Table 3.4.2 Village Numbers in Difficulties on Water Use

	Water Unsecured Villages	Partly Water Secured Villages	Water Secured, but Uncleaned Water Villages	Clean Water Secured Villages
Sagain	18	837	1,599	3,006
Magway	220	766	514	3,292
Mandalay	297	2,100	1,722	1,431
Total	535	3,703	3,835	7,729
Proportion (%)	3.4	23.4	24.3	48.9

DDA intends to solve problems in the water unsecured villages in "10 Year Project" by adopting deep wells, shallow wells, dug wells, reservoir improvement, gravity flow, river water, and others in accordance with the natural conditions surrounding the targeted villages.

Since December 2001 the Myanmar Government has been promoting a campaign of donation from charitable persons in and out of the country for tube well drilling in rural area. The tube wells to be drilled in this program normally have a four inches diameter and two different total depths of 60 m and 120 m. An airlift system is installed in each tube well to draw out groundwater. The donation might be efficient to share a part of the budget of "10 Year Project", however, it could not cover main part of the total budget. DDA expects that the present campaign would expedite implementation of the "10 Year Project"

3.5 Groundwater Survey in the Study Area

(1) Existing Well Monitoring and Geophysical Survey

Groundwater monitoring was conducted in each study Township for one year. About 10 - 15 of the existing tube wells were selected in each Township as the monitoring wells and the officer of each Township cooperated to take records of groundwater level and basic water quality test of each monitoring well in accordance with instruction of an expert of the Study Team. In cooperation with engineers and worker of DDA, the Study Team had conducted electric resistivity surveys in 110 target villages and traced the probable depth and stretch of the aquifer and evaluated possibility of groundwater development in each village.

(2) Selection of Test Well Drilling Site

For selecting 22 villages for test well drilling sites, the Study Team evaluated several factors such as accessibility of drilling machine to the village, supposed water quality, yield of water, aquifer type, electric resistivity result, and socioeconomic factor including water supply difficulties in 110-targeted villages. Two villages in each Township were selected by the comparative study in accordance with a flowchart shown in Fig. 3.5.1.

The final decision was made through discussion with Study Team and officers of the counterpart. Such evaluation procedures were sometimes repeated in case both sides could not agree at one time.

The criteria of the site selection are as follows:

1) The earlier condition in the flowchart takes precedence over the latters.
2) Two villages should be selected in each Township
3) Accessibility, Water quality, and Estimated yield were taken as the compulsory condition. However, Aquifer geology, Geophysical factor, and socioeconomic factor were taken as the suggestive.

The selected 22 villages are shown in Fig. 3.5.2.

(3) Test Well Drilling

JICA provided a drilling rig with a 300 m deep drilling capacity equipped with necessary tools and accessories to carry out the test well drilling. JICA had also repaired three DDA-owned drilling rigs from January to March 2002 by dispatching an expert and necessary spare parts in order to restore a 200 m deep drilling capacity. Test well drilling was commenced in June 2002 by deployment of these four drilling rigs and DDA dispatched four drilling teams and other supporting staff to carry the work. The work has been continued until February, 2003, and 21 deep tube wells with depths of 200 to 300m and 2 shallow wells with a depth of 60 m, altogether 23 tube wells have been drilled. The progress of the test well drilling is shown in Fig. 3.5.3.

Daily drilling record including geological features in every meter were made to grasp the hydrogeological characteristics in the area. After well developing, water quality test and pumping test were conducted in each tube well. Since these test wells had been intended to use as production wells, JICA procured 21 sets of helical rotor pumps and delivered them to the Study Area. Two sets of airlift pumping system, which consists of an air compressor, an engine and pipes, were procured locally and provided for the two shallow wells at Aungthar village in Natogyi Township. Among the 21 deep wells, three wells were not used as production wells due to the following reasons.

At Kangyikon N village in Nyaung-U Township, aquifer could not be confirmed from the ground up to 300 m deep in the test well. At Magyithonepin village in Pakokku Township, the test well had a yield of only 5 l/min, which was too little to use. At Thayetpin village in Chauk Township, a static water level was measured at 315 m deep in the test well, which was beyond specified heads of any pumps procured under the Study.

