If the project site is a district (Mudirya), the water office is directly under the supervision of the director general (Ma'mour), but if the site is a subdistrict (Markaz) or not an administrative level locality, the deputy district director (Assistant Ma'mour) who is head of the subdistrict has direct responsibility as the supervisor. This system is useful when final judgements and decisions are needed for management problems such as facilities troubles and repairs which can not be handled by the water offices; changes in water fee collection methods; or reorganization of water offices. Discussions on technical problems can be made with the GAREW through the director general (presently, the GAREW receives only the requests through the local administrative bodies).

(2) Personnel Plan

For sustainable management, operation and maintenance of the facilities, the setup of the water office including the number of personnel, their technical levels of the water office must adequately be established.

The organization of the water office is divided into two broad sections : the administrative section for responsibilities such as assets management and fee collection, and the technical section for routine facilities operation and maintenance ; and the director who has the highest responsibility is collectively in charge of both section.

The points to consider for this project in relation to personnel planning for the water office are as follows.

1) At each of the project sites, the duration of daily operation is 8 to 10 hours at the beginning, and will extend to a maximum of 16 hours at the end of the design period which would require a two-shift operation with at least three crew. Therefore, efforts should be made to give employees a leeway from the beginning that could be utilized for an opportunity for training to raise their technical levels. The person in charge should be a highly skilled person with over ten years of experience.

2) Concerning operation and maintenance of the facilities for both equipment and pipeline system, technology transfer is planned to be offered to the staff members of the respective water offices during the test run of the completed system. Even during the construction

stage, the staff of the water office as well as the counterpart personnel dispatched by the GAREW will be held responsible to assist in the smooth implementation of the construction works to be conducted by the Japanese side. Such invariable contact is anticipated to help them keep in close touch with the expertise and skills of the Japanese project.

3) The routine operation of the personnel will be as follows.

a. Equipment Related Matters

i Equipment operation and maintenance

The personnel is to engage in the operation of well pumps and booster pumps as well as periodic inspection and maintenance of the pumps and generators (works for generators include coolant additions and filter replacements which are not much different from those for automobile engines, and employment of skilled workers in this field who can handle these works would not be difficult.) The routine work on pumps include daily operations and lubricant additions (for booster pumps). Such routine works do not require any special technique, but to cope with emergency situations, the knowledge of pump characteristics and pump maintenance methods should be acquired.

ii Flow rate control

To accurately and continuously maintain the proper pumping and service rates, flow meters will be installed in the pump stations for this project. Flow rate adjustments can be made easily by operating the gate valve in accordance with flow meter reading, but this method has not yet been employed in the rural water supply system in Yemen. To prevent overpumping of the deepwell pumps, frequent flow rate inspections are especially advisable. Since flow rate control is essential for protecting both the pump and water source, flow meters should be effectively used.

iii Conservation of water source

In addition to protection of the water source through controlling pumping rates, a practice of regularly logging water level of the deepwell should be set up, using a portable water level meter to be supplied to each water office in the project. In case of continuous abnormal readings, the advise of an expert engineer can be consulted through the GAREW.

iv Recording

The measurements made on flow rates, water levels and other parameters will be recorded and kept as data for future use.

In addition to the above procedure, training on the proper operating methods of instruments attached to each equipment will be provided as well during technology transfer.

b. Pipeline System

i Gate valve control

To control water distribution or to stop the flow for partial repairs, the layout of gate valves and their purposes along the pipeline will be confirmed to plan a proper distribution system. Periodic inspection of valve movement should be carried out.

ii Confirmation of leakages and their countermeasures

Beside the flow meters for controlling pump operation, another flow meters will be installed along distribution lines in units of service areas (village or distribution network) so that consumption rates can be recorded. By observing flow rate balances, leakage occurrences and their degrees could be estimated. Since leakages can occur frequently in distribution branch lines and service lines, periodic surveillance and immediate treatments are required.

iii Repairing of damaged pipes

As a measure to enable easy repairing of pipe in any trouble, a flange or a union joint is designed to be connected by one location per ten unit lengths of pipe along the lines installed in the project. If a section of pipe is damaged, the nearest portion with a joint can be disconnected to reach the section in question for inspection and subsequent treatment.

Some of the sites such as Ahwar and Moodeyah already have skilled plumbers. Nevertheless, since the planned pipeline is lengthy and large in scale in every site, experienced plumbers need to be secured at each site.

As mentioned above, technology transfer will be carried out in this project, but a long term training course will not be conducted. The former RWSD, since its establishment, had held a periodic training course in rural water supply facilities at Sana'a headquarters under the auspices of the WHO, which has continuously been supporting the reinforcement of the RWSD and the present GAREW. After a brief suspension, the course was reopened in 1991 with the support of the Netherlands government, but it is presently discontinued due to a funding problem. Since training was one of the important conditions for the establishment of the GAREW, the prompt reopening of the course is most desirable. On the other hand, though the NWSA Aden Branch (formerly the PWC) is now completely disengaged from the rural water sector, each of the southern offices of the NWSA has ready-to-use training facilities and while the training in Sana'a is discontinued, the possibility to entrust the personnel training for this project to the NWSA should be taken into consideration.

In view of the activities explained above, the appropriate personnel plan to properly manage the project facilities will be as proposed in Table 4.7.

Table-4.7 Personnel Plan for Operation and Maintenance of Project Sites

( ):Present No.

	Manager	Clerk	Fee Collector	Mechanic	Plumber	Total	Remarks
Ahwar	1 (1)	2 (2)	3 (2)	6 (3)	6 (3)	18 (11)	Employs fully autonomous system including payment of staff salaries.
Moodeyah	1 (1)	3 (3)	3 (2)	6 (4)	6 (4)	18 (14)	Receives staff salaries from the Governorate office, all other expenses depending upon fee collection.
Al-Raidah/ Shamalya	1	2 (5)	3	6 (3)	6	18 (8)	5 representatives organize a kind of water committee. Due to small scale facilities, only 1 full-time operator among 3 technicians engages in daily operation. Facilities are being autonomously being run.
As Sadarah	1	2	3	6	6	18	No facilities, no water office at present in this site. In case the initial recruitment of full staff proves difficult, secure 4 members respectively for mechanics and plumbers, which shall be reinforced within 5 years.

(3) Equipment and Materials for Operation and Maintenance

1) Pumping Facilities

The results of the survey at the project sites have revealed that the water offices from time to time have been suffering from the breakdowns of pumps and or power units. The type of pump presently used at the sites is predominantly the diesel engine driven borehole pump, and most of the sites use a standardized product of one internationally known manufacturer. This manufacturer has agents in Aden as well as in Sana'a, but since pumps must be selected to meet various water source characteristics all around the country which results in numerous models, and spare parts for all models cannot be stocked, the delivery of products tends to delay and the continued degradation of the foreign currency situation in Yemen gives rise to difficulties in procurement procedures. However, according to the field survey this time, recently in Yemen, the trend towards using submersible pumps driven by electric power is gradually observed. The submersible pump is easy to maintain and is economical for sites where electricity is available, but if the motor burns due to an abnormal accident, the motor must be replaced in its entirely due to its closed structure. In order to avoid this kind of mishap, careful precautions in daily operations such as prevention of overpumping must be taken.

From the above viewpoint, concerning the pumping facility composed of a pump and a generator, spare parts necessary for two-year operation and maintenance is planned to be supplied in order to support the startup operation by the water offices at each site.

2) Water Source Related Equipment

For the operation and maintenance of water sources, the measurement of water level and flow rate is essentially important. In this view, a portable water level meter will be supplied to the water office at each site. The project also plans to control pumping from water sources with a flow meter. Since local procurement of this type of meters is not possible, one standby meter each for each size need to be included.

3) Pipelines

Special types of valves such as air vent valves, slow-closing check valves and high-pressure gate valves to be employed for this project will be provided with some extra units, since these valves could not easily be procured in Yemen. The supply will be made with one extra unit for each group and size of valve (in case of air vent valves, one or two).

(4) Operation and Maintenance Cost

1) Water Supply Practice at Project Sites

The facilities to be constructed in this project will be managed by the water office of each project site through water fees collected from the residents. However, before considering the long-term facilities maintenance plan, the present water supply conditions and facilities maintenance situation based on survey results will be explained below.

Presently at 3 project sites other than As Sadarah, water is served to residents through existing water supply facilities of varying types. Of these, at Moodeyah, the governorate office provides the personnel salaries, but fees collected from residents are used to cover costs for fuel, repairs and other maintenance activities. At the other sites, no subsidies from the local government are allotted whatsoever, and staff salaries and other operation and maintenance costs are covered by fees collected from residents.

The tariff systems are the metered and fixed methods. At the 3 Project Sites, fees are collected on a fixed basis according to household. The present water supply situations and water fees are summarized in Table 4.8. In addition, as reference, the present situation and fees at 4 other surveyed sites not included in this project are also indicated in Table 4.8.

Although large fluctuations are seen in the fees, in comparison to household monthly incomes ranging from YR3,000 to YR5,000 (according to site survey), an approximately 2.0% standard is shown.

However, in reality, at Ahwar, Moodeyah and Al-Raidah/Shamalya, the acquisition of a clean and stable supply of water through the present supply system is impossible. Therefore, the residents must rely on water from neighboring private deepwells and open wells, or kareefs (or cisterns of usually concrete construction, large in size, to store surface runoff during rainfalls); or water purchased from vendors which bears a heavy economical burden. Furthermore, open wells and kareefs are susceptible to contaminants flowing in from the ground surface, and become culture media for Schistosomiasis (Bilharzia).

According to the survey, the water vending price at 9 survey sites was YR100-130/m^3, and the daily per capita supply rate is limited to 10-20 lit. in Ahwar and Moodeyah; but at Al-Raidah/Shamalya, where the residents have no water source to rely on, the water purchase rate is above 50-80%. During the field survey under the basic design study for the Japanese grant project in the former North Yemen in 1991, the water vending price even at areas farthest north revealed similar ranges. As for the water purchase rate, accurate information is not available for sites receiving water supply service, but according to the survey at Ahwar and Moodeyah, the average consumption rate is about twice the present estimated supply rate. The present situation of water consumption of average families in Moodeyah (served population at about 20,000 persons) and Al-Sufilah (population: 5,000) which is the largest village in Al-Raidah/Shamalya are described below.

Table 4.8 Present Water Supply Situations and Water fees

a:Basic Design Study Sites

Site	Served Area	Number of Houses	Population	Daily Supply Rate	Present Fee (YR/house/month)	Unit Cost YR/m^3	Effective Accounted-for Rate
Ahwar	Ahwar Hay Badeed Al-Sharwa Total	400 250 60 710	7,000 3,800 700 11,500	230m^3	60	6.2	60% (assumed)
Moodeyah	Moodeyah Al-Magbabh Gezt Hageh Total	2,000 600 50 2,650	14,500 4,500 500 19,500	80m^3	52	57.5	80% (assumed)
Al-Raidah/ Shamalya	Al-Ka'a	100	1,000	30m^3	65	7.0	no pipe network

b:Survey Sites

Site	Served Area	Number of Houses	Pop.	Daily Supply Rate	Present Fee (YR/house/month)	Unit Cost YR/m^3	Effective Accounted-for Rate
Al-Radood	Al-Radood	270	4.000 3,800	180m^3	10/100gal	20.0	60% (assumed)
Gaishan	10 villages of Wadi Rhab	139	1,300	52m^3	100	12.2	80% (assumed)
Tor Al-Bah					3.0/100gal	6.0	60% (assumed)
Al-Faith/ Bani Baker			12,000	180m^3	6.5	14.4	60% (assumed)

Case I: Moodeyah

1. Daily Per Capita Service Rate=10 lit.
(The Moodeyah service area is divided into 2 zones each being served on alternate days. However, estimating from the distribution tank capacity and water source situation, the daily per capita service rate is less than 10 lit.).

2. Daily Per Capita Consumption Rate=35 lit.
(Average value estimated from survey results).

3. a. Daily Per Capita Water Purchase Rate
=(35-10)=25 lit/day
b. Water Purchase Price=YR 130/m^3
(average value from survey results).
c. Daily Per Capita Water Purchase Expenditure=(25 X 130/1,000)=YR 3.25

4. Family Structure Per Household=7.4
(Average value from survey results)
a. Monthly Per Household Water Purchase Expenditure
=(YR 3.25 X 7.4 persons X 30 days)=YR720
b. Monthly Per Household Water Fee=YR 52
c. Monthly Per Household Water Supply Expenditure=(720+52)=YR772

5. a. Average Monthly Per Household Income
= YR 3,000(Average value from survey results).
b. Per Household Water Supply Expenditure Ratio
=(772/3,000)=25.7%.

The values used in the above calculations are believed to be exaggerated, and therefore, the actual ratio should become much smaller. However, this reveals the present water supply trend of this area. From the inquiry at Moodeyah, if the present water service is improved, the residents are willing to pay 2 to 3 times the present monthly per household water fee of YR 52.

Case II: Al-Sufilah Village / Al-Raidah/Shamalya

This village has an open well which can be used three months out of the year, but during the other months, water is purchased from neighboring wells or kareefs (the latter is about four times cheaper).

1. a. Village Population: 5,000
   b. Total Number of Houses in Village: 350
   c. Average Number of Families Per Household=14.3 persons

2. a. Average Monthly Per Household Water Purchase Rate =6,000 lit.
   b. Average Daily Per Capita Consumption Rate ={6,000/(14.3 X 30)}=14 lit.

3. a. Water Purchase Price=YR 100/m^3
   b. Average Monthly Per Household Water Purchase Expenditure
      = {6 m^3 X YR 100 X 9 months)/12 months}=YR 450

4. a. Average Monthly Per Household Income=YR 4,000 (Average value from survey results)
   b. Per Household Water Supply Expenditure Ratio=(450/4,000)=11.3%

At Al-Raidah/Shamalya, with the exception of the village of Al-Ka'a which has are existing deepwell, the other 6 villages have similar situations, and the expenditure on water consumption for all village residents of this site can be estimated as follows.

1. a. Al-Ka'a Village
      Number of Houses: 100
      Monthly Management Cost: YR 6,500
   b. Other 6 Villages

Total Number of Houses: 713

Monthly Expenditure: (713 X YR 450)=YR 320,850

Therefore, Monthly Water Consumption Expenditure for all villages =(328,800 + 6,500)=YR 327,350

2. a. Average Monthly Per Household Expenditure
   ={327,350/(100+713)}=YR 402

   b. Per Household Water Supply Expenditure Ratio
   =(402/4,000) 10.0%

IBRD/IDA recommends that for developing countries the ratio of water fees to household income should be kept below 5%. However, as can be seen from the above examples, at 3 sites out of the project sites, the ratios are far above this recommended value due to unavoidable buying of expensive water as a result of degraded water services (at Ahwar and Moodeyah) and non-existence of water supply facilities (at Al-Raidah/Shamalya).

Of the sites presently being served with a water supply, the 2 sites of Ahwar and Moodeyah are the biggest in size. However, they are faced with many problems such as: the flow rate is extremely low; the water source is of poor quality; as the residential area expands, distribution networks are extended without consideration of the water source which decreases the supply rate and creates areas where the supply can not be reached; and sometimes water fees are not paid. Though details are unknown, the financial situation concerning operation and maintenance for both of these sites as obtained from site inquiries is as follows.

Table-4.9 Water Fee Balance for Ahwar and Moodeyah

Site	Monthly Income	Monthly Expenditure
Ahwar	YR 42,600 (max.)	Fuel, Oil: YR20,000 Personnel Salaries: YR20,000
Moodeyah	YR132,500 (max.)	Fuel, Oil: YR40,000 Maintenance & Office Expenditures: YR90,000

At Ahwar, from the fact that personnel salaries are not allocated from the governorate, management is severe and as seen from the mostly first aid repair conditions of pipelines, leakages are promoted. Moreover, they are faced with the dilemma that since satisfactory water services can not be given, water fees cannot be raised.

