Chapter 8 Hygiene Improvement Plan

8.1 Hygiene improvement activities

8.1.1 Necessity for setting up a hygiene improvement plan

A detailed study of the hygienic conditions in Kiffa city during the field research revealed the following.

(1) There is no infrastructure that can be referred to as water facilities, and the supply of drinking water that is safe for human health is not ensured.

(2) Shallow ground water in the city that serves the population's daily life is substantially contaminated. Colon bacilli were present in the water of most of the wells, and almost half of the total number of wells supplied water with a nitrate nitrogen concentration higher than the WHO standard for drinking water (result obtained from water analysis at the third field research). The cause for such high nitrate nitrogen concentration was contamination by human excretion.

(3) No sewage system has been installed, and hardly any organized cleaning or garbage collection activities exist. Therefore, garbage is piled up or spread out all over the city. Due to quick evaporation and filtration into the ground in a dry desert climate, stagnant sewage water is not visible on the ground. However, a stench fills the air as soon as it rains.

(4) Although most lavatories in residences use a soil infiltration type cesspit, people spend much time outdoors in a nomadic lifestyle and it is common that they relieve themselves where is convenient. Excrement of cattle and sheep in pasture is found everywhere. These also create the stench mentioned in (3).

(5) The population of the city shows little awareness of hygiene of the water they drink, or preservation of water resource. Although the study team confirmed that colibacillus can be destroyed by adding a small quantity of Javel, a chlorine-type bleaching agent, but hardly anybody uses it. Although wells in the city serve as the source of drinking water, no specific measures are taken to protect the well inlet or to keep animals away from the wells. It may be currently inevitable, but selling water from donkey-carts is also one of the factors of contamination of well water. Taking the example of the well in front of the Water utilization office, as donkey-carts gather around from early morning to evening, water spilled from the well mixes with donkey excrement. Also, the ropes and buckets used to draw the water and the drums for transport are far from being clean.

(6) Although it can be said that the hot and dry climate with strong sterilizing effect of ultraviolet prevents the outbreak of disease, cases of enteritis, dysentery, diarrhea and enteric canal parasitic diseases are significant. All these diseases are caused by unhygienic water.

Water facilities can be installed thanks to the subterranean water development project, and the supply of safe and hygienic water that meets the water quality standard can be ensured. As a result, improved hygienic conditions in Kiffa city can be expected, especially a decrease in the number of cases of water-related diseases. However, the study revealed the limited potential of the new water resource to be developed, so a plan must be examined to take water from several sources including the shallow ground water in the city. From the situation described above, preservation of the quality of the shallow groundwater is deemed impossible unless the hygienic conditions in Kiffa city are improved. Therefore, setting up of the hygiene improvement plan shall form an important part of this plan.

8.1.2 Measures for protection of water resources

Protection of water resources involves protection of new water sources in the northwestern region and the groundwater at the shallow aquifer in the city.

(1) Protection of new subterranean water sources

Protection of new subterranean water sources is obviously a very important issue. Since new wells shall be equipped with underwater pumps, it is not difficult to avoid direct contamination at the inlet. However, in order to avoid regional non-point contamination, it is suggested that measures be taken to keep people and animals away from the water source, at a scope covering a radius of up to 200 m from the well. It is a common tendency among Mauritanian people to gather around the water and construct a new residential area in proximity to the source. As there is no system to control the subterranean water source, people often drill wells at their convenience.

In order to achieve a sustainable use of limited subterranean water sources, restriction in quantity of use is important. Also for the purpose of preserving the quality of water, drilling of personal wells or living in the vicinity of the well serving as a source for the water supply plan must be prohibited. Judging from the current quality of water from many existing wells in Kiffa Coty, it can be said that wells that are not appropriately controlled and protected become the source of contamination leading

to pollution of water from the subterranean aquifer. Therefore, in addition to the vicinity of each well, it is necessary to designate the entire rainwater catchment basin as water resource protection area.

(2) Protection of shallow ground water sources in the city

There are over 1,000 shallow water wells in Kiffa city, and therefore it is virtually impossible to protect all of them. This study revealed that many of the wells are worthless for public use in terms of quantity and quality. It is therefore suggested to start by closing some of the wells for preventing quality deterioration of shallow ground water in parallel with the installation of water supply facilities. For example, wells showing a high concentration of ammonia nitrogen in addition to nitrate nitrogen are obviously contaminated directly from the ground surface. Therefore, the quality of the subterranean water in the vicinity is expected to improve gradually by closing the wells in question.

As the water supply from new sources starts, safe water from these sources shall be used for drinking purposes and the water from the shallow groundwater in the city for various other purposes. However, considering the fact that part of the shallow groundwater in the city satisfies the standard for drinking water, it is possible to select shallow wells meeting such conditions in terms of quantity and quality to supply drinking water. In that case, wells to supply drinking water shall be considered as supply wells with an underwater pump, subject to water protection measures as described in (1). The fact that the quality of water from well No. 127 that supplies the municipal water trucks is superior to other wells (especially in terms of number of colibacillus) shows that water pumping with a protected inlet is more effective for the preservation of water quality.

8.1.3 Wastewater treatment

As the result of subterranean water development and construction of water and sewage facilities, procurement of water for daily use becomes easier. At the same time, however, wastewater increases together with the increase of water consumption. Because there are no sewage facilities in Kiffa city, and Phase 1 of this project does not cover the installation of sewage facilities, we would like to propose a home wastewater disposal measure that local residents can take under their own initiative, and simplified sewage treatment measures that can be taken by local authorities and neighborhood organizations.

Unless a sewage treatment system is installed, the pollutant contained in wastewater produced in the urban district can not be reduced in volume or discharged to other areas. Although the fact is that there is no fundamental solution other than installation of a sewage treatment system, taking into consideration the current situation in Kiffa city, the animal excrement dispersed all over the city is more contaminative of organic matter and nitrogen than sewage. The odor that spreads on rainy days is proof of the accumulation of animal excrement on the ground. As the quantity of water supply increases and home wastewater is discharged in the urban district, the water will not only carry its pollutants but also dissolve the pollutants contained in animal excrement left on the ground, thus accelerating their infiltration into the ground, and eventually carrying the pollutants down to the subterranean aquifer.

In order to minimize such effects, we propose the installation of a simplified sewage treatment facility that shall be described in section 8.2.1.

8.1.4 Hygiene improvement activities under the initiative of local residents

To improve hygienic conditions, it is important to consider the hardware related to facilities. The awareness of and effort by every citizen of Kiffa city is essential to create a hygienic environment. As for causes of the poor hygienic conditions described in section 8.1.1, insufficient facilities is only one of them. By making efforts to change the residents' understanding of hygiene and their way of living, we believe there is considerable room for improvement of hygienic conditions. We hereby propose the following operation plan of hygiene improvement activities under the initiative of local residents.

(1) Disinfection of drinking water

Since the invention of chlorine disinfectant at the beginning of this century, disinfection of water has been used worldwide as the most important means of water treatment to guarantee safe and hygienic drinking water. WHO stresses the necessity of chlorine treatment not only for surface water but also for subterranean water (especially the shallow ground water) that is likely to be contaminated by bacteria. Although colibacillus were discovered in the water from all the shallow wells in Kiffa city, the water quality can be improved by simple disinfection with chlorine. The result of tests on disinfectant effect of Javel, a chlorine-based bleaching agent that is commonly used in Mauritania, conducted by the study team showed that no colibacillus was present in a bucketful of water (approx. 15 liters) after adding a few drops of Javel. Javel is a cheap chemical that enables production of sterile water with a cost that would

hardly affect the household economy. Since many Mauritanians drink water without boiling in advance, disinfection of drinking water is absolutely essential.

(2) Prevention of effect of nitrate nitrogen on infants

It is essential to educate the entire population about the effect of nitrate nitrogen on human health. Although some experts point out the possible carcinogenesis of nitrate nitrogen, what has been proven to date is its relation to methemoglobinaemia. WHO proposed its water quality standards based on this effect on health. Although adults are not exempted from the risk, infants under three months old face the greatest risk. Currently, it is estimated from the result of water quality analysis that the water from nearly half of the shallow wells in Kiffa city has a nitrate concentration higher than the standard value of 50 mg/L. This means that, even after the water and sewage systems are put in place, there is a risk that people will use water with high nitrate concentration for drinking purposes through ignorance and thus impair their health. What should be stressed here is that infants must not drink water with high nitrate concentration. This is also related to the hygiene education to be described in section 8.1.5.

