

NATIONAL DIRECTORATE OF WATER
REPUBLIC OF MOZAMBIQUE

No.

**BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR GROUNDWATER DEVELOPMENT
FOR
RURAL WATER SUPPLY
IN
ZAMBEZIA PROVINCE
IN
THE REPUBLIC OF MOZAMBIQUE**

MARCH 2001

**JAPAN INTERNATIONAL COOPERATION AGENCY
PACIFIC CONSULTANTS INTERNATIONAL**

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01-070

PREFACE

In response to a request from the Government of Republic of Mozambique (GOM), the Government of Japan decided to conduct a basic design study on the Project for Groundwater Development for Rural Water Supply in Zambezia Province and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Mozambique a study team from October 22 to December 10, 2000.

The team held discussions with the officials concerned of GOM, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Mozambique in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of GOM for their close cooperation extended to the teams.

March 2001

Kunihiko Saito
President
Japan International Cooperation Agency

March 2001

LETTER OF TRANSMITTAL

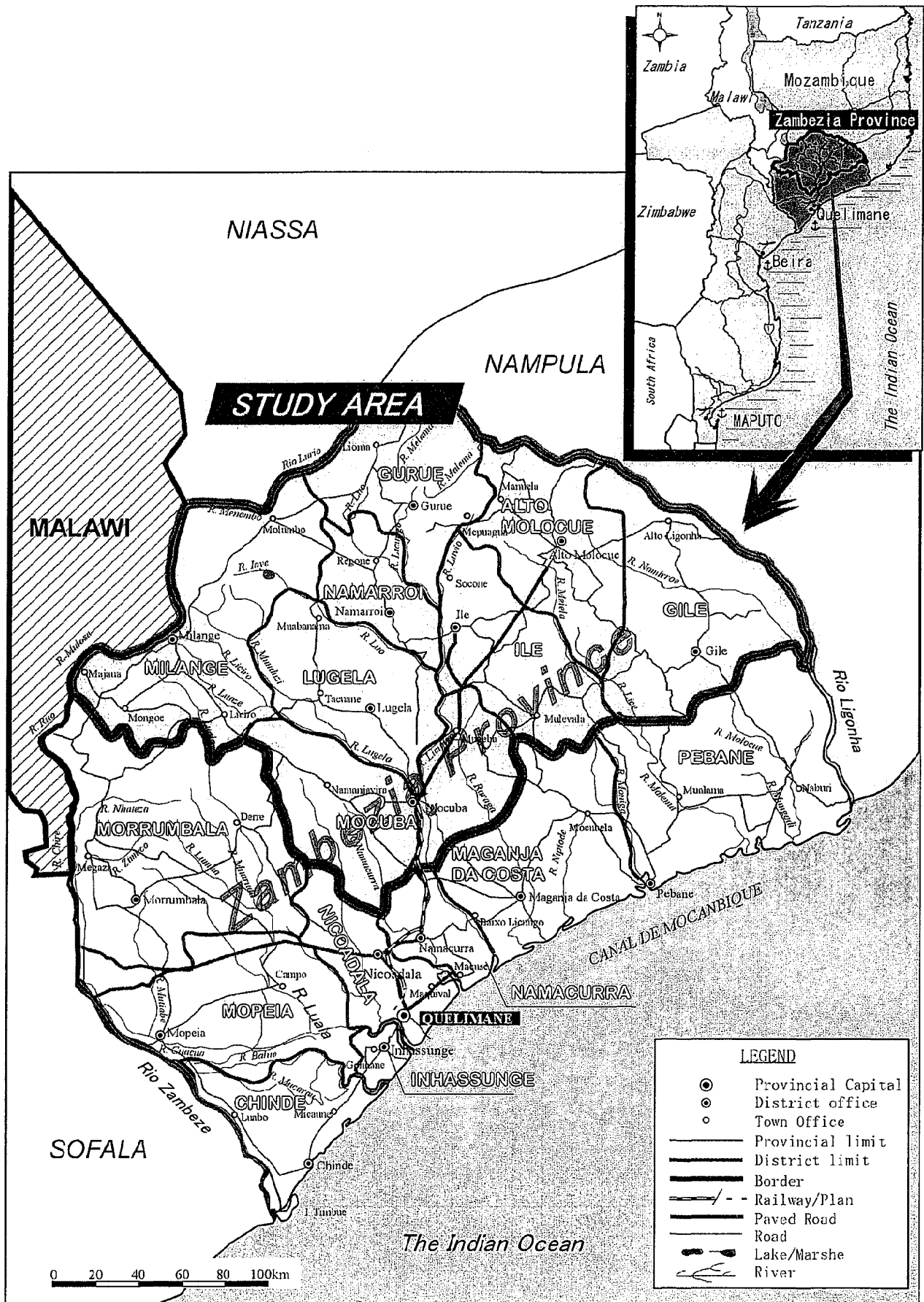
We are pleased to submit to you the basic design study report on the Project for Groundwater Development for Rural Water Supply in Zambezia Province in Republic of Mozambique.

This study was conducted by Pacific Consultants International, under a contract to JICA, during the period from October 16, 2000 to March 30, 2001. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Mozambique and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Soichiro Yumoto
Project Manager,
Basic Design Study Team on
the Project for Groundwater Development for
Rural Water Supply in Zambezia Province
Pacific Consultants International



PROJECT LOCATION MAP

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Abbreviations

MFAC:	Ministry of Foreign Affairs and Cooperation
MOPH:	Ministério das Obras Públicas e Habitação
DNA:	Direcção Nacional de Águas
DAR:	Departamento de Água Rural
DGRH:	Departamento de Geografic e Recursos Hídricos
DPOPH:	Direcção Provincial das Obras Públicas e Habitação
DAS:	Departamento de Água e Saneamento
EPAR:	Estaleiros Provinciais de Água Rural
PEC:	Participação e Educação Comunitaria
UNICEF:	United Nations International Children's Emergency Fund
CFPAS:	Centro de Formação Profissional de Águas e Saneamento
VLOM:	Village Level Operation and Maintenance
DTH:	Down the Hole
OJT:	On the Job Training
PVC:	Polyvinyl Chloride
JIS:	Japan Industrial Standard
BS:	British Standard

CHAPTER 1
BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

The Republic of Mozambique is situated in the south-eastern part of the African continent, of which land area is measured to be 799,380 km². The country's population is estimated as 15.7 million in 1997. The Zambezia province located at the south end of the north hilly area extending north of the Zambezi river, the largest international river in the country. The northern part of the province is generally hilly, while the southern low laying alluvial land along the coast is flat. The Project area of the northern eight (8) districts of the province extends 300 km from east to west and 180 km from north to south, and its area is measured to be about 54,600 km². The altitude of the Project area varies from 200 to 300 m in the southern hilly area but in the northern areas it exceeds 600 m.

The economic reform of Mozambique has been implemented with a support from IMF in 1987, and based on the Economic Reform Program (ERP) various reformation measures such as deregulation, privatization of government companies, cutback in foreign debt and financial deficit, abolish of subsidy, etc. have been carried out realizing a shift to floating exchange rate system and economic liberalization. Since 1998, the reform of each sector has been implemented in accordance with the sector programs. As for the water supply sector, the reformation is carried out in accordance with the National Water Policy (NWP) established in 1995. The rural water supply sector is considered to be the most important issue in the program, since the population who has an access to safe water is estimated as low as about 30 %.

The water supply situation of the rural areas in the Zambezia province is considered poor, and the service rate in the Zambezia province is about 14 % quite low comparing with the average value of the whole country. In the five year plan from 2000 to 2004, such low service rate is aimed to be improved to 30 %, the average of the whole country. Especially in the northern eight districts such as Gurue, Alto Morocue, Namarroi, Ile, Milange, Gile, Mocuba and Lugela, many wells were damaged and abandoned during the civil war, and the people in the province take their domestic water from springs and streams that run around their houses. According to the database of the Ministry of Health, peoples as many as 59,000 and 9,600 suffer from diarrhea and dysentery in 2000, respectively, and the improvement of water supply situation is considered as one of the urgent issues from the viewpoints of hygiene and sanitation.

Under these situations, the Government of Mozambique selected the northern eight (8) districts of which water supply situation is considered poor in the province, and requested to the Government of Japan i) to construct 150 tubewells and ii) to replace handpump units of the existing 30 wells in the these districts as well as iii) to provide equipment and materials necessary for these construction in order to improve the water supply situation in the area. This report presents the results of the basic design study carried out for the requested construction and rehabilitation of tubewells and procurement of necessary equipment and materials.

CHAPTER 2
CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Objectives of the Project

The Main Objective of the Project for Groundwater Development for Rural Water Supply in Zambezia Province in the Republic of Mozambique (hereinafter referred to as the Project) is to improve the water supply situation as mentioned below;

- Improvement of the water supply service ratio from 14% to 16% and life environment in the northern part of 8 districts
- Establishment of suitable operation and maintenance structures by the community inhabitants
- Capacity building of EPAR, in charge of construction works on well facilities, and other public authorities concerned in Zambezia

2.2 Basic Concept of the Project

(1) General

<Zambezia Province>

There are many projects having been implemented in Mozambique, and most of them are concentrated in the areas near Maputo located south of the Zambezia River. Consequently, the provinces located north of the river have been considered those left behind such development progress. There is no bridge crossing over the river except for that located near Tete, and they have to pass the territory of Malawi after crossing the river to reach the provinces located north of the Zambezi River. This difficult situation in transportation is considered to cause the backwardness of development in these provinces. The development progress of basic infrastructures such as railway, road and water supply facilities in these provinces are considered behind those in the provinces near Maputo located south of the Zambezi River, which have been considered as the disparity between both areas. The shortage of human resources and the less quality of the organizations that are responsible for facilitation of self-efforts of rural peoples are found to be one of the problems and their improvement and reinforcement are considered to be the urgent tasks in these provinces.

