9. GROUNDWATER DEVELOPMENT PLAN

The groundwater development potential in the Study Area is generally of sufficient level for domestic water supply use. As described in Section 5.2.4, the groundwater development potential per square kilometer ranges from 176 m^3/day (minimum in the Maharibo River basin) to 947 m^3/day (maximum in the Morondava River basin) in this area, which means that the potential per square kilometer is sufficient for supplying water to 8,800 people even in the minimum potential area, provided that the unit supply amount is fixed at 20 ℓ/c/d.

The areas where large quantities (61,800 m^3/day) of groundwater is pumped up for irrigation, industrial, and urban water supply use fall within an area with very high potential, the sub-basin of the Morondava River basin. The remaining capacity in this area is as much as 852 m^3/day/km^2 which is more than enough for rural water supply.

Consequently, sufficient quantities of groundwater can be obtained from anywhere in this Study Area. However two issues remain :

- Water quality : whether it is suitable for drinking
- Economic point of view : whether groundwater pumping is economically feasible or not, which is related to the required volume of water

With regard to quality, sea water intrusion is observed in most areas along the coast. Moreover, some parts of the coastal plain, even those that are further from the coast, are underlain with saline water aquifer interbedded with other beds containing fresh water, resulting in problems with saline water during the well drilling. At places close to dykes or fault lines, water quality may not be good enough for drinking due to dissolved substances from hot springs.

In consideration of the above, groundwater development should be carefully planned at each location, for example:

- Large-scale groundwater development should not be planned in areas along the coast in order to avoid sea water intrusion.
- Several extra drillings should be incorporated into the establishment of the well construction plan for coastal areas and where saline water aquifers are presumably interbedded.
- Well drilling should not be planned at points close to dykes or their related lineament in order to avoid hitting hot springs.

Regarding economic issues, the following measures have been taken into consideration in the planning of groundwater development.

- Borehole wells with manual pumps were planned for villages with a population less than 800 in order to minimize O/M costs.
- For the majority of the villages, with a population over 800 but not exceeding 3,000, a solar powered motor pump is to be introduced, for which fuel is not necessary (low operation costs).
- Introduction of motor pumps with diesel engine generators is limited to the villages whose financial capability (ability to pay) is adequate to cover O/M costs, and where there is a reliable fuel supply (access to fuel stations is possible, even during the rainy season).

9.1 Basic Concept for the Groundwater Development Plan

Since the groundwater development potential is sufficient in terms of quantity, as mentioned above, the volume to be developed shall be extrapolated from the water demand in the year 2005, that is, the unit supply amount (20 ℓ/c/d) multiplied by the estimated population in 2005 for each of the candidate villages. The developed groundwater is not for the purpose of supplementing existing water sources. Unsanitary domestic water sources in majority of the villages in the Study Area are to be replaced by safe water sources. This is the major concept of the groundwater development plan.

As for the project implementation schedule for groundwater development, villages with both high requirements for a safe water source and a comparatively good financial situation should be given priority (50 to 60 villages). The remaining listed candidate villages and the villages left off the list will follow the prioritized villages.

9.2 Groundwater Development Plan per Village

Table 9.1 presents the groundwater development plan in terms of quantity for each of the surveyed 81 candidate villages.

Electrical resistivity sounding was performed at 46 villages and test drilling at only 13 villages, but the overall hydrogeological analysis has made it possible to estimate the drilling depth required to hit an aquifer, and to estimate the production amount of each well. Resistivity sounding at the remaining 35 villages is necessary in order to determine the drilling depth more precisely before implementation of the project.

Table 9.1 Groundwater Development Plan (1/2)

Village			Population		Categorization (Prioritization)	Groundwater Development Plan				
No.	Name		in 1995	in 2005		Target Drilling Depth	Expected Pumping Discharge	Amount to be Developed	Estimated Water Level S.W.L	D.W.L
							ℓ/min.	ℓ/min.	GL-m	GL-m
106	Malaimbandy	# *	7,000	9,200	A A	250 m(6")	(>400)	380	30.00	(40.00)
103	Ankilizato	# *	4,200	5,500	A A	170 m(6")	300	260	22.60	115.00
25	Befasy	# *	2,000	2,600	A A	63 m(4")	560	140	5.57	9.98
104	Mandabe	# *	2,000	2,600	A A	103 m(6")	350	140	9.80	13.90
67	Analaiva	# *	1,520	2,000	A A	73 m(4")	715	110	3.70	4.81
23	Marerano	*	1,100	1,400	A A	170 m(6")	300	80	15.00	30.00
109	Tsianaloka	# *	1,000	1,300	A A	22 m(4")	70	70	13.17	14.49
110	Kiboy	*	930	1,200	A A	130 m(6")	200	70	15.00	30.00
115	Ankotrofotsy	*	908	1,200	A A	150 m(6")	350	70	15.00	25.00
107	Ampanotoka	*	900	1,200	A A	200 m(6")	75	70	35.00	50.00
97	Bezezika	# *	855	1,100	A A	48 m(4")	930	60	7.80	8.61
114	Ambatolahy	# *	800	1,100	A A	93 m(6")	350	60	13.41	24.27
31	Beleo		800	1,100	A A	70 m(4")	500	60	6.00	12.00
93	Beroboka Atm.	# *	783	1,000	A A	73 m(4")	767	60	2.95	5.21
46	Marofihitsa	# *	750	980	A A	38 m(4")	524	50	4.12	4.46
99	Ankilimida	*	600	790	A A	70 m(4")	600	40	15.00	30.00
5	Befamonty	*	450	590	A A	70 m(4")	150	30	5.00	15.00
9	Ankoba		410	540	A A	70 m(4")	150	30	5.00	15.00
100	Ampanihy		742	970	A B	100 m(4")	500	50	5.00	15.00
83	Ampataka	*	695	910	A B	50 m(4")	200	50	5.00	15.00
8	Nosibe	*	600	790	A B	100 m(4")	150	40	5.00	15.00
17	Ambivy II	*	500	660	A B	60 m(4")	350	40	5.00	15.00
20	Marolafika Atm.	*	500	660	A B	100 m(4")	300	40	5.00	15.00
101	Benato		500	660	A B	70 m(4")	800	40	5.00	15.00
55	Ampananiha		420	550	A B	70 m(4")	500	30	10.00	20.00
26	Antevamena		360	470	A B	70 m(4")	500	30	7.00	14.00
10	Antseranandaka No.		342	450	A B	60 m(4")	150	30	5.00	15.00
27	Mitsitiky		340	450	A B	100 m(4")	500	30	15.00	30.00
3	Antaly	*	327	430	A B	100 m(4")	150	20	5.00	15.00
102	Anolotsy		300	390	A B	70 m(4")	800	20	5.00	15.00
7	Nositonga		260	340	A B	48 m(4")	150	20	5.00	15.00
41	Farateny	*	250	330	A B	100 m(4")	600	20	5.00	15.00
60	Tandrokosy		238	310	A B	70 m(4")	700	20	8.00	16.00
34	Croise. Besotroka		200	260	A B	70 m(4")	500	10	10.00	20.00
39	Antsamaka		150	200	A B	70 m(4")	400	10	10.00	20.00
76	Laijoby (Avaratra)		150	200	A B	60 m(4")	500	10	15.00	25.00
16	Ambivy I	*	130	170	A B	150 m(6")	350	10	10.00	20.00
68	Betsipotika	*	120	160	A B	70 m(4")	700	10	7.00	15.00
94	Ankilivalo	*	2,960	3,900	B A	100 m(4")	800	220	10.00	15.00
52	Antsakamirohaka	*	1,600	2,100	B A	50 m(4")	500	120	5.00	15.00
112	Tsimafana	*	1,500	2,000	B A	100 m(4")	500	110	5.00	20.00

Test construction was made in this Study.
* Depth to aquifers have been estimated by conducting electric resistivity sounding.

Table 9.1 Groundwater Development Plan (2/2)

