5. WATER DEMAND

5.1 Major National Policies

In "Fiji's Ninth Development Plan 1986-1990" (DP9), the latest national development plan established, it was stated that "an adequate, reliable, and safe water supply", achieved by solving repeated water shortages, is one of the most important targets for the water supply sector. In order to achieve the targets, the capital expenditure programme for infrastructure/utilities development during DP9 was proposed by the government as shown below:

Sector	Capital Expenditure 1986-1990 (F$ million 1985 price)	% of Total (%)
Transport	87.6	38
Water Supply and Sewerage	67.5	29
Posts and Telecommunications	55.0	24
Energy	20.7	9
Total	230.8	100

However, numerical targets, such as a per capita consumption rate, service ratio, etc., were not mentioned in the national plan. Other strategies, where the numerical targets are defined, are not available.

PWD has prepared several manuals for the design and planning of the water supply project in Fiji. In terms of water demand projection, the following unit consumption rates are recommended to apply in the planning and designs of the manuals.

<u>Rural Water Supply Design Manual</u>

unit consumption rate	kind of water use/place
160 lpcd	for house connection
115 lpcd	for public standpipe, used for washing, cooking, drinking and bathing
45 lpcd	for public standpipe, used for drinking and bathing

<u>Water Supply Design Manual (Draft)</u>

200 lpcd	for the cities, Suva and Lautoka
150 lpcd	for town

In the Project, water demand projection was based on the results of the population projection considering the above unit consumption rate: The potential of groundwater resources, and the processes of water demand projection are described in the succeeding sections of this chapter.

5.2 Population Projections

5.2.1 General

In 1989 the Government of Fiji projected the national population for the period from 1991 to 2011, at intervals of 5 years, using a demographic analysis method based on the 1986 census and past population growth trends. According to this projection, the national population in 2011 is estimated at 941,841, which corresponds to 1.31 times the 1986 census. However, population projection by region has not been officially announced (see Table F-1.4 of APPENDIX-F).

The present population projections are made according to each community in the Study Area, aiming to provide the basic data required to estimate domestic water demand in the Study Area.

The projections are first based on urban and rural areas in the respective Tikinas, not by individual communities. Next, the growth rates, which are derived from the initial population projections, are used to project the population of communities included in the urban and rural areas. Three scenarios, high, medium and low variants, are prepared for the present projection.

5.2.2 Methodology

The population projections are made at intervals of five years for the period 1991 to 2011, using the 1986 census population and the proper population growth rate for the same period. A semi-component model, a combination of component and mathematical models, is applied to this projection. Both models are employed for estimating the natural and migrational growth rates, respectively.

Table 5.2.1 lists the growth rate of the whole population of Fiji for the period 1976 to 2011, together with the annual growth rate of population in the Study Area for the period 1976-1986.

The population growth rate (r) in the Study Area is approximately given as the sum of two rates: natural growth rate (r_1) and migrational growth rate (r_2). Of these, the natural growth rate (r_1) adopts the national population growth rate of Fiji shown in Table 5.2.1, and the medium variant of the initial migration rate (r_2) required for the 1991 population projection in the Study Area is based on the difference between the annual growth rate (r) in the Study Area and the national growth rate (r_1) for the period 1976-1986. The high and low variants of the migration rates are assumed to be 20 % up and 20 % down of the rate applied to the middle variant. The 1991 population estimated above is finalized after an adjustment in accordance with the process given in APPENDIX-F.

Following the 1991 population projection, a first approximate of the 1996 population is projected, using the 1991 finalized population and an annual growth rate assumed for the period 1991-1996. The 1996 population and the average annual growth rate for the period 1991-1996 are adjusted according to the same process as the 1991 population projection.

The populations in 2001, 2006 and 2011, and the annual rates of population growth for the periods 1996-2001, 2001-2006 and 2006-2011 are successively projected in accordance with the method indicated in the 1991 and 1996 population projections.

5.2.3 Results

Results of the population projections, according to the three scenarios of high, middle and low variants, are listed in Table 5.2.2. The total population of the Study Area in 2011 would be projected to be 138,852 for the high variant, 104,248 for the medium variant, and 85,707 for the low variant.

The high variant projected population for 2011 in the Study Area is estimated at 138,852, increasing by 43.1 % (annual growth rate of 1.44 %) from the 1986 population (97,018). This growth rate is high compared to the population growth rate of the whole country in the medium Scenario, shown in Table F-2.1.

On the other hand, in the medium scenario, the 2011 population of the whole Study Area is projected to 104,248 increasing by 7.5 % (annual growth rate of 0.29 %) from the 1986 population . It appears that this growth rate is rather low, due to the initial influence of a negative growth rate of migration.

The population projected under the low variant scenario would come to 85,707 in 2011. This population, which is lower than the 1986 population, would not be subject to the water demand forecast in the Study Area.

As a result, future water demand in the Study Area should be planned within the range of populations projected from scenarios of high and medium variants.

The average annual population growth rates by ethnic groups in the respective regions of the Study Area are estimated at intervals of five years for the period from 1991 to 2011(Table F-3.2 in APPENDIX-F).

Further for the same period, the populations of communities within regions are projected using the population growth rates of the respective regions according to the three scenarios, and divided into two kinds of areas, with or without a regional water supply system. These results are given in Tables F-3.3 to F-3.8 in APPENDIX-F.

Table 5.2.3 provides a summary of the projected population classified into urban and rural areas and areas with or without a regional water supply system in the Study Area. According to the high scenario, it is expected that the projected population in the Study Area will increase to 60,189 in 2011 from 49,846 in 1986 in areas with the regional water supply system, and to 78,664 in 2011 from 47,172 in 1986 in areas without the regional water supply system.

5.3 Present Water Consumption

In order to confirm the present water consumption in the Study Area, which were used as basic data for the water demand projections described in Sections 5.4 and 5.5, a water consumption study was carried out using the statistical records collected in the PWD Western Divisional Office. The records consist of production amounts of treated water from the existing water treatment plants for the regional water supply systems, and water consumption and the number of contracted consumers. The projected population served by the systems is also used for the study.

The collected records are, however, inconsistent, such as the production amounts are less than the water consumption, and the production amounts have large fluctuations yearly, and their reasons are not clarified. Therefore, this study was conducted by comparing and referring to the results of the interview survey and the values specified in the manuals prepared by PWD.

Table 5.3.1 shows the results of the study. The effective amounts in the table were calculated multiplying the total distribution amounts by 64 % of the effective ratio (= Effective Amount / Total Distribution Amount), which is converted from 36 % of the unaccounted for water proffered by the divisional office. The domestic use amounts were calculated based on the adopted ratio of domestic water use and the commercial water use, 80 % for the areas served by the Ba and Tavua/Vatukoula regional water supply systems, and 70 % for the area served by the Rakiraki regional water supply system, as estimated in Table 5.3.2.

In the area served by the Ba regional water supply system, the domestic water consumption was estimated from 1,986 to 4,394 m^3/day and the per capita consumption from 63 to 135 lpcd. The production records in 1990 and 1991 are assumed to be less than the actual production amounts. Also, the production amounts of groundwater between 1988 and 1992 are larger than the actual pumping rate, judging from the PWD statistical data and the fact that pump operations were sometimes stopped for long periods of the time due to poor maintenance according to the interview survey. It is judged, therefore, that the present per capita consumption of domestic water is around 140 lpcd, which is the highest ratio estimated.

In consideration of the progress of urbanization in this area, the per capita consumption was divided into urban and rural areas. The per capita consumption in the rural area was judged at 120 lpcd which is the same figure for the Tavua/Vatukoula area. The per capita consumption in the urban area was estimated at 180 lpcd, as follows:

$$X = E \cdot C$$

$$Y = (D \cdot A - X) / B$$

where,

Total population of the area in 1991		: A (=31,447 persons)
	Urban Area (Ba Town)	: B (=10,333 persons)
	Rural Area	: C (=21,115 persons)
Per Capita Water Consumption in the Whole Area		: D (=140 lpcd)
Per Capita Water Consumption in Rural Area		: E (=120 lpcd)
Water Consumption in Rural Area		: X (lpd)
Per Capita Consumption in Urban Area		: Y (lpcd)

then,

X = 120 lpcd • 21,115 persons = 2,533,800 lpd

Y = (140 lpcd • 31,447 persons - 2,533,800 lpd) / 10,333 persons = 180 lpcd

In the area served by the Tavua/Vatukoula regional water supply system, the domestic water consumption was estimated from 1,220 to 1,311 m^3/day and the per capita consumption from 97 to 118 lpcd. The range of these values is low and the highest value, around 120 lpcd, is considered to be the present conservative per capita consumption of domestic water in the area.

In the area served by the Rakiraki regional water supply system, the domestic water consumption was estimated from 668 to 874 m^3/day and the per capita consumption from 134 to 169 lpcd. The values in 1990, 1991, and 1992 are very high compared with the results of the interview survey and this is assumed to be caused by the smaller number of persons per household; 4 persons/household compared with an average of 6 to 7 persons/household in the Study Area. If the average number is applied to this area, the per capita consumption will be estimated from 83 to 105 lpcd. These figures are similar to those of the Tavua/Vatukoula area, therefore, the present per capita consumption of domestic water in the area is judged at around 120 lpcd, the same figure for the Tavua/Vatukoula area.

In areas without regional water supply systems, the domestic per capita consumption was judged at 80 lpcd, obtained from the interview survey.

