4.4 Water supply project by SONELEC

4.4.1 Outline of the project

(1) Scale of waterworks projects

Waterworks projects by SONELEC are currently executed in nine cities with greater population and higher rate of urbanization, i.e., Nouakchott, Ayoun, Nouadhibou, Atar, Rosso, Akjoujett, Boutilimitt, Aleg, and Mederdra. The scale of waterworks projects of the entire corporation is shown in Table 4.4-1.

Table 4.4-1 Scale of waterworks by SONELEC

Population (Total of 9 cities)	881,000
Number of beneficiaries of water supply (individual supply)	300,000
Supply rate	34 %
Number of public water taps	176
Maximum water distribution capacity	53,200 m^3/day
Average volume of water distribution	43700 m^3/ day
Maximum volume of water distribution	48400 m^3/ day
Average volume of water reception	41200 m^3/day
Number of personnel	261

Note) Number of personnel: Exclusive workers for waterworks section + workers in common management section

SONELEC is a public corporation executing the installation of water supply facilities using financial aid from international assistance organizations and government subsidies. In addition to water pumping and distribution facilities, it also builds water supply facilities (up to installation of a flowmeter) including installation pipes to each home, branching off from the distribution conduit.

(2) Organization

Fig. 4.4-1 and 4.4-2 show an overall organization and maintenance/management organization of waterworks project respectively.

The total number of employees of SONELEC is 892, of which 116 are involved in the waterworks project section (workers exclusively involved in waterworks section), 345 in the electricity project section (workers exclusively involved in electricity section), and 431 in a common management section (workers involved in the management section of both the waterworks and electricity sections). Also, 598 employees work in the head office and for the city of Nouakchott. The number of employees working in other branches of SONELEC is 294.

Of the total number of employees, 153 are involved in the maintenance and management section. The maintenance of mechanized equipment such as distribution pumps is the responsibility of the electrical technology department, and maintenance of the water distribution network is the responsibility of the water and sewage technology department. The maintenance/management of facilities in rural areas is ensured by the above mentioned electrical technology department that dispatches its personnel for inspection and repairs other than inspection and repairs of the distribution network.

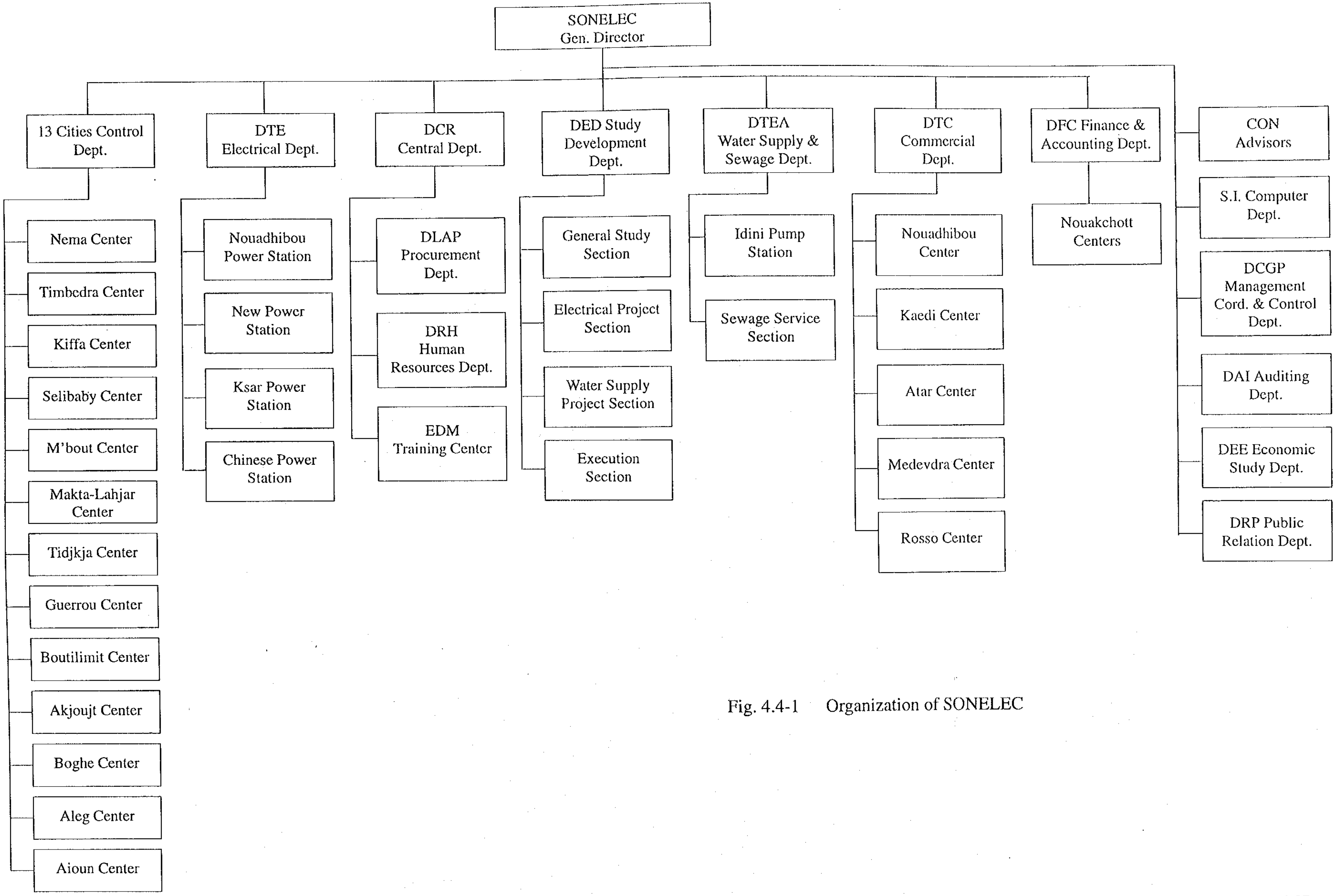


Fig. 4.4-1 Organization of SONELEC

Fig. 4.4-2 SONELEC – Maintenance Organization (1)

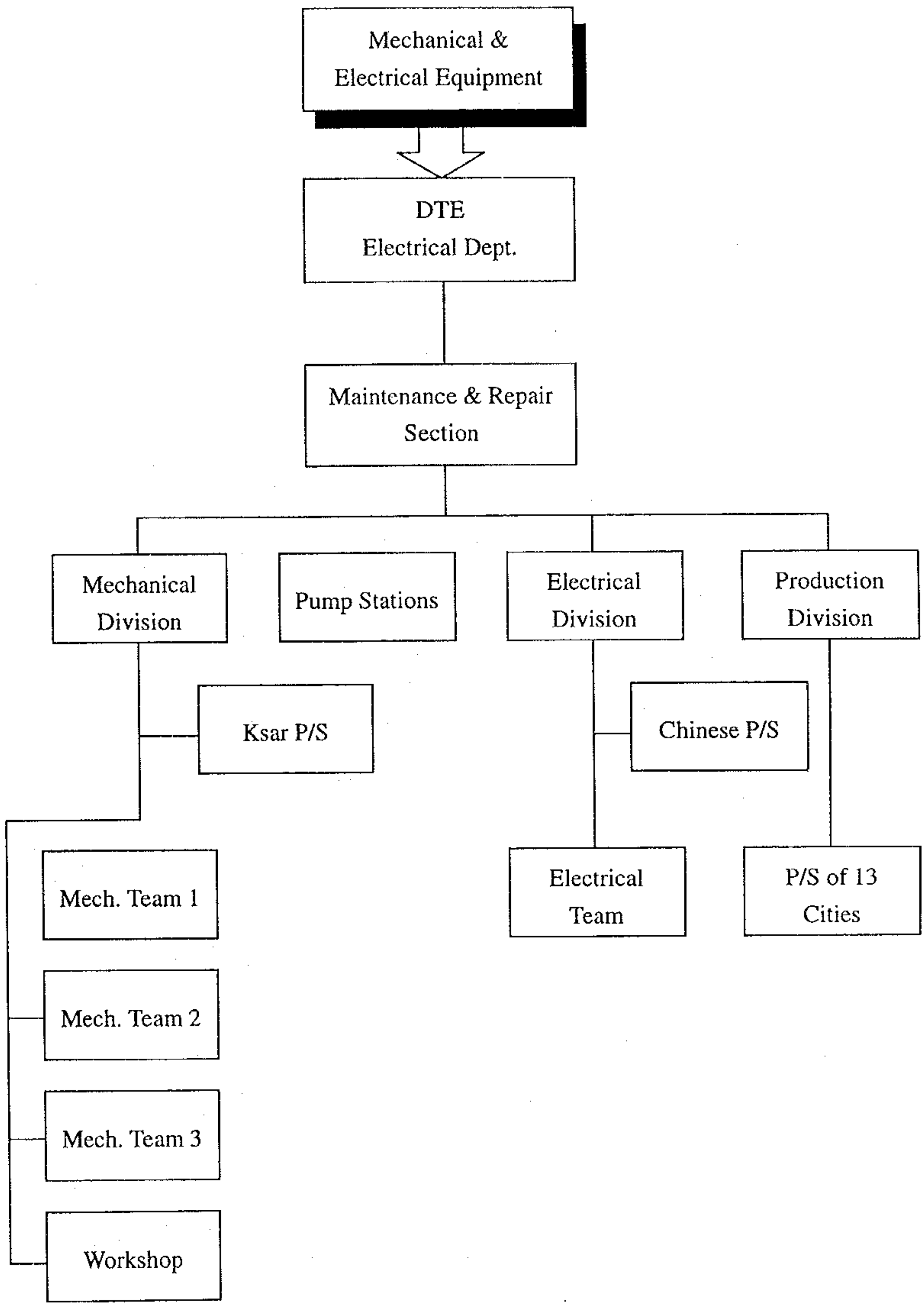
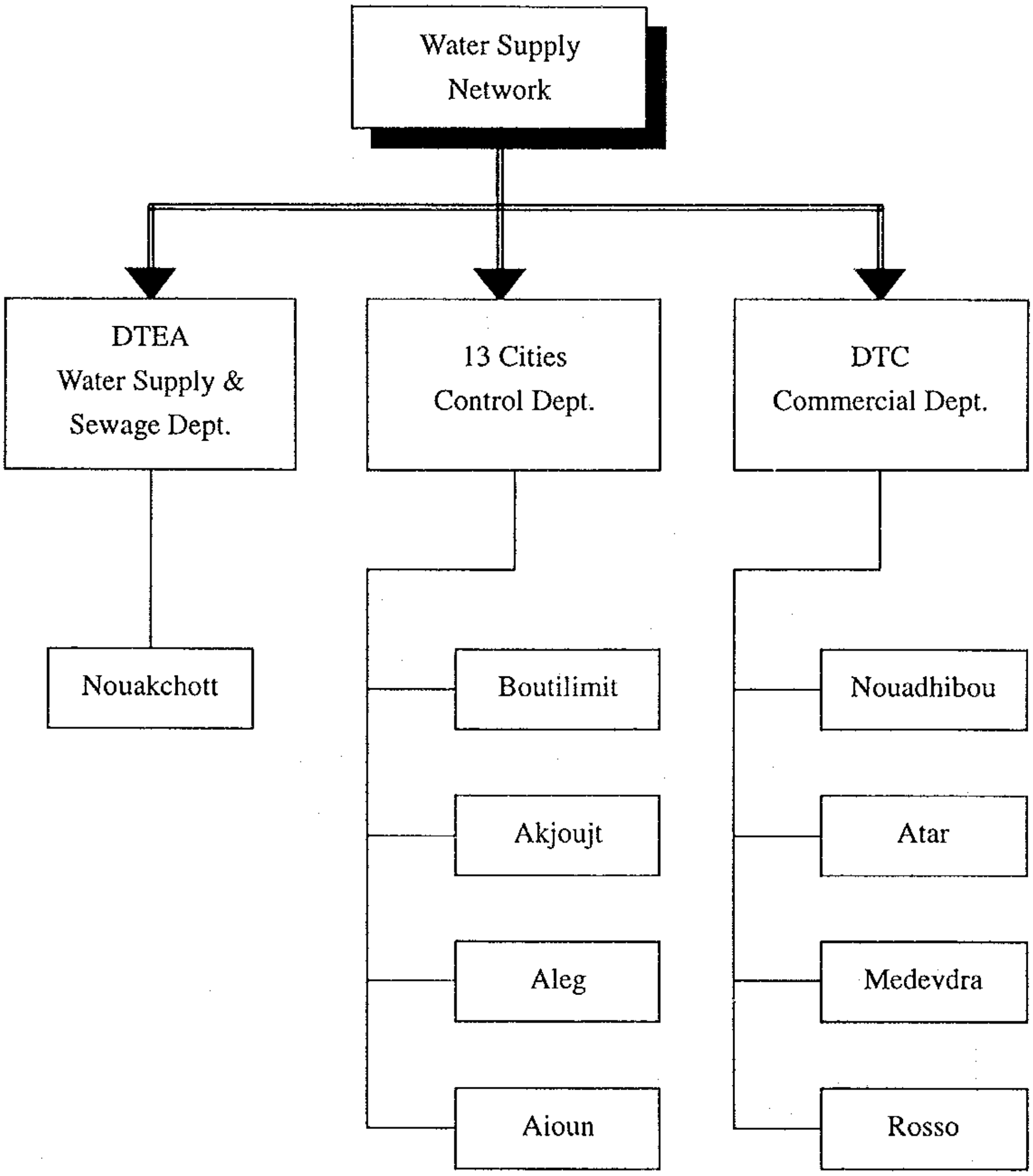


Fig. 4.4-2 SONELEC – Maintenance Organization (2)



(3) Price of water

1) Pricing system

The current pricing of water is shown in Table 4.4-2. This pricing applies to the whole nation. This pricing system can be characterized as follows.

① The tariff is divided into four categories: residential use, public water taps, shops and offices, and government organizations.

② The tariff for residential use is proportional to consumption.

③ A unique tariff is applied to public water taps, shops and offices, and government organizations, regardless of consumption.

④ The amount of security money to be paid at the conclusion of the contract (returned at cancellation of the contract) is proportional to the diameter of the water pipe. The security money shall be apportioned by SONELEC to expansion work for the piping network and installation of supply pipes as a TRF credit.

⑤ The basic monthly rate of 196UM is charged to every client.

⑥ A governmental tax of 4% shall be added to the amount billed to the client.

Table 4.4-2 Current pricing for tap water

Code No.	Purpose		Water charge (UM/m³)	Diameter of conduit and security money (UM)								Extra use (UM/ month)
				15 - 20mm	26 - 32mm	40 mm	50 - 60mm	80 mm	100 mm	150 mm	200 mm	
0120	Family	0 - 10m³/month	77.91									
		11 - 30m³/month	154.35	8,450	25,346	47,631	202,762	270,350	337,937	506,905	675,874	
		31m³/month or more	194.02									196
1110	Public water tap		77.91	8,450	25,346	47,631	202,762	270,350	337,937	506,905	675,874	
2220	Business/ industry		161.70	8,450	25,346	47,631	202,762	270,350	337,937	506,905	675,874	
4440	Government organizations		161.70	0	0	0	0	0	0	0	0	
Sew-age	Use of sewage UM/m3)	For 1m³ of water used	14.73									
	Water treated (UM/m³)	For vegetable producers	45.68									

2) Billing method

Cities with a waterworks project also have a power supply project. The rate of collection of water charges varies in different cities. It is 92% in Nouakchott but only 60% in Ayoun. One of the reasons for this low rate is that payment from government organizations that are large users has not been received.

Billing methods can be summarized as follows.

① Joint billing with electricity bill

② SONELEC employees deliver water bills directly to individuals.

③ Clients pay their water bill directly at business centers of SONELEC (eight centers in Nouakchott or billing section of SONELEC branch in other cities).

(4) Situation of management of waterworks projects

The financial situation of waterworks projects in the past three years is shown in Table 4.4-3. According to the table, business has been in the black for three consecutive years, proving sound management.

Table 4.4-3 Financial situation of waterworks projects by SONELEC (1994 - 1996)

(Unit: UM)

Item		Fiscal year	1994	1995	1996
Income	Water charges received		1,466,097,590	1,285,190,888	1,480,334,307
	Other income		68,195,084	345,697,121	257,311,077
	Total		**1,534,292,674**	**1,630,888,009**	**1,737,645,384**
Expenditures	Business expenses	Personnel expenses	236,449,743	158,163,883	135,472,704
		Cost of chemicals for treatment and sterilization (included in power expenses)			
		Power expenses (gasoline, electricity, etc.)	300,472,952	219,209,497	273,218,375
		Cost for repairs	150,404,463	133,686,326	130,274,100
		Depreciation cost	550,044,240	675,063,281	535,855,904
		Others			
		Subtotal	**1,237,371,398**	**1,186,122,987**	**1,074,821,083**
	Non-business expenses	Interest	85,598,157	104,411,845	71,283,052
		Others	60,118,825	182,947,444	313,239,556
		Subtotal	**145,716,982**	**287,359,289**	**384,522,608**
	Total		**1,383,088,380**	**1,473,482,276**	**1,459,343,691**
Net profit or loss			**151,204,294**	**157,405,733**	**278,301,693**

Chapter 5 Environment/Hygiene

5.1 Legislative system and organization relevant to environment and hygiene

5.1.1 Basic environmental law

In the Islamic Republic of Mauritania, the Ministry of Rural Development and Environment is in charge of elaborating the basic environmental law. The work team, including professors from the law department of the university, completed in June 1997 its first report on proposal of the basic environmental law. After modification taking into account opinions given by various authorities in and out of the nation, the team submitted the final report conforming to the draft of the basic environmental law to the National Assembly in September 1997. After deliberations by the National Assembly, the Islamic Republic of Mauritania shall have a basic environmental law.

The draft of the basic environmental law consists of 103 articles, outlined as below.

Chapter 1 General provisions
- 1. Definitions and objectives
- 2. Basic principles

Chapter 2 Management of environmental policy
- 1. Management organization
- 2. Management method
  - (1) National plan of environmental activities
  - (2) Study of environmental impacts
  - (3) Environmental fund

Chapter 3 Protection of natural resources
- 1. Protection of the atmosphere
- 2. Protection of water resources
- 3. Protection of ground and underground resources
- 4. Common provisions

Chapter 4 Measures against pollution and environmental destruction
- 1. Environmental protection facilities
- 2. Wastes
- 3. Noise and vibration
- 4. Odors, dust and radioactivity
- 5. Degradation of the landscape
- 6. Historic sites and monuments

Chapter 5 Penalties

Chapter 6 Final provisions

Item (2) of Article 2 of Chapter 2 above provides for the study of the environmental impact of projects that are likely to have a serious impact on the environment, and the system for examination and approval of such projects. In particular, a nature protection zone, natural resources (water, forest), and the ecological environment (soil erosion, desertification) are treated as important environmental issues. Article 2 of Chapter 3 defines provisions relevant to the prevention of water pollution, installation of drainage systems and water quality inspection.

5.1.2 Environmental criteria

Currently, environmental criteria in Mauritania have not yet been determined. According to the people concerned from the Ministry of Rural Development and Environment, the criteria on water, atmosphere and waste shall be determined successively after enforcement of the basic environmental law. With regard to the water quality criteria, a study was carried out five years ago by Chinese experts of the National Hygiene Center (CNH) at Nouakchott, the capital, constructed under Chinese assistance, and a draft for water quality criteria (Table 5.1-1) was submitted. However, it has not been adopted as the official water quality criteria. With CNH being the only agency that can conduct water quality inspection, inspections are actually conducted under the guidance of Chinese experts, using the standard values shown in Table 5.1-1. Apart from colon bacilli, most items in the said water quality criteria comply with the WHO criteria. There is no criteria to be applied for sewage drainage.