Village		Population		Categorization (Prioritization)	Groundwater Development Plan				
No.	Name	in 1995	in 2005		Target Drilling Depth	Expected Pumping Discharge	Amount to be Developed	Estimated Water Level S.W.L	Estimated Water Level D.W.L
						ℓ/min.	ℓ/min.	GL-m	GL-m
58	Bemanonga *	1,250	1,600	B A	100 m(4")	500	90	5.00	15.00
59	Marovoay *	1,247	1,600	B A	100 m(4")	700	90	5.00	15.00
113	Mananjaky	1,170	1,500	B A	30 m(4")	70	80	13.00	20.00
89	Ankaraobato	800	1,100	B A	70 m(4")	600	60	5.00	15.00
1	Andranopasy I # *	623	820	B A	30 m(4")	137	50	12.48	5.33
53	Androvakely *	550	720	B A	100 m(4")	500	40	5.00	15.00
40	Manomentimay *	436	570	B A	80 m(4")	500	30	5.00	15.00
82	Marofandiliha *	370	490	B A	80 m(4")	500	30	6.00	15.00
64	Andranomena A # *	210	280	A B	78 m(4")	402	20	+1.80	1.53
33	Misokotse *	800	1,100	B B	60 m(4")	500	60	7.00	15.00
70	Ampandra *	600	790	B B	80 m(4")	800	40	10.00	18.00
47	Ambararata # *	500	660	B B	73 m(4")	767	40	2.95	5.21
74	Tsinjorano *	450	590	B B	70 m(4")	800	30	10.00	20.00
36	Namakia	400	530	B B	60 m(4")	600	30	5.00	15.00
81	Malandirano	400	530	B B	60 m(4")	500	30	6.00	12.00
15	Miary *	365	480	B B	150 m(6")	350	30	10.00	20.00
48	Ankevo *	300	390	B B	80 m(4")	700	20	5.00	15.00
66	Croisement BST	204	270	B B	60 m(4")	700	20	8.00	18.00
18	Ambahia *	200	260	B B	80 m(4")	350	10	5.00	15.00
30	Bekininy Soarano	400	530	A C	70 m(4")	700	30	7.00	15.00
35	Amanga	400	530	A C	70 m(4")	500	30	5.00	15.00
4	Darika *	327	430	A C	100 m(4")	150	20	5.00	15.00
80	Analalava *	300	390	A C	60 m(4")	600	20	10.00	20.00
95	Ambohibary	300	390	A C	70 m(4")	800	20	5.00	15.00
79	Ambonio	270	350	A C	60 m(4")	500	20	10.00	17.00
65	Tanandava	250	330	A C	60 m(4")	500	20	5.00	15.00
11	Tsaramandroso	237	310	A C	60 m(4")	400	20	5.00	15.00
2	Andranopasy II	226	300	A C	70 m(4")	150	20	5.00	15.00
6	Ambatobe *	220	290	A C	60 m(4")	150	20	5.00	15.00
19	Besatrohaka *	210	280	A C	70 m(4")	150	20	5.00	15.00
29	Ankilatamahavelo	190	250	A C	70 m(4")	500	10	10.00	20.00
69	Amboloando	150	200	A C	60 m(4")	800	10	10.00	18.00
43	Andrananja	70	90	A C	60 m(4")	500	10	5.00	15.00
56	Antseranambondro	60	80	A C	60 m(4")	500	4	5.00	15.00
28	Andranovorisosotra	40	50	A C	70 m(4")	500	3	5.00	15.00
61	Bekonazy	40	50	A C	80 m(4")	700	3	10.00	18.00
50	Bevantaza	150	200	B C	70 m(4")	350	10	15.00	30.00
14	Tanambahiny	131	170	B C	100 m(4")	350	10	15.00	30.00
72	Antevamena II *	100	130	B C	70 m(4")	700	10	8.00	18.00
32	Anadabo	36	50	C C	60 m(4")	500	3	10.00	20.00

Test construction was made in this Study.
* Depth to aquifers have been estimated by conducting electric resistivity sounding.

10. PLAN ON WATER SUPPLY FACILITIES

10.1 Plan on Unit Supply Amount

The establishment of a water supply plan should always be based on two elements: "Unit Supply Amount" and "Population Served". There are two different ways in determining the unit supply amount in the Southwestern Region of Madagascar.

One is to follow the government guideline for rural water supply covering the whole of Madagascar (20 ℓ/c/d). Another is to be based on the results of the evaluation survey on the Phase I Project , that is, a smaller unit supply amount (15 ℓ/c/d, for example), putting the emphasis on easier and low cost maintenance in view of achieving sustainable conditions.

A thorough discussion was held on this matter between the JICA Study Team and the MEM Team at the meeting on the Interim Report, and as a result, the unit supply amount was decided at 20 liters on condition of the following, in order for the supply facilities to be effective and the facilities sustainable :

- MEM itself continues its effort to educate the inhabitants of the project area on the use of a safe water source and the payment for the services as the implementing body, and also appeals to the local authorities or the relevant ministries to do the same, as the coordinating body of the rural water supply sector.
- MEM strengthens its organization and system for the maintenance services, and educates the users on proper facility operation.

10.2 Service Population Plan

During the period of the study in Madagascar, the local administration was reorganized in accordance with the "decentralization policy", resulting in the majority of the Project candidate villages becoming parts of new "Communes" which are now the smallest units of the local administrative organization.

However, it was confirmed during the meetings on the Progress Report and Interim Report that the villages for the Study would remain the same and the objective area will not expand to cover the new communes. The groundwater development plan and the water supply plan, therefore, are to be established on the basis of the former "villages". Accordingly, the service population of each village is the projected population of the village in the target year of 2005.

Data on the population growth rate is not available in this area, therefore, the same rate as in the Phase I Project Area (2.76% per annum) is to be used. Assuming that the growth rate is constant, the projected population of the concerned villages in the year 2005 (after 10 years) is calculated as ;

$$\text{Present population} \times (1 + 0.0276)^{10}$$

As a result, the population served at each candidate village is forecast to become about 1.3 times the present population. These values are to be used in determining the scale of each facility.

10.3 Supply Facility Plan

The types of water supply facilities applicable in this Study Area are the following:

a. Hand pump wells for comparatively small-scale villages with a population less than 800 (1,000 in case of scattered village), and for villages where the dynamic water level is higher than 30 meters below the ground level. The number of wells to be constructed will depend on the population to be served in the village.

b. Simple supply system composed of a distribution system with communal faucets and intake facility (well and motorized pump powered by diesel engine generator or photo-voltaic panels). This type of supply facility has been planned at comparatively concentrated villages with a population over 800. The energy source has been selected in accordance with the following conditions:

- Photo-voltaic (Solar energy) system ---- For villages where the population is not so large, and at places where the dynamic water level in the well is not so deep, because the generation of high energy requires a large amount of investment. However, for villages with poor access to a fuel station, introduction of this system seems inevitable regardless of the high investment cost.

- Electricity generated by diesel engine ---- For densely populated villages and where there is financial capability to pay for the operation cost. In addition, villages with relatively easy access to a fuel station throughout the year even during the rainy season.

Based on the conditions mentioned above, the water supply facility for each of the candidate villages has been planned and tabulated in Table 10.1.

The scale of water supply facilities have been planned under the following conditions based on the unit supply amount of 20 ℓ/c/d and the projected population in 2005.

a. Hand pump facility

- Water collection hour: 4 hours in the morning and 3 hours in the afternoon, totaling 7 hours a day
- Pumping rate: 15 ℓ/min. during actual pumping, and 10 ℓ/min. on average taking blank time into consideration, that is, 600 ℓ/hour and 4.2 m^3/day.
- Number of wells required in one village: Water demand (population served multiplied by 20ℓ/c/d) is to be divided by 4.2 m^3/day.

b. Facilities equipped with motorized pump and communal faucets

Since this system is provided with a distribution tank, it is not necessary to consider water collection hours because the inhabitants can collect water at any time by opening the tap, so long as the tank is filled with water. The pumping rate and the capacity of the tank have been determined in conformity with water demand, which is within the range of groundwater development potential. In Table 10.1, the required pumping rates are also presented by fixing the pumping period at 6 hours a day.

The standard design of the facilities is as follows:

(1) Standard design of the well

The target depth of the well in each of the candidate village has been determined based on the hydrogeological analysis, especially on the results of the geophysical survey, and is tabulated in Table 9.1 along with the diameter of the wells.

The well screen should have an opening ratio of more than 3 % and a slot size of less than 1 mm, and must be installed at positions in relation with good aquifers. For the wells of high pumping rate at more than 300 liters per minute, it is better to use a screen with a larger opening ratio, i.e. 10 % or more.

(2) Standard design of the supply facility

The number of hand pump wells (1 to 4 wells) in each of the candidate villages is tabulated in Table 10.1, and these are to be located in accordance with the distribution of houses and are to be separated by more than 100 meters each other.

The standard design of the concrete pump base is given in Fig. 10.1.

For the motor pumped supply system, the well is to be constructed at a comparatively high elevated site in the village, and a raised distribution tank is to be constructed within 10 meters from the well. Water pumped by the submersible motor pump is conveyed to the distribution tank also by the pump, and is delivered to several communal faucets through branch type distribution pipes by natural flow.

A pressure gauge shall be affixed to the bend connecting the riser pipe with the conveyance pipe to the tank, and the sluice and check valves on the conveyance pipe. The distribution tank and the end of the distribution pipes shall be equipped with drain valves. A generator house or solar panels are to be constructed near the well in order to supply power to the pump. Figures 10.2 and 10.3 represent the schematic drawings of the total facility.

10.4 Estimation of Necessary Investment Cost

A cost estimation for the construction of the water supply facilities has been done under the following conditions and assumptions:

- The facility construction cost shall include the cost for the establishment of the project management office in the Morondava area, since this office is believed to be vital in order to make the project sustainable. The office complex shall comprise an office building, combined warehouse, workshop, and garage. The cost for the office establishment also includes the necessary equipment and materials for the maintenance of the wells, vehicles and the tools for repairing the pump and generator.
- The unit construction costs and material costs for the water supply facility are assumed to be same as that of the Phase I Project, however, the contingency is estimated at 8 % for the foreign portion and 10 % for the local portion.
- The construction cost for the hand pumps consists of the cost of works and materials for 4-inch wells, concrete pump base, and hand pump installation with spare parts delivery.
- The cost estimation for the construction of the semi-urban type facilities is divided into that of intake and distribution system.

The cost for the distribution system comprises the works and materials for the reservoir tank, distribution pipe and communal faucets; their size and number depend on the type and water demand of the villages.

