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

APRIL 2006

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

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 (Phase II) in the Hashemite Kingdom of Jordan and entrusted the study to the Japan International Cooperation Agency (JICA)

JICA sent to Jordan a study team from 18th November to 24th December, 2005.

The team held discussions 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 relation between our two countries.

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

April, 2006

Seiji Kojima
Vice-President
Japan International Cooperation Agency

April, 2006

Letter of Transmittal

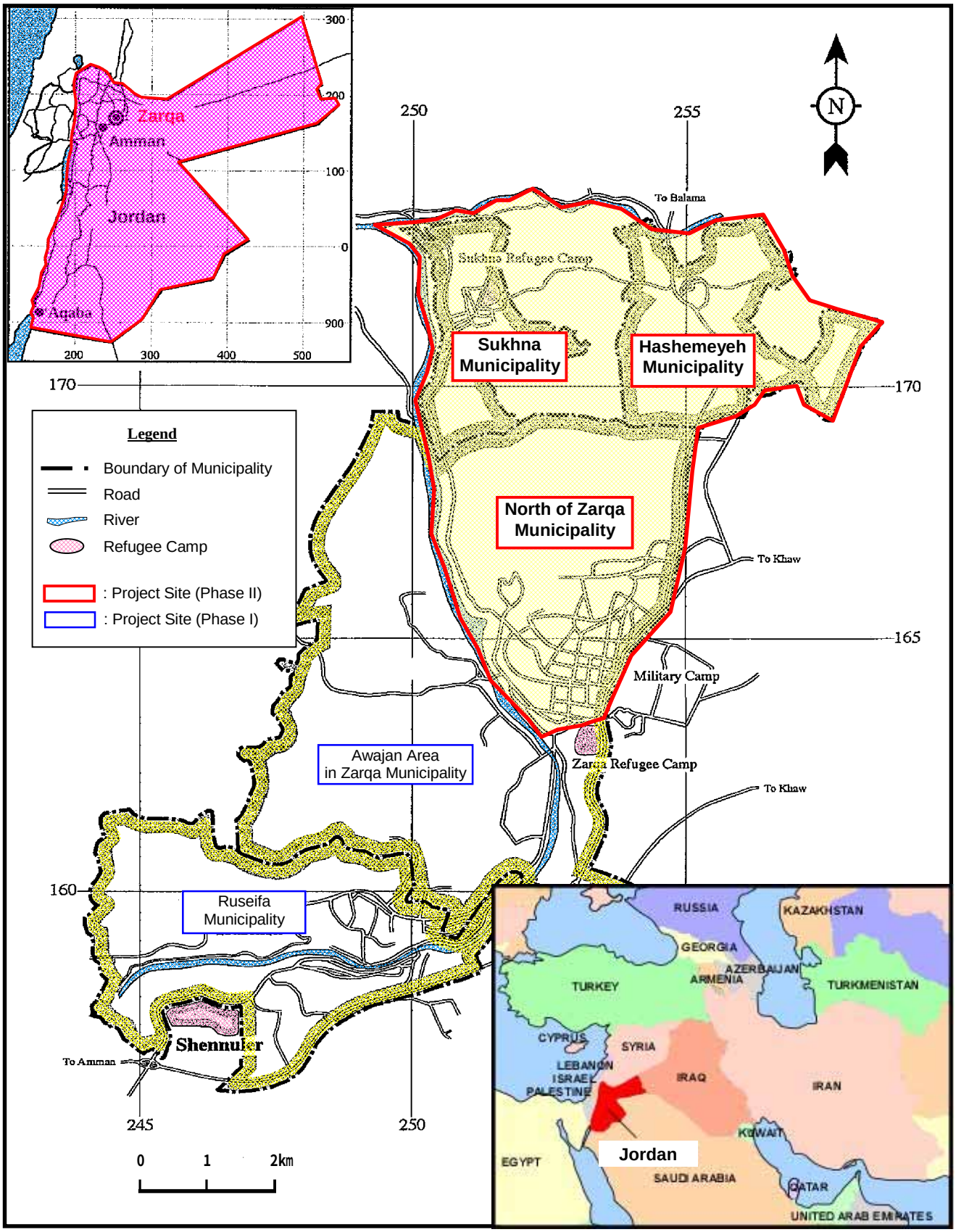
We are pleased to submit to you a Basic Design Study on the Project for Improvement of the Water Supply System for the Zarqa District (Phase II) in the Hashemite Kingdom of Jordan.

This study was conducted by Tokyo Engineering Consultants CO., LTD., under a contract to JICA, during the period from October 2005 to April 2006. 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.

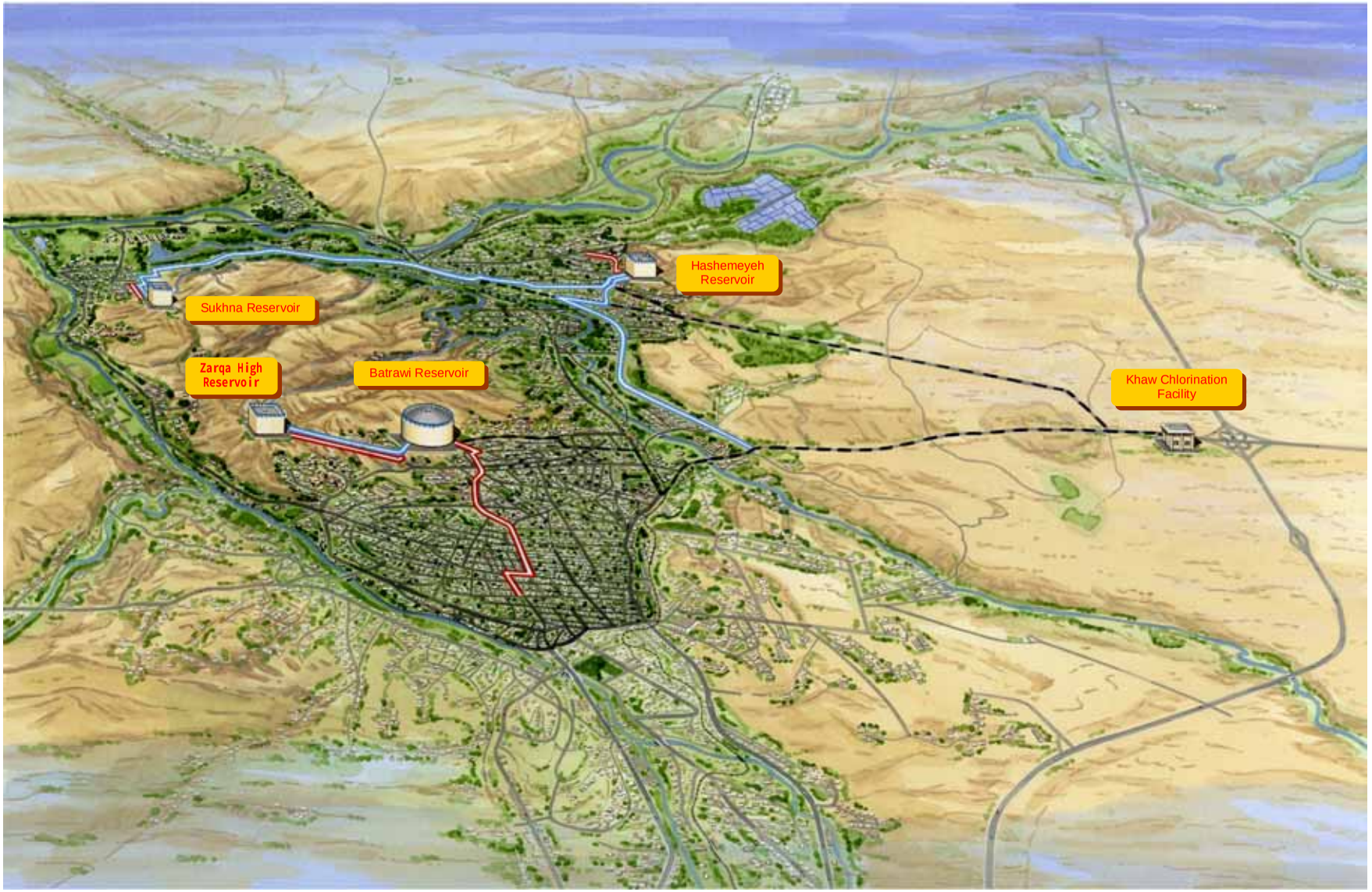
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Hirotaka SATO
Chief Consultant,
Basic Design Study on the Project for Improvement of the Water Supply System for the Zarqa District (Phase II) in the Hashemite Kingdom of Jordan
Tokyo Engineering Consultants Co., Ltd.



Project Site



The Completion Image of Water Supply Facilities

SUMMARY

Summary

On the per capita basis Jordan has one of the lowest levels of water resources potential (160m^3/year) in the world. To ensure the water resources for requirements of domestic use for rapidly increasing urban population and for agricultural use continuously is of vital importance. To tackle this problem Jordan established a long-term water policy in 1977, the National Water Strategy, which outlines the national basic policy concerning the development and management of water resources. The underlying policy stated in the National Water Strategy is to effectively optimize the utilization of limited water resources by managing/conserving water resources, enhancing the problem recognition of the public, and reforming the organizational system for water-related projects. Based on the Strategy, Jordan is currently enforcing a National Three-Year Socioeconomic Plan. The plan sets out the following objectives in the water and sewerage sector:

① Development and creation of new water resources
② Active exploitation of reclaimed wastewater for industrial and agricultural uses
③ Increase in desalinated water and its increased use for municipal water supply
④ Reduction in the rate of non-revenue water
⑤ Increase in the water supply volume for domestic use
⑥ Control of excessive groundwater pumping and protection from underground contamination

To achieve the above objectives and goals, the Government of Jordan has implemented a large number of water related projects. In addition, it also has received aid from donors and international organizations. Nevertheless to mention, Japan has continued to support Jordanian water sector through successive grant aid schemes, dispatch of experts and technical cooperation.

In this Study, the project site includes the northern part of Zarqa municipality, Hashemeyeh and Sukhna municipalities in the Zarqa Governorate and is located in the north-east of the Capital Amman. The population of the project area is estimated as 336,000 in 2004 and the population and water service connections are increasing rapidly at the rate of about 3 % and 4 %, respectively due to rapid population growth and influx of refugees from outside the country. Recently there has been influx of Iraqi refugees to the project area due to the war in Iraq. The Zarqa Governorate has the lowest per capita income in Jordan. The climate is a desert climate and therefore the difference in temperature between winter and summer and also daytime and night is very large. The average temperatures in summer and winter are about 32 ℃ and 16℃, respectively.

In the Zarqa District including Zarqa, Ruseifa, Hashemeyeh and Sukhna municipalities, actual water availability is extremely small due to the shortage of water sources and high ratio of non-revenue water of more than 50 % compelling water authority to supply water following district-wise rationing. According to the official request letter by the Government of Jordan, actual water availability per

capita is as low as 80 L/day although the water demand per capita is 136 L/day. It is estimated that the gap between demand and available water was 41,000 m^3/day in 2005 and would reach 61,000 m^3/day in 2015 if projects are not implemented.

To improve the serious water supply conditions and to improve the living conditions of the residents, the Government of Jordan, therefore, requested a technical assistance from the Government of Japan concerning the improvement of the water supply system in the Zarqa District. In response to the request, JICA implemented the development study of Improvement of Water Supply System in Zarqa District (JICA Development Study) and prepared a master plan (M/P) and conducted a feasibility study (F/S) from 1994 to 1996. The main objective of the study was to formulate the plan to reduce water loss and to supply limited water resources equitably. In this plan, it is recommended that the distribution network be divided into eight zones to optimize distribution pressure and thus reduce leakage. The proposal includes the development of facilities required for creation of pressure zones, moving to gravity supply from pumping systems and replacement of superannuated pipes.

Based on the proposal of this Study, the Government of Jordan requested the Government of Japan for the grant aid to establish four distribution zones in Ruseifa and Awajan areas. In response to the request, the Government of Japan dispatched a basic design study team to Jordan through JICA in December 2001. As a result, this request was realized, implemented and successfully completed in March 2005 as the Project for Improvement of Water Supply System in Zarqa District (Phase I).

Thereafter, the Government of Jordan requested the Government of Japan for the grant aid to improve water supply facilities of the rest four distribution zones in the area of the northern part of Zarqa municipality, Hashemeyeh and Sukhna municipalities in September 2004. In response to the request, and in order for the Government of Japan to implement a basic design study for the project, the Japan International Cooperation Agency (JICA) dispatched a basic design study team from 18 November to 24 December 2005. The study team discussed the request contents with the concerned parties from the government of Jordan and the Water Authority of Jordan (WAJ), carried out a study of current conditions in the project area, and collected related information. After the site survey and analysis of collected data in Japan, the study team prepared the draft final report including optimum facility plans considering adequacy as the Japanese grant aid. Again JICA dispatched the study team between March 10th and 18th, 2006 to explain and discuss the contents of the Project. The Jordanian Side accepted the contents of the Project including the works to be done by the Jordanian Side in principle. This final report was prepared based on the above findings of survey, analysis of results and discussions.

This project aims at improving the water supply conditions as mentioned below, and ultimately causing the improvement of the living conditions of the residents, through reconstruction of the existing water supply system.

- Increase of actual water availability through reduction of leakage by distributing water at appropriate water supply pressure
- Equitable water use through optimum water distribution management
- Sanitary, and safe water supply by appropriate chlorination

To achieve the project goals, the main components of the project include establishment of four water supply zones, construction of service reservoirs and a chlorination facility and installation of transmission and distribution mains. The basic design plan for the improvement of the water supply system was formulated based on the following design policies.

- The target year of this project shall be set as 2010 in consideration of appropriate scale as a grant aid project. However, the target year for the conveyance facilities, which are buried underground and difficult to extend once installed, shall be set 2015 in consideration of difficulties in phased future extension.
- In order to reduce leakage by supplying water at an appropriate water pressure and to enable fair water distribution, the existing water supply system shall be divided into four distinct distribution zones, namely, Zarqa High, Zarqa Low, Hashemeyeh and Sukhna.
- To improve the current complicated operation and troublesome maintenance of pumping water supply system, a service reservoir shall be constructed at the highest place in each distribution zone and a distribution main from the reservoir to the existing water mains shall be installed so as to supply water by gravity instead of pumping. According to the change of the system, required transmission mains and pumps shall be installed to convey the source water to the reservoirs.
- Service reservoirs shall be sited in locations that are hydraulically convenient and the least susceptible to negative environmental and social impact. With regard to distribution and transmission pipe routes, public roads shall be used as far as possible for easy maintenance and in line with the WAJ policy. In the meantime, although the project site includes a military park, which may be advantageous in hydraulic terms, the pipes shall not be laid within the park as problems may arise in future for maintenance due to restricted access.
- The use of existing facilities shall be considered into the plan as far as possible. Accordingly, a part of the existing Batrawi pumping station and the existing transmission pipe shall be used.
- The water supply system shall be developed so as to ensure water supply service of at least 3 days per week in the entire project area in order to achieve equitable distribution of limited water resources and improve water supply hours.
- The Project shall be formulated based on the WAJ's water allocation plan for the project area, according to which average daily water amount of 56,100 m^3/day will be ensured for the project area by the year 2010.
- The quality of water to be supplied shall be of an approved quality satisfying the Jordanian drinking water standards. In particular, some well waters used for consumption have excessive TDS levels and these waters shall be used after mixing with good quality lower

TDS water.

- A chlorination facility shall be constructed at the Khaw reservoir to ensure required levels of residual chlorine in all parts of the network throughout the water service duration and to supply sanitary and safe water.
- To enhance the capacity of distribution system operation and management important for maximum use of the constructed facilities, technical assistance in the form of soft component program shall be implemented.

Based on these design policies, the basic design for the Japanese grant aid is formulated. The major differences between the contents of the initial request and items newly confirmed are as follows.

- Following investigation of efficient water conveyance to the planned reservoirs located in each distribution zone and onsite investigation of the pipe routes, the design length of the transmission pipe increased by approximately 1.8 km (from 14.3 to 16.1 km). Although the original request included the use of an existing pipe, the on-site investigation proved that the pipe is in use for the transmission of water from Hashemeyeh Wells to the Zarqa Reservoir, which will be continued in the future as well, meaning that it would not be available to transfer water to the Hashemeyeh Reservoir.
- With the aim of distributing water efficiently within each distribution zone, network analysis was conducted to determine the appropriate pipe diameters and lengths. Consequently, the required length of water distribution pipes decreased.
- With an eye on Batrawi Pumping Station, which was newly constructed in 2002, it was decided to best exploit the existing facilities of the pumping station. With this in mind, in planning the pumping station in Batrawi, the existing pump house shall be used and existing pumps and electric equipment shall be replaced by the new equipment of the required capacities.
- The water supplied to Zarqa municipality is currently disinfected by chlorine at Zarqa Pumping Station. But there is a risk of pollution to water supplied to Hashemeyeh and Sukhna Municipalities if no additional chlorination facilities are used. As the water is expected to be transmitted from Khaw Pumping Station directly to each service reservoir upon completion of this project, the existing chlorination facility at Zarqa Pumping Station cannot be used thereafter. Considering this, in order to avoid discrete multiple siting of chlorination facilities or establishing facilities handling potentially hazardous chemical near a built up area, it was decided to construct a chlorination facility at Khaw Pumping Station. This was not included in the initial request, but requested newly in this study and its adequacy for becoming an additional component of the Project was accepted.
- In order to separate the planned four distribution zones, existing sluice valves at the boundary area will be closed. If there is no sluice valve near the separating point, a new sluice valve will be installed and closed. This was requested in this study and its adequacy for becoming an additional component of the Project was accepted.

- Zarqa Reservoir will be receiving reverse-osmosis treated water from local wells as well as water from Hashemeyeh wells. This water needs to be pumped up to the Batrawi Reservoir from Zarqa pumping station. To this end, the existing conveyance facilities between Zarqa Pumping Station and Batrawi Reservoir are required to be converted into transmission pipes. This was requested in this study and its adequacy for becoming an additional component of the Project was accepted.

Based on these design policies and findings, the outline of the project components are shown in the following table.

Facility	Route/Contents	
Service reservoirs	(1) Zarqa High	RC structure (rectangular), 2,500 m^3, L25.8 m x W 25.8 x H5.3 m
	(2) Hashemeyeh	RC structure (rectangular), 1,500 m^3, L20.8 m x W20.8 m x H 5.3 m
	(3) Sukhna	RC structure (rectangular), 1,000 m^3, L15.8 m x W15.8 m x H 5.7 m
	(4) Batrawi (Expansion)	PC structure (circular), 14,000 m^3, D46.7 m x H17.4
Transmission Mains	(1) Batrawi PS - Zarqa High Reservoir	Ductile cast iron pipe, dia. 300mm x L 2,072m
	(2) Khaw Junction - Hashemeyeh Reservoir	Ductile cast iron pipe, dia. 300mm x L 6,141m
	(3) Hashemeyeh Reservoir - Sukhna Reservoir	Ductile cast iron pipe, dia. 300mm x L 7,798m
Distribution Mains (Connection pipes)	(1) Zarqa High Reservoir to the existing distribution mains	Ductile cast iron pipe, dia. 300 mm x L 1,572 m
	(2) Hashemeyeh Reservoir to the existing distribution mains	Ductile cast iron pipe, dia. 300 mm x L1,338 m
	(3) Sukhna Reservoir to the existing distribution mains	Ductile cast iron pipe, dia. 200 mm x L 722 m
	(4) Batrawi Reservoir to the existing distribution mains	Ductile cast iron pipe, dia. 600 mm x L 3,080 m and dia. 400 mm x L 480 m
Batrawi Pumping Station	(1) Renewing of pumping equipment in the existing Batrawi PS (2) Multi stage centrifugal pump (3) Capacity: 5 m^3/min x 90 m head x 132 kW x 2 units (4) Diameter: suction 150mm x discharge 125mm	
Khaw Chlorination Facility	(1) Dosing equipment: 16 kg/h x 2 units (2) Chlorine leak detector 1 set and safety equipment 1set (3) Concrete building: L12m x W 10 m x H6.3 m	
Sluice Valves	(1) Dia. 300mm x 1 no. for separation of transmission (2) Dia. 150 mm x 3 nos. for distribution zoning (3) Dia. 100 mm x 2 nos. for distribution zoning (Japan side will conduct Construction work and Jordan side will conduct procurement of construction material including pipe.)	

The soft component program is targeted to enhance the capacity of the WAJ Zarqa office to effectively operate and maintain water distribution system 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.

The total project cost required is estimated as 2,310 million Japanese Yen including the Japan's Grant Aid portion (2,199 million Japanese Yen) and the Jordanian portion (111 million Japanese yen). The project will be implemented in 3 construction terms consisting of about 7 months for detailed design, tendering & contract and about 39 months for construction work.

After examination of the Project from the aspects of urgency, benefit, competency of maintenance, financial and environmental aspects as mentioned below, the Project is considered reasonable for implementation by the Japanese grant aid.