Moodeyah has received subsidies from the governorate twice in the past (YR 130,000 in 1989 and YR 100,000 in 1992), but these were spent on repaying loan debts and extension of pipelines.

2) Management Policy for Service Facilities

The water services in the project sites are presently on the course of degeneration even for rural administrative localities such as Ahwar and Moodeyah. The inferior situation arises from the fact that water fees cannot be raised, and even with low fees, many disorders of non payment occur; while at the same time, residents must cope with expensively purchased water.

For the sites confronted with degrading water use situations, when the facilities are completed in this project, the water supply management must be restructured to give continuously adequate supply services. As a consequence, an appropriate fee system which can not only compensate for the daily maintenance costs but also recover a part of the investment costs must be established in preparation for sudden breakdowns and accidents. This measure is indispensable for proper management of water supply.

Donor countries and international organizations for assistance to developing countries in the water supply sector are considering the assistance trend up to now, and have concluded that the following points are significant for project implementation.

a. Sufficient cost recovery to enable a sustained operation and maintenance of facilities.
b. Evidence of a concrete demand, that is, a willingness to bear the burden of operation and maintenance costs to meet the supplied service.
c. Community involvement at the stage of planning and implementation.
d. Promotion of women's participation.

At the stage of the site survey, efforts were made to consider the views of the water offices as well as the residents. In this respect, the actual situation of the sites were surveyed in detail and a willingness confirmation was made on the part of the residents in the case the project is realized (during the survey period, each site was visited and inquiries were carried out).

On the other hand, as to women's participation, in Yemen where Islamic traditions are especially strong, the present situation demands that women cannot participate actively outwardly, but the experience in the North revealed that the opinions of women, who are the actual users of water in the village society, are reflected in the residents' views (examples are the decision of public water stand locations and other opinions, but more directly, the rapid spread of house connections resulted from the fact that women and children who have long been involved in water fetching strongly demanded the reduction of their work load).

The specifications of the main facilities for this project do not require special technology and those generally constructed in Yemen were selected. The facilities can be sufficiently sustained with regular maintenance, but as for water fees which will become the foundation for a sound water service, an appropriate fee system and a fair and rational collection method are indispensable. The following policies will be considered for this project.

a. Decision Criteria for Water Fees

Water fees are determined based on an appropriate cost, but the calculation of the cost is generally made by the "overall cost principle", where the total cost during a fixed period is divided by the accounted-for flow rate. The total cost includes personnel expenses, fuel costs, consumable costs, repair costs and other expenditures, as well as amortization or depreciation costs. Usually, assets obtained through subsidies or allotments are not calculated into the cost as amortization. In actuality, in Yemen, when the GAREW hands over the facilities to the local governments/water offices, financial transactions are not required, but as judgment parameter for the real cost or to consider the level of water fee possible for sustained management, these are used as reference.

As criteria to decide the appropriateness of water fees calculated from the cost, the "In developing countries, water fees are within 5% of income" recommended by IBRD/IDA will be used as reference. As to the willingness of residents to pay, inquiries made to residents at the project sites revealed that if the present water services are improved they are fully willing to pay, which means that the concrete demand was confirmed.

Residents' incomes were also surveyed, and since the average family required a minimum daily expenditure of YR100, the average monthly per family income of YR3,000 from the surveyed results is not a high standard. Therefore, 5% of YR3,000=YR150 can be considered as the upper limit for the willingness to pay by a family.

b. Billing Method

As for the billing method, there are the fixed method and the metered method, but the fixed method is mainly used at the project sites. In the future, for house connections, a changeover to the metered method is appropriate, and already in Yemen, certainly urban water supplies, and some rural villages in the North and South are adopting the metered method. The project sites are using the fixed method, and at Ahwar and Moodeyah, a limited-hours supply is being carried out in which the residents are receiving insufficient supply of water; and therefore, since they cannot adopt the method of per tap fee or per capita fee as being used generally by other fixed method sites, they must rely on the per house uniform billing method. When this project is implemented, since the water use will increase enormously as compared to the present, a differential billing system should be introduced to prevent unfair billings. As an example, at Bani Baker (a Markaz with a population of 12,000 persons) of the survey site of Al-Faith/Bani Baker, water is supplied through public water stands. Since the water source cannot meet the demands of the entire population, a limited service is carried out, and a uniformly fixed fee of 5 Shilling/month(=YR 6.5) per person is collected without discrimination of old, young, male or female. Consequently, the monthly income of the water office is approximately YR 50,000 and with a YR 500,000 savings, the construction of a new standby pumping facility was carried out, which shows that a sound management is being practiced. At the other 2 sites, since they are administrative centers, the daytime population movement is heavy, and so extra fees should be collected from shops and restaurants. (As an example, at Tor Al-Bah, although a metered method is adopted, shops must pay 3 times the tariff of normal families.) On the other hand, at the farm village of Al-Raidah/Shamalya, since a tightly woven community society is formed due to the well recognized internal affairs of the village, a relatively fair, step-wise tariff system can be established using combinations of the numbers of families and water taps. In this project, the basic monthly per capita water tariff is established on the basis of the unit flow rate of 1 m^3, and assuming that the average household consists of 9 persons in the project sites, the basic monthly per household fixed tariff will be considered. This basic tariff on a fixed per capita, per household basis will become the basis for the unit service tariff of the metered method.

c. Accounted-For Flow Rate

Unlike the metered method, the actually used flow rate cannot be accurately determined with the fixed tariff billing method, and therefore, the unfairness on the side of the users is also felt. The extensive adoption of this method in the Yemen shows that the feeling of solidarity is strong in the rural communal society of this country. To alleviate this uncertainty and introduce an objective standard, in this project, water meters will be installed in the distribution mains to be branched to each village so that service rates can be metered on a community basis. The water office collects a fixed per capita fee in accordance with each flow rate supplied to the communities. This tariff will be calculated from the total tariff for a community according to the metered tariff method applied on a unit flow rate, and the cost will be divided by the population of the village. With this method, the unfair sense of the extensive community supply system can be reduced for even a little bit. Furthermore, this method can arouse the residents' consciousness towards the relationship of conservative water use to leakages, and can also bring an opportunity to foster good practices for proper water use in each community.

Since a high rate of fee collection is possible without any relation to leakages at the end of the line, this billing method is very favorable to the water office. However, the ratio of the effective flow rate of the distribution system to the production rate which is called the "effective ratio", is differentiated from the "accounted-for ratio", which is the ratio comparing the production rate to the fee collection rate when the metered method based on the metering at the end of the line is applied. Therefore, in this project, until the changeover is actually made to the metered method, billing based on the effective ratio is recommended. However, in the 2 sites of Ahwar and Moodeyah, since the distribution line forms a pipeline network, both sites can be divided into 2 or 3 old village squares, although they cannot be divided into blocks such as those of the farming area sites, and rough service assignments can be made.

For water tariff considerations, the assessment of the accounted-for flow rate is important, but in this project, since the accounted-for flow rate will be based upon the effective ratio, a collection rate of about 80% can be anticipated. However, since sites where leakages are actually seen in many locations can be found, such as the present Ahwar, lower collection rates are also predicted for reference.

(5) Consideration of Water Tariff

Under the conditions of the elements of this project explained previously, the calculations for the water tariff of the 4 candidate sites will be based on the following conditions and details.

a. Operation and Maintenance Cost

The operation and maintenance cost is composed of the following.

i. Personnel Salaries (as average of the surveyed sites, determined as follows)

*Director YR 4,000
*Manager (One each for each category)
YR 3,000
*General Worker YR 2,000

The personnel organization of each water office corresponds to 4.3.4-(2), and in between the period from commencement to the end of the design period, 2 additional personnel should be considered.

ii. Operation and Maintenance Cost for Generators

*Fuel Cost (Operating cost of engine and generator)
= YR 3.1/lit (present fixed price)
*Lubricant Cost (Lubricants for engine and generator)
= 10% of total fuel cost
*Consumable Cost
= 5% of total fuel cost

b. Repair Cost

The repair cost is considered to be mainly the cost for pipeline repairs, and about 3% of the collected fees will be appropriated. This is needed for purchase of pipe materials and contracting of repairs to specialized technicians.

c. Investment for Replacement of Equipment

Equipment such as pumps and generators need to be replaced due to wear after long periods of operation. The normal life of pumps is 15 years, but intermediate, partial replacements due to unexpected repairs may be required. Therefore, at an interval of 5 years, equipment such as motors and engines are assumed to be replaced 1/3 at a time of the entire equipment.

The water tariff calculation procedures for the 4 sites based on these conditions are shown in Appendix 4b. As a result of the calculations, the basic water tariffs viable for continuous management in each project site are indicated in the following table.

Table-4.10 Water Tariff by Project Area

Parameter	Ahwar	Moodeyah	Al-Raidah/ Shamalya	As Sadarah
Actual Water Tariff (Billing Method)	YR 60/mon/hh (Fixed rate)	YR 52/mon/hh (Fixed rate)	YR 65/mon/hh (Fixed rate)	- No facilities
Design Average Service Rate	50 lit/cap/day	40 lit/cap/d	50 lit/cap/d	50 lit/cap/d
Planned Water Tariff	YR 7.8/m^3	YR 8.3/m^3	YR 11/m^3	YR 7.8/m^3
Monthly Per Capita Rate	YR 12	YR 10	YR 16.5	YR 12
Monthly Per Household Rate (Ratio/Income)	YR 105 (3.5%)	YR 90 (3.0%)	YR 150 (4.9%)	YR 105 (3.5%)
Billing Method	Fixed method based on effective ratio	Same as left	Same as left	Same as left
Effective Ratio	60%	60%	80%	80%

CHAPTER V

BASIC DESIGN

CHAPTER V BASIC DESIGN

5.1 Design Policy

5.1.1 Policy with Respect to Natural and Social Conditions

The objective of this project is to construct and improve water supply facilities in four sites in the former South Yemen of the Republic of Yemen, where appropriate measures are urgently required to relieve the hardships of the residents acutely suffering from water shortages.

A greater part of the country's southern area is dominated by high temperatures with scanty precipitation nearly all the year round. One of its geological characteristics features a wide distribution of Precambrian hard rock series, particularly over the western half of the region. All these rigorous natural conditions contribute to producing less favorable environment for the development of groundwater resources there than that in the northern area. The survey for this project has proved that a majority of the candidate sites for this project are under influence of such harsh natural conditions, and as a result of the close examination of the 20 sites under the request, many sites had to be excluded from the project because of difficulties in securing water sources viable both in quantity and quality. Some of them were canceled since all available water sources were highly saline, even though their productions were adequate. Even among the four project sites finally selected for the implementation, some are seen unable to extend water service to their entire planned populations due to insufficient water production. For these sites, an optimum plan to utilize an available range of water is to be formulated.

In fact, besides being limited in production, most of the water sources earmarked for the project hardly have any alternatives in and around the respective sites. The use of such precious sources should be intended to meet the BHN of the residents in the first place. Under such circumstances, the needs for livestock should come second to those for human beings, even though livestock breeding is one of the economic essentials for the latter. The survey results indicate that the three project sites among four have so great a difficulty with the water sources, particularly in their productions, that planned facilities could serve only part of the entire population. The remaining site of As-Sadarah has affluent running water in the wadi, which has been and will be used by herds of livestock within the site. There is no need to give costly piped water to livestock at this site. In view of these specific water source conditions in the respective sites, this project is deemed in no position to plan sharing water with livestock.

Although the populations in the project sites are seen having such destabilizing factors as the movement of the Bedouins (unsettled nomads widespread in the southern part) as well as the migration of workers to other Gulf countries including Saudi Arabia, the planned populations for the project will be based on the numbers of permanent residents at the time of the survey. Since the survey was short and limited at each site, detailed information on migrant workers could not be collected. However, it has been judged that the latest big event to have affected a population trend in 1990 when a large number of migrant workers were repatriated in the wake of the Gulf War has nearly been settled, and that such an abrupt population movement should not occur any time soon without an eruption of another unforeseeable event.

The policy of this project is to utilize safe and stable water sources in order to contribute to the improvement in the living infrastructure and health environment in the rural societies. Based on this policy, deepwells will be adopted at the project sites to replace open wells which are susceptible to contamination. In order to obtain safe and stable new sources, the water basins for them in the respective sites have in common resulted to be located remotely from the planned service areas.

Generally, the basic policy for this project is to increase the residents' interest in the conservation of their precious water resources as well as their natural and living environment, and to aim for a gradual improvement in the habits of water use.

5.1.2 Policy for Local Construction

After unification in 1991, private enterprises from the former North Yemen began to operate in the southern part in the field of construction for water supply facilities which had been supervised by the former PWC under a socialist government. Particularly in the water supply sector, the companies from the north have become active in drilling work which was previously monopolized by a public corporation. The overall situation of the southern economy is now seen remarkably transformed into the market economy. Under these circumstances, the approach and method for construction will gradually be unified. This project intends to positively employ the conventional methods of construction specific to the South, in case these are expected to produce good effects.

One example is a "masonry tank", a reservoir prevailing in the southern part, which has a structure with their inside and outside walls lined with stones. The stone walls act as insulators against the severe heat of the region as well as reinforcing materials. This design has spread over the southern area as a standard specification of the former PWC, giving an appearance matching the surrounding natural environment. There are skilled labor forces for the construction of this type of tanks, and the level of craftsmanship is high. Therefore, it has been decided to adopt this method as a policy to encourage active participation of the regional communities and residents.

The basic policy of this project is to keep in check the complex designs requiring special techniques. Consideration is made to encourage the participation of the residents. The goal of this design backed by Japanese technology is to provide facilities which allow continuous operation and maintenance.

5.1.3 Policies Related to Operation and Maintenance

The water supply facilities to be completed through this project are to be operated and maintained by the water offices organized in the local government or by the village communities. As mentioned in Chapter 4, the project sites already have the existing water offices, though varying in their setups and sizes, except for one where a new organization needs to be established. Under such a situation, facilities and equipment to be turned over to them are intended to be those hardly requiring special techniques in their daily operation and maintenance. In line with this policy, focuses are put on (1) water sources, (2) pumps and generators, and (3) pipelines.

Water is absolutely in short supply not only in the project sites but throughout Yemen, and yet maximum pumping regardless of the characteristics of each water source is generally taking place. In fact, this practice has frequently caused the depletion of water resources. To prevent such overpumping, this project plans to provide a simple water level meter to each water office so that the operator can judge the situation of the deepwells which cannot be directly observed. A meter consists of a potable meter body with a calibrated cable having an electrode at one end. Operated by a battery, it is manually used by lowering the cable with the electrode into a well, and a lamp on the meter lights up or a signal emits when the electrode reaches the water level. For equipment such as pumps and power units, which are especially susceptible to trouble, special types will not be adopted, and those being commonly used in Yemen will be provided, together with a supply of necessary meters, gauges and protective switches to indicate the operational condition of each equipment as standard accessories for the purpose of making daily operations easy and accurate.

In general, the facilities and equipment to be provided in the project should not break down easily if they are operated and maintained with proper care each day. Upgrading the quality of the water office staff and exercising caution can guarantee sustained operation and maintenance. For such purpose, technology transfer through commissioning is planned to be conducted for the operators of the water offices when the completed facilities are turned over to the office.

5.1.4 Policies for Optimum Design for Facilities and Equipment

Integrating the policies mentioned above, efforts will be made to design the optimal facilities and equipment adaptable to the features of each site. In determining an overall facilities and equipment plan, the "optimum scale" is emphasized. In order to avoid a risk of planning and constructing large facilities without an adequate water source, the extensive water supply plans initially requested by the Yemeni side need to be scaled down in proportion to available water sources. Although aiming for an extensive water supply plan with improved water service is an acceptable concept, various conditions have to be met in order to achieve this goal. Therefore, as a result of analysis of the present situation, the scale of facilities and equipment will be proposed within a range where sustained operation and maintenance can be expected.

