public works." Moreover, it shall be calculated according to "guidelines" and "calculation table for operating loss prevention cost" about the machine procured from Japan. Appropriate conversion shall be made to reflect service time, transportation time and waiting time in a process.

iii) Calculation of the construction period

Required construction days are calculated concerning the water transmission line, distribution main and water reservoirs.

① Water transmission line construction

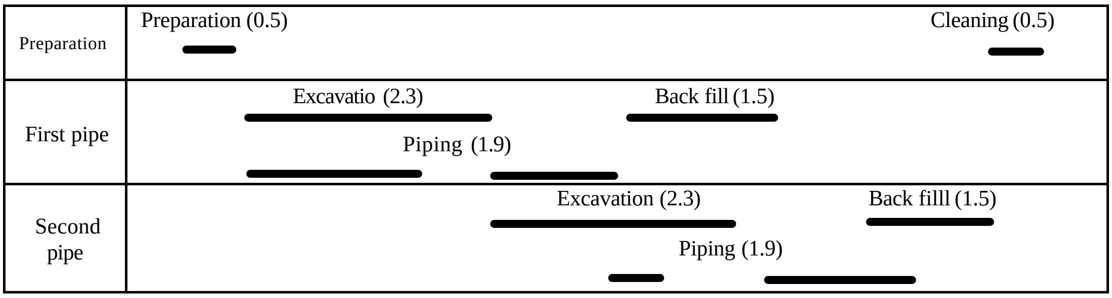
It is necessary to do work quickly and to minimize disturbance to the traffic and the residents during the construction, ensuring measures for traffic safety and protection of underground utilities, since pipe laying work is implemented along main roads with heavy traffic or the utility roads in residential areas. Therefore, the cycle of temporary enclosure installation, excavations, pipe laying, back filling, and road surface temporary restoration shall be completed within the working hours in a day. However, concerning the places excavated in a long period of time such as structure construction, temporary decking shall be applied to reduce the disturbance to the traffic.

In water transmission and distribution line, calculation is made for the standard diameter of 400mm.

The working time calculation will be carried out based on the construction quantity and working efficiency of straight pipe (6m).

Item	Q'ty	Unit	Basis of Working efficiency From The standard of estimation Ministry of Land Infrastructure and Transport public works and Water service enterprise business handbook	productivity (hrs)	Numer of teams	Calculated time (hrs)	Remarks
Preparation	1.00	lot			1	0.50	
Machine Excavation	6.48	m^3	Soft rock: $32m^3$/day, Soil: $127m^3$/day	4.00 15.88	1 1	1.13 0.41	Test pit is performed in another group. Soft rock 7: soil 3
Manual Excavation	0.38	m^3	0.26 person/m^3	0.48	1	0.80	For joint area.
Pipe laying	6.00	m	1.68 hrs/10m	5.95	1	1.01	Delivery of pipe material is performed during excavation.
Pipe jointing	1.00	ea.	0.11 person/ea.	1.14	1	0.88	
Back fill, Compaction	6.10	m^3			1	0.75	
Road restoration	6.30	m^2			1	0.75	
Cleaning	1.00	lot			1	0.50	

From the above calculation time, the work flow of two straight pipes is planned, as shown in the following Table.



Laying of two straight pipes requires 9 hours.

As calculated above, laying of straight pipes is estimated as 2 pipes/group/day.

Construction of special structures, such as valve chamber, air valve chamber, wash out and bend will require days estimated in the following Table. As construction of straight pipe will be most critical, the work for these special structures shall be made in parallel by other work group within the same period.

	Stop valve	Air valve	Wash out	Bend	Inverted siphon
Preparation, excavation, decking	3.0	1.0	1.0	1.0	2.0
Piping work	1.0	0.3	0.3	0.1	0.5
Structure work	20.0	15.0	15.0	3.0	6.0
Back fill, cleaning	2.0	1.5	1.5	1.0	1.5
Total	26.0	18.3	18.3	5.1	10.0

② Distribution reservoir construction

Construction days of a distribution reservoir of 6300m^3, which is largest in scale and critical in the schedule, is calculated as follows:

Work item		Q'ty	Unit	Productivity	Teams	Days of construction	Revised coefficient of working day 30/23	Construction period		Remarks
Preparation		1	lot		1	5	1.3	7	0	Including embankment and leveled land work
Excavation		2000	m^3	62.5	2	16	1.3	21	21	
Base slab work	pit work	1	lot		1	14	1.3	19	51	It is assumed as 14 days by 1 lot.
	form work	170	m^2	30	1	6	1.3	8		Construction date of form work is added to re-bar work, since re-bar work is done at the same time.
	Re-bar work	90	T	7	2	7	1.3	10		
	PC steel work	320	unit	15	2	11	1.3	15		
	concrete work	850	m^3	200	1	5	1.3	7		

Wall work	scaffolding work	2250	m^2	70	2	17	1.3	23	62	Construction days of scaffolding is not added to construction period, because of other work at the same time.
	form work	1650	m^2	30	2	28	1.3	37		
	Re-bar work	25	t	5	1	5	1.3	7		Construction days of1 layer is 14.5 day.
	sheath work	3500	m	450	1	8	1.3	11		
	concrete work	290	m^3	63	1	5	1.3	7		Casting concrete divides into 5 times.
Roof slab work	support work	8900	m^3	100	5	18	1.3	24	40.7	
	form work	1200	m^2	50	2	12	1.3	16		One third of form work may be possible to do with support work..
	re-bar work	18	t	5	1	4	1.3	6		Construction date of re-bar work is not added to constructing period because of form work at the same time.
	concrete work	230	m^3	57.5	1	4	1.3	6		
Prestressing work	vertical stressing work	335	unit	15	2	12	1.3	16	24	
	horizontal stressing work	180	unit	11	3	6	1.3	8		6 pilaster
Walk slab work	support work	1	lot		2	5	1.3	7	15	Construction days for scaffolding and form work are not added to constructing period because of other work at the same time.
	scaffolding work	1	lot		2	3	1.3	4		
	form work	130	m^2	20	2	4	1.3	6		
	re-bar work	3	t	2	1	2	1.3	3		
	concrete work	30	m^3	30	1	1	1.3	2		
Water proof work	inner woter proofing	8800	m^2	45	6	33	1.3	43	43	
	outer painting	2800	m^2	75	3	13	1.3	17		Construction date of painting work for outer wall is not added constructing period because of inner water proof work at the same time.
	roof water proofing	3800	m^2	45	3	29	1.3	38		Construction date of water proofing work for roof is not added constructing period because of outer painting work at the same time.
Accessories	stair	1	lot			5	1.3	7	24	
	hand rail	1	lot			10	1.3	13		
	inner ladder	1	lot			7	1.3	10		Construction date of inner ladder work is not added constructing period because of stair work at the same time.
	inner handrail	1	lot			0	1.3	0		
	lightning rod	1	lot			3	1.3	4		
Cleaning	removal scaffolding	11150	m^3	150	4	19	1.3	25	25	Parallel work of removal scaffolding and cleaning.
	cleaning	1	式			10	1.3	13		
Total									306	

If a plan is made in the above construction days as shown in detailed construction work schedule, the required time for construction shall be 10.5 months. Construction will be scheduled to proceed with two reservoirs simultaneously for efficient use of temporary materials and personnel.

2.2.2 Basic Plan

2.2.2.1 Water Distribution Plan

(1) Plan of Distribution Zone

1) Distribution Zoning

For stable water supply and leakage reduction, distribution zones are proposed to keep suitable distribution pressure by flow and pressure control. In each zone, reservoir is located at suitable elevation so that water is distributed by gravity.

In Hutten area, a new distribution zone was established in 2001, and distribution is made from a new distribution reservoir and an elevated reservoir. This new zone is included as a part of the zoning plan of the present project.

Taking into consideration elevation and topography of the project area, five distribution zones are planned as shown in Figure 2-5. Ground elevation of reservoir and elevation fluctuation in each zone is summarized in Table 2-10.

Table 2-10 Distribution Zoning

Zone	Reservoir Low Water Level (m)	Elevation Fluctuation (m)
Awajan Low	638	550－600
Awajan High	694	600－660
Ruseifa Low	750	650－715
Ruseifa High	807	710－775
Hutten (Existing)	776（800：Elevated Tank）	770－650

2) Population and Water Demand in each Distribution Zone

The planned population in each distribution zone is indicated in Table 2-11. Planned water demand in each zone is shown in Table 2-12

Table 2-11 Population in Planned Distribution Zones

Zone	2000	2005	2010	2015
Awajan Low	29,375	33,234	37,439	42,399
Awajan High	174,774	200,329	226,325	256,552
Ruseifa Low	94,062	110,333	125,753	143,810
Ruseifa High	25,395	29,868	33,995	38,733
Hutten	42,500	47,900	53,400	59,500
Sub Total	366,106	421,664	476,912	540,994
Other Zarqa Area	279,148	318,457	357,076	398,858
Zarqa District total	645,254	740,121	833,988	939,852

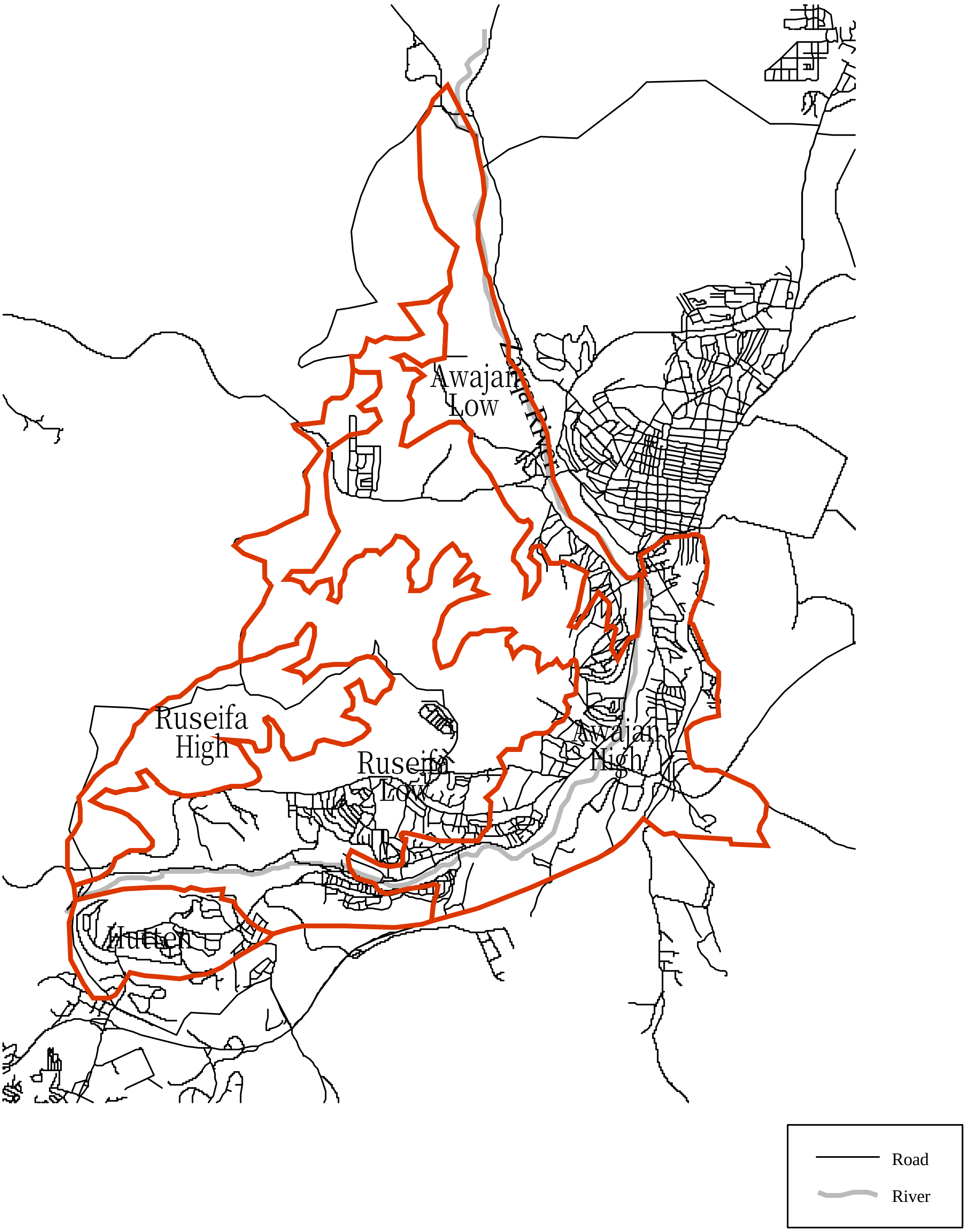


Figure 2 -5 Distribution Zones

Table 2-12 Planned Water Demand in Distribution Zone (Unit : m^3/day)

	2000	2005	2010	2015
Daily Average Water Demand				
Awajan Low	3,000	4,000	4,700	5,500
Awajan High	17,700	24,000	28,300	33,100
Ruseifa Low	9,500	13,200	15,700	18,600
Ruseifa High	2,600	3,600	4,200	5,000
Hutten	4,300	5,700	6,700	7,700
Sub Total	37,100	50,500	59,600	69,900
Other Zarqa Area	28,200	38,200	44,600	51,500
Total	65,300	88,700	104,200	121,400
Daily Maximum Water Demand				
Awajan Low	3,800	5,200	6,100	7,100
Awajan High	22,900	31,300	36,900	43,100
Ruseifa Low	12,300	17,200	20,500	24,200
Ruseifa High	3,300	4,700	5,500	6,500
Hutten	5,600	7,500	8,700	10,000
Sub Total	47,900	65,900	77,700	90,900
Other Zarqa Area	36,600	49,700	58,200	67,000
Total	84,500	115,600	135,900	157,900

(2) Distribution plan of water demand

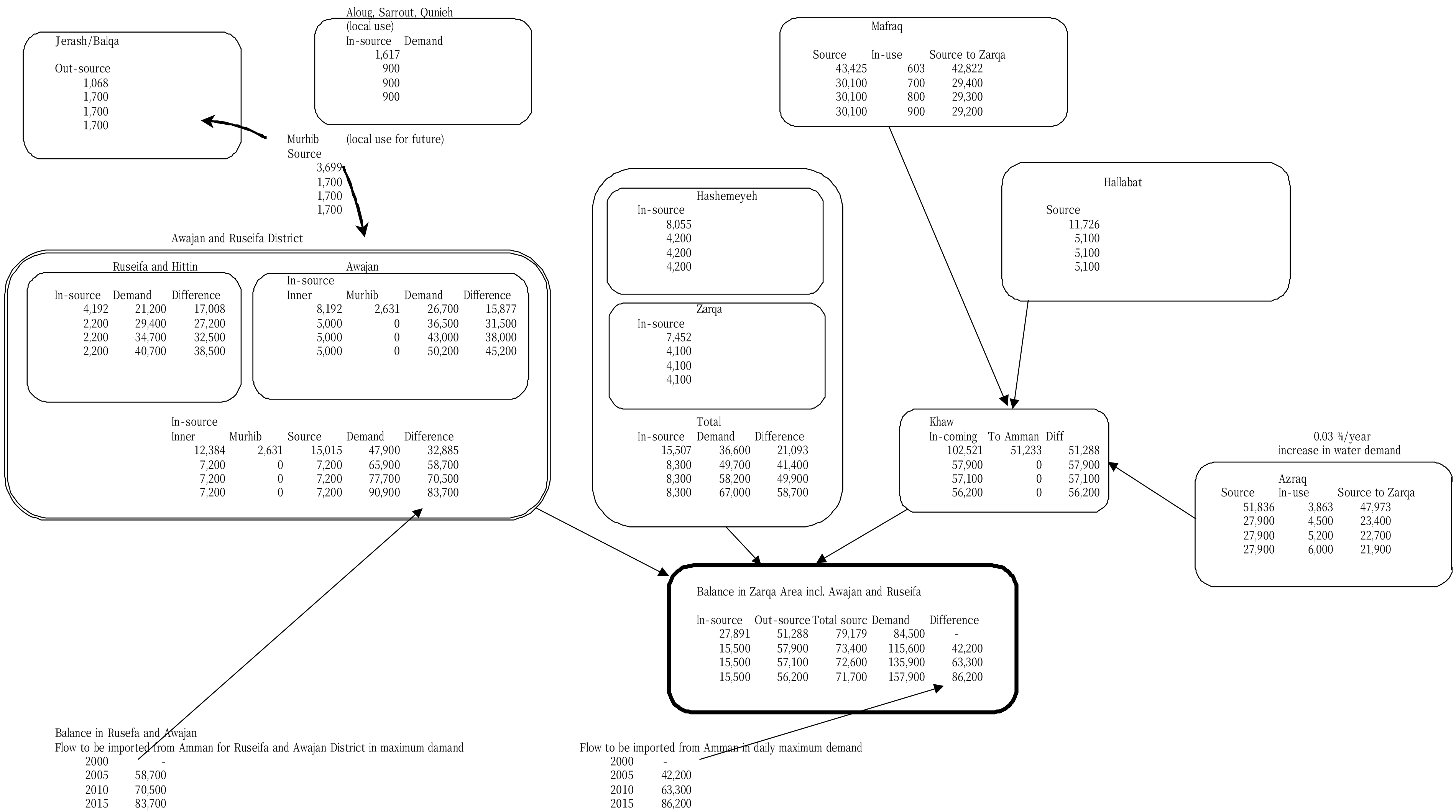
The amount of available water and water demand are indicated in Table 2-13. The volume of daily maximum water supply and demand are indicated in Figure 2-6.

Table 2-13 The Amount of Available Water and Demand in Zarqa Area (Unit: m^3/d)

	2005	2010	2015
The amount of available water supply			
(1) Transmission amount from Amman	118,000	151,000	118,000
(2) Water resources in Zarqa District	75,600	75,600	75,600
Total	193,600	226,600	193,600
Daily average water demand in Zarqa district			
Project area	50,500	59,600	69,900
Other Zarqa area	38,200	44,600	51,500
Total	88,700	104,200	121,400
Other Local Consumption (Assumption)	8,900	10,400	12,100
Daily maximum water demand in Zarqa district			
Project area	65,900	77,700	90,900
Other Zarqa area	49,700	58,200	67,000
Total	115,600	135,900	157,900
Other Local Consumption (Assumption)	11,600	13,600	15,800

Comparing the water supply with daily maximum demand in 2005 in above Table, the water resources in Zarqa district cannot cover total daily maximum demand in Zarqa, but can cover water demand in other area except for project area in Zarqa district. Moreover, approximately 25,000 m^3/d is surplus of water resources. This surplus can be used for water supply of the project area or the abstraction amount of local wells can be reduced by that amount. Water supply to the project area is made from Amman.

Figure 2-6 Water Balance in Daily Maximum Water Demand (m3/day)



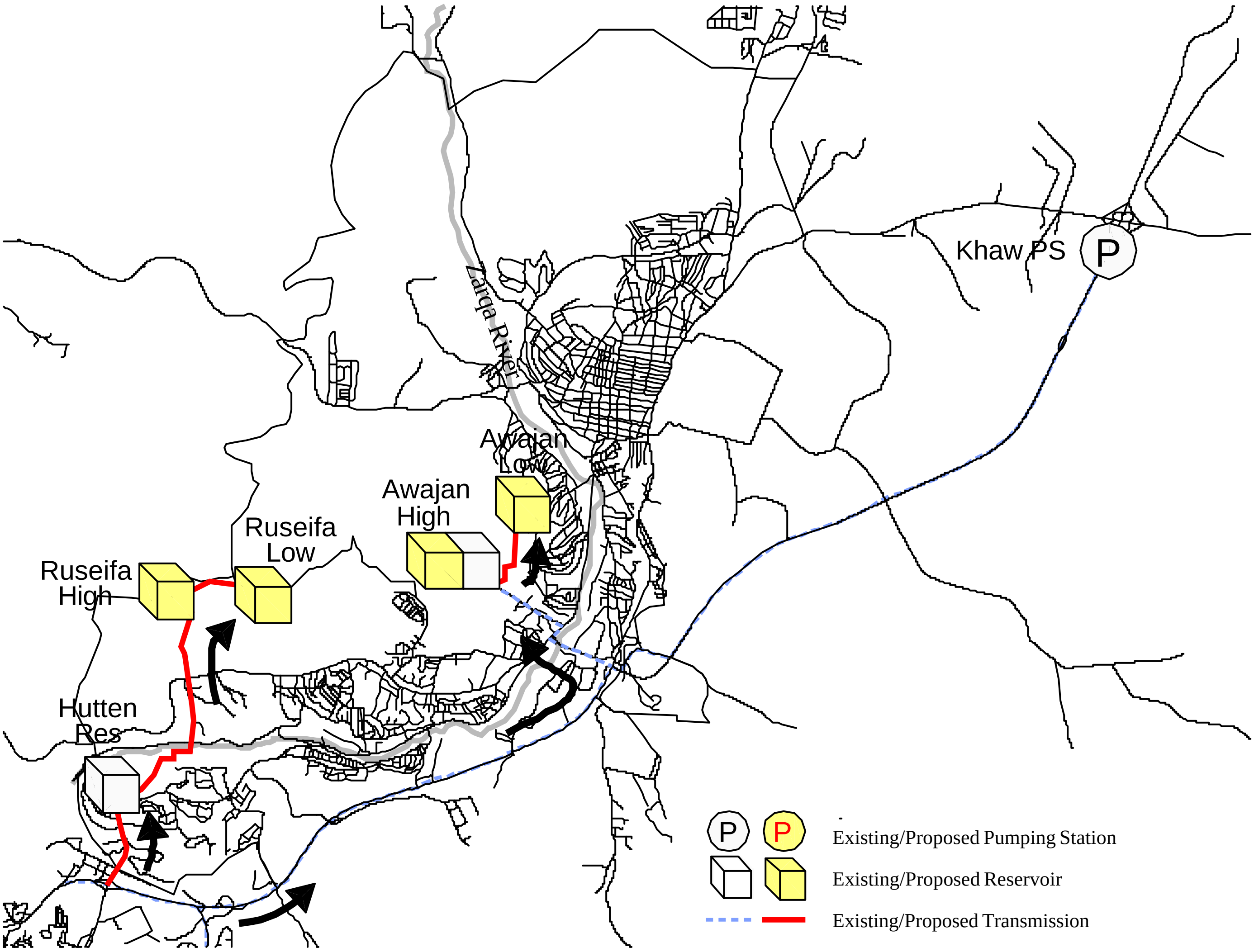
2.2.2.2 Water Transmission Plan

(1) Selection of transmission route

Water from Amman side shall be supplied by gravity through Dabouq reservoir and Kharabshe reservoir to the project area in Zarqa. The existing transmission pipeline (dia. 600 mm), which is now transmitting water from Khaw pump station to Amman, shall be utilized for this purpose.

Water to Ruseifa area shall be diverted at Hutten junction, and sent to Hutten distribution zone, Ruseifa high zone and Ruseifa low zone successively. Water to Awajan area shall be diverted at Awajan junction and sent to Awajan high zone and then Awajan low zone.