<Present Situation of the Rural Water Supply>

The water supply situation in rural areas of the Zambezia province is considered quite poor, and the service ratio of the whole rural areas of the province is 14 % which is considered low comparing with the average value of the whole country. According to the database of DPOPH-Zambezia, about 1,500 wells are registered including both shallow and deep wells, and most of them are considered to be constructed before civil war during the colonial period. Many wells were destroyed during the civil war and being left without any repairing. Out of 1,500 wells registered, one third equivalent to about 520 wells are situated in the eight (8) hilly districts, and the rests about 1,000 wells are situated in the other districts in the southern coastal areas. Especially in the northern eight (8) districts are so hilly that many operations of guerrilla fighting were carried out, and as a result, most of the wells and tubewells have been left without any repairing. Peoples in these districts take their water in small streams, springs, hand holes near their residences.

Annual occurrence of diarrhea and dysentery considered as one of the typical water borne diseases reaches about 59,000 and 9,600 according to the database of the Ministry of Health. Under these situations, the improvement of water supply situation is considered to be one of the urgent hygiene improvement programs in the province.

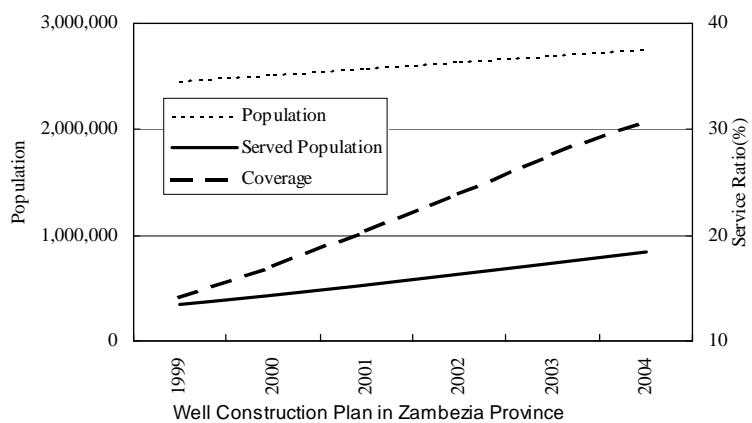
The design matrix of the Project is summarized in the following table.

Project Design Matrix

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal Improvement of rural water supply situations in Mozambique	Rater of water supply service	National statistics	Stable national economy Continuation of National Water Policy
Project Purpose Increase of rate of water supply service in the Zambezia Province	Served population, service areas and number of tubewells in the Zambezia province	Annual report of DAR and DA/EPAR	Continuation of Rural Water Transition Plan by DAR
Outputs Stable supply of safe water to the rural population	Progress of construction of water supply facilities Served population in the 8 districts Situation of management of constructed wells	Annual Report of EPAR, Monthly report of construction company, well registration, annual report on PEC activities, activity report of operation and maintenance group	Continuation of rural water supply projects by DAS/EPAR
Activities Construction of water supply facilities (150 new tubewells, replacement of handpumps of the existing 30 wells) Proper management of equipment and materials for groundwater development	Inputs		Capacity of executing agency Understandings and participation of villagers in construction, operation and maintenance and water charge collection Pre-conditions Proper human resources Agree to CBM activities Stable condition of security
	Japanese Side* Procurement of equipment and materials Equipment for drilling boreholes Geophysical survey equipment Construction of water supply facilities Transfer of knowledge Facilitation of rural peoples	Mozambiqan Side** Construction of water supply and drainage facilities Operation and maintenance Facilitation of rural people	
Remarks:	*: Covered by Japanese Grant Aid **: Undertakings of Mozambique		

(2) Rural Water Supply Plan

DPOPH-Zambezia aims to improve the service ratio of rural water supply in the province to about 30 %, the average level of the whole country by 2004 as illustrated in the figure. To achieve this aim, 574 shallow wells and 435 tubewells are planned to be constructed in the whole of the province. As shown in



the following table, 364 and 210 tubewells totaling 574 are planned to be constructed in the northern eight (8) and the southern nine (9) districts, respectively, and in the northern eight (8) districts, the tubewells of 60 - 80 numbers are planned to be constructed.

Tubewell Construction Plan in the Zambezia Province (2000 - 2004)

District	2000	2001	2002	2003	2004	Total	District	2000	2001	2002	2003	2004	Total
Grue	11	7	10	12	10	50	M. Costa	18	4	6	6	6	40
Ile	4	13	13	9	10	49	Pebane	10	6	7	6	4	33
Namarroi	22	10	9	10	7	58	Morrumbara	0	6	6	10	7	29
A. Molocue	0	9	10	12	9	40	Mojeia	0	4	4	7	4	19
Gile	0	8	10	13	12	43	Namacura	7	3	6	4	4	24
Lugera	16	7	12	9	9	53	Inhasunge	0	4	6	4	7	21
Mocuba	0	7	7	7	9	30	Sindi	0	7	4	7	7	25
Milange	11	7	6	9	8	41	Nicodala	0	4	3	6	6	19
-	-	-	-	-	-	-	Quelimane	0	0	0	0	0	0
North 8 D.	64	68	77	81	74	364	South 9 D.	35	38	42	50	45	210
							Zamvezia P.	99	106	119	131	119	574

(3) Confirmed Contents of the Request

According to the request of the Government of Mozambique dated June 1999, the following items are requested.

- Procurement of well drilling rigs and related equipment, operation and maintenance vehicles, and geophysical survey equipment including spare parts.
- Construction of 150 tubewells in the northern eight (8) districts of the Zambezia province.
- Replacement of handpumps of 30 existing wells.

Based on the request of the government of Mozambique, the contents of the request were confirmed as summarized below.

<Procurement of Equipment and Materials>

Drilling Rigs and Related Equipment, Operation and Maintenance Vehicles

According to the original request of the government of Mozambique, only one (1) set of drilling rig and other related equipment, operation and maintenance vehicles were requested. However, it is necessary to construct 60 to 80 deep tube-wells per year in the northern 8 district, which is the objective of the project in order to improve the current low water service ratio of 14% to approximately 30% which is the average level in the country as described in the rural water supply plan for the province. Therefore, it is obviously impossible to attain this target as scheduled with one set of drilling rig and other related equipment, etc. Therefore, the government of Mozambique strongly requested to increase the number to two (2) sets. Considering that the annual construction capacity of tubewells by one (1) set of drilling rig is 40 - 50 sites, it is found that the request of two (2) sets of drilling rig and the other related equipment is appropriate. Because of the time-consuming site moving due to poor accessibility and the difficult geological conditions for drilling basement rocks, suitable combination of the equipment is as follows:

- Two (2) sets of main drilling equipment such as drilling rig, standard accessories and tools, high pressure compressor are to be provided. Other supporting vehicles such as large, medium and small size tracks and water tank trailer, are to be two (2) sets in order to carry out drilling works smoothly with optimized transportation and logistics.
- There is no fuel station near the construction sites. In order to prevent unnecessary work interruption for fuel supply, it is required to set a stationary fuel tank at the sites from the

beginning of the construction works. Consequently, two (2) sets of 1,000 L capacity stationary water tanks will be set at each site, and these tanks will be refueled periodically by one (1) unit of 4,000 L capacity tank lorry truck.

- One (1) unit of truck mounted hydro-fracturing unit and one (1) unit of mobile workshop will be provided to support two (2) construction sites.

Geophysical Survey and Water Quality Analysis Equipment

DGRH is a department of DNA, responsible for survey on groundwater and related field such as collection and analyses of geophysical data. Though DGRH has 15 engineers capable to organize and deploy three (3) survey teams in the field, it is unable to fully utilize its potential due to shortage of the existing survey equipment, which include one (1) set of electrical resistivity and electromagnetic survey equipment. In order to facilitate the implementation of future rural water supply, it is urgently necessary to develop groundwater potential in fissure zone. Consequently, the additional equipment to organize three (3) survey teams will be introduced.

The number and specifications of the equipment and materials requested are modified as explained in the following table considering the purpose of usage and the type of work.

Confirmed Contents for the Procurement of Equipment and Materials

Requested Equipment	Minutes of Discussion on Nov. 1, 2000	Technical Note on Dec. 6, 2000
Track Mounted Drilling Rig, 1 unit	Considering the geological condition of the Project area, 2 sets of drilling equipment will be procured in order to facilitate the drilling works as planned by DPOPH Zambezia.	-
Standard Accessories and Tools for Rig, 1 lot	2 lots will be procured as same as the drilling rigs.	-
Track Mounted High Pressure Compressor, 1 unit	2 units will be procured as same as the drilling rigs.	Considering the access condition to the site and the self-weight of 6 t, the track-mounted type will be applied.
Pumping Test Appurtenances, 1 unit	2 units will be procured as same as the drilling rigs.	-
Crane Mounted Cargo Truck, Large Size, 1 unit	2 units will be procured as same as the drilling rigs. Crane capacity will be about 5 t.	-
Crane Mounted Cargo Truck, Medium Size, 1 unit	2 units will be procured as same as the drilling rigs. Crane capacity will be about 3 t.	-
Water Tank Trailer, 1 unit	2 units will be procured as same as the drilling rigs.	-
Small Size Track, 5 units	3 units for installation of pump units, pumping tests, etc. and 2 units for geophysical survey by DGRH.	1 track will be added in order to facilitate the installation of handpump considering that drilling works will be made by 2 sets of drilling rigs.
Motorcycle, 7 units	7 units for animators in the districts.	-
Fuel Tank, 3 sets	5 sets will be necessary for supplying fuel to the 2 sets of drilling rigs and supporting vehicles.	One tank lorry of 4,000 l capacity and one set of fuel tank are added considering the consumption of fuel by 2 sets of drilling equipment and distances between sites.
Pump Unit (VLOM Type), 1 lot	Afridev Pump will be applied.	-
Material and Equipment for Water Delivery system, 1 lot	-	-
Casing and Screen Pipes, 1 lot	-	-
Water Quality Analysis Equipment, 9 sets	-	-
Trailer Type Mobile Workshop, 1 unit	-	Track mounted type will be applied considering its weight and volume.
Truck Mounted Hydro-fracturing unit, 1 unit	-	-

Confirmed Contents for the Procurement of Equipment and Materials

Requested Equipment	Minutes of Discussion on Nov. 1, 2000	Technical Note on Dec. 6, 2000
Spare Parts, 1 lot	-	-
Personal Computer, 1 set	-	-
Copy Machine, 1 set	-	-
Tractor, 1 unit	-	Since the type of compressor and mobile workshop is changed from trailer to truck mounted type, tractor is no longer necessary and deleted from the request.
Geophysical Topographical Research Equipment - Electrical Receptivity Survey Equipment, Electromagnetic Survey Equipment, Electrical Well Logging Equipment, each 1 set	-	-
GPS, 2 units	-	-
Topographical Survey Equipment, 1 set	-	-

Any additional request was not made by the Government of Mozambique, and requested equipment and materials are confirmed as listed below.