In regard to equipment and materials, most of which are imported ones, stocks in the market is running short and procurement usually takes a long time due to the continuous tight foreign capital situation. Their prices have jumped in recent years, particularly after the Gulf Crisis/War. In water works, a lesser grade of pipe, which is weak though inexpensive, has lately been popular, in order to secure the necessary length of pipeline. Such a present trend seems to have an adverse effect on the continuous operation and maintenance of the facilities. Further details are mentioned in each facility plan, and proper selection will be aimed for the project, taking the results of the survey into account.

5.2 Design Conditions

5.2.1 Water Sources

As mentioned in detail in Chapter 3, the hydrogeological and water source characteristics in the project sites are diversified, but the water sources to be used in this project can be summarized as follows.

1) Ahwar (Abyan Governorate)

1. Hydrogeological Characteristics of the Site

   As Ahwar is located in the basin of the Wadi Ahwar, groundwater generally abounds through the entire area, and significant amounts of groundwater can be expected. However, because the area stretches on a coastal sand dune, the chloride contents of groundwater is quite high. However, along the narrow belt on both banks of the Wadi Ahwar, groundwater with a relatively good quality, probably the underflow of the wadi, is estimated to run.

2. Planned Water Source

   There are two unused deepwells in the left bank of the Wadi Ahwar drilled by the regional agricultural development plan by the former Soviet Union. The water analysis at these wells revealed quality was far better than those of the surrounding area, and these two wells are planned to be used for this project. They are some 70 m deep, tapping shallow alluvial aquifers at approximately 20 m to 50 m.

3. Planned Production Rate and Water Level

According to information available from the pumping tests performed by the former Soviet Union at the time of drilling in 1988, the maximum pumping rate was 13.2 lit/sec (800 lit/min) with a drawdown of 7.4 m (duration of pumping is unknown). As the production from the wells depends on the underflow through shallow formations, pumping at a rate less than 80% of the maximum is desirable as a safe yield. To secure a production rate as much as possible in view of a large planned population of this site, a ratio of 75% is recommended as a safe yield. The pumping plan at this rate of safe yield will be calculated as follows:

a. Pumping rate: 13.2 lit/sec (800 lit/min) x 0.75
= 10 lit/sec (600 lit/min)

b. Static water level: 10.9 m (actual measured value at the time of the survey, December 1993).

c. Pumping water level: 15.9 m (predicted value from an analysis of the Soviet test results)

As a result of the calculations, a supply rate of 20 lit/sec (1,200 lit/min) is possible for the Ahwar service zone, operating two wells simultaneously.

4. Notes

Pumping tests are necessary in order to obtain conclusive evidence of the exact rate of production, since the records of the former testing are not new and the pumping duration is unknown. (Although the GAREW proposed to carry out testing this time, it has been postponed due to a trouble with the testing equipment.) The main reason for the requirement of testing is that the fall of water level due to overpumping at the wells is feared to lead to inevitable invasion of saline water from the surroundings of the wadi reaches through which rather fresh underflow is suspected to pass. The details of the hydrogeological characteristics of the basin remain yet to be seen, and the plan to develop additional wells downstream to increase the production for meeting the total demand of the population must be postponed. In case this project could shed some light on the possibility of groundwater development in the wadi basin, increasing the production by drilling an additional well(s) may be envisaged.

2) Moodeyah (Abyan Governorate)

1. Hydrogeological Characteristics of the Site

Although Moodeyah is located inland on a plain and hilly area, major part of groundwater in the region contains high salinity except for that occurring along the reaches of the Wadi Wajar approximately 10 km east of the central area of Moodeyah. This basin is a zone of belt running along the old river channel. The shallow sedimentary formation underlain by the Precambrian bedrock form the aquifer in this wadi belt.

2. Planned Water Source

Five deepwells have been drilled in the reaches of the Wadi Wajar, and two of them are currently being used. The other three unused deepwells can be used for this project. During the field survey, water analysis was conducted by opening the well covers, and the results indicated groundwater in this basin raises no problem in quality at least at present. The depth of these wells is approximately 76 m. The five wells are installed close to each other. A new additional well is planned with a similar structure as there is a possible development point in the wadi downstream.

3. Planned Production Rate

As information for the existing wells, a simple data from the previous pumping test is available for the one well in service as the public water source for the Al-Qurath service zone which was developed by a Chinese project. However, the test pump seems to have been of small capacity, and the data is used only as reference. In place of such previous data, the observation during the field survey can provide enough information for making judgements. At the time of survey, the two wells in the Wadi Wajar basin were working, and the rates of 7.5 - 8.3 lit/sec (400-500 lit/m) were continuously being pumped.

The static water levels of the unused three wells in the basin were also measured when the welded caps were opened for water sampling. The drilling depth was 76 m with the static water level standing at an unexpectedly deep level of some 45 m.

Only two wells are working among five existing in the Wadi Wajar basin. If all these five wells are operated in the future upon completion of the project, the interference between the wells will grow large because they have been installed quite close to each other, causing the decline of the water levels in the wells. Furthermore, along with a possible reduction in flow rate due to the fall of water level, the brackish water from the surrounding area is feared to flow into this basin. Therefore, it will become necessary to control the pumping rates of these wells by limiting them to a safe yield so that sustained operation of the water sources would become possible. An average flow rate of currently working wells is 7.5 lit/sec (450 lit/min), and the maximum production for this project is proposed to be 75% of this figure.

a. Pumping rate: 7.5 lit/sec (450 lit/min) x 0.75
   = 5.6 lit/sec (340 lit/min)
b. Static water level: 45 m (measurement results of the three wells not in operation at the time of study)
c. No information available on the pumping water level due to unavailability of pumping test data

In regard to the flow rate, a total production of 22.4 lit/sec (1,360 lit/min) becomes possible by four wells, including the new additional well to be drilled under the project.

4. Notes

An accurate pumping test is necessary for the existing wells in the Wadi Wajar, as is the case with the site of

Ahwar. (The GAREW's testing plan included Moodeyah as well.) In order to conserve the water basin exclusively producing good groundwater in this area, overall control and surveillance of the basin is critically important. It is most desirable, therefore, that a single agency, which means the Moodeyah water office, undertake to comprehensively operate and maintain all the wells in the basin, including the two wells which are in operation at present. As the planned pumping tests have not yet been conducted, only limited information related to the characteristics of hydrogeology of the basin is available. However, since further development is judged to be difficult in view of the size of the Wadi Wajar basin, special attention should be paid to preserve it.

3) Al-Raidah/Shamalya (Hadramout Governorate)

1. Hydrogeological Characteristics of the Site

This area is located on a corner of the limestone highlands platform called the South Hadramout Arch, south of the east-to-west anticline, which is intersected by the Wadi Hadramout. The Wadi Hadramout is the largest wadi in the southern area. Securing a stable source of water on this plateau has been extremely difficult. As a by-product of the recent oil exploration in this area, however, the occurrence of deep-seated groundwater was confirmed by deepwell drilling to a depth over 400 m. It is assumed that the groundwater is located in the sandstone formation with high permeability under thick limestone layer, but this has not been solidly confirmed as yet.

2. Planned Water Source

The above deepwell is located close to the Al-Ka'a village of this site, and the well is mainly used by the residents in the village. The pumping rate was 5 lit/sec (300 lit/min) as a result of a simple flow rate measurement taken during the field survey. One problem, however, is that the water level is extremely deep reaching 350 m, and requires a special pumping capacity. An Italian-made pump is now used in the village at the present time, and pumping is successful. The flow rate from this well is insufficient for the water supply plan to all of the seven villages located at this site. An additional well with a similar structure is planned to be installed at a downstream point from this well under this project.

3. Planned Production Rate and Water Level

Judging from the pump capacity, the existing well is continuously pumping a stable amount of flow with only a very small drawdown. Although the low water level due to the location on the highland is a problem, the performance of the aquifer itself is good. Therefore, even if the flow rate is further increased, it will be within the range of the safe pumping rate with a pump which has a special capacity and structure. There is no problem to use the present 5 lit/sec (300 lit/min) as the discharge for one well.

a. Pumping rate: 5 lit/sec/well (300 lit/min)
   10 lit/sec (600 lit/min) for 2 wells in total
b. Static water level: 340 m
c. Pumping water level: 350 m

4) As Sadarah (Hadramout Governorate)

1. Hydrogeological Characteristics of the Site

As-Sadarah is located at the highest point of the upper stream, approximately 100 km north of the mouth of the Wadi Hagar, which flows through the Hadramout area into the Gulf of Aden. Surface water flows throughout the year in all channels until the wadi reaches the Gulf of Aden. The origin of stream flow is a spring occurring approximately 10 km upstream As Sadarah. Other than this water source, hot springs are distributed in many places within this site through which a long geothermal belt runs north to south. Hot springs reach the surface throughout the area when digging to a depth of only several meters.

2. Planned Water Source

Currently the residents use hot springs, which can be collected easily anywhere in the site, as the source for domestic water. As a water source for the overall water supply plan of the site, the residents desire to draw unpolluted running water from the upper stream of the Wadi Hagar. As the Wadi Hagar flows down near As-Sadarah, the water quality deteriorates as its salinity increases when mixed with discharges of hot springs. Furthermore, since the community area of the site as well as the hot spring areas in the surrounding are located on the flat area along the reaches of the wadi, and the hot springs can be reached by digging only three meters, artificial contamination from waste water from the community has grown much of concern among the residents. In view of such situation, the running water from the Wadi Hagar, which is approximately 5 km from As-Sadarah, is proposed to be collected in a infiltration gallery to be newly established under the project for distributing to the villages composing the site.

3. Planned Water Intake Rate

The wadi flow rate of the water intake point for this plan, which is located in the upper stream of Wadi Hagar, is 50 lit/sec (3,000 lit/min) or greater, even during the dry season at the time of the survey (December 1993). Therefore, the water intake rate is proposed to be 16.5 lit/sec (1,000 lit/min) based on the planned water supply rate.

5.2.2 Project Target Year

The target year of the project will decide the facilities scale, and therefore, factors such as (1) the trend of water supply demand, (2) the prospects of water intake and types of water sources, (3) the construction costs, and (4) the service life of the facilities needed to be considered. The target year is usually taken at 10 years to a maximum of 20 years. However, it is impossible to estimate the details of the scale of progress in villages where the indices to show the possibility of growth and prosperity are non-existent. Therefore, a relatively short period of time is set (10 years for Japanese small-scale water supply systems), while a 20 years plan is often taken for master plans on a long-term basis in the urban cities.

This is the general trend in advanced countries. In the case of depopulated villages in rural areas in Yemen, it is expected that equipment repair after breakdowns will require a longer period of time. Moreover, as future increases and improvements are difficult, the policy was taken from the very beginning to handle emergencies and unexpected changes by determining the largest facilities possible (in particular reservoirs) within the range of this project. Therefore, in the former North Yemen water supply project performed by previous Japanese loan and grant aid, there are examples where the target year was 20 years, as requested by North Yemen. Based on the water supply program standard after 1990 by the former PWC, 10 to 15 years is the appropriate range for rural villages.

The size and type of villages at the project sites vary, but a majority of the villages are central administrative areas for the rural areas and form compounds, including the central areas where urbanization is growing. Considering the mid-sized regional villages and the present rural water supply situation in the overall rural society, 15 years is appropriate as the target year. Beginning in 1993, the target year is 2008.

5.2.3 Determination of the Service Area

When determining the optimal scale of the facilities for each project site, based on the results of the survey, the target service area will be determined based on the following policies after examining the characteristics of each site.

1. Taking the daily possible water intake rate of the water sources as the supply limit, which was discussed in the section 5.2.1, the optimal service area is determined based on the water supply target population of the project target year.

2. In this case, the daily water intake rate increases if the operation hours are longer. However, a suspension of pumping is occasionally necessary in order to maintain the water source facilities and groundwater level. From a realistic point of view, the daily maximum operation hours is approximately 15 hours in the project target year.

3. The water supply plan for the central area in the site is a priority as a general rule. The degree of urgency is discussed based on the results of the survey for the village (district), which determines the priority order.

4. The villages which manage their own water supply facilities are found in the project sites. As a result of the study, independent water supply areas at the sites where the groundwater source is stable and without management problems are excluded from this project. In the areas where the groundwater source is insufficient, small-scale water supplies within the range of the possible water intake rate are more appropriate both technically and economically.

Table-5.1 shows the planned water service area and the planned served population in each site, which were examined based on the design policy. (Refer to section 3.3 for the location of villages, and refer to each article of this section for the various items in the project, including "planned served population," related to the examination of the service area.

5.2.4 Planned Served Population

The population of each project site is based on the response to the questionnaire from the local governments and water offices, as well as the inquiry surveys conducted in the villages at each site. When large differences existed, the actual situation was examined and confirmed.

The planned served population in the project target year for the site, composed of various villages may include those whose populations may have leveled off or decreased. Yet as information to accurately assess the population change at every site was not available, the same population growth rate has been applied to all the villages in the site through the target year. In this case, based on the water supply criteria set by the former PWC in 1990, the rate of 2.6% is used for the central communities of Ahwar and Moodeyah including some villages in their surroundings, which are located along major roads and where urbanization is predicted to grow in the future; the rate of 2.% is used for the other villages.

The planned served population in the project target year is that for the planned service areas decided on the basis of principles in Section 5.2.3. Table-5.1 presents a summary of the project sites showing the planned service area together with the target served population for the respective sites.

Table-5.1 Project Service Area and Served Population

	Project Site	Project Service Areas	Project Served Population		
			Villages	1993	2008
1	Ahwar	1. Two deepwells can be utilized for urgent supply in these areas, but they cannot satisfy the overall demand of the 20 villages in the Ahwar subdistrict under the initial request. Therefore, this project supplies water with priority given to the central community of Ahwar and some surrounding villages. 2. The following villages included in the request will be excluded from this project as they have independent service systems. Independent water supply areas: 1) Al-Hanad 2) Al-Shaga (includes Al-Masany and Al-Bandir) 3) Al-Rawad (includes Al-Goul) The quality of the existing water sources in these independent service areas is not so high in salinity, and the flow rates are stable. (However, The Al-Rawad system has been left out of operation due to a trouble with the engine. It is urgently necessary to take appropriate measures by dispatching a technician from the related agency.)	1) Ahwar 2) Hay Badeed 3) Al-Sharwa 4) Al-Garieb 5) Joul Hil 6) Al-Subel Total	7,000 3,800 700 800 1,300 300 13,900	10,287 5,585 1,029 1,077 1,756 404 20,138

2	Moodeyah	1. The whole area of the Moodeyah site under request is divided into several service area. However, the planned water production rate for this site cannot satisfy the total demand of the entire areas. 2. The highest priority of water supply for this site is given first to the "Moodeyah service area," including the central community of the site, and second to the "Al-Qurath service area," where the planned water sources are located. Since the height of the existing water tank in Al-Qurath is insufficient, water cannot be supplied to its new residential area involving 1/3 of the served population. The project plans to supplement this shortage. Villages in the Planned Service Areas : (1) Moodeyah water supply area 1) Moodeyah 2) Al-Magbabh 3) Gezt Hageh 4) Karn Achal 5) Karn Marm (2) Al-Qurath water supply area 1) Al-Qurath and others 3. In the "Al-Zyoar service area", the current water service has been in bad shape, chiefly because of the insufficient height of the existing water tank. The existing deepwell is stable in production, and the quality is within a permissible range. Service should be improved by appropriate measures such as improving the pipe network. As this service area has only one well, this project plans to provide a connection from a new line to the existing network of this area which can be opened for emergency supply in case of trouble with its facilities such as a pump failure. 4. Another service area in the Moodeyah site, "Al-Habir", formerly received water from the Moodeyah service area through an extension of network, which was later disconnected. When the Moodeyah service area starts its renewed service, pipe may be reconnected. In case "Moodeyah area" has surplus of water or an emergency supply is needed for "Al-Habir", it is recommended that the water be divided from Moodeyah to Al-Habir through valve operation. 5. The following service areas and villages have and operate independent service facilities, and therefore, they are excluded from this project. 1) Al-Quz/Al-Fara 2) Thouba	(1)Moodeyah 1) Moodeyah 2) Al-Magbabh 3) Gezt Hageh 4) Karn Achal 5) Karn Marm (2) Al-Qurath Refer to the annex-2.f	 14,500 4,500 500 1,500 100 2,900	 21,310 6,056 673 2,019 135 3,903
3	Al-Raidah/ Shamalya	All seven villages requested for the project		9,450	12,718
4	As Sadarah	All seven villages requested for the project		11,050	14,872

5.2.5 Unit Supply Rate

For the average daily per capita water supply rate in the rural water supply project, the criteria of the former PWC, which was involved in the planning for the southern area, are 40 lcd for the water supply from public stands, and 60 lcd for house connections. Yemen's request for the water supply project is based on the supply through public water stands at the project sites, but during discussions at the time of survey, Yemen requested that this project target the water supply through house connections as a background for improvement of the rural living standard in recent years. The survey for the basic design study has also confirmed that a greater part of rural communities have now switched to this method of house connections supplying.

