(5) Class C aquifer zone

In the Class C aquifer zone, local and discontinuous aquifer exists at less than 20 m in depth, including Herzberg's lens aquifer in the coastal area. Therefore, for groundwater development in Class C aquifer zone, it is recommended to dig protected shallow wells with a depth of 5-15 m.

9.1.2 Standard Drilling Method and Well Design

(1) Standard drilling method

The two drilling methods which were used in this study consisted of mud drilling and air hammer drilling.
Judging from the results of test drillings, in the area which is mainly composed of limestone or basaltic rocks, the air hammer drilling method is strongly recommended because of the speed of drilling works and to avoid troubles of frequently lost circulations.
On the other hand, in the areas consisting of sandstone, such as neritic sediments of the Middle to Upper Eocene, neritic or submarine sediments of the Lower to Upper Cretaceous and continental or neritic sediments of the Lower to Middle Jurassic, the mud drilling method is principally recommended.

(2) Standard tubewell design

The standard design of the hand pumped well and the motor pumped well are shown in Fig. 19 and Fig. 20, based on the results of test drilling conducted in this study.

a) Target depth and diameter of wells

The target depth of 6" diameter wells is 30-250 m and that of 4" diameter wells is 40-100m. This well drilling plan was made mainly on the basis of hydrogeological conditions obtained from the results of test drilling and electrical prospecting, as well as the population in each candidate site.

b) Logging

In order to identify the aquifer and decide on the screen position and length, spontaneous logging, resistivity and natural gamma ray logging is carried out after the drilling.
During drilling, in particular in the case of mud drilling, drill cuttings must be carefully observed for a complete geologic log.
In the area which is composed of limestone or basaltic rocks, geophysical logging alone is generally ineffective in detecting aquifers and aquifuges. The air hammer drilling method is, therefore, recommended not only to avoid troubles of frequently lost circulations, but also to speed up drilling works and to decide on the accurate screen position and length.

c) Casing

FRP (Fiberglass Reinforced Plastic) pipe is recommended for well casing in both 4" and 6" diameter boreholes, mainly because of water quality.

d) Screen

FRP pipe is also recommended for well screen in both 4" and 6" diameter boreholes, with a 5% ratio of openings and a slot size of 1.0 mm (horizontal slot screen). Based on test drilling experience, screen positions are set at multiple layers, and total screen length is principally designed as follows.

Borehole depth (m)	Screen length (m)
30	16
40 - 50	20
60 - 100	24 - 32
110 - 250	32 - 40

e) Gravel packing

It is not always necessary to carry out a sieve analysis for the selection of packing gravel.
Around the screen, gravel of a grain size of 2-3 mm is empirically used as filter.

f) Well completion

In the completion of a filter-packed well, except for the screen area, the annulus of the well between the borehole wall and casing is backfilled with drill cuttings. Moreover, in the top 5 m from the surface of the ground, cement grout is placed for prevention of contamination.

(3) Protected dug well

Protected dug wells are proposed as a self-help construction scheme by the communities. These protected dug wells can be excavated by hand by villagers using picks and shovel. The well is permanently lined with a curb consisting of brick or rock. The curb should be perforated or contain openings for entry of water, and must be firmly seated at the bottom. Dug wells must be deep enough to be several ten centimeters below the water table. Ground should be backfilled around the curb lining and the bottom of the well to control sand entry and possible cave in. All materials and manpower required for the dug well construction would be contributed by villagers.

Table 9.1.1 General development scale of the groundwater in the Class B_1 & B_2 aquifer zone

Class	District	Aquifer	Expected P/Discharge per a borehole	Target depth & diameter of borehole	
				Depth	Diameter
			l/min	m	mm
B_1	Sikily River basin	Neritic or submarine sediments of the Lower to Upper Cretaceous with basaltic rocks.	80-120	100	150
B_1	Sakanavaka River basin	Neritic & continental sediments of the Middle Jurassic.	80-120	100	150
B_1	Menamaty River basin	Continental deposits of the Lower Jurassic with Schistose sandstone.	50-100	100	150
B_2	Ambahikily of Mangoky River side	Neritic Sediments of the Middle to Upper Eocene.	80-150	200	150
B_2	Central part of Fiherenana River basin	Neritic or submarine sediments of the Lower to Upper Cretaceous with basaltic rocks.	80-120	150-200	150
B_2	Rezoky and Mangitraky River basins	Neritic & continental sediments of the Middle Jurassic.	80-120	150-200	150
B_2	Berenty-Betsileo of Isahena River basin	Neritic & continental sediments of the Lower Jurassic.	50-100	150-200	150

Table 9.1.2 Groundwater Development Plan by Village (1)

No	Village Name	Population in 1 990	Priority	Groundwater Development Plan Target D/Depth of Well			Expected P/discharge	Estimated Water Level S.W.L	D.W.L
							l/min	GL-m	GL-m
8	Mangolovolo	1,500	Aa	1 Borehole with M/Pump	30.0 m	φ6″	350	5.00 m	10.00 m
22	Manoy	540	Aa	1 Borehole with H/Pump (1 D/Borehole with H/Pump	40.0 m 42.0 m	φ4″ φ4″)	20 (20)	8.50 m (8.37 m)	9.50 m (9.00 m)
46	Berenty-Betsileo	2,340	Aa	1 Borehole with M/Pump	30.0 m	φ6″	500	3.00 m	10.00 m
49	Tanandava-Antaifasy	2,010	Aa	1 Borehole with M/Pump	100.0 m	φ6″	200	15.00 m	25.00 m
52	Soahazo	2,837	Aa	(1 D/Borehole + M/Pump	76.0 m	φ4″)	(290)	(36.70 m)	(38.60 m)
53	Analamisampy	756	Aa	1 Borehole with H/Pump (1 D/Borehole with M/Pump	70.0 m 71.0 m	φ4″ φ4″)	20 (20)	13.50 m (13.11 m)	18.90 m (18.60 m)
54	Belitsaka	1,315	Aa	(1 D/Borehole + M/Pump	66.0 m	φ4″)	(270)	(12.78 m)	(33.00 m)
55	Ampasikibo	2,000	Aa	(1 D/Borehole + M/Pump	50.0 m	φ4″)	(280)	(9.16 m)	(15.12 m)
56	Namaboha	1,505	Aa	(1 D/Borehole + M/Pump	83.0 m	φ4″)	(260)	(16.50 m)	(34.00 m)
63	Manombo-Atm	4,638	Aa	(1 D/Borehole + M/Pump	27.0 m	φ6″)	(420)	(4.53 m)	(5.53 m)
68	Benetsy	2,000	Aa	(1 D/Borehole + M/Pump	72.0 m	φ6″)	(300)	(13.51 m)	(17.30 m)
77	Andranovory	1,524	Aa	1 Borehole with M/Pump	150.0 m	φ6″	110	115.00 m	125.00 m
92	Mahaboboka	2,000	Aa	1 Borehole with M/Pump	30.0 m	φ6″		5.00 m	10.00 m
101	Ankilimalinika	3,845	Aa	(1 D/Borehole + M/Pump	66.0 m	φ4″)	(300)	(14.35 m)	(17.70 m)
a	Befandriana	3,000	Aa	(1 D/Borehole with M/Pump	53.0 m	φ6″)	(300)	(12.30 m)	(13.28 m)
b	Betsioky Nord	2,000	Aa	1 Borehole with M/Pump	150.0 m	φ6″	200	60.00 m	80.00 m
c	Andranohinaly	1,800	Aa	1 Borehole with M/Pump	250.0 m	φ6″	250	207.00 m	220.00 m
d	Sakaraha	3,935	Aa	1 Borehole with M/Pump (1 E/Borehole + M/Pump	100.0 m 30.8 m	φ6″ φ6″)	300 (144)	12.00 m (10.66 m)	20.00 m (21.60 m)
e	Ankazoabo	3,000	Aa	1 Borehole with M/Pump	100.0 m	φ6″	150	27.50 m	38.00 m
11	Andranomanintsy	1,400	Ab	1 Borehole with M/Pump	200.0 m	φ6″	350	30.00 m	40.00 m
14	Antsakoabe	800	Ab	1 Borehole with M/Pump	200.0 m	φ6″	350	30.00 m	40.00 m
25	Sihanaka	700	Ab	1 Borehole with H/Pump (1 D/Borehole with H/Pump	40.0 m 41.0 m	φ4″ φ4″)	20 (20)	6.00 m (5.74 m)	6.50 m (5.86 m)
29	Mangotroka	600	Ab	1 Borehole with H/Pump (1 D/Borehole with H/Pump	40.0 m 41.0 m	φ4″ φ4″)	20 (20)	3.60 m (3.57 m)	3.80 m (3.70 m)
34	Tandrano	3,500	Ab	(1 D/Borehole + M/Pump	150.0 m	φ6″)	(300)	(25.56 m)	(32.76 m)
35	Ampandramitsetaky	800	Ab	1 Borehole with M/Pump	150.0 m	φ6″	300	25.00 m	33.00 m
47	Ankilivalokely	1,230	Ab	1 Borehole with M/Pump	200.0 m	φ6″	200	20.00 m	40.00 m
58	Ankatrakatra	460	Ab	1 Borehole with H/Pump	70.0 m	φ4″	20	10.00 m	15.00 m
61	Beroroha	2,270	Ab	1 Borehole with M/Pump	50.0 m	φ4″	200	15.00 m	25.00 m
78	Befoly	864	Ab	1 Borehole with M/Pump	250.0 m	φ6″	200	178.56 m	185.00 m

Table 9.1.2 Groundwater Development Plan by Village (2)

No	Village Name	Population in 1 990	Priority	Groundwater Development Plan			
				Target D/Depth of Well	Expected P/discharge	Estimated S.W.L	Water Level D.W.L
					l/min	GL-m	GL-m
83	Andranolava	1,500	Ab	1 Borehole with M/Pump 100.0 m φ4″	250	20.00 m	27.00 m
96	Analamary	1,000	Ab	(1 D/Borehole + M/Pump 204.0 m φ6″)	(360)	(35.00 m)	(43.62 m)
40	Tanandava	400	Ba	1 Borehole with H/Pump 100.0 m φ6″	20	20.00 m	25.00 m
59	Ampihamy	1,468	Ba	(1 D/Borehole + M/Pump 53.0 m φ4″)	(300)	(8.30 m)	(15.33 m)
60	Ambondro	1,000	Ba	1 Borehole with M/Pump 50.0 m φ4″	200	10.00 m	15.00 m
65	Ankaraobato	1,850	Ba	(1 D/Borehole + M/Pump 75.0 m φ4″)	(350)	(3.40 m)	(6.40 m)
5	Ambalamoa	1,000	Bb	1 Borehole with M/Pump 150.0 m φ6″	150	20.00 m	30.00 m
6	Tsianihy	1,389	Bb	1 Borehole with M/Pump 150.0 m φ6″	150	20.00 m	30.00 m
7	Namatoa	750	Bb	1 Borehole with M/Pump 150.0 m φ6″	150	20.00 m	30.00 m
16	Ambiky	1,360	Bb	1 Borehole with M/Pump 200.0 m φ6″	100	25.00 m	35.00 m
				1 Borehole with H/Pump 50.0 m φ4″	20	5.50 m	6.20 m
23	Ampoza	700	Bb	(1 D/Borehole with H/Pump 50.0 m φ4″)	(20)	(5.25 m)	(5.98 m)
57	Antseva	800	Bb	2 Boreholes with H/Pump 140.0 m φ4″	40	15.00 m	20.00 m
62	Antsomarify	1,200	Bb	1 Borehole with M/Pump 50.0 m φ4″	200	15.00 m	20.00 m
				1 Borehole with H/Pump 45.0 m φ4″	20	25.50 m	26.00 m
67	Tsefanoka	880	Bb	(1 D/Borehole + H/Pump 45.0 m φ4″)	(20)	(24.30 m)	(25.00 m)
81	Manoroka	1,000	Bb	(1 D/Borehole + M/Pump 58.0 m φ4″)	(300)	(5.25 m)	(5.25 m)
86	Besakoa(2)	1,200	Bb	1 Borehole with M/Pump 100.0 m φ4″	250	20.00 m	26.00 m
				1 Borehole with H/Pump 70.0 m φ4″	20	16.50 m	17.00 m
88	Maninday	700	Bb	(1 D/Borehole + H/Pump 73.5 m φ6″)	(20)	(16.37 m)	(16.90 m)
90	Tanambao	800	Bb	3 Dugwells 10m×3	30	8.00 m	9.00 m
94	Andamasiny-Vineta	550	Bb	1 Borehole with M/Pump 150.0 m φ6″	100	20.00 m	30.00 m
98	Bereketa	500	Bb	1 Borehole with M/Pump 50.0 m φ4″	250	5.00 m	10.00 m
99	Ankilimitraloka	800	Bb	3 Dugwells 10m×3	30	8.00 m	9.00 m
13	Tanandava	620	Ca	1 Borehole with M/Pump 200.0 m φ6″	350	15.00 m	20.00 m
15	Talatavalo	642	Ca	1 Borehole with M/Pump 200.0 m φ6″	100	15.00 m	25.00 m
21	Antranosatra	570	Ca	1 Borehole with M/Pump 200.0 m φ6″	100	15.00 m	25.00 m
33	Andranomanintsy	780	Ca	1 Borehole with M/Pump 150.0 m φ6″	300	15.00 m	25.00 m
41	Ampoza	320	Ca	1 Borehole with H/Pump 150.0 m φ6″	20	35.00 m	40.00 m
42	Ipetsa Atm	120	Ca	1 Borehole with H/Pump 150.0 m φ6″	20	35.00 m	40.00 m
64	Antandroka	700	Ca	1 Borehole with H/Pump 50.0 m φ4″	20	15.00 m	20.00 m
69	Andrevo	2,200	Ca	5 Dugwells 10m×5	50	8.00 m	9.00 m
79	Ankororoka	100	Ca	1 Borehole with M/Pump 250.0 m φ6″	200	210.00 m	215.00 m
82	Iaborana	240	Ca	1 Borehole with M/Pump 200.0 m φ6″	200	70.00 m	80.00 m

Table 9.1.2 Groundwater Development Plan by Village (3)

No	Village Name	Population in 1 990	Priority	Groundwater Development Plan			
				Target D/Depth of Well	Expected P/discharge	Estimated S.W.L	Water Level D.W.L
					l/min	GL-m	GL-m
84	Lambomakandro	200	Ca	1 Borehole with H/Pump 100.0 m φ4″	20	15.00 m	20.00 m
91	Ambahimalitsy	800	Ca	3 Dugwells 10m×3	30	8.00 m	9.00 m
30	Nosy-Ambositra	1,000	Cb	1 Borehole with M/Pump 50.0 m φ4″	300	10.00 m	15.00 m
31	Tsiarimpioke	800	Cb	1 Borehole with M/Pump 50.0 m φ4″	300	10.00 m	15.00 m
71	Ampihalia	1,000	Cb	1 Borehole with M/Pump 50.0 m φ4″	300	10.00 m	15.00 m
72	Behompy	1,000	Cb	1 Borehole with M/Pump 50.0 m φ4″	300	10.00 m	15.00 m
73	Ambolonkira	450	Cb	1 Borehole with H/Pump 50.0 m φ4″	20	10.00 m	15.00 m
100	Ankilivalo	2,000	Cb	1 Borehole with M/Pump 100.0 m φ4″	250	15.00 m	20.00 m
1	Ankazomanga	600	D	2 Dugwells 7m×2	20	5.00 m	6.00 m
2	Beadabo	600	D	2 Dugwells 7m×2	20	5.00 m	6.00 m
3	befasy	600	D	2 Dugwells 7m×2	20	5.00 m	6.00 m
4	Ankilifolo(1)	400	D	1 Dugwell 7m×1	10	5.00 m	6.00 m
9	Ankida	15	D	1 Borehole with H/Pump 30.0 m φ6″	20	5.00 m	10.00 m
12	Berantala	506	D	1 Borehole with M/Pump 200.0 m φ6″	350	30.00 m	40.00 m
17	Marovato	375	D	1 Borehole with H/Pump 200.0 m φ6″	20	30.00 m	35.00 m
18	Andranoboka	600	D	1 Borehole with M/Pump 200.0 m φ6″	100	30.00 m	40.00 m
24	Ankilifolo(2)	450	D	1 Borehole with H/Pump 50.0 m φ4″	20	15.00 m	20.00 m
27	Basibasy	1,000	D				
36	Andranomafana	600	D	1 Borehole with M/Pump 100.0 m φ6″	120	15.00 m	25.00 m
37	Mamakiala	300	D	1 Borehole with H/Pump 100.0 m φ6″	20	15.00 m	20.00 m
38	Berenty-Ankilimasy	108	D	1 Borehole with H/Pump 100.0 m φ6″	20	15.00 m	20.00 m
39	Betsinefo	34	D	1 Borehole with H/Pump 100.0 m φ6″	20	15.00 m	20.00 m
43	Mandabe Atm	100	D	1 Dugwell 7m×1	10	5.00 m	6.00 m
44	Soatanimbary	70	D	1 Dugwell 7m×1	10	5.00 m	6.00 m
45	Sahanory Atn	200	D	1 Dugwell 7m×1	10	5.00 m	6.00 m
66	Andoharano	300	D	1 Borehole with H/Pump 50.0 m φ4″	20	10.00 m	15.00 m
70	Anjamala	150	D	1 Borehole with H/Pump 50.0 m φ4″	20	10.00 m	15.00 m
74	miary	2,000	D	1 Borehole with M/Pump 50.0 m φ4″	300	8.00 m	12.00 m
75	Befanamy	700	D	1 Borehole with H/Pump 50.0 m φ4″	20	8.00 m	12.00 m
76	Tsivonoabe	30	D	1 Dugwell 7m×1	10	5.00 m	6.00 m
80	Ambohimahavelona	2,000	D	Spring water	3,000		
89	Bevoalavo	240	D	1 Dugwell 10m×1	10	8.00 m	9.00 m
93	Mahasoa	30	D	1 Borehole with H/Pump 150.0 m φ4″	20	20.00 m	25.00 m
97	Antanimora	300	D	1 Borehole with H/Pump 150.0 m φ6″	20	30.00 m	35.00 m