Confirmed List of Equipment and Materials Requested

No	Items	Specifications	Quantity
① Equipment and Materials for Well Drilling			
1	Truck Mounted Drilling Rig	(1) Drilling Rig (Drilling Capacity: Max 200 m) (2) Truck (Driving system: All Wheel Drive (4x4, 6x6, etc.))	2 units
2	Standard Accessories and Tools for Rig	- Standard Accessories - Drilling tools - DTH Tools - Casing and tools - Fishing tools - Air Lifting tools, etc.	2 lots
3	High Pressure Compressor	(1) High Pressure Compressor (Capacity: 900cfm (25.5 m ³ /min)) (2) Truck (Driving System: All Wheel Drive (4x4 etc.))	2 units
4	Pumping Test Appurtenances • High Head/Low Head Pump • Diesel Engine Generator • Testing Equipment	(1) High Head/Low Head submersible Pump (2) Diesel Engine Generator: 5.5 kW (3) Testing Equipment	2 sets
5	Vehicles	(1) Crane Mounted Cargo Truck, Large Size Driving system : All Wheel Drive (4x4 etc.) Crane Capacity : Max. 4 t	2 units
		(2) Crane Mounted Cargo Truck, Medium Size Driving system : All Wheel Drive (4x4 etc.) Crane Capacity : Max. 3 t	2 units
		(3) Water Tank Trailer (Tank Capacity: 5,000 l)	2 units
		(4) Small size Truck (4WD Single Cabin Cargo)	6 units
		(5) Motorcycle (Semi-off road type)	7 units
6	Fuel Tank	(1) Tank Lorry (All Drive (4x4 etc., 4,000 l)) (2) Fuel Tank	1 unit 5 sets
7	Truck Mounted Hydro Fracturing Unit	(1) Hydro Fracturing Unit (All Wheel Drive (4x4etc.))	1 unit
② Equipment for Construction of Water Supply Facilities			
1	Handpump	(1) Afridev Type (0.2 l/sec, 60 m)	1 lot
2	Casing and Screen Pipes	(1) Casing (PVC, 4") (2) Screen (PVC, 4") (3) Caulerizer: 4"x 8-1/2" (4) Bottom Cap: 4"	1 lot
③ Geophysical Research and Water Quality Analyses Equipment			
1	Water Quality Analysis Equipment	- Portable Type - Parameters: (EC, Color, Hardness, Cl, NO ₃ , NO ₂ , SO ₄ , F, Ca, Mg, Na, Mn, Fe, PH)	9 sets
2	Geophysical Research Equipment	(1) Electric Resistivity Survey Equipment (2) Electromagnetic Survey Equipment (3) Borehole Logging Equipment (5) GPS (Satellite System)	2 units each
		(1) Topographical Survey Equipment (Telescope System)	1 set

Confirmed List of Equipment and Materials Requested

No	Items	Specifications	Quantity
④ Equipment for Maintenance			
1	Spare Parts	Spare parts related to the procured equipment, Drilling Rig, Vehicles, Geophysical Research Equipment related to the Project.	1 lot
2	Truck Mounted Mobile Workshop	(1) Equipment: Welding Machine, Generator, Electric tools, Hydraulic Tools, General Tools, etc. (2) Truck (All Wheel Drive (4x4, etc.))	1 unit
3	Personal Computer	IBM or Compatible Computer, O/S, Software, and Others	1 set
4	Copy Machine	A4~A3 with expansion and reduction functions	1 set

<Construction of Tubewells>

The interview survey was carried out at the site to confirm the location and the socio-economical situation of the requested 150 villages. Out 150 villages, two (2) villages were not found, and the remaining 148 villages were surveyed. It was found that the requests of six (6) villages are overlapped with the other ones. The remaining 142 villages were surveyed from the viewpoints of the construction condition (accessibility to a village) and the hydrogeology (groundwater potential). As a result, i) 45 villages are rejected due to poor accessibility for the drilling rigs, and ii) nine (9) villages are rejected due to poor groundwater potential expected. The remaining 88 villages are considered as those where the groundwater development by tubewell construction is possible.

These villages were examined from the socio-economical viewpoint by means of village survey, and the effect, efficiency and necessity of the well construction, and the sustainability of the operation and maintenance of the constructed wells were studied. Since two (2) villages appeared their negative intention and possibility to pay water charge, these two (2) villages were rejected from those for construction of wells. The remaining 86 villages were examined considering the urgency of well construction and the capacity to operate well facilities in sustainable situation based on the results of socio-economical survey; and the villages of which number of the existing wells is considered less comparing with their population are selected for those in which two (2) tubewells are proposed to be constructed (62 villages). The total of 148 tubewells are consequently proposed to be constructed in these 86 villages under the Project. The district-wise numbers of villages selected by the above screening are tabulated below.

District-wise Number of Villages Selected for Tubewell Construction

District	Requested Vil.		Access Impossible	Less Ground -water Potential	Vil. Possible for Well Const.	Impossible for Water Charge Collection	Vil. for Const. of 1 Well	Vil. for Const. of 2 Wells
	Request	Con -firmed						
Lugela	20	20	10	1	9	-	3	6
Grue	23	20	7	1	12	-	3	9
A. Morocue	23	23	6	0	17	2	2	13
Namarooi	19	18	5	4	9	-	7	2
Ile	26	23	3	2	18	-	1	17
Milange	21	21	10	1	10	-	2	8
Mocuba	9	8	2	0	6	-	3	3
Gile	9	9	2	0	7	-	3	4
Total	150	142	45	9	88	2	24	62

The list of the villages examined and the results of screening are shown in Table 2.2, and the

evaluation criteria applied for the screening are summarized in the following table.

Evaluation Criteria of Requested Villages for Well Construction

Evaluation Items	Criteria	Selection Manner
1. Access to the Village	A: Good Access B: Access during Dry Season C: Accessible by only small sized 4WD Off-road Cars D: Inaccessible even by 4WD Off-road cars	• Exclude C and D
2. Potential of Groundwater (Hydrogeological Condition)	A: Expectable Potential of Groundwater B: Poor Potential Expected	• Exclude C
3. Socio-economic Condition (Ranking with 4 steps of classification (<A=3、 B=2、 C=1、 D=0>), calculation of overall point of a village, and evaluation of each village with the classifications shown in the right cell.	Classified into 4 steps: A ($4 > A \geq 3$), B ($3 > B \geq 2$), C ($2 > C \geq 1$), D ($1 > D \geq 0$), and sub-divided into the following 3 steps. 0 ~ <0.4: + 0.4 ~ <0.7: no mark 0.7 ~ <1.0: -	• Exclude D • Villages which marked with more than C+ are examined in view of necessity of well and sustainability of management, and only those having much population comparing with available water points are selected for construction of 2 tubewells.

(Notes) Parameters considered in the socio-economic survey and evaluation criteria are shown in Table-1.2

As described later, the villagers of the target 86 villages have not yet been considered to be mobilized well enough to operate and maintain the constructed tubewells smoothly on sustainable conditions, since the activities of animators in charge of the target villages are stagnant. However, in the Gaza province, many tubewells out of those constructed under the previous Japanese grant aid project have still been operated and maintained by the villagers under the assistance of PEC-Gaza. Though the Gaza province is considered to be one of the advanced area in view of the villagers' mobilization, the situation of the Zambezia province seems to be improved to the same level as the Gaza province, if the villagers' mobilization is facilitated by strengthening operation and maintenance system as well as the extension system of animators through the provision of technical assistance under the Project. Furthermore, especially in the hilly area in northern part of Zambezia, there is not only low service ratio of water supply but also there are many communities with no water supply facilities. Therefore, prompt project implementation is desired earnestly.

It is, therefore, considered meaningful to provide 148 tubewells under the Project to supply safe water for better welfare of the villagers in the area on condition that the proper technical assistance is provided meanwhile in the Project.

<Replacement of Hand Pump>

Regarding replacement of handpumps, 30 wells were requested to be rehabilitated. Out of these, 17 shallow wells were to be eliminated due to high potentiality of harmful contamination, and thus, 13 wells were screened as project sites.

Confirmed Villages for Handpump Replacement

Administrative Unit	Number of Wells
1. <u>Mocuba District</u>	<u>11</u>
P.A. MOCUBA	8
P.A. MUGEBA	2
P.A. NAMANJAVIRA	1
2. <u>Lugela District</u>	<u>2</u>
P.A. MUNHAMADE	2
Total	13

<Other Items Confirmed>

The other item confirmed together with the above items in the Minutes of Discussion (M/D) and Technical Notes (T/N) are summarized in the following table.