The current situation of the water supply method in each project site and the supply rate (excluding purchased water) are as described in the following table.

Table-5.2 Present Water Supply Method and Supply Rate in the Project Sites

	Site Name	Water Supply Method	Supply Rate	Remarks
1	Ahwar	House connections	Ahwar subdistrict capital: approx. 25 lcd	The subdistrict Ahwar and its major villages have house connections. Some villages use public stands.
2	Moodeyah	House connections	Moodeyah service area:less than 10 lcd Al-Zyoar service area:less than 20 lcd Al-Qurath service area:less than 30 lcd	The majority of the villages have house connections. Only a few villages have public water stands.
3	Al-Raidah/ Shamalya	Mainly purchased water (1 public stand in one village)	Village using public water stand: 30 lcd	No pipeline network. A public stand is found near the well.
4	As Sadarah	No facilities	50 lcd	Villagers take water from hot springs.

Despite the request from the Yemeni side to upgrade the supply method to house connections, the actual service practice is utterly in bad shape because of shortage in the production from the water sources, as is the case with the sites of Ahwar and Moodeyah, and the residents have no choice but to depend on costly purchased water. While the current economic burdens on the residents are staggeringly high, their average water consumption rate remains far below 40 lcd, even though they combinedly use public service and purchased waters. This project includes the sites where the water sources are in polarized situations: Ahwar and Moodeyah deep in trouble with the water sources versus As-Sadarah having relatively abundant resources. To adapt to such diverse situations of the sites, the following policies are proposed to be applied for the supply rates and methods in the respective sites of the project.

1) Ahwar and Moodeyah

These two sites continue to use the existing system of house connections with the main distribution network replaced in the project. With the available productions of the planned water sources limited in both sites, the unit supply rates for the planned served populations in the service areas are confined as follows. (For the degraded distribution network of Ahwar which is feared to increase water leakage due to the rise in the water pressure after new facilities completed, measures to protect against such situation must be taken: the distribution main will be replaced under the project and branches shall be replaced by the Yemeni side, using materials to be provided in the project.)

1. Ahwar 50 lit/cap/day
2. Moodeyah 40 lit/cap/day

2) Al-Raidah/Shamalya

A complete water system will be constructed for the first time for this site through the project, and a supply system at the public water stands is judged relevant in order to deal with the urgent water demand at the site. However, there are signs among the residents in the site that they will try to take their own house connections from distribution mains to be installed in the project. In fact some residents have already expressed their intention to do so very soon after completion of facilities. Therefore, it is necessary to consider the future increase in consumption. Nevertheless, since water resource development is limited at this site, the unit supply rate of 50 lit/cap/day will be used.

3) As Sadarah

As is case with Al-Raidah/Shamalya, water supply facilities will be constructed for the first time in As-Sadarah as well through this project. Water will be supplied at the public stands with a unit rate of 50 lit/cap/day. Although the consumption rate at this site has already reached this level, given ample hot-spring and surface water, the major objective of this project is to supply clean drinking water, and if a shortage of water arises in the future, hot spring water, which is obtained easily within the site, can effectively be used for miscellaneous uses.

5.2.6 Planned Supply Rate

For the countrywide rural water supply of Yemen, where restricted water supplies have been continuing because of various reasons including severe water shortages, the concept of parameters such as the daily average, daily maximum and hourly maximum supply rates is hard to apply to planning. However, as house connections increasingly expand in a vast majority of rural communities, these parameters are becoming more important. In order to formulate the planning of facilities for the project, including the selection of the pipe diameters, the following criteria will be based upon:

1) Planned Daily Average Supply Rate

This rate is the planned supply rate in the project target year for each site, and is calculated as follows.

(Planned served population in the target year) x (Average daily per capita supply rate)

However, the basic daily planned supply rates for the project sites, including Ahwar and Moodeyah, depend on the available daily production rates from the planned water sources.

2) Planned Daily Maximum Supply Rate

This is generally 1.3 times the average supply rate. This value was adopted for the water supply criteria by the former PWC.

(Planned daily average supply rate x 1.3)

3) Hourly Maximum Supply Rate

This rate indicates a maximum consumption rate per hour of served population in the site, when the maximum number of taps in the villages are opened. The rate is used to determine the distribution pipe diameter. In case of Yemen, the two hours during the lunch time requires this rate. For small-scale water supply facilities standards of Japan, a flow ratio index based on the village population is used, which can also be effectively applied to this project. (An example for the calculation is presented in Appendix 4.b.)

(Daily maximum supply rate) x (Hourly maximum rate based on village population) 24 hours

5.3 Facilities Plan

5.3.1 Water Source Facilities

1) Type of Water Source Facilities

The major water source facilities in the project are planned to employ machine drilled deepwells, existing and to be newly drilled, except for one case of infiltration gallery designed to capture running waters. Table-5.3 shows the water source facilities for each site.

Table-5.3 Water Source Facilities for Project Sites

	Site Name	Conditions	Type of water source	Depth (m)	Number
1.	Ahwar	Existing	Deepwell	70 m	2
2.	Moodeyah	Existing New	Deepwell Deepwell	76 m 75 m	3
3.	Al-Raidah/ Shamalya	In use New	Deepwell Deepwell	418 m 450 m	1 1
4.	As Sadarah	New	Infiltration gallery	-	1

The characteristics of the above facilities are explained below.

1. Existing Water Sources

The existing deepwells currently not in use are planned to undergo pumping tests to examine their characteristics in detail under the project.

2. New Water Sources

i. Deepwell

The following are the characteristics of the deepwell structure.

a. The new wells are either of gravel-packed structure or non gravel-packed, depending on the characteristics of the formation planned to penetrate. The well for the site of Moodeyah is of the former type, where the aquifer is an unconsolidated formation of alluvium/diluvium or a soft rock, which needs to be provided with gravel pack around well screens to prevent the inflow of sand. On the other hand, the latter type is drilled through hard rock and gravel is not needed to be packed as is the case with Al-Raidah/Shamalya).

b. A type of wire-wound continuous slot-type screens having a large unit yield capacity, rather than a gas-welded slit screen, is recommended for the deepwells. The screen length is 30 m/well at maximum.

ii. Infiltration Gallery

A water source facility is planned in As-Sadarah which will collect running water from the upper stream of the Wadi Hagar. The facility is built of reinforced concrete, and consists of an intake section with filtering materials and wire-wound continuous slot-type screens and a water transmission/storage section. The facility is also equipped with water overflow structure in case of river flooding. The basic design drawings for the above facilities are presented in the Annex-5.

5.3.2 Pumping Facilities

This section discusses pumps and related auxiliary equipment for the water source facilities.

(1) Selection of Pumping Equipment

The two types of pumps most frequently used in Yemen are the diesel engine-driven borehole vertical pumps and the diesel generator-driven submersible motor pumps. The following is a comparison of the characteristics of both pumps.

Table-5.4 Type of Well Pumps

	Submersible motor pump	Borehole pump
Structure	One assembly of a pump and a motor, both installed in the well, driven by a power source (generator) on the ground surface through an electric cable.	A pump installed in the well and a drive unit on the ground surface, connected with a string of shafts for power transmission.
Power source	Electric power (generator)	Mechanical power transmission with an engine or electricity.
Capacity and Performance	High-speed rotation and high -pressure types are available	Due to the structure of the vertical axis, high-speed rotation is impossible, and a high head is difficult.
	Overloading may be caused through intrusion of sand or other foreign material, resulting in burning of motor.	Due to its mechanical structure, relatively durable against foreign materials.

Engine-driven borehole pumps have widely been used in Yemen due to part the power supply conditions, part ease of operation and maintenance. Except for the areas that require large total heads, engine-driven borehole pumps are generally recommended. This type are usually used at deepwell stations with a pump head less than 150 m. However, at the sites where a power station is located nearby and the use of three-phase alternating current is expected in the future (Moodeyah and Ahwar), the generator-driven submersible pump had better be used. In Al-Raidah/Shamalya where the static water level is deeper than 300 m, there is no choice but for a submersible motor pump.

(2) Control of Deepwell Pumping Equipment

A minimum control system is adequate for the project, viewing the current conventional practice of operation and maintenance in the country's rural water projects likely to have trouble in case of malfunctioning in a complex control system. One of the simple controls to be provided in the project is an automatic shutoff of pump running at a low water level in the deepwell to prevent an abrupt drop of water levels due to excessive pumping, which may result in motor burnout, pump failure and in the worst case eventual drying up of the deepwell itself. Nevertheless an automatic re-starting system triggered by a water level recovery is not necessary, since it is likely to make the control more complex. Even though a low level automatic stop is to be provided, regular water level measurements must be performed as a basic maintenance measure by the operators.

(3) Deepwell Pump Stations

The pump station for housing a deepwell pump and the well itself needs a special measure different from that for a booster pump. In case any trouble happens to the well or pump, a crane truck or sometimes a drilling machine is called for operation at the base of the well. Therefore to seclude the well entirely in a pump house is not advisable. In many local pump houses often seen in Yemen, the well is left in the open outside the shed which houses only an engine for driving a pump, as shown below.

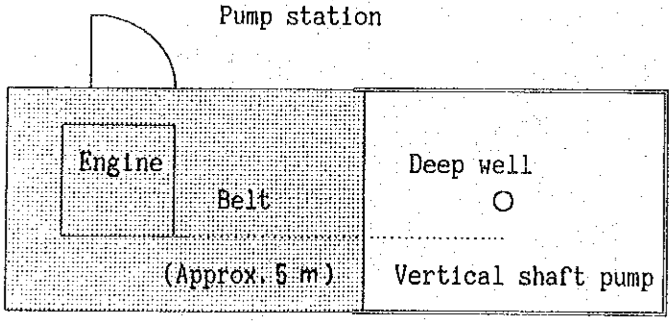


Figure-5.1 Local Pump Station Structure

Leaving the facility of a well in the open is not a wise way in terms of facilities protection and contamination prevention. Therefore, a design for the project is planned to provide a detachable structure of housing for the well, made of keystone steel plate fastened with bolts to the walls and floor of the pump station so that it can be removed when an operation is necessary at the base of the well. (Refer to the attached basic drawings.)

5.3.3 Booster Pump Facilities

(1) Types of Booster Pumps

In contrast to vertical pumps for deepwells, booster pumps are horizontal pumps directly coupled to drive units. In this project, booster facilities are planned for (1) Ahwar and Moodeyah, where a multiple number of water source wells are simultaneously operated to transmit water to the distribution tank, and the service rate must be adjusted; (2) As-Sadarah, where the distribution pipeline from the well to the final tank runs long over the rugged terrain; and (3) Al-Raidah/Shamalya, where the pipeline from the distribution tank to the villages runs on a nearly flat level for so long that distribution by gravity is impossible.

Two power sources to drive the booster pump are available: engine or diesel generator. The engine direct coupling drive is simple and economical, but electrical power is necessary when using the control system for booster pump protection. Therefore, the pump will basically be of an electric motor direct coupling-type and operated by a generator.

(2) Controls for Booster Pumps

Controlling of booster pump operation is based upon a similar principle to the one for the well pump, as follows:

1. Reservoir Low Water Level Control
   A booster pump shall be installed with a control panel including a system to automatically stop its running when the water level of the reservoir has dropped to its low.

However, the automatic recovery of operation is not considered to be necessary.

2. Reservoir High Water Level Alarm

The open structure of water tanks in Yemen allows excess water to discharge through overflow pipes and the pump continues to deliver water even after the tank is full. A control system which automatically stops the pumping when the tank is full is not used for rural water supply. The operators learn from experience to stop the pump after a certain period when the water tank becomes full. Operators keep watching pump running not to waste precious water.

As one of the improvement measures for this type of operation, a simple control equipment is used which indicates to the operators when the tank is full. When pressure changes are detected in the pipes, an alarm will go off. This system uses the phenomenon of dynamic water pressure rises in the service pipes when the destination water tank becomes full and overflows.

(3) Booster Pump Station

The main structure and finish of the booster pump station is the same as those of the well station except a well shed attached to the latter. In part of the sites, the booster pump is designed to be installed in the well station housing a generator for driving it and a deepwell pump simultaneously. Therefore, the pump station is slightly bigger as an engine coupling water service pump is installed for the latter.

5.3.4 Water Tanks

(1) Function of Water Tanks

The following types of water tanks are included in this project.

i. Booster Tanks

a. Where a distance of water transportation is quite long and the terrain is rugged, and a planned supply rate cannot be transmitted by gravity flow, water is delivered via a booster station consisting of a booster pump and a reservoir. The two sites of Al-

Raidah/Shamalya and As-Sadarah require this type of facilities in this project.

b. Where water is transported through one pipeline to a remote water tank by pumping water simultaneously from multiple wells, flows from the wells had better be collected at a first-stage reservoir near the water sources and then transported through a pumping main to the tank by a booster pump, in order to transmit a stable quantity of planned supply rate. This system applies to the sites of Ahwar and Moodeyah.

2. Distribution Tanks

The distribution tanks act as reservoirs for water distribution to the villages. Since water is distributed by gravity, the tanks are to be constructed at appropriately high locations in the site. Elevated water tanks are planned for Ahwar which is located on flat land.

(2) Structure of Tanks

The standard water tank structure for rural water projects in southern Yemen is a masonry tank, featuring side walls built of stone material. Its upper and lower slabs are normal reinforced concrete structure, but stones fixed with mortar line the inside and outside of the four side walls to reinforce the tank strength. The side walls of this tank are so thick that they have an effect to reduce the influence of the outside temperature on the stored water. This is a relevant structure for the country's southern area where intense heat lasts for long periods of time. The stone tank also blends with the surrounding environment. As this water tank was the standard specification of the former PWC, it has widely been used in various locations in South Yemen. Their capacities range from 10,000 gal (approximately 50 m^3) to 60,000 gal (approximately 300 m^3), increasing in units of 10,000 gal. Their standard specifications and drawings are available. When the capacity becomes extremely large, it is difficult for the tank to have sufficient strength in its stone wall, and normal reinforced concrete or panel tanks are used. (the 750 m^3 existing tank in Al-Raidah/Shamalya is concrete-made, and the water tanks in the Crater Area of Aden are ground panel tanks.)