Table 5.1-1 Draft for potable water quality criteria

Element	Limit value
Color	15 degrees (without any other unusual coloring)
Impurity	5 degrees
Strange odor or taste	No strange odor or taste to be generated
Visible substance to the naked eye	Absent
pH	6.5 - 9.0
Total hardness (as CaO)	250 mg/l
Ammonia nitrogen	0.2 mg/l
Nitrite nitrogen	0.02 mg/l
Nitrate nitrogen	10 mg/l
Chlorine ion	250 mg/l
Sulfate ion	250 mg/l
COD (as $KMnO_4$)	10 mg/l
Iron	0.3 mg/l
Manganese	0.1 mg/l
Zinc	1.0 mg/l
Copper	1.0 mg/l
Volatile phenol	0.002 mg/l
Anionic surface active agent	0.3 mg/l
Total evaporation residue	1000 mg/l
Fluorine	1.0 mg/l
Cyanogen	0.05 mg/l
Arsenic	0.05 mg/l
Cerium	0.01 mg/l
Cadmium	0.01 mg/l
Mercury	0.001 mg/l
Hexahydric chromium	0.05 mg/l
Lead	0.05 mg/l
Bacteria	100 /ml
Coliform groups	3 groups/l
Residual chlorine	0.3 mg/l at the exit of water purifying plant 0.05 mg/l at the end of conduit

5.1.3 Evaluation of environmental impact

In December 1995, the prime minister issued a law (No.96/060) concerning the establishment of a national council for environmental protection and development of Mauritania. According to this law, the national council was established, composed of the minister of rural development and environment, minister of economy of fisheries and marine products industry, a chairman, vice-chairman and vice ministers of governmental ministries and agencies. The roles of the national council are to determine national principles and policies on the environment, to examine protective, developmental and exploitative activities of natural resources, and to take necessary measures.

A secretariat, technical committee and local council are established under the national council. The technical committee shall be the core of discussions and plans related to environmental issues among the ministries, agencies and organizations concerned, to provide technical instructions for evaluation of environmental impact and to examine environmental reports. However, information obtained from the Ministry of Rural Development and Environment indicates that, since establishment of the national council and technical committee, there has been no example of evaluation of environmental impact or examination of environmental reports with regard to important development projects. Guidelines for evaluation of environmental impact seem yet to be elaborated.

5.2 Hygienic conditions of the city of Kiffa

5.2.1 Water hygiene

Most of the potable water in Kiffa city is obtained from shallow wells scattered over urban and surrounding areas. In addition to the city-owned well (source for the city's water supply truck) located along the Wadi Khoda 3 km northwest of the center of the city, and dozens of public wells (source of water sold from donkey-carts) located within the urban area, a total of 1,060 shallow wells were identified by this study. Over half of them are owned by individuals for drinking purposes. The result of interviews revealed that donkey-carts visited 218 wells to take water.

Two tests were conducted on the quality of shallow wells in the city, during the first and third field studies, and the condition of pollution of shallow ground water has been revealed. As stated in section 1.6 of Chapter 1, colon bacilli were found in the water from most of wells. About half of the wells examined showed a nitrate nitrogen concentration caused by raw sewage higher than WHO's potable water standard. However, many local residents used such wells for drinking purposes (see 1.6 for details on water quality).

Pollution of potable water may be generated not only at the source; there is also a possible risk of secondary contamination during transportation or at water storage facilities. The study group collected water from 22 water tanks in urban areas of Kiffa city in the first field study, and carried out water quality testing for coliform counting, using a water sampler made by Millipois (model No.MC00 100 25). Table 5.2-1 shows the test result. The fact that a great number of coliform bacteria were found in all water tanks reveal the gravity of secondary water contamination.

Water sampled from the municipal water supply trucks and from water carts pulled by donkeys was tested for coliform counting by means of simple test paper pack. As a result, no coliform contamination was discovered in the water from two municipal supply trucks in operation, but over 500/ml of coliform was found in the water from donkey-carts (a total of seven carts were inspected at each source). Water from municipal supply trucks was reexamined using a relatively sensitive water sampler, and the coliform count was shown as 4-6/ml. It can be said that municipal supply trucks distribute comparatively clean water as they disinfect it with decolorant (Javel de la couronne).

Although the use of decolorant for water carried on donkey-carts was obligatory, most water suppliers had neglected disinfection. It has been revealed that the propagation of colon bacilli occurred in the container, and as a result, the water distributed was more contaminated than the water at the source. However, as shown in Table 5.2-1, even when disinfected water was distributed by municipal supply truck, colon bacilli propagated in the water tank in homes (in most cases of concrete tanks, the water is supplied by municipal truck), causing secondary contamination. Therefore, in order to supply clean potable water, not only water quality control at the sources and in the processes of drawing and distributing water, but also hygienic control of water at each household is also very important.

Table 5.2-1 Result of water quality testing at water storage facilities

SITE NO.	TYPE OF WATER STORAGE FACILITIES	WATER TEMPERATURE	Ph	ELECTRIC CONDUCTIVITY	COLIBACILLUS
		℃		μS/cm	/ml
1	CONCRETE TANK	28.7	7.92	650	approx.500
2	CONCRETE TANK	30.9	7.49	607	approx.300
3	CONCRETE TANK	29.4	8.11	805	197
4	CONCRETE TANK	30.5	8.26	469	approx.500
5	200-LITRE DRUM	30.8	7.01	1343	approx.300
6	200-LITRE DRUM	29.1	8.49	1190	500 or more
7	CONCRETE TANK	29.6	7.38	607	186
8	CONCRETE TANK	29.4	8.26	511	approx.300
9	CONCRETE TANK	30.8	8.08	526	214
10	200-LITRE DRUM	26.3	7.73	1369	500 or more
11	CONCRETE TANK	28.7	7.03	619	approx.500
12	CONCRETE TANK	27.8	7.74	581	approx.500
13	CONCRETE TANK	28.4	8.33	2330	approx.500
14	CONCRETE TANK	26.8	7.85	591	240
15	CONCRETE TANK	28.9	7.65	610	approx.500
16	CONCRETE TANK	29.8	7.84	678	approx.500
17	200-LITRE DRUM	27.0	7.60	789	500 or more
18	CONCRETE TANK	29.5	8.60	550	approx.300
19	CONCRETE TANK	31.4	8.09	547	approx.500
20	200-LITRE DRUM	28.9	7.89	686	500 or more
21	CONCRETE TANK	27.8	8.04	1121	500 or more
22	CONCRETE TANK	30.5	7.79	604	approx.300

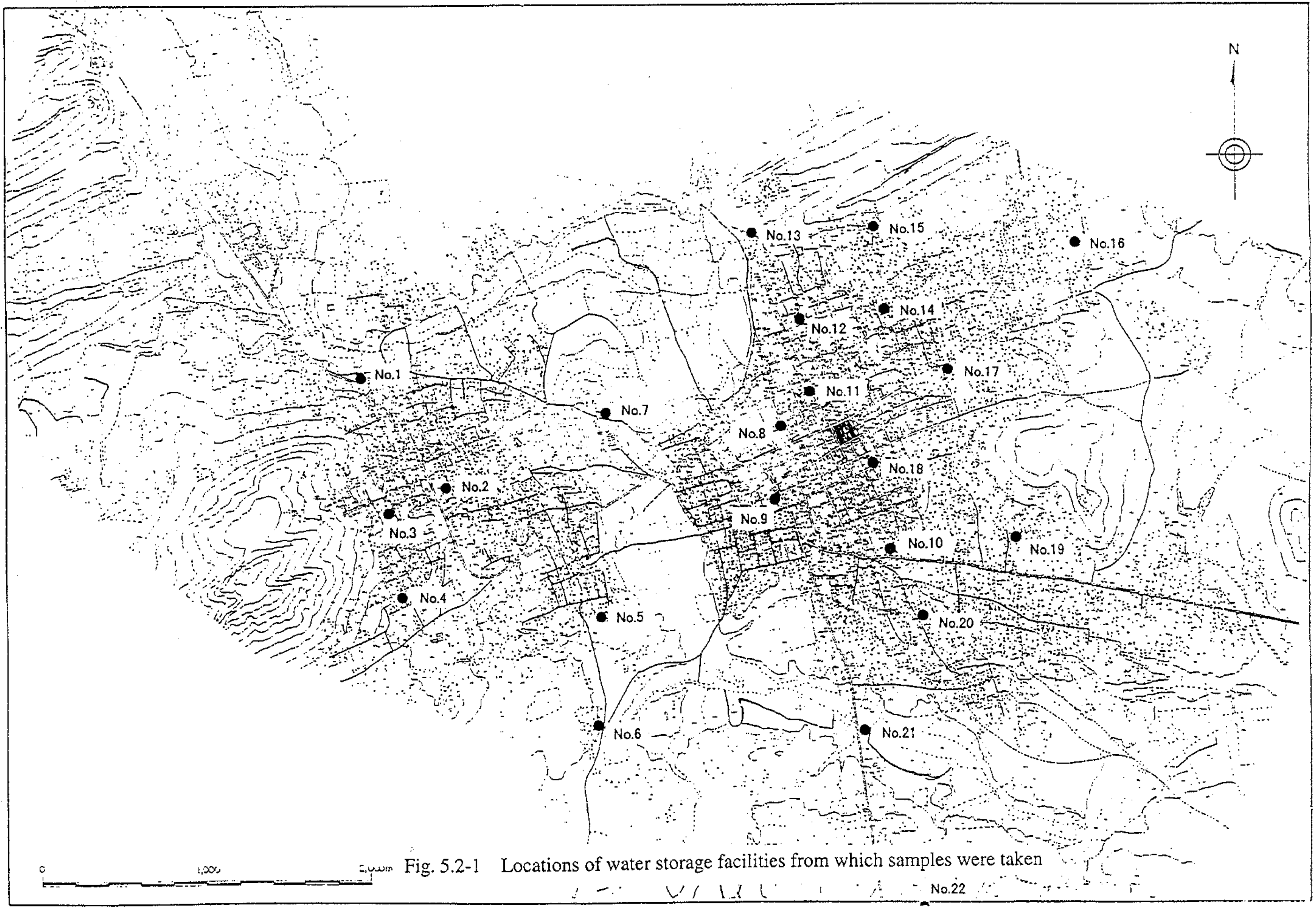


Fig. 5.2-1 Locations of water storage facilities from which samples were taken

5.2.2 Hygienic conditions of nitrogen-contaminated wells

Water analyses conducted during the first and third field researches revealed that some of shallow wells in the city were contaminated with nitrate nitrogen or ammonia nitrogen. As shown in Fig. 3.3-3 and 3.3-4 of Chapter 3, the areas in which shallow groundwater has a high concentration of nitrate nitrogen or ammonia nitrogen are around the center of urban area where houses are concentrated and much human activity occur.

As there is no sewage facility in Kiffa city, contamination by nitrogen does not exist in isolated spots but covers a distinct area. This proves that a large part of the subterranean aquifer is already contaminated.

In order to discover the cause of contamination, additional research was conducted on hygienic conditions around the wells with a significantly high concentration of nitrate nitrogen and ammoniac nitrogen. Research items included whether the wells were currently in use, protection of the well openings, presence of animal excrement around the wells, and distance from the closest lavatory. Table 5.2-2 shows the result of the research. The location of wells is shown in Fig. 3.3-1 of Chapter 3.

Table 5.2-2 Hygienic conditions of nitrogen-contaminated wells

No.	Well No.	NO_3-N (mg/L)	NH_3-N (mg/L)	Use of the well	Protection of the opening	Presence of animal excrement around the well	Distance from lavatory	Observations
1	87	116.0	0.11	In use	None	Scattered	21 m	Close to the road, many users of tents (for lodging use)
2	11	132.5	0.02	In use	Yes	Common	20 m	Outside the garden, opening of the well at ground level, protected by an old tire
3	350	319.0	0.01	In use	Yes	Common	21 m	In the garden, covered with a lid
4	360	157.0	0.14	In use	None	Common	13 m	Outside the garden, opening of the well at 20 cm above ground
5	347	1.2	4.0	Not in use	None	Scattered	17 m	In ruins, opening of the well at ground level allowing easy entry of dust and waste, ocher turbidity, not in use for a year
6	318	3.8	3.5	Not in use	Yes	Scattered	70 m	In ruins, opening of the well 40 cm above ground, odor of putrefaction, not in use for an unknown period
7	341	12.5	2.0	In use	Yes	Common	16 m	In the garden, opening of the well covered by tree branches removed at the time of use, quality of water varies from clean to putrid, reason unknown
8	292	10.5	31.0	In use	None	Common	19 m	In the garden, opening of the well 25 cm above ground, dumping ground in proximity with entry of garbage reported, odor of putrefaction, dark turbidity
9	304	7.5	2.45	Not in use	None	Common	8 m	In ruins, exhausted during dry season, opening of the well 50 cm above ground
10	525	8.0	2.2	In use	Yes	Scattered	17 m	In the garden, opening of the well 40 cm above ground, protected by an old tire, odor of putrefaction in dry season, reason unknown

Geographical distribution of nitrate nitrogen and ammonia nitrogen by degree of concentration was described in section 3.3 of Chapter 3. The four wells with an extremely high concentration of nitrate nitrogen of over 100 mg/L (No.1 - 4 of Table 5.2-2) are concentrated in a small area, all of them located near the road that passes through the center of the urban district from north to south. Although they are not in excellent hygienic condition, this is no different from most wells in the urban district. For example, well No. 350 that showed the highest concentration of nitrate nitrogen is located far from any lavatory, its opening is protected, and it has no direct pollutant. From this result, we can deduce that nitrate nitrogen as a source of contamination exists over a relatively broad area, in a non-point way.

On the other hand, of the six wells with a high concentration of ammonia nitrogen of over 2.0 mg/L (No.5 - 10 of Table 5.2-2), three are not in use and the other three are apparently contaminated by direct entry of pollutants due to carelessness of users or poor environmental conditions. For example, well No. 292 that showed the highest concentration of ammonia nitrogen has an important source of contamination, that is, the dumping ground in the proximity. As for well No. 341, although local people claimed that the well is covered with tree branches to avoid entry of foreign matter, it is not an appropriate method. It is possible that pollutant on the tree branches fall in the well when they are removed before using the well. There should be no ammonia nitrogen in the subterranean water unless human/animal excrement or bodies enter the wells. From the results of this research, we conclude that direct contamination from the ground surface is the cause of the presence of ammonia nitrogen.

5.2.3 Diseases caused by water

A survey on the conditions of diseases caused by water in the Kiffa region was conducted by interviewing doctors of the National Kiffa Hospital constructed under Chinese assistance. A recent example was the outbreak of cholera in some villages of the Kiffa region from April to June this year, as the result of which a total of 108 people were hospitalized. A survey data of how the patients' families obtained drinking water showed that none received water from the municipal water supply truck. Most patients used private shallow wells as source of water, with no disinfection and they seldom boiled water before drinking. Among all patients of the above mentioned hospital, symptoms of dysentery and common diarrhea were most prevalent, with over 2,000 patients per year.

There are also about 100 patients of bilharziasis. Apart from water in reservoirs (only during the rainy season), some shallow wells may be the source of contamination of bilharziasis.

Cases of intestinal parasitic diseases are also frequent in the Kiffa region: over 1,000 patients per year. As for other diseases, the results of blood tests conducted by the hospital revealed that 106 out of 250 samples were infected by the hepatitis B virus, a high rate of 41.6%.

5.3 Initial environmental evaluation (IEE)

5.3.1 General environmental situation of the study area

(1) Social environment

Kiffa is the capital of the state of Assaba, and the administrative and commercial center of the state. There are no concrete statistical figures about the city population, but it comprises a total of 11,000 households with an average of six members per household. Therefore, the population is estimated to be around 66,000. Mauritanians are said to be originally nomads, but in recent years nomads have been flowing into urban area, raising the proportion of the population involved in commerce and agriculture, and their residence tends to be fix. The population of Kiffa city has been rising since 1977 at a yearly rate of 3%, and the number of nomads has been decreasing rapidly, from 17,000 in 1977 to 5,200 in 1988 and to less than 3,000 as of 1997. Infants under 4 years old account for about 20% of the total population, and people in adolescence about 23%.

A total of five marketplaces headed by the Central Market at the center of the urban area constitute the center of commercial activities. In addition, a few pharmacies and other retail outlets are dispersed. Since electrification in 1990, small-scale factories are beginning to appear, but considering the small number of factories and workers, they do not constitute a major industry. Farming and pasturing remain the source of income of the majority of the population. However, apart from some farmers who own shallow wells for agricultural use, many farmers cultivate rainfed fields, which have been producing little harvest of vegetables due to successive years of drought. Food productivity has been extremely low, and so is the level of income of the residents. Many households suffer from poverty. World Vision, an NGO body, estimates that a family of six in Kiffa city requires 21,000 UM a month to sustain a living, but in reality, the average monthly income per household is only 7,000 UM.

With regard to education in the Kiffa region, elementary school attendance is 53% for boys and 27% for girls. In addition, 18% of boys and 4% of girls quit school before graduation. The reason suggested to explain this low school attendance is that people are unable to afford textbooks and school materials due to poverty, and that children are required to join the work force at a young age in order to support the family financially. The illiteracy rate as of 1993 was as high as 70%.

Medical facilities consist of the National Hospital of Kiffa constructed at the center of the city under Chinese assistance during the 1960s, with three health centers and one obstetrics/gynecology and pediatrics clinic outside the urban area. These facilities and the number of doctors are far from being sufficient, and there is a lack of medical equipment. At the National Hospital of Kiffa, important surgeries cannot be operated due to a lack of blood transfusion equipment and oxygen inhalers, and they are unable to provide sufficient emergency treatment. In particular, deaths of the newborn babies or the mothers at delivery are frequent. The death rate of babies in Mauritania is as high as 132/1000, and Kiffa is no exception. Apart from death at delivery, there are many cases of infantile death caused by diarrhea, malnutrition and malaria. Needless to say, the major causes for such deaths are poverty and aggravating hygienic conditions, but also because of the low education level, parents do not have basic knowledge about health control for their children. Whether the disease is fatal or not, parents rarely take their children to a doctor until they collapse.

The current situation of water supply facilities is as stated above (5.2 Hygienic conditions of the city). No sewage facility is installed. Most households in the urban area have a soil infiltration-type lavatory. This is made by simply digging a pit to pool excrement, of which the fluid substance infiltrates naturally into soil to leave the pit dry. A very few buildings have flush toilets, but the excrement is treated in the same way. A number of households do not use a toilet but use vacant land for the purpose. Wastewater from washing clothes or cooking is drained onto the ground. As the ground is covered with sand, even a large quantity of wastewater from the laundry infiltrates quickly down into the ground after flowing for five meters or so. Rainwater is drained into the Wadis.

There is no garbage collection or processing in Kiffa city. Garbage from families and markets is dumped on vacant land and allowed to dry naturally. Incineration of garbage in gardens is frequently seen. World Vision, an NGO body has provided several donkey-drawn garbage collection carts, but as the garbage collection is not organized, hardly any of them are in service.