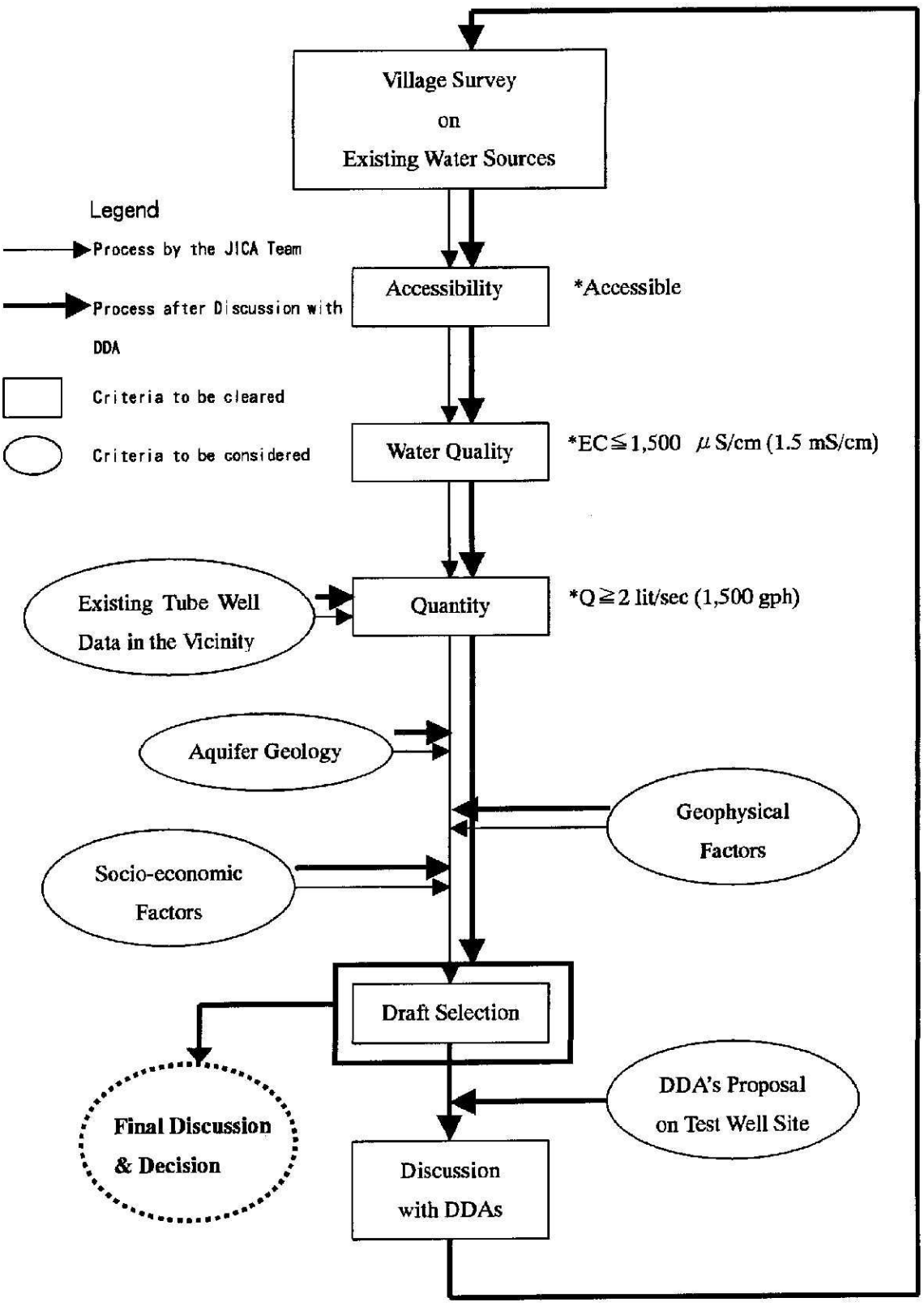
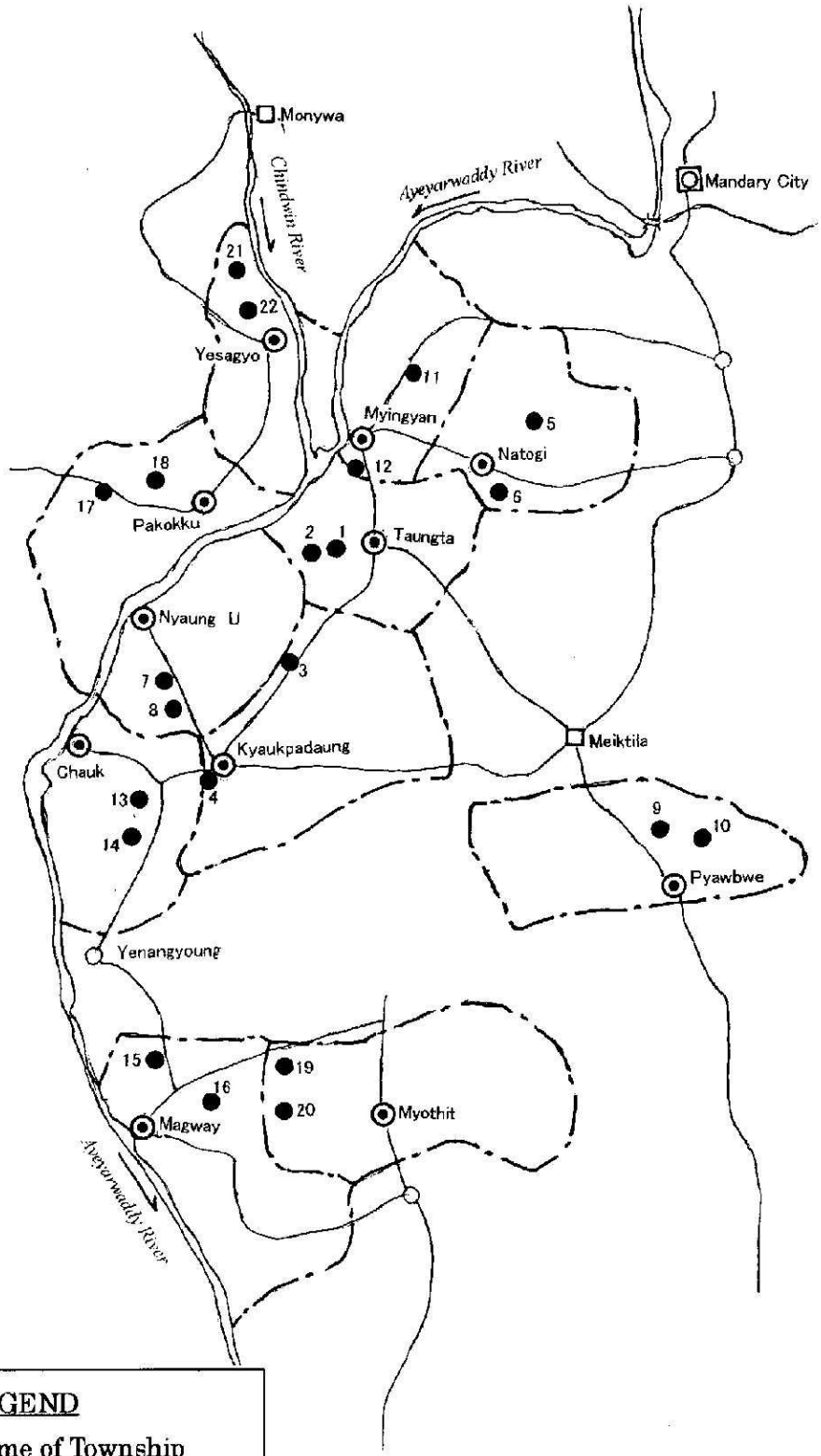


Fig. 3.5.1 Flow of Selection of 22 Test Well Construction Sites



LEGEND

◎ Name of Township

●1 Village where Test Well Constructed (No. is referred in Fig. 3.5.4)