Figure 2 -7 Outline of Transmission Root



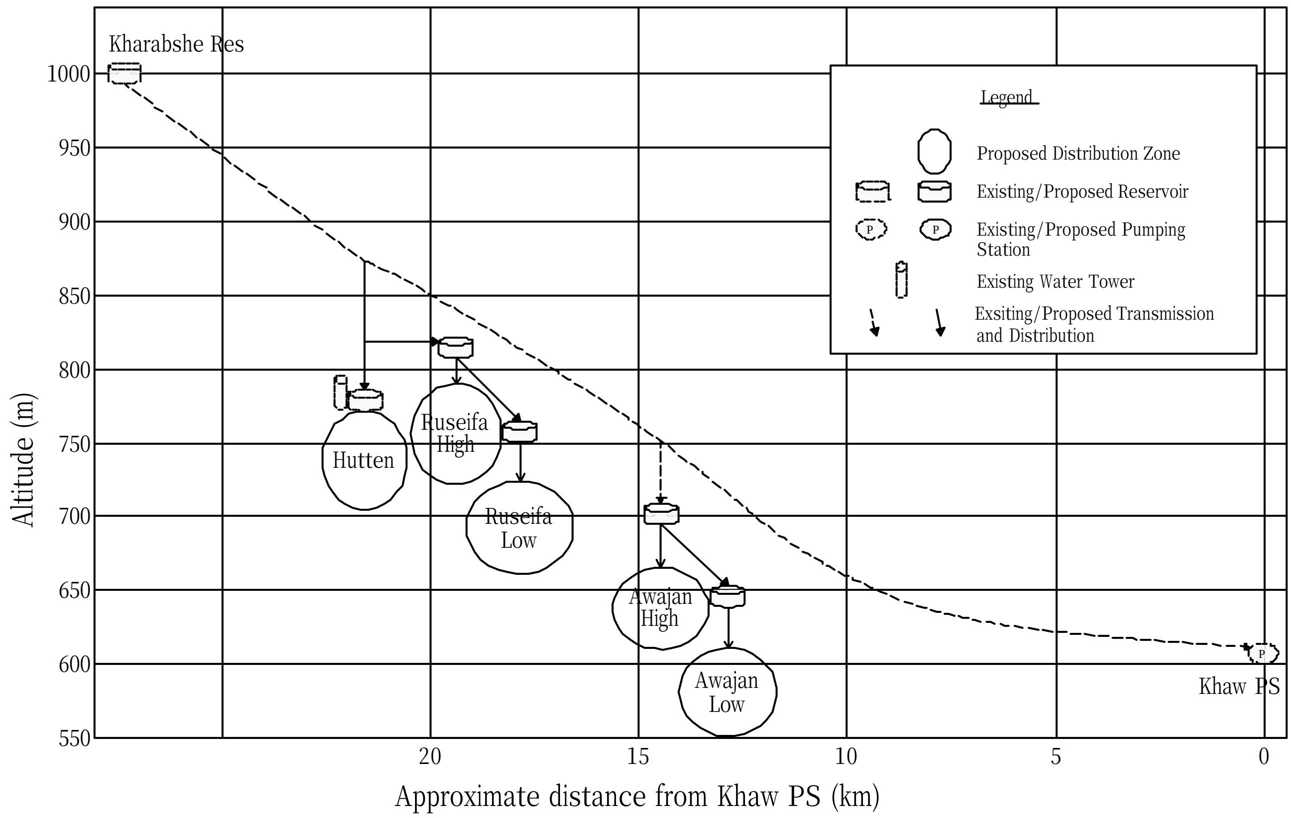
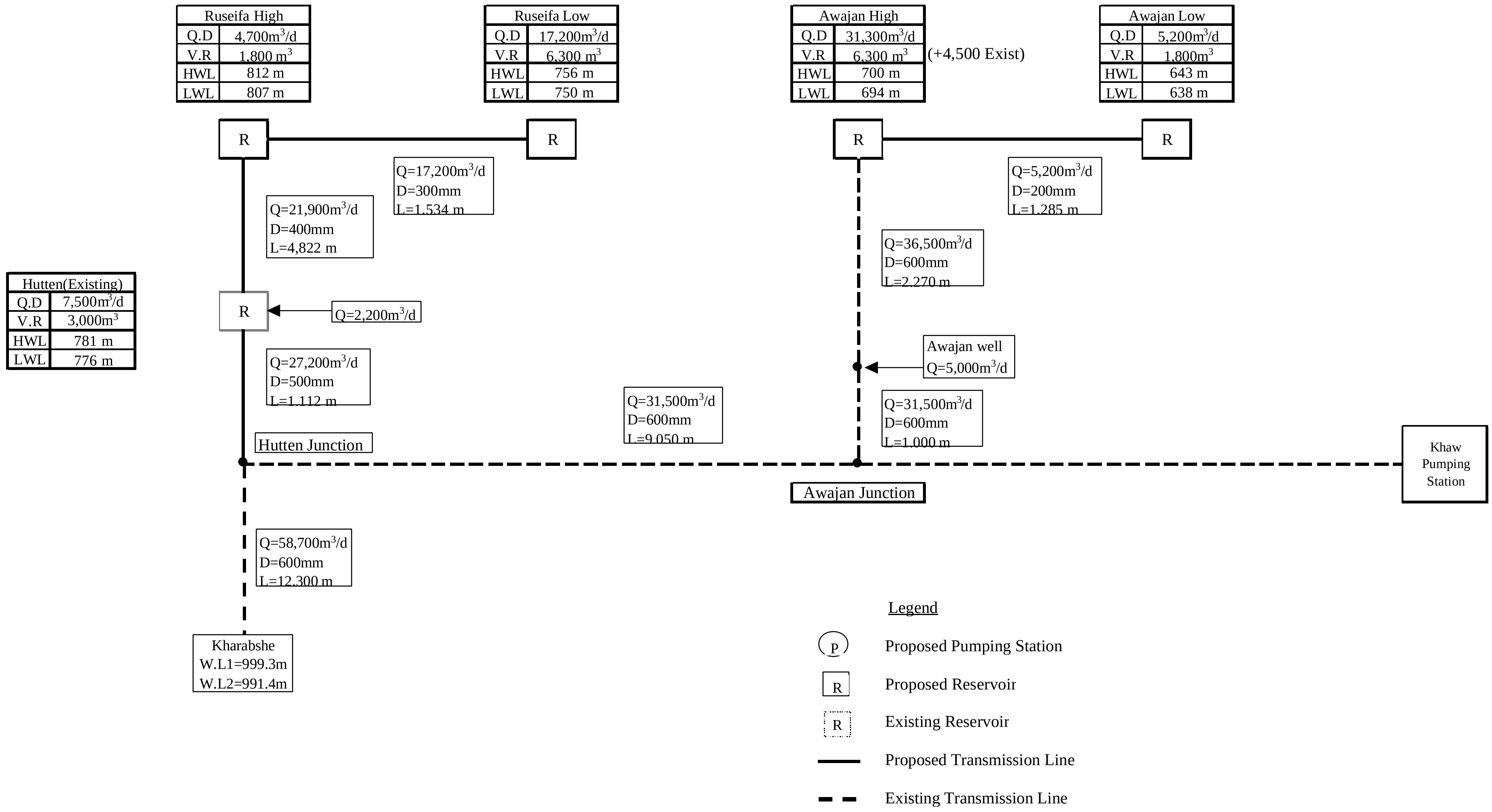


Figure 2-8 Transmission System



(2) Transmission Pipe Laying Route

The existing transmission pipeline between Khaw pump station and Amman (Ain Ghazal reservoir) is to be used to transmit water from Amman side. Water is diverted at Hutten junction to Hutten, Ruseifa high and Ruseifa low zones, and at Awajan junction to Awajan high and Awajan low zones. See Figure 2-9 and 2-10.

(1) Pipeline to Ruseifa zone

a. From Hutten junction to Hutten reservoir (500 mm dia)

Pipe runs from Hutten junction toward Schneller or Hutten refugee camp and finally to Hutten reservoir located in front of the camp. Pipe is laid on the roadside of Zarqa old road with two lanes on one way. The road is running in high-density commercial area with high traffic volume. There are many pedestrians.

b. From Hutten reservoir to Ruseifa High reservoir (400 mm dia)

After branching pipe to the Hutten reservoir, pipe runs on Zarqa old road, turns left at around 300 m and comes down toward Zarqa river on an 8 m wide steep slope. The pipe crosses the Zarqa river near bridge, then below railway, enters into housing area, runs straight approx. 800 m. After crossing Yajouz road, pipe runs in housing area and goes up on a steep slope in the developing housing area to Ruseifa High reservoir.

c. From Ruseifa High reservoir to Ruseifa Low reservoir (300 mm dia)

Pipe runs down and up along a ridge from Ruseifa High reservoir at the top of the hill and reaches to Ruseifa Low reservoir. The distance is approximately 1,500 m.

(2) Pipeline to Awajan zone

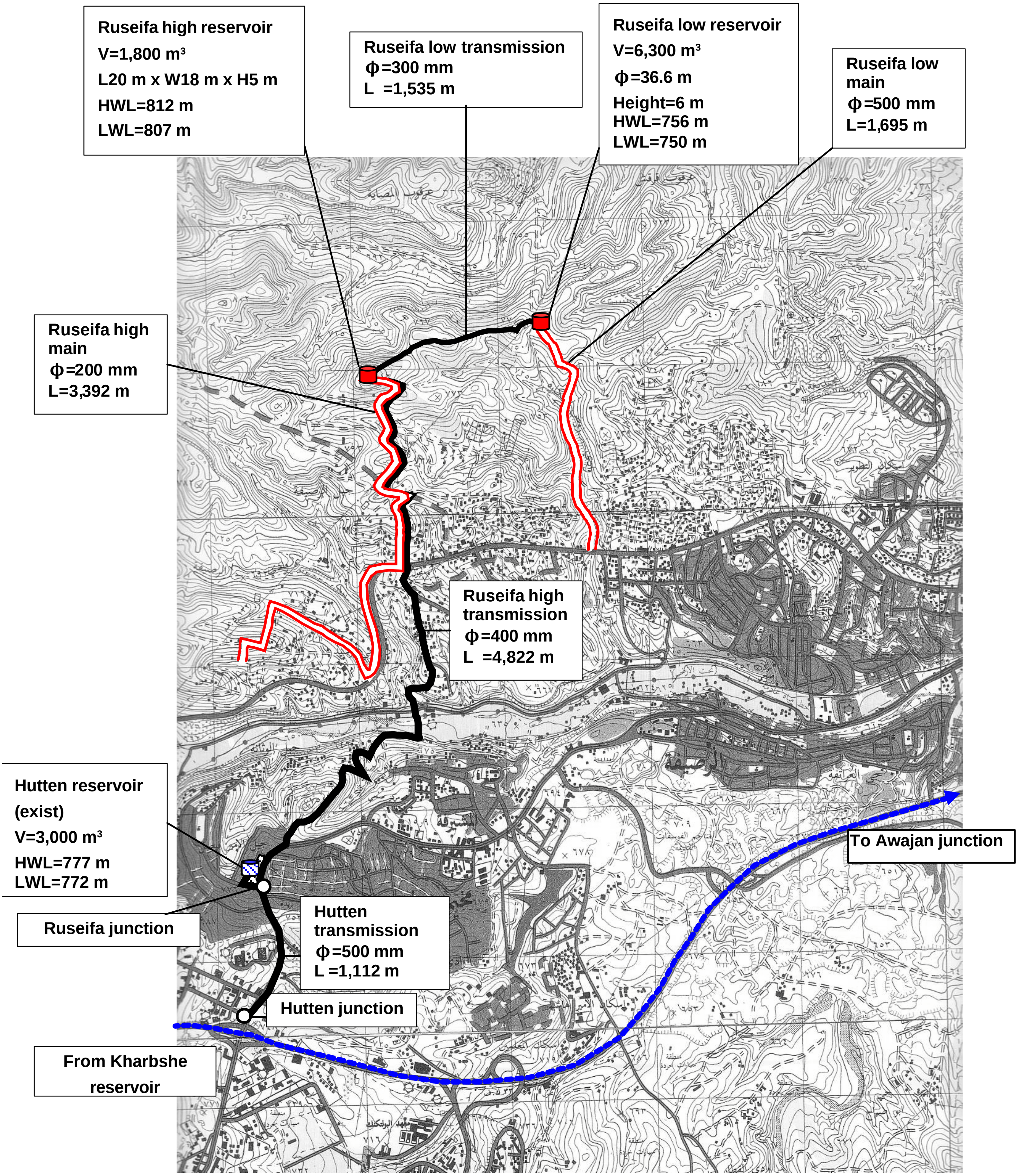
a. From Hutten junction via Awajan well to Awajan High reservoir (600 mm dia existing)

Pipe runs approx. 9 km from Hutten junction toward Khaw and branches at Awajan junction to Awajan wells. Collecting Awajan well water, the pipe runs along the roadside of two-lane road on one way, goes up a steep slope in the housing area and reaches to Awajan High reservoir.

b. From Awajan High reservoir to Awajan Low reservoir (200 mm dia)

Pipe runs down meandering on a 6 m wide road to Awajan Low reservoir. The distance is approx. 1,300 m.

Figure 2-9 Transmission Pipeline and Distribution Main - Ruseifa Area



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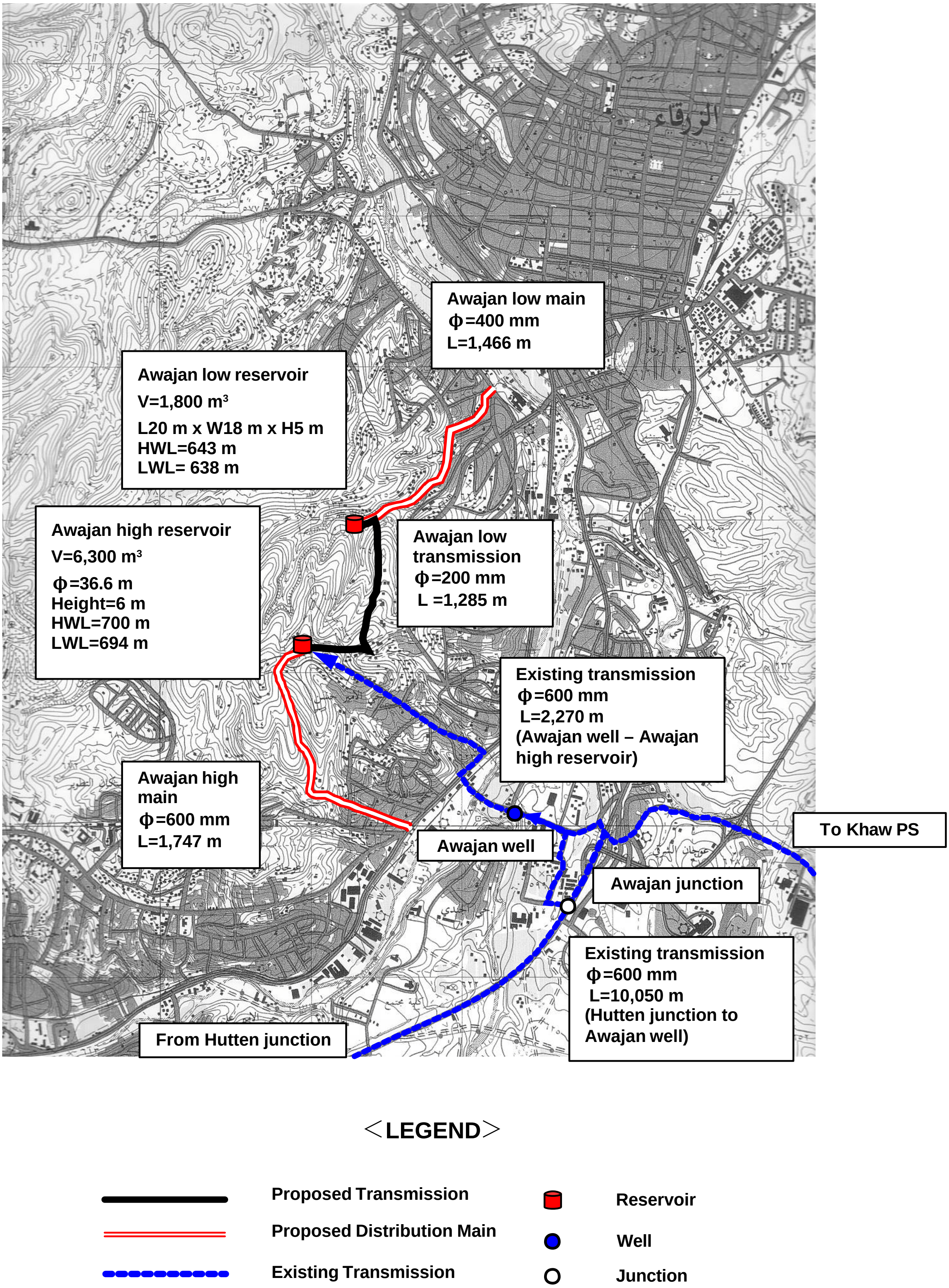
Proposed Transmission
Proposed Distribution Main
Existing Transmission
Proposed Reservoir
Existing Reservoir
Junction

Figure 2-10 Transmission Pipeline and Distribution Main - Awajan Area



(3) Selection of Pipe Diameter and Pipe Material

(1) Selection of Diameter

a. Calculation of Pressure Head

i) Pressure Head at Hutten junction

Water is sent from Amman through Kharabshe reservoir (HWL=999 m, LWL=991 m) to Hutten junction. Pressure head at Hutten junction is estimated as follows.

Kharabshe reservoir – Hutten junction:

L=12,300 m
Q=58,700 m^3/d (0.679 m^3/s)
D=0.6 m (Existing pipe)

$H_f=10.666*120^{-1.85}*0.60^{-4.87}*0.679^{1.85}*12,300=109$ m

Therefore, pressure head at Hutten junction will be 882 m (=991-109).

ii) Pressure at Awajan junction

Water branched at Hutten junction flows to Awajan wells via Awajan junction.

Hutten junction – Awajan wells:

L=10,050 m
Q=31,500 m^3/d (0.365 m^3/s)
D=0.6 m (Existing pipe)

$H_f=10.666*120^{-1.85}*0.60^{-4.87}*0.365^{1.85}*10,050=28$ m

Therefore, pressure head at Awajan will be 854 m (=882-28).

Calculation of friction loss against various diameters will be as follows.

Table 2-14 Calculation of Friction Loss against Various Diameter

Starting point Pressure head (m)	End point Pressure head (m)	Q (m^3/S)	L (m)	Friction loss (m) / Velocity (m/S)					Remarks
				200 mm	300 mm	400 mm	500 mm	600 mm	
Kharabshe res. 991	Hutten junction 882	0.679	12,300					109 2.40	New
Hutten junction 882	Ruseifa junction 875	0.315	1,112			20 2.50	7 1.61	2 1.11	New
Ruseifa junction 875	Ruseifa H. res. 816	0.253	4,822			59 2.01	20 1.29	7 0.90	New
Ruseifa H. res. 807	Ruseifa L. res. 759	0.199	1,534		48 2.82	12 1.58			New
Hutten junction 882	Awajan wells 854	0.365	10,050					28 1.29	Existing
Awajan wells 854	Awajan H. res. 846	0.422	2,270					8 1.49	Existing
Awajan H. res. 694	Awajan L. res. 656	0.060	1,285	38 1.91	5 0.85				New

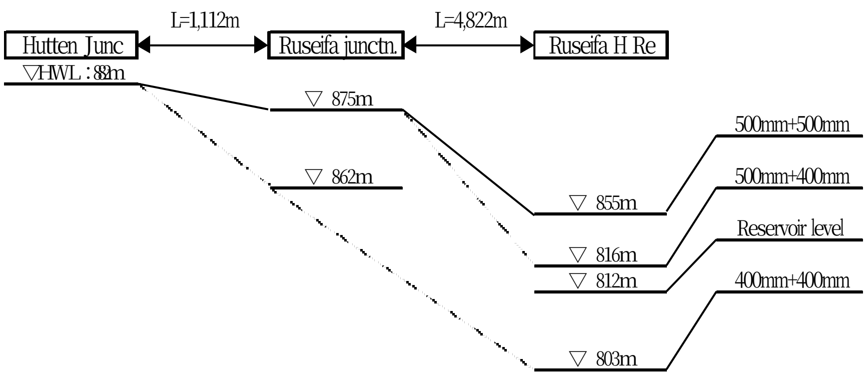
(Note) Upper row: Friction loss (m), Lower row: Velocity (m/s)

b. Selection of Diameter

Optimum diameters are selected considering the location (elevations) of the reservoirs, friction loss, and flow velocity as shown in Table 2-14. The high and low water levels of the reservoirs are as shown below.

Reservoir	HWL (m)	LWL (m)
Hutten (Existing)	777	772
Ruseifa High	812	807
Ruseifa Low	756	750
Awajan High	700	694
Awajan Low	643	638

Pressure head profiles for various combinations of diameters between Hutten junction – Hutten reservoir – Ruseifa High reservoir are as shown below.



i) Hutten junction – Hutten reservoir (Existing) – Ruseifa High reservoir

From the above figure, combination of 400 mm + 400 mm diameter pipes is not possible to carry the required discharge to Ruseifa High reservoir which is located at an elevation of 812 m. Therefore, 500 mm diameter between Hutten junction and Hutten reservoir, and 400 mm diameter pipes between Hutten reservoir and Ruseifa High reservoir are selected.

ii) Ruseifa High reservoir – Ruseifa Low reservoir

High water level in the Ruseifa Low reservoir is 756 m which is 56 m lower than Ruseifa High reservoir. 300 mm diameter pipe is selected considering friction loss and maximum velocity of 3.0 m/s.

iii) Awajan High reservoir – Awajan Low reservoir

Total length of the existing 600 mm diameter pipe from Hutten junction to Awajan High reservoir is approximately 12,300 m. Pressure head at Awajan High reservoir is at 854 mm as indicated in Table 2-14 and more than required pressure head of 700 m. The 200 mm diameter pipe is selected between Awajan High reservoir and Awajan Low reservoir considering elevation difference of 56 m, friction loss and maximum velocity of 3.0 m/s.

(2) Selection of Pipe Material

Comparison between ductile-cast iron pipe and steel pipe is shown in Table 2-15 based on JIS. From this comparison, ductile-cast iron pipe is selected for the following reasons:

- Economical considering material cost and construction cost
- Easy construction, specially for connection of pipe, and shorter construction period
- No need for welding and inspection of welding part
- Higher corrosion resistance

Table 2-15 Comparison of Pipe Material

1. General Characteristics			
Item		Ductile cast iron pipe	Steel pipe
(1) Specification	Applied code	JIS G 5526 5527	JIS G 3443 3451
(2) Material	Tensile strength (N/mm^2) Extensibility (%) Flexural strength (N/mm^2) Elastic modulus (kgf/cm^2) Hardness Poisson's ratio Specific gravity Thermal expansion coefficient (1/℃)	420 and over 10 and over 600 and over 1.6×10^6 230 0.28〜0.29 7.15 1.0×10^{-6}	400 and over 18 an over 400 and over 2.1×10^6 140 0.30 7.85 1.1×10^{-6}
(3) Pipe joint	Water tightness	◎ High water tightness using rubber for both male and female joint even for bending and biased moment	◎ Water tightness in case of sound welding
	Flexibility for expansion	◎ Flexible joint absorbs the stress due to expansion, uneven settling, etc.	○ Stress due to thermal expansion, uneven settling cannot be absorbed because of rigid joint of welding. Additional flexible joint is required for every certain distance.
	Protection for break away	○ Countermeasures such as concrete blocking, etc. are required for joints where uneven force exists.	◎ No countermeasures are required for welding joint.
(4) Corrosion resistivity	Material	◎ Material of oxides, silicates, etc protects corrosion	○ Anti corrosion painting is required.
	External corrosion protection	○ Corrosion protection is possible by polyethylene sleeve in case highly corrosive soil.	○ Special attention is required for anti corrosive painting on joints at site.
	Internal Corrosion protection	◎ Mortar lining is fine surface and effective against alkali corrosion.	○ Epoxy painting is damaged easier than mortar lining.
	Protection for galvanic corrosion	◎ Low corrosion due to low electric conductivity of ductile. Electric resistance: 50〜70μO-cm	○ Due to low electric resistance, higher possibility of galvanic corrosion, Electric resistance: 10〜20μO-cm

2. Construction			
(1) Construction easiness	Working atmosphere	◎ No limitation against weather condition because of simple joint	○ Limitation against weather condition in case of welding
	Jointing	◎ No special skill is required because of simple joint	○ Special skill is required for welding
	Inspection on joint parts	○ Confirm by check sheet	△ X ray test is required on welding portion
(2) Resistance to internal and external pressure	Resistance to internal pressure	◎ Resistant to higher internal pressure	◎ Resistant to higher internal pressure
	Resistance to impact	◎ Strong to external pressure because of high rigidity and flexibility	◎ Strong to external pressure
3. Economy			
(1) Investment cost	φ300, L=10m φ500, L=10m	◎ 1.00 1.00	○ 1.54 1.11
Overall evaluation		◎ Economical for material and construction cost. Superior to steel pipe for qualitative characteristics. Shorter construction period has merit for the construction of pipeline on busy traffic road.	○ Higher material and construction cost than ductile pipe. Special attention for corrosion protection is required. Longer construction period due to joint welding.