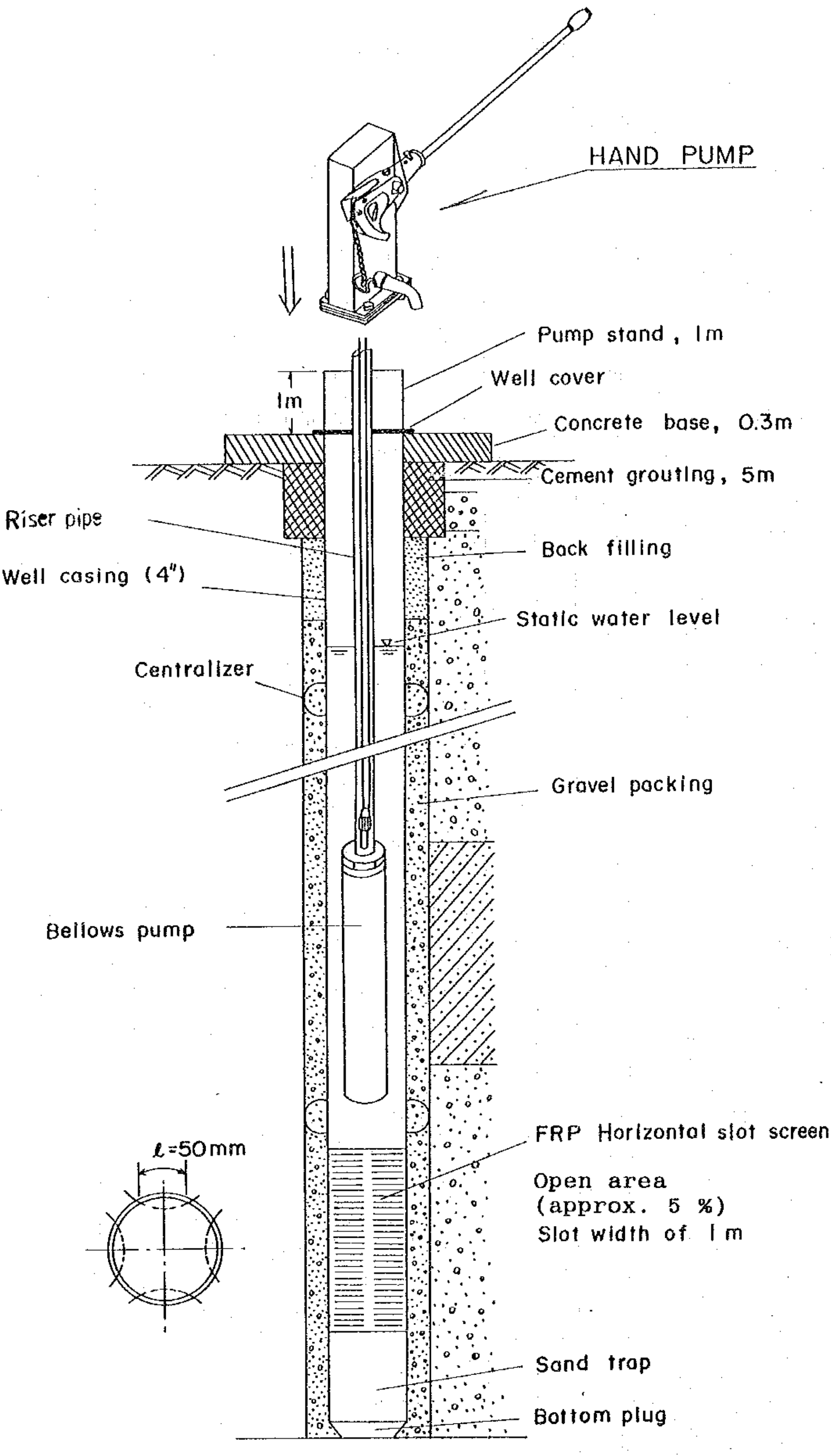


Fig. 9.1.1 Standard Well Design for Hand-pumped Well

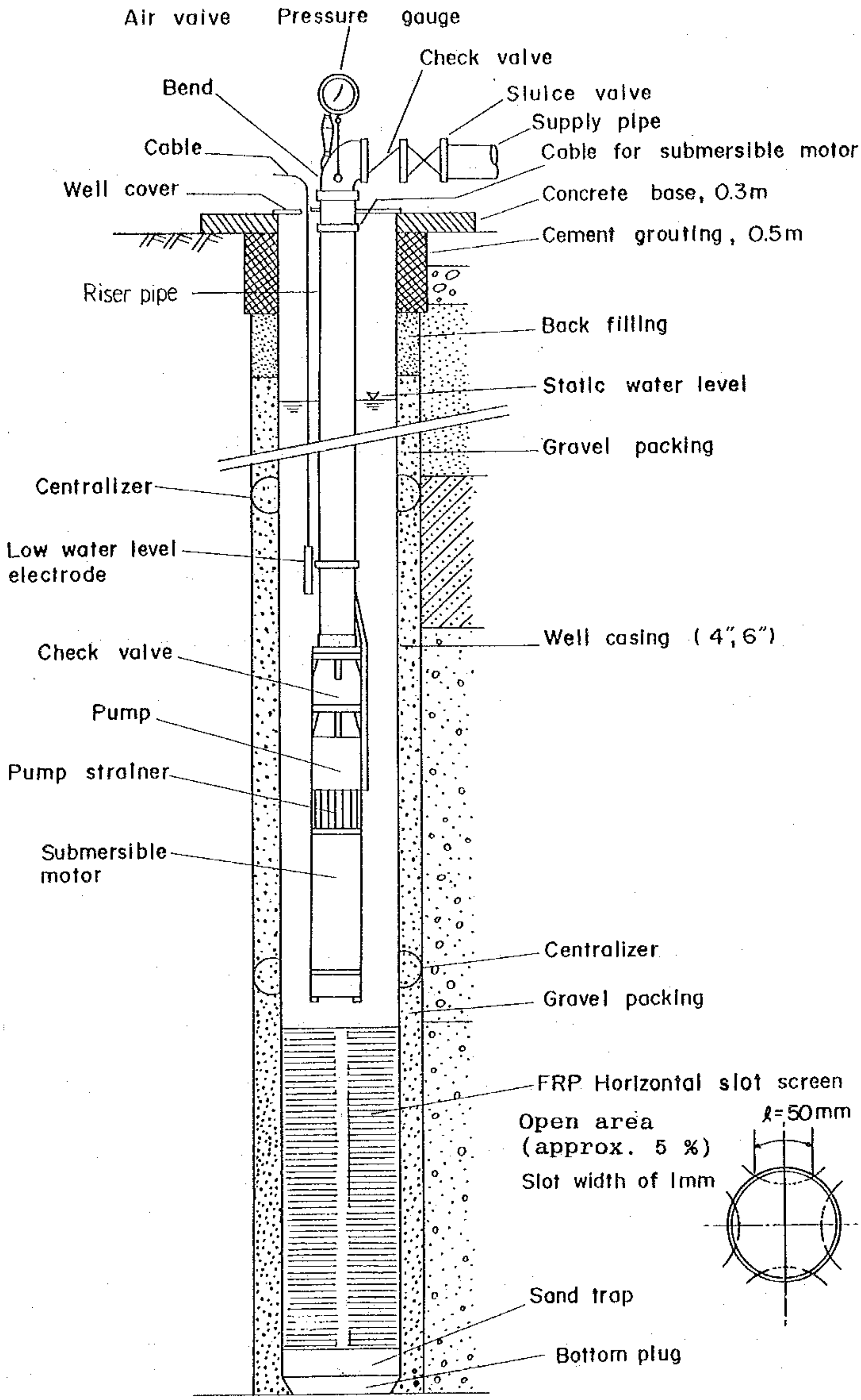


Fig. 9.1.2 Standard Well Design for Motor-pumped Well

9.2 Water Supply Plan

9.2.1 Objective

The main objective of the Project is to provide a safe water supply to satisfy domestic and cattle watering needs in the proposed 94-communities up to the year 2000, when the total population in the communities is projected to be 154,000.

At present, population in the communities faces a serious shortage of safe water and is forced to rely on questionable sources of water such as rivers, irrigation canals and dug wells (unprotected) which are possibly contaminated with germs and parasites.

The Project aim is to develop safe water supply sources in the communities, placing particular emphasis upon deep groundwater development which has not yet been carried out in the area. The Project is designed to be a workable and sustainable system technically and institutionally.

9.2.2 Approach to Planning

The approach adopted in formulating the Project is as follows.

(1) Selection of deep groundwater as a safe water source

In most cases, rural inhabitants in the Study Area have several traditional surface water sources in the neighborhood of their dwellings. The water available from the sources, however, is not necessarily safe for domestic use mainly due to probable bacteriological contamination.
Until recently, water resource development efforts for rural population in Toliara Province, which have been sporadic and limited, have been focused on the utilization of shallow groundwater (less than 10 meters in depth). In fact, wherever shallow groundwater is available, a well with or without a hand pump to draw water may be a reasonably safe water source, particularly for a small rural community of less than several hundred people. However, shallow groundwater is not commonly available in the area and, in a large community, it hardly satisfies the water

demand. Therefore, in the Project, a priority has been given on the development of deep groundwater, which is of better quality and comparatively plentiful in the area.

(2) Maximum convenience for users

Most rural people in the area are used to drawing water from nearby traditional water sources. In some cases, they do not choose a safe water source if it is located at a relatively far away place, persisting in using the nearest water source even if it is probably contaminated. Hard labour to operate a handpump sometimes makes users prefer the easily accessible traditional water source even if it is of lower quality.

In a rural water supply project, it is justifiable to employ plain and simple system as much as possible, in order to minimize capital investment and operation/maintenance costs, on consideration of the low income level and lack of trained technicians in the rural society.
However, if inconvenience to users is overlooked in the planning, a newly installed water supply facility may be ignored by community residents, turning the investment into a complete waste.
Due consideration should be given to least cost and maximum convenience to users in order to achieve a successful design of the system.

(3) Alternative plan

Though the choice range for a rural water supply project in the Study Area is relatively restricted depending on availability of water resources and community potential and capacity, there are still a few important alternative considerations worthy to be examined in the planning stage.

1) The package of candidate villages proposed for the Study is not necessarily the best selection in view of community population and potential.
In fact, some of the candidate villages do not even have the minimum population to justify provision of a new water supply system, while a considerable number of communities excluded from the Study have population and water demand exceeding the average among the candidate

villages. In the priority ranking assigned to the candidate villages by the Study, relatively low priority villages are classified into groups "C" and "D". An alternative program, replacing them with other urgent-water-demanding villages, though they are not included in the original village list, should be examined prior to the implementation of the water supply plan in villages in the "C" and "D" groups.
In such a case, it is strongly advisable that a properly designed systematic screening (field surveys) be performed in village-identification stage to save useless and time-consuming efforts in the succeeding studies.

2) The choice of equipment for lifting water, handpumps or motorized pumps, depends on a practical judgement. There is a well known principle that keeps technology in the rural water supply plan as simple as possible, so that local residents will be able to operate and maintain the system for a long time with a minimum of expenses.
In light of the principle, a handpump will have priority over a motorized pump.

However, use of handpumps is technically restricted to places with high water table and small water demand. Unfortunately, in most cases, these two conditions are not found together in the Study Area, particularly in the high priority-villages.
Consequently, use of motorized pump in the Study Area is not a free choice but rather the only solution.

(4) Water supply where groundwater is unavailable

Although groundwater is the only water source selected in the project, there are a few exceptional places where a reasonably accessible aquifer with adequate quality and capacity is not available. One possible solution for those places may be extension of a piping system to transport water, even if the water source is located far from the place. Such a solution, however, usually requires a considerable investment cost for long distance piping system, as well as a long construction period.

Furthermore, since such a regional water supply system may involve several rural communities, the project will raise a complicated problem how to share responsibility for operation and maintenance among several communities, who are, at the moment, not disciplined for a cooperative work. The problem is aggravated by the lack of public inter-institutional coordination mechanism which may be helpful to solve such a problem.

9.2.3 The Proposed Project

(1) Project description

1) Criteria for planning

The basic criteria for planning and design of the water supply project are summarized as follows.

(a) Design year : 2000, conforming to the national target year.

(b) Water supply districts : the community, FOKONTANY or KOMITY, is regarded as a unit water supply district.

(c) Beneficiary : community residents are the primary beneficiary. Cattle kept in neighboring land of the 13 villages also will be counted as beneficiary.

(d) Population served : the population to be served in 2000 will be estimated from the present population of individual community by applying an average yearly growth rate of 2.76%. Cattle to be watered is roughly guessed between 400 to 800 head per community.

(e) Design daily water consumption:
- 20 lcd for people
- 18 lhd for cattle

2) Outline of Sub-Projects

By examination of the whole study results, the Study Team prepared 94 separate water supply projects (Sub-Projects) for 94 candidate villages.
The remaining 12 villages will be left without planning,

for the time being, owing the following circumstances.

- Villages with fulfilled demand by the existing pilot supply facilities ----- 2 villages
- Villages which were abandoned ----- 6 villages
- Villages which at the moment have quite difficult access ------ 4 villages

Table 9.2.1 and 9.2.2 show the summary of project classification and individual sub-project descriptions.

(2) Water supply facilitles

1) Pump discharge rate

The discharge rate of a motorized pump is designed according to community daily water consumption and duration of pumping cycles. The daily water consumption is shown in Table 9.2.1 and the duration of pumping cycles is assumed as 6 hours a day, considering capacity for unexpected increase of water demand.
The discharge rate of a handpump, strictly speaking, will be determined by three factors: the pumping lift, the mechanical efficiency (depends on pump model) and the manual force by the pump user. However, 4 m^3/day -7m^3/day, of daily discharge can be assumed for an ordinary handpump.

2) Hourly peak load

The hourly peak load is an essential factor which affects the size of pipes in a distribution network.
Assuming that the daily water service period is 9 hours and the ratio between peak load and average load (for 9 hours) is 1.4 to 1.0 according to the monitoring of pilot water supply facilities, the following estimation method for the hourly peak load is proposed.

$$\frac{\text{Daily consumption (} m^3\text{/day)}}{9 \text{ (hours/day)}} \times \frac{1.4}{1.0}$$

$$= \text{Daily consumption} \times 0.156 \ (m^3\text{/hour})$$

3) Storage capacity of reservoir

A water supply system is stabilized by a service reservoir, which is designed to maintain a uniform pressure in the distribution system and to store water for periods of peak demand. The capacity of the reservoir will be planned based on the following principle.
The daily pumping hours are less than the daily water service hours by 3 hours. Therefore, when a reservoir has a capacity equivalent to "hourly peak load x 3hrs", the reservoir can fully perform the compensative function.
Based on the above mentioned idea, the individual reservoir capacity is decided as follows.

Daily water cosumption	Reservoir capacity
under 29m^3/day	10 m^3
30-49 m^3/day	15 m^3
50-79 m^3/day	30 m^3
over 80m^3/day	40 m^3

4) Number of public hydrant

The number of public hydrants will be decided based on the average capacity of the hydrant, i.e. 8m^3/day.

(3) Summary of equipment

The equipment required for individual community water supply project is listed in Table 9.2.2

(4) Typical design of the facilities

Schematic drawings of typical design of water supply facilities are shown in Fig. 9.2.1 (1)-(5).