Other Items Confirmed

Other Items Confirmed	
Items Confirmed in Minutes of Discussion (M/D) (November 1,2000)	- Respected organization of the procumbent equipments and facilities The equipments and facilities shall be properly operation and maintenance by the respective organization as staled below. - Drilling and related equipments: EPAR-Zambezia - Vehicles and motorcycles: PEC-Zambezia - Geophysical survey equipments: DGRH/DNA in Maputo - Constructed 150 tubewells: Respective villages - 30 tubewells of which hand pumps are replaced: Respective villages
	- Preparation of spaces for the provided equipment and materials Enough garages and store places to keep the provided equipments and materials properly shall be prepared by GOM.
	- Screening of villages for tubewell construction The villages requested for tubewell construction are to be examined in views of socio-economy, easiness of construction(access to village) and hydrogeology. And the unfit village shall be pass over.
	-Works to be done by GOM side The communities shall do the construction works of the fences around the completed apron and access roads.
	-Request to cooperation in technical assistance The consultant's service in technical assistance that is to assist animator's activities in order to facilitate community mobilization in the villages was requested.
Items Confirmed in Technical Notes (T/N) (December 6,2000)	-Respective organization of drilling rig and facilities Establishment of the contractor's base camp and garages are required for the drilling rig and relative facilities equipped in EPAR-Zambezia's Workshop in Mocuba. GOM should arrange a float yard and facilities.
	-Assurance of employment of the resigned animadors The drastic organization reforming by restructuring is taking to maintain the self-supporting accounting system and effective conduct in EPAR-PEC. Cause of that, number of animadors in EPAR-PAC got to small (three in Queimane, one in district area as a contract). Animator is need to implementation of the project in order to facilitate the community mobilization, monitoring and over looking about tubewell community responsible. Need number of animadors, discharged or new one, should be employed under the responsibility of GOM, at least one (1) animator shall be employed for one (1) district.
	-Rehabilitation and repair of the Bride There are two broken bridges on main road and it should be repaired because it is the only way to go to many villages. This rehabilitation and repair works should be conducted under the responsibility of GOM before the commencement of the construction works. The cost for this works shall be written in draft report.

2.3 Basic Design

2.3.1 Design Concept

(1) Concept for Natural Conditions

- The climate of Mozambique is characterized by the apparent rainy and dry seasons. The rainy season from December to February is hot and rainy, and the condition of access roads in the area becomes worse, and it is necessary to consider the road condition in the rainy season in establishing the construction plan.
- In the study area, within the weathered basement rock, the promising aquifer is considered to be the lower formation which containing fresh basement rocks. The Project requires development of groundwater originated in the fissured rocks at upper basement formation of approx. 100 m deep. The drilling plan and well structure considering such geological conditions, therefore, would be proposed.

(2) Concept for Social Conditions

- In Mozambique, in order to enable the villagers to operate and maintain the constructed wells smoothly on their own initiative by providing them with technical knowledge and sense of ownership of the well facilities, the animator of PEC takes an important role in mobilization and education of the villagers. It is necessary to coordinate with such activities

being conducted by PEC in implementing the Project.

- Access roads to the sites and the fencing around the apron of well facilities are required to be constructed by the villagers themselves to facilitate their participation in the operation of well facilities as well as to make them recognize their well as their own.
- (3) Concept for Construction Conditions and Utilization of Local Contractors and Materials
- Local contractors are needed to be utilized for construction of tubewells and replacement of handpumps.
 - The international standards such as BS, SABS, ISO, ASTM, etc. are employed for the materials incorporated in the facilities in order to keep compatibility among the materials to facilitate ease of construction as well as operation and maintenance after the construction.
 - Especially for the major equipment such as drilling rigs and vehicles, the products of the makers and manufacturers who have agents or factories in South Africa or Mozambique to assure the maintenance services.
- (4) Concept for Operation and Maintenance Capability of the Implementing Agency
- It is necessary to transfer the operator of EPAR the knowledge to operate and maintain the drilling rigs and appurtenant equipment and vehicles by On-the-Job Training (OJT). The drilling operations switching from rotary to Down-the-Hole (DTH) drilling methods are especially required.
 - It is indispensable to provide technical assistance as required in training and education activities of PEC, because the operation and maintenance groups have to conduct the operation and maintenance under the direction of PEC as having been done in the other existing wells so far.
- (5) Concept for Scope and Grade of Facilities and Equipment to be provided

<Construction of Tubewells>

- The study area is classified into the difficult areas for groundwater development, of which success rate of drilling well varies from 30 to 70 % according the data on groundwater development in Mozambique. Considering criteria of site selection that the areas, where yield is expected to be quite less, are rejected from those for well construction and the effect on increase of yield by applying the hydro-fracturing unit, success ratio of well construction and minimum yield will be decided.
- Since the handpump to be used for the Project is of the type available in the local market of Mozambique, the Afridev pump whose operation and maintenance method is assured by PEC will be applied for the Project.
- The water consumption of 20 l/day/capita is applied and a well covers the consumption of 500 population.
- Water supply facilities will be made by locally procurable materials with designing to protect groundwater and appropriate environment around the water point.

<Procurement of Equipment and Materials>

- The drilling rigs to be provided are of the types equipped with both rotary and DTH drilling methods in order to facilitate drilling works in fissured water.
- Track mounted type of equipment is proposed to be applied for those to be provided under

the Project in order to facilitate the mobility of equipment considering the natural conditions in the Project areas and access conditions to the drilling sites. However, the water tank which is transported near the drilling sites without filling water is of trailer type in order to reduce the necessary number of operator for operation and maintenance expenses.

- Small sized track is of a heavy-duty type of four-wheel drive considering the road conditions and the trailing and loading capacities.
- Since the motorcycle is proposed to be used for the activities of animators, it is of the semi-off-road type in order to facilitate the mobility under the bad road condition as well as the ease of operation and the economy of maintenance.

(6) Concept for Implementation Period

- Because of poor accessibility in the project area and long distance from Maputo, necessary period for transportation and mobilization should be considered longer. It is, therefore, proposed to implement the Project with (3) terms: the 1st term for procurement of equipment, materials and construction of some tubewells, and the 2nd and the 3rd terms for construction of remaining tubewells.
- Since it is impossible to approach some villages even by 4WD vehicle due to bad access to the well sites, it is necessary to set the implementation schedule so as to conduct the construction works in these villages during the dry season.
- In the implementation schedule of the drilling works with the provided drilling rigs, it is necessary to consider the technical skill of the operators to participate OJT training to ensure the safe and efficient technical transfer.

2.3.2 Basic Design

(1) General

<Target Villages for Construction of Tubewells>

The target villages for the construction of 148 new tubewells are 86 villages listed in Table-2.2, and the villages, where the existing 13 wells for replacement of handpumps are located, are listed in Table-2.3. The locations of these target villages are indicated in Fig.-2.1.

<Water Supply Plan>

According to the interview at site, the water consumption varies depending upon distances to sources, type of source available, etc., and about 20 l/day/capita is seemed to be consumed, and in Mozambique, the consumption of 20 l/day is usually applied for the rural water supply. Therefore, 20 l/day/capita is applied for the water consumption per capita of the Project. The served population is set at 500 as usually applied in the country. 10 m³/day of water is required for one (1) tubewell.

<Alternative Villages>

Out of the requested 150 villages, 86 villages are selected for construction of tubewells under the Project considering the construction condition (access condition to the construction site), the hydrogeological condition and the socio-economic conditions, and 62 villages of which necessity of well construction and potential to operate wells on sustainable condition are judged to be high are further selected for those where two (2) tubewells are proposed to be constructed. Consequently, 148 tubewells are proposed to be constructed under the Project. It may, however,

occur that the yield of constructed well is lower than the required by the Project due to poor hydrogeological situation resulting in giving up installation of pump unit. In this case, an alternative village will be designated to implement drilling works by confirming willingness of the community and their operation and maintenance capacity of facilities. The alternative village list prepared by DPOPH-Zambezia is shown in the table.

List of Alternative Villages

District	Priority	Administration Post	Localidade	Local	Population
Gurue	1	Mepuagiua	Mepuagiua	Macuaro	-
	2	Mepuagiua	Mepuagiua	Mococha	2,726
	3	Mepuagiua	Mepuagiua	Mogeia	891
	4	Mepuagiua	Mepuagiua	Invacula	1,359
	5	Mepuagiua	Mepuagiua	Impira	286
Ile	6	Ile	Sede	Mucuara	3,559
	7	Ile	Sede	Nmoela	4,190
	8	Mulevala	Chiraco	Malolo	1,572
Milange	9	Molumbo	Molumbo	Nipujho	-
	10	Molumbo	Molumbo	Curucuru	-
Mocuba	11	Mocuba	Munhiba	Mucacata	-
	12	Mocuba	Munhiba	Sassamanja	-
	13	Namanjavira	Namanjavira	Eramba	-
Gile	14	Gile/Sede	Nanhope	Namahica	684
	15	Gire/Sede	Nanhope	Nicacala	679
	16	Gire/Sede	Nanhope	Noria	835
	17	Gire/Sede	Nanhope	Inchipia	772
	18	Gire/Sede	Nanhope	Pilima	680
	19	Gire/Sede	Nanhope	Niame	778
	20	Gire/Sede	Nanhope	Vassele	756

<Groundwater Resources>

Groundwater Recharge

The groundwater resources for the Project are considered to be recharged by precipitation. The annual rainfall of the Project area is 1,200 mm/year according to the hydrogeological data of Mozambique, and the area is considered to be one of the areas which are abundant in rainfall. The hilly area of the Namarroi and the north of the Lugela districts having the annual rainfall exceeding 1,800 mm/year is considered to be the most abundant rainfall area in the Project area. The area of the Milange, the Lgela, the Namarroi, the Grue, the Alto Morocue and the north of the Ile districts have a rainfall of 1,400 mm/year, and the rainfall of the Mocuba and the south of the Ile districts varies from 1,200 to 1,400 mm/year.

Total volume of water lifted up by 148 tubewells is calculated to be 740 m³/day based on the daily consumption by one (1) tubewell, and the volume of annual rainfall is also calculated to be 180,000,000m³/year based on the annual rainfall of 1,200 mm/year as shown below.

$$54,600 \text{ km}^2 \times 0.0012 \text{ km/year} = 65.52 \text{ km}^3/\text{year} \Rightarrow 180 \text{ MCM/day}$$

The daily volume of pumping is equivalent to 0.0004 % only, and this is considered to be quite small and negligible comparing with the ordinary recharge rate of groundwater (1 %). Therefore, there is no strain to the groundwater potential by implementing the Project.

