THE HASHEMITE KINGDOM OF JORDAN
MINISTRY OF WATER AND IRRIGATION (MWI)
WATER AUTHORITY OF JORDAN (WAJ)

PREPARATORY SURVEY II REPORT ON THE PROJECT FOR REHABILITATION AND EXPANSION OF WATER SUPPLY FACILITIES IN SOUTHERN GOVERNORATES OF TAFIELEH AND MA'AN IN THE HASHEMITE KINGDOM OF JORDAN

NOVEMBER, 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey on the Project for Rehabilitation and Expansion of Water Facilities in Southern Governorates of Tafieleh and Ma'an in the Hashemite Kingdom of Jordan, and organized a survey team headed by Hirotaka Sato of Tokyo Engineering Consultants Co., Ltd. between April, 2010 to July, 2010.

The survey team held a series of discussions with the officials concerned of the Government of the Hashemite Kingdom of Jordan, and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

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

Finally, 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 survey team.

November, 2010

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SUMMARY

1. Overview of the Country

The Hashemite Kingdom of Jordan (hereinafter referred to as "Jordan") has a population of 5.85 million people (as of 2008) and land area of 89,316 km^2. It is surrounded by Israel (West Bank, Palestinian Interim Self-Government Authority) in the west, Syria in the north, Iraq in the east, and Saudi Arabia in the southeast. Western area of the Kingdom has a narrow valley, known as Jordan Valley, which spreads from Jordan River through the Dead Sea (which is 400m below sea level) and to the Gulf of Aqaba in the Red Sea. The east side of Jordan Valley is a plateau area of 600 ~ 1,500 m above sea level, and on the east of the plateau area is a desert area which covers around 75% of the national land. Most of the rainfall occurs during winter. The amount rainfall varies, reaching an average of up to around 660 mm in the northeast plateau and only around 120 mm in the desert area.

Most of the south region of Jordan, which is the project area, has desert or desert steppe climate, and its annual rainfall is around 200 mm or less, with extremely high evaporation, high-temperature in the summer, and dropping to below-freezing in the winter. Tafieleh Governorate is located at a hilly plateau, its elevation ranging from around 900 ~ 1,600 m, with annual average temperature of approx. 16℃, maximum temperature of approx. 46 ℃ and minimum of approx. 8℃. Ma'an Governorate is located at a flatland around 1,000 m above sea level, with annual average , maximum, and minimum temperatures of approx. 18, 45, and -6℃ respectively (as of 2008).

The per capita Gross National Income (GNI) of Jordan is 3,310 dollars, and for the Tertiary industries including tourism has the highest share of GDP accounting for 63.0%, followed by secondary industries accounting for 34.1%, and primary industries accounting for 2.9% (as of 2008). The economy of Jordan marked high growth, 5% yearly average from late 1980s to 2004, however, has worsened or is stagnated caused by the worldwide slowdown, particularly due to the impact of the global financial crisis of 2008.

Jordan is currently facing various problems, which include socioeconomic load due to influx of massive Iraqi refugees, poverty and unemployment rate remaining at a high level, and necessity of further development of infrastructure associated with the growing population due to the high birthrate, etc. The influx of Iraqi refugees is especially an additional economic load for fields such as water, education, and health, pressuring the economic infrastructure.

Tafieleh and Ma'an Governorates are the most undeveloped areas of Jordan, and the socioeconomic situation such as household income and unemployment rate of these areas are worse than that of the central and northern regions including Amman.

2. Background of the Project

The water resource and water supply development of Jordan have been implemented around the central area including the capital Amman. Cooperation of Japan and other donors have mainly been implemented around the central area; therefore the expanding regional gap of the water supply service and living standard are becoming a problem. The water administration of Tafieleh and Ma'an Governorates at the southern part of Jordan (Water Authority of Jordan (WAJ) Tafieleh office and Ma'an office) are supplying ground water by gravity from the distribution reservoir or sometimes by direct pumping. However, sufficient volume is not supplied due to problems such as the high ratio of non-revenue water (50% or more) or lack of capacity of trunk water supply system. Thus, the time for water supply is limited, and per capita revenue water is remaining at a low level (Tafieleh Governorate: approx. 73 L/day, Ma'an Governorate: approx. 100 L/day, WAJ statistics, 2008).

In an effort to reduce the non-revenue water of Jordan, the "Capacity Development Project for Non-Revenue Water Reduction" (2005~2008) and "Capacity Development Project for Non-Revenue Water Reduction (Phase 2)" (2009~2011) were implemented by Japan, which assist the development of the organizational structure of WAJ as well as its capacity. As a result of these projects, the capacity concerning the non-revenue water management of WAJ (detection of leakage and repair, etc.) was improved, and reduction of non-revenue water was achieved in the pilot area. Furthermore in Phase 2, water distribution management considering the difference in elevation, and strengthening of capacity for preventive management of non-revenue water are being implemented. However, aging of water distribution network in Tafieleh and Ma'an Governorates is severe, therefore fundamental measures including upgrading of distribution pipes are urgently needed for non-revenue water management. Moreover, the existing water supply system cannot meet the increasing water demand, and as a result, inefficient water transmission and distribution by using booster pump for residents of highlands is necessitated.

Under such background, the Government of Jordan had requested for a grant aid project to Japan in July 2008, for the purpose of improving the water supply service in Tafieleh Governorate and Ma'an Governorate by upgrading the water distribution network and building new reservoirs. In response to this request, a preparatory survey (part 1) was implemented in October 2009, where relevance of implementing the plan and necessity or priority of each component was reviewed. As a result, the southern area of Tafieleh Governorate including Tafieleh city and Ma'an city of Ma'an Governorate were chosen, for their high priorities assigned by the Government of Jordan, and large population of beneficiaries. The requests of the project area are shown below.

Tafieleh Governorate	• Construction of reservoirs (400 m^3×1, 1,000 m^3×1, 2,000 m^3×2) • Construction of pumping station (1 location) • Upgrade of water distribution network (ductile iron pipe, φ100~300 mm, approx. 30 km, and PE pipe, OD 63 mm, approx. 51 km)
Ma'an Governorate	• Construction of reservoirs (400 m^3×3, 1,000 m^3×2, 2,000 m^3×1) • Upgrading of water distribution network (ductile iron pipe, φ100~300 mm, approx. 33 km, and PE pipe, OD 63 mm, approx. 140 km)

Subsequently, the outline design survey for the project was decided to be implemented, and JICA had dispatched a preparatory study team (part 2) to the site from April 10 to July 16, 2010. At the field survey, the team held a discussion with the Government of Jordan and WAJ personnel regarding the contents of the request, surveyed on present state of the project site, and gathered related materials. The survey team reviewed the relevance and effectiveness of the project in the analysis after returning to Japan, and created a draft report on the preparatory survey, including the proposal for an optimum water supply system. Based on this plan, JICA dispatched a team for explaining the overview of the outline design to Jordan from October 23 to October 28, 2010, explained the contents of the plan, and held a discussion. As a result, the Government of Jordan had basically agreed with the contents of the plan. This final report was prepared based on the result of above mentioned survey, analysis, and discussion.

3. Overall Goal

Jordan established the “National Agenda 2006-2015” as a comprehensive national strategy, which presents the issues and measures that Jordan must address. Here, the issues of the water-related field are pointed out, such as insufficient recyclable water resource, depletion of groundwater, inefficient water distribution, inappropriate water charge, and insufficient sewage treatment capacity. As one of the measures, “streamlining of operation, maintenance, and management, and reduction of non-revenue water” was put forward.

Additionally, WAJ set up the following main objectives in the “Summary of Strategic Plan for 2007–2012”, which is the overall goal of this project.

① Reduce the gap between available water supply and demand (improve average daily water consumption per capita from 100 L as of 2006, to 120 L in 2012)
② Improve the high non-revenue water (NRW) ratio (national average NRW ratio 45% as of 2006, to 32% in 2012)
③ Enhance the responsibility and duties of WAJ based on the law
④ Strengthen beneficiaries-pay principle and personal funds
⑤ Improve customer satisfaction and promote cooperation of citizens

4. Current Situation and Problems of the Sector

The water administration in the southern area of Jordan which is the requested project area is supplying the water through gravity flow and pumping from the well which is the water resource. However, due to the high NON-REVENUE WATER ratio and lack of capacity of trunk water system, time for water supply is limited, and the volume of daily revenue water per capita remains at low level. The NON-REVENUE WATER ratio of the project area in Tafieleh Governorate is approx. 47%, and in the project area of Ma'an Governorate is approx. 61%, indicating higher percentage compared to the national average of 43.9% (as of 2008). Around half of the non-revenue water is assumed to be caused by leakage due to aging distribution pipes or high water supply pressure, and the rest caused by under registration of the meters or illegal connections. In addition, most of the distribution pipes are galvanized steel pipes or black steel pipes that have passed average of 22 to 39 years after installation. Galvanized steel pipes have low resistance to high water pressure and corrosion which can cause leakage, and additionally, the degradation of black steel pipes with tar coating on the inner side are causing water quality problems.

Furthermore, Tafieleh Governorate is located at a highland with undulated hills, but does not have pressure reducing facilities or water distribution zones to maintain appropriate water supply pressure. As a result, water pressure is high in the areas at low altitudes, while it is low in the areas at high altitudes, causing leakage or low water supply pressure. Additionally, lack of reservoir or aged pumps with inappropriate capacity cannot supply appropriate volume of water, therefore water supply is limited to 1-3 days/week in the southern regions of Tafieleh Governorate such as Bsaira, Gharandal and Qhadesiyeh etc. causing a great impact to the residents' lives.

5. Overview of the Study Results and Contents of the Project

(1) Project Area

From the time of request for this project (July 2008), components of the project for Tafieleh Governorate and Ma'an Governorate in the southern part of Jordan were planned. A preparatory survey was implemented based on this plan. However, the analysis result in Japan indicated that the project cost would exceed the budget limit prepared by the Government of Japan, therefore necessity to change the plan arose. The policy of reducing the components was discussed with the concerned agencies of Jordan, and was finally agreed that Tafieleh city and the south of the Tafieleh Governorate shall be selected for the project area.

(2) Project Objective

The objective of the project is to restructure the water transmission and distribution system (construction of reservoir, upgrading of distribution network, setup of water distribution zone, installation of pressure reducing facility, installation of water distribution monitoring system, and optimization of transmission pumping plant), reduce the non-revenue water volume, and equally distribute increased water availability, in order to improve the water supply service of the project area.

(3) Design Policy

This Grant Aid Project aims to construct reservoir, rehabilitate and expand pumping station, and upgrade aged water pipes in order to contribute to "the Upgrading and Expansion of Water Facilities at Tafieleh and Ma'an (WAJ existing plan)" prepared by the Government of Jordan which is targeting to improve the residents' lives through reduction of the non-revenue water, increase of the revenue water, and equitable water supply. This project is planned based on the policies below, taking the request by the Government of Jordan, field survey, and results of the discussion into account.

1) The target year of the project shall be 2015.
2) Reservoirs can be constructed by staged construction and the target year of the reservoirs shall be the same as the target year of the project. However, staged construction shall become difficult for pumping stations and distribution pipes in future. Therefore, the target year planned for the pumping station and distribution pipes shall be set 2025, which is the target year of the WAJ existing plan.
3) Based on the population growth rate predicted by the Department of Statistics of Jordan and the census of the past, the population of the project area is assumed to be 70,100 people in 2015, and the total population of the areas targeted for upgrading the distribution pipes (Tafieleh city, Bsaira, Gharandal, and Qhadesiyeh) is assumed to be 47,559 people.
4) The planned daily water supply amount per capita in 2015 is 147 L, planned revenue water amount per capita is 96 L, planned non-revenue water amount is 35%, and planned leakage ratio is 15%. Additionally, the planned minimum hydraulic water supply pressure is 0.25 MPa in principal.
5) The design policies for the facilities are as follows.
    - Water transmission system and water distribution system shall be separated, and appropriate water distribution zone shall be set for effective non-revenue water management and water distribution management.
    - Reservoirs shall be constructed, and water supply method shall be changed from pumping system to gravity flow method from reservoir.
    - Reservoirs shall be built at a location where environmental and social impacts are the least, and is hydrologically advantageous.
    - Pumping station and water transmission pipes shall be developed for the separation of distribution system from transmission system, construction of reservoirs, and change of water distribution method. The existing building of the pumping station at Erawath shall be utilized, and machine/electrical equipment shall be upgraded upon developing the pumping station.

- Pressure reducing valves shall be installed to the water distribution network in order to maintain water distribution pressure in an appropriate range.
- Flow meters and pressure gauges shall be installed to the reservoirs, pumping station, and water distribution zones, in order to develop a water distribution monitoring system. Flow volume and water pressure shall be monitored using this system at the WAJ Tafieleh office, which enables control and analysis of data.

6) Since the capacity of the WAJ Tafieleh office staff for water distribution management and non-revenue water management is insufficient, it is planned for capacity building regarding management and utilization the data of water distributed amount and non-revenue water through soft-components.

As a result of formulation of the outline design based on these policies, the major differences compared to the initial request and newly confirmed items were found as shown below.

1) One distribution reservoir was initially planned for Bsaira and Gharandal. However, separate distribution reservoirs shall be planned for each of Bsaira and Gharandal areas as a result of selecting hydrologically ideal location for reservoir considering the spreading of water supply area and the topography.
2) Enhancement of water transmission capacity was required for stable water supply to the southern area of Tafieleh (Bsaira, Gharandal, and Qhadesiyeh), therefore water transmission pipes shall be installed.
3) It is planned for the Japanese side to carry out the installation of distribution pipes of 100 mm or larger, while distribution pipes and water supply pipes of smaller than 100 mm shall be carried out by the Jordanian side. In order to ensure the installation of distribution pipes, Japan shall procure the pipe materials for distribution pipes of smaller than 100mm.

The table below shows the outline of project facility planned based on the above policies.

Facilities	Specification/capacity/quantity	
Reservoir	Bsaira	RC structure, rectangular shape, capacity: 1,200m^3 L 19.4m x W 18.8m x H 5.45m
	Gharandal	RC structure, rectangular shape, capacity: 600m^3 L 13.4m x W 12.8m x H 5.95m
Erawath Pumping Station (PS)	Rehabilitation for transmission pump for planned Gharandal reservoir	Renewal of existing pump equipment Q: 0.95m^3/min. x Head: 225m x 2 sets Horizontal shaft single suction multi-stages centrifugal pump Electrical works and instrumentation
	Expansion for transmission pump for existing Qhadesiyeh reservoir	Construction of a pump house for expansion pumping station Q: 1.5 m^3/min. x Head: 380m x 2 sets Horizontal shaft single suction multi-stages centrifugal pump Electrical works and instrumentation Air breathing valve for anti-water hammer : 3 sets (on the pipe between pumping station to existing Qhadesiyeh reservoir) Altitude valve in existing Qhadesiyeh reservoir
Transmission pipeline	Erawath PS－Planned Gharandal reservoir	DIP 150mm x 3,540m
	Bsaira Junction – Bsaira reservoir	DIP 200mm x 460m
	Bsaira entrance – Bsaira Junction	DIP 250mm x 2,270m
	Ain-El Baidha reservoir – Bsaira entrance	DIP 300mm x 7,950m
Distribution pipeline	Tafieleh city	DIP 100mm x 6,230m DIP 150mm x 3,020m DIP 200mm x 2,510m DIP 250mm x 2,210m DIP 300mm x 90m Pressure reducing valve: 4 places
	Bsaira	DIP 100mm x 3,300m DIP 150mm x 490m DIP 200mm x 2,930m DIP 250mm x 460m Pressure reducing valve: 7 places
	Gharandal	DIP 100mm x 2,460m DIP 150mm x 320m DIP 200mm x 1,000m Pressure reducing valve: 5 places
	Qhadesiyeh	DIP 100mm x 2,250m DIP 150mm x 1,780m DIP 200mm x 1,320m Pressure reducing valve: 6 places
Distribution monitoring system	Tafieleh city and Tafieleh south area	Central monitoring system: 1 set Flow meter for reservoir and pumpingstation: 12 sets Flow meter and pressure meter for District metwrd area(DMA): 3 sets
Procurement of pipe materials	Tafieleh city, Bsaira, Gharandal, Qhadesiyeh	HDPE OD 63mm x 50,600m

6. Construction Period and Estimated Project Cost

For the project, approx. 8 months for detailed design and tendering, and approx. 23 months for construction are estimated.

The estimated cost to be borne by WAJ required for the implementation of the Project is 7,433,800 JD.

7. Project Evaluation

(1) Relevance

1) Beneficiaries and population

The water service for the 70,100 residents in 2015 of the project area in Tafieleh Governorate which is one of the least developed governorates of Jordan shall be improved by implementing the project.

2) Project objective and BHN

The water supply time of the project area is 1~3 days/week, and the average daily revenue water per capita is only 84L, therefore the residents are forced to have inconvenient lives. The implementation of the project can lead to appropriate water supply pressure, reduce the leakage ratio, resulting in increase of water consumption, or enable water supply to more population in the future from the same water resource volume. Additionally, water supply time will be increased. The project enables to upgrade the water supply service to a certain level required for minimum standard of life and can contribute to satisfy the basic human needs (BHN).

3) Improvement of residents' lives and stabilization of standard of life

The implementation of the project contributes to improving the residents' lives through improvement of water supply service and thus the welfare in the remote area from the center of Jordan will improve, thereby contributing to the socioeconomic disparities between urban areas including Amman, and remote areas. Therefore, the project contributes to the stabilization of people's livelihood in Jordan.

4) Facilities that are Easily Operated and Maintained

By upgrading the water distribution network, setting up of water distribution zones, and restructuring the trunk transmission and distribution system, water supply facilities that can easily be operated and maintained will be developed. As a result, amount of work for operation and maintenance, and thus reduction of related costs are expected. Additionally, the reduced work will be utilized for implementing the activities for planned non-revenue water management. Furthermore, the equipment used in the project can be procured within Jordan or through the agencies. The pump, the main equipment of the project, is manually operated, which can be operated and maintained solely by the Jordanian side.

5) Contribution to Mid-to-long Term Development Plan

In the policy of the mid-to-long term plan of Jordan, the "National Water Strategy", the limited water resource shall be effectively used as much as possible. This project contributes to achieving the objective of the mid-to-long term plan through reducing leakages and non-revenue water.

6) Utilization of Technology of Japan

The project area is an extremely hilly terrain where control of water distribution pressure is difficult. Japanese technology is needed for method separating the distribution zone for controlling the water distribution pressure within the appropriate range, and installing pressure reducing valves to appropriate positions in the pipe network to adapt to such terrain.

7) Contribution to Measures for Environment and Climate Change

By implementing the project, water volume of intake and transmission can be reduced due to less leakage, and efficiency of the existing pumping station can be improved; therefore, the power consumption is reduced, resulting in reducing CO_2. Japan is addressing assistance for projects that settle the environmental and climate change issues including global warming, thus, the project matches the aid policy of Japan.

(2) Effectiveness

1) Quantitative Effects

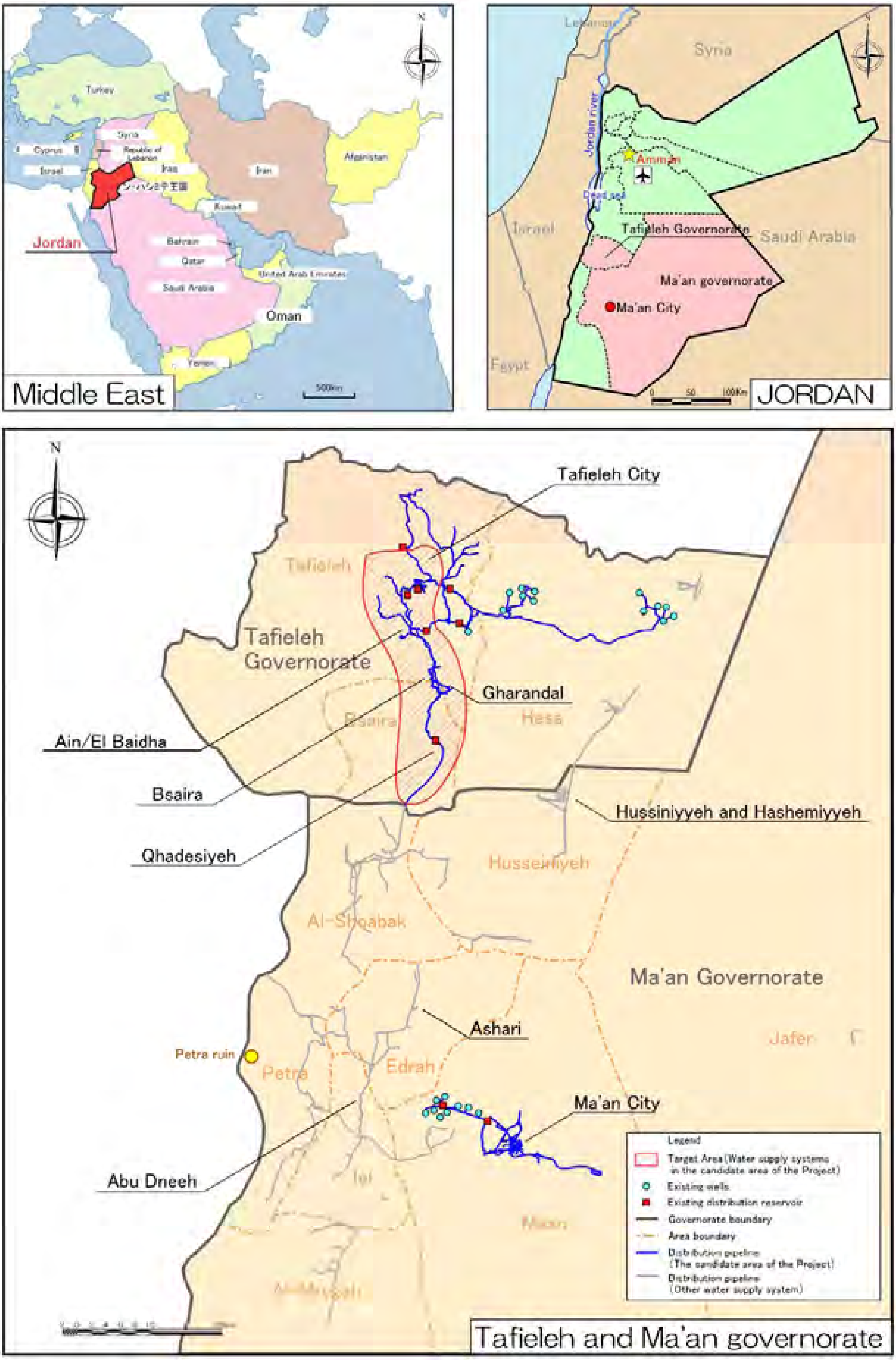
- The daily revenue earning water per capita in the area subject for upgrading of the water pipe network in Tafieleh Governorate (population: 47,559 people) increases from 84 L to 96 L.
- The NON-REVENUE WATER ratio reduces from approx. 47 % to 35%, and leakage ratio from 25 % to 15 %, in the area subject for upgrading of the water pipe network in Tafieleh Governorate.
- The no supply period can be shortened from 4~6 days/week to 3.5 days/week in the southern area of Tafieleh Governorate (Bsaira, Gharandal, and Qhadesiyeh).
- 3,488 MWh of power consumption is saved yearly due to the reduction of water leakage and improved efficiency of the water transmission pumps, as well as reducing 147,834JD operation, maintenance and management cost.
- Approx. 2,132 tons of CO_2 is reduced yearly due to the reduction of power consumption.