Table 9.2.1 Summary of Project Classification

Project Category / Village Priority Classification	Improvement of Traditional Dug well	Handpump-Base Project	Motorized pump-Base Project	
			On Exist Well	On New Well
Priority (Population)	(No.of projects)	(No.of project)	(No.of project)	(No.of project)
Aa(55,732)	0	2	8	9
Ab(19,812)	0	3	2	7
Ba (6,181)	0	2	2	0
Bb(16,911)	2	3	2	8
Subtotal (98,636)	2	10	14	24
C (17,740)	2	7	0	9
D (16,123)	10	10	1	5
Subtotal (33,863)	12	17	1	14
Total (132,499)	14	27	15	38

Table 9.2.2 Description of Water Supply Subprojects by Village (1)

No	Village Name	Priority	Gross Water Consumption Domestic Use	Gross Water Consumption Cattle Watering	Gross Water Consumption Total	Existing Safe Water Supply	Net Water Required	Proposed Type of Facility	Schistosomiasis	Community Characteristic	Water Source Characteristic	Project Characteristic
			(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)					
8	Mangolovolo	Aa	39.0	—	39.0	—	39.0	W·MP	YES	Large village near main road	High water table	Well & motorized pump-based system
22	Manoy	Aa	14.0	7.0	21.0	4.0 (P)	17.0	W·HP-CT	NO	Medium, well off village, near main road	High water table, slightly turbid	Well with handpump, one for cattle watering
46	Berenty-Betsileo	Aa	61.0	—	61.0	—	61.0	WW	YES	Large, well off village in remote place, center of distribution	Salty groundwater, underflow water is more suitable for drinking water	Simple water work system including slow sand filtration
49	Tanandava-Antaifasy	Aa	53.0	—	53.0	—	53.0	W·MP	YES	Large village in remote place, center of distribution	High water table by confined aquifer, requires deep well	Well & motorized pump-based system, long distribution piping is required
52	Soahazo	Aa	74.0	14.0	88.0	20.0 (P)	68.0	MP-CT	NO	Large, well off village on road-9, commerce is developing	Shallow groundwater is salty	Replace solar pump with conventional pump system, wide distribution piping required
53	Analamisampy	Aa	20.0	7.0	27.0	4.0 7.0 (P)	16.0	W·HP-CT	NO	Medium, well off village on road-9, commerce is developing	High water table	Well with hand pump, one for cattle watering
54	Belitsaka	Aa	34.0	14.0	48.0	7.0 (P)	41.0	MP-CT	NO	Large, well off village on road-9, commerce is developing	High water table	Replace handpump system with motorized pump system
55	Ampasikibo	Aa	52.0	14.0	66.0	4.0 7.0 (P)	55.0	MP-CT	NO	Large, well off village on road-9, commerce is developing	High water table	Replace handpump system with motorized pump system
56	Namaboha	Aa	39.0	14.0	53.0	7.0 (P)	46.0	MP-CT	NO	Large, well off village on road-9, commerce is developing	High water table by confined aquifer, requires deep well	Replace handpump system with motorized pump system
63	Manombo-Atm	Aa	122.0	—	122.0	4.0 (P)	118.0	MP	NO	Large, well off village in remote place, center of distribution and culture	High water table	Replace handpump with motorized pump system, wide distribution required
68	Benetsy	Aa	52.0	14.0	66.0	4.0 (P)	62.0	MP-CT	YES	Large, well off village on road-9, commerce is developing	High water table by confined aquifer, requires deep well	Replace handpump with motorized pump system; wide distribution piping required
77	Andranovory	Aa	40.0	—	40.0	—	40.0	W·MP	YES	Medium village on road-7, relies on water vendors	Very low water table	Well & motorized pump-based system

Table 9.2.2 Description of Water Supply Subprojects by Village (2)

No	Village Name	Priority	Gross Water Consumption Domestic Use	Gross Water Consumption Cattle Watering	Gross Water Consumption Total	Existing Safe Water Supply	Net Water Required	Proposed Type of Facility	Schistosomiasis	Community Characteristic	Water Source Characteristic	Project Characteristic
			(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)					
92	Mahaboboka	Aa	52.0	—	52.0	—	52.0	W·MP	YES	Large, well off village on road-7, commerce is developing	Very high water table	Well & motorized pump-based system; wide distribution piping requird
101	Ankilimalinika	Aa	101.0	14.0	115.0	4.0 (P)	111.0	MP-CT	NO	Large, well off village on road-9, commerce is developing	High water table, slightly salty	Replace handpump with motorized pump system, wide distribution required
a	Befandriana	Aa	79.0	—	79.0	24.0 (P)	55.0	MP-RH	NO	Large, well off village on road-9, commerce is developing	High water table	Expansion of capacity & distribution of existing system
b	Betsioky Nord	Aa	52.0	—	52.0	—	52.0	W·MP-RH	YES	Large village near road-9	Low water table, confined water, requires deep well	Rehabilitation including new well drilling & pumping system
c	Andranohinaly	Aa	47.0	—	47.0	—	47.0	W·MP-RH	NO	Medium, well off village on road-7, relies on water vendors	Very low water table	Rehabilitation, existing facility is useless
d	Sakaraha	Aa	103.0	—	103.0	—	103.0	W·MP-RH	YES	City on road-7	High water table by confined aquifer, requires deep well	Rehabilitation, large expansion in capacity and distribution is required
e	Ankazoabo	Aa	79.0	—	79.0	—	79.0	W·MP-RH	NO	City in remote place	High water table by confined aquifer, requires deep well	Rehabilitation, existing facility is useless
11	Andranomanintsy	Ab	37.0	—	37.0	—	37.0	W·MP	YES	Medium village near road-9, with promising farming	High water table by confined aquifer, requires deep well	Well & motorized pump-based system
14	Antsakoabe	Ab	21.0	14.0	35.0	—	35.0	W·MP-CT	YES	Medium village on road-9, with promising farming	High water table by confined aquifer, requires deep well	Well & motorized pump-based system
25	Sihanaka	Ab	18.0	—	18.0	4.0 (P)	14.0	W·HP	NO	Small village near road-9, with promising farming	Very high water table	Well with handpump
29	Mangotroka	Ab	16.0	—	16.0	4.0 (P)	12.0	W·HP	NO	Small village on road-9, with promising farming	Very high water table	Well with handpump
34	Tandrano	Ab	92.0	—	92.0	—	92.0	MP	YES	Large village in remote place, with promising farming	High water table by confined aquifer, requires deep well	Install motorized pump system on existing well
35	Ampandramitsetaky	Ab	21.0	—	21.0	—	21.0	W·MP	YES	Medium village in remote place, with promising farming	High water table by confined aquifer, requires deep well	Well & motorized pump-system

Table 9.2.2 Description of Water Supply Subprojects by Village (3)

No	Village Name	Priority	Gross Water Consumption: Domestic Use (m3/Day)	Gross Water Consumption: Cattle Watering (m3/Day)	Gross Water Consumption: Total (m3/Day)	Existing Safe Water Supply (m3/Day)	Net Water Required (m3/Day)	Proposed Type of Facility	Schistosomiasis	Community Characteristic	Water Source Characteristic	Project Characteristic
47	Ankilivalokely	Ab	32.0	—	32.0	—	32.0	W·MP	NO	Medium, well off village in remote place	High water table by confined aquifer, requires deep well	Well & motorized pump-system
58	Ankatrakatra	Ab	12.0	7.0	19.0	—	19.0	W·HP-CT	NO	Small, cattle breeding village, near road-9	High water table by confined aquifer, requires deep well	Well with handpump, one for cattle watering
61	Beroroha	Ab	59.0	—	59.0	—	59.0	W·MP	YES	Large village in remote place with promising farming	Very high water table	Well & motorized pump-system, wide distribution piping is required
78	Befoly	Ab	23.0	7.0	30.0	—	30.0	W·MP-CT	NO	Medium village on road-7, relies on water vendors	Very low water table, confined water, requires deep well	Well & motorized pump-system
83	Andranolava	Ab	39.0	—	39.0	—	39.0	W·MP	NO	Large vilage in remote place, with promising farming, center of district	High water table by confined aquifer, requires deep well	Well & motorized pump-system
96	Analamary	Ab	26.0	—	26.0	4.0 (P)	22.0	MP	NO	Medium village in remote place, with promising, farming	Medium water table, confined aquifer, requires deep well	Replace handpump with motorized pump-system
40	Tanandava	Ba	10.0	—	10.0	—	10.0	W·HP	YES	Small village, close to ANKZOABO city	High water table by confined aquifer, requires deep well	Well with handpump
59	Ampihamy	Ba	38.0	14.0	52.0	4.0 (P)	48.0	MP-CT	NO	Medium, cattle breeding village near road-9	Very high water table	Replace handpump with motorized pump-system
60	Ambondro	Ba	26.0	—	26.0	—	26.0	W·HP	NO	Medium village in remote place, with promising farming, difficult access	Very high water table	Well with handpump
65	Ankaraobato	Ba	48.0	—	48.0	—	48.0	MP	NO	Large, well off village on road-9	High water table by confined aquifer, requires deep well	Install motorized pump-system on a test well
5	Ambalamoa	Bb	26.0	—	26.0	—	26.0	W·MP	NO	Medium, poor village near road-9, with farming potential	High water table by confined aquifer, requires deep well	Well & motorized pump-system
6	Tsianihy	Bb	36.0	—	36.0	—	36.0	W·MP	NO	Medium, poor village near road-9, with farming potential	High water table by confined aquifer, requires deep well	Well & motorized pump-system
7	Namatoa	Bb	20.0	—	20.0	—	20.0	W·MP	YES	Small, poor village near road-9, with farming potential	High water table by confined aquifer, requires deep well	Well & motorized pump-system

Table 9.2.2 Description of Water Supply Subprojects by Village (4)

No	Village Name	Priority	Gross Water Consumption: Domestic Use	Gross Water Consumption: Cattle Watering	Gross Water Consumption: Total	Existing Safe Water Supply	Net Water Required	Proposed Type of Facility	Schistosomiasis	Community Characteristic	Water Source Characteristic	Project Characteristic
			(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)					
16	Ambiky	Bb	36.0	—	36.0	—	36.0	W·MP	NO	Small, poor village near road-9, with farming potential	High water table by confined aquifer, requires deep well	Well & motorized pump-system
23	Ampoza	Bb	18.0	—	18.0	4.0 (P)	14.0	W·HP	NO	Small, poor village near road-9, with farming potential	Very high water table	Well with handpump
57	Antseva	Bb	21.0	—	21.0	—	21.0	W·HP	NO	Small, poor village on road-9, with traditional wells	High water table by confined aquifer, requires deep well	Well & motorized pump-system
62	Antsomarify	Bb	31.0	—	31.0	—	31.0	W·MP	YES	Medium, poor village in remote place	High water table	Well & motorized pump-system
67	Tsefanoka	Bb	23.0	—	23.0	7.0 (P)	16.0	W·HP	NO	Medium, poor village, easy access from road-9, with farming potential	High water table	Well with handpump
81	Manoroka	Bb	26.0	—	26.0	4.0 (P)	22.0	MP	NO	Medium village, difficult access, with promising farming	Very high water table	Install motorized pump system, must supply to elevated place
86	Besakoa(2)	Bb	31.0	—	31.0	—	31.0	W·MP	YES	Medium village in remote place	High water table by confined aquifer, requires deep well	Well & motorized pump system, distribution piping required
88	Maninday	Bb	18.0	—	18.0	4.0 (P)	14.0	W·HP	NO	Small village, easy access from road-7	High water table by confined aquifer, requires deep well	Well with handpump
90	Tanambao	Bb	21.0	—	21.0	—	21.0	DW	YES	Small village in remote place, with farming potential	Very high water table	Protected dug well
94	Andamasiny-Vineta	Bb	14.0	—	14.0	—	14.0	W·MP	YES	Small village on road-7	High water table by confined aquifer, requires deep well	Well & motorized pump system
98	Bereketa	Bb	13.0	—	13.0	—	13.0	W·HP	NO	Small village in remote place	High water table	Well with handpump
99	Ankilimitraloka	Bb	21.0	—	21.0	—	21.0	DW	NO	Medium village in remote place, difficult access, with farming potential	Very high water table	Protected dug well
13	Tanandava	Ca	16.0	—	16.0	—	16.0	W·MP	YES	Small village on road-9 very poor, origin of big TANNANDAVA near it	High water table by confined aquifer, requires deep well	Well & motorized pump system

Table 9.2.2 Description of Water Supply Subprojects by Village (5)

No	Village Name	Priority	Gross Water Consumption			Existing Safe Water Supply	Net Water Required	Proposed Type of Facility	Schistosomiasis	Community Characteristic	Water Source Characteristic	Project Characteristic
			Domestic Use	Cattle Watering	Total							
			(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)					
15	Talatavalo	Ca	17.0	—	17.0	—	17.0	W·MP	NO	Small, poor village, separated small settlements	High water table by confined aquifer, requires deep well	Well & motorized pump
21	Antranosatra	Ca	15.0	—	15.0	—	15.0	W·MP	NO	Small, poor village, 2 separated settlements	High water table by confined aquifer, requires deep well	Well & motorized pump
33	Andranomanintsy	Ca	20.0	—	20.0	—	20.0	W·MP	YES	Medium, poor village in remote place	High water table by confined aquifer, requires deep well	Well & motorized pump
41	Ampoza	Ca	8.0	—	8.0	—	8.0	W·HP	YES	Small, poor village in remote place	High water table by confined aquifer, requires deep well	Well & motorized pump
42	Ipetsa Atm	Ca	3.0	—	3.0	—	3.0	W·HP	NO	Small, poor village in remote place	High water table by confined aquifer, requires deep well	Well & motorized pump
64	Antandroka	Ca	18.0	—	18.0	—	18.0	W·HP	NO	Small, poor village in remote place	High water table	Well & motorized pump
69	Andrevo	Ca	58.0	—	58.0	—	58.0	DW	YES	Large fishing village, well off	Fresh water lies on top of salty water	Protected dug well to controll drawing
79	Ankororoka	Ca	3.0	—	3.0	—	3.0	W·MP	NO	Tiny, poor village on road-7, subsistence farming	Very low water table	Well & motorized pump system
82	Iaborana	Ca	6.0	—	6.0	—	6.0	W·MP	NO	Small village in remote place	Low water table	Well & motorized pump system
84	Lambomakandro	Ca	5.0	—	5.0	—	5.0	W·HP	YES	Small, poor village in remote place	High water table by confined aquifer, requires deep well	Well with handpump
91	Ambahimalitsy	Ca	21.0	—	21.0	—	21.0	DW	YES	Medium village in remote place, promising farming far from consumers	Very high water table	Protected dug well
30	Nosy-Ambositra	Cb	26.0	—	26.0	—	26.0	W·HP	YES	Medium village in remote place, difficult access, good farming potential	Very high water table	Well with handpump
31	Tsiarimpioke	Cb	21.0	—	21.0	—	21.0	W·HP	NO	Medium village in remote place, traditional water source is abandoned, good farming potential	Very high water table	Well with handpump

Table 9.2.2 Description of Water Supply Subprojects by Village (6)

No	Village Name	Priority	Gross Water Consumption			Existing	Net	Proposed	Schistosomiasis	Community Characteristic	Water Source Characteristic	Project Characteristic
			Domestic Use	Cattle Watering	Total	Safe Water Supply	Water Required	Type of Facility				
			(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)					
71	Ampihalia	Cb	26.0	—	26.0	—	26.0	W·MP	NO	Medium village along FIHERENANA river, difficult access, good farming potential	Underflow water	Well & motorized pump system
72	Behompy	Cb	26.0	—	26.0	—	26.0	W·MP	NO	Medium village along FIHERENANA river, difficult access, mountainous	Underflow water	Well & motorized pump
73	Ambolonkira	Cb	12.0	—	12.0	—	12.0	W·HP	NO	Small poor village along FIHERENANA river, difficult access, mountainous	Underflow water	Well with handpump
100	Ankilivalo	Cb	52.0	—	52.0	—	52.0	W·MP	NO	Large, well off village in remote place, center of distri-bution, difficult access	High water table	Well & motorized pump system, wide distribution
1	Ankazomanga	D	16.0	—	16.0	—	16.0	DW	YES	Small poor village in northern part, subsistence farming	Very high water table	Protected dug well
2	Beañabo	D	16.0	—	16.0	—	16.0	DW	YES	Small poor village in northern part, subsistence farming	Very high water table	Protected dug well
3	befasy	D	16.0	—	16.0	—	16.0	DW	YES	Small poor village in northern part, subsistence farming	Very high water table	Protected dug well
4	Ankilifolo(1)	D	10.0	—	10.0	—	10.0	DW	NO	Small poor village in northern part, subsistence farming	Very high water table	Protected dug well
9	Ankida	D	0.4	—	0.4	—	0.4	W·HP	NO	Tiny village, poor, subsistence farming	High water table but deeper drilling necessary	Well with handpump
12	Berantala	D	13.0	—	13.0	—	13.0	W·MP	YES	Small village, poor, subsistence farming	In spite of high water table, deeper drilling is required	Well & motorized pump system
17	Marovato	D	10.0	—	10.0	—	10.0	W·HP	NO	Small village, poor, subsistence farming	In spite of high water table, deeper drilling is required	Well & motorized pump, no distribution pipe
18	Andranoboka	D	16.0	—	16.0	—	16.0	W·MP	NO	Small village, poor, subsistence farming	In spite of high water table, deeper drilling is required	Well & motorized pump
24	Ankilifolo(2)	D	12.0	—	12.0	—	12.0	W·HP	NO	Small village, poor, subsistence farming	High water table	Well with handpump