Water Quality

According to the results of field survey, the fluoride content of 2.19 mg/l is found to exceed the maximum value of the WHO guidelines (1.5 mg/l) in an existing well of Mocuba. Fluoride is added to the drinking water for preventing tooth from decaying, but much fluoride contents sometimes causes troubles on tooth. The United States Environmental Protection Agency (USEPA) set the maximum allowable value of 4.0 mg/l in 1974, and the guideline value of WHO is not considered as must. Therefore, though the observed value exceeds the guideline, it is not judged that the water is not suitable for drinking. In addition, such high value exceeding

the guideline is found in only one (1) well and there is not the other wells of which fluoride content exceeds it around this well. It is then judged that the water thereof is generally suitable for drinking. However, if the values exceeding the guideline to much extent are observed, the treatment of such wells will be determined discussing with the Mozambican side. There may be a possibility of high salinity water problem in Mozambique. Though there has not been any report on this matter yet in the target eight (8), counter measures will be decided upon discussion with Mozambique side if such saline water is found at drilling sites.

Standard Yield and Dynamic Water Level

Standard yield of successful well is set at 0.76 m³/hr based on 0.21L/sec of the capacity of the Afridev pump. Dynamic water level will be worked out with drawdown by pumping up water. Since in case of the Afridev pump, ordinary adult male can pump up water upto some -50 m of lifting head, hand pump will not be installed if the dynamic water level exceeds -50 m as an unsuccessful well. However, if the dynamic water level exceeds -50 m with more than 1.0 m³/hr of yield, the drilled well will be sealed without back filling, while it will be filled up in case of equal or below 1.0 m³/hr.

(2) Facility Plan

Components of Facilities and Construction Works

The components of facilities and incidental construction works in the project are as follows:

Components of Facilities

Facilities	Components and Construction Works
Construction Work at new sites	Tubewell: Drilling, Installation of Casing & Screen, Flushing/Finishing, Pumping facilities: Installation of Hand pump, Construction of Apron and Drainage, Construction of Fence
Rehabilitation Work for existing wells	Flushing wells, Replacement of Hand pump, Rehabilitation of Apron and Drainage, Construction of Fence

Remarks: Construction work of the fence will be borne by local beneficiaries to promote community participation.

The following items are considered on facility design.

- The proper protection works such as shield works by cementing are to be provided to prevent inflow of contaminated water from the ground surface into the well.
- Proper position of casing and screen pipes are to be set based on the results of electric logging in order to supply the safe drinking water with high productivity.
- It is necessary to take countermeasures by temporary casing etc. to prevent the collapse of tubewell during the drilling operation.
- Apron is to be constructed and surplus and contaminated water shall be drained out quickly for preventing the contaminated water to inflow into well and keeping sanitary conditions around the well.
- Fence is to be installed to prevent the intrusion of livestock into the well facility.
- It is required to confirm the availability of sufficient yield for supplying drinking water to 500 persons per one well.
- Civil works in the Project are only the construction of base of handpump and apron, and many similar type aprons have been constructed. Therefore, civil works around well such as apron etc. are based on DAR specifications.

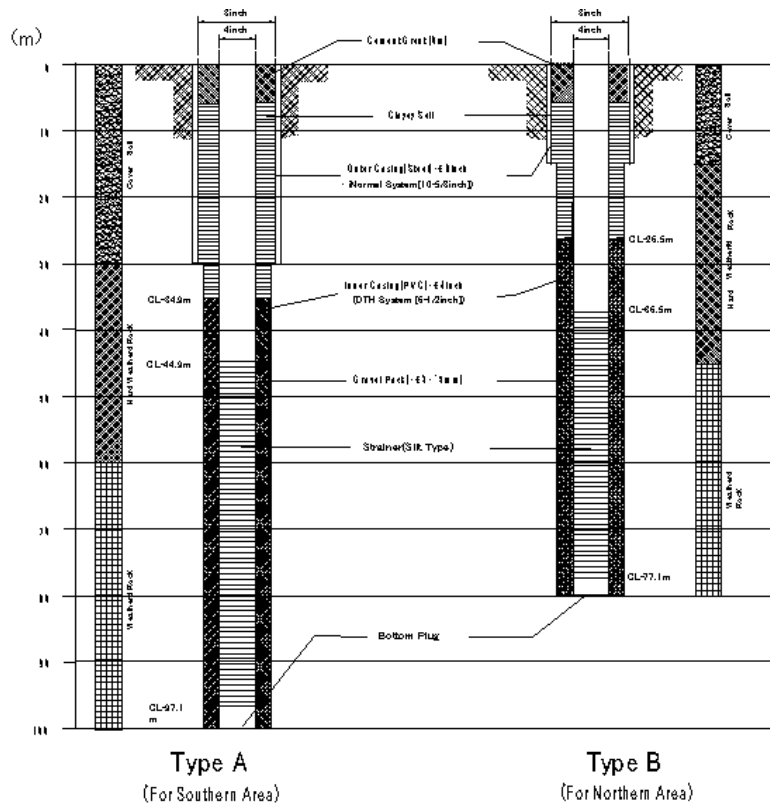
<Standard Tubewells>

Geological component in the Project area is shown in the table. Granite zone is found mainly in the southern area, while gneiss zone in the northern area. Drilling works will be carried out in two (2) different procedures depending upon the geological conditions of the southern and the northern areas shown in Fig.-2.2. Referring to the geological conditions mentioned in the table, well dimensions are determined. Maximum well depth is set at 100 m in the southern area, and the protection pipe of dia. 200 mm is to be installed up to the depth of 30 m (Type A). Maximum well depth is set at 80 m in the northern area, and the protection pipe of dia. 200 mm is to be installed up to the depth of 15 m (Type B). The screen pipes are installed in the high weathering and the lower weathering zones, and their length is set at 50 % of the whole depth. Standard well structure is shown in the Basic Design Drawings attached hereto.

Geological Component in the Project Area

(Unit : m)

1. Granite Zone						
Geological Division \ Site	A	B	C	D	E	F
Cray Soil	2.2	3.0	6.2	3.2	13.8	2.7
Sandy Soil	-	-	0.8	10.0	3.7	-
Gravel	-	-	1.2	-	-	-
high weathering zone	18.4	20.5	16.4	11.8	16.0	31.2
Depth of Surface Layer	20.6	23.5	24.6	25.0	33.5	33.9
Mean Depth	26.8					
2. Gneiss Zone						
Geological Division \ Site	A	B	C	D	E	
Cray Soil	13.0	0.5	0.5	3.0	0.5	
Sandy Soil	-	-	-	3.0	9.0	
Gravel	-	-	8.0	4.0	3.5	
High weathering zone	-	6.5	5.5	8.0	-	
Depth of Surface Layer	13.0	7.0	14.0	18.0	13.0	
Mean Depth	13.0					



STANDARD TUBEWELL

Well types applied to each area are shown in the following table.

Well Type in Each Area

Name of District	Village Number	
	Type A (52 villages)	Type B (34 villages)
Lugela	4,5,6,14,15,17,18,19,20 (9)	
Gurue		21,27,30,31,34,35,36,37,38,39,40,41 (12)
Alto Molocue	42,51,53,54,56,62,63,64 (8)	45,46,48,49,52,58,60 (7)
Namarroi	68,74,77 (3)	65,69,70,79,81,82 (6)
Ile	84,85,86,87,92,93,96,97,98,99,101,104,108 (13)	88,89,90,95,105 (5)
Milange	113,116,124,126,127,129 (6)	118,119,120,121 (4)
Mocuba	132,135,136,137,138,139 (6)	
Gile	140,141,142,143,145,147,148 (7)	

Drilling Procedures

The drilling in the surface coverage soil will be conducted by a rotary method with drilling bit of 270 mm dia., and a protection pipe of 200 mm will be installed. The drilling of basement rock is conducted with a drilling bit of 216 mm dia. The rotary drilling with mud circulation will be made in surface soil and a part of hard-weathered rock, but in the weathered rock it is impossible to continue the rotary drilling. Therefore, the drilling method will be changed in the weathered rock from rotary to DTH methods.

Drilling works will be repeated only two times at the same site, and if 2nd drilling hole is judged to be unsuccessful, 3rd trial will not be done. In this case, another village will be selected among previously-mentioned alternative village list according to the priority order after completion of proper justification procedures including socio-economic survey and confirmation of community willingness.

(3) Procurement Plan of Equipment and Materials

The basic considerations for determining the equipment and materials to be procured are as follows:

Basic Consideration for Determination of Equipment and Materials to be Procured

No.	Items	Consideration
① Equipment and Materials for Well Drilling		
1	Truck Mounted Drilling Rig	Considering the geological conditions in the Project area, the rig should be equipped both with the rotary method of mud circulation and the DTH method of compressed air circulation. Because most of the roads in the Zambezia province is unpaved and road condition is quite poor, the drilling rig should be truck-mounted type to gain mobility. The drilling capacity should be more than 150 m with a diameter of 8-5/8 in considering the position of target aquifer.
2	Standard Accessories and Tools for Rig	The supply of spare parts from South Africa and the maintenance support system should be assured.
3	High Pressure Compressor	Since the compressor will be used for drilling by DTH method, its capacity should match the requirement by drilling rig. Its weight becomes so heavy that it is difficult to trail it, the truck-mounted type should be applied.
4	Pumping Test Appurtenances	The size of appurtenances should fit the diameter of lifting pipe size of 4 in.
5	Truck Mounted Hydro-fracturing Unit	The hydro-fracturing unit will be used for gaining and improving the yield of drilled tubewell, and its driving system should be 4WD for the mobility in the site.