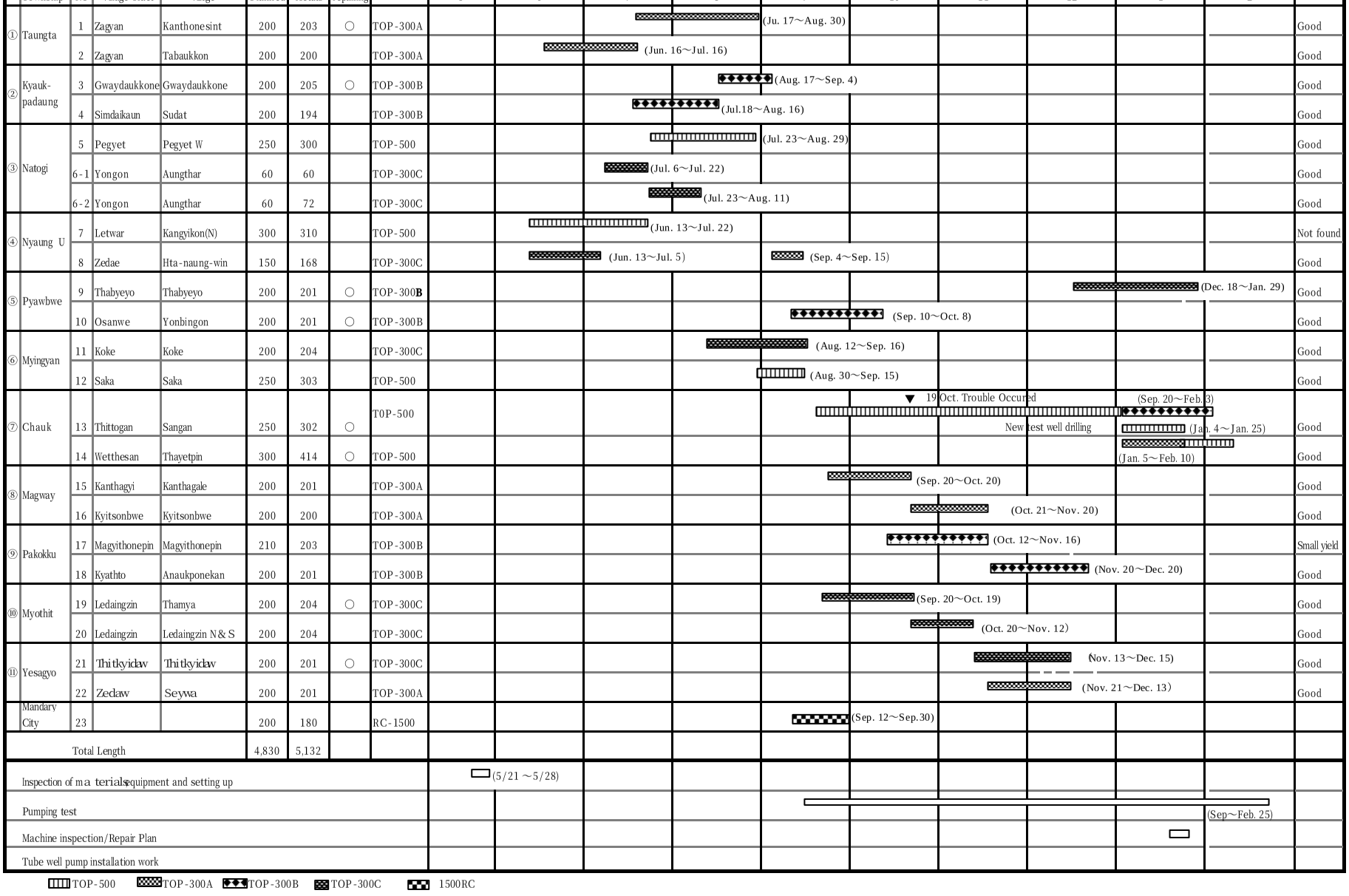
Township Boundary

Road

Fig. 3.5.2 Location of Test Well Drilling Site

Fig. 3.5.3 Progress of Drilling Work in The Central Dry Zone

	Township	NO	Village Tract	Village	Drilling depth (m) Planned	Drilling depth (m) Actual	Road repairing	Machine type	Aquifer Condition
①	Taungta	1	Zagyan	Kanthonesint	200	203	○	TOP-300A	Good
		2	Zagyan	Tabaukkon	200	200		TOP-300A	Good
②	Kyauk-padaung	3	Gwaydaukkone	Gwaydaukkone	200	205	○	TOP-300B	Good
		4	Simdaikaun	Sudat	200	194		TOP-300B	Good
③	Natogi	5	Pegyet	Pegyet W	250	300		TOP-500	Good
		6-1	Yongon	Aungthar	60	60		TOP-300C	Good
		6-2	Yongon	Aungthar	60	72		TOP-300C	Good
④	Nyaung U	7	Letwar	Kangyikon(N)	300	310		TOP-500	Not found
		8	Zedae	Hta-naung-win	150	168		TOP-300C	Good
⑤	Pyawbwe	9	Thabyeyo	Thabyeyo	200	201	○	TOP-300B	Good
		10	Osanwe	Yonbingon	200	201	○	TOP-300B	Good
⑥	Myingyan	11	Koke	Koke	200	204		TOP-300C	Good
		12	Saka	Saka	250	303		TOP-500	Good
⑦	Chauk	13	Thittogan	Sangan	250	302	○	T0P-500	Good
		14	Wetthesan	Thayetpin	300	414	○	TOP-500	Good
⑧	Magway	15	Kanthagyi	Kanthagale	200	201		TOP-300A	Good
		16	Kyitsonbwe	Kyitsonbwe	200	200		TOP-300A	Good
⑨	Pakokku	17	Magyithonepin	Magyithonepin	210	203		TOP-300B	Small yield
		18	Kyathto	Anaukponekan	200	201		TOP-300B	Good
⑩	Myothit	19	Ledaingzin	Thamya	200	204	○	TOP-300C	Good
		20	Ledaingzin	Ledaingzin N&S	200	204		TOP-300C	Good
⑪	Yesagyo	21	Thitkyidaw	Thitkyidaw	200	201	○	TOP-300C	Good
		22	Zedaw	Seywa	200	201		TOP-300A	Good
	Mandary City	23			200	180		RC-1500	
Total Length					4,830	5,132			



Another one at Yonbingon in Pyawbwe Township was an artesian well, for which pump was not necessary. Therefore four sets of well pumps were no need to be installed for the above three unsuccessful wells and an artesian well.

The result of the test well drilling is shown in Table 3.5.1.

Pump installation work have been done for two months from May 2003 under supervision of an engineer of the Study Team. Consequently, 17 sets of well pumps were installed in total except the above three unsuccessful test wells and an artesian well. DDA has constructed a set of reservoir, pump house, and pipe between the pump and the reservoir for each tube well on its own responsibility.

The two unsuccessful tube wells in Magyithonepin and Thayetpin villages will be used as monitoring wells to trace water level and water quality in future. However, the one in Thayetpin village can be utilized as the production well if a pump with an enough capacity is procured. The above four sets of well pumps unused this time can be installed for the wells to be drilled in the "10 Year Project" in the Central Dry Zone in future. The specifications of these four well pumps are as follows,

Table 3.5.2 Specification for Well Pumps to be Stored in DDA's Warehouse

Head(m)	Discharge (gal/hr)	Well Diameter (mm)	Length of Riser Pipe (m)	No.	Engine (kW)
220	3,000	>120	220	1	15.5
170	1,500	>100	170	1	7.3
120	1,000	>120	120	1	3.0
100	1,000	>100	100	1	3.0

Groundwater Zoning Maps were prepared based on the results obtained by the above mentioned hydrogeological surveys and test well drilling. The maps were prepared in each Township and assumed groundwater levels, electric conductivities ranges, etc. were shown on them.

Table 3.5.1 Result of Installation of Pumps for Test Wells

	Village Tract	Village	Population		Water Demand		Pumping Test Result Water Level			Pump to be installed			Ground Tank proposed Capacity (gallon)	
			Year 2001	Year 2010	Total Demand (gal/day)	Required Pump Rate (gal/hr)	Static Water Level	Dynamic Water Level	Discharge (gals/hr)	Discharge (gals/hr)	Head (m)	Installation Depth (GL-m)		
Taungtha	Zagyan	Kanthonesint	1,332	1,564	23,460	2,932	-130.6	-130.6	3,165	3,000	220	-150	8,000	
	Zagyan	Tabaukkon	410	481	7,221	903	-149.0	-157. 0	2,255	1,800	200	-170	5,000	
Kyaukpadaung	Gwaydaukkone	Gwaydaukkone	1,560	1,832	27,476	3,434	-159.0	-160.0	2,110	2,000	170	-170	5,000	
	Simdaikan	Sudat	500	587	8,806	1,101	-121.0	-123.0	2,413	2,000	170	-180	5,000	
Natogyi	Pegyet	Pegyet W	1,261	1,481	22,209	2,776	-24.0	-46.0	7,530	5,000	170	-100	8,000	
	Yongon	Aungthar					-21.0	-50.0	264					Two sets of Air Copressor were supplied already
			902	1,059	15,886	1,986	-15.0	-56.0	343		-		2,000	
Nyaung U	Letwae	Kangyikon N	700	822	12,329	1,541			-	Not available due to unidentidication of aquifer.				
	Zedae	Htanaungwin	750	881	13,209	1,651	-99.0	-110.0	3,165	2,000	170	-130	5,000	
Pyawbwe	Thabyeyo	Thabyeyo	500	587	8,806	1,101	-24.0	-72.0	198	1,000	120	-130	3,000	
	Osanwa	Yonbingon	350	411	6,164	771			-	Artesian well				
Myingyan	Koke	koke	2,500	2,935	44,031	5,504	-14.0	-56.0	7,029	5,000	170	-100	15,000	
	Saka	Saka	1,001	1,175	17,630	2,204	-46.0	-54.0	8,176	3,000	220	-100	6,000	
Chauk	Thittogan	Sangan	700	822	12,329	1,541	-178.0	-181.0	1,055	1,500	270	-210	4,000	
	Wetthesan	Thayetpin	1,150	1,350	20,254	2,532	-315.0	-315.0	1,600	Installation of Pump was not available due to the deep groundwater level, which is beyond specified heads of the procured pumps.				
Magway	Kanthagyi	Kanthagale	1,146	1,346	20,184	2,523	-107.0	-108.0	3,560	2,000	170	-155	7,000	
	Kyitsonbwe	Kyitsonbwe	5,000	5,871	88,063	11,008	-163.0	-164.8	642	1,000	220	-175	3,000	
Pakokku	Magyithonepin	Magyithonepin	350	411	6,164	771	-194.0	-196.0	66	Not available due to very small yield.				
	Kyathto	Anaukponekan	950	1,115	16,732	2,091	-96.0	-110.0	3,560	2,000	170	-153	6,000	
Myothit	Ledaingzin	Thamya	2,500	2,935	44,031	5,504	-122.0	-124.1	1,780	2,000	170	-165	6,000	
	Ledaingzin	Ledaingzin N&S	3,000	3,523	52,838	6,605	-69.6	-72.5	5,934	3,000	170	-155	8,000	
Yesagyo	Thitkyidaw	Thitkyidaw	3,000	3,523	52,838	6,605	-15.7	-22.4	10,549	5,000	170	-100	12,000	
	Zedaw	Seywa	1,075	1,262	18,933	2,367	-25.1	-25.4	9,587	2,000	170	-100	6,000	