(3) Improvement of water conveyance and storage facilities

As described in Chapter 5, our test on hygienic conditions of the water in the water conveyance and storage facilities revealed that there was more coliform than the subterranean water at the source. This shows that, even if the tap water supplied is of good quality, there is still a risk of secondary contamination by storing it in unclean reservoirs. When we study the situation in other cities where water supply facilities have been installed, donkey-drawn water carts still exist even in the areas with public water taps, and out of habit, houses with individual water supply still store water in the tank before use. In this case, the problem of secondary contamination exists even after the waterworks project has been completed. Preventive measures for such contamination are to improve the conveyance method of water, stop manual drawing of water, and ensure a periodic cleaning of storage facilities by users to keep them in a clean condition. Sterilization with the bleaching agent Javel as described in (1) is also efficient.

(4) Preservation of private wells

Measures shall be taken to preserve the wells for public supply by the waterworks project control section as described in section 8.1.2. For a great number of private wells, even if they are not used for drinking purpose, it is necessary that owners take the initiative to preserve their wells to preserve the shallow groundwater and to be able to

supply in case of emergency. For this purpose, we suggest making the opening of wells higher than the ground level so that wastewater on the ground does not flow into the well, covering the well to avoid the entry of dust and sand, and building an apron to avoid the spilled water from soaking and soiling the area around the well.

8.1.5 Hygiene education

The purpose of hygiene education is to provide the residents with hygiene-related knowledge including the relation between the living environment and human health, hygienic conditions of drinking water, and importance of water resource preservation, as well as technical details such as the method of dealing with facility problems as described in sections 8.1.2 - 8.1.4 above, and to call their awareness to the importance of hygiene improvement. As UNICEF and other NGOs develop various activities, it is recommended that the hygiene education be provided in liaison with these organizations. In particular, UNICEF activities for the formation of neighborhood organizations and diffusion of hygienic lavatories are directly related to our project. We hereby propose the following steps of hygiene education.

(1) Education on water quality

Provide residents with basic knowledge on the principal index of water quality related to human health, i.e., colibacillus and nitrate nitrogen. Lectures shall be given to explain these problems in plain language and using simple drawings. Common issues such as sources of colibacillus and nitrogen, channels of contamination of the ground surface and subterranean water, and what diseases are caused by drinking contaminated water shall be discussed. The purpose of this education is to help people understand that absence of visible dirt or off-flavor in the water does not mean that it is suitable for drinking, there are invisible pollutants, the subterranean water we commonly use is already contaminated, and that the preservation of water resources is important.

(2) Education on hygienic life

Hygienic life refers to personal and familial lifestyle related to hygiene. The former includes constant practices of washing hands and taking a bath, while the latter includes washing dishes and clothes, as well as cleaning the lavatory. Since more than the minimum demand of water not only for drinking but also for a hygienic life shall be satisfied thanks to subterranean water development and execution of the water and sewage project, the purpose of the education on hygienic life is to improve the level of life and hygiene through efficient use of tap water. This education shall be provided

when the supply of tap water starts. If the residents can actually feel the improvement in their life by the water supply service, they will naturally be more conscious about supporting the water projects and preservation of water resources.

(3) Technical instruction for hygiene activities

Technical instruction needs to be given in order to develop hygiene activities under the initiative of local residents suggested in section 8.1.4. It is suggested that various lectures be provided on disinfection of drinking water, periodic cleaning of water conveyance and storage facilities, preservation of private wells and installation of simplified septic tanks, to explain to each household the methods and precautions to be taken.

8.2 Preservation plan of groundwater at shallow aquifer in the city

8.2.1 Preservation plan of shallow groundwater

Following are the measures to be taken for the preservation of shallow groundwater in the city that was suggested above in 8.1 "Hygiene improvement activities."

In the urgent- and long-term improvement plans to be executed in Kiffa city, it is necessary to ensure 30 liters per person per day by the supply system decided upon in our urgent improvement plan and 10 liters per person per day by the shallow wells that are currently in use.

During the first field research of this plan, water level observation and water quality analysis of approx. 1,000 shallow wells in the city were conducted, and a detailed water quality analysis was conducted on 200 wells during the second field research. From the results of these researches, it is known that in addition to the water supply via conduit, there are 13 shallow wells that can supply water with relatively good quality that can be used as drinking water by injecting chlorine-type disinfectant, as shown in Fig. 7.3-8.

For the other shallow wells that can supply water for various daily uses other than drinking, in order to maintain the water quality for continued use in the future, it is necessary to prevent contamination of the shallow groundwater by human and animal excrement and to endeavor to preserve water quality.

As stated in section 8.1.1 above, in order to preserve the shallow groundwater in Kiffa city, it is necessary for each of the service plans to execute a hygiene improvement plan as follows.

(1) Urgent improvement plan (target year: 2005)

1) Prevention of contamination of wells in the city

To prevent contamination of wells in the city, improvements in the structure of the wells shall be made. See Fig. 8.2-1.

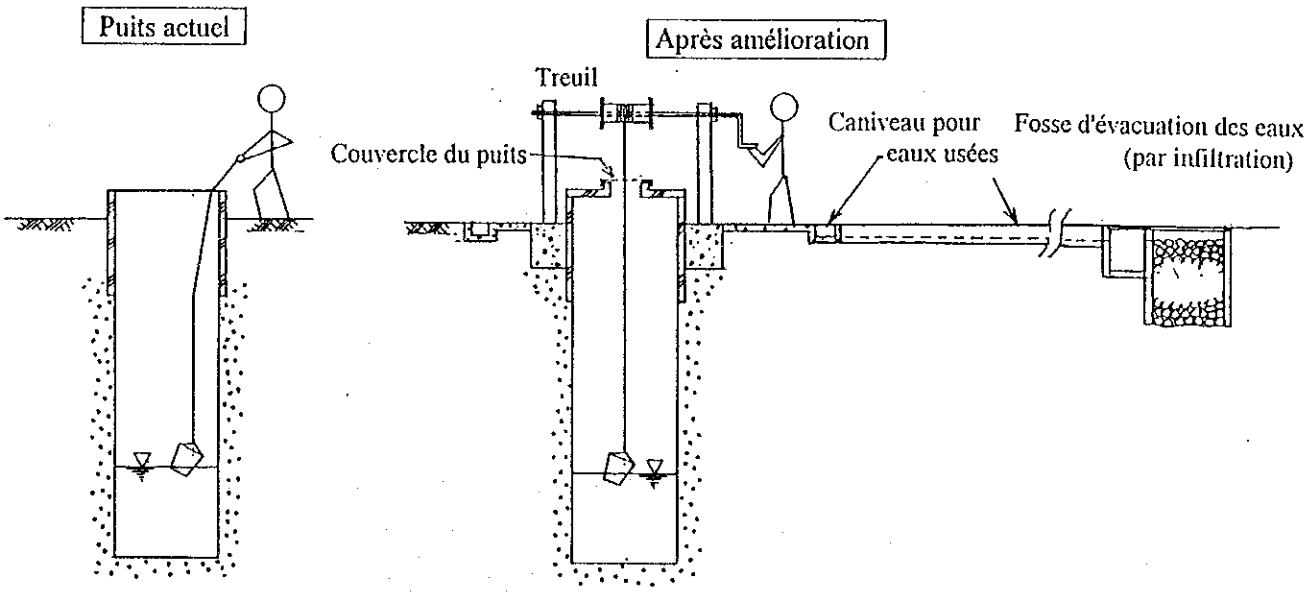

Fig. 8.2-1 An example of a well with improved structure

2) Prevention of subterranean water contamination by discharged sewage

As stated in section 8.1.3 above, to prevent the contamination of shallow ground water by infiltration of home wastewater into the ground, installation of the following simple treatment facilities is suggested as a preliminary measure before the full-scale sewage service.

① Simple septic tank and disposal tank for home use

The form of septic tank can be similar to the toilet tank used for each house, and there is no problem if the current toilet tank is also used as a septic tank. If the toilet tank is used as a septic tank, as wastewater flows in, water is pooled to some extent and decomposition of organic matter by propagation of anaerobic bacteria can be expected. Although the water pooled eventually infiltrates into the ground, it is far more hygienic than direct infiltration.

