PART II GROUNDWATER STUDY

List of Tables

List of Figures

Chapter 1 Hydrogeological Investigation

1.1 Interpretation of Aerial Photos

The study area is principally composed of hard basement rocks except with small size overburden of Quaternary deposits along the streams. Prior to the various hydrogeological investigations at site, the aerial photos were interpreted to find and to check the favorable hydrogelogical conditions to select exploratory (test) well sites. However, these aerial photographs were not available in the target communes of K-1 and K-2. The results of the interpretation are shown in the following table and the location maps are presented in Supporting Report-A.

Table 1.1 Interpreted Lineament

Commune	Near the commune center	In the center
Dak Ui Commune (K-3)	L-1 : East Part of Commune Center Along The Dak Ui River Clear, N5~10°E, L=6km, Fault?	L-2 : Along the Dak Biong River Clear, N35°W, L=4km, Fault?
		L-3 : West Part of Hamlet No.8 Clear, N5°W, L=5km, Fault?
		L-4 : West Part of Hamlet No.9 Relatively Clear, N35°W, L=3km, Fault?
		L-5 : North Part of Hamlet No.7 and 8 Relatively Clear, N50°E, L=1.5km, Fault?
		L-6 : North Part of Hamlet No.2 Relatively Clear, N-SE, L=2km, Fault?
Dak Hring Commune (K-4)	No Lineament	L-1 : Near Hamlet No.9 Relatively Clear, N30°W, L=2km, Fault?
Sa Nghia Commune (K-5)	L-1 : Along The Ea Noi River Relatively Clear, N40°E, L=3km, Fault?	No Lineament
Chu Hreng Commune (K-6)	No Lineament	L-1~4 : Southeast part of Commune Clear, N30°W, L=3~4km, Fault?
		L-5 : East part of Commune Clear, N20°E, L=6km, Fault?
		L-6 : Northeast of Commune Clear, N45°E, L=4km, Fault?

(1) Dak Ui commune (K-3)

Six (6) lineaments are detected in the commune and are composed of two directions of N-S and NNW-SSE.

(2) Dak Hring commune (K-4)

One (1) lineament running in a NW-SE direction is detected in the eastern part of commune center.

(3) Sa Nghia commune (K-5)

One (1) lineament running in a NE-SW direction is detected in the commune center.

(4) Chu Hreng commune (K-6)

Six (6) lineaments are detected in the southern and eastern parts of the commune. They can be classified into two directions of NNW-SSE and NNE-SSW. The lineaments of the NNW-SSE direction are much clearer than NNE-SSW direction lineaments.

1.2 Hydrogeology

The Central Highlands, except for those in the Lam Dong province, can be divided into eight hydrogeological zones as described below:

Table 1.2 Hydrogeological Characteristics in the Central Highlands

Hydrogeology		Thickness (m)	Yield (l/sec)	Specific yield (l/sec/m)
Alluvial sediments (Q_4)	Sand, silt and gravel	3 –5		0.05-0.33
Pleistocene sediments (Q_{1-3})	Sand, silt and gravel	10-15	0.2-0.4	
Neogene sediments (N)	Sandstone, conglomerate, siltstone	10-500		0.06-0.54
Middle Pleistocene basalt (βQ_2)	Olivine basalt	10-150	0.16-14.68	0.01-3.06
Upper Neogene – lower Pleistocene basalt (βN_2-Q_1)	Tholeitic basalt	80-150	0.16-10.47	0.01-3.59
Cretaceous sedimentary rocks (K)	Sandstone, conglomerate, siltstone			0.02-0.2
Jurassic sedimentary rocks (J_{1-2})	Limestone, sandstone, conglomerate, siltstone			0.05-0.33
Cambrian – Archeozoic metamorphic rocks and granites (PR-γ)	Gneisses and granites			0.01-0.03

(Source: General Department of Geology and Mines)

Figure 1.1 shows a hydrogeological map in the Central Highlands. Hydrogeological profiles in the Central Highlands are shown in Supporting Report-A.

The classification of well production in the Central Highlands area can be estimated as shown below:

Table 1.3 Classification of Well Production in the Central Highlands

Class	Yield (l/s)	Specific Yield (l/s/m)
Rich and very rich	1.0 – 5.0 and higher	0.5 – 1.0 and higher
Medium	0.5 – 1.0	0.2 – 0.5
Poor	0.1 – 0.5	0.05 – 0.2
Very poor (aquitard)	< 0.1	< 0.05

(Source: General Department of Geology and Mines)

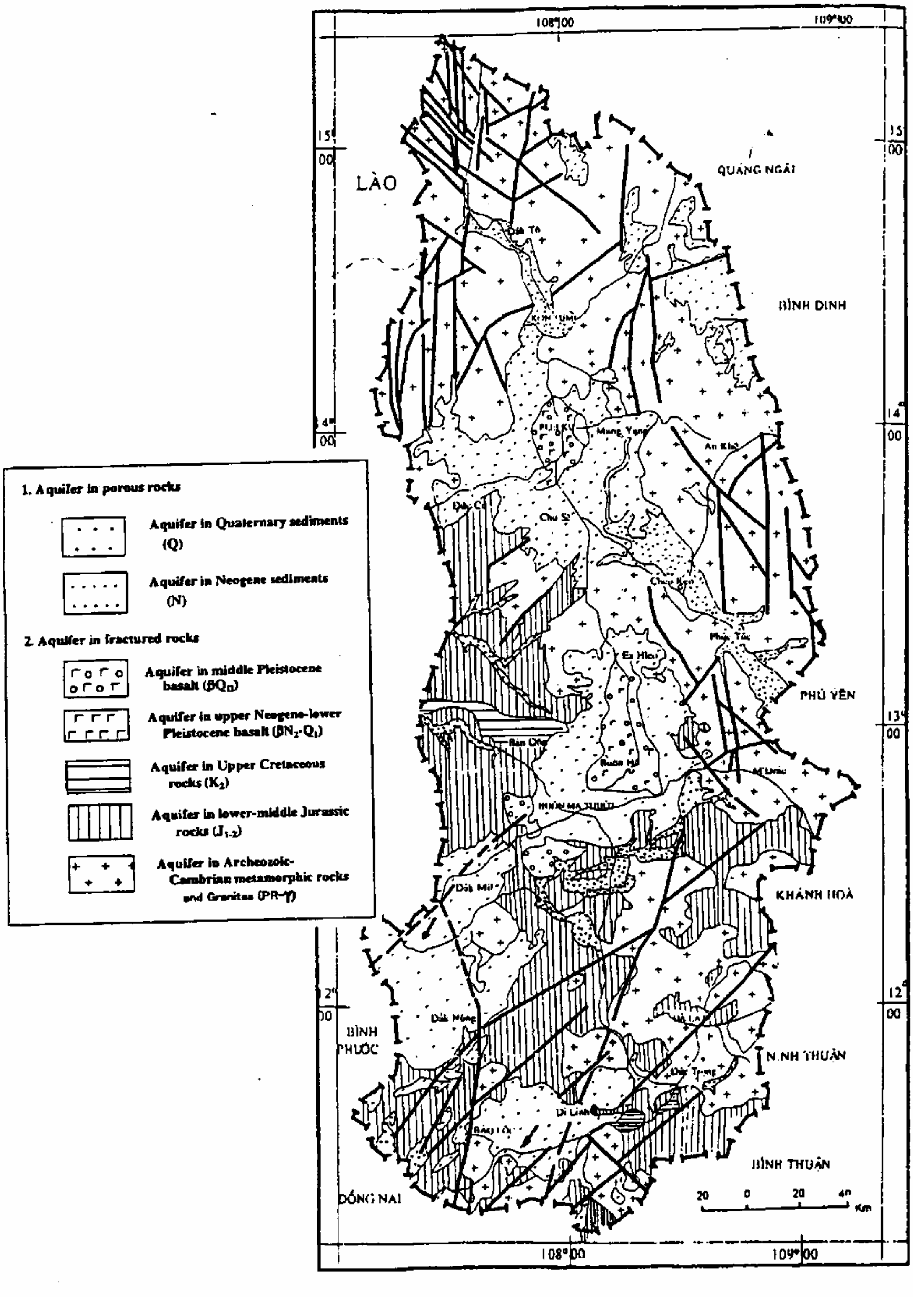


Figure 1.1 Hydro Geological Map of Central Highlands

Chapter 2 Geophysical Prospecting

For the purpose of selection of exploratory (test) drilling sites in the proposed 6 communes, geophysical prospectings by both electrical and electro-magnetic soundings were carried out. Both sounding methods aim to detect an indication of groundwater potential by the variation of electrical resistivity (the mathematical inverse of electrical conductivity) of the subsurface vertically and/or horizontally. Electrical resistivity of earth materials is an indication of the lithology and the characteristics of aquifers. Resistivity measurements and the interpretation are used to determine the type of rocks, the depth to bedrock and the depth to aquifers.

2.1 Electrical Sounding

Electrical soundings of a Wenner electrode array were made by two-dimensional measurement along 12 survey lines as shown in Table 2.1.

Table 2.1 Quantity of Geophysical Prospecting Work

Province	Commune	Electrical sounding Line	Electro-magnetic sounding
Kom Tum	Bo Y	-	47
	Dak Su	-	50
	Dak Ui	4	-
	Dak Hring	4	-
	Sa Nghia	-	51
	Chu Hreng	4	-
Total		12	148

The electrical sounding data were interpreted by two-dimensional model inversion method. This analysis assumes that the geological structure is two-dimensional and determines the optimum resistivity distribution of a two-dimensional model for each line. The finite element method is applied to the forward analysis and the non-linear least squares method with a smoothness constraint is applied to the optimization of resistivity distribution.

2.2 Electro-magnetic Sounding

Electromagnetic soundings at 148 points were made along 15 survey lines as shown in Table 2.1. The electro-magnetic sounding data were interpreted by one-dimensional layered model inversion method. Based on the inversion method, a model that best fitted the sounding data was obtained by iteratively adjusting the parameters (resistivity and thickness of layers) after inputting an initial model.

2.3 Results of Geophysical Prospecting

Fresh rocks generally show higher resistivity, and compact volcanic rocks especially have high resistivity more than 1,000 ohm-m. The resistivity of weathered or fractured saturated rocks and sedimentary rocks become lower. Water along faults and fractures in the rock will demonstrate low resistivity anomalies against the compact and fresh rock. Very low resistivity, less than 10 ohm-m, possibly points to a high content of clay.

The results of both electrical and electro-magnetic soundings are presented in Data Book. The promising zone, that could be recognized to be an aquifer in the area, ranges from 30 to 100 ohm-m in resistivity by reflecting on the geological and hydrogeological conditions.

Chapter 3 Exploratory Well Drilling

The 6 exploratory (test) wells were planned and 8 drilling works were carried out on time. The drilling points and depths were determined based on the analyses of geophysical prospecting and hydrogeological investigation. Each drilling site was determined through discussion among the study team, CERWASS engineers and authorities of the target communes/towns. The result was used for evaluation of the production capacity of well, possibility of groundwater development plan and water quality check.

3.1 Exploratory Wells

The 8 exploratory (test) wells were drilled at the 6 target communes as shown in the following table. The seven (7) test wells were drilled in Dac Lac province, seven (7) test wells in Gia Lai province and six (6) plus two (2) additional test wells in Kon Tum province.

Table 3.1 General Features of Test Wells

Target commune/town		Coordinate (UTM)		Elevation (m)	Drilling depth (m)	Reaming depth (m)
		Latitude	Longitude			
K1	Bo Y	1623379	782270	683	170	50
K2	Dak Su	1625301	785786	676	50	-
K2A	Dak Su	1610205	783252	670	80	50
K3	Dak Ui	1613032	177275	685	160	38
K4	Dak Hring	1614163	813989	669	100	-
K4A	Dak Hring	1612578	812878	560	45	-
K5	Sa Nghia	1593473	803796	588	100	-
K6	Chu Hreng	1584716	177337	590	98	40

3.2 Geology and Well Structure

Through the course of the drilling and well construction, the geology of each test well was carefully recorded through observation of core samples and geophysical logging data were interpreted as shown in the following table.

Table 3.2 Geology of Test Wells

Commune/Town		Geology
K1	Bo Y	Neogene sediment (N), Gneiss (PR)
K2	Dak Su	Neogene sediment (N), Gneiss (PR)
K3	Dak Ui	Gneiss (PR)

The geology and well structure of each well are shown in Figures 3.1 to 3.4 and interpretation graphs of geophysical logging tests are presented in Data Book.

The test wells were so designed that screen pipes should not be installed in the first aquifer so as to avoid interaction between the first and deeper aquifers. However, in the case that enough well yield could not be expected because of geological structure at K1 (Bo Y), K2A (Dak Su) and K3 (Dak Ui), screen pipes were also installed in the first aquifer.

3.3 Pumping Test

The pumping test in this Study is composed of four (4) types, namely 1) a preliminary yield test during four (4) hours pumping, 2) Six (6) step-drawdown tests during a total of twelve (12) hours, 3) constant continuous pumping test during seventy-two (72) hours and 4) recovery test during twelve (12) hours. The step-drawdown test was conducted in six (6) steps of two (2) hours pumping for each step prior to the constant continuous pumping test. After casing and screen pipes were installed and well development was performed, the pumping test was carried out.

Transmissivity is an ability of aquifer to transmit groundwater per unit time through an aquifer in unit width under unit hydraulic gradient. The transmissivity values, which are analyzed by the Theis analysis method, range from 1.5 to 21 m^2/day. The Neogene sediments and gneiss aquifers in K1 (Bo y) and K2 (Dak Su) have lower transmissivity. The basalt aquifers have wide range of transmissivity and specific capacities.

Specific capacity defines the rate at which groundwater is transmitted through unit width of an aquifer under unit hydraulic gradient. Specific capacity values are obtained from the pumping discharge and final drawdown of the constant continuous pumping test. The specific capacity values of aquifers in the test wells range from 0.003 to 0.18 l/s/m.

Storage coefficient means the water volume, which an aquifer releases from or takes into storage, per unit surface area of the aquifer per unit change in head. In this study the storage coefficient values are obtained from the Theis method and the Cooper-Jacob method. Most of the aquifers in exploratory wells belong to a category of confined aquifer. The storage coefficient of K1 (Bo Y) is 0.42 and the aquifer belongs to a category of unconfined aquifer. The storage coefficient of K2 (Dak Su) is 0.0055 and the aquifer belongs to a category of semi-confined aquifer.

During the constant continuous pumping tests, groundwater levels of several dug wells near the drilled wells were observed and monitored. However, there was no available existing shallow well to monitor in K1 (Bo Y) and K6 (Chu Hreng). The groundwater levels of the observation wells did not decline during 72-hour pumping. It means that the influence by pumping of the exploratory wells was negligible. However, there found to be some groundwater lowering in the existing dug well of K3 (Dak Ui).

The hydrogeological characteristics of the test wells in the target communes/towns are summarized in the following table.

Table 3.3 Hydrogeological Parameters of Test Wells

Target Commune /town		Aquifer Geology	Aquifer length (m)	Static water level (m)	Transmissivity (m^2/day)	Storage coefficient
Kon Tum province						
K1	Bo Y	Neogene sediments and gneiss	24	0.88	1.5E+0	4.2E-1
K2	Dak Su	Neogene sediments and gneiss	32	0.80	7.9E+0	5.5E-3
K3	Dak Ui	Gneiss	28	0.90	2.1E+1	5.7E-4
K6	Chu Hreng	Neogene sediments and gneiss	14	12.50	6.0E-2	2.9E-1

Coordinates: X:1620281 N, Y: 782252 E, Z: 680m

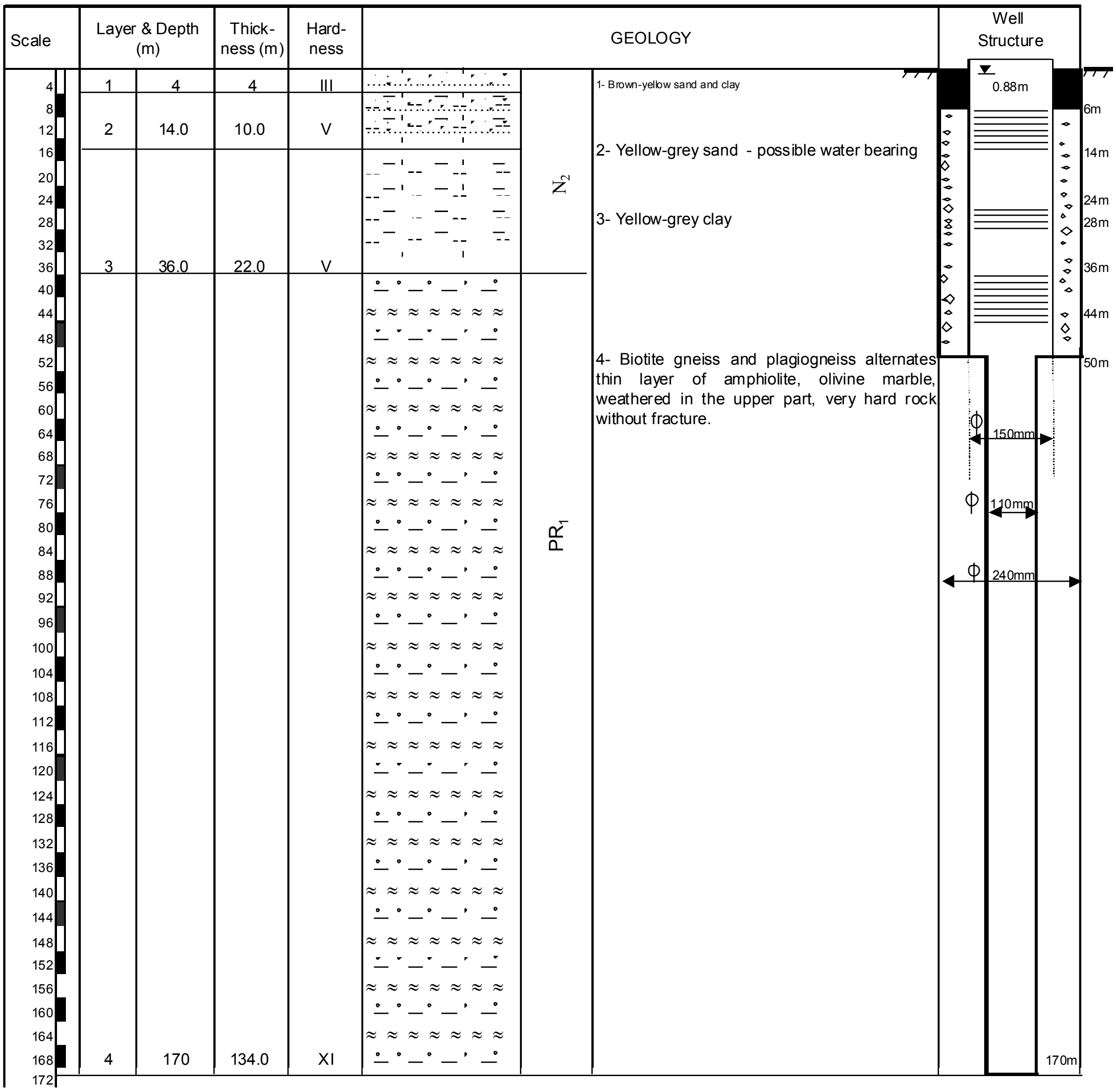
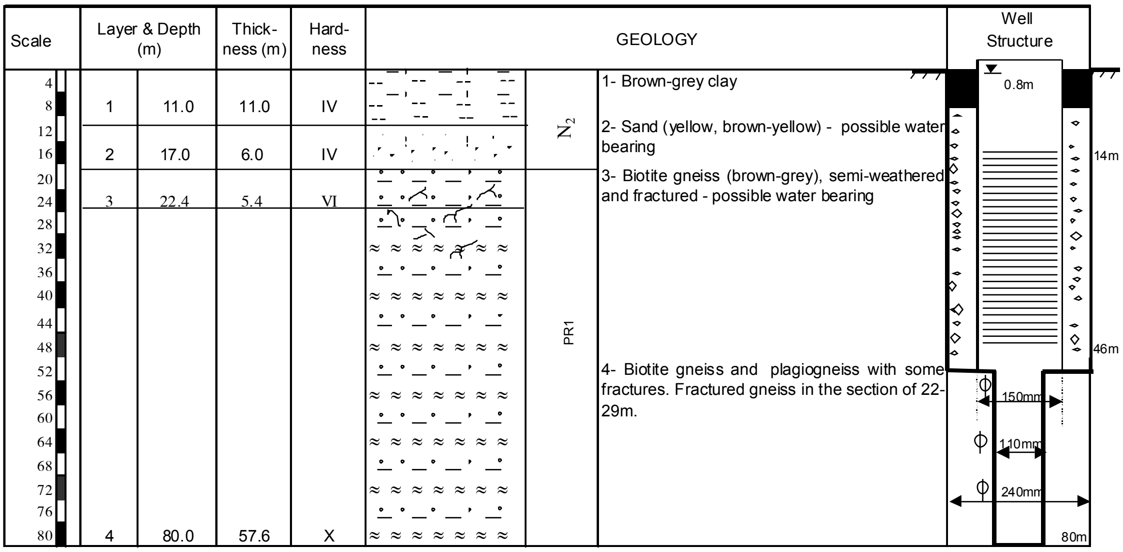


Figure 3.1 Geology and Well Structure of Test Well at Bo Y Commune (K1)

Coordinates: X:1610205 N, Y: 783252 E, Z: 670m



Scale	Layer & Depth (m)		Thick-ness (m)	Hard-ness	GEOLOGY			Well Structure
	1	11.0	11.0	IV		N_2	1- Brown-grey clay	
	2	17.0	6.0	IV			2- Sand (yellow, brown-yellow) - possible water bearing	
	3	22.4	5.4	VI		PR1	3- Biotite gneiss (brown-grey), semi-weathered and fractured - possible water bearing	
	4	80.0	57.6	X			4- Biotite gneiss and plagiogneiss with some fractures. Fractured gneiss in the section of 22-29m.	