3.6 Groundwater Potential and Policy of Improving Water Use Conditions

(1) Groundwater Potential

Based on various surveys done in this Study, major targeted aquifers to be developed in the Central Dry Zone are Alluvial aquifer, Irrawddy Formation aquifer, and Pegu Group aquifer. The Alluvial aquifer, which exists in unconsolidated sediments of silt, sand, or gravels, is generally the most important groundwater source due to its high porosity and permeability. However, the Alluvial sediment is not found so common in the Central Dry Zone. It is distributed mainly along big rivers and its tributaries. On the other hand, Irrawddy Formation and Pegu Group are found widely in this zone. Although consolidated sedimentary rocks such as sandstone and conglomerate of the Irrawddy Formation and Pegu Group have a poorer potential of groundwater comparatively than the Alluvial layer, fissure water saturated in fractured or weathered zone in these rocks being developed by tectonic faults or folds are expected to be as good and promised aquifer.

The result of the field survey shows that groundwater in the study is available generally for the rural water supply purpose. However, as the fissure aquifer generally distributes limitedly in width and in depth, the following activities are highly recommended for developing groundwater in the study area:

- To grasp hydrogeological feature of the targeted area by analyzing data of the existing tube wells and other hydrogeological data.
- To conduct a geophysical survey carefully, and
- To design tube well structure based on the above analyses and well logging data.

It is also suggested to design the structure and location of tube wells for preventing from extracting the groundwater contained with saline or high minerals.

(2) Policy of Improving Water Use Conditions

The most common water source for villages in the Central Dry Zone is traditional rain-fed reservoirs. Dug wells are also widely used in the rural area. These water sources drop the water level and finally dry off in dry season. Therefore the water use conditions is directly affected by whether the village has alternative water sources near it.

Almost rivers and creaks in the Central Dry Zone dry out in dry season except the Ayeyarwaddy River and a few tributaries of it. Of course the flow of these rivers is reduced largely in dry season. Villages located near these rivers have an advantage to

access water easily. Villagers in many other villages located far from these rivers have to spend a lot of time to fetch water from deep wells in other villages or other possible water sources.

Groundwater development projects in the rural area in Myanmar have been implemented actively from 1980s by some international aid organization such as UNDP, UNICEF, or NGOs. Thousands of tube wells have been constructed through those projects. Not only villagers having the tube well in their village but also many people living in the surrounding villages depend on the tube well as an irreplaceable water source. The tube well is operated and maintained by a water committee formed by the villagers and the committee charges the users for their water consumption. Through the experience of using the tube well in other village, villagers, who have not their own tube well yet, have a basic knowledge on how to manage the facilities and eager to have a tube well in their village. They have basically a high incentive to manage the facilities including sharing its operational cost.

Most of villages in the study area have a range of population among hundreds and two thousands. They are isolated each other by several miles of distance. This means a water system connecting each village by a pipeline is normally more expensive than tube well constructions. In addition, taking the groundwater potential into account, groundwater development project adopting point-source water supply system is judged to be the most suitable for improving water use conditions in the villages. In order to secure the project management more sustainable, mechanical and financial trainings to the targeted villages on the initial operation stage and periodical monitoring on the facilities by the authorities are required.

Although the depth of the existing tube wells is generally limited up to nearly 200m, it was confirmed that deeper aquifers up to nearly 300m were distributed in some of the study villages. Therefore introduction of drilling equipment with an enough capacity is important to carry out widely and stably the groundwater development in the study area.

3.7 Component of Proposed Project

(1) Objectives of Proposed Project

Objectives of the proposed project are to provide villages hygienic and healthy living circumstance by supplying safe and enough water and thereby to reduce burden of the

villagers in fetching water from outside the village for several hours in the dry season. It is expected that villagers could increase their income by making good use of the time saved by decreasing water fetching work.

(2) Status of Proposed Project

As the proposed project shares in a significant element of "10 Year Project" of DDA, "10 Year Project" could not be accomplished without the proposed project. Target of the proposed project is 110 villages, which belong to six Townships in Mandalay Division and five Townships in Magway Division. There are 21,700 of households and 117,100 of populations living in these 110 villages in year 2001. The population is expected to increase up to 137,500 in 2020.

(3) Component of the Proposal

The present main water sources in the targeted villages are rain fed reservoirs/ponds or dug wells. Villagers try to use the pond water as long as possible in the dry season. Such basic water using style would not be changed in future. Because the pond water is the most economical and accessible source in the village. Unfortunately there is no river or spring to be useful through the year as the alternative water source within the accessible distance from the targeted villages. Therefore the project proposes the following basic measures.

- Groundwater development project as an alternative water source in the dry season.
- Measures for villages where could not use groundwater sufficiently
- Enhancement of operation and maintenance capacity for tube wells facilities and well drilling machine in order to guarantee a sustainable project implementation

(4) Groundwater Development Project

In accordance with the result of the field reconnaissance, there is no river or spring to be useful through the year as the alternative water source near the target villages. Therefore, groundwater is the most reliable and applicable water source, if it could be economically exploited. The results gained through hydrogeological survey and the test well construction indicate that it would be possible to obtain enough groundwater to cater the water demand in almost all the target villages on condition that the tube well has a depth from 200m to 300m, even though some of them are situated on the Pegu Group, which hydro-geologically shows a tendency of saline groundwater, or some are on the Irrawaddy Formation with a small optimum yield. From the hydrogeological point of view, as the target aquifer would be

mainly fissure water in rock layer, which exists quite narrow area, it is suggested to analyze carefully the results of hydrogeological surveys of electrical & electromagnetic resistivity and well logging so that even a small indication of aquifer should not be missed.