The intake system comprises a single well with a diameter of 4 inches or 6 inches equipped with a submersible motor pump, the well diameter depending on the volume of water to be pumped (outer diameter of the pump). The power source is a diesel engine generator accompanied by a generator house at 8 villages, and a set of solar panels at 17 villages. The power supply, that is, the capacity of the generator or the number of solar panels depends on the water demand of the villages.

For all of the 81 villages surveyed, excluding the village of Andranomena where a well was constructed during the study period, the facility construction cost is estimated at about 7.54 million US Dollars as shown in the following table.

Facility construction cost for 80 villages (Unit = US$)

Items	Foreign	Local	Total
Construction Cost		2,359,515	2,359,515
Equipment and Material Cost	4,064,791	-	4,064,791
Administration and Engineering Cost	325,184	188,761	513,945
Contingencies	351,198	254,827	606,025
Total	4,741,173	2,803,103	7,544,276

- Number of wells and their total length:
  4-inch well : 135 wells totaling 10,025 m drilling
  6-inch well : 6 wells totaling 1,070 m drilling
- Number of the supply facilities by type:
  Diesel Engine Generator Type 8 sets
  Solar Energy Type 17 sets
  Hand Pump Type 121 sets

With the addition of the cost to set up the Morondava management office, the construction cost for the works in the 80 villages totals about 9.43 million US Dollars as shown in Table 10.2.

In view of the ideal project implementation, that is, from the viewpoints of urgent necessity and a favorable socio-economic condition, the cost of the facilities in the 60 prioritized villages has been estimated, and presented in the table below.

Facility Construction Cost for the 60 Villages Selected (Unit = US$)

Item	Foreign	Local	Total
Construction Cost		2,085,777	2,085,777
Equipment and Material Cost	3,552,457		3,552,457
Administration and Engineering Cost	284,197	166,862	451,059
Contingencies	306,932	225,263	532,195
Total	4,143,586	2,477,902	6,621,488

- Number of wells and their total length :

4-inch well :	103 wells,	totaling	7,795 m	drilling
6-inch well :	6 wells,	totaling	1,070 m	drilling

- Number of supply facilities:

Diesel Engine Generator Type	8 sets
Solar Energy Type	17 sets
Hand Pump Type	89 sets

With the addition of the cost of setting up the Morondava management office, the construction cost for the 60 selected villages totals about US$ 8.5 million as shown in Table 10.3. The cost of setting up the office includes the construction cost of the buildings, and the equipment and materials for the maintenance of facilities :

. Borehole Logging, Equipment for Water Quality Analysis

. Pumping Test Equipment

. Vehicles

Cargo Truck with Crane 4x4	1 unit
4WD Station-wagon	1 unit
Pick-up Truck	1 unit

. Maintenance Tools	1 unit
. Well Service Machine	1 unit
. Spare Parts	L. S.

Table 10.1 Water Supply Facilities by Village (1/4) (Hand Pump Type)

Village		Population		Categori-zation	Well				Hand Pump	
No.	Name	in1995	in2005		Diameter	Depth	S.W.L / D.W.L (GL-m / GL-m)	Q'ty	Capacity×Head	Q'ty
99	Ankilimida	600	790	A A	φ4"	70 m	(15.00 / 30.00)	4	15 ℓ/min× 30.0 m	4
5	Befamonty	450	590	A A	φ4"	70 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
9	Ankoba	410	510	A A	φ4"	70 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
83	Ampataka	695	910	A B	φ4"	50 m	(5.00 / 15.00)	4	15 ℓ/min× 15.0 m	4
8	Nosibe	600	790	A B	φ4"	100 m	(5.00 / 15.00)	4	15 ℓ/min× 15.0 m	4
17	Ambivy II	500	660	A B	φ4"	60 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
20	Marolafika Alm.	500	660	A B	φ4"	100 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
101	Benato	500	660	A B	φ4"	70 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
55	Ampananiha	420	550	A B	φ4"	70 m	(10.00 / 20.00)	3	15 ℓ/min× 20.0 m	3
26	Antevamena	360	470	A B	φ4"	70 m	(7.00 / 14.00)	2	15 ℓ/min× 14.0 m	2
10	Antseranandaka N.	342	450	A B	φ4"	60 m	(5.00 / 15.00)	2	15 ℓ/min× 15.0 m	2
27	Mitsitiky	340	450	A B	φ4"	100 m	(15.00 / 30.00)	2	15 ℓ/min× 30.0 m	2
3	Antaly	327	430	A B	φ4"	100 m	(5.00 / 15.00)	2	15 ℓ/min× 15.0 m	2
102	Anolotsy	300	390	A B	φ4"	70 m	(5.00 / 15.00)	2	15 ℓ/min× 15.0 m	2
7	Nositonga	260	340	A B	φ4"	50 m	(5.00 / 15.00)	2	15 ℓ/min× 15.0 m	2
41	Farateny	250	330	A B	φ4"	100 m	(5.00 / 15.00)	2	15 ℓ/min× 15.0 m	2
60	Tandrokosy	238	310	A B	φ4"	70 m	(8.00 / 16.00)	2	15 ℓ/min× 16.0 m	2
34	Croise. Besotroka	200	260	A B	φ4"	70 m	(10.00 / 20.00)	2	15 ℓ/min× 20.0 m	2
39	Antsamaka	150	200	A B	φ4"	70 m	(10.00 / 20.00)	1	15 ℓ/min× 20.0 m	1
76	Laijoby Avaratra	150	200	A B	φ4"	60 m	(15.00 / 25.00)	1	15 ℓ/min× 25.0 m	1
16	Ambivy I	130	170	A B	φ4"	150 m	(10.00 / 20.00)	1	15 ℓ/min× 20.0 m	1
68	Betsipotika	120	160	A B	φ4"	70 m	(7.00 / 15.00)	1	15 ℓ/min× 15.0 m	1
53	Androvakely	550	720	B A	φ4"	100 m	(5.00 / 15.00)	4	15 ℓ/min× 15.0 m	4
40	Manomentimay	436	570	B A	φ4"	80 m	(5.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
82	Marofandiliha	370	490	B A	φ4"	80 m	(6.00 / 15.00)	3	15 ℓ/min× 15.0 m	3
70	Ampandra	600	790	B B	φ4"	80 m	(10.00 / 18.00)	4	15 ℓ/min× 18.0 m	4
47	Ambararata	500	660	B B	(φ4" φ4"	73 m 75 m	(2.95 / 5.21) (3.00 / 5.00)	1) 2	15 ℓ/min× 5.0 m	3
74	Tsinjorano	450	590	B B	φ4"	70 m	(10.00 / 20.00)	3	15 ℓ/min× 20.0 m	3

Table 10.1 Water Supply Facilities by Village (2/4) (Hand Pump Type)

Village		Population		Categori-zation	Well					Hand Pump	
No.	Name	in1995	in2005		Diameter	Depth	S.W.L GL-m	D.W.L GL-m	Q.ty	Capacity×Head	Q.ty
36	Namakia	400	530	B B	φ4"	60 m	(5.00	/ 15.00)	3	15 ℓ/min× 15.0 m	3
81	Malandirano	400	530	B B	φ4"	60 m	(6.00	/ 12.00)	3	15 ℓ/min× 12.0 m	3
15	Miary	365	480	B B	φ4"	150 m	(10.00	/ 20.00)	2	15 ℓ/min× 20.0 m	2
48	Ankevo	300	390	B B	φ4"	80 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
66	Croisement BST	204	270	B B	φ4"	60 m	(8.00	/ 18.00)	2	15 ℓ/min× 18.0 m	2
18	Ambahia	200	260	B B	φ4"	80 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
35	Amanga	400	530	A C	φ4"	70 m	(5.00	/ 15.00)	3	15 ℓ/min× 15.0 m	3
30	Bekininy Soarano	400	530	A C	φ4"	70 m	(7.00	/ 15.00)	3	15 ℓ/min× 15.0 m	3
4	Darika	327	430	A C	φ4"	100 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
80	Analalava	300	390	A C	φ4"	60 m	(10.00	/ 20.00)	2	15 ℓ/min× 20.0 m	2
95	Ambohibary	300	390	A C	φ4"	70 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
79	Ambonio	270	350	A C	φ4"	60 m	(10.00	/ 17.00)	2	15 ℓ/min× 17.0 m	2
65	Tanandava	250	330	A C	φ4"	60 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
11	Tsaramandroso	237	310	A C	φ4"	60 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
2	Andranopasy II	226	300	A C	φ4"	70 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
6	Ambatobe	220	290	A C	φ4"	60 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
19	Besatrohaka	210	280	A C	φ4"	70 m	(5.00	/ 15.00)	2	15 ℓ/min× 15.0 m	2
29	Ankitatamahavelo	190	250	A C	φ4"	70 m	(10.00	/ 20.00)	2	15 ℓ/min× 20.0 m	2
69	Amboloando	150	200	A C	φ4"	60 m	(10.00	/ 18.00)	1	15 ℓ/min× 18.0 m	1
43	Andrananja	70	90	A C	φ4"	60 m	(5.00	/ 15.00)	1	15 ℓ/min× 15.0 m	1
56	Antseranambondro	60	80	A C	φ4"	60 m	(5.00	/ 15.00)	1	15 ℓ/min× 15.0 m	1
28	Andranovorisosotra	40	50	A C	φ4"	70 m	(5.00	/ 15.00)	1	15 ℓ/min× 15.0 m	1
61	Bekonazy	40	50	A C	φ4"	80 m	(10.00	/ 18.00)	1	15 ℓ/min× 18.0 m	1
50	Bevantaza	150	200	B C	φ4"	70 m	(15.00	/ 30.00)	1	15 ℓ/min× 30.0 m	1
14	Tanambahiny	131	170	B C	φ4"	100 m	(15.00	/ 30.00)	1	15 ℓ/min× 30.0 m	1
72	Antevamena II	100	130	B C	φ4"	70 m	(8.00	/ 18.00)	1	15 ℓ/min× 18.0 m	1
32	Anadabo	36	50	C C	φ4"	60 m	(10.00	/ 20.00)	1	15 ℓ/min× 20.0 m	1