Fig. 8.2-2 shows an example of a simple septic tank for home use and ground infiltration facility. This consists of a two-compartment septic tank and a disposal tank. Although water stoppage treatment with cement is required for the wall and bottom of the two-compartment septic tank, the disposal area can be made of bare earth, as the treated water shall infiltrate into the ground.

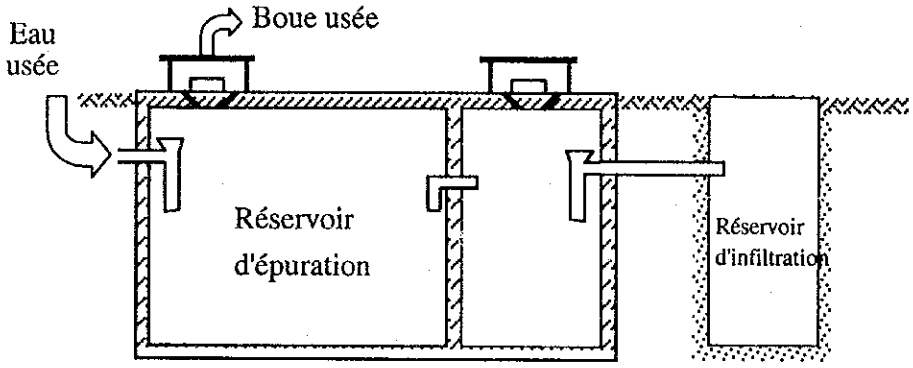

Fig. 8.2-2 An example of a simple septic tank for home use

② Imhoff tank and disposal field trench for multiple dwelling residence

Fig. 8.2-3 shows an example of a simple system in which home and commercial sewage is collected at a commercial and concentrated residential area by a simple sewer, and the sewage goes through precipitation and anaerobic decomposition treatment in the Imhoff tank that is larger than a septic tank in scale. The treated water is conveyed to the disposal field trench and infiltrates into the ground. Similarly, Fig. 8.2-4 shows the outline of a disposal field trench, and Fig. 8.2-5 shows the Imhoff tank.

Although servicing of the system is more costly than for the simple septic tank for home use, the former is suitable for regions with economic capacity because of a better treatment performance. As cities in dry area such as Kiffa city are very likely to adopt a simple treatment + soil infiltration method for the final installation of a sewage system, the proposed system is considered as a model for the future sewage system.

Since the topography of Kiffa city does not allow rainwater to flow out of the city, with wadi serving as natural drainage canals, water is pooled in several low areas in the city to become ponds that appear only during the rainy season. Because these ponds are used as the source of water for farming other than for drinking purpose, it is important not to let urban home wastewater reach there. The above sewage treatment measure was proposed for this purpose.

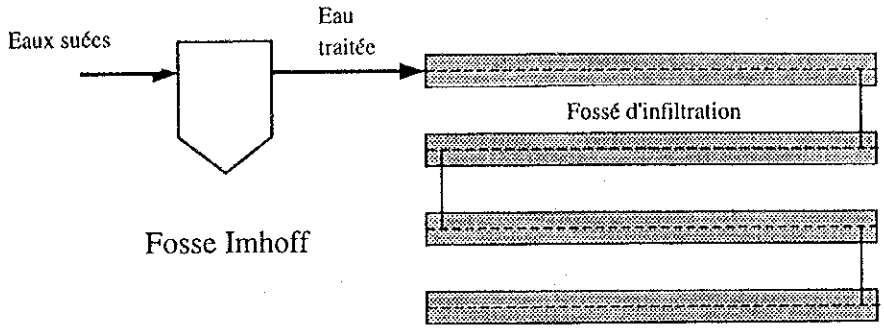

Fig. 8.2-3 Outline of the collective system of simple sewage treatment and soil infiltration

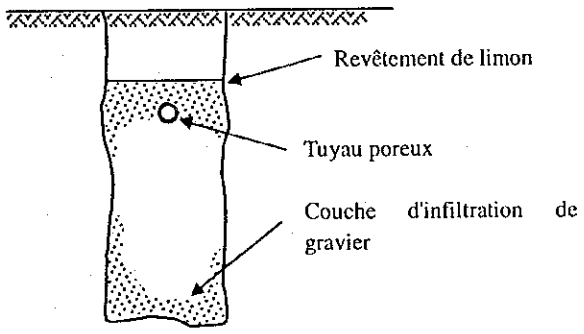

Fig. 8.2-4 Outline of a disposal field trench (cross-section)

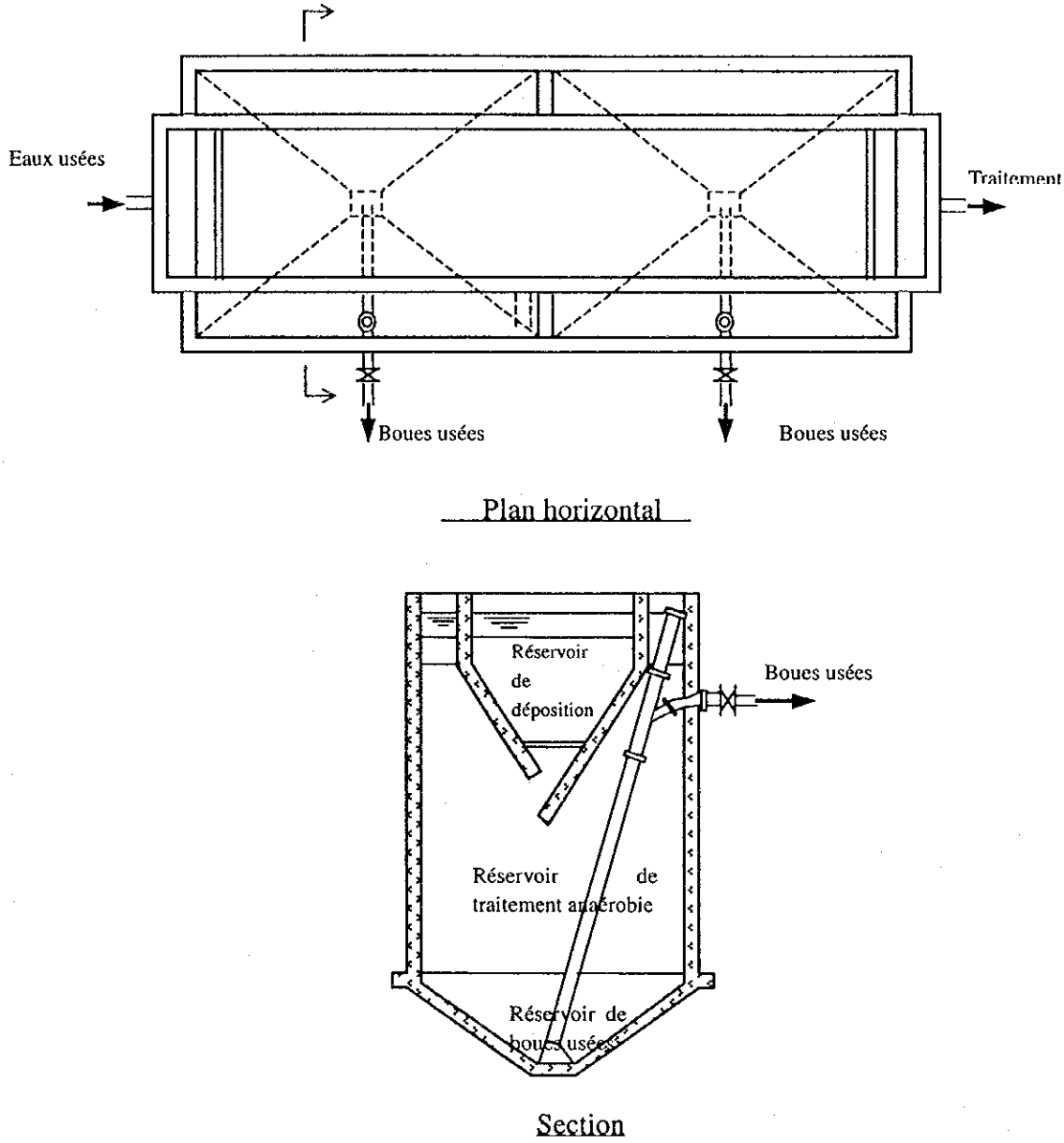

Fig. 8.2-5 Outline of an Imhoff tank

(2) Long-term improvement plan (target year: 2015)

① Promotion of preventive measures against contamination of wells in the city

Promote further the well structure improvement project carried out in the course of the urgent improvement plan.