2) Qualitative Effects

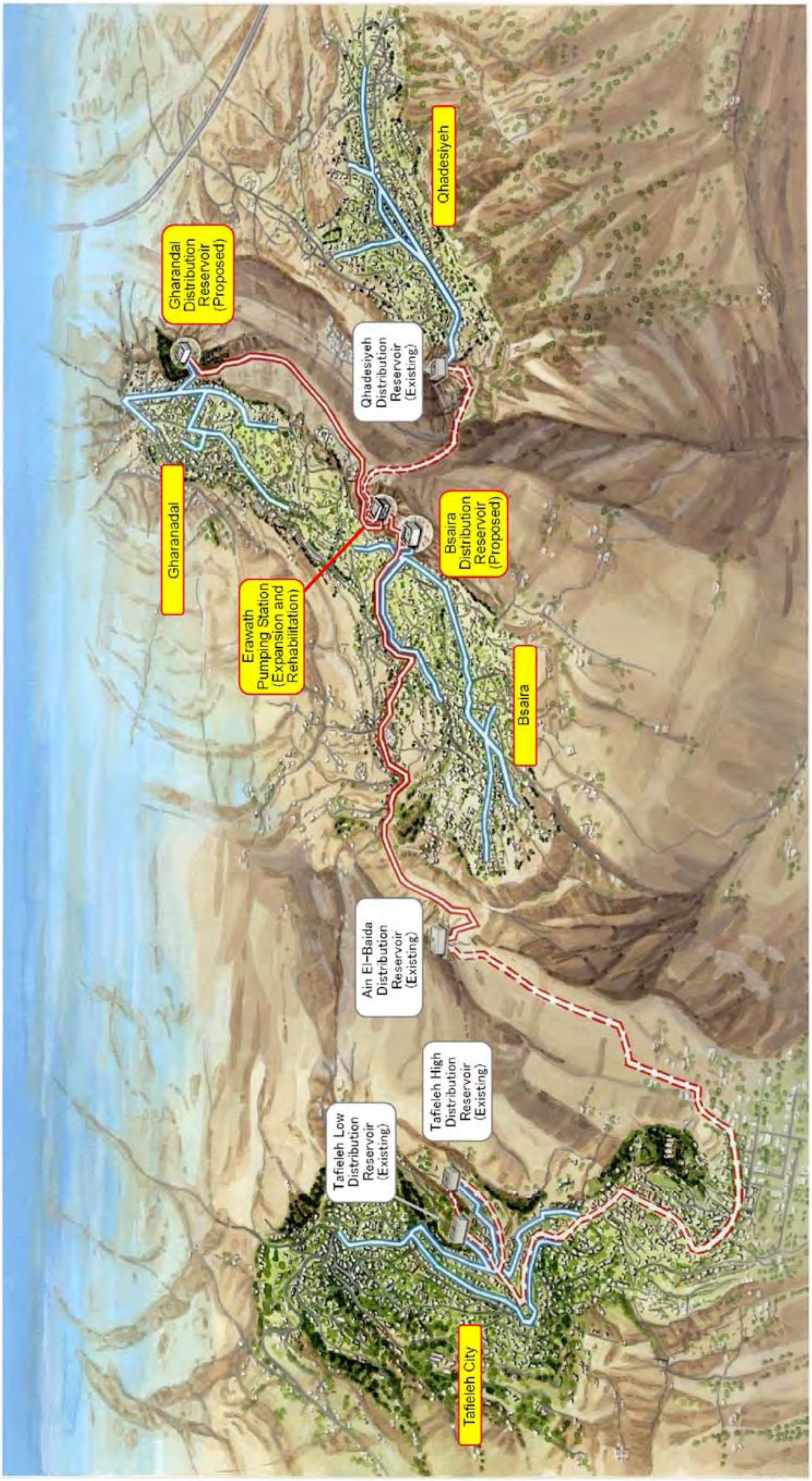
- The living environment of the residents is improved because of the increase of consumable water volume, improvement of water supply pressure, tar detached from aged pipes, and elimination of rust-colored water.

- The capacity concerning water distribution management and non-revenue water management of WAJ Tafieleh office staff improves as an outcome of implementation of the soft-component.

As stated above, the project contributes to the improvement of the living environment of the residents in Tafieleh city and the southern area of Tafieleh Governorate and can expect the aforementioned effects, therefore the relevance of implementing the Grant Aid Project is at high degree, and is potentially effective.



Location Map



Perspective

Preface
Summary
Location Map
Perspective

Table of Contents

Chapter 1 Background of the Project 1-1

1-1 Background of the Project 1-1
1-2 Natural Conditions 1-2
1-3 Social and Environmental Considerations 1-3

Chapter 2 Contents of the Project 2-1

2-1 Basic Concept of the Project 2-1
2-1-1 Target Area of the Project 2-1
2-1-2 Overall Goal and Project Purpose 2-1
2-1-3 Outline of the Project 2-2
2-2 Outline Design of the Project 2-5
2-2-1 Design Policy 2-5
2-2-2 Basic Plan 2-10
2-2-3 Outline Design Drawings 2-56
2-2-4 Implementation Plan 2-85
2-3 Obligations of Recipient Country 2-109
2-4 Project Operation Plan and Maintenance Plan 2-111
2-4-1 Basic Principle of Operation and Maintenance 2-111
2-4-2 Assignment of Distribution Manager 2-111
2-4-3 Organization of Operation and Maintenance 2-112
2-5 Project Cost Estimation 2-115
2-5-1 Initial Cost Estimation 2-115
2-5-2 Operation and Maintenance Cost 2-116
2-5-3 Other Relevant Issues 2-118

Chapter 3 Project Evaluation 3-1

3-1 Preconditions of the Project 3-1
3-1-1 Preconditions for Implementing the Project 3-1
3-1-2 Preconditions and External Conditions for Achieving the Overall Plan of the Project .. 3-1

3-2 Project Evaluation 3-3
3-2-1 Relevance 3-3
3-2-2 Effectiveness 3-5

List of Table

Table 1-1 Foreseen Impacts of the major Project Component 1-3
Table 2-1 Expected Outcomes of the Project in Tafieleh Project area 2-3
Table 2-2 Comparison of Components of the Request and Result of the Outline Design 2-4
Table 2-3 Estimated Future Population Growth Rates for Tafieleh Governorate 2-10
Table 2-4 Estimated Future Population in Tafieleh Governorate 2-11
Table 2-5 Estimated Future Population in the Project Area in Tafieleh Governorate 2-11
Table 2-6 Served Population Ratio According to the 2004 Census (%) 2-11
Table 2-7 Estimated Future Served Population in the Project Areas in Tafieleh Governorate 2-11
Table 2-8 Future Population by Township in the Tafieleh Governorate 2-12
Table 2-9 Non-revenue Water Ratio and its Variation in the Tafieleh Governorate 2-12
Table 2-10 Analysis of Served Volume and Used Volume of Water in the Areas Served by the Hase and Zabda Water Sources in the Tafieleh Governorate 2-13
Table 2-11 Leakage Ratio Estimated from the Pilot Project 2-13
Table 2-12 Planned Leakage Ratio and Planned Non-Revenue Water Ratio in the Pipe Renewal Area and Non-Renewal Area 2-14
Table 2-13 Time Coefficient Estimated from the Pilot Project 2-16
Table 2-14 Design Criteria for Water Supply Pressure 2-18
Table 2-15 Planned Conditional Values for Water Demand in the Project area of Tafieleh Governorate 2-18
Table 2-16 Existing Distribution Areas 2-19
Table 2-17 Capacity and Elevation of Existing Distribution Reservoirs 2-19
Table 2-18 Division of Planned Water Distribution Zones and Water Transmission and Distribution Method 2-22
Table 2-19 Planned Future Population by Distribution Zone in Project Area of Tafieleh Governorate 2-25
Table 2-20 Planned Water Supply Amount by Distribution Zone in Project Area of Tafieleh Governorate 2-25
Table 2-21 Comparison of Alternatives for Transmission Method in the South Tafieleh Area2-29
Table 2-22 Study of Distribution Reservoir Capacity in Project area in Tafieleh Governorate2-30
Table 2-23 Study of Candidate Sites for the Planned Bsaira Distribution Reservoir 2-31
Table 2-24 Study of Planned Gharandal Distribution Reservoir Candidate Site 2-33
Table 2-25 Specifications of Planned Distribution Reservoir 2-34

Table 2-26 Capacity and Head of Planned Pumps 2-36
Table 2-27 Specification for Pump/Motor 2-36
Table 2-28 Pump Shaft Power and Motor Output 2-37
Table 2-29 Countermeasures of Water Hammer 2-37
Table 2-30 Estimated Population and Population Density in Tafieleh in 2015 2-40
Table 2-31 Average Age of Distribution Pipe 2-40
Table 2-32 Comparison of Area for Pipe Renewal 2-41
Table 2-33 First Screening Result for Selection of Pipe Renewal Area 2-41
Table 2-34 Planned Transmission Pipeline 2-42
Table 2-35 Length of Planned Distribution Pipeline by Diameter and Area 2-42
Table 2-36 Specifications of Valves 2-43
Table 2-37 Specification of the Pressure Reducing Valve 2-46
Table 2-38 Central Monitoring System 2-54
Table 2-39 Field Equipment 2-54
Table 2-40 Summary of Planned Facilities 2-55
Table 2-41 Demarcation of Construction Works of Facilities between the Two Countries 2-88
Table 2-42 Japanese Supervision Organization in the Site 2-91
Table 2-43 Contractor's Work Control System 2-92
Table 2-44 Quality Control Plan 2-93
Table 2-45 Procurement Plan for Main Materials and Equipment 2-94
Table 2-46 Detailed Activities of Soft Component 2-101
Table 2-47 Staff Assignment Plan 2-102
Table 2-48 Soft-Component Project Design Matrix（PDM） 2-108
Table 2-49 Obligation of Recipient Country 2-110
Table 2-50 Major Facilities and Equipments for Management and Control 2-112
Table 2-51 Standard Inspections Items for Pumping Stations 2-113
Table 2-52 Periodical Inspection Items for Reservoirs 2-113
Table 2-53 Periodical Inspection Items for Transmission and Distribution Pipes 2-114
Table 2-54 Periodical Inspection Items for Flow Meter and Pressure Reducing Valve 2-114
Table 2-55 Summary of Estimated Costs to be covered by Jordanian Side 2-115
Table 2-56 Operation and Maintenance Cost of Erawath Pumping Station in 2015 2-116
Table 2-57 Reduction Volume of Water Leakage with and without the Project 2-117
Table 2-58 Electricity Consumption per Cubic Meter of Water Produced 2-117
Table 2-59 Estimation of Electricity Cost Reduction with and without the Project in 2015 2-117
Table 2-60 Estimation of Revenue Increase by Reduction of Leakage in 2015 2-118

List of Figure

Figure 2-1 Typical Water Demand Pattern.. 2-15
Figure 2-2 Annual Variation of the Value of Average Water Supply Amount by Month Divided by the Average Water Supply Amount by Year.. 2-16
Figure 2-3 Existing Status of Water Distribution to Tafieleh City.. 2-20
Figure 2-4 Division of Water Distribution Zones and Arrangement of Transmission and Distribution Mains in Tafieleh City 2-21
Figure 2-5 Elevation Profile of Planned Water Distribution Zones and Existing Water Transmission and Distribution System 2-23
Figure 2-6 Existing Water Transmission and Distribution System and Water Distribution Areas of Tafieleh Governorate Project Area 2-24
Figure 2-7 Comparison of Water Transmission and Distribution Methods from Ain El Baida to Bsaira, Erawath Pumping Station and Gharandal Areas.. 2-28
Figure 2-8 Bsaira Distribution Reservoir Candidate Site 2-31
Figure 2-9 Planned Gharandal Distribution Reservoir Candidate Site 2-32
Figure 2-10 Gharandal Distribution Reservoir Candidate Site 2-34
Figure 2-11 Location of Pressure Reducing Valve (Tafieleh City)...................................... 2-46
Figure 2-12 Location of Pressure Reducing Valve (Bsaira).. 2-47
Figure 2-13 Location of Pressure Reducing Valve (Gharandal) 2-47
Figure 2-14 Location of Pressure Reducing Valve (Qhadesiyeh).. 2-48
Figure 2-15 Location of Field Equipment for Monitoring in Tafieleh Area 2-51
Figure 2-16 System Configuration.. 2-52
Figure 2-17 Relation between Various Components.. 2-97
Figure 2-18 Problem Analysis Tree and Goal Chart.. 2-99
Figure 2-19 Implementation Plan of Soft Component.. 2-103
Figure 2-20 Detailed Activity Plan 2-104
Figure 2-21 Implementation Schedule.. 2-109

Appendices

Appendix 1: Member List of the Study Team I-1

Appendix 2: Study Schedule II-1

Appendix 3: List of Parties Concerned in the Recipient Country III-1

Appendix 4: Minutes of Discussions IV-1

Appendix 5: Soft Component (Technical Assistance) Plan V-1

Appendix 6: Other Relevant Data VI-1

Data 1. Water Quality in the Target Area in the Governorates of Tafieleh and Ma’an VI-2

Data 2. GIS Basic Map and Database of Transmission and Distribution Pipelines VI-6

Data 3. Socio Condition Survey VI-9

Data 4. Proposed served population and Proposed water supply in the Target Area in the Governorates of Tafieleh and Ma’an VI-30

Data 5. Result of Well Pumping Test VI-32

Data 6. Result of Hydraulic Calculation for Transmission System in Tafieleh governorate VI-33

Data 7. Result of Analysis for Prevention Countermeasure of Water Hummer in Erawath Pumping Station VI-34

Data 8. Hydraulic calculation result of distribution system in Tafieleh governorate VI-49

Data 9. Result of Corrosion Test VI-68

Data 10. Study of Existing Pressure Reducing Equipments VI-73

Data 11. Cost Estimation for Jordanian Side Cost Obligation (Laying Cost of pipelines) VI-76

Data 12. Outline Design in the Target Area of Ma’an Governorate VI-77

Data 13. Review of Water Supply Plan for Hussiniyyeh, Ashari, and Abu Dnneh in Ma’an Governorate VI-117

Data 14. Study of the Project as Grant Aid for Environment and Climate Change Measures VI-127

Data 15. Planned Assess Road for Planned Distribution Reservoir in Bsaira and Gharandal VI-134

Abbreviations

AWC	Aquba Water Company
DIP	Ductile Iron Pipe
DMA	District Metering Area
DOS	Department of Statistics
DZ	Distribution Zone
E/N	Exchange of Notes
EIA	Environmental Impact Assessment
EIB	Europe Investment Bank
EPA	Environment Protection Agency
EU	European Union
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GPRS	General Packet Radio Service
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Society for Technical Cooperation)
HDPE	High Density Polyethylene Pipe
JD	Jordan Dinar
KfW	Kreditanstalt für Wiederaufbau (German government-owned development bank)
M/D	Minutes of Discussions
MPa	Mega Pascal (1 bar = 0.1 MPa)
MWI	Ministry of Water and Irrigation
OD	Outer diameter
PDM	Project Design Matrix
PRV	Pressure Reducing Valve
RC	Reinforced Concrete
USAID	United State Agency for International Development
WAJ	Water Authority of Jordan
WAJ Existing Plan	Upgrading and Expansion of Water Facilities at Tafieleh and Ma’an (2005)

CHAPTER 1 BACKGROUND OF THE PROJECT

Chapter 1 Background of the Project

1-1 Background of the Project

The water resource and water supply development of Jordan have been implemented around the central area including the capital Amman. Cooperation of Japan and other donors have mainly been implemented around the central area; therefore the expanding regional gap of the water supply service and living standard are becoming a problem. The water administration of Tafieleh Governorate and Ma'an Governorate at the southern part of Jordan (Water Authority of Jordan (WAJ) Tafieleh office and Ma'an office) are supplying ground water as a water resource by gravity from the distribution reservoir or sometimes by direct pumping. However, sufficient volume is not supplied due to problems such as the high ratio (50% or more) of non-revenue water or lack of capacity of trunk water supply system. Thus, the time for water supply is limited, and revenue water per capita is remaining at a low level (Tafieleh Governorate: approx. 73 L/day, Ma'an Governorate: approx. 100 L/day, WAJ statistics, 2008).

In an effort to reduce the non-revenue water of Jordan, the "Capacity Development Project for Non-Revenue Water Reduction" (2005~2008) and "Capacity Development Project for Non-Revenue Water Reduction (Phase 2)" (2009~2011) were implemented by Japan, which assisted the development of the organizational structure of WAJ as well as its capacity. As a result of these projects, the capacity concerning the non-revenue water management of WAJ (detection of leakage and repair, etc.) was improved, and reduction of non-revenue water was achieved in the pilot area. Furthermore in Phase 2, water distribution management considering the difference in elevation, and strengthening of capacity for preventive management of non-revenue water is being implemented. However, aging of water distribution network in Tafieleh and Ma'an Governorates is severe, therefore fundamental measures including upgrading of distribution pipes are urgently needed for non-revenue water management. Moreover, the existing water supply system cannot meet the increasing water demand, and as a result, inefficient water transmission and distribution by using booster pump for residents of highlands is necessitated.

Under such background, the Government of Jordan had requested for a grant aid project to Japan in July 2008, for the purpose of improving the water supply service in Tafieleh Governorate and Ma'an Governorate by upgrading the water distribution network and building new reservoirs. In response to this request, a preparatory survey (part 1) was implemented in October 2009, where relevance of implementing the plan and necessity or priority of each component were reviewed. As a result, the southern area of Tafieleh Governorate including Tafieleh city and Ma'an city of Ma'an Governorate were chosen, for their high priorities assigned by the Government of Jordan, and large population of beneficiaries. The requests of the project area are shown below.

Tafieleh Governorate	• Construction of reservoirs (400 m^3×1, 1,000 m^3×1, 2,000 m^3×2) • Construction of pumping station (1 location) • Upgrade of water distribution network (ductile iron pipe, φ100~300 mm, approx. 30 km, and PE pipe, OD 63 mm, approx. 51 km)
Ma'an Governorate	• Construction of reservoirs (400 m^3×3, 1,000 m^3×2, 2,000 m^3×1) • Upgrading of water distribution network (ductile iron pipe, φ100~300 mm, approx. 33 km, and PE pipe, OD63 mm, approx. 140 km)

Subsequently, the outline design survey for the project is decided to be implemented, and JICA had dispatched a preparatory study team (part 2) to the site from April 10 to July 16, 2010. At the field survey, the team held a discussion with the Government of Jordan and WAJ personnel regarding the contents of the request, surveyed on present state of the project site, and gathered related materials. The study team reviewed the relevance and effectiveness of the project in the analysis after returning to Japan, and created a report (draft) on the preparatory survey, including the proposal for an optimum water supply system. Based on this plan, JICA dispatched a team for explaining the overview of the outline design to Jordan from October 23 to October 28, 2010, explained the contents of the plan, and held a discussion. As a result, the Government of Jordan had basically agreed with the contents of the plan. This final report was prepared based on the result of above mentioned survey, analysis, and discussion.

1-2 Natural Conditions

The Hashemite Kingdom of Jordan (hereinafter referred to as “Jordan”) has a population of 5.85 million people (as of 2008) and land area of 89,316 km^2. It is surrounded by Israel (West Bank, Palestinian Interim Self-Government Authority) in the west, Syria in the north, Iraq in the east, and Saudi Arabia in the southeast. Western area of the Kingdom has a narrow valley, known as Jordan Valley, which spreads from Jordan River through the Dead Sea (which is 400m below sea level) and to the Gulf of Aqaba in the Red Sea. The east side of Jordan Valley is a plateau area of 600 ~ 1,500 m above sea level, and on the east of the plateau area is a desert area which covers around 75% of the national land. Most of the rainfall occurs during winter. The amount rainfall varies, reaching an average of up to around 660 mm in the northeast plateau and only around 120 mm in the desert area.

Most of the south region of Jordan, which is the project area, has desert or desert steppe climate, and its annual rainfall is around 200 mm or less, with extremely high evaporation, high-temperature in the summer, and dropping to below-freezing in the winter. Tafieleh Governorate is located at a hilly plateau, its elevation ranging from around 900 ~ 1,600 m, with annual average temperature of approx.

