2-2 Outline Design of the Project

2-2-1 Design Policy

The basic policy and various discussions on the contents of the assistance that have been examined by the basic design study will be described below.

2-2-1-1 Basic Policy

1) Selection of the Project site

In determining the target sites for the Project, the requested sites by the Yemeni side, which were 20 sites in 5 Governorates, were screened based upon the following criteria.

a. Priority of Yemeni side
b. Urgency on the needs of water supply facilities
c. Groundwater potential
d. Security condition
e. Operation and Maintenance Capacity of the communities

As a result, due to the safety regulation explained in [1-2 Project Summary], one site was removed and 19 sites in 5 Governorates were selected for the Project. The detailed results of examination are presented in Annex.

2) Confirmation of the obligations of the Yemeni side

For the Project, the Yemeni side requested the rehabilitation and expansion of existing water supply facilities as well as the construction of new ones. For the rehabilitation and expansion works, the study examined the possibility that the equipment such as generator, pump, engine and pumping materials will be procured by Yemeni side, however, as those equipments require the test operation and adjustment, it has been decided that Japanese side will take the responsibility for them in order to ensure the completion of installation and start the operation in time to meet the schedule of the Project.

The major responsibilities to be taken by the Yemeni side are as follows:

a. Securing access to the workplace within the Project site
b. Securing and levelling of lands for deep wells, machinery houses, reservoirs, etc.
c. Carrying plumbing materials within the site (if there is steep and the work seems to be difficult, it will be done by Japanese side).
d. Preparation of stock-yards for materials within the site (for temporary use)

e. Installation of water supply pipes to each house from the main distribution line and water meter (including material and work)

3) Environmental Protection

For execution of the Projects in Yemen, The Environmental Impact Assessment (EIA) is required in accordance with the Environmental Protection Act, Article 35 of the EIA. The results of Initial Environmental Examination (IEE) done in the Development study was approved by the Environmental Protection Authority (EPA) and judged that further investigation would be deemed not necessary for the Project. During the Basic Design Study, it was confirmed that the above EPA's approval is still valid.

The initial study proposed to EPA measures to reduce concerns which are, 1) effects to water vendors, 2) water rights, 3) the impact on groundwater. This study confirmed such measures had been agreed by EPA. Therefore, the category could be lowered from Category B to C.

4) Operation and maintenance of the facilities

According to the Yemeni policy under the rural water supply, the operation and maintenance of facilities for the rural water supply should be undertaken by its users. Following this policy, the Project will provide assistance for establishing the operation and maintenance system as well as for hygiene education to villagers.

5) Study on cost reduction

For the cost estimation of the Project under the grant aid assistance, the following main principles have been taken into account for the cost reduction.

a. The materials and equipment to be used in the Project will basically be those available in local markets, although their qualities and durability might be at lower levels than those products in Japan.
b. Carrying construction materials such as pipes to workplace will be done by residents of the Project site (the installation will be done under the construction company).
c. The number of public faucets in each site will be as minimum number as possible. The installation of public faucets will be provided in some public institution only.
d. The number of Japanese supervisors of construction work will be limited to one, and local labour will cover this work as many as possible.
e. The contractor's engineer also will be as minimum number as possible within the limits not to affect the quality and schedule control.
f. The local standards will be adopted for the facilities' design and specification.
g. Where the both deep well pump and booster pump for water transmission are required in a pump station, installing a diesel engine for each pump is a common layout in Yemen, whereas one diesel generator will replace the conventional engine in this Project.

6) Security measures

The following basic policy will be applied for the security measure.

a. Following the safety instructions issued by JICA, Japanese will not travel to areas indicated by JICA.
b. Information will be collected closely with JICA Yemen office, Embassy of Japan and from the Implementing Agency. Any instruction will be followed as soon as possible.

2-2-1-2 Policy concerning Natural Conditions

1) Hydrogeological Conditions

a. Confirmation on the water source of the Project

24 deep wells (from 120m to 470m in depth) will be employed as water source for the 19 sites. All the deep wells were previously constructed by the Yemen side and, pumping test and water quality analysis were completed to examine the potential of deep wells. In this Study, existing data was reviewed and actual conditions of the deep wells were examined by removing the existing well caps. The examination included to measure well depth, water level, pH, EC and temperature. The results of the study on actual conditions of the deep wells are shown in annex.

As concerns the sites S-07 Bait Al Hadrami and S-09 Ruhm in Sana'a Governorates, the water levels of the deep wells dropped 22m and 44m respectively from those of the development study in 2006. As the lowering of water levels affects the operation of the facility, pumps, pipelines, etc. in the future, re-confirmation of capacity of deep wells such as well development and pumping test will be done during the implementation stage.

b. The use of deep wells

In Yemen, agricultural irrigations use the groundwater extensively. Therefore there has been a wide concern which over-pumping of groundwater seems to result in regional drying- up in some water sources. In Sana'a and Taiz basin in particular, where the Government of Yemen have established a "specially protected area for groundwater protection", the new groundwater developments are basically prohibited for agricultural and industrial purpose and for the existing ones, license system have been introduced to control the over-pumping. However, this regulation excludes the deep wells for public water supply.

For the facilities planned under the Project, the following sensitization policy to the villagers and related institution will be implemented.

a. To operate the deep well within the recommended discharge as a safe yield
b. Not to develop new wells within the interference area of the Project well
c. To measure water level of the Project well periodically for the monitoring purpose and

inform the GARWSP branch as soon as possible in any abnormal case

c. Water quality

The water quality in the Project, will comply with the Yemeni guidelines. This guideline, which is adopted by GARWSP, is the same as WHO's one. According to the existing data, the water quality of the deep wells of the Project, are almost in a range of acceptable level. The data of water quality is shown in the Annex.