The British-made prefabricated steel plate panel tanks have been employed as elevated water tanks. This tank was used in the previous Japanese project, for both elevated and ground tanks. The water tank of this type installed for the first time in North Yemen under the loan project is more than 10 years old, and the tank is still in use without any problems. Corrosion resistant and rust resistant coatings applied on the surface of panels provide strong protection even under the tropical coastal climate such as in the Tihama lower pressure zone in North Yemen.

As a result of an examination of the actual situation related to water tank facilities in South Yemen, and an evaluation of the Japanese results, the following water tank structure is appropriate for this project

1. Ground water tank: Masonry tanks
2. Elevated water tank: Steel panel tanks

Although the water tank level indicator is generally not equipped with the masonry tanks in Yemen, an appropriate indicating instrument is equipped for this project.

(3) Tank Volume

1. Booster Tanks

Since the booster tank acts as an intermediate reservoir to on the way of water transportation, its volume is based on the retention period of the booster pump discharge rate, where the retention period of 60 minutes is used. The booster tank uses a type of masonry tank with the volumes for each site as follows.

a. Ahwar 100 m^3
b. Moodeyah 100 m^3
c. As-Sadarah 50 m^3

2. Distribution Tanks

The distribution tank volume is based upon the house connection method, where the required water storage volume based upon an analysis of the service rate from the water source and the water consumption rate represents the basic volume.

Although the water consumption in each project area varies, the typical water consumption pattern in Yemen is presented based on the results of the field survey, which is shown in the Appendix-4.a. As this annex shows, the basic water storage volume can be calculated through a graph analysis of the service rate cumulative curve and the cumulative consumption curve based on the daily water consumption distribution. The following table shows the water tank volumes for each project site based on the result of the graph analysis.

Table-5.5 List of Water Tanks in the Project Site

	Site Name	Conditions	Type	Capacity
1	Ahwar	New	Elevated tank of steel panels	250 m^3
2	Moodeyah	New	Ground tank, masonry	300 m^3
3	Al-Raidah/ Shamalya	Existing New New	Ground reinforced concrete Ground tank, masonry Ground tank, masonry	750 m^3 100 m^3 150 m^3
4	As Sadarah	New	Ground tank, masonry	300 m^3

5.3.5 Pipelines

(1) Classification of Pipelines

Pipelines for the water supply facilities are classified depending on their functions. All of the pipelines to convey water by pressure directly to the distribution tank from the water source or via a booster station are called "pumping main" pipelines. The pipelines installed for supply to the villages from the water tank are classified as "distribution" pipelines and "service" pipelines. Furthermore, the distribution lines can be divided into the "distribution mains" (distribution lines without service or house connections) and the "distribution branch" lines (distribution lines with house connections). However, the pipelines in the rural villages are different from those in the cities, where the pipe mains and branch lines cannot be clearly distinguished. The basic principle for distribution lines of this project is to install all the major distribution lines under the project except for service lines. However, pipelines connecting distribution lines with public water stands, which are grouped as service lines, are included in the project.

(2) Pipe Materials

The types of pipe materials used in Yemen for water supply are as follows.

1. Ductile cast-iron pipes (only for water supply in large cities, such as the capital, Sana'a)
2. Galvanized steel pipes for water supply (covering over 90% of existing pipelines in the country)
3. Asbestos cement pipes for water supply (not in use in the North, but still common in the South. Strength is low compared with other pipes.)

Among the above types of pipes, the majority used throughout the nation are galvanized steel pipes. Although inexpensive, vinyl pipes are not in use since most of the land is made up of hardrock outcroppings where most of lines must be laid exposed. Exposed vinyl pipes are vulnerable to extreme temperature changes.

Only galvanized steel pipes have so far been used in the Japanese projects in North Yemen. Further in the North, which is dominated by mountains and rugged terrain, high-pressure pipes with thick walls (conforming to JIS G-3443) are frequently required for pumping mains.

Strong and flexible pipes must be used for this project. As a result of the examination of the water transportation and distribution plan, the following pipes can be selected.

1) Ductile cast-iron pipes

In this project, the pumping and distribution lines with a diameters of 200 mm must be used in the two sites of Ahwar and Moodeyah. Part of 200 mm line in Moodeyah needs to be laid exposed in a rugged mountainous area, and such working condition requires a firmly welded and supported line of 200 mm galvanized steel pipe on the rock bed. Major part of 200 mm lines to be used both in Ahwar and Moodeyah are ductile cast iron pipe of Type-T with slip-on joint, which is excellent in workability. These lines are designed to be buried in the field along the roads. Although the cast iron pipe has rarely been used in the rural water projects in Yemen, the project plans to employ this type of pipe because of difficulty in locally recruiting a lot of welding technicians for completing long welded lines of 200 mm steel pipes.

2) Galvanized steel pipe for water supply

For the pipelines with diameters less than 200 mm, threaded galvanized steel pipe is used, as has been the case with the foregoing projects. For the steel pipelines, a flange or union coupling is designed to be installed every 10 sections of pipe (5.5 m/pc), which is the standard construction method in Yemen. Whenever local maintenance, inspection or repair is necessary, this measure enables the easy removal of pipe sections. The diameters of pipes range from 25 mm to 150 mm. This project does not need high-pressure pipe except for some extension of pump connections in As-Sadarah since the pump discharge pressure at the booster pump stations there exceeds well over 100 m.

3) Pipe Sizes

Pumping main, distribution and service lines in this project require pipe sizes ranging from 25 mm to 250 mm. For the calculation of sizes, the following formulas have been employed, based upon the unit quantity of flow through the pipe:

Pipe diameter 50 mm or less : Empirical formula of Tokyo Metropolitan Water Works
65 mm or more : Hazen-Williams formula

The calculation also must take the velocity of flow at a given quantity into account. A higher velocity can make a pipe size smaller, but results in a larger capacity of a power unit for a pump due to the increase of pressure head. Experience has determined an "economic velocity" which can balances the relations of a pipeline to equipment in terms of the cost including both their construction as well as operation and maintenance. According to this standard, the economic velocity for the pipe sizes up to 150 mm used for this project is recommended to be 0.7 to 1.0 m/sec.

This project has further taken the following factors into consideration.

1. Pumping main
   A smaller velocity is effective for protecting pipelines against water hammering. In this view, the lower range of economic velocity has been reduced to 0.5 m/sec to overcome the complicated changes in mountainous slopes through which pumping main is installed.

2. Distribution Lines
   The service pressure at each village has to be considered when determining distribution pipe size. In this project, the standards of the former PWC are also referred to and consideration is made to ensure a terminal service pressure of 10 m or greater.

(4) Other Plumbing Materials

Various plumbing devices including valves are necessary along the pumping main and distribution pipelines, as follows:

1. Air vent valves : to be installed at the highest points of

prominently elevated sections along the course of pipeline
2. Drain valves : to be installed at depressed sections along the pipeline courses where such arrangements are considered necessary, using gate valves

(5) Measures to Protect Pipelines against Damages

1. Expansion and Contraction of Pipelines

Pipelines in the country's mountainous regions are mostly exposed on rocky ground surface. Directly affected by the typical highlands climate intensely differing in temperature during day and night, in some cases reaching 20 C, the exposed lines follow a cycle of expansion and contraction. In an extreme case, this movement results in breakages in pipe connections. A rough estimate of such expansion and contraction range is about 1 cm for every 100 m of pipeline.

To absorb this expansion, several types of special fittings are effective, but most of them have difficulties in the installation on long pipelines over the rugged terrains. In particular, the fittings for high-pressure service are limited and costly, and their use in quantities is not considered practical. Local pipelines have no such fittings, but manage to avoid possible damage through an arrangement of pipes during installation. The pipelines do not run straight, having many bends, artificial or natural due to the weight of a pipeline, which function to absorb the expansion; lots of elbow-to-elbow connections along steep slopes are another arrangement for evading contortion. Pipelines in previous Japanese projects successfully employed such arrangements, and this experience will be utilized for the pipeline design for exposed pipes.

2. Water Hammering

The transmission lines in this project involve a high risk of causing water hammering due to their long distances over intensively varying rugged terrains of the sites. Water hammering may result in damages to pipelines and pumps. To safeguard against such accidents, the following measures are judged to exert practical effects.

a. Check valves for pumps shall be of slow-closing type.
b. Transmission lines shall be of large diameters and their velocities kept to a minimum.

These measures have already been taken in the previous projects, and water hammering countermeasures using special auxiliary devices have been taken for the areas where topographical changes are intense. Although the respective countermeasures involve cost increase, they are judged to be indispensable, and necessary measures will be taken mainly using the above two items after sufficient examination.

5.3.6 Service Facilities

In order to increase the effectiveness of the facilities, public water stands will be installed in proper locations within the villages of each site of Al-Raidah/Shamalya and As-Sadarah, where new distribution networks will be installed. House connections in a portion of the villages will be made in the future, but some residential groups are predicted to continue the effective use of public stands. This ratio cannot be determined because of regional differences. According to the former PWC planning standards, the maximum ratio for house connections is 70% in the rural villages.

Three types of public water stands, in accordance with the number of taps, will be used for this project. (Refer to the attached basic design drawing for details.)

In regard to the taps to be installed on these stands, since the water tank will be installed at an elevated location, part of the villages near the tank tends to have high-pressure water supply. An ordinary type of 5 kg/m^3 tap, therefore, is weak, and a ball valve pressure-tight water tap which has been used in the foregoing projects will be used.

5.4 Details of Planning for the Project Sites

5.4.1 Ahwar

Category	Facilities	Status	Specifications	Q'ty
Water Source	Deepwell	Existing	70.3m	1 No.
	Deepwell	Existing	70.0m	1 No.
Intake Facilities	Deepwell Pump	New	Submersible motor pump 600 l/m x 70 m x 11kw	1 No.
	Drive Unit	New	Diesel generator 37KVA, 400V	1 No.
	Deepwell Pump Station	New	Reinforced concrete construction with concrete block wall	2 No.
	Deepwell Pump	New	Submersible motor pump 600 l/m x 115 m x 18.5kw	1 No.
	Drive Unit	New	Diesel generator 37KVA, 400V	1 No.
Transmission Facilities	Booster Tank	New	100m^3 ground type	1 No.
	Booster Pump	New	Horizontal type volute pump 1,200 l/m x 77 m x 37kw	2 No.
	Drive Unit	New	Diesel generator 70KVA, 400V	Combine
	Booster Pump Station	New	Reinforced concrete construction with concrete block wall	Combine
	Pumping Main	New	W-1 to Booster Tank: GSP 100A W-2 to Booster Tank: GAP 100A Booster Tank to Distr. Tank: DIP 200A GSP 150A	620m 2,180m 1,614m 2,500m
Distribution Facilities	Distribution Tank	New	250m^3 elevated panel tank	1 No.
	Distribution Line	New	GSP 150 A GSP 100 A GSP 80 A	2,530m 545m 2,060m

5.4.2 Moodeyah

Category	Facilities	Status	Specification	Q'ty
Water Source	Deepwell	Existing	76 m	1 No.
		Existing	76 m	1 No.
		Existing	76.21 m	1 No.
		New	75 m	1 No.
Intake Facilities	Deepwell Pump	New	Submersible motor pump 340 l/m x 100 m x 11kw	4 No.
	Drive Unit	New	Diesel generator 37KVA, 400V	3 No.
		New	Diesel generator 130KVA, 400V	1 No.
	Deep Well Pump Station	New	Reinforced concrete construction with concrete block wall	3 No.
Transmission Facilities	Booster Tank	New	100 m^3 ground type	1 No.
	Booster Pump	New	Horizontal type volute pump 1.200 l/m x 77 m x 37kw	1 No.
	Booster Pump Station	New	Reinforced concrete construction with concrete block wall	1 No.
	Pumping Main	New	W-1 to Booster Tank: GSP 80A W-2 to Booster Tank: GSP 80A W-3 to Booster Tank: GSP 100A W-4 to Booster Tank: GSP 100A Booster Tank to Distribution Tank: GSP 200A	60m 140m 820m 1,340m 1,245m
Distribution Facilities	Distribution Tank	New	300m^3 ground type	1 No.
	Distribution Line	New	DIP 200 A GSP 200 A GSP 65 A	10,500m 615m 820m

5.4.3 Al-Raidah/Shamalya

Category	Facilities	Status	Specification	Q'ty
Water Source	Deepwell	Existing	8" x 418 m	1 No.
	Deepwell	New	8" x 450 m	1 No.
Intake Facilities	Deepwell Pump	Existing	Submersible motor pump 400 l/m x 327 m x 18.5kw	1 No.
	Deepwell Pump	New	Submersible motor pump 300 l/m x 360 m x 37kw	1 No.
	Drive Unit	New	Diesel generator 130KVA, 400V	1 No. (Combine)
	Deepwell Pump Station	New	Reinforced concrete construction with concrete block wall	1 No. (Combine)
Transmission Facilities	Booster Pump	New	Diesel driven horizontal type 300 l/m x 40 m x 25ps	1 No.
		New	Diesel driven horizontal type 450 l/min x 100m x 25ps	1 No.
		New	Horizontal type volute pump 300 l/m x 120 m x 11KW	1 No.
	Booster Pump Station	New	Reinforced concrete construction with concrete block wall	2 Nos.
	Booster Tank	Existing	$15m^3$ ground type	1 No.
		New	$50m^3$ ground type	1 No.
	Pumping Main	New	GSP 80 A GSP 100 A GSP 150 A	1,630m 6,320m 2,190m
Distribution Facilities	Distribution Tank	Existing	$750m^3$ ground type	1 No.
		New	$100m^3$ ground type	1 No.
		New	$150m^3$ ground type	1 No.
	Distribution Line	New	GSP 50 A GSP 80 A GSP 100 A GSP 150 A	1,490m 6,010m 3,550m 650m
Service Facilities	Public Fountain	New	2-Tap 4-Tap 6-Tap	1 No. 4 Nos. 7 Nos.

5.4.4 As Sadarah

Category	Facilities	Status	Specification	Q'ty
Water Source	Surface Water	New	Infiltration gallery	1 No.
Intake Facilities	Intake Pump	New	Diesel driven horizontal volute pump 1,000 l/m x 20 m x 25ps	2 Nos.
	Intake Pump Station	New	Reinforced concrete construction with concrete block wall	1 No.
Transmission	Facilities			
	Pumping Main	New	Intake pump station to Booster Station No. 1: GSP 150A	590m
System 1	Booster Pump	New	Horizontal type volute pump 1,000 l/m x 120 m x 37kw	2 Nos.
	Drive Unit	New	Diesel generator 100KVA, 100V	1 No.
	Booster Pump Station	New	Reinforced concrete construction with concrete block wall	1 No.
	Pumping Main	New	Booster Station No.1 to Booster Station No. 2: GSP 150 A	3,090m
	No.1 Booster Tank	New	$50m^3$ ground type	1 No.
System 2	Booster Pump	New	Horizontal type volute pump 1,000 l/m x 130 m x 37 kw	2 Nos.
	Drive Unit	New	Diesel generator 100KVA, 400V	1 No.
	Booster Pump Station	New	Reinforced concrete construction with concrete block wall	1 No.
	Pumping Main	New	Booster Station No. 2 to Distribution Tank: GSP 150 A	3,447m
	No.2 Booster Tank	New	$50m^3$ ground type	1 No.
	Distribution Tank	New	$300m^3$ ground type	1 No.
	Distribution Line	New	GSP 50 A GSP 80 A GSP 100 A GSP 125 A GSP 150 A	3,074m 1,440m 2,490m 1,029m 3,626m
Service Facilities	Public Fountain	New	6-Tap 4-Tap	9 Nos. 4 Nos.