② Prevention of subterranean water contamination by installation of sewage facilities

In the long-term improvement plan, the prevention of subterranean water contamination from sewage shall be intended through development of sewage septic tanks and installation of conduits and simple sewage treatment facilities.

Fig. 8.2-6 shows the concept of sewage system servicing, and Fig. 8.2-7 shows the sewage facilities plan.

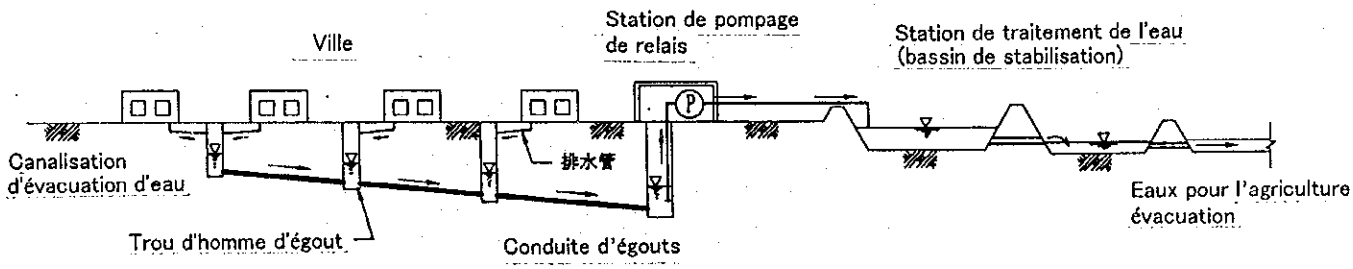

Fig. 8.2-6 Concept of sewage system servicing

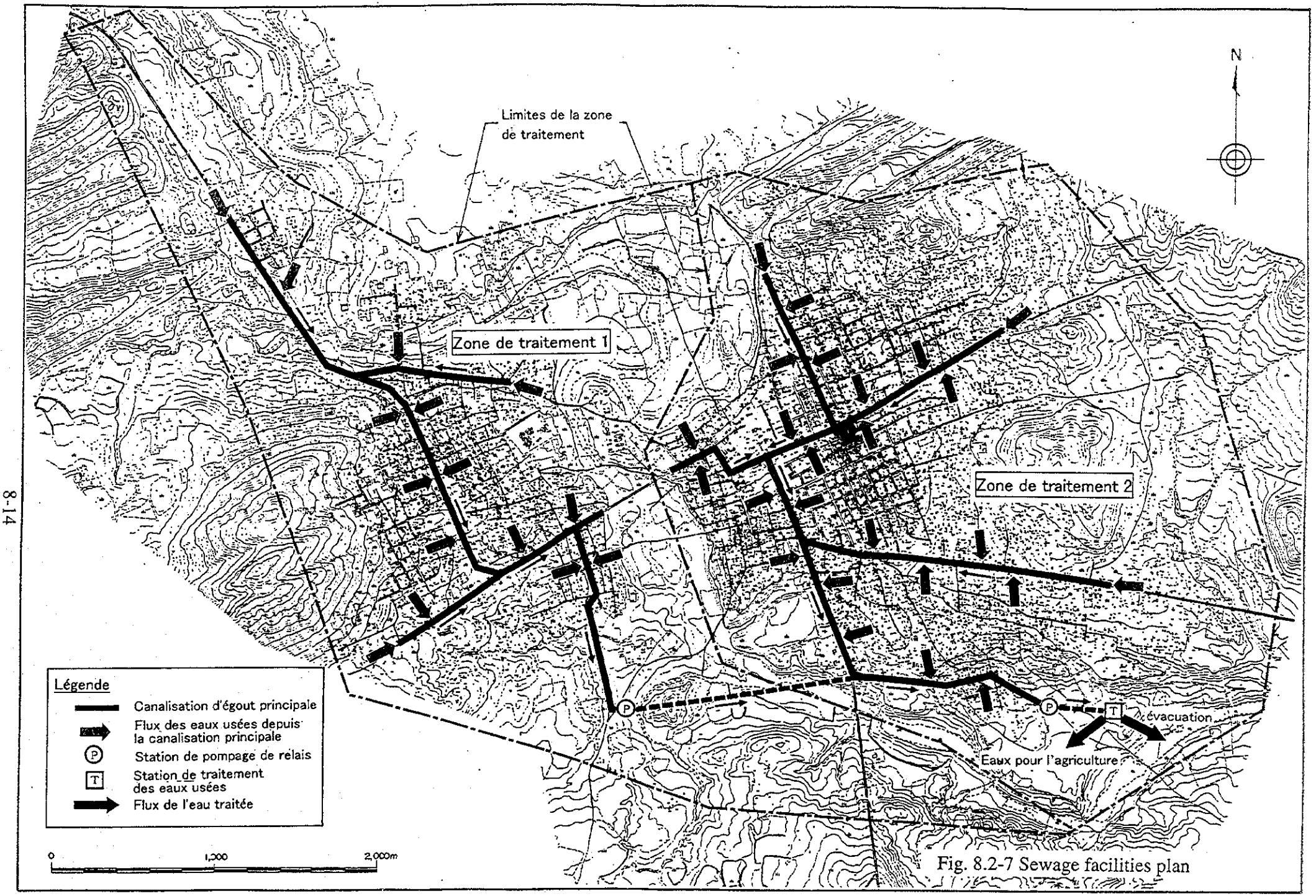

Fig. 8.2-7 Sewage facilities plan

Chapter 9 Project Evaluation and Implementation Plan

9.1 Economic and financial evaluation

9.1.1 Economic evaluation

The purpose of economic evaluation is to verify the appropriateness of this project for the national economy.

This project includes components for support of hygienic education as well as construction, operation and maintenance of water-supply facilities. Hygienic education has been carried out in Kiffa, including support by the UNDP, UNICEF, etc. It contains elements such as nutrition, family planning, etc., in addition to prevention of water-borne diseases. Accordingly, it is difficult to estimate costs for prevention of such diseases or for education regarding use of water only. Therefore, this economical evaluation does not include the benefits (effects) and costs of hygienic education.

(1) Methodology

1) Analysis index

In this economic evaluation, costs and benefits are analyzed after estimation of economical costs and benefits. The economic internal rate of return (EIRR), the net present value (NPV) and the benefits-costs ratio (B/C) are estimated. Then, evaluation is made using these as indices. The discount rate for calculation of the NPV and the B/C and opportunity cost to be compared with the EIRR should be 10%. This is the same figure as is used in the master plan of waterworks improvement and completion in 10 cities in Mauritania.

For both costs and benefits, prices in 1998 are used. The period of evaluation is 20 years (1999 - 2021) after use of the facilities. The remaining values of facilities immediately after the evaluation period are counted up as negative costs in one year, 2021.

2) Economic costs

The costs integrated in Chapter 6 are financial costs. They are the costs actually paid by an executor for construction and operation of the facilities when the project is executed. Economic costs are values for the national economy in Mauritania,

regarding resources (material, manpower, land, etc.) invested for execution of the project, and the calculated cost based on economic prices. Upon economic evaluation, the following points are considered and financial costs are converted into economic cost.

- Taxes (customs, domestic consumption tax, etc.) included in financial costs are subtracted as a transfer item that is excluded from economic values.
- For non-trade property (the portion of internal currency) in financial costs, border prices are generally estimated with the standard conversion factor (SCF) obtained with the following formula. However, according to statistics of customs in Mauritania in recent years, customs are much greater than import tax. Therefore, the SCF should be 1 in this analysis.

$$SCF = \frac{\text{(Import amount (CIF)+Export amount (FOB))}}{\text{(Import amount (CIF)+(Import customs)-Import subsidy+Export amount (FOB)+Export subsidy-Export customs)}}$$

- Because of the high unemployment rate in Kiffa, the scarcity value of inexperienced labor is considered to be low. Therefore, potential value (economic cost) for inexperienced labors should be 50% of financial costs.
- Land to be expropriated for execution of the project is not used for economic activities now. As it doesn't contribute to production, its economic value should be 0.

(2) Economic benefits

Economic benefits in this projects are as follows. They were obtained by calculating the difference in amounts if the project is executed and if it is not.