2) Temperature and rainfall

In the Project area, the minimum and maximum temperature is around 9 and 40 degree centigrade respectively. Therefore, the materials such as concrete and pipes which can be affected by the temperature will be taken in consideration.

As the concrete work especially under the high temperature affects the quality, hot-weather concreting will be adopted when the temperature reaches more than 30degree. Thus, during or immediately after the concreting work such as the mixing, transportation, concreting, curing, etc., procedure to lower the temperature of the concrete will be considered.

Besides, temperatures difference between day and night can reach to 20 degree. As the pipelines will mostly be exposed on the ground, expansion and compression of pipes can occur and in extreme case, concentration of distortion can cause damage in the pipeline. For the countermeasure and design details, refer to "2-2-2 Facility Construction Plan"

For the preparation of the construction schedule, the effect of the rainy season will be taken into consideration. There is a small rainy season from April to May and a major rainy season from July to September when the number of rainy days with more than 10mm/day precipitation can reach more than 15 days in some cases. This heavy rain can cause difficulties in access to facilities in and around the wadi (seasonal dry valley). Therefore, during the rainy season, the amount of construction works will be reduced in the planning of the construction schedule.

3) Topography and Geology

a. Correction of power unit output by altitude

In some Project sites, the altitude reaches more than 2000m. Hence, power units for pumps such as generators and engines require the correction of outputs by altitude.

b. Foundation strength of some location for facility construction

The majority of the locations, where machinery house and reservoirs are planned to be installed, are in rocky areas and strong enough for foundation. However, for the following sites, where the locations for machinery house and/or reservoirs have been filled with soil, soil test will be required to be performed during the Detailed Design Study to examine the strength of soil for the facilities foundations.

Table 2-3 Target site for soil test

Site name	Location of soil test
S-09 Ruhm	Machinery house for the deep well
D-01 Elow Al-Mikhlaf	Machinery house for the deep well
I-02 Al-Sana	Machinery house + Booster station for the deep well
I-04 Al-Jahlah & Al Meshraq	Machinery house for the deep well

2-2-1-3 Policy for Socio-economic Factors

1) House connection

In recent years, the design of rural water supply projects in Yemen tends to include house connections. As mountainous area is common in Yemen, even if public faucet is installed, maybe the distance to fetch water is shortened but still the work to carry the water in a high slope access remains. In such a situation, the villagers have strongly requested to make a house connection, and GARWSP to facilitate this demand, have started to adopt the design with the possibility of house connections. Moreover, from the point of view of operation and maintenance, as the villagers are responsible for that, a house connection with water meter can have better effects in terms of water fee collection. In this Project also, the design policy is considering house connections, but the responsibility under the Japanese side will be until the main distribution pipe. The house connections, including materials and manpower, will be under the Yemeni side responsibility.

2) Awareness and ability for operation and maintenance by the villagers

As a condition for the implementation of rural water supply, water user association are required to be organized. Therefore, in the Project also, water user association will be formed and registered as juridical person, with assistance of the Project for capacity building of associations.

According to the results of the socio-economic survey, sensitization of residents is highly necessary in terms of operation and maintenance of the water supply facilities by the water user association. In the survey about responsibility of operation and maintenance of facilities, replies to the question of "who is responsible for the operation and maintenance of the facility to be constructed?", were diverse; by the Government (20.5%) at first, each village sheikh (19.7%), local NGOs (18.7%) and the water use association (19.7%). In this survey the status of water user association was not high, and creation of awareness among residents of a principle that the water user association should have a responsibility will become important.

The cost of operation and maintenance will be borne by the users, and according to the field survey, the result shows that they have capacity to pay the estimated water fee. On the other

hand, the amount of Willingness To Pay (WTP) is low. Sensitization will be required to raise awareness of necessity. For example, according to the field survey result, the average of WTP per site is YR100 to YR500/month, and the necessary water fee for proper operation and maintenance is YR550 to YR2,100/month(based on operation and maintenance fee per person and considering 7.2persons/household), showing a wide gap. However, according to the pilot project implemented in 3 sites (Al-Mahweet, Sana'a, Dahmar) during the development study in 2007, the water fees were YR150/m^3(Al-Mahweet), YR100/m^3(Sana'a) and YR200/m^3(Dahmar). It means, an average of YR2,160 to YR4,320/month/family is the amount paid as water fee, showing that there is capacity and willing to pay. Also, in the Project sites where there is an existing water supply facility, the water fee charged for the operation and maintenance was YR130/m3 to YR250/m3.

According to the result of field survey, it is possible to sensitize the villagers to afford the water fees, but to assure the supply of safe water, the Project will support through software component to communicate with the users and to organize the structure for the operation and maintenance.

3) Health and hygienic environment, sanitary habit and awareness

For the effective use of safe water by the users, obtained through the water supply facility constructed under the Project, promotion on the improvement of knowledge, attitude and habit through software component on hygiene education will be executed.

2-2-1-4 Policy on Construction/Procurement

For construction equipment and materials, cement, concrete blocks and aggregates are locally produced and steel products are imported and distributed. It is expected that there is no difficulty in using the locally distributed equipment and materials for construction of concrete structures such as machine houses and reservoirs to be constructed in this Project.

For steel pipe materials, the products made in Saudi Arabia, India and Pakistan are distributed, which are manufactured in accordance with the BS (U.K.) or ASTM (U.S.A.). However, depending on the manufacturer, there is a variation in the quality per lot of production according to the information from the Implementing Agency. Therefore, attention will be required in the selection and quality inspection of the materials for construction. There is an agent that has made the test in Sana'a University independently and in this Project also, test will be done according to the necessity.