- The water supply service in the project area, which is located in the lowest income Governorate, will be improved and thus the living conditions of a population of about 374,000 in 2010 will be improved.
- Area-wise water rationing is practiced and water is supplied only 12 to 72 hours per week due to insufficient water amount, insufficient capacity of water supply facilities and inappropriate arrangement of facilities. The actual water availability per capita is as low as 84 L/day which is too low to live in the urban area and therefore, the residents are subjected to an inconvenient life. After the project implementation, the increased water allocation by the Jordanian Side and the reduced leakage from 31 % in 2004 to 25 % in 2010 will increase actual water availability to 113 L/day. In addition, water will be supplied for at least three days in the entire project area and chlorinated water will be supplied to maintain sanitary safety of the water.
- Waiting time for water supply will be reduced and purchase of expensive water from private tankers will be eased. Inconvenient living conditions due to the low level of water supply service will be improved. The improvement of the water supply service will contribute to improved living conditions of the Palestine and Iraqi refugees in the project area. This will further contribute to the stabilization of people's livelihood in the area.
- In the basic design, the facility plan considers changing pumping distribution to gravity distribution so as to ease operation and maintenance and to maintain the sustainability of the facilities by reducing pumping costs. This will reduce the work load and costs for operation and maintenance of the WAJ Zarqa office. The Zarqa office has 615 technical and administrative staff and enough experience in operating and maintaining water supply facilities. It can appropriately operate and maintain the completed facilities without problem.
- Currently the balance between operating expenditure and receipt of the WAJ Zarqa office is in the red. After the project implementation in 2010, it is estimated that it will be in the black

due to reduced leakage, increased water supply amount and efficient operation of pumps. The Project will contribute to improvement of financial conditions of the WAJ Zarqa office.

- In a national long-term policy, the National Water Strategy, the Government of Jordan establishes the policy of effectively optimizing the utilization of limited water resources. Under this policy, a comprehensive plan for improvement of water supply system for the Zarqa Governorate is now being prepared to increase the availability of per capita water amount for domestic use to 130 liters, approaching the national goal (150 liter) by the target year of 2025, through efforts such as reduction in the leakage ratio. Therefore, the Project conforms to the national policy.
- The WAJ successfully implemented the first phase of this Project, whose components are similar to this Project, by implementing the works to be done by the Jordanian Side. Therefore, the Project can be implemented by the WAJ without problem. Concerning the water allocation to the project area, the water allocation plan by the Jordanian Side is formulated by considering only water resources development projects that are currently ongoing and are expected to be completed soon. Therefore, it is judged that the water allocation to the project area can be assured.
- The study team does not foresee any serious environmental impact by the implementation of the Project.

The aspects requiring further improvement and related recommendations for the successful implementation of the Project and the sustainable operation and maintenance after the completion of the Project are described as follows.

- For the smooth implementation of the Project and the achievement of the targets, the WAJ should commit to secure expenses pertaining to the procurement of sluice valves and other required materials to separate water supply zones, land acquisition, leveling and other preparation of the reservoir sites, construction of access roads, installation of reservoir overflow pipes and preparation of a training room and procurement of required equipment for soft component programs, and should implement these components on time.
- The balance between non-operating expenditure and receipt will still be in the red in 2010. Toward achieving a financially sound WAJ Zarqa office by covering non-operating expenditure, the largest of which is depreciation, the followings are proposed for stepwise implementation:
    - Reduction of non-revenue water ratio
    - Improvement of willingness to pay of the customers for water supply by improved water services
    - Increase in water tariff
- The WAJ should certainly implement the water allocation plan for the project area to secure the required amount of water by reducing water transmission amount from Khaw pumping station to Amman and increasing water amount to the project area after the completion of

ongoing water resources development projects.

- The WAJ should operate and maintain the constructed facilities, especially the reservoirs by routine patrol and stationed monitoring. It is required to control the level of water in the reservoirs and pump operation, by which the overflow of water from the reservoirs, that is, wastage of precious water resources, does not occur. Furthermore, the WAJ should assign staff with technical skills to the constructed chlorination facility at Khaw for better operation and maintenance.
- The WAJ should incorporate the completed facilities in their ongoing project on improvement of the water supply system of Zarqa Governorate and to formulate an appropriate improvement plan, in which the completed facilities should be utilized effectively by planning installation of secondary distribution mains and service pipes and rehabilitation of the networks.
- The WAJ shall coordinate between this Project and the JICA's on-going technical assistance project on the Capacity Development Project for Non-Revenue Water Reduction, which is implemented by dispatching experts to WAJ Project Management Unit (PMU), in order to reduce leakage further and increase actual water availability.
- The WAJ should follow necessary procedures on environment and acquire approvals from the Ministry of Environment for implementation of the finally agreed project components according to Jordanian environmental regulations. If the study of Environmental Impact Assessment (EIA) is required, the WAJ should complete the study with necessary procedures and obtain approvals from Ministry of Environment for the project implementation before a formal decision of the Project implementation is made by the government of Japan at the latest.

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Abbreviations

B/D	Basic Design
DCIP	Ductile-cast iron pipe
D/D	Detailed Design
DOS	Department of Statistics
E/N	Exchange of Notes
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EU	European Union
FS	Feasibility Study
HWL	high water level
JOD	Jordan Dinar
JICA	Japan International Cooperation Agency
JV	Joint Venture
lpcd	litters per capita per day
LWL	low water level
M/D	Minutes of Discussions
MCM, mcm	million cubic meters
MCM/Y	million cubic meters per year
MP	Master Plan
MWI	Ministry of Water and Irrigation
NGO	Non-governmental organization
NO_3	Nitrate
NRW	Non-Revenue Water
ODA	Official Development Assistance
OJT	On the Job Training
PC	Pre-stressed concrete
PDM	project Design Matrix
PMU	Project Management Unit
PS	Pumping station
PQ	Prequalification
PVC	Polyvinyl chloride
RC	Reinforced concrete
RES., Res.	Reservoir
RO	Reverse Osmosis
RW	Revenue Water
TDS	Total dissolved solids
USAID	United States Agency for International Development
WAJ	Water Authority of Jordan
WTP	Water Treatment Plant

CHAPTER 1

Background of the Project

CHAPTER 1 Background of the Project

The gravest social and environmental challenge that Jordan has faced since the independence is the scarcity of water. On the per capita basis Jordan has one of the lowest levels of water resources potential in the world. With recent rapid population increase in Jordan, its available water resource per capita is significantly decreasing. In Jordan the water resources development and management has been considered as the most important policy matter with underlying basic policy of effectively and equitably optimizing the utilization of limited water resources.

The project area includes the northern part of Zarqa municipality, Hashemeyeh and Sukhna municipalities in Zarqa Governorate District, which is located in the north-east of the Capital city of Amman and is the most important industrial zone in the country. The Governorate accommodates a population of about 800,000 in 2004, out of which it is estimated that the project area contributes 336,000. Due to immigration of the refugees to the project area, the population and water service connections are rapidly increasing at about 3 % and 4 % per annum, respectively.

The project area has been developed along the slopes of both sides of Zarqa River with altitudes varying from about 480 to 710 meters above sea level. Due to the presence of highly undulated hills in the project area, water is supplied by pump with insufficient pressure at higher altitude and with large amount of leakage at lower altitude, resulting in over 50-percent of non-revenue water (NRW) and unstable and inequitable water supply.

Because of the scarce water resources available for municipal water supply in Jordan and in the project area in particular, and the high rate of water loss as indicated by more than 50 % of non-revenue water (NRW) ratio, the area currently suffers water shortage and water is supplied following water rationing service. According to the official request by the Government of Jordan, the per capita actual water use is only 80 L/day although the water demand per capita is 138 L/day. Therefore, the gaps between demand and available water is estimated to be 41,000 m^3/day in 2005 and would reach a value of 61,000 m^3/day in 2015 if projects are not implemented.

To improve the serious water supply conditions and to improve the living conditions of the residents, the Government of Jordan, therefore, requested a technical assistance from the Government of Japan concerning the improvement of the water supply system in the Zarqa district. Upon the request of Jordan, JICA implemented the development study of Improvement of Water Supply System in Zarqa District (JICA Development Study) and prepared a master plan (M/P) and conducted a feasibility study (F/S) from 1994 to 1996. The main objective of the study was to formulate the plan to reduce water loss and to supply limited water resources equitably. In this plan, it is recommended that the distribution network should be divided into eight zones to optimize distribution pressure and thus reduce leakage. The proposal includes the development of facilities required for creation of pressure zones, moving to gravity supply from pumping systems and replacement of superannuated pipes.

Based on the proposal of this Study, the Government of Jordan requested the Government of Japan for the grant aid to establish four distribution zones in Ruseifa and Awajan areas. In response to the request, the Government of Japan dispatched a basic design study team to Jordan through JICA in December 2001. As a result, this request was realized, implemented and successfully completed in March 2005 as the Project for Improvement of Water Supply System in Zarqa District (Phase I).

Thereafter, the Government of Jordan requested the Government of Japan for the grant aid to improve water supply facilities of the rest of four distribution zones in the area of the northern part of Zarqa municipality, Hashemeyeh and Sukhna municipalities in September 2004. The contents of the request are shown inTable 1.1.1.

Table 1.1.1 Contents of the Request

(1) Overall Goal	To improve living conditions of the residents in the target area through improvement of the water supply services.	
(2) Project Goal	To reduce water losses in the network and increase net water supply by distributing water at appropriate pressures	
(3) Outcome	To construct main water transmission and distribution facility in Zarqa, Hashemeyeh and Sukhna municipalities	
(4) Effectiveness Indicators	Service population, service ratio, service hours, net water supply quantity, per capita water use and leakage ratio	
(5) Request facility	Construction of Distribution Reservoirs ・Zarqa High Reservoir (4,000 m^3) ・Hashemeyeh Reservoir (2,000 m^3) ・Sukhna Reservoir (1,000 m^3) ・Batrawi Reservoir (12,500 m^3) Installation of Transmission Mains ・Batrawi Pumping Stations～Zarqa high Reservoir (400mm x 2,280m) ・Existing Batrawi Reservoir to Hashemeyeh Reservoir (Dia. 400 mm x 100 m, Dia. 300 mm x 2,300 m, Dia. 250mm x 1,900m) ・Hashemeyeh Junction～Sukhna Reservoir (Dia. 150mm x 6800 m, Dia. 200mm x 1000 m) Installation of Distribution Mains (Connection pipes) ・Dia. 200 mm ~ Dia. 600 mm x 15,9000 m) Construction of Pumping Equipment ・Pump: 2.7 m^3 /min x87 m x 75 kW x 4 units (1 stand-by)	
(6) Target Area	The northern part of Zarqa municipality and Hashemeyeh and Sukhna municipalities	
(7) Beneficiary	Approximately 740,000 persons	
(8) Implementation Agency	Water Authority of Jordan (WAJ)	
(9) Demarcation of the Works	Japanese Side	・ Construction of the facilities (Transmission and distribution mains, and pumping station)
	Jordanian Side	・ Construction of distribution pipes (Dia. 100 mm x 46,700 m)

CHAPTER 2

Contents of the Project

CHAPTER 2 Contents of the Project

2.1 Basic Concept of the Project

2.1.1 Overall Goal and Project Purpose

On the per capita basis Jordan has one of the lowest levels of water resources potential in the world. To ensure the water resources for domestic use with a recent rapid population increase in the urban areas and for agricultural use continuously is of vital importance. To tackle this problem Jordan established a long-term water policy in 1977, the National Water Strategy, which outlines the national basic policy concerning the development and management of water resources. The underlying policy stated in the National Water Strategy is to effectively optimize the utilization of limited water resources by managing/conserving water resources, enhancing the problem recognition of the public, and reforming the organizational system for water-related projects. Based on the Strategy, Jordan is currently enforcing a National Three-Year Socioeconomic Plan. The plan sets out the following objectives in the water and sewerage sector:

① Development and creation of new water resources
② Active exploitation of reclaimed wastewater for industrial and agricultural water uses
③ Increase in desalinated water and its increased use for municipal water use
④ Reduction in the rate of non-revenue water
⑤ Increase in the water supply volume for domestic use
⑥ Control of excessive groundwater pumping and protection from underground contamination

Following this national plan, a comprehensive plan for improvement of water supply system for the Zarqa Governorate is now being prepared to increase the per capita water amount for domestic use to 130 liters, approaching the national goal (150 liter: National Water Master Plan(NWMP)), through efforts such as reduction in the leakage ratio by the target year of 2025.

Under these policy and plans, this project aims at improving the following aspects of water supply conditions, and ultimately leading to improvement of the living conditions of the residents, through reconstruction of the existing water supply system.

- Increase of actual water availability through reduction of leakage by distributing water at appropriate water supply pressure
- Equitable water use through optimum water distribution management
- Sanitary safe water supply by appropriate chlorination

2.1.2 Basic Concept of the Project

To achieve the overall goal, the following outcomes are expected in the project.

- Required water amount is allocated to the project area
- Water supply system is developed by establishment of four water supply zones, construction of water distribution reservoirs and a chlorination facility and installation of transmission and distribution mains
- The constructed water supply system is managed, operated and maintained by technology transfer of water distribution management and the allocation of appropriate staff and budget

Out of these outcomes, the development of the water supply system and the technology transfer are expected to be implemented by the Japan's grant aid. The outline of the project is shown in Table 2.1.1 and differences in the expected effects are shown in Table 2.1.2.

Table 2.1.1 Outline of the Project

(1) Overall Goal	To improve living conditions of the residents in the target area through improvement of the water supply services.	
(2) Project Goal	To reduce leakage in the network and increase actual water availability by distributing water at appropriate pressures To attain equitable water supply by appropriate water distribution management To supply sanitary safe water	
(3) Outcome	• Required water amount is allocated to the project area • Water supply system is developed by establishment of four water supply zones, construction of water distribution reservoirs and a chlorination facility and installation of transmission and distribution mains • The constructed water supply system is managed, operated and maintained by technology transfer of water distribution management and the allocation of appropriate staff and budget	
(4) Effectiveness Indicators	Service population, service ratio, service hours, net water supply, leakage ratio, unpleasantly low pressure areas and water quality	
(5) Input	Construction of service reservoirs ・Zarqa High Reservoir (2,500 m^3) ・Hashemeyeh Reservoir (1,500 m^3) ・Sukhna Reservoir (1,000 m^3) ・Batrawi Reservoir (expansion: 14,000 m^3) Installation of Transmission Mains ・Batrawi Pumping Stations～Zarqa high Reservoir (300mm x 2,072) ・Khaw Junction～Hashemeyeh Reservoir（300mm x 6,141m ） ・Hashemeyeh Reservoir～Sukhna Reservoir (300mm x 7,798m) Installation of Distribution Mains (Connection pipes) Zarqa High Reservoir to the existing distribution mains (300 mm x 1,572 m) Hashemeyeh Reservoir to the existing distribution mains (300 mm x 1,338m) Sukhna Reservoir to the existing distribution mains (200 mm x 7322m) Batrawi Reservoir to the existing distribution mains (600 mm x 3,080 m and 400 mm x 480 m) Renewing of Pumping Equipment in the Existing Batrawi Pumping Station ・Pump: 5 m^3/min x 90 m x 132 kW x 2 units (1 stand-by) ・Electrical equipment Construction of Chlorination Facility in the Existing Khaw Pumping Station ・Dosing equipment (16kg/hour x 2 nos.) ・ Building (L12m x W10m x H 4.5m） Separation of Distribution Zones and Conversion of the Existing Distribution Mains to Transmission Mains Sluice valves: 6 nos. (to be procured by Jordanian Side)	
(6) Target Area	The northern part of Zarqa Municipality and Hashemeyeh and Sukhna Municipalities	
(7) Beneficiary	Approximately 374,000 persons	
(8) Implementation Agency	Water Authority of Jordan (WAJ)	
(9) Demarcation of the Works	Japanese Side	・ Construction of service reservoirs and chlorination facility ・ Installation of transmission mains and distribution mains ・ Renewing of transmission pump equipment ・ Installation of sluice valves (materials shall be procured by Jordanian side) ・ Technology transfer on water distribution management (soft component)
	Jordanian Side	・ Allocation of required water resources amount for the project area ・ Procurement of sluice valves and other required materials for installing sluice valves ・ Provision of the construction sites for water distribution reservoir ・ Development of the reservoir site by construction of access road, fence, green area, light and overflow pipe ・ Management, operation and maintenance of the constructed water supply system and appropriate water distribution management ・ Provision of equipment and facility to implement the soft component

Table 2.1.2 Expected Effects of the Project

No.	Indicators for project benefits	Unit	2005	2010	
			(Present)	Without the Project	With the Project
1	Estimated population	person	336,265	373,711	373,711
2	Estimated service population	person	329,540	373,711	373,711
3	Estimated un-served population	person	6,725	0	0
4	Service ratio	%	98%	100%	100%
5	Estimated percentage of low water pressure area (in annual daily average water demand	%	—	30	0
6	Estimated percentage of low water pressure area (in annual daily maximum water demand	%	—	70	0
7	Weekly water supply hours	Hours/ week	12 - 72	12-72	72
8	Water supply pressure	bar	0 – 10	0-10	1 - 7
9	Total water supply	m^3/day	40,300	56,100	56,100
10	Total net water supply (use)	m^3/day	27,807	38,700	42,100
11	Estimated leakage ratio	%	31	31	25
12	Per capita net water supply (use)	lpcd	84	104	113
13	Per capita total water supply	lpcd	122	150	150
14	Water quality (residual chlorine)	-	Some samples do not comply with the statutory provision	Some samples will not comply with the statutory provision	All samples will comply with the statutory provision
15	Additional effects	To change water supply system from energy-intensive pumping system to gravity system and to obtain savings in energy use			

Note: Low water pressure area is estimated as the area below water pressure of 10 m (1.0 bar).

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

(1) Basic Policy

1) Project Site

The project site shall include the northern part of Zarqa municipality, Hashemeyeh, and Sukhna municipalities.

2) Scope of Japanese Assistance

The scope of Japanese assistance includes the construction of service (or distribution) reservoirs, pumping station, chlorination facility, and installation of transmission and distribution mains (main distribution pipes). Valves required to separate distribution zones shall be procured and provided by WAJ but their installation is included in the Japanese side. In addition, the necessary water distribution control and monitoring equipment shall be installed. Installation of distribution pipes is not included.

3) Target Year for the Setting of Facility Capacity

The target year of this project shall be set in consideration of appropriate scale as a grant aid project. However, the target year for the conveyance facilities shall be set in consideration of difficulties in phased future extension.

4) Separation of the Water Supply System and Setting of Distribution Zones

The existing water supply system lacks distinct distribution zones and feeds water by pumping. Consequently, the existing system suffers significant temporal and spatial fluctuations in the supply pressure, resulting in high leakage ratios and regionally inequitable water services.

In order to improve this condition, to reduce leakage by supplying water at an appropriate water pressure, and enable fair water services, the existing water supply system shall be divided into distinct distribution zones. Service reservoirs shall be constructed in each distribution zone and water shall be supplied by gravity, but not by pumping. In consideration of the candidate sites proposed by WAJ, the service reservoirs shall be located in such sites from where it will be possible to supply all the area within their distribution zones with a reasonable pressure.

5) Siting of Facilities

Service reservoirs shall be sited in locations that are hydraulically convenient and the least susceptible to environmental and social impact. With regard to distribution and transmission main routes, public roads shall be used as far as possible for easy maintenance and in line with the WAJ policy. In the meantime, although the project site includes a military park, which may be advantageous in hydraulic terms, the pipes shall not be laid within park as problems may arise in future for maintenance due to restricted access.

6) Effective Use of Existing Facilities

The use of existing facilities shall be considered into the plan as far as possible.

7) Quality of Water

The quality of water to be supplied shall be of an approved quality satisfying the Jordanian drinking water standards. In particular, it should be noted that some well water used for consumption have excessive TDS levels. In addition, appropriate chlorination shall be planned to ensure required levels of residual chlorine throughout the water service duration.

(2) Design Concept for Natural Conditions

Since the daytime temperature in the project site is expected to exceed 40℃ in summer, quality control needs to be ensured, with special attention paid to concrete placement. On the other hand, countermeasures against frost in the winter are not needed when laying distribution and transmission mains. However, potentially insufficient vaporization of chlorine in chlorine tanks at room temperature in the winter should be taken in consideration.

The type of soil at the project site consists of gravel-mixed limestone and limestone. With sufficient bearing capacity of soil for the above-mentioned type, the ground layer is suitable for supporting the foundation structure. On the other hand, rock excavation will be required in many sections of the pipe laying route. Provided the underground water level is sufficiently low, there will be no need to consider measures against the underground water level when planning the foundation structure.

The geographic features of the project site are rugged, with elevations ranging from approximately 480 to 710 mAD. In light of such geographic features, due consideration will be required in siting the service reservoirs and setting distribution zones so as to achieve an appropriate water supply pressure.

(3) Design Concept for Socioeconomic Conditions

In light of the principal road of the industrial area in Zarqa District being included in the pipe laying route (in the vicinity of Hashemeyeh), consideration should be given to construction methods, to

ensure that the construction does not interfere with the local industry. In addition, consideration should be given to construction methods for the water distribution mains laying route (within Zarqa Municipality) and the pipe laying route (between Hashemeyeh and Sukhna) so that the construction does not interfere with the local commercial activities, because they are located in urban agglomerations in busy areas of the municipality.