Table 9.2.2 Description of Water Supply Subprojects by Village (7)

No	Village Name	Priority	Gross Water Consumption Domestic Use (m3/Day)	Cattle Watering (m3/Day)	Total (m3/Day)	Existing Safe Water Supply (m3/Day)	Net Water Required (m3/Day)	Proposed Type of Facility	Schistosomiasis	Community Characteristic	Water Source Characteristic	Project Characteristic
27	Basibasy	D	26.0	—	26.0	4.0 (P)	22.0	Supply from Analatelo	YES	Large village in remote place, center of district	Available but poor quality not suitable for drinking	Transfer pipeline from ANALATELO
36	Andranomafana	D	16.0	—	16.0	—	16.0	W·MP	NO	Small, poor village in remote place, subsistence farming	In spite of high water table, deeper drilling is required	Well with handpump
37	Mamakiala	D	8.0	—	8.0	—	8.0	W·HP	NO	Small, poor village in remote place, subsistence farming	In spite of high water table, deeper drilling is required	Well with handpump
38	Berenty-Ankilimasy	D	3.0	—	3.0	—	3.0	W·HP	NO	Tiny, poor village in remote place, subsistence farming	In spite of high water table, deeper drilling is required	Well with handpump
39	Betsinefo	D	0.9	—	0.9	—	0.9	W·HP	YES	Tiny, poor village in remote place, subsistence farming	In spite of high water table, deeper drilling is required	Well with handpump
43	Mandabe Atm	D	3.0	—	3.0	—	3.0	DW	YES	Tiny, poor village in remote place, subsistence farming	Very shallow aquifer	Protected dug well
44	Soatanimbary	D	2.0	—	2.0	—	2.0	DW	NO	Tiny, poor village in remote place, subsistence farming	Very shallow aquifer	Protected dug well
45	Sahanory Atn	D	5.0	—	5.0	—	5.0	DW	YES	Tiny, poor village in remote place, subsistence farming	Very shallow aquifer	Protected dug well
66	Andoharano	D	8.0	—	8.0	—	8.0	W·HP	NO	Small, poor village far from road-9, subsistence farming	In spite of high water table, deeper drillling is required	Well with handpump
70	Anjamala	D	4.0	—	4.0	—	4.0	W·HP	NO	Tiny, poor village along FIHERENANA river, difficult access	Underflow water	Well with handpump
74	Miary	D	52.0	14.0	66.0	—	66.0	W·MP-CT	NO	Large village near TOLIARA City, supplied by JIRAMA	High water table	Well & motorized pump system
75	Befanamy	D	18.0	—	18.0	—	18.0	W·HP	NO	Medium village near TOLIARA City, supplied by JIRAMA	High water table	Well & motorized pump system
76	Tsivonoabe	D	0.8	—	0.8	—	0.8	DW	NO	Tiny, poor village on road-9, subsistence farming	High water table	Protected dug well
80	Ambohimahavelona	D	52.0	—	52.0	—	52.0	Spring	NO	Large village, center of district, good farming potential	Spring can be used	Piping from spring

Table 9.2.2 Description of Water Supply Subprojects by Village (8)

No	Village Name	Priority	Gross Water Consumption			Existing	Net	Proposed	Schistosomiasis	Community Characteristic	Water Source Characteristic	Project Characteristic
			Domestic Use	Cattle Watering	Total	Safe Water Supply	Water Required	Type of Facility				
			(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)	(m3/Day)					
89	Bevoalavo	D	6.0	—	6.0	—	6.0	DW	NO	Small, poor village in remote place, subsistence farming	High water table	Protected dug well
93	Mahasoa	D	0.8	—	0.8	—	0.8	W·HP	YES	Tiny, poor village on road-7, subsistence farming	In spite of high water table, deeper drilling is requird	Well with handpump
97	Antanimora	D	8.0	—	8.0	—	8.0	W·HP	NO	Small, poor village in remote place, subsistence farming	In spite of high water table, deeper drilling is requird	Well with handpump

Table 9.2.3 Water Supply Facilities by Village (1)

No	Village Name	Priority	Proposed Type of Facility	Well: Dimension (Static Water Level / Dinamic Water Level)	Well Quantity: Exist	Well Quantity: New	Hand Pump: Capacity×Head	Hand Pump: Q'ty	Submarged Motor pump: Capacity×Head	Submarged Motor pump: Q'ty	Engine Generator: Output (KVA)	Engine Generator: Q'ty	Reservior Capacity (m3)	Water Supply Point: Public Hydrant	Water Supply Point: Watering Place
8	Mangolovolo	Aa	W·MP	φ6″ × 30.0 m (5.00 m/ 10.00 m)		1	—		108 l/min× 16 m	1	12.5	1	15	5	—
22	Manoy	Aa	W·HP-CT	φ4″ × 40.0 m (8.50 m/ 9.50 m)	1	3	20 l/min×10 m	3	—		—		—	—	1
46	Berenty-Betsileo	Aa	WW	φ6″ × 30.0 m (3.00 m/ 10.00 m)		1	—		169 l/min× 16 m	1	12.5	1	30	8	—
49	Tanandava-Antaifasy	Aa	W·MP	φ6″ ×100.0 m (15.00 m/ 25.00 m)		1	—		147 l/min× 31 m	1	12.5	1	30	7	—
52	Soahazo	Aa	MP-CT	φ4″ × 76.0 m (36.70 m/ 38.60 m)	1		—		244 l/min× 45 m	1	17.0	1	30	10	1
53	Analamisampy	Aa	W·HP-CT	φ4″ × 71.0 m (13.11 m/ 18.60 m)	1	2	20 l/min×19 m	2	—		—		—	—	1
54	Belitsaka	Aa	MP-CT	φ4″ × 66.0 m (12.78 m/ 33.00 m)	1		—		133 l/min× 39 m	1	17.0	1	15	5	1
55	Ampasikibo	Aa	MP-CT	φ4″ × 50.0 m (9.16 m/ 15.12 m)	1		—		172 l/min× 22 m	1	12.5	1	30	8	1
56	Namaboha	Aa	MP-CT	φ4″ × 83.0 m (16.50 m/ 34.00 m)	1		—		147 l/min× 40 m	1	17.0	1	30	6	1
63	Manombo-Atm	Aa	MP	φ6″ × 27.0 m (4.53 m/ 5.53 m)	1		—		339 l/min× 12 m	1	5.5	1	30	16	—
68	Benetsy	Aa	MP-CT	φ6″ × 72.0 m (13.51 m/ 17.30 m)	1		—		183 l/min× 24 m	1	12.5	1	30	8	1
77	Andranovory	Aa	W·MP	φ6″ ×150.0 m (115.00 m/125.00 m)		1	—		111 l/min×131 m	1	37.0	1	15	5	—
92	Mahaboboka	Aa	W·MP	φ6″ × 30.0 m (5.00 m/ 10.00 m)		1	—		144 l/min× 16 m	1	12.5	1	30	7	—
101	Ankilimalinika	Aa	MP-CT	φ4″ × 66.0 m (14.35 m/ 17.70 m)	1		—		319 l/min× 24 m	1	17.0	1	40	14	1
a	Befandriana	Aa	MP-RH	φ6″ × 53.0 m (12.30 m/ 13.28 m)	1		—		219 l/min× 20 m	1	12.5	1	30	10	—
b	Betsioky Nord	Aa	W·MP-RH	φ6″ ×150.0 m (60.00 m/ 80.00 m)		1	—		144 l/min× 86 m	1	37.0	1	30	7	—
c	Andranohinaly	Aa	W·MP-RH	φ6″ ×250.0 m (207.00 m/220.00 m)		1	—		131 l/min×226 m	1	55.0	1	15	6	—
				φ6″ ×100.0 m (12.00 m/ 20.00 m)		1	—		186 l/min× 26 m	1	12.5	1			—
d	Sakaraha	Aa	W·MP-RH	φ6″ × 30.8 m (10.66 m/ 21.60 m)	1		—		100 l/min× 28 m	1	10.0	1	30	24	—
e	Ankazoabo	Aa	W·MP-RH	φ6″ ×100.0 m (27.50 m/ 38.00 m)		1	—		150 l/min× 44 m	1	12.5	1	30	10	—
11	Andranomanintsy	Ab	W·MP	φ6″ ×200.0 m (30.00 m/ 40.00 m)		1	—		103 l/min× 46 m	1	17.0	1	15	5	—
14	Antsakoabe	Ab	W·MP-CT	φ5″ ×200.0 m (30.00 m/ 40.00 m)		1	—		97 l/min× 46 m	1	17.0	1	15	4	1
25	Sihanaka	Ab	W·HP	φ4″ × 40.0 m (6.00 m/ 6.50 m)	1	2	20 l/min× 7 m	2	—		—		—	—	—
29	Mangotroka	Ab	W·HP	φ4″ × 40.0 m (3.60 m/ 3.80 m)	1	2	20 l/min× 4 m	2	—		—		—	—	—
34	Tandrano	Ab	MP	φ6″ ×150.0 m (25.56 m/ 32.76 m)	1		—		256 l/min× 39 m	1	17.0	1	40	12	—
35	Ampandramitsetaky	Ab	W·MP	φ6″ ×150.0 m (25.00 m/ 33.00 m)		1	—		58 l/min× 39 m	1	17.0	1	10	3	—
47	Ankilivalokely	Ab	W·MP	φ6″ ×200.0 m (20.00 m/ 40.00 m)		1	—		89 l/min× 46 m	1	12.5	1	15	4	—
58	Ankatrakatra	Ab	W·HP-CT	φ4″ × 70.0 m (10.00 m/ 15.00 m)		3	20 l/min×15 m	3	—		—		—	—	—
61	Beroroha	Ab	W·MP	φ4″ × 50.0 m (15.00 m/ 25.00 m)		1	—		164 l/min× 31 m	1	12.5	1	30	8	—
78	Befoly	Ab	W·MP-CT	φ6″ ×250.0 m (178.56 m/185.00 m)	1		—		83 l/min×191 m	1	55.0	1	10	3	1
83	Andranolava	Ab	W·MP	φ4″ ×100.0 m (20.00 m/ 27.00 m)		1	—		108 l/min× 33 m	1	17.0	1	15	5	—

Table 9.2.3 Water Supply Facilities by Village (2)

No	Village Name	Priority	Proposed Type of Facility	Well: Dimension Static Water Level / Dinamic Water Level	Well: Quantity Exist	Well: Quantity New	Hand Pump: Capacity×Head	Hand Pump: Q'ty	Submarged Motor pump: Capacity×Head	Submarged Motor pump: Q'ty	Engine Generator: Output	Engine Generator: Q'ty	Reservior Capacity	Water Supply Point: Public Hydrant	Water Supply Point: Watering Place
96	Analamary	Ab	MP	φ6″ ×204.0 m (35.00 m/ 43.62 m)	1		–		72 l/min× 50 m	1	17.0	1	10	4	–
40	Tanandava	Ba	W・HP	φ6″ ×100.0 m (20.00 m/ 25.00 m)		1	20 l/min×25 m	1	–		–		–	–	–
59	Ampihamy	Ba	MP-CT	φ4″ × 53.0 m (8.30 m/ 15.33 m)	1		–		144 l/min× 22 m	1	12.5	1	30	6	1
60	Ambondro	Ba	W・HP	φ4″ × 50.0 m (10.00 m/ 15.00 m)		3	20 l/min×15 m	3	–		–		–	–	–
65	Ankaraobato	Ba	MP	φ4″ × 75.0 m (3.40 m/ 6.40 m)	1		–		133 l/min× 13 m	1	5.5	1	15	6	–
5	Ambalamoa	Bb	W・MP	φ6″ ×150.0 m (20.00 m/ 30.00 m)		1	–		72 l/min× 36 m	1	12.5	1	10	4	–
6	Tsianihy	Bb	W・MP	φ6″ ×150.0 m (20.00 m/ 30.00 m)		1	–		100 l/min× 36 m	1	12.5	1	15	5	–
7	Namatoa	Bb	W・MP	φ6″ ×150.0 m (20.00 m/ 30.00 m)		1	–		56 l/min× 36 m	1	12.5	1	10	3	–
16	Ambiky	Bb	W・MP	φ6″ ×200.0 m (25.00 m/ 35.00 m)		1	–		100 l/min× 41 m	1	10.0	1	10	5	–
23	Ampoza	Bb	W・HP	φ4″ × 50.0 m (5.50 m/ 6.20 m)	1	2	20 l/min× 7 m	2	–		–		–	–	–
57	Antseva	Bb	W・HP	φ4″ × 70.0 m (15.00 m/ 20.00 m)		3	20 l/min×20 m	3	–		–		–	–	–
62	Antsomarify	Bb	W・MP	φ4″ × 50.0 m (15.00 m/ 20.00 m)		1	–		86 l/min× 26 m	1	12.5	1	15	4	–
67	Tsefanoka	Bb	W・HP	φ4″ × 45.0 m (25.50 m/ 26.00 m)	1	2	20 l/min×26 m	2	–		–		–	–	–
81	Manoroka	Bb	MP	φ4″ × 58.0 m (5.25 m/ 5.25 m)	1		–		72 l/min× 12 m	1	5.5	1	10	4	–
86	Besakoa(2)	Bb	W・MP	φ4″ ×100.0 m (20.00 m/ 26.00 m)		1	–		86 l/min× 32 m	1	17.0	1	15	4	–
88	Maninday	Bb	W・HP	φ4″ × 70.0 m (16.50 m/ 17.00 m)		2	20 l/min×17 m	2	–		–		–	–	–
90	Tanambao	Bb	DW	10.0 m (8.00 m/ 9.00 m)		4	–		–		–		–	–	–
94	Andamasiny-Vineta	Bb	W・MP	φ6″ ×150.0 m (20.00 m/ 30.00 m)		1	–		39 l/min× 36 m	1	10.0	1	10	2	–
98	Bereketa	Bb	W・MP	φ4″ × 50.0 m (5.00 m/ 10.00 m)			–		36 l/min× 16 m	1	10.0	1	10	2	–
99	Ankilimitraloka	Bb	DW	10.0 m (8.00 m/ 9.00 m)		4	–		–		–		–	–	–
13	Tanandava	Ca	W・MP	φ6″ ×200.0 m (15.00 m/ 20.00 m)		1	–		44 l/min× 26 m	1	10.0	1	10	2	–
15	Talatavalo	Ca	W・MP	φ6″ ×200.0 m (15.00 m/ 25.00 m)		1	–		47 l/min× 31 m	1	10.0	1	10	3	–
21	Antranosatra	Ca	W・MP	φ6″ ×200.0 m (15.00 m/ 25.00 m)		1	–		42 l/min× 31 m	1	10.0	1	10	2	–
33	Andranomanintsy	Ca	W・MP	φ6″ ×150.0 m (15.00 m/ 25.00 m)		1	–		56 l/min× 31 m	1	10.0	1	10	3	–
41	Ampoza	Ca	W・HP	φ6″ ×150.0 m (35.00 m/ 40.00 m)		1	20 l/min×40 m	1	–		–		–	–	–
42	Ipetsa Atm	Ca	W・HP	φ6″ ×150.0 m (35.00 m/ 40.00 m)		1	20 l/min×40 m	1	–		–		–	–	–
64	Antandroka	Ca	W・HP	φ4″ × 50.0 m (15.00 m/ 20.00 m)		3	20 l/min×20 m	3	–		–		–	–	–
69	Andrevo	Ca	DW	10.0 m (8.00 m/ 9.00 m)		6	–		–		–		–	–	–
79	Ankororoka	Ca	W・MP	φ6″ ×250.0 m (210.00 m/215.00 m)		1	–		8 l/min×221 m	1	55.0	1	10	1	–
82	Iaborana	Ca	W・MP	φ6″ ×200.0 m (70.00 m/ 80.00 m)		1	–		17 l/min× 86 m	1	17.0	1	10	1	–
84	Lambomakandro	Ca	W・HP	φ4″ ×100.0 m (15.00 m/ 20.00 m)		1	20 l/min×20 m	1	–		–		–	–	–
91	Ambahimalitsy	Ca	DW	10.0 m (8.00 m/ 9.00 m)		4	–		–		–		–	–	–