(2) Natural environment

Kiffa city is located in the Sahel region at the south of the Sahara Desert, a dry region with high temperature and little rain. In the urban area there are Wadis extending over 25 km, including the Wadi of Khoda, but the flow of water can be seen only between July and September, i.e., during the period of concentrated rainfall. In this season, water is pooled in lowlands in the city, making several natural reservoirs. Some people use the water from these reservoirs for livestock, washing and bathing, but as the water is not permanently present, reservoirs cannot be used as a water resource. Since shallow ground water that is currently used depends on the quantity of recharge, there is a potential of constant water shortage following an increasing demand in water.

Especially between 1989 and 1992, annual rainfall fell continuously from 375 to 124 mm, causing a serious situation in which the water level in the wells fell, or some wells ceased to function. Since 1993, rainfall has been regaining its average level, but no improvement has been seen in the situation of underground water. As shown in the result of the well water salinity measurement conducted as a part of this study, underground water in some regions has already become saline and unsuitable for drinking. Although we cannot jump to a conclusion due to lack of a long-term observation data, the lost balance between incoming and outgoing water including recharge, evaporation and use of water may be considered as one of the causes for high salinity.

Sandstorm occurs in the windy season. This is a major cause of desertification. Due to dryness, vegetation is scarce in the study area, not a suitable living environment for wild animals.

(3) Pollution

As there is hardly any industry and the population density is low, pollution problems are few in the study area. However, the well water quality analysis shows artificial contamination of shallow ground water. Infiltration of raw sewage and wastewater into the ground, and animal excrement and other wastes are considered as possible sources of contamination.

5.3.2 Initial environmental evaluation (IEE)

Purposes of initial environmental evaluation (IEE) are: [1] to evaluate global impacts of a subterranean water development project on the natural and social environment, and [2] to examine the necessity of environmental impact assessment (EIA) upon execution of a project. This evaluation shall be carried out in compliance with the "Guidelines of environmental consideration (subterranean water development section and water supply section)" compiled by the Japan International Cooperation Agency (JICA).

(1) Environmental impact evaluation matrix

Table 5.3-1 shows environmental evaluation factors given by the guidelines and the matrix of impact factors generated by execution of a subterranean water development plan. Under the three categories of social environment, natural environment and pollution, 23 factors shall be evaluated. As for the impact factors, i.e., items of the project, drilling of wells and water supply facilities for the construction phase and water intake from wells and water supply for the operation phase were considered.

According to the results of field study, impacts were evaluated for each item of the project and environmental factors, based on the assumption of content and scope of project to be executed. The presence or absence of environmental impact and extent of impact were classified into four grades: favorable impact, possible impact, serious impact, and no impact, and the result of evaluation was entered in the matrix of Table 5.3-1.

Table 5.3-1 Initial environmental impact evaluation matrix

Environmental factors		Content of project			
		Construction phase		Operation phase	
		Drilling of wells	Installation of water supply facilities	Water intake from wells	Water supply
Social environment	Moving of residents				
	Economic activities			O	O
	Transportation and living facilities	△	△	O	O
	Division of region				
	Historic sites and cultural properties				
	Rights of water and membership				
	Public health and hygiene			O	O
	Wastes	△	△		
	Disasters				
Natural environment	Geographical and geological features				
	Soil erosion				
	Subterranean water	△		△	
	Conditions of lakes, ponds and rivers				
	Coast and sea				
	Animals and plants				
	Weather				
	Landscape				
Pollution	Air pollution				
	Water pollution				
	Soil pollution				
	Noise and vibration		△		
	Ground subsidence				
	Stench				

O: Favorable impact anticipated
X : Possibility of serious impact
△ : Possible impact
Shaded part : No impact anticipated

(2) Evaluation criteria

1) Social environment

Since execution of a subterranean water development project will enable the supply of tap water to satisfy both the quantitative and qualitative demand of Kiffa city, the living standard of the population is expected to improve. In addition, if the deep ground water can be used in daily life, the quantity of shallow ground water used in the urban area is expected to be substantially reduced. By converting this surplus into farming water for vegetable cultivation, development of agriculture and related industries can be promoted. Therefore, favorable impacts at the operation phase can be expected in "economic activities" and "transportation and living facilities." Following the construction work of water source and distribution facilities in the construction phase, an increase in traffic might affect the daily life of some residents, but this impact shall be limited to the urban area in which houses are relatively concentrated.

A subterranean water development project must affect the business of some 300 water sellers using donkey carts who are currently very active. Compared with the improvement in the life of tens of thousands of citizens, such an impact may not require special consideration upon execution of the project. Promotion of economic activities such as agriculture mentioned above is expected to generate new working opportunity for the water sellers.

Many residents of Kiffa city have been using water of a quality unsuitable for drinking, and it is clear that there has been a negative impact on health due to diseases caused by water. Execution of the project is expected to generate a favorable impact on hygiene, thanks to the supply of drinking water of better quality. By supplying a sufficient quantity of water and by converting the water used in daily life to other purposes, a greater amount of water can be used for washing, bathing, installation of flush toilets and for a cleaner environment, resulting in improved personal and environmental hygiene. With an increase in the use of tap water, sewage shall also increase. Following improvement of water-related services, an increase in the population of Kiffa city is expected, and therefore the increase of contamination must be taken into consideration. However, current water contamination in Kiffa city seems to be caused by inefficient hygienic control rather than dense population or excessive generation of contamination. This problem shall be examined in detail at "settlement of hygiene improvement plan" in the third phase of this study.

With regard to rights to subterranean water, the water law of Mauritania (law No. 85-144) explicitly states that the subterranean water on state-owned land and on the land owned by public organizations (including wells and other water sources) is national property. Therefore, the nation retains the right to develop and to exploit such subterranean water sources. On the other hand, the rights for drilling of wells and exploitation of subterranean water on private land are of an individual nature that does not require any approval of the water utilization department. Water sources of this subterranean water development project do not extend to private land, so no conflict relative to water rights is expected to arise.

At the phase of drilling of wells and construction of water supply facilities, excess earth from construction work and other wastes shall be generated. Waste disposal should not be a serious problem in Kiffa city, where there is plenty of vacant land, but precautions must be taken to avoid any possible disturbance in the life and economic activities of the residents.

The subterranean water development project is not of such a nature as leads to moving of the population or to division of the region. There are no historic sites or cultural properties in the development areas. Moreover, no possibility is anticipated that any disaster shall be caused by this project.

2) Natural environment

Since this subterranean water development project concerns inland regions, it shall not affect any coast or sea area. In the development areas, there are Wadis in which water flows from time to time during the rainy season, but no rivers, lakes or ponds with constant water flow. Considering the size and content of the project, no impact is anticipated on any environmental factors, i.e., geographic or geological features, soil erosion, animals and plants, weather, or landscape. Therefore, should there be any matter of concern among the eight factors regarding the natural environment, the only one might be the impact on "subterranean water." The underground water level might be lowered due to pumping. Especially in the case in which subterranean water is exploited in the vicinity of the urban area, special attention should be paid to the impact on the shallow wells that are currently most commonly used. For this purpose, the issue of lowering of the underground water level shall be closely examined at the same time as general evaluation of the quantity of subterranean water at the second phase of this study.

3) Pollution

Since the subterranean water development project shall not generate any contaminant, there shall be no negative effect leading to air pollution, water pollution, soil pollution or problem of odors. Noise and vibrations shall be generated in the course of construction work. In the case in which wells are drilled in the vicinity of the urban area, noise and vibrations caused by drills may affect the life of local residents.

Subsidence caused by subterranean water exploitation will not take place because the aquifer is composed of hard bedrock and overlying layer is sand. Since this is a subterranean water development project for the purpose of supplying water, no large-scale pumping is expected, but in the case of subterranean water development in the vicinity of the urban area, it is recommended to conduct long-term observation of the underground water level.

(3) Necessity of environmental impact assessment (EIA)

In the initial environmental evaluation stated above, none of the 23 environmental factors in Table 5.3-1 represent any possibility of serious impact. Even for the five factors that might be affected, impact can be minimized by taking necessary measures upon execution of the project as stated in 2). Therefore, there is no need to conduct an environmental impact assessment at the next phase.

Chapter 6 Groundwater Development Plan

6.1 Development plan of groundwater at shallow aquifer in Kiffa

In the development plan, the potential capacity of shallow groundwater pumped up from about 1,000 shallow wells in the city of Kiffa is 240,000 m^3/year, as reviewed in Chapter 3. In contrast, the present pumped volume is 330,000 m^3/year. In the year 2000, when water can be conveyed from the northwest water source area, the potential development volume will increase to about 300,000 m^3/year, assuming that about 10% of the conveyed water may permeate through the ground. If sewer systems are built in Kiffa by the year 2015, this underground water permeation will become unavailable. In view of these factors, the development plan of groundwater at shallow aquifer in Kiffa will be implemented according to the timetable as shown in Table 6.1-1. This means that the water supply and demand will balance in 2005 if the present water pumping is regulated and the volume of pumped water is reduced by about 9% to keep its level at 300,000 m^3/year. Given that the sewage system building projects start in 2010, it is desirable to enhance the cut of water pumping more aggressively and to reduce the volume of pumped water by about 27% in 2015.

Table 6.1-1 Development plan of groundwater at shallow aquifer in Kiffa

Unit: m^3/year

	Present	2000	2005	2010	2015
Projects		Construction of water supply facilities	Regulation of water pumping -9%	Regulation of water pumping -17%	Building of sewage systems Regulation of water pumping -27%
Water buildup by rainfall	300,000	300,000	300,000	300,000	300,000
Water permeation of water conveyed from the northwestern district	0	73,000	73,000	73,000	0
Maximum available pumped water	240,000	298,000	298,000	298,000	240,000
Pumped water	330,000	330,000	300,000	274,000	240,000
Water balance	-90,000	-32,000	-2,000	24,000	0

6.2 Groundwater development plan in the northwest water source area

(1) Volume of groundwater in the development planned in the northwest water source area

The potential volume of groundwater available from development in this northwest water source area totals 1,200,000 m^3/y, as examined in Chapter 3.

The present volume of pumped water in each region is as follows. In region A, only a dozen shallow wells are available in the riverbed of Khouda Wadi to supply water for daily life and water for small-scale irrigation for village residents. In region B, there is only one shallow well to provide drinking water for domestic animals. In region C, in addition to about 20 shallow wells, there is one deep well that is used to supply water to a solar water supply system for the village of Kandra. The present pumped water volume in this catchment area is estimated at as little as 1.5% of the developable capacity as shown in Table 6.2-1, an amount that is practically negligible.

Given these facts and the water demand, the Groundwater development plan in the northwest water source area should be as shown in Table 6.2-1. The planned pumped water volume in the northwest water source area is 730,000 m^3/year in 2005 and 1,150,000 m^3/year in 2015. This means that the groundwater development in this area is sufficient to fill the water demand of Kiffa until 2115.

Table 6.2-1 The Groundwater development plan in the northwest water source area

Unit: m^3/year

Groundwater basin	Built-up water volume	Volume available for pumping	Present pumped water volume estimated	Plan 2005	Plan 2015	Wells in use
Region A	800,000	640,000	5,000	560,000	600,000	JF-2,JF-5A, JF-7B,F-5,F-6
Region B	210,000	170,000	2,500	170,000	170,000	JF-13A
Region C	490,000	390,000	10,000	0	380,000	About 4 new wells
Subtotal	1,500,000	1,200,000	18,000	730,000	1,150,000	
Shallow wells in the city	---	---	---	300,000	240,000	
Total water supply				1,030,000	1,390,000	
Water demand				1,026,000	1,387,000	

(2) Development plan targeted for 2005

1) Location of production wells

Based on the result of the series of hydraulic and geological studies mentioned in Chapter 3, a single promising water source was identified at a point 10 to 15 km to the northwest of Kiffa. In the Groundwater development plan toward the target year of 2005, six wells that afford ample volume of quality water will be chosen from the wells test-bored for this survey and from the existing deep wells yet untapped. These wells will be converted for actual water production. The location of the test-bored wells to be put into actual production is shown in Fig. 6.2-1.

2) Structure of the production well

The structure of the test-bored wells to be converted for actual production is shown in "S-1 Test boring survey" in the supporting report. Their specification is shown below;

Table 6.2-2 Structure of the production well

Groundwater basin	Well No.	Aquifer	Bored length	Well diameter	Volume of pumped water	Section in which strainers are installed
A	JF-2	Pelite	58.0m	6 inch	9.5m^3/h	GL-23m GL-39m
	JF-5A	Pelite	62.0m	6 inch	7.2m^3/h	GL-24m GL-52m
	JF-7B	Pelite	46.0m	6 inch	18m^3/h	GL-11m GL-40m
	F-5	Pelite	66.0m	6 inch	54m^3/h	GL-8m GL-40m
	F-6	Pelite	42.0m	6 inch	70m^3/h	GL-11m GL-39m
B	JF-13A	Pelite	253.39m	6 inch	37m^3/h	GL-19m GL-47m

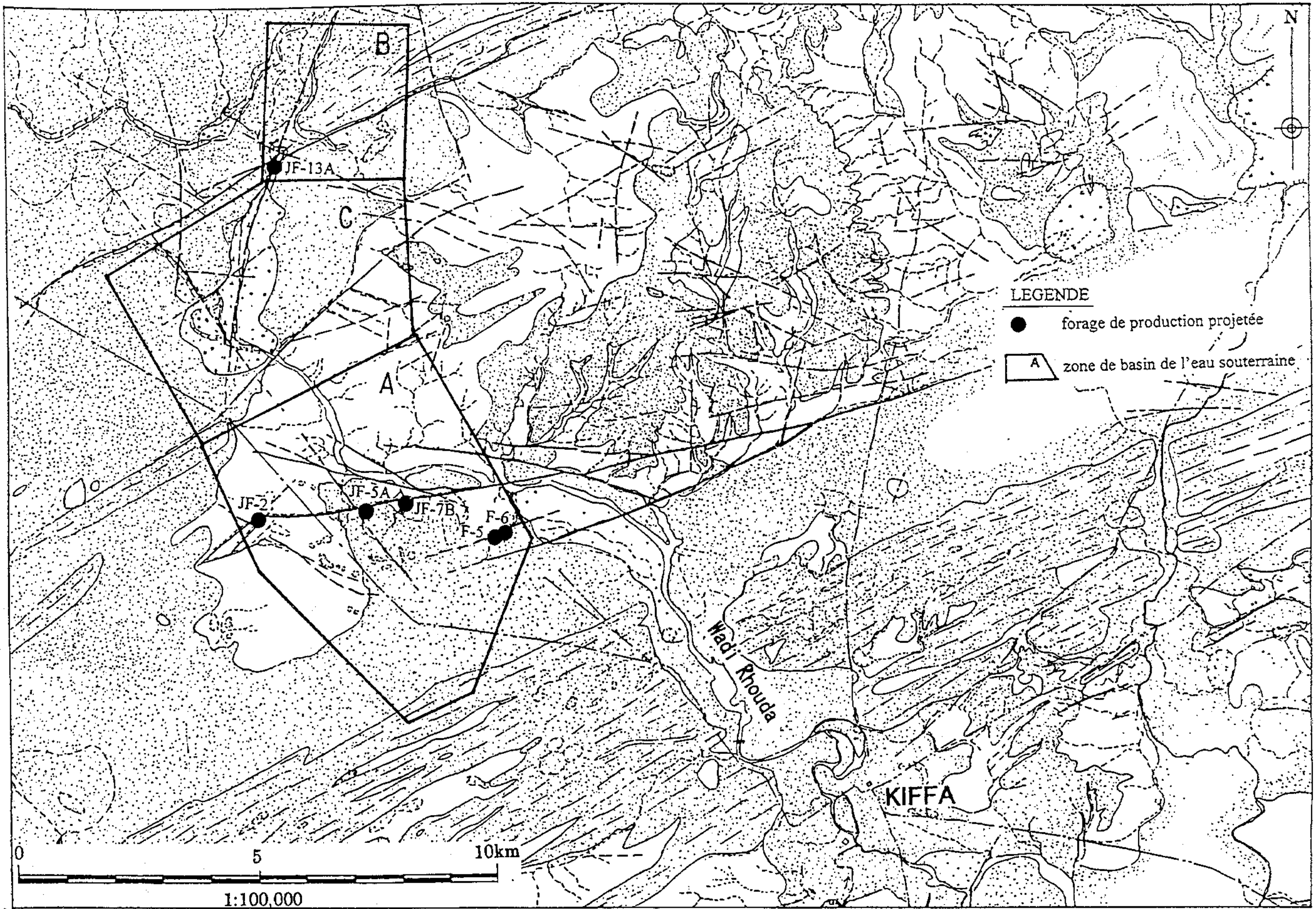


Fig. 6.2-1 Map of groundwater basin and the location of deep wells to be used for the water supply plan

(3) Development plan toward the target year of 2015

1) Location of the production wells

As stated in (1), the Groundwater development plan toward the target year of 2015 needs the boring of new wells in the development zone shown as C in Fig. 6.2-1.

Zone C has a fault running from the north to the south, along which groundwater is assumed to flow. Consequently, production wells should be located along this fault. The present test boring survey, however, has shown that even a small deviation from the fault may result in virtually no groundwater production. Therefore, in making a location plan for production wells, it is crucial to determine the position of the fault. This underscores the importance of a preliminary survey.

The result of the present survey has proved the effectiveness of horizontal electrical prospecting. Therefore, in the future Groundwater development plan in Zone C, horizontal electrical prospecting and surface survey should be conducted first to determine the position of the fault before making a plan for the location of wells.

2) Specification for the boring of production wells

In the Groundwater development plan toward the target year 2015, the specification of the well will be same as that of the test-bored well in the present survey. The standard well structure is shown below:

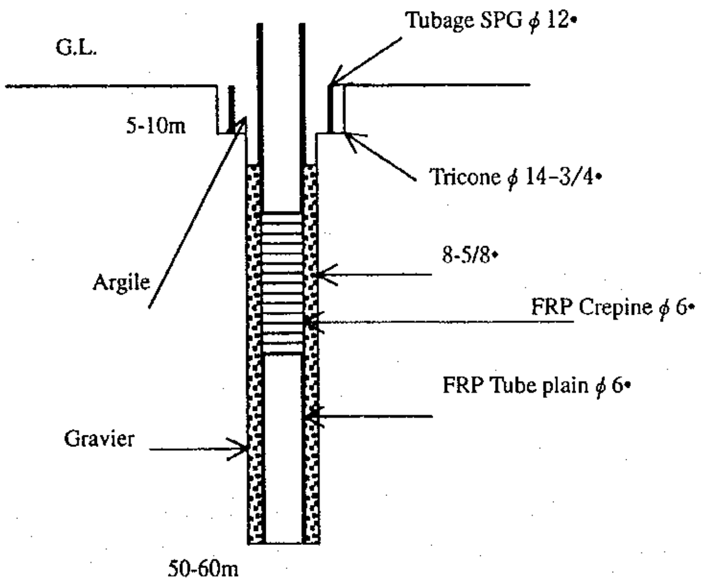


Fig. 6.2-2 Standard structure of the well in the water supply plan toward the target year 2015

The above standard well structure is shown for reference only. The actual well structure and depth and the number of wells will depend on the hydrological and geological site conditions.

6.3 Groundwater management plan

(1) Management plan of groundwater at shallow aquifer in Kiffa

1) Conservation of good quality groundwater

As reviewed in Chapter 3, groundwater of relatively good quality is distributed and available in the still underdeveloped area to the northwest of Kiffa. Because areas where safe water is available like this area are extremely limited, it is believed that groundwater in this area is very important as a future water source of Kiffa.

Accordingly, it is desired that the city authority take groundwater conservation measures such as regulating development activities in this area.