16℃, maximum temperature of approx. 46 ℃ and minimum of approx. 8℃. Ma'an Governorate is located at a flatland around 1,000 m above sea level, with annual average , maximum, and minimum temperatures of approx. 18, 45, and -6℃ respectively (as of 2008).

The type of soil at the project sites in Tafieleh and Ma'an consists of gravel-mixed limestone or limestone bedrock with thin silt or gravel-mixed silt layers on the surface.

1-3 Social and Environmental Considerations

This project has been categorized into "C" according to the JICA Guidelines for Social and Environmental Considerations.

Administration for the evaluation of environmental impact in Jordan is undertaken by the Environmental Impact Assessment Directorate in the Ministry of Environment. Evaluation of environmental impact is prescribed in EIA Bylaw No. 37/2005.

Environmental affects related to the major project component are as follows. The survey team has not foreseen any serious negative environmental impact by the implementation of the project. However, it was confirmed in the Minutes of Discussion on 28th, October 2010 that the Jordanian side shall confirm the necessity of the environmental impact assessment for the project component to the concerned agencies, and when deemed necessary, the environmental impact study must be implemented and be completed.

Table 1-1 Foreseen Impacts of the major Project Component

Component	Foreseen Social Environmental Impacts
Installation of transmission and distribution pipelines	Planned pipes are buried in public roads and, therefore, no impact is foreseen except traffic disturbance during the construction n stage. However, the adequate traffic control is required in Tafieleh city, where there is only one main road passing through the city.
Rehabilitation and expansion of Erawath Pumping Station	No land acquisition is required for the expansion of pumping station since the land is available in the existing premise of the pumping station. There is no neighbor near the pumping station and, therefore, impact of noise during the construction stage and the impact of the noise and vibration during the operation stage of pumping station are foreseen as minimum.
Construction of reservoirs at Bsaira and Gharandal	The land for the reservoirs and their surrounding areas are barren land and there is no houses and land use. The land for the reservoirs is owned by the government and the land for the access road to the both reservoirs is owned by private. The land acquisition of access road is required but the social impact will be minor since there is no house and land use on the land.

CHAPTER 2 CONTENTS OF THE PROJECT

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Target Area of the Project

From the time of request for this project (July 2008), components of the Project for Tafieleh Governorate and Ma'an Governorate in the southern part of Jordan were planned. A preparatory survey was implemented based on this plan. However, the result of analysis in Japan indicated that the project cost would exceed the budget limit prepared by the Government of Japan, therefore necessity to change the plan arose. The policy of reducing the components was discussed with the concerned agencies of Jordan, and was finally agreed that Tafieleh city and the south of the Tafieleh Governorate shall be selected for the project area. The outline design of the target area of Ma'an Governorate and the review of water supply plan for Hussiniyyeh, Ashari, and Abu Dnneh in Ma'an Governorate are shown in Data 12 and Data 13, Appendix 6, respectively.

2-1-2 Overall Goal and Project Purpose

Jordan established the "National Agenda 2006-2015" as a comprehensive national strategy, which presents the issues and measures that Jordan must address. Here, the issues of the water-related field are pointed out, such as insufficient recyclable water resource, depletion of groundwater, inefficient water distribution, inappropriate water charge, and insufficient sewage treatment capacity. As one of the measures, "streamlining of operation, maintenance, and management, and reduction of non-revenue water" was put forward.

Additionally, WAJ set up the following main objectives in the "Summary of Strategic Plan for 2007–2012".

a) Reduce the gap between available water supply and demand (improve average daily water consumption per capita from 100 L as of 2006, to 120 L in 2012)
b) Improve the high non-revenue water ratio (national average NRW ratio 45% as of 2006, to 32% in 2012)
c) Enhance the responsibility and duties of WAJ based on the law
d) Strengthen beneficiaries-pay principle and personal funds
e) Improve customer satisfaction and promote cooperation of citizens

In the overall goals, Jordan plans to improve water supply situation of the citizens through reducing lost water or non-revenue water and increase available water. Under the overall goal, this project aims to improve the living conditions of the project area of Tafieleh city and Tafieleh south areas in

Tafieleh Governorate through increase of the actual water availability per capita and fair distribution water at the target year of 2015.

2-1-3 Outline of the Project

To contribute to the achievement of the overall goal, renewal of aged distribution networks and restructuring of the transmission and distribution system including establishment of distribution monitoring system will be carried out in this project which will reduce leakage, increase available water per capita and make fair distribution of water to the citizen of the project areas. For this purpose, the following activities are planned in the project. In addition, soft component will be implemented to strengthen the capacity of water distribution management.

(1) Activities of Japanese Side

a) Renewal of distribution mains and installation of pressure reducing valves
b) Strengthening of transmission mains
c) Construction of service reservoirs
d) Rehabilitation and expansion of pumping station
e) Establishment of distribution monitoring system
f) Procurement of distribution secondary pipes
g) Soft component for strengthening of water distribution management capacity

(2) Activities of Jordanian Side

① Installation works of the distribution secondary pipes procured by Japanese side in Tafieleh
② Replacement of service connections
③ Construction of access roads to the planned reservoirs and land reclamation of reservoir sites
④ Adequate budget arrangement for management, operation and maintenance of the constructed facilities

Implementation of this project is expected to yield the outcome as shown in Table 2-1.

The comparison of the components of the project between the request of the M/D (Minutes of Discussions) in the inception of this survey and the results of the outline design is shown in Table 2-2.

Table 2-1 Expected Outcomes of the Project in Tafieleh Project area

No.	Indicators	Unit	2010	2015
1	Target population of distribution monitoring system	Person	0	70,100
2	Target population of renewal of distribution network	Person	-	49,300
3	Low water pressure area or no water supply area	%	There are several suffered areas and it increases in summer when water demand is high	Suffered areas will be eliminated through constructed facilities and distribution management
4	Water supply hours	hours/week	24 - 72	84
5	Supply pressure	MPa	0 – 2.3	0.25 – 0.6 (By distribution zones and pressure reducing valves)
6	Leakage ratio	%	25	15
7	Non-revenue water ratio	%	47	35
8	Average daily revenue water per capita	L/c/d	84	96
9	Average daily water supply amount per capita	L/c/d	160	147
10	Average daily water supply amount in the network renewal area	m^3/d	7,250	With project: 7,000 Without project: 7,930 Annual saving: 339,500 m^3
11	Average daily revenue water amount in the network renewal area	m^3/d	3,840	With project: 4,550 Without project: 4,203 Annual increase: 126,700 m^3
12	Saving energy and electricity and electricity cost	Savings of energy and electricity cost of intake and transmission pumping stations because of reduction of leakage and improved efficiency of Erawath pumping station.		

Table 2-2 Comparison of Components of the Request and Result of the Outline Design

Component	Gov.	M/D in April, 2010	Result of Outline Survey
1. Constriction of reservoir	Tafieleh	Tafieleh south (2,000m^3×1)	1）Bsaira reservoir: 1200m^3x 1 place 2）Gharandal reservoir: 600m^3x 1 place
2. Installation of transmission mains	Tafieleh	None	1) Ain-El Baidha res. to Bsaira reservoir: dia. 200～300mm x 10.68 km 2) Erawath PS to Gharandal reservoir: dia. 150mm x 3.54 km
3. Improvement of transmission pumping station (PS)	Tafieleh	Tafieleh south: 1 place, pump house, 4 sets of pumps	Erawath pumping station (PS) 1) Renewal of existing PS for Gharandal: pump 2 sets 2) Expansion of PS for Qhadesiyeh: pump 2 sets and pump house
4. Renewal of distribution network	Tafieleh	Distribution mains and secondary: Installation of pipes OD 63 mm or more than OD 63 mm x about 83 km	1) Tafieleh city, Bsaira, Gharandal Qhadesiyeh: Installation of dia. 100 mm or more than dia. 100mm x 30.37km 2) Tafieleh city, Bsaira, Gharandal Qhadesiyeh: Procurement of pipe materials of OD 63 mm x 50.6km
	Ma’an	Distribution mains: Pipes 100 mm or more than dia. 100 mm, about 38 km	None
5. Installation of pressure reducing valves	Tafieleh	Tafieleh gov.: 10 places	Tafieleh city, Bsaira, Gharandal and Qhadesiyeh: PRV 22 places.
6. Establishment of distribution monitoring system	Tafieleh	Flow meter 10 places	1) Tafieleh city, Bsaira, Gharandal and Qhadesiyeh: Flow meter 15 places and Pressure meter 3 places 2) Central monitoring system in WAJ Tafieleh office
	Ma’an	Flow meter 20 places	None
7. Soft component	Both govs.	Distribution management capacity improvement	Distribution management capacity improvement for WAJ Tafieleh
Jordanian side	Tafieleh	・Installation of pipes dia. less than OD 63 mm x about 88 km	・Installation of pipes procured by Japanese side : 50.6 km ・Service connections: (diameter 25 mm and 20 mm) x 118 km and customer water meter
	Ma’an	Installation of pipes dia. less than 100 mm x about 148 km	None

2-2 Outline Design of the Project

2-2-1 Design Policy

(1) Basic policy

1) Target area of the project

The target area or the project area is taken as Tafieleh city and the southern area of the Tafieleh Governorate.

2) Scope of cooperation

The scope of cooperation is as given below. This scope will be examined in this outline design.

a) Renewal of distribution mains and installation of pressure reducing valves
b) Renewal of distribution secondary pipe
c) Restructuring of transmission and distribution main system including construction of reservoirs and delineation of distribution zones
d) Improvement of pumping station at Erawath
e) Establishment of distribution monitoring system
f) Soft component on distribution management capacity improvement

3) Target year related to setting the scale of facilities

The target year of the project is to be set considering the scale of facilities appropriate for the grant aid program. However, the target year of the facilities, such as pipelines and pumping equipment, is to be set considering that stepwise expansion in the future is difficult.

4) Issues to be resolved and measures

The issues to be resolved in the project are to reduce non-revenue water including leakages, to increase the quantity of water that can be consumed, to correct the non-uniform regional water supply, and to ensure fair and uniform water supply. The measures below are to be studied to achieve this objective.

- Separation of water transmission and distribution systems
- Use of gravity flow distribution from the distribution reservoir
- Setting appropriate water distribution zones
- Installation of appropriate pumps
- Renewal of aged distribution pipelines

- Installation of pressure reducing facilities
- Construction of distribution monitoring system for managing non-revenue water

5) Construction of system for effective water distribution management and non-revenue water management

The water supply facilities of the project area in the Tafieleh Governorate are located in the water supply areas that have a difference in elevation of about 100 to 250 m. No pressure-reducing valves are installed in the existing distribution network and there are no clear divisions into water distribution zones. Consequently, appropriate water distribution management, which includes control of high supply pressure by installation of pressure-reducing valves and dividing into water distribution zones, is not being performed. It results in high leakage ratio and the non-uniform regional water supply.

Pumps with the same high head are being used from the existing Erawath pumping station and water is being transmitted and distributed to two areas at different elevations, therefore, when distributing water to the distribution zone at low elevation, high water supply pressure occurs, which causes the water leakage to increase.

The following measures are to be adopted to the project area of the Tafieleh Governorate, to reduce the water leakage, to manage water distribution appropriately, and to improve the water supply situation:

① Separate the water distribution system from the water transmission system to facilitate management of non-revenue water and water distribution, and furthermore, divide into water distribution zones.

② Construct a distribution monitoring system to facilitate management of non-revenue water and water distribution.

③ Install pressure-reducing valves to reduce the water supply pressure and thus reduce leakage.

④ Construct distribution reservoirs to minimize the variation in water supply pressure, and adopt the gravity flow distribution method for distributing water from the distribution reservoir.

6) Renewal of aged distribution network

The cause of the high non-revenue water ratio in the project area is the existence of an aged distribution network in addition to the high water supply pressure. By renewing the distribution network which is old and from which water leaks frequently, the amount of water leakage can be reduced and the available water amount can be increased.

7) Adoption of the project which contributes to climatic and global warming measures

Energy consumption is to be reduced by renewing pumping equipment having inappropriate head and discharge rate to suitable pumping equipment. The energy consumption of pumps at water source will also be reduced by reducing the amount of water leakage.

8) Selection of sites for distribution reservoirs

For planned distribution reservoir, locations with hydraulically appropriate elevation are to be selected so that water distribution to the target distribution zones is effective. Furthermore, public land that can be easily acquired is to be selected as the reservoir site so that environmental and social impacts are minimized.

9) Effective utilization of existing facilities

Existing utilities are to be utilized as effectively as possible so that project funds are used to maximum effectiveness. In this line, the exiting house of Erawath pumping station shall be utilized and transmission mains, on which less leakage accidents occur, shall also be utilized.

10) Study of items under the responsibility of the Japanese side and the Jordanian side considering required technologies

Technologies required for the construction work of the planned facilities are to be studied, and the responsibilities of both sides are to be re-examined, especially for installation of distribution secondary pipes.

11) Utilization of Geographic Information System (GIS) in planning

GIS was utilized to make an optimized plan effectively and efficiently since the survey areas are located in highly undulated terrains and extend to a vast area (see Data 2 in Appendix 6).

(2) Policy on natural conditions

During the summer season in the project area, the day temperatures sometimes exceed 40℃. Therefore, special care needs to be taken when placing concrete and quality controls need to be properly enforced.

The geological features of the project area are gravel mixed with limestone (earth and sand) and limestone ground (soft rock). Since the ground has adequate bearing capacity considering geological conditions, it is suitable as direct foundation for service reservoir. On the other hand, rock excavation is necessary in many sections of the pipe laying routes.

Measures to prevent corrosion of pipelines are to be studied because the soil in the project area is very corrosive.

The project area in the Tafieleh Governorate has rugged undulating terrain at an elevation ranging from 900 m to 1,600 m. The position of distribution reservoir is to be selected, the water distribution zones set and pressure-reducing valves planned considering such terrain so that water supply pressure is appropriate.

(3) Policy on socioeconomic conditions

Water supply rationing is being implemented in the project area because of the rugged undulating terrain and the shortage of water transmission and distribution capacity of the facilities. The water supply timing varies with the area. The minimum supply is one day per week and the maximum is three days per week. The supply timing has a major impact on the daily life of the residents. Plans are to be made to remove such inconsistencies in the water supply and to ensure fair distribution of the limited water supply so that the number of days of water supply increases. The result of socio-economic survey on water use is given in Data 3 in Appendix 6.

The renewal of distribution network in Tafieleh city is to be carried out in commercial areas and densely populated residential areas. Therefore, the construction method used should be such that hindrance to daily life and business activities is minimized as far as possible. Similarly, construction methods for major main roads with heavy traffic are to be selected such that the effects of the work on the through traffic and safety are properly considered..

The project area is located in a low-income area within Jordan, and benefits are to be considered in construction works.

(4) Incorporating other project training programs

A project for rehabilitation of waterworks was implemented in the year 2000 in Petra city, Ma'an Governorate, and pressure reducing tanks and pressure reducing valves were installed with the purpose of controlling the distribution pressure. However, valves had to be replaced frequently, leading to obstruction in operation and maintenance. Therefore, the valve specifications in these pressure reducing facilities and maintenance of the same are to be evaluated, and training programs for the same are to be introduced.

(5) Policy related to procurement

All materials and equipment that can be procured in Jordan will be procured in Jordan, in principle. Materials and equipment that cannot be procured in Jordan or the quality of which cannot be adequately ensured, are to be procured from a third country or from Japan. As far as possible, materials and equipment are to be procured locally and laborers employed locally because this will contribute to the local economy of the project area.

(6) Policies related to construction methods and construction periods

The critical path of this work is the pipeline work. Appropriate number of work teams are to be set, and appropriate overall work period is to be decided.

Since the pipe laying work involves road excavation work, plans for the work are to be formulated considering minimal disturbance to traffic. The necessary safety measures related to the work are to be carried out.

(7) Policy on operations and maintenance capability of the implementing organization

WAJ is the implementing agency for this project, and will be responsible for the operation and maintenance after this project is completed. The Technical Affairs Directorate, WAJ will be the department responsible for design and supervision. The routine maintenance of the transmission and distribution facilities after completion of the work will be responsibility of the WAJ Tafieleh office in the Tafieleh Governorate.

The facilities plan is to be implemented such that the facilities and the systems are simple and easy to maintain and operate. The operation and maintenance plan is to be formulated such that the materials and equipment for maintenance owned by WAJ are utilized as far as possible.

Since the overall water distribution management of the waterworks system and non-revenue water management capability of the WAJ Tafieleh office are inadequate, support through soft component is to be provided so that their management capacity improves and the construction effects of the facilities of the project are demonstrated to the maximum extent possible.

2-2-2 Basic Plan

(1) Design conditions

1) Target year

The facility initially requested is to be provided by 2025 according to the “Upgrading and Expansion of Water Facilities at Tafieleh and Ma’an, 2005 (hereafter called “WAJ existing plan”).” However, the target year of this plan is taken as 2015, in principle, considering that the scale is appropriate for Japanese grand aid.

Stepwise expansion of pipeline and pumping facilities in the waterworks is difficult in the future; usually, a long target year for a facility is set. Since the difference in planned water amounts in 2015 and 2025 for Tafieleh is about 15%, the planned water supply volume in 2025 according to the WAJ existing plan is taken as the water transmission and distribution capacity. Stepwise construction of distribution reservoir is generally the basis. Since expansion can be made to suit the increase in water demand, the design of the reservoir is performed taking 2015 as the planned target year. Accordingly, the planned water volume is estimated up to 2025.

2) Planned total population and served population

There are no population estimates for the project area according to the Department of Statistics (DOS) in Jordan. Based on the estimates of census in the past for the project area and the population growth rate in the future for the whole of Jordan, the population growth rates in the Tafieleh Governorate were set as given below.

Table 2-3 Estimated Future Population Growth Rates for Tafieleh Governorate

Item	2009-2010	2011-2015	2016-2020	2021-2025
Population growth rate	1.7%	1.7%	1.5%	1.3%

The total future population in the Tafieleh Governorate was estimated based on the population estimated by DOS in 2009 and the population growth rates.

Table 2-4 Estimated Future Population in Tafieleh Governorate

Item	2010	2015	2020	2025
Estimated population	85,100	92,600	99,800	106,500

The future population in the project area was estimated as shown below. The total population in the target year (2015) for Tafieleh Governorate was estimated as 70,100 persons.

Table 2-5 Estimated Future Population in the Project Area in Tafieleh Governorate

Item	2010	2015	2020	2025
Future population in project area in Tafieleh Governorate	64,500	70,100	75,600	80,600

According to the 2004 census, the served population ratios for Tafieleh Governorate are as shown in the table below. The project area is urban area, and the unserved population mainly consists of Bedwin. Accordingly, the served population ratio of the project area is taken as 100% in 2010, and the same figure (100%) is planned for the future also. Consequently, the served population is the same as the total population, and is as given in the table below.

Table 2-6 Served Population Ratio According to the 2004 Census (%)

Item	Urban area	Rural area	Total
Served Population Ratio	99.8	94.2	97.8

Table 2-7 Estimated Future Served Population in the Project Areas in Tafieleh Governorate

Item	2010	2015	2020	2025
Target served population ratio	100 %	100 %	100 %	100 %
Served population in the project area	64,500	70,100	75,600	80,600

The population in each township in the project area of the Tafieleh Governorate is estimated as shown in the table below.

Table 2-8 Future Population by Township in the Tafieleh Governorate

Township	2010	2015	2020	2025
Al Mansoura	4,199	4,577	4,978	5,351
Tafieleh	21,898	23,664	25,158	26,448
Sanfahah	3,450	3,762	4,089	4,394
Nemta	159	174	189	204
Ain-El Baidha	11,373	12,391	13,477	14,485
Bsaira	10,340	11,273	12,197	13,048
Gharandal	4,816	5,253	5,716	6,143
Qhadesiyeh	8,265	9,006	9,796	10,527
Total	64,500	70,100	75,600	80,600

3) Planned non-revenue water ratio and leakage ratio

The leakage ratio for waterworks in the project area has not been measured nor estimated. Statistical data that could be obtained are non-revenue water amount, which is the total of leakage and administration loss, and the ratio of non-revenue water. The table below shows the non-revenue water ratio and its variation of the Tafieleh Governorate. The non-revenue water ratio exhibits an increasing trend from 2007 to 2008.

Table 2-9 Non-revenue Water Ratio and its Variation in the Tafieleh Governorate

Governorate	2007	2008	Non-revenue water ratio and its variation in 2007-2008
Tafieleh Governorate	46.6%	52.0%	5.4%
Average for Jordan	43.3%	43.9%	0.6%

The water sources in the project areas for Tafieleh Governorate are Hase and Zabda. These water sources are also used as water sources in areas other than the project areas. The amount of water transmitted to the project areas has not been measured by flowmeter, so it is difficult to separate and calculate the produced water amount in the project areas only. For this reason, the analysis of distributed amount and non-revenue water in the project areas of the Tafieleh Governorate is to be performed taking the entire area to which water is supplied from the Hase and Zabda water sources. This area includes Ies and the northern areas of Tafieleh. The calculated project area is called the area served by Hase and Zabda water sources in Tafieleh Governorate. The numeric values calculated for this area are regarded as typical values of the project area in the Tafieleh Governorate.

Based on the total produced water amount (total water supply volume) and the total water amount measured by customer water meters (revenue water) from 2007 to 2009 in the areas served by the Hase and Zabda water sources in Tafieleh Governorate, the daily average water supply amount, the non-revenue water volume and the non-revenue water ratio were calculated. Moreover, the daily average per capita water supply amount and the revenue water amount were calculated from the estimated population. The non-revenue water ratio for 2009 was calculated as 47%.