Table 9.2.3 Water Supply Facilities by Village (3)

No	Village Name	Priority	Proposed Type of Facility	Well: Dimension, Static Water Level, Dinamic Water Level	Well Quantity: Exist	Well Quantity: New	Hand Pump: Capacity×Head	Hand Pump: Q'ty	Submarged Motor pump: Capacity×Head	Submarged Motor pump: Q'ty	Engine Generator: Output	Engine Generator: Q'ty	Reservior Capacity	Water Supply Point: Public Hydrant	Water Supply Point: Watering Place
30	Nosy-Ambositra	Cb	W·HP	φ4″ × 50.0 m (10.00 m/ 15.00 m)		3	20 l/min×15 m	3	–		–		–	–	–
31	Tsiarimpioke	Cb	W·HP	φ4″ × 50.0 m (10.00 m/ 15.00 m)		3	20 l/min×15 m	3	–		–		–	–	–
71	Ampihalia	Cb	W·MP	φ4″ × 50.0 m (10.00 m/ 15.00 m)		1	–		72 l/min× 21 m	1	10.0	1	10	4	–
72	Behompy	Cb	W·MP	φ4″ × 50.0 m (10.00 m/ 15.00 m)		1	–		72 l/min× 21 m	1	10.0	1	10	4	–
73	Ambolonkira	Cb	W·HP	φ4″ × 50.0 m (10.00 m/ 15.00 m)		2	20 l/min×15 m	2	–		–		–	–	–
100	Ankilivalo	Cb	W·MP	φ4″ ×100.0 m (15.00 m/ 20.00 m)		1	–		144 l/min× 26 m	1	10.0	1	30	7	–
1	Ankazomanga	D	DW	7.0 m (5.00 m/ 6.00 m)		3	–		–		–		–	–	–
2	Beadabo	D	DW	7.0 m (5.00 m/ 6.00 m)		3	–		–		–		–	–	–
3	befasy	D	DW	7.0 m (5.00 m/ 6.00 m)		3	–		–		–		–	–	–
4	Ankilifolo(1)	D	DW	7.0 m (5.00 m/ 6.00 m)		2	–		–		–		–	–	–
9	Ankida	D	W·HP	φ6″ × 30.0 m (5.00 m/ 10.00 m)		1	20 l/min×10 m	1	–		–		–	–	–
12	Berantala	D	W·MP	φ6″ ×200.0 m (30.00 m/ 40.00 m)		1	–		36 l/min× 46 m	1	10.0	1	10	2	–
17	Marovato	D	W·HP	φ6″ ×200.0 m (30.00 m/ 35.00 m)		1	20 l/min×35 m	1	–		–		–	–	–
18	Andranoboka	D	W·MP	φ6″ ×200.0 m (30.00 m/ 40.00 m)		1	–		44 l/min× 46 m	1	10.0	1	10	2	–
24	Ankilifolo(2)	D	W·HP	φ4″ × 50.0 m (15.00 m/ 20.00 m)		2	20 l/min×20 m	2	–		–		–	–	–
27	Basibasy	D	Supply from Analatelo				–		–		–		–	–	–
36	Andranomafana	D	W·MP	φ6″ ×100.0 m (15.00 m/ 25.00 m)		1	–		44 l/min× 31 m	1	10.0	1	10	2	–
37	Mamakiala	D	W·HP	φ6″ ×100.0 m (15.00 m/ 20.00 m)		1	20 l/min×25 m	1	–		–		–	–	–
38	Berenty-Ankilimasy	D	W·HP	φ6″ ×100.0 m (15.00 m/ 20.00 m)		1	20 l/min×20 m	1	–		–		–	–	–
39	Betsinefo	D	W·HP	φ6″ ×100.0 m (15.00 m/ 20.00 m)		1	20 l/min×20 m	1	–		–		–	–	–
43	Mandabe Atm	D	DW	7.0 m (5.00 m/ 6.00 m)		1	–		–		–		–	–	–
44	Soatanimbary	D	DW	7.0 m (5.00 m/ 6.00 m)		1	–		–		–		–	–	–
45	Sahanory Atn	D	DW	7.0 m (5.00 m/ 6.00 m)		1	–		–		–		–	–	–
66	Andoharano	D	W·HP	φ4″ × 50.0 m (10.00 m/ 15.00 m)		1	20 l/min×15 m	1	–		–		–	–	–
70	Anjamala	D	W·HP	φ4″ × 50.0 m (10.00 m/ 15.00 m)		1	20 l/min×15 m	1	–		–		–	–	–
74	Miary	D	W·MP-CT	φ4″ × 50.0 m (8.00 m/ 12.00 m)		1	–		183 l/min× 18 m	1	12.5	1	30	8	1
75	Befanamy	D	W·HP	φ4″ × 50.0 m (8.00 m/ 12.00 m)		2	20 l/min×12 m	2	–		–		–	–	–
76	Tsivonoabe	D	DW	7.0 m m (5.00 m/ 6.00 m)		1	–		–		–		–	–	–
80	Ambohimahavelona	D	Spring				–		–		–		–	–	–
89	Bevoalavo	D	DW	10.0 m m (8.00 m/ 9.00 m)		1	–		–		–		–	–	–
93	Mahasoa	D	W·HP	φ4″ ×150.0 m (20.00 m/ 25.00 m)		1	20 l/min×25 m	1	–		–		–	–	–
97	Antanimora	D	W·HP	φ6″ ×150.0 m (30.00 m/ 35.00 m)		1	20 l/min×35 m	1	–		–		–	–	–

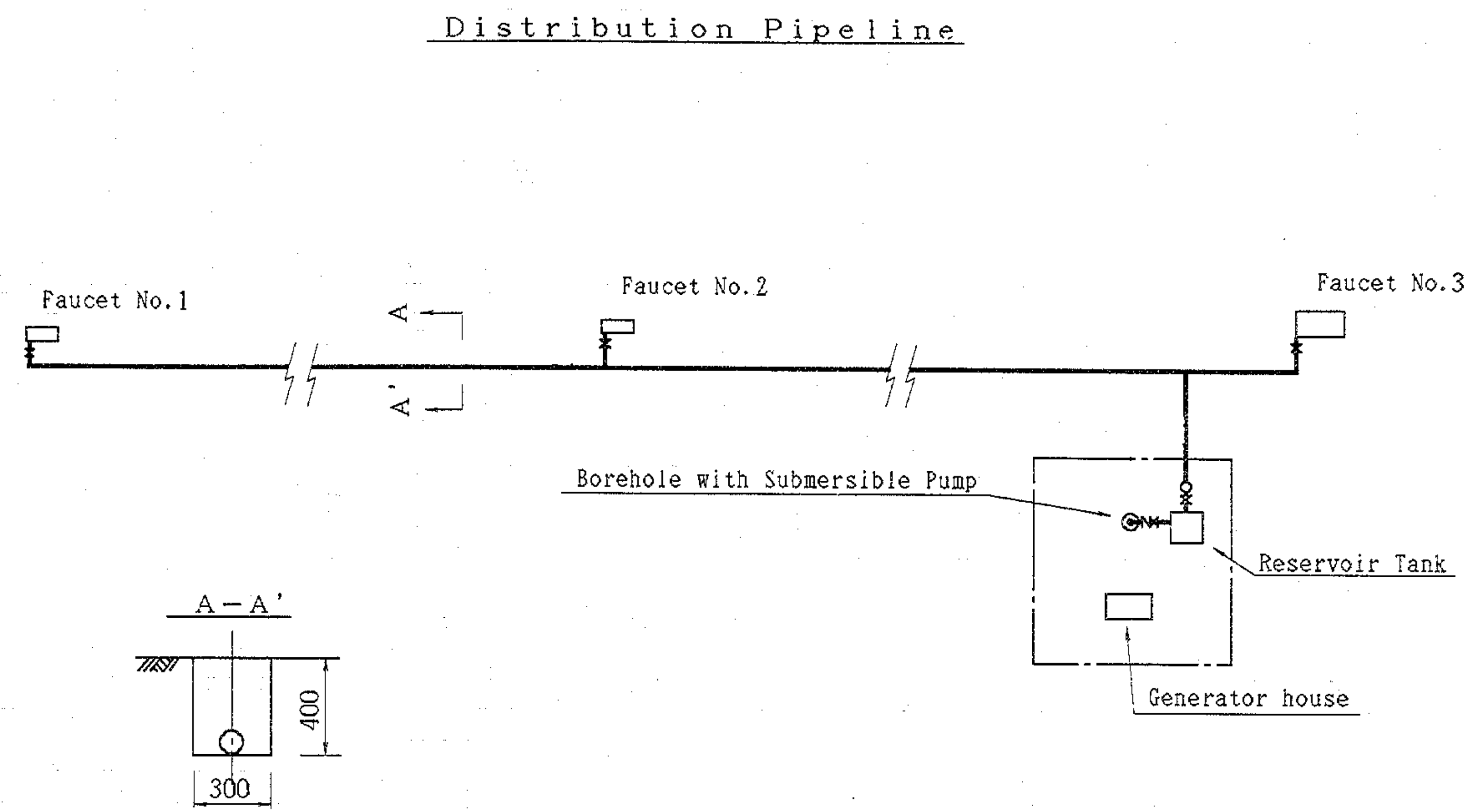


Fig. 9.2.1 Typical Design of the Facility(1)

Faucet Base

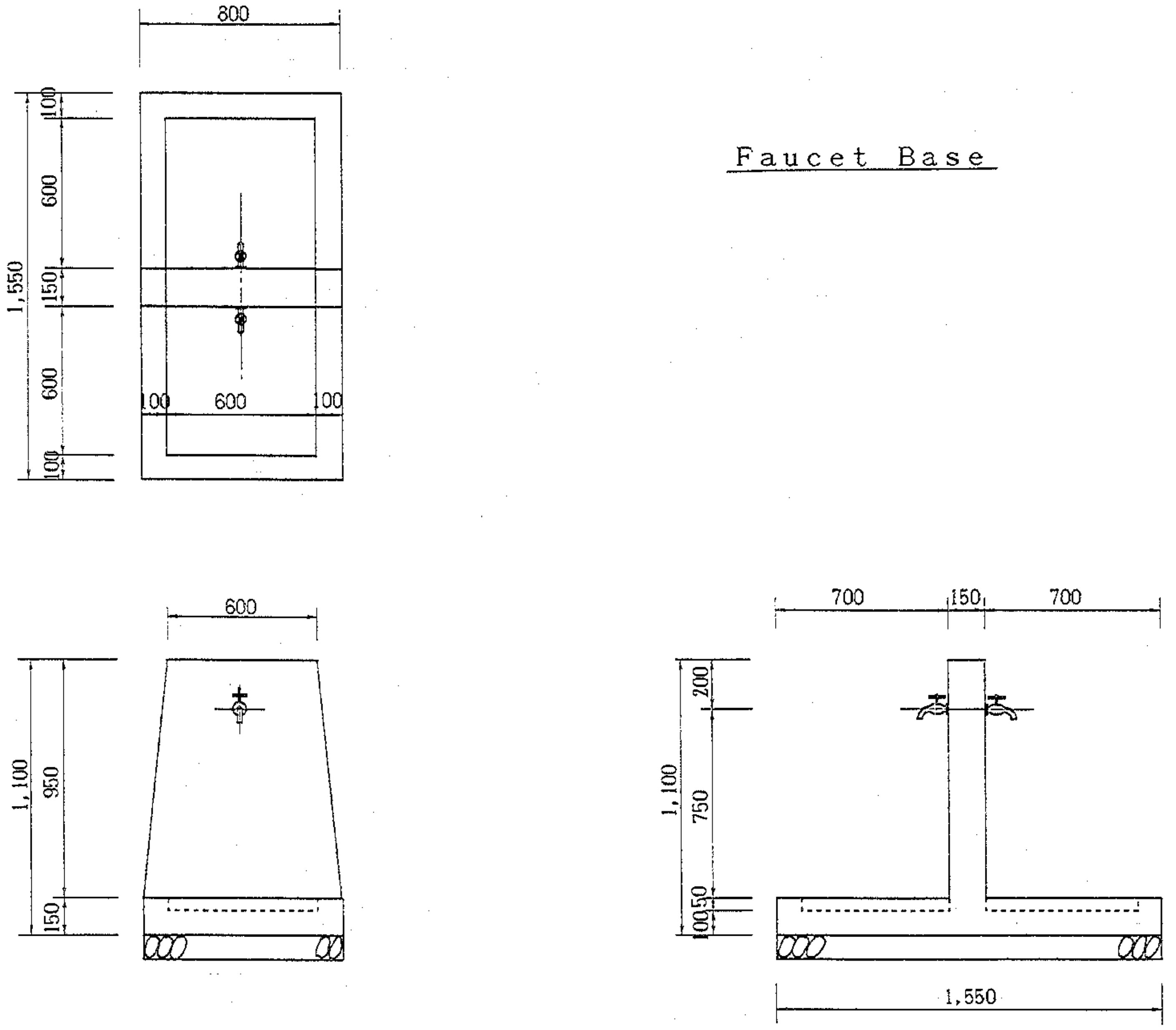
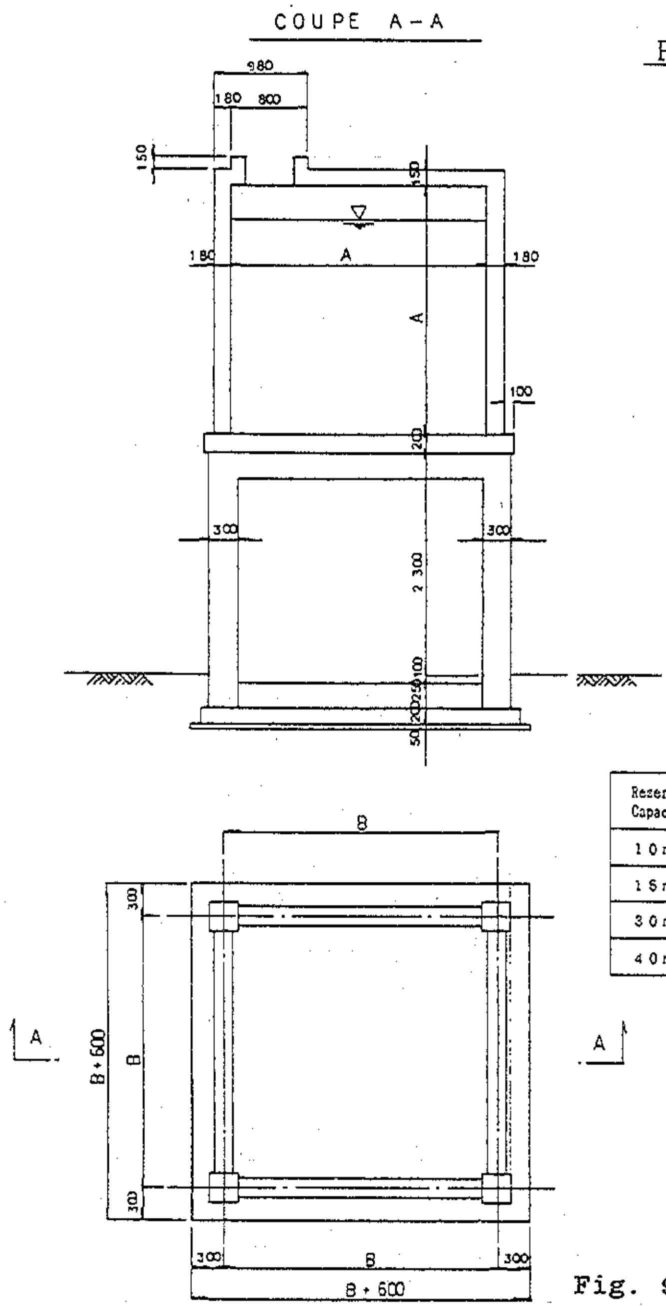
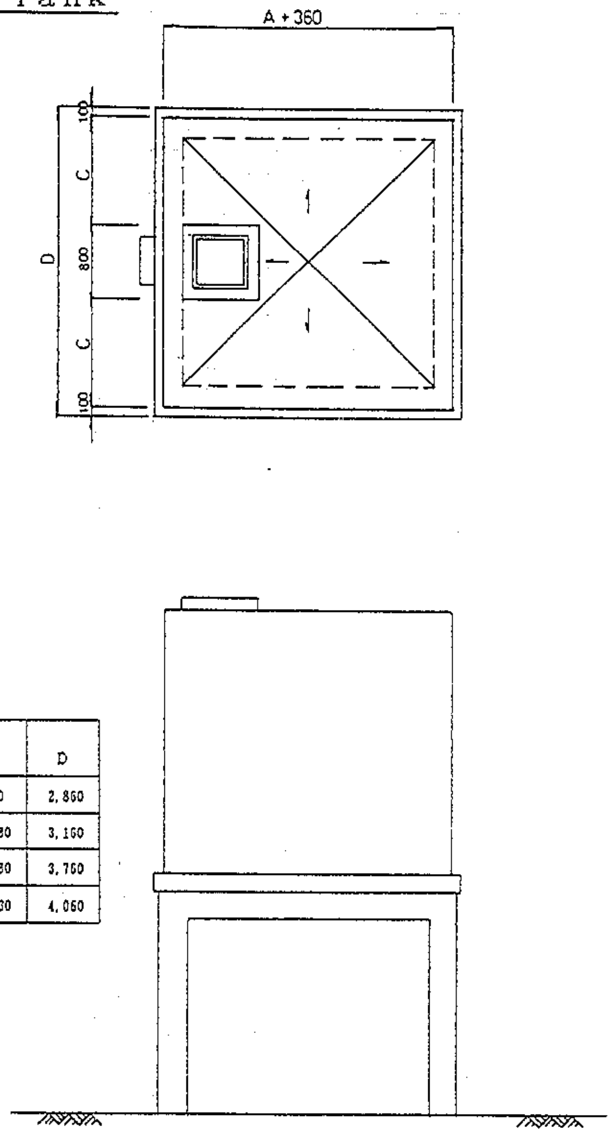