5.4 Domestic Water Demand Projection

5.4.1 Projected Per Capita Water Consumption

In Section 5.3, the present per capita consumption of the domestic water in the Study Area was analyzed by area as shown below:

Areas with the Regional Water Supply Systems	
Ba, Urban	180 lpcd
Ba, Rural	120 lpcd
Tavua/Vatukoula	120 lpcd
Rakiraki	120 lpcd
Areas without the Regional Water Supply Systems	80 lpcd

The future per capita domestic water consumption was projected by referring to the existing design criteria of PWD. In the " Rural Water Supply Manual" prepared by PWD, the unit consumption rate of 160 lpcd was utilized for house connections in the rural areas' water supply system. In the "Water Supply Design Manual (Draft)", the unit consumption rate of 200 lpcd was proposed to apply for the city water supply, and 150 lpcd was defined for the town water supply. These values were shown in Section 5.1.

In consideration of the above, three kinds of projected per capita water consumption were applied to the domestic water demand projection in 2011 in the Study, as explained below.

In the areas served by regional water supply systems, except the Ba urban area, the 160 lpcd defined for house connections in the rural areas' water supply system was applied as the projected per capita domestic water consumption in 2011. The 200 lpcd for the city water supply was adopted in the Ba urban area, since the present per capita consumption in this area was estimated at 180 lpcd, which is greater than the 160 lpcd and 150 lpcd for the town water supply.

In areas without regional water supply systems, 80 lpcd is utilized as the per capita consumption for domestic water demand in 2011. This amount is the present estimated per capita water consumption in this area.

The projected per capita domestic water consumption in 2011 for each area is shown as follows:

Areas with the Regional Water Supply Systems	
Ba, Urban	200 lpcd
Ba, Rural	160 lpcd
Tavua/Vatukoula	160 lpcd
Rakiraki	160 lpcd
Areas without Regional Water Supply Systems	80 lpcd

5.4.2 Projected Domestic Water Demand

According to the study described in Section 5.2, Population Projections, there are three scenarios for estimating population growth, high, middle and low as shown in Table 5.2.2. The domestic water demand was projected by multiplying the population served with the projected per capita water consumption. In the following, two kinds of domestic water demand forecast were carried out, the areas with and without regional water supply systems.

(1) Water Demand in the area with a regional water supply system

For the area with a regional water supply system, future water demand was predicted considering the following conditions.

i) Population of the high scenario in 1991 was used as the present population,
ii) The three scenarios of population predicted at intervals of five years for the period from 1991 to 2011 described in Section 5.2, were adopted for the future population,
iii) The present per capita consumption for domestic use, shown in Section 5.3, was used for the present water demand projection,
iv) The per capita consumption in 2011 for domestic use estimated in Clause 5.4.1, was used for the water demand projection in 2011, and
v) The per capita consumption between 1991 and 2011 are linearly interpolated at intervals of five years.

The water demand in the area with a regional water supply system was estimated as shown in Table 5.4.1. This will be about 10,170 m^3/day for a population of 60,189 in 2011. The present water demand in the area was estimated at about 6,510 m^3/day for a population of 49,122.

(2) Water demand in the area without a regional water supply system

For the area without a water supply system, future water demand was predicted considering the following conditions.

i) Population of the high scenario in 1991 was used as the present population,
ii) The three scenarios of population predicted at intervals of five years for the period from 1991 to 2011 described in Section 5.2, were adopted for the future population
iii) The constant per capita consumption, 80 lpcd shown in Section 5.3, was used, and
iv) The water demand for the period from 1991 to 2011 are linearly interpolated at intervals of five years, based on the projected population.

The water demand in the area without a regional water supply system is shown in Table 5.4.2. This will be 6,290 m^3/day for a population of 78,664 in 2011. The present water demand in the area was estimated about at 3,990 m^3/day for a population of 49,830.

5.5 Commercial Water Demand Projection

According to the present water consumption study in Section 5.3, commercial water use ratios in the Study Area were estimated at 20 % of the effective amount for the Ba and Tavua/Vatukoula areas and 30 % of the effective amount for the Rakiraki area.

Since commercial activity in the Study Area is not expected to rapidly progress in the future, it is judged that the ratio of commercial water use against the domestic water use will be maintained. In addition, the commercial water demand is expected to be generated only in the areas with a regional water supply system and not in the areas without a regional water supply system.

Therefore, the commercial water demands were estimated by multiplying the domestic water demand with the ratio of commercial water use against domestic water use. The commercial water demand was predicted under the following conditions.

i) The three scenarios of domestic water demand at intervals of five years for the period from 1991 to 2011 as estimated in Table 5.4.1 were adopted for commercial water demand, and

ii) A ratio of commercial water use against domestic water use in each area was derived from the adopted water use ratio shown in Table 5.3.2, as follows:

The ratio of commercial water use against domestic use:

Ba:	25 % (= 20 % / 80 %)
Tavua:	25 % (= 20 % / 80 %)
Rakiraki:	43 % (= 30 % / 70 %)

The commercial water demand will be 2,720 m^3/day in 2011 as shown in Table 5.4.3. The present commercial water demand in the area was estimated at about 1,740 m^3/day.

6. OVERALL WATER SUPPLY DEVELOPMENT PLAN

6.1 Development Principle

6.1.1 General Concept

Ordinarily, an overall water supply development plan is composed of several development schemes designed to meet a projected water demand for all areas faced by water shortage problems. This is achieved by providing adequate groundwater sources covering the whole study area. However, the groundwater development potential in this Study Area was judged to be limited due to the scarce groundwater resources identified from the results of the groundwater resources evaluation explained in Chapter 4 of this report.

Therefore, the overall water supply plan concerning groundwater development in the Study Area could be formulated from only nine development schemes, even though the groundwater potentials are planned to be exploited as much as possible. The plan was made based on the groundwater development potentials examined, and considering the level of urgency for water requirements identified through the survey. The principles of the development plans are as follows:

i) The proposed communities to receive water supply from the groundwater development plan are selected from areas with an inadequate water supply and identified groundwater development potential.
ii) The scale of the proposed plan is determined by the possible pumping rate of the production wells without causing environmental impact, and
iii) The production wells for the proposed schemes are selected in principle from the existing test wells drilled by JICA or MRD which had been confirmed to produce sufficient groundwater for the formulation of the proposed water supply plan.

6.1.2 Type of Water Supply Development Schemes

The type of the proposed development schemes was selected considering the present water supply condition of each proposed area and each location of each well. They are divided into the following four types.

(1) Single community system

This system is proposed for communities without a PWD regional water supply systems at present and/or in future. The proposed system consists of a well, a pipeline, and a service reservoir, and will be independent from the PWD system. This closed system will belong to the community and will be managed by the community after the completion of construction.

The service area covers all /part of the community. The scale of the water supply facilities was determined to meet the water demand in the year 2011. 20 % of the estimated water demand is added as un-accounted for water and this value was used for the design of the water supply system.

The groundwater is pumped by submersible pumps and sent to the service reservoir, it is then distributed to each consumer in the service area through the distribution pipes by gravity. UPVC pipes are basically used for the pipelines, and a chlorination system is utilized at the service reservoir for the disinfection of the water .

(2) Expansion for regional system

This system is applied to the communities served at present and/or to be served in the future with a PWD regional water supply system. The existing and/or expanded system does not cover the whole area of the community. The proposed system also consists of a well, a pipeline, and a service reservoir. This system will be merged into the PWD system and will be managed by the PWD after completion. Therefore, the future expansion plan of the PWD system in and around the community must be taken into consideration for this proposed plan.

The service area is defined as where PWD pipes are not installed at present and/or not to be installed in the future expansion plan. The area, where water is not supplied by the PWD water supply system even though pipes are presently installed, was also selected as the service area. The scale of the water supply facilities was also determined to meet water demand in the year 2011. 20 % of the estimated water demand in 2011 is added as un-accounted for water for the design of the water supply system.

The groundwater is pumped by submersible pumps and sent to the service reservoir, it is then distributed to each consumer through the distribution pipes by gravity. UPVC pipes are basically used for the pipelines, and a chlorination system is utilized at the service reservoir for the disinfection of the water .

(3) Supplemental water sources for the regional system

This system consists of wells, a pipeline, and an existing PWD service reservoir which does not belong to any community, as it is located in the urban area of the Ba regional water supply system. The optimum pumping plan considered combining water use with the water of the PWD regional system, however the ratio of groundwater to the PWD water was only 4 %. Therefore, the operation plan of this system was converted to a simple supplemental water system to be used conjunctively with the existing regional system. Water quality, which exceeds the drinking water standards, is improved by diluting it with the uncontaminated water of the regional water supply system.

(4) Emergency water source system

This system is proposed as an emergency water supply for communities who experience extremely severe water shortages in the dry season and do not have adequate wells. The proposed wells for the system are JICA test wells which have a limited capacity and poor water quality and are located in areas, where there is an adequate water supply system. The water in this system will be supplied to the communities by water tanker (4,200 l) at a rate of 400 l/house/week, equivalent to the present emergency water amount. The period of the emergency water supply is limited to the dry season (about 6 months a year). Water which exceeds the drinking water standards will be improved by the water treatment system at the proposed well site.

6.2 Development Schemes

Based on the foregoing conditions, 9 development schemes are proposed and their principle features and locations are shown in Table 6.2.1 and Fig. 6.2.1, respectively.

For the single community system and the expansion of the regional system, the projected water demand at the target year of 2011 plus 20 % of the water demand were adopted for the supply yield (design capacity of the system). Development in stages was not considered for the construction of the water supply facilities. The supply yield of the supplemental water sources for the regional system was determined as the production capacity of the proposed well examined by the groundwater simulation study, described in Section 4.3. For the emergency water source system, the supply yield was determined considering the cycle time for supplying the water and the pumping operation time so that the water can be carried from the proposed well to the service areas in its existing condition. These supply yields were also determined in consideration of the production capacity of the proposed well, which was evaluated in the Study.

The water supply facilities for the proposed schemes was roughly designed based on the existing map on a scale of 1 : 50,000 and the results of the site reconnaissance, and by referring to the existing PWD manual. The principle features of the proposed water supply facilities of each scheme are shown in Table 6.2.2. The outlines of the 9 proposed schemes are described hereunder.