Due to limited water sources, shortage in the capacity of water supply facilities, and rugged geographical features, water supply rationing is implemented in the project site on a daily basis. Service hours vary among regions from a minimum of 12 hours per week to a maximum of 72 hours per week, resulting in a significant impact on the daily life of residents. The plan shall aim to improve such unequal water service and contribute to the fair distribution of limited water and an increase in the water service days.

With Palestinian refugee camps existing within the project site, consideration should be given to the benefits of the relatively low-income refugees.

(4) Incorporation of Lessons Learned from the Phase I Project

This project shall be improved with lessons learned from the Phase I Project, which was implemented in Ruseifa Municipality of the Zarqa District and Awajan Area.

- There were shortfalls in the water sources and supply amount, due to delays in Water Resources Development Projects by obligations of recipient country. In this project, water supply plans shall be formulated based on conservative estimates of water sources.
- The implementation of soft component programs could sufficiently enhance the capabilities of personnel in the WAJ HQ office. The target of the soft components in this project is only the personnel of the Zarqa WAJ office who are related to the project, and their capabilities shall be strengthened through this component.

(5) Design Concept for Utilization of Local Contractors

Construction contractors in Jordan are ranked from Grade 1 to 3 by industry. Relatively large construction companies are categorized in Grade 1. These companies are usually engaged in many construction projects including aid projects within Jordan or joint venture projects with foreign companies. The skills and construction technologies acquired by such companies should be utilized. Due consideration shall be given to this fact in the design concept of this project.

(6) Design Concept for Procurement Method

Materials and equipment available in local market and meeting quality requirement shall be locally procured in Jordan. Materials and equipment that are not available in Jordan shall be procured from a

third country or from Japan. The origin of materials shall be decided based on economical cost.

(7) Design Concept for the Construction Method and Period

This plan shall be implemented in three phases, divided in accordance with the construction contents and expected to produce required benefits. The critical path in this construction is the construction works of service reservoirs. As the total length of planned distribution and transmission mains laying is as much as 24 km, the optimum total construction period shall be set in consideration with a proper number of construction crews.

Due consideration will be given to the construction plan to minimize traffic obstruction during excavation of roads for pipe laying. In addition, required safety measures such as the allocation of safety facilities and crossing guards with peripheral traffic safety shall be adopted during implementation. As there are some schools located in the vicinity of a service reservoir construction sites, due consideration shall be given to safety measures for school children.

(8) Design Concept for Support of Operation/Maintenance Capabilities of the Implementation Body

WAJ is the implementing agency of this project and is also expected to be in charge of the operation and maintenance of the water system following the project completion. Daily maintenance of the water transmission and distribution systems upon completion of construction is expected to be handled by Zarqa WAJ office.

Simple and easily maintainable facilities and maximum use of existing materials and equipment with WAJ shall be given due consideration in the facility plan.

Water distribution control and management capabilities of Zarqa WAJ office shall be enhanced through the soft component. This will allow the benefits of construction of the main facilities to be used optimally.

Plans shall also be formulated regarding the public relations for this project.

2.2.2 Basic Plan

2.2.2.1 Design Conditions

(1) Target Year

The target year of this project shall be 2010, with the proper scale of Japanese grant aid cooperation in mind although the request listed the facilities required for improvement by 2015 according to the JICA Development Study in 1996.

The capacity of conveyance facilities shall be set at a level that will allow the maximum water demand to be met in 2015 as requested because of the difficulties involved in phased future expansion of these facilities. However, service reservoirs and pump equipment shall be designed with 2010 as the target year because it is reasonable for such facilities to be constructed in a phased manner and also such facilities are expandable in accordance with the increase in water demand. Therefore, the basic design parameters such as water demand shall be estimated for the year 2015.

(2) Planned Population and Service Population

Estimated population figures in the project area were obtained from the Department of Statistics (DOS), Jordan. This estimate covers the year 2003 and also from 2005 to 2020 at an interval of five years as shown in Table 2.2.1. WAJ extrapolated the DOS population figures and made an estimate for 2025. In addition to the areas in Zarqa Governorate, Zarqa WAJ also supplies water to some other villages in its neighboring Balqa Governorate, Mafraq Governorate, and on the border with Jerash Governorate.

The assumed population growth rate in the estimate, which shows a downward trend, conforms to the previous trend and is evaluated as an appropriate estimation. Those values estimated by WAJ shall be adopted as part of the planned population in this project.

Table 2.2.1 Estimate of Population in the Water Service Area of Zarqa WAJ Office

No.	Area	1994*1	2003 DOS*2	2005 DOS	2010 DOS	2015 DOS	2020 DOS	2025 WAJ
1	Zarqa Municipality (include Awajan)	340,261	472,848	499,601	565,253	633,317	702,667	772,006
2	Hashemeyeh Municipality	13,936	17,750	18,754	21,218	23,773	26,376	28,979
3	Sukhna Municipality	9,764	12,880	13,609	15,397	17,251	19,140	21,029
4	Ruseifa Municipality	134,495	240,630	254,244	287,654	322,291	357,583	392,869
5	Hettin camp	36,218	48,243	50,973	57,671	64,615	71,691	78,765
6	Zarqa Area（sum of 1-5 above）	534,674	792,351	837,181	947,193	1,061,247	1,177,457	1,293,648
7	The rest of Zarqa Governorate	104,326	69,649	73,590	83,260	93,286	103,502	113,715
8	Zarqa Governorate (sum of 6 and 7)	639,000	862,000	910,771	1,030,453	1,154,533	1,280,959	1,407,363
	Outside of the Zarqa Governorate							
9	Mafraq Governorate		2,397	2,533	2,866	3,210	3,561	3,913
10	Balqa Governorate		9,239	9,762	11,045	12,375	13,729	15,084
	WAJ Zarqa Service Area (sum of 8,9 and 10)		873,636	923,066	1,044,364	1,170,118	1,298,249	1,426,360
	Assumed population growth rate (%)			2.79	2.5	2.3	2.1	1.9

Note: *1 Population Census in 1994
*2 Estimated using DOS (Department of Statistics) in 2003 and 2020
*3 Assuming the growth rate of 1.9 % to estimating population in 2025 (WAJ estimate).

The project site covers Zarqa, Hashemeyeh, and Sukhna Municipalities but does not include the Awajan Area (Phase I) of Zarqa Municipality. The future population in the project site, except the Awajan Area, was estimated as shown in Table 2.2.2. The estimation method and the estimated population distribution in the project area are as shown in Annex-1.

Table 2.2.2 Planned Population in the Project Area

Area	2005	2010	2015	2025
The northern part of Zarqa Municipality (Exclude Awajan area)	303,902	337,096	368,327	425,723
Hashemeyeh Municipality	18,754	21,218	23,773	28,979
Sukhna Municipality	13,609	15,397	17,251	21,029
Total	336,265	373,711	409,351	475,731
Service coverage (%)	98	100	100	100
Service population	329,540	373,711	409,351	457,731

The water supply ratio of Zarqa in 2004 was estimated at 98% by the Ministry of Planning and Statistics. While the water supply ratio in 2005 is estimated as 98% following the case in 2004, the future ratio shall be taken as 100%. Table 2.2.2 shows the estimated service populations in future.

(3) Planned Leakage Ratio

There is no data available on the correct estimate of leakage ratio in the Zarqa District. The available statistics (Table 2.2.3) shows non-revenue water which is the sum of real and apparent losses. Leakage is the main component of real loss.

Table 2.2.3 Non-Revenue Water in the Water Service Area of Zarqa WAJ Office

(MCM/y: Million Cubic Meter per Year)

Item	Unit	2002	2003	2004
Total water supply	MCM/y	34,412,052	36,965,882	37,687,744
Non-revenue water	MCM/y	15,217,373	17,934,637	18,031,784
Non-revenue water ratio	%	55.8	51.5	52.2

In general, the leakage ratio in Jordan is presumed to be half of the non-revenue water. The present leakage ratio in the Zarqa District is estimated as 31% based on the results of pilot area studies conducted by JICA Development Study in 1996. Although minor repair works for water service pipes are being carried out on a daily basis, the leakage ratio in 2005 shall be estimated to remain at the same level as in 1996 because no major program for repair and rehabilitation has been implemented for the water supply facilities since then.

WAJ has set the planned leakage ratio for 2025 as shown in Table 2.2.4. The leakage ratio in this project shall be set as shown in other rows of the same Table based on the study done in Annex-7.

Table 2.2.4 Planned Leakage Ratio at the Project Site

	Unit	2005	2010	2015	2025
Planned leakage ration (WAJ plan)	%	31	28	20	15
Planned by Basic Design Study Team *1	%		25		
Adopted leakage ratio	%	31	25	20	15

Note: *1: refer to Annex-7

(4) Planned Daily Average Water Consumption and Water Supply per Capita

WAJ has set the planned daily average water consumption per capita for 2025 as shown in the following Table. WAJ plans to increase the daily average water supply per capita to 108 lpcd by 2010 and to 130 lpcd by 2025. With this in mind, the current leakage ratio needs to be reduced to 15% by 2025.

Based on the above-mentioned conditions, the planned daily average water supply amount (including leakage) and water consumption per capita (excluding leakage) for the period from 2005 to 2025 in this project will be planned as shown in Table 2.2.5.

Table 2.2.5 Planned Leakage Ratio and Per Capita Water Consumption and Supply

Items	Unit	2005	2010	2015	2025
WAJ plan					
Planned leakage ratio	%	31	28	20	15
Planned per capita actual capital consumption per day	lpcd	90	108	125	130
Planned per capita water supply per day	lpcd	130	150	156	153
Target in this project					
Planned leakage ratio	%	31	25	20	15
Planned per capita actual capital consumption per day	lpcd	84	113	125	130
Planned per capita water supply per day	lpcd	130	150	156	153

(5) Parameters for Setting Facility Size

General annual fluctuations in water demand are shown in Figure A. The water demand generally reaches its peak in the summer and bottoms out in winter. Figure B shows the general daily fluctuations in water demand. The hourly water demand increases in the morning and evening when water consumption activities increase. Since water consumption activities fall drastically at night, the only demand at night is basically attributable to leakage under normal water service conditions. At the project site, however, due to the implementation of water supply rationing, households store water in their water tanks overnight on water supply days for their use on non-supply days. Consequently, water demand is expected to remain high even during the night time.

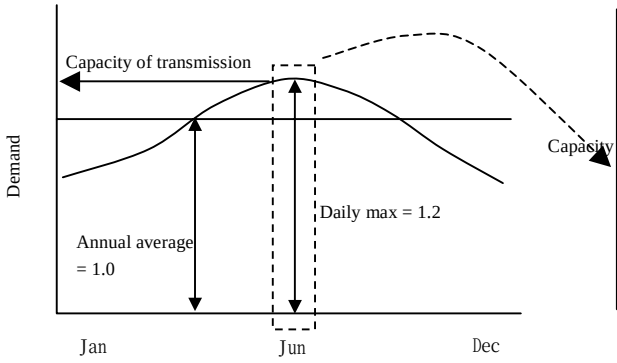


Figure A Annual fluctuation

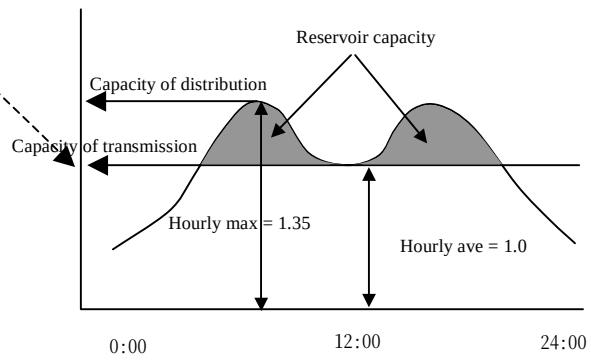


Figure B Daily fluctuation

Typical Water Demand Fluctuation

In consideration of the above water demand patterns, the following water demand which is generally used in designing water supply facilities, will be adopted in designing this project:

Transmission mains and transmission pumping stations: Sufficient capacity to supply the daily maximum water demand.

Distribution pipes and distribution pumping stations: Sufficient capacity to distribute hourly maximum demand on the day of peak water demand.

Service reservoirs: Sufficient capacity to absorb the difference in flow between the constant inlet water amount from the transmission mains and the diurnal demand fluctuation on a day when the yearly water demand peaks.

(6) Planned Load (Peak) Factor and Reservoirs Capacity

The planned load factor and the service reservoir capacity to determine the facility capacities shall be set as follows:

a) Daily Maximum Coefficient (Planned Load Factor due to Seasonal Change)

The monthly water supply variations in the water service area of the Zarqa WAJ office in 2004 are shown in Table 2.2.6. The demand coefficient bottoms out in January and December at 0.92 and peaks in June at 1.10. Because the above values represent variations on a monthly basis and because the maximum value is considered to have been observed under the condition that demand is suppressed due to a shortage of water resources in the summer when the water supply peaks, the actual daily maximum coefficient is estimated as 1.1 or higher. Although in most cases, a daily maximum coefficient of approximately 1.5 is applied in water demand planning in Jordan, in this project, the planned daily maximum coefficient of demand will be set at 1.2 to avoid designing of excessive facilities and improve the current values under suppression.

Table 2.2.6 Monthly Water Supply Variations in the Water Service Area of the Zarqa WAJ Office (2004)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Ave.
Average monthly water supply (m^3/day)	94,309	102,036	96,902	104,529	107,347	113,271	108,982	104,543	102,825	103,222	98,471	94,353	102,566
Coefficient of variation	0.92	0.99	0.94	1.02	1.05	1.10	1.06	1.02	1.00	1.01	0.96	0.92	1.00

b) Hourly Maximum Coefficient (Planned Load Factor due to Hourly Daily Change)

Although the planned load factor due to hourly change can be obtained from the hourly change curve at the project site, there is no applicable data. In other similar projects in Jordan, a maximum value of 1.5 is adopted. WAJ adopts an hourly maximum coefficient of 1.35 in this project site. At the project site, water supply rationing is currently in force. In general, the hourly maximum coefficient diminishes under rationed water supply compared to normal water service, because the peak flow is restricted. In this project site, a planned hourly maximum coefficient of 1.35, which is smaller than the value normally used in planning, will be adopted in consideration of the fact that water supply rationing is expected to be continued, even after 2010.

c) Planned Service Reservoir Capacity

In general, the service reservoir has the following three functions:

- To absorb the flow difference between the constant inlet water amount from the transmission mains and the diurnal demand fluctuation,
- To back up for a discontinuation of the water service in the event of an accident, draught, etc.,
- To reserve water for fire fighting.

In Jordan, water supply rationing is common. Hence, in addition to the back-up function, reserving the water for fair water distribution is an important function of the service reservoir.

According to the result of flow pattern analysis in Awajan and Ruseifa, reservoir capacity corresponding to the absorption of flow fluctuation is 3-7 hours. This value is based on the condition that demand is suppressed, that is, the peak daytime flow is cut. If supply satisfies demand, the required retention time becomes higher.

In Jordan, a retention time of 12 hours is widely applied. In order to avoid excessive facility sizes, however, this project will apply 8 hours or more of daily maximum demand to the service reservoir capacity at the target year of 2010. For subsequent years, WAJ shall ultimately reach its goal of 12 hours or more through its own self-help efforts.

(7) Planned Water Supply Pressure

WAJ plans to set the water supply pressure for the water distribution network within the range 2.5 to 7.0 bar (water pressure equivalent to 25 to 70 m). Many four-storied buildings are located in the Project area. In order to supply water directly to four-storied buildings, a water pressure equivalent to 15m to 20m is required. In this project, a planned water supply pressure of 2.5 bars will be applied as a target value. However, in some geographically disadvantageous areas (some of the hills in the Zarqa low distribution zone), the minimum water pressure during the hourly maximum water supply shall be set at a target of 1.0 bar or more from the ground level.

(8) Network Analysis and Flow Rate Formula

EPANET2 of EPA, USA, is used as the network analysis software for deciding the sizes of distribution and transmission network facilities. Hazen-Williams Formula will be applied for calculating the friction loss of pipes.

(9) Water Quality

The quality of water to be supplied shall be of an approved quality satisfying the Jordanian drinking water standards shown below. It should be noted that problematic items in terms of the quality of water sources at the project site are TDS and NO_3. At present, water derived from water sources with high levels of the above items is supplied by mixing with water from good water sources.

In order to supply water that is microbiologically safe and sanitary, appropriate chlorination should be planned to maintain the required residual chlorine at the final point of the water service.

Parameter	Allowable	Maximum allowable *
pH	(6.5- 8.5)	-
TDS	500	1500
TH	300	500
LAS(MBAS)	0.2	0.5
NH_4	0.5	0.5
Al	0.1	0.2
Mn	0.1	0.2
Fe	0.3	1.0
Cu	1.0	1.5
Zn	3	5
Na	200	400
Cl	200	500
SO_4	200	500

Note: * if good quality of water sources is not available.

Parameter	Symbol	Allowable (mg/l)
Arsenic	As	0.01
Lead	Pb	0.01
Cyanide	CN	0.07
Cadmium	Cd	0.003
Crum	Cr	0.05
Barium	Ba	1.5
Selenium	Se	0.05
Boron	B	2
Mercury	Hg	0.002
Silver	Ag	0.1
Nickel	Ni	0.07
Antimony	Sb	0.005
Fluoride	F	2
Nitrite	NO_2	2
Nitrate	NO_3	50*

Note: * the allowable concentration is 70 mg/l if good quality of water sources is not available.

2.2.2.2 Study and Planning Items

In the facility plan of the following section, the following study and planning will be discussed:

No.	Study Items	Contents of planning and study items
(1)	Alternative Plans for the Planned Facilities	
(2)	Distribution Zoning Plan	
(3)	Planned Service Population in Distribution Zones	
(4)	Planned Water Supply Amount (Water Demand)	
(5)	Planned Water Supply Amount	・ Planned Annual Water Demand ・ Current Water Resources in the Water Service Area of Zarqa WAJ office ・ Related Water Resources Development Projects ・ Water Distribution Scenario and Water Demand-Supply Balance
(6)	Water Balance in the Water Service Area of Zarqa WAJ Office in the Target Year	
(7)	Selecting Sites for the Facilities	・ Selection Sites for the Reservoirs ・ Selection of Water Transmission Pipeline Route ・ Selection of Water Distribution Pipeline Route
(8)	Determining the Capacity of the Planned Facilities	・ Capacity of the Planned Reservoirs ・ Diameter of the Planned Transmission Mains ・ Capacity of the Planned Transmission Mains ・ Diameter of the Planned Distribution Mains ・ Evaluation of the Capacity of Pumps at Khaw Pumping Station ・ Study on Water-Hammer Action of the Water Transmission System
(9)	Separating Distribution Zones and Converting Existing Pipes into Transmission Mains	・ Separation Plan ・ Plan for Converting the Existing Distribution Mains into the Water Transmission Mains
(10)	Pipeline Plan	・ Connecting the Planned Transmission mains and Existing Conveyance Facilities ・ Connecting the Planned Distribution Mains and Existing Conveyance Facilities ・ Pipe Materials ・ Auxiliary Facilities ・ Protection of Fittings ・ Crossing the Railroad ・ Joint Construction
(11)	Pumping Station Plan	
(12)	Reservoir Plan	・ Structure and form ・ Foundation Form and Facility Location Plan ・ Ancillary Facilities ・ Connection with Existing Reservoir and Pumping Facilities at Batrawi
(13)	Chlorination Facility Plan	・ Current Chlorine Disinfection ・ Study of Alternatives ・ Chlorination Facility Specifications
(14)	Water Distribution Control and Monitoring Plan	・ Operations and Management Plan ・ Control and Metering Facilities Plan
(15)	Water Quality Improvement Plan	・

2.2.2.3 Facility Plan

(1) Alternative Plans for the Planned Facilities

Table 2.2.7 shows the differences in the facility contents from the proposed request. Figure 2.2.1, Figure 2.2.2 and Figure 2.2.3 show the facility layout plans of the alternative plans. Finally, Table 2.2.8 shows a summary of evaluation of the alternatives.

A. Original request: Request proposal of WAJ dated August 2004 (closely related to the JICA's Proposal for Development Study (1996))
B. WAJ's plan in M/D: The proposal currently under preparation by WAJ with hired local consultants.
C. Final facility plan: The plan formulated by the JICA basic design study team as an optimum plan.