Table 2-10 Analysis of Served Volume and Used Volume of Water in the Areas Served by the Hase and Zabda Water Sources in the Tafieleh Governorate

Year	Annual total water supply amount	Average water supply amount	Revenue water amount	Non-revenue water amount	Non-revenue water ratio	Estimated population	Daily average water supply amount per capita	Daily average revenue water volume per capita
	(m^3/year)	(m^3/day)	(m^3/year)	(m^3/year)	(%)	(Persons)	L/person/day	L/person/day
2007	3,556,430	9,744	1,946,457 *1	1,609,973	45	70,993	137	75
2008	4,085,522	11,193	2,083,772	2,001,750	49	72,070	155	79
2009	4,296,532	11,771	2,269,858	2,026,674	47	73,660	160	84
Average	3,979,495	10,903	2,100,029	1,879,466	47	72,241	151	79

Note 1: Since the water meter values (governmental organization) in 2007 were found to be abnormal compared to the values in 2008 and 2009, the values for 2007 were corrected using the trend values of 2008 and 2009.
Source: Annual report of WAJ Tafieleh, etc.

The minimum flow rate at night was measured in a pilot project, which was part of the JICA Technical Cooperation Project, and the leakage ratio was summarized as shown below. The leakage ratio was in the range of 20% to 40%. From the results of analysis in other areas, the leakage amount is generally estimated to be about half the non-revenue water amount. In this project, the present leakage ratio is estimated as approximately half the non-revenue water ratio.

Table 2-11 Leakage Ratio Estimated from the Pilot Project

Township	Governorate	Measured month	Leakage ratio	Remarks
Al Mansoura	Tafieleh	Dec. 2007	22%～23%	No actual pressure adjustment
Sanfahah	Tafieleh	Aug. 2009	31%	No actual pressure adjustment
Odruh 1	Ma'an	Dec. 2006	45%	No actual pressure adjustment
Odruh 1	Ma'an	Dec. 2006	31%	Actual pressure adjustment
Odruh 1	Ma'an	Apr. 2007	36%	Actual pressure adjustment
Zarqa city	Zarqa	1997	31%	Not known if adjusted for pressure or not

Source: JICA Technical Cooperation Project and JICA Development Study Report for Zarqa

The leakage ratio after project implementation in the project area of the WAJ Existing Plan has been planned as 15%. The leakage ratio after implementing measures for non-revenue water estimated in the JICA Technical Cooperation Project is estimated as approximately 15%. Furthermore, based on the experience of renewing networks in other developing countries, the leakage ratio after renewing the distribution network including the service connections, is estimated as 15% approximately. Accordingly, the planned leakage ratio of the distribution network renewal area of this project is set as

15%. If the service connections are laid accurately as in Japan and control activities are implemented to prevent leakage subsequently, the leakage rage can be lowered below 15%.

The target value of non-revenue water ratio of WAJ is 25 %. The current non-revenue water ratio in the project area of Tafieleh Governorate is 47 %. WAJ is vigorously engaged in measures against non-revenue water presently; however, the WAJ's plan of lowering the non-revenue water ratio within the five-year period up to the target year of 2015 is not realistic. Accordingly, it is planned to lower the non-revenue water ratio to 25 % by 2025. The planned leakage ratio, non-revenue water ratio, and administrative loss (loss other than water leakage) percentage of the distribution network in the renewal areas in the project area are set as in the table below. Furthermore, the setting values of areas where distribution networks of the project area are not to be renewed are also shown in the same table.

Table 2-12 Planned Leakage Ratio and Planned Non-Revenue Water Ratio in the Pipe Renewal Area and Non-Renewal Area

(Units: %)

Item	Current	Distribution network renewal area			Distribution network non-renewal area		
	2010	2015	2020	2025	2015	2020	2025
1. Planned leakage ratio	25	15	15	15	25	20	15
2. Planned non-revenue water ratio	47	35	30	25	45	35	25

4) Planned average daily water consumption per capita and water supply amount

WAJ has taken the target value of the daily average water supply amount per capita including the non-revenue rate of 25 % as 150 liters. Assuming the planned leakage ratio as 15 %, the calculation gives the average daily water consumption per capita as 127.5 liters. The average daily water consumption per capita for 2010 is estimated as 112 L for the project area of Tafieleh Governorate. The existing consumption amount for Tafieleh Governorate is 112 L. If the water leakage amount reduces by 2015, the amount can increase up to the figure mentioned here. Accordingly, the planned average daily water consumption per capita of the project area in the Tafieleh Governorate is taken as 125 L.

5) Factors for setting capacity of planned facilities

Figure A below shows the general change in the water demand within a year. The water demand is maximum in summer and minimum in winter. Figure B shows the general change in water demand within a day. The water demand in a day increases in the morning and in the evening when activities to consume water are more frequent. In the night time, water consumption becomes very small, so the amount of water leakage becomes the amount of only water demand, under normal water supply conditions. However, in the project area, due to the rationing of water supply, water is stored by each household at night on days the water is supplied; therefore, water consumption activities increase even on days when water supply is rationed. For this reason, the water demand is estimated to be high even at night time.

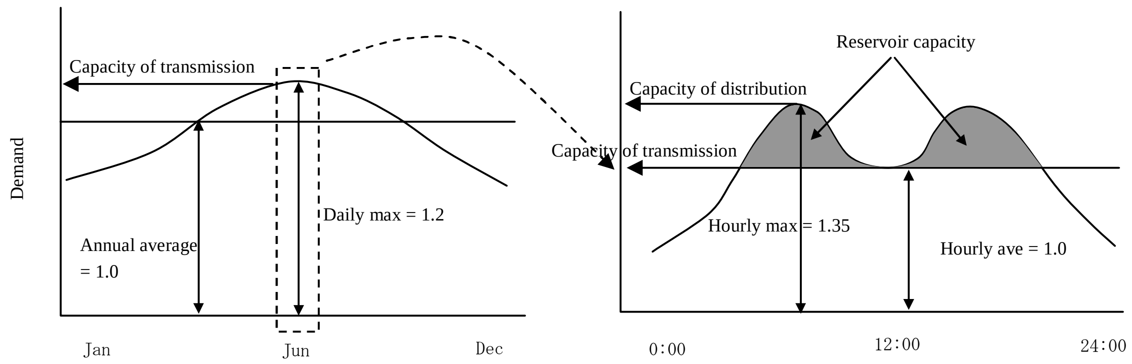


Figure A　Annual fluctuation

Figure B　Daily fluctuation

Figure 2-1　Typical Water Demand Pattern

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 pump: To have the capacity to supply the planned daily maximum water supply amount
- Distribution pipe and distribution pump: To have the capacity to distribute the planned hourly peak water supply amount on the day the planned daily maximum water supply amount is generated.
- Distribution reservoir: To have the capacity to adjust the difference in the distribution amount that varies hourly according to the consumer demand and fixed flow rate of the transmission system on a day on which the planned daily maximum water supply amount is generated.

6)　Planned daily maximum coefficient (1/load factor) and capacity of distribution reservoir

The planned daily maximum coefficient and planned storage hours of distribution reservoir for deciding the capacity of the facility are set as given below.

a)　Planned daily maximum coefficient due to seasonal change

Coefficient of variation of the water supply amount on a monthly basis is calculated as shown in the figure below by dividing the daily average water supply amount by month by the daily average water supply amount by year. The maximum value of the coefficient of monthly variation (daily maximum coefficient) of Tafieleh is 1.48. Currently, since the water supply amount in summer is inadequate, the coefficient of monthly variation is estimated to be higher than the current value when the water supply amount is adequate and the distribution conditions are ideal. Also, since this value is calculated using the daily average of the monthly water supply amount, it is estimated that the actual daily variation is likely to become larger. The planned value used in the Study and Design Directorate, WAJ is 1.5. Considering the above, the daily maximum coefficient (1/load factor) of this project, is taken as 1.5.

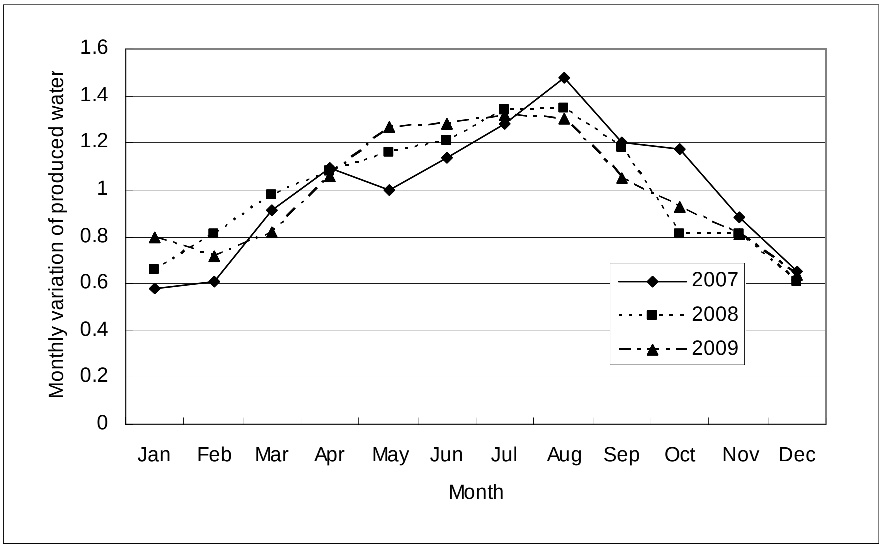


Figure 2-2 Annual Variation of the Value of Average Water Supply Amount by Month Divided by the Average Water Supply Amount by Year

b) Planned hourly maximum coefficient

The time coefficient is the ratio of the hourly peak water supply amount to hourly average water supply amount. The time coefficient was calculated as shown in the table below from the measured flow rate data in the pilot project, which was part of the JICA Technical Cooperation Project. The time coefficient of the measured data is about 2.0. The design value of the Study and Design Directorate, WAJ is in the range of 1.5 to 2.0. Accordingly, the time coefficient is set as 2.0 based on the design values of WAJ and referring to the actually-measured values in the pilot project area.

Table 2-13 Time Coefficient Estimated from the Pilot Project

Item	Measured month	Time coefficient
Time Coefficient	Aug. 2009	1.95

Source: JICA Technical Cooperation Project

c) Planned distribution reservoir capacity

A distribution reservoir generally has the functions given below.

- To adjust the difference in variable distribution amount by time according to the consumer demand and constant flow rate from the water transmission system
- Back-up in case the water supply is stopped because of accident or water shortage
- To store water for extinguishing fires
- To reduce the fluctuation in distribution pressure by distributing water from the distribution reservoir to the water distribution zones by gravity flow.

Water supply is rationed because of the shortage of water resources and other reasons in Jordan. Storage function for the equitable distribution of water is an important function. The project area in Tafieleh are remote from the water source areas, and since there are no alternative water sources, if an accident occurs to the transmission system, water supply is likely to be suspended for a long period. For this reason, the storage capacity of the distribution reservoir should be set at a higher feasible value.

WAJ usually prepares the waterworks plan considering a planned daily maximum water supply amount of 12 or more hours for a distribution reservoir. Storage capacity for 12 hours to 1 day has been set corresponding to the planned daily maximum water supply amount in the WAJ Existing Plan for the project area. The capacity of the distribution reservoir in the Guidelines on the Design of Water Supply Facilities of Japan too is taken as 12 hours and more. Consequently, the capacity of the distribution reservoir for the target year of 2015 is taken as the planned daily maximum water supply amount corresponding to a period of 12 hours.

7) Planned water supply pressure

The range of water supply pressure in the distribution network as per WAJ guideline is 0.25 MPa to 0.6 MPa (2.5 bar to 6.0 bar). Two-storey buildings are mostly found in the project area. Usually, water can be supplied directly to two-storey buildings if the water supply pressure is about 0.15 MPa. To supply water to four-storey buildings, a pressure of about 0.25 MPa is necessary.

The target value of planned minimum water supply pressure is taken as 0.25 MPa for this project. However, to avoid enormous expenses to satisfy the above standard when supplying water to areas that are hydraulically disadvantageous because of the relationship between the distribution reservoir and location/topography, the following standards are adhered to, which also exist in the WAJ Existing Plan:

Table 2-14 Design Criteria for Water Supply Pressure

In daily maximum water supply	In hourly peak water supply	Maximum water pressure
P > 0.25 MPa(2.5 bar)	P> 0.05 MPa(0.5 bar)	P < 0.7 MPa (7.0 bar)

8) Distribution network analysis and flow system

The network analysis software EPANET2 of the US EPA is used to decide the diameters of the water transmission and distribution system. The Hazen-Williams equation below is used for loss calculations for pipelines.

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

H: Friction loss (m)
Q: Flow rate (m^3/sec)
D: Pipeline diameter (m)
L: Pipeline length (m)
C= Hazen-Williams Head Loss Coefficient (100 used for existing pipes, 110 used for new pipes for the project)

9) Summary of planned conditions for water demand

The planned conditions for water demand in the project area by network renewal are and non-renewal area are summarized in the table below.

Table 2-15 Planned Conditional Values for Water Demand in the Project area of Tafieleh Governorate

Item	Units	Current	Network renewal area			Network non-renewal area		
		2010	2015	2020	2025	2015	2020	2025
Planned average daily water consumption per capita	L/person/day	112	125	125	125	112	125	125
Planned average daily water supply amount per capita	L/person/day	149	147	147	147	149	156	147
Planned maximum water demand per capita	L/person/day	224	221	221	221	224	235	221
Planned leakage ratio	—	0.25	0.15	0.15	0.15	0.25	0.20	0.15
Planned daily maximum coefficient	—	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Time coefficient	—	2	2	2	2	2	2	2

(2) Water distribution zoning plan and planned zone water demand

1) Water distribution zone plan

The project area of the Tafieleh Governorate can be divided into the existing water distribution zones from the viewpoint of administrative district boundaries, topography and geography. The existing water distribution zones are shown in Table 2-16 together with the distribution reservoirs of the supply sources and pumping stations. The elevation of the distribution reservoirs in the project area are shown in Table 2-17.

Table 2-16 Existing Distribution Areas

Township	Distribution reservoir /pumping station in charge
Al Mansoura	Ies, Tafieleh low service reservoir, and Aima
Tafieleh	Tafieleh low service reservoir, Tafieleh high service reservoir, Ies distribution reservoir, direct distribution from transmission and distribution pipelines from the Ain-El Baidha distribution reservoir
Sanfahah & Arafeh, Erwayyem	Ain-El Baidha distribution reservoir
Nemta	Ain-El Baidha distribution reservoir
Ain-El Baidha	Ain-El Baidha distribution reservoir
Bsaira	Ain-El Baidha distribution reservoir
Gharandal	Water pumped directly from the Erawath pumping station
Qhadesiyeh	Qhadesiyeh distribution reservoir（transmitted from the Erawath pumping station）

Table 2-17 Capacity and Elevation of Existing Distribution Reservoirs

Existing reservoir /pumping station	Elevation of base of reservoir (m)	Elevation of top of reservoir (m)	Capacity（m^3）
Tafieleh old distribution reservoir (high)	1184.5	1188.6	1,000
Tafieleh new distribution reservoir (low)	1101.8	1105.9	4,500
Ain-El Baidha distribution reservoir	1353.0	1356.5	5,000
Erawath pumping station tank	1292.0	1296.0	300
Qhadesiyeh distribution reservoir	1601.0	1603.5	1,000
Ies distribution reservoir (northern part of Tafieleh)	1285	—	2,000

In this plan, water is supplied by water distribution zone (DZ) after clearly demarcating the water distribution zones. The existing demarcation of water distribution zone under this plan may be used as-is except for the two points below, which includes correction and addition.

- Existing distribution reservoirs are at two locations in Tafieleh city. Since residents are staying at a higher elevation than the existing distribution reservoir, this zone is to be treated as one water distribution zone. Considering the elevation at the position of the water distribution zone, 3 water distribution zones (highest service zone, high service zone, low service zone) are set according to the difference in elevation. Moreover, the water distribution zones are divided into two zones: west and east in low and high zones.

- A small population is found between Ain-El Baidha and Bsaira; here also one water distribution zone is considered.
- The distribution zones of Bsaira and Gharandal are separated by hydraulically optimized line.

The water supply to Tafieleh city is currently being done from the Ain-El Baidha distribution reservoir, the Ies distribution reservoir, the Tafieleh low service and high service reservoirs, and the Aima distribution reservoir. The transmission of water to the Tafieleh high service and low service reservoirs is mainly from the Ain-El Baidha distribution reservoir, but it is also being done from the Ies distribution reservoir. In this way, the water transmission and distribution to Tafieleh city is through multiple water sources. The transmission and distribution pipelines are congested in the city and the distribution of water is very complex.

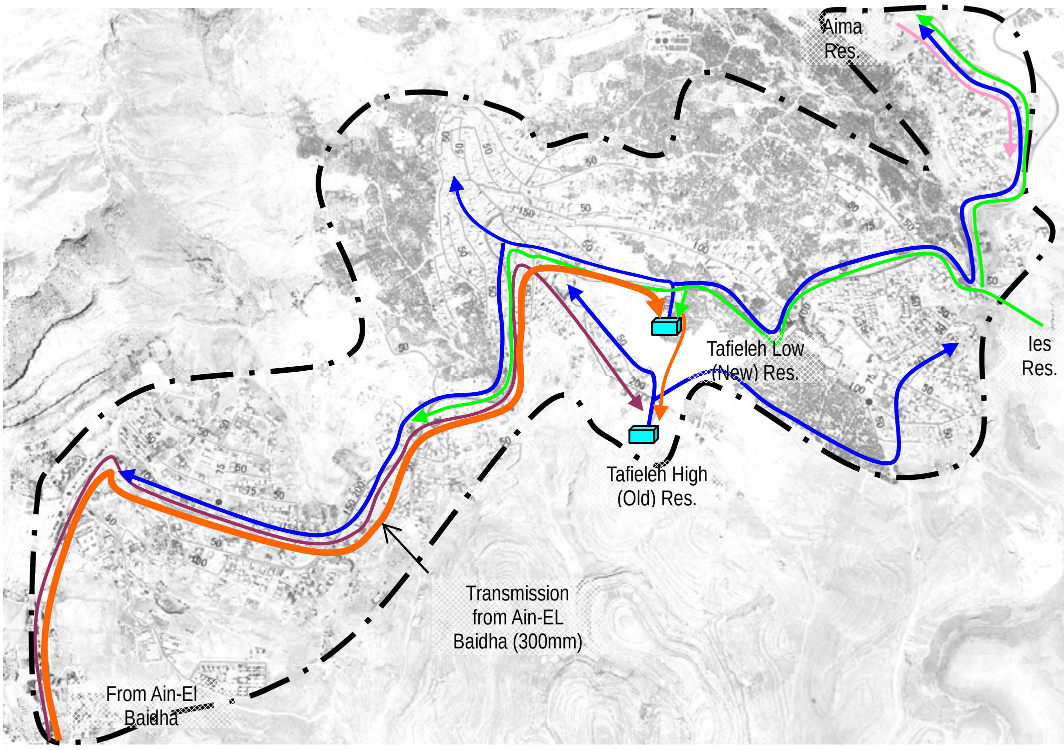


Figure 2-3 Existing Status of Water Distribution to Tafieleh City

In this way, the transmission and distribution network in which water distribution controls are complicated, is to be improved. A water transmission and distribution system is to be constructed such that both water distribution management and non-revenue water management are easy. For this reason, a gravity flow system is to be used from the two distribution reservoirs in the Tafieleh city after separating the water transmission and distribution system and forming water distribution zones. The figure below shows the planned division of water distribution zones and the arrangement of water transmission and distribution pipelines in Tafieleh city.

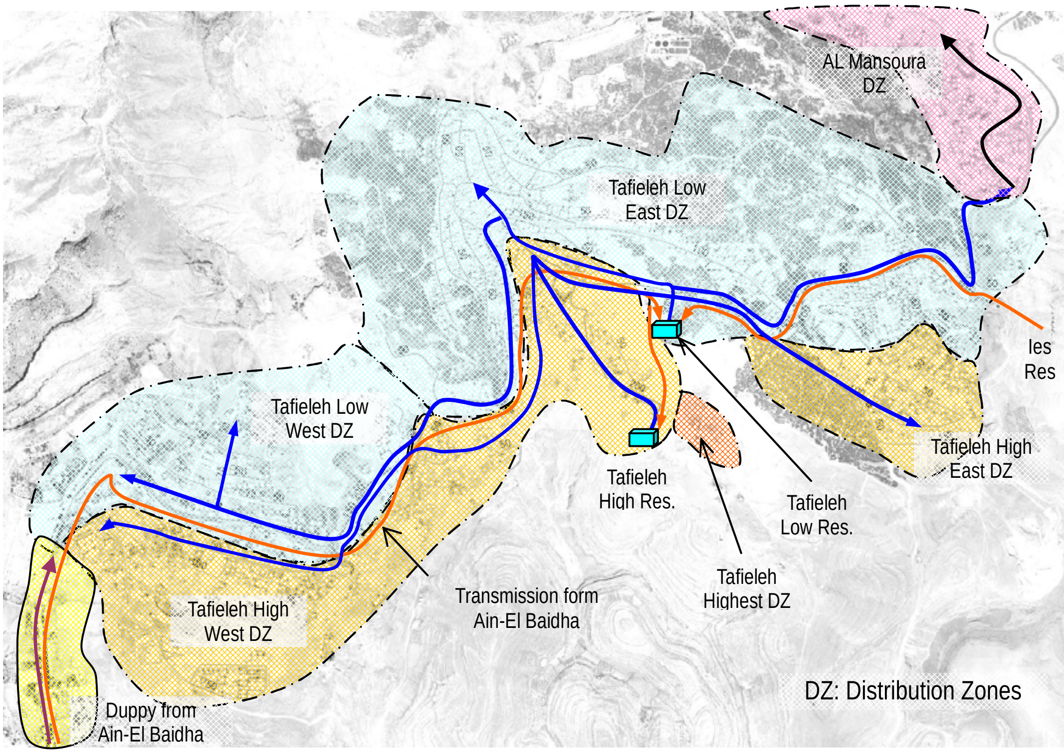


Figure 2-4 Division of Water Distribution Zones and Arrangement of Transmission and Distribution Mains in Tafieleh City

Considering the above, the water distribution zones are divided as shown in Table 2-18. The water transmission and distribution method to each water distribution zone is also explained in the same table. The elevation profile of planned water distribution zones and existing water transmission and distribution system and existing water transmission and distribution system and water distribution areas of Tafieleh Governorate project area are shown in Figure 2-5 and Figure 2-6, respectively.