1) Proposed Well Facilities

In case that the design optimum yield of a tube well is over the water demand of a village, one tube well should be drilled. On the other hand, in case that the optimum yield cannot cater the demand, two wells should be constructed in the village. In case the two tube wells cannot cater the demand, more tube wells are not considered to drill in this study, because operation of these facilities might give the village a heavy burden. It is recommended that DDA has to trace such villages from the financial and operational points of view and to expand the facilities when the villages was confirmed to have enough capacity to expand the systems in future.

Depth of the proposed wells is designed at a range from 200 m to 300 m based on the results of the hydrogeological analysis. The diameter of well casing is a six inches from the points of discharge volume and well pump diameter to be installed. In accordance with the results of the test well drilling, the characteristics of the proposed wells for each village are decided as shown in Table 3.7.1.

18 numbers of the test wells constructed and succeeded in obtaining good aquifer by this study should be taking into account as the production wells. Deducting these constructed wells, the total numbers of the proposed 200m and the 300m deep wells are 98 and 22 respectively, 120 wells altogether as shown in Table 3.7.2.

Depending on results of the test well construction, static water level and dynamic water level inside of the tube wells are difficult to be estimated in each site because the expected aquifers' positions are not even. Therefore a helical rotor type pump, which has a higher applicability to a large change of groundwater level than the ordinal submersible motor pump, is recommendable to be adopted in the proposed project.

Table 3.7.1 Proposed Production Wells in Target Vollages

Township	No.	Village Tract	Village	Population 2001	Population 2010	Water Demand in 2010 (gal/day)	Proposed Well Structure (*Result of Test Well*) W. Level (GL-m) Static	W. Level (GL-m) Dynamic	Pumping test Discharge (gal/hr)	Well Depth (m)	Pump for Test Well Dischg. (gal/hr)	Pump for Test Well Head (m)	Proposed Pump Capacity Discharge (gal/hr)	Proposed Pump Capacity Head (m)	Proposed Pump Capacity Pump level (GL-m)	Proposed Ground Tank Capacity (gal)	Remarks
Taungtha Township	1	Magyi-pinte	Pegingyaw	881	1,034	15,517				200			1000 x 2	170		5,000	2 well facilities will be constructed.
	2	Zagyan	Kanthonesint	1,332	1,564	23,460	-130.6	-130.6	3,165	*200*	3,000	220	-	-		8,000	Test Well
	3	Zagyan	Tabaukkon	410	481	7,221	-149	-157	2,255	*200*	2,000	170	-	-		5,000	Test Well
	4	Aungtha	Aungtha	1,012	1,188	17,824				200			1000 x 2	170		3000 x 2	2 well facilities will be constructed.
	5	Thaputsu	Dahatan	453	532	7,978				200			1,000	170		3,000	
	6	Chauk-gwa	Twinbye	1,677	1,969	29,536				200			2000 x 2	170		5000 x 2	2 well facilities will be constructed.
	7	Thaputsu	Kyaukpon	824	968	14,513				200			1000 x 2	170		3000 x 2	2 well facilities will be constructed.
	8	Simigan	Thazi	876	1,029	15,429				200			1000 x 2	170		3000 x 2	2 well facilities will be constructed.
	9	Panpaung	Magyigon	413	485	7,274				300			1,000	270		3,000	
	10	Magincho	Sizongon	558	655	9,828				200			1,500	170		3,000	
		Total		8,436	9,905	148,579											
Kyaukpadaung Township	1	Gwaydaukkone	Gwaydaukkone	1,560	1,832	27,476	-159	-160	2,110	*200*	2,000	170			166	5,000	Test Well
	2	Popa	Chaungbya	696	817	12,258				300			1,500	270		4,000	
	3	Tanga-kan	Tangakan	786	923	13,843				200			2,000	170		5,000	
	4	Letpanpin	Htantawgyi	780	916	13,738				200			2,000	170		5,000	
	5	Kanbauk	Kanbauk	1,456	1,710	25,644				200			3,000	170		9,000	
	6	Simdaikan	Sudat	500	587	8,806	-121	-123	2,413	200	1,800	200	-	-		5,000	Test Well
	7	Simdaikan	Sagyaw	461	541	8,119				200			1,000	170		3,000	
	8	Sonywa	Kanyai & Salindaung	500	587	8,806				200			1,000	170		3,000	
	9	Twinphyu	Inbingyi	850	998	14,971				300			1,500	270		4,000	Exst.1500gal/hr
	10	Kyauksayitkan	Lwinpinkone	800	939	14,090				300			1000 x 2	270		3000 x 2	2 well facilities will be constructed.
		Total		8,389	9,850	147,751											

Township	No.	Village Tract	Village	Population		Water Demand in 2010	Proposed Well Structure (*Result of Test Well*)				Pump for Test Well		Proposed Pump Capacity			Proposed Ground Tank Capacity (gal)	Remarks
							W. Level (GL-m)		Pumping test Discharge (gal/hr)	Well Depth (m)	Dischg. (gal/hr)	Head (m)	Discharge (gal/hr)	Head (m)	Pump level (GL-m)		
				2001	2010	(gal/day)	Static	Dynamic									
Natogyi Township	1	Pegyet	Pegyet W	1,261	1,481	22,209	-24	-46	7,530	300	5,000	170				14,000	Test Well
	2	Thaminbe	Buthigyin	965	1,133	16,996				200			2,000	170		6,000	
	3	Mogan	Mogan W	699	821	12,311				200			1000 x 2	170		2000 x 2	2 well facilities will be constructed.
	4	Thangwa	Thangwa	774	909	13,632				200			2,000	170		5,000	
	5	Gwegon	Thapandaw	856	1,005	15,076				200			1000 x 2	170		3000 x 2	2 well facilities will be constructed.
	6	Letwe	Letwe	2,087	2,450	36,757				200			5,000	170		13,000	
	7	Nyaungon	Nyaungon	774	909	13,632				200			1000 x 2	170		3000 x 2	2 well facilities will be constructed.
	8	Pyayachaung	Thintabaw	856	1,005	15,076				200			2,000	170		5,000	
	9	Ketlan	Ketlan	3,200	3,757	56,360				200			1000 x 2	170		3000 x2	2 well facilities will be constructed.
	10	Yongon	Aungthar				-21	-50	264	60	Air Compressor						Test Well
				902	1,059	15,886	-15	-56	343	200			1000 x 2	170		3000 x 2	2 well facilities will be constructed.
		Total		12,374	14,529	217,937											
Nyaung U Township	1	Kantharyar	Kantharyar	1,375	1,614	24,217				200			1,500	170		4,000	Exst.1200gal/hr
	2	Kuywa	Kuywa	1,000	1,174	17,613				200			2,000	170		6,000	
	3	Phalankan	Phalankan	1,500	1,761	26,419				200			1000 x 2	170		3000 x2	2 well facilities will be constructed.
	4	Setsetyo	Setsetyo	1,000	1,174	17,613				300			1000 x 2	270		3000 x 2	2 well facilities will be constructed.
	5	Letwae	Kangyikon N	700	822	12,329	-	-		300							Test Well (Dry well)
	6	Letwae	Kangyikon S	570	669	10,039				300			1,500	270		4,000	
	7	Taungzin	Kaungpinsi	1,708	2,005	30,082				200			2000 x 2	170		5000 x 2	2 well facilities will be constructed.
	8	Setsetyo	Myetkhataw	600	705	10,568				200			1,000	170		4,000	
	9	Htipu	Ywalu	600	705	10,568				200			1,000	170		4,000	
	10	Zedae	Htanaungwin	750	881	13,209	-99	-110	3,165	200	2,000	170	-	-	130	5,000	Test Well
		Total		9,803	11,510	172,655											
Pyawbwe Township	1	Thabyeyo	Thabyeyo	500	587	8,806	-24	-72	200	200	1,000	120	-	-		3,000	Test Well
	2	Osanwa	Yonbingon	350	411	6,164	Artesian Well		3500	200			-	-		-	Test Well
	3	Faungtan	Yebyu	535	628	9,423				200			1,500	170		3,000	
	4	Faungtan	Paukaingyo	535	628	9,423				200			1,500	170		3,000	
	5	Kyette	Kyette	1,000	1,174	17,613				200			2,000	170		6,000	
	6	Kongtha	Thabok	750	881	13,209				200			1,500	170		5,000	
	7	Magyigon	Magyigon	650	763	11,448				200			1,500	170		4,000	
	8	Sabaegon	Pegan N	420	493	7,397				200			1,000	170		3,000	
	9	Sabaegon	Pegan S	480	564	8,454				200			1,000	170		3,000	
	10	Sabaegon	Nyandaw	331	389	5,830				200			1,000	170		2,000	
		Total		5,551	6,518	97,767											