Figure 3.2 Geology and Well Structure of Test Well at Dak Su Commune (K2A)

Coordinates: X:1613032 N, Y: 177275 E, Z: 685m

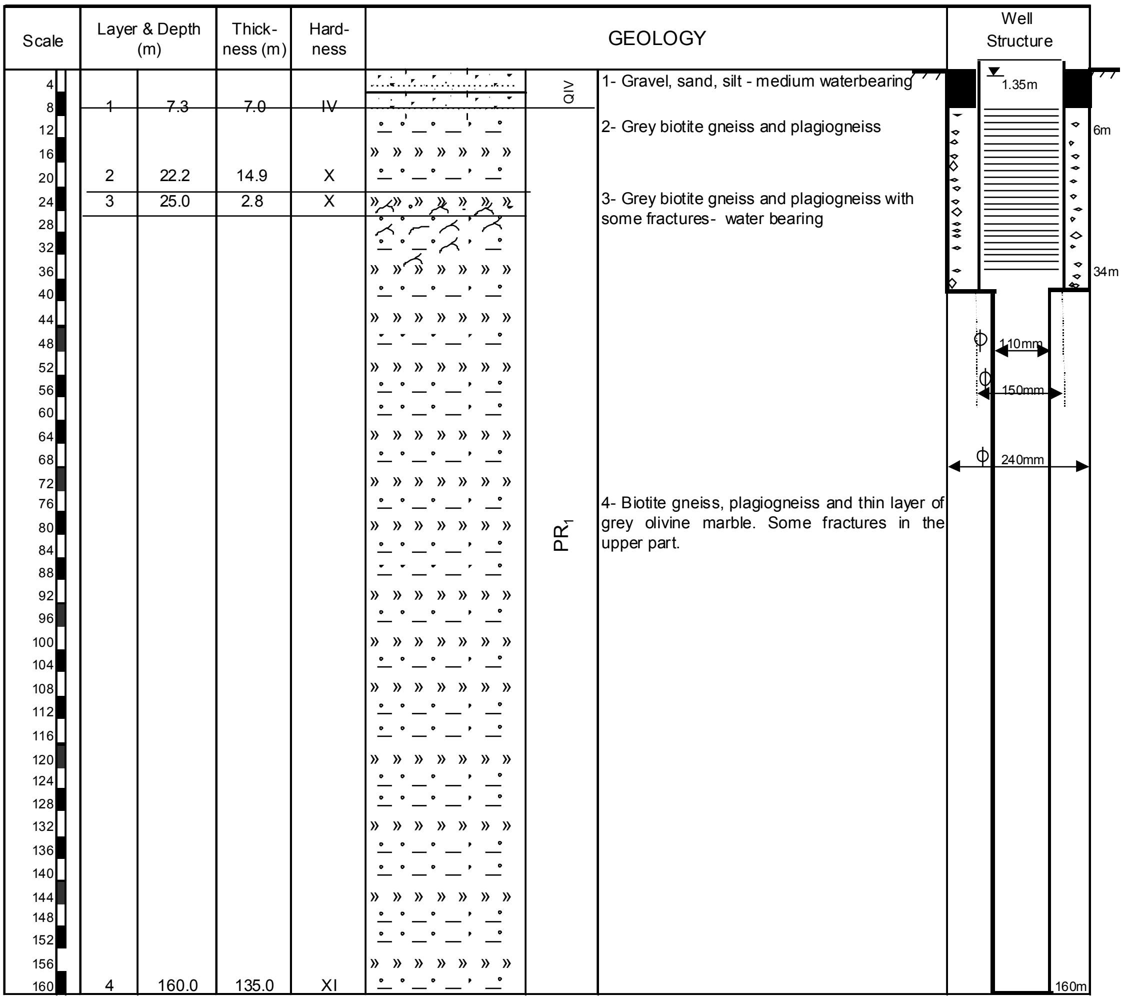
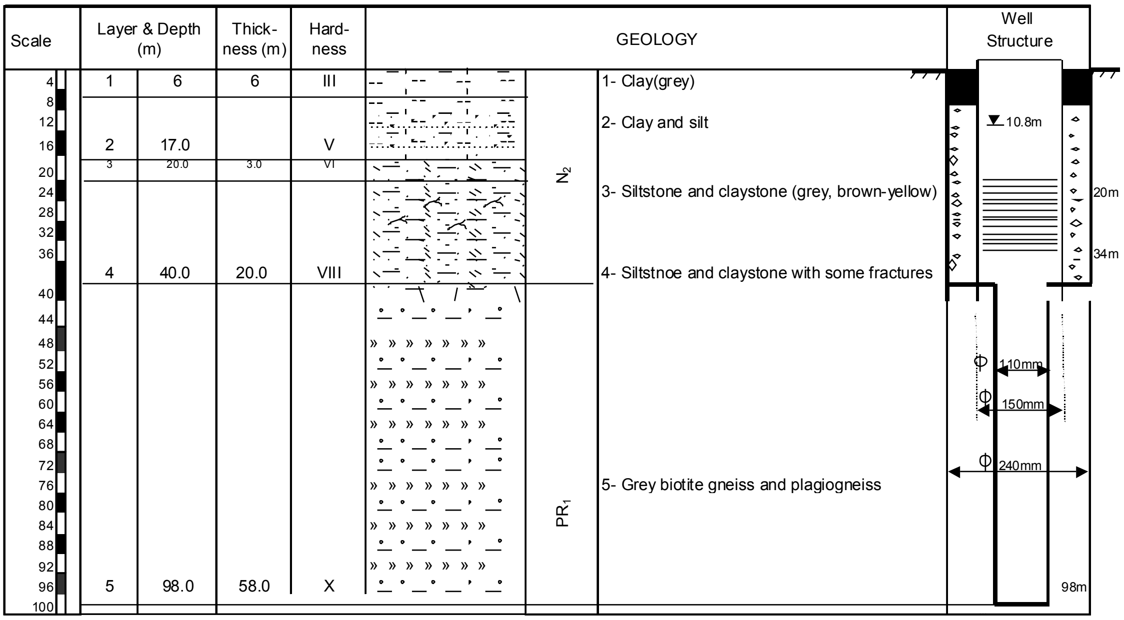


Figure 3.3 Geology and Well Structure of Test Well at Dak Ui Commune (K3)

Coordinates: X:1584716 N, Y: 177337 E, Z: 590m



Layer & Depth (m)		Thick-ness (m)	Hard-ness	GEOLOGY		
1	6	6	III		N_2	1- Clay(grey)
2	17.0		V			2- Clay and silt
3	20.0	3.0	VI			3- Siltstone and claystone (grey, brown-yellow)
4	40.0	20.0	VIII			4- Siltstnoe and claystone with some fractures
5	98.0	58.0	X		PR_1	5- Grey biotite gneiss and plagiogneiss

Figure 3.4 Geology and Well Structure of Test Well at Chu Hrang Commune (K6)

Chapter 4 Evaluation of Groundwater Resources

4.1 Water Balance Study

As a result of the water balance analysis by Sugawara's tank model, the annual groundwater recharge is estimated as 535.5 mm/year (1.5 mm/day) in the Srepok river basin. The groundwater recharge of 1.5 mm/day is equivalent with an amount of 1500 m^3/day/km^2.

4.2 Safe Well Yield

The relationship between discharges and drawdowns of the step-drawdown test shows that the optimum yield of the exploratory wells can be assumed to be nearly equal to the maximum discharge of the step-drawdown test, although the optimum yield can generally be recognized to be seventy (70) % of the critical yield. When the exploratory wells produce an extraction rate of 300 m^3/day for future water supply, the extraction rate can be recognized to be much lower than a groundwater recharge of 1.5 mm/day. From a macroscopic viewpoint of the water balance in the Srepok river basin, several production wells can extract groundwater within 1 km^2. Therefore, the safe well yield of each exploratory well can be recognized to be equal to the optimum yield.

The safe well yields of each exploratory well are summarized in the following table.

Table 4.1 Safe Well yield of Each Commune/Town

Target commune/town		Safe well yield		Permissible dynamic groundwater level (depth from ground surface)
		(m^3/day)	(liter/sec)	
Kon Tum province				
K1	Bo Y	86	1.0	40
K2	Dak Su	149	1.7	35
K3	Dak Ui	259	3.0	32
K4	Dak Hring	-	-	-
K5	Sa Nghia	-	-	-
K6	Chu Hreng	-	-	-

*: Based on the pumping test of the existing boreholes for D2 and D6

4.3 Groundwater Level Monitoring

In general, groundwater level monitoring is indispensable to detect problems of groundwater over-exploitation. According to the National Program of Groundwater Monitoring in the central highlands under the Ministry of Industry, the groundwater level monitoring in the three provinces of Dac Lac, Gia Lai and Kon Tum has been conducted since 1993 at 73 monitoring wells.

There is no observation well in the target communes of the Kon Tum province. When groundwater development is planned properly with adequate intervals between wells to avoid local groundwater level lowering (cone effect), it is judged to be sustainable and to contribute to the improvement of the living standards of the people by supplying clean and safe water. Monitoring of groundwater level for the existing and newly constructed wells is essential for management of groundwater resources. The groundwater level data are taking by automatic recording system which are provided by the Study Team since June 2001. The recording will continue by using remaining recording paper for one year more.

Automatic groundwater level recorders were installed for the 4 successful test wells at June 2001. Kon Tum PCERWASS has been continuing the monitoring work. The recorded data is shown in Supporting Report A Chapter 5.4. It does not show any indication for lowering of groundwater levels from the result.

Chapter 5 Water Quality

Water quality analysis was conducted twice during the first field survey and the F/S period for the wells explored by the study team and the alternative water sources (the rivers in K4, K5, and K6) by the publicly authorized laboratory, i.e., for 18 items by the Institute Hygiene and Epidemiology Institute, the Ministry of Health as shown in Table5.1. For Dioxin analysis a water samples (K1) was taken and analyzed by Hanoi National University.

For the samples taken from the test wells explored by the study, no harmful substances, i.e. arsenic and dioxin, were found. However, the iron content was relatively high in K1 (Bo Y, 3.55 mg/l), K2 A (Dak Su, 2.64 mg/l) and K3 (Dak Ui, 3.49 mg/l). Iron removal treatment will be needed for domestic use of the groundwater.

Coliform, NH_3, and NO_2 were more accurately analysed at the F/S phase. The results show that deep groundwater is safe from contamination. However, careful sealing near the surface and sanitation improvement in and around the production wells is essential.

Since the groundwater potential was too small in K4 (Dak Hring), K5 (Sa Nghia), and K6A (Chu Hreng), the water quality analysis was conducted for the water taken from the river, which was envisaged to be an alternative source. No harmful substances were identified for the three river water samples as well. Turbidity was analyzed during the F/S phase for K-4. As the water quality analysis for turbidity was only conducted in the dry season (November 2001), the turbidity analysis should be conducted in rainy season before the detailed design. The iron content in K5 (Nghia Hoa) was the highest (4.58 mg/l) among the 20 samples.

Table 5.1 Result of Water Quality Analysis for JICA Test Well and Alternative Water Resources

Sampl. No.	Type	Temp.	pH	EC	DO	TDS	Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	Cl^-	SO_4^{2-}	Total Fe	NO_2^-N	NO_3^-N	NH_4^+	PO_4^{3-}	$COD/KMnO_4$	F	As	Mn^{2+}	Coliform*
		(℃)		(μ S/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	MPN/100
K-1-0	Well	26.8	7.25	183.6	2.23	151.457	16.20	7.557	9.89	2.028	111.75	0.142	3.897	3.55	<0.001	0.01	0.028	0.09	0.315	0.0300	0.0010	0.1000	11
K-2-0	Well	24.1	7.23	178.7	1.75	151.873	16.28	8.432	9.66	1.950	112.61	1.985	0.96	2.64	<0.001	0.01	0.031	0.07	0.157	0.0100	0.0010	0.0650	17
K-3-0	Well	24.7	7.19	864	1.17	597.608	151.38	10.753	6.44	0.663	184.71	0.496	243.18	3.49	0.005	0.03	0.046	0.04	0.630	1.3200	0.0050	0.1211	33
K-4-0	River	26.7	7.13	66.6	3.15	50.979	5.12	3.074	2.30	1.833	36.66	0.071	1.92	1.88	0.002	0.11	0.035	<0.01	3.226	0.2100	0.0010	0.0050	130
K-5-0	River	25.6	7.15	68.8	3.64	51.037	4.62	2.151	3.45	4.095	33.49	0.496	2.75	4.58	0.005	0.12	0.059	<0.01	7.082	0.1900	0.0010	0.0150	180
K-6-0	River	33.2	7.60	89.4	3.04	68.223	2.46	5.346	5.06	3.822	48.25	0.351	2.94	3.02	0.005	0.06	0.073	<0.01	2.518	0.0800	0.0010	0.0210	2800
G-1-0	Well	27.5	7.32	198.7	1.16	170.062	4.34	2.807	31.97	2.535	124.32	0.915	3.19	0.82	0.030	0.06	0.052	0.03	0.157	0.6600	0.0010	0.0130	33
G-2-0	Well	28.1	7.00	338	3.04	211.444	24.72	12.758	12.65	4.062	142.62	0.993	13.10	0.21	0.002	0.19	0.074	0.10	0.157	0.2900	0.0032	0.1950	0
G-3-0	Well	27.0	7.20	61.7	2.56	166.645	14.38	11.900	7.13	2.964	126.88	0.213	3.89	0.40	<0.001	0.05	0.029	0.14	0.236	0.1007	0.0040	0.0975	34
G-4-0	Well	29.2	7.59	273	5.55	225.997	10.80	13.171	22.43	4.095	155.18	0.355	19.97	0.36	0.010	0.01	0.179	0.07	0.079	0.8000	0.0022	0.1740	5
G-5-0	Well	28.6	7.29	656	2.28	568.373	24.20	20.679	94.30	17.550	410.47	0.071	1.10	0.47	0.001	0.01	0.147	0.06	0.079	0.2900	0.0026	0.0630	23
G-6-0	Well	27.3	6.98	775	1.25	195.322	40.40	13.940	34.96	1.521	57.26	158.350	7.28	3.10	<0.001	9.09	0.138	0.04	0.779	0.0870	0.0034	0.0672	46
G-7-0	Well	27.0	7.18	501	1.42	426.749	42.12	23.219	28.75	1.989	311.34	15.775	3.55	2.07	0.002	0.01	0.098	0.05	0.866	0.2200	0.0010	0.2860	43
D-1-0	Well	25.3	6.43	153.0	2.63	125.028	8.80	7.946	9.66	1.833	93.88	1.407	1.50	0.11	0.001	0.06	0.035	0.06	0.079	0.1300	0.0010	0.0111	31
D-2-0	Well	26.4	6.42	100.6	2.56	64.614	4.92	3.900	5.29	1.599	39.10	0.780	9.02	0.39	0.002	0.02	0.049	0.12	0.157	<0.0001	0.0010	0.0410	11
D-3-0	Well	26.5	7.99	553	1.77	495.166	3.98	3.159	126.50	1.443	309.88	0.284	13.92	0.12	<0.001	0.60	0.103	0.08	0.551	0.2800	0.0060	0.0120	22
D-4-0	Well	25.9	7.85	401	1.59	335.710	2.52	0.620	94.30	3.354	215.70	3.332	15.90	3.76	0.080	0.12	0.071	0.14	0.630	0.6700	0.0010	0.0390	33
D-5-0	Well	27.7	6.93	558	2.35	340.127	70.96	6.051	12.88	1.356	240.65	0.355	7.87	0.82	0.020	0.06	0.233	0.06	0.236	<0.0001	0.0040	1.1110	8
D-6-0	Well	28.0	6.23	145.6	1.92	208.916	21.60	11.676	9.20	2.652	155.37	0.213	8.21	0.65	0.010	0.02	0.072	<0.01	0.630	0.0857	0.0046	0.0755	0
D-7-0	Well	28.1	6.54	186.0	2.02	126.073	9.04	6.282	11.96	3.042	86.56	0.071	9.12	4.09	0.011	0.01	0.293	0.03	0.236	0.0500	0.0010	0.3590	43
Total	nos.	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	max	33.2	7.99	864	5.55	597.608	151.38	23.219	126.50	17.550	410.47	158.350	243.18	4.58	0.080	9.09	0.293	0.14	7.082	1.3200	0.0060	1.1110	2800
	min	24.1	6.23	61.7	1.16	50.979	2.46	0.620	2.30	0.663	33.49	0.071	0.96	0.11	<0.001	0.01	0.028	<0.01	0.079	<0.0001	0.0010	0.0050	0
	average	27.2	7.13	318	2.35	236.570	23.94	8.771	26.94	3.219	149.83	9.333	18.66	1.83	0.009	0.53	0.092	0.059	0.940	0.2752	0.0023	0.1436	175
Standard 505 of MOH		-	-			1,000						250	400	0.5	0	10	3.0			1.5	0.05	0.1	

*tests were conducted in the first field survey and F/S. Source: Study Team

Class B with exception of Fe and Mn are not marked due to allowable values for health.

PART III MASTER PLAN STUDY

Chapter 1 Water Supply Master Plan.................................. KIII1-1

Chapter 2 Selection of Priority Projects............................... KIII2-1

List of Tables

Chapter 1 Water Supply Master Plan

1.1 Purposes

The purpose of the water supply master plan is to propose solutions for rural water supply in the study area in accordance with the guidelines of the National Rural Clean Water Supply and Sanitation Strategy up to year 2020 (NRWSS). According to the NRWSS, piped water supply by groundwater development is studied as main purposes.

1.1.1 Strategy

NRWSS gives clear numerical targets to be achieved up to **2010 (phase 1)** and **2020 (phase 2)**, and this master plan follows the same time schedule and targets. The strategy emphasizes the need for the demand responsive approach resulting in the need for presenting technology options, and for enabling the users to make an informed choice of solutions.

The present study is a groundwater investigation which points towards a **centralized piped water supply system for the prioritized systems**. Alternative solutions are given for the systems, where piped water supply is unfeasible.

The master plan shall present various options for the supply, and discuss the advantages and disadvantages of the proposals. This shall be based on the effectiveness of the solutions for bringing clean drinking water to users, capital cost, cost and complexity of operation and maintenance, appropriate level of operation and maintenance and availability of spare parts.

1.1.2 Level of Service and Service Coverage

According to the NRWSS, the users should decide the "level of service". Service items in this sense mean:

- method of supply,
- user demand,
- service hours, and
- service pressure.

Level of service is described as follows:

Table 1.1 Level of Service

Service item	Level of service
Supply method	A: **House connection** by piped supply B: **Public taps** by piped supply C: Individual household systems such as private dug well.
User demand	NRWSS quotes a demand of **60 l/c/d** for years 2010 and 2020.
Service hours	Basically **24 hours**.
Service pressure	40 m head (4 bar) at maximum, and up to 4 m at peak hours.

The introduction of the centralized piped water supply systems will provide the opportunity for the local residents to choose house connections (supply method A) and public taps (supply method B). Individual households are responsible for the improvement of the existing dug wells (supply method C) with the help of UNICEF and the local governments.

Service coverage is based on the NRWSS for the year 2010 and 2020. In the following table, the coverage of 25% in the year 2001 and 50% in the year 2005 was decided based on the present and probable future implementation plan.

Table 1.2 Service coverage

Year	2001	2005	2010	2020
Coverage (%)*1	25	50	85	100

*1: Coverage means population served as percentage of total population

** NRWSS targets, the coverage ratio of the year 2001 and 2005 were estimated by the Study Team.

In Kon Tum province, 18 systems were identified to supply drinking water for service coverage users.

1.1.3 Population Forecast

The population was projected for years 2005, 2010, 2015 and 2020 for every system in the study area. The population and population growth rates were collected from all the people's committees during the first field investigation period, and updated at the F/S phase. The growth rate is assumed to be the same for the figures in each commune/town.

The population growth rates of K1 (Bo Y. commune) and K2 (Dak Su commune) are higher than 10% because these communes adopt a special migration policy to take as many migrants as possible. However, the growth rates of these communes are expected to continue up to 2005 and scale down to the regional average about

2.0% after 2006 through 2020 according to the information obtained from the people's committees.

Table 1.3 Projected Populations

Commune	No. of	No. of	Growth Rate (%)*	Growth Rate (%)*	Population	Projection			
	Villages	Household	2001-2005	2006-2020	2000	2001	2005	2010	2020
Kon Tum province									
K1-1: Bo Y	7	724	**18.00**	**2.00**	3087	**3643**	**7062**	**7797**	**9505**
K1-2: Bo Y	1	71	**18.00**	**2.00**	277	**327**	**634**	**700**	**853**
K2-1:Dak Su	3	193	**18.00**	**2.00**	638	**753**	**1460**	**1612**	**1964**
K2-2:Dak Su	1	43	**18.00**	**2.00**	198	**234**	**453**	**500**	**610**
K2-3:Dak Su	9	413	**18.00**	**2.00**	1925	**2272**	**4404**	**4862**	**5927**
K2-4:Dak Su	1	54	**18.00**	**2.00**	236	**278**	**540**	**596**	**727**
K3-1: Dak Ui	5	417	**2.03**	**2.03**	2306	**2353**	**2550**	**2819**	**3447**
K3-2:Dak Ui	2	151	**2.03**	**2.03**	762	**777**	**843**	**932**	**1139**
K3-3:Dak Ui	2	69	**2.03**	**2.03**	332	**339**	**367**	**406**	**496**
K3-4:Dak Ui	2	186	**2.03**	**2.03**	975	**995**	**1078**	**1192**	**1457**
K3-5:Dak Ui	2	184	**2.03**	**2.03**	851	**868**	**941**	**1040**	**1272**
K4-1: Dak Hring	3	607	**2.40**	**2.40**	2474	**2533**	**2785**	**3136**	**3976**
K4-2:Dak Hring	1	61	**2.40**	**2.40**	277	**284**	**312**	**351**	**445**
K4-3:Dak Hring	4	217	**2.40**	**2.40**	1222	**1251**	**1376**	**1549**	**1964**
K4-4:Dak Hring	4	262	**2.40**	**2.40**	1323	**1355**	**1490**	**1677**	**2126**
K4-5:Dak Hring	1	84	**2.40**	**2.40**	479	**490**	**539**	**607**	**770**
K5: Sa Nghia	3	338	**1.90**	**1.90**	1553	**1583**	**1706**	**1875**	**2263**
K6: Chu Hreng	5	315	**2.40**	**2.40**	1572	**1610**	**1770**	**1993**	**2526**

*The shaded parts in the table show that rapid population growth will follow the development plan up to 2005, and will scale down (about 2.0%) after 2006 through 2020. The population projections for the other communes/towns apply the same growth rates.

1.2 Water Demand Forecast

The future water demands were calculated based on the target coverage and user demand (q) set out as follows:

Table 1.4 Calculated Water Demand

Year	2001	2005	2010**	2020**
Coverage (%)[*1]	25	50	85	100
Demand (q) (l/c/d)[*2]	30	30	60	60

*1: Coverage means population served as percentage of total population

*2:l/c/d means litter per capita per day

**NRWSS targets, the coverage ratio of the year 2001 and 2005 were estimated by the Study Team.

The necessary water supply quantities are calculated by different definitions, namely, 1) daily average supply (**Q_{av}**), 2) daily maximum supply (**Q_{max}**), and 3) daily maximum hourly supply (**q_{max}**). The necessary water supply quantity projections are shown in the following tables. These are to be used for the design of the water supply facilities in each system.