Fig. 9.2.1 Typical Design of the Facility(2)

Reservoir Tank





Reservoir Capacity	A	B	C	D
1 0 m3	2,300	2,480	930	2,860
1 5 m3	2,600	2,780	1,080	3,160
3 0 m3	3,200	3,380	1,380	3,760
4 0 m3	3,500	3,680	1,530	4,060

Fig. 9.2.1 Typical Design of the Facility(3)

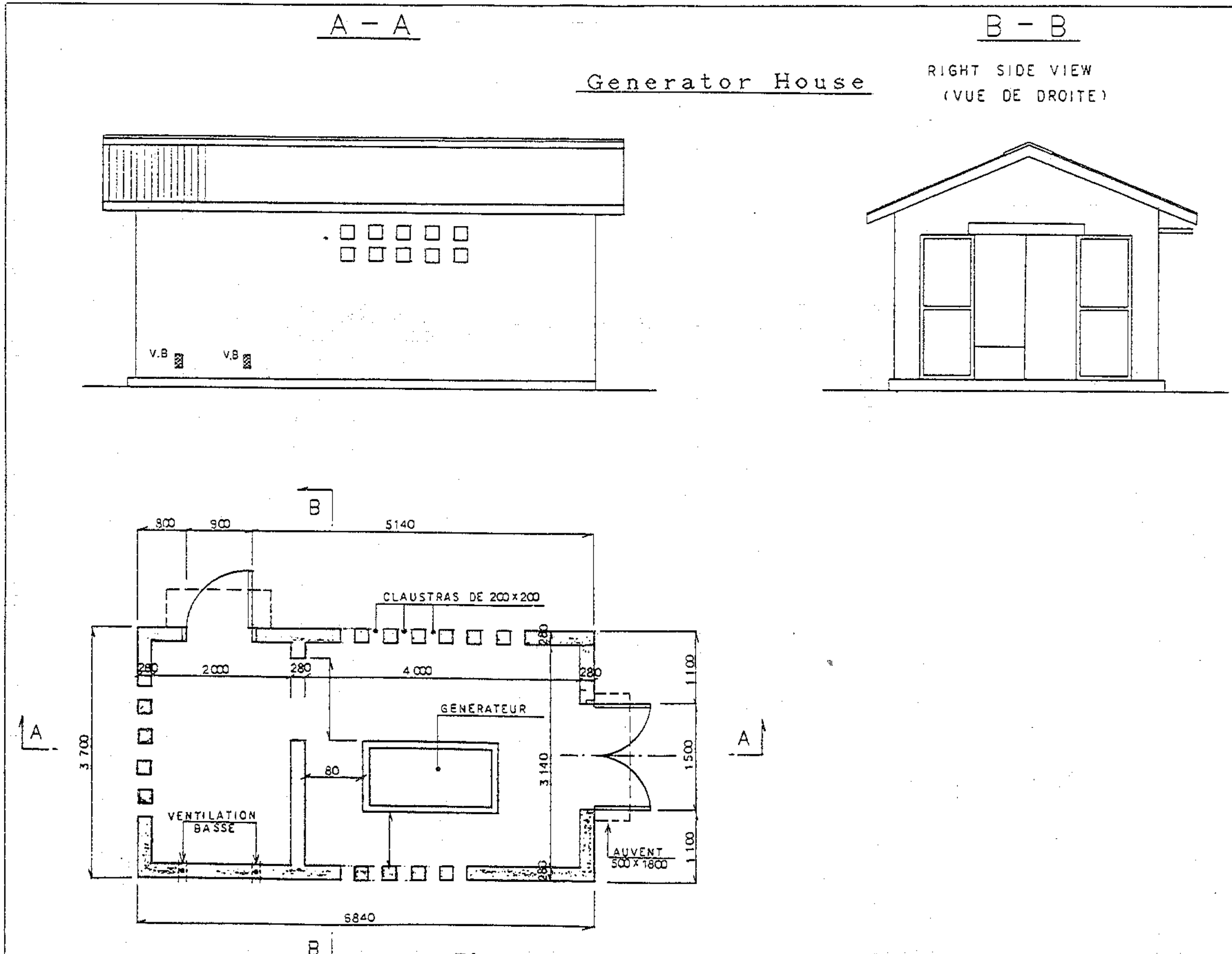


Fig. 9.2.1 Typical Design of the Facility(4)

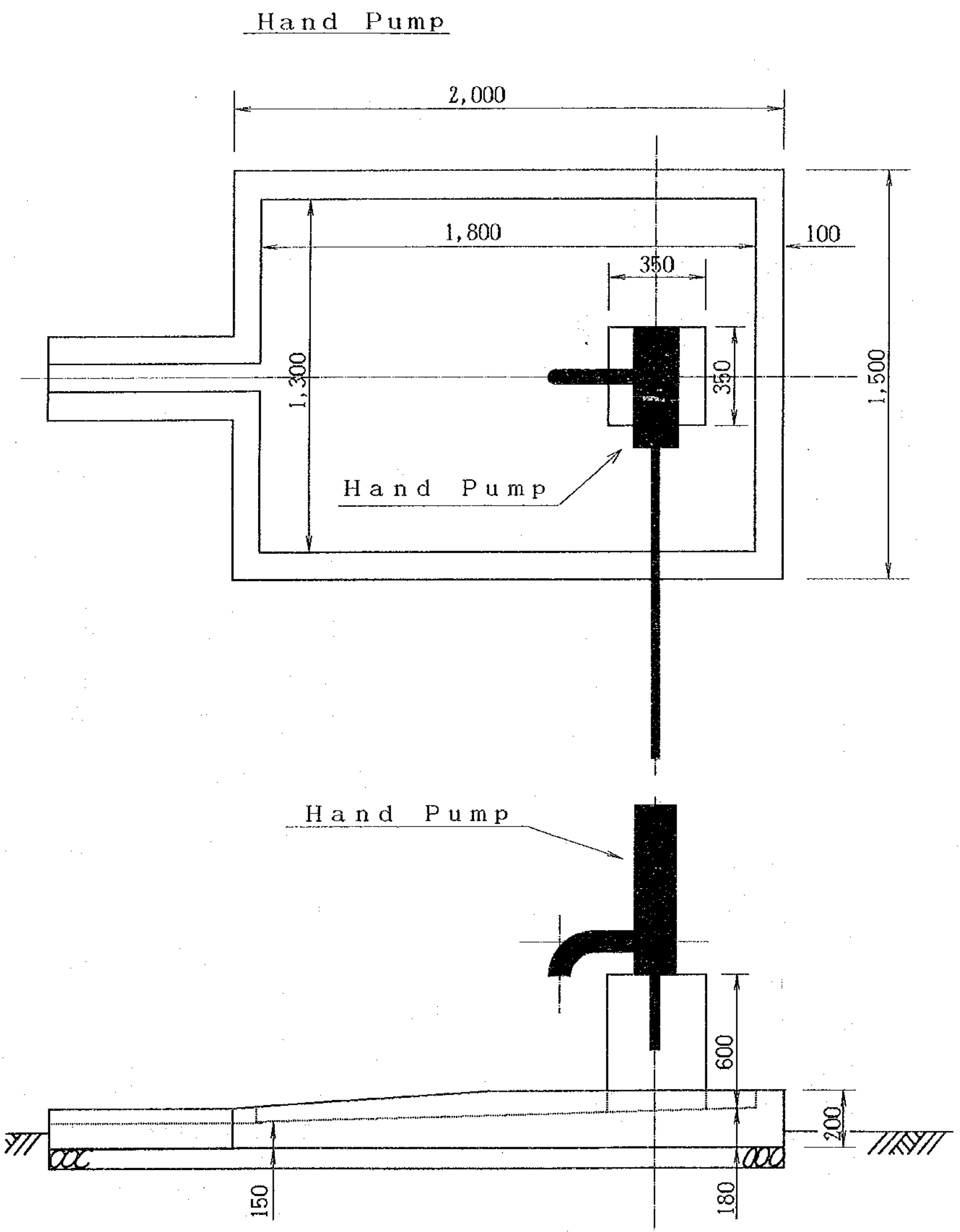


Fig. 9.2.1 Typical Design of the Facility(5)

9.3 Project Implementation

9.3.1 Basic concept

As already discussed, candidate villages are classified into 6 ranks according to their natural potential for groundwater development and socio-economic conditions.
Priority areas for project implementation consist of villages classified as Aa, Ab, Ba and Bb, for which project implementation plan was prepared.
Although water supply plans were prepared for villages with C and D rankings, implementation plan for C and D ranked villages should be formulated only after giving due consideration to other medium to large size villages existing in the Study Area.

9.3.2 Implementation Plan

(1) Implementing Agency

The Ministry of Industries, Energy and Mines(MIEM) would be the implementing agency of the Project, and the Bureau of Water and Hydrogeology of MIEM will be in charge of actual project management and coordination. The MIEM Toliara branch will assist project implementation, particularly in field construction supervision.

(2) Basic policy

Implementation of the proposed project is urgently required to solve safe water supply problems in the Study Area. At present, however, lack of financial and technical resources in the rural water supply sector hinders prompt self reliant implementation of the project, and assistance by external aid agencies is strongly required.
Circumstances are gradually becoming favorable now for self-help schemes. For instance, rural people begin to show willingness to participate in the project implementation and its operation and maintenance, accepting to share the necessary expenses.

MIEM possesses three drilling rigs with trained crews and supporting equipment/vehicles, enough to drill relatively shallow wells, of less than 150m. However, for the imple-

mentation of the proposed project, still the role of international aid, financially and technically, is of great importance and quite indispensable.
Therefore, it is recommended that most design, procurement and construction activities be carried out by foreign contractors hired and supervised by MIEM, utilizing funds from multilateral or bilateral cooperation.
However, certain field activities such as construction of waste water drainage ditches and fences around well will be undertaken by rural beneficiaries.

Considering the national target year of 2000, a short implementation period would be rather desirable for urgency of water demand. A period of 2 to 3 years may be a realistic minimum period required to provide a sufficient lead time for establishing a maintenance system and a strong back-up capability of MIEM.
A hasty implementation of the project is not wise from the viewpoint of keeping resource allocation balanced among several human or social oriented sectors.

Total implementation period consists of 2-phases as indicated in the next paragraph.
The sub-projects to be implemented in the first phase were selected from the high priority group, placing emphasis on regional urgency of water demand and difficulty of exploiting groundwater. Villages in Fiv. TOLIARA II, Fiv. SAKARAHA and Fiv. ANKAZOABO satisfy the above mentioned conditions, namely, scarcity of traditional water sources and quite deep aquifers.
The majority of handpumps installed on test wells are to be replaced with motorized pumps, so that testwells will become production wells. The replacement of pumps will be completed during Phase 1 and Phase 2 of project implementation. Fig. 9.3.1 shows the location of sub-project villages.

(3) Implementation schedule

A timetable with a likely duration of 32 months over 2 phases would be proposed for completing 50 sub-projects.

Although preparation for the project implementation is not mentioned in the schedule, the implementation cannot begin

until the proposed project has been approved by the Madagascar Government, financial resources have been secured, and a consultant engaged to prepare basic design and tender documents for selection of a contractor.
In the schedule, realistic allowance is provided for each step of the implementation process, design, preparation and approval period, tender evaluation, recommendation, negotiation and contract signature.

Critical activities throughout project implementation are those concerning deep tube well construction as follows.

- Procurement of a drilling rig and necessary equipment capable of boring deeper than 200m.

- Marine and inland transportation of equipments.

- Drilling work in predetermined fields.

- Well casing installation and well development.

Following table and Fig.9.3.2 shows the proposed project implementation schedule.

Table Summary of Project Implementation Schedule

Phase	Phase 1	Phase 2
Duration	18 months	14 months
No.of villages	17(Aa-Bb)	33(Aa-Bb)
Beneficiary		
-inhabitants	37,689	61,894
-cattle	6,000	2,000
No.of tube wells	6"x9;1280 m	6"x11;1560 m
to be bored	4"x4; 320 m	4"x22;1180 m
(Total depth)		
No.of facilities		
per category		
- DW	-	2
- W.HP	2	9
- MP	4	9
- W.MP and RH	11	12
- W.W	-	1

(5) Operation and Maintenance Program

(a) Organization and responsibility

As discussed in the water supply planning study, it is desirable that the operation and maintenance (O&M) system, which is a centralized system at first, be gradually shifted to the local, decentralized systems through three stages.

In the beginning system, beneficiary communities would organize water commitees and assign caretakers, mainly to operate the facilities and carry out routine, rather minor maintenance work.

The central organization, MIEM(Toliara), would technically back up water commitees with their mobile maintenance teams, particularly in major repairs.

Individual responsibility of the organizations involved in the O&M system would be as follows.

Table   Organization for Operation and Maintenance

Organization and/or Agency	Responsibility and task
Village-level:	
Village-wise Water Commitee and Caretakers	- Operation of facilities - Routine maintenance such as site cleaning, visual inspection of leak on pipe and reservoirs, maintenance of drainage, touch-up painting etc. - Management of pump operation and water service - Keeping a log-book - Emergency notification, if any, to MIEM as well as regular reporting - Collection of O&M fees from users
Central-level: (regional level) MIEM (Toliara Branch)	- Preventive maintenance by regular inspections - Repair work in the field and work-shop - Inventory control of spare parts - Data and information control - Training of caretakers
National-Level: MIEM (Head office)	- Monitoring of operation and maintenance activities - Overseas procurement - Training planning

(b) O&M cost and its allocation

An example of working capital which must be borne by beneficiary villages is as mentioned below.

Table Sample of Annual Recurrent Cost

Case	Cost Item	FMG/year
1. For hand pump-based supply system	Salary of caretaker	6,000
Estimation basis: population 300	Pump spare parts	70,000
	Transportation	20,000
	Other cost	10,000
	Total	106,000
	Cost per capita	353
2. For motorized pump-based supply system	Salary of caretaker	12,000
Estimation Basis: population 1000	Fuel oil	1,500,000
	Spare parts	500,000
	Transportation	40,000
	Other cost	50,000
	Total	2,102,000
	Cost per capita	2,102

The rural population is estimated to have the capacity to pay the cost estimated above.

(c) Investment and budget for support activity

A government agency, MIEM(Toliara Branch) would play an essential role to assist rural communities for maintaining water supply facilities. However, its support would be limited as it is assigned only a modest ordinary budget. The most important and urgent action to be taken by the government is strengthening the Garage and Workshop Department in MIEM(Toliara Branch).

(i) New mobile maintenance teams should be established in the Department.
One team should start their service within 1991, while the second team would start by 1994, following the proposed project implementation schedule.
Staffing and operating cost requirements of a team are shown below.

Team member	Person
- Mechanic	1
- Assistant Mechanic	1
- Clerk	1
- Driver	1

Operating cost (a year)	FMG/Year
- Salaries of staff	2,700,000
- Fuel oil (for regular patrol)	720,000
- Vehicle maintenance	1,000,000
- Stationery and others	20,000
- Insurance	300,000
Total	4,740,000

(ii) Investment for workshop

For metal work, installation and assembly work, the following machinery, equipment and tools should be provided to the workshop.