(3) Auxiliaries

The following are required at Hutten junction, Hutten reservoir and Awajan junction.

1) Hutten junction

i) Flow meter

Two sets of flow meter are installed to check water flow to Ruseifa and Awajan.

- Type: Ultra sonic flow meter with detector and converter
- No. of sets: 2
- Outdoor terminal (main 30A, branch 20A x 6): 1 set

ii) Shut off valve (Manual)

- 500 A (FC, with operation rack and extended stem): 1 set
- 600 A (FC, with operation rack and extended stem): 2 sets

2) Hutten reservoir

i) Control Valve

- 200 A (FC, with operation rack and extended stem): 1 set
- 400 A (FC, with operation rack and extended stem): 1 set
- 500 A (FC, with operation rack and extended stem): 1 set

3) Awajan junction

i) Control valve

- 600 A (FC, with operation rack and extended stem): 3 sets

(4) Water Hammer

As water transfer is by gravity and valve operation is made manually and slowly in principle. In the case of stoppage of water transfer, only a static pressure is assumed, and water hammer will not be anticipated. Therefore, measures for water hammer is not considered.

(5) Earth Coverage

Jordan standard for earth coverage of pipe is minimum 1.0 m. Minimum clearance of 0.5 m from the bottom of sewer branch pipe is also specified when pipe is crossed.

2.2.2.3 Service Reservoir

(1) Storage Volume

Reservoir volume is decided considering fluctuation absorption of daily supply and demand, back up at emergency, etc. Generally, 12 hrs of retention time is applied in Jordan. In this project, however, approximately 8 hours retention time in year 2005 is applied due to economy. This capacity will be a half of 12 hours retention in 2015. The calculated reservoir volume is as follows.

Reservoir	Demand (m^3/d)	New Reservoir (m^3)	Remarks
Ruseifa High reservoir	4,700	1,800	
Ruseifa Low reservoir	17,200	6,300	
Awajan High reservoir	31,300	6,300	Existing (4,500 m^3)
Awajan Low reservoir	5,200	1,800	

(2) Type of Construction

Three types of reservoir structures, i.e., prestressed concrete (PC), reinforced concrete (RC) and steel structures are compared in Table 2-16. PC structure has characteristics of high water tightness, long life, high resistance to earthquake and easy maintenance. On the other hand, construction costs of PC and RC have a threshold of approximately 3,000 m^3, under which RC structure is economical and over which PC is economical. Therefore, RC structure is adopted under 3,000 m^3, and PC structure is adopted over 3,000 m^3.

Table 2-16 Comparison of Reservoir Structure

Item	PC structure	Point	RC structure	Point	Steel	Point
Structure	• Larger span structure is possible due to its small volume of concrete • High resistance to earthquake	3	• Big foundation is required due to large volume of concrete for big reservoir	2	• More expandable than concrete, small rigidity • Anti-chlorine painting for internal and weather proof painting for external required	1
Performance	• No crack occurs by applying pre-stress and using high strength concrete • High water tightness and non corrosive construction	3	• Crack may happen because of repeating dry and wet condition due to water level fluctuation	1	• High water tightness, however more corrosive than concrete	2
Construction easiness	• Special supervision is required due to its complexity of construction • High strength concrete more than 300kg/cm^2 is required. • No waterstop is required	1	• No special method is required.	3	• All welding construction at site • Non destructive test on welding portion is required.	2
Maintenance	• Work volume is small due to non-crack and non corrosive nature	3	• Leakage protection is required when crack occurs.	2	• Periodical maintenance for internal and external painting, thus higher maintenance cost, is required.	1
Economy	? Lower initial cost than RC structure for reservoirs more than 3,000m^3	2	? Higher initial cost than PC structure for reservoirs more than 3,000m^3	1	• Initial cost is lower than PC and RC structure	3
Others	• Suitable for limited area as higher construction is possible. • Symbolic view due to circular construction with dome roof	3	• Height is limited due to economical point • Rectangular construction is popular and no merit from view	2	• Painting on external surface is possible	1
Evaluation	○	15	△	11	×	10

Note: ○ :Best (3), △ :Better (2), × :Worse (1)

(3) Layout

Layouts of four reservoirs are shown in Figures 2-12 to 2-15. Each area is inclined area and has stiff ground consisting of sandstone.

1) Ruseifa High Reservoir (1,800 m^3, L 20.0 m x W 18.0 m x H 5.0 m)

Approach road is from north side where road is running. Structure is located on cutting area and its ground level is 807 m.

2) Rusaiafa Low reservoir (6,300 m^3, 36.6 m diameter, 6.0 m height)

Ground level is 750 m.

3) Awajan High reservoir (6,300 m^3, 36.6 m diameter, 6.0 m height)

New reservoir will be constructed next to the existing reservoir. Ground level is 694 m.

4) Awajan Low reservoir (1,800 m^3, L 20.0 m x W 18.0 m x H 5.0 m)

This area is located in a steep slope. Ground level is 638 m.

(4) Accessories for each Reservoir

1) Ruseifa High reservoir

Water from Amman is branched at Hutten junction and sent to Hutten reservoir where 6,000 m^3/d is taken, and finally reaches to Ruseifa High reservoir. Inlet pipe size is 400 mm in diameter. From the reservoir, water is transmitted to Ruseifa Low reservoir with 300 mm diameter pipe and distributed to Ruseifa high zone with 200 mm diameter pipe. To check and control the flow and level, flow meter, level indicator and valves are installed.

i) Flow meter: at inlet pipe (φ400 mm)
① Ultrasonic type with detector and converter :1 set

ii) Level indicator: installed in the reservoir
① Float type level indicator : 1 set

iii) Manual valve
① Inlet of reservoir
300A (Cast steel, with operation rack and extended stem) : 3 sets
② Outlet of reservoir
200A (FC): 1 set
250A (FC): 1 set
300A (FC): 1 set
② On reservoir
150A (FC) : 1 set

iv) Outdoor Distribution Board (Main 30A/3ph, Branch 30A/3ph + 20A×5) : 1set

2) Ruseifa Low reservoir

Water comes from Ruseifa high reservoir with Φ300 mm pipe and distributed from the reservoir with Φ500 mm distribution main pipe. To check inlet flow, distribution flow and water level, flow meter and level indicator are installed.

i) Flow meter at inlet pipe (Φ300 mm)
   ① Ultrasonic type with detector and converter :1 set

ii) Level indicator : installed in the reservoir
   ① Float type level indicator: 1 set

iii) Manual valve
   ① Inlet of reservoir
      300A (FC) :3 sets
   ② Outlet of reservoir
      300A (Butterfly, FC, with gear) :1 set
      500A (FC) :1 set
   ③ On reservoir
      150A (FC) :1 set

iv) Outdoor Distribution Board (Main 30A, Branch 20A×6) :1 set

3) Awajan High reservoir

Water is transmitted through Awajan junction to Awajan High reservoir with Φ600 mm existing pipe. Qmax = 5,000 m^3/d is injected in the pipe from Awajan wells. From the reservoir, water is transmitted to Awajan Low reservoir with Φ200 mm pipe and also distributed to Awajan High zone with Φ600 mm distribution main. To check inlet flow, distribution flow and water level, flow meter and level indicator are installed.

i) Flow meter
   ① Ultrasonic type with detector and converter: 1 set

ii) Level indicator in the reservoir
   ① Ultrasonic type with detector and converter: 2 sets

iii) Manual valve
   ① Inlet of new reservoir
      400A (Pressure reducing valve, FC, with gear, operation platform and extended stem): 1 set
      400A (Cast steel, with operation platform and extended stem): 3 sets
   ② Outlet of new reservoir
      200A (Shut off valve, FC): 1 set
   ③ Outlet of existing reservoir
      300A (Shut off valve, FC): 1 set
      600A (Butterfly valve, FC, with gear): 1 set
   ④ On connecting pipe
      200A (Shut off valve, FC): 1 set

iv) Outdoor distribution board (Main 30 A, Branch 20 A×6) :1 set

4) Awajan Low reservoir

Water comes from Awajan High reservoir with Φ200 mm pipe and distributed to respective zones with Φ400 mm distribution main. To check inlet flow and water level, flow meter and level indicator are installed.

i) Flow meter

① Ultrasonic type with detector and converter: 1 set

ii) Level indicator in the reservoir

① Float type: 1 set

iii) Manual valve

① Inlet of reservoir

200A (FC) : 3 sets

② Outlet of reservoir

400A (FC) : 1 set

② On reservoir

100A (FC): 1 set

iv) Outdoor distribution board (Main 30A, Branch 20A × 6) : 1 set

2.2.2.4 Distribution Main

(1) Planned hourly maximum demand

Planned hourly maximum demand in each distribution zone is as follows. Zoning is shown in Figure 2-11.

Ruseifa High zone
- RH-A zone: 84.1 m^3/h (0.023 m^3/s, new)
- RH-B zone: 124.2 m^3/h (0.035 m^3/s, expanded area)
- RH-C zone: 82.8 m^3/h (0.023 m^3/s, served area)

Ruseifa Low zone
- RL-A zone: 172.8 m^3/h (0.048 m^3/s, expanded area)
- RL-B zone: 903.0 m^3/h (0.251 m^3/s, served area)

Awajan High zone
- AH-A zone: 263.7 m^3/h (0.073 m^3/s, expanded area)
- AH-B zone: 1,689.5 m^3/h (0.469 m^3/s, served area)

Awajan Low zone
- AL zone: 324.0 m^3/h (0.090 m^3/s, served area)

(3) Selection of Distribution Main Pipe

To connect supply water from each reservoir to existing network, four distribution main pipes are required as shown in Table 2-17. For newly constructed zones, Jordan side will construct network piping including distribution mains. Planned location of four distribution main pipes is shown in Figures 2-9 and 2-10.

Diameter of the distribution main pipes is decided so that supply pressure in any places of each distribution zone can be kept at least 25 m considering friction loss of distribution main and network piping and ground elevation. As a result, 200 mm, 500 mm, 600 mm and 400 mm are adequate sizes of distribution main in RH-C, RL-B, AH-B and AL zone respectively. One rank smaller size cannot keep minimum supply pressure of 25 m.

Table 2-17 Plan of Water Distribution Mains

Zone	Ruseifa High			Ruseifa Low		Awajan High		Awajan Low
Sub zone	RH-A	RH-B	RH-C	RL-A	RL-B	AH-A	AH-B	AL
Population in 2005	8,630	12,743	8,495	17,720	92,613	27,048	173,281	33,234
Per capita consumption in 2005 (lpcd)	90	90	90	90	90	90	90	90
Leakage ratio in 2005 (%)	25	25	25	25	25	25	25	25
Daily Av Flow (m^3/d)	1,036	1,529	1,019	2,126	11,114	3,246	20,794	3,988
Daily Max Flow (m^3/d)	1,346	1,988	1,325	2,764	14,448	4,219	27,032	5,185
Hourly Maximum Flow (m^3/h)	84.1	124.2	82.8	172.8	903.0	263.7	1,689.5	324.0
Diameter (mm)			**200**		**500**		**600**	**400**
Length (m)			3,392		1,695		1,747	1,466
C Coefficient			100		110		120	110
Unit Friction Loss (m/1000m)	-	-	5.0	-	4.0	-	4.5	1.8
Friction Loss (m)	-	-	17.0	-	6.8	-	7.8	2.6
Reservoir LWL (m)	807.0	807.0	807.0	750.0	750.0	694.0	694.0	638.0
Critical Point Ground Elevation (m)			760		700		630	595
Network Friction Loss (m)			3		15		27	10
Supply Pressure at Critical Point (m) (Min. 25 m)			27		28		29	30
Network Piping	New	New	Existing	New	Existing	New	Existing	Existing

Comparison according to the variation of pipe size

Zone	RH-C		RL-B		AH-B		AL	
Hourly Maximum Flow (m^3/d)	82.8	82.8	903.0	903.0	1,689.5	1,689.5	324.0	324.0
Diameter (mm)	**200**	**150**	**500**	**450**	**600**	**500**	**400**	**300**
Length (m)	3,392	3,392	1,695	1,695	1,747	1,747	1,466	1,466
C Coefficient	100	100	110	110	120	110	110	100
Unit Friction Loss (m/1000m)	5.0	20.4	4.0	6.7	4.5	12.9	1.8	8.7
Friction Loss (m)	11.1	44.9	7.1	11.8	6.8	19.3	2.6	12.7
Reservoir LWL (m)	807.0	807.0	750.0	750.0	694.0	694.0	638.0	638.0
Critical Point Ground Elevation (m)	760	760	700	700	630	630	595	595
Network Friction Loss (m)	3	3	15	15	27	27	10	10
Supply Pressure at Critical Point (m) (Min. 25 m)	27	- 25	28	23	29	17	30	20
Judgment	○	×	○	×	○	×	○	×

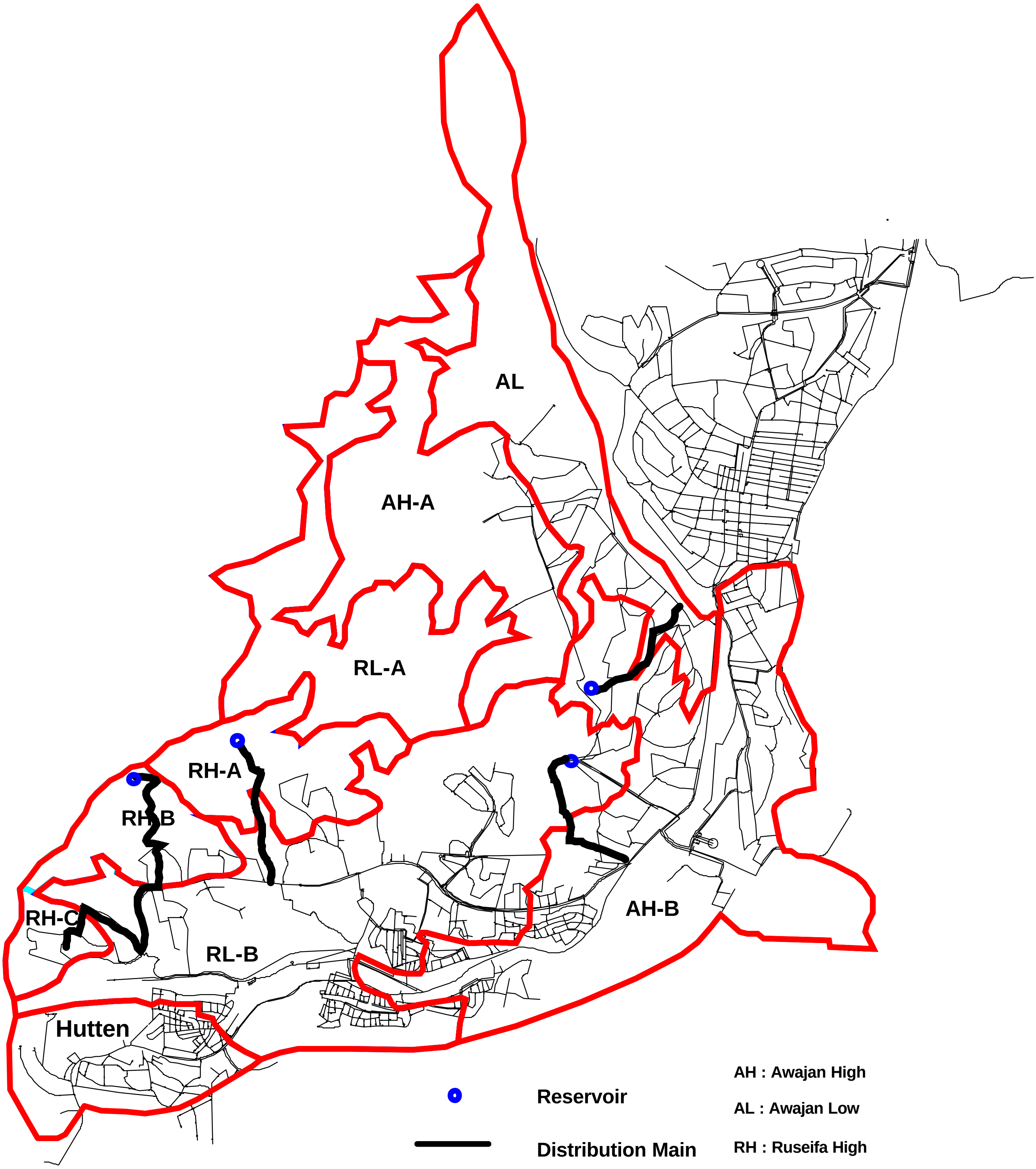


Figure 2-11 Distribution Sub-Zones

2.2.2.5 Facility Plan

Facilities to be implemented under the project are tabulated below:

Table 2-18 List of Facilities

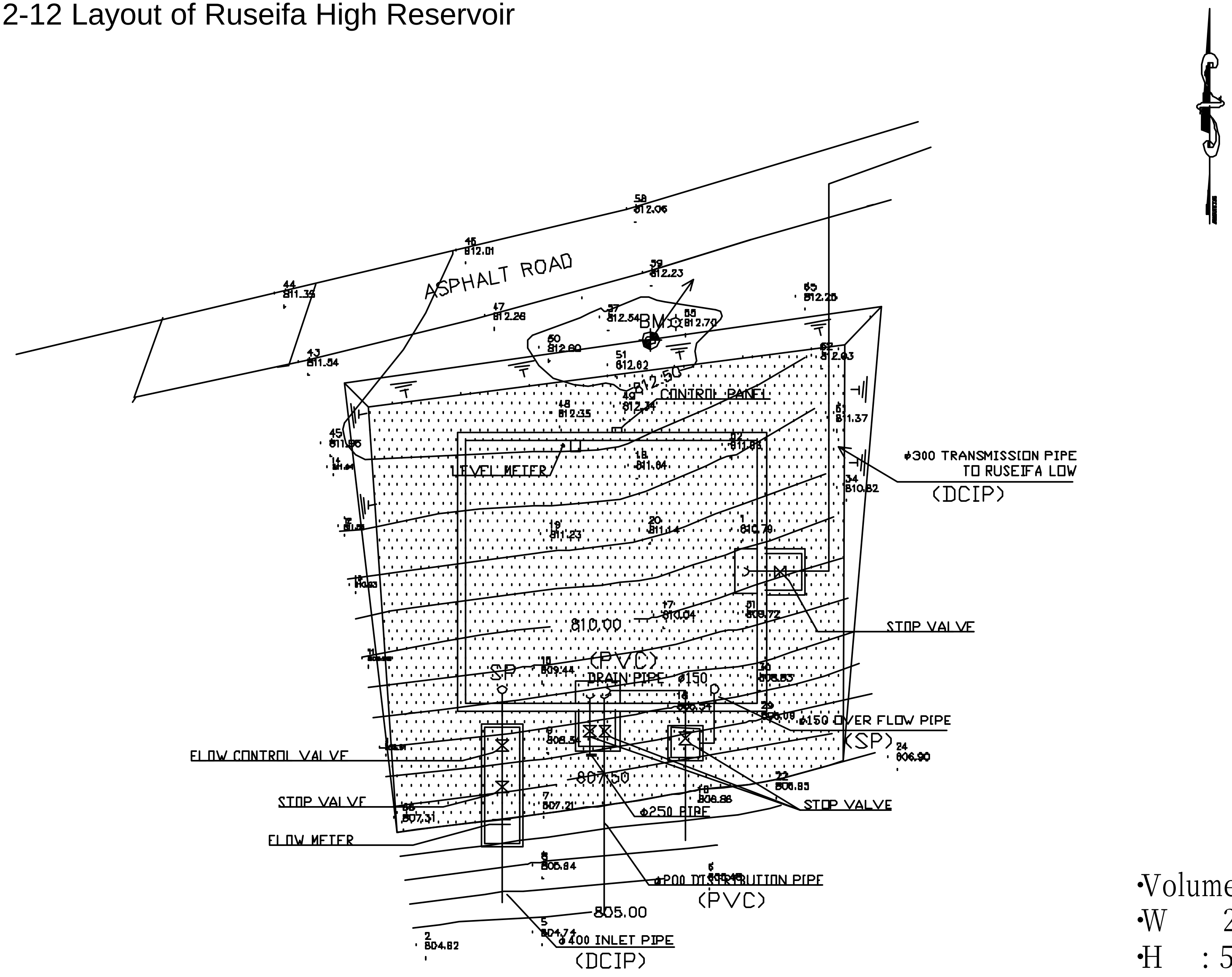
Category	Item
1. Transmission pipe and accessories	1) Hutten Junction – Ruseifa Junction DCIP dia. 500 mm x 1,113 m 2) Ruseifa Junction – Ruseifa High Reservoir DCIP dia. 400 mm x 4,782 m 3) Ruseifa High Reservoir – Ruseifa Low Reservoir DCIP dia. 300 mm x 1,560m 4) Awajan High Reservoir – Awajan Low Reservoir DCIP dia. 200 mm x 1,280 m 5) Hutten Junction Ultrasonic flow meter x 2, manual valve x 3 6) Ruseifa Junction Manual valve x 3 7) Awajan Junction Manual valve x 3
2. Reservoir	1) Ruseifa High Reservoir •RC structure (rectangle), L20.0m x W18.0m x H5.0m, cap. 1,800m^3 •with: ultrasonic flow meter x 1, level gauge x 1, manual valve x 7 2) Ruseifa Low Reservoir •PC structure (circular), dia. 36.6m, height 6.0m, cap. 6,300m^3 •with: ultrasonic flow meter x 1, level gauge x 1, manual valve x 6 3) Awajan High Reservoir •PC structure (circular), dia. 36.6m, height 6.0m, cap. 6,300m^3 •with: ultrasonic flow meter x 1, level gauge x 2, release valve x 1, manual valve x 10 4) Awajan Low Reservoir •RC structure (rectangle), L20.0m x W18.0m x H5.0m, cap. 1,800m^3 •with: ultrasonic flow meter x 1, level gauge x 1, manual valve x 5 5) Hutten Reservoir, existing •with: ultrasonic flow meter x 1, level gauge x 2, release valve x 1, manual valve x 5
3. Distribution Main	1) From Ruseifa High Reservoir DCIP: dia. 200 mm x 3,352 m 2) From Ruseifa Low Reservoir DCIP: dia. 500 mm x 1,726 m 3) From Awajan High Reservoir DCIP: dia. 600 mm x 1,712 m 4) From Awajan Low Reservoir DCIP: dia. 400 mm x 1,467 m

2.2.3 Basic Design Drawing

The following basic design drawings are attached:

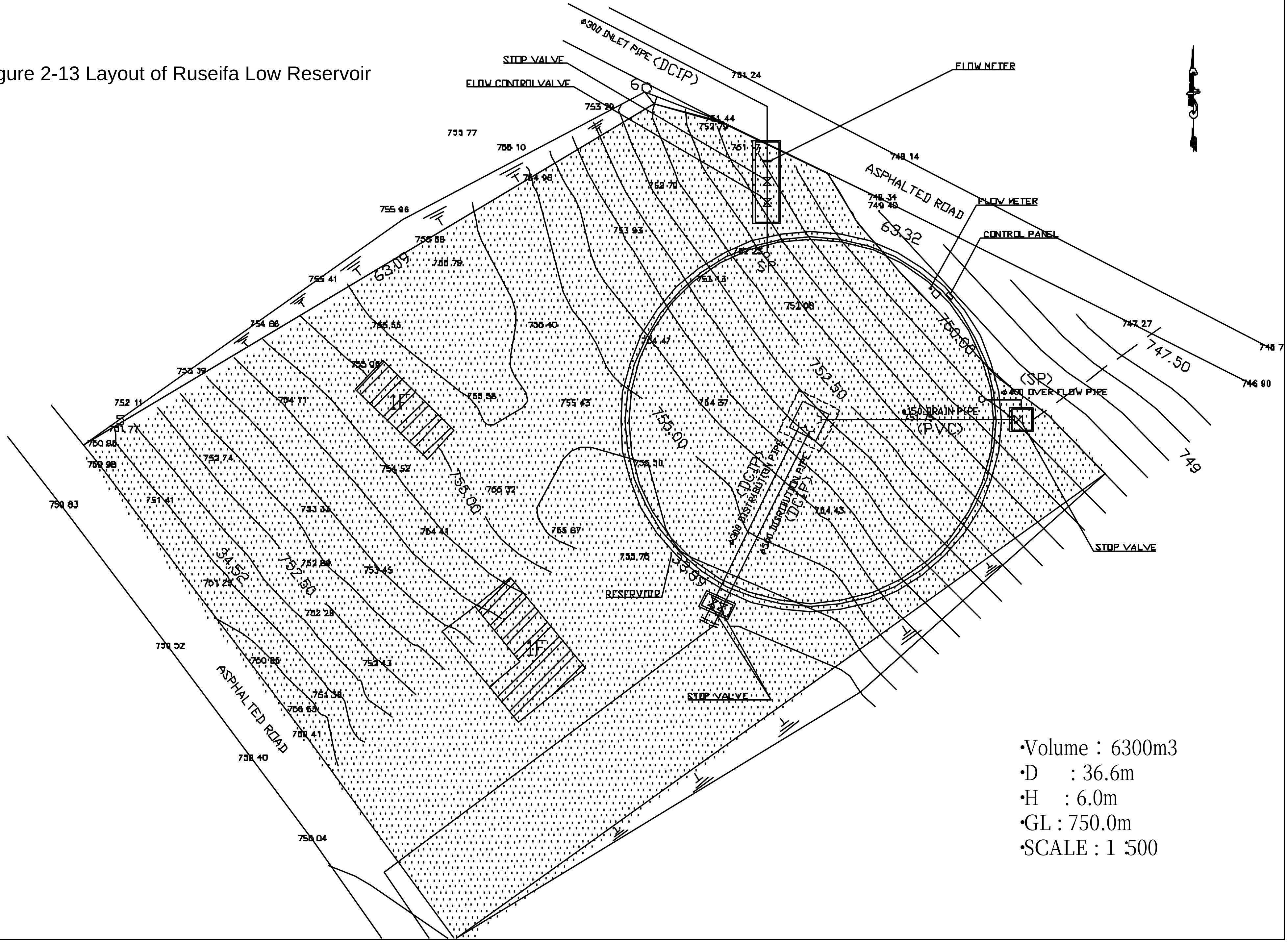
Distribution reservoir:	layout and general drawing
Transmission pipe:	plan and profile
Distribution main:	plan and profile

Figure 2-12 Layout of Ruseifa High Reservoir



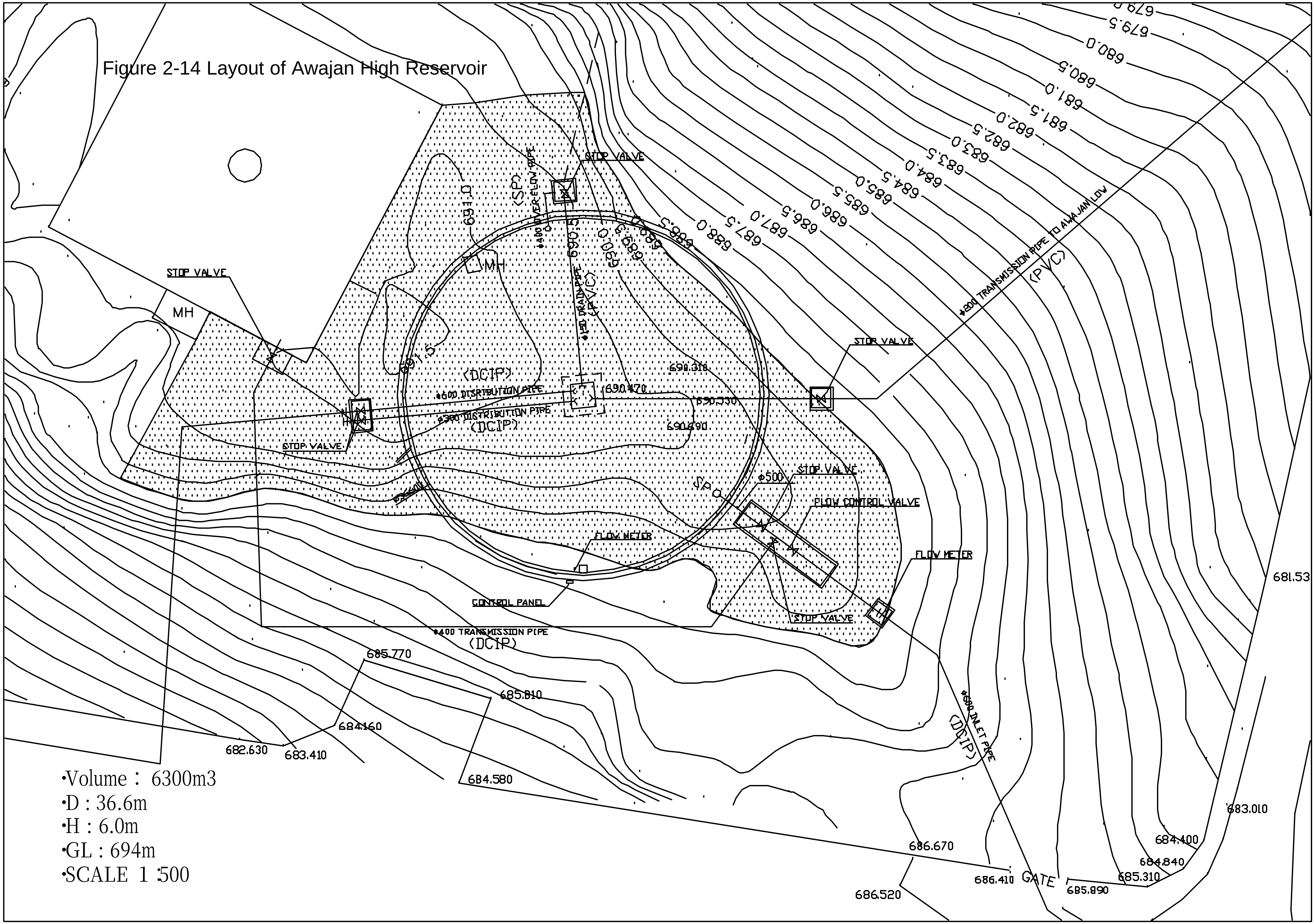
•Volume 1800m3
•W 20m xL 18m
•H : 5.0m
•GL : 807m
•SCALE : 1 300

Figure 2-13 Layout of Ruseifa Low Reservoir



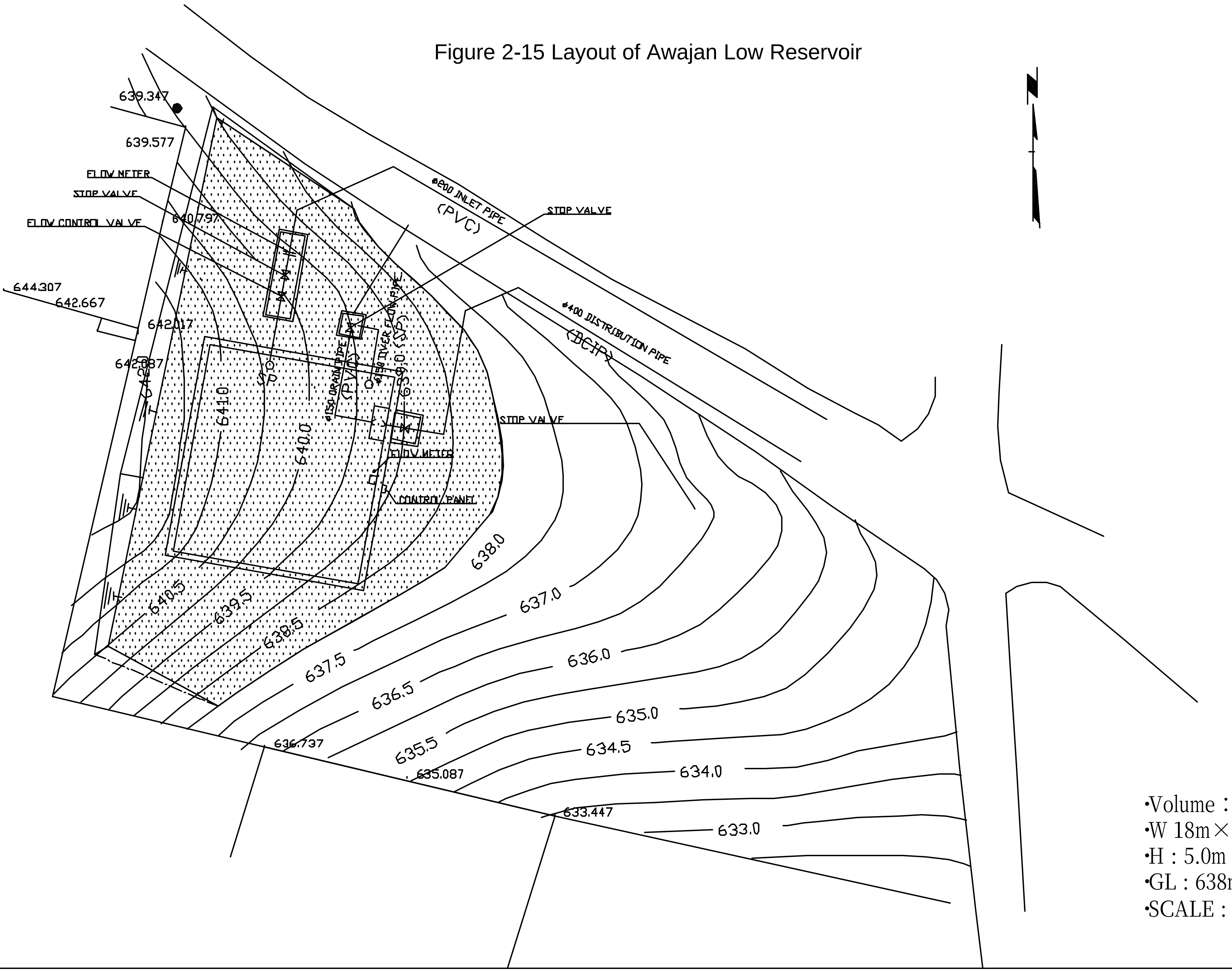
•Volume : 6300m3
•D : 36.6m
•H : 6.0m
•GL : 750.0m
•SCALE : 1 :500

Figure 2-14 Layout of Awajan High Reservoir



•Volume： 6300m3
•D : 36.6m
•H : 6.0m
•GL : 694m
•SCALE 1 :500

Figure 2-15 Layout of Awajan Low Reservoir



- Volume：1800m3
- W 18m×L 20m
- H：5.0m
- GL：638m
- SCALE：1 :500

Figure 2-16

Awajan High & Rusaifa Low RESERVOIR

GENERAL VIEW S=1/300

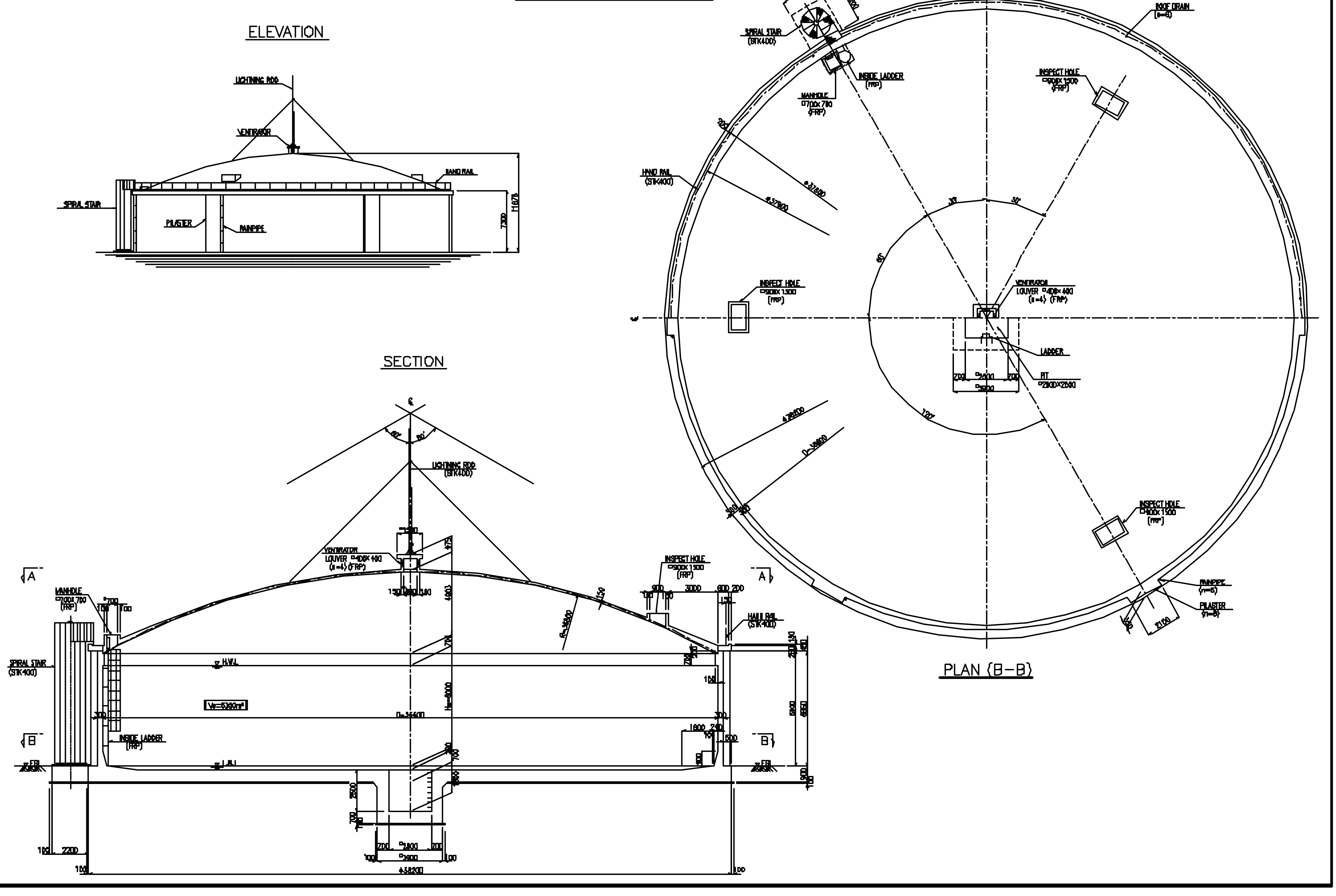
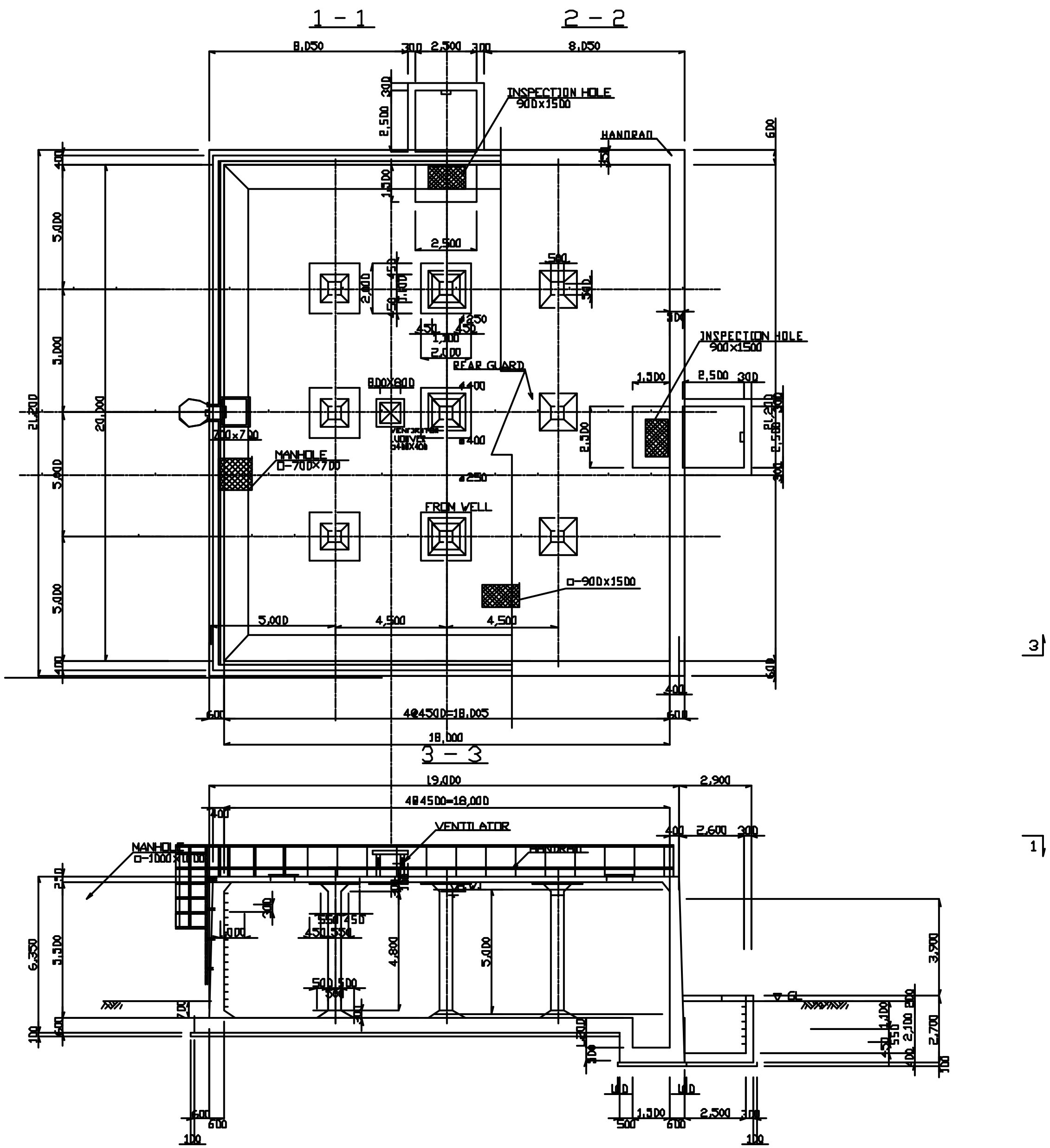


Figure 2-17

DISTRIBUTION RESERVOIR (1/2)



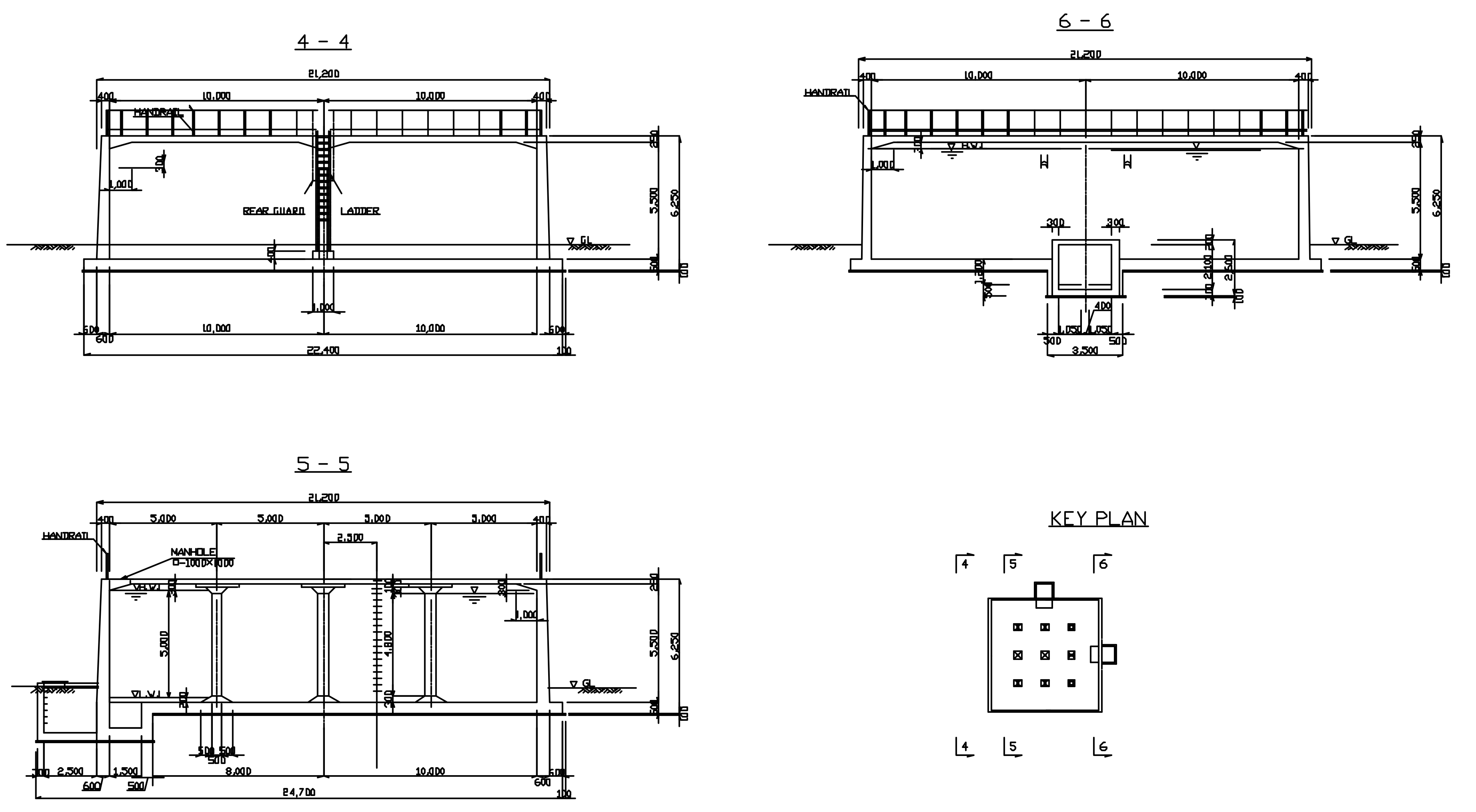
REVISIONS		
No. Date	Description	Approved

ZARUKA
JORDAN
TOKYO ENGINEERING CONSULTANTS CO.,LTD.
RUSAIFA HIGH 3800M3
DISTRIBUTION RESERVOIR (1/2)
Designed Date Checked Date Approved Date
Drawing Reference
Drawing Reference TEC
District Subdistrict Sequence
Data File title

Figure 2-18

DISTRIBUTION RESERVOIR (2/2)

S=1/200



REVISIONS					
No.	Date	Description	Approved	ZARUKA	AVAJAN LOW 1800M3, RUSAIFA HIGH 1800M3
				JORDAN	DISTRIBUTION RESERVOIR (2/2)
				TOKYO ENGINEERING CONSULTANTS CO.,LTD.	Designed / Date / Checked / Date / Approved / Date