1) Those that occur because the outbreak of diseases caused by water decreases as a result of supply of safe water.
   ① Reduction in medical treatment costs
   ② Increase in the production amount (or the value of decreased hours) because working hours increase as a result of decrease in hours required for medical treatment, rest, recuperation and nursing

2) Increase in the production amount resulting from reduction of hours/labor to secure water, or costs to purchase water

Based on limited information, the items stated above were roughly calculated and estimated. The results are covered in the Supporting Report. Here, Kiffa citizens' willingness-to-pay for water is estimated and will be considered as an economic benefit.

The amount of money that is now paid for water by Kiffa citizens is the willingness-to-pay in this analysis, as in other analyses generally conducted in the field of water supply.

(3) Results of analysis

1) Estimation of economic costs

Regarding construction costs and operation, maintenance and management costs, the Supporting Report describes the results of conversion of financial costs to economic costs based on the method stated in the section of the methodology. The summary of the main results are shown in the following table.

Table 9.1-1 Economic costs and financial costs

Costs	A. Economic Costs	B. Financial Costs	A/B
Construction Costs (in the early stage)	1,506,140	2,084,000	72%
Operation, Maintenance and Management Costs (in 2005)	19,034	20,619	92%

2) Estimation of economic costs

According to a household questionnaire survey, UM.25,174/household/year is paid on average to secure water for the home. As the average number of family members covered by the questionnaire is 6.6 per household, the cost per person is about UM[3],800/person/year. Economic benefits are obtained by multiplying this unit price per person by population with water supplied. Since the number of such population is considered to be 77,000 in 2005, the result of calculation of economic benefits in this project is about UM.294 million in 2005. The results of calculation of economic benefits from 2002 to 2012 are shown in the Supporting Report.

Costs paid by Kiffa citizens to secure water is now 7.4% of household income (estimated to be UM[3]38,500 per household per year). Since it is said that their willingness-to-pay is generally 3% - 5% of household income, this is a considerably high figure. From another viewpoint, this figure shows a situation in which Kiffa citizens must pay expensive costs for water, i.e., where they are distressed about securing water for living, because the water is indispensable for human life.

3) Estimation of indices

The following figures are obtained from calculation with the benefits and costs stated above: 14.0% for the economic internal rate of return, 1.27 for the benefit/cost ratio and UM440 million for the net present value. Benefits and costs in the evaluation period and the results of calculation of these three indices are attached to the Supporting Report.

4) Valuation

Because the economic internal rate of return is over 10%, it is possible to judge that this project will produce a good impact on economy of Mauritania. Therefore, it can be said that this project should be executed in terms of national economy. Profit to be brought in the economy of Mauritania by execution of this project is UM.440million in present value.

As a result of sensitivity analysis, we found that economic propriety of this project would not be lost. This is because the economic internal rate of return will be maintained at 10% even if benefits decrease by 21% in all years in the evaluation period, or if construction costs increase by 30%.

9.1.2 Financial evaluation

Financial analysis is carried out to examine and verify financial soundness of a project for an operating, maintaining and managing organization. In this case, it is an analysis of how new incomes and expenses to be brought by execution of the project will influence finances of SONELEC.

(1) Methodology

The results of economical analysis indicate economic propriety of this project in the national economy. Therefore, this project should be executed for economic development and improvement of welfare for the nation's people, from the viewpoint of the government of Mauritania or SONELEC, which is a public service corporation. For this reason, verification and examination is carried out here regarding which option(s) should be taken in order to operate and continue the project among possible options in the existing framework of financing, policies of rates, etc.

First of all, the financial internal rate of return is estimated based on incomes and expenses of SONELEC. Then, possible options for financing, policies of rate etc., are

determined. Under these conditions, estimation is made for the profit/loss statement and the cash flow statement, and sound operation is examined and verified.

Since connection costs will be paid by each household, they will not be incomes nor expenses of SONELEC. Accordingly, they are not included in this financial analysis. For cash flow, surplus will be used as working capital for other services and we expect to receive 10% interest.

(2) Results of analysis and their evaluation

1) Estimation of financial internal rate of return

The financial internal rate of return (FIRR) of this project will be negative (see the Supporting Report). The investment fund for execution of this project should not be raised by a loan because of the existing rate system (as this analysis is made with fixed prices in 1998, a raise of the rate to adjust for inflation means maintenance of the existing rate system). In addition, judging from SONELEC's present financial conditions, such as its balance sheet, it is almost impossible to execute the project with its own funds.

If a loan is used, it will be obtained from a foreign country because the possibility of a long-term loan is low in Mauritania. The rate of interest of Arab Fund, a representative financing organization, is 3.5%. For the FIRR of 3.5%, it is necessary to raise the current rate by 3.7 times.

Average willingness-to-pay for the water rate is estimated with answers to the question about it in the household questionnaire, and is approximately UM.1,100/month or UM.13,000/year per household. This amount is about 2.8 times higher than the current rate. It is also 3.8% of the average household income. Since it is said that willingness-to-pay is generally 3% - 5%, this amount is considered reasonable. However, if the rate is raised by 2.8 times, the FIRR will be only 1.6%.

From the examinations stated above, we conclude that the initial investment in this project should not be made with a loan. Therefore, a grant from a foreign country or the government is required.

In this financial analysis, a grant is assumed for the initial investment suggested to be carried out from 1999 to 2001. On this assumption, the profit/loss statement and

the cash flow statement are estimated for this project. Then, examination is made regarding methods of financing for expansion work and renewal of facilities from 2006 to 2008.

2) Estimation of profit/loss statement and cash flow statement

If the water rate is kept at the national average level, the accumulated fund until 2006 will be small even if the initial work of the priority service is carried out with grant,. In addition, as profitability of the expansion in 2006 work will be low as the initial investment, it is difficult to conduct it with a loan. If the expansion is executed with a grant, we expect that renewal of facilities after 20 years that will be able to be afforded with accumulated funds.

If a higher level of the rate than the current is applied (in addition to a raise due to inflation) and the actual level is made twice over 20 years, it will be possible to cover the shortage of accumulated funds with a loan on the conditions (those of Arab Fund) of the interest rate of 3.5% and the repayment period of 30 years (including the 5-year period of deferment for both interest and principal). (In this case, even if the average actual household income is same as at present, the water rate in 2021 will be 3% of the average household income or less.) It is also estimated that funding for renewal of facilities will be able to be afforded with the accumulated fund. (The results of estimation of the profit/loss statement and the cash flow statement in the two cases stated above are attached to the Supporting Report.)

It is anticipated that the policy of a twice raise in addition to a raise due to inflation will encounter political difficulties. However, in our opinion, it is a policy to be considered in the term of sound operation of future waterworks projects as well, partly because the current rate is much lower than willingness-to-pay. We can also recommend a raise of the rate if waterworks projects will be expanded to smaller cities with little population where the average income is low and willingness-to-pay for water seems low. For example, a rate equivalent to about 3% of household income will be collected in each city and surplus funds in large cities will be used as compensation for smaller cities.

Of course, accompanying a raise of the rate, there will be the necessity of such a policy that the average rate will be 3% of household income by imposing a lower rate on people using a minimum amount of water and a higher rate on people using a large amount, in consideration of poor households. As the nature of a public corporation, it

is never allowed that SONELEC will promote only in cities with high profitability and neglect expansion to districts with lower profitability. It is also never allowed that an increase in incomes will lead to increase in unnecessary costs. For these reasons, the goal of spreading water service should be established, and policies for monitoring operation and productivity of waterworks projects are indispensable.

9.2 Social evaluation

9.2.1 Grouping of the population

The question was raised regarding the "risk" of the increased attraction of Kiffa city once a water supply equipment as projected will be installed. We also asked ourselves about the conclusions which observations in the recent and less recent past were established, regarding an eventual correlation between the evolution of water resources and the volume of inhabitants in a city such as Kiffa or in other towns or cities with the installation of a water supply system comparable of the system to be used in Kiffa.

In the remote past, we have had indications allowing us to conclude on the cause and effect between the disappearance of a city and the drastic drop in its water resources (particular example of Tegdaoust/Awdaghust near Tamchaket). At present, we still do not have a data system allowing the assumption of a cause and effect between the installation of a water supply system and increase in the population of a Mauritanian city.

If we exclude urban areas which have definitively deteriorated, we can distinguish 3 stages in the urban development history of Mauritania.

A first generation of small oasis towns was apparent between the 11th and 15th century (Ouadane, Oualata, Tichit, Chnigueti) whose commercial activity was essentially linked to the trans-Saharian trade. These villages, whose biggest population probably never exceeded 5000 residents, suffered significant decline for a multitude of reasons which cannot be sufficiently enumerated in this report. Today, the sites are half in ruin. The installation of new water supply equipment (diesel, solar and/or wind) sometimes dating back to the beginning of the 70s (Chingueti and so on) have hardly contributed to the stopping this decline.