Basic Consideration for Determination of Equipment and Materials to be Procured

No.	Items	Consideration
6	Vehicles	Crane Mounted Cargo Trucks, Large and Medium Sizes Both trucks will be used for transporting, loading and unloading the materials, tools, accessories, etc. for the construction of tubewells; the large truck will be used for long materials and parts, such as drill bit and pipes, and the medium one for multipurpose and trailing. The driving system should be 4WD.
		Water Tank Trailer The water tank trailer is of the capacity of 5,000 l, and the vacant tank will be trailed to the water points near the drilling sites.
		Tank Lorry The tank lorry will be used for supplying fuel to the 2 sets of drilling rigs. To convey fuel of 2,000 l to each drilling site, it should be of 4,000 l tank capacity. To gain the mobility at the sites, its driving system should be 4WD. The fuel tanks are indispensable to store the conveyed fuel at sites.
		Small Size Truck The small size trucks should be of 4WD in order to gain the strong ness and durability under the poor access road conditions and the loading conditions.
		Motorcycle The motorcycles are indispensable for the animators' activities in the sites, they should be of the semi off-road type of 100 cc to gain operability and economy under the poor road conditions in the area. 8 numbers of motorcycles are required in order to distribute them to all the animators to be assigned in each district in the Project area.
② Equipment for Construction of Water Supply Facilities		
1	Handpump	The Afridev pump that is considered as the standard type in Mozambique will be used for the Project.
2	Casing and Screen Pipes	The PVC pipes made in South Africa will be applied considering its prices and ease of procurement, because it conforms to the international standard.
③ Geophysical Research and Water Quality Analysis Equipment		
1	Water Quality Analysis Equipment	The water quality analysis equipment is used for the site analysis to be carried at sites during the drilling works, and the parameters to be analyzed are EC, hardness, color, Cl, NO3, NO2, SO4, F, Ca, Mg, Na, Mn, Fe, PH, etc. as specified in the guidelines of WHO. 5 sets will be procured for 2 teams of new rigs, 2 teams of existing percussion rigs, and 1 manual drilling team.
2	Geophysical Research Equipment	The geophysical survey includes horizontal and vertical survey, and the electric receptivity and the electromagnetic surveys are used. The borehole logging equipment which is used for determining the position of screen pipes in the well should be of the capacity to measure up to the depth of 200 m.
④ Equipment for Maintenance		
1	Spare Parts	The spare parts for drilling rigs and related supporting vehicles, and geophysical survey equipment, etc. will be considered to be procured for the operation and maintenance by the organizations receive them.
2	Truck Mounted Mobile Workshop	The mobile workshop will be furnished with all the necessary equipment, machine, tools, etc. necessary for repair and maintenance of the drilling rigs, etc. at site.
3	Personal Computer	The personal computer should be furnished with the operation system and software as well as peripherals which will be necessary for producing training materials used for PEC activities and preparing and maintaining the database of the wells managed by PEC.
4	Copy Machine	The copy machine will be used for the PEC activities to facilitate the villagers for participatory activities.

Hydro-fracturing Unit

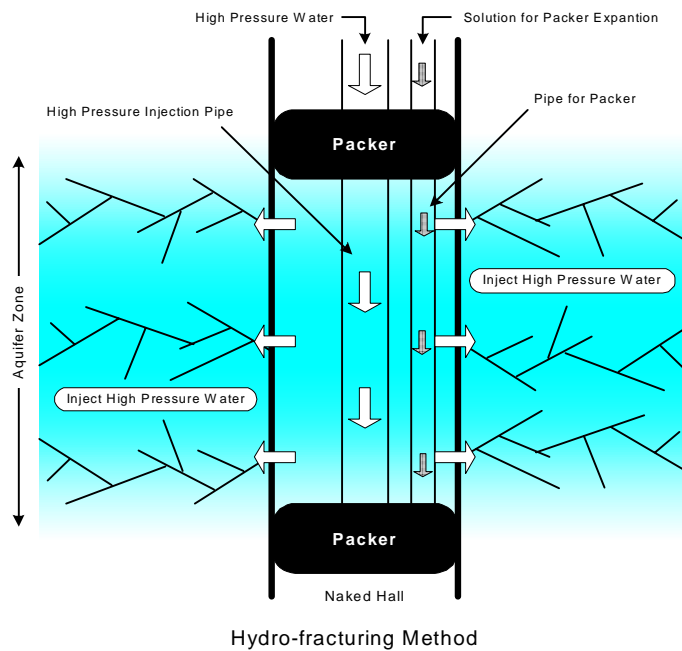
Hydro-fracturing method has been introduced since 1947 mainly in field of oil development. In order to improve yield of newly constructed well or deteriorated old wells as rehabilitation works, this has been also applied. Recently, the hydro-fracturing is becoming popular to improve yield in such cases that development of natural fractures is insufficient and/or permeability coefficient is too low in the rock.

This method utilize highly pressurized water injection into fractures in the rock, resulting in development of further cracks and fractures artificially with setting up of expandable packers to isolate the borehole between targeted aquifer and other parts. Injecting pressurized water

through the packer into the borehole, small hair cracks are gradually and continuously plied, resulting in spoke-wise cracks to be grown. Consequently, yield will be improved by linking these newly generated cracks efficiently beyond the targeted aquifer to neighboring parts. According to the actual data of the hydro-fracturing method in Uruguay, sufficient effect has been observed by 1.5 to 1.9 times increase of yield by comparing before and after application of this method.

Procedures of this method is as follows:

- 1) After installation of the work casings, drilling borehole until the targeted depth by DTH method.
- 2) Flushing the inside of the borehole and installing the packers to plug the top and low ends of the fractured aquifer.
- 3) Expanding packers to isolate aquifer and other parts, and then injecting highly pressurized water into fractures.



<Procurement of Equipment and Materials for Well Construction>

Procurement plan of the necessary equipment and material for construction of well facilities is as follows:

- Afridev pump is to be procured for easy maintenance and conformity to the specifications of Mozambique as standard VLOM type. This type of handpump is produced locally and available in Mozambique.
- Casing and screen pipes used in Mozambique are imported from Europe or South Africa and it is possible to procure them in local markets. Therefore, casing and screen pipes are to be procured in Mozambique or South Africa.
- Forming agent for DTH drilling, bentonite/CMC for rotary drilling and gravel materials for well construction, etc. are available in South Africa or Mozambique.
- Drilling bits are available in South Africa. Therefore, it is procured in South Africa as same as drilling rigs.
- Cement, reinforcing bar, temporary materials and gravels, etc. are procured in Mozambique.
- Materials for the protection fence constructed by the beneficial villagers are available in local market and are procured by villagers themselves.

<Procurement Plan of Geophysical Survey and Drilling Equipment>

Major Equipment and Materials

The necessary equipment and materials for construction of well facilities with handpump are as follows:

- ① Equipment for Tubewell Construction
 - Drilling rigs and accessories
 - Equipment and materials for survey works (geophysical survey equipment, bore hole logging equipment, pumping test equipment, GPS, topographic survey equipment)
 - Service and supporting vehicles for well drilling
- ② Equipment and Materials for Facility Construction
 - Casing and screen pipes for well
 - Mud materials for well drilling
 - Other materials such as cement, sand, gravel, etc.
- ③ Water Quality Analysis Equipment
- ④ Workshop Tools for Operation and Maintenance
 - Tools and machine for repairing
 - Spare parts for drilling equipment
 - Spare parts for handpump

Specifications and quantities of major equipment and materials are shown in Table-2.4, and the countries for procurement of equipment and materials are as follows:

Countries for Procurement of Equipment and Materials

Equipment and Materials	Procurement	Reasons
Truck Mounted Drilling Rigs, Standard Accessories and Tools for Rig, and Truck Mounted High Pressure Compressor	South Africa	These are not produced locally in South Africa production and assembling is conducted and its quality is sufficient for specifications. After-sales services and supply of spare parts are possible through agents or makers in South Africa.
Pumping Test Appurtenances	Japan	These are not produced locally. Sufficient service system by agents in South Africa is not expected.
Trailer and Fuel Tank, Fuel Tank Lorry, 4WD for working/Truck, and Motorcycle	South Africa	Production and assembling are conducted or procurement is possible through agent in South Africa.
Hand pump	Mozambique	Afridev pump produced locally is adopted.
Casing/Screen Pipes	Mozambique or South Africa	The products conforming to South African Standard (SABS) and international standards are available.
Bentonite and Aggregate	Mozambique	Available in local Mozambique
Drilling Bit	South Africa	Available through agent or maker in South Africa.
Water Quality Analyses Equipment	Japan or South Africa	Available through agent or maker in Japan or South Africa.
Truck Mounted Mobile Equipment (for maintenance)	Japan	Because of the complicated composition of equipment, Japanese products are adopted.
Truck Mounted Hydro-fracturing Unit	Japan	The unit is basically produced in the United States, but re-modeling and assembling will be required for the use considered in the Project.
Geophysical Research Equipment/GPS/ Topographical Equipment	Japan	Production and assembling are not conducted in Mozambique and South Africa. Considering technical support and services in the future, they will be procured in Japan.
Personal Computer/ Copy Machine	Mozambique	Procurement and services are available at local agent.