Drawing Reference

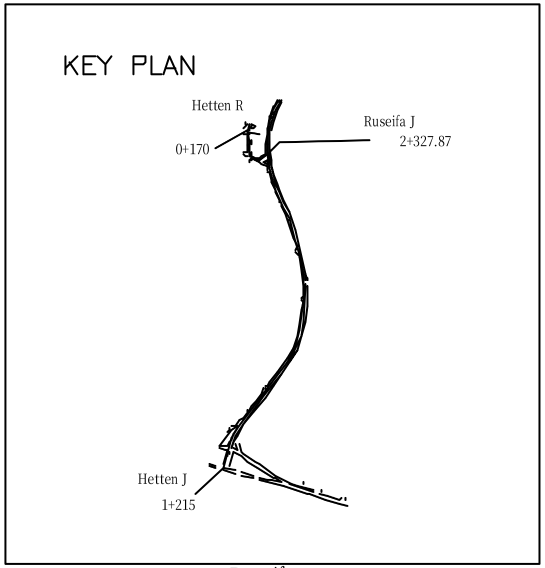
Drawing Reference TEC

District Subdistrict Sequence

Data File title

Figure 2-19

①② Transmission Main
D500 Hutten Junction - Ruseifa Junction
D200 Ruseifa Junction - Hutten Reservoir



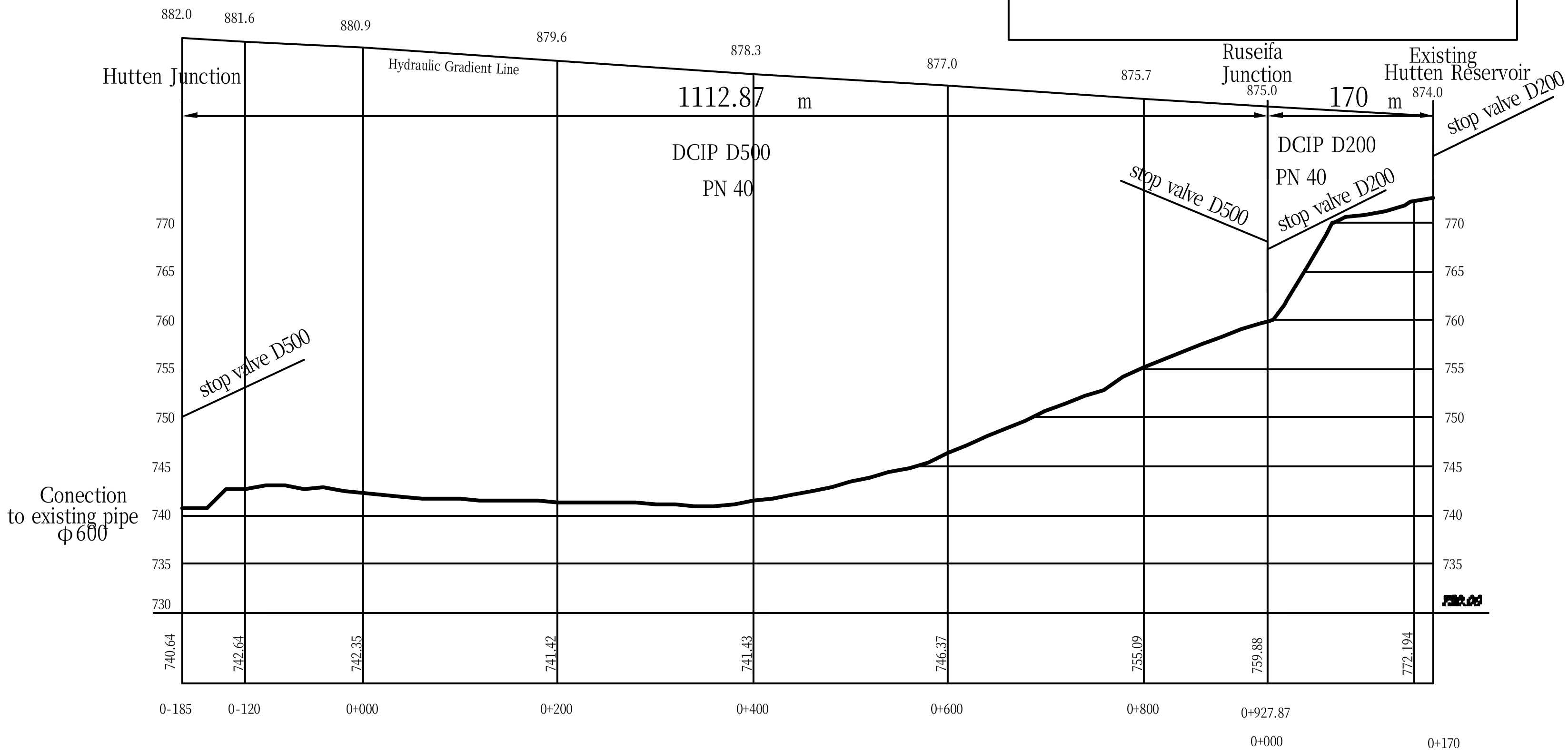


Figure 2-20

③ Transmission Main
D 400
Ruseifa Junction - Ruseifa High Reservoir

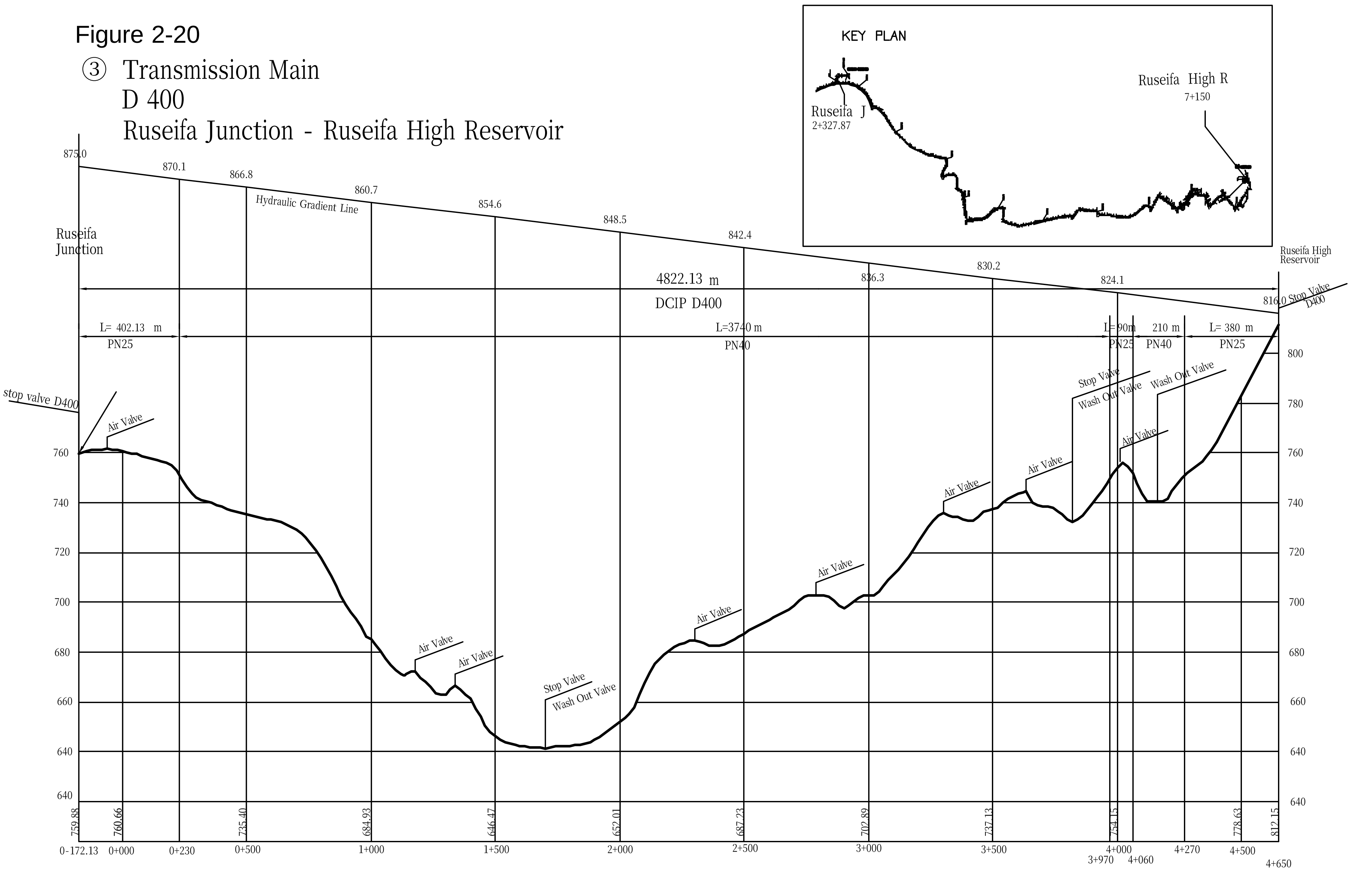
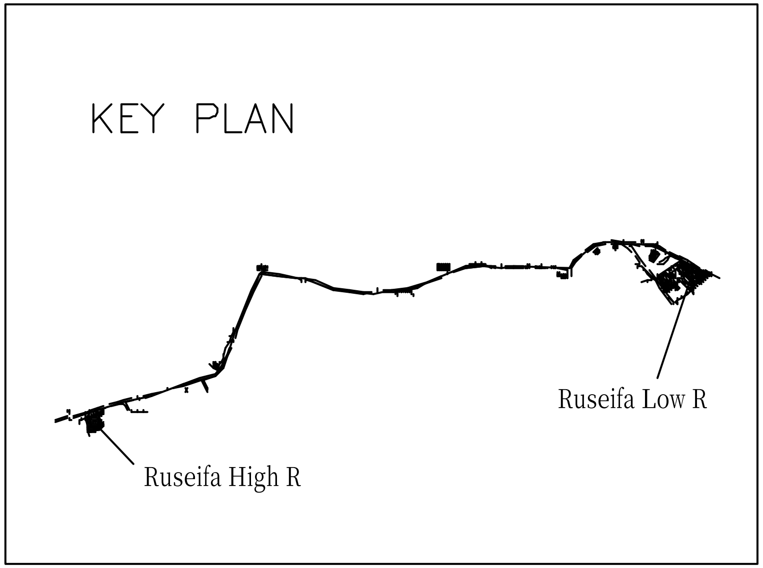


Figure 2-21

④ Transmission Main
D300
Ruseifa High Reservoir - Ruseifa Low Reservoir



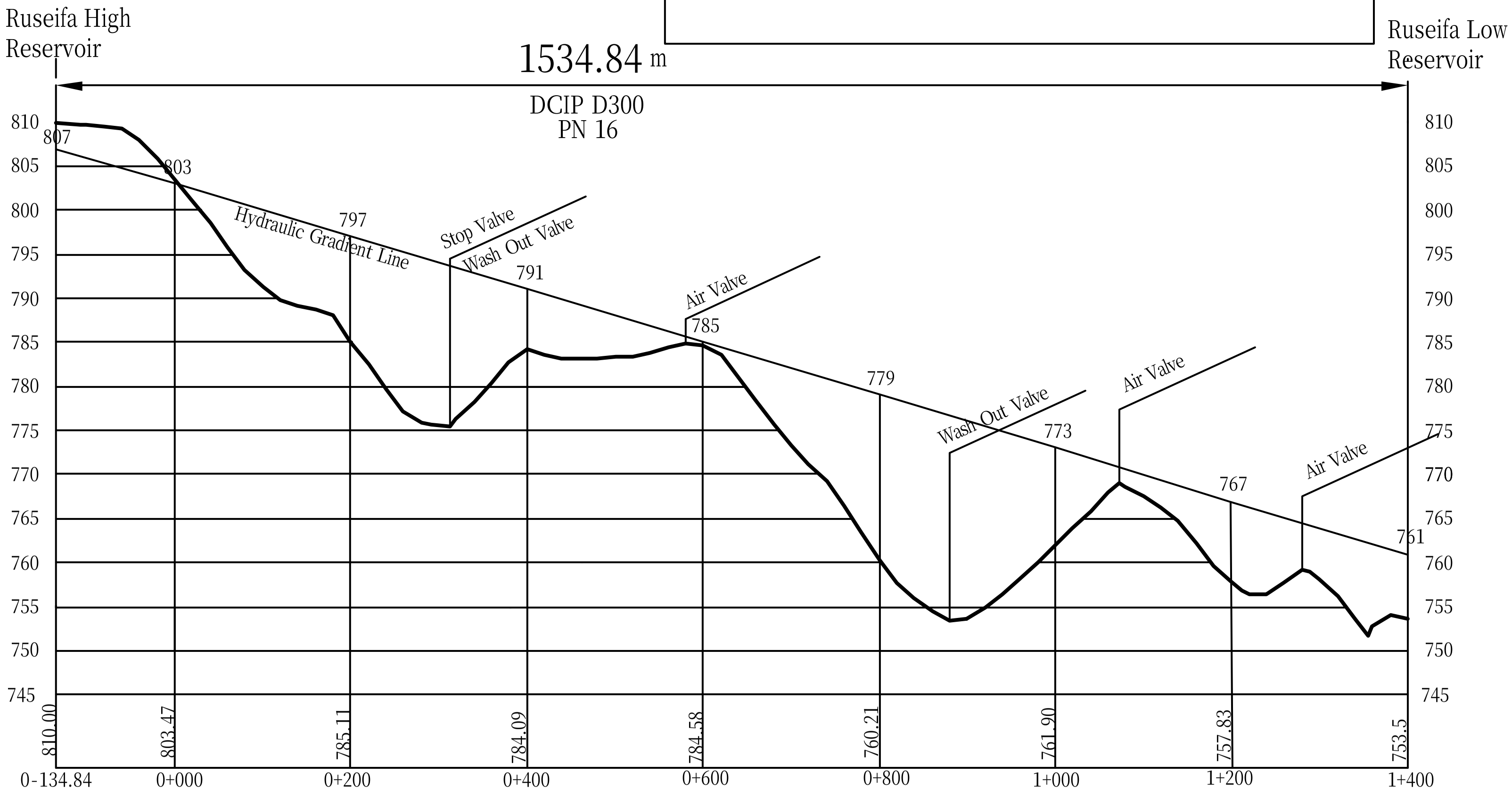
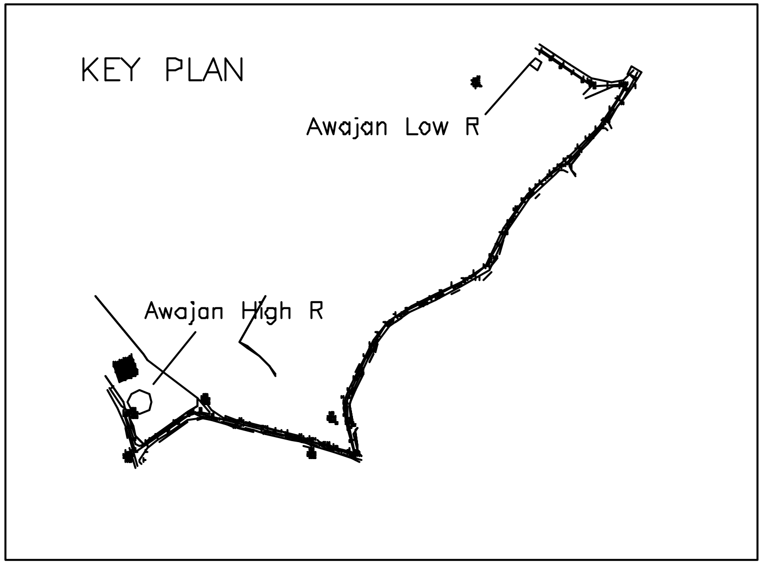


Figure 2-22

⑤ Transmission Main
D200
Awajan High Reservoir - Awajan Low Reservoir



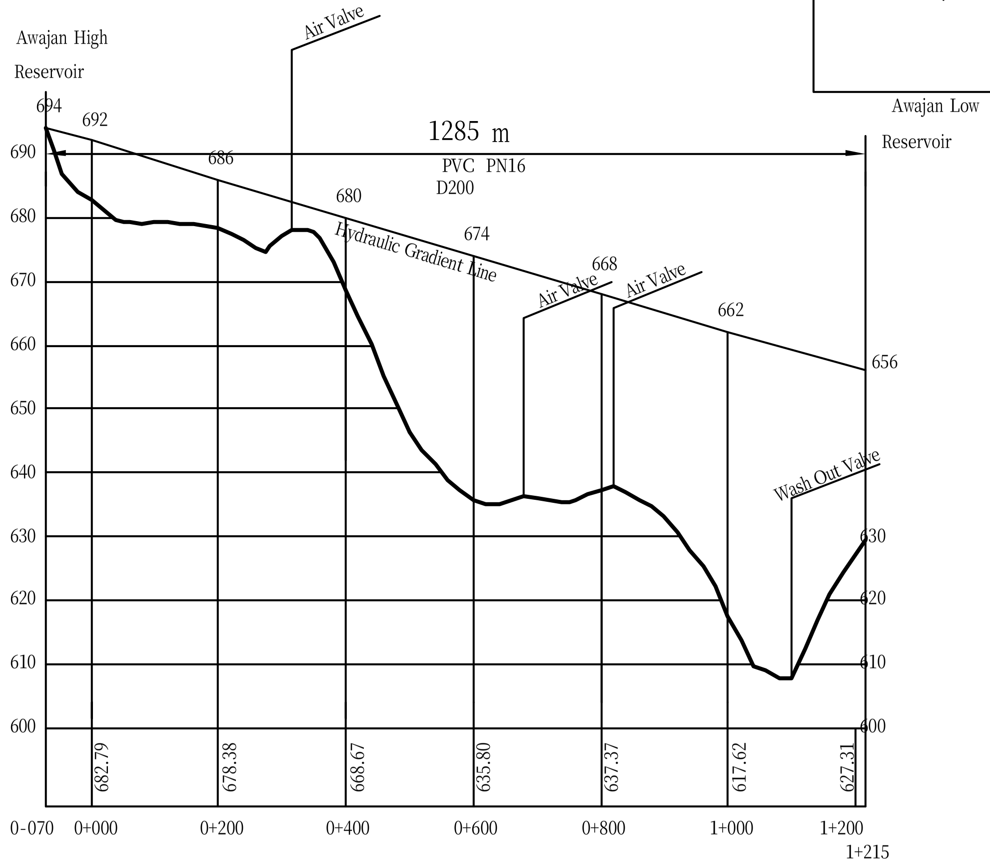
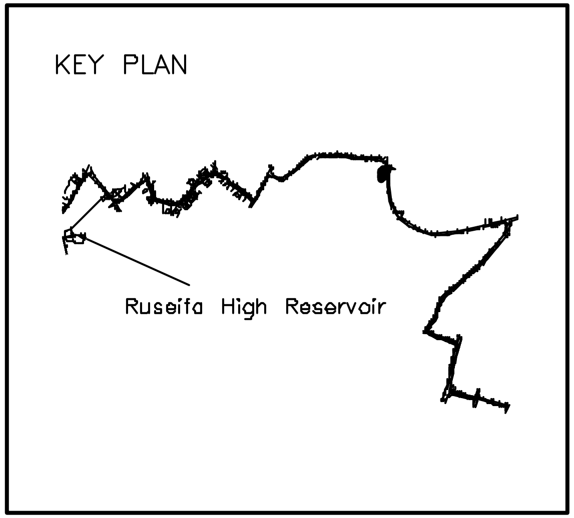


Figure 2-23

⑥ Distribution Line
D200
Ruseifa High Reservoir-



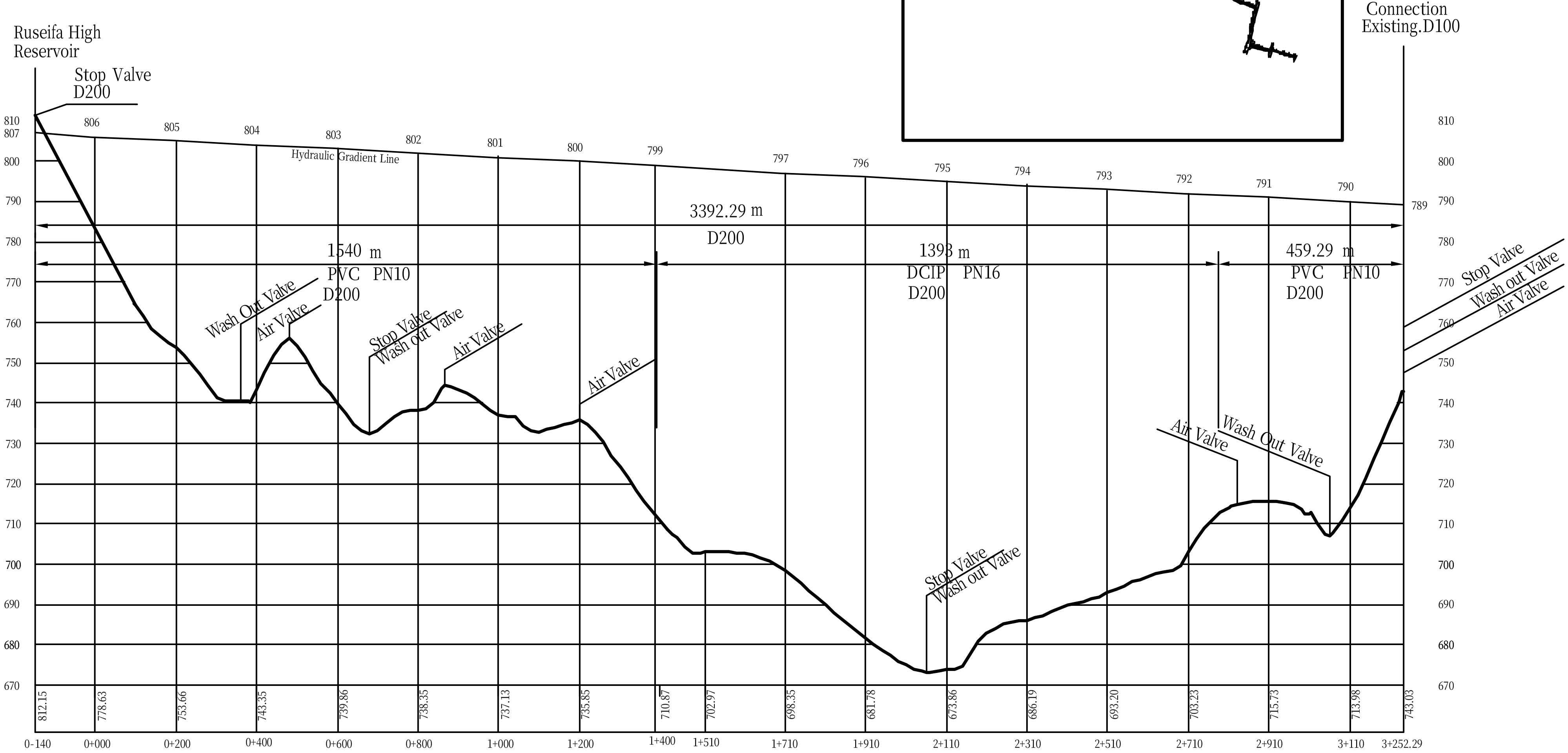
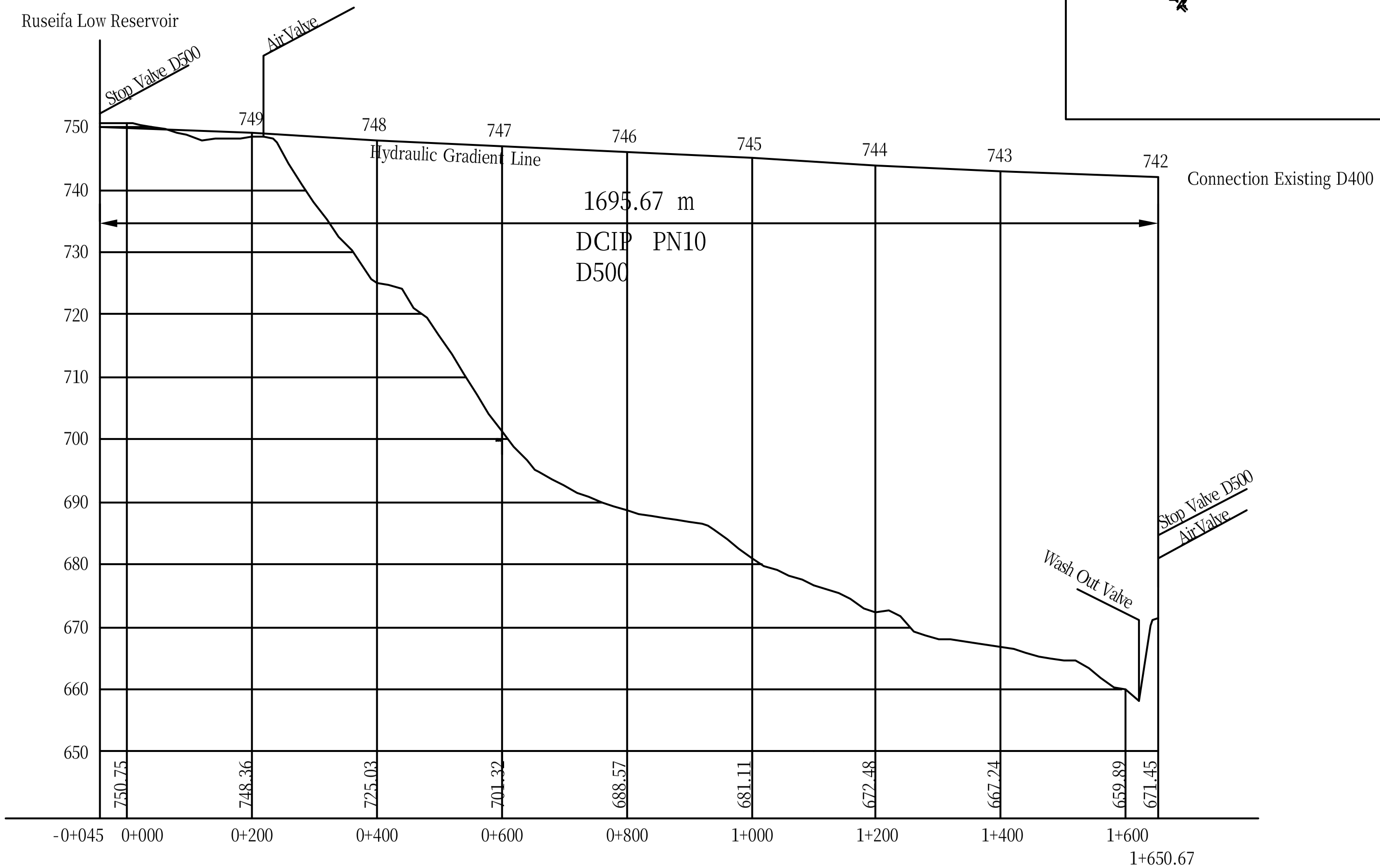