The second generation of Mauritanian towns, to which Kiffa and the majority of regional capitals belong, arose from the French colonization (1902-1960). These towns, often provided from the end of the 50s with a small water supply system, were in fact only small administrative centers with no point of attraction for the surrounding rural populations, where the great majority were nomads.

The explosion of the urban phenomenon was mainly observed with the drought which swept Mauritania in 1968. The very rapid growth of most of the existing towns and the

emergence of many others started during this climatic crisis. The urban population of Mauritania therefore increased from around 3% in the beginning of the 50s to more than 41% today.

All new towns were built around water supply ports. However, neither the growth of the existing towns nor the emergence of new human settlements may be associated with this single factor. The potential settlers or rural migrants were looking for means of subsistence (assistance of any nature, etc.), health care, a place to educate their children, work, etc. They were and are still motivated by the need to affirm their particular identities, in particular, to group themselves based on tribal origins. Communication means, in particular the so called "road to hope" where Kiffa constitutes the midway stage, have contributed significantly to migratory movements. The maintenance of connections with the rural hinterlands where part of the family continued to lead a pastoral or agricultural existence, was another factor in the residential choice of the potential migrants or settlers.

To our knowledge, the improvement of potable water supply equipment has never played a specific role in the progression curve of the population in a Mauritanian town.

In Kiffa, as elsewhere in Mauritania, it was mainly the above-mentioned climatic problem of drought which led to demographic growth. Unfortunately, we do not have the statistical means to establish an annual correlation between the evolution of rainfall and population growth as suggested during the mentioned workshop.

The Agrhymet program (PNUD/CILSS/OMM) which may have research data did not provide any indications regarding the rainfall factor alone.

In general, these rainfall data indicate a significant drop in rainfall with respect to the past 30 years. According to the Agrhymet sources, the 384.2 mm average for the 1950-1967 period dropped to the above-mentioned average of 235.5 mm per year.

The lowest rainfall years were in the 70's to the beginning of 1980. As shown in available demographic data, this period marks the increase of population in Kiffa.

Table 9.2-1 Evolution of the Kiffa population

(unit: UM. thousand)

Year	1924	1946	1962	1972	1977	1985	1988
Population	197	1,807	4,359	7,300	10,7,3	18,390	29,292

However, the preceding paragraphs show increasing growth in Kiffa, almost exclusively due to the presence of the reservoir (limited etc.) in the Assaba region whose inhabitants have also contributed to the migratory flows in the direction of Nouakchott and the mining cities north of Mauritania.

In summary, the installation of a water supply equipment in Kiffa may not significantly modify the demographic growth rate of this city, which depends on a complex combination of other factors.

9.2.2 Impact of the building of water supply installations in villages surrounding Kiffa.

One of the questions regarding the building of water supply installations involves the supply of water in 6 villages surrounding Kiffa and which are part of its commune: Kendra, Kreikett, Wed Rodha, Meissah, Hassi Bekaye and Oum Echgag.

These villages, which are relatively far from the city center (between 7 and 18 km) were not taken into consideration during the preceding evaluations of the population in the Assaba capital and in the evaluation of its future evolution.

We have relatively precise estimates for 5 of these sites, established in 1987 by the Central Census Office, but updated data is not available. However, approximate figures were obtained from local heads and spokesmen for the population. These data are as follows:

Table 9.2-2 Estimate of the population in villages around Kiffa

Village	Hassi Bekaye	Wad Rodha	Oum Echgag	Kendra	Kreiket	Meisah
Pop. 1987	230	353	319	722	291	?
Pop. 1997	2,000	430	472	1,200	483	397

These villages are not covered by the electrical network recently installed in Kiffa, which

is limited to the city itself.

The two most important villages, Hassi Bekaye and Kendra, are equipped with solar pumps with a theoretical daily production capacity of 20 m^3 for Hassi Bekaye and 30 m^3 for Kendra.

In Kendra, a village "rich" in water, has 5 water posts, and 3 private connections. In Hassi Bekaye whose residents appear to have more modest income, there are no private connections and water from the solar pump is distributed by 4 water posts. In other villages, water is simply provided by wells.

Evaluations for a future water supply system expect the persistent use of well water to cover part of the needs, aside from drinking water, of the Kiffa inhabitants. The village of Kendra, and to a lesser extent, Hassi Bekaye, may now satisfy a big fraction of their current water consumption needs due to available solar equipment.

In passing, we may note that this equipment is managed by employees hired by the Hydraulic Department, and (in principle) applying the rate recommended by the department, which is 80 UM/m^3 supplied to the water posts.

In any case, the availability of water as noted and estimated during phases preceding the study, does not imply that the distant periphery of Kiffa may be supplied by the drillings provided. The cost of transporting water by a tank truck may be too high. Furthermore, the previous experiment of having these trucks managed by the municipality has not been very encouraging (problems of maintenance and spare parts etc.).

Solutions to be considered for the 4 villages not equipped with solar pumps will consist of local measures which will at least include steps for the identification and hygienic protection of the most important water supply points.

9.2.3 Price of water, management systems and social inequalities

Given the dimensions of the equipment to be installed in Kiffa and the advantages of including the management for electricity under SONELEC, it seems that the latter will be the best partner for managing the future water supply installation.

The question is how to avoid the possibility that the equipment will serve only those who

can afford private connections for water at lower cost.

Significant disparities may be assumed between the income of the more prosperous and the poor inhabitants of Kiffa. Very roughly, certain districts (Jedida, the administrative district etc.) may be considered as "richer" than others (Debai, Seif, Timicha, etc.). Unfortunately, results of the questionnaire survey and the available literature do not allow a precise verification of these concerns.

The only information available refers to the general incidence of poverty in Mauritania and in Kiffa.

The Survey on the Informal Urban Sector (ONS, January 1997) a sector which certainly represents more than two thirds of employment in Kiffa, states that for the entire Mauritania, 35.5% of employees in this sector receive a salary less than 5,000 UM/month (SMIG - Guaranteed Minimum Wage is 5,312 UM at the time of the survey). Among these wage earners, 5.1% receive at least 2,500 UM/month, while 89% among them receive less than 1,000 UM/month.

The problems of revenue in Kiffa may be indirectly approached through an analysis of the existing poverty situation conducted by the World Bank in order to limit the negative social effects of structural adjustment policies.

Surveys conducted within this framework have tried to evaluate the state of poverty based on household expenses. Two annual volumes of expenses corresponding to the 2 poverty thresholds were retained in order to define "poverty" and "extreme poverty" (in 1995), respectively at 53,841 UM and 40,709 UM.

According to these criteria, 26.8% of the city inhabitants were affected by cities other than Nouakchott (including Kiffa). In "center cities", which include Kiffa, the incidence of poverty is even higher since it covers 50.9% of the inhabitants.

"Extreme poverty" affects 21.9% of the inhabitants of cities other than Nouakchott (including Kiffa).

According to this study, the structure of the average household expenses according to place of residence is as follows:

(Unit: UM)

Average Expense	Place of residence				Overall
	Nouakchott	Other city	Rural river	Other rural areas	
Self-consumption	104	2,189	10,565	16,632	8,773
Food	319,775	261,191	226,239	182,639	240,362
Education	1,318	921	361	532	788
Health	8,813	3,078	2,788	2,796	4,527
Lodging	98,828	57,794	3,983	3,170	38,824
Jewelry	1,741	2,106	299	462	1,057
Household equipment	6,977	6,390	1,949	3,330	4,626
Construction materials	7,699	5,344	2,103	2,037	4,161
Clothes, cloth	36,024	32,322	21,667	29,854	30,648
Personal articles	13,945	12,417	3,638	4,840	8,414
Household maintenance	28,017	18,912	14,407	10,410	17,321
Transport, gasoline	16,220	4,432	532	941	5,719
Hairstyling, cutting	10,630	957	0	13	456
Total expenses	539,469	417,753	288,870	253,456	365,323

According to this Table, Kiffa has an annual total expense of 417,753 UM. This figure, which represents an average for all cities other than Nouakchott, only deviates by 15.38% from the total average expenses per household (353,533 UM) given in the JICA/Hydrological Department Survey.