In this Project, the locally distributed equipment and materials will be adopted as many as possible from the viewpoints of cost reduction, availability of spare parts and economy of operation and

maintenance. However, the high-pressure pipe materials and valves which are not locally distributed will be examined for customized production or procurement from Japan. Basically, plumbing materials which are locally available will be treated as local procured materials.

2-2-1-5 Policy on Use of Local Contractors

In the project implemented by GARWSP, the prior registration system for companies is established. Not only the companies, but also the manufacturers of the deep well pumps that are also included in the main equipment are ranked.
As the results of inspecting the construction in the pilot sites in the development study, the construction of schools under the Japanese grant aid cooperation and the facilities constructed by local contractors in the projects by other donors, it has been confirmed that the local contractors have a certain level of capabilities which can be used for this Project. However, it is necessary to supervise the works thoroughly in order to secure the work quality required for the general grant aid assistance. Full attention for safety control and work schedule control should be paid because the local private contractors are not so highly aware of it.

As the target sites are distributed in a wide range, the work sites will be concentrated in a range by Governorate. At the Governorate capital, base office (including a storage yard for materials) will be set up in order to deal smoothly with transportation of equipment and materials and supply of consumables. By so doing, the works under the Project can be supervised efficiently.

2-2-1-6 Policy on Operation and Maintenance Capability

The implementing agency of this Project is GARWSP, under the Ministry of Water and Environment, and is in charge of rural water supply projects. The headquarter of GARWSP is located in the capital city of Sana'a, and is planning and coordinating the projects, through their branches in 19 Governorates.

Actually, the Government of Yemen is promoting the decentralization, and GARWSP is also enforcing the organizational reform to transfer a portion of the authorities from the headquarters to branch offices. For the present Project, the following role sharing policy will be adopted between GARWSP headquarter, its branch, local authorities and the villagers.

Table 2-4 Role sharing between GARWSP, local authorities and villagers

GARWSP headquarter	Implementation supervision, project coordination
GARWSP branch and local authorities	・Formation of water user association (support on the registration to the Ministry of Local Administration, approval, etc.) ・Strengthening the existing water user association ・Sensitization on the groundwater conservation ・Follow-up and monitoring
Villagers	・Preparation of access road within the site ・Transportation of pipes within the site ・House connection (including material and work) ・Operation and maintenance of the facilities

After the completion of construction work under the Project, the responsibility in terms of ownership and operation and maintenance of the facilities will be undertaken by the water user association. For the proper operation and maintenance of the facilities, assistance from the Social Mobilization Team (SMT) formed by GARWSP headquarter, its branch and local authorities are indispensable. Therefore, in the Project, as an initial support, will be implemented the software component as part of technical support.

2-2-1-7 Policy on Grade of Facilities and Equipment

The water supply facilities will be designed for sufficient durability as public facilities and ease of operation, inspection and maintenance, as well as for easy usage by the target site villagers.

Facility design, specification of equipment and materials for construction design haven't been standardised yet by GARWSP. Thus, GARWSP usually use the ones of Social Fund for Development or BS (U.K.) depending on the project and donors. For this Project, basic policy for the standards is to use the ones of SFD which is commonly used in GARWSP and also adopted in the development study.

The details for each facilities and equipment for the Project is shown in the paragraph "2-2-2 Facility Construction Plan".

2-2-1-8 Policy on Construction Method and Construction period

1) Construction Method

The construction method will be described below.

a) Piping works

The exposed piping method will be adopted to lay steel pipes except the case of crossing a wadi or a road. The plumbing work (for laying pipe materials) will be done by manpower. A working team consisting of plumbers and general workers will be organized to do the piping work.

The high-pressure pipe of pumping main to a distribution reservoir to be constructed at a high altitude should be constructed most carefully. It is appropriate to use the method of welding both pipe ends with a flange for flange connection. The pipe should also be fixed with a concrete support stand.

For the use of screw connection, in accordance with the work standards of GARWSP, in each 8 pipe section of standard size, will be provided an installed-union joint for ease of inspection and maintenance of the pipeline.

The concrete support stand for exposed piping will be installed depending upon the topographic and slope conditions.

- Pipe laying

  Pipe laying work will be done by manpower from installation of galvanized steel pipes (GSP) to connection work.

- Pipe inspection

  Prior to pipe installation, sufficient pipe inspection will be carried out to check any cracks and other faults.

- Pipe installation

  Prior to pipe installation, the inside of each pipe will be cleaned, and each pipe will be installed accurately.

- Installation of valves

  Since exposed piping will be adopted, the valve box of a gate valve or air valve will be made of steel or concrete and installed on the ground, except buried piping section across a road or wadi.

b) Concrete work

Concrete will be placed in the cast-in-place method. The mixing and metering of concrete will be made by manpower and a portable mixer will be used basically. However, if a small quantity of leveling concrete is used or if concrete mixing doesn't require high quality, the mixing work will be done by manpower in the field. Excavation and refilling required at a concrete placing location will be done by manpower.

c) Machinery house

A machinery house will mainly be built by excavation, concrete work, fitting and

finishing works and all the works will be done by manpower.

d) Distribution reservoir, pressure-reducing water tank construction works

Both the distribution reservoir and the pressure-reducing water tank will have normal reinforced concrete structures.

e) Public faucet

The public faucet work will be done by manpower as the piping work. A working team of plumbers and general workers will undertake this work.

f) Counter measure for sites having high altitude gradient

Many Project sites are located in a mountainous area, and there are sites where the difference of altitude from the water source to the distribution reservoir reaches to more than 500m. In those sites, taking in consideration the pressure of the pipes, a booster station will be installed accordingly in an intermediate position to pump water to the main reservoir. Also, in case the pressure in the distribution pipe is high, pressure reducer tank will be installed accordingly.