Figure 2-24

⑦ Distribution Line
D500
Ruseifa Low Reservoir-



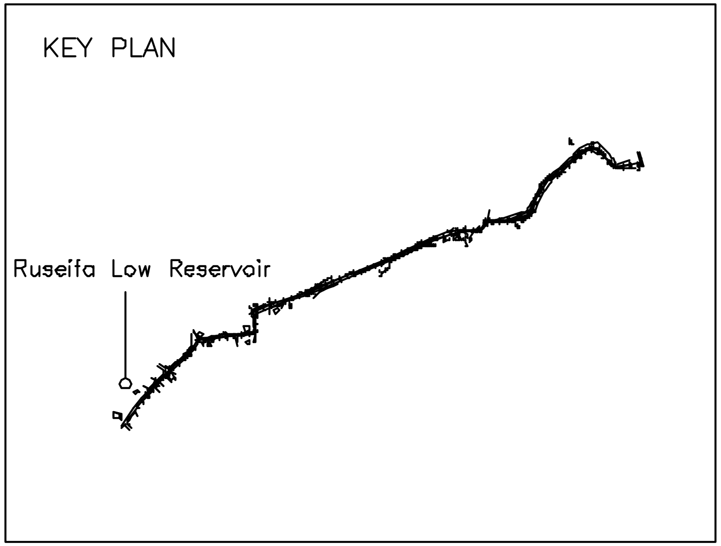


Figure 2-25
⑧ Distribution Line
D600
Awajan High Reservoir–

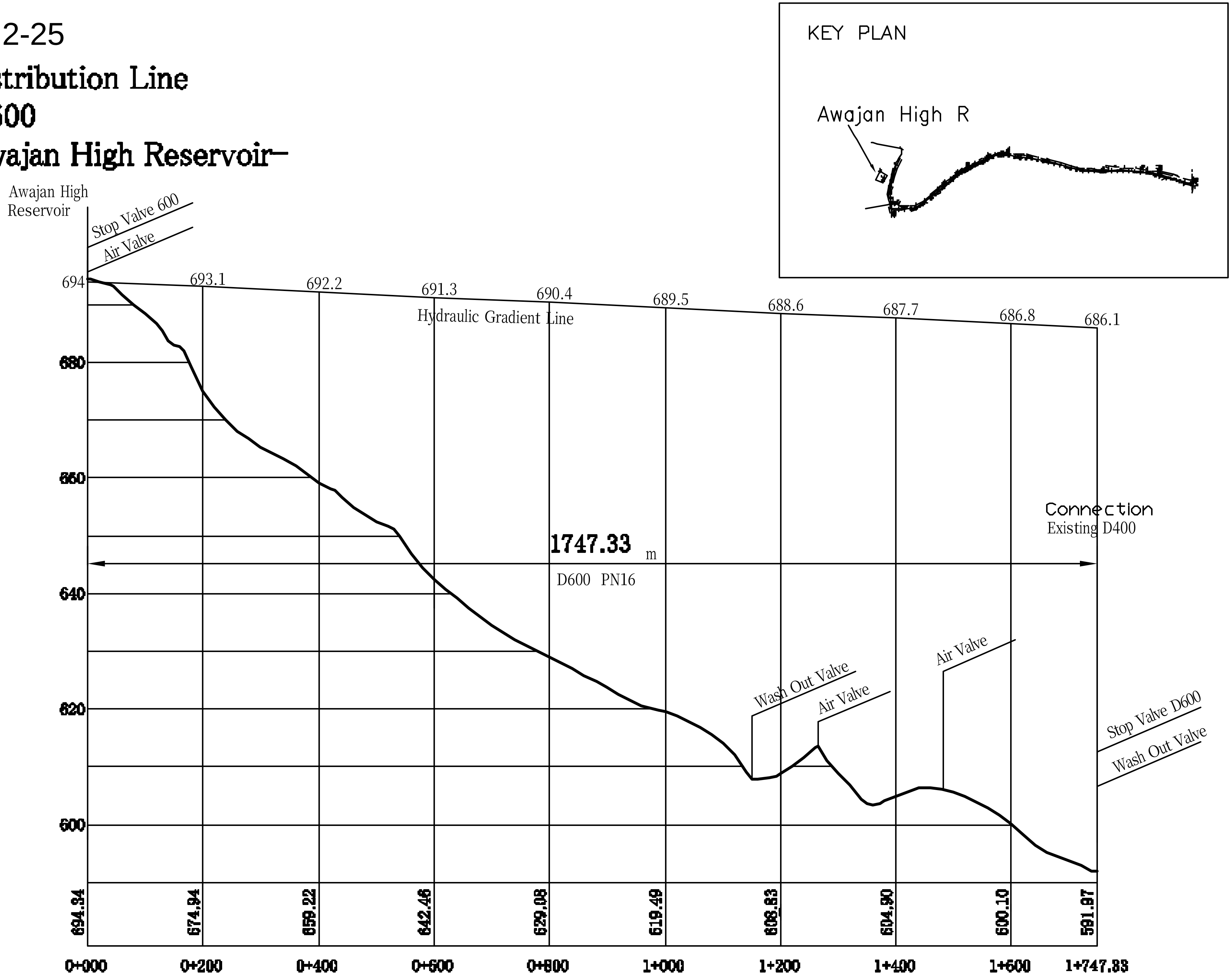
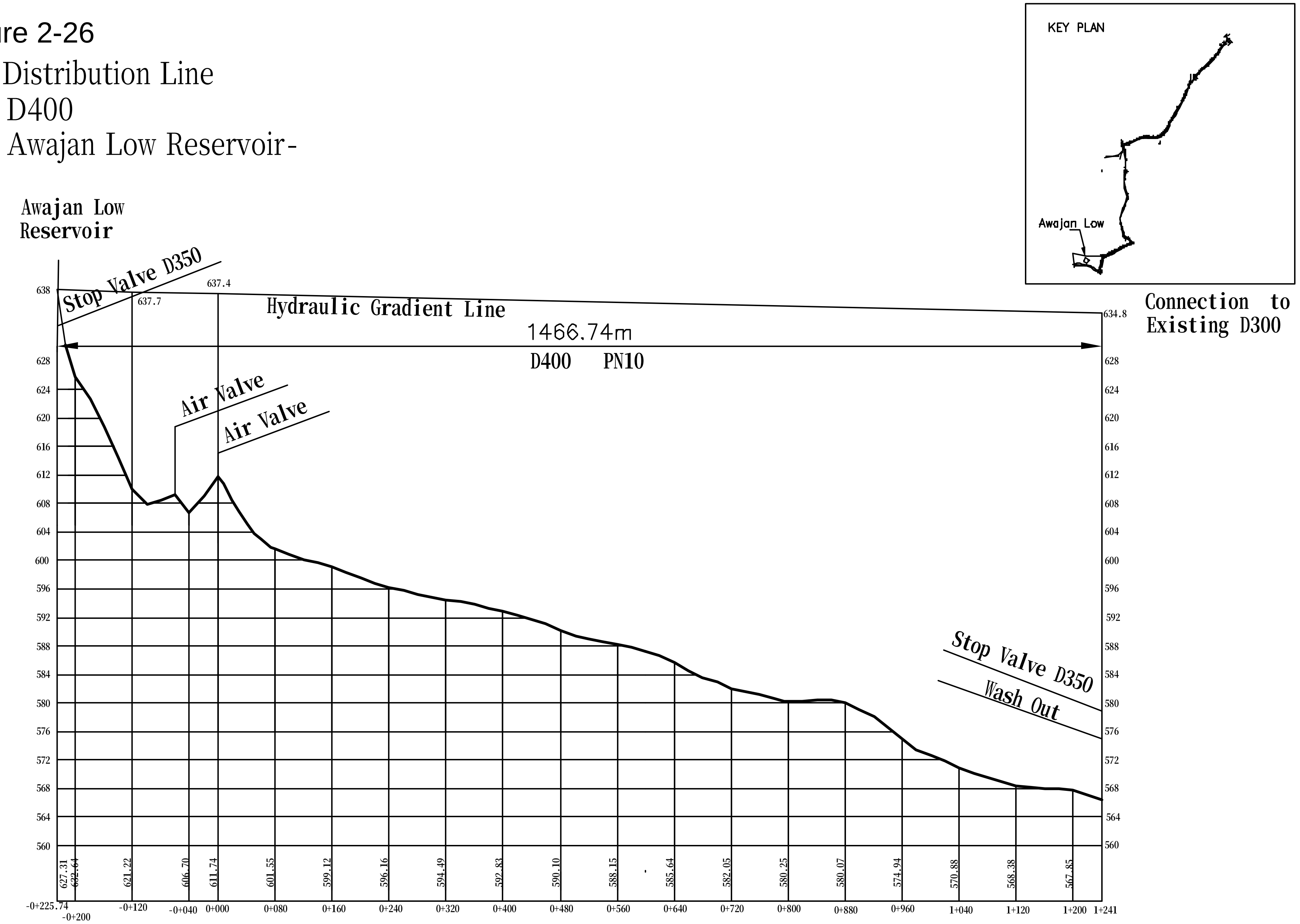


Figure 2-26

⑨ Distribution Line
D400
Awajan Low Reservoir-



2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

The present project shall be implemented within the framework of Japan's Grant Aid Program. Hence, the project must be brought into implementation after approval by the Government of Japan (GOJ) of the implementation of the project and the exchange of Verbal Notes between the Japanese and the Jordanian governments. The Verbal Notes shall become effective on the date when the ratification of Notes is noticed to the Japanese Government by the Jordanian Government.

Basic procedures and particular considerations in the implementation of the project are as follows:

1) Executing Organization

Water Authority of Jordan (WAJ) under Ministry of Water and Irrigation shall be the project executing organization of the present project. WAJ is in charge of water supply and wastewater within the entire Jordan, and consists of eight departments (Water affairs, Wastewater affairs, Technical affairs, Financial affairs, Administrative affairs, South region, Middle region and North region). Water Affairs Department shall be in charge of the project. Zarqa Directorate office, which belongs to the Middle Region Department, shall operate and maintain facilities to be constructed under the project.

2) Consulting Engineer

A consulting engineer of the Japanese national shall enter into contract with the Jordanian executing organization for engineering services for design and supervision of construction works for construction of facilities and procurement of materials under the present project, and shall undertake services of detailed design and supervision of construction works. He shall also prepare tender documents for the project and undertake prequalification of contractors and tendering services on behalf of the project executing organization.

3) Contractor

A Japanese contractor, who shall be selected by the Jordanian side within the framework of Japan's grant aid program, shall undertake construction of facilities and procurement of material under the present project. The contractor shall provide necessary facilities for communication, for supply of spare parts, repair services and other services required after completion of the project.

4) Need for Japanese Expert

The pre-stressed concrete structure is adopted for two of four distribution reservoirs. There are many pre-stressed concrete structures in Jordan. They are constructed by contractors, who are assisted by foreign partners, particularly in construction technique and equipment for the pre-stressed concreting. It is, therefore, desirable that the Japanese contractor shall provide construction technique, equipment and expert for the pre-stressed concreting, and shall undertake technology transfer.

2.2.4.2 Implementation Conditions

1) Conditions in the implementation

a. Pipe-laying Works

Since pipe laying routes have dense traffic, erection of temporary fence, excavating, laying of pipe, backfilling and temporary recovery of pavement shall be made in one-day cycle. Works requiring longer time such as valve chamber and pipe protection structure shall be made with recovery plate against traffic disturbance.

Where most of excavation takes place at rocky soil, large breaker and backhoe will be used and earth supporting will not be required. Pipes shall be placed at laying bed by large truck crane. Connection shall be the push-on (T) type and the mechanical (K) type. Protection of pipe fittings shall be made with concrete protection of the $18N/mm^2$ strength.

Underground structures such as electricity and telephone cables, and sewers are buried everywhere along the route. These structures may be detoured by adjusting the depth of pipe, while suspended protection shall be made if required.

b. Construction of distribution reservoir

Rectangular reinforced concrete structure and circular prestressed concrete structure are adopted for distribution reservoirs. Inside of reservoirs shall be painted with epoxy resin for protection against corrosion by water.

2) Legal consideration

A Japanese contractor shall register with Ministry of Trade and Industry for its commercial activity including the constructer's activities. Labor permit for Japanese in Jordan may be issued only after this registration. Besides the commercial registration, a Japanese contractor shall register with Chamber of Commerce and Tax Bureau, and shall become member of Jordanian Constructors Association.

It is a duty of the registered company to nominate a legal advisor and an accountant and submit every fiscal year an audited financial report, which shall be the basis for exemption of tax or tax return.

2.2.4.3 Consultant Supervision

A consultant team shall be organized to undertake detailed design and supervision of construction works in accordance with procedures of Japan's grant aid program. At the stage of the supervision of construction works, the consultant shall dispatch the below listed supervisors to undertake control of construction schedule, quality and safety of works.

Team leader	1 person	visiting
Supervisor for structure and pipe laying	1	resident
Supervisor for structure construction	1	visiting
Supervisor for pipe laying work	1	visiting
Supervisor for mechanical works	1	visiting
Total	5 persons	

1) Policy of supervision of construction

The consultant shall supervise the contractor's construction works basically to secure the quality of works and complete the works safely in the schedule stipulated in the contract.

Major checklist in the supervision of construction work is given below:

a. Schedule control

Actual progress is compared with the construction schedule submitted with the contract. If delay is expected, the consultant shall advise the contractor to prepare measure to remedy and complete the work within the schedule.

b. Quality control

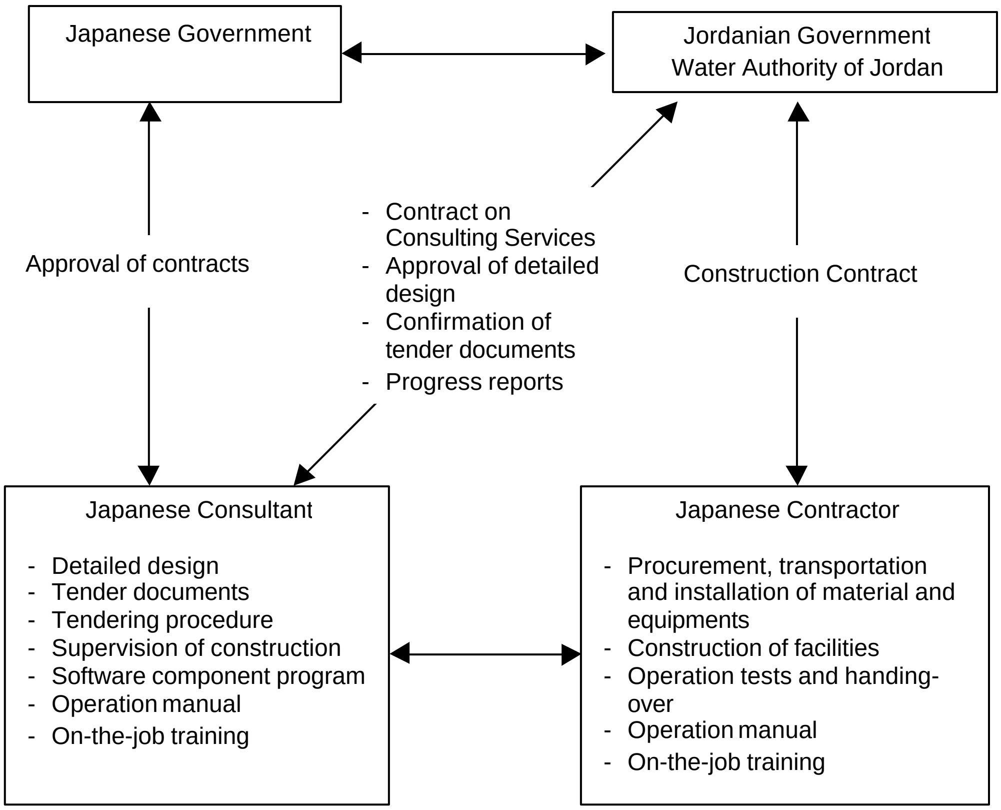
The consultant shall verify quality of facilities and material as specified in the specifications. If quality of the work is not fully ensured, he shall instruct the contractor to correct, rectify or change the quality of the work.

c. Safety control

The consultant shall establish rules for safety control, appoint a safety duty manager of the contractor, and advise on every precaution to avoid accident during the construction work. He also advise the contractor to undertake periodical check of construction machines, regular vehicle operation and welfare and secured rest of laborers.

2) Relations among major parties

Relations among major parties are shown below:



3) Management of construction works

Parts of construction of reservoirs and pipe-laying works may be sub-contracted to local contractors. Construction of pre-stressed concrete structure, however, will require Japanese specialist and skilled experts. Installation of transmission pipe will require emphasized safety control, since the work will be done in the major highways surrounded by important facilities and buildings.

A Japanese contractor shall be selected among contractors, who have accumulated experience on similar works with integrated quality, schedule and safety control in the overseas locations. Taking into consideration the scale and components of the present project, the required contractor's personnel residing in and visiting to site will be assumed as follows:

Site Representative of the Contractor	1 person	Liaison with related parties
Administrative officer	1	Labor control, procurement
Pipe-laying engineer	1	Transmission pipeline
Construction engineer for reservoirs	1	Distribution reservoirs
Electro-mechanical engineer	1	Electric and mechanical works
Total	5 persons	

2.2.4.4 Quality Control Plan

The present project requires quality control for each component of works, such as pipe-laying work in the major highway, distribution reservoir with strict water-tightness and durability, etc. Japanese standards shall be applied to such important facilities as transmission and distribution pipelines and distribution reservoirs. However, for the general-purpose materials such as concrete, reinforcing bars, etc. Jordanian standards may be applicable. Jordanian standards shall also be applied to the water quality.

Item.	Details.	Item Of Quality control	Test & Inspection
Water pipe (Transmission & distribution pipe)	Pipe Material (Ducktail pipe, PVC pipe)	Tensile strength Dimension	Factory test report Measurement Visual inspection
	Pipe laying	Position Fitting Water leakage	Measurement Visual inspection Torque test Water pressure test
Reservoir (Distribution)	Foundation ground	Bearing capacity	Plate bearing test
	Concrete	Material Aggregate Cement Flesh concrete Compressive strength	Physic-chemical test Grading test Factory test report Slump, Air, Chloride content Test Compressive strength test
	Reinforcement-bar	Material Strength test Arrangement	Tensile test Measurement Visual test
	Prestressed concrete Work	Material Dimension Cabling Grouting	Factory test report Visual test Measurement of Tensile force & Creep Measurement grounding volume
	Concrete structure	Dimension	Measurement Leveling
	Water proofing	Material Coating Film thickness Adhesive strength	Factory test report Visual inspection Measurement Tensile strength test Water filling test
Water system	Mechanical Valve Installation	Equipment Function	Factory test report Performance test

2.2.4.5 Procurement Plan

1) Country of origin

(1) Labor

Construction engineers and skilled laborers (carpenter, plasterer, etc.) can be locally hired from Jordan.

According to the Jordanian labor regulations, working hours and overtime allowance are as follows:

Standard working hours	per week per day	48 hours 8 hours
Overtime allowance	weekday holiday	150 percent 200 percent

Official wage rates are not established in Jordan. The lowest rates shall be applied among quotations from multiple local contractors.

(2) Materials and equipment

a. Pipe for transmission and distribution

Ductile cast iron pipes are selected taking into consideration easiness of local procurement, after-sales services (repair, spare parts, consumables, etc.), economy, etc. They shall be procured from Japan or from the third countries.

b. Accessories

Accessories like flow meters, water level gauge, valves, etc. are not locally manufactured. They shall be procured from Japan or from the third countries. They shall be procured basically in one package in order to avoid inconsistency among them and troubles therefrom.

(3) Construction machines

Construction machines such as large breaker, backhoe, bulldozer, dump truck, roller, etc. can be leased out from local constructors. Sufficient quantity and types are available. Local leasing will be more economical than mobilizing from Japan or the third countries, taking into consideration costs of transportation and period of utilization.