Table 1.5 Necessary Water Supply Quantities

Necessary water supply quantity	**Definitions**
Daily Average Supply (Q_{av})	• Q_{av} = population * q * 1.2 • 20% is added here for leakage. This will require a very efficient O&M organization, otherwise the leakage will be higher.
Daily Maximum Supply (Q_{max})	• $Q_{max} = Q_{av}$ * 1.3 • coefficient value (1.3) is applied for seasonal fluctuation. • Q_{max} is used to determine: Number of required wells (depending on yield), Dimensions of raw water pipes, Dimensions of treatment plants, Dimensions of elevated tanks, and Dimensions of reservoirs.
Daily Maximum Hourly Supply (q_{max})	• $q_{max} = Q_{max}$ *2.0/24 =1.3 *2.0 Q_{av} /24 • coefficient value (2.0) is applied referring Japanese standard for rather small piped system in rural area. • q_{max} is used to determine dimensions of distribution pipes.

Note: The above formula was following the Vietnamese guide line for water supply plan and mutual agreement with CERWASS

Table 1.6 Calculation of necessary water supply quantity: Kon Tum Province

Qav:Daily average supply(m^3/day), Qmax:Daily maximum supply(m^3/day), Qmax:Daily maximum hourly supply(m^3/hour)

Year	**2001**			**2005**			**2010**			**2020**		
Community	Qav	Qmax	qmax	Qav	Qmax	qmax	Qav	Qmax	qmax	Qav	Qmax	qmax
K1-1: Bo Y	32.8	**42.6**	**3.55**	127.1	**165.3**	**13.77**	477.2	**620.4**	**51.70**	684.4	**889.7**	**74.14**
K1-2: Bo Y	2.9	**3.8**	**0.32**	11.4	**14.8**	**1.24**	42.8	**55.7**	**4.64**	61.4	**79.8**	**6.65**
K2-1:Dak Su	6.8	**8.8**	**0.73**	26.3	**34.2**	**2.85**	98.6	**128.2**	**10.68**	141.4	**183.9**	**15.32**
K2-2:Dak Su	2.1	**2.7**	**0.23**	8.2	**10.6**	**0.88**	30.6	**39.8**	**3.32**	43.9	**57.1**	**4.76**
K2-3:Dak Su	20.4	**26.6**	**2.21**	79.3	**103.1**	**8.59**	297.6	**386.8**	**32.24**	426.8	**554.8**	**46.23**
K2-4:Dak Su	2.5	**3.3**	**0.27**	9.7	**12.6**	**1.05**	36.5	**47.4**	**3.95**	52.3	**68.0**	**5.67**
K3-1: Dak Ui	21.2	**27.5**	**2.29**	45.9	**59.7**	**4.97**	172.5	**224.3**	**18.69**	248.2	**322.6**	**26.89**
K3-2:Dak Ui	7.0	**9.1**	**0.76**	15.2	**19.7**	**1.64**	57.0	**74.1**	**6.18**	82.0	**106.6**	**8.88**
K3-3:Dak Ui	3.0	**4.0**	**0.33**	6.6	**8.6**	**0.72**	24.8	**32.3**	**2.69**	35.7	**46.4**	**3.87**
K3-4:Dak Ui	9.0	**11.6**	**0.97**	19.4	**25.2**	**2.10**	73.0	**94.8**	**7.90**	104.9	**136.4**	**11.37**
K3-5:Dak Ui	7.8	**10.2**	**0.85**	16.9	**22.0**	**1.83**	63.7	**82.8**	**6.90**	91.6	**119.1**	**9.92**
K4-1: Dak Hring	22.8	**29.6**	**2.47**	50.1	**65.2**	**5.43**	191.9	**249.5**	**20.79**	286.2	**372.1**	**31.01**
K4-2:Dak Hring	2.6	**3.3**	**0.28**	5.6	**7.3**	**0.61**	21.5	**27.9**	**2.33**	32.0	**41.7**	**3.47**
K4-3:Dak Hring	11.3	**14.6**	**1.22**	24.8	**32.2**	**2.68**	94.8	**123.2**	**10.27**	141.4	**183.8**	**15.32**
K4-4:Dak Hring	12.2	**15.9**	**1.32**	26.8	**34.9**	**2.90**	102.6	**133.4**	**11.12**	153.1	**199.0**	**16.58**
K4-5:Dak Hring	4.4	**5.7**	**0.48**	9.7	**12.6**	**1.05**	37.2	**48.3**	**4.03**	55.4	**72.0**	**6.00**
K5: Sa Nghia	14.2	**18.5**	**1.54**	30.7	**39.9**	**3.33**	114.7	**149.1**	**12.43**	162.9	**211.8**	**17.65**
K6: Chu Hreng	14.5	**18.8**	**1.57**	31.9	**41.4**	**3.45**	122.0	**158.5**	**13.21**	181.9	**236.4**	**19.70**

1.3 Choice of Technology

The NRWSS stresses the need for appropriate technology, easy operation and maintenance, low cost and sustainability. This section will describe 3 main technical options that may be seen as suitable for the study area: 1) centralized piped network, 2) small piped network, and 3) household system.

Table 1.7 Principal Definition of Options

Option	Service Level	Population served	Definition
Option1 Centralized piped system	HC+PH	2,000<	Single piped system serves several villages and hamlets.
Option2 Small piped system		1,000 - 2,000	A simple piped system serves only in each village or hamlet.
Option3 Household system	PWS	<1,000	A point water supply system for individual house or a few houses.

Notes:
HC(House Connection):Water delivered to each house via a piped system
PH(Public Hydrant):Water delivered to public taps via a piped system and carried manually to each house
PWS (Point Water Supply): Water from individual household facility such as a dug well to the owner house occasionally including neighbouring houses

1.3.1 Option 1: Centralized Piped Network

A piped system enables all (or most) of households to be connected to a piped water supply system. General descriptions of this option is as follows:

- Densely populated areas are feasible for this solution.
- The water source will be a deep well for most communities, although some communities may be supplied from a surface water source.
- This option can centralize more complicated processes such as water treatment and pump operation.
- A single operation and maintenance organization will be needed.
- Relatively long supply pipelines will be needed if the housing density is not high enough (e.g. as the systems in Kon Tum province). Long lines place a higher demand on maintenance in order to avoid high leakage rates (up to 50% or more).
- As the users will have to pay for the connection themselves, it may be a problem for poor households.

- In areas with high poverty rates there could also be a number of public taps. Public taps are furthermore included for kindergartens, schools, health clinics, hospitals and other public utilities.

Photo 1 shows the central of D6 (Kien Duc town). This is a semi-urban area with little resemblance to a rural area. A centralized piped water supply system is feasible.

1.3.2 Option 2: Small Piped Network

In the small piped network option, each (or a few) village has its own small piped network. General descriptions of this option are as follows:

- This option is suitable for small communities located in remote areas far from the main communities and with small number of households from 2-100.
- A shallow well with a sufficient yield is needed.
- A treatment plant will also have to be constructed in each community (if needed).
- The construction cost per capita of this option may become high.

Photo 2 shows a remote area in G4-2, with long distance between houses in the villages. The choice of options may actually be decided by the location of water sources and the degree of treatment needed.

1.3.3 Option 3: Household System

Dug wells often get polluted and they risk drying up in the dry season. Many problems related to pollution of the dug wells can be solved by improved construction of the shallow wells e.g. covering apron, installation of hand pump and possibly lining of the well. General descriptions of this option are as follows:

- Simple filters in order to remove iron and to remove bacteriologic contamination may be needed.
- This option is relatively inexpensive and requires little operation and maintenance.
- Improved sanitary and hygienic practices are important.

Photo 3 shows a dug well in D3-3. It is installed with apron and raised side. It might be improved with a hand pump or possibly a small electric pump, thereby reducing the risk of contamination and making operation easier.

Photo 1 Semi-urban area (D6). Well suited for piped water supply (Option1)

Photo 2 Thinly populated area (G4). Long pipelines increase cost and risk of leakage (Option 2)

Photo 3 Dug well. Well constructed with apron and raised sides.

This type could be improved with a handpump or small electric pump (Option 3)

The plan includes two phases (phases 1 and 2) in accordance with the NRWSS. The following shows the consequences of each phase:

Table 1.8 Phasing of the NRWSS

Phase	Water supply
Phase 1: 2002 –2010:	Supply by centralized piped water network is implemented in larger, densely populated 5 systems prioritized for piped supply systems in Kon Tum province. Water supply is improved in other areas by improving household systems, mostly shallow dug wells.
Phase 2: 2011 to 2020:	Extending the distribution pipes of the already established network continues the improvement of the supply. New piped networks are constructed in systems with much population.

The water supply master plan for a total of 18 systems in the study area is shown in Table 1.9. The summary of the selection of the options is shown in the Table 1.10.

Table 1. 9 Water Supply Master Plan

System	Population			Phase 1	Phase 2
	2000	2010	2020		
KONTUM					
K1-1 Bo Y	3087	7797	9505	Piped network	Extension of distribution pipes by well
K1-2	277	700	853	Household systems	Connection to K1-1, or household systems by well
K2-1 Dak Su	638	1612	1964	Piped network	Extension of distribution pipes by well
K2-2	198	500	610	Household systems	Household systems by well
K2-3	1925	4862	5927	Piped network	Extension of distribution pipes by well
K2-4	236	596	727	Household systems	Connection to K2-3, or Household systems
K3-1 Dak Ui	2306	2819	3447	Piped network	Extension of distribution pipes by well
K3-2	762	932	1139	Household systems	Small piped system by well
K3-3	332	406	496	Household systems	Connection to K3-1, or Household systems by well
K3-4	975	1192	1457	Household systems	Small piped systems by well
K3-5	851	1040	1272	Household systems	Small piped systems by well
K4-1 Dak Hring	2474	3136	3976	Piped network	Extension of distribution pipes
K4-2	277	351	445	Household systems	Household systems
K4-3	1222	1549	1964	Household systems	Piped network
K4-4	1323	1677	2126	Household systems	Piped network
K4-5	479	607	770	Household systems	Household systems
K5 Sa Nghia	1553	1875	2263	Household systems	Piped network by surface water
K6 Chu Hreng	1572	1993	2526	Household systems	Piped network by surface water

Note: When average distribution pipe line length per one household is over than 70m, Option 3 was selected from low economical condition and high leakage risk.

Table 1.10 Summary of the Selection of the Options

Phase	Option	Number of systems	Remarks
Phase 1	**Option 1**	**Kon Tum:5**	• Priority projects for option 1 were further investigated at the F/S phase.
	Option 2	**No system**	• No system is recommended for a small piped system at phase 1.
	Option 3	**Kon Tum:13**	• Improvement of the existing dug wells, and construction of dug wells are realistic for remote areas. No groundwater sources were identified in K5 and K6.
Phase 2	**Option 1**	**Kon Tum:9**	• Distribution pipes of the firstly prioritized systems will be extended, and connected to some neighboring systems. • Systems in K4-3, K4-4, K5, K6 may be included in piped network if subsidy arrangement is prepared.
	Option 2	**Kon Tum:3**	• 3 systems with a population more than 1,000 may be appropriate for small piped systems at phase 2 if fund is available.
	Option 3	**Kon Tum:6**	• Systems with a population less than 1,000 even at phase 2 are not suitable for piped systems.

Chapter 2　Selection of Priority Projects

2.1　Introduction

2.1.1　General Concept

The study especially targets piped water supplied by groundwater. The Vietnamese government is also intent on being involved in piped supply schemes. The NRWSS states that “the government’s grant system is established with the aims of supporting full piped water supply schemes which can ensure good water quality, sustainable development from the both viewpoints of economy and capability of O&M, and convenient, handy use of water.”

The 18 systems were identified in the 6 target communes. Out of 18 systems, 5 systems will be chosen for centralized piped schemes.

The selection is partly based on the criteria proposed by the local governments (provincial and central governments), and the criteria additionally included by the study team.

The priority systems were more evaluated in detail for F/S and later described in PART IV Chapter 4 with regard to technical, institutional (inc. O&M), social, financial and economic considerations.

2.1.2　Criteria by Vietnamese Side

The following criteria were locally proposed by the Vietnamese side (each province) at the beginning of the study: 1) shortage of water, 2) population density, 3) groundwater potential, 4) financial affordability, 5) poverty, and 6) infrastructure. All of these criteria are included in the selection criteria from the reasons described below:

Table 2.1 Criteria for the Selection of the Urgent Communes (by Vietnam side)

Province	Shortage of water	Population density	Groundwater potential	Poverty	Financial affordability	Infrastructure (road/electricity)
Kon Tum	◎			◎		○
Gia Lai	◎	◎	○			○
Dac Lac	◎	◎	◎		◎	○

◎ very important, ○ important

Shortage of water is a crucial criterion for every province, and systems with a serious problem concerning water supply should be first prioritized.

Population density remains vital for the two provinces of Gia Lai and Dac Lac by Vietnamese side because construction and maintenance costs are generally economical if the communities are densely populated.

Groundwater potential is important because treatment costs can be generally lower.

Poverty is serious in the study area. The local governments (e.g. Kon Tum province), whose living standard is low, are concerned about poverty and ethnic minority issues. Equity should be considered, and this criterion should be included.

Financial affordability has been evaluated as important from the sustainable operation and maintenance viewpoints. The NRWSS states that "to achieve sustainability it is necessary to ensure adequate and timely financial resource, not only for construction of the facilities but for management, operation and replacement of the facilities at the end of their service life."

Existing infrastructure, i.e. roads and electricity, is also considered decisive for the project selection. Piped water supply will not be operational without electricity, and accessibility is measured by the distance and road conditions. This criterion is integrated with population density, because where population is dense infrastructure is generally developed.

2.1.3 Proposed Criteria

In addition to the criteria locally proposed, three criteria are necessary for the selection. The reasons for the addition of the three criteria are elaborated below:

Sustainable operation and maintenance is the key to the sustainable management of rural water supply systems. The NRWSS says, "to achieve sustainability it is necessary to ensure the ability of continuous and prolonged operation of facilities."

Gender issues are also important for the selection. In most of the minority-oriented communities in the study area, women play the major role in water supply and taking water from springs or streams. WU is widely organized in Vietnam, and makes the role of women potential for the management of the piped supply systems.

Environmental considerations will be necessary. The study area is widely covered by basalt where groundwater potential is generally high. It is important to analyze whether the water level in dug wells is lowered by development of deep unconfined aquifers.

Thus, eight (8) items were chosen for the selection of priority projects after a series of discussions between the Vietnamese counterparts and the study team:

1) urgency and necessity,
2) population density and infrastructure,
3) groundwater potential (water quantity and quality),
4) poverty and ethnic minority,
5) financial affordability,
6) operation and maintenance (O&M),
7) gender, and
8) environmental considerations.

All the items were evaluated in five classes (highest A=3, Ba=2.5, B=2, Bc=1.5 and lowest C=1) for all the 18 systems identified in the study area, and then final prioritization is calculated by weighting eight items by multiplying factors 10 for items 1 to 7 and 3 for item 8.

2.2 Evaluation of Each Criterion

2.2.1 Urgency and Necessity (refer Table 2.2)

The shortage of drinking water is the most critical issue to be solved. Urgency and necessity were derived from the present conditions of water supply, especially, water quantity and water quality, considering the magnitude of population.

The component of urgency and necessity is defined as the multiplication of the present population (a) and the percentage of people unsatisfied with water quality (b) and water quantity (c). Both data were obtained from the social survey conducted by the study team in 2001 in each commune. The magnitude of population, the percentages of unsatisfied quantity and quality are classified into 5 classes, and the criteria for urgency and necessity is calculated as follows.

Table 2.3 Criteria for Urgency and Necessity

Urgency and necessity	Population = **a**	Unsatisfied with quality = **b**	Unsatisfied with quantity = **c**	**Urgency = a*(b+c)/1000**
Very urgent (A)	9,000 <	81% <	61% <	**3.0 <**
Fairly Urgent (Ba)	6,500 - 9,000	61 - 80%	46 - 60%	**2.0 – 3.0**
Urgent (B)	4,000 - 6,500	41 - 60%	31 - 45%	**1.0 – 2.0**
Moderately urgent (Bc)	1,500 - 4,000	21 - 40%	16 - 30%	**0.5 - 1.0**
Not so urgent (C)	<1,500	< 20%	< 15%	**<0.5**

An overall perspective shows that the communes in Kon Tum provinces suffer more from water shortages.

As a result of the preliminary evaluation, the component of urgency and necessity was highly evaluated in K2-3 and K1-1.

2.2.2 Population Density and Infrastructure (refer Table 2.4)

The population density was evaluated considering the cost-effectiveness of the construction of the rural water supply facilities. The lengths of main pipes will become longer and less cost-effective where population is sparsely populated within a system. Unaccounted-for-water (UFW) will become enormous where main pipes are inefficiently elongated with a limited number of users in a vast area. For the population density, the population was divided by the estimated service area of the systems. The evaluation criteria are shown below.

Table 2.5 Criteria of Population Density

Population density	**Point**	**Population density (person/ha)**
Very populated (A)	3.0	20.0 =<
Fairly populated (Ba)	2.5	15.0-20.0
Populated (B)	2.0	9.0-15.0
Moderately populated (Bc)	1.5	4.5-9.0
Not so populated (C)	1.0	<4.5

For water supply facilities, especially, deep groundwater, electric pumps will be necessary to boost water up from deep wells to elevated tank. An accessible asphalt road is convenient for constructors to bring necessary materials such as submersible pumps, pipes, cement, gravel, sand, etc. Remote villages in mountainous areas are therefore lesser advantage to construct piped water supply facilities due to inaccessibility and lack of infrastructure. The factor of infrastructure is then integrally evaluated by access roads, remoteness from the center of commune/town, in 5 classes from A (very developed) to C (very underdeveloped). The evaluation criteria of infrastructure are shown below.

Table 2.6 Criteria for Infrastructure

Infrastructure and accessibility = d	Point	Criteria of evaluation
Very accessible (A)	3.0	Center of district, along the main provincial road
Fairly accessible (Ba)	2.5	Not center of district, but good accessibility
Accessible (B)	2.0	Relatively good accessibility
Moderately accessible (Bc)	1.5	Relatively bad access
Not so accessible (C)	1.0	No electricity, no access road, or 3 km away from the main road

As a result of the evaluation, K4-1 was highly evaluated with regard to population density and infrastructure. K4-1 system is located in the center of the communes/towns and along the main provincial road. The systems in remote areas were generally classified into the lowest class due to inaccessibility and lower population density.

2.2.3 Groundwater Evaluation (refer Table 2.7)

Groundwater potential was evaluated by both quality and quantity of the water in the wells explored by the study team. The alternative surface water resources were identified for some of the systems (K4-1, K5 and K6).

As a result of the water quality analysis, it was found that the poisonous chemicals (i.e. arsenic, dioxin) were not found in all the samples. However, relatively high levels of coliform and contents of chemical substances, i.e. iron (Fe) and manganese (Mn) were identified in some water samples. These items of water quality require treatment for iron and manganese removal, chlorination, and the water system will become more expensive and complicated. As shown below, each water quality parameter is divided into 5 classes of value range.

Table 2.8 Criteria for Quantity and Water Quality Parameters

Point	Safe yield (l/s) = b	Coliform (MPN/100 ml) = c	NH_4 (mg/l) = d	Fe (mg/l) = e	Mn (mg/l) = f
3.0	4.0 l/s <	< 3	< 0.05 mg/l	< 0.5 mg/l	< 0.1 mg/l
2.5	3.0 - 4.0 l/s	3 - 10	0.05 - 0.1 mg/l	0.5 - 1.0 mg/l	0.1 - 0.2 mg/l
2.0	2.0 - 3.0 l/s	10 - 50	0.1 - 1.0 mg/l	1.0 - 2.0 mg/l	0.2 - 0.3 mg/l
1.5	1.0 - 2.0 l/s	50 - 100	1.0 - 1.5 mg/l	2.0 - 3.0 mg/l	0.3 - 0.5 mg/l
1.0	< 1.0 l/s	100 <	1.5 mg/l <	3.0 mg/l <	0.5 mg/l <

On the other hand, water quantity is classified into 5 classes of value range depending on the safe well yields of the explored wells. Where the surface water resources were identified, it is evaluated as the middle class (A).

Table 2.9 Groundwater Evaluation

Groundwater potential	**Quantity (point) = b**	**Water quality = (c+d+e+f)/4**	**GW potential g =b*(c+d+e+f)/4**
Very potential (A)	2.7 <	2.7 <	**7.0 <**
Fairly potential (Ba)	2.5 - 2.7	2.5 - 2.7	**6.0 - 7.0**
Potential (B)	2.0 - 2.5	2.0 - 2.5	**5.0 - 6.0**
Moderately potential (Bc)	1.5 - 2.0	1.5 - 2.0	**3.0 - 5.0**
Not so potential (C)	< 1.5	< 1.5	**<3.0**

As a result, the systems in K3-1 was evaluated rather higher rank with regard to potential of groundwater resources. The well yield of K3-1 is 3.0 l/s, and the quality is rather good for both drinking and domestic water. The systems in K1-1, K2-1 and K2-3 are not so excellent as the safe well yield is not sufficient (less than 2.0 l/s) or partly because the water requires treatment.

2.2.4 Poverty and Ethnic Minority (refer Table 2.10)

Equal distribution of safe and clean water to the poor should be considered from the viewpoint of being a basic human need. As an unequal distribution of social and natural resources easily leads to unstable social conditions in the Central Highlands, the two factors - poverty and ethnic minority - were examined for social equity. Ethnic minority communities are generally poor and need additional support.

The poverty ratio and the ratio of the ethnic minorities of every commune/town (every village in some communes/towns) were collected through the social survey. The poverty ratio is classified into 5: from A (very poor) to C (not so poor) as well as the ratio of ethnic minorities.

Table 2.11 Criteria for Poverty and Ethnic Minority

Poverty	Population = **a**	Poverty ratio = **b**	Ethnic minority ratio = **c**	**Poverty = a*(b+c)/100/1000**
Very poor (A)	9,000 <	40 - 50%	65 % <	**5.0 <**
Fairly poor (Ba)	6,500 - 9,000	30 - 40%	50 - 65 %	**3.0 - 5.0**
Poor (B)	4,000 - 6,500	20 - 30%	35 - 50 %	**2.0 - 3.0**
Moderately poor (Bc)	1,500 - 4,000	10 - 20%	20 - 35 %	**1.0 - 2.0**
Not so poor (C)	<1,500	< 10%	< 20%	**<1.0**

As a result of the evaluation (see Table 2.10), the K1-1 system was highly evaluated with regard to poverty and ethnic minority proportion.

The poverty ratio in Kon Tum province generally exceeds more than 20%.

2.2.5 Financial Affordability (refer Table 2.12)

The component of financial affordability considers both willingness to pay (WTP) for piped water supply and ability to pay (ATP, 3% and/or 5% of the annual income), both of which were collected through the social survey. The objective of the study is to establish a planning foundation for the implementation of sustainable services in future. The social survey actively involved the possible beneficiaries of the piped schemes that are financially affordable. A water supply system usually consists of several deep wells, a treatment plan (if necessary), a reservoir, an elevated tank, main pipes, and the system requires a certain scale to be financially viable.