2) Construction Period

The work periods will be in accordance with the following policy:

Since many of 19 work sites of this Project are distributed in a wide range in 5 Governorates, it is necessary to do the works at several sites simultaneously if possible. Therefore, the sites will be divided into 2 groups by facility scale as shown in Table 2-5.

Table 2-5 Division of working groups

Working Group	Governorates and Number of Sites	Remarks
Group 1	3 Governorates, 11 sites (Al Mawheet, Sana'a and Taiz)	The number of sites is high, but includes relatively small-scale sites.
Group 2	2 Governorates, 8 sites (Dahmar and Ibb)	A high volume of plumbing works are required and include many works at sharp slopes in mountainous areas.

As the number of sites and the piping work volumes (approx. 170km) are relatively large, as many working teams as possible will be assigned to the works to shorten the work periods. The works at 2 sites may be done simultaneously within each group. In particular, for the plumbing work requiring a long work period, 2 to 3 working teams will be assigned to each site. Considering the design, specifications and quality as well as early completion of each work will be aimed. During the civil work, building work, plumbing work and installation

work at each site, there may be a work period in which a maximum of 10 working teams may work at one site. Therefore, a sufficient management system will be required.

2-2-2 Basic Plan

2-2-2-1 Overall Plan

1) Construction of new and rehabilitation of water supply facilities

The requested items in each target site can be classified into two major components, and the plan in each component is as follows:

Table 2-6 Site classification and planned facility

Site Classification	Definition	Characteristic	Planned Facility
New construction site	There is no existing water facility or the existing one is not working. Or need to expand the existing water supply facility	Because the villagers can not get drinking water continuously, they are forced to buy water or to use from unprotected water source.	• Procurement and installation of pumping system • Construction of machinery house • Construction of reservoir • Procurement and installation of pipelines • Construction of public faucet • Rehabilitation of reservoir that actually is not in use.
Rehabilitation site	The existing water supply facility is working (working totally or partially)	Even if the water facility is working, the villagers can not get enough amount of water. And, the conditions of the existing pumping equipment are very old.	• Change of existing pumping equipment • Limited to a new deep well, procurement and installation of pumping equipment, construction of pumping main from machinery house to the reservoir, and booster station if necessary. • Procurement and installation of distribution pipe. • Rehabilitation of existing reservoir which is not in use.

Based on the above information, the classification of each site will be as follow:

Table 2-7 Classification of each site

Code	Site name	Classification
A-03	Ozlat Al Jaradi	Rehabilitation
S-02	Jarban	New
S-04	Qamlan-Bait Al Najrani	New
S-05	Afesh	Rehabilitation
S-07	Bait Al Hadrami	New
S-09	Ruhm	New
D-01	Elow Al Mikhlaf	New
D-02	Hamal-Bait Al Jabar	New
D-03	Hegrat Al A'asham	New
D-05	Mayfa'at Yaer	New (Rehabilitation)
D-07	Al Asakera	New
I-01	Asfal Bani Saba	New
I-02	Al Sana	New
I-04	Al Jahlah & Al Meshraq	New
T-02	Bani Al Suror	Rehabilitation
T-03	Sheb Humran	Rehabilitation
T-04	Yafoq Bani Hamad	Rehabilitation
T-05	Al Azaez	Rehabilitation
T-06	Al Khunha	New

2-2-2-2 Facility Construction Plan

1) Specifications for water supply project

a) Design standards for water supply facilities

The standards adopted by GARWSP conventionally and the design policy established in the development study were verified and the design policy adopted by this Project are shown in the following table.

Table 2-8 Design standards for water supply facilities

Item	Standard
Design period	10 years
Population growth rate	2.07 - 3.04 %/year (the rate in each Governorate is adopted)
Unit supply rate	Maximum: 40 litter/cap/day Minimum: 20 litter/cap/day
Daily average supply	Planned served population × Unit water supply
Daily maximum water supply	Daily average water supply × 1.0
Hourly maximum supply	Daily maximum water supply ÷ 24hr × K=2～4
Pump operation duration	To be determined depending upon the water source capacity, water demand and working condition of pump operators
Distribution reservoir capacity	An appropriate capacity is selected from the standard distribution reservoir based on the water supply quantity for 12 hours. For the case including the booster tank, the water conveyance capacity for at least 2 hours is included.

b) Design period

The general design period in Yemen is 20 years, but the project period for pump equipment is 10 years. In this Project, the middle-term period of 10 years will be adopted.

c) Planned water supply population and population growth rate

The planned water supply population for a target project year is estimated by multiplying the population at each site by the population growth rate in each Governorate based on the 2004 census. As the population growth rate, the values in the 2004 – 2007 population forecasts by Governorate that the Central Statistical Organization uses (Al Mawheet: 2.87%; Sana'a: 2.07%; Dahmar: 3.04%; Ibb: 2.47%; and Taiz: 2.47%) will be adopted in this Project. The target project sites and population of beneficiaries are shown in Table 1-1.

d) Water supply unit requirement

GARWSP uses the values of 40litter/cap/day in the mountainous area and 50litter/cap/day in the coastal area. As the areas for this Project are mountainous areas, the former values is basically used, however, the original preset values may exceed the water source capacity because of the population growth has changed in the target project. Therefore, 25litter – 40litter/cap/day (in the development study) is changed into 20 – 40litter/cap/day in considering the balance between the water source capacity and the Project target population.