Table 10.1 Water Supply Facilities by Village (3/4) (Engine Generator Type)

Village		Population		Categori-zation	Well					Submersible Motor Pump	Engine	Reservoir	Public	Pipe Line			
No.	Name	in 1995	in 2005		Diameter	Depth	S.W.L GL-m	D.W.L GL-m	Q'ty	Capacity×Head	Generator	Capacity	Faucet	φ4" (m)	φ3" (m)	φ2 1/2 (m)	φ2" (m)
106	Malaimbandy	7,000	9,200	AA	φ6"	250 m	(35.00 /	80.00)	1	340 ℓ/min × 95.0 m	55.0 KVA	40m³	22	600	400		400
103	Ankilizato	4,200	5,500	AA	φ6"	170 m	(25.00 /	115.00)	1	310 ℓ/min × 130.0 m	55.0 KVA	40m³	13	200	200		1,200
67	Analaiva	1,520	2,000	AA	φ4"	73 m	(3.70 /	4.81)	0	110 ℓ/min × 30.0 m	10.0 KVA	20m³	5		200	300	700
115	Ankotrofotsy	908	1,200	AA	φ6"	150 m	(15.00 /	25.00)	1	70 ℓ/min × 40.0 m	10.0 KVA	15m³	3				50
97	Bezezika	855	1,100	AA	φ4"	50 m	(8.00 /	9.00)	1	70 ℓ/min × 30.0 m	10.0 KVA	15m³	3				400
114	Ambatolahy	800	1,100	AA	φ6"	93 m	(13.41 /	24.27)	0	60 ℓ/min × 40.0 m	10.0 KVA	10m³	3				50
94	Ankilivalo	2,960	3,900	BA	φ4"	100 m	(10.00 /	15.00)	1	220 ℓ/min × 30.0 m	12.5 KVA	40m³	9	200	400	200	200
58	Bemanonga	1,500	2,000	BA	φ4"	100 m	(5.00 /	15.00)	1	100 ℓ/min × 30.0 m	10.0 KVA	15m³	4		200		400

Table 10.1 Water Supply Facilities by Village (4/4) (Solar Energized Type)

Village		Population		Categori-zation	Well					Submersible Motor Pump	Solar	Reservoir	Public	Pipe Line			
No.	Name	in 1995	in 2005		Diameter	Depth	S.W.L GL-m	D.W.L GL-m	Q'ty	Capacity×Head	Energized	Capacity	Faucet	φ4" (m)	φ3" (m)	φ2 1/2 (m)	φ2" (m)
25	Befasy	2,000	2,600	AA	φ4"	63 m	(5.57 /	9.98)	0	200 ℓ/min × 25.0 m	2.38 KW	30m³	6				1,000
104	Mandabe	2,000	2,600	AA	φ6"	103 m	(9.80 /	13.90)	0	200 ℓ/min × 30.0 m	2.86 KW	30m³	6		200	200	800
23	Marerano	1,100	1,400	AA	φ6"	170 m	(15.00 /	30.00)	1	110 ℓ/min × 45.0 m	2.36 KW	15m³	3				50
109	Tsianaloka	1,000	1,300	AA	φ4"	35 m	(13.00 /	15.00)	1	100 ℓ/min × 30.0 m	1.43 KW	15m³	3				50
107	Ampanotoka	900	1,200	AA	φ6"	200 m	(35.00 /	50.00)	1	90 ℓ/min × 65.0 m	2.78 KW	15m³	3				50
110	Kiboy	930	1,200	AA	φ6"	130 m	(15.00 /	30.00)	1	100 ℓ/min × 45.0 m	1.99 KW	15m³	3				50
31	Beleo	800	1,100	AA	φ4"	70 m	(6.00 /	12.00)	1	80 ℓ/min × 30.0 m	1.14 KW	10m³	3				50
93	Beroboka Atm.	783	1,000	AA	φ4"	70 m	(3.00 /	5.00)	1	80 ℓ/min × 20.0 m	0.75 KW	10m³	2				50
46	Marofihitsa	750	980	AA	φ4"	40 m	(4.00 /	5.00)	1	80 ℓ/min × 30.0 m	1.07 KW	10m³	2		3,000		50
100	Ampanihy	742	970	AB	φ4"	100 m	(5.00 /	15.00)	1	80 ℓ/min × 30.0 m	1.06 KW	10m³	2				50
52	Antsakamirohaka	1,600	2,100	BA	φ4"	50 m	(5.00 /	15.00)	1	160 ℓ/min × 30.0 m	2.28 KW	20m³	5				500
112	Tsimafana	1,500	2,000	BA	φ4"	100 m	(5.00 /	20.00)	1	150 ℓ/min × 40.0 m	2.86 KW	20m³	5				50
59	Marovoay	1,247	1,600	BA	φ4"	100 m	(5.00 /	15.00)	1	130 ℓ/min × 30.0 m	1.78 KW	20m³	4				500
113	Mananjaky	1,170	1,500	BA	φ4"	30 m	(13.00 /	20.00)	1	120 ℓ/min × 30.0 m	1.67 KW	15m³	4				500
89	Ankaraobato	800	1,100	BA	φ4"	70 m	(5.00 /	15.00)	1	80 ℓ/min × 30.0 m	1.14 KW	10m³	3				50
1	Andranopasy I	623	820	BA	φ4"	50 m	(7.00 /	15.00)	1	70 ℓ/min × 30.0 m	0.89 KW	10m³	2		5,000		500
33	Misokotsa	800	1,100	BB	φ4"	60 m	(7.00 /	15.00)	1	80 ℓ/min × 30.0 m	1.14 KW	10m³	3				600

Table 10.2 Investment Cost (80 Villages)

(Unit=US$)

Item		Foreign	Local	Total
Project Management Office	Land and Construction Cost		174,512	174,512
	Equipment and Material Cost	1,438,495		1,438,495
	Administration and Engineering Cost	115,080	13,961	129,041
	Contingencies	124,286	18,847	143,133
	Sub-total	1,677,861	207,320	1,885,181
Well Drilling & Water Supply Facility	Construction Cost		2,359,515	2,359,515
	Equipment and Material Cost	4,064,791		4,064,791
	Administration and Engineering Cost	325,184	188,761	513,945
	Contingencies	351,198	254,827	606,025
	Sub-total	4,741,173	2,803,103	7,544,276
Total		6,419,034	3,010,423	9,429,457

Table 10.3 Investment Cost (60 Villages)

(Unit=US$)

Item		Foreign	Local	Total
Project Management Office	Land and Construction Cost		174,512	174,512
	Equipment and Material Cost	1,438,495		1,438,495
	Administration and Engineering Cost	115,080	13,961	129,041
	Contingencies	124,286	18,847	143,133
	Sub-total	1,677,861	207,320	1,885,181
Well Drilling & Water Supply Facility	Construction Cost		2,085,777	2,085,777
	Equipment and Material Cost	3,552,457		3,552,457
	Administration and Engineering Cost	284,197	166,862	451,059
	Contingencies	306,932	225,263	532,195
	Sub-total	4,143,586	2,477,902	6,621,488
Total		5,821,447	2,685,222	8,506,669