5.5 Implementation Plan

5.5.1 Structure for Implementation

This project is aimed at constructing water supply facilities suitable to the characteristics of each of the four project sites in two southern and eastern governorates in Yemen under Japan's grant aid system. In establishing the implementation plan for the project, the formulation of the most relevant setup and period for construction are of vital importance. Although the local market for the construction of water supply facilities remains yet to reach an appreciable level, the involvement of local enterprises and labor force is highly encouraged to support smooth progress of works under harsh natural and social environments.

The executing agency is the GAREW under the MEW, which has been playing the role of the executing agency in the previous and ongoing Japanese rural water supply projects. The chairman of the GAREW is to supervise overall administration of the project as general manager, and the bilateral department engages in direct handling of the project implementation through activities of full-time counterparts of two or three selected from this office as well as cooperative engineering staff assigned in specialty divisions for supporting the progress of the project.

Under such supervising and supporting setup of the executing agency, a Japanese consulting firm is employed mainly for making the detailed design of the project, assisting in the execution of the tender and supervising the construction work.

The construction work is carried out by a Japanese company which has been awarded a contract through the tender. The contractor is held responsible for constructing the water supply facilities in strict compliance with the requirements of the specifications and drawings under the administration of the GAREW and the supervision by the consultant. The headquarter office of the contractor is installed in the capital of Sana'a, where the GAREW's main office is located, with its staff headed by a project manager engaging in controlling the quality and progress of work under the contract. On the other hand, the site managers are assigned to head the construction teams in the respective sites where the work progresses. They are responsible for smooth progress of work in the respective sites in coordination with the project manager at the head office.

The construction of water supply facilities under this project involves drilling work, civil work, plumbing and mechanical work. In view of a technical level in this country, it is considered to be critically important that the contractor should establish an organization of its engineering staff in various fields of specialties to control the quality and progress of the work so that it could accomplish the work satisfactorily within the designated period under Japan's grant aid system. For a part of the construction works, for example, stone tanks which are widely used in South Yemen, active participation of local specialists is required, but the quality and schedule control of local specialists will also come under the control system of the Japanese engineers.

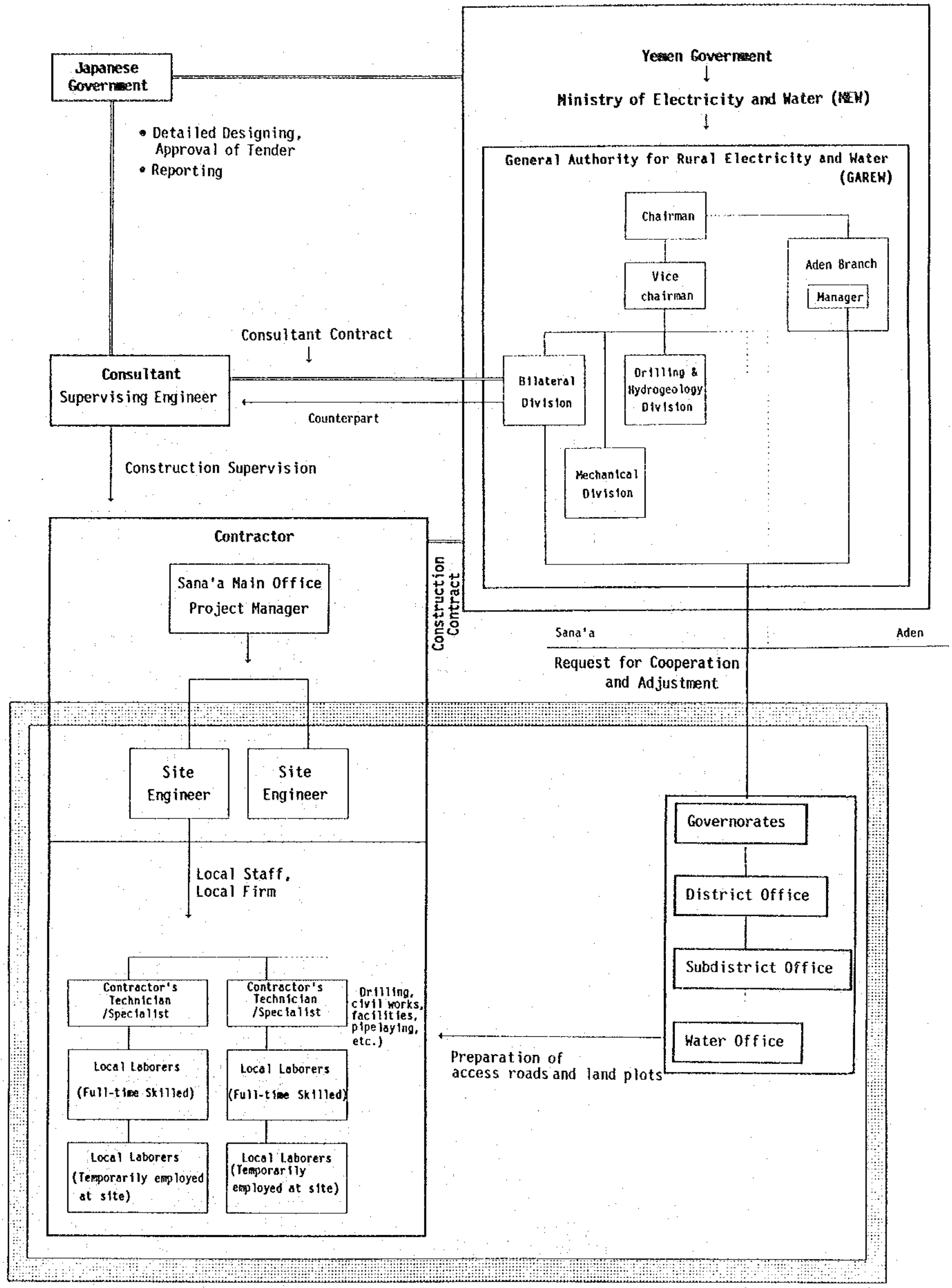
The water offices of the local governments are in charge of performing coordination between the contractor and the communities at the sites in order to ensure smooth execution of the project. These offices operate with the district director as general manager. This organization will be in charge of the facilities operation after being entrusted with the facilities and equipment from the GAREW after facilities completion. As the agency which possesses direct relations and interest in the progress of execution, the offices will carry out, under the direction of the GAREW, the preparation of access, repair roads and secure land necessary for the work, developing a network of cooperation for the implementation of the project with the communities. Figure-5.2 shows a diagram of the implementation system.

5.5.2 Construction Supervision Plan

The detailed design and construction supervision will be conducted by the Japanese consultant, on the basis of Japan's grant aid system. The details are as follows.

(1) Pre-construction Stage
- Detailed design
- Preparation of tender documents
- Administration of tender process
- Evaluation of tender results
- Assistance to the contractor

Fig.5.2 Implementation System



(2) Construction Stage — Construction supervision
Inspection and technology transfer
Preparation of reports

The detailed design is carried out by the consultant to establish the detailed plan for the facilities and equipment, based upon the field survey in the sites involved in the project. During the field survey, special attention is paid to clarify the situation of land to be used for the construction work, particularly concerning the courses of pipelines, with the cooperation and coordination of the GAREW and the water offices so that no questions would be raised among villagers during the actual work. The results of the detailed design are reflected in the subsequent preparation of tender documents, and the schedule of the tender is decided with the consent of concerned offices and agencies of the government of Japan. The consultant administers and controls the process of tendering for and on behalf of the executing agency, evaluates its results and assists the executing agency in concluding the contract with an eligible Japanese firm.

As a first step during the construction stage, the consultant's staff carries out the transfer of the project sites to the construction firm, and as the work proceeds, they engage in supervising it with the cooperation and coordination of the concerned offices and agencies as well as the executing agency on the Yemeni side. When the construction of the facilities is completed, they conduct the inspection and direct technological transfer on the operation and maintenance. Upon completion and delivery of facilities, the final completion report is prepared by the consultant.

5.5.3 Procurement Plan

(1) Local Procurement

Oil production in Yemen started during the late 1980s, and continuous efforts for exploration has actively been conducted by foreign joint ventures mainly in the southern governorates, especially in Hadramout and Shabwa. As industrial products, cement production facilities continue to be improved, and cement can be obtained easily. As a result of the survey of the local market, the following materials are recommended to be procured in this country for the execution of the project.

1. Cement

The supply of cement is stable with plants operating at Basil, completed with assistance by the former Soviet Union (annual production 250,000 tons); at Amran, completed by a Japanese company (annual production 500,000 tons); and at Mafraq, completed in 1993 by a Japanese loan project.

2. Concrete Blocks

Small house industries are located throughout Yemen, and concrete blocks can easily be obtained.

3. Aggregate and Water

Aggregate in general is of degraded quality, with coarse aggregate made of crushed basaltic rock and fine one containing much silt. However, a steady supply, relatively good in quality, is found in the suburbs of the capital, and procurement mainly in this area is planned for the project. The water used for the work can be obtained in and around the sites.

4. Fuel

Although prices have been raised, the production and supply of petroleum and diesel oil have been stable, and are expected to hardly raise problems for the operation of construction vehicles and equipment.

5. Borehole Pumps

The great majority of deep well pumps in this country are shared by diesel engine driven vertical shaft pumps, imported from European countries such as Italy, Denmark, and Cyprus. Since the procurement of their spare parts are much easier and local conditions for maintenance are better than with submersible motor pumps, this type of pumps are planned to be purchased locally for use in the facilities where high-lifting capacities are not required. Diesel engines for the pumps are to be procured, based upon the recommendation of the pump manufacturer.

(2) Procurement in Japan

Most of equipment and materials for the construction of water supply facilities are imported ones in Yemen, and their procurement has long been in difficult conditions due to severe import restrictions by the government, deriving from shortages of foreign reserves. To make the matter worse, progressive inflation since the outbreak of the Gulf war has sent market prices of all imported products skyrocketing. Under the present circumstances, therefore, main equipment and materials are planned to be procured in Japan, since they are stable both in quality and prices. These products are listed as follows:

1. Materials for water well construction
   Well casing and well screen

2. Pumps
   Submersible motor pumps for deep wells and multi-stage volute pumps for booster pumps

3. Power drive units
   Diesel engine driven generator

4. Water tank materials
   Steel panel for elevated tanks, steel frames

5. Plumbing materials
Steel pipe, fittings and valves

(3) Construction Equipment and Vehicles

The project sites are dispersed countrywide, with the construction work planned to proceed simultaneously in two separate sites. Under such a situation, the headquarters for construction work is planned to be stationed in capital of Sana'a where the main office of the executing agency is located for the purpose of developing the most effective and efficient controlling of the work. For the headquarters' management and control of the quality and progress of work, cargo trucks for transportation of equipment/materials and 4-wheel drive vehicles, etc. are required as well as for the execution of work developed in vast areas of the sites. In addition, one unit of crane truck is necessary for handling heavy equipment/materials. Local acquisition of such construction equipment/vehicles is not easy either through procurement or through lease. In this view, they are proposed to be procured in Japan.

The trucks and small four-wheel drive cars suitable for severe road conditions are mostly of Japanese made. Vehicles from other countries are not often seen, and therefore, Japanese vehicles are convenient in terms of maintenance and operation. Bringing vehicles from Japan is both easy and economical.

There are no rentals and leases for construction machinery. Hourly rentals are rarely seen in the cities, and maintenance is not good. From the experience of the previous projects, procuring construction machinery in Yemen is extremely difficult. As the construction machinery will be fully operated over a long period of time in this project, procuring them in Japan is considered best.

(4) Temporary Facilities

For temporary facilities such as offices and lodgings quarters, etc., both in Sana'a and in the sites, a similar difficult situation is prevalent. These facilities are planned to be procured in Japan as well.

5.5.4 Implementation Schedule

The implementation schedule for this grant aid project is as follows.

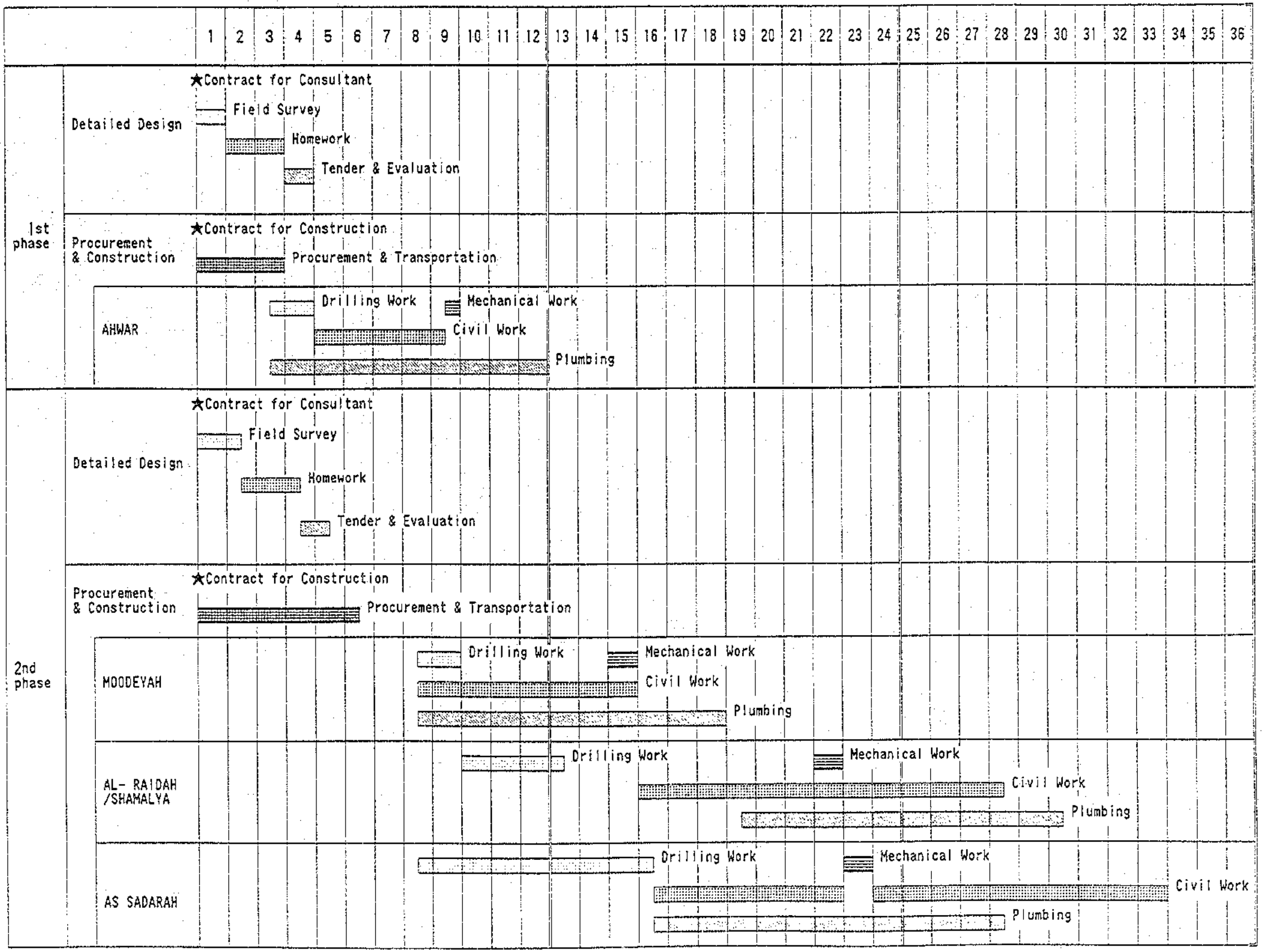
Exchange of notes between governments
Consulting contract
Detailed design and preparation of tender documents
Tendering and conclusion of the construction contract
Procurement of equipment and materials
Shipping of procured equipment and materials, and their customs clearance
Field construction work
Delivery of completed facilities

The construction at each project site consists of various work, including drilling. Construction will be completed approximately 10.5 to 12 months after concluding the construction contract. The best plan is to divide the overall construction term into two phases, considering the distribution of construction costs and based on the priority order of the work. The implementation schedule is as follows.