e) Daily average water supply and daily maximum water supply

The concepts of daily average water supply and daily maximum water supply are not adopted by GARWSP. In this Project, the daily average water supply quantity is estimated by multiplying the project water supply population per site by the water supply unit requirement. For the daily maximum water supply quantity, because of the limited water source capacity, the same value as the daily average water supply quantity is adopted.

f) Hourly maximum water supply

The time span in which the highest quantity of water is consumed in Yemen is the hours at the lunch time (about 2 hours). GARWSP has established 12-hour water supply for the population of 2,000 or more and 8-hour water supply for the population of less than 2,000, and adopted the time coefficients of K=2 and K=3 respectively. In this Project, the pipe diameter will be determined using the maximum time ratio in the simplified water service facility standards of Japan as well as the above standards.

g) Pumping discharge

The pumping discharge rate in the Project is determined by the recommended pumping discharge or less than that.

h) Water treatment

The water source of the Project are all deep wells, and as the water quality analysis done previously is within the water quality guideline, water treatment will not be done.

i) Pump operating time

GARWSP adopts the pump operation time of 8 hours a day for the population of less than 2,000 and 12 hours for 2,000 or more. In this Project, the same conditions are basically used, but the appropriate duration of operation will be set based on the balance between the water source capacity and the water supply demand and on the working condition of pump operators.

j) Distribution reservoir capacity

GARWSP sets the water supply quantity depending upon the type of distribution reservoir, the quantity for 12 hours from a ground type distribution reservoir and that for 8 hours from an elevated type distribution reservoir. The standard distribution reservoir capacity is set to $25m^3$, $40m^3$, $50m^3$, $75m^3$, $100m^3$, $250m^3$ and $500m^3$ for the ground type. In this Project, appropriate values of distribution reservoir capacity (25 m^3, 40 m^3, 50 m^3, 75 m^3 and 100 m^3) will be selected out of the GARWSP standard capacities based on the water supply quantity for 12 hours because the distribution reservoirs are of ground type only. For the

case of including the booster station facilities, the pumping water quantity for at least 2 hours is considered to be included as the pumping water control capacity.

2) Facility Design

a) Water source facilities

- Deep wells

The water source type adopted in this Project is deep wells only and all deep wells will be provided with a casing screen and filled with gravel in the annular space. All the deep wells have been constructed by Yemen and as mentioned before, pumping test is completed. Following are the list of recommended discharge and the Project discharge rate.

Table 2-9 Discharge rate of Project deep wells

Code	Site name	Well Code	Recommended Discharge (l/s)	Project Discharge (l/s)
A-03	Ozlat Al Jaradi	A-03	10.4	10.4
S-02	Jarban	S-02	2.0	2.0
S-04	Qamlan-Bait Al Najrani	S-04	5.6	1.2
S-05	Afesh	S-05	3.2	3.2
S-07	Bait Al Hadrami	S-07	3.2	3.2
S-09	Ruhm	S-09	3.0	3.0
D-01	Elow Al Mikhlaf	D-01	2.4	2.0
D-02	Hamal-Bait Al Jabar	D-02	3.5	3.5
D-03	Hegrat Al A'asham	D-03	5.0	3.3
D-05	Mayfa'at Yaer	D-05	2.6	2.6
D-07	Al Asakera	D-07	4.5	4.0
I-01	Asfal Bani Saba	I-01	4.5	4.5
I-02	Al Sana	I-02	3.9	3.9
I-04	Al Jahlah & Al Meshraq	I-04	4.1	4.1
T-02	Bani Al Suror	T-02/1	5.1	5.1
		T-02/3	2.6	2.6
		T-02/4	5.4	5.4
T-03	Sheb Humran	T-03/1	4.0	4.0
		T-03/4	4.2	4.2
T-04	Yafoq Bani Hamad	T-04	3.0	3.0
T-05	Al Azaez	T-05/2	2.0	2.0
		T-05/5	6.0	6.0
		T-05/6	3.8	3.8
T-06	Al Khunha	T-06	8.8	3.1

- Deep well pump type and power source

The pumps widely used in Yemen are two types of “vertical type shaft pump/diesel

engine drive" and "submersible motor pump/diesel generator drive". The use of commercial power as a power source is not generally used for rural water supply in Yemen and regarded as disadvantageous because there are some problems such as a high operation cost and an interruption of operation due to a power failure.
In selection of pump types, an appropriate pump should be selected from various factors such as pumping rate, pump head and geographical conditions. The both types of pump are compared in the next table.

Table 2-10 Comparison of deep well pump types

	Vertical Shaft Pump	Submersible Motor Pump
Mechanism	A power engine is installed on the ground and a pump is installed underwater, and both are connected by a rotary shaft to transmit the power.	The pump combined with an electric motor as a unit is installed underwater and operated by an electric power fed through a power cable from the power source on the ground.
Drive power	Diesel engine drive	Diesel generator drive
Pump head	200m or less The vertical structure makes high-speed rotation impossible and it is difficult to keep a high pump head.	200m or more High-speed rotation and high pump head are available.
Operation and maintenance, etc.	Maintenance is easy because of a mechanical system.	The repair cost is high in event of a failure.

The vertical type shaft pump/diesel engine drive that is capable of relatively easy maintenance is generally used in Yemen and basically, it is preferable to adopt that type of pump, especially in the areas requiring no high pump head. It is desirable that the vertical shaft pump, in which the well depth and well construction workmanship (such as bend) largely affect the efficiency, is adopted for the wells with a water level which is not so high, in order to keep stable operation. In this Project, the vertical shaft pump/diesel engine drive will be adopted for the pump with the pump head of 100m or less, taking into account the future decrease of water level and the stable operation of the pump, and the underwater motor pump/diesel generator will be adopted if a high pump head is required or if the well is separated from the machine house for a topographical reason.