Table 2-19 Expected Source of Material, Equipment and Construction Machines

Item	Jordan	Japan	Third Country	Remarks
Material and equipment				
Cement	○			
Aggregate	○			
Reinforced steel bar	○			
Mold	○	○		Plywood is less expensive in Japan
Supporting material	○	○		
PVC Pipe	○			
Concrete Pipe	○			
Block	○			
Tile	○			
Ductile-cast iron pipe		○	○	Straight, bend, collar and valves from EU
Special pipe material		○		Specially high pressure, safery and distribution in time
Steel for PC		○		Strength, quality, conformity with prestressing equipment

Ladder, cover of reservoir		○		Anti-corrosive material
Flow meter, level meter		○		Safety, conformity with distribution system
Construction machines				
Backhoe	○			
Dump truck	○			
Crane	○			
Bulldozer	○			
Concrete mixing car	○			
Concrete pump car	○			
Restressing equipment		○		Strenght of stressing, conformity with PC steel material
Generator	○	○		Lease from Japan is less expensive, if needed for the prolonged period
Air compressor	○			
Truck crane	○			

2) Transportation plan

(1) Route of transportation

Materials and equipments procured from Japan or the third countries can be unloaded at Aqaba port and transported through National Highways 15, 25 and 35, and through Amman to the project sites. It is necessary to make package within the inland traffic limitation, that is, 4.2 m in height, 3.25 m in width and 50 tons in weight.

(2) Packaging for transportation

a. Packaging

Materials and equipments shall be properly packaged before shipment to protect from degradation of quality. Case packaging and crate packaging for smaller materials and palette packaging for larger materials shall be considered.

b. Others

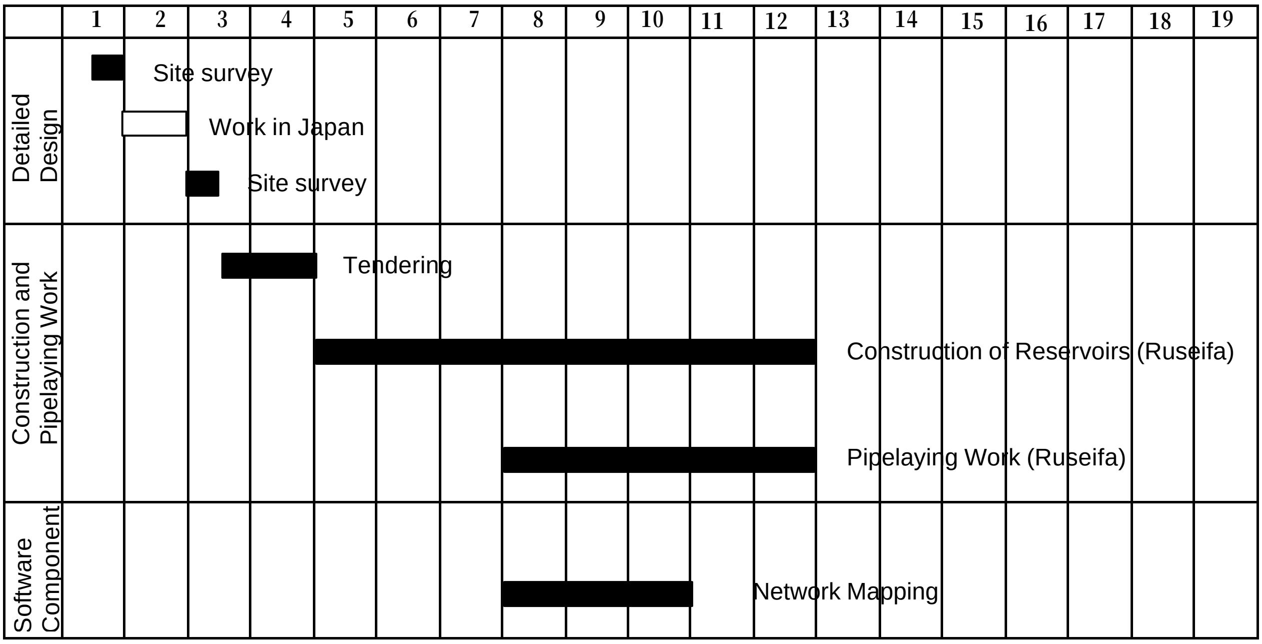
Cost of loading, ocean freight tariff, unloading at the local port, inland transportation and insurance shall be considered.

2.2.4.6 Implementation Schedule

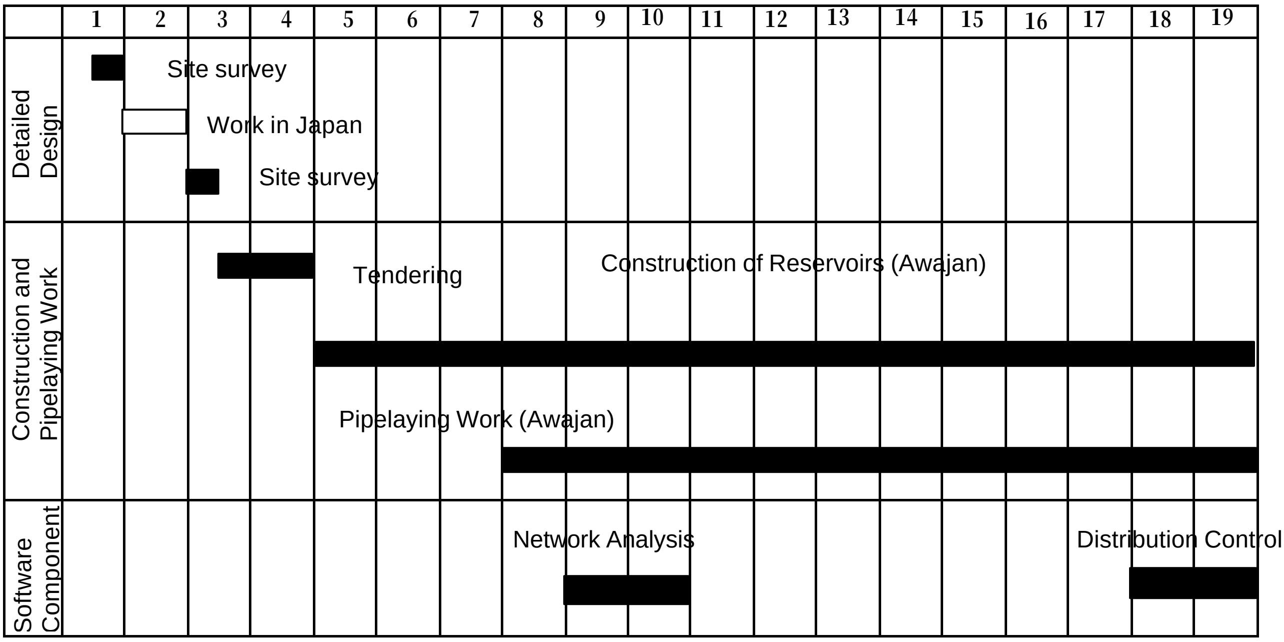
After approval by the Japanese Government, the Jordanian and the Japanese government shall exchange verbal notes and the present project will be brought into implementation. The implementation of the project consists of three major stages: *first*, detailed design and preparation of tender documents, *second*, tender and award of contract, *third*, procurement of materials and equipments, and construction of facilities as shown in Figure 2-27.

Figure 2-27 Implementation Schedule

Construction 1 (Ruseifa)



Construction 2 (Awajan)



2.3 Obligations of Recipient Country

The necessary measures and obligations of the Jordanian side for the project are listed as follows:

(1) Expansion of service area

(2) Rehabilitation of service pipes and water meters

(3) Delimitation of the distribution zones

(4) Other obligations auxiliary to the work by Japanese side

a. Procurement and preparation of land including leveling and construction of retaining wall where necessary for distribution reservoirs
b. Provision of electric power and water supply during construction and for operation of 4 distribution reservoirs and 3 junctions of transmission line
c. Securing debris disposal sites (Ruseifa: in 3 km; Awajan: in 5 km)
d. Landscaping (pavement, drainage, lighting, fence and gate) of reservoir sites
e. Construction of drain pipes from reservoirs to the existing drain/sewers
f. Construction of operator's rooms in sites
g. Emptying of existing pipe in connecting to Awajan High reservoir, cleaning before operation and removal of existing facilities (toilet, pluming and manhole)
h. Suspension of water transmission, emptying of water and cleaning of the existing transmission in works for connection and branching of transmission pipe
i. Furnishing of water required for pressure test, water filling test and other tests for transmission and distribution pipe and reservoir
j. Provision of chemicals for disinfection and test operation of pipelines and reservoirs
k. Cooperation in consultation and procedures for traffic control in works along highways and major roads
l. Provision of facilities necessary for unloading, customs and exemption of duties of materials at port in Jordan
m. Provision of facilities necessary for exemption of customs and domestic duties in Jordan for procurement of materials and equipments and dispatch of personnel of Japanese and Japanese juridical person, who are engaged in the project
n. Provision of facilities necessary for entry into and stay in Jordan of Japanese, who are engaged in the project
o. Proper use, operation and maintenance of the facilities and equipment constructed or procured under the Japanese Grant Aid program
p. Provision of fund to cover all the other costs necessary for implementation of the project, which is not included in the Japanese Grant Aid program

(5) Costs for Undertaking of the Jordanian side

Costs for the Jordanian undertaking will be as follows:

a.	Expansion of service area	2.00 million JD
b.	Rehabilitation of Service pipes and water meters	0.36
c.	Delimitation of the distribution zones	0.33
d.	Other obligations auxiliary to the work by Japanese side	(0.21)
i.	Preparation of land for reservoirs	0.02
ii.	Electric power for construction and operation	0.05
iii.	Fence, gates and landscaping of reservoir sites	0.03
iv.	Construction of drain pipes	0.09
v.	Emptying of water in junction works	0.03
Total		2.89 million JD

2.4 Operation and Maintenance Plan

2.4.1 Organization for Operation and Maintenance

Operation and maintenance of the present project will be made directly by the Zarqa Directorate office of WAJ. As shown in Figure 2-28, Zarqa office with approximately 660 personnel has 7 departments, i.e., Technical Affairs, Water Supply, Ruseifa Water Supply, Sanitary Sewerage, Subscribers, Unaccounted-for Water, Administration and Accounting. Water Network Division of Water Supply Department is in charge of distribution facilities except the pumping facilities. Watcher/operators of the reservoirs in the project area will be under this division. Operators of Hutteen, Ruseifa high and low reservoirs, which are located in Ruseifa municipality though, should also be under this division, since the entire transmission system under the project needs to be controlled by one unit. The Water Network Division shall primarily operate the transmission and distribution facilities under the present project. It is expected that Unaccounted-for Water Department will primarily take charge of the distribution control within the distribution sub-zones, which will be delimitated with the Jordanian fund. Coordination between the division and the department will be important. It is desired to establish a clear coordination and demarcation of roles through development of sustainable control of distribution networks by the software component program.

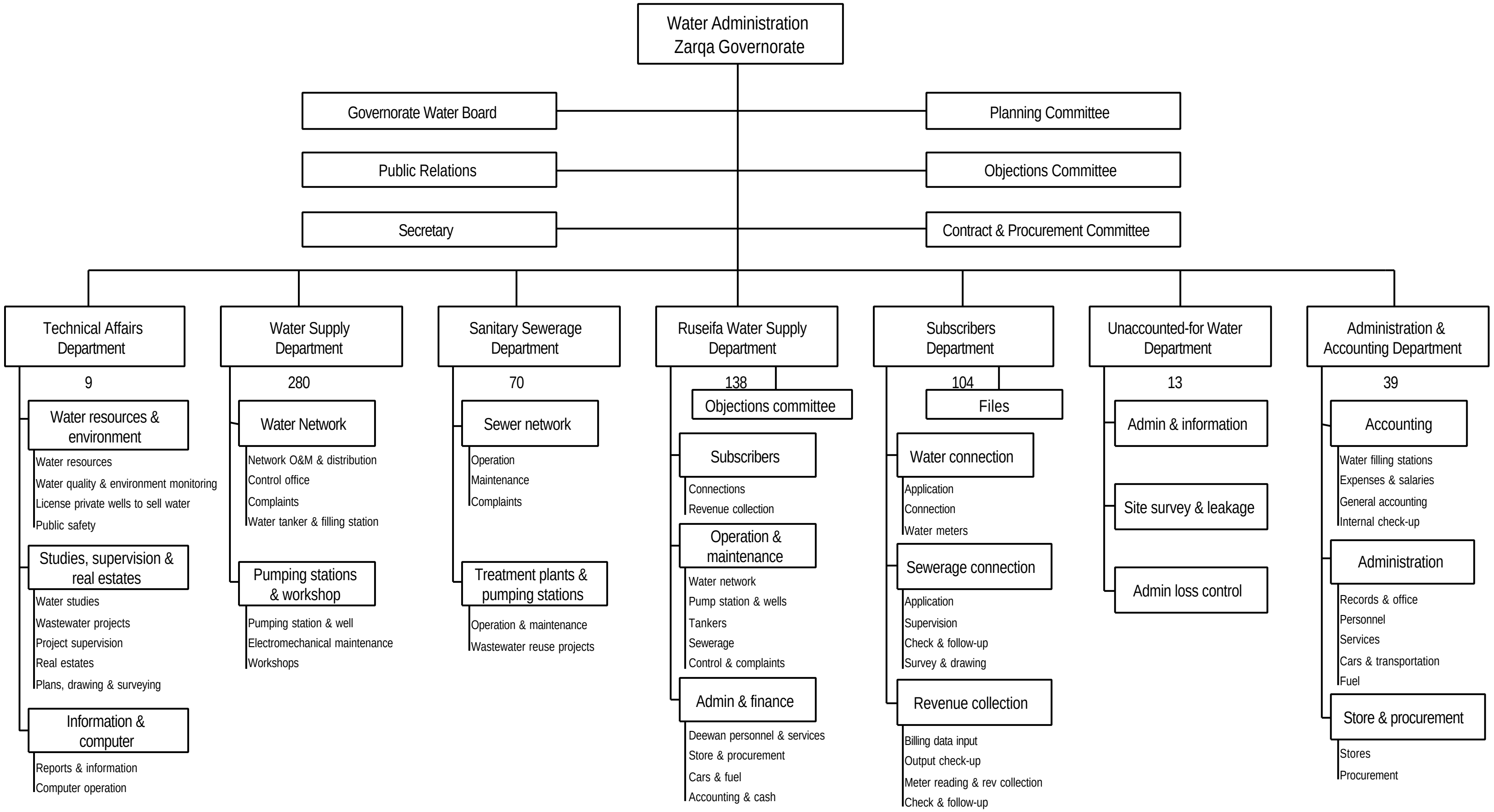


Figure 2-28 Organization Chart of Water Authority of Jordan, Zarqa Governorate

2.4.2 Operation of Transmission and Distribution Facilities

Allocation of water

The area of the project shall receive the treated surplus water of 43,300 cu m/d from the Amman transmission network in 2005. The volume of water is expected to increase to 52,400 cu m/d in 2010, as the demand grows. Since the Amman transmission system is operated by the Amman Directorate of WAJ, it will be necessary to establish a deed to allocate the water to WAJ, Zarqa, that operates water supply system in the project area. Secretary General, WAJ, and the detailed design study team agreed on the allocation of water on May 26, 2002.

Control of water volume to reservoirs

Volume of inflowing water to the reservoirs listed below shall be controlled by valve at the inlet pipe with reference to the flow meter at inlet and water level of reservoir. Once valve position is set to match the inflowing volume, further manipulation is not necessary, unless water level of reservoir abnormally rises or drops beyond the allowable range. The water level fluctuates sharply when flow or pressure varies by such accident as destruction of transmission or distribution pipeline or by sudden fluctuation of demands. It may cause significant secondary accidents. Water level of reservoirs should be monitored continuously.

- Hutteen reservoir and elevated reservoir
- Ruseifa high reservoir
- Ruseifa low reservoir
- Awajan high reservoir (existing and new)
- Awajan low reservoir

Pressure valves are installed at necessary locations of transmission pipelines to control flows to reservoirs at different altitudes. Valves are installed at Hutteen and Awajan junctions to close the flow in the case of repair or accident. However, they shall not be operated to control flow.

Placement of watcher/operator

A team of 4 watcher/operators is placed for monitoring and operation of each of the existing Zarqa pump station, Awjan high reservoir and others. A watcher/operator among four is always at the position with 24-hour shift. Teams of watcher/operators are already placed at Hutteen and Awajan high reservoirs. Additional personnel needed for the present project shall be 12 watcher/operators to organize 3 teams for Ruseifa high and low, and Awajan low reservoirs.

2.4.3 Costs of Operation and Maintenance

Major costs of operation and maintenance, that will incur in WAJ, Zarqa office, can be calculated as follows:

- Increase of salary and personnel costs consist of 12 technicians for watcher/operators of reservoirs.

  @ 250 JD/month x 1.1 (10% social charge) x 12 persons x 12 months = 39,600 JD

  Annual increase will be 39,600 JD. It will increase the total personnel costs by 2.3 percent.

- Electric power consumption of pumps used for water supply to the project area will be reduced. It is assumed that 95 percent of the total power cost is for pumps, and 45 percent of supplied volume is distributed to Awajan and Ruseifa areas, both of which are located at higher altitudes.

  4,038,167 JD (Total power cost at WAJ, Zarqa in 2000) x 0.95 x 0.45 = 1,726,316 JD

  Annual power cost will be reduced by some 1.7 million JD. It accounts for 42 percent of total power cost.

Overall change in costs is a reduction of 1.69 million JD. It accounts for 28 percent of all the operation and maintenance costs incurred at WAJ, Zarqa in 2000. Operation and maintenance costs, therefore, will not increase, but decrease by more than 20 percent.

2.5 Software Component Program

2.5.1 Need for Software Component Program

(1) Current situation and problems of operation and maintenance

Problems of the distribution network operation in Zarqa area (causes, central problem, effects) are shown in the problem series (Figure 2-29). They may be listed as follows:

- Conditions of networks are not grasped.
- Hydraulic characteristics are not grasped.
- Technique to control distribution network is weak.
- It is difficult to control distribution network due to undulating topography.

These problems cause a central problem, that is, operation of distribution network is not effective. This in turn causes many effects: effective rehabilitation cannot be planned, suitable distribution sub-zones cannot be delimitated, and effective distribution control cannot be made. These again result in high unaccounted-for water rates and unfair water rationing.

(2) Role of software component in the present project

Transmission facilities or infrastructures for distribution control will be constructed in this project. Maximum benefits of the project, however, will not be brought about, unless the Jordanian undertakings including delimitation of sub-zones, daily operation of distribution control, periodical replacement of superannuated pipes, operation and maintenance of distribution networks, etc. are not properly made. In view of the present situation, it will be difficult for the Jordanian capacity alone to undertake these projects. This software component program is, therefore, intended to assist the Jordanian implementing agency in the Jordanian undertaking by improving sustainable operation capacity of the distribution networks.

(3) Goal of the software component program

The goal series (Figure 2-30) show linkages of goals to improve capacity to operate and maintain the distribution networks. To reach the goal, approaches are identified as shown in Figure 2-31. Three approaches thus identified are listed below:

- Network mapping approach
- Network analysis approach
- Capacity improvement approach to control distribution

These three components will comprise a project for transfer of integrated management technology for distribution network, and will be undertaken in the present software component program. The program is intended to upgrade capacity of operation and maintenance and thereby bring about the benefits of the grant aid project (reduction of unaccounted-for water and fair distribution of water) to their full extents.

2.5.2 Work Program

(1) Objectives

This software component program is targeted to establish capacity to effectively operate and maintain distribution networks and control the water distribution by transferring integrated technologies of network mapping, network analysis and the water distribution control. Once the capacity is established, fair water distribution (water distribution control) and effective and continuous reduction of leakage will be brought about.

(2) Outputs

Outputs can be grouped into three. Once these three outputs are attained, integrated capacity to manage the distribution networks will be brought about.

1) Conditions of networks can be easily grasped.
   a. Network information is mapped.
   b. Network mapping technique is transferred.

2) Hydraulic characteristics of network can be easily grasped.
   a. Network analysis models are formulated.
   b. Network analysis technique is transferred.

3) Technology of distribution control will be improved.
   a. Updating of network mapping is made when new network is installed.
   b. Distribution sub-zones are hydrologically analyzed and planned.
   c. Technology of distribution control is transferred.

It is noted that the project area has undulating topography where distribution control is extremely difficult. The distribution control suited for such topography will be important.

2.5.3 Activities

(1) Mapping of distribution networks

a. Preparation, introduction seminar, collection of drawings
   - Set up the office, C/P meeting, site visit, preparation
   - Technology introduction seminar

b. Network mapping
   i. Preparation of base map by geographic information system
      - Set up the software of GIS and network analysis
      - Collection of water supply drawings
      - Collection of data map (contours, roads, city block)
      - Adjustment of map data (put into GIS database)

   ii. Input of (present) network information
      - Formulate the input system of network data
      - Training on network data input
      - Input of network map (transmission and distribution mains, water supply pipes, valves)
      - Input of attribution data of network (kind of pipes, diameter, age, elevation, valve, distribution reservoir, pump)
      - Input of distribution zone
      - Site survey 1 (water pressure, water rationing)
      - Site survey 2 (facilities check, valve check, test drilling)
      - Prepare the map record of distribution mains repairs (if data is available)
      - Analysis and input of attribution data on network attributes (coefficient of pipe roughness)
      - Final adjustment
      - Collection and visualization of network attributies

c. Transfer of network mapping technology (including operation)
   - Introducing seminar on network mapping (outlines of GIS and mapping software)
   - Seminar on network mapping (explanation of input data, method)
   - Preparation of seminar (collection of result, visualization)
   - Seminar and workshop of final network mapping technology

(2) Transfer of network analysis technology

a. Formulation and simulation of network analysis model
   - Population estimation in divided areas
   - Demand estimation in divided areas (present and future)
   - Survey of coefficient of demand variation (including literature search)
   - Confirmation of pump and valve operation (water supply rationing)
   - Identification and formulation of network models (measurement of pressure and flow)
   - Simulation of present network (pressure, flow, direction)
   - Formulation of new distribution zone models
   - Network analysis of new distribution zone (pressure, flow, direction)

b. Transfer of network analysis technology

   i. Technology transfer through on-the-job training

   ii. Workshop for technology transfer on network analysis
   - Variation of demand
   - Network hydraulics
   - Method of network analysis simulation
   - Advanced tool of network analysis software
   - Presentation of analysis result

(3) Technology transfer on water distribution control

a. Updating of network information as is expanded

b. Design, analysis and adjustment of distribution sub-zones
   - Simulation of water distribution and zone adjustment
   - Design sub-zones
   - Simulated distribution control in sub-zones
   - Adjustment of sub-zones (measurement of pressure and flow)
   - Practical training of distribution control (measurement of pressure and flow)
   - Formulation of distribution planning (using network analysis software)

c. Workshop for integrated technology transfer
   - Distribution control (case study: Japan)
   - Distribution control (case study: Zarqa)
   - Planning of distribution operation (case study: Zarqa)

d. Reporting
   - Preparation of manual of network mapping system
   - Preparation of manual of distribution control
   - Preparation of completion report

2.5.4 Inputs

(1) Schedule and inputs

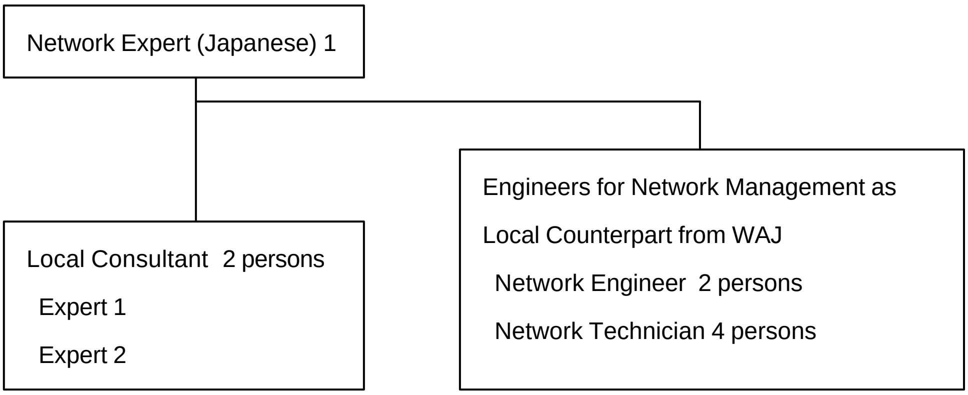
Schedule of the project is divided into three terms, each of which corresponds to one of three outputs described above. Outputs and schedules of terms are shown below:

1	Mapping of distribution networks and technology transfer	3 months
2	Transfer of network analysis technology	2 months
3	Technology transfer on water distribution control	2 months

Schedule of each activity is shown in Figure 2-32 and the input in Figure 2-33. Figure 3-34 shows detailed activities.