6.2.1 Vutuni Creek Community Scheme

The Ba regional water supply covers only about 10 % of the population in the Vutuni Creek community. Two communal systems were constructed, however, they are not working due to lack of maintenance and repair. The distribution pipes of the system were broken and only a few households, in the vicinity of the water sources, are served with the water.

This scheme is a single community system. The service area was selected in the southern half of the community along Vutuni Road, which is densely populated and has no piped water supply system. The water demand in 2011 was estimated at 50 m^3/day and the supply yield of the system is estimated at 60 m^3/day.

The water source of the scheme is TW001, drilled by JICA for this Study as a test well. The well has a diameter of 150 mm and a depth of 76 m. The water will be pumped by submersible pump with a capacity of 0.84 l/s in the discharge and 102 m in the head, then discharged to the proposed service reservoir through a transmission pipe, 75 mm diameter x 400 m long. A service reservoir with a storage volume of 75 m^3 is planned to be constructed on the hill 250 m west of the well and the water will be disinfected by chlorination at the reservoir. The water will be supplied to the households through distribution pipes, 75 mm diameter x 4,600 m long. The general layout of the system is shown in Fig. 6.2.2 (1).

6.2.2 Kukunirewa Community Scheme

There is no regional or communal system in this community. At present, the main sources of water are rainwater and dug wells in the rainy season, and dug wells, creek water and emergency water in the dry season. The scheme is a single community system. The system is planned to cover the whole area of the community. The water demand in 2011 was estimated at 37 m^3/day and the supply yield of the system is estimated at 45 m^3/day.

The water source for this system is groundwater from TW008 which has a diameter of 150 mm and a depth of 74.45 m, and was drilled by JICA as a test well. The water will be supplied from the well to the proposed service reservoir by a submersible pump with a head of 129 m and a discharge of 1.3 l/s through a transmission pipe, 75 mm diameter x 1,100 m long. The reservoir will be constructed in the southwest of the community and will have storage volume of 60 m^3. The water will be chlorinated in the reservoir and then supplied to the service area through distribution pipes, 75 mm diameter x 1,600 m long and 50 mm diameter x 1,500 m long. The general layout of the system is shown in Fig. 6.2.2 (2).

6.2.3 Vatuyaka Expansion Scheme

The Vatuyaka community is served by the PWD regional water supply system. The water source of the existing system is groundwater from the existing PWD well (GW034) which is currently sent into the existing Vatuyaka reservoir, but this is only distributed to about 47 % of the area of the community, mainly along the Vatuyaka Road.This expansion system scheme was proposed using the MRD well (GW035) for the eastern and southern areas of the community where the existing PWD system does not cover. The water demand in 2011 was estimated at 90 m^3/day and the supply yield of the system is estimated at 108 m^3/day.

The proposed well with a diameter of 150 mm and a depth of 45 m, was drilled by MRD as a test well. The water will be supplied from the well to the proposed service reservoir by submersible pump with a head of 111 m and a discharge of 1.5 l/s through a transmission pipe, 75 mm diameter x 3,950 m long. The reservoir will be constructed in the northeast edge of the community and will have a storage volume of 135 m^3. The water will be chlorinated in the reservoir and then supplied to the service area through distribution pipes, 100 mm diameter x 1,530 m long, 75 mm diameter x 3,250 m long, and 50 mm diameter x 400 m long. The general layout of the system is shown in Fig. 6.2.2 (3).

6.2.4 Varadoli - Veisaru Supplemental Scheme (1)

This supplemental scheme is located in the Varadoli and Veisaru regions of the Ba area. There are no water shortages in this area, because it is covered by the Ba regional water supply system. However, the regional water supply system requires more water sources, so a supplemental water scheme was proposed.

The water source for this system is groundwater from TW004 and TW005. The availability of groundwater development in the Ba Uplands was confirmed by the groundwater simulation study and the supply yield of the system, 57.6 m^3/day from TW004 and 100.8 m^3/day from TW005, totaling 158.4 m^3/day, was determined as the production capacity of the wells based on the condition that TW004 and TW005 are simultaneously operated.

Submersible pumps, having a head of 74 m and a rate of 0.8 l/s at TW004 and 70 m and 1.4 l/s at TW005, will be installed and the pumped water will be sent to the existing Varadoli service reservoir located about 500 m west of TW 004, via a new transmission pipeline, of 75 mm diameter x 6,100 m long (Fig. 6.2.2 (4)). The water will be supplied from the service reservoir to the existing distribution pipe network of the regional system by a booster pump to be newly installed at the service reservoir site. This is because the water level in the reservoir is lower than HGL of the pipe network near the reservoir.

The water quality of TW005 is good but the concentration level of iron and manganese exceeds WHO standards. However, mixed with the reserved surface water in the existing reservoir is expected to decrease the concentration level to less than WHO standards, by the time the water is supplied. Treated water of 101 m^3/day, deducting un-accounted for water of the regional system (36 % of the supply yield) from the supply yield of 158.4 m^3/day, can be supplied to about 500 to 630 consumers.

6.2.5 Varadoli - Veisaru Supplemental Scheme (2)

This supplemental scheme is proposed as an alternative to the Varadoli - Veisaru supplemental scheme (1). The water source for this system is groundwater from TW004, TW005, and TW000 which will be newly drilled. The supply yield of the system, 57.6 m^3/day from TW004, 72 m^3/day from TW005, and 144 m^3/day from TW000, totaling 273.6 m^3/day, was also determined as the production capacity of the wells based on the groundwater simulation study examined on the condition that they are simultaneously operated.

Submersible pumps, having a head of 74 m and a rate of 0.8 l/s at TW004, 68 m and 1.0 l/s at TW005 and 70 m and 2.0 l/s at TW000, will be installed and the pumped water will be sent to the existing Varadoli service reservoir via new transmission pipelines, 100 mm diameter x 5,500 m long and 75 mm diameter x 1,200 m long (Fig. 6.2.2 (5)). The water will be supplied from the service reservoir to the existing distribution pipe network of the regional system by booster pump to be newly installed at the service reservoir site.

The water quality of TW005 will also be mixed with the reserved surface water in the existing reservoir and this is expected to decrease the concentration levels to less than WHO standards. Treated water of 175 m^3/day, deducting un-accounted for water of the regional system from the supply yield of 273.6 m^3/day, can be supplied to about 870 to 1,090 consumers of the Ba regional water supply system.

6.2.6 Rabulu Expansion Scheme

This expansion system scheme will cover the Rabulu village (R-18) and Rabulu community (R-19). There is no regional water supply system at present but PWD has proposed to extend the Tavua/Vatukoula regional water supply system to these areas. In the Rabulu community, there is a communal water supply system consisting of one borehole, one reservoir, and distribution pipes, however, the system is not in operation at present as the pump is out of order and the community could not raise funds for repairs. Presently, dug wells are the main water source. However, the well capacities decrease in the dry season, therefore river water and emergency water are used as alternative sources. Emergency water is supplied every year from August to December on a weekly basis at a rate of two drums per household.

Opposite this area in Yaqara Rancho, a big capacity test well was drilled by MRD in 1989. It is situated on the left bank downstream of the Yaqara river, about 6 km east of Rabulu village. However, groundwater development has not been planned, as no-one inhabits the test well area. Therefore, this expansion system was proposed using the MRD well (GW254) to compensate the water shortage of Rabulu village and Rabulu community. This scheme is categorized as an expansion scheme, because the proposal states that the Tavua / Vatukoula regional water supply system be extended to both communities.

The water demand in 2011 was estimated at 35 m^3/day for Rabulu village (R-18) and at 114 m^3/day for Rabulu community (R-19), totaling 149 m^3/day and the supply yield of the system is estimated at 180 m^3/day. The well has a diameter of 200 mm and a depth of 38.3 m. The submersible pump, having a discharge of 2.5 l/s and a head of 104 m, will be installed at the proposed well site. The pumped water will be discharged to the proposed service reservoir through a transmission pipe, 100 mm diameter x 6,800 m long. A service reservoir with a storage volume of 230 m^3 will be constructed on the hill in the east-northern part of the community and the water will be disinfected by chlorination at the reservoir. The water will be supplied to the households through the distribution pipes, 150 mm diameter x 850 m long, 100 mm diameter x 2,200 m long, and 75 mm diameter x 3,600 m long. The general layout of the system is shown in Fig. 6.2.2 (6).

6.2.7 Vaileka Emergency Scheme

This emergency scheme consists of one well and three service communities, Naria (R-16), Volivoli (R-26), and Dociu (R-31), as shown in Fig. 6.2.1. The water source for this scheme is groundwater from TW012 which was constructed by JICA for a test well of the Study and its dimensions are 150 mm in diameter and 74.45 m in depth. The supply yield of the scheme was determined at 15 m^3/day considering the cycle time of the delivery and the pump operation time for the supply.

The water will be supplied to each house in the service areas by a 4,200 l PWD water tanker. It must be ensured that 400 l of the water will be supplied to each house weekly during the dry season of about 6 months. A treatment facility is not planned at the well site because the water is of suitable quality.

6.2.8 Yalalevu Emergency Scheme

This emergency scheme consists of one well and two service communities, Vatia (T-34) and Garampani (T-45), as shown in Fig. 6.2.1. The water source for this scheme is the groundwater from JICA test well TW 002 and its dimensions are 150 mm in diameter and 35 m in depth. The supply yield of the scheme was determined at 20 m^3/day considering the cycle time of the delivery and the pump operation time for the supply.

The water will be supplied to each house in the service areas by a 4,200 l PWD water tanker. It must be ensured that 400 l of water will be supplied to each house weekly during the dry season of about 6 months. An iron and manganese removal facility will be provided at the well site, since these levels are slightly higher than WHO standards. Chlorination will be effective in removing iron and manganese.