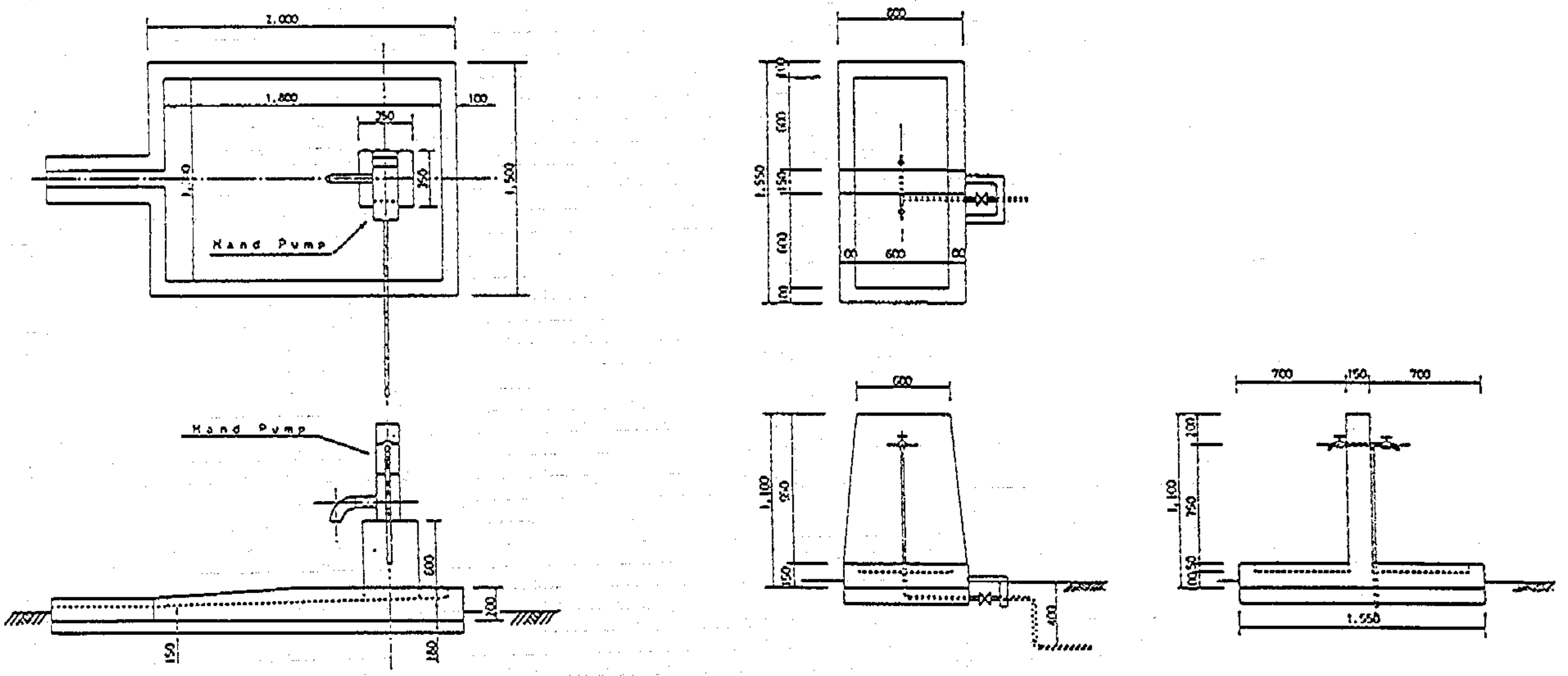
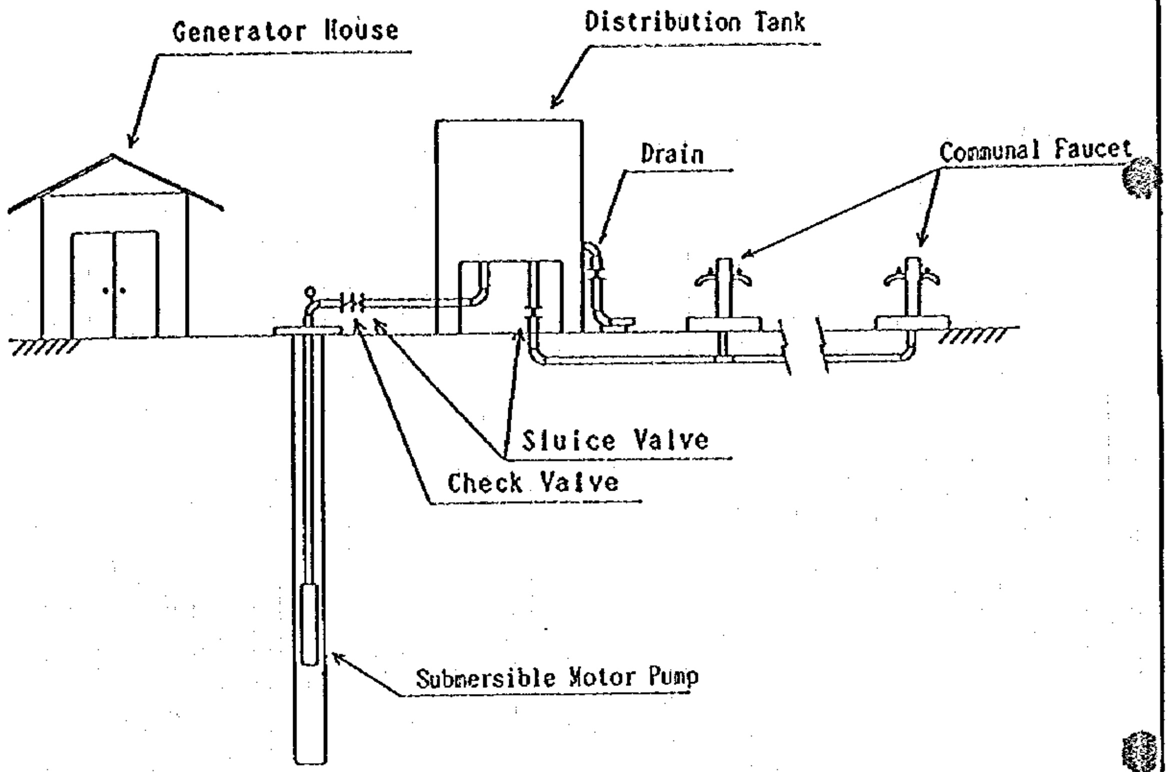


Fig. 10.1 Standard Design of the Concrete Pump Base and Communal Faucets



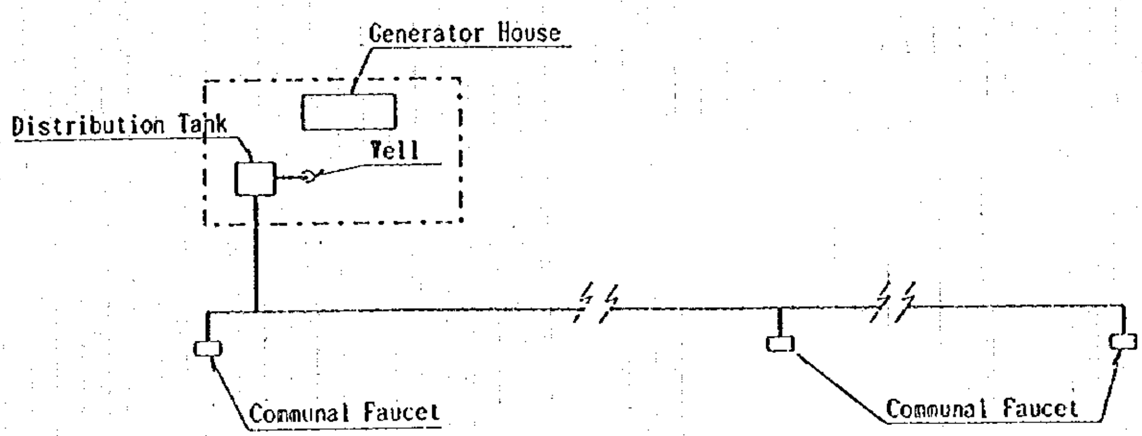


Fig. 10.2 Schematic Drawing of Water Supply System (with Pumping by Diesel Engine Generator)

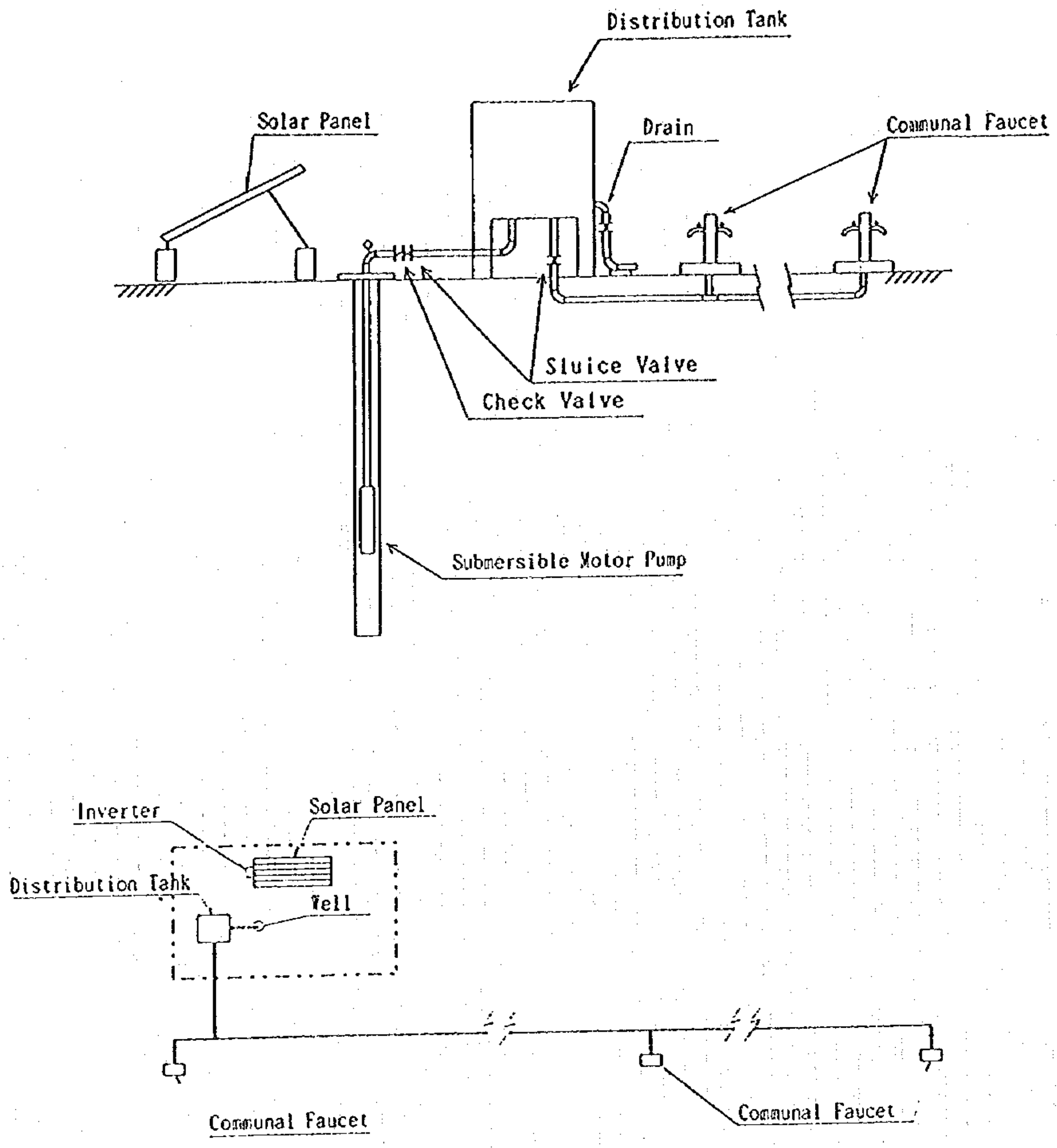


Fig. 10.3 Schematic Drawing of Water Supply System (with Solar Energized Pumping)