Table 2-18 Division of Planned Water Distribution Zones and Water Transmission and Distribution Method

Distribution zone (DZ)	Existing reservoir / pumping station		Elevation of base of reservoir (m)	Elevation of water distribution zone (m)	Difference in elevation (m)	Planned water transmission and distribution method
Al Mansoura	Ies, Tafieleh low service reservoir		1101.8	895 – 1055	160	Water should be distributed only from Tafieleh Low reservoir
Tafieleh Overall						In principle, water is not distributed directly from Ies and Ain-El Baidha.
Tafieleh highest	Ain-El Baidha		1353.0	1175 – 1250	75	There is a small area to which water cannot be distributed by gravity flow from the Tafieleh high reservoir. Water is to be directly distributed from the Ain-El Baidha reservoir to this area through the transmission pipeline.
Tafieleh high	East	Tafieleh high	1184.5	1050 - 1175	125	Area in which water can be transmitted by gravity flow from the Tafieleh high reservoir and area in which water cannot be distributed by gravity flow from the Tafieleh low reservoir.
Tafieleh high	West	Tafieleh high	1184.5	1050 - 1175	125	Area in which water can be transmitted by gravity flow from the Tafieleh high reservoir and area in which water cannot be distributed by gravity flow from the Tafieleh low reservoir.
Tafieleh low	East	Tafieleh low	1101.8	900 – 1060	160	Area in which water can be distributed by gravity flow from the Tafieleh low reservoir
Tafieleh low	West	Tafieleh low	1101.8	950 - 1050	100	Area to which water can be distributed by gravity flow from the Tafieleh low reservoir and which is remote from the reservoir (west part)
Sanfahah & Arafeh, Erwayyem	Ain-El Baidha		1353.0	1005 – 1155	150	Same as the existing water transmission and distribution system
Nemta	Ain-El Baidha		1353.0	1150	20	Same as the existing water transmission and distribution system
Ain-El Baidha	Ain-El Baidha		1353.0	1185 – 1345	160	Same as the existing water transmission and distribution system
				1050 (Sel'e)	20	
Between Ain-El Baidha and Bsaira	Ain-El Baidha		1353.0	1240 – 1295	55	Same as the existing water transmission and distribution system
Bsaira	Ain-El Baidha		1353.0	1000 – 1275	275	Same as the existing water transmission and distribution system. Since the location of Bsaira is remote from Ain-El Baidha, separation of the water transmission and distribution systems, and installation of distribution reservoir are necessary.
Gharandal	Erawath pumping station			1270 – 1430	160	Arrangement of distribution reservoirs is necessary since distribution is directly from the existing pump.
Qhadesiyeh	Qhadesiyeh		1601.0	1350 - 1580	230	Same as the existing water transmission and distribution system

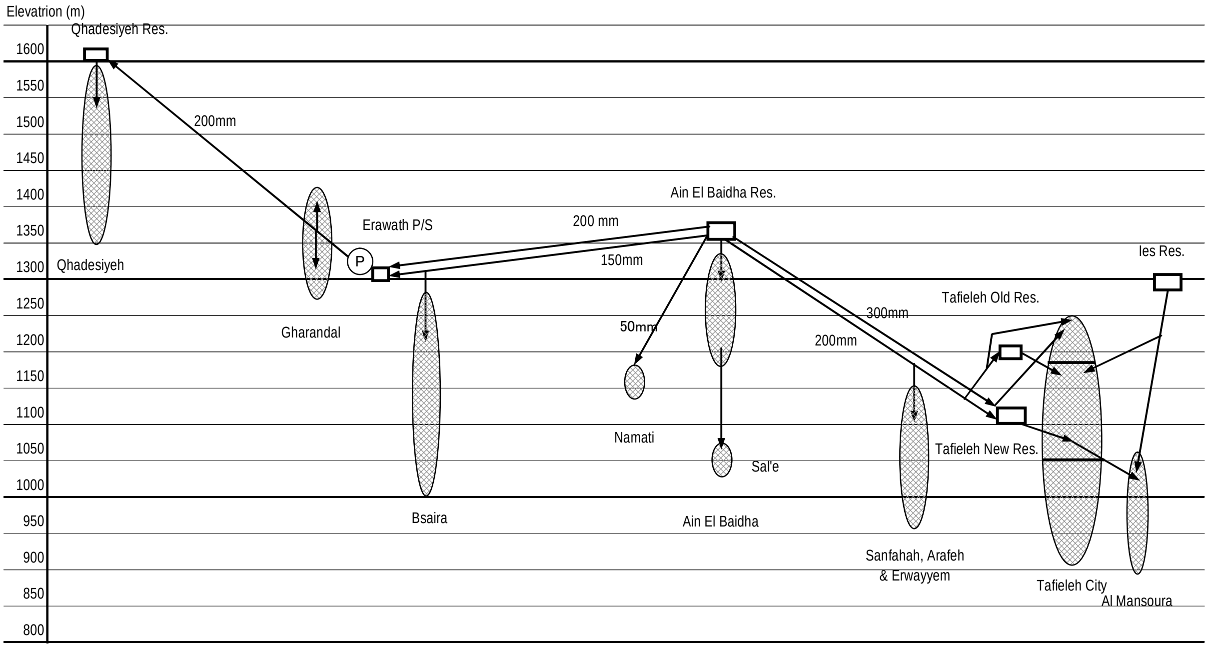


Figure 2-5 Elevation Profile of Planned Water Distribution Zones and Existing Water Transmission and Distribution System

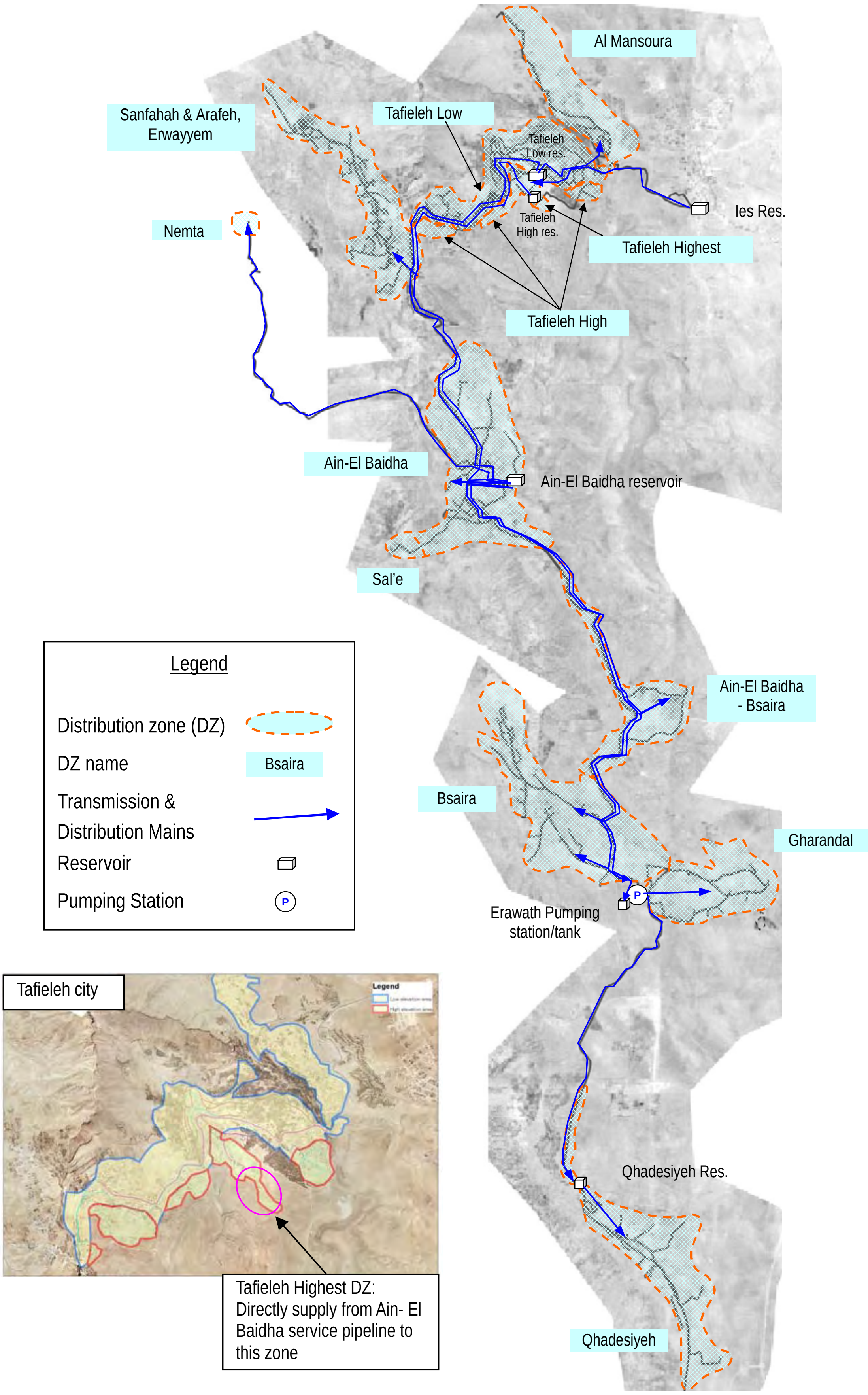


Figure 2-6 Existing Water Transmission and Distribution System and Water Distribution Areas of Tafieleh Governorate Project Area

2) Planned served population by water distribution zone

Table 2-19 Planned Future Population by Distribution Zone in Project Area of Tafieleh Governorate

Distribution reservoir and pumping station	Water distribution zone	2010	2015	2020	2025
Tafieleh low reservoir	Al Mansoura	4,199	4,577	4,978	5,351
	Tafieleh low east	12,432	13,373	14,004	14,504
	Tafieleh low west	5,859	6,363	6,917	7,429
Tafieleh high reservoir	Tafieleh high east	1,464	1,599	1,739	1,868
	Tafieleh high west	2,073	2,252	2,414	2,556
Ain-El Baidha (AEB) reservoir	Tafieleh highest	70	77	84	91
	Sanfahah	3,450	3,762	4,089	4,394
	Nemta	159	174	189	204
	Ain-El Baidha	10,918	11,893	12,935	13,900
	AEB-BSR1	455	498	542	585
	AEB-BSR2	818	895	975	1,051
	Bsaira (BSR)	9,522	10,378	11,222	11,997
Erawath pumping station (ERW)	Gharandal	4,739	5,169	5,625	6,045
	ERW-QAD1	77	84	91	98
Qhadesiyeh (QAD) reservoir	Qhadesiyeh	7,660	8,348	9,078	9,754
Cement company	ERW-QAD2	605	658	718	773
Total		64,500	70,100	75,600	80,600

3) Water demand by distribution zone

Table 2-20 Planned Water Supply Amount by Distribution Zone in Project Area of Tafieleh Governorate

(m^3 /day)

Distribution reservoir and pumping station	Water distribution zone	Planned average daily water supply amount				Planned daily maximum water supply amount			
		2010	2015	2020	2025	2010	2015	2020	2025
Tafieleh low	Al Mansoura	628	674	732	787	943	1,012	1,099	1,182
	Tafieleh low east	1,857	1,967	2,060	2,133	2,786	2,952	3,090	3,201
	Tafieleh low west	875	936	1,018	1,092	1,313	1,405	1,527	1,639
Tafieleh high	Tafieleh high east	219	235	256	275	329	354	384	413
	Tafieleh high west	310	332	355	376	465	498	533	564
Ain-El Baidha (AEB)	Tafieleh highest	10	11	12	13	16	17	19	20
	Sanfahah	516	554	601	646	775	833	903	971
	Nemta	24	26	28	30	36	39	42	45
	Ain-El Baidha	1,632	1,752	1,902	2,045	2,452	2,631	2,857	3,071
	AEB-BSR1	68	74	80	86	103	111	120	130
	AEB-BSR2	123	133	143	155	185	200	215	233
	Bsaira (BSR)	1,424	1,528	1,651	1,764	2,140	2,295	2,479	2,649
Erawath pumping station (ERW)	Gharandal	709	761	827	889	1,065	1,142	1,243	1,335
	ERW-QAD1	12	13	13	15	18	19	20	22
Qhadesiyeh (QAD)	Qhadesiyeh	1,145	1,230	1,335	1,435	1,721	1,847	2,004	2,155
Cement company	ERW-QAD2	91	97	106	114	137	146	159	171
Total		9,640	10,322	11,118	11,856	14,483	15,500	16,692	17,799

A synoptic table of planned future population and planned water supply amount by distribution zone in the project area of Tafieleh is given in Data 4 in Appendix 6.

(3) Evaluation of water supply sources for the project Area

The planned average daily water supply amount in 2015 is 10,322 m^3/day. The results of yield test of Hase wells which are the main source of the project area are attached in Data 5 in Appendix 6. Based on the results, assuming 20 hours/day pumping, the potential source amount was estimated at 15,984 m^3/day. The estimated source amount exceeds the planned average daily water supply amount in 2015. Therefore, the existing wells can cover the average water demand for the project area in 2015. It can also cover the maximum water demand in 2015. The results of water quality test of raw water of wells or water in reservoirs are attached in Data 1 in Appendix 6. According to these data, the source water is no problem as a drinking water source in terms of water quality.

(4) Study of planned water transmission and distribution system in the project area

1) Scope of study on water transmission and distribution

The following studies are made to select an optimum plan.

- Alternative plans for water transmission and distribution from Ain-El Baidha - Bsaira - Erawath pumping station - Gharandal and Qhadesiyeh zones
- Alteration of transmission pipe from Ain-El Baidha reservoir to the reservoirs in Tafieleh city

2) Alternative plans for water transmission and distribution in the south Tafieleh

a) Present water transmission and distribution system

Water is currently being transmitted and distributed to the south Tafieleh (Bsaira, Gharandal, Qhadesiyeh) from the Ain-El Baidha distribution reservoir.

- Bsaira: <u>Water is being distributed directly by gravity flow</u> from the Ain-El Baidha distribution reservoir about 10 km away through 200-mm distribution pipeline. However, the diameter of the pipe is small and the distribution capacity is low, therefore, areas at high elevation are dissatisfied with the water supply.
- Gharandal: Similarly, water is being received at the distribution reservoir (300 m^3) of the Erawath pumping station through supply pipelines of 200 mm from Ain-El Baidha at a distance of about 10 km, and is <u>directly distributed by pumping from the pumping station.</u>
- Qhadesiyeh: Similar to Gharandal, water is being received at the distribution reservoir (300 m^3) of the Erawath pumping station through supply pipelines of 200 mm from Ain-El Baidha, and this water is pumped to the Qhadesiyeh distribution reservoir (1000 m^3) from the pumping station. The

water is distributed by gravity flow from the distribution reservoir.

b) Alternative proposal

To select the optimum system, the four alternative proposals for water transmission and distribution were prepared and compared (see Figure 2-7). The request from WAJ for distribution reservoir was for one reservoir in the Gharandal zone but alternative proposals were made considering the installation of distribution reservoir in the Bsaira zone in addition to Gharandal. The status of water distribution to the Qhadesiyeh zone is practically the same in all the alternative proposals. Therefore, for comparison purpose, the systems excluding Qhadesiyeh system were compared and studied.

Proposal A: To transmit the water demand amount for Bsaira, Gharandal, and Qhadesiyeh from the Ain-El Baidha distribution reservoir to the Erawath pumping station by installing one transmission main, and to pump the water demand amount for Bsaira and Gharandal areas to the planned Gharandal distribution reservoir, and to supply the water from the planned Gharandal distribution reservoir to the Bsaira zone and the Gharandal zone. (1 planned distribution reservoir plan in Gharandal)

Proposal B: To transmit the water demand amount for Bsaira, Gharandal and Qhadesiyeh from the Ain-El Baidha distribution reservoir to the planned Bsaira distribution reservoir and the Erawath pumping station, by installing one transmission main, to pump the water to the planned Gharandal distribution reservoir and the existing Qhadesiyeh distribution reservoir, and to distribute the water from each of the distribution reservoir (2 planned distribution reservoir of Bsaira and Gharandal)

Proposal C: To transmit the water demand amount for Gharandal and Qhadesiyeh from the Ain-El Baidha distribution reservoir up to the Erawath pumping station by installing additional one transmission pipeline. Water is to be directly distributed to the Bsaira zone by branching off a line from the planned supply pipeline. To pump the water to the planned Gharandal distribution reservoir and the existing Qhadesiyeh distribution reservoir, and then distribute it. (1 planned distribution reservoir of Gharandal and combined water transmission and distribution system)

Proposal D: To transmit the water demand amount for Gharandal and Qhadesiyeh from the Ain-El Baidha distribution reservoir up to the Erawath pumping station by installing additional transmission pipeline. At the same time, to directly distribute the water to the Bsaira zone through the same supply pipelines by installing another transmission main. To pump the water from the Erawath pumping station to the planned Gharandal distribution reservoir and the existing Qhadesiyeh distribution reservoir, and then distribute it to the various zones. (1 planned distribution reservoir of Gharandal and separate water transmission and distribution system)

c) Selection of optimum proposal

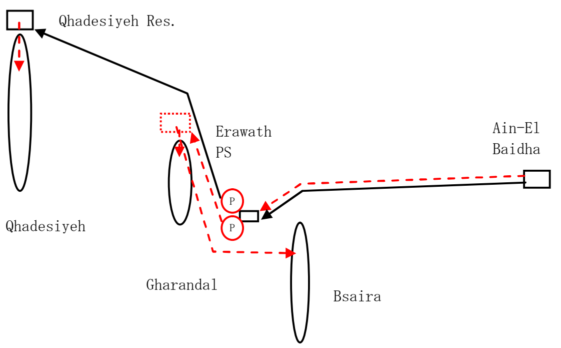
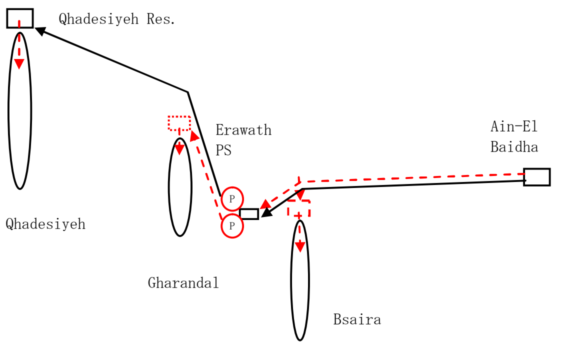
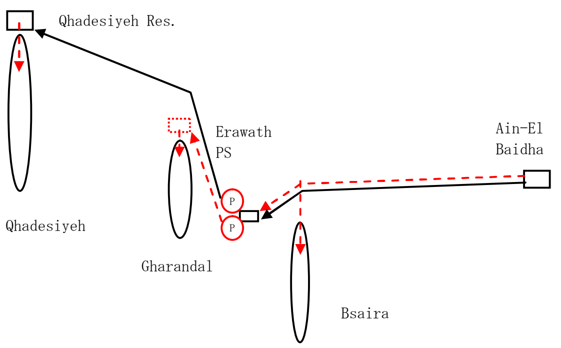
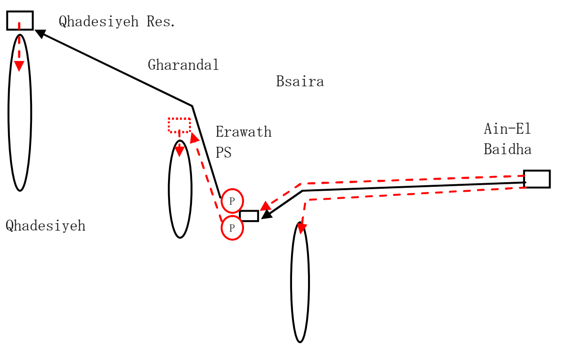
Alt.	Schematic layout	Contents of Required Facility
A		Transmission pipelines: 1. Ain-El Baidha – Bsaira. Dia. 200 to 300 mm x 10.7 km 2. Erawath PS – Gharandal res. Dia. 250 x 3.6 km Pumping station: 2.8 m^3/s Distribution reservoir: 1,800 m^3 x 1
B		Transmission pipelines: 1. Ain-El Baidha – Bsaira res. Dia. 200 to 300 mm x 10.7 km 2. Earwath PS – Gharnadal res. Dia. 150 x 3.6 km Pumping station: 0.95 m^3/s Distribution reservoir: 1,200 m^3 x 1, 600 m^3 x 1
C		Transmission pipelines: 1. Ain-El Baidha – Bsaira Dia. 300 to 350 mm x 10.7 km 2. Erawath PS – Gharandal res. Dia. 150 x 3.6 km Pumping station: 0.95m^3/s Distribution reservoir: 600 m^3 x 1 Pressure-reducing valve: 1 location Flow rate control valve: 1 location
D		Transmission pipelines: 1. Ain-El Baidha – Bsaira. Dia. 150 to 300 mm x 19.7 km 2. Erawath PS – Gharandal res. Dia. 150 x 3.6 km Pumping station: 0.95 m^3/s Distribution reservoir: 1 x 600 m^3 Pressure-reducing valve: 1 location

Figure 2-7 Comparison of Water Transmission and Distribution Methods from Ain El Baida to Bsaira, Erawath Pumping Station and Gharandal Areas

The comparison of these alternatives is shown in table below. The alternative D was eliminated due to higher cost. The alternative A was also eliminated due to high initial cost and higher operation and maintenance cost of pumping station. Finally, the alternative B was selected as an optimum alternative as the cost difference between the lowest alternative (C) is less than 3 %, transmission and distribution method is more advantageous than the alternative C, and, furthermore, this system conforms with WAJ water transmission and distribution policy. The result of hydraulic calculation of water system of alternative B is given in Data 6 in Appendix 6.