Machinery and Tools	Quantity
- Centre Lathe	1
- Hack Sawing Machine	1
- Upright Drilling Machine	1
- Electrical Bench Grinder	3
- Portable Electric Drill	2
- Hydraulic Jack	3
- Meter Testing Boards	1
- Electricians Tool Set	3 sets
- Mechanics Tool Set	3 sets
- Plumbing Tool Set	3 sets
- Work Benches with Vice	3
- Miscellaneous Hand Tools	3 sets
- Manual Oil Pump	3

9.3.3 Project Cost and Financing

As mentioned in Sub-section 9.3.2, implementation of the project is divided into two phases.

Although only tentative at this preliminary stage, the total investment cost required for the project is estimated at US$ 9,823,000 of which US$ 7,235,000 would be in foreign exchange and US$ 2,588,000 in local currency.

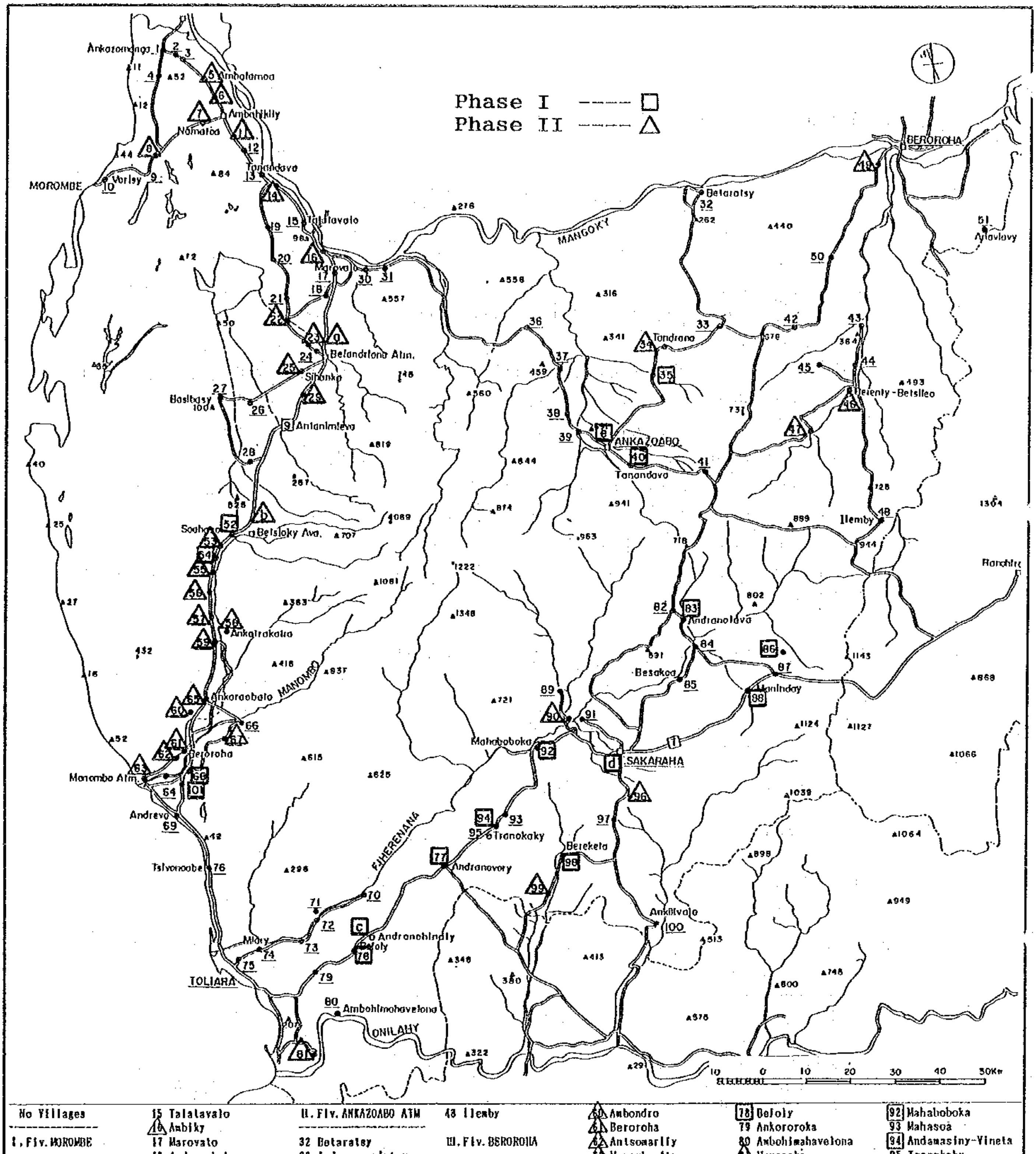
Considering the large investment cost anticipated for the project and the present financial situation of the Government of Madagascar, formation of a program for financing the project through external aid from multilateral or bilateral donor agencies is indispensable. Grant aid from foregin governments will be requested to cover the entire foreign exchange cost and a portion of the local currency cost of the project.

Anticipated investment cost for the project is as shown in following table.

Table Project Investment Cost

Unit: thousand US$

Component	Phase I	Phase II	Total
Civil Work	701	992	1,693
Boring Work	643	1,136	1,779
Equipment & Installation	745	769	1,514
Piping & Installation	422	450	872
Sub-total	2,511	3,347	5,858
Drilling Rig and Supporting Equipment/Vehicle	2,591	-	2,591
Engineering Service	408	268	676
Price Contingency	371	327	698
Total	5,881	3,942	9,823



No Villages

I. Fiv. MOROMBE

1 Ankazomanga
2 Beadabo
3 befasy
4 Ankilifolo(1)
5 Ambalamoa
6 Tsianihy
7 Namatoa
8 Mangolovolo
9 Ankida
10 Vorisy
11 Andranomanitsy
12 Berantala
13 Tanandava
14 Antsakoabe
15 Talatavalo
16 Ambiky
17 Marovato
18 Andranoboka
19 Satrambondro
20 Mahavozokely
21 Antranosatra
22 Manoy
23 Ampoza
24 Ankilifolo(2)
25 Sihanaka
26 Demoka
27 Basibasy
28 Analatelo
29 Mangotroka
30 Hosy-Amboaitra
31 Tsiarimpioke

II. Fiv. ANKAZOABO ATM

32 Betaratsy
33 Andranomanintsy
34 Tandrano
35 Ampandramitsetaky
36 Andranomafana
37 Mamakiala
38 Berenty-Ankilimasy
39 Betsinefo
40 Tanandava
41 Ampoza
42 Ipotsa Atm
43 Mandabe Atm
44 Soatanimbary
45 Sahanory Atn
46 Berenty-Betsileo
47 Ankilivalokely
48 Ilemby

III. Fiv. BEROROHA

49 Tanandava-Antalfasy
50 Anjamitikitra
51 Anaviavy

IV. Fiv. TOLIARA I/II

52 Soahazo
53 Analamisampy
54 Belitsaka
55 Ampasikibo
56 Namaboha
57 Antseva
58 Ankilimiavotoka
59 Ampihamy
60 Ambondro
61 Beroroha
62 Antsoamarify
63 Manombo-Atm
64 Antandroka
65 Ankaraobato
66 Andoharano
67 Tsefanoka
68 Benetsy
69 Andrevo
70 Anjamala
71 Ampihalia
72 Dehompy
73 Ambolonkira
74 miary
75 Befanamy
76 Tsivonoabe
77 Andranovory
78 Befoly
79 Ankororoka
80 Ambohimahavelona
81 Manoroka
101 Ankilimalinika

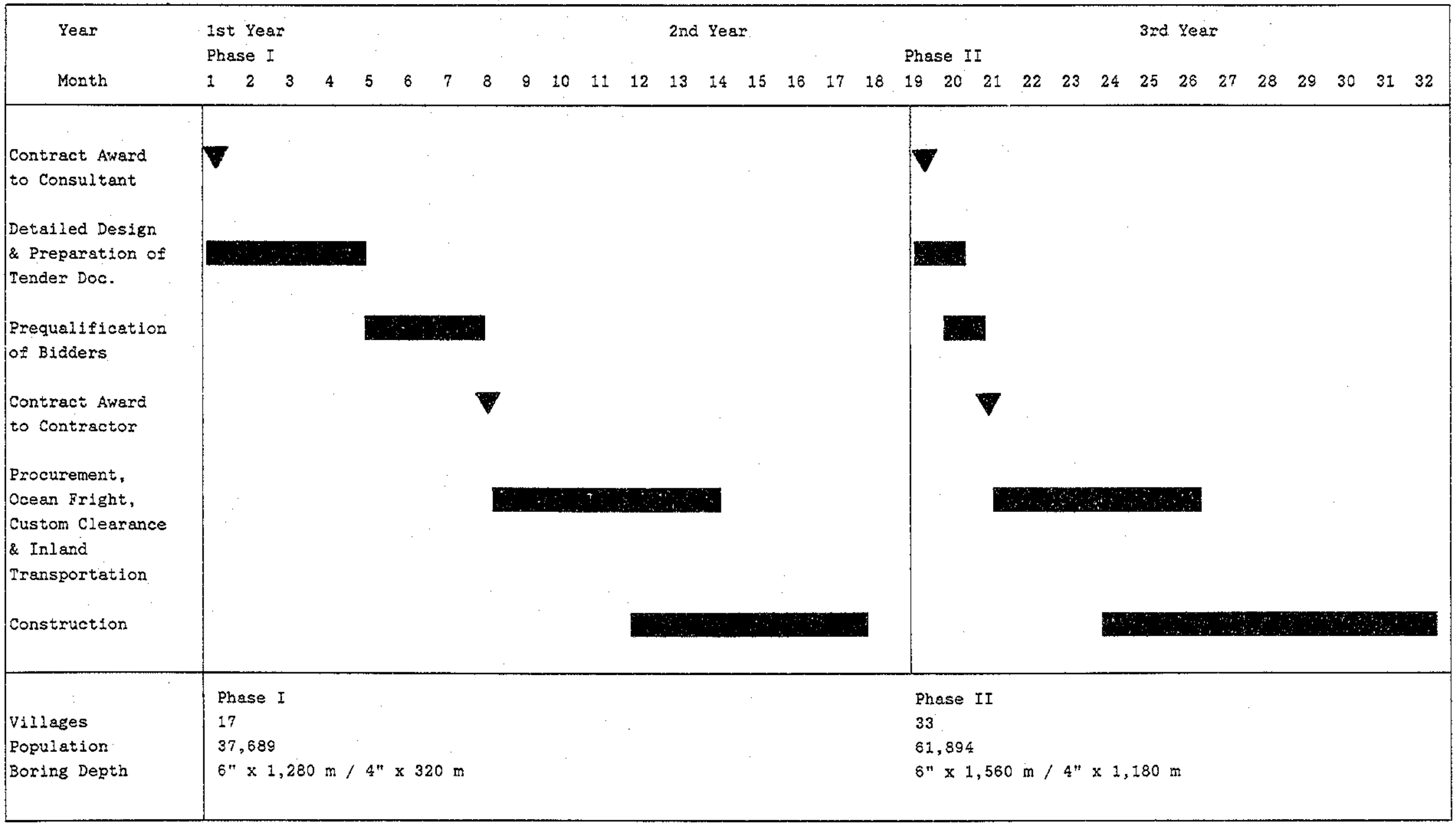
V. Fiv. SAKARAHA

82 Iaborana
83 Andranolava
84 Lambomakandro
85 Besakoa(1)
86 Besakoa(2)
87 Ampandra
88 Manindry
89 Bevoalavo
90 Tanambao
91 Ambahimalitsy
92 Mahaboboka
93 Mahasoa
94 Andamasiny-Vineta
95 Tranokaky
96 Analamary
97 Antanimora
98 Bereketa
99 Ankilimitraloka
100 Ankilivalo

a Befandriana
b Betsioky Nord
c Andranohinaly
d Sakaraha
e Ankazoabo

Fig. 9.3.1 Location of 50 Sub-projects

Fig. 9.3.2 Project Implementation Schedule



9.4 Project Evaluation

9.4.1 Beneficiary Villages

Supplying drinking water to small rural communities in Toliara Province appears to require no more justification than stating the fact of being the driest area of Madagascar with extremely poor surface water resources. Water shortage is so acute as to preclude village residents from adequately satisfying their demand for the most basic needs, i.e., personal hygiene. Worse yet, water shortage suffocates production possibilities, to the extent of making Toliara Province the lowest per-capita rice producer of all six provinces in the country. Therefore, the Government of Madagascar has accorded high priority to the development of the southwestern region, which includes Toliara Province.

Implementation of this project would increase provision of safe water supply to beneficiary villages by 1,995 cu.m per day. Since safe water supply in 1990 is estimated at only 131 cu. m per day, the benefits from this increased safe water supply is quite significant.

The beneficiary population is estimated at 76,016 in 1990, growing to 99,583 in the year 2000. The 1990 beneficiary population amounts to 21.4% of the population of five Prefectures, which totally or partially comprised the project objective area. These five Prefectures consisting of Toliara II, Morombe, Sakaraha, Ankazoabo and Beroroha had a combined population of 337,158 in 1988, which was estimated to have grown to 356,025 in 1990. The population of Toliara Province was estimated at 1,650,000 in 1990, and if the population served with water supply in Toliara I is estimated at 100,000, then the implementation of this project would bring the water supply served population up to around 10% of the entire Toliara Province population.

In practice, however, the number of beneficiaries will be considerably larger if proper account is taken of people passing through the village, and residents of nearby communities where some reason prevented installation of their own water supply facilities. In this regard, during the successive meetings held in different villages to organize the village water committees, great emphasis was placed on the need to share water with residents of neighbor villages.

9.4.2 Willingness to Pay (WTP)

(1) Survey on household WTP

A questionnaire survey was conducted in selected villages concerning the willingness to pay (WTP) of village residents for water supply services. On the assumption that housewives and children are the family members responsible for hauling water for the household, the survey attempted to directly ask individual housewives how much each household would be willing to pay for an improved water service.

It should be pointed out that "willingness to pay" presupposes "ability to pay", due to the survey method of obtaining question replies directly from respondents. In other words, it is assumed that respondents give their WTP answers by taking into account their financial capabilities.

Villages were selected from those assigned high and medium degrees of priority from hydrogeological and socioeconomic viewpoints (Aa, Ab, Ba, Bb), with three levels of stratification based on the size of the village population. Sample villages were classified as "small" when the population was under 1,000, "medium" when the population was between 1,000 and 2,500, and "large" when the population was over 2,500.

These three strata were designed to represent the "typical" villages in the Study Area. In addition, the interview survey was conducted in some "non-typical" villages, such as two villages which depended completely on purchased water (Befoly and Andranovory), and a village where the pilot facilities constructed during the Study would completely satisfy the village water needs (Tranokaky).

A total of 12 villages were selected, and 20 families in each village were interviewed individually. In two small villages, completion of 20 interviews turned out to be impossible. By using a structured questionnaire, the interviewee was asked, through several rounds, to think and make a choice on different sets of suggested amounts of money, leading to an open-ended question where he/she could freely state the amount he/she was willing to pay for water service. The willingness to pay data was collected from 223 families.

(2) Results of the WTP survey

Responses from households were used to estimate the average willingness to pay of each sample village. Survey results from each village are summarized as follows.

Village	WTP (FMG/fam./mo.)	Standard Deviation
Maninday	227	284
Ambolonkira	233	230
Ampasikibo	398	293
Beroroha	378	347
Soahazo	679	339
Ankilimalinika	478	447
Befoly	1,040	310
Andranovory	1,233	635
Tranokaky	763	578
Ankaraobato	855	719
Antseva	513	334
Mahaboboka	608	359

The above table presents survey results for villages paired on the basis of similar WTP. Maninday and Ambolonkira represent small villages, Ampasikibo and Beroroha medium size villages, Soahazo and Ankilimalinika large villages, Befoly and Andranovory villages totally dependent on purchased water, Tranokaky a village partially dependent on purchased water where a pilot water supply facility was constructed, while Ankaraobato, Antseva and Mahaboboka are villages where WTP was higher than expected in reference to population size. Unusual circumstances may explain higher than expected WTP in these villages, all stemming from urgent needs for safe water. Residents of Ankaraobato obtain water from irrigation canals, 80% of respondents in Antseva reported using salty water, and Mahaboboka depends on river water which turns turbid during the rainy season.

Since a test of hypothesis showed no statistical difference between the mean willingness to pay of paired villages under different categories, either of the paired values can be taken as the willingness to pay. However, to be on the safe side, the lower of the paired values is taken as the willingness to pay, as shown below.