11. OPERATION AND MAINTENANCE

11.1 Establishment of Water Associations

Some of the villages in the Study Area have water associations for water source management, but are mostly irrigation related, only a few for domestic water use. All candidate villages should have autonomous water management associations for the purpose of sustainable O/M of the water supply facilities prior to project implementation. Therefore, promotional activities for the organization of the water associations were undertaken by the Joint Study Team with the village inventory surveys. Also, trial water associations were established in the pilot project. Repeated discussions were held with the villagers to formulate water associations in the 6 villages of the pilot project.

The water associations were established in the following manner:

- A meeting was called by the village head.
- The Joint Study Team explained the regulations of the water association and the roles of the executive members (president, secretary, accountant, sanitary coordinator, and mechanics).
- Election of the executive members by the villagers.
- Detailed explanation on the management of the water association to the elected executive members, including book keeping.

11.2 Demarcation of Responsibilities for Operation and Maintenance

The economic aspect of operation and maintenance is one of the critical issues in a rural water supply project. Although motivation and participation of beneficiaries is important, the operation and maintenance of facilities do not function well without proper financial, technical and institutional background of the parties concerned. In this project, there are mainly three parties concerned for the operation and maintenance. They are MEM, local authorities and the water association of the beneficiary villages. In this section, the budgetary and institutional constraints in each party will be examined, thereby formulating the realistic operation and maintenance plan of the project.

As explained in the above, since neither of the above three parties concerned is sufficiently endowed with budgetary and institutional resources, each party must cooperate to share the burden of the operation and maintenance by mobilizing the available resources. It is needless to say that MEM has primary burden of the operation and maintenance. The important point here is that the operation and maintenance should be planned not ideally but more realistically. In this sense, the realistic demarcation of responsibilities for the operation and maintenance are planned as below.

1) MEM

The most realistic demarcation of responsibilities of the Morondava office of MEM are:

a) to manage and control the overall operation and maintenance program.

b) to conduct periodical patrols in villages and check the problems of facilities.

c) to technically support the minor repair of facilities.

d) to repair the medium-sized breakdowns at the cost of villages. (The medium-sized repair includes the replacement of batteries and the repair of hand pumps.)

e) to repair the major breakdowns at its own costs and personnel. (The major repair includes the replacement of pumps and generators and rehabilitation or re-drilling of boreholes.)

f) to plan and conduct the periodical seminars for training on the minor repair of facilities by repair kits and training on the financial management of water associations.

As mentioned before, setting up the Morondava office is a basic condition for the above demarcation of responsibilities for MEM. It is important to plan the annual time table for the periodical patrols and training seminars.

2) Local Authorities

The most realistic demarcation of responsibilities of local authorities are:

a) to assist the communication for villages in case of needs (Departemanta office).

b) to give technical advise to villages (local development committee).

Since the office of Departemanta is the center of the community in rural areas, the office is in a position to assist the communication from villages to the Morondava office of MEM in case of necessity. Each office of Departemanta to which a candidate village belongs will convey the message to the Morondava office through their telephone equipment immediately upon request of villagers. The date and contents of the communication should be recorded.

The office of Departemanta will also convey the message from the Morondava office to villages in such a case as notifying the date for seminars. If a office of Departemanta has no telephone equipment, the office will transmit messages to police stations nearby with wireless communication systems.

When the Morondava office is set up, the MEM representative will be a member of the Morondava local committee. As a result, the representative will make a technical transfer on facilities O/M to other members of the committee so that they will be able to technically advise the villagers when required.

3) Water Association

The most realistic demarcation of responsibilities of the water association of villages are:

a) to manage water associations properly.

b) to collect the operation and maintenance fee regularly and equitably.

c) to operate facilities properly.

d) to repair minor breakdowns of facilities at its own costs and personnel.

e) to report medium-sized breakdowns of facilities to the MEM or JIRAMA, and apply for the immediate repair at their own cost. (The medium-sized repair includes the replacement of batteries, repair of pumps and/or generator, re-development of wells, etc.)

f) to report major breakdown of facilities to the Morondava office of MEM and apply for immediate repair. (The major repair includes the replacement of pumps and generators, and re-drilling of boreholes.)

g) to cooperate with in the seminar conducted by the MEM.

The important point for the operation and maintenance is equity and sustainability of water associations of villages. Equity will be maintained by negative incentives for non-payers. If a household is reluctant to pay for the operation and maintenance fee in spite of its affordability to pay, the use of facilities should be suspended. The association will neutrally decide this suspension after some warning period.

Sustainability of a water association shall be maintained by positive incentives for the members of water associations. The association members should be compensated for the proper amount of wage for its assignment, which is publicly and neutrally decided by the association. However, these monetary incentives are mandatory measures, and the most crucial issue is improvement of people's awareness of the importance of operation and maintenance of facilities.

The total operation and maintenance cost is estimated at FMG 281.7 million (US$70,912) per year, assuming a project life is 30 years, however, cost increase due to inflation is not included in the calculations.

The maintenance cost is divided into two. Firstly, the burden of the project management office comprising: running costs of the office, cost for periodic patrol, and the rehabilitation or redevelopment services of the wells (2 to 4 years per well). And secondly, the burden of the individual water associations formed in the villages where the project was implemented, comprising: running costs of the facilities, and the cost for overhaul and replacement of the pumping and generating equipment.

(1) Operation and Maintenance Cost Covered by MEM

The average annual operation cost mostly borne by the project management office:

Salary and allowances	FMG	12,600,000
Fuel and lubricants for vehicles	FMG	3,280,000
Repair and overhaul of equipment	FMG	8,563,000
Well rehabilitation and vehicle replacement	FMG	16,842,000
Other expenses	FMG	1,200,000
Total	FMG	42,485,000 (US$ 10,696)

It is assumed that there will be one person per position in the project management office.

- Manager	FMG	300,000 / month
- Secretary	FMG	150,000 / month
- Water Supply Facility Technician	FMG	250,000 / month
- Driver	FMG	200,000 / month
- Guard	FMG	150,000 / month
Total	FMG	1,050,000 / month

(2) Operation and Maintenance Cost Covered by Water Association

The annual operation and maintenance costs borne by the water associations differ according to the type of facility.

1) The annual O/M cost for the hand pump type facility for 35 villages totals about FMG 59 million/ year, with an average per village of about FMG 1.69 million/ village/ year. The monthly amount borne by a household ranges from FMG 900 to FMG 2,000/ month/ house.

The monthly O/M cost per village is presented in Table 11.1.

2) The annual O/M cost for the solar powered type facility for 17 villages totals about

FMG 37 million/ year, with an average of about FMG 2.18 million/ village/ year. The monthly amount borne by a household ranges from FMG 400 to FMG 1,500/ month/ house.

The monthly O/M cost per village is presented in Table 11.2.

3) The annual O/M cost for the diesel engine generator facilities for 8 villages totals about FMG 143 million/ year, with an average about FMG 17.89 million/ village/ year. The monthly amount borne by a household ranges from FMG 1,400 to FMG 4,000/ month/ house.

A monthly O/M cost per village is presented in Table 11.3.