2) Regulation of water pumping

As stated in "Development plan of groundwater at shallow aquifer in Kiffa," an excessive amount of groundwater is now pumped up in Kiffa as the volume of groundwater now developed in Kiffa exceeds the built-up groundwater volume. Therefore, parallel with the completion of water supply facilities, the volume of pumped water should be limited in future.

To implement the regulation of water pumping, all the wells both new and existing should be registered under control by the administration, which should regulate water pumping from wells whose water level is continuously going down or from wells of poor water quality. The record book prepared by the present survey will be very helpful in registering the existing wells.

(2) Management plan in the northwest water source area

1) Monitoring of groundwater level

At present, in order to observe groundwater level, recording water gauges are installed on the test-bored wells which will be converted to the production well in future. When the water supply facilities are completed in future, these gauges will be re-installed on other test-bored wells to record any fall of water level in catchment areas due to groundwater development.

The condition of test-bored wells in the present survey and the wells installing recording water gauges are shown in the table below. The location of the wells is shown in Fig.6.2-1. As is evident from the table, the wells scheduled to be used as the production well have their well-head protected by concrete for easy installation of recording water gauges. Most of the wells on which recording water gauges will be re-installed in the future, however, have their well-head unprotected in spite of the installation of inserted casings. This condition can be the cause of foreign materials accumulating in the gap between the casing and the wall of the well, so the well-heads of these wells need protection urgently.

Table 6.3-1 Wells with recording water gauge

Well No.	Well condition	Well now installing recording water gauge	Well to re-install a recording water gauge in future
JF-1	×		
JF-2	○	★	
JF-3	△		★
JF-4	△		
JF-5	△		★
JF-5A	○	★	
JF-6	△		
JF-7	×		
JF-7A	○		★
JF-7B	○	★	
JF-8	○		
JF-8A	×		
JF-8B	×		
JF-9	×		
JF-10	△		
JF-11A	×		
JF-11B	△		★
JF-12A	△		
JF-12B	△		★
JF-13A	○	★	
JF-13B	×		
JF-14	△		
F6	○	★	

○ Well having both casing pipe and protected well-head
△ Well having a casing pipe but no protected well-head
× Re-filled well now out of use

2) Monitoring of water quality

Water of the wells that will be converted for production wells in the future is generally good in quality and fulfills the requirements for potable water. It should be noted, however, that groundwater high in salinity is variably spotted in the northwest water source area, and the possibility of such high-salinity groundwater being mixed cannot be avoided.

In this regard, each production well should have a water quality inspection twice a year, including the measurement of salinity (TDS).

The inspection should cover the following 29 items in accordance with the "Standard for the quality of potable water (Draft)" in Mauritania: Chromaticity, turbidity, bad smell and taste, matters visible to the naked eye, pH, total hardness, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, chlorine ions, sulphate ions, COD, iron, manganese, zinc, copper, volatile phenol, anion active agent, TDS, fluorine, cyanogen, arsenic, cerium, cadmium, mercury, hexavalent chromium, lead, bacteria, colon bacilli.

3) Water quality conservation measures

Because the northwest water source area is sparsely inhibited, the groundwater contains no contaminants such as nitrite nitrogen or colon bacillus derived from human activities. However, groundwater in this area is found in a shallow, non-pressurized strata and is extremely vulnerable to surface contamination. In view of the fact that groundwater in the same shallow, non-pressurized strata in the urban region of Kiffa is widely contaminated by nitrite nitrogen and colon bacilli, it is evident that any development activities carried out in the northwest water source area will contaminate groundwater in the region.

Consequently, it is judged that a water source conservation area should be set up in the northwest water source area, where pasturing and other agricultural activities as well as housing development activities should be strictly regulated or prohibited. Such a water source conservation area should be located in groundwater basins A, B and C, shown in Fig. 6.2-1.

Chapter 7 Water Supply Plan

7.1 Contents of the project

The contents of the project in the water supply plan are as follows.

(1) Target years of the plan

Target years in the water supply plan should be the periods for both urgent and long-term improvement plan. They are set as follows.

a. Year 2005: Urgent improvement plan
b. Year 2015: Long-term improvement plan

(2) Developable amount of underground water

According to the valuation of recharge storage stated in Chapter 3.4, the developable amounts of underground water are established as follows.

a. Points of development as water sources

Water sources should be the northwest water source (a water source 12 - 20 km northwest of the city; see Fig. 6.2-1) and the underground water at shallow aquifer in the city.

b. Developable amount

The developable amounts of underground water are as shown in Table 7.1-1.

Table 7.1-1 Developable amounts of underground water

Plan year	Northwest water Source		Underground water at shallow aquifer	Total
	Areas A and B	Area C		
2005	730,000	0	300,000	1,030,000
2015	770,000	380,000	240,000	1,390,000

(3) Area covered by the plan

Kiffa city has an area with a radius of 20 km from the central part as its administrative district. This consists of the urban district and 6 independent neighboring communities. The area to be covered by the water supply plan should be the urban district.

(4) Population served by the plan

1) Current population

The area to be covered by the water supply plan is the urban district where the population is estimated to be 60,921 (as of 1997)(See Table 4.2-1)

The population in Kiffa city was 29,292 in 1988 according to the latest census, and there is no accurate data about it now. The above-mentioned population was based on the result of consideration of the policy of expansion of the Kiffa city district, in addition to the survey carried out in 1997 by the Planning Ministry. In the Planning Ministry survey, population was estimated by the number of houses seen in air photos and the typical number of family members in one house, and is the most reliable.

The classification of areas used in Table 4.2-1 is same as presented in the Planning Ministry surveys, and allows for appropriate classification of the present situation in Kiffa city. These are as follows.

I : Old urban distract

II : New urban district developed under the plan

III : Area where development has advanced spontaneously.

2) Population in the plan

Populations in the target years of the plan, 2005 and 2015, are examined. Regarding the population in 2005, as shown in the social survey, there are three surveys that are the bases of our survey; the "Survey in Ten Cities for the Plan of Improvement and Completion of Water Supply" by the Ministry of Water and Energy, the "Urban Panning of Kiffa city, 1995" by Mauritania Employment Promotion Public Corporation (AMEXTIPE) and a forecast of 1997 based on the census carried out in 1988 by the National Statistics Bureau (OCN). Partly because these surveys were carried out at different times, there are considerable differences in the present population and the rate of increase as shown in Table 7.1-2.

Table 7.1-2 Forecast of population

Survey	Population at the time of the survey	Rate of increase (%)	Population in 2005
National statistics bureau (OCN 1988)	29,292	5.0	68,533
Survey in ten cities (1995)	31,556	4.1	54,300
Urban planning (1997)	59,506	2.9	74,800

Each population in 2005 was calculated using the respective report by the JICA survey group.

It was stated in the 10 cities survey that population would continue to flow in and increase over a considerable period. However, the urban planning, survey suggests the rapid anchoring/inflow in the '80s has come to an end, and the rate of annual increase in population of 2.9%, indicating relative stability, was adopted as the average for the whole city. The current population, a base of a forecast of population, in the survey in 10 cities was based on the result of the census, while what was used in the urban planning was figures based on their original survey and using the number of houses seen in air photos.

According to the national survey regarding migration carried out by the National Statistics Bureau, nomads accounted for 35% of the population in 1997 as opposed to 12.1% in 1988. This means that one-sided urbanization will not occur, and concentration in the capital, Nouakchott, from local cities is pointed out.

Therefore, based on the survey for the urban planning in 1997 as follows, and with the rate of annual increase of 2.9%, the populations in the plan were established as shown in Table 7.1-3. Though these results are slightly over the population forecast 2005 in the other two surveys stated above, they are almost equal to those forecast for 2015 in these surveys.

Table 7.1-3 Current population and population in the plan

Year	Population (persons)	Population in each area	
		I and II groups	III group
Current (1997)	60,921	36,975	23,946
2005	77,000	50,000	27,000
2015	100,000	80,000	20,000

(5) Planned amount of water supply and demand

1) Planned amounts of water supply

In consideration of the conditions in Kiffa city, situated in the inland dry zone in Sabusahara, the small amount of rainfall, limited recharge storage, rapid increase in population, etc., reliable sources of water are important. With regard to the developable amount of underground water around Kiffa city stated in Chapter 5, development of underground water will not be possible unless a water supply unit is kept low.

Therefore, although it is indispensable for urban hygiene to supply safe water, the amount of water planned to be supplied in 2005 should not be increased drastically from the present amounts of water used, and users' ability to bear a financial burden should be taken into consideration. In addition, the planned amount should be the amount of water supplied, which includes the consumption at the existing shallow wells in the city (10 liters/person/day).

Observation of social and development conditions in the city clarifies the areas where pipes for water supply to each house cannot be laid, and the presence of residents who cannot afford the costs of household water supply. Therefore, a the public water tap system is indispensable.

For these reasons, the planned amount of water supplied in each supply system is determined as shown in Table 7.1-4.

Table 7.1-4 Planned amount of water supplied in each supply system

Target year	Water supply system	Population covered by water supply	Amount of water supplied (little/person/day)
2005	Water supplied to each house	50,000	40 (10 of which are underground water at shallow aquifer)
	Public water tap	27,000	30 (10 of which are underground water at shallow aquifer)
	Total	77,000	
2015	Water Supplied to each house	80,000	40 (10 of which are underground water at shallow aquifer)
	Public water tap	20,000	30 (10 of which are underground water at shallow aquifer)
	Total	100,000	

These planned amounts of water supplied almost correspond to the target value in the basic water-supply policies in Mauritania, 40 liters/person/day, described in 4.1-(5).

2) Planned amounts of water demand

In order to calculate the demand for water, classification into water supply for individual houses and public water taps is made. In this case, the amounts of demand should be planned with classification of areas according to the progress of area development stated above. Areas I and II are classified as areas with water supply for individual houses, and Area III is classified as an area with a public water tap system.

Kiffa city's authorities are now making an urban plan for areas classified as Area III (burgeoning areas where unplanned development is being carried out) in the 2005 plan. Re-development is planned to be carried out in these areas. Accordingly, it is considered the rate of Area II (areas under development based on the urban plan) increases. Therefore, demand for water is estimated in the 2015 plan by raising the rate of water supplied to individual houses to 80%.

Annual amounts of water demand in 2005 and 2015, which are calculated in the above-mentioned manner, are as shown in Table 7.1-5.

Table 7.1-5 Amounts of water demand in each target year

Target year	Water supply system	Population covered by water supply	Amount of water demand (m^3/year)
2005	Water supply for individual houses	50,000	730,000
	Public water tap	27,000	296,000
	Total	77,000	1,026,000
2015	Water supply for individual houses	80,000	1,168,000
	Public water tap	20,000	219,000
	Total	100,000	1,387,000

7.2 Water supply plan

7.2.1 Basic policies

Public methods of water supply for the approximately 60,000 residents, or about 10,000 households, in Kiffa city are only three water-supply wagons owned by the city. Otherwise, What residents can do is only to draw water by hand from a nearby well (among about 1,000 wells in the city), or to buy water from water sellers who use a donkey to draw a cart loaded with a water tank. These methods of supply limit residents' use of water to 20 liters or less per day.

Underground water at shallow aquifer in the city is polluted by dirty water after daily use, and human and animal waste. This water reaches the level unsuitable for drinking. Conditions of pollution indicate that contaminants directly get into wells from the surrounding area. They also indicate that the aquifers themselves are polluted.

(1) Development of sources of water

Except in a few places, pollution of underground water at shallow aquifer in the city is advancing. In addition providing sufficient quantity, it is necessary to newly develop sources of safe water.

As described in Chapter 3, in the survey district with a radius of 20 km from Kiffa city, only one promising source of water located 10 - 15 km northwest of the city could be specified as a source of water for urban planning. Therefore, the development areas covered by the water supply plan are aquifers with a depth of 50 -100 m around faults in these pelite strata.

It is judged that the sustainable and developable annual amount of underground water in these water source areas is about 1.2 million m^3 in total, and that the demand in 2015 will be able to be satisfied if it is properly controlled. On the other hand, the Ayoun sandstone east of Kiffa city is a possible source of water according to the hydrogeologic surveys in this survey. However, since it was evaluated that a large developable amount of water could not be expected, the Ayoun sandstone is not considered as part of the development plan with preventive measures for water quality.

Instead, among existing wells with relatively good quality water that exist in the city, wells usable for drinking were specified based on the detailed water analysis in this survey. They are taken into consideration as sources of water for the water supply plan with preventive measures for water quality.

(2) Water supply plan

Pollution of currently-used underground water at shallow aquifer in the city is serious, and obtaining a supply of drinking water from new sources is an urgent problem. In consideration of existing conditions such as the inland dry zone in Sabusahara, small amount of rainfall, limited recharge storage and a rapid increase in population, reliable water sources are extremely important, and a water supply unit must be restricted as much as possible. Observation of social and developing conditions in the city reveals areas where there are no road, which are necessary for installation of water pipes for supply to individual houses, and also the existence of residents who cannot afford the cost of water supply to each house. Therefore, we consider the system in which water supply for individual houses and public water taps are mixed.

Forty liters/person/day was determined as the planned amount of water to be supplied to individual houses in this water supply plan. To achieve this, it is necessary to control, in a practically effective manner, the amount of water used. As a method for this, restricting of water supply to certain hours will be introduced.

(3) Operation of water-supply facilities

According to the central government's policies for non-governmentalization, work for urban water supply activity has been transferred to the Water and Electric Power Public Corporation (SONELEC), and operation, maintenance and management of water-supply facilities in villages has been entrusted to private undertakers. Introduction of operation by commercial companies has had a remarkable effect in managerial improvement. On the other hand, operation is carried out not from the viewpoint of the circumstances of poor users with public water taps but from the viewpoint of the administrators' circumstances (resulting in inconvenient placement, irregular operating hours, higher sales prices than those of water supply for individual houses, etc.). Consideration of public welfare is required.

Therefore, even if operation, maintenance and management of the main facilities are industrialized, operation for maintenance and management of public water taps, and systems to strengthen public service functions, including autonomous maintenance and management by residents' organizations, should be discussed.

7.2.2 Restriction of water supply to certain hours

As mentioned in Section 7.2.1, the sources of water around Kiffa city are limited. It is therefore necessary to take measures for restricting the amount of water used.

As a method for this, the system of restricting water supply to certain hours, which is generally adopted in Mauritania, is applied to this plan.

(1) Preconditions

Factors to be considered for restricting water supply to certain hours are as follows:

① Areas in which water supply will be restricted to certain hours, and what those hours will be, should be determined to ensure that water-supply facilities need will not be excessively large.

② The time periods of greatest water used (7 - 9 o'clock in the morning and 6 - 8 o'clock in the evening) should be taken into consideration when establishing water-supply hours.

③ The manual opening and closing of valves will be necessary to restrict water supply to certain hours. Attention should be paid so that enormous effort and cost will not be required for maintenance and management because the number of valves concerned will be great.

④ The pipe network should be planned so that a certain amount of water will be supplied to the whole service area even if a main duct is damaged by an accident.

⑤ The pipe network should be discussed on the assumption that residents will secure or consume the fixed amount of water supplied within the determined hours of water supply.

(2) Division of areas with restriction of water supply to certain hours

In Kiffa city, two urban districts spread out west and east of the Wadi Rhouda. Relatively independent pipe networks are formed in these western and eastern areas (see Fig. 7.3-3). Therefore, areas with restriction of water supply to certain hours are divided into two parts, eastern and western.

(3) Establishment of hours and time zones of water supply

In the case of restriction of water supply to certain hours, it is supposed that residents will use water simultaneously in the time periods of water supply so that a large amount of water will be used in a short period of time. There is the possibility that the amount stored in distributing reservoirs will be completely used during these periods, causing the inside of the distributing ducts to have negative pressure. Therefore, it is necessary to establish hours and time periods of water supply in order to prevent it.

In consideration of the above-mentioned preconditions, we examined changes the storage amounts in distributing reservoirs according to passage of hours of water supply in three cases: 7, 6 and 5 hours. The results are shown in figures 7.2-1, 7.2-2 and 7.2-3, respectively.

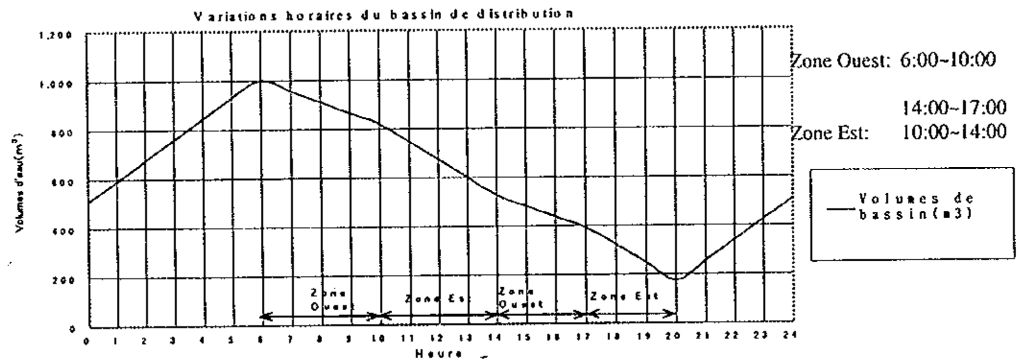


Fig. 7.2-1 Changes in storage amounts in distributing reservoirs based on passage of time (7-hour water supply)

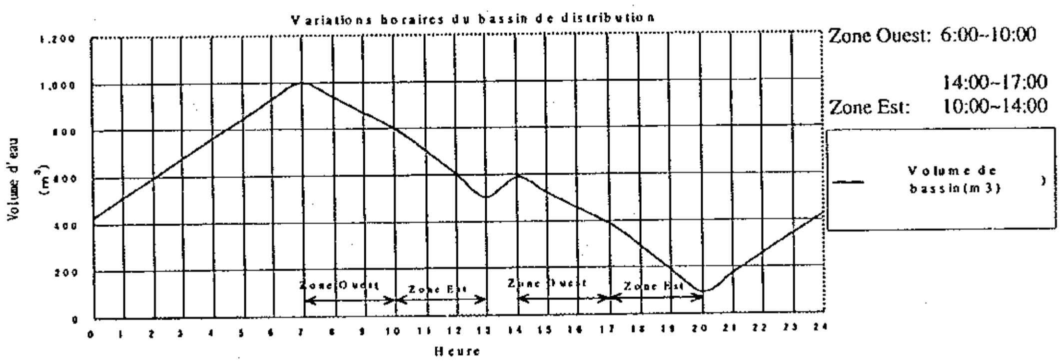


Fig. 7.2-2 Changes in storage amounts in distributing reservoirs based on passage of time (6-hour water supply)

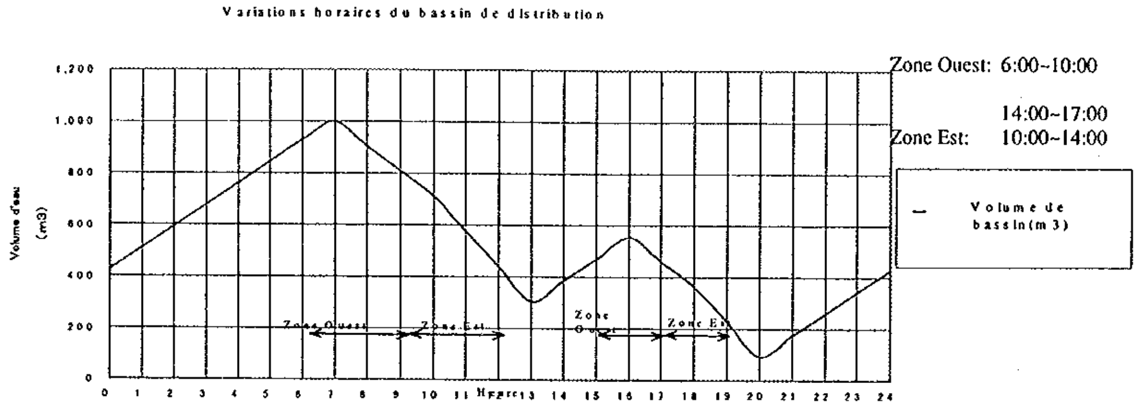


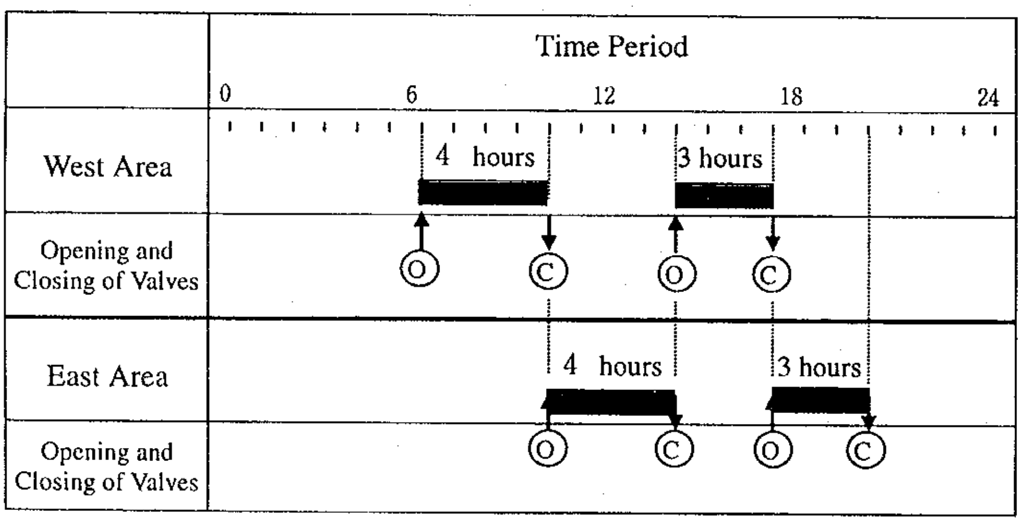
Fig. 7.2-3 Changes in storage amounts in distributing reservoirs based on passage of time (5-hour water supply)

As can be seen from these results, in the case of 5- and 6-hour water supply to the eastern area, the amount of storage in distributing reservoirs is as little as about 90 m^3 at the end of the supply period. There is the possibility that the amount of water storage will be 0 or less when the largest amount of water supply per day is recorded.