To establish the basis for a self-sustaining operation and maintenance based on the demand driven approach, the users should be presented with service levels based on what they are willing to pay. It also assumes that in the long run, the users will have to meet the full costs of operation and maintenance as well as costs associated with replacement for equipment and materials and all extension and upgrading to the facilities, according to the NRWSS.

The level of service is piped water supply, and a willingness to pay survey was conducted with 30 samples in every commune/town. The willingness to pay was then divided by the ability to pay, to find the level of demand for piped water supply (WTP/ATP). Finally, the affordability of each system was calculated by multiplying the number of households and the WTP/ATP.

Table 2.13 Criteria for Financial Affordability

Financial Affordability	No. of household (a)	WTP (c)	ATP (d)	WTP/ATP (e) = c/d	**Affordability (f) = a*e**
Very affordable (A)	1,800 <	400 thou. <	50 thou. <	1.0 <	**1000 <**
Fairly affordable (Ba)	1,000 - 1,800	300 thou. - 400 thou.	40 thou. - 50 thou.	0.8 - 1.0	**500 - 1,000**
Affordable (B)	500 - 1,000	200 thou. - 300 thou.	30 thou. - 40 thou.	0.6 - 0.8	**300 - 500**
Moderately affordable (Bc)	300 - 500	100 thou. - 200 thou.	20 thou. - 30 thou.	0.4 - 0.6	**100 - 300**
Not so affordable (C)	< 300	< 100 thou.	< 20 thou.	< 0.4	**< 100**

As a result of the evaluation of financial affordability, the systems in Kon Tum provinces are not good as a whole. The WTP in K1, K5 and K6 is higher than the other communes. The systems in the remote areas were evaluated as unpromising with regard to financial affordability.

2.2.6 Operation and Maintenance Potential (refer Table 2.14)

With regard to O&M potential, 1) leadership of the people's committee, 2) understanding of rural water supply and sanitation issues, 3) relevant experience, and 4) O&M complexity were evaluated (1.0 to 3.0 points for each) through the interviews with the relevant local officials at the people's committee during the first and the second field survey. The evaluation was mostly on the qualitative and commune/town basis.

The people's committee (either commune/town or district) will be basically responsible for the services of operation and maintenance, and the evaluation of its leadership is crucial. The O&M of piped water systems need relevant knowledge on appropriate technologies and complexity of O&M, and the level of understanding on rural water supply and sanitation was examined. Understanding on cost recovery is essential for sustainable operation of the piped schemes.

Some of the water supply systems will need chlorination, iron and manganese removal for water treatment, which will make the systems more complex to operate. The piped supply systems will also become more complicated by using longer pipe lines (for higher possibility of unaccounted for water).

Relevant experience was derived from the similar experience in the management of electricity, and the existing piped supply systems. The management of electricity is very similar to that of piped water supply (although the district people's committee is generally responsible for the former), and experience in promotion of house connections will be useful for piped schemes.

The results of the survey show that the component of O&M potential is highly evaluated in K3 where the leadership by the people's committee is generally strong and the community organizations, i.e. WU, farmers' union, youth union are well organized so as to carry out community activities. The communes in Kon Tum province are generally evaluated as underdeveloped with regard to O&M potential and need intensive training for sustainable operation and maintenance.

2.2.7 Gender Perspective (refer Table 2.15)

Gender perspective was evaluated by two factors: 1) a degree of active WU, and 2) the percentage of those who take water from springs and/or streams. Data on both factors were collected through the social survey.

The role of WU will become very important as women become involved in the promotion of safe and clean water, and the solid organization to manage and operate sustainable water supply systems. Traditionally, Vietnamese WU has been actively working for the creation of equal opportunities for women in education, the improvement of health care for women and children, and the promotion of the role of women in leadership and decision-making. The organization of WU is generally more developed in the Kinh dominated communities, and the role of WU can be integrated in the management of the piped supply systems.

In the study area, the majority of people take water from shallow dug wells, either privately or publicly owned and located near houses. However, water is still taken from springs and/or streams away from houses especially in minority-oriented remote villages. In such cases, women usually take water from springs and/or streams and are keen on the issues relevant to domestic water supply. Women play an important role in water supply, and if the piped water supply system is installed, the burden of fetching water will be reduced.

The weightings of the two factors are evenly distributed because both factors are equally essential to raise the living standard of women. As a result of the evaluation, the systems in K4 commune was highly evaluated with regard to gender perspective.

2.2.8 Environmental Evaluation (refer Table 2.16)

Three factors were evaluated in terms of environmental impacts: 1) water level fluctuations of shallow dug wells near the wells explored by the study team, 2) well structure, and 3) bad smell. Negative environmental impacts of groundwater development should be minimum.

The pumping tests were conducted to obtain the hydrogeological data. Only slight fluctuations were identified in the observation wells in K3-1, i.e. 0.4 m. The wells in K1-1, K2-1, and K3-1 take water from the unconfined aquifer. The water taken from the unconfined aquifer has a possibility of the contamination by human and animal waste, and needs additional considerations for the public health. However, the well structures of the explored wells have 10 m concrete protection at the top of the wells, and the chance of contamination is low.

As a result of the environmental evaluation, most of the proposed systems were highly evaluated except the system in K3-1 due to the possible water level fluctuations in the shallow dug wells near the explored well.

2.3 Conclusion (refer Table 2.17)

The calculation of the total scores is presented in Table 2.17. As a result of the calculation, out of all the 18 systems in the study area 5 systems (ranks 1 to 21) were selected as the prioritized systems as summarized in Table 2.18, and the water supply master plan will mainly focus on these systems at the following F/S phase.

The selected 5 systems can be verified as follows:

- With the 21 priority systems in the 3 provinces, 86% of the population in the study areas can be supplied by piped water at phase 1, which will be in line with the NRWSS target.
- All of the most urgent and necessary systems (K1-1, K2-3 and K3-1) are included in the priorities.
- Most of the target communes/towns are included except K5 (Sa Nghia) and K6 (Chu Hreng).
- All of the systems with the highest demand from poor and ethnic minority households are selected for the priorities.
- Most of the priority systems have a certain level of financial affordability except K2-1, K3-1 and K4-1.
- The systems in K5 and K6 were not selected, mainly due to lack of groundwater potential and relatively small scale of the systems with high O/M costs by surface water sources.
- The small-sized piped water supply systems in K4-3, K4-4, K5 and K6 are recommended for full piped systems at phase 2 if financial and water resources are available.
- The small systems in remote areas were generally not selected, i.e. K1-2, K2-2, K2-4, K3-2, K3-3, K3-4, K3-5, K4-2 and K4-5. These systems are rather suitable for the improvement of existing water sources (dug wells) with regard to cost effectiveness and easy operation and maintenance.

Finally, the priority systems will be implemented only when the relevant institutional (inc. O&M), financial, economic, technical, and social issues are solved and sustainability is ensured.

Table 2.18 Prioritized Systems

System	Population served	Estimate Service Coverage
KONTUM	**20487**	
K1-1 Bo Y	**3087**	**Population served by piped systems at phase 1: 10,430 (51%)**
K2-1 Dak Su	**638**	
K2-3 Dak Su	**1925**	
K3-1 Dak Ui	**2306**	
K4-1 Dak Hring	**2474**	
TOTAL (3 provinces)	**128,343**	**110,167 (86%)**

Table 2.2 Urgency and Nessecity (Item 1)

Commune/Town Name		Number of Villages	Number of Households	Population in 2000 (a)		Unsatisfied with quantity (%) (b)		Unsatisfied with quality (%) (c)		Urgency a*(b +c)/1000	
Kon Tum Province											
K1: Bo Y C.	K1-1	7	724	**3,087**	Bc	**60**	B	**13**	C	2.25	**Ba**
	K1-2	1	71	**277**	C	**60**	B	**13**	C	0.20	**C**
K2: Dak Su C.	K2-1	3	193	**638**	C	**83**	A	**46**	Ba	0.82	**Bc**
	K2-2	1	43	**198**	C	**83**	A	**46**	Ba	0.26	**C**
	K2-3	9	413	**1,925**	Bc	**83**	A	**46**	Ba	2.48	**Ba**
	K2-4	1	54	**236**	C	**83**	A	**46**	Ba	0.30	**C**
K3: Dak Ui C.	K3-1	5	417	**2,306**	Bc	**49**	B	**7**	C	1.29	**B**
	K3-2	2	151	**762**	C	**49**	B	**7**	C	0.43	**C**
	K3-3	2	69	**332**	C	**49**	B	**7**	C	0.19	**C**
	K3-4	2	186	**975**	C	**49**	B	**7**	C	0.55	**Bc**
	K3-5	2	184	**851**	C	**49**	B	**7**	C	0.48	**C**
K4: Dak Hring C.	K4-1	3	607	**2,474**	Bc	**30**	Bc	**0**	C	0.74	**Bc**
	K4-2	1	61	**277**	C	**30**	Bc	**0**	C	0.08	**C**
	K4-3	4	217	**1,222**	C	**30**	Bc	**0**	C	0.37	**C**
	K4-4	4	262	**1,323**	C	**30**	Bc	**0**	C	0.40	**C**
	K4-5	1	84	**479**	C	**30**	Bc	**0**	C	0.14	**C**
K5: Sa Nghia C.		3	338	**1,553**	Bc	**64**	Ba	**2**	C	1.02	**B**
K6: Chu Hreng C.		5	315	**1,572**	Bc	**53**	B	**10**	C	0.99	**Bc**
Gia Lai Province											
G1:Kong Tang T.		11	1,163	**5,567**	B	**3**	C	**3**	C	0.33	**C**
G2: Nhon Hoa C.		15	1,906	**11,084**	A	**23**	Bc	**13**	C	3.99	**A**
G3: Chu Ty T.		8	1,481	**6,377**	B	**30**	Bc	**16**	Bc	2.93	**Ba**
G4:Thang Hung C.	G4-1	5	858	**4,292**	B	**16**	C	**16**	Bc	1.37	**B**
	G4-2	1	51	**249**	C	**16**	C	**16**	Bc	0.08	**C**
	G4-3	1	66	**325**	C	**16**	C	**16**	Bc	0.10	**C**
	G4-4	3	103	**390**	C	**16**	C	**16**	Bc	0.12	**C**
G5:Nghia Hoa	G5-1	5	696	**3,288**	Bc	**20**	C	**20**	Bc	1.32	**B**
	G5-2	1	66	**362**	C	**20**	C	**20**	Bc	0.14	**C**
G6: Ia Rsion	G6-1	7	710	**3,843**	Bc	**67**	Ba	**67**	A	5.15	**A**
	G6-2	2	134	**688**	C	**67**	Ba	**67**	A	0.92	**Bc**
G7: Kong Yang	G7-1	5	374	**1,507**	Bc	**50**	B	**50**	Ba	1.51	**B**
	G7-2	1	48	**212**	C	**50**	B	**50**	Ba	0.21	**C**
	G7-3	1	26	**132**	C	**50**	B	**50**	Ba	0.13	**C**
	G7-4	2	109	**547**	C	**50**	B	**50**	Ba	0.55	**Bc**
	G7-5	1	50	**128**	C	**50**	B	**50**	Ba	0.13	**C**
Dac Lac Province											
D1: Krong Nang T.		9	1,998	**10,795**	A	**0**	C	**0**	C	0.00	**C**
D2: Ea Drang C.		13	2,631	**14,853**	A	**30**	Bc	**23**	Bc	7.87	**A**
D3: Krong Buk C.	D3-1	7	1,192	**6,619**	Ba	**7**	C	**8**	C	0.99	**Bc**
	D3-2	5	640	**3,453**	Bc	**7**	C	**8**	C	0.52	**Bc**
	D3-3	8	766	**3,494**	Bc	**7**	C	**8**	C	0.52	**Bc**
D4: Ea Drong C.	D4-1	6	1,245	**6,901**	Ba	**30**	Bc	**30**	Bc	4.14	**A**
	D4-2	4	431	**1,805**	Bc	**30**	Bc	**30**	Bc	1.08	**B**
D5: Ea Wer C.	D5-1	9	963	**4,992**	B	**53**	B	**47**	Ba	4.99	**A**
	D5-2	1	64	**313**	C	**53**	B	**47**	Ba	0.31	**C**
	D5-3	1	46	**197**	C	**53**	B	**47**	Ba	0.20	**C**
D6: Kien Duc T.		8	2,062	**8,626**	Ba	**26**	Bc	**12**	C	3.28	**A**
D7:Krong Kmar T.		8	1,169	**5,735**	B	**7**	C	**3**	C	0.57	**Bc**

Source: the JICA study team

Note:

Data on a, b, and c were obtained through the rapid rural appraisal.

Class	Range (population = a)	Range (quantity = b)	Range (quality = c)	Final
A	9,000 <	81% <	61% <	**3.0 <**
Ba	6,500 < < 9,000	61 < < 80	46 < < 60	**2.0 - 3.0**
B	4,000 < < 6,500	41 < < 60	31 < < 45	**1.0 - 2.0**
Bc	1,500 < < 4,000	21 < < 40	16 < < 30	**0.5 - 1.0**
C	<1,500	< 20	< 15	**< 0.5**

Table 2.4 Population Density and Accessibility (Item 2)

Commune/Town Name		Number of Villages	Population in 2000 (a)		Estimated Service Area (ha) (b)	Population Density (persons/ha) (c) =a/b		Infrustracture and Accessibility (d)		Population Density and Infrastructure (f) = (c+d)/2	
Kon Tum Province											
K1: Bo Y C.	K1-1	7	3,087	Bc	400	7.7	Bc	1.5	Bc	1.50	B
	K1-2	1	277	C	150	1.8	C	1.0	C	1.00	C
K2: Dak Su C.	K2-1	3	638	C	100	6.4	Bc	1.5	Bc	1.50	B
	K2-2	1	198	C	100	2.0	C	1.0	C	1.00	C
	K2-3	9	1,925	Bc	250	7.7	Bc	1.5	Bc	1.50	B
	K2-4	1	236	C	100	2.4	C	1.0	C	1.00	C
K3: Dak Ui C.	K3-1	5	2,306	Bc	250	9.2	B	1.5	Bc	1.75	B
	K3-2	3	762	C	300	2.5	C	1.5	Bc	1.25	Bc
	K3-3	1	332	C	150	2.2	C	1.5	Bc	1.25	Bc
	K3-4	2	975	C	200	4.9	Bc	1.5	Bc	1.50	B
	K3-5	2	851	C	200	4.3	C	1.5	Bc	1.25	Bc
K4: Dak Hring C.	K4-1	3	2,474	Bc	150	16.5	Ba	3.0	A	2.75	A
	K4-2	1	277	C	150	1.8	C	1.0	C	1.00	C
	K4-3	4	1,222	C	300	4.1	C	1.5	Bc	1.25	Bc
	K4-4	4	1,323	C	300	4.4	C	1.5	Bc	1.25	Bc
	K4-5	1	479	C	150	3.2	C	1.0	C	1.00	C
K5: Sa Nghia C.		3	1,553	Bc	200	7.8	Bc	2.0	B	1.75	B
K6: Chu Hreng C.		5	1,572	Bc	300	5.2	Bc	1.5	Bc	1.50	B
Gia Lai Province											
G1:Kong Tang T.		11	5,567	B	250	22.3	A	2.5	Ba	2.75	A
G2: Nhon Hoa C.		15	11,084	A	300	36.9	A	3.0	A	3.00	A
G3: Chu Ty T.		8	6,377	B	150	42.5	A	3.0	A	3.00	A
G4:Thang Hung C.	G4-1	5	4,292	B	250	17.2	Ba	3.0	A	2.75	A
	G4-2	1	249	C	100	2.5	C	1.5	Bc	1.25	Bc
	G4-3	1	325	C	150	2.2	C	1.0	C	1.00	C
	G4-4	3	390	C	200	2.0	C	1.0	C	1.00	C
G5:Nghia Hoa	G5-1	5	3,288	Bc	200	16.4	Ba	2.5	Ba	2.50	A
	G5-2	1	362	C	150	2.4	C	1.0	C	1.00	C
G6: Ia Rsion	G6-1	7	3,843	Bc	400	9.6	B	2.0	B	2.00	Ba
	G6-2	2	688	C	150	4.6	Bc	1.0	C	1.25	Bc
G7: Kong Yang	G7-1	5	1,507	Bc	200	7.5	Bc	2.0	B	1.75	B
	G7-2	1	212	C	100	2.1	C	1.0	C	1.00	C
	G7-3	1	132	C	50	2.6	C	1.0	C	1.00	C
	G7-4	2	547	C	150	3.6	C	1.0	C	1.00	C
	G7-5	1	128	C	100	1.3	C	1.0	C	1.00	C
Dac Lac Province											
D1: Krong Nang T.		9	10,795	A	200	54.0	A	2.5	Ba	2.75	A
D2: Ea Drang C.		13	14,853	A	250	59.4	A	3.0	A	3.00	A
D3: Krong Buk C.	D3-1	7	6,619	Ba	300	22.1	A	2.5	Ba	2.75	A
	D3-2	5	3,453	Bc	400	8.6	Bc	2.0	B	1.75	B
	D3-3	8	3,494	Bc	800	4.4	C	1.0	C	1.00	C
D4: Ea Drong C.	D4-1	6	6,901	Ba	300	23.0	A	2.5	Ba	2.75	A
	D4-2	4	1,805	Bc	150	12.0	B	2.0	B	2.00	Ba
D5: Ea Wer C.	D5-1	9	963	C	200	4.8	Bc	3.0	A	2.25	Ba
	D5-2	1	64	C	100	0.6	C	1.0	C	1.00	C
	D5-3	1	46	C	100	0.5	C	1.0	C	1.00	C
D6: Kien Duc T.		8	8,626	Ba	200	43.1	A	3.0	A	3.00	A
D7:Krong Kmar T.		8	5,735	B	250	22.9	A	3.0	A	3.00	A

Source: the JICA study team

Note:
Data on a, b, and c were obtained through the rapid rural appraisal.

Class	Point		Population density		Final
A	3.0		20 <		2.5 <
Ba	2.5		15 -20		2.0 - 2.5
B	2.0		9 - 15		1.5 - 2.0
Bc	1.5		4.5 - 9		1.0 - 1.5
C	1.0		< 4.5		< 1.0

Table 2.7 Groundwater Evaluation (Item 3)

Commune/Town Name		No. of Villages	No. of Households in 2000 (a)		Safe well yield (l/s) (b)		Coliform (MPN/100ml) (c)		NH4 (mg/l) (d)		Fe (mg/l) (e)		Mn (mg/l) (f)		Groundwater Potentail (g) = b*(c+d+e+f)/4	
Kon Tum Province																
K1: Bo Y C.	K1-1	7	**724**	B	**1.0**	Bc	**11**	B	**0.069**	Ba	**3.55**	C	**0.100**	A	**3.2**	Bc
	K1-2	1	**71**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
K2: Dak Su C.	K2-1	3	**193**	C	**1.7**	Bc	**17**	B	**0.045**	A	**2.64**	Bc	**0.065**	A	**3.6**	Bc
	K2-2	1	**43**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	K2-3	9	**413**	Bc	**1.7**	Bc	**17**	B	**0.045**	A	**2.64**	Bc	**0.065**	A	**3.6**	Bc
	K2-4	1	**54**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
K3: Dak Ui C.	K3-1	5	**417**	Bc	**3.0**	Ba	**33**	B	**0.041**	A	**3.49**	C	**0.121**	Ba	**5.3**	B
	K3-2	3	**151**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	K3-3	1	**69**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	K3-4	2	**186**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	K3-5	2	**184**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
K4: Dak Hring C.	K4-1	3	**607**	B	**S**	B	**130**	C	**0.047**	A	**1.88**	B	**0.005**	A	**4.5**	Bc
	K4-2	1	**61**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	K4-3	4	**217**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	K4-4	4	**262**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	K4-5	1	**84**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
K5: Sa Nghia C.		3	**338**	Bc	**S**	B	**180**	C	**0.049**	A	**4.58**	C	**0.015**	A	**4.0**	Bc
K6: Chu Hreng C.		5	**315**	Bc	**S**	B	**5800**	C	**0.073**	Ba	**3.02**	C	**0.021**	A	**3.8**	Bc
Gia Lai Province															-	
G1:Kong Tang T.		11	**1,163**	Ba	**3.7**	Ba	**33**	B	**0.014**	A	**0.08**	A	**0.013**	A	**6.9**	Ba
G2: Nhon Hoa C.		15	**1,906**	A	**2.0**	B	**34**	B	**0.102**	B	**0.21**	A	**0.195**	Ba	**4.8**	Bc
G3: Chu Ty T.		8	**1,481**	Ba	**3.7**	Ba	**34**	B	**0.023**	A	**0.40**	A	**0.098**	A	**6.9**	Ba
G4:Thang Hung C.	G4-1	5	**858**	B	**3.0**	Ba	**33**	B	**0.000**	A	**0.36**	A	**0.174**	Ba	**6.6**	Ba
	G4-2	1	**51**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	G4-3	1	**66**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	G4-4	3	**103**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
G5:Nghia Hoa	G5-1	5	**696**	B	**2.0**	B	**23**	B	**0.033**	A	**0.47**	A	**0.063**	A	**5.5**	B
	G5-2	1	**66**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
G6: Ia Rsion	G6-1	7	**710**	B	**4.7**	A	**46**	B	**0.263**	B	**3.10**	C	**0.067**	A	**6.0**	Ba
	G6-2	2	**134**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
G7: Kong Yang	G7-1	5	**374**	Bc	**5.0**	A	**43**	B	**0.009**	A	**2.07**	Bc	**0.286**	B	**6.4**	Ba
	G7-2	1	**48**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	G7-3	1	**26**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	G7-4	2	**109**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	G7-5	1	**50**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
Dac Lac Province																
D1: Krong Nang T.		9	**1,998**	A	**4.0**	A	**31**	B	**0.072**	Ba	**0.11**	A	**0.011**	A	**7.9**	A
D2: Ea Drang C.		13	**2,631**	A	**2.6**	B	**21**	B	**0.022**	A	**0.39**	A	**0.041**	A	**5.5**	B
D3: Krong Buk C.	D3-1	7	**1,192**	Ba	**4.8**	A	**22**	B	**0.000**	A	**0.12**	A	**0.012**	A	**8.3**	A
	D3-2	5	**640**	B	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	D3-3	8	**766**	B	**0.0**	C	-	-	-	-	-	-	-	-	-	C
D4: Ea Drong C.	D4-1	6	**1,245**	Ba	**3.1**	Ba	**33**	B	**0.038**	A	**3.76**	C	**0.039**	A	**5.6**	B
	D4-2	4	**431**	Bc	**0.0**	C	-	-	-	-	-	-	-	-	-	C
D5: Ea Wer C.	D5-1	9	**1,073**	Ba	**3.7**	Ba	**8**	Ba	**0.047**	A	**0.82**	Ba	**1.111**	C	**5.6**	B
	D5-2	1	**963**	B	**0.0**	C	-	-	-	-	-	-	-	-	-	C
	D5-3	1	**64**	C	**0.0**	C	-	-	-	-	-	-	-	-	-	C
D6: Kien Duc T.		8	**2,062**	A	**3.0**	Ba	**0**	A	**0.216**	B	**0.65**	Ba	**0.076**	A	**6.6**	Ba
D7:Krong Kmar T.		8	**1,169**	Ba	**6.4**	A	**43**	B	**0.017**	A	**4.09**	C	**0.359**	Bc	**5.6**	B

Source: the JICA study team

Note:
The parameters, b, c, d, and e were analyzed by the publicly authorized institute.