Table 2.2.7 Facility Contents in Alternatives

	A. Original Request	B. WAJ's Plan (in M/D)	C. Final Plan
1. Target year	2015	2025	2010 (reservoir and pump) / 2015 (pipe)
2. Facility components			
Construction of reservoir	(1) Zarqa High (4,000 m^3)	(1) Zarqa High	(1) Zarqa High (2,500 m^3)
	(2) Hashemeyeh (2,000 m^3)	(2) Hashemeyeh	(2) Hashemeyeh (1,500 m^3)
	(3) Sukhna (1,000 m^3)	(3) Sukhna	(3) Sukhna (1,000 m^3)
	(4) Batrawi (12,500 m^3)	(4) Batrawi	(4) Batrawi (14,000 m^3)
Construction of transmission mains	(1) Batrawi Pumping Station to Zarqa High Res. (Dia. 400mm x 2,200 m)	(1) Batrawi Pumping Station to Zarqa High Res.	(1) Batrawi Pumping Station to Zarqa High Res. (Dia. 300 mm x 2.1km)
	(2) Batrawi Res. to Hashemeyeh Res. — Dia. 400 mm x 100 m; Dia. 300mm x 2,300 m; Dia. 250 mm x 1,900m	(2) Batrawi Res. to Hashemeyeh Res.	None.
	(partly using the existing pipelines)		
	(3) Junction to Sukhna Res. — Dia.150 mm x 6800 m; Dia. 200 mm x 1000 m	(3) Hashemeyeh Pumping Station to Sukhna Res.	(2) Hashemeyeh Res. to Sukhna Res. (Dia. 300 mm x 7.8 km)
		(4) Khaw Pumping Station to Hashemeyeh Res.	(3) Khaw junction to Hashemeyeh Res. (Dia. 300 mm x 6.2 km)
			(4) Valve installation to use the existing pipeline from Zarqa Pumping Station to Batrawi Res. for proposed transmission.
Total	Dia.150mm-400mm x 14.3 km		300 mm x about 16.1 km
Construction of pumping station	(1) Batrawi Pumping Station	(1) Batrawi Pumping Station	(1) Batrawi Pumping Station Renewing pumping equipment in the existing Batrawi Pumping Station.
		(2) Hashemeyeh Pumping Station	None.
Construction of distribution mains	Dia. 600 mm to 200 mm, L = 15,900 m	Dia. 600 mm to 200 mm, L = 15.9 km	Dia. 600 mm to 200 mm, L = about 7.2 km
Construction of chlorination facility	None	None	Chlorination facility in Khaw Pumping Station
Installation of sluice valves	Only description of separation of the distribution zones	Sluice valve installation for separation of distribution zones.	Sluice valve installation to separate distribution zones and to use the existing distribution mains as proposed transmission mains from Zarqa PS to Batrawi Res.

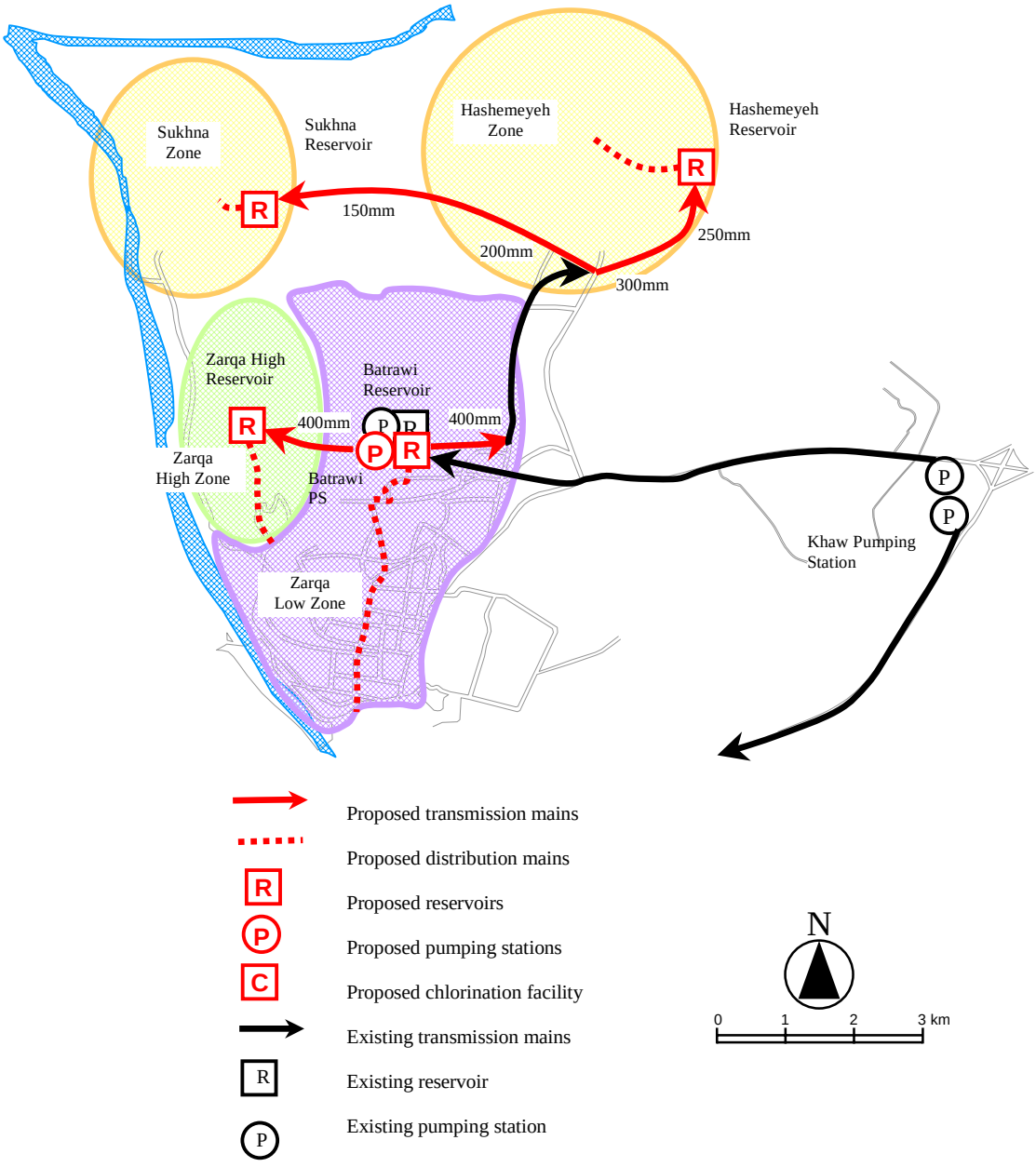


Figure 2.2.1 Initial Requested Facilities

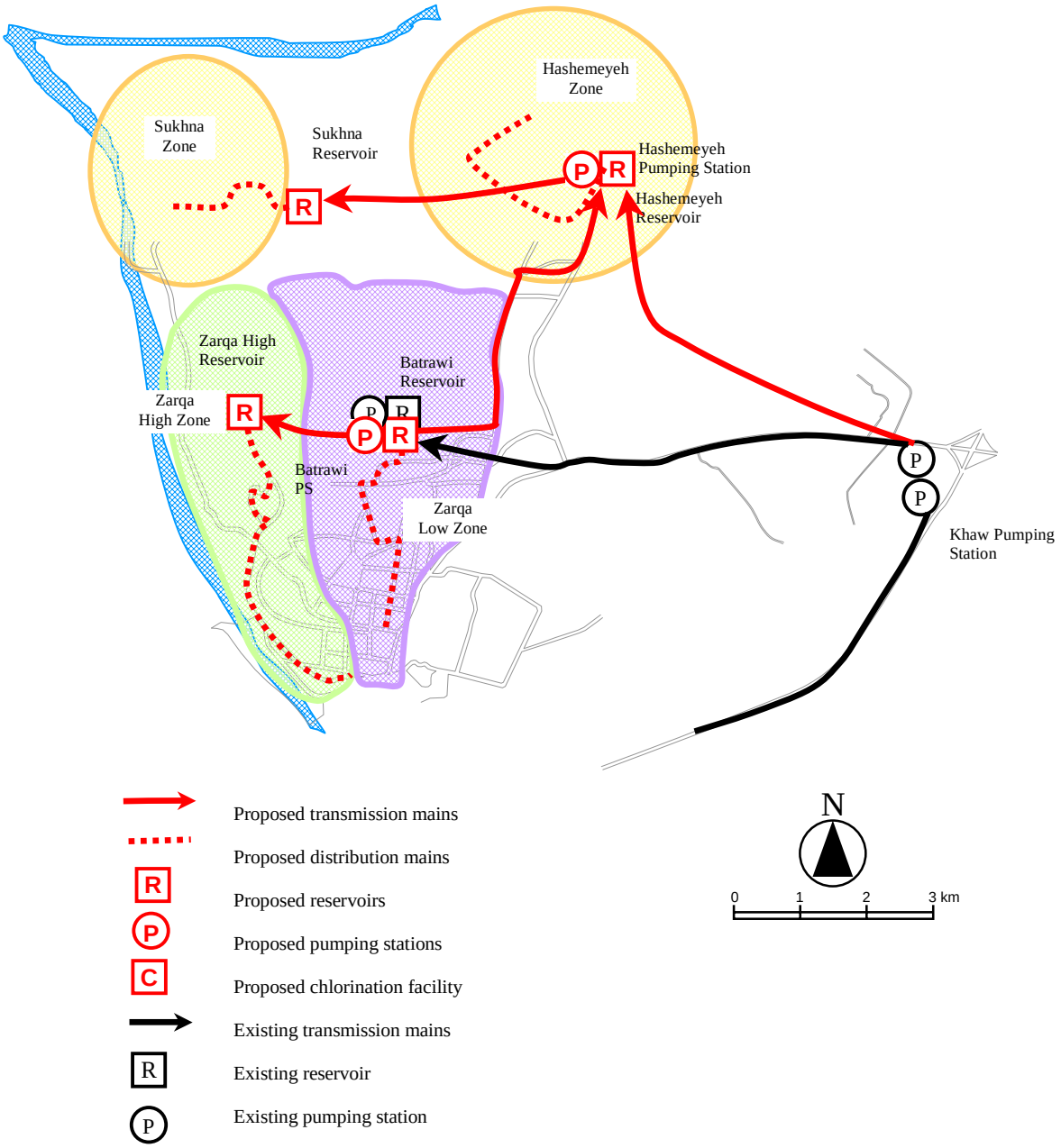


Figure 2.2.2 New WAJ's Plan (in the M/D)

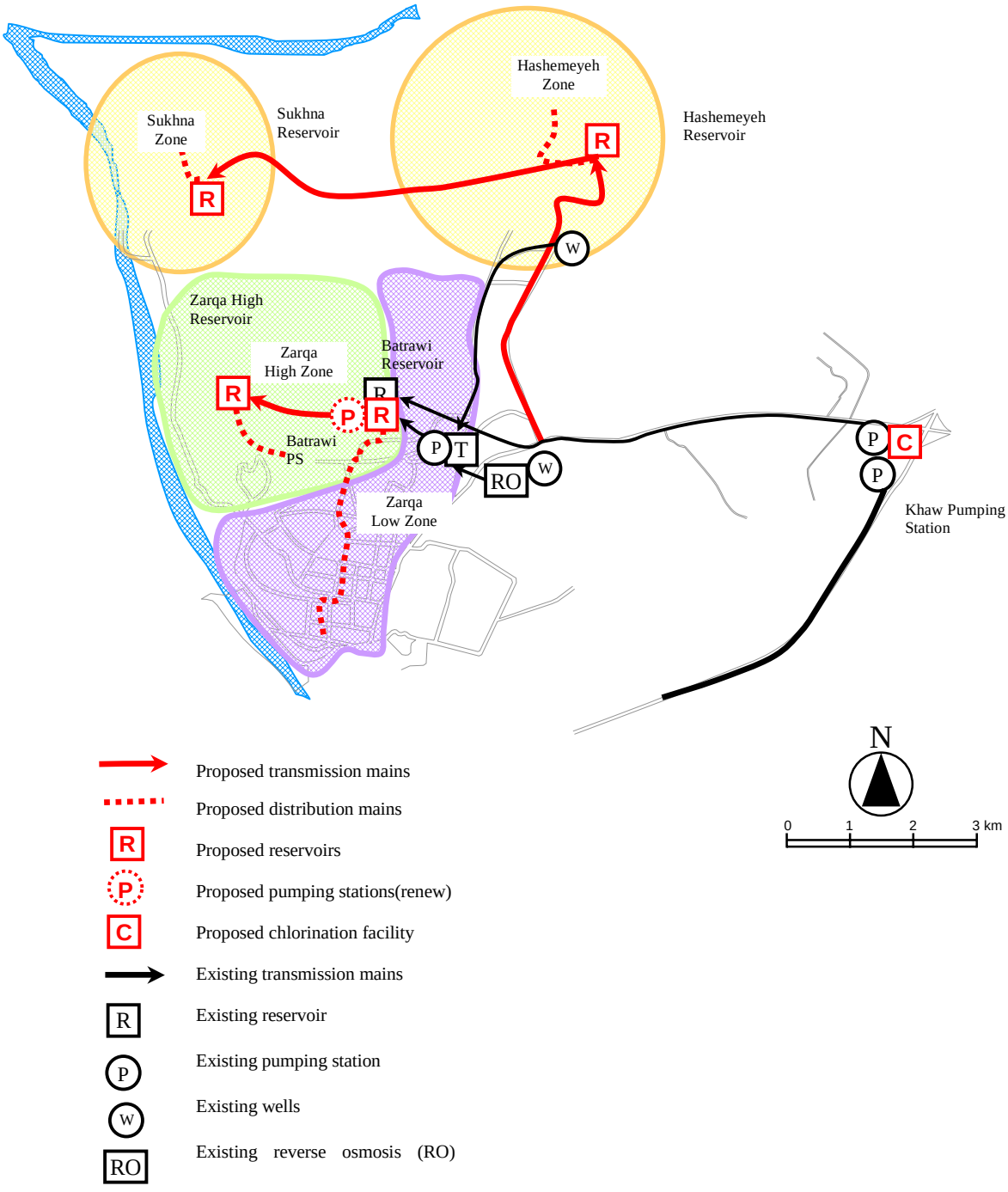


Figure 2.2.3 Final Facility Layout Plan

Table 2.2.8 Evaluation of the Proposed Facility Layout Plan

Layout plan	Evaluation
A. Original request	• The layout of water supply facilities and water distribution zoning are almost the same as the final plan. • The only difference is that existing water pipes will be used for part of the transmission route from the Batrawi Reservoir to the Hashemeyeh Reservoir. However, existing water distribution pipes are currently in use for the transmission of water from Hashemeyeh Well to the Zarqa Reservoir and are also expected to be used for similar purposes in future. • This plan includes no plan for chlorination facilities.
B. On-going WAJ's plan	• Although it is almost the same for the layout of water supply facilities, it differs in terms of the water distribution zoning of the high and low zones of Zarqa. In consideration of the current network layout and elevation, the proposed water distribution zoning is difficult to implement. • In light of the high water demand in Zarqa High Zone, considerable capacity is required for the service reservoir there. However, the lack of adequate sites means it is difficult to construct a service reservoir to accommodate the required amount of water. In addition, major expansion of transmission pumps will be required to transmit a large amount of water from the Batrawi Reservoir to Zarqa High Zone. • The expansion in capacity of transmission pumps will entail an increase in electrical expense. Accordingly, it is inefficient to transmit water pumped up to from the Zarqa High Reservoir (710 m) down to an area with an elevation of approximately 530 m. • Because the construction site of Sukhna Reservoir is situated at a high elevation (630 m), water pumps are required to transmit water from the Hashemeyeh Reservoir to the Sukhna Reservoir. This is disadvantageous in maintenance terms. In addition, because the elevation of the existing water service area is approximately 560 m or less, sufficient water supply pressure will be available if the reservoir is constructed at an elevation of approximately 590 m. • Because the facility layout and capacity setting in this particular plan are aimed at 2025, such facility contents are too large for this project. • This plan includes no plan for chlorination facility.
C. Final facility plan	• With consideration given to the ease of maintenance, the facility plan was prepared to minimize the placement of pumping stations as far as possible. • The water distribution zoning was planned with emphasis on realistic feasibility. • Water distribution zoning was planned to target the most effective optimization of the water level of the Zarqa High Reservoir (approximately 710 m) and that of the Zarqa Low Zone (Batrawi) Reservoir (approximately 645 m). This water distribution zoning is expected to allow facility costs to be minimized as well as the electrical expense required to transmit water to the Zarqa High Reservoir. • This water distribution zoning will also minimize both maintenance costs and the initial investment. • Chlorine facility will be planned in order to supply sanitary and safe water.

Major differences from the originally proposed request and additional components are as follows:

- Construction of transmission mains (dia. 150 mm - 400 mm x 14.3 km to dia. 300 mm x approximately 16.1 km)
- Construction of distribution mains (dia 600 mm - 200 mm, 15.9 km to dia. 600 mm - 200 mm, approximately 7.2 km)
- New construction of Batrawi Pumping Station to Exploitation of the existing Batrawi Pumping Station (replacement of machinery and electric facilities)

- Addition of one extra chlorination facility
- Addition of installation of sluice valves (6 nos.) to separate distribution zones and to use the existing distribution mains as transmission mains from Zarqa PS to Batrawi Reservoir (Japan side will conduct Construction work and Jordan side will conduct procurement of construction material including pipe).

The background to the aforementioned differences in the request is as follows:

- Construction of transmission mains (dia. 150 mm - 400 mm x 14.3 km to 300mm x approximately 16.1 km)

Following investigation of efficient water transmission to the planned reservoirs sites in each distribution zone and onsite investigation of those pipe routes, the design length increased by approximately 1.8 km. Although the original request included the use of an existing pipe route, the on-site investigation proved that the pipe route was in use for the transmission of water from Hashemeyeh Well to the Zarqa Reservoir, meaning that it would not be available to transfer water to the Hashemeyeh Reservoir.

- Construction of water distribution pipes (dia. 600 mm - 200 mm, 15.9 km to dia. 600 mm - 200 mm, approximately 7.2 km)

With the aim of efficiently distributing water within each distribution zone, network analysis was implemented to determine the appropriate pipe diameters and lengths. Consequently, the required length of water distribution pipes decreased.

- New establishment of Batrawi Pumping Station to Exploitation of the existing Batrawi Pumping Station (replacement of machinery and electric facilities)

Considering the existing Batrawi Pumping Station, which has been newly constructed in 2002, it was decided to best exploit the facilities of the pumping station. With this in mind, in planning this facility, the existing pump building will be used and the required equipment in the plan will be replaced with existing machinery (pumps) and electric facilities according to the required capacities.

- Addition of one chlorination facility

The water to be supplied to Zarqa municipality is disinfected by chlorine at Zarqa Pumping Station. On the other hand, however, there is a risk of the water supplied to Hashemeyeh and Sukhna Municipalities being polluted because no chlorination facilities are used.

Because water is expected to be transmitted from Khaw Pumping Station directly to each service

reservoir upon completion of this project, the existing chlorine injectors at Zarqa Pumping Station cannot be used thereafter.

With this in mind, in order to avoid discrete multiple siting of chlorination facilities or establishing facilities handling potentially dangerous chemical near a built up area, it was decided to install a chlorination facility in Khaw Pumping Station.

- Sluice valve installation to separate distribution zones and to use the existing distribution mains as proposed transmission mains

In order to separate the planned four distribution zones, the existing sluice valves will be closed. If there is no sluice valve near the separating point, a new sluice valve will be installed and closed.

Water pipes to convey RO-treated water stored in Zarqa Reservoir and Hashemeyeh Well water from Zarqa Pumping Station to Batrawi Reservoir are needed. To this end, the existing conveyance facilities (with a diameter of 400 mm) between Zarqa Pumping Station and Batrawi Reservoir are converted into transmission mains.

(2) Distribution Zoning Plan

Weekly rationing of water supply service is currently practiced in the entire water service area due to shortage of water resources and insufficient capacity of water supply facilities. The water supply hours are from half a day to three days per week. The current water supply zones and service level are explained in the Table below and Figure 2.2.4. The very low water pressure area is the higher area of the Zarqa main city and most of the residents in the service area use water tanks (2 m^3) on the roof to store water in the service hours.

Table 2.2.9 Water Supply Zones and Service Time

Sub-Zone No.	Area	Supply Time		Hours	Source of pumping
		From	To		
		Zarqa Area			
Z-A	Al-Zarqa, Al Joedea, Al Amer Mohmod, Iben Seena	Friday morning	Sunday morning	48	Zarqa PS
Z-B	Al Khweria Low	Sunday evening	Tuesday evening	48	Zarqa PS
Z-C	Center of the city	Wednesday morning	Friday morning	48	Zarqa PS Low pressure
Z-D	Hay Masoun, Jabl Al Mkher, Al Hashea, Al Thobeia	Sunday morning	Wednesday morning	72	Batrawi PS
		Hashemeyeh			
H-A	East area of Hashemeyeh	Friday morning	Sunday morning	48	Hashemeyeh PS
H-B	West area of Hashemeh	Monday morning	Wednesday morning	48	
H-C	Al Kenba Al Samra	Sunday morning	Monday morning	24	
		Sukhna			
S-A	West area of Sukhna	Wednesday morning	Thursday morning	24	Hashemeyeh PS
S-B	Sukhna refugee camp and the center of the town	Sunday morning	Tuesday morning	48	
S-C	East area of Sukhna	Tuesday morning	Wednesday morning	24	
S-D	Sukhna Daheia	Wednesday morning	Wednesday evening	12	Sukhna boosting PS
S-E	Al Salheia	Wednesday morning	Friday morning	48	Sukhna boosting PS
S-F	Abo Al Ziqan	Monday morning	Thursday morning	72	Sukhna boosting PS

On the basis of the water distribution zoning in the Development Study (JICA, 1996), distribution zones of the project area will be set as shown in Figure 2.2.5 to supply water at the appropriate pressure in the entire service area considering arrangement of existing water supply facilities and elevation in the area. This water distribution zoning will divide the project area into Zarqa High, Zarqa Low, Sukhna, and Hashemeyeh Distribution Zones. The elevations of each distribution zone of the water service area are as shown in Table 2.2.10.