1. Phase I Ahwar
2. Phase II Moodeyah, Al-Raidah/Shamalya, and As-Sadarah

Table-5.6 shows the comprehensive construction schedule divided into 2 phases.

Table 5.6 IMPLEMENTATION SCHEDULE



5.5.5 Scope of Responsibilities

The responsibilities of both the Yemeni and Japanese sides for the implementation of the project are as follows:

(1) Responsibilities of the Yemeni Side

1) To acquire, clear and level the land necessary for the construction of water supply facilities, such as water sources, machine rooms, water tanks, pipes, water service facilities, temporary offices, accommodations for construction workers, and store yards at the project sites.

2) To provide and maintain access to each water supply facility construction site as well as to repair and expand the roads necessary for construction in the project sites.

3) To install pipelines in three of the four project sites using the plumbing materials to be supplied under the project.

4) To construct other facilities outside the scope of this project included in this basic design plan.

(2) Responsibilities of the Japanese Side

1) To construct the following water supply facilities in the four sites where this basic design plan will be implemented.

1) Water sources
2) Water intake facilities (including deepwell pump stations)
3) Transmission facilities (including booster pump stations)
4) Distribution facilities (including water tanks), and
5) Service facilities such as public water stands

The project sites are as follows:
1. Ahwar (Abyan governorate)
2. Moodeyah (Abyan governorate)
3. Al-Raidah/Shamalya (Hadramout governorate)
4. As-Sadarah (Hadramout governorate)

2) To bear the cost of all equipment and materials, temporary facilities, construction equipment and vehicles necessary for accomplishing the work other than those to be borne by the Yemeni side.

3) To supply plumbing materials to three project sites among four to extend distribution pipes after completion of the pipeline construction by the Japanese side, as planned in this basic design.

4) Construction supervision for this project

(3) Cost Estimate for Expenses to Be Borne by the Yemeni Side
(Unit: One Thousand Yemen Riyal)

1)	Land acquisition, cleaning & grading:	YR 300
2)	Access preparation & maintenance:	YR 175
3)	Installation work of distribution branch lines:	YR 5,005
4)	Pumping test for Ahwar and Moodeyah	YR 550
5)	Personnel Dispatch Cost	YR 1,520
	Total Cost Estimate:	YR 7,550

CHAPTER VI

PROJECT EVALUATION AND CONCLUSION

CHAPTER VI PROJECT EVALUATION AND CONCLUSION

6.1 Project Evaluation

This project is aimed at constructing water supply facilities at four (4) sites ranking higher in the priority among the candidate sites in need of water supply facilities, for a present population of 57,200 with a target of a planned served population of 80,000 in total. It has an effect to support the GAREW's ongoing efforts to promote the national rural water supply scheme.

These facilities are to be managed by the water offices under the local governments controlling the respective sites. Their components, types and structures have been designed with care so as to be operated and maintained by the water offices with little difficulty, based upon their expertise and experiences, and the water services as well as management are expected to be dramatically improved through the operation of these facilities, resulting in the enhancement of environmental health and sanitation. Moreover, it will play a role to stabilize and upgrade the rural life, contributing to one of the top-priority policies of the government to improve rural infrastructure.

Various effects anticipated from the Project implementation are compared with the present conditions as follows:

Table-6.1 Effects of the Project/Extent of Improvement

Current Situation/ Difficulties	Measures Taken by the Project	Anticipated Effects/ Improvement Range
1. **Ahwar** 1) The Ahwar water service has been put in a bad shape due to its decreased supply, degraded quality (highly saline) and low service pressure. One third of the town's population is complaining of lack of water, and has been forced to buy costly water.	1) The project can employ two existing deepwells located on the left bank of the Wadi Awhar about 5 km north of the town, which meet the purpose of the project in quantity and quality. The town's dilapidated elevated tank and distributed mains are to be replaced with new facilities, which will increase service pressure and decrease leakage.	1) The current supply rate is estimated to be less than 20 lcd, whereas a rate of 50 lcd will become possible through the implementation of the project. Improved service will result in enhancement of welfare and health of the citizens. Water purchase will cease, relieving citizen's heavy economic burden.
2) The Ahwar water office is autonomously run, based on revenue from water service. But due to degenerated service, raising water rates is not possible, and the office's finance has been paralyzed.	2) The citizens have a willingness to pay, if the service is improved. A new rate of YR 105/household/ month is to be adopted to restore finance of autonomous management of the office. Its service area is divided into several blocks of communities, each with a flow meter to measure a flow rate for collecting water bills in a reasonably fair way, and to minimize leakage in network.	2) Revised water rates and improved method of water billing will increase revenue of the water office, which makes it possible to improve the service including repairs of lines. New facilities will give a chance of enlightening citizens' recognition of water service, creating opportunities of citizens' positive contribution.

Current Situation/ Difficulties	Measures Taken by the Project	Anticipated Effects/ Improvement Range
2. Moodeyah 1) The site covering the Moodeyah district capital and surrounding villages are divided into 4 large service zones, each having problems in quantity and quality. Particularly in the Moodeyah service zone, the daily per capita supply rate is estimated at less than 10 lcd, leaving the citizens to depend most of their water on costly water vending. In the Al-Qurath Service Zone the height of tank location is not enough, leaving 1/3 of population without water.	1) The existing three wells in the Al-Qurath basin 10 km east of the town can be used for the project thanks to their productivity and good water quality. The priority of supply is given to the hardest-hit Moodeyah service zone. An additional well is planned downstream the same basin to cover the shortages of water in Al-Qurath zone as well. To the other 2 zones, the connections can be provided in preparation for emergency supply. This measure will enhance the effect of the project.	1) Residents in Moodeyah and Al-Qurath can enjoy increased rate of supply of 40 lcd. The Zyoar service zone with only one water well located on the way between Al-Qurath and Moodeyah can receive emergency supply through the connection to new distribution main. After the town receives new supply, the existing system for the town can be transferred to the Al-Habir service zone next to town, now with its source highly saline, though the supply rate is quite limited through the new connection.
2) Degenerated water service has resulted in rejection of paying water bills. The district water office is suffering from loan repayment and trouble with collection of bills.	2) The citizens are eager to get a new project which can ease their hardship from lack of water. Since demand is so high that a revised water rate of YR 85/household/month could be accepted by them without hesitation. The new rate could increase revenue, picking up the management of the	2) The Moodeyah water office can remedy its crippled finance and management through revenue increase, and can further improve the service for the beneficiaries.

Current Situation/ Difficulties	Measures Taken by the Project	Anticipated Effects/ Improvement Range
2. **Moodeyah** (Continued)	office to a sound state. The fees collection is to improve through adoption of metered rate based on the combined use of meter reading and flat-rate billing, as is the case with Ahwar.	
3. **Al-Raidah/Shamalya** The site is composed of 7 villages scattered over the highland plateau, where water resources are scarce except one deepwell successfully drilled in recent years. All the villages except one nearby the well of a population of nearly 10,000 depend on costly water vending for most of the year. An average consumption is 15 lcd. Due to use of unsanitary water sources including kalifs from water vending, bilharzia is spreading among the villagers.	The project plans to use the existing well plus one new deepwell to meet the demand of the whole area. Relevant facilities will be designed to meet the BHN of the population and to improve health and sanitation of the site.	A daily per capital supply of 50 lcd is served to the entire population of the site, contributing the enhancement of health and sanitation in environment. A water rate recommended becomes less than half, compared with the cost of water vending, relieving heavy economic burden of the residents. The water service is to be managed by a water office organized by representatives from each village for the first time, providing opportunities of residents' participation in activities for the community.

Current Situation/ Difficulties	Measures Taken by the Project	Anticipated Effects/ Improvement Range
4. **As-Sadarah** This site is composed of 9 villages including the As-Sadarah sub-district capital, where water can easily be obtained from surface stream and hot spring sources. The site has no water facilities due to this convenient water environment. However, water quality of the current sources can not be said to be good and artificial contamination is now feared due to locations of existing sources in crowded residential areas. The residents are in need of safe drinking water service.	1) The water source for the project for the system to be installed in the site for the first time is surface stream from a spring about 5 km up-stream of the community. The system is planned to cover the whole population of the site, serving a daily per capita rate of 50 lcd. 2) The water facility is managed by a water office to be organized in the subdistrict office. The site has experience and expertise of organizing the activities of the community through management of huge palm oil plantation. New management is planned to be promoted with cooperation and participation of residents, based upon planned water billing system to use flow-metering for the respective villages.	1) The project will supply clean water of 50 lcd to the entire population of the area, leading to improvement of health and sanitation of the site environment and reducing incidence of water-borne disease and digestive organ disorder. 2) The activities of new water office will offer enhanced opportunities of residents' participation and cooperation in collection of water bills and maintenance of pipelines within the villages, leading to strengthening ties among the villages.

6.2 Conclusion

As one of the top-priority policies in the National Reform Program approved by the National Assembly in 1992, the united government is promoting to enhance the rural infrastructure including water projects for closing gaps for the rural residents making up over 80% of the entire nation for the improvement of the quality of their life as well as the regional development through activities of the concerned offices and agencies supported by bilateral assistance. However, the water supply project is lagging behind with the present coverage hovering around 40% because of technical difficulty to ensure reliable water sources under harsh natural conditions as well as a financial constraint. The GAREW in charge of the project, however, is making hard efforts to boost the coverage to a level of 80 % by the year 2010 in connection with the Action Plan adopted by the National Population Conference in 1993.

This project is aimed at urgently providing safe and stable domestic water to four (4) rural communities dispersedly located in two (2) southern and eastern governorates of the country where the shortages of water are acute, by means of constructing water supply facilities which could sustainable be operated and maintained and could improve water service in quantity and quality, leading to the enhancement of health and sanitation of the residents as well as relieving economic burden of depending on costly water vending. Moreover, the improved service will help to remedy the current plight in the management and finance of the water offices and to contribute to better service in the future.

The implementation of the Project not only meets the BHN of the residents in the concerned communities but is anticipated to make a contribution to one of the top-priority policies of the government for rural development. In view of these benefits, the Project is judged to be worthwhile and feasible for the extension of grant aid by the government of Japan.

6.3 Recommendations

This project aims to provide water facilities mainly to the regional water service plans covering the central areas of local administration. Upon completion of the construction of facilities under the project, the new water service is to launch through management of the local government's water offices. In view of such situation, the following points are recommended to be based upon for its sustained operation and maintenance. Several stages have been assumed, however, to attain to a desirable level in the development of systems, since the current conditions and stances of the project sites vary a great deal.

(1) Establishment of appropriate billing systems and related measures

Stage 1 (Initial setup)

1) The water office of each project site shall set up a proper billing system for its sustained management/operation and maintenance of facilities, and aim to acquire full cooperation of the residents for establishing a sound financial management as well as a good service to be appreciated by them. The criteria for water billing system are proposed to be based upon the broadly accepted principle that the water fees in developing countries should basically be confined to less than 5 percent of household income, preferably to less than its 3 percent.

2) The water fee shall be determined, based upon the cost principle, and the cost should include contingency in preparation for unexpected breakdowns of equipment/facilities so that they could be repaired or replaced without serious difficulty. Further, the concept of amortization or depletion is recommended to be introduced in the financial management, since this element could provide fund for the new capital improvements of facilities and equipment upon the expiry of their lives.

3) Based upon such a view and policy, the water rates recommended to the project sites in this project have been calculated in this report. The initial basic water rates to be adopted for

a 3-year period by the four water offices under the project are proposed as follows:

a. Ahwar
   Fixed rate: YR 105/household/month
   (in case of metered rate: YR 8.0/m^3)
   which roughly corresponds to 3.5% of average household income

b. Moodeyah
   Fixed rate: YR 90/household/month
   (in case of metered rate: YR 8.5/m^3)
   which roughly corresponds to 3.0% of average household income

c. Al-Raidah/Shamalya
   Fixed rate: YR 150/household/month
   (in case of metered rate: YR 11.0/m^3)
   which roughly corresponds to 4.9% of average household income

d. As Sadarah
   Fixed rate: YR 105/household/month
   (in case of metered rate: YR 8.0/m^3)
   which roughly corresponds to 3.5% of average household income

These water fees shall be increased as years pass by in proportion to the escalation of the production cost so that the operation and maintenance could be sustained in fine shape.

4) This project is designed to install water meters on distribution mains, which are appointed to the respective villages or blocks of villages for metering the respective volumes of distributed water flow. As the first step, the metered volume of flow is to be billed, based upon the metered rate to the respective villages or their blocks, and then the aggregate amounts of the metered rates shall be divided by the numbers of the populations composing the respective villages, to be paid by each household based upon a fixed rate per person. This method of billing metered rates to the respective villages will be the most effective way to collect

water fees. It is also expected to have an effect to promptly draw attention of the villagers to unaccounted-for water or leakage.

Stage 2: (Measures to be taken as the initial setup proceeds)

1) To raise revenues through water service, the ratio of accounted-for water should be increased by containing leakage as much as possible, as follows:

   a. The water offices shall routinely measure the rates of flow respectively on the pumping mains and on the distribution mains on everyday basis. The comparison of the flow-rate readings may warn about probable occurrences of leakage on these main lines, and if there is any, the water offices shall promptly take steps for repairing.
   b. Further, the staff members of the water office shall practice to make regular rounds of their service areas for inspecting pipelines, since most of leaks tend to occur in connections of smaller pipes including service lines to households. If they find any such leaks, they should arrange the repair cost to be fairly shared among responsible households.

2) The water offices of Ahwar and Moodeyah where already house connections exist are requested to undertake the survey of existing house connections, and to open negotiations with each household which is responsible for leaking. The basic rule of cost sharing for repairs shall be that the water office is responsible for those on distribution mains to branches, while the household, for those on house connections.

3) The water rates for Al-Raidah/Shamalya and As-Sadarah are considerably higher than those for Ahwar and for Moodeyah. This is because the former has virtually no existing facilities. As a possible means to reduce the rates, the villagers in both sites are advised to offer full cooperation to the operation of the water offices by sharing the routine works such as water billing and collecting as well as pipeline inspection within their own villages so that expenses thereof could be curtailed.

4) In Ahwar and Moodeyah where the commercial zones exist, large-volume consumers such as shops and restaurants shall be more heavily charged than ordinary households for the purpose of containing a waste of water as well as having the former share a larger portion of expenses.

Stage 3: (To be promoted after Stage 2)

1) The rates proposed for the Stage 1 are relatively higher than those applied in other rural areas, because the former includes costs for expenses not only of operation and maintenance but of depreciation. It must be noted that the rate of unaccounted-for water considerably affects revenues based on either the metered-rate or fixed-rate tariff system. In case of the former, revenues decrease in proportion as leakage increases, while in case of the latter, a great many beneficiaries may feel that water rates are unfair because there are those who use more and pay the same rates. During the initial stage of the operation, the Moodeyah and the Ahwar offices must resume the fixed rate billing, since the existing connections have no meters, but they are recommended to prepare gradually to switch to the metered-rate tariff system lest the residents should have any complaints about the water rate system.

2) The plumbing work to be locally undertaken from now on is advised to adopt the following measures:

   a. House connections should have the individual gate valves.
   b. The repairs of damaged sections shall be made in normal way using proper fittings instead of a prevalent method to wrap a used car tire rubber tube around them. The water offices may currently find trouble in locally locating such materials or have financial difficulty in shifting to a normal measure, but in the near future when they can receive the increased revenue, the water offices shall prepare stores of necessary fittings and other miscellaneous piping materials.