6.2.9 Koronubu Emergency Scheme

This emergency scheme consists of one well and three service communities, Nabatolu (B-19), Natunuku village (B-32), and Vatusui (B-58), as shown in Fig. 6.2.1. The water source for this scheme is the groundwater from JICA test well TW 002 which is 150 mm in diameter and 18.80 m in depth. The water is supplied to each house in the service areas by a 4,200 l PWD water tanker. The supply yield of the scheme was determined at 20 m^3/day considering the cycle time of the delivery and the pump operation time for the supply. It must be ensured that water of 400 l of water will be supplied to each house weekly during the dry season of about 6 months. A turbidity removal facility will be provided at TW 006, since this level is above WHO standards. Pre-chlorination and direct filtration were proposed as an effective method in removing turbidity.

6.3 Cost Estimates

6.3.1 Construction Costs

The construction costs of the proposed water supply development schemes mentioned above were estimated under the following conditions.

(i) Prices : December 1994,

(ii) Foreign exchange : US$ 1.00 = J.Yen 100, F$ 1.00 = J.Yen 70,

(iii) Engineering services (E/S) : 10 % of the direct construction cost summed up in foreign currency (F/C),

(iv) Physical contingency: 15 % of the direct construction cost and engineering service cost,

(v) Value-added tax (VAT) : 10 % of the costs of the construction material and equipment,

(vi) Import duty : 10 % of the costs in F/C of the construction material and equipment,

(vii) Price contingency : 5 % of the costs in local currency (L/C) and 3 % in F/C of the land acquisition, the direct construction cost, E/S, physical contingency, VAT and import duty, and

(viii) The unit price for land acquisition : estimation according to the Regional Lands Departments in the area of the development schemes.

The construction cost for each scheme was estimated for two conditions, with and without the construction cost of the existing wells. The first is used to evaluate each scheme and the second is only for reference purposes, as shown in Table 6.3.1. A summary of construction costs for the respective water supply schemes is as follow:

Construction Cost (with the cost for the existing well)

(Unit : F$)

Scheme	L/C	F/C	Total
1. Vutuni Creek	323,642	60,925	384,567
2. Kukunirewa	228,418	56,211	284,629
3. Vatuyaka	413,209	75,953	489,162
4. Varadoli-Veisaru (1)	272,515	123,595	396,111
5. Varadoli-Veisaru (2)	397,362	181,874	579,236
6. Rabulu	685,561	113,477	799,038
7. Vaileka (Naria, Volivoli, Dociu)	53,021	28,116	81,137
8. Yalalevu (Vatia, Garampani)	62,740	23,903	86,643
9. Koronubu (Nabatolu, Natunuku, Vatusui)	108,086	20,233	128,308

6.3.2 Operation and Maintenance Costs

The operation and maintenance costs required to implement each water supply development schemes consist of the followings;

(i) Personnel expenses for O&M of the water supply facilities,
(ii) Electric charge for the submersible pump and the booster pump,
(iii) Chemical costs for chlorination,
(iv) Repairing expenses for the equipment of the submersible pump and booster pump, and
(v) Water transportation costs for the emergency scheme.

The annual O&M costs were estimated as shown in Table 6.3.2 and summarized below.

Annual O&M Cost (Year 1997)

(Unit : F$)

Scheme	L/C	F/C	Total
1. Vutuni Creek	1,487	516	2,003
2. Kukunirewa	1,350	552	1,902
3. Vatuyaka	4,536	540	5,076
4. Varadoli-Veisaru (1)	10,876	1,248	12,124
5. Varadoli-Veisaru (2)	18,820	1,872	20,692
6. Rabulu	3,316	660	3,976
7. Vaileka (Naria, Volivoli, Dociu)	62,960	336	63,296
8. Yalalevu (Vatia, Garampani)	94,395	456	94,851
9. Koronubu (Nabatolu, Natunuku, Vatusui)	94,365	324	94,689

Annual O&M Cost (Year 2011)

(Unit : F$)

Scheme	L/C	F/C	Total
1. Vutuni Creek	3,434	516	3,950
2. Kukunirewa	3,815	552	4,367
3. Vatuyaka	7,619	540	8,159
4. Varadoli-Veisaru (1)	10,876	1,248	12,124
5. Varadoli-Veisaru (2)	18,820	1,872	20,692
6. Rabulu	11,322	660	11,982
7. Vaileka (Naria, Volivoli, Dociu)	70,260	336	70,596
8. Yalalevu (Vatia, Garampani)	105,295	456	105,751
9. Koronubu (Nabatolu, Natunuku, Vatusui)	105,265	324	105,589

6.4 Economic Evaluation

6.4.1 General

For the nine development schemes proposed in Section 6.2, an economic evaluation of each project was carried out to determine economic ranking. This was done by comparing the present values of the economic benefit and cost using the Economic Internal Rate of Return (EIRR) and the Net Present Value (NPV). The following conditions and assumptions were set for estimating the economic benefit and cost:

(1) Transfer payments such as value added tax (VAT), income tax, and import and export duties are not included in the economic cost and benefit.
(2) Inflation is not taken into account.
(3) The construction works for all schemes commences at the beginning of the 1996 and are completed in one year.
(4) The project life is taken as 30 years after completion of construction, and the benefit and cost for operating and maintaining the facilities (O&M cost) will accrue every year throughout the period of the project life.

6.4.2 Economic Cost

The economic cost of each project is estimated based on the construction cost and O&M cost shown in Section 6.3 using the conditions and assumptions above, and is summarized as follows:

Scheme	Economic Const. Cost (1996)	Economic O&M Cost	
		1997	2011
1. Vutuni Creek	347,100	1,900	3,820
2. Kukunirewa	256,511	1,800	4,240
3. Vatuyaka	442,300	4,940	7,990
4. Varadori-Veisaru(1)	353,903	11,800	11,800
5. Varadori-Veisaru(2)	517,679	20,180	20,180
6. Rabulu	722,674	3,830	11,740
7. Vaileka	72,730	63,240	70,540
8. Yalalevu	77,405	94,770	105,670
9. Koronubu	116,830	94,630	105,530

Unit : F$

Included the above O&M cost is the operation cost of an emergency water tanker, estimated at F$ 120 per round trip at 1994 prices, according to the information obtained from PWD officers. This includes personnel expenses of approximately one-third of the total cost. The economic cost of the personnel expenses is assumed to rise at an average annual rate of 2 %, based on the growth trend of the per capita GDP of Fiji. This rise of personnel expenses is applied to the O&M cost for the three Emergency Schemes, Vaileka, Yalalevu and Koronubu, during their project life.

In addition, the cost for replacement of pumps is required for all nine schemes in the year 2012, 16 years after completion. Annual flows of O&M and replacement costs are shown in Tables 6.4.4 to 6.4.12.

6.4.3 Estimates of Economic Benefit

The economic benefit of the project is given as the difference between water supply conditions with and without the projects. Estimates of this benefit are mainly composed of three categories; (1) saving of time spent to fetch water, (2) reduction of emergency water supply costs, and (3) increase in water volume to be supplied to the water supply system.

(1) Timesaving Benefit

Households in areas without a water supply system spend several hours every day to fetch domestic water from distant water sources such as wells, rivers, creaks, and springs. After completion of the water supply system, these households will be able to save on time spent to fetch domestic water.

This timesaving benefit is given as a product of the saved hours and the monetary value per hour. The average daily savings of hours in households for each community are estimated on information obtained through the questionnaires (Tables E-2.7 and E-2.8, Appendix E).

On the other hand, the monetary value per hour can be estimated based on the monthly household income, obtained through the questionnaires (Table E-2.4, Appendix E). This estimate is made under the following assumptions:

(A) The total working time of each household is taken as eight-hours per day for the month,

(B) Employment opportunities for the hours saved are assumed to be 50 % of usual, and

(C) The monthly household income is assumed to rise at an annual rate of 2 %, based on the trend of real growth in the per capita GDP of Fiji.

The average daily timesaving benefit per household is given as a product of the average daily saving of hours per household and the monetary value per hour. Based on this daily benefit, the average annual benefit for the community served can be calculated using the number of households and the time served throughout the year. The average daily saving of hours per household and the monetary value per hour for each community, together with other conditions required for estimating the benefit are listed in Table 6.4.1.

(2) Benefit of Reduction in Emergency Water Supply Costs

Objective communities of the proposed seven schemes, excepting the two supplemental schemes, have been supplied with emergency water from PWD for 6 months of the dry season. The emergency water was supplied at a rate of 400 to 800 litters per household each week by a PWD water tanker with a carrying capacity of 4,200 litters.

As mentioned in the estimates of O&M cost in Section 6.4.2, the operation cost of the PWD water tanker was estimated at F$ 120 per round trip at 1994 prices. Approximately one-third of the operation cost is personnel expenses. An economic cost of the personnel expenses is assumed to rise at an average rate of 2 % per annum, based on the trend of real growth of the per capita GDP of Fiji. Accordingly, the economic operation cost of the PWD water tanker will increase year by year under the condition of "without project".

After completion of the water supply system, the emergency water supply will fall into disuse. The reduction in operation cost of the emergency water tanker will be appropriated as a benefit of the project. Conditions of the benefit estimates for each scheme are given in Table 6.4.1.

The benefits of (1) and (2) above, are applied to seven schemes; two community schemes, two expansion schemes, and three emergency schemes. The annual benefit of the project for each scheme in 1997 is estimated under the conditions shown in Table 6.4.1. This calculation is given in Tables 6.4.2 and 6.4.3.

For example, the Vutuni community scheme's (B-63) annual timesaving benefit per household in 1997 is estimated at F$ 107 using the household income of

F$ 71/month, a saving time of 2 hours/day, and assuming that the employment opportunity for surplus time is 50% of the usual situation. On the other hand, the annual benefit for reduction of emergency water supply cost per household in the same year is estimated at F$ 335 using the operation cost of water tanker of F$ 122.45 per round trip, the carrying capacity of 4,200 litters/tanker, the quantity of water supplied of 400 litters/household/week, the utility rate of emergency water of 75 % to the total water consumption in the dry season, and assuming that the emergency water supply is six months per annum.