Class	Point	Well yield = a	Coliform =b	NH4 = c	Fe = d	Mn = e	GW potential = f
A	3.0	4.0 l/s <	3 =<	< 0.05 mg/l	< 0.5 mg/l	< 0.1 mg/l	**7.0 <**
Ba	2.5	3.0 - 4.0 l/s	4 - 10	0.05 - 0.1 mg/l	0.5 - 1.0 mg/l	0.1 - 0.2 mg/l	**6.0 - 7.0**
B	2.0	2.0 - 3.0 l/s	11 - 50	0.1 - 1.0 mg/l	1.0 - 2.0 mg/l	0.2 - 0.3 mg/l	**6.0 - 5.0**
Bc	1.5	1.0 - 2.0 l/s	51 - 100	1.0 - 1.5 mg/l	2.0 - 3.0 mg/l	0.3 - 0.5 mg/l	**5.0 - 3.0**
C	1.0	< 1.0 l/s	< 101	1.5 mg/l <	3.0 mg/l <	0.5 mg/l <	**< 3.0**

Table 2.10 Poverty and Ethnic Minority (Item 4)

Commune/Town Name		Number of Villages	Number of Households	**Population in 2000**		**Povety ratio (%)**		**Ratio of ethnic minorities (%)**		**Poverty**	
				(a)		**(b)**		**(c)**		**a* (b + c)/100/1000**	
Kon Tum Province											
K1: Bo Y C.	K1-1	7	724	**3,087**	Bc	**27**	B	**63**	Ba	2.78	**B**
	K1-2	1	71	**277**	C	**27**	B	**90**	A	0.32	**C**
K2: Dak Su C.	K2-1	3	193	**638**	C	**20**	Bc	**0**	C	0.13	**C**
	K2-2	1	43	**198**	C	**72**	A	**100**	A	0.34	**C**
	K2-3*	9	413	**1,925**	Bc	**30**	B	**56**	Ba	1.66	**Bc**
	K2-4*	1	54	**236**	C	**39**	Ba	**56**	Ba	0.22	**C**
K3: Dak Ui C.	K3-1	5	417	**2,306**	Bc	**32**	Ba	**54**	Ba	1.98	**Bc**
	K3-2	3	151	**762**	C	**32**	Ba	**54**	Ba	0.66	**C**
	K3-3	1	69	**332**	C	**32**	Ba	**54**	Ba	0.29	**C**
	K3-4	2	186	**975**	C	**32**	Ba	**54**	Ba	0.84	**C**
	K3-5	2	184	**851**	C	**32**	Ba	**54**	Ba	0.73	**C**
K4: Dak Hring C.	K4-1	3	607	**2,474**	Bc	**4**	C	**23**	Bc	0.67	**C**
	K4-2	1	61	**277**	C	**22**	B	**100**	A	0.34	**C**
	K4-3	4	217	**1,222**	C	**37**	Ba	**96**	A	1.63	**Bc**
	K4-4	4	262	**1,323**	C	**27**	B	**96**	A	1.63	**Bc**
	K4-5	1	84	**479**	C	**27**	B	**100**	A	0.61	**C**
K5: Sa Nghia C.		3	338	**1,553**	Bc	**5**	C	**8**	C	0.20	**C**
K6: Chu Hreng C.		5	315	**1,572**	Bc	**15**	Bc	**64**	Ba	1.24	**Bc**
Gia Lai Province											
G1:Kong Tang T.		11	1,163	**5,567**	B	**12**	Bc	**29**	Bc	2.28	**B**
G2: Nhon Hoa C.		15	1,906	**11,084**	A	**28**	B	**66**	A	10.42	**A**
G3: Chu Ty T.		8	1,481	**6,377**	B	**11**	Bc	**57**	Ba	4.34	**Ba**
G4:Thang Hung C.	G4-1	5	858	**4,292**	B	**22**	B	**9**	C	1.33	**Bc**
	G4-2	1	51	**249**	C	**45**	A	**100**	A	0.36	**C**
	G4-3	1	66	**325**	C	**52**	A	**100**	A	0.49	**C**
	G4-4	3	103	**390**	C	**48***	A	**100**	A	2.27	**B**
G5:Nghia Hoa	G5-1	5	696	**3,288**	Bc	**28**	B	**14**	C	1.38	**Bc**
	G5-2	1	66	**362**	C	**52**	A	**0**	C	0.19	**C**
G6: Ia Rsion	G6-1	7	710	**3,843**	Bc	**39**	Ba	**50**	B	3.42	**Ba**
	G6-2	2	134	**688**	C	**87**	A	**100**	A	1.29	**Bc**
G7: Kong Yang	G7-1	5	374	**1,507**	Bc	**27**	B	**17**	C	0.66	**C**
	G7-2	1	48	**212**	C	**57**	A	**100**	A	0.33	**C**
	G7-3	1	26	**132**	C	**41**	A	**100**	A	0.19	**C**
	G7-4	2	109	**547**	C	**50**	A	**100**	A	0.82	**C**
	G7-5	1	50	**128**	C	**20**	Bc	**0**	C	0.03	**C**
Dac Lac Province											
D1: Krong Nang T.		9	1,998	**10,795**	A	**15**	Bc	**10**	C	2.70	**B**
D2: Ea Drang C.		13	2,631	**14,853**	A	**8**	C	**8**	C	2.38	**B**
D3: Krong Buk C.	D3-1	7	1,192	**6,619**	Ba	**14**	Bc	**50**	B	4.24	**Ba**
	D3-2	5	640	**3,453**	Bc	**13**	Bc	**39**	B	1.80	**Bc**
	D3-3	8	766	**3,494**	Bc	**19**	Bc	**23**	Bc	1.47	**Bc**
D4: Ea Drong C.	D4-1	6	1,245	**6,901**	Ba	**21**	B	**80**	A	6.97	**A**
	D4-2	4	431	**1,805**	Bc	**14**	Bc	**43**	B	1.03	**Bc**
D5: Ea Wer C.	D5-1	9	1,073	**963**	C	**24**	B	**50**	B	0.71	**C**
	D5-2	1	963	**64**	C	**28**	B	**100**	A	0.08	**C**
	D5-3	1	64	**46**	C	**18**	Bc	**0**	C	0.01	**C**
D6: Kien Duc T.		8	2,062	**8,626**	Ba	**7**	C	**5**	C	1.04	**Bc**
D7:Krong Kmar T.		8	1,169	**5,735**	B	**8**	C	**1**	C	0.52	**C**

Source: the JICA study team

Note:

Data on a, b, and c were obtained through the rapid rural appraisal.

Class	Range (population = a)	Range (poverty = b)	Range (minority = c)	**Final**
A	9,000 <	40 - 50%	65 % <	**5.0 <**
Ba	6,500 < < 9,000	30 - 40%	50 - 65 %	**3.0 - 5.0**
B	4,000 < < 6,500	20 - 30%	35 - 50 %	**2.0 - 3.0**
Bc	1,500 < < 4,000	10 - 20%	20 - 35 %	**1.0 - 2.0**
C	<1,500	< 10%	<20%	**< 1.0**

Table 2.12 Financial Affordability (Item 5)

Commune/Town Name		No. of Villages	No. of Households in 2000 (a)		Annual Household Income (VND) (b)		Annual WTP (VND) (c)		ATP (3% of Income, VND) (d) = (b)*0.03		WTP/ATP (e) = (c) /(d)		Affordability (f) = (a)*(e)	
Kon Tum Province														
K1: Bo Y C.	K1-1	7	724	B	8,566,667	C	170,400	Bc	257,000	Bc	0.66	B	480.0	B
	K1-2	1	71	C	8,566,667	C	170,400	Bc	257,000	Bc	0.66	B	47.1	C
K2: Dak Su C.	K2-1	3	193	C	4,123,333	C	123,200	Bc	123,700	C	1.00	Ba	192.2	C
	K2-2	1	43	C	4,123,333	C	123,200	Bc	123,700	C	1.00	Ba	42.8	C
	K2-3	9	413	Bc	4,123,333	C	123,200	Bc	123,700	C	1.00	Ba	411.3	B
	K2-4	1	54	C	4,123,333	C	123,200	Bc	123,700	C	1.00	Ba	53.8	C
K3: Dak Ui C.	K3-1	5	417	Bc	5,174,074	C	88,320	C	155,222	C	0.57	Bc	237.3	C
	K3-2	3	151	C	5,174,074	C	88,320	C	155,222	C	0.57	Bc	85.9	C
	K3-3	1	69	C	5,174,074	C	88,320	C	155,222	C	0.57	Bc	39.3	C
	K3-4	2	186	C	11,333,333	Bc	168,000	Bc	340,000	B	0.49	Bc	91.9	C
	K3-5	2	184	C	5,174,074	C	88,320	C	155,222	C	0.57	Bc	104.7	C
K4: Dak Hring C.	K4-1	3	607	B	9,230,769	Bc	74,769	C	276,923	Bc	0.27	C	163.9	C
	K4-2	1	61	C	4,500,000	C	68,571	C	135,000	C	0.51	Bc	31.0	C
	K4-3	4	217	C	7,214,286	C	102,857	Bc	216,429	Bc	0.48	Bc	103.1	C
	K4-4	4	262	C	4,500,000	C	68,571	C	135,000	C	0.51	Bc	133.1	C
	K4-5	1	84	C	4,500,000	C	68,571	C	135,000	C	0.51	Bc	42.7	C
K5: Sa Nghia C.		3	338	Bc	11,800,000	Bc	146,400	Bc	354,000	B	0.41	Bc	139.8	C
K6: Chu Hreng C.		5	315	Bc	8,456,667	C	132,400	Bc	253,700	Bc	0.52	Bc	164.4	C
Gia Lai Province														
G1:Kong Tang T.		11	1,163	Ba	15,783,930	Ba	286,667	B	473,518	Ba	0.61	B	704.1	Ba
G2: Nhon Hoa C.		15	1,906	A	27,040,000	A	308,727	Ba	811,200	A	0.38	C	725.4	Ba
G3: Chu Ty T.		8	1,481	Ba	17,971,000	Ba	370,400	Ba	539,130	A	0.69	B	1017.5	A
G4:Thang Hung C.	G4-1	5	858	B	12,257,143	B	305,714	Ba	367,714	B	0.83	Ba	713.3	Ba
	G4-2	1	51	C	11,000,000	Bc	261,600	B	330,000	B	0.79	B	40.4	C
	G4-3	1	66	C	2,800,000	C	192,000	Bc	84,000	C	2.29	A	150.9	C
	G4-4	3	103	C	2,800,000	C	192,000	Bc	84,000	C	2.29	A	235.4	Bc
G5:Nghia Hoa	G5-1	5	696	B	13,948,077	B	318,316	Ba	418,442	Ba	0.76	B	529.5	Ba
	G5-2	1	66	C	15,000,000	B	135,000	Bc	450,000	Ba	0.30	C	19.8	C
G6: Ia Rsion	G6-1	7	710	B	15,810,345	Ba	302,069	Ba	474,310	Ba	0.64	B	452.2	Ba
	G6-2	2	134	C	15,810,345	Ba	302,069	Ba	474,310	Ba	0.64	B	85.3	C
G7: Kong Yang	G7-1	5	374	Bc	11,262,292	Bc	312,706	Ba	337,869	B	0.93	Ba	346.1	Ba
	G7-2	1	48	C	7,790,000	C	240,000	B	233,700	Bc	1.03	A	49.3	C
	G7-3	1	26	C	5,878,000	C	240,000	B	176,340	C	1.36	A	35.4	C
	G7-4	2	109	C	5,878,000	C	240,000	B	176,340	C	1.36	A	148.3	Bc
	G7-5	1	50	C	7,390,000	C	300,000	B	221,700	Bc	1.35	A	67.7	C
Dac Lac Province														
D1: Krong Nang T.		9	1,998	A	18,986,667	A	174,000	Bc	569,600	A	0.31	C	610.3	Ba
D2: Ea Drang C.		13	2,631	A	13,450,000	B	235,385	B	403,500	Ba	0.58	Bc	1534.8	A
D3: Krong Buk C.	D3-1	7	1,192	Ba	16,365,385	Ba	164,308	Bc	490,962	Ba	0.33	C	398.9	B
	D3-2	5	640	B	10,000,000	Bc	180,000	Bc	300,000	Bc	0.60	Bc	384.0	B
	D3-3	8	766	B	19,000,000	A	260,000	B	570,000	A	0.46	Bc	349.4	B
D4: Ea Drong C.	D4-1	6	1,245	Ba	13,640,001	B	162,200	Bc	409,200	Ba	0.40	C	493.5	B
	D4-2	4	431	Bc	13,640,001	B	162,200	Bc	409,200	Ba	0.40	C	170.8	C
D5: Ea Wer C.	D5-1	9	1,073	Ba	7,583,333	C	94,800	C	227,500	Bc	0.42	Bc	447.1	Bc
	D5-2	1	963	B	7,583,333	C	94,800	C	227,500	Bc	0.42	Bc	401.3	Bc
	D5-3	1	64	C	7,583,333	C	94,800	C	227,500	Bc	0.42	Bc	26.7	C
D6: Kien Duc T.		8	2,062	A	18,933,333	A	413,200	A	568,000	A	0.73	B	1500.0	A
D7:Krong Kmar T.		8	1,169	Ba	15,453,333	Ba	192,000	Bc	463,600	Ba	0.41	Bc	484.1	B

Source: the JICA study team

Note:
Data on b and c were obtained through the socal survey.

Class	No. of household = a	Annual Income = b	WTP = c	ATP = d	WTP/ATP = e	Affordability = f
A	1,800 <	18 mil. <	400 thou. <	50 thou. <	1.0 <	1000 <
Ba	1,000 - 1,800	15 mil. - 18 mil.	300 thou. - 400 thou.	40 thou. - 50 thou.	0.8 - 1.0	500 - 999
B	500 - 1,000	12 mil. - 15 mil.	200 thou. - 300 thou.	30 thou. - 40 thou.	0.6 - 0.8	300 - 499
Bc	300 - 500	9 mil. - 12 mil.	100 thou. - 200 thou.	20 thou. - 30 thou.	0.4 - 0.6	100 - 299
C	< 300	< 9 mil.	< 100 thou.	< 20 thou.	< 0.4	< 99

Table 2.14 O&M Potential (Item 6)

Commune/Town Name		No. of Villages	No. of Households in 2000		Leadership		Understanding of RWSS issues		Relevant experience		O&M complexity		O&M potential	
			(a)		(b)		(c)		(d)		(e)		(f) = (b+c+d+e)/4	
Kon Tum Province														
K1: Bo Y C.	K1-1	7	**724**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B
	K1-2	1	**71**	C	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B
K2: Dak Su C.	K2-1	3	**193**	C	**2.0**	B	**1.5**	Bc	**2.0**	B	**2.5**	Ba	**2.0**	B
	K2-2	1	**43**	C	**2.0**	B	**1.5**	Bc	**2.0**	B	**2.0**	B	**1.9**	Bc
	K2-3	9	**413**	Bc	**2.0**	B	**1.5**	Bc	**2.0**	B	**2.0**	B	**1.9**	Bc
	K2-4	1	**54**	C	**2.0**	B	**1.5**	Bc	**2.0**	B	**2.0**	B	**1.9**	Bc
K3: Dak Ui C.	K3-1	5	**417**	Bc	**2.5**	Ba	**2.5**	Ba	**2.5**	Ba	**2.0**	B	**2.4**	B
	K3-2	3	**151**	C	**2.5**	Ba	**2.5**	Ba	**2.5**	Ba	**2.0**	B	**2.4**	B
	K3-3	1	**69**	C	**2.5**	Ba	**2.5**	Ba	**2.5**	Ba	**2.0**	B	**2.4**	B
	K3-4	2	**186**	C	**2.5**	Ba	**2.5**	Ba	**2.5**	Ba	**2.0**	B	**2.4**	B
	K3-5	2	**184**	C	**2.5**	Ba	**2.5**	Ba	**2.5**	Ba	**2.0**	B	**2.4**	B
K4: Dak Hring C.	K4-1	3	**607**	B	**2.5**	Ba	**2.0**	B	**2.0**	B	**1.5**	Bc	**2.0**	B
	K4-2	1	**61**	C	**2.5**	Ba	**2.0**	B	**2.0**	B	**1.0**	C	**1.9**	Bc
	K4-3	4	**217**	C	**2.5**	Ba	**2.0**	B	**2.0**	B	**1.0**	C	**1.9**	Bc
	K4-4	4	**262**	C	**2.5**	Ba	**2.0**	B	**2.0**	B	**1.0**	C	**1.9**	Bc
	K4-5	1	**84**	C	**2.5**	Ba	**2.0**	B	**2.0**	B	**1.0**	C	**1.9**	Bc
K5: Sa Nghia C.		3	**338**	Bc	**2.5**	Ba	**1.5**	Bc	**2.0**	B	**1.5**	Bc	**1.9**	Bc
K6: Chu Hreng C.		5	**315**	Bc	**2.0**	B	**1.5**	Bc	**2.0**	B	**1.5**	Bc	**1.8**	Bc
Gia Lai Province														
G1:Kong Tang T.		11	**1,163**	Ba	**2.5**	Ba	**2.0**	B	**2.0**	B	**2.0**	B	**2.1**	B
G2: Nhon Hoa C.		15	**1,906**	A	**1.5**	Bc	**3.0**	A	**2.0**	B	**2.5**	Ba	**2.3**	B
G3: Chu Ty T.		8	**1,481**	Ba	**2.5**	Ba	**2.0**	B	**2.5**	Ba	**2.5**	Ba	**2.4**	B
G4:Thang Hung C.	G4-1	5	**858**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.5**	Ba	**2.1**	B
	G4-2	1	**51**	C	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B
	G4-3	1	**66**	C	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B
	G4-4	3	**103**	C	**2.0**	B	**2.0**	B	**2.0**	B	**1.5**	Bc	**1.9**	Bc
G5:Nghia Hoa	G5-1	5	**696**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.5**	Ba	**2.1**	B
	G5-2	1	**66**	C	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B
G6: Ia Rsion	G6-1	7	**710**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B
	G6-2	2	**134**	C	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B
G7: Kong Yang	G7-1	5	**374**	Bc	**2.0**	B	**2.0**	B	**2.0**	B	**1.5**	Bc	**1.9**	Bc
	G7-2	1	**48**	C	**2.0**	B	**2.0**	B	**2.0**	B	**1.5**	Bc	**1.9**	Bc
	G7-3	1	**26**	C	**2.0**	B	**2.0**	B	**2.0**	B	**1.5**	Bc	**1.9**	Bc
	G7-4	2	**109**	C	**2.0**	B	**2.0**	B	**2.0**	B	**1.5**	Bc	**1.9**	Bc
	G7-5	1	**50**	C	**2.0**	B	**2.0**	B	**2.0**	B	**1.5**	Bc	**1.9**	Bc
Dac Lac Province														
D1: Krong Nang T.		9	**1,998**	A	**2.0**	B	**2.0**	B	**2.0**	B	**2.5**	Ba	**2.1**	B
D2: Ea Drang C.		13	**2,631**	A	**3.0**	A	**3.0**	A	**3.0**	A	**2.5**	Ba	**2.9**	A
D3: Krong Buk C.	D3-1	7	**1,192**	Ba	**2.5**	Ba	**2.5**	Ba	**2.0**	B	**2.5**	Ba	**2.4**	B
	D3-2	5	**640**	B	**2.5**	Ba	**2.5**	Ba	**2.0**	B	**2.0**	B	**2.3**	B
	D3-3	8	**766**	B	**2.5**	Ba	**2.5**	Ba	**2.0**	B	**1.5**	Bc	**2.1**	B
D4: Ea Drong C.	D4-1	6	**1,245**	Ba	**2.5**	Ba	**2.5**	Ba	**2.0**	B	**2.5**	Ba	**2.4**	B
	D4-2	4	**431**	Bc	**2.5**	Ba	**2.5**	Ba	**2.0**	B	**2.5**	Ba	**2.4**	B
D5: Ea Wer C.	D5-1	9	**1,073**	Ba	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B
	D5-2	1	**963**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B
	D5-3	1	**64**	C	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B
D6: Kien Duc T.		8	**2,062**	A	**3.0**	A	**3.0**	A	**3.0**	A	**2.5**	Ba	**2.9**	A
D7:Krong Kmar T.		8	**1,169**	Ba	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B	**2.0**	B

Source: the JICA study team

Note:
The factors, b, c, d, and e were evaluated by interviewing with the local officials.