Nevertheless, these 2 figures remain much higher than the annual average revenue per household, taken into consideration in the work progress report (21,000 x 12 = 252,000 UM). This difference is partly explained by the tendency of respondents to under-declare their income in surveys, and due to the fact that transfer revenues and money sent by migrant relatives, significantly contribute to covering expenses of relatives remaining in Kiffa, are probably not declared.

Tax collections may have constituted a means of discriminating charges to applicants for private water connections. In reality, these are quite imprecise. Only government employees, representing from 200 to 450 persons (based on the figure given by the study on 10 cities, or approximate figures provided by the Wilaya or prefecture) may be classified according to taxable income collected since income tax was repealed. However, these only represent a modest fraction of the entire urban employed sector (12% according to the study on 10 cities). As compared to big traders and owners of large herds whose income are

difficult to evaluate precisely (taxes on cattle have been eliminated since 1972), employees of the administration, or at least based on their official income, will not represent a privileged social class.

Neither do profile descriptions of the districts nor their socio-professional categories offer reliable bases for the classification of Kiffa inhabitants in terms of revenue.

Even if we recommend a study on the cost of a private connection to make it available to the biggest number of inhabitants, it will not be realistic to consider reducing this cost based on the assumed revenue level of the district or the person requesting a private connection.

The social cost of individual connections applied by SONELEC outside Nouakchott, which we have noted in a preceding report as amounting to 2,000 UM, may be considered for an increase (around 4,000 UM) based on the existence of a relatively well-to-do class in Kiffa city, which however cannot be pinpointed individually, based on the actual status of our data.

To avoid transport costs and the intervention of retailers, we can also suggest the installation of "cooperative water taps" to be managed by groups of neighbors composed of a small number of families (from 5 to 20) who will designate a head and who will organize themselves to assure the payment of charges. A more precise definition of the functions of these family groups, the dimensions and facilities required to benefit from facilities available in order to manage equipment, will require more investigation and specific training.

In any case, if the management unit applies "real prices", only a minor fraction of the population in the Assaba capital can avail of water through the easiest means, that is, through individual taps. In spite of the advantages which the water supply equipment may provide to the entire population, it may in this case, increase disparities between well-to-do and the poorer inhabitants of Kiffa.

9.2.4 Water selling donkey-carts

The question of the price of water is closely related to the function of water carts which presently constitute the essential means of water distribution in the city. Evidently, there is some contradiction between the maintenance of their activity and standardized access to water at basic rates proposed by SONELEC.

The sometimes very high price of water (up to 7 times its price from the tap) is almost

solely due to the intermediate service. The multiple transfers in water containers for transport by donkeys largely affect the hygienic quality of the water.

However, even if a big number of private water taps are installed in the city, there will always remain a significant portion of the population who will continue to buy water at retail, transported by carts.

Most of the carts (or more precisely, drivers who do not own the carts) are Mali seasonal workers whose eventual job redeployment is not a priority concern for Mauritanian authorities.

However, the following must be taken into consideration: the loss of profit for cart owners due to the loss or reduction of the distribution market, and the fact that part of this activity will remain useful for supplying water to the poorest inhabitants and those living farthest from Kiffa.

The carts are also often used to transport products other than water, and are even used as transport "taxis" by some of the Kiffa residents. We may consider assistance in the form of modifying the form of the carts to allow the owner to specialize in the transport of passengers and baggage (provision of seats, covered roofs, baggage holders, etc.). Carts used to transport water may be equipped with a more hygienic container (water-proof, transfer of water from the tap and not through a plastic hose, etc.).

A small preliminary survey of the carts and their equipment will certainly be required (number of carts operating, cost of investment, number of persons employed, economic resources generated according to types of transport provided - water, passengers, merchandise, etc. -, the sharing of income between cart owners and drivers, the sociological profile of owners and drivers, the type of adjustments to be provided and the contractual procedures for their implementation, etc.).

9.3 Technical evaluation

9.3.1 Development of sources of water

(1) Method to Select Sites for Excavation of Production Wells

Hydrogeology and aquifers around Kiffa city were clarified. Then, the method was established for development of water sources that would be necessary to be conducted by the Water utilization office and SONELEC to cope with future increase in demand for water.

As a result, sites and depth of excavation are determined as follows. It is possible to realize them with investigating equipment and materials currently owned by the Water utilization office and at their present technical level.

1) Sites

Aquifers in the area 10 -15 km northwest of the city center are in the fracture part of pelite strata. For effective development of water sources, it is necessary to confirm lineaments with air photos and by on-the-spot survey, and to specify locations by electric investigation. Locations of lineaments have been already shown in this survey. For future development, sites of excavation will be determined by horizontal electric investigation where a measurement line will be placed in the direction crossing the main lineament. With this, it will be possible to judge aquifers with patterns of appearance of anomalies that will be obtained from the results of a series of electric investigation in this survey.

2) Depth

Aquifers in this new water source area are located in the fracture part of pelite strata at 20 - 70 m deep. In tillites below that part, there is the possibility that electrical conductivity in underground water may be high. Therefore, it is not suitable for development of underground water for drinking.

(2) Preservation of quality of underground water at shallow aquifer in the city

As a matter of course, the recharge storage of underground water in the new water source areas, found in this survey, is limited. Accordingly, it is necessary to use underground water at shallow aquifer in the city in order to satisfy demand for water in Kiffa city. Underground water at shallow aquifer in the city is a low-cost water resource that doesn't require long-distance transportation. Therefore, preservation of

the quality of underground water at shallow aquifer in the city, which is being contaminated more and more, is important not only in the term of environmental quality but from the economical viewpoint.

As a method to preserve the quality of underground water at shallow aquifer in the city, improvement and completion of sewer systems will be eventually required. In consideration of the economic conditions in Kiffa city, the following step-by-step improvement is suggested.

1) Preservation of quality of water in existing wells

To preserve the quality of water and effectively use water around the public well for water-supply wagons in the Segatar district with good quality of water, and also at 5 public water taps.

2) Promotion of treatment at sewage purification tanks

The existing treatment of foul water/raw sewage is direct percolation treatment. The treatment of water through sewage purification tanks will be introduced to improve the quality of percolating water.

3) Improvement and completion of sewer system

To construct facilities for treatment of sewage through ducts/drainage ways and facilities for reuse of treated water.

9.3.2 Water supply plan and water-supply facilities plan

(1) Supply of safe water

There is severe pollution of underground water at shallow aquifer in the city, which is now used by residents in Kiffa city. The supply of safe water is an urgent problem. This plan will allow safe water to be supplied to all residents, although the amount is the required minimum, because hygienic underground water will be developed at sources of water outside the city and conducted to the city. Then, the above-mentioned problem will be completely solved.

(2) Appropriate technology

In order to continuously maintain and operate the planned water supply project, it is important to adopt technology appropriate for social and economic conditions and for the technical level in the area covered by the plan. For determination of the water

supply plan and the water-supply facilities plan, the following matters are considered.

1) Restriction of planned amount of water supplied

Kiffa city is located in the inland dry zone of Sabusahara, and sources of water are severely limited. Therefore, it is unavoidable to establish the minimum value for drinking water. SONELEC has 40 - 50 liters/person/day as a target value for urban water supply in Mauritania. However, considering the forecast of increase in the population in Kiffa city and the realistic developable amount of water sources around the city, confirmed in this survey, that value cannot be employed as it is. Restriction of the below-mentioned planned amount of water supplied will enable appropriate development of water sources and continuous maintenance and operation of the water-supply activities.

Water supply to individual houses : 40 liters/person/day

Water supply at public water taps : 30 liters/person/day

2) Public water taps

As the present situation in Kiffa city, rapid concentration of population has been advancing, triggered by droughts in the 1970s, and development as a city is not carried out according to a plan. In areas around the old district, where development has been being advanced in these years (population to be included in the plan is 27,000 of a total of 77,000 citizens, according to forecast of population in 2005), planning and improvement of roads is behind. Therefore, the main and branch lines for water supply activities cannot be improved and completed. Residents in these burgeoning areas are generally poor and cannot bear the economical burden for improvement and completion of water-supply facilities. For these reasons, the individual-house water supply system is not employed as a method of water supply in the plans for these areas. Instead, the solution is taken by adopting the public-water-tap system to main roads which have been decided already.

3) Configuration of an easy to maintain and manage water supply system

In the water-supply facilities plan, consideration is given to the technical level applicable for water service activities in Kiffa city and also to human resources that can be arranged there. It is necessary to organize a water supply system that can be maintained and managed. In the facilities plan developed from this point of view, the following items are considered.