Table 2-21 Comparison of Alternatives for Transmission Method in the South Tafieleh Area

Item	Alt. A	Alt. B	Alt. C	Alt. D
Ratio of direct construction cost	1.091	1.028	(1.00) base	1.307
Maintenance and operation costs	The pumping const for transmitting the distribution water amount of Bsaira zone to Gharandal reservoir increases compared to proposal B, C, D.	Same as 3 alternatives		
Water transmission and distribution management	Water transmission and distribution are separated, and through gravity flow, water flows from the planned distribution reservoir to the Bsaira zone, therefore distribution controls are easy.	Water transmission and distribution are separated, and through gravity flow, water flows from the planned distribution reservoir to the Bsaira water, therefore distribution controls are easy.	The water distributed to Bsaira and transmitted to the Erawath pumping station has to be controlled by one pipeline; water transmission and distribution controls are complicated. In addition to flow control valve, if automatic system is added, the cost increases.	water transmission and distribution are separated, but since distribution reservoir and Bsaira water distribution zone are distant from each other, timely distribution controls are not possible.
Leakage management	Gravity flow from the Gharandal distribution reservoir to the Bsaira zone; if pressure-reducing valves are installed at appropriate positions, leakage reduces.	Gravity flow from the Bsaira distribution reservoir to the Bsaira zone, therefore, the maximum hydrostatic water pressure is low, and leakage is also low.	The maximum hydrostatic water pressure of the Bsaira water distribution zone is more than that of Alt. B by about 50 m. Pressure-reducing valves before distribution to the Bsaira zone are necessary for controlling water leakage.	Same as Proposal C.
WAJ design policy	The WAJ design policy is separate water transmission and distribution, and gravity flow system from the distribution reservoir; this proposal matches the policy.	The WAJ design policy is separate water transmission and distribution, and gravity flow system from the distribution reservoir; this proposal matches the policy.	The WAJ design policy related to new facilities is separate water transmission and distribution; this proposal does not match the policy.	Same as Proposal B.
Overall evaluation	Both construction cost, and maintenance and operation costs are high	Construction cost is slightly higher than that of Alt.C, but this alt is superior to Alt C considering water transmission and distribution management, and leakage controls, and it also matches the WAJ design policy. (Selected)	Construction cost is minimum. Distribution management is difficult.	Construction cost is high.

3) Alteration of transmission pipe to the reservoirs in Tafieleh city

Existing transmission pipelines coming from Ain-El Baidha reservoir to Tafieleh reservoirs will be utilized in this plan.

The water is conveyed from a pipeline (dia. 200 mm) from Ain-El Baidha reservoir to the Tafieleh high reservoir. There are many branch-offs on this pipeline. This pipeline shall be used to supply water before entering Tafieleh city in this plan and shall not be used for transmission and distribution pipe after entering into the city. A new distribution main shall be installed from the reservoirs in Tafieleh city to distribute water in Tafieleh city.

A transmission line (dia. 300 mm) from Ain-El Baidha is directly connected to Tafieleh low reservoir. This pipeline should be used for transmission line to Tafieleh low and high reservoirs. For this purpose, this transmission line should be connected with the existing pipeline that goes to the high reservoir in or around the low reservoir. By this measure, water can be directly transmitted from Ain-El Baidha reservoir to the low and high reservoirs without connection.

(5) Distribution reservoir plan

1) Study of distribution reservoir capacity

The required distribution reservoir site in the project area in 2015 is shown together with the existing capacity in the table below. The capacity of existing distribution reservoir satisfies the distribution amount in 2015. The required capacities of the planned Bsaira and the planned Gharandal distribution reservoirs are 1,200 m^3 and 600 m^3 respectively.

Table 2-22 Study of Distribution Reservoir Capacity in Project area in Tafieleh Governorate

Distribution reservoir /pumping station	Elevation of base of distribution reservoir/ low water level (m)	Existing capacity (m^3)	Required capacity (m^3)	Planned capacity (m^3)
Tafieleh old reservoir (high service zone)	1184.5	1,000	430	-
Tafieleh new reservoir (low service zone)	1101.8	4,500	2,690	-
Ain-El Baidha reservoir	1353.0	5,000	1,920	-
Erawath pumping station tank	1292.0	300	-	-
Qhadesiyeh reservoir	1601.0	1,000	920	-
Planned Bsaira reservoir	1305	-	1,150	1,200
Planned Gharandal reservoir	1470	-	570	600

2) Planned Bsaira distribution reservoir site

The Bsaira distribution reservoir has to be installed at an elevation of 1,305 m or higher in order to distribute water at appropriate supply pressure to the Bsaira water distribution zone. The construction site should preferably be a site owned by the government. Field survey was conducted at sites that satisfy these conditions, and the site owners were confirmed by the Land Department. The result was that the 2 locations in the figure below were selected as candidate sites for the Bsaira distribution reservoir. The results of the study at these two locations are shown in the table below. After evaluation, the location at A was selected as the site for the distribution reservoir.

Table 2-23 Study of Candidate Sites for the Planned Bsaira Distribution Reservoir

Condition	Candidate Site A	Candidate Site B
Hydraulic conditions	Elevation is 1300 m to 1315 m; ideal site for distribution reservoir considering elevation and hydraulic aspects.	Elevation is 1315m to 1325 m; elevation is slightly high for a distribution reservoir; water supply pressure likely to increase. The diameter of supply pipelines to be newly installed from the Ain El Baidha distribution reservoir will increase.
Social conditions	Since construction roads and piping routes will pass through private land, purchase of such private land may be necessary. The private land is currently not being used for any purpose.	Since construction roads and piping routes do not pass through private land, purchase of such private land is not necessary.
Evaluation	(Selected) The site is at an ideal position hydraulically, but purchase of private land is necessary. However, since such land is not being used, it can be purchased easily.	

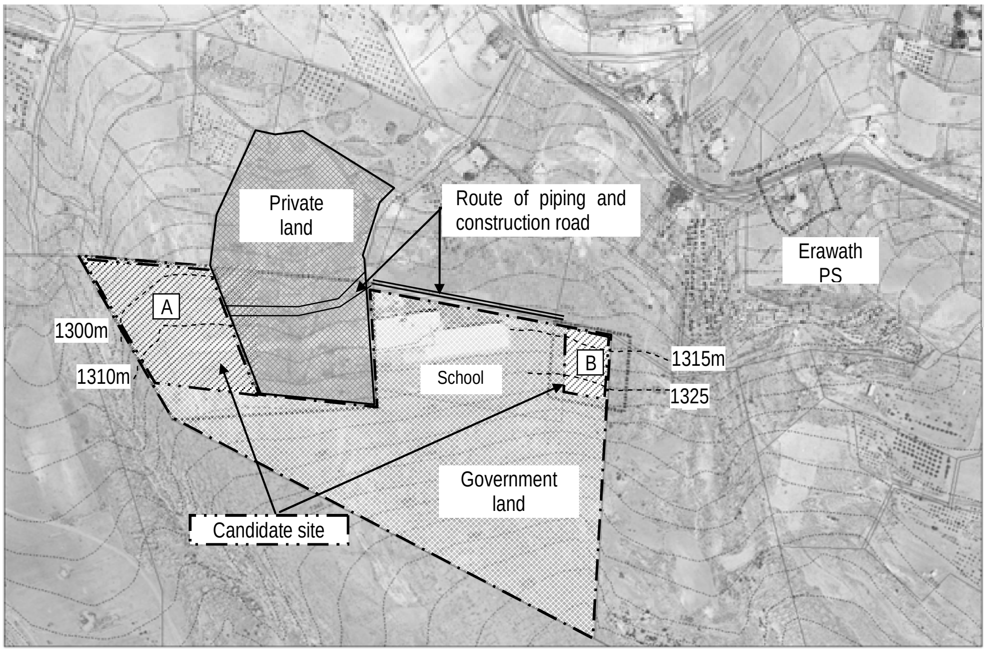


Figure 2-8 Bsaira Distribution Reservoir Candidate Site

3) Gharandal distribution reservoir candidate site

The Gharandal zone is surrounded by hills. Several locations for candidate distribution reservoir exist that satisfy the condition of government-owned land. During the field survey, candidate sites at six locations were studied. The table below shows comparison and evaluation of 6 locations. The optimum distribution reservoir elevation for distributing water to the Gharandal zone is around 1470 m. The results of the study showed that location C was close to the Erawath pumping station, and also close to the water distribution zone. It was also hydraulically most advantageous, and the construction cost as well as the pump power consumption were the least, so this location is selected as the site for the planned Gharandal distribution reservoir.

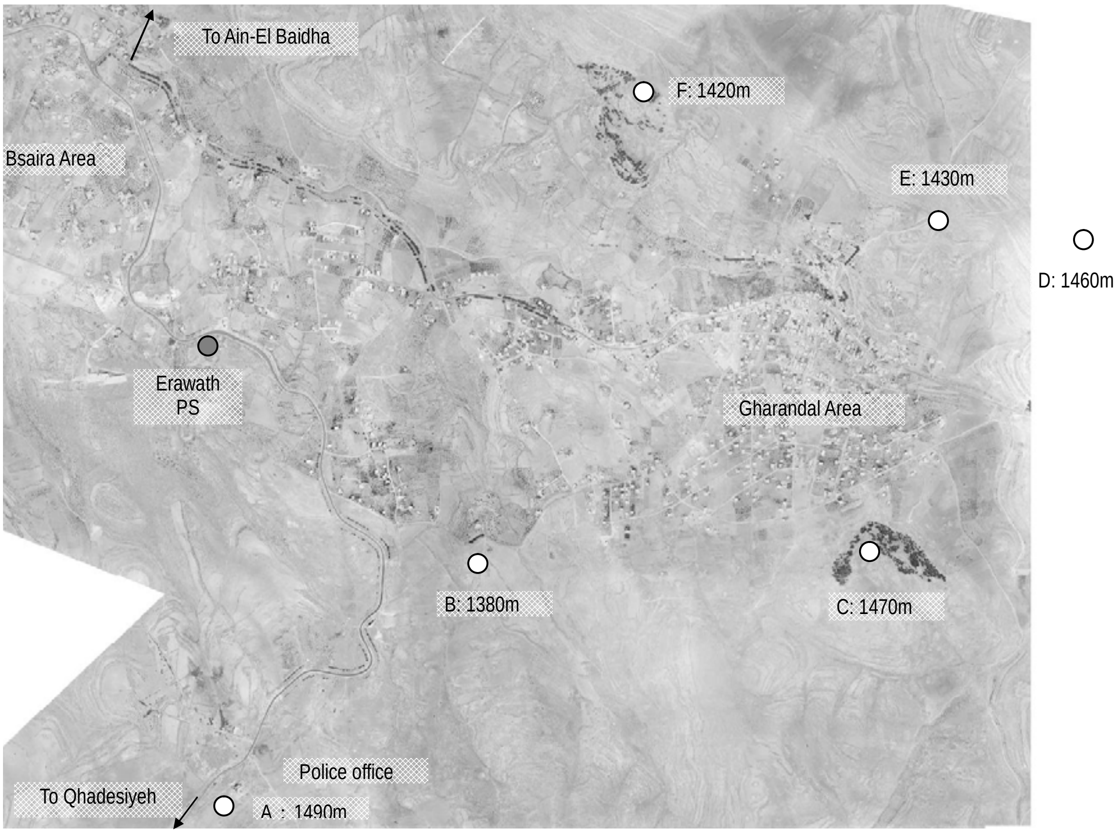


Figure 2-9 Planned Gharandal Distribution Reservoir Candidate Site

Table 2-24   Study of Planned Gharandal Distribution Reservoir Candidate Site

Candidate Site	Features	Evaluation
A	Far from the Erawath pumping station and the center of the Gharandal zone; the length of the water transmission and distribution pipelines will increase. The elevation from the water distribution zone of the Erawath pumping station and the Gharandal zone is high, pump lift will be high, and the water supply pressure to the water distribution zone will also be high, so this is disadvantageous. Pump power consumption will be maximum in this case.	
B	Close to Erawath pumping station, moreover, the elevation is not high; therefore, the pump life is small and the energy consumption will be minimum. However, since the elevation is low, there may be areas where adequate water supply pressure cannot be ensured.	
C	Distance from the Erawath pumping station is about the medium level among the various proposals. An elevation of nearly 1470 m can be ensured. Also close to the center of the water distribution zone, and is hydraulically the optimum site. Short distance access road to the reservoir will be necessary.	Selected
D	Far from the Erawath pumping station and the Gharandal water distribution zone; length of water transmission and distribution pipelines is likely to be maximum. No roads exist at present; construction of long distance access roads will be necessary.	
E	Close to the center of the water distribution zone, it is hydraulically advantageous from the aspect of water distribution. Since adequate elevation cannot be ensured, areas where adequate water supply pressure cannot be ensured will come up. Distance from the Erawath pumping station is longer than that of Proposal C; pump lift is higher and pipeline length is longer than that of Proposal C.	
F	Far from both the Erawath pumping station and water distribution zone, so the water transmission and distribution pipelines will become longer. Elevation is also low, so there may be areas where adequate water supply pressure cannot be ensured.	

The arrangement of the planned Gharandal distribution reservoir facility is shown in the following figure.

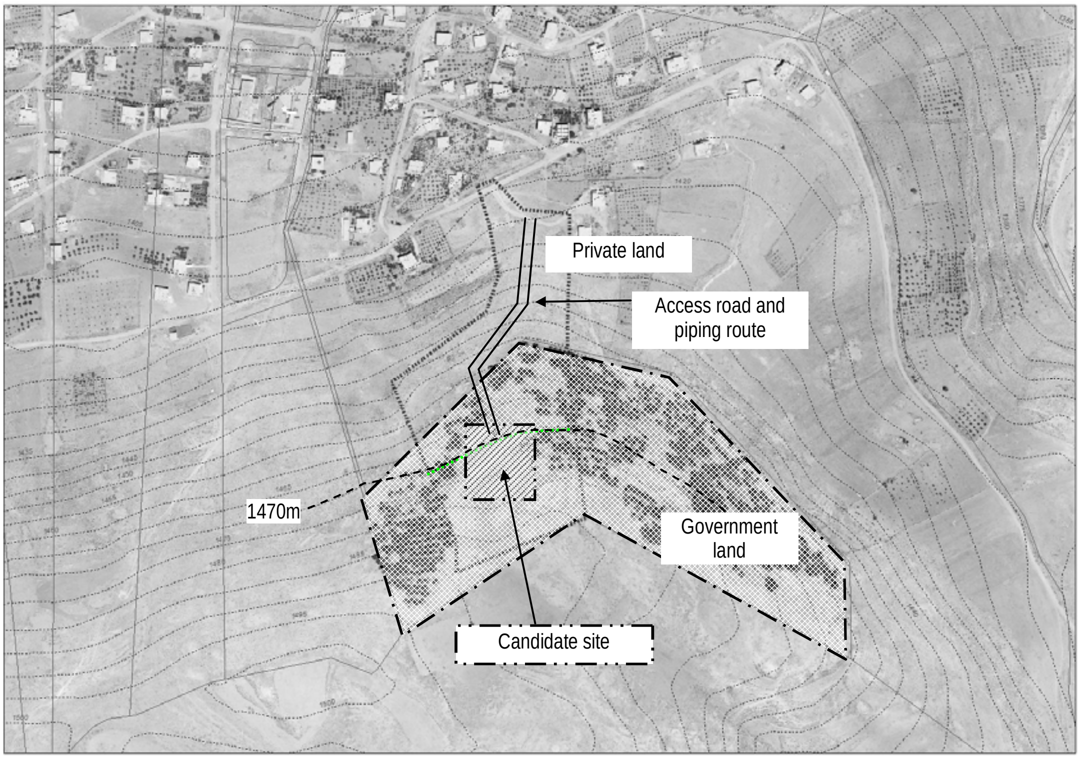


Figure 2-10 Gharandal Distribution Reservoir Candidate Site

4) Specifications of planned distribution reservoir

a) Structure and Dimension

The low water level of the distribution reservoir is set as given below in order to ensure the necessary water supply pressure to the water distribution zones and the necessary capacity of the planned distribution reservoir.

Table 2-25 Specifications of Planned Distribution Reservoir

Distribution reservoir /pumping station	Planned effective capacity (m^3)	Low water level of distribution reservoir (m)	High water level of distribution reservoir (m)	Effective depth (m)	Structure
Planned Bsaira distribution reservoir	1,200	1305	1308.8	3.8	Reinforced Concrete
Planned Gharandal distribution reservoir	600	1470	1474.4	4.3	Reinforced Concrete

b) Foundation and Facility Layout

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. The access road of planned reservoirs in Bsaira and Gharandal is planned as shown in Data 15, Appendix 6.

c) Ancillary Facilities

Piping plans for the facilities in each reservoir include inlet, outlet, bypass, overflow and drainage pipes. In addition, water level meters will be installed as necessary for operations and monitoring. Altitude valves will be installed in the distribution reservoir to eliminate overflow from the distribution reservoir. Altitude valves will also be installed in the Qhadesiyeh distribution reservoir to which water is transmitted from the Erawath pumping station. In addition, flow meters will be installed at the outlet of distribution pipe in accordance with distribution monitoring system.

(6) Renewal and extension plan of Erawath pumping station

1) Area to be covered by renewed and additional pumps

By defining clearly water supply and water distribution area from the reservoir, the area is divided into Gharandal area (low altitude area) and Qhadesiyeh area (high altitude area) and water supply to two areas is made separately from Erawath pump station. Owing to water transmission to the locations having different altitudes, that is; from Erawath pump station (altitude: 1292 m) to the existing Qhadesiyeh reservoir (altitude: 1601 m) and from the same to the planned Gharandal reservoir (altitude: 1470 m), the water transmission pumps are required to have different heads.

The existing pumps will be renewed and used for Gharandal area. Meanwhile the additional pumps for Qhadesiyeh area will be installed newly with the pumping station in the same site as the existing ones. Accordingly, as a priority of installation, the additional pumps having higher heads will first be installed and operated to distribute water to both areas. Then the existing pumps will be renewed.

2) Pump capacity and head

The capacity of pumps in Erawath pump station is calculated from the planned daily maximum water supply amount to each area in year 2025 and their required head is calculated based on the difference in altitude and head loss. These design conditions are shown below.

Table 2-26   Capacity and Head of Planned Pumps

Pumps for transmission area	Planned maximum daily water supply amount (m^3/day)	Pump capacity (m^3/min.)	Pump head (m)
Gharandal	1,335	0.95	225
Qhadesiyeh	2,155	1.5	380

3)   Policy for Renewal of Existing Pump Station

The pumps and the related facilities in the existing pump station were not designed for this pump station but were transferred from other pump station. Accordingly, the capacity and head of the pumps are inadequate. Furthermore these pumps are superannuated and repaired frequently. Taking this situation into account, all the pumps and the related mechanical and electrical facilities shall be replaced.

4)   Extension of pump station building

The pump building shall have a structure composed of reinforced-concrete, beam, slab and wall.

5)   Pump/Motor

Each pump carries water fed from the tank in the site of Erawath pump station. The pump/motor is specified below.

Table 2-27   Specification for Pump/Motor

Specification	For Gharandal (Rehabilitated pump station)	For Qhadesiyeh (Expanded pump station)
Pump		
Quantity	2 sets (one standby)	2 sets (one standby)
Capacity（m^3/min.）	0.95	1.5
Head (m)	225	380
Applicable Standard	ISO9905 & 9906	ISO9905 & 9906
Type	Horizontal shaft single suction multi-stages centrifugal pump	Horizontal shaft single suction multi-stages centrifugal pump
Size（Suction x Discharge）	φ100 mm x 80 mm	φ125 mm x 100mm
Material (Body/Impeller)	Cast Iron/Bronze Casting	Cast Iron/Bronze Casting
Motor		
Applicable Code	IEC6043 & 60072	IEC6043 & 60072
Electric Power (Nominal Voltage)	AC380V, 3 Phase、50Hz	AC380V, 3 Phase、50Hz
Control Power	AC220V, 1 Phase、 50Hz	AC220V, 1 Phase、 50Hz
No. of Pole/Max. Rotation Speed	2P/3000rpm	2P/3000rpm
Type	Totally Enclosed Fan Cooled Three Phase Squirrel Cage Induction Motor	Totally Enclosed Fan Cooled Three Phase Squirrel Cage Induction Motor
Starting Method	Star Delta	Reactor
Operating Method	Manual Operation at Site	Manual Operation at Site

The pump shaft power and the motor output are shown in Table 2-28. However the pump shaft powers are for reference only because pump efficiencies vary depending on pump manufacturers.

Table 2-28 Pump Shaft Power and Motor Output

	Gharandal	Qhadesiyeh
Pump Shaft Power (kW)	65	166
Motor Output (kW)	75 (75) *	191 (200) *

* indicates motor rated output.

6) Principal facilities incidental to pump/motor

a) Water hammer protection equipment

Water hammer analyses on the pump systems for the two areas were made by plotting pipeline profile and minimum and maximum hydraulic grade lines by the graphic method. The result shows that water hammer occurs in both the pump systems. Accordingly, the following countermeasures are proposed. The result of analysis of anti-water hummer measures is given in Data 7 in Appendix 6.