The pump installation depth of -30m will be adopted in this Project for safety as the dynamic water level of -20 to -30m is normally adopted depending upon the drawdown of water level in Yemen.

b) Booster pump facilities

- Pump type and power source for booster pump

  The booster pump generally adopted is a horizontal type centrifugal pump. As the power source, the commercial power is not generally used as for deep well pumps, but the diesel engine drive or the diesel generator is used. In this Project, the diesel engine drive will be adopted because it is simple and economical. However, the diesel generator will be used at the site A-03 in this Project because the existing power source is a generator. In installing a deep well pump and a booster pump in the same machinery house and if the deep well pump is a submersible motor pump, a diesel generator capable of operating both pumps will be installed for cost reduction.

c) Machinery house

The machinery house is a facility to house the deep well pump equipment and water conveyance equipment, which will be designed for ease of maintenance because such equipment will have a high necessity for replacement with spare parts in future. If the deep well pump equipment is installed, the work using a large-type crane vehicle or drilling machine carried on a truck will be required in event any failure is caused in the deep well pump or in the deep well itself. Therefore, basically, the deep well pump will not be housed in the machine house, but separated as a deep well pit adjacent to the machine house.

Structure: Reinforced concrete structure (using concrete blocks as walls)

d) Distribution reservoir

The distribution reservoir has the functions of serving as a water storage tank to distribute water through gravity flow to the rural communities within the water supply area and as a water storage tank for conveying water by a pump up to a distribution reservoir located at a high level. As described in the design policies, the appropriate total water supply capacity will be selected from the standard water capacity values in considering the water supply capacity for 12 hours to the water supply area and the water conveyance control capacity for 2 hours.

Structure: Reinforced concrete structure
Standard capacity: 25, 40, 50, 75 and 100m^3

For the rehabilitation work for the existing distribution reservoirs, the distribution reservoirs in use will not be rehabilitated, but be operated as they are. For the reservoirs that remain unused after their construction in which the internal waterproofing materials may be deteriorated, the rehabilitation work will be done including the waterproofing work, valve chamber replacement and surface coating to ensure their sustainable operation.

e) Distribution pipelines

- Selection of pipe type

  The pipe types generally used for rural water supply in Yemen are galvanized steel pipe and vinyl pipe, but most of the pipes in use are the galvanized steel pipes which are capable of exposed piping for the geographical features in Yemen. Vinyl pipes are inexpensive and highly applicable to construction, but must be underground and there is limitation in the construction areas. In the target areas under this Project, the galvanized steep pipes will be adopted because most of the terrains are covered by outcrops of hard rocks that are difficult to bury the vinyl pipes. For the hydrostatic pressure of less than 250m, the pipe connection with BS1387 medium screws will basically be adopted, but for the hydrostatic pressure range of 250m or more to less than 450m, the pipe connection with BS1387 heavy flanges will be adopted.

  Pipe length: 6m

  Pipe diameter: Selected out of ¾, 1, 1 ½, 2, 2 ½, 3 and 4 inches

  Specifications: BS1387 medium or heavy

- Selection of pipe diameter

  The formula used for pipe discharge calculations in Yemen is the Hezen-Williams formula. The pipe discharges in this Project will be calculated by the Weston formula for the nominal diameter of less than 2 inches, and by the Hezen-Williams formula for the nominal diameter of 2 ½ inches in order to select an appropriate pipe diameter to ensure the water supply at an economical pipe diameter and at an appropriate pressure.

- Discharge pipe

  An appropriate pipe type to respond to the pump discharge pressure will be selected and the flange connection will be adopted for pipe joints.

  Discharge: The pump discharge will be applied.

- Pumping main

  The pipelines may be used at an area having high level differences. In selecting the pipe type, a pipe type to respond to a high water pressure will also be considered.

  Discharge: The pump discharge will be applied.

- Distribution pipes

  The pipe diameter will be determined by discharge calculation to obtain the dynamic water pressure of about 5 to 10m to each household. The pipe section in which water supply is required will be paid attention to keep hydrostatic pressure within 100m or less, and sections in which water supply is not assumed will be provided with a suitable pressure reducing means to control the hydrostatic pressure not to exceed 250m. For branching off the service water, the distribution pipe will be equipped with a T-type joint. The construction work and materials for house connection pipes will be done with the costs borne by local residents.

  Discharge: The maximum hourly water supply quantity will be applied.

- Other considerations

  Other considerations for pipeline design will be described below.

  - Countermeasure against pipe expansion

    Yemen has a geographical feature that hard rocks are widely distributed on the ground surface and the open piping method is adopted in most of piping sites. The temperature difference between the daytime and the night-time is very high and exceeds 20°C in some areas, so that the open piping is always subject to repeated expansion and contraction. In an extreme case, a strain may be concentrated on a part of a pipe, resulting in a fractural accident. To absorb such pipe expansion and contraction impact, there is a method of using an expansion joint, but it is not usual in Yemen, where the countermeasure to provide a pipe with a deflection is taken in laying a pipeline linearly. In this Project, the same countermeasure will also be taken to protect the pipes against fractures due to repeated expansion and contraction.
  - Pipe support concrete

    A concrete support for a pipe will be provided to prevent any uneven force applicable to a pipe bend (basically 3 inches or more) or to respond to any topographical change (hollow or sharp slope).
  - Union joint

    A union joint for pipe dismounting will be installed at every length of 50m (per 8 pipes) in order to prevent any accident such as water leakage after laying pipes or to facilitate the maintenance.