Table 11.1 Monthly Operation and Equipment Maintenance Cost for 35 Villages (H/P)

(FMG/month)

No. Village	Population in 1995	Population in 2005	No. of Pump	Salary	Maintenance	Total
3 Antaly	327	430	2	50,000	72,100	122,100
5 Befamonty	450	590	3	50,000	108,200	158,200
7 Nositonga	260	340	2	50,000	72,100	122,100
8 Nosibe	600	790	4	50,000	144,200	194,200
9 Ankoba	410	540	3	50,000	108,200	158,200
10 Antseranandaka N.	342	450	2	50,000	72,100	122,100
15 Miary	365	480	2	50,000	72,100	122,100
16 Ambivy I	130	170	1	50,000	36,100	86,100
17 Ambivy II	500	660	3	50,000	108,200	158,200
18 Ambahia	200	260	2	50,000	72,100	122,100
20 Marolafika Atm.	500	660	3	50,000	108,200	158,200
26 Antevamena	360	470	2	50,000	72,100	122,100
27 Mitsitiky	340	450	2	50,000	72,100	122,100
34 Croise. Besotroka	200	260	2	50,000	72,100	122,100
35 Amanga	400	530	3	50,000	108,200	158,200
36 Namakia	400	530	3	50,000	108,200	158,200
39 Antsamaka	150	200	1	50,000	36,100	86,100
40 Manomentimay	436	570	3	50,000	108,200	158,200
41 Farateny	250	330	2	50,000	72,100	122,100
47 Ambararata	500	660	2	50,000	72,100	122,100
48 Ankevo	300	390	2	50,000	72,100	122,100
53 Androvakely	550	720	4	50,000	144,200	194,200
55 Ampananiha	420	550	3	50,000	108,200	158,200
60 Tandrokosy	238	310	2	50,000	72,100	122,100
66 Croisement BST	204	270	2	50,000	72,100	122,100
68 Betsipotika	120	160	1	50,000	36,100	86,100
70 Ampandra	600	790	4	50,000	144,200	194,200
74 Tsinjorano	450	590	3	50,000	108,200	158,200
76 Laijoby Avaratra	150	200	1	50,000	36,100	86,100
81 Malandirano	400	530	3	50,000	108,200	158,200
82 Marofandiliha	370	490	3	50,000	108,200	158,200
83 Ampataka	695	910	4	50,000	144,200	194,200
99 Ankilimida	600	790	4	50,000	144,200	194,200
101 Benato	500	660	3	50,000	108,200	158,200
102 Anolotsy	300	390	2	50,000	72,100	122,100
Total (35 Villages)			88	1,750,000	3,173,200	4,923,200

(US$ 1,239)

Table 11.2 Monthly Operation and Equipment Maintenance Cost (Solar Type)

(FMG/month)

No. Village	Population in 1995	Population in 2005	Salary	Maintenance	Total
1 Andranopasy I	623	820	100,000	79,400	179,400
23 Marerano	1,100	1,400	100,000	79,400	179,400
25 Befasy	2,000	2,600	100,000	79,400	179,400
31 Beleo	800	1,100	100,000	79,400	179,400
33 Misokotsa	800	1,100	100,000	79,400	179,400
46 Marofihitsa	750	980	100,000	79,400	179,400
52 Antsakamirohaka	1,600	2,100	100,000	79,400	179,400
59 Marovoay	1,247	1,600	100,000	79,400	179,400
89 Ankaraobato	800	1,100	100,000	79,400	179,400
93 Beroboka Atm.	783	1,000	100,000	79,400	179,400
100 Ampanihy	742	970	100,000	79,400	179,400
104 Mandabe	2,000	2,600	100,000	114,100	214,100
107 Ampanotoka	900	1,200	100,000	79,400	179,400
109 Tsianaloka	1,000	1,300	100,000	79,400	179,400
110 Kiboy	930	1,200	100,000	79,400	179,400
112 Tsimafana	1,500	2,000	100,000	79,400	179,400
113 Mananjaky	1,170	1,500	100,000	79,400	179,400
Total	18,745	24,570	1,700,000	1,384,500	3,084,500

(US$ 776)

Table 11.3 Monthly Operation and Equipment Maintenance Cost (E.Generator Type)

(FMG/month)

No. Village	Population in 1995	Population in 2005	Salary	Fuel & Oil	Maintenance	Total
58 Bemanonga	1,250	1,600	100,000	530,600	118,000	748,600
67 Analaiva	1,520	2,000	100,000	530,600	118,000	748,600
94 Ankilivalo	2,960	3,900	100,000	663,300	161,000	924,300
97 Bezezika	855	1,100	100,000	530,600	118,000	748,600
103 Ankilizato	4,200	5,500	100,000	2,547,100	347,000	2,994,100
106 Malaimbandy	7,000	9,200	100,000	3,820,600	347,000	4,267,600
114 Ambatolahy	800	1,100	100,000	530,600	118,000	748,600
115 Ankotrofotsy	908	1,200	100,000	530,600	118,000	748,600
Total	19,493	25,600	800,000	9,684,000	1,445,000	11,929,000

(US$ 3,003)

12 PROJECT EVALUATION

The Project is designed to supply potable water for the villagers in the south-western region of Madagascar, thereby meeting the basic human needs in the rural areas where water shortage is so alarming as to be affected by severe waterborne diseases. The Project was economically evaluated in terms of cost-benefit analysis, was financially evaluated in terms of cost recovery and foreign loan disbursement, and was socially evaluated in terms of social impacts on gender and equity.

12.1 Economical Evaluation

The Project was economically assessed in the context of the national economy. The basic methodology employed in the economic evaluation is the cost-benefit analysis which employs EIRR as a criterion to judge the economic viability. The reduction in waterborne diseases was quantified in the form of monetary value by means of the Disease Impact Analysis (DIA) method which converted the reduction in waterborne diseases into the saved life expectancy. Two cases were set up for the economic evaluation: Case A (all the 80 candidate villages) and Case B (highly prioritized 60 villages).

The result of the economic evaluation shows that although all the EIRR for Case A recorded 1.27% and the EIRR for Case B recorded 1.48%, both are very low. The result implies that the economic viability of the Project is not so high compared with projects of other sectors, adding that a grant aid or soft loans with an extremely high grant element shall be required for the implementation of the Project.

12.2 Financial Evaluation

The Project was financially assessed in terms of the financial viability of the Project from the viewpoint of project entities. The financial viability of the Project was evaluated in terms of two project entities: water associations and the government of Madagascar. The former financial soundness was judged by the cost recovery analysis of water associations, and the latter was gauged by the foreign loan disbursement analysis of the government of Madagascar.

As regards the cost recovery of water associations, in any type of facilities, the water fee collected by the associations will successfully cover the operation and maintenance cost, generating accumulated cash balance sufficient to cover even a small part of the capital cost.

As regards the foreign loan disbursement of the government of Madagascar, even in the case where the concessionality level is low with a high grant element, the maximum payment of both interest payment and amortization occupy a small part of the recurrent budget of the government of Madagascar.

In summary, it could be safely argued that both the cost recovery of the water associations and the foreign loan disbursement of the government of Madagascar verify the financial soundness of the Project.

12.3 Social Evaluation

The Project was socially assessed in terms of the distribution of benefits among various social groups. It is often the case that who will be benefited or the distribution of benefits among various social groups has been neglected. Therefore, the Project was evaluated from the viewpoints of gender and equity, two major groupings of the society.

In connection with the social impact on women, as the implementation of the Project will make the beneficiary villages be conveniently located for fetching water, a great deal of women's time for fetching water will be saved.

In connection with the social impact on equity, the Project, which shall benefit the region where the mortality rate by waterborne diseases are worse off than any other region, will mitigate inequitable distribution of health resources among regions, thereby giving favourable social impacts on the regional socio-economic situation.

In addition to the favourable social impacts on gender and equity, the Project will accrue other unquantifiable social impacts such as the creation of community development, enhancement of health and sanitary conditions, and strengthening of the relation between the governmental officials and the people.

12.4 Overall Project Evaluation

Although the economic viability of the Project is not so high compared with the opportunity cost of capital in Madagascar, it is suggested that the Project be urgently implemented by mobilizing the financial sources such as a grant aid or a soft loan with the relatively high grant element, taking into consideration the fact that:

1) the Project is financially sound in terms of both the cost recovery of the water associations and the foreign loan disbursement of the Malagasy government, and

2) the Project will have favourable social impacts on gender and equity together with other social benefits.

13. CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusions

Listed below are the major conclusions derived from the results of the Study.

(1) Evaluation for the Phase I Project

The daily operation of the water supply facilities appeared to be generally good, except for a few villages in the Phase I Project area. This was evident by the comparatively high collection rate of operation fees and the supply of good quality water to the beneficiaries under the management of the water associations formed in each of the concerned villages.

However, none of the motorized supply systems were operating properly so far as the supply amount is concerned. The average daily supply amount per person ranges from only 2 to 10 liters a day, regardless of the fact that the facilities are capable of providing each person with the recommended 20 liters a day.

This fact is explained by economization of operational expenses; this frame of mind has probably originated from the following two factors :

- The villagers have long been accustomed to use water free of charge, so therefore a sense of willingness to pay for the water supply services has not been established in this area.
- Not enough effort has been put into the campaign and education on the use of safe domestic water by the authorities concerned. In particular, periodical patrols by the most responsible body, the MEM Regional Office, has been outstandingly poor.

(2) Socio-Economic Conditions

Shortages of safe water for domestic use are severe in most of the candidate villages, resulting in high incidence of waterborne diseases and also in the prevention of the social and economic development activities.

The populations of the candidate villages is much smaller than those in the Phase I area. Of 81 villages surveyed, the number of the villages with a population (1995) over 1,000 was 13, and the average population of the remaining 68 villages was 390. A comparison of the 50 villages by population with the Phase I area villages (1990, before project implementation) is given below:

Population scale	Number of Villages	
	Phase II area (1995)	Phase I area (1990)
Over 3000	2	6
1000~2999	11	26
500~999	21	15
under 500	16	3

Since the main economic activities are limited to self-sufficient small-scale agriculture and stock farming in most of the candidate villages in the Phase II Study Area, the average household income is lower than in the Phase I area, and consequently, the affordability to pay for the water supply services is lower than that in the Phase I area.