Township	No.	Village Tract	Village	Population		Water Demand in 2010	Proposed Well Structure (*Result of Test Well*)				Pump for Test Well		Proposed Pump Capacity			Proposed Ground Tank Capacity (gal)	Remarks
							W. Level (GL-m)		Pumping test Discharge (gal/hr)	Well Depth (m)	Dischg. (gal/hr)	Head (m)	Discharge (gal/hr)	Head (m)	Pump level (GL-m)		
				2001	2010	(gal/day)	Static	Dynamic									
Myingyan Township	1	Pyawt	Chinmyikyin	476	559	8,384				200			1,000	170		3,000	
	2	Ywatha	Ywatha	2,800	3,288	49,315				200			3000 x 2	270		8000 x 2	2 well facilities will be constructed.
	3	Koke	koke	2,500	2,935	44,031	-14	-56	5,275	200	5,000	170	-	-		15,000	Test Well
	4	Koke	Ywathaya	1,554	1,825	27,370				200			4,000	170		9,000	
	5	Taywinbo	Kyaungbyugan	1,000	1,174	17,613				200			2,000	170		6,000	
	6	Pya	Pya	3,038	3,567	53,507				200			3000 x 2	170		9000 x 2	2 well facilities will be constructed.
	7	Kuywa	Kuywa	2,061	2,420	36,299				300			2500 x 2	270		6000 x 2	2 well facilities will be constructed.
	8	Saka	Saka	1,001	1,175	17,630	-46	-54	8,176	300	3,000	170	-	-		6,000	Test Well
	9	Gwebinyo	Gwebinyo	236	277	4,157				200			1,000	170		2,000	
	10	Gwebinyo	Taungshe	1,000	1,174	17,613				200			2,000	170		6,000	
		Total		15,666	18,395	275,918											
Chauk Township	1	Gwegyo	Sharbin	1,200	1,409	21,135				300			1000 x 2	270		4000 x 2	2 well facilities will be constructed.
	2	Thittogan	Sudat	1,058	1,242	18,634				300			1000 x 2	270		3000 x 2	2 well facilities will be constructed.
	3	Thittogan	Sangan	700	822	12,329	-178	-179	1,200	300	1,500	270	-	-		4,000	Test Well
	4	Thalonthwe	Pyaywa	800	939	14,090				300			1000 x 2	270		3000 x 2	2 well facilities will be constructed.
	5	Kywedat	Kywedatywama	1,000	1,174	17,613				300			2,000	270		6,000	
	6	Suyitkan	Kyeiksu S	456	535	8,031				200			1,000	170		3,000	
	7	Swebaukkan	Zigyobin S	450	528	7,926				300			1,000	270		3,000	
	8	Wetthesan	Thayetpin	1,150	1,350	20,254	-315	-315	1,600	415	-	-	1,500	320		4,000	Test Well
	9	Swebaukkan	Yela	957	1,124	16,855				300			2,000	270		6,000	
	10	Thanbo	Kyauktaing	557	654	9,810				300			1,000	270		3,000	
		Total		8,328	9,778	146,677											
Magway Township	1	Kanthagyi	Kanthagale	1,146	1,346	20,184	-107	-107.85	3,560	200	2,000	170	-	-		7,000	Test Well
	2	Kyitsonbwe	Kyitsonbwe	5,000	5,871	88,063	-163	-164.8	642	200	1,000	170	-	-		3,000	Test Well, Exst.10000gal/hr
	3	Payapyo	Payapyo N	1,045	1,227	18,405				200			1000 x 2	170		3000 x 2	2 well facilities will be constructed.
	4	Thabyesen	Minwa S	540	634	9,511				200			1,000	170		3,000	
	5	Thabyesen	Thabyesen N	250	294	4,403				200			1,000	170		2,000	
	6	Leya	Taungyartaw	470	552	8,278				200			1,000	170		3,000	
	7	Papaesan	Ywataw	224	263	3,945				200			1,000	170		2,000	
	8	Kunon	Yonekone	815	957	14,354				200			2,000	170		5,000	
	9	Alebo	Inbinkan	610	716	10,744				200			1,500	170		4,000	
	10	Alebo	Ywakuitsan	145	170	2,554				200			1,000	170		2,000	
		Total		10,245	12,029	180,440											