Table-2.1 Well Construction Plan for Rural Water Supply of Each District in Zambezia Province

District	1999	2000			2001			2002		
		Total	Tube-well	Dug Well	Total	Tube-well	Dug Well	Total	Tube-well	Dug Well
Gurue		19	11	8	13	7	6	18	10	8
Ile		8	4	4	23	13	10	22	13	9
Namarroi		38	22	16	17	10	7	16	9	7
Alto Molocue		0	0	0	16	9	7	18	10	8
Gile		0	0	0	14	8	6	17	10	7
Lugela		27	16	11	12	7	5	21	12	9
Mocuba		0	0	0	12	7	5	13	7	6
Milange		19	11	8	12	7	5	10	6	4
8 Districts (North)		111	64	47	119	68	51	135	77	58
M. Costa		31	18	13	8	4	4	11	6	5
Pebane		18	10	8	10	6	4	12	7	5
Morrumbala		0	0	0	10	6	4	11	6	5
Mopeia		0	0	0	8	4	4	8	4	4
Namacurra		12	7	5	6	3	3	10	6	4
Inhasunge		0	0	0	8	4	4	10	6	4
Chinde		0	0	0	12	7	5	8	4	4
Nicodala		0	0	0	7	4	3	6	3	3
Quelimane		0	0	0	0	0	0	0	0	0
9 Districts (South)		61	35	26	69	38	31	76	42	34
Whole of Zambezia Prov.		172	99	73	188	106	82	211	119	92
Served Pop.	-	86,000	49,500	36,500	94,000	53,000	41,000	105,500	59,500	46,000
Acc. Served Pop.	344,551	430,551	-	-	524,551	-	-	630,051	-	-
Population	2,461,076	2,517,681	-	-	2,575,588	-	-	2,634,826	-	-
Coverage (%)	14.0	17.1	-	-	20.4	-	-	23.9	-	-

District	1999	2003			2004			Total of 5 Years		
		Total	Tube-well	Dug Well	Total	Tube-well	Dug Well	Total	Tube-well	Dug Well
Gurue		20	12	8	18	10	8	88	50	38
Ile		16	9	7	18	10	8	87	49	38
Namarroi		17	10	7	12	7	5	100	58	42
Alto Molocue		20	12	8	16	9	7	70	40	30
Gile		22	13	9	21	12	9	74	43	31
Lugela		16	9	7	16	9	7	92	53	39
Mocuba		12	7	5	16	9	7	53	30	23
Milange		16	9	7	14	8	6	71	41	30
8 Districts (North)		139	81	58	131	74	57	635	364	271
M. Costa		10	6	4	10	6	4	70	40	30
Pebane		10	6	4	8	4	4	58	33	25
Morrumbala		18	10	8	12	7	5	51	29	22
Mopeia		12	7	5	8	4	4	36	19	17
Namacurra		7	4	3	8	4	4	43	24	19
Inhasunge		8	4	4	12	7	5	38	21	17
Chinde		12	7	5	12	7	5	44	25	19
Nicodala		10	6	4	11	6	5	34	19	15
Quelimane		0	0	0	0	0	0	0	0	0
9 Districts (South)		87	50	37	81	45	36	374	210	164
Whole of Zambezia Prov.		226	131	95	212	119	93	1009	574	435
Served Pop.		113,000	65,500	47,500	106,000	59,500	46,500			
Acc. Served Pop.		743,051	-	-	849,051	-	-			
Population		2,695,427	-	-	2,757,422	-	-			
Coverage (%)		27.6	-	-	30.8	-	-			

Table 2.2 Evaluation and Selection of Villages for Tubewell Construction

District	No.	Post Administrativo	Localidade	Aldeia	Latitude				Longitude				Altitude(m)	Area of Aldeia (Km2)	Population of Aldeia	Road Condition	Hydrogeological Condition	Existing Water Sources				Feasible Villages for Tubewell Construction	Evaluation fo Socio-economic Survey			Number of Tubewell Construction	Tubewell Type	
					All	Move	Hand Hall	River	General Evaluation	Village for 2 Tubewell Construction(B- & C+)	The reason for excluding from the C+ classification																	
												Pump																
Lugela (20)	1	Muabanama	Muabanama	Sede												D	-						×	-			0	
	2	Muabanama	Comone	Sede												D	-						×	-			0	
	3	Muabanama	Mpemula	Sede												D	-						×	-			0	
	4	Munhamade	Munhamade	Sede	16	35	52	36	58	22	183	300	1500	B	A	7	2	0	1	○	B-	Pop. ratio small			1	A		
	5	Munhamade	Cuba	Sede	16	33	19	36	51	75	280	120	1800	A	A	4	4	10	0	○	C+	Has pump wells			1	A		
	6	Munhamade	Mulide	Sede	16	22	50	37	0	66	475	22	1310	B	A	0	0	60	0	○	C				1	A		
	7	Lugela	Mussengane	Sede												D	-						×	-			0	
	8	Lugela	Puthine	Sede	16	21	29	36	51	34	450	16	4200	C	C	0	0	240	0	×	-					0		
	9	Lugela	Nagobo	Sede												D	-						×	-			0	
	10	Lugela	Iaba	Sede												D	-						×	-			0	
	11	Tacuane	Tacuane	Mucula												D	-						×	-			0	
	12	Tacuane	Ebide	Muriamuando												D	-						×	-			0	
	13	Muabanama	Comone	Nipevone												D	-						×	-			0	
	14	Munhamade	Tenede	Sede	16	18	82	36	59	36	485	20	893	A	A	0	0	60	0	○	B-	Pop. ratio small			1	A		
	15	Tacuane	Ebide	Sede(Namirine)	16	24	14	36	34	58	340	250	750	B	A	0	0	220	0	○	B-	Pop. ratio small			1	A		
	16	Tacuane	Mabo 1st	Sede												D	-						×	-			0	
	17	Tacuane	Tacuane	Sede	16	22	11	36	30	91	340	300	900	B	A	0	0	125	0	○	C+	Pop. ratio small			1	A		
	18	Munhamade	AltoLugela	Sede	16	43	23	36	56	11	154	30	1174	B	A	3	0	10	0	○	C+	○			2	A		
	19	Munhamade	Tenede	RumulaAlto	16	18	46	37	1	53	420	40	1173	B	A	0	0	150	0	○	C+	○			2	A		
	20	Lugela	Mobede	Mulageia	16	24	28	36	42	54	340	35	2500	B	A	0	0	2	0	○	C+	○			2	A		
												Sub-total				9			3			13						
Gurue (20)	21	Lioma	Lioma	Sede	15	10	39	36	48	2	708	60	4172	A	A	6	1	0	1	○	B-	○			2	B		
	22	Lioma	Lioma	Nanivacha	15	12	59	36	54	23	735	25	1198	C	A	0	0	0	2	×	-					0		
	23	Mepuagiua	Mepuagiua	Gomoli	15	30	79	37	3	97	750	10	2882	B	C	0	0	90	0	×	-					0		
	24	Lioma	Nintulo	Sede												D	-						×	-			0	
	25	Lioma	Lioma	Chicopera												D	-						×	-			0	
	26	Socone	Socone	Walasse												D	-						×	-			0	
	27	Lioma	Lioma	Missagula	15	9	29	36	47	11	715	15	988	B	A	0	0	1	0	○	C+	○			2	B		
	28	Lioma	Mualigane	Sede	15	3	2	37	17	29	752	60	1828	C	A	0	0	14	0	×	-					0		
	29	Gurue	Muchimua	Sede	15	36	21	36	59	50	680	40	1063	C	A	0	0	150	0	×	-					0		
	30	Lioma	Magige	Sede	15	19	59	36	44	42	746	45	3600	A	A	3	3	0	7	○	C+	○			2	B		
	31	Mepuagiua	Mepuagiua	Sede	15	32	39	37	11	54	630	60	2462	B	A	4	4	500	0	○	C+	Has pump wells			1	B		
	32	Mepuagiua	Mepuagiua	Injabo	15	35	64	37	8	40	680	27	3345	C	A	0	0	30	0	×	-					0		
	33	Mepuagiua	Vehua	Sede	15	20	53	37	16	16	913	100	1229	C	A	0	0	6	4	×	-					0		
	34	Lioma	Tetete	Maharal	15	27	8	36	37	37	825	30	3000	B	B	0	0	5	2	○	C+	○			2	B		
	35	Mepuagiua	Nipive	Sede	15	52	92	37	5	99	520	18	1294	B	A	0	0	80	2	○	C+	○			2	B		
	36	Mepuagiua	Nicoropale	Sede	15	49	19	37	5	47	600	18	792	B	B	0	0	200	0	○	C	Pop. ratio small			1	B		
	37	Mepuagiua	Incize	Sede	15	41	55	37	6	14	680	10	1302	A	A	0	0	30	3	○	C+	○			2	B		
	38	Gurue	Murrimo	Sede	15	22	43	36	49	19	782	40	2857	A	A	0	0	20	0	○	C					1	B	
	39	Gurue	Murrimo	Goveia	15	20	57	36	49	16	793	65	2456	B	A	0	0	5	1	○	C+	○			2	B		
	40	Gurue	Murrimo	Nanzua	15	23	27	36	50	53	766	17	1586	B	A	0	0	12	0	○	C					1	B	
41	Lioma	Lioma	Nihoma	15	8	2	36	49	0	674	30	1460	B	A	0	0	0	3	○	B-	○			2	B			
												Sub-total				12			8			20						
Alto Molocue (23)	42	AltoMolocue	AltoMolocue	Nipaia	15	42	50	37	43	17	530	30	1751	A	A	2	2	150	3	○	B-	Pop. ratio small			1	A		
	43	AltoMolocue	Chapala	Cnere	15	48	10	37	35	27	610	53	5300	B	B	0	0	40	0	○	B-	No wills to pay			0			
	44	Nauela	Nauela	Rugula	15	27	39	37	30	4	758	40	1610	C	A	0	0	0	2	×	-					0		
	45	AltoMolocue	Ecole	Vacha	15	27	37	37	39	4	740	35	1036	A	A	0	0	12	0	○	C+	○			2	B		
	46	AltoMolocue	Nivava	Nacutxo	15	39	18	37	32	2	700	40	1155	B	A	0	0	15	2	○	C+	○			2	B		
	47	Nauela	Nauela	Tuatu/Malao	15	27	25	37	28	43	794	35	1002	C	A	0	0	5	0	×	-					0		
	48	Nauela	Mohiua	Inagu	15	14	60	37	25	8	810	30	10000	A	A	0	0	30	3	○	C+	○			2	B		
	49	Nauela	Nauela	Nepo	15	21	82	37	24	17	820	15	1900	B	A	0	0	180	3	○	C+	○			2	B		
	50	Nauela	Nauela	Eleve												D	-						×	-			0	
	51	AltoMolocue	Chapala	Natelaca	15	48	48	37	34	31	569	53	5300	B	A	0	0	40	0	○	B-	○			2	A		
	52	Nauela	Mohiua	Carmano	15	16	79	37	20	82	850	16	3234	B	A	0	0	24	2	○	C+	○			2	B		
	53	AltoMolocue	Chapala	Sede	15	51	81	37	38	37	480	45	2009	A	A	1	1	500	3	○	C+	○			2	A		
	54	AltoMolocue	Nacuaca	Murepueteia	15	53	34	37	55	35	459	99	694	B	A	0	0	5	1	○	C+	Pop. ratio small			1	A		
	55	AltoMolocue	Nivava	Nicarari												D	-						×	-			0	
	56	AltoMolocue	Mutala	Muchampua	15	56	12	37	50	37	471	10	2500	B	A	0	0	6	0	○	C+	○			2	A		
	57	AltoMolocue	Ecole	Namugoma												D	-						×	-			0	
	58	Nauela	Nauela	Narice	15	22	28	37	32	11	774	90	6000	A	A	0	0	15	0	○	B-	○			2	B		
	59	AltoMolocue	Caiaia	Napala												D	-						×	-			0	
	60	Nauela	Nauela	Sede	15	26	26	37	26	14	807	40	14918	A	A	3	0	8	0	○	C+	○			2	B		
	61	AltoMolocue	Mahua	Sede	15	40	37	37	38	11	620	80	1900	A	A	0	0	4	2	○	C+	No wills to pay			0			
	62	AltoMolocue	Mutala	Sede	15	56	3	37	49	58	480	12	4211	B	A	0	0	20	0	○	C+	○			2	A		
	63	AltoMolocue	Mutala	Muhirro	15	55	18	37	52	21	495	11	1985	B	A	0	0	6	0	○	B-	○			2	A		
	64	AltoMolocue	Mutala	Uelela	16	0	20	37	58	23	364	15	1518	A	A	0	0	4	0	○	B-	○			2	A		
													Sub-total				17			13			28					