(3) Groundwater Development Potential of the Study Area

The Groundwater Development Potential in this Study Area is generally high. The area is composed of 11 sub-areas : 3 coastal plains and 8 river basins, of which the daily groundwater development potential per square kilometer for 8 sub-areas is given below. Even in the smallest potential sub-area (Maharibo river basin) is of sufficient level for groundwater use of domestic water supply.

Sub Areas	Area (km^2)	Development Potential of the area (m^3/day)	Daily D/P per 1 km^2 (m^3/day km^2)
Morondava Plain	6,006	5,689,932	947
Andranomena River Basin	882	499,151	566
Morondava River Basin (1)	677	170,983	253
(2)	3,885	850,229	219
Sakeny River Basin	2,183	443,808	203
Maharivo River Basin (1)	602	106,085	176
(2)	2,299	411,565	179
Kirindy River Basin	1,050	301,927	288
Maintapaka River Basin (1)	397	123,884	312
(2)	364	102,487	282
Mangoky River Basin (1)	1,301	490,816	377
(2)	3,173	1,347,004	424

For the other 3 sub-areas: Tsiribihina River basin, Tsiribihina delta and Mangoky delta, the development potential per unit area (1 km^2) has not been estimated by means of a macroscopic water balance analysis. It is assumed, however, that these sub-areas also have a high potential. The deltas are underlain by a vast thick clay bed overlying sandy layers of a confined aquifer.

(4) Existence of poor quality groundwater

In many places within the delta and coastal plains, aquifers of saline water are interbedded with fresh water aquifers. In such places the wells should be carefully constructed with the well screens properly positioned at the fresh water aquifer. It is estimated approximately half of the boreholes will encounter saline water aquifers, of which around 50% may be dealt with by sealing of saline portion, while the others will require additional drilling, resulting that approximate 25% extra drilling within the deltas and coastal plains should be considered at the time of the well construction planning.

At the places where dykes are present, the groundwater may not be potable due to the high content of dissolved matters related with hot springs. The drilling point, especially for deep well construction, should be kept away from dykes or related fault lines.

(5) Groundwater development plan and water supply facilities plan

For all of the 81 surveyed villages, a groundwater development plan was established to supply 20 liters daily to each of the projected population in 2005, by construction of the appropriate number of borehole well in the concerned villages.
Three types of water supply facilities have been planned in accordance with the socio-economic categorization of the candidate villages, especially in due consideration of easy and low cost operation and maintenance :

a. Borehole wells equipped with a hand pump, one well supplying 210 persons, therefore, the necessary number of wells per village is the quotient of the projected village population divided by 210.
[For the 55 villages where the population is about 800 or smaller.]

b. Single borehole well equipped with submersible motor pump, and the distribution system composed of a distribution tank, distribution pipeline and communal faucets. One faucet is to supply not more than 400 people, therefore, the necessary number of faucets is the quotient of population divided by 400. The energy for the motor pumps is to come from photovoltaic solar panels. The number of panel varies depending on pump head and the volume of water to be pumped up.

[For the 17 villages with populations over 800 and not exceeding 2000.]

c. Same source and similar distribution system as b.), but, the electrical power is derived from a diesel engine generator.
   [This type of system is for the 8 villages located along or close to national routes 34 and 35, where access to fuel supply is possible even in the rainy season.]

(6) Operation and Maintenance

Basically, operation and maintenance of the water supply facilities should be undertaken autonomously by the project beneficiaries, that is, by water associations in the concerned villages.

However, since it is natural that there is a limitation in both financial and technical aspects for autonomous management in the rural areas, a large amount of assistance and guidance from the concerned authorities is necessary, especially from the project implementing body and the local authorities.

The demarcation of responsibility for operation and maintenance is as follows:

- Water associations are responsible for the daily operation of the facilities and repairing minor troubles with their own funds, the regularly collected O/M fee.
- MEM, as the implementing body of the project, is responsible for the management and control of the overall O/M program by conducting periodical patrols. The establishment of a branch office in Morondava is essential in order to fulfill this responsibility. MEM is also responsible for the heavy repair works, replacement of pumping and power generating equipment, and rehabilitation or re-drilling of the borehole wells with their own funds and manpower, or seeking the technical assistance from JIRAMA.
- Decentralized administrative units, especially Departemantas, are responsible for providing assistance with communication between the villages and MEM. Local committees like the Morondava Development Committee are responsible for giving technical and institutional guidance to the concerned villages.

(7) Project Cost

Covering the 81 surveyed villages, the facility construction cost, including the management office setting up cost, administrative and engineering costs and contingencies, totals approximately US$ 9.43 million.

For the 60 prioritized villages, which are categorized as AA, AB, BA and BB, the construction cost of those items listed above totals approximately US$ 8.5 million.

(Foreign portion : US$ 5.82 million, Local portion : FMG 10,908 million)

The annual operation and maintenance cost covering the 60 prioritized villages comprises the following 3 factors, totaling approximately 72,435 US Dollars.

a) Average annual running cost of the project management office (assumed Morondava branch office of MEM) : US$ 10,696

b) Average annual maintenance cost for the wells : US$ 1,523

c) Annual operation and maintenance cost, excluding the maintenance of the wells, totals US$ 60,216 with the following breakdown :

	Range		Total	Average
	Min.	Max.		
Hand pump well for 35 villages	260	587	14,868	425
Solar powered supply system for 17 villages	541	646	9,312	547
Diesel engine powered supply system for 8 villages	2,262	12,893	36,036	4,504
Total			77,352	

(8) Project evaluation

The Project was economically assessed in the context of national economy. The reduction in waterborne diseases was quantified in the form of monetary value by means of the Disease Impact Analysis (DIA) method which converted the reduction in waterborne diseases into the saved life expectancy.

The result of the economic evaluation shows that although all the EIRR recorded 1.48%, implying that the economic viability of the Project is not so high compared with projects of other sectors, adding that a grant aid or soft loans with an extremely high grant element shall be required for the implementation of the Project.

The Project was financially assessed from the viewpoint of project entities. The financial viability of the Project was evaluated in terms of two project entities: water associations and the government of Madagascar judged by the foreign loan disbursement analysis.

For the recovery of water associations, in any type of facilities, the water fee collected by the associations will successfully cover the operation and maintenance cost, generating accumulated cash balance sufficient to cover even a small part of the capital cost. And, for the foreign loan disbursement of the government of Madagascar, even in the case where the concessionality level is low with the low grant element, the maximum payment of both interest payment and amortization occupy a small part of the recurrent budget of the government of Madagascar.

In summary, it could be safely argued that both the cost recovery of the water associations and the foreign loan disbursement of the government of Madagascar verify the financial soundness of the Project.

The Project was socially assessed in terms of the distribution of benefits among various social groups. The Project was evaluated from the viewpoints of gender and equity, two major groupings of the society.

As the implementation of the Project will make the beneficiary villages be conveniently located for fetching water, a great deal of women's time for fetching water will be saved. The Project, which shall benefit the region where the mortality rate by waterborne diseases are worse off than any other region, will mitigate inequitable distribution of health resources among regions, thereby giving favourable social impacts on the regional socio-economic situation.

Although the economic viability of the Project is not so high compared with the opportunity cost of capital in Madagascar, the following has been concluded:

1) the Project is financially sound in terms of both the cost recovery of the water associations and the foreign loan disbursement of the government of Madagascar, and

2) the Project will have favourable social impacts on gender and equity together with other social benefits.

13.2 Recommendations

(1) Project implementation

Although the economic internal rates of return of the Project are quite low, there is no doubt that the critical shortage of potable water in the villages of the south-western region requires a swift solution, also there is no question that the social benefits from the project would be great, especially in the 60 prioritized villages.

Therefore, in consideration of the social benefits and associated favorable effects, the immediate implementation of the Project is highly recommended, provided that a soft loan or a grant can be obtained.

(2) Operation and maintenance

Many of the candidate villages in the Study Area have in the past, been involved in rural water supply projects, but the periods which these supply facilities remained functioning were generally very short ranging from 2 to 4 years. After the supply facilities broke down people were obliged to return to primitive water collection practices, due mainly to the poor operation and maintenance methodology. In addition, many of the candidate villages have never benefited from water supply services, therefore, it is difficult to establish a good sense of operation and maintenance in a short period.

As seen in the Phase I Project area, some of the benefited villages have preferred economizing running costs rather than providing adequate supplies of safe water through out the year, thus reducing the effectiveness of the project. Since there is a limitation in the autonomous management at each of the villages caused by the long established tradition of not paying for water, great assistance and guidance from the concerned authorities should be extended to the villages. Thus, it is highly recommended that MEM, not only as the implementing body of the Project but also as the body responsible for the management of the Project, should strengthen the maintenance system by opening a management office at Morondava as a branch office to the Toliara Regional Office.

It is believed that the Project will not be effective without conducting the patient enlightenment and encouragement of the villagers on the use of supplied water through periodic patrol. It is also recommended that MEM acts as the coordinating body in the Morondava area for involving the decentralized administrations and JIRAMA in maintenance related matters. Because, even if MEM opens the branch office in Morondava, patrol services or countermeasures against any troubles in the villages located to the south of the Kabatomana River would become somewhat difficult during the rainy season.