The annual benefit per household is given as a sum of the timesaving benefit and the benefit of reducing the emergency water supply cost. As a result, the total annual benefit in 1997 for the Vutuni Creek community scheme is estimated at F$ 16,236 using the number of 48 households in 1997 shown in Table 6.4.1. The annual benefit in 1997 for the other schemes was also calculated in the same method, as shown in Tables 6.4.2 and 6.4.3, and these results are summarized in table on next page.

As stated in Items (1) and (2) above, the economic value of time saved and the economic personnel expenses in the operation cost of the emergency water supply tanker are assumed to rise at a rate of 2 % per annum. Taking this rise into account, the expected annual benefit of the project would be increased every year during the period of the project life. Annual flows of the economic benefit are given in Tables 6.4.4 to 6.4.12.

(3) Benefit of Increase in the Quantity of Water supplied to the Water Supply System

This benefit is applied to the Varadori-Veisaru Supplemental Schemes (1) and (2). According to these schemes, water yielded from the well is supplied to the existing distribution network of the Ba regional water supply system, via transmission pipelines and a service reservoir. Accordingly, the quantity of the domestic water supplied would be increased by this quantity. The economic benefit is given as an increase in public income produced from the increased water quantity.

The effective quantity of water supplied is estimated at 101.4 m^3/day, deduced as an unaccounted quantity of 36 % from the production water of 158.4 m^3/day for the Varadori-Veisaru supplemental scheme (1). For the Varadori-Veisaru supplemental scheme (2), effective supplied water of 175.1 m^3/day would be obtained from the production water of 158.4 m^3/day. The supplied water is assumed to be a constant quantity throughout the period of the project life, according to the foregoing development plan. The project benefits for these schemes are estimated under the following conditions:

- The unit water charge at the beginning of 1995 according to information obtained from PWD is set as F$ 0.1202/m^3 for domestic use, and F$ 0.4156/m^3 for commercial use.

- These water charges are generally expected to change in proportion to inflation. However, because that the rise in prices is not accounted for in the economic analysis, and the cost estimates in the present study are based on prices at the beginning of 1995, the unit water charges above are applied as constant figures to during the period of the project life.

- The ratio of domestic and commercial consumption is assumed to be 80 : 20, based on PWD statistical data.

Under the above conditions, the annual economic benefits for the Varadori - Veisaru supplemental scheme (1) are estimated to be F$ 6,543, consisting of F$ 3,509 for the domestic use and F$ 3,034 for commercial use. The annual benefits for the same scheme (2) are estimated at F$ 11,301, composed of F$ 6,061 for domestic use and F$ 5,240 for commercial use. These annual benefits would accrue every year throughout the period of the project life, as shown in Tables 6.4.4 and 6.4.5.

(4) Summary of the Economic Annual Benefit in 1997

The economic annual benefit in 1997 for each scheme is summarized below:

Scheme	Annual Benefit (F$)	Scheme	Annual Benefit (F$)
1. Vutuni Creek	16,236	6. Rabulu	79,598
2. Kukunirewa	8,505	7. Vaileka	45,052
3. Vatuyaka	20,368	8. Yalalevu	75,111
4. Varadori-Veisaru(1)	6,543	9. Koronubu	50,003
5. Varadori-Veisaru(2)	11,301		

Unit : F$

6.4.4 Results of the Economic Analysis

Using the annual flows of the economic cost and benefit for each scheme shown in Tables 6.4.4 to 6.4.12, the economic internal rate of return (EIRR) and the net present value (NPV) are calculated and the results are summarized in the following table:

Schemes		EIRR (%)	Present Value(F$)* Cost	Benefit	Net
1. Vutuni Creek		2.51	343,101	162,162	-180,939
2. Kukunirewa		-0.67	262,289	89,535	-172,753
3. Vatuyaka		1.64	460,626	207,772	-252,854
4. Varadori-Veisaru(1)	below	-1.00	422,855	56,073	-366,782
5. Varadori-Veisaru(2)	below	-1.00	643,558	96,849	-546,710
6. Rabulu		13.59	727,232	979,915	252,684
7. Vaileka	below	-1.00	646,089	428,385	-217,704
8. Yalalevu	below	-1.00	938,603	719,445	-219,158
9. Koronubu	below	-1.00	972,707	470,637	-502,064

* Discount rate : 10 %

Of nine schemes, the Rabulu expansion scheme achieves a comparatively high EIRR of 13.59 %, which indicates economic feasibility. This is mainly due to a high timesaving benefit (see Table 6.4.2).

Following the Rabulu expansion scheme are the Vutuni Creek community scheme and the Vatuyaka expansion scheme with low EIRRs of 2.51 % and 1.64 %, respectively, which are not economically feasible. These low percentages of EIRR chiefly results from low time saving benefits, is due to the average low income per household.

EIRR for the Kukunirewa community scheme indicates a negative percentage, -0.67 %. However, the total economic benefit (F$ 354,215) sufficiently exceeds the total economic O&M cost (F$ 125,430) for the period of the project life (see Table 6.4.5). Accordingly, although this as well as the Vutuni Creek and Vatuyaka schemes are not economically feasible, it will be possible to economically operate and maintain the project after completion of the facilities.

The other five schemes are not economically feasible, and even the operation and maintenance of the project seems to be difficult to justify because the O&M costs exceed the benefits every year for the period of project life, as shown in Tables 6.4.7, 6.4.8, 6.4.10, 6.4.11, and 6.4.12. However, the areas to be served by the three emergency schemes always experience low water pressure and water supply shortages, therefore they are expected to have a fair effect on social environmental improvement.

In conclusion, the first priority from a socio-economic point of view would be given to the Rabulu expansion scheme followed in order by the Vutuni Creek community scheme, the Vatuyaka expansion scheme, the Kukunirewa community scheme, and the three emergency schemes.

6.5 Environmental Impact

The groundwater development will cause impact on the natural and social environment. The results of the environmental assessment of the groundwater development in the study area are as follows;

(1) Land subsidence

In the study area, there is no soft strata, therefore, groundwater pumping will not cause land subsidence.

(2) Sea water intrusion

Saline water intrusion of groundwater occurs in parts of the Study Area. Some test wells are located at a low elevation, and saline water intrusion is possible. According to the results of the groundwater simulation (see section 3.3), we can prevent salt intrusion by reasonable planning of the groundwater development.

(3) Influence on the existing wells

According to the results of the groundwater simulation, groundwater development by the new wells will not affect the influence of drawdown to other existing wells.

(4) Groundwater pollution from agrochemicals

The main land use of the Study Area is sugar cane. A vast amount of agrochemicals and fertilizers are consumed in sugar cane planting. According to the results of the chemical examination of agrochemicals and fertilizers, the constituents of all items are less than the limits in concentration levels or water quality standards.

Therefore, contamination by agrochemicals and fertilizers does not occur in the Study Area.

(5) Health

Eleven test wells were drilled in the study area and seven were planned for groundwater development. The constituents that are above WHO standards for potable water are as follows :

TW001	-
TW002	Iron(Fe), Manganese(Mn)
TW004	-
TW005	Color, Turbidity, Iron, Manganese, Aluminum
TW006S	Turbidity
TW008	-
TW012	-

The water quality of TW001, TW004, TW008 and TW012 satisfies the criteria for a potable water supply. The groundwater of TW002 is planned as an emergency water source, however the concentration level of iron and manganese is higher than the standards set down for a potable water supply. It will be necessary to install iron and manganese removal equipment. The groundwater of TW005 is planned as a supplemental source for the existing water supply system. The concentration level of several constituents in this water exceed WHO standards. This groundwater will be supplied to the reservoir and mixed with the reserved surface water. It is expected that mixing will reduce the concentration of the above constituents resulting in reducing the levels to within WHO guidelines. The turbidity in TW006S is higher than WHO standards, therefore it is recommended that filtering equipment be installed.

7. WATER SUPPLY DEVELOPMENT PLAN ON PRIORITY SCHEMES

7.1 Selection of Priority Schemes

In chapter 6, nine water supply schemes were proposed and examined to formulate the overall water supply development plan in the Study Area. Based on the results of the socio-economic and environmental evaluations described in Section 6.4 and 6.5 of this report, four schemes, Vutuni Creek Community, Kukunirewa Community, Vatuyaka Expansion, and Rabulu Expansion, were judged to have a higher ranking out of the proposed nine schemes. The others have a negative value and it is judged not viable to proceed with a more detailed study.

The degree of water shortages of the four schemes are almost the same, according to the results of the field investigations conducted in the course of the Study. For the selection of priority schemes, the following were taken into consideration:

- To mitigate the present water shortage problems as much as possible, it is judged that schemes with a large population have a priority, and
- Communities in the vicinity of urban areas are regarded as having a higher degree of emergency in implementation of the schemes.

In consultation with PWD, the following three schemes were finally selected as the priority schemes, and their preliminary design will proceed.

- Vutuni Creek Community Scheme
- Vatuyaka Expansion Scheme
- Rabulu Expansion Scheme

7.2 Design Criteria

Prior to the preliminary design of the selected three schemes, it is required to define the design criteria. PWD prepared the following three design manuals for the design and planning of the water supply project in Fiji :

- Rural Water Supply Design Manual, November 1984
- Water Supply Design Manual (Draft), 1990
- Rural Water Supply in Fiji

It seems that the design criteria/guidelines described in the above manuals are not definitely established and are subject to change and/or modification in conformity with the configuration of a water supply scheme. The design criteria for the preliminary design of the selected schemes were, therefore, prepared referring to the design manuals, as shown in Table 7.2.1.