(2) Concerning the organizational setup of the water offices, each of the office directors should mind not only recruiting the number of personnel required for the facilities operation but assuring to have qualified technicians for each line of operation. On the other hand, the GAREW is desired to reopen its training course for local operators as soon as practicable to offer opportunities for them to boost their abilities. The directors must encourage their staff to catch and join such opportunities.

(3) Concerning the function of the local government/water offices in the management of water facilities, the provisions of law currently are obscure. The activity of these offices in this sector has been left at the discretion of each organization at best, as formerly was. It is recommended, therefore, that the law and regulations for supporting and controlling the water offices including a subsidy system by the government be gradually instituted so that the senior offices of local government, particularly those in the southern part, could continue to extend their possible support to the management of water offices including one of the project sites, Al-Raidah/Shamalya, which is not an administrative center and may feel difficulty in expecting support from the central government.

APPENDIX

APPENDIX I

GENERAL DOCUMENTS

APPENDIX I-a Minutes of Discussions

MINUTES OF DISCUSSIONS

BASIC DESIGN STUDY ON
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES
OF
THE REPUBLIC OF YEMEN

In response to a request from the Government of the Republic of Yemen, the Government of Japan decided to conduct a Basic Design Study on the Project for Rural Water Supply in the Southern and Eastern Governorates (hereafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Yemen a study team, which is headed by Dr. Yuji Maruo, Senior Development Specialist in groundwater development with JICA, and is scheduled to stay in the country from November 20 to December 26, 1993.

The team held discussions with the officials concerned of the Government of Yemen and conducted a field survey at the study area.

In the course of discussions and field survey, both parties have confirmed the main items described on the attached sheets. The team will proceed further works and prepare the Basic Design Study report.

Sana'a, December 25, 1993

丸尾祐治

Dr. Yuji Maruo, Leader
Basic Design Study Team
JICA

Dr. Amin A. Mohamoud, Chairman
General Authority for
Rural Electricity and Water
Ministry of Electricity and Water

Mr. Hisham Sharaf Abdulla
Director General of Bilateral
Cooperation with Industrialized
Countries,
Ministry of Planning and Development

ATTACHMENT

1. Objective

The objective of the Project is to construct water supply facilities consisting of water wells as water sources, pumping facilities, water tanks, pipelines and public fountains for the people in the rural areas of the Southern and Eastern Governorates of the Republic of Yemen.

2. Project Sites

The Project sites for the Basic Design Study are listed as follows:

1)	Tor Al-Bah	(Lahj Governorate)
2)	Al-Faidah/Bani Baker	(Lahj Governorate)
3)	Ahwar	(Abyan Governorate)
4)	Moodeyah	(Abyan Governorate)
5)	Gaishan	(Abyan Governorate)
6)	Al-Mafod/Ermah	(Shabwa Governorate)
7)	Al-Raydah/Shamalyah	(Hadramout Governorate)
8)	As Sadarah	(Hadramout Governorate)
9)	Al-Radood	(Hadramout Governorate)

Each project site listed above shall further be studied in detail by the Basic Design Study team in the light of such elements as the possibility of assuring safe and stable water sources, etc. for the purpose of confirming its feasibility. Therefore, the Project sites are not necessarily the sites for the implementation.

Tor Al Bah and Al Raydah/Shamalyah were newly proposed by the Yemeni side as the project sites instead of Tukar and Mayfa respectively, considering the present conditions of water supply.

3. Executing Agency

The General Authority for Rural Electricity and Water, the Ministry of Electricity and Water is responsible for the land acquisition, water rights, implementation, operation and maintenance of the Project.

4. Items Requested by the Government of Yemen

After discussions with the Basic Design Study Team, the following items were finally requested by the Yemeni side.

1) Construction of water facilities in the aforementioned Project sites

2) Procurement of materials, equipment and spare parts for the construction of water facilities in the above Project

3) Procurement of services for the implementation of the Project.

4) Procurement of geophysical exploration equipment such as electric resistivity meter and electro-magnetic survey equipment.

However, the final components of the Project will be decided after further studies.

5. Items Agreed by Both Sides during the Discussions

1) In case the Japanese Government has decided the implementation of the Project, the Yemeni side shall make its best efforts to extend full cooperation to the Project including the possible participation of the inhabitants of the respective sites in the Project.

2) Pumping tests of the existing wells at two (2) sites, namely Ahwar and Moodeyah, will be conducted by the General Authority as soon as possible, and the results of the tests will be delivered immediately to the team.

3) The Yemeni standards of per capita water supply rates would not always be applicable in certain Project sites, in case available water sources are limited in those areas.

4) The Sana'a headquarters of the General Authority shall bear responsibility on all the decisions in the Yemeini side during the Project period.

6. Japan's Grant Aid System

(1) The Government of the Republic of Yemen has understood the system of Japanese Grant Aid explained by the team.

2) The Government of the Republic of Yemen will take necessary measures, described in Annex I for the smooth implementation of the Project, on condition that the Grant Aid Assistance by the Government of Japan is extended to the Project.

7. Schedule of the Study

1) Based on the Minutes of Discussions and technical examination of the study results, JICA will prepare the draft report in English and dispatch a mission in order to explain its contents around the end of March 1994.

2) In case the contents of the report is accepted in principle by the Yemeni side, JICA will complete the final report and send it to the Government of Yemen by the end of April 1994.

* * * * *

ANNEX I

UNDERTAKING BY THE GOVERNMENT OF THE REPUBLIC OF YEMEN IN CASE JAPAN'S GRANT AID IS EXTENDED

1. To provide data and information necessary for the Project.

2. To provide, secure, clear and level land and access at each construction site prior to the commencement of construction of water facilities.

3. To ensure speedy unloading, tax exemption, customs clearance at the port of disembarkation and prompt inland transportation, of products purchased for the Project in accordance with the agreement to be concluded between the Government of the Republic of Yemen and the Government of Japan.

4. To make necessary arrangements for the entry into and stay in the Republic of Yemen, of Japanese nationals whose services may be required in connection with the supply of the products and the services under the verified contracts for the Project.

5. To exempt Japanese nationals involved in the Project from customs duties, internal taxes and other fiscal levies which may be imposed in the Republic of Yemen with respect to the supply of equipment/machines and services under the verified contracts for the Project in accordance with the agreement to be concluded between the Government of the Republic of Yemen and the Government of Japan.

6. To bear commissions to the Japanese foreign exchange bank for the banking services based upon the Banking Arrangement for the Project.

7. To bear all expenses, other than those to be borne by the Grant Aid necessary for the execution of the Project.

8. To assign exclusive counterpart staff in the General Authority for Rural Electricity and Water, Ministry of Electricity and Water for the execution of the Project including siting, drilling, installation of water facilities, etc. prior to the commencement of the Project.

9. To maintain and use properly and effectively the facilities constructed and equipment purchased under the Grant Aid for the Project.

* * * * *

Consultation on Draft Report

Minutes of Meeting

MINUTES OF DISCUSSIONS
BASIC DESIGN STUDY
ON
THE PROJECT FOR RURAL WATER SUPPLY
IN THE SOUTHERN AND EASTERN GOVERNORATES
OF
THE REPUBLIC OF YEMEN
(CONSULTATION ON DRAFT REPORT)

In November 1993, the Japan International Cooperation Agency (JICA) dispatched a Basic Design Study team on the Project for RURAL WATER SUPPLY IN THE SOUTHERN AND EASTERN GOVERNORATES OF THE REPUBLIC OF YEMEN (hereinafter referred to as "the Project"),to the Republic of Yemen,and through discussions,field survey,and technical examination of the results in Japan, has prepared the draft report of the study.

In order to explain and consult the Yemeni side on the components of the draft report, JICA sent to the Republic of Yemen a study team, which is headed by Mr. Kiyoto KUROKAWA ,First Basic Design Study Division, Grant Aid Study and Design Department,JICA, and is scheduled to stay in the country from March,30th to April 7th,1994.

As a result of discussions, both parties confirmed the main items described on the attached sheets.

Sana'a,April 6th,1994

Approved,

Mr. Kiyoto KUROKAWA
Leader
Basic Design Study Team
JICA

Dr.Amin A.Mohamoud
Chirman
General Authority for
Rural Electricity and
Water,
Ministry of Electricity
and Water.

Mr.Abdul Wali Al-Agel
Depty Minister
for Economic and
Technical Cooperation,
Ministry of Planning and
Development.

ATTACHMENT

1.Components of Draft Report

The Government of Yemen has agreed and accepted in principles the components of the Draft Report proposed by the team.

2.Japan's Grant Aid system

(1)The Government of Yemen has understood the system of Japanese Grant Aid explained by the team.

(2)The Government of Yemen will take the necessary measures , described in ANNEX-1,for smooth implementaion of the Project on condition that the Grant Aid assistance by the Government of Japan is extended to the Project.

3.Futher schedule

The team will make the Final report in accordance with the confirmed items, and send it to the Government of Yemen by the end of May 1994.

4.Main working share

Main working share is shown in ANNEX-II

5.Recommendations

Importance of recommendations given in the draft final report has been confirmed as shown in ANNEX-III.

6. The GAREW (The General Authority for Rural Electricity and Water), head office will have full responsibility for supervising the Project.

ANNEX-I

Undertaking by the government of the Republic of Yemen in case Japan's grant aid is extended.

1.To provide data and information necessary for the Project.

2.To provide,secure,clear and level land and access at each construction site prior to the commencement of the construction of water facilities.

3.To ensure speedy unloading,tax exemption,customs clearance at the port of disembrkation and prompt inland transportation,of products purchased for the project in accordance with the Exchange of Notes to be concluded between the Gvernment of the Republic of Yemen and the Government of Japan.

4.To make necessary arrangement for the entry into and stay in the Republic of Yemen,of Japanese nationals whose services may be required in connection with the supply of the products and services under the verified contracts for the Project.

5.To exempt Japanese nationals involved in the Project from customs duties,internal taxes and other fiscal levies which may be imposed in the Republic of Yemen with respect to the supply of equipment/machines and services under the verified contracts for the Project in accordance with the Exchange of Notes to be concluded between the Gvernment of the Republic of Yemen and the Government of Japan.

6.To bear commissions to the Japanese foreign exchange bank for the banking services based upon the Banking Arrangement for the project.

7.To bear all expenses other than those to be borne by the Grant Aid necessary for the execution of the Project.

8.To assign exclusive counterpart staff in General Authority for Rural Electricity and Water , Ministry of Electricity and Water for execution of the Project including siting,drilling,installation of water facilities, etc. prior to the commencement of the Project

9.To maintain and use properly and effectively the facilities constructed and equipment purchased under the Grant Aid for the Project.

10.To ensure the safty and security of Japanese nationals and belongings involved in the Project against abduction ,theft etc.

ANNEX-II

Both sides confirmed that working share of implementation is shown in the the table.

Table ; Main Working Share

Yemeni side	Japanese side
1.To acquire,clear and level the land for construction of facilit -ies,especialy in the following main sites: A.Ahwar 1)Booster station 2)Elevated tank 3)Pumping main lines B.Moodeyah 1)Additional new well 2)Booster station 3)Distribution reservoir 4)8-inche transporting line C.Al-Raidah/Shamalya 1)Reservoir for Al-Sufila and Al-Rahb villages. D.As-Sadarah 1)Distribution reservoir 2.To acquire the existing wells; 1)Deepwells drilled under the Russian project in Ahwar. 2)Three wells in Al-Qurath area in Moodeyah. 3.To provide and maintain acccess roads including the following; a.Access to distribution reservoir of 300 m3 in Moodeyah b.Access to tank locations for Al-Rahb and Al-Sufila villages in Al-Raidah/Shamarya. c.Access to location of intake facilities and tanks in As-Sadarah 4.To install distribution branches using materials supplied under the project in the following sites; a.Awahar b.Al-Raidah/Shamarya c.As-Sadarah 5.To repair leakage in existing pipelines in Ahwar. 6.To offer training to staff of water offices in every site of the Project.	1.To construct the water supply facilities for 4 sites. a.Awahar b.Moodeyah c.Al-Raidah/Shamarya d.As-Sadarah 2.To supply piping materials for the extension of distribution lines in three project sites as follows; a.Awahar b.Al-Raidah/Shamarya c.As-Sadarah

ANNEX-III

Through discussions, importance of the recommendations for the Project implementation given in the draft final report, is confirmed as listed below and with understanding of these recommendations, the projects can be regarded as the model of the small-medium scale semi-urban water supply schemes in Yemen.

1.Financial self-sustenance of the Projects.

(1)The water tariff system should be set to maintain financial self -sustenance of the water supply office in each of the project site.

The GAREW should direct the local governments/the water supply offices about relevant measures for collecting water charge.

(2)In case the water supply offices require the assistance of the GAREW, they will assist them in technically and direct the local governments to assist them financialy.

2.Technical self-sustenance of the Projects.

(1)Much attention should be paid for water leakage on the distribution lines to have the efficient opperation of the Project.

(2)The GAREW will direct the local governments/the water supply offices about relevant measures for fixing water leakage on the distribution lines to have the efficient opperation of the Project.

(3)The GAREW will hold a trainning for the staff of local governments/the water supply offices about pumping operation method including water level, quality and quantity mesurement.

3.Water tariff.

(1)The water fee should be increased in proportion to the increase of the water production cost.

(2)The water fee should include the contingency in preparation for unexpected breakdowns.

(3)The GAREW should supervise the local governments/the water supply offices about cost-recovery water charge level of the Projects.

4.Water tariff collection.

(1)At the first step, the water tariff should be charged based upon the metered rate to the respective villages.

Each respective village will collect the water charge from the villager by fixed rate method.

(2)Next step, the water tariff should be charged based upon the respective house metered rate.

Appendix I-b Itinerary of Field Survey

No.	Date		Place	Trip	Activity
1	93/11/19	Fri	Trip	-Tokyo to Paris	-Flight: AF275
2	93/11/20	Sat	Sana'a	-Paris to Sana'a	-Flight: AF8030
3	93/11/21	Sun	Sana'a	-Courtesy call	-Ministry of Planning and Development -GAREW -Embassy of Japan
4	93/11/22	Mon	Sana'a	-Meeting -Preparation for Survey	-GAREW -Preparation for Survey trip
5	93/11/23	Tue	Aden	-Sana'a to Aden	-Trip
6	93/11/24	Wed	Aden	-Courtesy call -Meeting -Data collection	-Consulate of Japan -GAREW-Aden Branch -Data collection
7	93/11/25	Thu	Site No.1-Tor Al-Bah	-Courtesy call/ Meeting -Survey -Aden	-Lahj Governor, NWSA - Tor Al-Bah Branch -Site survey -Trip
8	93/11/26	Fri	Site No.1-Tor Al-Bah	-Survey -Aden	-Site survey -Trip
9	93/11/27	Sat	Site No.1-Tor Al-Bah	-Survey -Aden	-Site survey
10	93/11/28	Sun	Site No.3-Ahwar	-Coutesy call -Survey/Ahwar	-Abyan Governor -Site Survey
11	93/11/29	Mon	Site No.3-Ahwar	-Survey	-Site survey
12	93/11/30	Tue	Site No.3-Ahwar	-Survey -Ahwar to Aden	-Site survey -Trip
13	93/12/01	Wed	Site No.4-Moodeyah	-Aden to Moodeyah	-Site survey
14	93/12/02	Thu	Site No.4-Moodeyah	-Survey	-Site survey
15	93/12/03	Fri	Site No.4-Moodeyah	-Survey -Moodeyah to Ataq	-Site survey -Trip
16	93/12/04	Sat	Site No.6-Al-Mafod/Ermah	-Ataq to Al-Mafod/Ermah -Survey	-Trip -Site survey