Class	No. of household = a	Leadership = b	Understanding = c	Experience = d	Complexity = e	O&M potential = f
A	1,800 <	3.0	3.0	3.0	3.0	2.8 <
Ba	1,000 - 1,800	2.5	2.5	2.5	2.5	2.5 - 2.8
B	500 - 1,000	2.0	2.0	2.0	2.0	2.0 - 2.5
Bc	300 - 500	1.5	1.5	1.5	1.5	1.5 - 2.0
C	< 300	1.0	1.0	1.0	1.0	< 1.5

Table 2.15 Gender Perspective (Item 7)

Commune/Town Name		Number of Villages	Number of Households	**Active WU (%)** **(a)**		**Taking Water from Surface Water (%)** **(b)**		**Gender perspective** **(b + c)/2**	
Kon Tum Province									
K1: Bo Y C.	K1-1	7	724	**37**	B	**43**	B	40	B
	K1-2	1	71	**37**	B	**0**	C	19	Bc
K2: Dak Su C.	K2-1	3	193	**0**	C	**23**	Bc	12	Bc
	K2-2	1	43	**0**	C	**0**	C	0	C
	K2-3	9	413	**0**	C	**0**	C	0	C
	K2-4	1	54	**0**	C	**23**	Bc	12	Bc
K3: Dak Ui C.	K3-1	5	417	**14**	Bc	**46**	B	30	B
	K3-2	3	151	**14**	Bc	**46**	B	30	B
	K3-3	1	69	**14**	Bc	**46**	B	30	B
	K3-4	2	186	**14**	Bc	**46**	B	30	B
	K3-5	2	184	**14**	Bc	**46**	B	30	B
K4: Dak Hring C.	K4-1	3	607	**38**	B	**0**	C	19	Bc
	K4-2	1	61	**38**	B	**0**	C	19	Bc
	K4-3	4	217	**57**	Ba	**71**	A	64	Ba
	K4-4	4	262	**0**	C	**100**	A	50	Ba
	K4-5	1	84	**0**	C	**100**	A	50	Ba
K5: Sa Nghia C.		3	338	**33**	B	**0**	C	17	Bc
K6: Chu Hreng C.		5	315	**17**	Bc	**0**	C	9	C
Gia Lai Province									
G1:Kong Tang T.		11	1,163	**93**	A	**7**	C	50	Ba
G2: Nhon Hoa C.		15	1,906	**70**	A	**0**	C	35	B
G3: Chu Ty T.		8	1,481	**77**	A	**0**	C	39	B
G4:Thang Hung C.	G4-1	5	858	**38**	B	**0**	C	19	Bc
	G4-2	1	51	**33**	B	**17**	Bc	25	Bc
	G4-3	1	66	**33**	B	**17**	Bc	25	Bc
	G4-4	3	103	**33**	B	**17**	Bc	25	Bc
G5:Nghia Hoa	G5-1	5	696	**85**	A	**0**	C	43	B
	G5-2	1	66	**25**	Bc	**0**	C	13	Bc
G6: Ia Rsion	G6-1	7	710	**77**	A	**0**	C	39	B
	G6-2	2	134	**77**	A	**0**	C	39	B
G7: Kong Yang	G7-1	5	374	**83**	A	**0**	C	42	B
	G7-2	1	48	**50**	Ba	**100**	A	75	A
	G7-3	1	26	**50**	Ba	**100**	A	75	A
	G7-4	2	109	**50**	Ba	**50**	Ba	50	Ba
	G7-5	1	50	**50**	Ba	**100**	A	75	A
Dac Lac Province									
D1: Krong Nang T.		9	1,998	**40**	B	**10**	Bc	25	Bc
D2: Ea Drang C.		13	2,631	**50**	Ba	**3**	C	27	Bc
D3: Krong Buk C.	D3-1	7	1,192	**58**	Ba	**0**	C	29	Bc
	D3-2	5	640	**58**	Ba	**0**	C	29	Bc
	D3-3	8	766	**58**	Ba	**0**	C	29	Bc
D4: Ea Drong C.	D4-1	6	1,245	**13**	Bc	**11**	Bc	12	Bc
	D4-2	4	431	**13**	Bc	**0**	C	7	C
D5: Ea Wer C.	D5-1	9	1,073	**33**	B	**20**	Bc	27	Bc
	D5-2	1	963	**33**	B	**100**	A	67	Ba
	D5-3	1	64	**33**	B	**20**	Bc	27	Bc
D6: Kien Duc T.		8	2,062	**73**	A	**0**	C	37	B
D7:Krong Kmar T.		8	1,169	**57**	Ba	**0**	C	29	Bc

Source: the JICA study team

Note:
Data on a and b were obtained through the social survey.

Class	WU = a	Surface water = b	**Gender**
A	70 <	70 <	70 <
Ba	50 - 70	50 - 70	50 - 70
B	30 - 50	30 - 50	30 - 50
Bc	10 - 30	10 - 30	10 - 30
C	< 10	< 10	< 10

Table 2.16 Environmental Evaluation (Item 8)

Commune/Town Name		No. of Villages	No. of Households in 2000		Groundwater lowering (m) (a)		Depth of well (m) (b)		Bad smell (c)		Environment (d) = (a+b+c)/3	
Kon Tum Province												
K1: Bo Y C.	K1-1	7	**724**	B	**0.0**	A	**50**	B	**0**	A	**2.7**	Ba
	K1-2	1	**71**	C	-	-	-	-	-	-	-	B
K2: Dak Su C.	K2-1	3	**193**	C	**0.0**	A	**50**	B	**0**	A	**2.7**	Ba
	K2-2	1	**43**	C	-	-	-	-	-	-	-	B
	K2-3	9	**413**	Bc	**0.0**	A	**50**	B	**0**	A	**2.7**	Ba
	K2-4	1	**54**	C	-	-	-	-	-	-	-	B
K3: Dak Ui C.	K3-1	5	**417**	Bc	**0.4**	B	**38**	Bc	**0**	A	**2.2**	B
	K3-2	3	**151**	C	-	-	-	-	-	-	-	B
	K3-3	1	**69**	C	-	-	-	-	-	-	-	B
	K3-4	2	**186**	C	-	-	-	-	-	-	-	B
	K3-5	2	**184**	C	-	-	-	-	-	-	-	B
K4: Dak Hring C.	K4-1	3	**607**	B	-	-	-	-	-	-	-	B
	K4-2	1	**61**	C	-	-	-	-	-	-	-	B
	K4-3	4	**217**	C	-	-	-	-	-	-	-	B
	K4-4	4	**262**	C	-	-	-	-	-	-	-	B
	K4-5	1	**84**	C	-	-	-	-	-	-	-	B
K5: Sa Nghia C.		3	**338**	Bc	-	-	-	-	-	-	-	B
K6: Chu Hreng C.		5	**315**	Bc	-	-	-	-	-	-	-	B
Gia Lai Province												
G1:Kong Tang T.		11	**1,163**	Ba	**0.0**	A	**112**	A	**0**	A	**3.0**	A
G2: Nhon Hoa C.		15	**1,906**	A	**0.0**	A	**110**	A	**0**	A	**3.0**	A
G3: Chu Ty T.		8	**1,481**	Ba	**0.0**	A	**85**	Ba	**0**	A	**2.8**	A
G4:Thang Hung C.	G4-1	5	**858**	B	**0.0**	A	**150**	A	**0**	A	**3.0**	A
	G4-2	1	**51**	C	-	-	-	-	-	-	-	B
	G4-3	1	**66**	C	-	-	-	-	-	-	-	B
	G4-4	3	**103**	C	-	-	-	-	-	-	-	B
G5:Nghia Hoa	G5-1	5	**696**	B	**0.0**	A	**135**	A	**0**	A	**3.0**	A
	G5-2	1	**66**	C	-	-	-	-	-	-	-	B
G6: Ia Rsion	G6-1	7	**710**	B	**0.0**	A	**158**	A	**0**	A	**3.0**	A
	G6-2	2	**134**	C	-	-	-	-	-	-	-	B
G7: Kong Yang	G7-1	5	**374**	Bc	**0.0**	A	**110**	A	**1**	C	**2.3**	B
	G7-2	1	**48**	C	-	-	-	-	-	-	-	B
	G7-3	1	**26**	C	-	-	-	-	-	-	-	B
	G7-4	2	**109**	C	-	-	-	-	-	-	-	B
	G7-5	1	**50**	C	-	-	-	-	-	-	-	B
Dac Lac Province												
D1: Krong Nang T.		9	**1,998**	A	**0.0**	A	**100**	A	**0**	A	**3.0**	A
D2: Ea Drang C.		13	**2,631**	A	**0.0**	A	**120**	A	**0**	A	**3.0**	A
D3: Krong Buk C.	D3-1	7	**1,192**	Ba	**0.0**	A	**70**	Ba	**0**	A	**2.8**	A
	D3-2	5	**640**	B	-	-	-	-	-	-	-	B
	D3-3	8	**766**	B	-	-	-	-	-	-	-	B
D4: Ea Drong C.	D4-1	6	**1,245**	Ba	**0.0**	A	**116**	A	**0**	A	**3.0**	A
	D4-2	4	**431**	Bc	-	-	-	-	-	-	-	B
D5: Ea Wer C.	D5-1	9	**1,073**	Ba	**0.7**	Bc	**35**	Bc	**0**	A	**2.0**	B
	D5-2	1	**963**	B	-	-	-	-	-	-	-	B
	D5-3	1	**64**	C	-	-	-	-	-	-	-	B
D6: Kien Duc T.		8	**2,062**	A	**0.0**	A	**120**	A	**0**	A	**3.0**	A
D7:Krong Kmar T.		8	**1,169**	Ba	**0.0**	A	**39**	Bc	**0**	A	**2.5**	Ba

Source: the JICA study team

Note:
The parameters, b, c, d, and e were analyzed by the publicly authorized institute.

Class	Point	Water level = a	Well depth (m)	Smell	Environment
A	3.0	= 0	100 <	0	**2.8 <**
Ba	2.5	0 - 0.3	70 - 100	-	**2.5 - 2.8**
B	2.0	0.3 - 0.5	50 - 70	-	**2.0 - 2.5**
Bc	1.5	0.5 - 1.0	30 - 50	-	**1.5 - 2.0**
C	1.0	1.0 <	< 30	1	**< 1.5**

Table 2.17 Final Prioritization

Item No.		Number of	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Final Evaluation	
Description		Villages	**Urgency**	**Population Desnsity and Infrastructure**	**GW Potentail**	**Poverty**	**Financial Affordability**	**O&M Potential**	**Gender**	**Environment**	**Total Score**	**Rank***
Weight			**10**	**10**	**10**	**10**	**10**	**10**	**10**	**3**		
Kon Tum Province												
K1: Bo Y C.	K1-1	7	**Ba**	**B**	Bc	**B**	B	**B**	B	**Ba**	**147.5**	**12**
	K1-2	1	**C**	**C**	C	**C**	C	**B**	Bc	**B**	**91.0**	**40**
K2: Dak Su C.	K2-1	3	**Bc**	**B**	Bc	**C**	C	**B**	Bc	**Ba**	**112.5**	**21**
	K2-2	1	**C**	**C**	C	**C**	C	**Bc**	C	**B**	**81.0**	**46**
	K2-3	9	**Ba**	**B**	Bc	**Bc**	B	**Bc**	C	**Ba**	**127.5**	**17**
	K2-4	1	**C**	**C**	C	**C**	C	**Bc**	Bc	**B**	**86.0**	**44**
K3: Dak Ui C.	K3-1	5	**B**	**B**	B	**Bc**	C	**B**	B	**B**	**131.0**	**16**
	K3-2	3	**C**	**Bc**	C	**C**	C	**B**	B	**B**	**101.0**	**31**
	K3-3	1	**C**	**Bc**	C	**C**	C	**B**	B	**B**	**101.0**	**31**
	K3-4	2	**Bc**	**B**	C	**C**	C	**B**	B	**B**	**111.0**	**22**
	K3-5	2	**C**	**Bc**	C	**C**	C	**B**	B	**B**	**101.0**	**31**
K4: Dak Hring C.	K4-1	3	**Bc**	**A**	Bc	**C**	C	**B**	Bc	**B**	**121.0**	**18**
	K4-2	1	**C**	**C**	C	**C**	C	**Bc**	Bc	**B**	**86.0**	**44**
	K4-3	4	**C**	**Bc**	C	**Bc**	C	**Bc**	Ba	**B**	**106.0**	**26**
	K4-4	4	**C**	**Bc**	C	**Bc**	C	**Bc**	Ba	**B**	**106.0**	**26**
	K4-5	1	**C**	**C**	C	**C**	C	**Bc**	Ba	**B**	**96.0**	**38**
K5: Sa Nghia C.		3	**B**	**B**	Bc	**C**	C	**Bc**	Bc	**B**	**111.0**	**22**
K6: Chu Hreng C.		5	**Bc**	**B**	Bc	**Bc**	C	**Bc**	C	**B**	**106.0**	**26**
Gia Lai Province												
G1:Kong Tang T.		11	**C**	**A**	Ba	**B**	Ba	**B**	Ba	**A**	**164.0**	**7**
G2: Nhon Hoa C.		15	**A**	**A**	Bc	**A**	Ba	**B**	B	**A**	**179.0**	**4**
G3: Chu Ty T.		8	**Ba**	**A**	Ba	**Ba**	A	**B**	B	**A**	**184.0**	**2**
G4:Thang Hung C.	G4-1	5	**B**	**A**	Ba	**Bc**	Ba	**B**	Bc	**A**	**159.0**	**9**
	G4-2	1	**C**	**Bc**	C	**C**	C	**B**	Bc	**B**	**96.0**	**38**
	G4-3	1	**C**	**C**	C	**C**	C	**B**	Bc	**B**	**91.0**	**40**
	G4-4	3	**C**	**C**	C	**B**	Bc	**Bc**	Bc	**B**	**101.0**	**31**
G5:Nghia Hoa	G5-1	5	**B**	**A**	B	**Bc**	Ba	**B**	B	**A**	**159.0**	**9**
	G5-2	1	**C**	**C**	C	**C**	C	**B**	Bc	**B**	**91.0**	**40**
G6: Ia Rsion	G6-1	7	**A**	**Ba**	Ba	**Ba**	Ba	**B**	B	**A**	**179.0**	**4**
	G6-2	2	**Bc**	**Bc**	C	**Bc**	C	**B**	B	**B**	**111.0**	**22**
G7: Kong Yang	G7-1	5	**B**	**B**	Ba	**C**	Ba	**Bc**	B	**B**	**141.0**	**13**
	G7-2	1	**C**	**C**	C	**C**	C	**Bc**	A	**B**	**101.0**	**31**
	G7-3	1	**C**	**C**	C	**C**	C	**Bc**	A	**B**	**101.0**	**31**
	G7-4	2	**Bc**	**C**	C	**C**	Bc	**Bc**	Ba	**B**	**106.0**	**26**
	G7-5	1	**C**	**C**	C	**C**	C	**Bc**	A	**B**	**101.0**	**31**
Dac Lac Province												
D1: Krong Nang T.		9	**C**	**A**	A	**B**	Ba	**B**	Bc	**A**	**159.0**	**9**
D2: Ea Drang C.		13	**A**	**A**	B	**B**	A	**A**	Bc	**A**	**184.0**	**2**
D3: Krong Buk C.	D3-1	7	**Bc**	**A**	A	**Ba**	B	**B**	Bc	**A**	**164.0**	**7**
	D3-2	5	**Bc**	**B**	C	**Bc**	B	**B**	Bc	**B**	**121.0**	**18**
	D3-3	8	**Bc**	**C**	C	**Bc**	B	**B**	Bc	**B**	**111.0**	**22**
D4: Ea Drong C.	D4-1	6	**A**	**A**	B	**A**	B	**B**	Bc	**A**	**174.0**	**6**
	D4-2	4	**B**	**Ba**	C	**Bc**	C	**B**	C	**B**	**116.0**	**20**
D5: Ea Wer C.	D5-1	9	**A**	**Ba**	B	**C**	Bc	**B**	Bc	**B**	**141.0**	**13**
	D5-2	1	**C**	**C**	C	**C**	Bc	**B**	Ba	**B**	**106.0**	**26**
	D5-3	1	**C**	**C**	C	**C**	C	**B**	Bc	**B**	**91.0**	**40**
D6: Kien Duc T.		8	**A**	**A**	Ba	**Bc**	A	**A**	B	**A**	**189.0**	**1**
D7:Krong Kmar T.		8	**Bc**	**A**	B	**C**	B	**B**	Bc	**Ba**	**137.5**	**15**

Source: the JICA study team

***Shaded systems (Ranks 1 to 21) are prioritized for rural water supply in this study.**

Class	Point
A	3.0
Ba	2.5
B	2.0

PART IV FEASIBILITY STUDY

Chapter 3 Environmental Impact Assessment (EIA)..............KIV3-1

Chapter 4 Feasibility Evaluation..KIV4-1

CHAPTER 5 PILOT MODELS CONSTRUCTION..............KIV5-1

Chapter 6 Recommendations for Implementation Schedule and Method..............KIV6-1

Chapter 7 Project Evaluation..............KIV7-1

List of Tables

List of Figures

Chapter 1 Feasibility Study for the Five Priority Systems

1.1 Water Supply System for the Feasibility Study

The study selected the high ranking 5 systems of Phase-1 for the Feasibility Study as shown below, as those are likely to be judged as feasible than the other 13 systems of Phase-2. The facts were also taken into consideration that there are many uncertainties in Phase-2 systems in conducting a feasibility study.

In the Master Plan Study, the estimated 18 water supply systems needed for the 6 communes were prioritised. The 18 systems were then devised into 2 phases in accordance with the NRWSS policy. The high ranking 5 water supply systems were categorised as Phase-1 and to be implemented by the year of 2010 and the other 13 systems as Phase-2 to be implemented by the year of 2020.

Table 1.1 Selected Priority Systems

System	Population			Phase 1	Phase 2
	2000	2010	2020		
K1-1 Bo Y	3087	7797	9505	Piped network	Extension of distribution pipes by well
K2-1 Dak Su	638	1612	1964	Piped network	Extension of distribution pipes by well
K2-3	1925	4862	5927	Piped network	Extension of distribution pipes by well
K3-1 Dak Ui	2306	2819	3447	Piped network	Extension of distribution pipes by well
K4-1 Dak Hring	2474	3136	3976	Piped network	Extension of distribution pipes

1.2 Targets of Water Supply Program

The targets of water supply program for the Feasibility Study are set as the same targets for Master Plan Study as shown below.

Table 1.2 Targets of Water Supply Program

Targets of Water Supply Program		
NRWSS	Phase-1	Phase-2
Target Year	2010	2020
Population to be served	85 %	100 %
Water requirement per capita	60 L/d/c	
Duration of service	24 h/day	

1.3 Water Demand Projection

The water demand projection described in the Master Plan was conducted based not only on the information collected in Master Plan stage but also on the information updated for the Feasibility Study. The water demand projection used for the Master Plan Study therefore is used for this Feasibility Study.

Table 1.3 Calculated Water Demand

Year	2001	2005	2010**	2020**
Coverage (%)[*1]	25	50	85	100
Demand (q) (l/c/d)[*2]	30	30	60	60

*1: Coverage means population served as percentage of total population

*2:l/c/d means litter per capita per day

**NRWSS targets, the coverage ratio of the year 2001 and 2005 were estimated by the Study Team.

1.4 Groundwater Development Plan

1.4.1 Present Groundwater Resources

Out of the 5 priority systems, the water sources have been identified for groundwater resources for the 3 systems, and river water for the 1 systems in K4-1. The last 1 system in K2-3 is proposed to connect existing water supply system. The safe well yields for the 3 wells explored by the study team are shown below. The detail is described in PART II, Chapter 4 “Evaluation of Groundwater Resources”

Table 1.4 Safe Well Yields of Explored Wells

Prioritized System		Safe well yield (m^3/day)	(liter/sec)	Geology	Remarks
Kon Tum province					
K1-1	Bo Y	**86**	1.0	Neogene sediment (N), Gneiss (PR)	**Unconfined aquifer**
K2-1	Dak Su	**149**	1.7	Neogene sediment (N), Gneiss (PR)	**Unconfined aquifer**
K2-3	Dak Su	-	-	Neogene sediment (N), Gneiss (PR)	**Proposed supply from reservoir of Ngoc Hoi**
K3-1	Dak Ui	**259**	3.0	Gneiss (PR)	**Unconfined aquifer**
K4-1	Dak Hring	-	-	Neogene sediment (N), Gneiss (PR)	**River water will be used.**

* (refer to PART II, Chapter 4)

The 3 wells explored by the study team have enough quantity of water for the initiation of the piped supply systems. However, in a number of systems more wells will be required.

1.4.2 Necessary Groundwater Development

The following table shows the numbers of wells which will be required by 2010 and 2020 based on the water supply plans and safe well yields of the wells used for piped supply. The present quantity of water in the wells of K1-1 will not satisfy the future water demand even in 2005. In K1-1 there is a need to explore 7 more wells up to 2010 even if the JICA wells are utilized. The explored wells in K2-1 and K3-1, have enough water for water supply plans and will not require any additional wells up to 2010.

Table 1.5 Number of Required Wells

Prioritized system	Safe well yield (m³/day)	Water Supply Plan (m³/day)				Required wells		Existing Wells (to be used)
		2001	2005	2010	2020	2010	2020	
K1-1: Bo Y	**86**	42.6	165.3	620.4	889.7	**7**	3	1
K2-1: Dak Su	**149**	8.8	34.2	128.2	183.9	**0**	1	1
K2-3: Dak Su	-	26.6	103.1	386.8	554.8	**3**	1	-
K3-1: Dak Ui	**259**	27.5	59.7	224.3	322.6	**0**	1	1
K4-1: Dak Hring	-	29.6	65.2	249.5	372.1	-	-	-

The necessary drilling points in future are shown with the shadow zones in the figures in the Supporting Report A labeled “Groundwater potential and the most promising drilling area”. The exact locations shall be decided through the discussion with the people’s committee and PCERWASS to avoid private land. The locations shall also be decided considering well interval of 300m or over, distance from latrine (shall be 50m apart from latrine) or to prevent noise pollution (shall be 20m apart from house).

For the purpose of selecting of potential groundwater areas in the study area, geophysical prospecting by electrical and electromagnetic sounding was carried out in the first field investigation stage.

The resistivity of weathered or fractured saturated rocks and sedimentary rocks becomes lower. Water along faults and fractures in the rock will demonstrate low resistivity anomalies against the compact and fresh rock. Very low resistivity - less than 10 ohm-m - possibly indicates existence of a high content of clay.

The resistivity of promising zones, that could be an aquifer, ranges from 30 to 100 ohm-m, reflecting the drilling experience of this study. The successful ratio by the 20 drilling was 90% (17 wells were constructed) in the 3 provinces. The sites for the future production wells could be close to the successful exploratory wells because the hydrogeological data and the results from the electrical sounding and electro-magnetic survey in the first investigation are available to analyze the suitable positions. In this case, further geological and hydrogeological investigations can be avoided. The surface water resources for K4, K5 and K6 have enough discharges in dry season.

1.5 Water Quality and Necessary Treatment

1.5.1 Review of Water Quality Analysis

Water quality analysis was carried out for 23 items shown in Part II, Chapter 5 in the first investigation and for 3 items (coliform, nitrate, and nitrite) in the F/S period.

Necessary treatment is decided based on the result of the water quality analysis of the exploratory wells and in accordance with Standard 505 of the MOH for separate systems and rural areas. The standard is somewhat more lenient than the WHO standard for some parameters, e.g. an iron content of 0.5 mg/l is allowed.

The following general observations are made (refer to PART II Chapter 5):

- The iron content of groundwater was high in K1-1, K2-1 K2-3 and K3-1. High iron content was also found in the surface sources of K4-1. Iron and manganese in the water do not pose a health risk, but they leave colored deposits in installations or stains on clothes, and unpleasant taste.
- Some manganese content is found in K3-1.
- The water is generally soft.
- Some of the groundwater samples have a certain level of coliform.
- No treatment is necessary for arsenic and fluoride.
- Dioxin was not detected in the analyzed samples (K1-1). The result is shown in Data Book "Water Quality"

1.5.2 Recommendations for Treatment

The following preliminary recommendations on treatment can be made, and an overview is seen in the following table.