Village type (population)	Willingness to pay (FMG/fam./mo.)
Small (under 1,000)	225
Medium (1,000-2,500)	375
Large (over 2,500)	475
Purchased water	1,040
Purchased water and rivers	760

By rounding up or down the WTP values, results from the questionnaire survey on the willingness to pay of village households can be summarized as follows.

Village type (population)	Willingness to pay (FMG/family/month)
Small (under 1,000)	200
Medium (1,000 - 2,500)	400
Large (over 2,500)	500
Purchased water	1,000
Purchased water and river	750

If the last two categories "purchased water" and "purchased water and river" are ignored as special cases, and the high and medium priority villages (Aa, Ab, Ba, Bb) are classified according to the population size, the monthly financial contribution to be expected from the 50 beneficiary villages of the proposed Project can be calculated. The survey for water supply planning determined accurately the population of each village. On the other hand, 7 was the average family size obtained from questionnaire survey of 223 households concerning willingness to pay. Then, the number of families in each village is estimated by dividing the village population by 7.

(3) Financial contributions based on WTP

The assumptions underlying the financial contributions from villagers are the following.

a) The Project is to start in 1991 with design works and procurement of drilling machinery, and the assumed Project life is 10 years.

b) Drilling and construction works will be implemented in 1992 and 1993.

c) Water supply and financial contributions will begin in

1993.

d) Financial contributions are based on the village population: 200 FMG per family per month from "small" villages (less than 1,000 people or 143 families), 400 FMG per family per month from "medium" size villages (1,000-2,500 people or 143-357 families), and 500 FMG per family per month from "large" villages (more than 2,500 people or 358 families).

e) Useful life of equipments are assumed at 10 years, with zero scrap value.

f) Motorized pumps are assumed to be operated 4 hours a day, 365 days a year.

g) Diesel fuel is estimated to cost FMG 422 per liter, the price level prevailing in November 1990.

h) The assumed exchange rate is 1US$=1,418FMG, the rate prevailing in November 1990.

The resulting financial contributions from villagers were estimated at US$44,000 per year after 1993. This amount would be enough to cover operation and maintenance costs of the Project, which were estimated at US$38,000 per year as detailed in Section 9.3. This case ssumes 100% contribution from village households. Being more realistic, assuming 10% of households cannot make financial contributions, the Project would still cover operation and maintenance costs.

However, if every village is looked at individually, there will be communities which will not be able to cover operation and maintenance costs. An example would be a small village with less than 1,000 inhabitants, where hydrogeological conditions determine installation of a water supply facility based on deep tubewell. In a case like this, a subsidy from a governmental or non-governmental organization would be necessary. Since the project as a whole can cover operation and maintenance costs, the problem of subsidies would not exist if a rural water supply corporation, similar to JIRAMA, is established. Then, this rural water supply corporation would collect the contribution from villages, resulting in a cross-subsidy from the financially strong villages to the poor villages.

On the other hand, according to the questionnaire survey, there are villages which are willing to contribute significantly more than the amount expected from their population size. In this regard, there will certainly be quite a few villages where their willingness to pay would cover not only recurrent costs, but also at least part of investment costs. Willingness to pay survey, if conducted in every village, would be able to clarify the real financial capabilities of the villages included in the Project.

Although the proposed maintenance system described in Chapter 8 envisages increasing participation of local administrative offices and residents, their responsibilities would be mostly in the area of operation and maintenance. Accordingly, the Government of Madagascar, through appropriations in the MIEM budget, should be responsible for the replacement of water supply facilities, which are viewed as social infrastructure of the country.

(4) Limitations

a) Estimated villagers financial contributions are based on willingness to pay, which was calculated using results of questionnaire survey from sample households in 12 villages. Ideally, questionnaire survey should be conducted in every village.

b) The disorganized layout of houses within villages made it difficult to draw random samples.

c) The characteristics of the "frame" from which to draw the samples were unknown.

d) Independent household opinions were difficult to obtain, particularly in small villages, due to the novelty of foreigners and the interview process, causing practically the whole village to gather around the interviewer.

e) Sample villages were selected on main roads and at a reasonable distance from Toliara City, so that the questionnaire survey in a given village could be completed in one single day.

9.4.3 Other benefits

(1) Human health improvement

Diarrhea was the third most important cause of outpatient consultation, hospitalization, and mortality in hospitals for both Toliara Province and Madagascar in 1987. However, the percentages of diarrhea and other digestive ailments were higher for Toliara Province than for Madagascar under the categories of outpatient consultation (9.0% and 8.4%), hospitalization (7.9% and 6.6%), and mortality in hospitals (7.4% and 7.0%).

In addition, the percentage of hospitalization due to bilharziasis or schistosomiasis in Toliara Province was three times higher than the national average: 2.8% against 0.9%. Also, during the detailed survey of candidate villages, 35 of them reported as being affected by bilharziasis. Of these 35 villages, 19 (54%) will benefit from improved water supply facilities to be provided by the Project.

The above data indicate that Toliara Province is worse off than the whole country as far as water-borne and water-related diseases are concerned. Although the productivity effects of improved health are difficult to quantify, there is no question that provision of safe drinking water will result in lower incidence of water-borne and water-related diseases, leading to better health, and consequently to improved well being and more productive life.

(2) Time saving

The national water policy aims at providing rural water supply facilities in such a way that, for any family, one round trip to the water source takes no more than 15 minutes. However, within the Study Area, residents of many villages had to fetch water from far away sources, due to the lack of water source, in the village, or the poor quality of local water source, such as wells with salty water. An extreme example was given by Soahazo, where residents depended on a water source located 6km away, having to resort to ox carts to bring water in 200-liter drums.

If conveniently located water supply facilities are installed, the benefits to be obtained from the saved time, that otherwise will have to be devoted to hauling water, depend on the availability of work alternatives to productively use the saved time. These work alternatives are yet to be created in the Study Area. However, there is no doubt that the time saving will benefit housewives and children, who shoulder the bulk of water hauling task for the family. It is entirely possible that children are sacrificing study time, or completely giving up going to school for the sake of hauling water. The time saving, in conjunction with appropriate education programs, can help to improve the social status of women. As a matter of fact, education programs can be designed to encourage increased women participation in community affairs, or to induce women to assume a leadership role in hygiene matters.

The actual benefits of time saving can only be ascertained on an ex-post evaluation, that is, some time after the water supply facilities are in operation. This implies the need for a detailed ex-ante evaluation, so that a careful comparative study can be conducted on the time use pattern of women and children before and after operation of water supply facilities.

(3) Reduced expenses

Some villages along route 7, such as Befoly, Andranovory and Andranohinaly do not have water sources at a reasonable distance, having to depend completely on water sold at 2,500 FMG to 4,000 FMG per 200-liter drum. A typical family reportedly buys a drum of water every two to three days, or at the very least once a week. Then, a typical family will have to spend between 10,000 FMG and 40,000 FMG a month just on water. It appears that the household expense on water comprises an inordinately high proportion of household total income.

If deep tube wells are drilled in Befoly, Andranovory and Andranohinaly, even if the village residents pay for the operation and maintenance costs, instead of purchasing water, a considerable amount of money can be saved. These savings from reduced expenses could be used for productive purposes. Direct benefits will accrue to the estimated 700 to 800 households in Befoly, Andranavory and Andranohinaly. Assuming they contribute 1,000 FMG per month for the operation and maintenance, instead of spending 10,000 FMG per month on water purchased during 6 months of the dry season, the savings for the residents of the three villages are estimated at around 40,000,000 FMG per year.

(4) Community development

During the field work of the Study, a great deal of time and effort were put into explaining the role of the village water committees so that the villagers could actively participate in the operation and maintenance of water supply facilities. This kind of endeavor has no precedence in the Study Area, and if the villagers acquire enough experience and confidence, it may turn into an engine of growth through the undertaking of similar self-help projects.

(5) Development of the rural water supply sector

As explained elsewhere, the rural water supply sector is unfortunately weak in terms of financial, technical and institutional capabilities. This project may become the means to shed light on the urgent needs of the rural water supply sector, thereby helping to appropriate the resources required to strengthen the sector financially, technically and institutionally.

9.4.4 Overall Evaluation

The Project is designed to satisfy basic human needs of people living in a environment were the climate is harsh and where economic opportunities are yet to be developed. Specific merits of the Project are the following.

(1) Operation and maintenance costs of the Project as a whole can be covered even assuming financial contributions from 90% of households.

(2) The health improvement benefits would be considerable, since the project area shows a higher incidence of digestive ailments and schistosomiasis than the country as a whole.

(3) Implementation of the Project will alleviate the hard work performed by women and children, fetching water for the family.

(4) Savings from reduced expenses by 700 to 800 families, that live in three villages completely dependent on purchased water, would amount to an estimated 40,000,000 FMG per year.

(5) Community participation in the management of water supply facilities is expected to induce similar communal efforts which would lead to community development.

(6) Implementation of the Project is expected to lead the way for the strengthening of the the rural water supply sector.

10. CONCLUSIONS AND RECOMMENDATIONS

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10.1 Conclusions

10.1.1 Groundwater Potential

As the final results of comprehensive analysis and evaluation on hydrogeology, a hydrogeological map of the Study Area was completed in Phase III of the study, with a particular focus on the potentiality of groundwater resources.

As shown in this hydrogeological map, the potential of groundwater resources in the Study Area is generally high, except in some areas where hydrogeological conditions and water quality are poor. The groundwater potentiality in the Study Area is expected to be sufficient in capacity, not only to overcome existing shortages of drinking water, but also to develop future agricultural or industrial activities in some high potential areas. Main high potential areas which were confirmed from the results of test drilling in this study are as follows.

Area	Specific capacity (m^3/day/m)
Befandriana	438.58
Sihanaka	232.26
Analatelo	7,224.00
Mangotroka	281.35
Soahazo	173.33
Manombo Atm	609.23
Toliara*	3,057.00

* Limestone aquifer in the eastern area of Toliara as Miary and Manoroka

10.1.2 Social and Economic Potential

In this study, a detailed survey on existing conditions of individual communities was conducted in order mainly to understand and investigate the community need for safe water and the community's positive participation in maintaining the future water supply facility, financially and institutionally.

As a conclusion, this detailed survey confirmed the following.

1) In general, the majority of candidate villages in the Study Area have several traditional water sources, natural and artificial, within their living area or in the neighborhood. However, the water is not necessarily safe for domestic use mainly due to probable bacteriological contamination.

2) More than 30 candidate villages reported as suffering from schistosomiasis, which is hard to wipe out in practice because of the difficulty to effectively control the snail population in the stagnant water.

3) In several villages on route 7, an absolute shortage of water for domestic use is observed. These villages depend solely on the delivery from water vendors who charge unimaginable high prices, i.e. 2,500 to 4,000 FMG per drum (200 liters).

4) Because of the above mentioned existing conditions of water sources for domestic use, the resulting order of priority for community need for safe water was as follows.

Degree of priority	No. of village	Population
I (High)	40 (41.7%)	64,719(62.6%)
II(Medium)	31 (32.3%)	27,419(26.5%)
III(Low)	25 (26.0%)	11,308(10.9%)
Total	96	103,446

5) In villages with I(high) and II(medium) rankings in the above mentioned community need for safe water, the majority of inhabitants have keen interest and enthusiastic willingness to participate in maintaining water supply facilities, and also they might be reasonably solvent, with rather positive willingness to pay for a water supply service.

6) Large communities on route 9 and medium size communities on route 7 may have sufficient solvency to cover not only recurrent costs but also a portion of capital costs.

7) The accuracy of these considerations were confirmed through several field survey and actual establishment of operation and maintenance systems for the pilot water supply facilities.

10.2 Recommendations

10.2.1 Groundwater Development and Management

(1) Effective Data Collection and Utilization

Basic data for the evaluation of groundwater resources are meteorological data, hydrogeological data, groundwater level records and borehole data (geological maps, logging records, pumping test records, hydrological data). These data should be collected continuously in the future and be input into the data base system established at the MIEM Toliara Branch Office. The necessary cooperation from governmental and other agencies concerned are desirable and hereby requested. In addition, in the future, legal and regulatory investigation is desired for groundwater management on a national level.

(2) Continued Observation of Discharge and Water Level

It is necessary to continue the observation of river system discharge and groundwater level carried out in this study. The facilities for discharge observation are not functioning well at many stations. In order to continue these observations, it is necessary to basically examine and assess the facilities of the entire Study Area.

(3) Groundwater Exploration

The success of well drilling depends on the results of the groundwater exploration. The drilling sites must be chosen based on the results of detailed hydrogeological survey and geophysical prospecting. This procedure offers positive results in drilling and is effective by its low cost. It is strongly recommended to drill boreholes of more than 250m for the success of groundwater development in the area of limestone plateau along route 7.

(4) On-the-Job-Training

Groundwater development has its own comprehensive technology with complex and far-reaching components, thereby making vast knowledge and experience essential. Consequently, a necessary condition for the groundwater engineer is that he/she possess the technology which corresponds to the specialized fields of groundwater exploration, well drilling, pumping test, quantitative analysis, development and monitoring. In the future, it is expected that the concerned agencies choose the proper personnel for the detailed design stage and the construction stage of the Project, in order to bring up the level of the engineering staff through on-the-job-training.

10.2.2 Implementation of the Water Supply Project

(1) Management of groundwater resources

Groundwater is a precious natural resource for the area in which it exists. It is a resource which might be developed and managed by experienced and knowledgeable inhabitants of the area. It is desirable that research and discussions on utilization and management of groundwater resources be conducted throughout the project implementation.

(2) Project implementation

It is judged that the proposed project is feasible from technical and socioeconomic viewpoints. It is also judged that the project has a high priority considering the natural and socioeconomic condition of the area. Therefore, early implementation of the project is strongly recommended.

(3) Operation and maintenance

It is recommended that the daily operation and maintenance be carried out by the water committee composed of the village inhabitants. It is also desirable that the MIEM Toliara Office strengthen its financial and technical base in order to be able to provide the necessary assistance for the operation and maintenance of water supply facilities in the medium to large size villages.

10.2.3 Women Participation in Development

(1) Water for the family

Securing adequate water supply for the family demands tremendous amounts of time and energy, especially in the semi-desertic area of southern Madagascar. The heavy task of fetching water for the family is usually the responsibility of women and children. Construction of easily accessible water points has the potential to give women plenty of free time, which can be effectively utilized to increase women's participation in social and economic activities.

(2) Training and education programs

It is recommended that MIEM take the initiative, with the assistance of appropriate government and non government organizations, to set up training and education programs in beneficiary villages. These training programs should be designed so as to take advantage of the potentially free time, which the project implementation would make available to women. Suggested areas of training are women participation in community affairs, leadership role of women in sanitation and hygiene matters, and craft and cottage industries for women. Effective training programs in these areas will mobilize powerful, and so far untapped resources for socioeconomic development of rural communities.

10.2.4 Sanitation

(1) Status of village sanitation

Implementation of the Project will require continued monitoring and actions on the following sanitation aspects:

- consumption of water from new improved sources;
- drainage of water spilled around wells; and
- in the long-run, as water consumption increases, disposal of domestic waste water.

One finding from monitoring pilot water supply facilities showed that water consumption from improved sources decreased to half in the rainy season. This implies that villagers go back to traditional water sources, when these are plentiful, rather than using better quality water. This regrettable outcome reflects lack of awareness on sanitation, and will diminish the expected benefits from implementing the Project.

Likewise, a common sight of the few remaining US AID built wells with handpumps was the pool of mud surrounding the base of the pump. Villagers faced not only the inconvenience of having to step into the mud to get water, but also running the risk of contaminating the just-pumped-up well water by splashing or dropping mud into the water container. Worse yet, seepage of polluted mud water over the long-run may end up contaminating the aquifer. The same problem may arise in connection with domestic waste water, when water consumption increases sufficiently.

(2) Improvement of village sanitation

Wells to be built through the Project will be designed with appropriate pump bases so as to minimize the chances of mud pools being formed around wells. In addition, the village Water Committee and Care-taker should be instructed to keep the drainage around the well in good working condition.

However, the most effective way to deal with the sanitation matters described above is to improve the population awareness on sanitation. Then, a widespread education campaign is called for, targetting school children, patients of health-care centers, housewives and the general population.

The education should focus on the importance of clean water, avoidance of contaminated drinking water, actions that individuals can take to prevent water contamination, simple measures applicable before using unsafe water, and methods for appropriate disposal of waste water. The content of the required education implies the need for a cooperative effort between MIEM, Ministry of Education and Ministry of Public Health.

Sanitation is an integral component of water supply projects. Accordingly, full benefits from water supply projects can be expected only when sanitation matters are given due considerations, and appropriate countermeasures are taken.

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CARTE HYDROGEOLOGIQUE DE MADAGASCAR (1) RÉGION DU SUD-OUEST
HYDROGEOLOGICAL MAP OF MADAGASCAR (1) SOUTH-WESTERN REGION