- Underground pipe (exposed pipe)
  Most of pipes will be of exposed piping, but underground or overhead pipes will be installed in crossing a road or wadi.

f) Public faucet

In Yemen, it is usual the water is supplied by house connection and the use of many public faucet is limited to the period from the start of water supply until the house connection to each household is completed. However, it is expected to use the public faucet continuously in public facilities such as mosques and schools, and the public faucet can function as a water supply base until the water is supplied to each household. Therefore, public water taps will be installed in main public facilities and at the central areas of rural villages.

Number of public water taps: 2 tap type.

Structure: Reinforced concrete

2-2-3 Basic Design Drawings

The water supply facilities of 19 water supply systems at 19 sites under this Project are summarized in Table 2-11. The layout drawings of 19 water supply systems under this Project are shown in Fig. 2-1 through Fig. 2-19, the water supply facilities drawings in Fig. 2-20 through Fig. 2-33 and the water supply system flow charts in Fig. 2-34 through Fig. 2-52 respectively.

Table 2-11 List of Water Supply Facilities

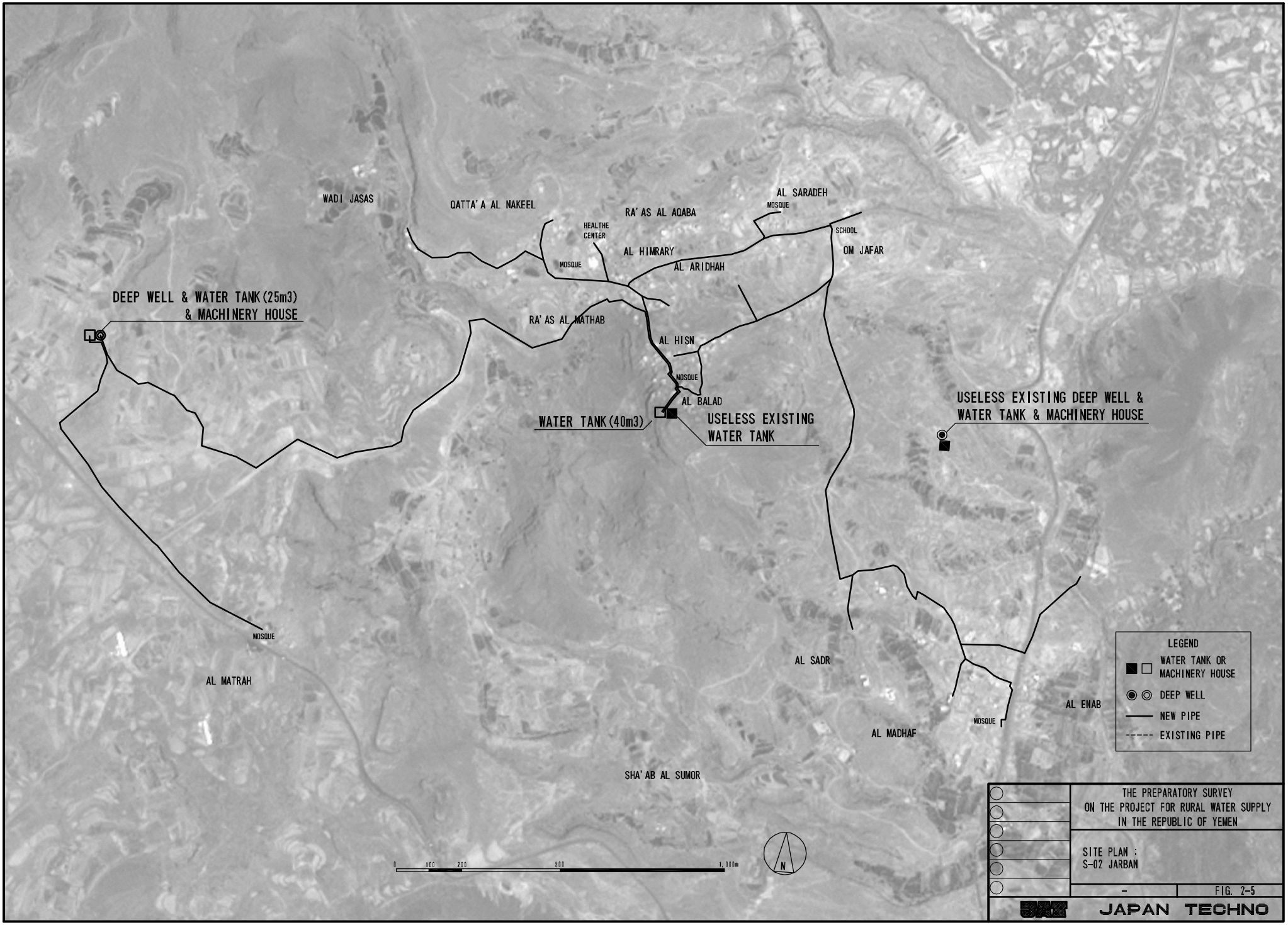
Governorate	Code	Site	Population			Water Supply		Well	New Construction													Rehabilitation					
			Base Year 2006	Growth	Design Year 2019	Unit Supply Amount	Supply amount	Depth	Pump			Machinery House		Reservoir					PF	Pipeline	MH	Reservoir					
									Type	Discharge	Head	Type	Q'ty	25	40	50	75	100				25	40	50	75	100
			Inhab.	%	Inhab.	L/cap/d	m^3/day	m		L/s	m			m^3	m^3	m^3	m^3	m^3	Type	m	Q'ty	m^3	m^3	m^3	m^3	m^3
Al-Mahweet	A-03	Ozlat Al Jaradi	20,786	2.87	30,028	25	751	150	SP	10.4	122																
									HP	10.4	217																
									HP	10.4	238																
Sana'a	S-02	Jarban	1,611	2.07	2,103	40	84	450	SP	2.0	361	B	1	1	1				3	10,622							
									HP	2.0	81	1 Gen. x 2 pumps															
	S-04	Qamlan-Bait Al Nairani	629	2.07	821	40	33	145	VP	1.2	90	A-2	1	1					3	2,928							
	S-05	Afesh	3,680	2.07	4,804	35	168	300	SP	3.2	246									527	2			1		1	
									HP	3.2	227																
	S-07	Bait Al Hadrami	2,550	2.07	3,329	40	133	410	SP	3.2	276	A-1	1	1					3	7,644			1			
	S-09	Ruhm	4,567	2.07	5,961	30	179	470	SP	3.0	377	A-1	1			2			6	17,267						
Dahmar	D-01	Elow Al Mikhlaf	926	3.04	1,367	40	55	273	SP	2.0	197	1 Gen. x 2 pumps															
									HP	1.9	129	B	1	1					3	11,928				2		
									HP	1.6	136	C	1													
	D-02	Hamal-Bait Al Jabar	2,475	3.04	3,654	40	146	310	SP	3.5	307	A-1	1						3	11,953					1	
	D-03	Hegrat Al A'asham	1,592	3.04	2,350	40	94	320	SP	3.3	197	1 Gen. x 2 pumps															
									HP	3.3	178	B	1						3	5,835		1		1		
	D-05	Mayfa'at Yaer	1,515	3.04	2,237	40	89	127	SP	2.6	284	A-1	1	1		1			5	4,481						
									HP	2.6	148	C	1													
	D-07	Al Asakera	1,944	3.04	2,870	40	115	304	SP	4.0	276	A-1	1														
									HP	3.2	162	C	1			1			3	13,595			1	1		
									HP	0.7	155	C	1													
Ibb	I-01	Asfal Bani Saba	9,311	2.47	12,787	25	320	305	SP	4.5	247	A-1	1														
									HP	4.5	239	C	1			1	1	1	3	19,513						
									HP	4.5	245	C	1													
	I-02	Al Sana	6,026	2.47	8,276	30	248	272	SP	3.9	304	A-3	1														
									HP	3.9	185	C	1			1	2		3	20,529						
									HP	3.2	163	C	1													
	I-04	Al Jahlah & Al Meshraq	10,467	2.47	14,375	20	288	305	SP	4.1	118	1 Gen. x 3 pumps															
									HP	4.1	219	D	1			1		2	3	20,710						
									HP	4.1	165																
Taiz	T-02	Bani Al Suror	9,385	2.47	12,889	40	516	230	SP	5.1	200																
									HP	3.9	218																
									HP	3.9	272				1					2,889						
								251	SP	2.6	253																
								190	SP	5.4	197	A-1	1														
									HP	5.4	247	C	1														
	T-03	Sheb Humran	23,732	2.47	32,591	20	652	400	VP	4.0	153	A-2	1														
									HP	4.0	244									1,478						
								260	SP	4.2	205																
									HP	4.2	262																
	T-04	Yafoq Bani Hamad	6,844	2.47	9,399	25	235	220	SP	3.0	336																
									HP	3.0	177																
	T-05	Al Azaez	11,784	2.47	16,183	30	485	246	SP	6.0	242	A-1	1														
								120	SP	2.0	231									2,295						
									HP	5.0	220																
								280	SP	3.8	317	A-1	1														
	T-06	Al Khunha	1,579	2.47	2,169	40	87	200	SP	3.1	154	A-3	1			1			4	16,721						
Total			121,403		168,193		4,678	24	47				26	5	2	8	3	3	45	170,915	2	1	2	5	1	1