- **Chlorination** may be avoided for small systems as it complicates the operation and maintenance with high cost of O&M. However it can not totally be avoided if coliform is still found. For the larger systems, a chlorinator should principally be installed.

- **Iron removal** may be necessary in the systems of K1-1, K2-1 K2-3 and K3 1.
- **Manganese removal** may be required in the communes K3-1.
- For the system of K4-1, **surface (river) water** is often subject to bacteriological contamination. In the rainy season the water often becomes turbid, which complicates the treatment. In addition, the river water contains a high content of iron. The water should consequently be treated for removal of turbidity and the water should be disinfected. A simple technology option has been recommended for treatment of surface water.
- The need for treatment should be reconfirmed by repeated water quality analysis before the detailed design.

Table 1.6 Recommended Treatment

System	**Source**	**Treatment**			
		Problem	**Filtration**	**pH adjust. Recom-mended**	**Disinfection**
K1-1: Bo Y	Deep well	Iron	Aeration + Slow sand filter	No	Chlorination
K2-1: Dak Su	Deep well	Iron	Aeration + Slow sand filter	No	Chlorination
K2-3: Dak Su*	Deep well	Iron	Aeration + Slow sand filter	No	Chlorination
K3-1: Dak Ui	Deep well	Iron Mangan.	Aeration + Slow sand filter	No	Chlorination
K4-1: Dak Hring	River	Iron Bacteria Turbidity	Roughing filter + Slow sand filter	No	Chlorination

*K2-3 is proposed to connect existing water supply system. The description in the table above is thought to be using local groundwater source.

1.6 Design for Piped Schemes

1.6.1 Design Principles

"Appropriate technology" or even "simple technology" should not necessarily mean not only "low cost", but also for "easy operation of system" by the people of commune level. Even though less advanced methods are recommended, the materials used should be good. The following are the basic recommendations for the design principles of the piped supply systems.

- Automatic or simple (or manual) pump controls are recommended.

- As far as possible gravity will be used for transport of water.
- Local materials should preferably be used for construction in order to ensure the availability of spare parts.
- Pipe material and fittings should be of good quality in order to minimize pipe bursts and leakage.
- Water meters are delicate equipment and only good quality meters should be used, otherwise it will quickly break down or the accuracy will degrade.
- Pumps with good efficiency should be used in order to save operating costs.
- Installations should be properly performed. Poor pipe work will certainly increase leakage rates.

1.6.2 Design Criteria

This section includes the Vietnamese design criteria "TCXD 33 (1985)" titled as "water supply external networks and facilities design standard". This master plan follows this design criteria, and the following table shows the design items and design criteria.

Table 1.7 Design Criteria

Design Item	Design Criteria
Service hours	• Basically 24 hours.
Submersible Pumps	• Submersible pumps are dimensioned to deliver the required maximum daily supply quantity (Q_{max}) in 2020 around 20 hours pumping (4 hours is considered for sudden public power drop and maintenance).
Booster pumps	• Booster pumps pumping to elevated tanks should deliver the maximum hourly supply (q_{max}).
Distribution Pipe Dimensions	• The distribution pipe dimensions will be calculated so as to deliver the required service pressure in the maximum hourly supply (q_{max}) for 2020.
Treatment Plants	• Treatment plants will be dimensioned for delivering the maximum daily supply (Q_{max}) within 20 hours in 2010 and less (corresponding to the demand) before that.
Reservoirs	• Reservoir size will be constructed to balance the fluctuating demand from the distribution system against the water supply, and to act as a safeguard for the continuation of the supply should there be any breakdown or stop by maintenance at the sources. The dimension is as 8 times the average hourly demand in the maximum daily supply (Q_{max}) for 2010.
Elevated Tanks	• Elevated tanks are set for the accumulation of water pressure, and usually are located at the highest locations close to reservoirs. Elevated tank size is determined by the consumption in the average hourly demand in the maximum daily supply (Q_{max}) for 2020.
Service Pressure	Pressure at user should be: • Maximum: 40 m (4 bar). Higher pressure (up to 6 bar) can be accepted in some areas if no other source is available. Pressure reducing installations should be considered. • Minimum: 6 m (0.6 bar). In the peak situation 4 m may be accepted in small areas if the achievement of higher pressure will be costly.
Public Taps	• Public taps will be installed at all public buildings, e.g. peoples committee offices, schools, kindergartens, health centers etc. The communities may decide on more public taps to be installed.
Flow Water Meters	• Bulk water meters are to monitor water production and consequently unaccounted-for water, in various areas of the water supply system. • Bulk water meter shall be installed in the front of each village/hamlet and/or diverging point from main distribution pipeline to secondary pipeline.

Note: The Criteria was basically applied Vietnamese standards in this study.

1.6.3 Alternatives for the 5 Piped Schemes

The 5 prioritized systems are varying with regard to elevations and pressure, and the locations of the water supply facilities should be efficient. This section prepares the three main alternatives for economical centralized piped supply as described below:

(1) Alternative 2

This solution is proposed where simple water treatment is necessary, which basically involves removal of excess contents of iron and manganese. Chlorination after slow sand filtration may require when a long retention time is expected by large scale reservoir.

The deep well submersible pumps transfer water through a treatment plant (aeration tower and slow sand filtration) to a ground level reservoir. Booster pumps then transfer water to an elevated tower, from where the water flows by gravity to the distribution network.

(2) Alternative 2a

This variation of Alternative 2 is proposed where the topography allows for a treatment plant and reservoir to be placed at relatively high ground. There is no need for booster pumps or an elevated tower.

The main problem of this alternative is to locate a suitable position for the treatment plant at a relatively high ground level, while considering that there will also be the need for proper access to the treatment plant (the requirement for access to a reservoir only is less critical). Chlorination at filtration will be required.

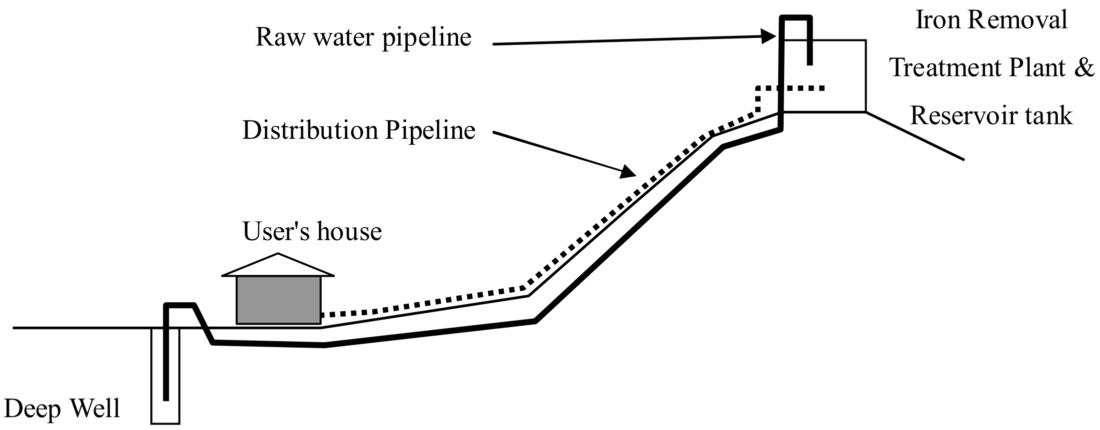


Figure 1.1 Typical Layout of Alternative 2a

(3) Alternative 2b

This variation of alternative 2 is proposed where it is not possible to find a suitable location for a treatment plant for iron or manganese removal at a high position. Consequently, the treatment plant may be placed near the deep well, and the water boosted to a reservoir site. From the reservoir, the water flows by gravity to the distribution network.

This solution introduces the need for secondary booster pumps, however, an advantage is that the treatment plants can be more conveniently positioned with easy access.

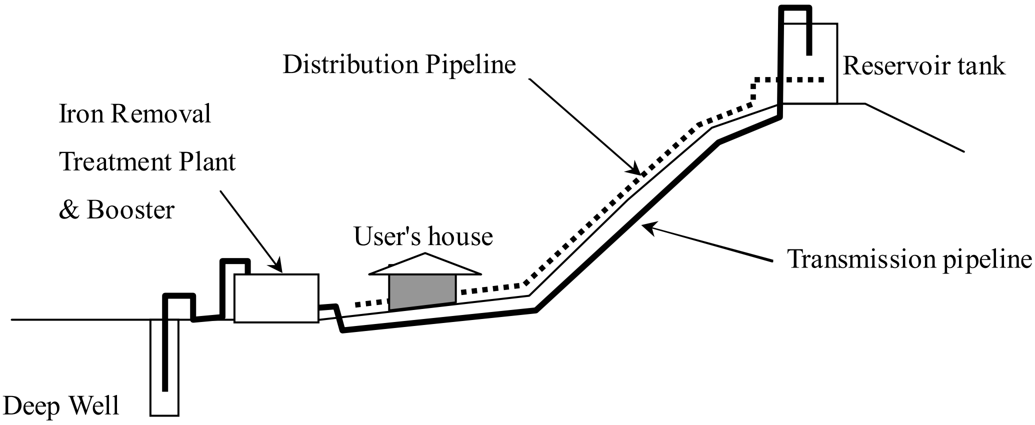


Figure 1.2 Typical Layout of Alternative 2b

(4) Alternative 3

This solution is proposed for the treatment of surface water. The intake consists of a concrete inlet chamber along river course. Simple treatment plant which consists of a roughing filter (pre-filter) will be installed in front of raw water pipeline. The treatment facility of slow sand filter and chlorination shall be planned by gravity system. From there the water pumps up to elevated tower reservoir.

In order to reduce the power cost a gravity system of the treatment plant, the topographic survey was carried out in K4-1 for the upstream of conceivable treatment plant. The intake is selected 1 km upstream of the treatment plant. Therefore, a raw water pipe of at least 1 km in length would be necessary.

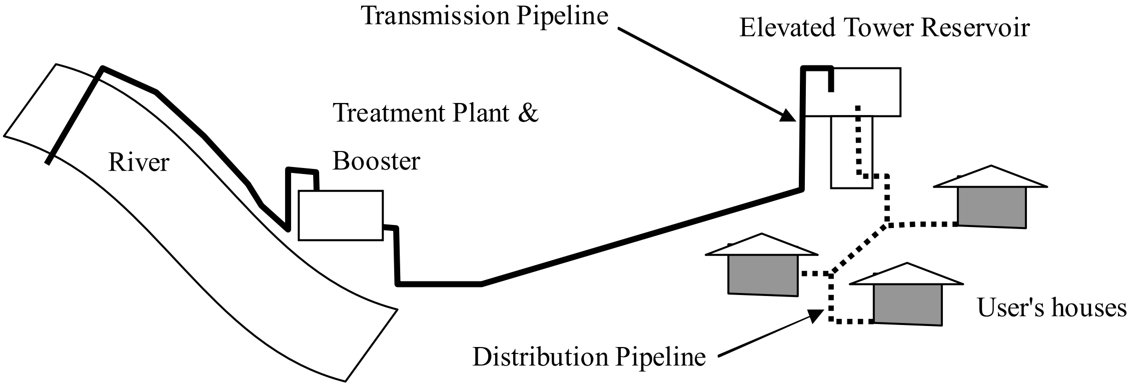


Figure 1.3 Typical Layout of Alternative 3

Table 1.8 Overview of Proposed Water Supply Systems

Prioritized System	**Alterna -tive**	**Description and Comments**
KONTUM		
K1-1 **Bo Y**	**2b**	• Submersible pumps transfer water through treatment plant placed nearby the deep well. • Iron removal by aeration and slow sand filtration. • Boosters pump treated water up to ground level reservoir. Gravity flow from reservoir to the network.
K2-1 **Dak Su**	**2b**	• Submersible pumps transfer water through treatment plant placed nearby the deep well. • Iron removal by aeration and slow sand filtration. • Boosters pump treated water up to ground level reservoir, and flows by gravity to the network.
K2-3 **Dak Su**	**2a**	• Submersible pumps transfer water up to treatment plant adjacent the reservoir at high position. Iron removal by aeration and slow sand filtration. Gravity flow from reservoir to villages. • Water will be supplied up to a ground level reservoir and flows by gravity to the network.
K3-1 **Dak Ui**	**2a**	• Submersible pumps transfer water to treatment plant placed at high location. • Iron removal by aeration and slow sand filtration. • Treated water is boosted up to ground level reservoir, and flows to the network by gravity.
K4-1 **Dak Hring**	**3**	• Surface water source. • Gravity flow or intake pumps transfer water through treatment plant from river. • Treatment by roughing filter and slow sand filter. • Treated water is boosted to an elevated reservoir placed at the highest point in K4-1.

1.6.4 Layout of the Water Supply Systems

This section provides a general description of the contents of the drawings. Layout drawings were required to take construction quantities and cost estimate on the proposed water supply systems. A layout drawings for the prioritized five systems has been provided indicating a proposed water supply networks in the feasibility study level that changes and additions from the 18 systems in the master plan.

The diagrams in Appendix 1 ("Layout Drawings of Water Supply System") detail the final proposed water supply networks for each of the systems. The layout drawings in Appendix 1 have been updated where necessary, of which the changes and additions by the updated results at the F/S stage are:

- Newly decided intake location and raw water pipe line route,
- Addition of some main distribution pipes,
- Change in pipe lengths and diameters of several main distribution pipes,
- The proposed location of water treatment plants,
- Change of location of elevated reservoirs (K4-1),

(1) Deep Wells

The locations of the wells drilled by the study team are shown in the drawings. Although more than one deep well is required for most systems in order to cover the user demand at phase 1, the final location of these wells shall be confirmed in detailed design phase.

(2) Raw Water Pipes

Proposed routing and diameters of raw water pipelines are shown in the drawings. The routing was chosen so that the pipelines would always run alongside roads for easy identification and maintenance, and simpler location.

For the raw water pipes from new deep wells, which have not been identified, a length of 1,500 meters between well and reservoir tank for these raw water pipes has been conservatively estimated and included in the design and cost estimates considering the present conditions.

(3) Main Distribution Pipes

The main distribution pipes are shown in the drawings with diameter and approximate length indicated. The diameters of the pipes were designed for year 2010/2010, based on hydraulic calculations described in the next section.

The main distribution pipes can supply all main areas with water at sufficient pressure, such that the secondary network (which will be designed during the detailed design phase) can supply all households. Main distribution pipes are normally of diameter 75 mm to 200 mm.

Distribution pipes should preferably be constructed along roadside shoulders for easy access and maintenance, however this installation may not always be possible.

(4) Secondary Distribution Pipelines

For most systems many of the houses were concentrated along the main roads. Thus, one main distribution pipeline along each side of the main road where the residential people request it could supply most of the households. There are some houses located away from the concentrated area along the roads, so several secondary pipes are necessary to enable water supply to these areas. Secondary pipelines are normally of diameter 25 to 65 mm.

Secondary pipes will be designed during the detailed design phase, such that water supply pipelines are located near all households and thereby enabling them to connect to the system. Secondary pipelines are generally not shown in the drawings of this report, however the required quantities to supply all houses in the villages have been estimated.

The quantity of secondary pipes needed was estimated following the criteria below:

- An estimate of the length of the village,
- The need for one or two pipes along the road to the village

(5) Proposed location of Treatment Plants and Reservoirs

The proposed location of treatment plants and reservoirs were determined as preliminary level, which should be examined in detailed design stage, taking into account the following:

- Water should be directly transferred by submersible pumps to treatment plants, and flow by gravity to the reservoirs, in order to avoid secondary pumping. This may not always be possible because the location of treatment plants (e.g. on hilltops) may be unfavorable, with regards to site access.
- If possible, reservoirs should be located at high locations, so that the water can gravitate to the system.
- Space for the construction of treatment plants and reservoirs should be readily available.

- ♦ The water works should preferably be placed on public ground, in order to avoid compensation to private landowners.

(6) Water Meter

The three kinds of water meter are planned to install, one is at the submersible pump outlet on the surface, second is bulk meter at the main division points of the distribution pipe line, and the third is for each house connection point. The former two meters shall use special meter assembled in Vietnam by foreign manufacturers. The house meter shall be made in China or India.

1.6.5 Hydraulic Calculations

The proposed water supply schemes have been analyzed using a computer aided hydraulic calculation software package for piped networks, specifically "Epanet". The "Darcy-Weiss" equation was the basic calculation process for the analysis.

(1) Analysis Guidelines

The following guidelines were applied for the analysis:

- ♦ The maximum hourly supply in year 2020 was used for dimensioning the pipes. This provided a conservative calculation for the design in all periods up to year 2020.
- ♦ A number of the systems were further analyzed in order to determine and view how flow and pressure varied during the course of an average day.
- ♦ A pipe roughness factor of 0.1 mm was used. This is a conservative value, which takes into account the possibility of deposits on the pipe wall over time (a typical value for new pipes is 0.01 to 0.05).
- ♦ All main distribution pipelines in the system were included in the analysis. Some secondary pipelines were also included for several systems.
- ♦ Pumping mains were generally not included in the analysis as the design of a single pumping pipe is relatively simple and does not require computer analysis. Design of pumping mains with multiple pumps networked together may be more complicated, however as the locations and details on future deep wells are not yet known, the multiple pump case cannot be analyzed at this stage.
- ♦ Water supply quantities were distributed amongst network nodes on the basis of water demands and knowledge gained from inspections during the field surveys. The supply quantities were distributed in a conservative manner by,

for example, placing half (or a third) of the consumption at the farthest point of the pipe.

- The criterion for minimum pipe pressure was 6 meters head at all locations, but preferably up to 7 meters, so as to take into account friction losses in secondary pipes.
- Alternatively, it is sound practice to maintain minimum flow velocities in the pipes (preferably above 0.2 m/s). This is in order to avoid stagnant water and to achieve a self-cleaning effect within the pipes.
- Accurate pipe invert levels are of high importance towards accurate results of the analysis. Surface levels have been obtained during the field visits with the use of altimeters and by the study of topographic maps (1:50.000). Several critical lines were subject to carry out a topographic survey, in order to confirm the levels of the main areas for supply. However, elevations of some secondary pipe routes may still not be sufficiently accurate and should be confirmed during detailed design.

(2) The Results of the Analysis

The results of the analysis are included in the Data Book, Chapter7, together with print outs of the results in the form of network maps. The results are graphically shown on the maps, featuring pressures for the nodes and flow velocities for the pipes (values are shown underneath the respective nodes and pipes, with node numbers and pipe numbers also shown). The analysis results are included after each network map, detailing complete information on the water supply system flows and pressures.

The results specify elevations, supply quantity and pressures for the nodes; and lengths, dimensions, velocities and head losses (per km) for the pipes.

The following significant results of the analysis can be seen:

- Generally, there were no problems in achieving the required pressures throughout most areas in the network. However, there were isolated areas where it was difficult to reach sufficient pressure during maximum hourly supply times. During times outside the maximum hourly supply periods (usually lasting only a few hours per day) there was no difficulty for all areas in obtaining sufficient pressure.

- A maximum height limit for elevated reservoirs of 10 meters was used in the analysis. Higher pressures can be achieved by increasing the height of these towers.
- Water Supply networks can be adjusted to optimal pressures and supply flows with the aid of computer software calculations. The resulting output often lists many different pipe dimensions and numerous changes in dimensions along pipes. Some such results are not desirable with regards to operations and maintenance, so repeated changes to pipe dimensions were subsequently avoided and the results altered accordingly.
- One particular result of the computer analysis was that the outskirts of systems only required very small pipe diameters. However, allowing for future water supply system expansion, these very small dimensions (below 65 mm) were avoided at pipe ends in most networks.
- The analysis results formed, in part, the basis for the estimation of pipe quantities. However, most secondary pipes will only be correctly evaluated after detailed survey maps are completed and detailed design has been performed. At this stage, lengths of such secondary pipes have been only approximately estimated from information gathered during site visits.

1.7 Standard Designs of Water Supply Facilities

The main components of each proposed network system are outlined in Supporting Report B, Appendix 2 (“Spread Sheet on Design of Water Supply Facilities”). Typical designs of the water supply works have been prepared and the drawings are included in Supporting Report B, Appendix 3 (“Standard Designs of Water Supply Facilities”).

Summary of water supply facilities for each system is show in the table below.

Table 1.9 Summary of the Water Supply Facilities

Commune/ Town Name	Number of Villages		Population 2010	Water demand 2010 Qav (m^3/day)	Number of Bulk meter	Number of existing wells (yield;m^3/day)	Number of required wells till 2010	Number of Pump till 2010	Number of reservoir tank (Cap.;m^3)	Elevated tower	Treatment plant	Raw water pipeline (km)	Distribution pipeline (km)	Number of Public tap
K1: Bo Y C.	**K1-1**	**7**	**7797**	**477**	**10**	**1(100)**	**7**	**8**	**1 (207)**	**0**	**1**	**6.0**	**22**	**8**
	K1-2	1	700	43	1	Household systems								
K2: Dak Su C.	**K2-1**	**3**	**1612**	**99**	**2**	**1(150)**	**0**	**1**	**1(42)**	**0**	**1**	**1.5**	**11**	**4**
	K2-2	1	500	31	1	Household systems								
	K2-3	**9**	**4862**	**298**	**9**	**0(150)**	**3**	**3**	**1(129)**	**0**	**1**	**1.0**	**19**	**10**
	K2-4	1	596	37	1	Household systems								
K3: Dak Ui C.	**K3-1**	**5**	**2819**	**173**	**6**	**1(250)**	**0**	**1**	**1(74)**	**0**	**0**	**0.0**	**10**	**45**
	K3-2	2	932	57	3	Household systems								
	K3-3	2	406	25	1									
	K3-4	2	1192	73	2									
	K3-5	2	1040	64	2									
K4: Dak Hring C.	**K4-1**	**3**	**3136**	**192**	**4**	**river water**		**-**	**1(73)**	**1**	**1**	**0.5**	**21**	**5**
	K4-2	1	351	22	1	Household systems								
	K4-3	4	1549	95	4									
	K4-4	4	1677	103	4									
	K4-5	1	607	37	1									
K5: Sa Nghia C.		3	1875	115	3									
K6: Chu Hreng C.		5	1993	122	1									

A general summary of specifications for water supply works is presented below. Refer to Supporting Report B, Appendix 4 (“Technical Specifications”) for further detailed specifications for pipelines, valves, chambers, etc. The designs have been detailed to an extent that they can easily be modified to the single communes with regard to dimensions.

The following Standard Drawings are included:

- Typical deep well structure,
- Typical design of well head and well house building,
- Typical iron and manganese removal plant (aeration tower, reaction tank, and slow sand filter),
- Typical surface water treatment plant (horizontal roughing filter and slow sand filter),
- Chlorination system,
- Sludge basins and sand washing basins,
- Typical reservoirs,
- Pumping stations,
- Pipelines,
- Typical public taps - Alternative 1 to 3, and
- Water meters.