Table-2.3 Confirmed Well for Replacement of Hand Pump

Location (Name of Village etc.)	Number	Location (Name of Village etc.)	Number
1. MOCUBA District		3. LUGELA District	
1.1 P.A. MOCUBA		3.1 P.A. MUNHAMADE	
(1) CIDADE DE MOCUBA		(1) LOC. ALTO LUGELA	
Aldeia Matebe 1	1(F)	EP1. Namagona	1(F)
Posto Agrícola, Escola Básica	1(F)	Sede	1(F)
Bive, Cruzamento			
Mangolamelo (A)	1(F)		
Mangolamelo (B)	1(F)		
Mugonda	1(F)		
Murraba	1(F)		
Socondinho	1(F)		
1.2 P.A. MUGEBA		LUGELA Sub-total	2
(1) LOC. MUGEBA			
Nigula	1(F)		
Centro de Saúde de Muaquiua	1(F)		
1.3 P.A. NAMANJAVIRA			
(1) LOC. de Alto Benfica	1(F)		
Sede			
MOCUBA Sub-total	11		
(Note) F: Deep tubewell		TOTAL	13

Table-2.4 List of Equipment and Materials to be Procured

No.	Items	General Specifications	Quantity	Notes	Station
① Equipment and Materials for Well Drilling					
1	Truck Mounted Drilling Rig	a) Drilling Rig (Drilling Capacity: Max 200 m) b) Truck (Driving system: All Drive (4x4, 6x6, etc.))	2 units	Considering the geological conditions in the Project area, the rig should be equipped both with the rotary method of mud circulation and the DTH method of compressed air circulation. The drilling capacity should be max. 200 m with a diameter of 4-3/4 inches for DTH method.	EPAR
2	Standard Accessories and Tools for Rig	- Standard Accessories - Drilling tools - DTH Tools - Casing and tools - Fishing tools - Air Lifting tools, etc.	2 units	The supply of spare parts from South Africa and the maintenance support system should be assured.	EPAR
3	High Pressure Compressor	(1)High Pressure Compressor (Capacity: 900cfm (25.5 m ³ /min)) (2) Truck (Driving System: All Drive (4x4 etc.))	2 units	Since the compressor will be used for drilling by DTH method, its capacity should match the requirement by drilling rig. Its weight becomes so heavy that it is difficult to trail it, the truck-mounted type should be applied. 2 units shall be required for number of the drilling rig.	EPAR
4	Pumping Test Appurtenances	(1) High Head/Low Head submersible Pump (2) Diesel Engine Generator: 5.5 kW (3) Testing Equipment	2 units	The size of appurtenances should fit the diameter of lifting pipe size of 4 inch. 2 units shall be required for number of the drilling rig.	EPAR
5	Vehicles	(1)Crane Mounted Cargo Truck, Large Size Driving system : All Drive (4x4 etc.) Crane Capacity : Max. 4 t	2 sets	Both trucks will be used for transporting, loading and unloading the materials, tools, accessories, etc. for the construction of tubewells; the large truck will be used for long materials and parts, such as drill bit and pipes, and the medium one for multipurpose and trailing. The driving system should be 4WD. 2 sets shall be required for number of the drilling rig.	EPAR
		(2)Crane Mounted Cargo Truck, Medium Size Driving system : All Drive (4x4 etc.) Crane Capacity : Max. 3 t	2 sets		
		(3) Water Tank Trailer (Tank Capacity: 5,000 l)	2 sets	The water tank trailer is of the capacity of 5,000 l, and the vacant tank will be trailed to the water points near the drilling sites by medium size truck. 2 sets shall be required for number of the drilling rig.	EPAR
		(4) Small size Truck (4WD Single Cabin Cargo)	6 sets	2 sets for geophysical survey, 2 sets for installation of hand pump (PEC) and 2 sets for transporting the construction materials and supplementation. The small size trucks should be of 4WD in order to gain the strong ness and durability under the poor access road conditions and the loading conditions.	EPAR, PEC, DGRH, 2 sets each
		(5) Motorcycle (Semi-off road type)	8 sets	The motorcycles are indispensable for the animators' activities in the sites, they should be of the semi off-road type of 100 cc to gain operability and economy under the poor road conditions in the area. 8 numbers of motorcycles are required in order to distribute them to all the animators to be assigned in each district in the Project area.	PEC
6	Fuel Tank	(1) Tank Lorry (All Drive (4x4 etc., 4,000 l)	1 set	The tank lorry will be used for supplying fuel to the 2 sets of drilling rigs. To convey fuel of 2,000 l to each drilling site, it should be of 2,000 l tank capacity. To gain the mobility at the sites, its driving system should be 4WD. The fuel tanks are indispensable to store the conveyed fuel at sites.	EPAR
		(2) Fuel Tank	4 sets	Two fuel tanks (1,000 l) shall be arranged at each site for fuel stock.	EPAR

Table-2.4 List of Equipment and Materials to be Procured

No.	Items	General Specifications	Quantity	Notes	Station
7	Truck Mounted Hydro-fracturing Unit	Hydro Fracturing Unit (All Drive (4x4etc.))	1 set	The hydro-fracturing unit will be used for gaining and improving the yield of drilled Tubewell in fissure water aquifer, and its driving system should be 4WD for the mobility in the site.	EPAR
② Equipment for Construction of Water Supply Facilities					
1	Hand pump	Afridev Type (0.2 l/sec, 60 m)	1 lot	The Afridev pump that is considered as the VLOM standard type in Mozambique will be used for the Project.	EPAR
2	Casing and Screen Pipes	(1) Casing /Screen (PVC, 4") (2) Caulerizer: 4"x 8-1/2" (3) Bottom Cap: 4"	1 lot	The PVC pipes made in South Africa will be applied considering its prices and ease of procurement, because it conforms to the international standard.	EPAR
③ Geophysical Research and Water Quality Analysis Equipment					
1	Water Quality Analysis Equipment	- Portable Type - Parameters: (EC, Color, Hardness, Cl, NO3, NO2, SO4, F, Ca, Mg, Na, Mn, Fe, PH)	9 sets	5 sets will be procured for 2 teams of new rigs, 2 teams of existing percussion rigs, and 1 manual drilling team. And 4 sets will be procured for 1 team of existing survey, 2 teams of new survey and Maputo headquarters. Total is 9 sets. Analysis items are based on WHO guideline.	EPAR 5 sets and DGRH 4 sets
2	Geophysical Research Equipment	(1)Electric Receptivity Survey Equipment (2)Electromagnetic Survey Equipment (3) GPS (Satellite System)	2 units each	The geophysical survey includes horizontal and vertical survey, and the electric receptivity and the electromagnetic surveys are used for station of DGRH. GPS is procured for searching the site location.	DGRH
		(4) Borehole Logging Equipment	2 units	2 sets shall be required for number of the drilling rig.	EPAR
		(5) Topographical Survey Equipment (Telescope System)	1 lot	Topographical Survey Equipment shall be procured for the detailed geophysical survey point for station of DGRH.	DGRH
④ Equipment for Maintenance					
1	Spare Parts	Spare parts related to the procured equipment, Drilling Rig, Vehicles, Geophysical Research Equipment related to the Project	1 lot	The minimum spare parts shall be procured for no hindrance of operation and maintenance after the completion of the construction	-
2	Truck Mounted Mobile Workshop	(1)Equipment: Welding Machine, Generator, Electric tools, Hydraulic Tools, General Tools, etc. (2)Truck (All Drive (4x4, etc.))	1 unit	The mobile workshop will be furnished with all the necessary equipment, machine, tools, etc. necessary for repair and maintenance of the drilling rigs, etc. at site. 4 WD truck mounted type shall be procured since it is required the mobility for conducting service of 2 drilling teams	EPAR
3	Personal Computer	IBM or Compatible Computer, O/S, Software, and Others	1 set	These specifications shall be fit for preparing and maintaining the database of the wells managed by PEC and PEC activities.	PEC
4	Copy Machine	A4~A3 with expansion and reduction functions	1 set		PEC