Table 2.2.10 Elevation Variations among Planned Distribution Zones of the Water Service Area

Proposed Distribution Zones	Elevation Variation in Service Area (m)
Zarqa Low Zone	625-530
Zarqa High Zone	708-615
Hashemeyeh Zone	610-530
Sukhna Zone	560-480

In each zone, the planned service reservoir will be located at a suitable position and elevation, to allow water to be distributed by gravity. Figure 2.2.6 shows the elevation profile of existing and planned water supply systems.

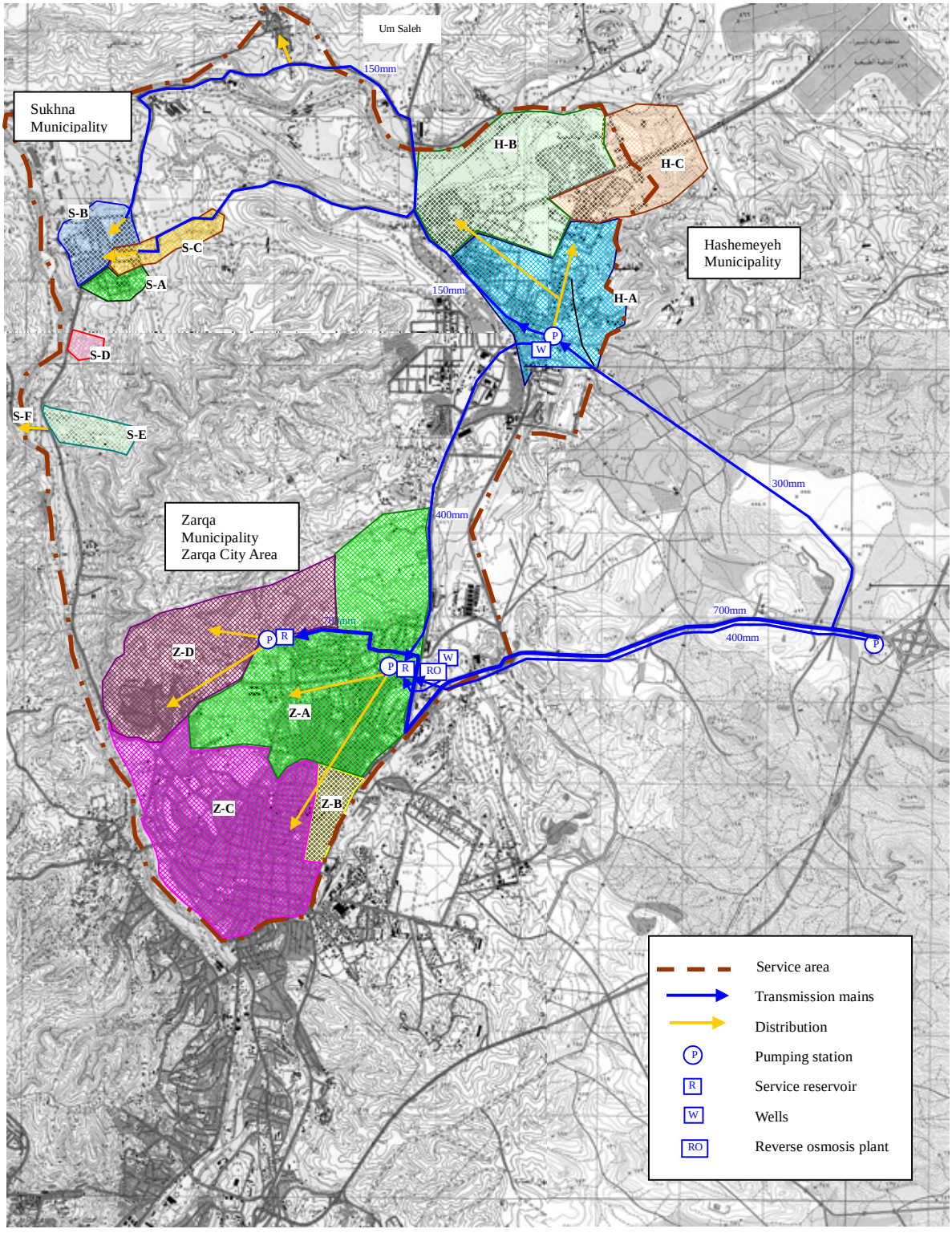


Figure 2.2.4 Water Service Area by WAJ Zarqa, Existing Rationing Service Zoning and Existing Major Water Supply Facilities

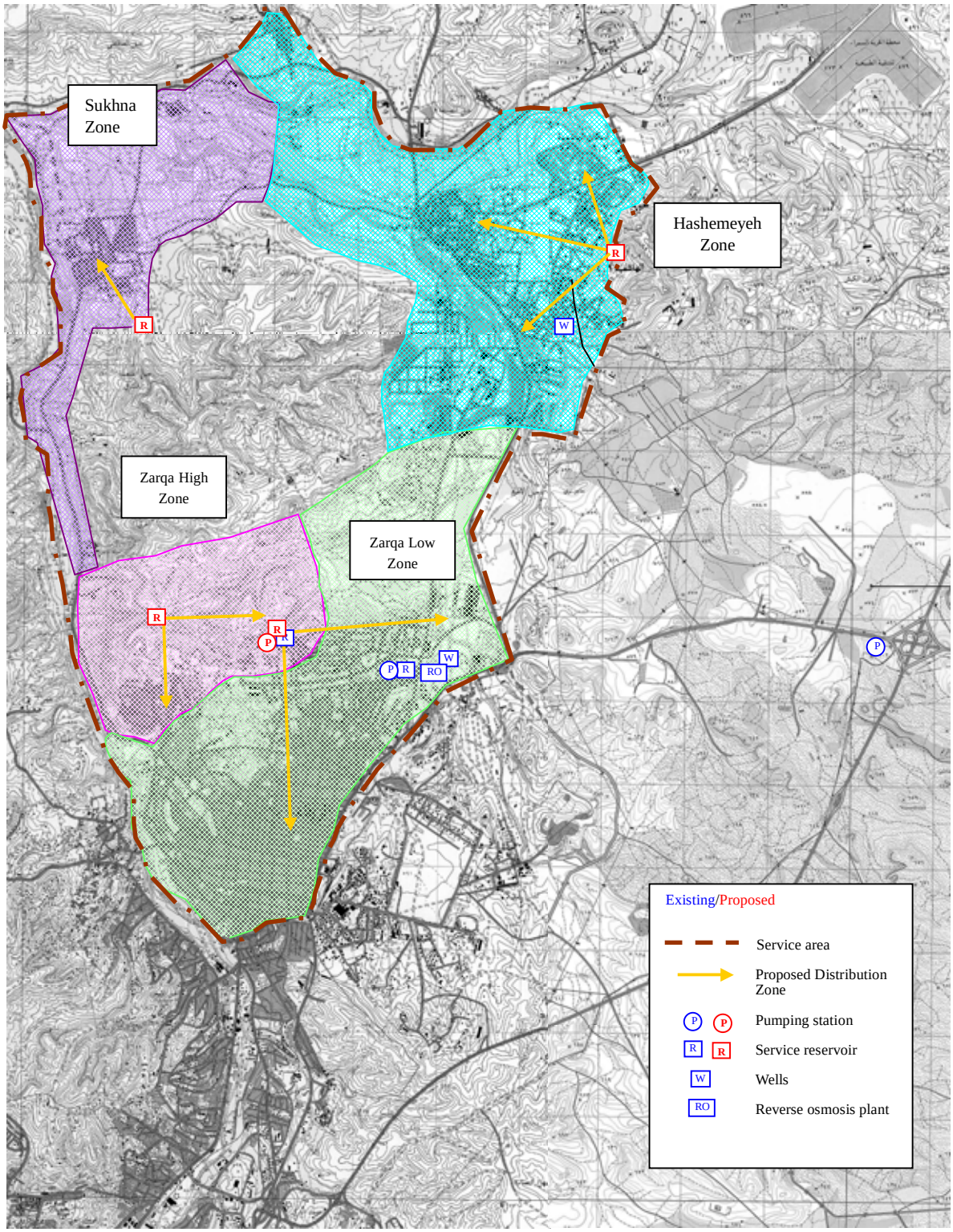
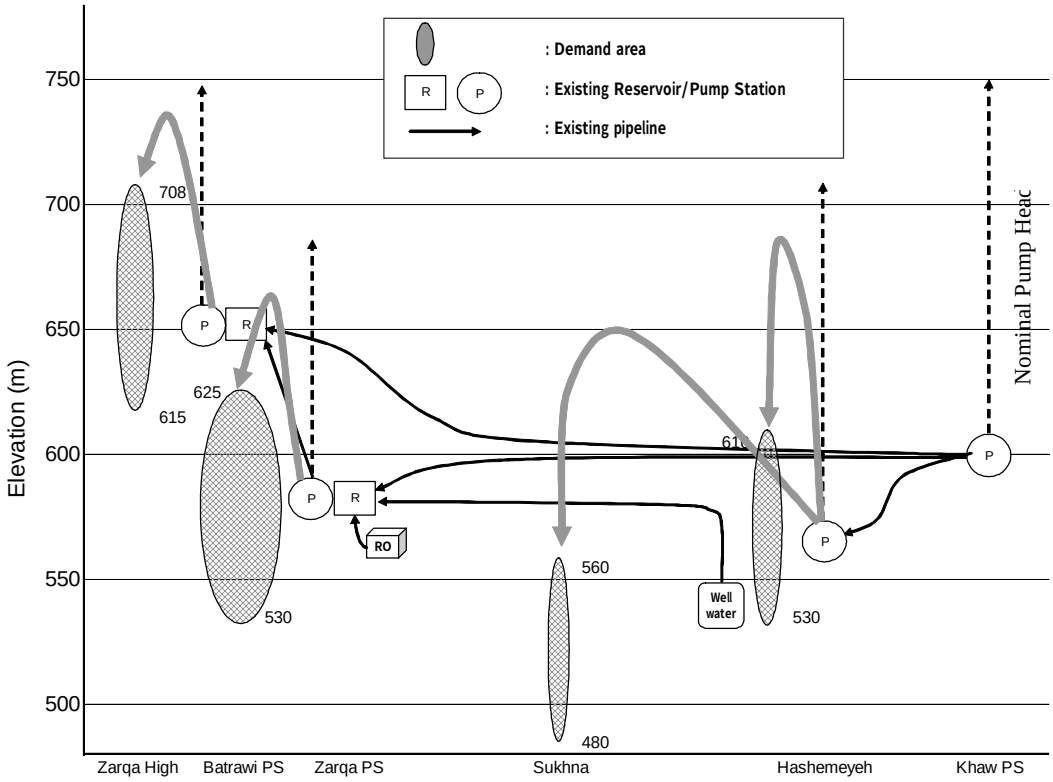
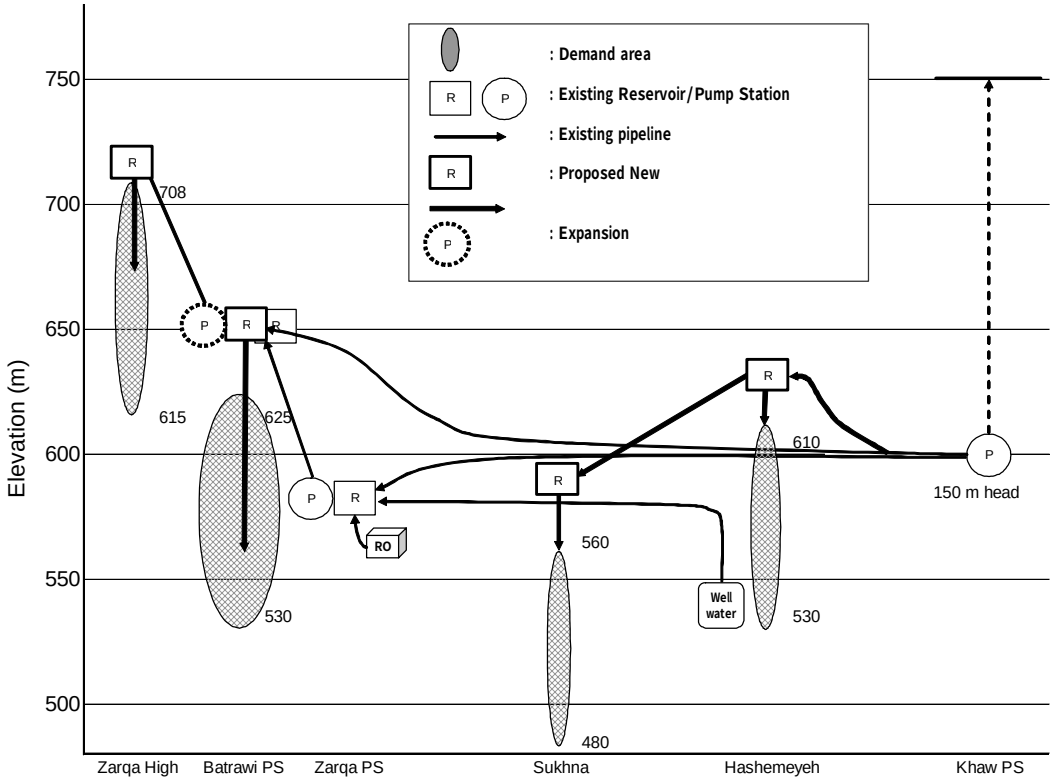


Figure 2.2.5 Planned Distribution Zones and Service Reservoirs



(Existing water supply systems)



(Planned water supply systems)

Figure 2.2.6 Elevation Profile of Water Supply Systems

(3) Planned Service Population in Distribution Zones

Table 2.2.11 shows the planned service population, calculated based on the planned water distribution zoning, future population distribution, and water supply ratio (100%) by distribution zone.

Table 2.2.11 Planned Service Population by Distribution Zone

Proposed Distribution Zones	Estimated Population			
	2005	2010	2015	2025
Zarqa Low Zone	270,315	297,236	320,299	358,948
Zarqa High Zone	33,587	39,860	48,028	66,775
Hashemeyeh Zone	18,754	21,218	23,773	28,979
Sukhna Zone	13,609	15,397	17,251	21,029
Total	336,265	373,711	409,351	475,731

(4) Planned Water Supply Amount (Water Demand)

Table 2.2.12 shows the planned water supply amount, calculated based on the planned daily average water consumption per capita, leakage ratio, and daily maximum coefficient.

Table 2.2.12 Planned Water Supply Amount by Distribution Zone

Proposed Distribution Zones	Daily average water demand (m^3/day)				Daily maximum water demand (m^3/day)			
	2005	2010	2015	2025	2005	2010	2015	2025
Zarqa Low Zone	32,400	44,600	50,000	54,900	38,900	53,500	59,900	66,000
Zarqa High Zone	4,000	6,000	7,500	10,200	4,800	7,200	9,000	12,300
Hashemeyeh Zone	2,300	3,200	3,700	4,400	2,700	3,800	4,400	5,300
Sukhna Zone	1,600	2,300	2,700	3,200	2,000	2,800	3,200	3,900
Total	40,300	56,100	63,900	72,700	48,400	67,300	76,500	87,500

(5) Planned Water Supply Amount

a) Planned Annual Water Demand

For the water sector management by the WAJ in Jordan, where water resources are scarce, water resource development, water distribution and demand control are managed on a nationwide basis and water distribution is planned on a yearly basis, based on the water supply area of each regional WAJ office. Under such circumstances, water distribution to the whole water service area of the WAJ

Zarqa office is taken into consideration when planning water distribution to this project site. The gross water demand in the water service area of Zarqa WAJ office was estimated as shown in Table 2.2.13 and the details as shown in Annex- 2. Of this, the water demand in the project site is 20.5 million m^3/year (2010).

Table 2.2.13 Annual Gross Water Demand in the Water Service Area of Zarqa WAJ Office

	2005	2010	2015	2025
WAJ Zarqa office service area (MCM/y)	40.44	57.20	66.61	79.64
Project site (MCM/y)	14.71	20.48	23.32	26.54

b) Current Water Resources in the Water Service Area of Zarqa WAJ office

Table 2.2.14 shows the water resources related to the water service area of Zarqa WAJ office and the amount of water transmitted to and received from other areas in 2004. At present, the water resources within the Zarqa area amount to 44.86 million m^3/year and the amount of water diverted from Mafraq governorate is 10.46 million m^3/year. Of the above water, the amounts transmitted from Zarqa to Amman, Balqa, Jerash, and Mafraq are 16.43 million m^3/year, 0.24 million m^3/year, and 0.14 million m^3/year, respectively. In addition, to conserve and preserve the Azraq Marshland, 1.07 million m^3/year of water is used. Therefore, the net water sources available for Zarqa Governorate and those in the water service area of Zarqa WAJ office are 37.44 million m^3/year and 38.89 million m^3/year, respectively. The details of the water sources are as shown in Annex-3.

Table 2.2.14 Water Resources Related to the Water Service Area of Zarqa WAJ Office and the Amount of Water Transmitted to and Received from Other Areas (2004)

Water Allocation/Sources	MCM/y (Million m^3/year)
Water sources in Zarqa Governorate	44.86
Import form Mafraq Governorate	10.46
(1) Total water in Zarqa Governorate	**55.32**
Export to the other Governorates	
To Amman (out of the WAJ Zarqa service area)	-16.43
To Balqa and Jerash Govt. (inside the WAJ Zarqa service area)	-0.24
To Mafraq Govt. (inside the WAJ Zarqa service area)	-0.14
(2) Total export to other Governorates	**-16.81**
Al-Azraq wetland (not for municipal use)	-1.07
(3) Net water production for Zarqa Governorate service area	**37.44**
(4) Net water production in WAJ Zarqa service area	**37.82**

c) Related Water Resources Development Projects

Table 2.2.15 and Figure 2.2.7 show the water resources development projects related to this project

that are underway or expected in future. When the Mujib, Zara, and Ma'en water Desalination and Conveyance Project (Balqa) is completed in 2006, in addition to small-scale water sources developments in the Zarqa area, the water supply to Amman is expected to significantly increase, which will enable a reduction in the water amount transmitted from the Zarqa area (Khaw Pumping Station) to Amman and a consequent increase in the water supply to Zarqa.

Table 2.2.15 Water Resources Development Projects

Project name	Increase in water supply amount (million m^3/year)	Description	Progress
Tamween Well Development (Zarqa)	3.94	Development of wells at Tamween (450 m^3/hour) and injection of well water into water pipes in Khaw-Amman.	Expected to be completed at the end of 2005. WAJ own budget.
Efficient Use of Wells at Wadi Al-Halabat and Improvement of the Water Transmission Line (Zarqa)	5.26	Wells were developed at 6 locations (600 m^3/hour). Pipelines to collect water from wells and water transmission lines to the existing Halabat Pumping Station are expected to be developed for utilization of the well water. The water will be transmitted to Khaw Pumping Station via the existing water transmission lines.	Design is completed. With contractors having been selected, construction is expected to be completed within 2006. WAJ own budget.
The Mujib, Zara, and Ma'en Water Desalination and Conveyance Improvement Project (Balqa)	45	With the aim of increasing the water supply amount to the Amman area, the water supply system to desalinate the brackish water taken from the Wadi Zara, Ma'an, and Mujib areas and transmit the desalinated water from the Dead Sea area to the Amman area (improvement of pipeline and Al-Muntazah Pumping Station). A transmission water amount of 45 million m^3/year will be transmitted to existing water pipes at Dabouq.	Under construction. Expected to be completed in June 2006. WAJ own budget and USAID finance.
Disi- Amman Water Transmission Project (BOT)	100	Development of facilities to develop Disi fossil water and transmit it to the Amman area. The average gross water is estimated to be 100 million m^3/year (120 in summer, 80 in winter).	Development of Disi fossil water is expected to be completed by 2015. This water source development will enable water transmission from Amman to the Zarqa area. With the designing stage having been completed, the project is sounding out capital sources. Design by USAID.