In addition, it is considered that 7-hour water supply is a limit in respect to maintenance and management. Therefore, a 7-hour water supply period is adopted.

Fig. 7.2-4 shows a one-day schedule for restricting water supply to 7 hours.

Fig. 7.2-4 Schedule for restricting water supply to 7 hours



C=Close O=Open

7.2.3 Contents of the water supply plan

The contents of the water supply plan are as shown in Table 7.2-3.

Table 7.2-3 Contents of the water supply plan

Target year and population	Contents of the plan
Urgent improvement plan (year 2005, 77,000 people)	• Development of water sources in the northwest water source area and Areas A and B • Construction of ducts for water conduction from the in the northwest water source area to inside of the city • Supply of drinking water by water supply through ducts (2 systems: one in the northwest water source area and one for wells in the city) • Preservation of quality of water at wells in the city (improvement of well structures and manually-operated pumps) • Use of underground water at shallow aquifer in the city as non-drinking water
Long-term improvement and Completion plan (year 2015, 100,000 people)	• Development of water sources in Area C in the northwest • Increase in supply of drinking water by water supply through ducts • Improvement of quality of underground water at shallow aquifer in the city • Restriction and control of pumping-up of underground water at shallow aquifer in the city

7.3 Facilities plan

7.3.1 Basic policies

(1) Facility specifications

The specifications of water-supply facilities should be determined based on a water supply source unit (30 liters/person/day) in the urgent improvement plan (2005), population in the plan, range of improvement and completion, etc. With an increase of facilities and equipment taken into consideration, a facilities plan should be made based on the following items, as shown in Table 7.3-1.

Table 7.3-1 Items to be considered when determining specifications of facilities

Main facilities	Items to be considered when determining specifications of facilities
Well/lift pump station	Determine the planned amount of water pumped up based on the safe amount of water pumped up determined from results of pumping tests at production wells in this survey. Select a pump suitable for the necessary amount of water to be pumped up, with the working ratio of the well taken into consideration.
Ducts for water conduction	Select a pipe diameter that will be able to conduct the necessary amount of water from each well at the minimum speed of a running stream or faster.
Water conveyance pump station	Construction of a new pump station for increasing the number of pumps is not economical. Therefore, in order to cope with the plan with 2015 as a target year, a civil engineering and construction plan in which the addition of at least one pump is possible, should be part of the urgent improvement plan.
Ducts for water conveyance	Because an increase of ducts will be possible for increasing the amount of water supply due to an increase in population, a duct plan capable of accommodating the planned amounts of water supply in 2005 should be made.
Distributing reservoirs	The increase of ponds should be easy. The specifications of facilities should be suitable for a water supply source unit of 30 liters/person/day in the urgent improvement plan. Future increases of distributing reservoirs should be taken into consideration for a facilities placement plan.
Water mains	Changes of laying water mains, accompanying an increase in the amount of water supply due to future increases in population, would require enormous construction costs and not be economical. It is possible, however, to increase or decrease the amount of flow in a duct by allowing a certain range of the speed of flow. Therefore, a duct plan should be capable of coping with the planned amount of water supply in 2015.

(2) Facilities plan

In consideration of the present situation of urban water supply systems in Mauritania, a facilities plan should be made with the following items taken into consideration so as to realize a water supply system featuring low construction cost and easy and low-cost maintenance and management, and will not cost much and which will be able to cope with a future increase.

① As a water supply method, distributing reservoirs should be put in high places in the city with water supplied by the natural down-flow method.

② Pipes to be used should be those of the pipe materials, types and diameter generally used in Mauritania.

③ The depth of laying of ducts should be the minimum required (1.0m).

④ Pumps whose parts will be easily obtained in Mauritania should be selected.

⑤ The design criteria applied in Mauritania, if any, should be conformed to. If there is no such design criteria, then design should be carried out with reference to Japanese criteria.

7.3.2 Design policies

Table 7.3-2 shows the summary of design conditions established according to the contents of the project (stated in 7.1) and the basic policies (stated in 7.3.1).

Table 7.3-2 Design conditions for the facilities plan

No.	Item	Design condition		Remarks
1	Target year	Year 2005	Year 2015	
2	Population in the plan	77,000 people	100,000 people	Estimated with the results of the on-the-spot survey
3	Maximum amount of water supplied per person per day			
	• Water supply for individual houses	30 liters/person/day (65% of population)	30 liters/person/day (80% of population)	
	• Public water tap	20 liters/person/day (35% of population)	20 liters/person/day (20% of population)	
4	Maximum amount of water supplied per day	2,000 m^3/day	2,800 m^3/day	("3" stated above) x Population in the plan
5	Time coefficient (for water ducts)	2.0		To be determined according to the actual conditions in Mauritania
6	Minimum running water pressure at the end of water branches			
	• Water supply for individual houses	1.0 kg/cm^2		According to the SONELEC criteria
	• Public water tap	0.5 kg/cm^2		According to the SONELEC criteria
7	Minimum speed of a running stream in a duct	0.3 m/s		With reference to Japanese criteria
8	Water pond capacity	Portion for 8 - 12 hours of the maximum amount of water supplied per day		To be determined according to the actual conditions in Mauritania
9	Pipe type			
	• Water conduction duct	Ductile cast iron pipe		Common in Mauritania
	• Water conveyance duct	Ductile cast iron pipe		Common in Mauritania
	• Water main	Hardened polyvinyl chloride (PVC)		Common in Mauritania
	• Water branch	Hardened polyvinyl chloride (PVC)		Common in Mauritania
	•Pipe equipped with a public water tap	Hardened polyvinyl chloride (PVC)		Common in Mauritania
10	Depth of covering earth to lay ducts under the ground	1.0 m		According to the SONELEC criteria
11	Population borne by a public water tap	500 - 700 people/tap		To be determined according to the actual conditions in Mauritania

7.3.3 Basic policies for the water supply system

7.3.3.1 Configuration of the water supply system

A water supply system is composed of the following facilities. The conceptual figure of the water supply system in this plan is shown in Fig. 7.3-1, and distances between facilities and differences in altitude are shown in Fig. 7.3-2. Basic design drawings of all facilities are as shown in the drawings.

① Well/lift pump station
② Water conduction duct
③ Water conveyance pump station
④ Water conveyance duct
⑤ Distributing reservoir
⑥ Water duct

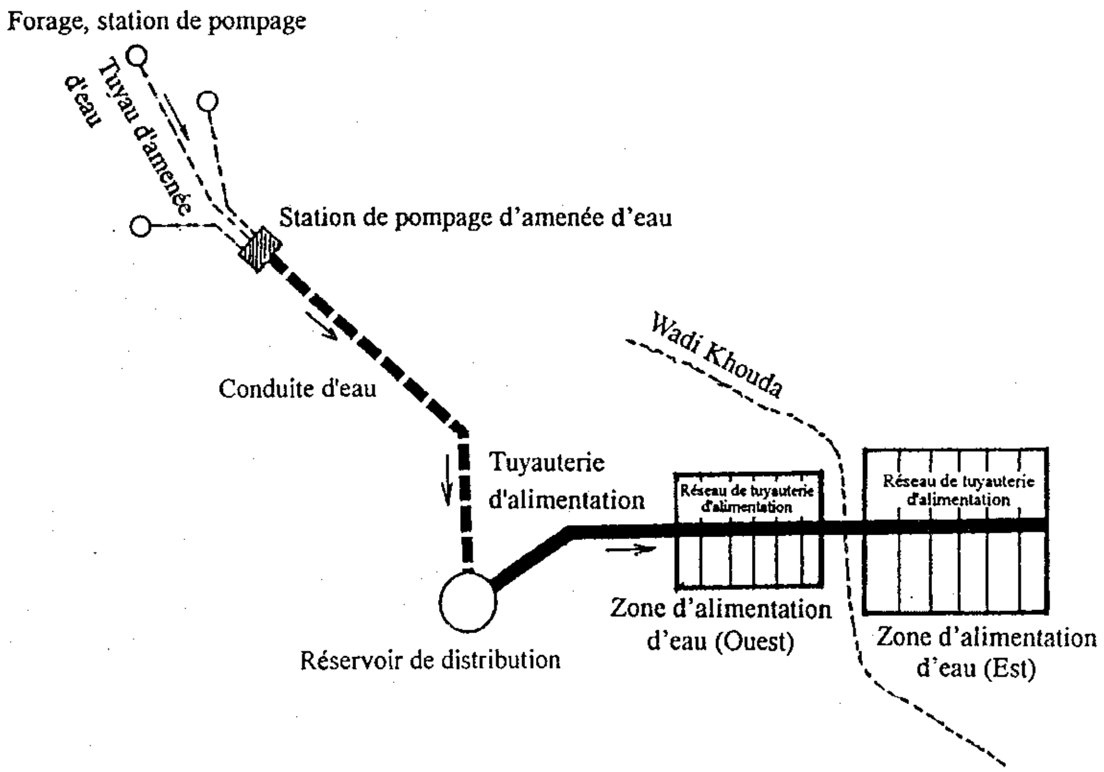


Fig. 7.3-1 Conceptual figure of the water supply system

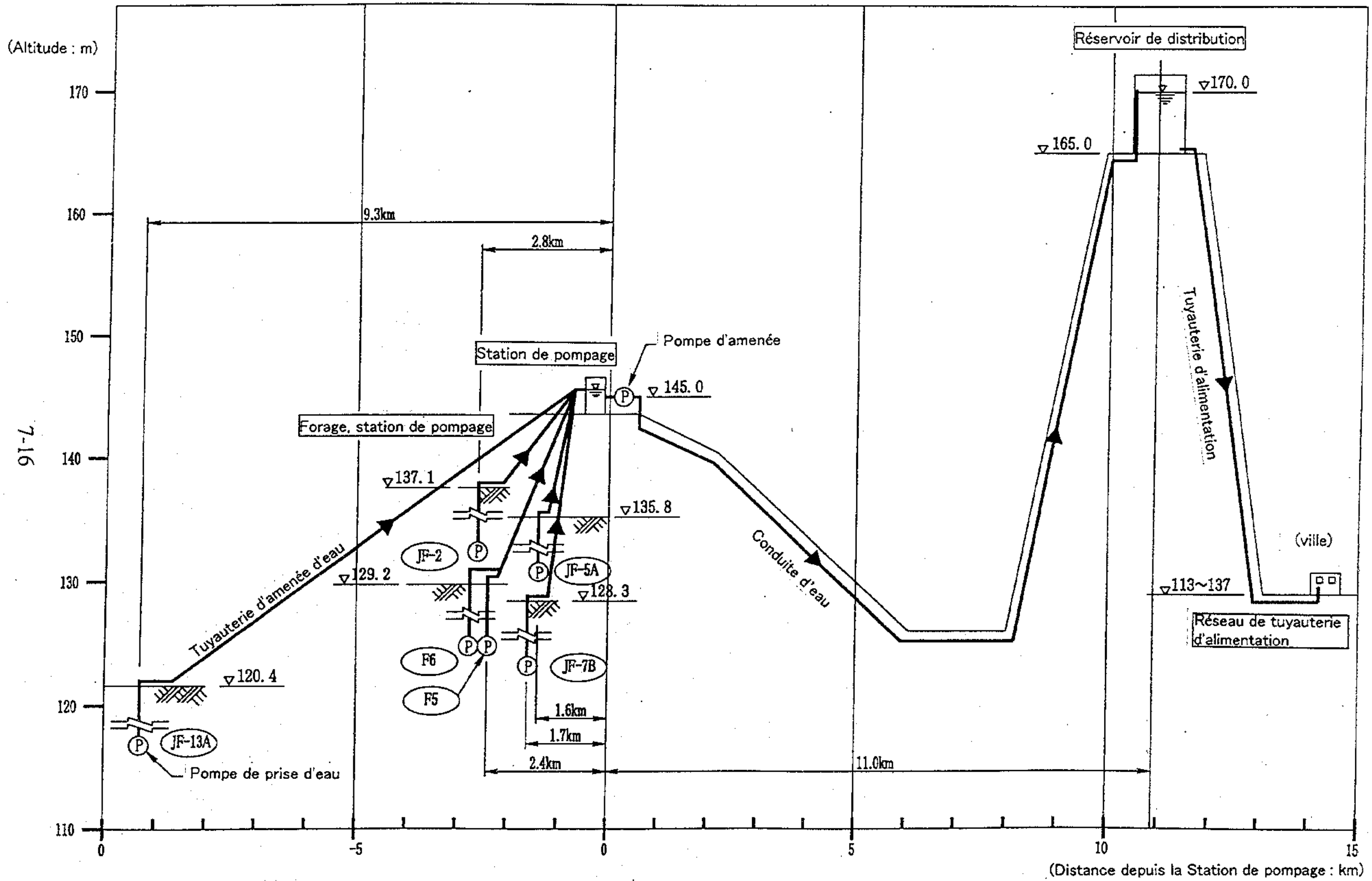


Fig. 7.3-2 Distances between facilities and differences in altitude

7.3.3.2 Establishment of facility specifications

(1) Well/lift pump station

1) Maximum amount of water supplied per day

The maximum amount of water supplied per day in the urgent improvement plan is calculated by the following formulas:

Maximum amount of water supplied per day = Maximum amount of water supplied per person per day (water supply for individual houses) x Population covered by water supply for individual houses + Maximum amount of water supplied per person per day (public water taps) x Population covered by water supply through public water taps

Therefore:

Maximum amount of water supplied per day = 0.03 x (77,000 x 0.65) + 0.02 x (77,000 x 0.35) = 2,041 m^3/day

Then, the maximum amount of water supplied per day should be 2,000 m^3.

On the other hand, in the long-term improvement and completion plan,

Maximum amount of water supplied per day = 0.03 x (100,000 x 0.8) + 0.02 x (100,000 x 0.2) = 2,800 m^3/day

Thus, it should be 2,800 m^3/day.

2) Planned amount of water pumped up

Wells employed in this water supply plan should be those with a larger amount of water pumped up (5 m^3/h or more) according to the results of test pitting. Safe amount of water pumped up, planned amount of water pumped up, depth, and water level of each well are as shown in Table 7.3-3.

Table 7.3-3 Planned amount of water pumped up at each well

Well No.	Safe amount of water pumped up (m^3/h)	Planned amount of water pumped up (m^3/h)	Depth of well (m)	Water level of well (m)
JF-2	11	10	58	14.3
JF-5A	5	5	62	13.6
JF-7B	18	15	46	7.7
JF-13A	30	25	58	4.1
F-5	35	25	66	8.0
F-6	35	25	66	8.0
Total	134	105		

3) Capacity of lift pumps

The working hours of lift pumps should be 20 hours per day in order to secure the maximum amount of water supply per day (2,000 m^3). Capacity and specifications of a lift pump at each well are shown in Table 7.3-4. As lift pumps, underwater pumps for deep wells will be adopted.

Considering that the working rate of a well is generally about 80%, the necessary amount of water pumped up should be established so that, even if one well is out of operation for maintenance, etc., the maximum amount of water supplied per day will be able to be obtained by the other lift pumps.

Table 7.3-4 Capacity and specifications of pumps for pumping up of water

Well No.	Altitude (m)	Necessary amount of water pumped up (m^3/minute)	Lift (m)	Number of pumps	Specifications	Depth of installation (m)
JF-2	137.1	0.2	50	1	Bore of 50 mm, 3.7 kW	30
JF-5A	135.8	0.1	45	1	Bore of 40 mm, 2.2 kW	30
JF-7B	128.3	0.3	50	1	Bore of 65 mm, 5.5 kW	20
JF-13A	120.4	0.5	70	1	Bore of 65 mm, 11.0 kW	25
F-5	129.2	0.5	45	1	Bore of 65 mm, 7.5 kW	20
F-6	129.2	0.5	45	1	Bore of 65 mm, 7.5 kW	20

The lift of a pump is determined in consideration of the water level of the wells, difference in altitude between location of the pump and a water-conducting pump station, friction head loss inside the pipe of a water conveyance duct, etc.

(2) Water conveyance pump station

A water conveyance pump station consists of water tank to temporarily gather water pumped up from wells, and a water conveyance pump facilities to convey water from the water tank to a distributing reservoir.

1) Planned amount of water conveyed

The planned amount of water conveyed should be 2,000 m^3, which is same as the maximum amount of water supplied per day.

2) Capacity of water conveyance pump

The capacity of a water conveyance pump is determined in consideration of the discharge requirement, difference in altitude, friction head loss of a water duct to a distributing reservoir, etc.

The capacities of water conveyance pumps are as shown in Table 7.3-5.