The transmission and distribution pipes will be mainly UPVC pipes and installed underground in trenches. A typical section of the pipe trench is shown in Fig. 7.2.1. For river/creek crossings, the pipes will be attached to a bridge, or installed on a culvert, or underneath the river/creek, depending on the topographic conditions and the condition of the existing facilities. Galvanized steel pipes will be applied to the pipe material in the crossing portions. Standard designs of the crossing are shown in Fig. 7.2.1.

Air valves will be installed at each peak point along the pipelines and sluice valves will be installed on the pipelines downstream of connection/branching points. The minimum diameter of the distribution pipes will be 75 mm, however 50 mm will be used where the water is distributed to less than 6 houses. Service pipes will be made of polyethylene with a diameter of 15 mm and the length is assumed to be 15 m from the branch of the distribution pipe.

Service reservoir will be a ground type made of reinforced concrete. The effective depth of the reservoir is set at 3 m.

7.3 Proposed Development Schemes

The preliminary design of the selected three schemes was conducted based on the results of the detailed field investigation, referring to the topographic survey results, proffered by MRD. The survey works were conducted by a private company contracted to MRD and the works were instructed by MRD staff and the JICA Study Team.

The water supply facilities of each scheme will consist of a test well drilled by JICA or MRD, a submersible pump, transmission pipelines, a service reservoir, a distribution pipe network, and service pipes to house connection. The chlorination facility will be constructed at the service reservoir site. The well water will be pumped up by electricity which will be supplied through a new power transmission cable connected from the nearest existing FEA 11 kV power transmission line. The submersible pump will be operated and controlled automatically by a timer switch installed with the pump. This timer switch was selected from several alternatives considering its simplicity and economy. The pump operation time is set by the timer switch at 20 hours/day.

The principle features of the water supply facilities of each schemes are shown in Table 7.3.1.

7.3.1 Vutuni Creek Community Scheme

(1) Water source facilities

The proposed well is TW001, drilled by JICA for this Study, and is located at center of the service area. The well has a diameter of 150 mm and a depth of 76 m. A submersible pump, having a head of 102 m and a discharge of 0.84 l/s, will be installed at the well site. The pumping operation time controlled by a timer switch is planned at 20 hours/day. The power source will be supplied through a new 2.5 km 11 kV power transmission cable. The voltage will be reduced down by a 30 kVA transformer, newly installed at the well site. The pumped water will be conveyed through the transmission pipe to the service reservoir, planned to be situated on a hill, 250 m west of the well.

(2) Water transmission facilities

A transmission pipeline, 75 mm diameter x 410 m long, will be laid along the Vutuni road and will then climb a steep slope between the road and the service reservoir site. The service reservoir has a storage capacity of 75 m^3 (5.0 m wide x 5.0 m long x 3.0 m high). HWL and LWL of the reservoir are set out at El. 113.0 m and El. 110.0 m, respectively, considering the topographic condition of the service area. A chlorination facility will be constructed at the reservoir site and the water will be chlorinated at a rate of 5.6 kg/week. The plan for the transmission facilities is shown in Fig. 7.3.1 (1).

(3) Water distribution facilities

Distribution pipes will be laid along Vutuni road about 2.0 km to the west and 2.4 km to the east of the service reservoir. There are 6 drain culverts and 3 creek crossings by submersible bridges along the pipeline route. To cross the existing drain culverts at 5 locations, the pipe will be laid in the space between the road surface and the crown of the culvert and at location, the pipe will be installed underneath the water course beside the culvert. To cross the creeks with submersible bridges, the pipe will be laid below the creek 2 locations and will be attached to the bridge at 1 location. Galvanized steel will be applied to the pipe material at the crossing sites.

All the pipes will be 75 mm in diameter and 4,590 m in length. 10 air valves will be installed at each peak point of the pipe network and 7 sluice valves will be set at the branch points.

The plan of the water distribution facilities is shown in Fig. 7.3.1 (1).

7.3.2 Vatuyaka Expansion Scheme

(1) Water source facilities

The water source of this scheme is the GW035 well which is located just beside the existing trim line. The well with a diameter of 150 mm and a depth of 45 m was drilled by MRD as a test well. The water will be pumped up at the well site by submersible pump with a head of 111 m and a discharge of 1.5 l/s. The pumping operation time controlled by a timer switch is planned at 20 hours/day. Electricity for the pumping will be supplied through a new 0.3 km 11 kV power transmission cable. The voltage will be reduced by a 30 kVA transformer at the well site. The pumped water will be discharged through a transmission pipe into the service reservoir situated on a hill in the northeast of the community.

(2) Water transmission facilities

A transmission pipeline will be laid along the trim line, Vatuyaka road, and Daro road connecting to the service reservoir. The pipeline will be 3,950 m in long and 75 mm in diameter. On the pipeline route, there are 11 drain culverts and 1 creek crossing by a submersible bridge. To cross the existing drain culverts, the pipe will be laid in the space between the road surface and the crown of the culvert at 6 locations and will be installed underneath the water course beside the culvert in 5 locations. To cross the creek with the submersible bridge, the pipe will be attached to the bridge. Galvanized steel will be applied to the pipe material at the crossing sites. 12 air valves and 2 sluice valves will be installed on the pipeline.

The service reservoir has a storage capacity of 135 m^3 (6.0 m wide x 7.5 m long x 3.0 m high). HWL and LWL of the reservoir are set at El. 93.0 m and El. 90.0 m, respectively, considering the topographic condition of the whole service area. A chlorination facility will be constructed at the reservoir site and the water will be chlorinatied at a rate of 10.1 kg/week.

The plan of the transmission facilities is shown in Fig. 7.3.1 (2).

(3) Water distribution facilities

The distribution pipes will be laid on Daro, Sorokoba, and Khaisa roads, covering the service area. There are 14 drain culverts. The pipe will be laid in the space between the road surface and the crown of the culvert at 12 locations to cross the existing drain culverts, and will be installed underneath the water course beside the culvert in 2 locations. Galvanized steel pipe will also be used for the crossings.

The distribution pipe network will consist of pipes, 100 mm diameter x 1,530 m long, 75 mm diameter x 3,230 m long, and 500 mm diameter x 410 m long. 12 air valves will be installed at each peak point of the pipe network and 8 sluice valves will be installed at each branch point.

The plan of the water distribution facilities is shown in Fig. 7.3.1(2).

7.3.3 Rabulu Expansion Scheme

(1) Water source facilities

The proposed well of this scheme is GW254 which is located just beside Nasayani road about 1.5 km from Kings road. The well, with a diameter of 200 mm and a depth of 38.3 m, was drilled by MRD as the test well in 1989. The water will be pumped up at the well site by a submersible pump with a head of 104 m and a discharge of 2.5 l/s. A timer switch will be installed to control the pumping operation time of 20 hours/day. A new 1.5 km 11 kV power transmission cable will be constructed to supply the electricity for pumping. A 30 kVA step-down transformer will be installed at the site. The pumped water will be carried through the transmission pipeline to the proposed service reservoir which will be situated on a hill in the east-northern part of the community.

(2) Water transmission facilities

The transmission pipeline will be laid along Nasayani road and Kings road and then to pass through the community connecting to the service reservoir. The pipeline will be 6,800 m in long and 100 mm in diameter. On the pipeline route in Nasayani road, the pipe will be laid just beside the existing fence of Yaqara Rancho. On Kings road, the pipeline will be mainly laid in the shoulder of the road on its left side to the west. There are lots of the existing road crossing facilities along the pipeline route, consisting of 8 drain culverts and 3 bridges. To cross the existing drain culverts, the pipe will be laid in the space between the road surface and the crown of the culvert at 7 locations and underneath the water course beside the culvert at 1 location. To cross the creek by bridge, the pipe will be installed underneath the water course beside the bridge at 2 locations and will be attached to he bridge at 1 location. Galvanized steel is applied to the pipe material at the crossing sites. 8 air valves and 4 sluice valves will be installed on the pipeline.

The service reservoir has a storage capacity of 230 m^3 (8.5 m wide x 9.0 m long x 3.0 m high). HWL and LWL of the reservoir are set at El. 65.0 m and El. 62.0 m, respectively, considering the topographic conditions of the whole service area. A chlorination facility will be constructed at the reservoir site and the water will be chlorinated at a rate of 16.8 kg/week.

The plan of the transmission facilities is shown in Fig. 7.3.1(3).

(3) Water distribution facilities

The distribution pipes will be laid on Rabulu road 3 km south from the junction with Kings road and about 2 km west (to the Indian school) and 1 km east on Kings road. There are 15 drain culverts and 4 creeks with bridges. The pipe will be laid in the space between the road surface and the crown of the culvert at 15 locations to cross the existing drain culverts. At 2 of the 15 culvert crossings, the pipe will be laid on the culvert encased by concrete as there is not enough to install the pipe in a trench. To cross the creeks, the pipe will be installed underneath the water course beside the bridge at 3 locations and will be attached to the bridge at 1 location. Galvanized steel pipe will also be used for the crossings.

The distribution pipe network will consist of pipes, 150 mm diameter x 850 m long, 100 mm long x 2,180 m long, and 75 mm long x 3,600 m long. 12 air valves and 11 sluice valves will be installed in the pipe network. On the eastern pipe route along Kings road, the distribution pipe will be installed parallel with the transmission pipe in the same trench.

The plan of the water distribution facilities is shown in Fig. 7.3.1 (3).

7.4 Implementation Programme

The selected three schemes, Vutuni Creek Community Scheme, Vatuyaka Expansion Scheme, and Rabulu Expansion Scheme, will be realized in the year 1996 and their implementation schedules are presented in Figures 7.4.1 to 7.4.3.

The financial arrangement for the implementation of the schemes will be made within 1995 following the completion of the Study in May, 1995. Land acquisition will be intermittently carried out in parallel with the financial arrangement and will be finished in January, 1996. The topographic survey and detailed design are scheduled to commence at the beginning of January, 1996 and the construction will follow the completion of the design.