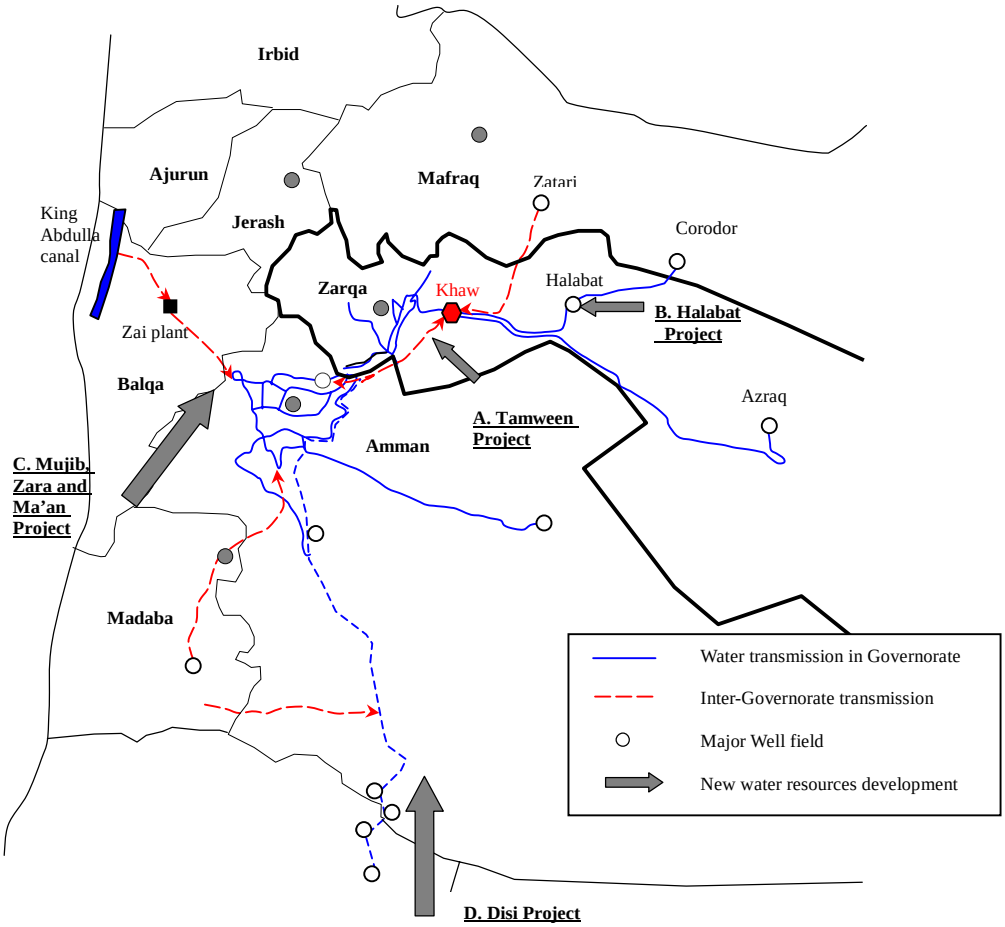


Figure 2.2.7 Related Water Resources Development and Intra-regional Water Transmission System

d) Water Distribution Scenario and Water Demand-Supply Balance

The scenario of water distribution to the water service area of Zarqa WAJ office as developed by WAJ is shown below and the detail of distribution is shown in Table 2.2.16. Furthermore, the demand-supply balance of water in the water service area of Zarqa WAJ office is shown in Table 2.2.17.

Water Distribution Scenario

- The existing water resources in Zarqa area and the amount of water received from other areas will remain the same.
- The small-scale water resources development projects underway in Zarqa will be completed in 2006 and the water produced through the new resources will be utilized for water supply to the water service area under the responsibility of Zarqa WAJ office.

- After completion of the Mujib, Zara, and Ma'en Project (within 2006), water transmitted from Zarqa (Khaw Pumping Station) to Amman will be reduced so as to satisfy the water demand from the water service area of Zarqa WAJ office.
- The Disi fossil water project will be completed by 2015, enabling water transmission from the Amman side.

Table 2.2.16 Details of Water Distribution to the Water Service Area of Zarqa WAJ Office

(million m^3/year)

Water Allocation/Sources	**2004**	**2010**	**2015**	**Remarks**
Water sources in Zarqa Governorate	44.86	44.86	44.86	
Import from Mafraq Governorate	10.46	10.46	10.46	
(1) Total water in Zarqa Governorate	55.32	55.32	55.32	
Export to the other Governorates				
To Amman (out of the WAJ Zarqa service area)	-16.43	-6.25	0.00	After completion of Mujib, Zara and Ma'an project, water transmission from Zarqa to Amman will be reduced.
To Balqa and Jerash Govt. (inside the WAJ Zarqa service area)	-0.24	-0.62	-0.69	
To Mafraq Govt. (inside the WAJ Zarqa service area)	-0.14	-0.15	-0.18	
Al-Azraq wetland (not for municipal use)	-1.07	-1.07	-1.07	
(2) Net water production for Zarqa Governorate service area	-17.88	-8.09	-1.94	
(3) Net water production in WAJ Zarqa service area	37.44	47.23	53.38	
(4) New water development				
Tamween well development		3.94	3.94	
Wadi Al-Halabat well development		5.26	5.26	
Disi water development			3.16	After completion of this project, water transmission from Amman to Zarqa will be possible.
Total new sources		9.20	12.36	
(5) Net water production for Zarqa Governorate service area	37.44	56.43	65.74	
(6) Net water production in WAJ Zarqa service area	37.82	57.20	66.61	

Table 2.2.17 Demand-Supply Balance of Water in the Water Service Area of Zarqa WAJ Office

(MCM/y: million m^3/year)

Items	2005	2010	2015
Water supply for WAJ Zarqa service area	(37.82)	57.20	66.61
Water demand of WAJ Zarqa service area	40.40	57.20	66.61
Water demand of the project site	14.70	20.48	23.32
Water supply and demand balance in the WAJ Zarqa service area	-	0	0

Note: (37.82): actual figure in 2004

As of 2010, the water demand in the water service area of WAJ Zarqa office will be able to be satisfied by restricting the water transmission from Khaw Pumping Station to Amman from 16.43 million m^3/year to 6.25 million m^3/year. On the other hand, as of 2015, the water demand and supply will be balanced by transmitting 3.16 million m^3/year of water from the Amman side after completion of the

Disi fossil water project. However, even if the Disi fossil water project is not completed as scheduled, water supply satisfying 95% of the water demand can be secured.

(6) Water Balance in the Water Service Area of Zarqa WAJ Office in the Target Year

Figure 2.2.8 shows the estimated current (2005) water balance in the water service area of Zarqa WAJ office and Figure 2.2.9 shows the planned water balance in the target year (2010) in the same area.

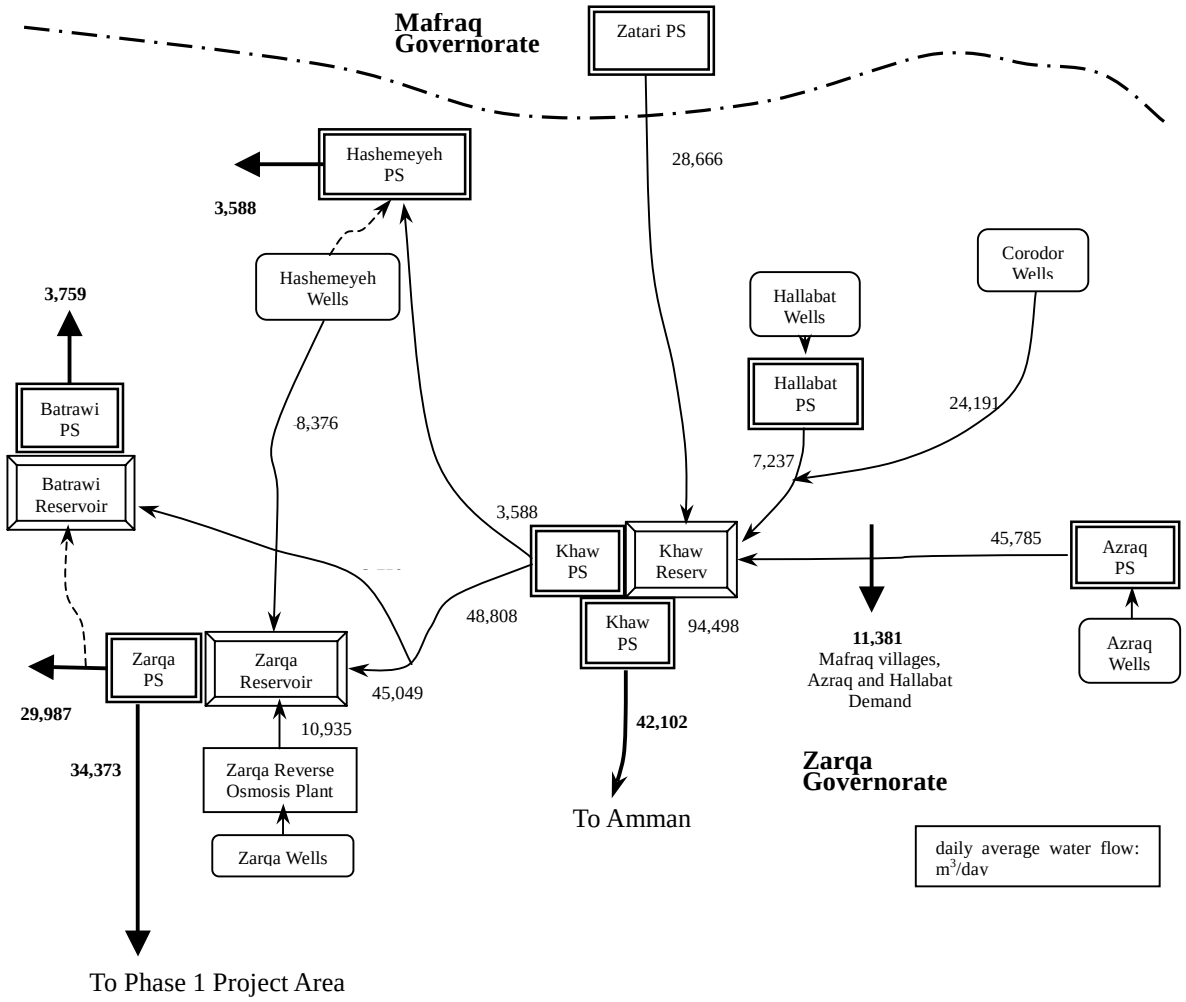
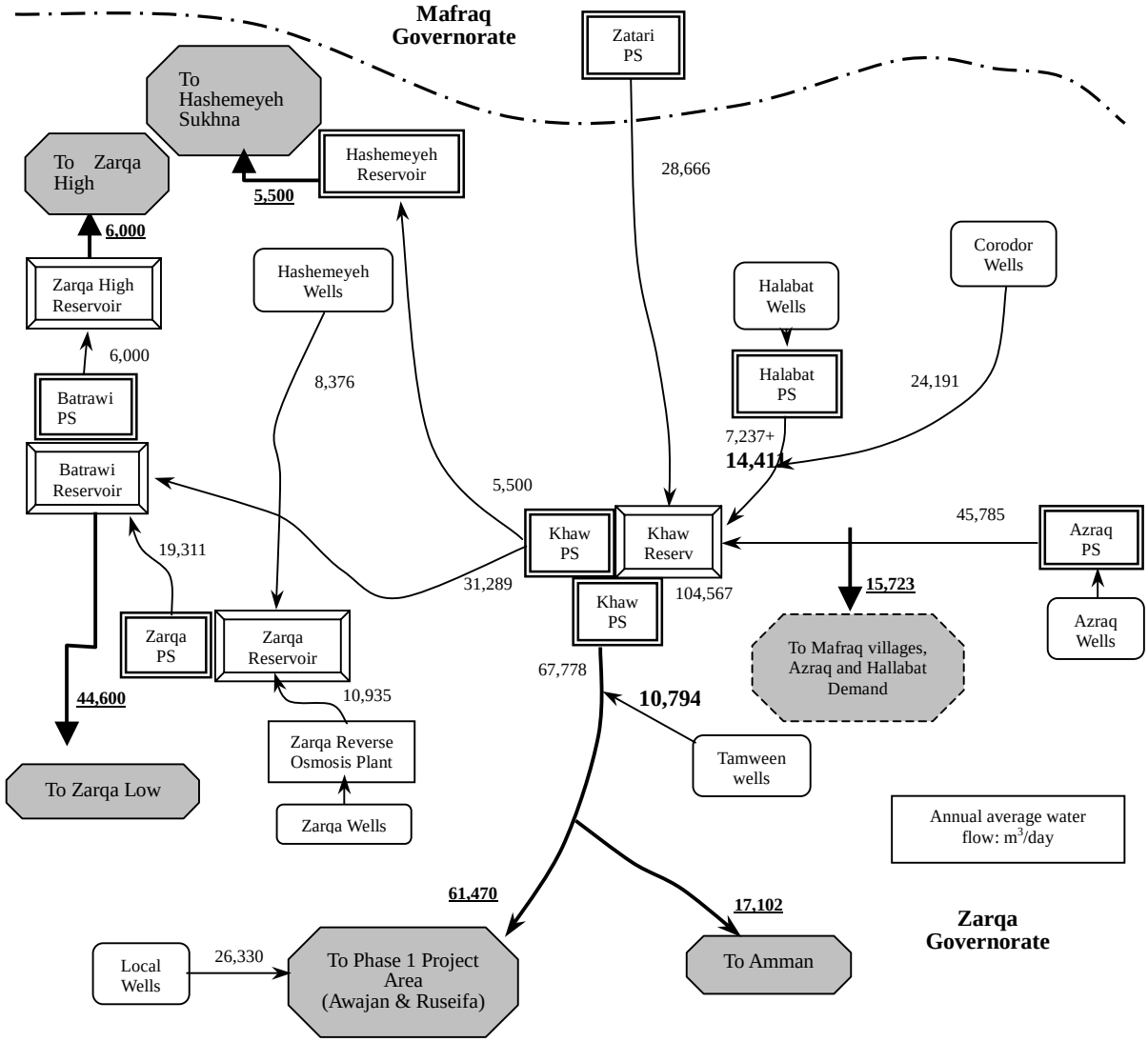


Figure 2.2.8 Estimated (Current) Water Balance in the Water Service Area of Zarqa WAJ Office



Note: The large bold numbers indicate the water amount that will be increased after the on-going projects.

Figure 2.2.9 Planned Water Balance in the Water Service Area of Zarqa WAJ office in the Target Year (2010)

(7) Selecting Sites for the Facilities

1) Selection of Sites for the Reservoirs

Figure 2.2.10 shows the sites selected for the reservoirs and Table 2.2.18 explains the existing conditions and evaluation of proposed sites for reservoirs.

Table 2.2.18 Existing Conditions and Site Selection for the Reservoirs

Symbol	Reservoir	Municipality	Registration No.	Approximate Elevation (m)	Existing land use	Owner
A	Batrawi	Zarqa	5991, 4667, 8272, 8271 etc	625－640	Vacant	Municipality
B	Zarqa High	Zarqa	1505, 1504	710	Vacant	WAJ
C	Hashemeyeh	Hashemeyeh	429, 419 etc	640－645	Vacant	National
D	Sukhna	Sukhna	413 etc	585	Vacant	Private

	Reservoir	Points of Discussion in Siting the Reservoirs
A	Batrawi	Originally, an existing small land owned by the WAJ was planned for the reservoir site, however, it was found later that adjacent land thereto belongs to Zarqa Municipality (according to the deputy mayor and the registry). Zarqa Municipality said that it was no problem to transfer the land to the WAJ for constructing a reservoir. Accordingly, this adjacent land has been selected as the planned land for the reservoir.
B	Zarqa High	WAJ secured this land for constructing the reservoir already in 1995. This land is therefore appropriated for the reservoir.
C	Hashemeyeh	A land at an altitude of around 625 m, where constructing a short access road is feasible, was selected jointly with WAJ. The land is, however, nationally owned, thus requiring handing over of land property in the near future.
D	Sukhna	The site was selected after surveying land around 585 m in altitude from where water can be transmitted by gravity from Hashemeyeh Reservoir to Sukhna Reservoir. At first, constructing the reservoir at around an altitude of 630m was studied based on WAJ's plan, however, considering that i) it is infeasible to transmit water by gravity from Hashemeyeh Reservoir, ii) it is difficult to construct an access road (due to the sharp inclination and the long extension to the candidate site), and iii) a water distribution by gravity from an altitude of about 585m can provide a sufficient pressure to distribute water to the service areas at around 560m to 480m, construction of the reservoir at this altitude was excluded from consideration. The selected land is, however, privately-owned, which hence requires acquisition of the land in the near future.

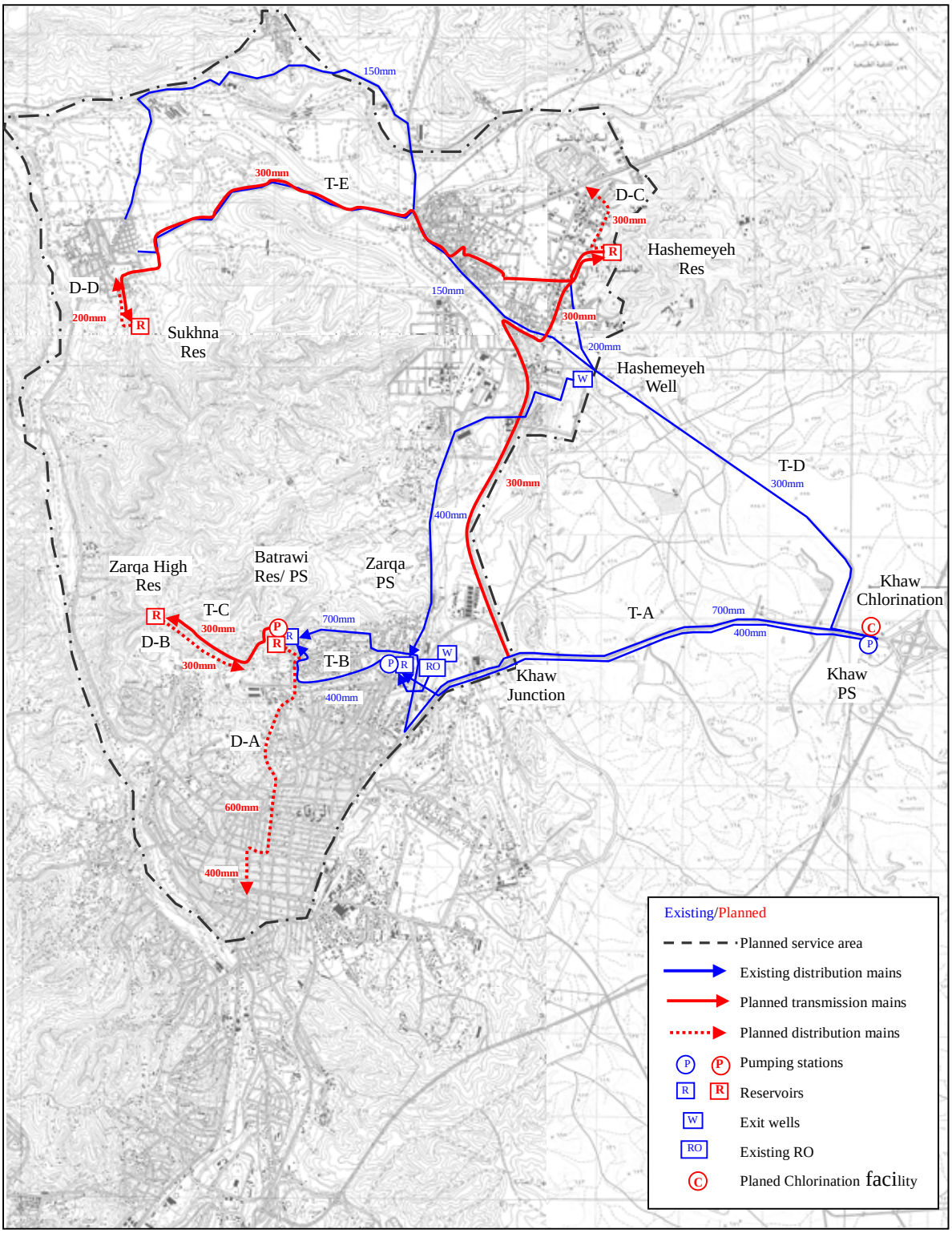


Figure 2.2.10 Layout of the Planned Facilities

2) Selection of Water Transmission Pipeline

The water transmission pipelines selected are summarized in Figure 2.2.10. The following Table explains the rationale for the decisions.

	Pipeline	Studies on Transmission Pipeline
T-A	From Khaw Pumping Station to Batrawi Reservoir	Water transmission from Khaw Pumping Station to Batrawi Reservoir in Zarqa currently runs through existing two pipes (with diameters of 700mm and 400mm). The pipe with a diameter of 700mm is a new ductile cast-iron pipe laid in 2002. The other pipe with a diameter of 400mm is an aged steel pipe. The ductile pipe will be used as the transmission mains in this project.
T-B	From Zarqa Pumping Station to Batrawi Reservoir	Currently, water is distributed from Zarqa Pumping Station by pumping directly to the service areas. Zarqa Pumping Station and Batrawi Reservoir are connected by the existing pipe with a diameter of 400mm, and the water left over after pumping is stored in the reservoir. In other words, Batrawi Reservoir acts as an adjusting (balancing) reservoir. In the future plan, low-quality water from Hashemeyeh Well and reverse-osmosis (RO)-treated water from Zarqa Well will be conveyed from Zarqa Pumping Station to Batrawi Reservoir where it will be mixed with good-quality water from Khaw Pumping Station before being distributed by gravity to the distribution zones or conveyed to Zarqa High Reservoir. Water transmission from Zarqa Pumping Station to Batrawi Reservoir uses the existing conveyance facilities with a diameter of 400mm. The transmission pipeline from Zarqa Pumping Station will be established by separating the distribution pipes connected to this pipeline using valves. In addition, the separated pipes are connected to other existing conveyance facilities running nearby and used again for water service.
T-C	From Batrawi Reservoir to Zarqa High Reservoir	Since there is no water pipe from Batrawi Reservoir to Zarqa High Zone, new water pipes will be laid. A road with a sufficient width for laying pipes was selected as the transmission pipeline route.
T-D	From Khaw Pumping Station to Hashemeyeh Reservoir	Pipes with a diameter of 200mm to 300mm are used to distribute water from Khaw Pumping Station to Hashemeyeh District. This pipeline consists of steel pipes laid in 1980s and is causing frequent leakage due to ageing. Furthermore, the pipeline runs through the military park where it is difficult to perform adequate maintenance work. Besides, this pipeline is used as both distribution and transmission mains and therefore, has branches for the distribution pipes. Due to the frequency of leakage and difficulty in maintenance, this pipeline is not sufficiently reliable as transmission mains, and moreover, since it is inseparable from the distribution pipes to serve only as transmission mains, this existing line will not be used as the transmission mains in this project. In the future plan, this pipeline will be used as backup transmission mains as well as distribution pipes. A new transmission pipeline from Khaw Pumping Station will be secured for this project. The pipeline will take the following shortest route detouring the military park. Khaw Pumping Station - Zarqa-Khaw Highway - Zarqa Highway Junction - Zarqa/Hashemeyeh Highway - Hashemeyeh Reservoir The existing ductile cast-iron pipe with a diameter of 700mm will be used through Khaw Pumping Station → Zarqa－Khaw Highway → Zarqa Highway Junction. For the rest of pipeline between Zarqa-Hashemeyeh Highway and Hashemeyeh Reservoir, a new pipe will be laid.
T-E	From Hashemeyeh Reservoir to Sukhna Reservoir	Since planning the shortest route from Hashemeyeh Reservoir to Sukhna Reservoir is feasible, this route will be adopted as the transmission pipeline.