Table 7.3-5 Capacity and specifications of water conveyance pumps

Target year	Planned amount of water conveyed (m^3/minute)	Amount of discharge (m^3/minute/pump)	Lift (m)	Number of pumps	Specifications
2005	1.4	0.7	45	3 (2 for daily use + 1 spare)	Single suction centrifugal pump (Bore of 65 mm, 9.2 kW)
2015	2.0	0.7	45	4 (3 for daily use + 1 spare)	

3) Receiving tank

The capacity of a receiving tank is calculated as the capacity during 20-minute continuous operation of a water conveyance pump. As the receiving tank will be united with a water conveyance house, its capacity should be determined in consideration of the capacity of the water conveyance pump(s) in the future (long-term improvement and completion plan).

Then, the result is as follow:

Effective capacity of a receiving tank

= 0.7 m^3/minute x 20 minutes x 3 pumps = 42 m^3

The capacity is thus determined to be 40 m^3.

(3) Water conveyance duct

The diameter of a water conveyance duct is designed for the maximum amount of water supplied per day in 2005.

Water conveyance ducts convey water from a water conveyance pump station to a distributing reservoir, and will be able to be increased.

The specifications of water conveyance ducts in the target years, 2005 and 2015, are shown in Table 7.3-6.

Table 7.3-6 Specifications of water conveyance ducts in each target year

Target year	Duct	Amount of water conveyed (m^3/S)
2005	250 mm x 1 duct	0.023
2015	250 mm x 1 duct 150 mm x 1 duct	0.032

In order to cope with an increase in demand for water in the future (2015), the capacity of pump that will accommodate the increased amount of discharge will be increased. In this case, upon selection of lift for a water conveyance pump, an increase in friction head loss will be taken into consideration.

(4) Distributing reservoir

A distributing reservoir will be created in a high place in Kiffa city to convey water with natural down-flow. Capacity of the water supply should be equivalent to 12-hour operation for the maximum amount of water supplied per day, which is employed in various cities in Mauritania.

One distributing reservoir will be made on high ground (at 165 m height) on the west side of the city. The capacity is as follows:

$2{,}000 \times 12/24 = 1{,}000 \text{ m}^3$.

(5) Distributing duct

A distributing duct consists of a water main to supply water throughout the service area, and water branches diverging from a water main and laid so that a water pipe can be connected to each home (see Fig. 7.3-3).

Water mains shall be laid out to form a loop in order to ensure stable quantity and pressure.

The water main diameter is planned to cope with the future increase in demand for water, and to secure the minimum running water pressure (water supply for individual houses: 1.0 kg/cm^2, public water tap: 0.5 kg/cm^2) at the end of a distributing duct at ordinary times.

As for the drain pipe network, the following four cases have been studied for the eastern and western districts, considering the continued water feed upon application of feeding by hour and in the case of damage to the main route (abnormality), as described in section (7.2.2).

Case A : 7-hour water supply -- At ordinary times (amount of water supplied in 2005)
Case B: 7-hour water supply -- At abnormal times (amount of water supplied in 2005)
Case C: 7-hour water supply -- At ordinary times (amount of water supplied in 2015)
Case D: 7-hour water supply -- At abnormal times (amount of water supplied in 2015)

The results of the 4 cases described above are shown in Figs. 7.3-4 - 7.3-7. (For the results of calculation for the pipe network, see S-5 "Calculation for the Pipe Network" in the Supporting Report.)

The results indicate the pipe diameter of a water main is a bore of 63 mm - 300 mm, and the total length is about 41 km (including water mains excluded from calculation for the pipe network).

The bore of the water branches, determined from the minimum pipe diameter, is 50 mm, which is commonly employed in Mauritania.

(6) Public water tap

Public water taps will be installed in Area III formed in such a way as natural generation, each public water tap will be installed within the range with a maximum radius of 300 m. It is determined that the population covered by the tap is 500 - 700 people. This number is the criteria of Mauritania. For structure/form, the tap should have 6 cocks of the kiosk type.

Fixing pipes from a water branch to the public water tap should be PVC pipes with a bore of 32 mm.

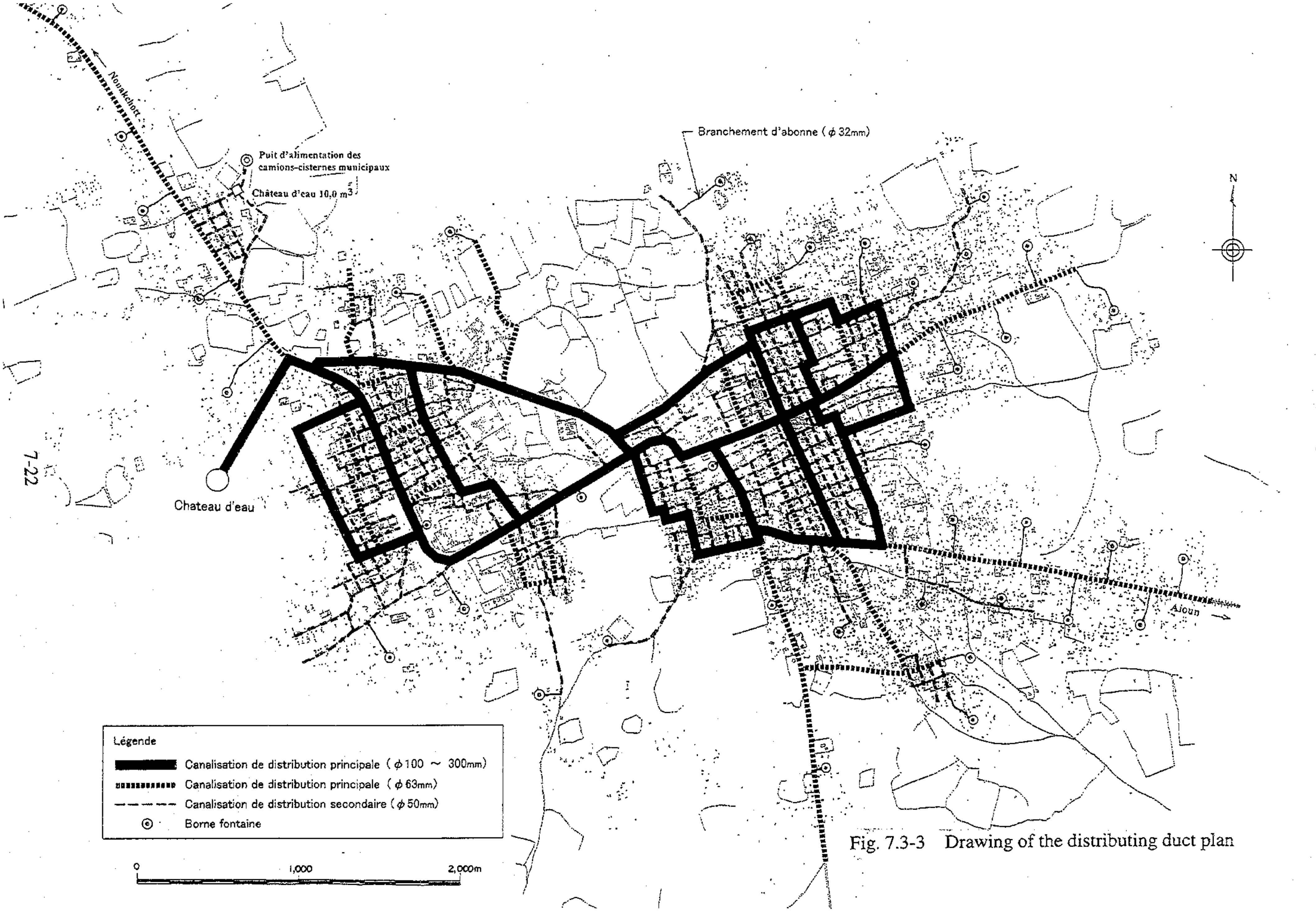


Fig. 7.3-3 Drawing of the distributing duct plan

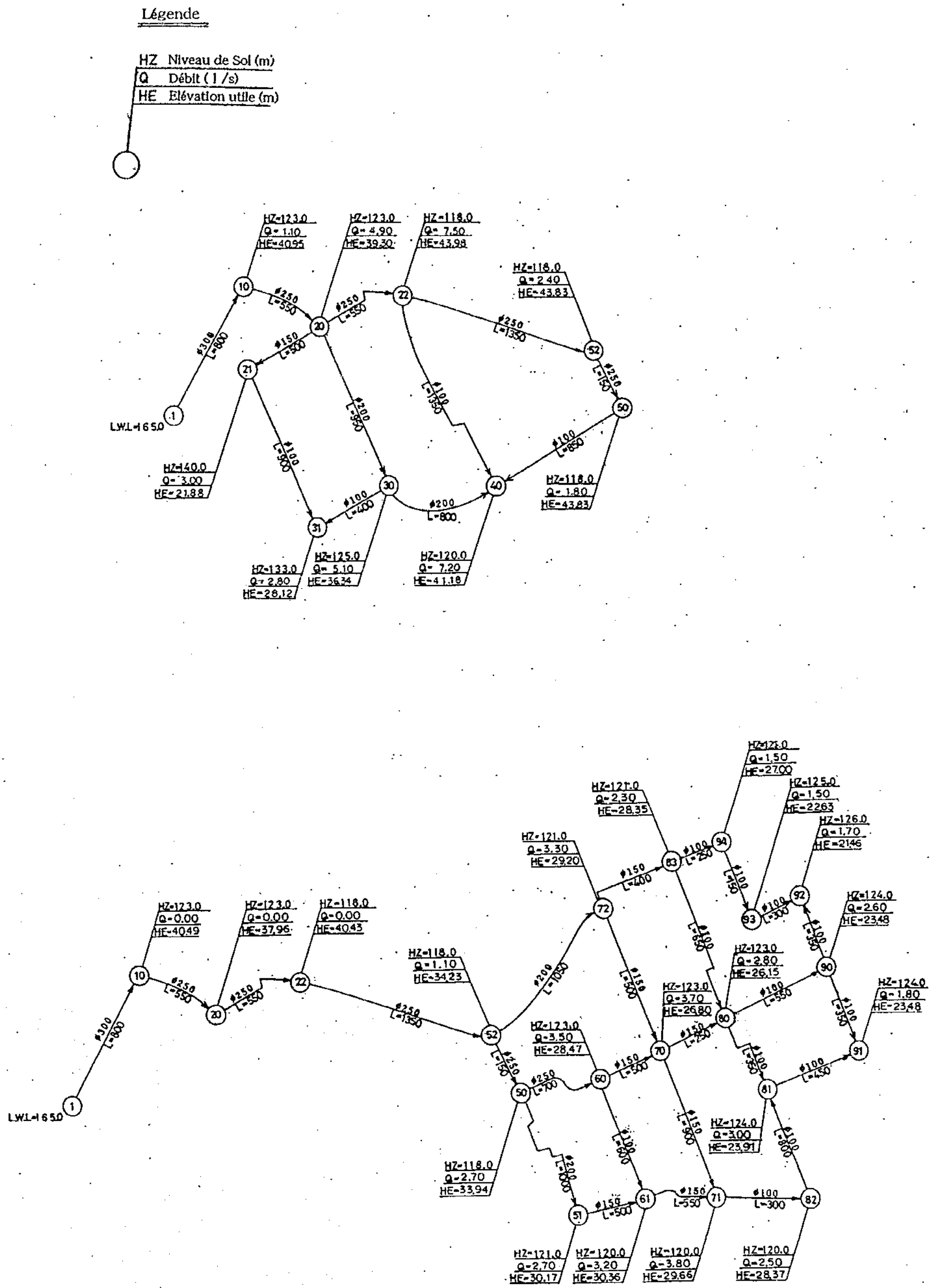


Fig. 7.3-4 Case 1 : 7-hour water supply at ordinary times (amount of water supplied in 2005)

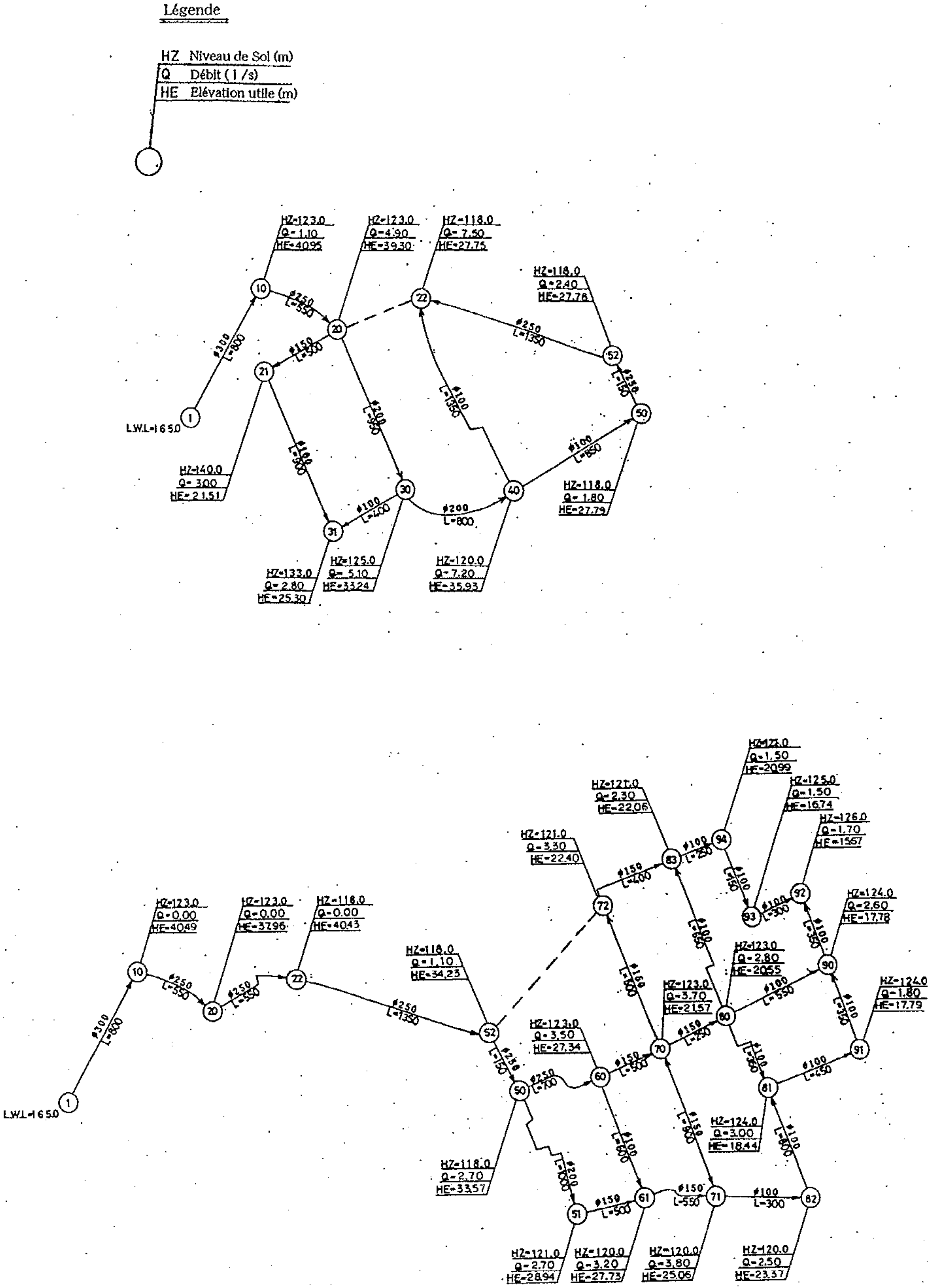


Fig. 7.3-5 Case 2 : 7-hour water supply at abnormal times (amount of water supplied in 2005)

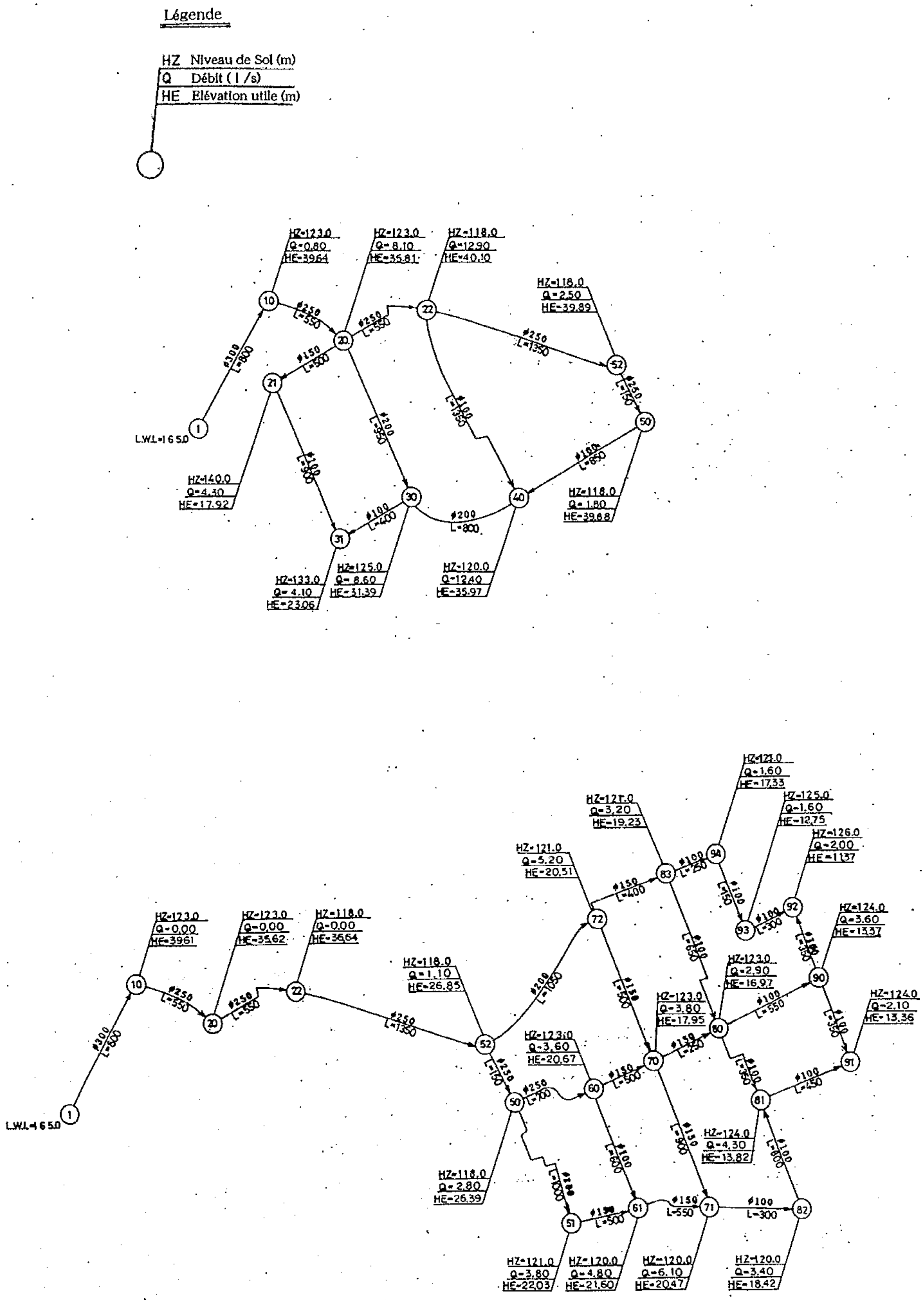


Fig. 7.3-6 Case 3: 7-hour water supply at ordinary times (amount of water supplied in 2015)