Table 2-29 Countermeasures of Water Hammer

Pump	Water hammer analyses	Countermeasure
For Gharandal	It proved that negative pressure would occur in the pipeline for length of 1.2 km between the location of 2.5 km from the pump station and the reservoir because the pipeline profile in this section exceeds the minimum hydraulic grade line.	This negative pressure can be avoided by equipping a flywheel on the pump so that the maximum and minimum hydraulic grade lines can be improved. The GD^2 of a flywheel shall be 7 kg-m^2. If a flywheel is small, it is the best countermeasure plan both from the technical and cost aspects.
For Qhadesiyeh	It proved that negative pressure would occur in the pipeline for length of 1.4 km between the location of 4.2 km and 5.6 km from the pump station because the pipeline profile in this section exceeds the minimum hydraulic grade line.	To improve the maximum and minimum hydraulic grade lines, three kinds of countermeasure plans were studied. Its result is as follows; i. fly wheel As the huge fly wheel having GD^2 of 150kg・m^2 is required, it is difficult to install it on the pump. ii. Air pressure tank As the high pressure tank and air compressor of 40 kg/cm^2 are required, this countermeasure has high risk in maintenance and cost aspects. iii. Air breathing valve The air breathing valve is the most suitable countermeasure in technical and cost aspects. Three air breathing valves having size of 100 mm shall be installed at the location of 4.5 km from the pump.

b) Electrical Incoming Panel

The existing Erawath pump station has the contracted electric power of 250 kVA. The power demand required for pump operation under this project is calculated as approximately 800 KVA at star delta starting. Accordingly, the existing contracted electric power is insufficient. Jordan side is required to change the existing contracted electric power with the electric power company and to replace the existing transformer of 250 kVA. Finally, transformer capacity is determined by the Contractor based on the output of pump motor.

The incoming panel is installed in Qhadesiyeh pump station to distribute primary power to the power/control panel for each pump. The panel shall be indoor use metal closed self-standing type. The applicable standard shall be IEC 60439. The power distributed shall be AC 380 V, 3 phase, 4 wires, 50 Hz. The main parts of the panel are DS, LA, ACB, GR, MCCB, ampere meter, and voltage meter.

Quantity

Incoming Panel：1 panel

c) Power/Control Panel

The applicable standard shall be IEC 60439. The power circuit and control circuit are equipped in the same panel. The panel shall be indoor use metal closed self-standing type. The pump starter shall be star delta starter. Start/stop of the pump is made by manual operation. The main parts of the unit are MCCB, MC, transformer, and ampere meter.

Quantity

For Gharandal pump：2 panels

For Qhadesiyeh pump：2 panels

d) Pump Discharge Check Valve

The pump discharge check valve is installed in the pump discharge pipeline and used to prevent back flow. The check valve has a main disc and a sub-disc to avoid pressure rise. The main disc has a counterweight and the sub-disc has hydraulic dashpot.

Specifications:

Specifications	For Gharandal	For Qhadesiyeh
Quantity	2	2
Flange rating	PN 30	PN 40
Materials: Body Disc Spindle	Ductile Cast Iron Ductile Cast Iron Stainless Steel	

e) Sluice Valve

Sluice valves are installed in the pump suction and discharge pipeline for operation and maintenance.

Specifications;

<table>
<tr><th>Specifications</th><th>For Gharandal</th><th>For Qhadesiyeh</th></tr>
<tr><td>Quantity</td><td>4</td><td>4</td></tr>
<tr><td>Materials for suction side : Body
Disc
Spindle
Materials for discharge side : Body
Disc
Spindle</td><td colspan="2">Cast Iron
Cast Iron
Copper Alloy or stainless steel
Ductile Cast Iron
Ductile Cast Iron
Copper Alloy or stainless steel</td></tr>
<tr><td>Flange Rating
Pump suction side
Pump discharge side</td><td>
PN 10
PN 30</td><td>
PN 10
PN 40</td></tr>
</table>

f) Chain Block for Maintenance

The chain block is equipped on I beam fixed under the ceiling. Traveling and winding operation is made by manual. Rated load shall be 2 tons.

Quantity

For Gharandal pump：1 lot

For Qhadesiyeh pump：1 lot

(7) Replacement plan of distribution network

The materials of water pipes in the project area consist mostly of fragile galvanized steel or black steel and the average age of pipe is 22 years to 39 years. Galvanized pipe is very week to high water pressure, easily corroded and is main cause of leakage. Aged tar-coated black steel pipe causes water quality degradation including rusty water in network. To supply safe and stable water, replacement of these aged pipes is a major concern in the project area.

1) Prioritization of replacement of distribution network

The project areas are spread over very wide area and it is not possible to implement entire network replacement within limited budget. To focus more suitable and limited area for replacement by Japanese side, the priority is given to the area for selection. The selection criteria are shown below.

- Population scale and density: cost-effectiveness, the number of beneficiaries
- Pipe age: non-revenue water reduction
- Frequency of leaks: non-revenue water reduction

- Water supply pressure: non-revenue water reduction

2) Population scale and density

The estimated population and population density in Tafieleh in 2015 by town/area are shown in tables below. The largest population in Tafieleh is Tafieleh city followed by Ain-El Baidha and Bsaira. Population density is highest in Tafieleh city and its neighboring town of Al Mansoura.

Table 2-30 Estimated Population and Population Density in Tafieleh in 2015

Town	Estimated population	Rank	Population density (p/ha)	Rank
Al Mansoura	4,577	6	69	2
Tafieleh city	23,664	1	84	1
Sanfahah and neighbor	3,762	7	24	8
Nemta	174	8	42	4
Ain-El Baidha	12,391	2	35	6
Bsaira	11,273	3	33	7
Gharandal	5,253	5	43	3
Qhadesiyeh	9,006	4	40	5
Total/average	70,100	-	45	-

3) Age of distribution network

The data of construction year of distribution network were collected from WAJ staff in charge of distribution network maintenance. The collected pipe age data were stored in GIS together with pipe material and diameter. The average age of distribution network by area is shown in table below. Qhadesiyeh has the oldest pipe with 39 years of average age.

Table 2-31 Average Age of Distribution Pipe

Area	Average age
1. Al Mansoura	21.8
2. Tafieleh city	23.1
3. Sanfahah and neighbor	23.6
4. Ain-El Baidha	27.6
5. Bsaira	30.0
6. Gharandal	21.6
7. Qhadesiyeh	39.0

4) Frequency of leakage

According to WAJ staff, the ranking of leakage frequency is shown in table below.

- 1st: Tafieleh city center : 10~20 repairs in a day
- 2nd: Bsaira city center

- 3rd: Qhadesiyeh center
- 4th: Gharandal

5) Selection of pipe renewal area

The following table shows a summary of the values of criteria stated above.

Table 2-32 Comparison of Area for Pipe Renewal

Area	Population in 2015	Pop density (p/ha)	Average pipe area (years)	Frequency of leaks	Water pressure	Request from Jordan	Selection
Tafieleh							
Al Mansoura	4,577	69●	21.8				
Tafieleh city	23,664●	84●	23.1	●			●
Sanfahah and neighboring area	3,762	24	23.6		High●		
Ain-El Baidha	12,391●	35	27.6●				
Bsaira	11,273●	33	30.0●	●	High●	●	●
Gharandal	5,253	43	21.6	●	High●	●	●
Qhadesiyeh	9,006	40	39.0●	●	High●	●	●

Note: ● indicates priority area for replacement.
Nemta is excluded as it is very small area.
JICA technical cooperation project is on going for reducing NRW in Sanfahah and neighboring area.

Considering the comparison table above, the following areas are selected as distribution pipe renewal area.

Table 2-33 First Screening Result for Selection of Pipe Renewal Area

Selected area	Reasons	Estimated population in network upgrading area
• Tafieleh city	Frequent leakage, large beneficiaries, high water pressure	23,664
• Bsaira	Frequent leakage, large beneficiaries, high water pressure, Establishment of a transmission system is planned for this town. It is more effective to replace pipe together with this new system.	10,378
• Qhadesiyeh	Frequent leakage, large beneficiaries, high water pressure, oldest pipe age, Establishment of a transmission system is planned for this town. It is more effective to replace pipe together with this new system.	5,169
• Gharandal	High water pressure, frequent leakage Establishment of a transmission system is planned for this town. It is more effective to replace pipe together with this new system.	8,348
	Total	47,559

Note: For the estimated population in network renewal area, refer Table 2-19.

(8) Pipeline plan

1) Planned transmission pipeline

The diameter and length of the planned transmission pipeline is calculated as shown in table below based on network analysis.

Table 2-34 Planned Transmission Pipeline

(m)

Route	Diameter	Length
Ain-El Baidha – Bsaira enterance	300 mm	7,950 m
Bsaira entrance – Bsaira junction	250 mm	2,270 m
Bsaira Junction – planned Bsaira reservoir	200 mm	460 m
Erawath pump station – planned Gharandal reservoir	150 mm	3,540 m
Total		14,220 m

2) Renewal of distribution network

The diameter and length of the planned distribution main and secondary mains in pipe renewal area are calculated as shown in table below based on network analysis. The result of network analysis is given in Data 8 in Appendix 6.

Table 2-35 Length of Planned Distribution Pipeline by Diameter and Area

(m)

Diameter	Tafieleh	Bsaira	Gharandal	Qhadesiyeh	Total
300 mm	90	0	0	0	90
250 mm	2,210	460	0	0	2,670
200 mm	2,510	2,930	1,000	1,320	7,760
150 mm	3,020	490	320	1,780	5,610
100 mm	6,230	3,300	2,460	2,250	14,240
50 mm	14,790	14,550	9,700	11,560	50,600
Total	28,850	21,730	13,480	16,910	80,970

3) Pipe materials

According to the pipe materials stipulated in the WAJ standards, high density polyethylene (HDPE) pipe has been adopted for pipe outer diameter (OD) equal and less than 63 mm and ductile cast-iron (DI) pipe has been adopted for pipe diameter more than 100 mm. In this project, considering the past adoption record of WAJ and following advantages of ductile cast-iron pipe, DI pipe is adopted for pipe with diameter more than 100 mm and HDPE pipe for pipe with diameter equal and less than OD 63 mm.

Advantages of ductile cast-iron pipe

① Its excellent workability allows a quick pipe laying process which only requires a day for excavation, laying of pipe and backfilling, thereby minimizing impacts to transportation services.
② Its connection method is simple, which requires no special skills and allows easy securing of water tightness with the local technical level.
③ In the project area, the existence of corrosive soil was confirmed. DI pipe has excellent corrosion resistance. In addition, its high rigidity and flexibility provides an excellent crashproof function. It is also durable.
④ Adopting of the WAJ pipe selection standard is advantageous in terms of maintenance of pipe and provision of pipe materials. Therefore, the pipes installed in the project could be utilized for long time with proper maintenance activities by WAJ.

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.

Table 2-36 Specifications of Valves

Type	Installation point and specifications
Sluice valves	Sluice valve will be installed on the connection point of the distribution pipes and maintenance points. 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 ・ 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 major roads where separation-resistant fittings will be used considering construction speed.

6) Joint construction

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

7) Corrosion protection

According to WAJ staff, high corrosive soil to pipe exists in the project area. As a result of field survey, corrosiveness of soil was evaluated and high corrosion soil was found along planned pipeline route in Tafieleh city.

Polyethylene sleeve protection, which is the most economical and easiest way for corrosion protection, is selected as corrosion protection for pipe. The sites of protection are 2 places and 2 km in total in Tafieleh city. The study and evaluation results are given in Data 9 in Appendix 6.

(9) Procurement plan of pipe materials for installation by Jordanian side

The topography in Tafieleh is highly undulating and it is likely difficult to plan and implement the pipe installation work by Jordanian side. Therefore, installation of the pipe with OD 63 mm was also requested to Japanese side by Jordanian side in the Minutes of Discussion in October 2009. However, as a result of distribution network analysis, installation of pressure reducing valves are not required for pipe with diameter less than 100 mm, and installation of these small diameter pipes is not difficult in Jordan. Because technical problems are reduced, these small pipes should also be the responsibility of Jordanian side. However, considering cost bearing capability of Jordanian side for this project, procurement of pipe materials should be the responsibility of Japanese side.

1) Scope of procurement	- The project area for procurement of pipe is Tafieleh city, Bsaira, Gharandal and Qhadesiyeh
2) Pipe material	- High density polyethylene pipe: OD 63 mm (PN16)
3) Total length of pipe to be procured	- 50,600 m
4) Auxiliary Facilities	- Fittings, joints, and sluice valves (at connections)

(10) Design for pressure reducing valve

The pressure reducing valve is designed to lower the distribution water pressure and is installed with pipe renewal works. The existing pressure reducing valves in Petra, Ma’an were studied in terms of conditions of setting and degree of damage by cavitation and the results were utilized to design adequate pressure reducing valves in the this project. The study result of pressure reducing valves in Petra is given in Data 10 in Appendix 6.

1) Installation conditions and nominal diameter of the valves

The difference between water level at outlet of the reservoir and water service areas is very high in

Tafieleh area because of geological conditions. This results into high differential pressure in pipelines. In order to reduce leakage of water due to high pressure in pipelines, the water pressure in service area is controlled to approximately less than 6 bars based on the design standard of WAJ by means of pressure reducing valves. Design of valve is prepared considering protection against valve erosion due to cavitations. The cavitations factor (σ1) is calculated using the following formula.

$\sigma_1 = H_2+10/((H_1- H_2)$

where,

H_1 : primary pressure of valve (MPa or m)

H_2 : secondary pressure (MPa or m)

In addition to σ1, there is specific cavitations factor (σ2) to each valve. Regarding σ1 and σ2, when σ1 is larger than σ2, cavitations will not be generated. According to the result of Petra area survey, in cases when σ1 is less than 0.5 to 0.7, in some valves erosion of the valve seat occurred because of cavitations. Therefore, the cavitations factor (σ1) is considered to be more than 0.7.

Nominal diameter (mm) for pressure reducing valve is designed smaller than pipeline size in order to have dispersed pressure reduction. However, water velocity through the valve should be less than 2 m/s and the Cv value should be positive. The Cv value is calculated using the following formula.

Cv＝11.6×Q×vG/⊿P

Cv : flow rate factor

Q: flow rate (m^3/h)

G: specific gravity (water : 1)

dP: differential pressure (kMp) (dP＝P1－P2)

(P1 : primary pressure, P2 : secondary pressure)

The nominal diameter and cavitations factor (σ1) is shown in Table 2-37 and the location of valve installation is shown in Figure 2-11 to Figure 2-14.

Table 2-37 Specification of the Pressure Reducing Valve

No.	Location/ Location No.	Pipeline Conditions					Specifications for pressure reducing valve					
		1. Pipe Dia.	2. Pipe Material	3.P. Press (MPa)	4.S. Press (MPa)	5. DP (MPa)	6. V (m/s)	7.Q (m^3/day)	8. Q (m^3/h)	Cv-value	valve dia.	σ_2 (factor)
1	Tafieleh 1	100	DI	0.63	0.5	0.13	2.008	766.1	31.92	32.48	75	4.62
2	Tafieleh 2	100	DI	0.68	0.3	0.38	1.581	603.1	25.13	14.95	75	1.05
3	Tafieleh 3	100	DI	0.6	0.3	0.3	2.054	783.7	32.65	21.87	75	1.33
4	Tafieleh 4	100	DI	0.62	0.3	0.32	0.717	273.5	11.4	7.39	75	1.25
5	Bsaira 1	100	DI	0.51	0.3	0.21	1.833	699.16	29.13	23.32	75	1.90
6	Bsaira 2	100	DI	0.61	0.3	0.31	1.490	568.35	23.68	15.60	75	1.29
7	Bsaira 3	200	DI	0.35	0.3	0.05	1.461	3962.66	165.11	270.86	200	8.00
8	Bsaira 4	200	DI	0.66	0.3	0.36	1.278	3468.05	144.5	88.34	200	1.11
9	Bsaira 5	200	DI	0.66	0.3	0.36	1.858	2835.22	118.13	72.22	150	1.11
10	Bsaira 6	200	DI	0.68	0.3	0.38	1.430	2182.8	90.95	54.12	150	1.05
11	Bsaira 7	100	DI	0.62	0.3	0.32	1.062	405.06	16.88	10.95	75	1.25
12	Gharandal 1	200	DI	0.61	0.3	0.31	1.482	2261.64	94.24	62.09	150	1.29
13	Gharandal 2	200	DI	0.64	0.3	0.34	1.055	1609.67	67.07	42.19	150	1.18
14	Gharandal 3	100	DI	0.57	0.3	0.27	1.008	384.83	16.03	11.32	75	1.48
15	Gharandal 4	100	DI	0.57	0.3	0.27	0.830	316.8	13.2	9.32	75	1.48
16	Gharandal 5	100	DI	0.59	0.35	0.24	0.747	285.07	11.88	8.90	75	1.88
17	Qhadesiyeh 1	200	DI	0.57	0.3	0.27	1.381	3747.15	156.13	110.22	200	1.48
18	Qhadesiyeh 2	200	DI	0.6	0.3	0.3	1.299	3524.9	146.87	98.36	200	1.33
19	Qhadesiyeh 3	100	DI	0.54	0.3	0.24	0.747	285.2	11.88	8.90	75	1.67
20	Qhadesiyeh 4	150	DI	0.66	0.3	0.36	1.058	717.95	29.91	18.29	100	1.11
21	Qhadesiyeh 5	150	DI	0.64	0.3	0.34	1.890	1281.55	53.4	33.59	100	1.18
22	Qhadesiyeh 6	100	DI	0.54	0.3	0.24	1.247	475.6	19.82	14.84	75	1.67

Notes: 3. Primary pressure, 4. Secondary Pressure, 5. Differential pressure, 6. Velocity, 7.& 8. Flow rate, DI: Ductile Caste Iron Pipe

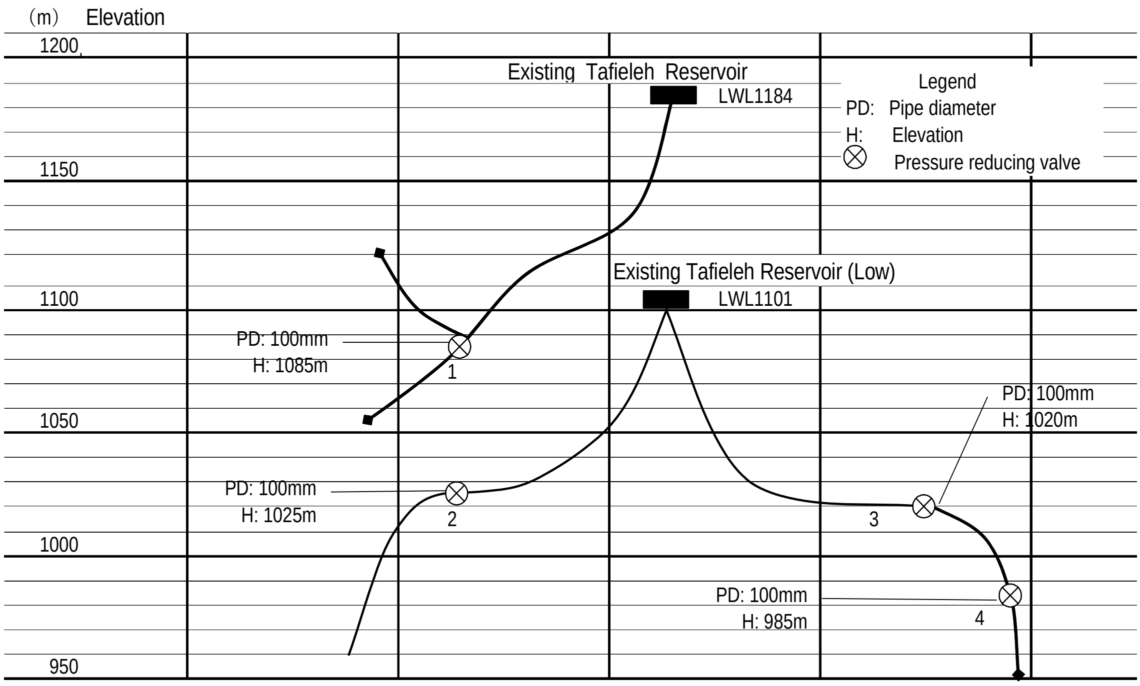


Figure 2-11 Location of Pressure Reducing Valve (Tafieleh City)

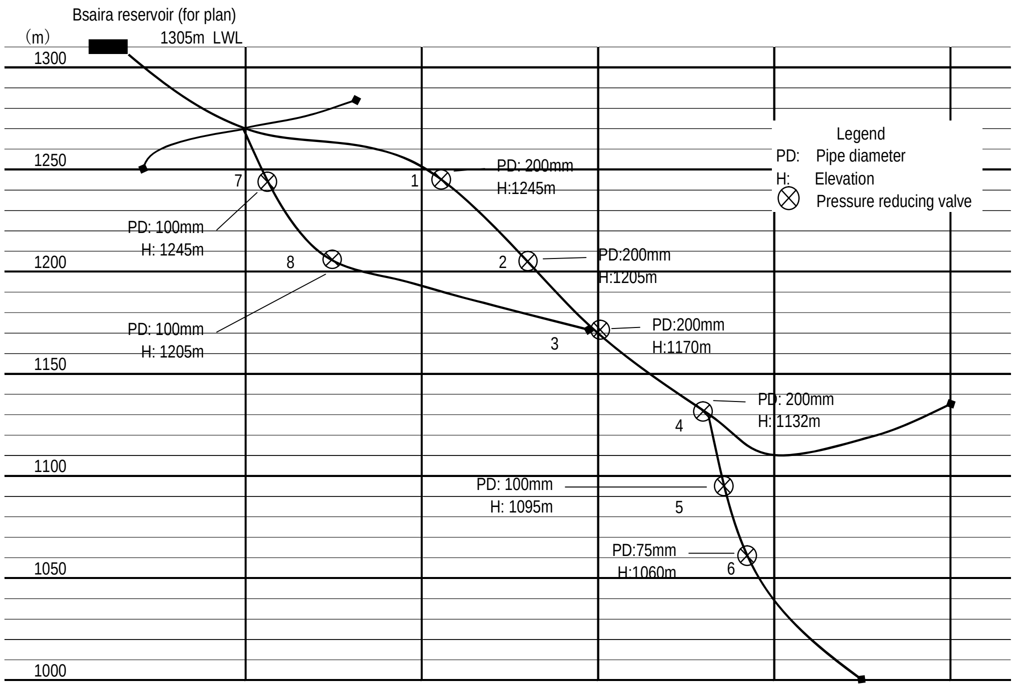


Figure 2-12 Location of Pressure Reducing Valve (Bsaira)