All the construction works will be completed by the end of 1996 and the water supply will commence in late 1996 / early 1997.

7.5 Operation, Maintenance and Management Plan

To check that water supply facilities are properly operated and are functioning, it is recommended that the following inspection and maintenance procedures are carried out, and the results recorded to assist in further inspection and maintenance.

Daily inspection and maintenance

- water level at the service reservoir
- groundwater level in the well
- pumping head and discharge
- electric voltage and current of the submersible pumping equipment

Weekly inspection and maintenance

- setting bleaching powder in the chlorination facility
- water quality

Monthly inspection and maintenance

- water leakage from the transmission and distribution pipes
- insulation resistance value of the submersible pump equipment.

Other than the recommended inspection and maintenance, it is also required to conduct an overhaul of the submersible pump at intervals of several years. The first overhaul is recommended within 1~ 2 years after the commencement of the pump operation, with the following overhaul being determined based on the results of the first overhaul.

The submersible pumps will be controlled by a timer switch and the pump operation time is set at 20 hours/day, which is determined based on the supply yield in the year 2011 (design capacity of the system). However, the water demand and supply yield are assumed to be less than the design capacity of the system for 10~15 years after completion of the water supply facilities, therefore the operation time should be modified according to the actual supply volume.

There are two types of water supply system in the selected schemes, the single community system and the expanded regional system. The operation, maintenance and management plan (OMM plan) on the selected schemes were, therefore, recommended for the two methods.

As far as the expansion system is concerned, PWD, by itself, will implement the design and the construction of the water supply facilities, and will own the system as a part of the PWD regional system. PWD will also collect the water charges according to the water tariff stipulated by them. Therefore the proposed water supply schemes of the expansion system will be operated, maintained, and managed by PWD as at present. The OMM of the existing water supply facilities of the Ba and Tavua/Vatukoula regional water supply systems has been conducted effectively. In fact the PWD Ba and Tavua district offices were awarded "good maintenance of water treatment plant" awards in 1994. If the present OMM modes are carried out for the proposed expansion systems , no problems may arise. There is no need to recommend a new OMM method of the proposed expansion systems.

On the other hand, the water supply facilities of the Vutuni Creek Community Scheme will be constructed by PWD with the cooperation of the community, reprovision of unskilled labor. When the facilities are completed, PWD will maintain them for a period of 6 months, then they will be handed over to the community, which will become entirely responsible for the OMM. Therefore, a proper OMM plan must be established, as the community has not had experience especially in operating systems composed of pumps. The existing communal system of the Vutuni Creek community failed due to improper maintenance.

During the 6 months maintenance period, it is recommend to conduct the following:

- PWD will hold seminars to explain how to operate, maintain and manage the water supply facilities,
- PWD will prepare an O&M manual in terms of technical and operational points, and
- the community will set up an water supply union.

The recommended organization of the water supply union for the community is shown in Fig. 7.5.1. The union will consist of three sections from each task force. The seminar aims at instructing the OMM method to the water supply unit and the engineering section will conduct O&M in accordance with the manual. To cope with problems technically difficult to solve without PWD assistance, it is recommended to establish a cooperative system between PWD and the union so that PWD can assist the community.

Water charges will be determined in consideration of the costs of electricity for pumping and spare parts. The water charge will be collected and funded by the administration section of the union. PWD will prepare a store room for spare parts, which is included in the construction of the scheme and the community must manage the spare parts. The community can use the spare parts for repairs, and must replenish stocks out of the fund.

Also, the recommended plan would be effective for OMM of the existing communal water system, and will be expected to be a model case for OMM of the existing/planned communal systems. The details of the manual, contents of the seminar, and tasks of the each section in the union should be examined according to the detailed configuration of the water supply system determined in the proceeding detailed design stage.

7.6 Cost Estimates

7.6.1 Construction Costs

The construction costs were estimated at the December, 1994 price level for the respective proposed water supply schemes. They comprise local and foreign currency components and are divided into direct and indirect construction costs, contingency, and tax and duty. The indirect construction cost include land acquisition and engineering services. The contingency consists of the physical contingency and the price escalation. The direct construction cost is based on the work quantity and the unit price of the corresponding work item.

The basis and condition of the cost estimate are as follows:

(1) Conditions of procurement

The main construction materials and equipment will be procured as follows:

<u>Local</u>

UPVC pipe, cement, sand, gravel, reinforcing bar, forms, support and scaffolding materials, chemicals

<u>Foreign</u>

galvanized steel pipe, valves, flow meter, screen, casing pipe, submersible pump

(2) Unit price by work item

This covers the direct cost of labor, materials and equipment and indirect costs such as overhead, and site expenses.

(3) Exchange rate

The foreign exchange rate was assumed at US 1.00 = J.Yen 100, F$ 1.00 = J.Yen 70.

(4) Land acquisition

It has been based on the area to be covered by the construction of the service reservoir, and its unit price, as given by the Regional Lands Departments in each area.

(5) Engineering services

These are assumed to be 10 % of the direct construction cost summed up in local currency portion.

(6) Contingency

The physical contingency is assumed to be 10 % of the sum of the direct and indirect construction costs. The price escalation is also assumed to be 5 % per annum for the local currency component and 3 % for the foreign currency component.

(7) Value-added tax and import duty

The value-added tax is assumed to be 10 % of the costs for the construction material and equipment and import duty is assumed to be 10 % of the costs in the foreign currency for the construction material and equipment.

(8) Costs for insurance

The costs for insurance is excluded from the construction cost.

The total construction costs for each scheme are estimated for two cases, with and without the construction cost for the existing wells, and are shown in Tables 7.6.1 to 7.6.3. A summary of the total construction costs and the direct construction costs are as follows:

Total Construction Cost (with the construction cost for the existing well)

(Unit : F$)

No.	Scheme	L/C	F/C	Total
1.	Vutuni Creek	298,152	65,343	363,495
3.	Vatuyaka	422,937	62,937	485,874
6.	Rabulu	682,545	88,306	770,851

Direct Construction Cost (with the construction cost for the existing well)

(Unit : F$)

No.	Scheme	L/C	F/C	Total
1.	Vutuni Creek	220,810	48,800	269,610
3.	Vatuyaka	316,300	47,003	363,303
6.	Rabulu	510,151	65,949	576,100

7.6.2 Operation, Maintenance and Replacement Costs

The operation and maintenance costs required to implement the each water supply development scheme consist of the following;

(i) Personnel expenses for O&M of the water supply facilities,
(ii) Electric charge for the submersible pump,
(iii) Chemical costs for chlorination,
(iv) Repairing expenses for the equipment of the submersible pump, and
(v) Value-added tax for the chemicals and the equipment.

The annual O&M costs are estimated according to the OMM plan, as shown in Table 7.6.4 and summarized below.

Annual O&M Cost (Year : 1997) (Unit : F$)

Scheme		L/C	F/C	Total
1.	Vutuni Creek	2,137	588	2,725
3.	Vatuyaka	5,636	612	6,248
6.	Rabulu	4,866	732	5,598

Annual O&M Cost (Year : 2011) (Unit : F$)

Scheme		L/C	F/C	Total
1.	Vutuni Creek	4,084	588	4,672
3.	Vatuyaka	8,719	612	9,331
6.	Rabulu	12,872	732	13,604

Some of the facilities, especially the mechanical and electrical equipment for the pumping facilities, have shorter lives than the civil works, and will require replacement within the project service life. The replacement cost for the pumping equipment is assumed to be encountered 15 years after the initial investment, considering of the life of the equipment.

8. PROJECT EVALUATION

8.1 Economic Evaluation

8.1.1 General

The economic evaluation in this chapter aims to examine the economic feasibility for the three schemes; (1) the Vutuni Creek community scheme, (2) the Vatuyaka expansion scheme and (3) the Rabulu expansion scheme, by comparing the economic benefit and the more accurate economic cost.

The comparison is carried out using the Economic Internal Rate of Return (EIRR) and the Net Present Value (NPV), under the conditions and assumptions for estimating the economic benefit and cost, shown in Section 6.4.1.

8.1.2 Economic Cost

The economic cost for the three schemes is estimated from the construction cost and O&M cost shown in Section 7.5. Annual flows of these costs are indicated in Tables 8.1.1, 8.1.2 and 8.1.3, and are summarized as follows:

Scheme	Economic Construction Cost (1996)	Economic O&M Cost	
		1997	2011
1. Vutuni Creek	326,338	2,610	4,530
2. Vatuyaka	439,707	6,100	9,150
3. Rabulu	697,191	5,440	13,350

Unit : F$

In addition to the above O&M cost, a replacement cost for the pump is required for each scheme in the year 2012, 16 years after completion of the facilities. Its cost is estimated at F$ 15,610 for the Vutuni Creek community scheme, F$ 16,170 for the Vatuyaka expansion scheme, and F$ 18,780 for the Rabulu expansion scheme.

8.1.3 Economic Benefit

The economic benefit of the project is given as the difference between the water supply conditions with and without the projects. Estimates of this benefit are mainly composed of two categories; (1) savings of time spent to fetch water, and (2) reduction of emergency water supply costs.

A methodology of the benefit estimates is stated in Section 6.4.3, and the benefits for the three schemes are the same as values given in this Section, that is, the annual benefit in 1997 is estimated to be F$ 16,236 for the Vutuni Creek community scheme, F$ 20,368 for the Vatuyaka expansion scheme, and F$ 79,598 for the Rabulu expansion scheme. The annual benefit flows for these schemes are indicated in Tables 8.1.1 to 8.1.3.