Township	No.	Village Tract	Village	Population 2001	Population 2010	Water Demand in 2010 (gal/day)	Proposed Well Structure (*Result of Test Well*) W. Level (GL-m) Static	W. Level (GL-m) Dynamic	Pumping test Discharge (gal/hr)	Well Depth (m)	Pump for Test Well Dischg. (gal/hr)	Pump for Test Well Head (m)	Proposed Pump Capacity Discharge (gal/hr)	Proposed Pump Capacity Head (m)	Pump level (GL-m)	Proposed Ground Tank Capacity (gal)	Remarks
Pakokku Township	1	Padaingchone	Myauklukan	1,800	2,114	31,703				200			2,000	170		5,000	Exst. 2000gal/hr
	2	Magyithonepin	Magyithonepin	350	411	6,164	-194	-196	66	300			1,000	270		2,000	Test Well, Reconstruction
	3	Kanyet	Kyauksayitkan	750	881	13,209				200			1,500	170		5,000	
	4	Kyathto	Anaukponekan	950	1,115	16,732	-96	-110	3,560	200	2,000	170	-	-		6,000	Test Well
	5	Chaukkan	Chaukkan W	1,432	1,681	25,221				200			1,500	170		4,000	Exst. 3000gal/hr
	6	Kyathto	Kyathtoe	577	677	10,162				200			1,000	170		4,000	
	7	Palan O	Palan O	2,700	3,170	47,554				200			1000 x 2	170		3000 x 2	Exst. 1000gal/hr 2 well facilities will be constructed.
	8	Sabae	Sarkyin	800	939	14,090				200			1000 x 2	170		3000 x 2	2 well facilities will be constructed.
	9	Palan O	Kanpauksu	730	857	12,857				200			1,500	170		4,000	Exst. 2000gal/hr
	10	Sabae	Sabae W	1,444	1,695	25,432				200			1000 x 2	170		3000 x 2	Exst. 300gal/hr 2 well facilities will be constructed.
		Total		11,533	13,542	203,125											
Myothit Township	1	Ledaingzin	Thamya	2,500	2,935	44,031	-122	-124.1	1,780	200	2,000	170	*3000	*170		6,000	Test Well, *Exst. 3000gal/hr(damaged)
	2	Ledaingzin	Ledaingzin N&S	3,000	3,523	52,838	-69.6	-72.5	5,930	200	3,000	170	1,500	170		8000+4000	Test Well, Exst. 2440gal/hr
	3	Yebye	Natkan	1,200	1,409	21,135				200			1,500	170		4,000	Exst.1500gal/hr
	4	Ledaingzin	Aungmyinthar	750	881	13,209				200			1,500	170		5,000	Exst.1500gal/hr
	5	Ledaingzin	Pogyi	2,000	2,348	35,225				200			1000 x2	170		3000 x2	Exst.1000gal/hr 2 well facilities will be constructed.
	6	Yondaw	Myinsu	390	458	6,869				200			1,000	170		3,000	Exst.3000gal/hr
	7	Gwegyo	Gwegyo W	900	1,057	15,851				200			1000 x 2	170		3000 x 2	2 well facilities will be constructed.
	8	Yondaw	Yondaw	2,568	3,015	45,229				200			1500 x 2	170		5000 x 2	Exst.1500gal/hr 2 well facilities will be constructed.
	9	Wagyiaing	Wagyiaing	3,000	3,523	52,838				200			1000 x 2	170		3000 x 2	Exst.500gal/hr 2 well facilities will be constructed.
	10	Wagyiaing	Ngwelay	1,500	1,761	26,419				200			1,500	170		4,000	Exst.3000gal/hr
		Total		17,808	20,910	313,644											
Yesagyo Township	1	Pyiba	Byiba	804	944	14,160				200			1,000	170		2,000	Exst.1200gal/hr
	2	Thitkyidaw	Thitkyidaw	3,000	3,523	52,838	-15.7	-22.4	10,549	200	5,000	170	-	-		12,000	Test Well, Exst. 1800+500gal/hr
	3	Wetkdaw	Thitkaukseik	655	769	11,536				200			1,500	170		4,000	exst.2400gal/hr
	4	Zedaw	Seywa	1,070	1,256	18,845	-25.1	-25.4	9,587	200	2,000	170	-	-		6,000	Test Well, Exst. 400gal/hr
	5	Salingon	Sattwa	637	748	11,219				200			1,500	170		4,000	Exst.1350gal/hr
	6	Kyaukka	Chinyagone	692	813	12,188				200			1,500	170		4,000	Exst.2000gal/hr
	7	Kyaukka	kyaukka	420	493	7,397				200			1,000	170		3,000	Exst.?gal/hr
	8	Kyaukka	Kyauktaga	326	383	5,742				200			1,000	170		2,000	Exst.?gal/hr
	9	Tangedaw	Zidaw	640	751	11,272				200			1,000	170		4,000	Ex.750gal/hr
	10	Tangedaw	Kunthigan	700	822	12,329				200			1,500	170		4,000	Exst.6000gal/hr
		Total		8,944	10,502	157,526											
		Ground Total		117,077	137,468	2,062,020											

Table 3.7.2 Number of Proposed Tube Wells

Division	Name of Township	Depth of Tube Well: 200m	Depth of Tube Well: 300m	Total
Mandalay	Taungtha	12	1	13
	Kyaukpadaung	5	4	9
	Natogyi	14	-	14
	Nyaung-U	8	3	11
	Pyawbwe	8	-	8
	Myingyan	9	2	11
Magway	Chauk	1	11	12
	Magway	9	-	9
	Pakokku	11	1	12
	Myothit	13	-	13
	Yesagyo	8	-	8
	Total	98	22	120

A set of reservoir, pump house, and a connecting pipeline is necessary for each tube well. These facilities shall be constructed by the local authorities. The water will be supplied through the faucets installed on the reservoir. In case groundwater shows high iron content, an apparatus for reducing iron contents will be installed if necessary. Drawings of the proposed facilities are shown in Fig. 3.7.1 to 3.7.6.

2) Period and Manners for Project Implementation

The proposed project shall link to "10 Year Project" of DDA and expedite its implementation. Assuming that the proposed project is commenced from fiscal year 2004 and continued for five years, the project would be completed in the year 2009. This schedule seems very significant, because the fiscal year 2009 is coincident with the final target year of "10 Year Project" of DDA.

Five operable the existing drilling rigs of DDA, which were donated in 1983 and 86, are planned to deploy for the "10 Year Project". However, the project requires more several numbers of drilling rigs due to the big numbers of tube wells to be drilled by the completion time of the project. Two rigs donated from Japan for a project in northern Shan State in 2001 are under operation in the project sites. Therefore, no DDA-own drilling rigs have time to work in the proposed project. On the other hand, JICA provided a drilling rig with a 300m-deep capacity in 2002 for the study. Although some of accessories and tools provided with it have been consumed already, the machine can be used for the proposed project with necessary accessories and tools to be newly supplemented. Consequently two more drilling rigs with a drilling capacity of 200 m to 300 m deep are needed in order to drill the total proposed wells within five years.

Some thousands of shallow and deep tube wells have been constructed through rural water

supply projects implemented since 1980's. Among them there are cases in which tube well could not be used and abandoned due to deterioration of pumping equipment or clogging of well strainers during many years using. It is quite obvious that rehabilitation or restoration works for such troubled tube wells would be more required in future. Therefore it is highly recommended that equipment and tools for the work of rehabilitation or restoration of tube wells shall be provided and the technology shall be transferred to DDA so as to secure more sustainable implementation of the project.

DDA has experiences of three groundwater projects as follows,

- Urban Water Supply Project in 1983: for groundwater development and water supply facilities construction in two Townships.
- Urban Water Supply Project in 1986: the same component in other nine Townships.
- Groundwater Development in the Northern Shan State in 2001: Rural water supply by the groundwater development.

The above two upper projects had been implemented by the General Affairs Department (GAD), the predecessor of DDA, under the Ministry of Home and Religious Affairs. DDA is carrying out the above last project. The construction works of those projects were actually performed by DDA or the predecessor by using equipment and materials donated by Japanese Grant Aid with the local budget. Through the implementation of those projects, DDA has a good understanding of the system of Japan's Grant Aid. Therefore it can be said that DDA is capable to implement construction work of the proposed project if the necessary equipment and materials are supplied, on the same basis of those former projects.

3) Equipment and Material Procurement Plan and Cost Estimation

Equipment and materials required for the proposed project is as shown in Table 3.7.3. This includes drilling rigs, supporting equipment, well materials, pumps, and inspection devices necessary to complete 120 of tube wells construction. A set of equipment and tools for rehabilitation of the existing tube wells and a mobile workshop for repairing or reforming of machine, accessories, etc. to be applied in the drilling sites are also included. Myanmar side shall construct reservoirs, pump houses, related pipes and also bear expenses of fuel and labors for the drilling work.