3) Selection of Water Distribution Pipeline

	Zone	Studies on Distribution Pipeline
D-A	Zarqa Low	The planned water distribution mains for this zone starts from Batrawi Reservoir and runs through the center of the municipality to the south end of the zone. This route was selected so as to avoid the dozens of objects buried in the ground in Zarqa and allow a sufficient width for laying pipes.
D-B	Zarqa High	The planned distribution mains for this zone starts from Zarqa High Reservoir and takes the same route as the planned transmission mains before connected to the existing conveyance facilities (with a diameter of 200mm) near Batrawi Reservoir.
D-C	Hashemeyeh	The planned water distribution mains for this zone starts from Hashemeyeh Reservoir and will be connected to the conveyance facilities (with a diameter of 150mm) situated in the northwest region where is hydraulically disadvantageous comparatively due to its altitude higher than the other parts of the zone.
D-D	Sukhna	The planned water distribution mains for this zone starts from Sukhna Reservoir and takes the same route as the planned transmission pipeline before connected to the conveyance facilities (with a diameter of 150mm) situated in the southern part of the municipality.

(8) Determining the Capacity of the Planned Facilities

1) Capacity of the Planned Reservoirs

The reservoir capacities are set as shown in Table 2.2.19, so that they can store water to be supplied for 8 hours, which is the maximum daily water demand. In addition, WAJ is considering a bulk buying of reservoir sites for up to 2025 on this occasion, and thus, for the referential purpose to derive area necessary for construction, estimation of a necessary reservoir capacity as of 2025 and possibility of augmenting the reservoir capacity at the candidate sites in 2025 are given below.

Table 2.2.19 Capacity of the Planned Reservoirs

Reservoir	Calculated volume (m^3)		Existing volume (m^3)	Required additional volume (m^3)	Planned total volume (m^3)		Possibility of augmenting the reservoir capacity at the candidate sites in 2025
	2010	2025		2010	2010	2025	
Batrawi (Zarqa Low)	17,800	33,000	4,000	13,800	18,000	33,000	Not possible, new site required
Zarqa High	2,400	6,200	0	2,400	2,500	6,500	Possible of 2,500m^3
Hashemeyeh	1,300	2,700	0	1,300	1,500	3,000	Possible
Sukhna	900	2,000	0	900	1,000	2,000	Possible
Planned storage hours (hr)	>8	>12					

2) Diameter of the Planned Transmission Mains

The diameters of transmission mains are set as shown in Table 2.2.20, which enable water transmission at the maximum daily water demand. The results of hydraulic calculation to set the

capacity are given in Annex-5.

Table 2.2.20 Diameter of the Planned Transmission Mains

	Routes	Distance (m)	Diameter (mm)	Existing or proposed
T-A	Khaw PS to Batrawi Res.	9,100	700	Existing
T-B	Zarqa Ps to Batrawi Res.	2,500	400	Existing
T-C	Batrawi PS to Zarqa High Res.	2,080	300	**Proposed**
T-D	Khaw PS to Hashemeyeh Res.	10,750	-	-
T-D1	- Khaw PS to Khaw Junction	4,600	700	Existing
T-D2	- Khaw Junction to Hashemeyeh Res.	6,150	300	**Proposed**
T-E	Hashemeyeh Res. to Sukhna Res.	7,800	300	**Proposed**

3) Capacity of the Planned Transmission Pumps

Existing Batrawi Pumping Station

Batrawi Transmission Pumping Station is the only pumping station to be newly constructed in this project. Batrawi has a distribution pumping station constructed in 2002. The specifications of the existing pumping facilities are as provided below.

Flow direction	Nos.	Capacity (m^3/h)	Head (m)	Power (kW)	Remarks
To Zarqa High Area	No.1	150	100	75	1 stand by
(Distribution pump)	No.2	150	100	75	

Planned Batrawi Pumping Station

The specifications for new required pumps are set as follows, based on an assumption that the capacity for transmitting water to Zarqa High Reservoir equals to the maximum daily water demand in Zarqa High Zone. In addition, in determining the pumping head, efficient combination of transmission main diameter and pumping head was selected. Annex -5 provides the results of network analysis for determining the transmission main diameter and pumping head.

Flow direction	Nos.	Capacity (m^3/h)	Head (m)	Remarks
Zarqa High Reservoir	No.1	300	90	1 stand by
(Transmission pump)	No.2	300	90	

As mentioned above, water supply by pumps will need to be increased in the target year. The existing building of Batrawi Pumping Station will be effectively reused in this project; the specifications for

pump and power supply facilities will be upgraded to accommodate a high capacity, thereby utilizing existing facilities and saving cost. The existing pumps and electrical facilities will be transferred to existing Zarqa Pumping Station for effective reuse.

4) Diameter of the Planned Water Distribution Mains

The diameters of water distribution pipes are as shown in Table 2.2.21, which enable water distribution at the hourly maximum water demand. The results of hydraulic calculation to determine the pipe sizes are given in Annex-6.

Table 2.2.21 Diameter of the Planned Water Distribution Mains

Symbol	Routes	Distance (m)	Diameter (mm)
D-A	Batrawi Res. to the existing distribution mains	-	-
D-A1	Batrawi Res. to the existing distribution point 1	3,080	600
D-A2	The point 1 to point 2	480	400
D-B	Zarqa High Res. to the Existing distribution mains	1,572	300
D-C	Hashemeyeh Res. to the existing distribution mains	1,338	300
D-D	Sukhna Res. to the existing distribution mains	722	200

5) Evaluation of the Capacity of Pumps at Khaw Pumping Station

Necessity for adding transmission pumps at Khaw Pumping Station in 2015 was studied. The details of the study are provided in Annex 5. In evaluation, two cases are studied; whether or not the local water resources of Zarqa and Hashemeyeh Wells will be used.

The study identified that there was no need for adding pumps in the target year. However, if Khaw Pumping Station should also supply water instead of the water from Hashemeyeh and Zarqa Wells spare pumps will be required there. The shortage will need to be supplemented by WAJ as necessary.

6) Study on Water-Hammer Action of the Water Transmission System

Starting and stopping the pump trigger water-hammer in the pumping section of the transmission mains. If the water-hammer action is serious to a certain extent, it may have damage or impact to the pipeline. An analysis on water-hammer action was conducted and following necessary countermeasures shall be implemented.

Route	Result of Analysis and Countermeasures
① Khaw PS to Batrawi Reservoir (Existing pipeline)	The water hummer is lower than the Japanese standard and no countermeasure is required.
② Khaw PS to Hashemeyeh Reservoir	The water hummer is lower than the Japanese standard and no countermeasure is required.
③ Batrawi PS to Zarqa High Reservoir	The water hummer is more than the Japanese standard and the countermeasure that the weight of cup-ring of Batrawi PS shall be taken.

(9) Separating Distribution Zones and Converting Existing Pipes into Transmission Mains

1) Separation Plan

In order to separate the planned four distribution zones, the existing sluice valves will be closed. If there is no sluice valve near the separating point, a new sluice valve will be installed and closed. The positions of existing valves and those to be newly installed are shown in Figure 2.2.11, whereas the details of the new valves are provided below.

Distribution Zone	Diameter	Quantity
Zarqa High and Low Distribution Zones	100 mm 150 mm	2 3
Separation from the other distribution zones	Existing sluice valves will be used.	6

2) Plan for Converting the Existing Distribution Mains into the Planned Transmission Mains

Water pipes to convey RO-treated water stored in Zarqa Reservoir and Hashemeyeh Well water from Zarqa Pumping Station to Batrawi Reservoir are needed. To this end, the existing conveyance facilities (with a diameter of 400 mm) between Zarqa Pumping Station and Batrawi Reservoir are converted into transmission mains. A valve required for the conversion is shown in Figure 2.2.11, whereas its details are as given below.

Detail	Diameter	Quantity
Converting existing pipes to the transmission mains	300 mm	1

(10) Pipeline Plan

1) Connecting the Planned Transmission Mains and Existing Conveyance Facilities

Connecting points of the planned transmission mains and existing conveyance facilities are as follows (Figure 2.2.11).

Table 2.2.22 Connecting Point of the Planned Transmission Mains and Existing Conveyance Facilities

Planned transmission mains	Location	Connecting diameter (Planned pipes – Existing pipes)	Remarks
Khaw Junction - Hashemeyeh Reservoir	Before Hashemeyeh Reservoir	300mm－200mm	Distribution and transmission mains from Existing Khaw Pumping Station to Hashemeyeh Reservoir will be connected with planned transmission mains to serve as the backup transmission pipeline.
Hashemeyeh Reservoir - Sukhna Reservoir	Outskirt of Hashemeyeh Municipality	300mm－150mm	This connection is necessary in order to supply water to small villages on the outskirts of Hashemeyeh. At present, water service is provided from the direction of Hashemeyeh. The high altitude of the area results in an insufficient water pressure if supplied through the existing distribution pipes, and so water will need to be supplied directly from the planned transmission mains as an exception.

2) Connecting the Planned Distribution Mains with Existing Distribution Mains

The connecting points of the planned distribution mains and existing distribution mains are planned as follows (Figure 2.2.11).

Table 2.2.23 Connecting Point of the Planned Distribution Mains and Existing Conveyance Facilities

Connection pipelines (Distribution mains)	Locations	Connection diameter (Planned – existing)
Zarqa Low area	1. City location 1 2. City location 2 3. City location 3 4. City location 4 5. City location 5 6. The end of pipe	600mm－300mm 600mm－300mm 600mm－300mm 600mm－300mm 400mm－300mm 400mm－200mm
Zarqa High area	1. Just outside of reservoir 2. The end of pipe	300mm－100mm 300mm－200mm
Hashemeyeh Zone	1. City location 1 2. The end of pipe	300mm－200mm 300mm－150mm
Sukhna Zone	1. The end of pipe	200mm－150mm

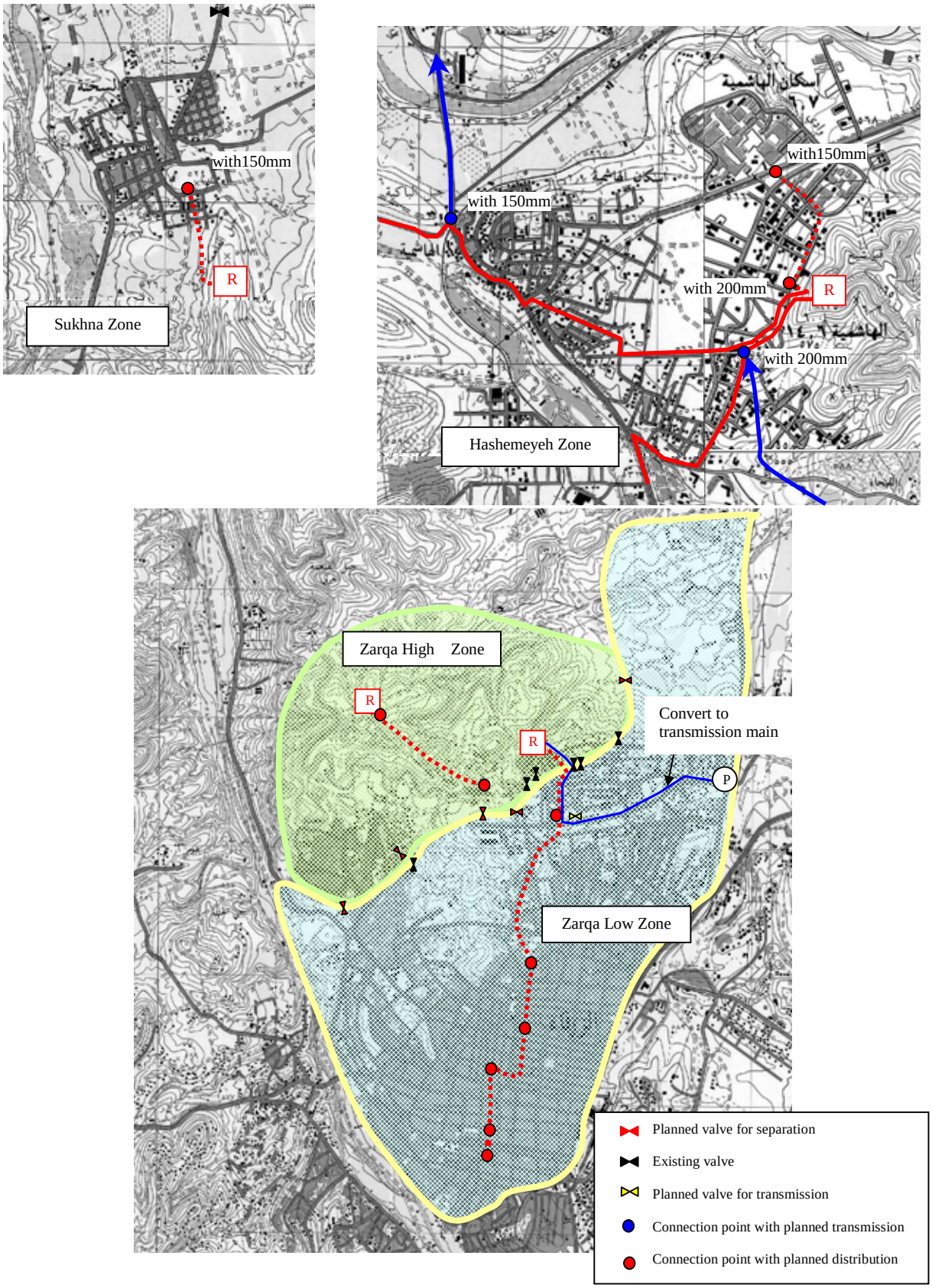


Figure 2.2.11 Locations of Planned Points of Sluice Valve Installation and Connection Points with the Existing Distribution Mains

3) Pipe Materials

Out of the pipe materials stipulated in the WAJ standards, ductile cast-iron pipe has been selected as the materials for the planned transmission and distribution mains in view of the diameter of the mains (600 - 200mm) and the experience of Jordan in using the material. On the other hand, as for pumps, steel pipe will be used in consideration of workability.

Merits of ductile cast-iron pipe

① Its excellent workability allows a quick pipe laying construction which only requires a day for excavation, laying of pipe and backfilling, thereby minimizing impacts to transportation services.
② Its connecting method is a joint construction, which requires no special skills and allows easy securing of water tightness with the local technical level.
③ The joint structure has an excellent flexibility and is advantageous in such events as ground movement due to earthquake or other reasons.
④ Its excellent corrosion resistance combined with high rigidity and flexibility provides an excellent crashproof function. It is also durable.
⑤ The material was used in the first phase project for Zarqa. Hence it is advantageous to use the same material from the prospects of spare parts procurement and maintenance.

4) Auxiliary Facilities

Auxiliary facilities, namely sluice valves, drain valves and air valves, will be installed at necessary points on the pipeline. The following table shows the detailed plan for each valve type.

Type	Installation point and specifications
Sluice valves	Sluice valve will be installed on the primary side of the connecting point of the planned transmission and distribution mains and existing pipes. The specifications shall be as follows: ・ Type: Sluice valve ・ Material: Cast iron or ductile cast iron ・ Connecting method: Flange joint
Air valves	Air valve will be installed at protrusion points along the pipeline. The specifications shall be as follows: ・ Type: air valve chamber ・ Connecting method: Flange joint
Drain valve	Drain valve will be installed at concave points along the pipeline. The specifications shall be as follows: ・ Type: Sluice valve (80 or 100 mm) ・ Material: Cast iron ・ Connecting method: Flange joint

5) Protection of Fittings

Fittings shall be protected by concrete thrust blocks except for the urban areas and the trunk roads where separation-resistant fittings will be used.

6) Crossing the Railroad

The laying route for the planned Hashemeyeh - Sukhna transmission mains crosses a railway track connecting Jordan (Amman) to Syria (Damascus). Considering the fact that the railway only operates twice a week (Monday and Thursday) which allows sufficient time for construction, regular excavation works will be carried out with adequate protection of the rail and after proper consultation of WAJ with the relevant organization.

7) Joint Construction

In light of the workability, economical efficiency and security of required water tightness, T- type (push-on) joints will be used.

(11) Pumping Station Plan

The plan sets 2010 as the target year for pumping equipment. The Batrawi Pumping Station pumping water to Zarqa High Reservoir should have enough capacity to pump maximum daily demand volume. The project includes upgrading of the electrical and metering facilities.

Mechanical equipment	Electrical equipment
Type: Multi stage centrifugal pump	Receiving panel: 1 set
Diameter: suction 150mm x discharge 125mm	Pump panel: 2 sets
Discharge: 5 m^3/min (300 m^3/h)	Control panel: 1 set
Actual Head : 90 m	Instrumentation panel: 1 set
Motor power: 132 kW	
Numbers: 2 units (1 duty and 1 stand by)	

(12) Reservoir Plan

1) Structure and form

RC-structured reservoirs have an economically effective depth of about 4-5 m. Therefore, if there are no constraints on land and the reservoir depths can be adjusted within this range, RC structures will be used. Otherwise, pre-stressed concrete (PC) structures will be used.

For Zarqa High Reservoir (2,500 m^3), Hashemeyeh Reservoir (1,500 m^3) and Sukhna Reservoir (1,000 m^3), sufficient land is available for the construction of facilities and a depth of approximately 4 m can be set, so that RC structure (rectangular), which offers excellent economy at this scale, will be used.

For the Batrawi Reservoir (14,000 m^3), an effective depth of 9 m will be set because capacity is large and the available land is limited. The large depth means that there will be substantial load on the walls, which would require greater use of steel reinforcement and thicker walls if the RC structure were to be used. This will make the RC structure uneconomical. Therefore, the Batrawi Reservoir will be of a PC structure and circular in shape.

In light of the forms of the reservoirs and ground heights etc., planned water levels, effective depths and structures have been determined as shown in Table 2.2.24.

Table 2.2.24 Planned Water Levels and Structures for Reservoirs

Reservoir	Planned volume (m^3)	Low water level (mAD)	High water level (mAD)	Effective depth (m)	Structure
Zarqa Low (Batrawi)	14,000	645	654	9	PC (circular)
Zarqa High	2,500	710	714	4.1	RC (rectangle)
Hashemeyeh	1,500	625	629	4.1	RC (rectangle)
Sukhna	1,000	585	589	4.5	RC (rectangle)

2) Foundation Form and Facility Location Plan

The reservoir foundations will be built with the direct foundation method because the soil for the planned locations of the structures has sufficient bearing capacity to be used as foundation ground. The facilities should be designed in such a way that all the portion of the foundation will be in direct contact with the natural soil surface and no portion will be hanging. If sufficient space is available, facilities will be located in a manner that will enable the future additions to the reservoir.

3) Ancillary Facilities

Piping plans for the facilities in each reservoir include inlet, outlet, bypass, overflow and drainage pipes. In addition, metering equipment (water level meters, flow meters) and control valves will be installed as necessary for operations and monitoring. Concerning outflow pipe, installation of mechanical overflow stop valve was considered but after study this equipment was not adopted due to the following reasons.

- There is no experience to install this valves in Jordan
- It is easy to break since high pressure is placed on the fragile body
- It cannot be repaired in Jordan once it is broken
- At present such valves are not installed in the existing facilities in the project area and overflow is avoided by operating pumps and closing valves manually.
- It is ready made structure of stainless and very expensive.

At present, operations and maintenance of existing facilities are done primarily by hand. In this plan, therefore, the same method shall be adopted to monitor and control overflow at reservoirs, in which the water level in reservoirs shall be periodically monitored and if required pumps shall be stopped or required valves closed so as not to overflow water from reservoir.

In this basic plan, basically, the overflow will not occur because water will be transmitted to reservoirs by planned pump operations and the reservoirs and distribution mains (connection pipes) have enough capacity so as to absorb the daily fluctuation of water demand. However, the overflow might occur at night in winter (November to March) when the water demand becomes small if transmission pump operation is not appropriate. Therefore, the WAJ should monitor the water level at reservoirs carefully in November when the demand is reduced and make a transmission pump operation plan for winter so as not to overflow water from reservoirs.