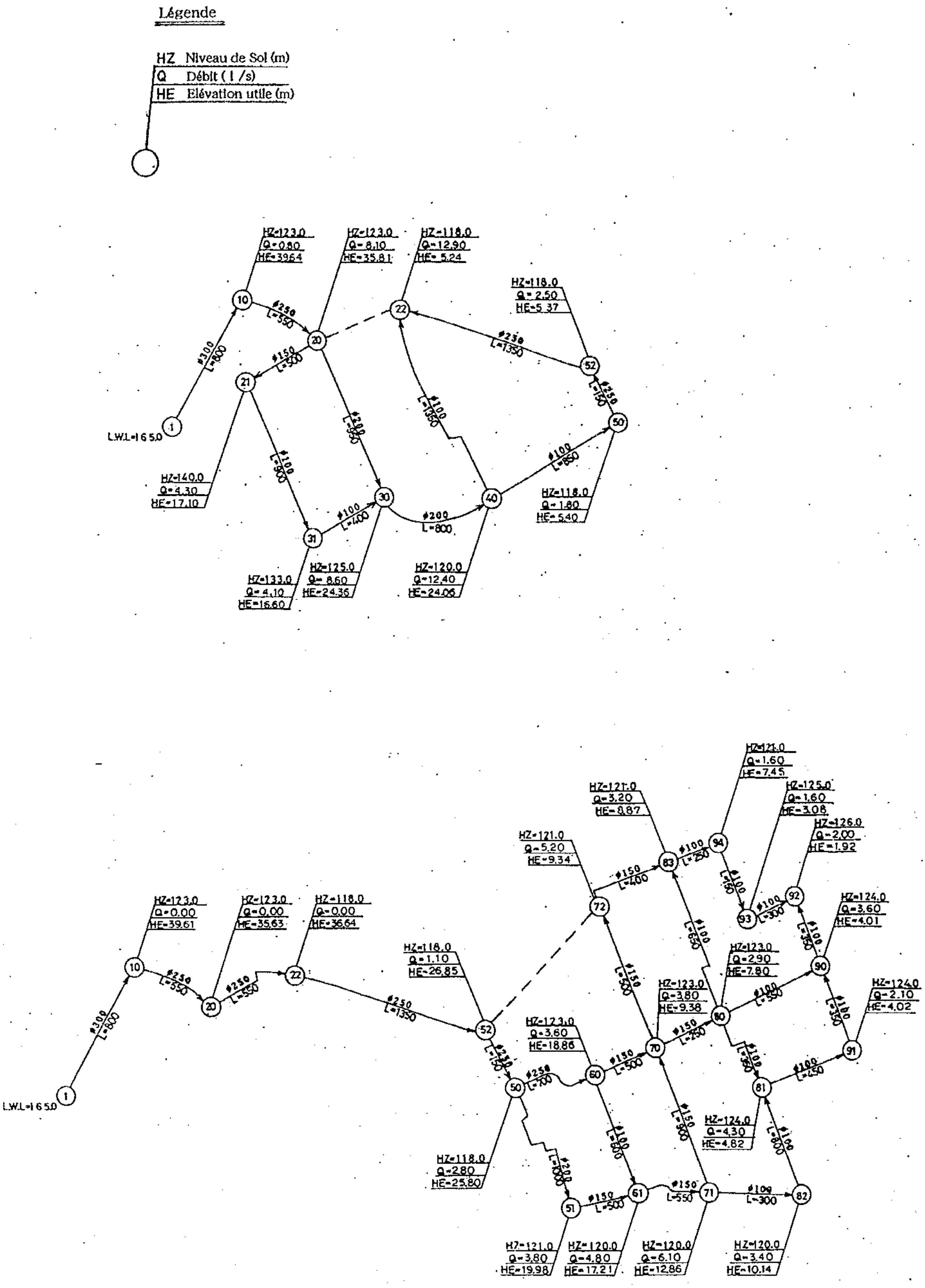


Fig. 7.3-7 Case 4 : 7-hour water supply at abnormal times (amount of water supplied in 2015)

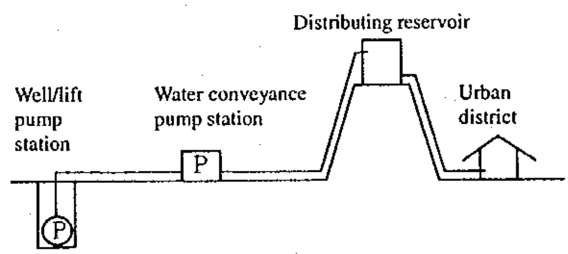
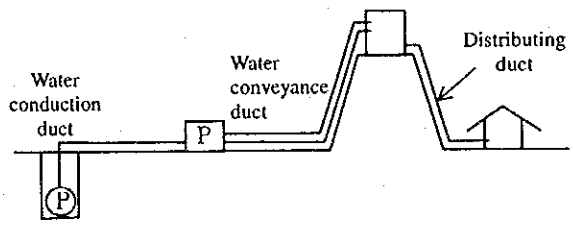
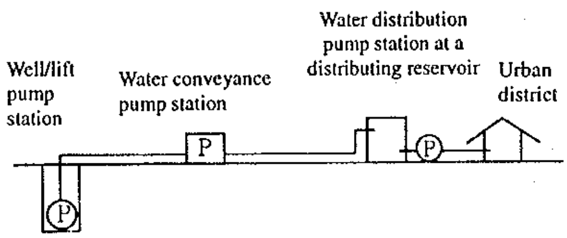
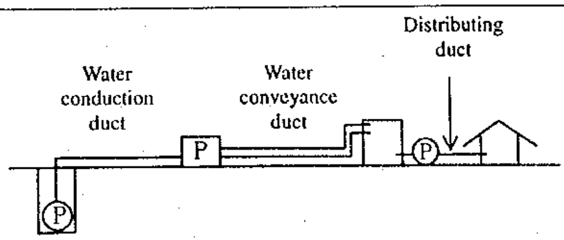
7.3.3.3 Examination of alternative plans

(1) Contents of alternative plans

A water-supply facilities plan should be made considering the actual situation of water-supply systems in Mauritania and also taking account of economical efficiency, the degree of difficulty in maintenance and management, etc. Various kinds of possible alternative plans should be examined by comparison, and an optimum facilities plan should be made.

The following examinations were held for 4 alternative plans as shown in Table 7.3-7.

Table 7.3-7 Alternative water-supply facilities plans

No.	Characteristics	Typical figure
CASE-1	• One water conveyance pump station • One distributing reservoir on high ground on the west side • Water distribution by the natural down-flow method	
CASE-2	• Two water conveyance ducts • One distributing reservoir on high ground on the west side • Water distribution by the natural down-flow method	
CASE-3	• One water conveyance duct • One distributing reservoir on low ground on the west side • Water distribution by pump pressurization	
CASE-4	• Two water conveyance ducts • One distributing reservoir on low ground on the west side • Water distribution by the pump pressurization method	

The contents of the water-supply facilities in each alternative plan are shown in Table 7.3-8.

Table 7.3-8 Contents of water-supply facilities in alternative plans

	CASE-1	CASE-2	CASE-3	CASE-4
Well/lift pump station	6 stations	6 stations	6 stations	6 stations
Lift pump				
• Number of pumps	6	6	6	6
• Amount of discharge	0.1 - 0.5 (m^3/minute/pump)	0.1 - 0.5 (m^3/minute/pump)	0.1 - 0.5 (m^3/minute/pump)	0.1 - 0.5 (m^3/minute/pump)
• Lift	45 - 70 m	45 - 70 m	45 - 70 m	45 - 70 m
Water conduction duct				
Pipe type	Pipe made of ductile cast iron	Pipe made of ductile cast iron	Pipe made of ductile cast iron	Pipe made of ductile cast iron
• Ø 200 mm	2,800 m	2,800 m	2,800 m	2,800 m
• Ø 150mm	9,500 m	9,500 m	9,500 m	9,500 m
• Ø 100mm	4,500 m	4,500 m	4,500 m	4,500 m
Water conveyance pump station	One station	One station	One station	One station
Water conveyance pump				
• Number of pumps	3 (including one spare pump)	3 (including one spare pump)	3 (including one spare pump)	3 (including one spare pump)
• Amount of discharge	0.7 (m^3/minute/pump)	0.7 (m^3/minute/pump)	0.7 (m^3/minute/pump)	0.7 (m^3/minute/pump)
• Lift	45 m	40 m	40 m	45 m
Receiving tank	One tank	One tank	One tank	One tank
• Capacity	40 m^3/tank	40 m^3/tank	40 m^3/tank	40 m^3/tank
Water conveyance duct	One duct	2 ducts	One duct	2 ducts
• Bore	250 mm	200 mm	200 mm	150 mm
• Length	11,000 x one duct	11,000 x 2 ducts	10,200 x one duct	10,200 x 2 ducts
• Pipe type	Pipe of ductile cast iron	Pipe of ductile cast iron	Pipe of ductile cast iron	Pipe of ductile cast iron
Distribution Station				
Distributing reservoir	One set (two reservoirs)	One set (two reservoirs)	One set (2 reservoirs)	One set (2 reservoirs)
• Capacity	1000 m^3 (500 m^3 x 2 reservoirs)	1000 m^3 (500 m^3 x 2 reservoirs)	1000 m^3 (500 m^3 x 2 reservoirs)	1000 m^3 (500 m^3 x 2 reservoirs)
• Location of installation	High ground on the west side (EL = 165 m)	High ground on the west side (EL = 165 m)	Level ground on the west side (EL = 125 m)	Level ground on the west side (EL = 125 m)
• Method of distribution	Natural down-flow	Natural down-flow	Pump pressurization	Pump pressurization
• Structure/form	RC structure, rectangle	RC structure, rectangle	RC structure, rectangle	RC structure, rectangle
Distributing pump				
• Pump house	—	—	One house	One house
• Number of pumps	—	—	4 (including one spare pump)	4 (including one spare pump)
• Amount of discharge	—	—	1.0 (m^3/minute/pump)	1.0 (m^3/minute/pump)
• Lift	—	—	40 m	40 m
Water main				
• Pipe type	PVC pipe	PVC pipe	PVC pipe	PVC pipe
• Ø 300 mm	800 m	800 m	800 m	800 m
• Ø 250 mm	2,450 m	2,450 m	2,450 m	2,450 m
• Ø 200 mm	3,850 m	3,850 m	3,850 m	3,850 m
• Ø 150 mm	3,600 m	3,600 m	3,600 m	3,600 m
• Ø 100 mm	8,750 m	8,750 m	8,750 m	8,750 m
• Ø 63 mm	21,600 m	21,600 m	21,600 m	21,600 m
Water branch				
• Pipe type	PVC pipe	PVC pipe	PVC pipe	PVC pipe
• Bore of 50 mm	52,000 m	52,000 m	52,000 m	52,000 m
Public water tap	39 taps	39 taps	39 taps	39 taps
• Type of fixing pipe	PVC pipe	PVC pipe	PVC pipe	PVC pipe
• Bore of 32 mm	8,200 m	8,200 m	8,200 m	8,200 m

(2) Results of examinations

The results of the examinations of alternative plans are shown in Table 7.3-9.

Table 7.3-9 Results of examinations of alternative plans

	Construction costs	Maintenance and Management costs	Measure for accidental damage of water conveyance duct	Comprehensive valuation
CASE-1	The lowest.	Lower than those in Cases 3 and 4 because water is distributed by natural down-flows.	There is the possibility that supply of water will be temporarily suspended because there is only one duct.	◎
	○	○	△	
CASE-2	The highest. 10% higher than those in Cases 1 and 3.	Lower than Cases 3 and 4 because water is distributed by natural down-flows as in Case 1.	It is possible to secure supply of water to some degree because there are two ducts.	○
	X	○	○	
CASE-3	Low, almost the same as those in Case 1.	The highest because water is distributed by pump pressurization.	There is the possibility that supply of water will be temporarily suspended because there is only one duct.	△
	○	X	△	
CASE-4	Lower than those in Case 2, but about 5% higher than Cases 1 and 3.	The highest because water is distributed by pump pressurization.	It is possible to secure supply of water to some degree because there are two ducts.	△
	△	X	○	

It is judged from the table shown above that Cases 1 and 2 are suitable as a water supply system. However, since the construction costs of water conveyance ducts in Case 2 are higher than Case 1 by 10%, we consider that the water supply system in Case 1 is the most suitable from the viewpoint of maintenance as well.

7.3.4 Plan of use of underground water at shallow aquifer

Shallow wells that have good quality and will be able to be used as drinking water are 13 wells for public use, shown in Fig. 7.3-8. Among them, one well is used as a source of water for municipal water-supply wagons. The amount of water pumped up at this well is about 150 m^3/day which is more than other wells. For the usage plan, this well is classified separately from other wells, most of which are sources of water for water selling by donkey-cart.

① Shallow well for municipal water-supply wagons: Water supply through ducts to specified areas

② Other shallow wells: Water supply by hand pumps

(1) Water supply through ducts to specified areas

The well for this supply is located in the Belemtar East district. Therefore, the range of water supply by the well should be areas with higher population density and near the well, in the Belemtar East district. Service areas selected from these viewpoints are shown in Fig. 7.3-9.

The population subject to water supply in the area covered is 2,700. As the maximum water supplied per person per day is 30 liters/person/day, the maximum amount of water supplied per day is about 80 m^3.

Water should be supplied as follows, and as shown in Fig. 7.3-8. Lift pump → Overhead water tank → Distributing duct → Water supply for individual houses and public (common) water tap. (For the drawing of facilities, see the collection of drawings.)

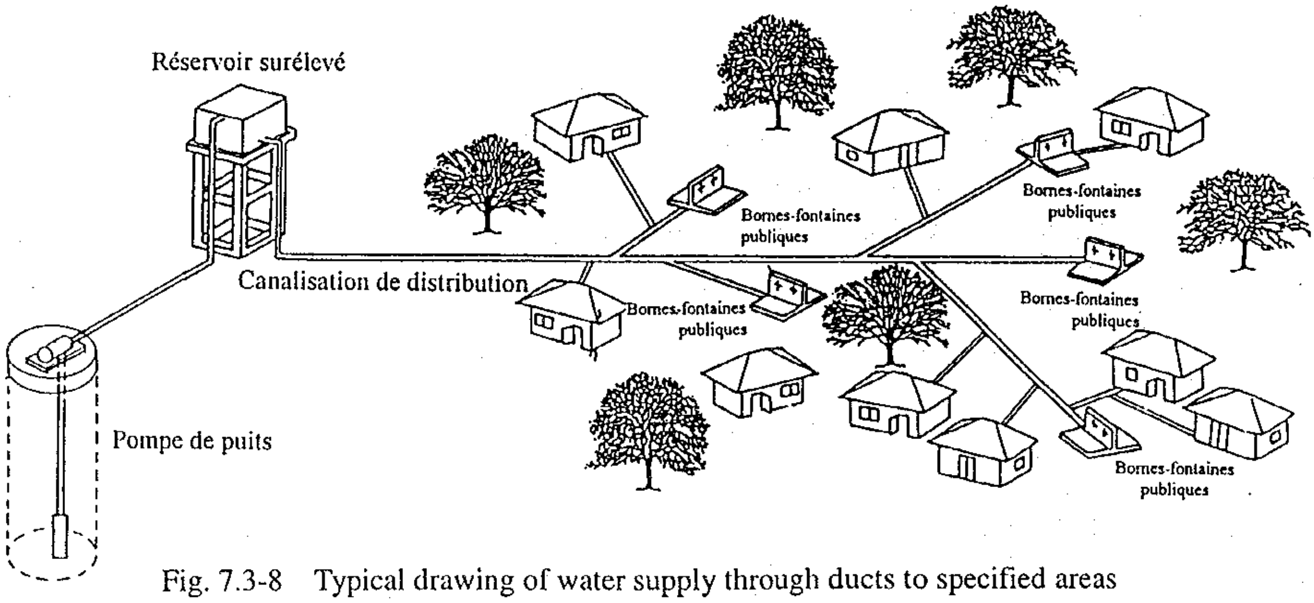


Fig. 7.3-8 Typical drawing of water supply through ducts to specified areas

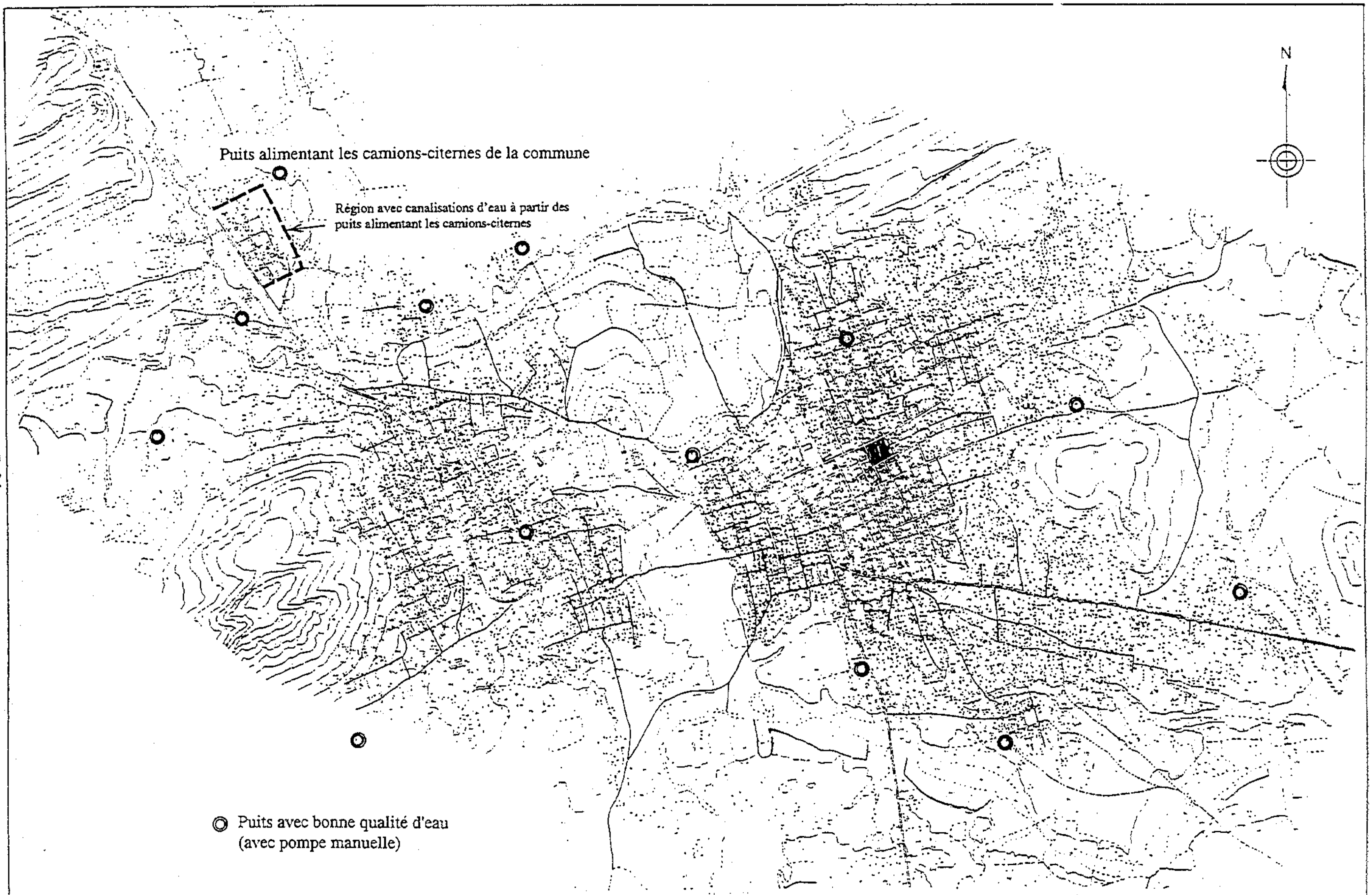


Fig. 7.3-9 Locations of shallow wells with good water quality

(2) Water supply by hand pumps

The wells concerned are now mainly used by water sellers with donkey-carts. Therefore, as to the structure of the wells, the foot of a well should be protected with concrete to keep the excrement of donkeys from permeating into the well, and sufficient measures for drainage should be taken. In addition, they should be equipped with hand pumps so that residents and sellers will be able to draw water easily. Fig. 7.3-10 shows an example of water supply facilities with a hand pump.