(2) Project organization

To implement the activities described above, the following organization, led by a Japanese expert for distribution network management, shall be established:



For the project office, the implementing agency shall provide one room in the headquarters of WAJ.

(3) Equipment and computer programs

a. Computer 1, color printer 1 and accessories (to be provided by the implementing agency)
b. Pressure gauge, flow meter and other measurement equipment (to be provided by the implementing agency)
c. Computer programs for network mapping and geographical information system (to be provided by the Japan side)
d. Computer program for network analysis (to be provided by the Japan side)

2.5.5 Dispatch of Expert

A Japanese expert will be assigned among from those who have designed distribution zoning through network mapping and analysis utilizing geological information system.

Project:	Basic Design Study on the Project for Improvement of the Water Supply System for the Zarqa District	Period:	
Target area: Zarqa District, Jordan	Target group: Engineers and technicians in WAJ	Date: March, 2002	

Narrative summary	Objectively verifiable indicators	Means of verification	Important assumptions
Overall goal 1. Reduced UFW rate 2. Fair water distribution	1. Improve the water leakage rate 2-1 No area of poor water supply condition 2-2 The water distribution pressure at 25m to 60m	1-1 Data of accounted-for water rates from WAJ, Zarqa 1-2 Data of leakage repairs from WAJ,Zarqa 2-1 Data of water supply from WAJ, Zarqa 2-2 Data of water pressure from WAJ, Zarqa	? The Jordan side will implement the network rehabilitation plan continuously ? The Jordan side will implement water distribution plan continuously ? The grant aid facility (Japan and Jordan share the cost) is completed
Project purpose Establish capacity to effectively operate and maintain distribution networks	Four network control engineers are trained.	? Final report by Japanese expert ? Annual report of WAJ	? Engineers with transferred technology will keep working ? Network mapping data will be updated continuously
Outputs 1. Conditions of networks can be easily grasped 2. Hydraulic characteristics of network can be easily grasped 3. Technology of distribution control will be improved	1 Input of 100 % of network information 2 Can utilize more then 80 % of network analysis software 3 The number of appropriate distribution sub-zones are increased	1 Investigate minutely network mapping data 2 Japanese expert will judge 3 Japanese expert's completion report and GIS map	? Data of present distribution network can be collected to the greater extent
Activities 1-1 Collection of distribution network information 1-2 Distribution network mapping 1-3 Input of network information 1-4 Transfer of network mapping technology 2-1 Prepare the model of network analysis 2-2 Transfer of network analysis technology 3-1 Update the new distribution network information 3-2 Design, analysis and adjustment of distribution sub-zones 3-3 Workshop for integrated technology transfer	Inputs Japan Human resources Expert for distribution network management: 7M/M Local consultants: 2 (persons) x2.5 5M/M Machinery Software for network mapping and analysis ArcMap and InfoWorks	Jordan Human resources Staff of WAJ Engineer for network management 2 persons Assistant 4 persons Facility One room in WAJ Machinery 1 Conputer for mapping Color printer and equipment Water pressure and flow measuring equipment	? Jordan side allocate enough time to this component ? Appropriate human resource is chosen as Japanese expert Pre-conditions ? WAJ has willingness to promote this component ? Network mapping team is organized ? Grant aid facility is implemented

Figure 2-29 Problem Analysis

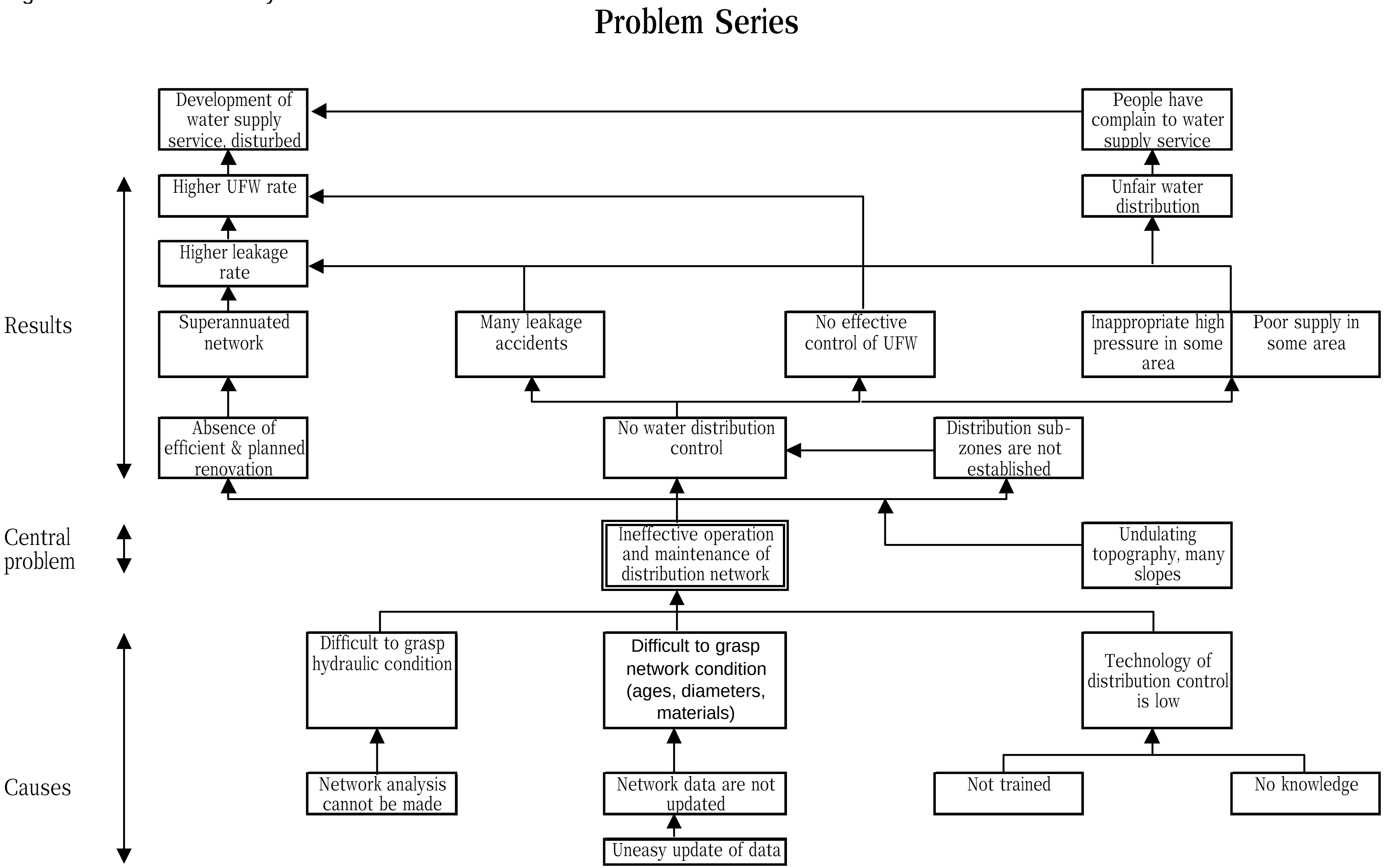


Figure 2-30 Goal analysis

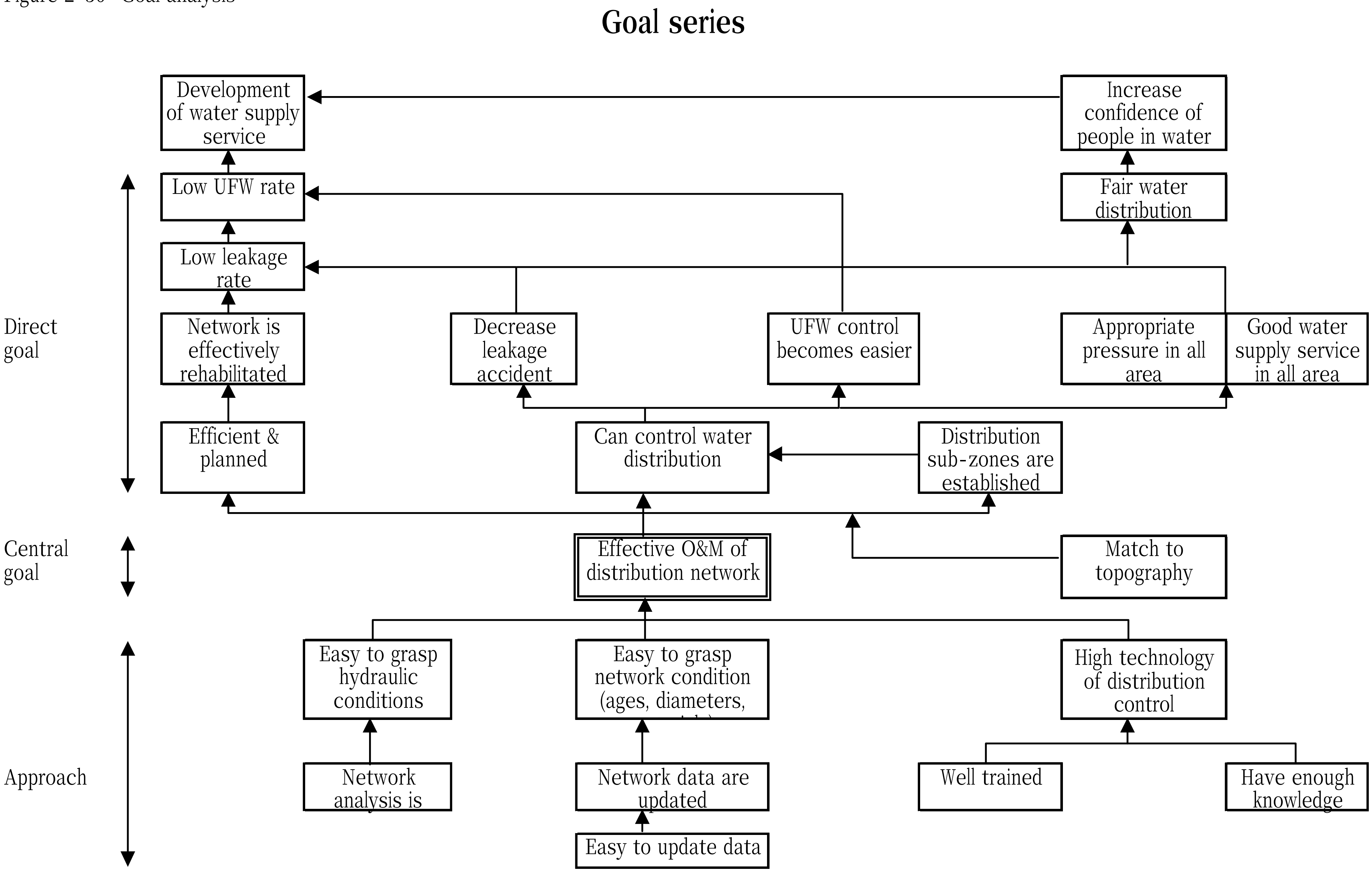


Figure 2-31 Confirmation of aproaches

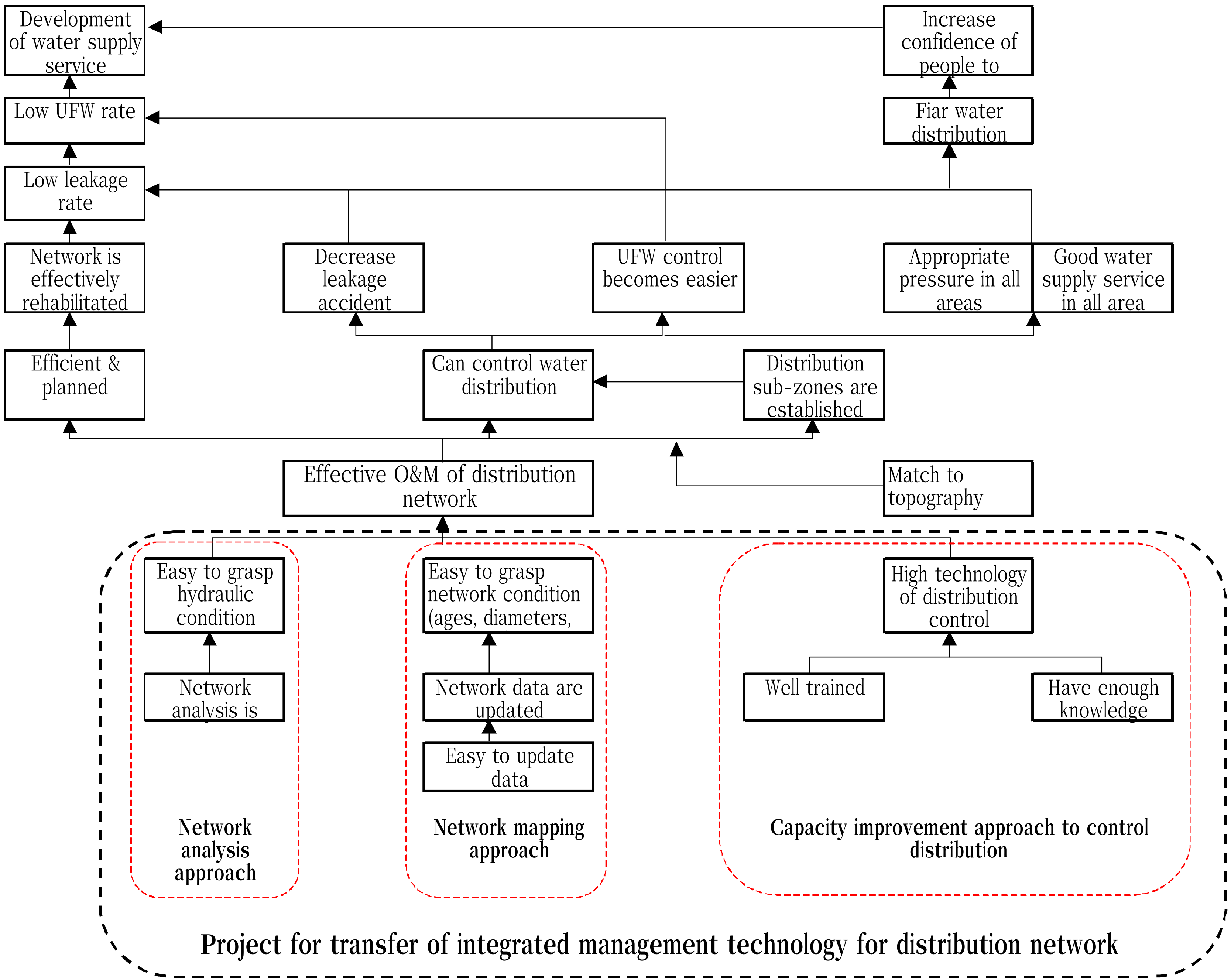


Figure 2-32 Implementation Schedule

Period	Main Activities	Period / Month	First period of supervision 1	2	3		Latter period of supervision 4	5		After completion 6	7
Phase I	(1) Mapping of distribution networks	①Preparation, introduction seminar, collection of drawings									
		②Network mapping									
		a) Preparation of base map by geographic information system									
		b) Input of network information									
		③Transfer of network analysis technology									
Phase II	(2) Transfer of network analysis technology	①Formulation and simulation of network analysis model									
		②Transfer of network analysis technology									
Phase III	(3) Technology transfer on water distribution control	①Updating of network information as is expanded									
		②Design, analysis and adjustment of distribution sub-zones									
		③Workshop for integrated technology transfer									
		④Preparation of completion report and manuals									

Figure 2-33 Input

Period / Month	Beginning of supervision 1	2	3		Latter of supervision 1	2		After completion 1	2
Japanese expert (Class 4)									
Network engineer (WAJ) 2 persons									
Assistant network engineer 1 (WAJ) 2 persons									
Assistant network engineer 2 (WAJ) 2 persons									
Local consultant (No1)—Civil engineer with 5 years experience GIS mapping, network mapping, collection of drawings, population survey									
Local consultant (No2)—Surveyor GIS mapping, network mapping, collection of drawings, topography, population survey									

Figure 2-34 Detail Activities (1/3)

Activities	Activities (Period / Month / Date)	First Dispatch (Month 1: Date 1–30; Month 2: Date 31–60; Month 3: Date 61–90)	C/P	Necessary facilities Text／Report
(1) Mapping of distribution networks	Travelling			
	①Preparation, introduction seminar, collection of drawings			
	①-1 Set up the office, C/P meeting, site visit, preparation		1	
	①-2 Technology introduction seminar		1,2	Technology transfer plan
	②Network mapping			
	a) Preparation of base map by geographic information system			
	②-1 Set up the software of GIS and network analysis			ArcView, InfoWorks
	②-2 Collection of water supply drawings		1,2	
	②-3 Collection of data map (contours, roads, city block)		1,2	
	②-4 Adjustment of map data (put into GIS database)			ArcView, InfoWorks
	b) Input of (present) network infomation			
	②-5 Formulate the input system of network data		1,2	
	②-6 Training on network data input		1,2	ArcView, InfoWorks、IW training manual
	②-7 Input of network map (transmission and distribution mains, water supply pipes, valves)		2	ArcView, InfoWorks
	②-8 Input of attribution data of network (kind of pipes, diameter, age, elevation, valve, distribution reservoir, pump)		2	ArcView, InfoWorks
	②-9 Input of distribution zone			ArcView, InfoWorks
	②-10 Site survey 1 (water pressure, water rationing)		2	Pressure gauge、ArcView
	②-11 Site survey 2 (facilities check, valve check, test drilling)		2	Tools、ArcView
	②-12 Prepare the map record of distribution mains repairs (if data is available)		1,2	ArcView
	②-13 Analysis and input of attribution data on network attributes (coefficient of pipe roughness)			ArcView, InfoWorks
	②-14 Final adjustment			ArcView, InfoWorks
	②-15 Collection and visualization of network attibuties		1	ArcView, InfoWorks
	③ Transfer of network mapping technology (including preparation)			
	③-1 Introducing seminar on network mapping (outlines of GIS and mapping software)	△	1,2	Outlines of software
	③-2 Seminar on network mapping (explanation of input data, method)	△	1,2	IW training manual
	③-3 Preparation of seminar (collection of result, visualization)		1,2	ArcView, InfoWorks
	③-4 Seminar and workshop of final network mapping technology	△△△	1,2	Report on network mapping
	Preparation of departure			
	Departure			

Note 1：Power Point software will be used on seminar
Note 2：C/P 1 is chief engineer, C/P 2 is assistant engineer

Figure 2-34 Detail Activities (2/3)

Period: Second Dispatch — Month: 4 (Date 91–120), 5 (Date 121–150)

Main activities	Activities	C/P	Necessary facilities Text/Report
(2) Transfer of network analysis technology			
	Travelling		
	① Formulation and simulation of network analysis model		
	①-1 Population estimation in divided areas	1	
	①-2 Demand estimation divided areas (present and future)	1	
	①-3 Survey of coefficient of demand variation (including literature search)	1,2	Various literature、record of meter flow
	①-4 Confirmation of pump and valve operation (water supply rationing)	2	
	①-5 Identification and formulation of network models (measurement of pressure and flow)	2	ArcView, InfoWorks flow, pressure
	①-6 Simulation of present network (pressure, flow, direction)	1	ArcView, InfoWorks
	①-7 Formulation of new distribution zone models		ArcView, InfoWorks
	①-8 Network analysis of new distribution zone (pressure, flow, direction)	1	ArcView, InfoWorks
	② Transfer of network analysis technology		
	②-1 Technology transfer through on-the-job training	1,2	
	②-2 Workshop for technology transfer on network analysis		
	a) Variation of demand	1,2	
	b) Network hydraulics	1,2	Referenc books of
	c) Method of network analysis simulation	1,2	IW training manual
	d) Advanced tool of network analysis software	1,2	IW training manual
	e) Presentation of analysis result	1,2	ArcView, InfoWorks
	Preparation of departure		
	Departure		

Figure 2-34 Detail Activities (3/3)

Activities	Activities	Third Dispatch (Month 4: Dates 151–180; Month 5: Dates 181–210)	C/P	Necessary facilities Text／Report
(3) Technology transfer on water distribution control	Travelling			
	① Updating of network information as is extended		1,2	
	② Design, analysis and adjustment of distribution sub-zones			
	②-1 Simulation of water distribution and zone adjustment		1	ArcView, InfoWorks
	②-2 Design sub-zones		1	ArcView, InfoWorks
	②-3 Simulated distribution control in sub-zones		1	ArcView, InfoWorks
	②-4 Adjustment of sub-zones (measurement of pressure and flow)		2	ArcView, InfoWorks Measurment machine
	②-5 Practical training of distribution control (measurement of pressure and flow)		1,2	ArcView, InfoWorks Measurment machine
	②-6 Formulation of distribution planning (using network analysis software)		1	ArcView, InfoWorks
	③ Workshop for integrated technology transfer			
	③-1 Distribution control (Case study: Japan)	△	1,2	Japanese literature
	③-2 Distribution control (Case study: Zarqa)	△	1,2	Preparation
	③-3 Planning of distribution operation (Case study: Zarqa)	△	1,2	Preparation
	④ Reporting			
	④-1 Preparation of manual of network mapping system		1,2	Manual preparation
	④-2 Preparation of manual of distribution control		1,2	Manual preparation
	④-3 Preparation of completion report			Report preparation
	Preparation of departure			
	Departure			

Chapter 3 Project Evaluation and Recommendations

Chapter 3 Project Evaluation and Recommendations

3.1 Effects of the Project

By implementing the project, the following direct and indirect effects are expected:

(1) Direct Effects

a. The served population in Russeifa and Awajan area will be increased to 410,000 persons at the target year 2005 from 340,000 persons at present.

b. At present, hours of supply are 10 hours to 36 hours per week, and inequitably distributed to different areas. More than 96 hours supply per week is expected in all the areas, and discontinuation of supply will be largely decreased.

c. By maintaining the appropriate distribution pressure, residents in the higher zones will enjoy longer supply hours, improvement of unaccounted-for water, reduction of leakage and breakage of distribution pipes and reduction of repair costs are also expected.

d. Volume of supply will increase from 70 liters to 90 litters per person per day. Sanitation situation in the project area is expected to improve.

e. By adopting the gravity flow system for the place of the present pumping transmission systems, electric power costs and hence total operation costs will be largely reduced.

(2) Indirect Effects

a. By improved sanitation situation through upgraded water supply services, cases of waterborne diseases such as typhoid, para typhoid, hepatitis A, will be reduced.

b. Need to buy expensive water from private water vender will become less and infrequent. Stable life of citizens is ensured.

c. Citizens in the project area, particularly those in Ruseifa area including refugees and displaced people will be benefited. Improved water supply services to those vulnerable will contribute to the social and political stability.

3.2 Recommendations

For the efficient implementation of this project, the Jordanian side is required to install the well-balanced distribution facility and establish the suitable system of operation and maintenance. This project will be more smoothly and effectively implemented, provided that the followings are ensured:

Completion of the preceding projects

Water should be allocated by completion of "Dier Alla-Zai-Amman Water Project Stage II" under the German loan through KfW and "Zara and Ma'in Brackish Water Desalination Project" with the US assistance through USAID by 2005. WAJ is required to pay best efforts to avoid delay of these two projects.

Development and expansion of distribution network

The distribution network should be developed and expanded suitably following the development of major facilities of transmission pipeline, distribution reservoirs and mains.

Appropriate operation

Delineation of distribution zones, distribution control and periodical replacement of superannuated pipes should be implemented in the expanded distribution network.