4) Connection with Existing Reservoir and Pumping Facilities at Batrawi

There is an existing reservoir (4,000 m^3) at the site of the planned Batrawi Reservoir. Appropriate connections will be required between the planned and existing reservoirs and also with the Batrawi Pumping Station in order to effectively utilize the existing reservoir. The high water level of the planned reservoir (654 m) differs from the high water level of the existing reservoir (648 m), and direct connections between the two reservoirs would result in discharge from the overflow pipe of water from the existing reservoir at a level of 648 m, which would make it impossible for the planned reservoir to utilize capacity in excess of 648 m. We will deal with this in the following manner. See Figure 2-2-10 for an illustration.

- Water sent from the Khaw Pumping Station will first be received by the planned reservoir.
- The existing reservoir will store overflowed water from the planned reservoir.
- A check valve will be installed in the existing reservoir so that water will flow from the existing reservoir to the distribution zones but there will be no direct inflow of water from the planned reservoir.
- Piping will be re-laid so that water is taken into the Batrawi Pumping Station.
- Piping around the reservoir will be re-laid accordingly.

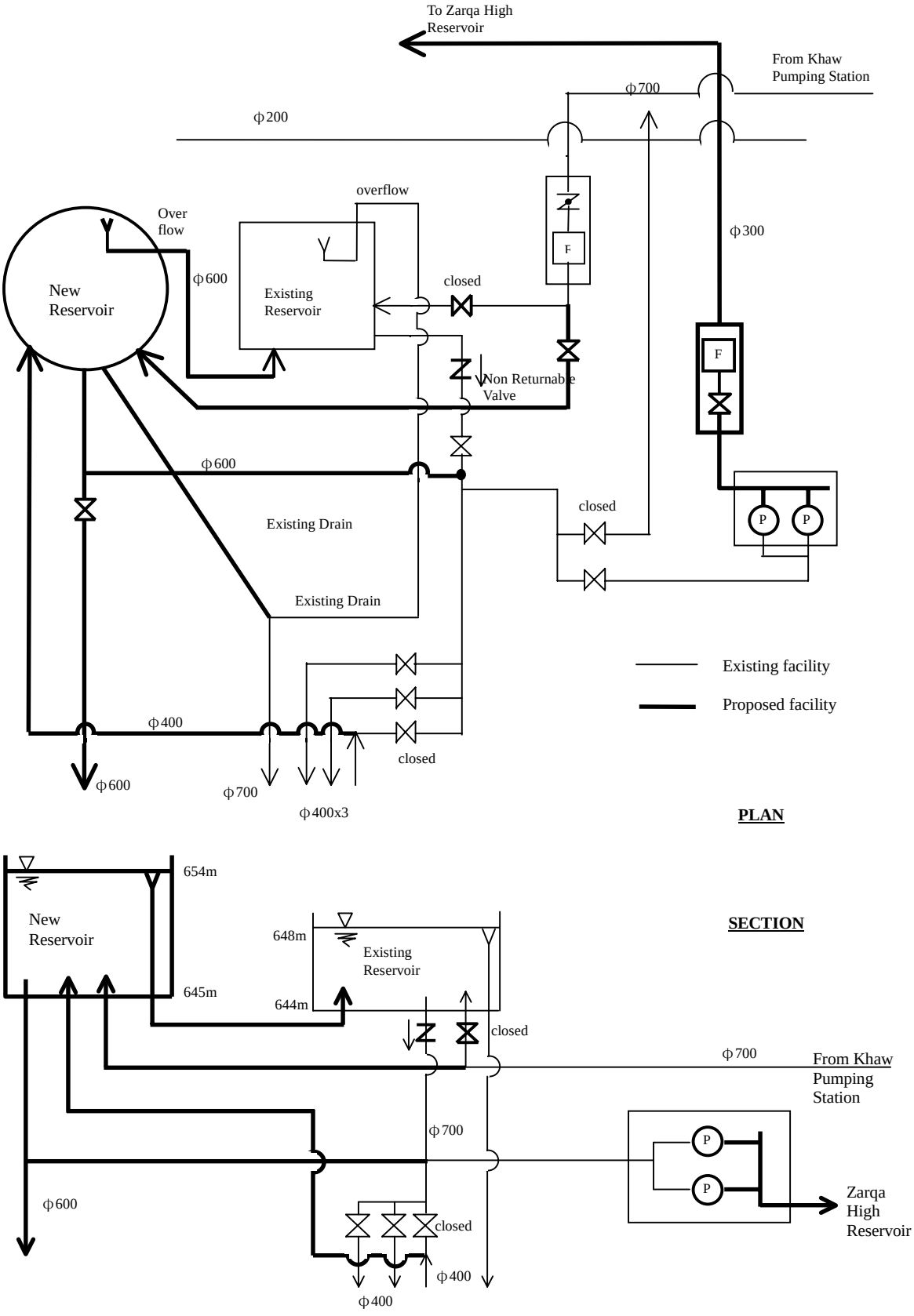


Figure 2.2.12 Connection Diagram for Planned and Existing Batrawi Reservoirs and Pumping Station

(13) Chlorination Facility Plan

1) Current Chlorine Disinfection

WAJ injects chlorine so as to maintain levels at 1.5 mg/L at the pumping station exit and 0.2-0.8 mg/L at the farthest point in the service area, thereby ensuring the microbiological safety of the water. Due to intermittent water supply water pressure in the pipes may drop to zero or even negative during non-supply days. This raises the probability of an intrusion of polluted water into the pipes. The chlorination system will be planned so as to maintain adequate residual chlorine levels at the extremities and supply water that is microbiologically safe.

Below is a description of chlorination practices at the water sources for the project site.

Water sources	Chlorination facility	Location of chlorination dosing	Flow direction	Distance to Khaw PS
Azraq wells	yes	Azraq PS	Khaw PS	Approx. 70km
Hallabat wells	yes	Hallabat PS	Khaw PS	Approx. 23km
Corodor wells	no	Hallabat PS	Khaw PS	Approx. 50km
Zatari wells	yes	Zatari PS	Khaw PS	Approx. 28km
Zarqa wells	yes	Zarqa PS	Zarqa PS	―
Hashemeyeh wells	no	Zarqa PS	Zarqa PS	―

Water from the Azraq, Hallabat, Corodor and Zatari wells is sent to the Khaw Pumping Station, and after storage in a 12,000 m^3 reservoir it is sent to the Zarqa Reservoir, Hashemeyeh Pumping Station and Amman. Neither the Khaw Pumping Station nor the Hashemeyeh Pumping Station has chlorination facilities. At the Zarqa Reservoir, water from the Hashemeyeh Well, Khaw Pumping Station and Zarqa Well is mixed together and chlorinated before being supplied from the Zarqa Pumping Station to the distribution zones. Currently, the water sent to the Hashemeyeh and Sukhna Zones is not chlorinated after chlorination at the water source and it is possible that residual chlorine is not maintained at sufficient levels.

2) Study of Alternatives

The water supply and plan for this project envisions water being sent directly from the Khaw Pumping Station to the Batrawi Reservoir and Hashemeyeh Reservoir, so it will not pass through the chlorination facilities at the Zarqa Pumping Station. This will make it difficult to manage residual chlorine and it is highly likely that residual chlorine will not be maintained at sufficient levels. The plan therefore calls for the placement of chlorination facilities at an appropriate location. Table 2-2-25 summarizes the location alternatives and study findings for these facilities.

The conclusion is to adopt Alternative C in which chlorination facilities are located at Khaw Reservoir because this offers the best safety measures against chlorine leakage, the easiest and most certain water quality management and cost advantages as well.

Table 2.2.25 Chlorination Facility Alternatives

Alternative		Description	Evaluation	Grade
A	Use existing chlorination facilities	・Use the existing chlorination facilities at Zarqa. ・Install new chlorination facilities at the Hashemeyeh Reservoir.	・Has the advantage of using existing facilities.	○
			・If the existing Zarqa facilities are used, additional pumps will need to be installed at the Zarqa Pumping Station in order to send water to the Batrawi Reservoir because the altitude of the Zarqa Pumping Station is 80 m below the Batrawi Reservoir. ・The pumps in the existing Khaw Pumping Station cannot be used effectively. ・Use of the existing obsolete pumps at Zarqa will reduce the reliability of water flows. ・The area around the Hashemeyeh Reservoir is residential and sufficient safety measures will need to be put in place to protect against chlorine leakage. ・A greater number of pumps has disadvantages in terms of both initial investments and running costs. It will also be necessary to install chlorination facilities at the Hashemeyeh Reservoir. In addition to higher costs, management will also be more complex because the chlorination facilities will be decentralized.	×
B	Install new, decentralized facilities	・Install new chlorination facilities at the Batrawi Reservoir. ・Install new chlorination facilities at the Hashemeyeh Reservoir.	・The area around the Batrawi Reservoir and Hashemeyeh Reservoir where the project is planned is residential and sufficient safety measures will need to be put in place to protect against chlorine leakage. ・Decentralized chlorination facilities will be more complex to manage.	×
C	Install in a single location	・Install new chlorination facilities at the Khaw Reservoir.	・Water quality management is easier because chlorination facilities are installed at a single location at the Khaw Reservoir. ・Centralized management has advantages for both maintenance and water quality management. ・This alternative has the lowest initial investment. ・There are no residences in the vicinity of the Khaw Reservoir, so expensive measures to prevent chlorine leakage are not required.	◎

3) Chlorination Facility Specifications

Given below are the plans and specifications for chlorination facilities.

Plan	Specifications
Daily average flow: 105,000 m^3/day Daily maximum flow: 126,000 m^3/day Dosing rate (average): 2 mg/l (maximum): 3 mg/l Dosing amount (daily average): 252g/day (10.5kg/h) (daily max): 378kg/day (15.75kg/h) Frequency of cylinder exchange in average doing rate: ・ Capacity of cylinder: 800kg ・ Frequency: 3.2 days/cylinder ・ Storage requirement: more than 10 days (Japanese guidelines) ・ Required number of cylinders: more than 4 sets ・ Simultaneous use of cylinders: 3 sets ・ Required cylinder stand: 3 for operation and 4 for standby	1. Dosing equipment: 16 kg/h x 2 units 2. Water supply pump: 2 units 3. Leak detector: 1 set 4. Hoist: 1 set 5. Cylinder stand: 1 set 6. Electrical panel: 1 set 7. Air conditioner: 1 set 8. Safety equipment: 1set

(14) Water Distribution Control and Monitoring Plan

The WAJ Zarqa office has a plan for centralized management of water flow, but at present, operations and maintenance are done primarily by hand. This project will install facilities that enable on-site operations and management. However, facilities will be located so as to enable efficient distribution control and management. It is desirable that WAJ move to the centralized management on its own at some point in the future.

1) Operations and Management Plan

We will install control equipment centrally in two locations so as to provide for efficient flow control and management. This will allow facilities requiring management to be concentrated at the Batrawi Reservoir and Hashemeyeh Reservoir and therefore result in operational and maintenance efficiency gains.

- Batrawi Reservoir will control and manage intake volumes from Khaw Pumping Station and outflow volumes to the Zarqa High Reservoir.
- Hashemeyeh Reservoir will control intake volumes from Khaw Pumping Station and outflow volumes to the Sukhna Reservoir.

2) Control and Metering Facilities Plan

At Batrawi Reservoir, intake volumes will be managed with an existing flow meter; at Zarqa High Reservoir, outflow volumes will be managed with the flow meter at Batrawi Pumping Station and controlled pump operation time. Two flow meters and control valves will be installed on the Hashemeyeh Reservoir intake pipe and Sukhna Reservoir outflow pipe to provide control and

management. Water level gauge will be installed at each reservoir so that water levels can be monitored on-site at the reservoir. Given below is the location plan for control and management equipment.

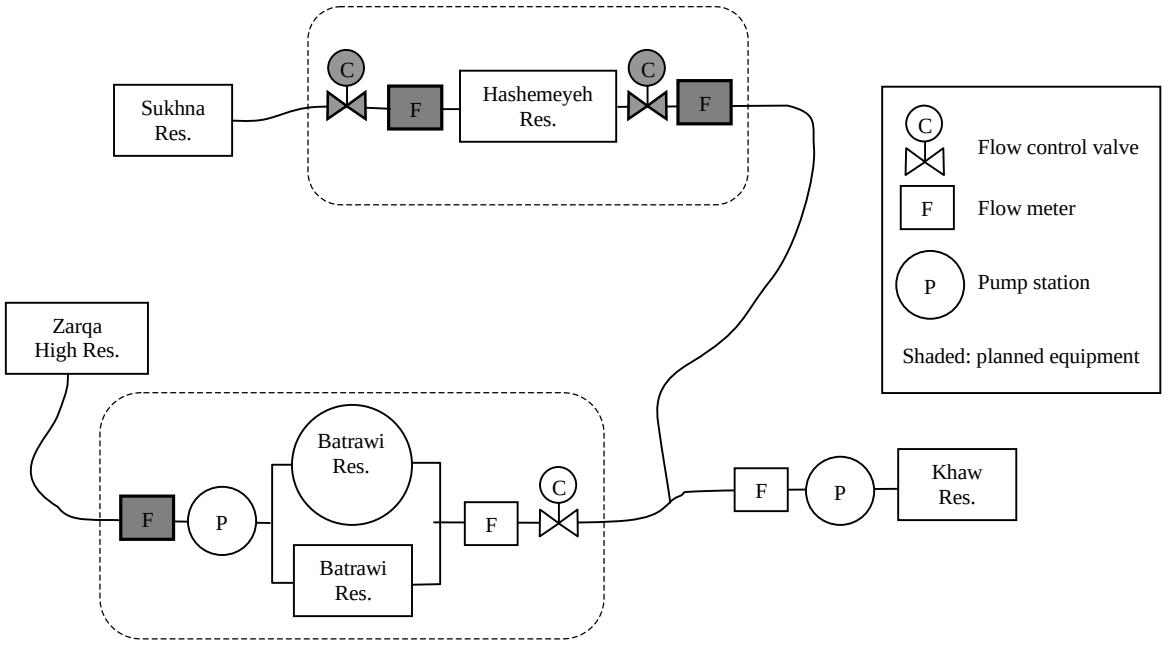


Figure 2.2.13 Locations of Proposed Flow and Flow Control Equipment

(15) Water Quality Improvement Plan

The water quality parameters that need attention in the service area are Total Dissolved Solids (TDS) and NO_3. The water quality data are compiled in Annex-10. Currently, the water of Zarqa and Hashemeyeh Wells does not comply with the water quality standards of WAJ in terms of TDS. To comply with the standards, WAJ treats Zarqa Wells water by reverse osmosis (RO) and mixing Hashemeyeh Wells water with RO treated water and good quality water from Khaw Pumping Station. The current level of water quality (TDS and NO_3) is shown in Figure 2.2.14.

In this Basic Plan, to comply with the standards, Hashemeyeh Wells water, RO treated water and good quality water from Khaw Pumping Station will be mixed in Batrawi Reservoir for distribution (Case 1). In addition, the water quality is estimated if Hashemeyeh Wells water is mixed with a large amount of water in Khaw Reservoir in order to improve the water quality further (Case 2).

The estimated water quality (TDS and NO_3) is shown in Table 2.2.26. In both the cases, the water quality complies with the standards.

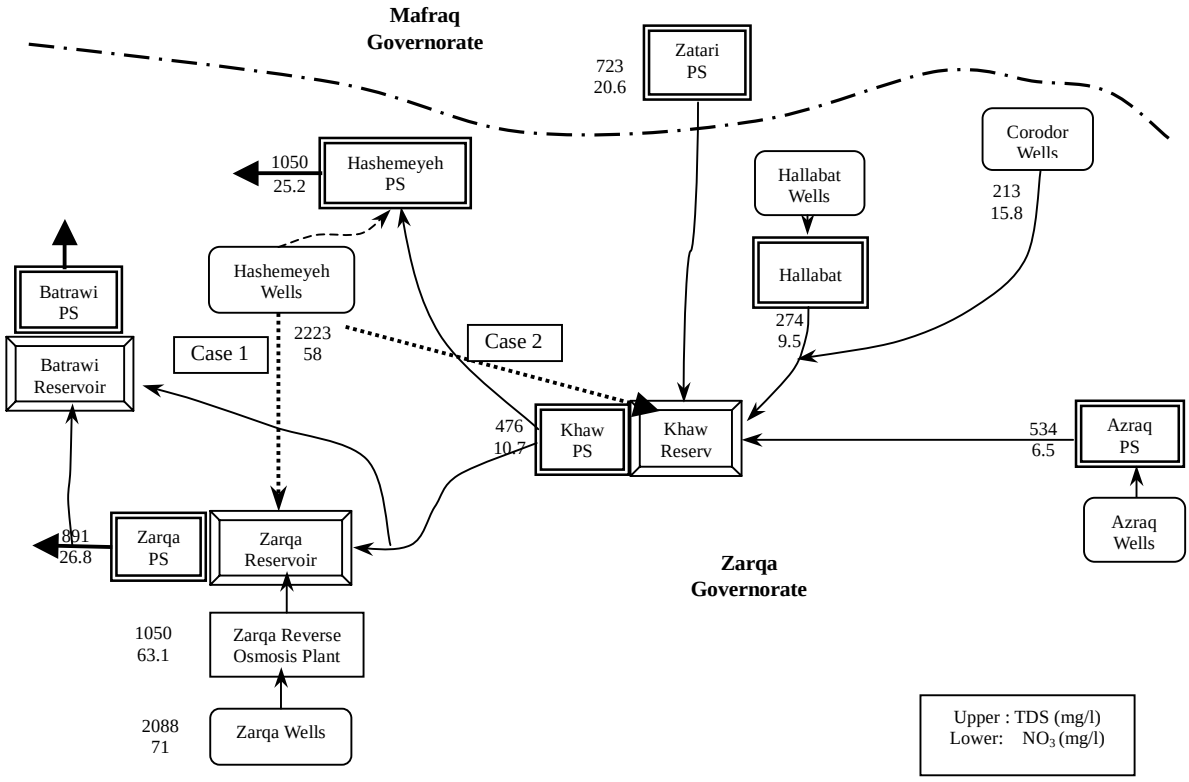


Figure 2.2.14 Current Water Quality Conditions of TDS and NO_3

Table 2.2.26 Estimated TDS and NO_3 Concentration after mixing in Batrawi Reservoir with the Project

Water sources/pumping station	Water supply (m^3/day)	TDS (mg/l) of raw water	Estimated TDS after mixing (mg/l)	NO_3 of raw water (mg/l)	Estimated NO_3 after mixing (mg/l)
Case 1					
Hashemeyeh well water	8,376	2,223		58	
Zarqa well water after RO	10,935	1,050		63.1	
Water in Khaw pumping station	31,289	476		10.7	
Estimated concentration in Batrawi Reservoir	(50,600)		**889**		**30**
Case 2					
Hashemeyeh well water	8,376	2,223		58	
Water in Khaw pumping station	104,567	476		10.7	
Estimated concentration after mixture in Khaw Reservoir	(112,943)		**606**		**14**
Zarqa well water after RO	10,935	1,050		63.1	
Water in Khaw pumping station	39,665	606		14	
Estimated concentration in Batrawi Reservoir	(50,600)		**702**		**25**

2.2.2.4 Summary of Facility Plan

Facility	Route/Contents	
Service reservoirs	(1) Zarqa High	RC structure (rectangular), 2,500 m^3, L25.8 m x W 25.8 x H5.3 m
	(2) Hashemeyeh	RC structure (rectangular), 1,500 m^3, L20.8 m x W20.8 m x H 5.3 m
	(3) Sukhna	RC structure (rectangular) , 1,000 m^3, L15.8 m x W15.8 m x H 5.7 m
	(4) Batrawi (Expansion)	PC structure (circular), 14,000 m^3, D46.7 m x H17.4
Transmission Mains	(1) Batrawi PS - Zarqa High Reservoir	Ductile cast iron pipe, dia. 300mm x L 2,072m
	(2) Khaw Junction - Hashemeyeh Reservoir	Ductile cast iron pipe, dia. 300mm x L 6,141m
	(3) Hashemeyeh Reservoir - Sukhna Reservoir	Ductile cast iron pipe, dia. 300mm x L 7,798m
Distribution Mains (Connection pipes)	(1) Zarqa High Reservoir to the existing distribution mains	Ductile cast iron pipe, dia. 300 mm x L 1,572 m
	(2) Hashemeyeh Reservoir to the existing distribution mains	Ductile cast iron pipe, dia. 300 mm x L1,338 m
	(3) Sukhna Reservoir to the existing distribution mains	Ductile cast iron pipe, dia. 200 mm x L 722 m
	(4) Batrawi Reservoir to the existing distribution mains	Ductile cast iron pipe, dia. 600 mm x L 3,080 m and dia. 400 mm x L 480 m
Batrawi Pumping Station	(1) Renewing of pumping equipment in the existing Batrawi PS (2) Multi stage centrifugal pump (3) Capacity: 5 m^3/min x 90 m head x 132 kW x 2 units (4) Diameter: suction 150mm x discharge 125mm	
Khaw Chlorination Facility	(1) Dosing equipment: 16 kg/h x 2 units (2) Chlorine leak detector 1 set and safety equipment 1set (3) Concrete building: L12m x W 10 m x H6.3 m	
Sluice Valves	(1) Dia. 300mm x 1 no. for separation of transmission (2) Dia. 150 mm x 3 nos. for distribution zoning (3) Dia. 100 mm x 2 nos. for distribution zoning	