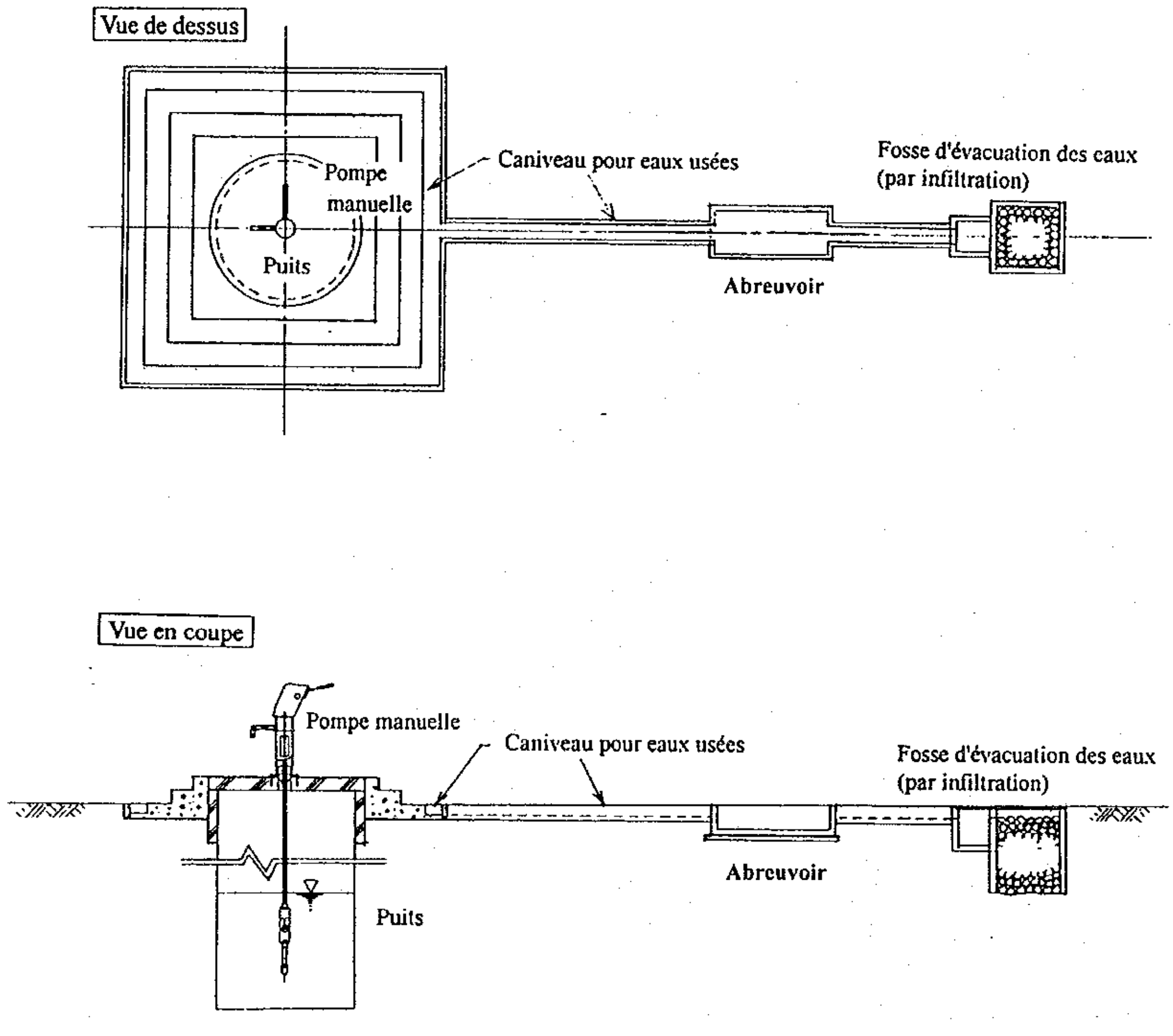


Fig. 7.3-10 Water supply facilities with a hand Pump

7.4 Plan of material and equipment procurement

7.4.1 Circumstances of material and equipment procurement

Among material and equipment related to construction of water supply facilities, the main construction materials and equipment are as shown in Table 7.4-1.

Table 7.4-1 Market conditions of main construction materials and equipment

Material/equipment name	Market conditions
Pipe made of ductile cast iron	Not produced in Mauritania. Necessary quantity is imported for each project. No distribution.
PVC pipe	Not produced in Mauritania, but imported ones are widely distributed in general.
Pumping equipment	Not produced in Mauritania. All are imported.
Electrical equipment	Not produced in Mauritania All are imported.
Cement	A cement plant in Nouakchott. Available in Kiffa but about 20% higher than in Nouakchott.
Reinforcing rod	An ironworks (National Public Mining Industry Corporation) in Nouadhivou where reinforcing rods with a diameter of up to 16 mm are manufactured. For rods with a diameter of over 16 mm, imported ones from Europe, etc., are distributed.
Coarse aggregate (gravel)	A stone pit at about 3 km southwest of Kiffa city. The outer layer of about 1 m-thickness is a gravel stratum that is excavated by people. What is screened there is used as gravel.
Fine aggregate (sand)	Sand in wadis around Kiffa city is used. Particularly, sand in a wadi about 1 km southwest of the city is used.
Concrete block	Those self-manufactured at construction sites are usually used. Distributors are in Kiffa city.
Steel material	Available in Nouakchott. Difficult to get in Kiffa.
Timber	Available in Nouakchott. Also available in Kiffa, but kinds and quantity are limited.
Gasoline/gas oil	Available in Kiffa. Imports are about 10% higher than Nouakchott.

7.4.2 Planned countries for procurement of materials and equipment

Judging from the market conditions related to procurement of materials and equipment in Mauritania and Kiffa city, we except the main materials and equipment expected to be necessary for the construction of water-supply facilities in Kiffa city, and planned countries for their procurement, to be as shown in Table 7.4-2.

Table 7.4-2 Main materials and equipment related to construction of water-supply facilities in Kiffa city, and planned countries for procurement

Main materials and equipment	Planned countries for procurement		
	Japan	Mauritania	Third country
General material			
• Cement		○	
• Reinforcing rod		○	
• Coarse aggregate		○	
• Fine aggregate		○	
• Mold		○	
For deep wells			
• Materials and equipment for deep wells	○		
• Lift pump	○		○
For Water conduction/conveyance/distribution facilities			
• Pipe of ductile cast iron			○
• PVC pipe		○	
• Valves			○
• Overhead-tank (FRP)	○		
• Water conveyance pump	○		○
• Underwater pump for shallow wells	○		○
• Hand pump			○

7.5 Plan of maintenance and management organization

(1) Form of maintenance and management

In Mauritania, waterworks projects are now conducted by SONELEC in ten cities. Forms of maintenance and management of water-supply facilities in these cities are generally as shown in Fig. 7.5-1.

Among these, the personnel required for operation, maintenance and management related to water-supply facilities of SONELEC local centers are as show in Table 7.5-1.

SONELEC has a Training Center in Nouakchott. According to the plan, planned personnel for maintenance and management of SONELEC will receive 6 months of onsite training. Then, they will participate in study and training, including review of the previous training, for techniques of operation, maintenance and management related to electric and waterworks activities for about 2 weeks in the Center. The system to foster personnel required for maintenance and management is complete in SONELEC.

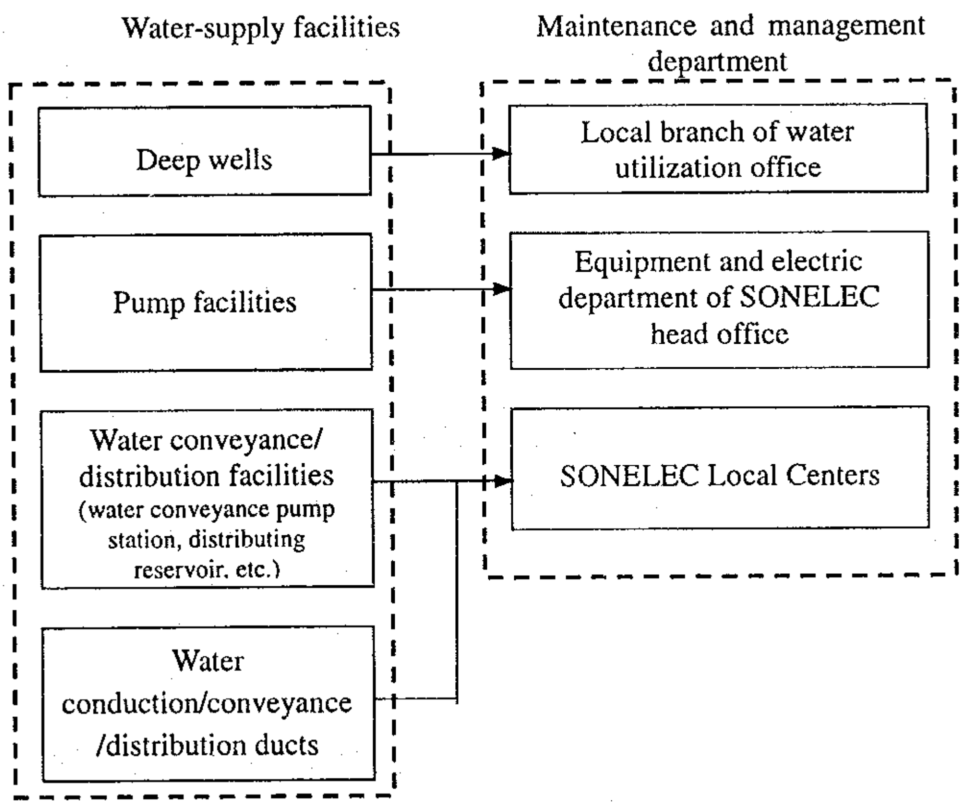


Fig. 7.5-1 General form of maintenance and management of waterworks

Table 7.5-1 Personnel required for maintenance and management of water-supply facilities in SONELEC Local centers

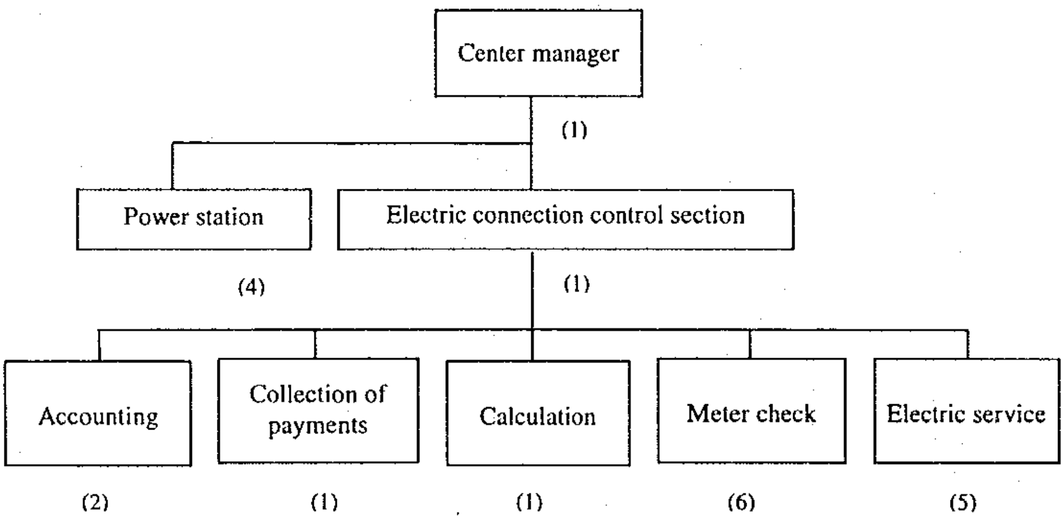
Post name	Number of people	Remarks
Electric/water supply connection control	1	Holding both electric and water supply divisions
Pump station	2	
Accounting	2	Holding both electric and water supply divisions
Collection of payments	1	Holding both electric and water supply divisions
Calculation	1	Holding both electric and water supply divisions
Meter check	5～10	Holding both electric and water supply divisions
Water supply service	3～6	

(2) Organization plan for Kiffa center of SONELEC

The Kiffa Center of SONELEC in Kiffa city currently conducts electric-power supply work for the city.

If a water service project is started in Kiffa city, it is reasonable from the viewpoint of the city size that SONELEC should undertake operation, maintenance and management because this organization has the complete maintenance and management system for urban water supply.

The present organization chart of the SONELEC Kiffa Center is shown in Fig. 7.5-2.



(21 people in total)

Fig. 7.5-2 Organization chart of SONELEC Kiffa center (as of 1998)

On the other hand, personnel required for operation, maintenance and management necessary for waterworks activities after execution of the waterworks project in Kiffa city are as shown in Table 7.5-2, with consideration given introducing the restriction of water supply to certain hours.

Table 7.5-2 Personnel required for operation, maintenance and management of waterworks activities in Kiffa city

Post name	Number of people	Remarks
Water conveyance pump station and distributing reservoir	4	One individual for each, one person in charge of maintenance and inspection for each
Control of water supply connection	0	Electrical division also holds this work.
Accounting	0	Electrical division also holds this work.
Collection of payments	0	Electrical division also holds this work.
Calculation	0	Electrical division also holds this work.
Meter check	6	
Water supply service	10	Two persons for maintenance and inspection, 8 for valve opening/closing
Total	20	

An organization chart (planned) of SONELEC after execution of the waterworks project is shown in Fig. 7.5-3.

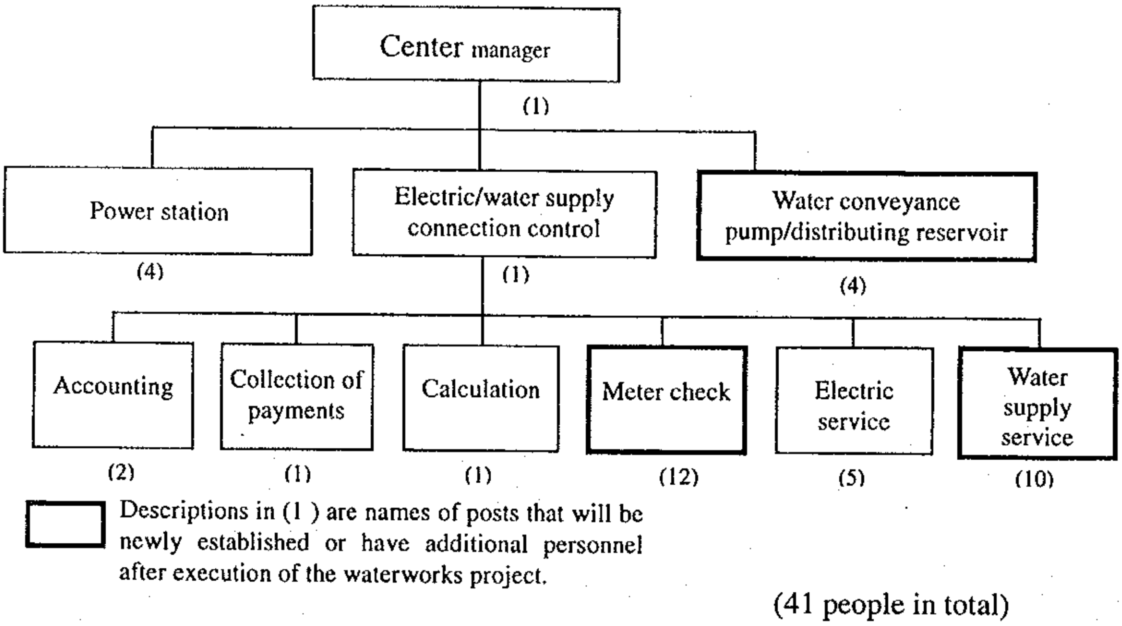


Fig. 7.5-3 Organization chart (planned) of SONELEC Kiffa center after execution of the waterworks project

7.6 Estimation of operating expenses

Contents of the water-supply facilities construction project, reported in 7.3 (Facilities Plan), are as shown in Table 7.6-1.

Table 7.6-2 shows the operating expenses necessary for construction of these facilities. The operating expenses were integrated on the base of execution by domestic undertakers in Mauritania, including all costs and expenses such as direct construction expenses, indirect costs, design management costs, etc. (For the breakdown, see "S-6" in the Supporting Report.)

Table 7.6-1 Contents of the water-supply facilities construction project

Name of work	Specifications	Unit	Quantity	Remarks
1.Well/lift pump station				
• Lift pump	Q = 0.1 m^3/minute, H = 50 m	Pump	1	
	Q = 0.2 m^3/minute, H = 50 m	Pump	1	
	Q = 0.3 m^3/minute, H = 50 m	Pump	1	
	Q = 0.5 m^3/minute, H = 45 m	Pump	1	
	Q = 0.5 m^3/minute, H = 70 m	Pump	2	
2. Water conduction duct				
• Pipe of ductile cast iron	Bore of 200 mm	m	2,800	
	Bore of 150 mm	m	9,500	
	Bore of 100 mm	m	4,500	
3. Water conveyance pump station				To secure space for one additional pump in or after 2006.
• Water conveyance pump	Q = 0.7 m^3/minute, H= 45 m,	Pump	3	
• Receiving tank	V = 40 m^3, RC structure	Set	1	
4. Water conveyance duct				
• Pipe of ductile iron cast	Bore of 250 mm	m	11,000	
5. Distributing Reservoir				
• Distributing reservoir (on ground)	1000 m^3, RC structure	Set	1	Installation level EL=165m
6. Distributing Facilities				
• Distributing duct	Bore of 300 mm	m	800	
	Bore of 250 mm	m	2,450	
	Bore of 200 mm	m	3,850	
	Bore of 150 mm	m	3,600	
	Bore of 100 mm	m	8,750	
	Bore of 63 mm	m	21,600	
	Bore of 50 mm	m	52,000	
• Public water tap				
- Water tap	Kiosk type, 6 cocks	Unit	39	
- Fixing pipe (PVC pipe)	bore of 32 mm	m	8,200	
• Shallow-well pump	Q = 0.2 m^3/minute, H = 20 m	Pump	1	
• Overhead water tank	V= 10 m^3, H = 10m	Unit	1	
• Well with a hand pump	With 1 pump	Unit	9	
	With 2 pumps	Unit	3	
7. Electric wiring work				
• Inside the city - Water conveyance pump station		m	14,000	Including a transformer
• Water conveyance pump station - Lift pump station		m	15,500	

Table 7.6-2 Operating expenses of the water-supply facilities construction project

Name of work	Amount (UM)
1. Well/lift pump station	150,898,000
2. Water conduction duct	551,510,000
3. Water conveyance pump station	86,310,000
4. Water conveyance duct	759,000,000
5. Distributing reservoir	75,647,000
6. Distributing facilities	676,890,000
7. Electric wiring work	147,500,000
Total	2,447,755,000