Table 3.7.3 Equipment and Materials to be Procured from Foreign Countries

	Categories	Name of Machine	Specifications	Quantity
1	Well Drilling	1) Truck Mounted Drilling Rig	300 m deep capacity	2 Set
2	Tools and Accessories	1) for the above Drilling Rig	300 m deep capacity	2 Set
		2) for Drilling Rig (JICA Provided in 2001, including consumed ones during the test well drilling under this Study for DDA-owned rigs)		1 Set
3	Supporting Equipment	1) Air Compressor		3 Sets
		2) Long body Cargo Trucks	4WD, 6 ton loading capacity with 3t crane	2 Sets
		3) Medium size Cargo Trucks	4WD, 3 ton loading capacity	2 Sets
		4) Water Bowser (Tanker)	$8m^3$, 4WD	3 Sets
		5) Pick up car	4WD、W-Cabin	4 Sets
		6) Mobile Workshop	With equipment and tools	1 Set
		7) Truck mounted well Repairing Equipment		1 Set
		8)Pumping Test Equipment	φ100mm, 800lit/min φ80mm, 400lit/min	3 Sets
4	Well Materials	Well Casing φ12”		3,600m
		Well Casing φ6”		22,270m
		Screen φ6”	SUS,	3,930m
		Centerizer		1 Set
		Bentonite, CMC		1 Set
5	Well Pump	Helical Rotor Pump with Diesel Engine	1000gal/hr～5000gal/hr	121 Sets
6	Others	Well logging equipment	Capable to logging is up to 400 m deep/	1 Set
		Water quality equipment		1 Set

The materials to be procured in local is as follows,

Table 3.7.4 Materials to be Procured in Local

Material	No.
Cement	1 Lot
Sand, Gravel	1 Lot
Diesel Oil	1 Lot
Other Raw Materials	1 Lot
Labor	1 Lot

The project cost consists for purchasing equipment and materials from the foreign countries was estimated at US$ 9.0 million. The cost for procuring local materials to be born by the local Government was estimated at US$350 thousand.

4) Operation and Maintenance Plan

Village committees have been formulated in all the target villages and they have been taking various actions for operating the existing facilities such as ponds, dug wells or shallow wells and for improving hygienic conditions of the villages. The proposed water supply facilities are not new to the villagers and can be managed by the water committee to be organized by the villagers. Since each of the villages belongs to one of Township Development Committees, which are under the jurisdiction of DDA, the villages can obtain necessary assistances from the Township in case of any problems arising after the project commencement. It is highly recommended to create a cooperative relationship between the villages and the township office for the proposed project to produce results. On that basis, Township officers are expected to be involved in educational programs for improving the water supply and hygienic conditions in the villages and also in training villagers for operation and maintenance of the facilites.

DDA has a full responsibility to maintain the drilling equipment, supporting equipment, tools and accessories. At present DDA has more than ten numbers of vehicles including cargo trucks and truck mounted drilling rigs. As some more equipments are expected to provide by the proposed project, workshops with adequate equipment and skilled mechanics for maintenance should be essential. However, DDA has no properly arranged workshop at present. In the Central Dry Zone, there are several workshops with well skilled technicians and adequate equipment, which belong to other departments such as Myanmar Petroleum and Power Enterprise, Myanmar Railways, or a middle scale workshop of WRUD. If it is possible to obtain proper supports from these workshops in the project implementation, the success of the project could be secured firmly. Therefore it is the highest recommendation that the central government should sufficiently coordinate between such ministries and departments for utilizing their workshops in the propose project.

(2) Alternative Measures Other Than Groundwater

There is no useful river through the year near the target villages. Therefore, the following measure were proposed for the villages unable to utilize groundwater sufficiently, namely i) Measure for expansion of duration of reservoir utility, ii) Rainwater harvesting by Roof Catchments, iii) Emergency water supply by water bowsers.

For the proposal i) above, excavation of the existing ponds and changing the direction of streams to the pond were recommended. It is necessary to design in detail especially for changing the direction of streams based on a geographical survey of the surrounding area.

Proposal ii) is applicable by comparatively small structure. And materials to be used are purchasable in local and construction is also easy. The construction cost is estimated around US$ 1000 to 1 US$ 500 for the one unit. Above two proposals are measures to make a good use of rainwater and the villagers can manage construction on the basis of voluntary work. Proposal iii) is an idea for emergency occasion and not considered for a permanent measure. A reference drawing of the rainwater harvesting by roof catchments is shown in Fig. 3.7.7.

3.8 Financial and Economic Analyses

An average water tariff was recommended to set between Ks 20 and Ks 25 per 50gallons for the target villages in the proposed project, assuming that it should cover the operation cost and basic repair cost for the facilities, and also taking the villagers' affordability to pay for water into account.

In case that the propose project would be implemented without subsidy, water tariff was estimated at around Ks 80 per 50gallons in order that the Financial Internal Rate of Return (FIRR) of the proposed project should be more than 7.0%. It was judged that this water tariff was too high for the villagers to accept and the proposed project should be implemented with substantial subsidy from foreign and/or the central governments. Therefore assuming that the procurement cost of the initial construction cost and a half of the replacement cost of pump, which was scheduled in 16 years after the initial installation, were subsided, FIRR was worked out at 7.0% with the water tariff of Ks 20 per 50gallons.

On the other hand, Economic Internal Rate of Return (EIRR) was worked out at 5.7 % by assuming the following benefits:

- To reduce water fetching time in dry season and to make a good use of surplus time for waged work
- To increase water consumption due to water charge reduction in dry season.
- To reduce medical expense because of improvement of hygienic conditions by using safe water.

The results gained by the analysis show that the project is not financially feasible. However, since the project aims at improvement of living conditions in the poor villages by supplying safe and sufficient water, the implementation of the project can be justified from the view point of Basic Human Need.

3.9 Technology Transferred in the Study

All the field works had been carried out in cooperation with the Study Team and engineering staff of DDA. The status of technology transfer in the Study were as follows:

(1) Test Well Drilling

Drilling of 23 test wells was conducted in cooperation with 4 drilling teams of DDA during eight months under supervision of two Japanese experts of the Study Team. A drilling team normally consists of one driller head and one assistant driller and three or four supporting staff. The driller heads had about 20 year drilling experiences and showed a high applicable performance during the work. However, it was observed that they needed a basic drilling operational technology and also they had not adequate experiences of drilling tube wells of over 200 m depth. Therefore, Japanese expert gave OJT basis trainings about mad mixing, drilling speed control suitable to the ground conditions, well logging, recording of drilling column, etc. Through this training the drillers have mastered applicable skills and technologies to be adopted in the fieldwork. The drillers have also understood difficulties of drilling in case depth of the tube well exceeding 200 m in the Study area.

(2) Hydrogeological Prospecting

Before the Study started, DDA's electrical resistivity sounding equipment had deteriorated and been out of order for years. DDA has some talented geologists who have basic knowledge about the hydrogeological prospecting technology, they had no chance to apply their particular knowledge in the field after the equipment became out of order. Therefore, drilling work had been managed without depending on such survey result, so drilling ended in failure sometimes.

JICA provided a set of electrical resistivity sounding equipment and a set of electromagnetic sounding equipment to DDA through this Study. Electrical resistivity sounding technology was transferred through actual survey work, which had been conducted in the entire 110 target villages for four months under instruction of two Japanese experts in this Study. Electromagnetic sounding technology, which was new to DDA, was also transferred through one-month training consisting of lectures and OJT basis fieldwork in 15 villages in four Townships, where the underground feature had not been traced so clearly by the electrical resistivity survey. The geologists have mastered how to operate the both equipment and to evaluate the survey results through the fieldwork. DDA is now capable to manage hydrogeological prospecting by its self. DDA has recognized the effectiveness of these hydrogeological prospecting technologies and made a plan to expand the survey area to