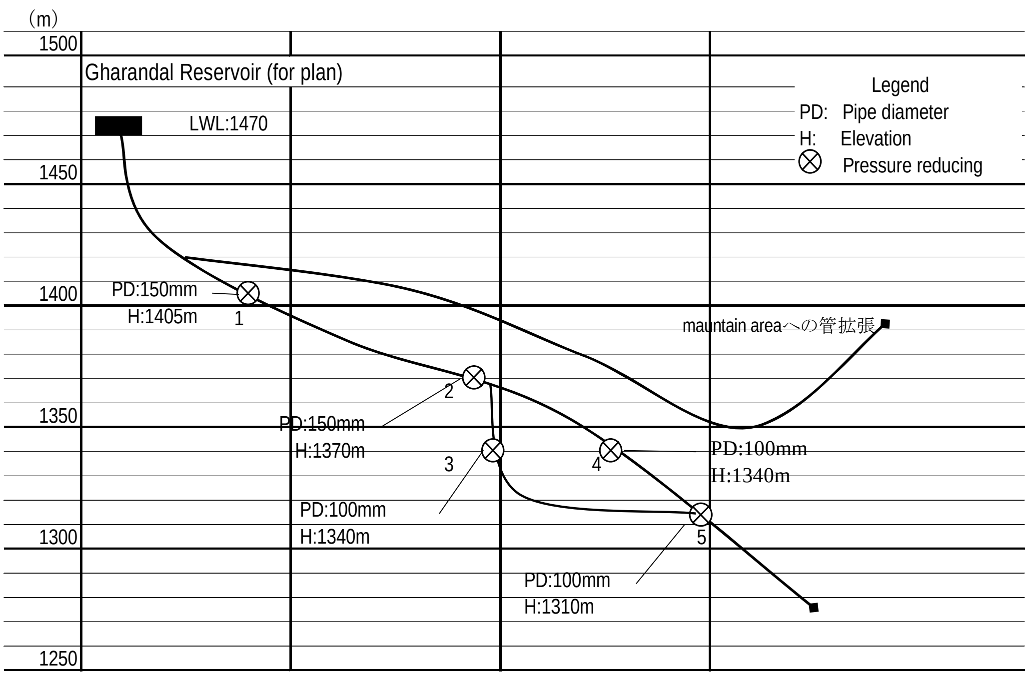


Figure 2-13 Location of Pressure Reducing Valve (Gharandal)

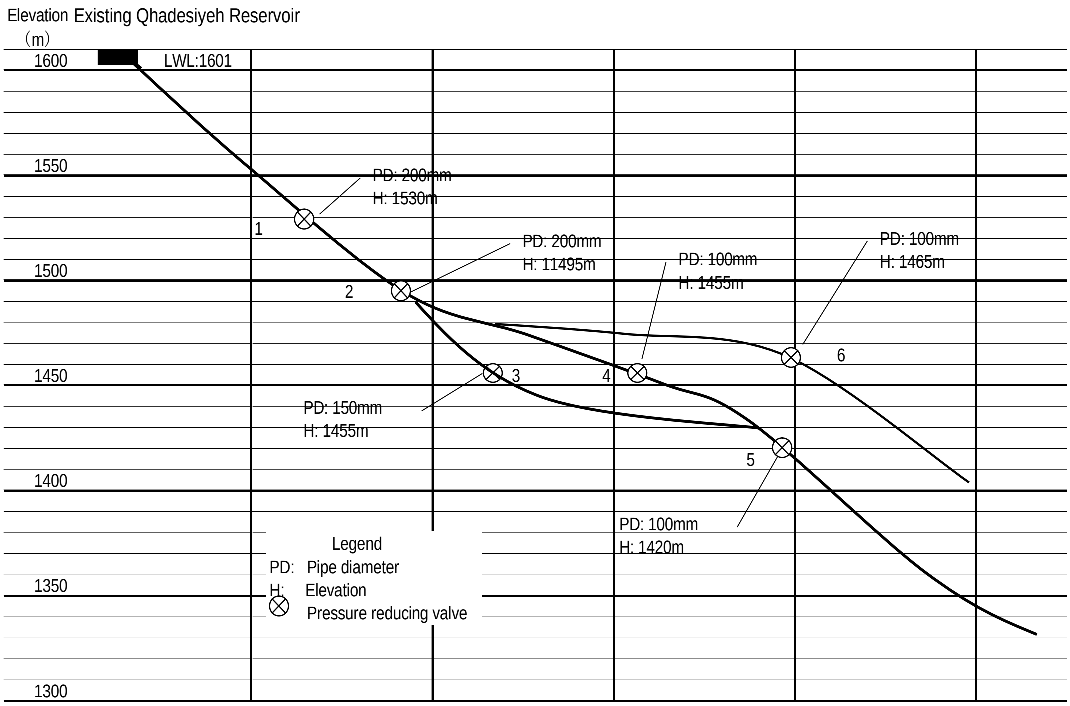


Figure 2-14 Location of Pressure Reducing Valve (Qhadesiyeh)

2) Installation method of the pressure reducing valve

The basic concept of valve installation is shown in drawings below. At the location of the valve, bypass pipeline is provided for maintenance of valve and strainer is installed before the valve for protection of valve against foreign materials in water.

Specifications

<table>
<tr><td>Pressure Reducing Valve</td><td>The type of driving force of the valve is self-support system which harnesses water pressure in the pipeline. The valve consists of main valve and pilot valve. Main valve is of diaphragm type. The function of the pilot valve is to hold constant secondary pressure of the valve. The valve connection is flange type and flange rating of ISO, PN-16 is applied.
Nominal diameter and Quantity<table><tr><th>Diameter（mm）</th><th>Quantity</th></tr><tr><td>75</td><td>12</td></tr><tr><td>100</td><td>2</td></tr><tr><td>150</td><td>4</td></tr><tr><td>200</td><td>4</td></tr><tr><td>Total</td><td>22</td></tr></table>Material
Valve body: Ductile Cast Iron
Diaphragm: Special Rubber
Valve spindle: Stainless Steel
Pilot valve: Gun Metal and Stainless Steel</td></tr>
<tr><td>Strainer</td><td>The function of the strainer is protection against flow of foreign materials such as pebble or sand to the pressure reducing valve. The strainer consists of strainer body, lid and punching plate type strainer.
The mechanism of strainer includes pulling out punching plate with accumulated foreign materials for easy cleaning. The strainer is flange end type and flange rating of ISO, PN-16 is applied.
Quantity: 22 sets (same as pressure reducing valve)
Material
Strainer body and lid: Ductile Cast Iron
Strainer: Stainless Steel</td></tr>
<tr><td>Stop valve</td><td>For maintenance of pressure reducing valve, the stop valves are installed at inlet and outlet of pressure reducing valve and in bypass pipe. Type of the valve is sluice valve with PN-16 flanged end.
Quantity and Nominal Diameter<table><tr><th>ND（mm）</th><th>Quantity</th></tr><tr><td>75</td><td>36</td></tr><tr><td>100</td><td>6</td></tr><tr><td>150</td><td>12</td></tr><tr><td>200</td><td>12</td></tr><tr><td>Total</td><td>66</td></tr></table>Material
Valve box: Ductile Cast Iron
Valve body: Ductile Cast Iron
Spindle: Stainless Steel</td></tr>
</table>

(11) Monitoring system for water supply system

1) Objective for introduction of monitoring system

Currently the rate of non-revenue water for water supply system in the project area is about 50 %, which is very large. Above all, the water transmission and distribution management is not carried out adequately because of unavailability of measuring data on leakage. In this project, flow meters will be installed at inlet and/or outlet of reservoirs, the pump station and DMA (District Metering Area) and flow and pressure can be monitored at the central monitoring station in WAJ Tafieleh office. Therefore, the rate of leakage can be grasped and it is possible to make improvement plan on leakage and reduce its rate. Furthermore, Monitoring of flow by zone makes it easy to prepare and implement non-revenue water reduction plan including the priory of leakage control among the distribution zones.

It is possible to control sluice valve in distribution zone promptly by monitoring flow and pressure at the central monitoring station and to improve uneven water distribution by preventing unbalanced flow.

2) Facilities to be monitored

The facilities to be monitored by the monitoring system in Tafieleh are shown below.

Tafieleh Area
・ Outlet of reservoir：6 (10 flow meters) ・ Outlet of water transmission pump：1 (2 flow meters) ・ Inlet of DMA：3 (3 flow meters and 3 pressure meters)

Flowmeter is installed all the outlet and inlet above but pressure meter will be installed only in inlet of DMA. Details for the facilities to be monitored are shown in Figure 2-15.

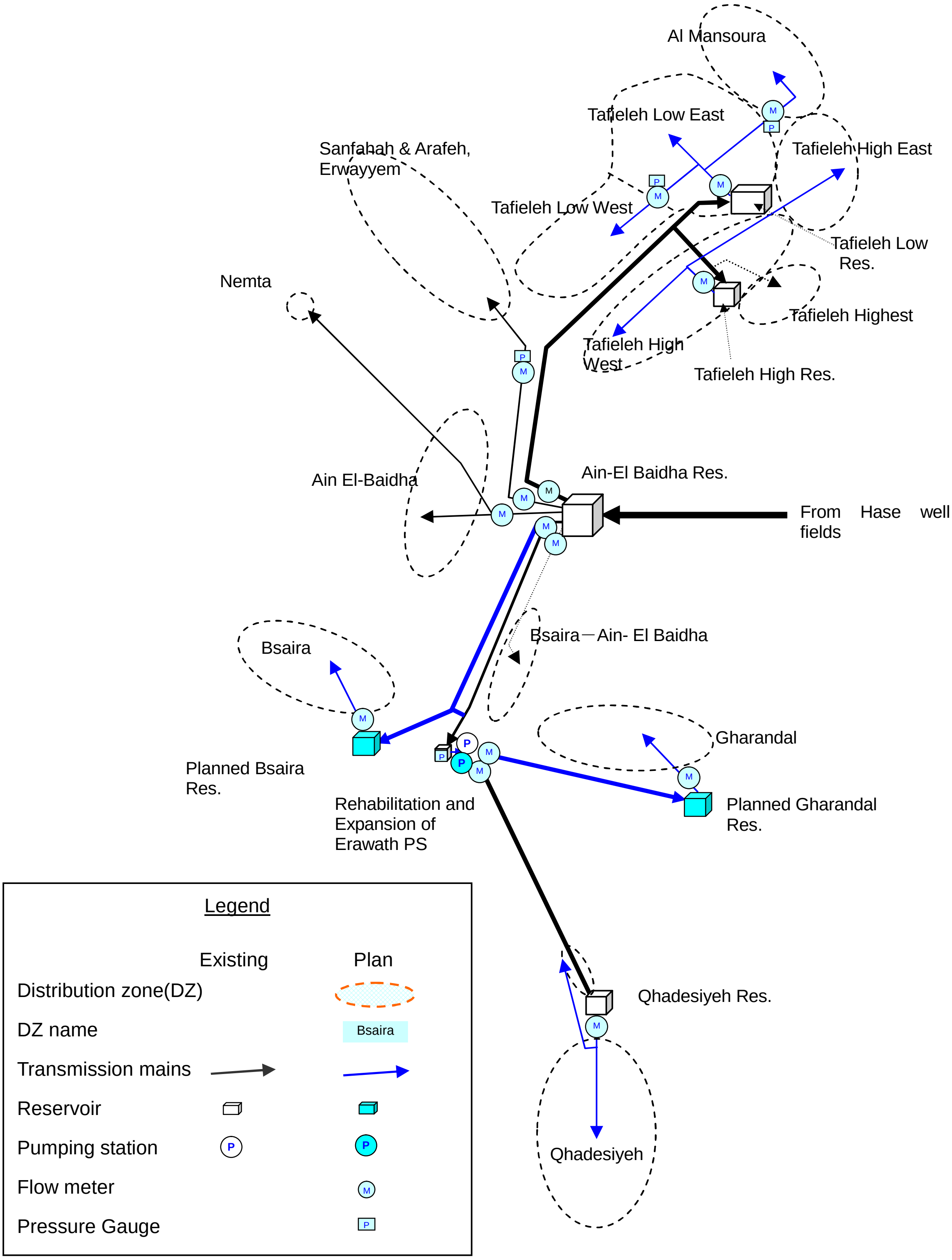


Figure 2-15 Location of Field Equipment for Monitoring in Tafieleh Area

3) Monitoring system

The central monitoring stations will be located at WAJ Tafieleh office and receive, analyze and accumulate pressure and flow data transmitted from the facilities to be monitored. Outlet of the reservoir and the pump station has more than one flow meter. As these flow meters are installed in the same site, all signals from the flow meters are input to an interface panel. An interface panel consists of converter and GPRS (General Packet Radio Service) modem. Field data are collected at the interval of 15 minutes and transmitted once a day to the central monitoring station. The accumulation time at the interface panel shall be 24 hours. The mobile communication network (GPRS or GSM) is used to transmit the data.

The central monitoring system consists of GPRS router, server, monitoring display, printer and power supply unit (including UPS), and these equipment is installed on the desk. The server collects data from the interface panels in the field and holds them. In addition, it makes out historical trend graph/chart and reports (daily, monthly and annually) based on the data collected. These reports shall be made out and printed by efficient and easy-to-use software tools. The process and historical data shall be stored for one year and the report data shall be stored for five years. The system configuration is shown in Figure 2-16.

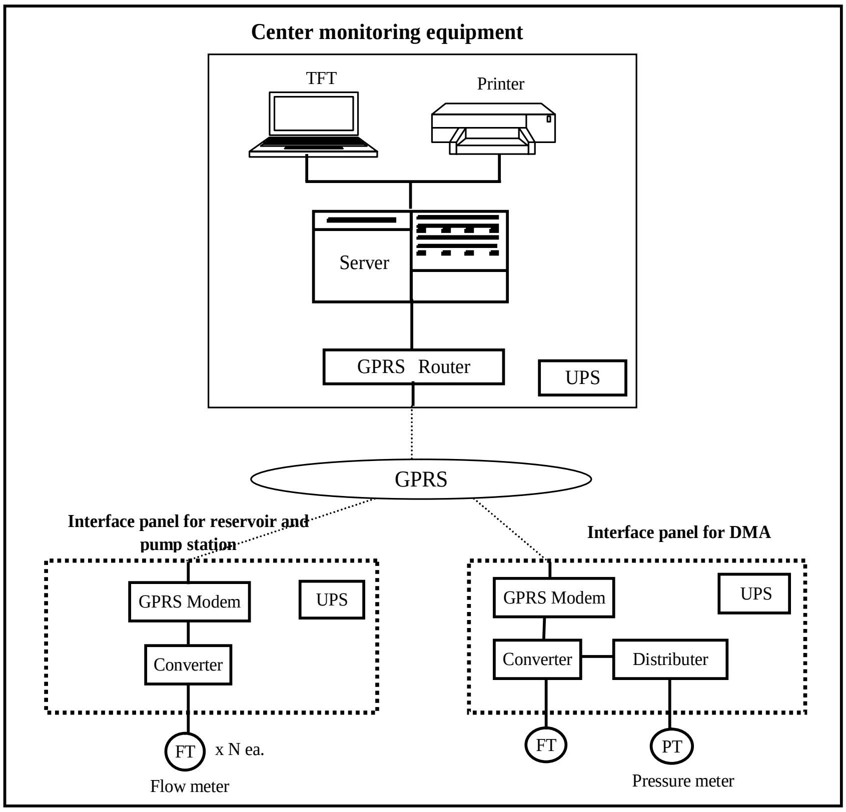


Figure 2-16 System Configuration

4) Specification for major equipment of monitoring system

Central monitoring system

Equipment	Specifications
Server	CPU: Intel Xeon Processors, 2.4 GHz or Higher, Min. 450GB Memory: Minimum 4 GB (with ECC) HDD: Minimum 450GBx2 (with RAID 1) Optical Driver: 24xCD-ROM/RW, 8xDVD-R, 6xDVD-RW Network Interface: 100Basse-TX/1000Base-TX Operating System: Windows 2003 Server Standard
TFT Monitor	Type: TFT（Thin Film Transistor） Size: 16 inch wide size Resolution: 1680x1050
Printer	Type: Color Laser Printer RAM Size: 96MB Paper Size: A3, A4 Network Interface: 100Base-TX/1000Base-TX
GPRS Router	Type: Industrial GPRS Router Interface: Ethernet
UPS	Type: Standby Power Inverter Feed Type Capacity: 500VA Input: AC220V, 50Hz Output: AC220V, 50Hz Back-up Time: 120minutes Interface: Ethernet

Field Equipment

Equipment	Specifications
Flow Meter	Type: Ultrasonic Clamp-on Type Flow Velocity: 0.5-20ｍ/sec Accuracy: within +/-1% at maximum flow rate Power Supply: AC220V 50Hz or DC24V Output Signal: DC4-20ｍA Output Contact: 1contact IP Rating: IP65 or higher
Pressure Meter	Type: Water-proof type（IP67） Mounting: Pole mounted Body: Stainless Steel Power Supply: DC24V Output Signal: 4-20ｍA, 2 wires Accuracy: within +/-0.1％ at maximum pressure Pressure Range: 0-16 bar
Converter	CPU: 60k step or higher I/O Unit: Digital/Analog Interface: 100Base-TX
GPRS Router	Type: Industrial GPRS Router Interface: Ethernet
UPS	Type: Standby Power Inverter Feed Type Capacity: 500VA Input: AC220V, 50Hz Output: AC220V, 50Hz Back-up Time: 120minutes Interface: Ethernet
Interface Panel	Type: Outdoor use, metal enclosed, self-standing

5) Location and quantity of equipment

Table 2-38 Central Monitoring System

Installation place	TFT	Server	Printer	GPRS Router	UPS	Power supply unit
WAJ Tafieleh office	1	1	1	1	1	1

Table 2-39 Field Equipment

Location	Flow meter	Pressure Transmitter	GPRS Router	UPS	Interface Panel
Reservoir Ain-El Baidha	5		1	1	1
Reservoir Qhadesiyeh	1		1	1	1
Reservoir Tafieleh Low	1		1	1	1
Reservoir Tafieleh High	1		1	1	1
Pump Station Erawath	2		1	1	1
Reservoir Bsaira	1		1	1	1
Reservoir Gharandal	1		1	1	1
DMA Tafieleh (Mansoura)	1	1	1	1	1
DMA Tafieleh (Sanfahah)	1	1	1	1	1
DMA Tafieleh (Low 2)	1	1	1	1	1
Total	15	3	10	10	10

(12) Public relations (PR) activities

Public relations (PR) are the important part of the project. The Government of Jordan, the beneficiary of the project, shall conduct effective PR activities for the project, with assistance from Japanese side. The following are responsibilities of both sides involved in implementing project activities including schemes under PR activities. The Japanese side will facilitate the implementation of following PR activities.

- ODA advertisement board
- Inscription of ODA mark on the lid of valve chambers
- Inscription plate (stone)
- Painting messages and pictures related to water supply and ODA mark on the wall of reservoir

Jordanian side shall be responsible for facilitating the following PR activities.

- Paintings contests related to water supply for wall painting on planned reservoirs
- Public awareness activities for the project

(13) Summary of facility plan

The following table summarizes facility plan.

Table 2-40 Summary of Planned Facilities

Facilities	Specification/capacity/quantity		
Reservoir	Bsaira	RC structure, rectangular shape, capacity: 1,200m^3 L 19.4m x W 18.8m x H 5.45m	
	Gharandal	RC structure, rectangular shape, capacity: 600m^3 L 13.4m x W 12.8m x H 5.95m	
Erawath Pumping Station (PS)	Renewal for transmission pump for planned Gharandal reservoir	Renewal of existing pump equipment Q: 0.95m^3/min. x Head: 225m x 2 sets Horizontal shaft single suction multi-stages centrifugal pump Electrical works and instrumentation	
	Expansion for transmission pump for existing Qhadesiyeh reservoir	Construction of a pump house for expansion pumping station Q: 1.5 m^3/min. x Head: 380m x 2 sets Horizontal shaft single suction multi-stages centrifugal pump Electrical works and instrumentation Air breathing valve for anti-water hammer : 3 sets (on the pipe between pumping station to existing Qhadesiyeh reservoir) Altitude valve in existing Qhadesiyeh reservoir	
Transmission pipeline	Erawath PS－Planned Gharandal reservoir		DIP 150mm x 3,540m
	Bsaira Junction – Bsaira reservoir		DIP 200mm x 460m
	Bsaira entrance – Bsaira Junction		DIP 250mm x 2,270m
	Ain-El Baidha reservoir – Bsaira entrance		DIP 300mm x 7,950m
Distribution pipeline	Tafieleh city		DIP 100mm x 6,230m DIP 150mm x 3,020m DIP 200mm x 2,510m DIP 250mm x 2,210m DIP 300mm x 90m Pressure reducing valve: 4 places
	Bsaira		DIP 100mm x 3,300m DIP 150mm x 490m DIP 200mm x 2,930m DIP 250mm x 460m Pressure reducing valve: 7 places
	Gharandal		DIP 100mm x 2,460m DIP 150mm x 320m DIP 200mm x 1,000m Pressure reducing valve: 5 places
	Qhadesiyeh		DIP 100mm x 2,250m DIP 150mm x 1,780m DIP 200mm x 1,320m Pressure reducing valve: 6 places
Distribution monitoring system	Tafieleh city and Tafieleh south area		Central monitoring system: 1 set Flow meter for reservoir and pumping station: 12 sets Flow meter and pressure meter for District metered area(DMA): 3 sets
Procurement of pipe materials	Tafieleh city, Bsaira, Gharandal, Qhadesiyeh		HDPE OD 63mm x 50,600 m