8.1.4 Results of the Economic Analysis

Using the annual flows of the economic cost and benefit for each scheme shown in Tables 8.1.1 to 8.1.3, the economic internal rate of return (EIRR) and the net present value (NPV) are calculated and the results are summarized in the following table:

	EIRR	Present Value(F$)*		
Schemes	(%)	Cost	Benefit	Net
1. Vutuni Creek	2.62	330,608	162,162	-168,447
2. Vatuyaka	1.25	468,507	207,772	-260,735
3. Rabulu	13.83	718,160	979,915	261,755

* Discount rate : 10 %

Of the three schemes, the Rabulu expansion scheme achieves a comparatively high EIRR of 13.83 %, which indicates economic feasibility. This is mainly due to the high timesaving benefit (see Table 6.4.2).

The Vutuni Creek community scheme and the Vatuyaka expansion scheme indicate low EIRRs of 2.62 % and 1.25 %, respectively, which are not economically viable. These low percentages of EIRR chiefly result from low time saving benefits due to the average low income per household.

However as shown in Tables 8.1.1 and 8.1.2, the annual economic benefits for these two schemes sufficiently exceed the annual economic O&M costs each year during the period of the project life. Accordingly, although these schemes are not economically feasible, it will be possible to economically operate and maintain the project after completion of the facilities.

8.1.5 Sensitivity Analysis

Several conditions and assumptions based on professional experiences and appropriate judgment by experts, have been carefully set throughout the study, but there is always some question as to the degree of reliability of the inputs. A test is therefore carried out to judge sensitivity of EIRR in regard to variations in the estimated economic costs and benefits.

The sensitivity of EIRR for the Rabulu expansion scheme is tested for 5 % and 10 % increases in the economic cost and the 5 % and 10 % decreases in the economic benefits. The results are summarized as follows:

EIRR Sensitivity Test

Decrease in	Increase in Cost		
Benefit	0%	5%	10%
0%	13.83	13.18	12.58
5%	13.15	12.52	11.94
10%	12.45	11.84	11.28

As shown, EIRR for the Rabulu scheme maintains a high figure of 11.28 %, which indicates economic feasibility, even for the unfavorable case where decrease in benefit and increase in cost are both 10%.

EIRR for the Vutuni Creek schemes falls to 0.85 %, when a 10 % increase in cost and a 10 % decrease in benefit are combined, and the Vatuyaka scheme indicates a negative EIRR for the 10 % increase in cost, or the 10 % decrease in benefit.

8.2 Financial Analysis

This analysis is carried out for the two expansion schemes of Vatuyaka and Rabulu, where the domestic water will be supplied by the regional water supply system in the near future. The financial evaluation is given by comparing the cost and revenue of the project. According to the cost estimates stated in Section 7.5, the project costs for these schemes are as follows:

Scheme	Construction Cost 1996	O&M Cost 1997	O&M Cost 2011
1. Vatuyaka	485,874	6,248	9,331
2. Rabulu	770,851	5,598	13,604

Unit : F$

The project revenue is estimated using the unit water charge and the quantity of water supplied for domestic use. According to the water supply plan stated in Section 7.2, the effective quantity of water supplied is planned to be 54 m^3/day in 1996 and 90 m^3/day in 2011 for the Vatuyaka scheme, and for the Rabulu scheme it is 41 m^3/day in 1996 and 149 m^3/day in 2011. The unit water charge is set to be F$ 0.1202/m^3 at the beginning of 1995, according to information obtained from PWD.

The unit water charge is generally expected to change in proportion to a rise in the domestic prices. In the present study, the annual revenue is therefore examined in terms of two kinds of water charges, with and without inflation, where the average inflation rate is assumed to be 5 % per annum.

Under the above conditions, the annual revenue for the two schemes is estimated for the period of project life. The results are given in Tables 8.2.1 to 8.2.4, and are summarized as follows:

Annual Revenue of the Project

	Without Inflation		With Inflation	
	1997	2011	1997	2011
1. Vatuyaka	2,337	3,895	2,572	8,263
2. Rabulu	1,774	6,448	1,952	13,678

Unit : F$

FIRR for the two schemes is estimated using the annual flows of cost and revenue shown in Tables 8.2.1 to 8.2.4. However, both percentages are a negative figure for all schemes, and the annual O&M cost also exceeds the annual revenue for every year of the project life. Accordingly, the two schemes seem to be difficult financially to realize.

8.3 Summary of Project Evaluation

8.3.1 Vutuni Creek Community Scheme

According to this scheme, it is planned to transfer the water supply facilities from PWD to the Vutuni Creek community after completion of the facilities. Therefore the community and its inhabitants will become to share only the cost to operate and maintain the facilities.

A possibility of their share for this O&M cost is examined based on the economic analysis, without an evaluation of financial aspect, for reason that the water supply system of communities in Fiji is operated in a fashion unique to themselves, and share of the O&M cost between the community and its inhabitants is different by community and time.

As stated in Section 8.1.4, the Vutuni Creek community scheme indicates a low EIRR of 2.62 %, which is difficult economically to realize. However, the annual benefit exceeds the annual O&M cost every year during period of the project life, that is, it means that the operation of the water supply system is economically possible.

In addition to this matter, inhabitants of the Vutuni Creek community have lived under so unfavorable condition that most of their daily water have to fetch from the distant creek, because they have no wells. Realization of this scheme could therefore be expected to have a fair effect on social environmental improvement, even though the economic effect is low.

8.3.2 Vatuyaka Expansion Scheme

This scheme indicates a negative FIRR ,which is not financially feasible, due mainly to the low water charge, and EIRR indicates a low rate of 1.25 %, which is not economically viable, due to the low household income, despite the water supply is under unfavorable conditions. However, the economic annual benefit exceeds the economic annual O&M cost every year during period of the project life. Therefore the operation and maintenance of the water supply system will be economically possible.

This community is the most economically poor, compared to the other two communities. Most of households are farm families, and an average household income was less than F$ 50 per month in 1992. A large number of households depend on rivers and springs as water source, and further emergency water of PWD in dry season. Accordingly, this scheme could also be expected to have a fair effect on social environmental improvement, even though the economic and financial effects are low.

8.3.3 Rabulu Expansion Scheme

This scheme indicates a negative FIRR ,which is not financially viable, due chiefly to the low water charge. While, EIRR achieves a high rate of 13.83 %, which indicates economic feasibility, owing to the high household income.

The majority of households depend on dug wells far away from their households as water source, and have spent much hours to fetch their domestic water. Accordingly, this scheme could also be expected to have, in addition to the economic effect, a fair effect on social environmental improvement.

9. ENVIRONMENTAL ASSESSMENT

In this Study, we have planned three water supply systems, the Vutuni creek community scheme, the Vatuyaka expansion scheme, and the Rabulu expansion scheme. The groundwater development will cause as impact to the natural and social environment. The results of the environmental assessment of the groundwater development are as follows;

9.1 Vutuni Creek Community Scheme

Vutuni creek community is located in the Mountainous Area. The main aquifer is volcanic rocks, and there is no soft strata. Therefore, groundwater pumping will not cause land subsidence and saline water intrusion. The source for the water supply is the planned TW001 well. According to the results of the water quality analysis, the water quality satisfies the criteria for a potable water supply. Thus potable water can be supplied after sterilizing.

9.2 Vatuyaka Expansion Scheme

This area is located in Ba Uplands near the coast. The main aquifer is volcanic rocks, and there is no soft strata, thus groundwater pumping will not cause land subsidence. According to the results of the groundwater simulation, we can prevent salt water intrusion by the reasonable planning of the groundwater development. The source well is GW035, and the water quality of this well is very good. Therefore potable water can be supplied after sterilizing.

9.3 Rabulu Expansion Scheme

The source well of this water supply scheme is GW254. The main aquifer is volcanic rocks, and there is no soft strata. Therefore, groundwater pumping will not cause land subsidence and saline water intrusion. According to the results of the pumping test, the groundwater level does not recover without pumping. Therefore it is recommended that the groundwater level be monitored and the pumping rate be controlled, or alternatively an artificial recharge system will be considered.

10. CONCLUSIONS AND RECOMMENDATIONS

The Study Area is underlain by well consolidated basaltic and sedimentary rock masses of the Tertiary in which the fractured section forms the essential aquifer.

The Study Area is classified into 13 groundwater regions depending on the hydrogeological characteristics. The transmissivity of the aquifer is generally low, therefore, a typical borehole such as the test well yields 1 to 5 l/sec of water even in the medium and excellent potential regions.

Accordingly, for the master plan of overall water supply development, nine schemes were formulated using the existing test wells on which the yield had been confirmed. Among these nine schemes, three priority schemes were selected for further study based on the economical analysis.

The three schemes, the Vutuni Creek, the Vatuyaka, and the Rabulu, have positive EIRRs and the annual economic benefits exceed the annual O&M costs in each during the period of the project life, though FIRRs in them are negative.

Notwithstanding the relatively low economic and financial returns it is recognized that water supply development is one of the important basic needs for insuring subsistence in the Study Area, especially in the areas faced with water shortage problem. It has been confirmed that a safe and stable water supply will contribute to preserving public health and hygiene and promoting sustainable economic growth. It is recommended that the proposed priority water supply development scheme be implemented urgently, following the completion of the Study.

However, it is evident that the groundwater resource are unable to fulfill all of the future water demand in the whole Study Area. It is also recommended to develop surface water source available in major rivers, in addition to the groundwater development.

There are three possible sites for constructing a dam/weir to take water at the upstream of Toge in the Ba river. The water resource study on the Ba river basin be conducted for the regional development in terms of water supply for domestic, industrial, tourism, agricultural uses, etc., to cover the Northwest Viti Levu including the Ba area.

Proper groundwater management for proposed schemes should be carried out for sustainable groundwater use in order to prevent serious groundwater mining and deterioration of water quality. In addition to, artificial recharge study will be required before implementation of Rabulu Scheme, because the proposed well (GW254) is located at near coast lower elevation and water recovery was not normal when pumping test was executed.

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