① Configuration of equipment

Three systems are separated at water-conveyance pump stations with buffer function and distributing reservoirs. They are systems for the conduction of water from production wells, conveyance to the urban district and distribution in the city. Each of them consists of a pump and pipes, which is easy to be operated, maintained and managed. Particularly in the distributing system, the natural-down-flow method is employed, beginning from distributing reservoirs. This means that there are no machines nor electrical equipment. Therefore, maintenance and management are easy.

② Low-pressure distributing duct network

Most of the residences covered by the water supply plan in Kiffa city are one-story houses, and one contractor will have one water supply point. Therefore, in the area for water supply to individual houses, it is possible to establish 10 kg/cm^2 as the minimum running water pressure at the end of distributing ducts. As a result, all distributing ducts can be operated at relatively low water pressure.

(3) Restriction of water supply to certain hours

Throughout this water supply plan, effective use of poor water resources is a problem. Measures for restriction of consumption are considered, and employment of an escalating water rate is proposed for operation. On the other hand, in the facilities plan, water supply on the assumption of restriction of water supply to certain hours is included in the initial plan. It is not forecast that the planned daily amount of water supplied will increase much more than the initial plan in the areas concerned. Therefore, execution of restriction of water supply to certain hours is assumed in order to restrict consumption. As a concrete measure, for effective use of the distributing duct network, divisions of distributing areas and arrangements of main lines and cutoff valves are considered in order to adjust time and hours of water supply in each of the distributing blocks.

9.4 Implementation plan

9.4.1 Project priority

As repeated in this report, the results of the surveys clearly show that, under the present situation of water supply in Kiffa city, pollution of underground water at shallow aquifer being used by the residents now is advancing to the extent where the WHO's standards are greatly exceeded. We consider it is indisputable that supply of safe drinking water to residents should be the problem of the highest priority.

The following two methods, both of which are important, are possible for solution of this problem.

- To find new sources of water supply outside the city.
- To improve the quality of underground water at shallow aquifer in the city.

As a result of the hydrogeologic survey, it was found that promising aquifers are located around 15km northwest of the city. This means that a source of water was identified. On the other hand, it was also confirmed that improvement of the quality of underground water at shallow aquifer would require long-term execution of measures. For these reasons, a water supply plan was made with this as the priority. In this plan:

- underground water will be developed to satisfy short-term demand for water by the new source of water in the northwest, and
- water will be conducted to Kiffa city and supplied through a piping network.

On the other hand, from the long-term viewpoint, it is expected that demand for water will increase with the increase in population, and the new source of water naturally has a limited amount of water. Therefore, it is indispensable to execute activities for hygienic improvement and for improvement and completion of sewer systems in order to secure water sources by improvement of the quality of underground water in the place close to the residents, i.e., at shallow aquifer in the city.

9.4.2 Implementation plan

Fig. 9.4-1 ("Implementation plan of the Kiffa city water supply project") shows an implementation plan in each fiscal year for the above-mentioned project with priority and the long-term-planned project until 2015.

(1) Water supply plan with priority

As a project with priority, development of underground water at the new water source in the northwest of the city, and construction of water-supply facilities will be executed as fast as possible in order to supply the required minimum amount of hygienic and safe water in 2005.

(2) Second water source development and Construction of water-supply facilities

The second water source development will be carried out at the northwest water source to satisfy increased demand for water accompanying an increase in population in and after 2005. For this purpose, water-supply facilities (water-conducting and conveyance facilities and inside-the-city distributing facilities) will be also increased with 2006 as a target year. We judge that a limit of recharge storage in the northwest water source area is such that it will cover demand for water in 2015. For other developments after 2015, it is necessary to consider other measures for water sources.

(3) Preservation of quality of underground water at shallow aquifer in the city

Measures for preservation of water quality will be immediately taken for essential wells where underground water at shallow aquifer is used and whose water quality remains good now.

(4) Control of pumping-up of underground water at shallow aquifer in the city

In the water supply plan, underground water to be newly developed will be supplied for drinking water. For a part of water for daily life, it is considered to use existing underground water at shallow aquifer in the city. According to the forecast, this underground water at shallow aquifer in the city will be excessively pumped up as a result of increase in demand for water in and after 2005 if its use is not controlled. These private wells also require measures for restriction of pumping-up and for control.

(5) Improvement and completion of purification tanks

Treatment of home and raw sewage is the most effective measure for improvement of quality of underground water at shallow aquifer in the city. Though full-scale improvement and completion of sewer systems is expected, it is judged from Kiffa city's financial conditions that early execution will be difficult. Therefore, purification tanks will be installed at each residence, as a measure before the improvement and completion stated above.

(6) Improvement and completion of sewage ducts and treatment facilities

As a drastic measure for improvement of the quality of underground water at shallow aquifer in the city, real sewage facilities with ducts and treatment equipment will be constructed aiming at completion in 2015. In this plan, reuse of treated water for agriculture is taken into consideration. It is considered as a help for development of water sources after 2015.

9.4.3 Fund plan

Figure 9.4-1 ("Implementation plan of the Kiffa city water supply project") shows the summary of the required amount of investment based on the implementation plan of the water supply project until 2015.

Fig. 9.4-1 Implementation plan of the Kiffa city water supply project

Implementation	Implementation year																
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(Water supply development plan)																	
Development of sources of water	■																
Construction of water-supply facilities	■	■															
Development of new sources of water								■									
Expansion of water-supply facilities									■	■							
Preservation of quality of underground water at shallow aquifer in the city		■	■	■	■	■	■										
Control and restriction of pumping-up of underground water in the city								■	■	■	■	■	■	■	■	■	■
(Hygienic improvement plan)																	
Prevention against polluting wells in the city		■	■	■	■	■	■	■	■	■	■	■					
Installation of purification tanks		■	■	■	■	■	■										
Improvement and completion of sewage ducts and treatment facilities													■	■	■	■	■
Water supply amount (m^3)				336	389	450	521	605	632	661	691	723	756	791	827	865	905
Required amount of investment for the water supply project (million UM)	104.0	990.0	990.0					43.0	398.0	398.0							
Operation and maintenance cost (million UM)				17.5	18.4	19.4	20.6	22.0	22.5	23.0	27.0	27.5	28.0	28.6	29.2	29.9	31.0

9.5 Recommendations

(1) Protection of water sources and preservation of water quality

This survey found a promising source of water northwest of the city. Some wells for underground water at shallow aquifer in the city were also specified as those with good water quality. We would like to recommend that measures be taken for protection of water sources and for preservation of their water quality, without waiting for full-scale construction of water-supply facilities based on the water supply plan.

1) Protection of water sources

In the water source area in the northwest, no people are living and water quality is good. In order to preserve long term, protective measures such as prohibition of house construction and of land use for agriculture should be taken throughout the area of 5 km x 10 km.

2) Preservation of water quality

Similarly, for the wells with good water quality in the city, urgent measures to prevent pollution around wells should be taken.

(2) Monitoring of ground water levels and water quality

As an assumption for execution of the water supply plan, water levels and quality will be regularly monitored at the wells for the new water source and for underground water at shallow aquifer in the city, and accumulation of data will be started.

For the contents of monitoring, see Chapter 6 (" Groundwater development plan ").

(3) Operation and management of public water taps

In the water supply plan, water supply with public water taps is suggested in some areas according to the conditions of urban development and economy. In the method to operate public water taps in other cities that has been employed by SONELEC, operation is entrusted as profit-making work to an individual. Some people point out that, as a result, users have social disadvantages such as payment of high water rates.

A possible measure to improve this is operation and management of public water taps by a regional residents' organization, such as a livelihood cooperative association. We expect that the city will prepare execution of the project and give a guidance of concrete formation of such an organization.

(4) Discussion on establishment of water rates in Kiffa city

As pointed out in the financial analysis for evaluation of the project, in the planned project, the amount of water supply is restricted to the minimum to continuously use the limited amount of water resources in the area. As a result, water rate incomes are also limited and water-supply facilities are financially ineffective. On the other hand, residents now purchase water from water-sellers using donkey-pulled wagons, whose price is far higher than the water rate. It is considered that it is reasonable to specially establish water rates in the water supply project for Kiffa city in order to reduce this present amount paid by the residents by about the half. We recommend discussion of revision of water rates for the purpose of sound development of water service activities.