Pump: 47 units
Generator: 24 units
Engine: 18 units

SP: Submersible Pump/Borehole Pump
HP: Horizontal Booster Pump
VP: Vertical Booster Pump

MH: Machinery House


EXISTING WATER TANK(200m3)
EXISTING WATER TANK(75m3)
& MACHINERY HOUSE NO.2
EXISTING WATER TANK(50m3)
& MACHINERY HOUSE NO.1
EXISTING DEEP WELL
& MACHINERY HOUSE
LEGEND
WATER TANK OR MACHINERY HOUSE
DEEP WELL
NEW PIPE
EXISTING PIPE
0 200 400 1,000 2,000m
N
THE PREPARATORY SURVEY
ON THE PROJECT FOR RURAL WATER SUPPLY
IN THE REPUBLIC OF YEMEN
SITE PLAN :
A-03 OZLAT AL JARADI
-
FIG. 2-4
JAPAN TECHNO


WADI JASAS
QATTA'A AL NAKEEL
RA'AS AL AQABA
HEALTHE CENTER
MOSQUE
AL HIMRARY
AL ARIDHAH
AL SARADEH
MOSQUE
SCHOOL
OM JAFAR
DEEP WELL & WATER TANK(25m3)
& MACHINERY HOUSE
RA'AS AL MATHAB
AL HISN
MOSQUE
AL BALAD
WATER TANK(40m3)
USELESS EXISTING
WATER TANK
USELESS EXISTING DEEP WELL &
WATER TANK & MACHINERY HOUSE
MOSQUE
AL MATRAH
AL SADR
AL ENAB
MOSQUE
AL MADHAF
SHA'AB AL SUMOR
LEGEND
WATER TANK OR MACHINERY HOUSE
DEEP WELL
NEW PIPE
EXISTING PIPE
0 100 200 500 1,000m
N
THE PREPARATORY SURVEY
ON THE PROJECT FOR RURAL WATER SUPPLY
IN THE REPUBLIC OF YEMEN
SITE PLAN :
S-02 JARBAN
-
FIG. 2-5
JAPAN TECHNO