1.7.1 Well Structure and Well Head

Standard design for well structure is shown in the Figure 1.4. Dimension of the proposed well in Kon Tum province is as following;

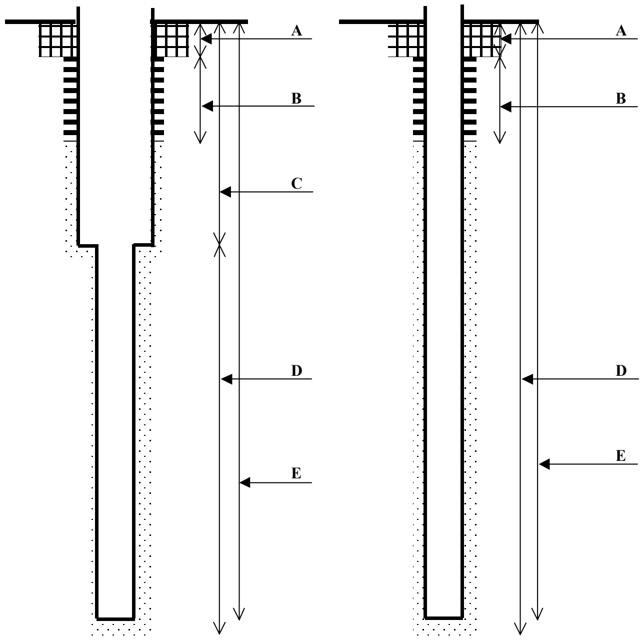
Diameter of drilling hole : 240mm
Casing and Screen pipes : 150mm (FRP material)
Planned Depth : 50m in average

The proposed assembly of a wellhead consists of: air valve, pressure gauge (0 to 10 bar), non-return valve, gate valves, water meter, pipework, and anti-waterhammer protection (optional).

None of the wellheads included in the study required pipes greater than 100 mm in diameter, and most wells shall only require 80 mm diameter pipeworks. Pipework may be fabricated from galvanized iron.

Pump house should be equipped with a tripod with crane for the well house buildings for easy installation and removal of the submersible pumps.

Waterhammer analysis should be carried out in detailed design stage all pumping mains and protection against waterhammer pressure surges should be installed at pump stations as needed.



Type-1
(Solar pump + Generator pump system)

Type-2
(Public power pump system only)

Figure 1.4 Standard design for well structure

1.7.2 Iron and Manganese Removal

The designs illustrate a typical Vietnamese standard design for iron removal plants, which is considered appropriate, considering the water quality test results in the study area. The following are the important points concerning iron and manganese removal:

- **Manganese removal can be performed by means of aeration and slow sand filtration.** This process requires very effective aeration and careful operation of the filter, which should never become dry and should preferably receive a constant flow of water.
- The purpose of aeration is to provide sufficient time for the iron and manganese oxidization reaction processes to complete. The hydraulic retention time should be approximately 40 minutes.
- The aeration system consists of a series of small water pipes (25 mm dia.) perforated with outlet holes (3 - 5 mm dia. at approximately 50 mm spacing), from where the outflow of water falls down upon a series of plates in turn, and finally on to the surface of the reaction tank. Some maintenance is necessary because the pipe outlet holes may become blocked with iron deposits over time.
- Proper ventilation is necessary to enable the supply of sufficient oxygen, as well as assisting in the removal of possible dissolved gases in the water, such as hydrogen sulphide.
- Removing the products created during the iron and manganese oxidization processes is achieved by the use of a filter, consisting of several sand layers of differing particle size. The maximum hydraulic filter speed should be 5 m/day for slow sand filtration.
- Iron removal can be performed by means of aeration and slow sand filtration. The periodical washing or replace of the surface layer (10cm) in slow sand filter is approximately 3 to 6 months intervals, depending upon its water treated volume and size of sand filtration.

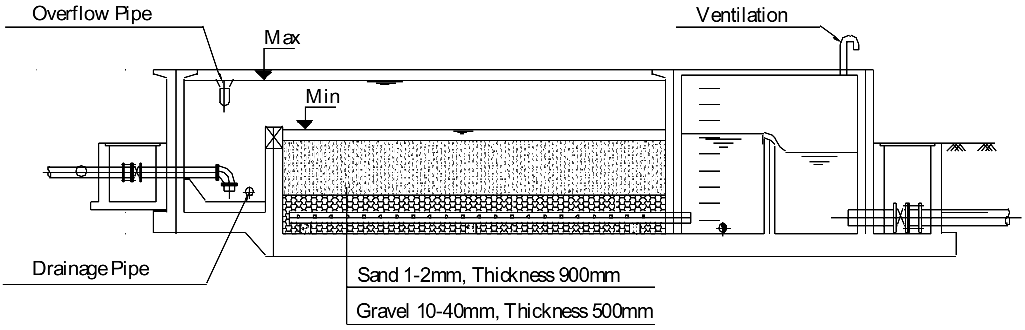


Figure 1.5 Standard design for Slow Sand Filter

1.7.3 Surface Water Treatment

Treatment of surface water is more complicated than for groundwater for several reasons, such as rivers and streams becoming more turbid during the rainy season. More significantly, it is possible that upstream areas of river and stream intakes are used for bathing, washing clothes and defecating, and may therefore be biologically contaminated.

The following is the main points of surface water treatment:

- The process of surface water treatment follows roughing filter, followed by slow sand filter.
- Complete removal of turbidity may present a problem during the rainy season, however this can only be verified after testing the water quality following heavy rain.
- The water quality analysis showed that the surface water had high iron content. The roughing and slow sand filters are together able to remove the iron.
- The purpose of the roughing filter is to remove the bulk of the turbidity content and also some of the iron content contained in the raw water. The filter shall be equipped with drains. From the roughing filter the water flows by gravity to the slow sand filter.
- The slow sand filter is a simpler alternative to the slow sand filter, and contains very fine sand, requiring a larger filter area.
- Slow sand filters do not require backwashing or the operation of backwash pumps, however the filter sand needs to be periodically removed, washed and replaced. Washing of the filters should be performed every 3 months, however washing may need to be more frequent during the rainy season.

- ♦ In order to guarantee the fulfillment of all water supply quality standards, it may be necessary to employ flocculation, sedimentation and filtration processes followed by disinfection. Such full-scale treatment complicates the operation and maintenance procedures and increases the costs.

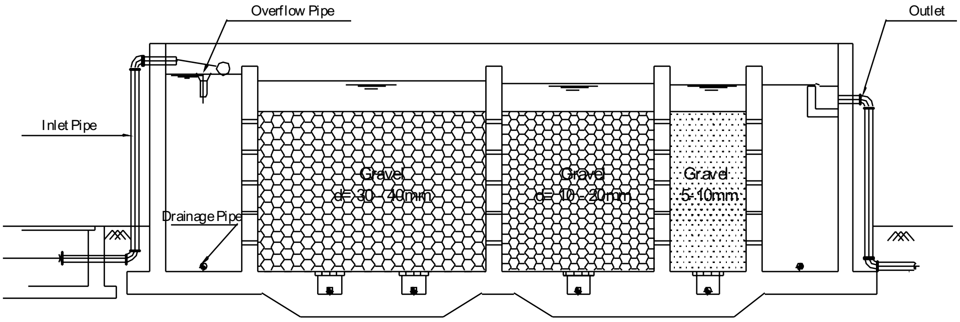


Figure 1.6 Standard design for Roughing Filter

1.7.4 Chlorination

Deep groundwater does not normally require a disinfection process by chlorination, provided that the deep well and installation works were properly installed and constructed, and the required safety zone has been established around the deep well. The need for disinfection will also depend on how well the deep aquifer has been protected from possible seepage from upper aquifers. For several systems there exists this risk of contamination of the unconfined aquifer from above (e.g. K1-1, K3-1).

However, there is always the risk of pollution of treated water, while stored in reservoirs for long retention time or through breaks in damaged pipes. The points to be highlighted for chlorination are as follows:

- ♦ As an option, the chlorination equipment of chlorine gas shall be installed where a large reservoir tank and long retention time are expecting and/or shallow groundwater sources. For smaller rural villages in case of a few hours retention time, chlorination can be installed later during phase 2 (2010 – 2020).
- ♦ Surface water that has been treated by roughing filter and slow sand filter normally also becomes bacteriological clean, however this cannot be guaranteed. Therefore, the water should, in theory, be disinfected by chlorination.

- The disadvantages of the chlorination process are that it complicates the treatment process; particularly in the way the chlorine should be continually and correctly dosed against measured water flow, and should be well mixed, which is sometimes difficult to achieve. The efficiency of disinfection also depends on the content of other substances in the water.
- The cost of delivering chlorine to the plant needs to be added to the overall operations and maintenance cost. Chlorine is also a dangerous chemical substance that requires careful handling and storage.
- An alternative chlorination system is presently being used in treatment plants for several water schemes in Vietnam. This particular disinfection process produces chlorine from salt (NaCl) through electrolysis. This eliminates the risk of handling and storing chlorine, however the risk of the system breaking down and requiring spare parts is increased.

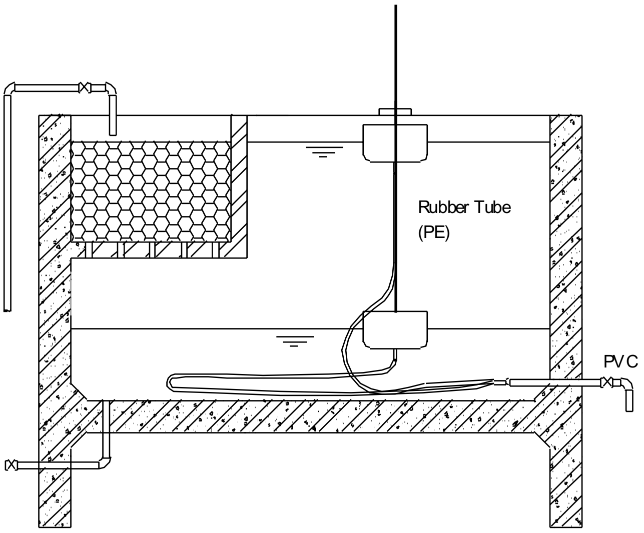


Figure 1.7 Standard design for Chlorination System

1.7.5 Sand Washing Basins (Alternative3 and K4.1)

The purpose of sand washing basins is to facilitate washing of the filter sand media to a clean efficient procedure. The basins are simple structures where the sand can be placed securely for washing, enabling the water to drain away, and all the sand remain for drying.

Following this settlement, the overlying water can be drained away to a stream or river.

The following points are highlighted for sludge basin and sand washing basins:

- The sand-washing basins can be constructed as simple concrete boxes. The size shall be decided in detailed design stage depending on the availability of land use condition.

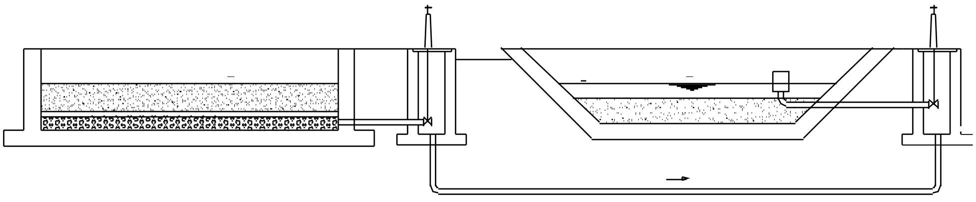


Figure 1.8 Standard design for Sand Washing Basins

1.7.6 Reservoirs

- The purpose of reservoirs is to balance the varying supply quantity (up to maximum hourly supply) against the relatively steady production flows of the water works, with the use of water storage.
- Reservoirs shall be constructed in reinforced concrete, and shall be equipped with overflows large enough to accommodate the maximum expected flows from inlet pipes.
- The reservoir shall be equipped with sufficient ventilation in order to empty the reservoir of air, when filling with water.
- The reservoir shall have a piped washout installed at its base.
- All openings shall be covered with screening in order to prevent birds, rats, etc. from entering the reservoirs.

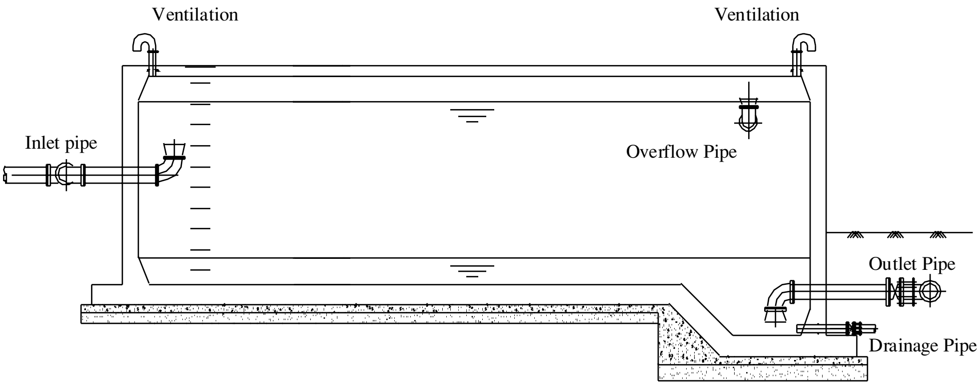


Figure 1.9 Standard design for Reservoir

1.7.7 Pumping Stations

Two kinds of pumps are used in the systems: submersible pumps and booster pumps

Submersible pumps:

- These are the most commonly used, for pumping from the deep wells to surface reservoirs or treatment plants.
- The submersible pumps proposed fall within a relatively narrow range for flow yields and lifting heads. The maximum proposed yields vary between 6 m3/hr and 22 m3/hr.
- The lifting heads vary between 60 and 110 meters.
- Most pumps could be operated from power supplied from a one-phase power grid.
- Only in perhaps 0 to 3 instances would 3 –phase power supply be required.

Booster Pumps:

- Where elevated tanks are constructed it becomes necessary to pump water from ground reservoirs to elevated tanks using booster pumps.
- Booster pumps are also necessary in the case of secondary pumping requirements from low elevation treatment plants to reservoirs located at higher levels.
- Booster pumping to elevated towers typically only provides small lift, e.g.15 to 20 m. Booster pumping from treatment plants to reservoirs may need to lift 40 to 50 m.
- Pumps should be carefully designed to operate near optimum efficiencies, based on the design parameters of flow and head.
- If the pump operates outside (above or below optimum flows) its optimum efficiency, this means that the power consumption becomes higher for each m3 lifted, resulting in increased costs to water production or distribution.

Control of Pumping:

- Control of pumping is proposed to be manual to the highest extent possible. For example, a pump may be started manually in order to fill up a reservoir, and stopped manually when full.
- A pumping schedule should be prepared from the experience gained during operation, and by considering the water consumption.
- Another simple way of controlling start and stop operations of pumps is by using float control switches in the reservoirs. When the reservoir is full, the

float lever becomes horizontal and trips a switch that signals the pump to stop. After the water level drops, the float lever will hang vertically, tripping a switch that signals for the pump to start. This method may require the installation of cables over relatively long distances to carry signals from the float control switch to the deep well pump panel, which results in the risk of possible damage to cabling.

Motor Protection:

- Motor control panels, as recommended by the pump supplier, shall be included in the installation of pumps.
- Control panels shall include necessary pump protection devices to protect against, e.g.: dry running, voltage surge, under/over voltage, lightning transient surge protection, thermal overload protection, phase failure protection shall be included for three phase pumps.

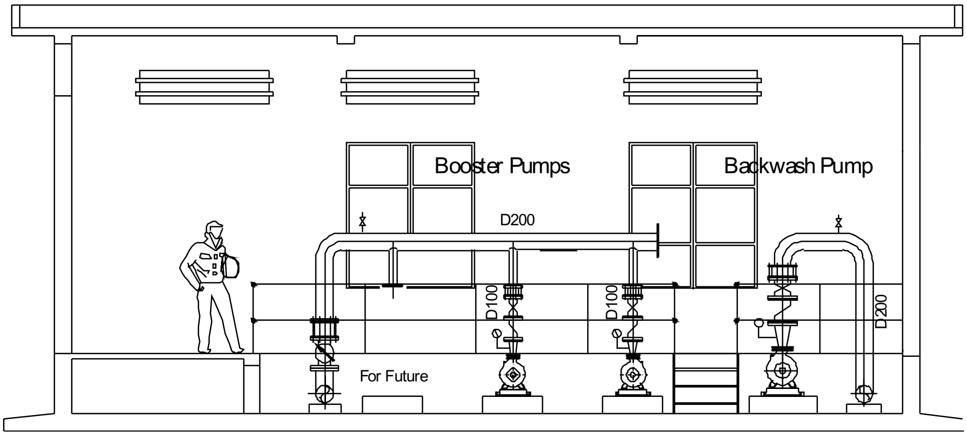


Figure 1.10 Standard design for Pumping Station

1.7.8 Pipelines

Most of the proposed water supply schemes are relatively small and with pipe dimensions below 100 mm diameter. Only a few main distribution lines may be of larger diameters up to 125 mm, 150 mm or 200 mm. Detailed specifications for water supply pipes are included in Supporting Report B, Appendix 4 (Technical Specifications).

Raw Water Pipelines:

- Raw water mains are proposed to consist of galvanized iron pipes.
- Mains passing through farmland should principally be installed in trenches deep enough to cover the pipes with minimum 1000 mm of soil, in order to avoid damage resulting from the planting of coffee, and other crops, shrubs and trees.

Distribution Pipelines

- Galvanized iron (GI) pipes have traditionally been used for water distribution mains in Vietnam. In places where it may be necessary to construct the mains either above ground or at shallow depths, GI pipes should be used.
- However, high density polyethylene (HDPE) and unplasticized polyvinyl chloride (uPVC) pipes are now also widely used. Such plastic pipes are less costly and do not corrode, once buried.
- uPVC pipes may become brittle if they are subjected to sunlight, thus should be stored accordingly.
- It is proposed to use uPVC Class 6 bar pressure for pipes 100 mm diameter and above, and HDPE for pipes below 100 mm diameter. In areas where heavy external forces may be exerted on the pipe, e.g. road crossings, GI pipes should be used or the plastic pipe should be housed within a protective steel sleeving. Concrete encasement should not be used for plastic pipes.
- Several areas have large differences in elevation. In such cases, Class 10 bar pressure pipes should be used, or if hydraulic calculations result in maximum operating pressures exceeding 60 metres.
- A minimum soil cover of 600 mm is recommended for distribution pipes within footpath areas for protection against normal loads and to provide nominal protection towards obstructing access for illegally made connections. A minimum cover of 1000 mm is recommended in roads to avoid damage from vehicles, trucks, road works and other works.

Pressure Testing:

- All water supply mains shall be pressure tested with the pipe joints uncovered.
- The pipes should be tested to 1.5 times the working pressure, and the pressure loss should be measured at each end of the section of main being tested.

Disinfection:

- All mains shall be flushed with clean water, until the water emerging from the flushing operation is visibly clear. Following the flushing procedure, and before commissioning and handing over of water mains or plant, all parts that will be in contact with the water supply shall then be disinfected.
- The disinfection process provides that all such sections of the pipeline be immersed with a 50 mg/l chlorine solution for 24 hours. If the concentration of chlorine after the test is less than 25 mg/l, the testing shall be repeated based on international guideline.
- Following disinfection, the system shall be thoroughly flushed until the residual chlorine content is below 1 mg/l.

1.7.9 Valve Chambers

Isolation Valves

- The purpose of isolation valves is to provide the possibility of carrying out repairs on sections of the water supply network, without causing supply to be cut-off to other areas of the village.
- A number of valves have been included in the estimates in order to facilitate the above procedures. Isolation valves are proposed to be resilient wedge soft-seated gate valves.
- All gate valves should be installed in watertight lockable valve chambers.
- Detailed specifications are included in Supporting Report B, Appendix 4 (Technical Specification).

Air Valves, Washouts and Thrust Blocks:

- Generally, it is not considered necessary to install air valves on distribution lines as house connections will act to release air. It was estimated that there will be a few points where air valves will be necessary along the raw water mains, which will be determined during the detailed design.
- Washouts should be installed on main distribution pipes at low points by installing a flanged branch off-take with valve.
- Thrust blocks should be constructed at all points of change in direction (bends and tees), changes in diameter and dead ends, on all raw water mains and distribution mains (100 mm diameter and larger). Thrust blocks consist of a concrete block with the pipe adequately embedded to transfer the forces. The

surface area of the thrust block bearing against the undisturbed soil surface shall be sufficient for the particular type of soil to support such force.

1.7.10 Public Taps

Three types of public taps have been included as standard designs in the drawings:

- ♦ Alternative 1 uses a tap for dispensing water directly from the distribution main. The tap is installed on a concrete slab, with a slight slope for drainage.
- ♦ Alternative 2 uses 3 taps for dispensing water, and a small storage volume (1 m3) as a back-up supply, during periods of the maximum amount served, times of power failure or during reduced pumping times. There is a single tap on a sloping concrete slab.
- ♦ Alternative3 includes a small storage as a back-up supplying, bathing rooms for men and for women, with 3 taps for supplying water. This type is suited to very poor villages.
- ♦ Pipes and taps shall be manufactured from metal, such as GI or bronze. Plastic pipes must not be used to prevent damages by hunging the water vessels on the pipe.

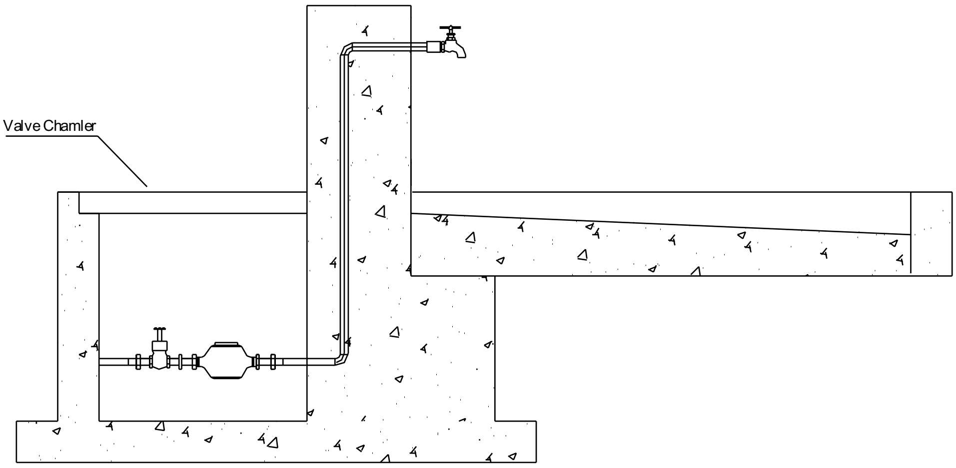


Figure 1.11 Standard design for Public Tap

1.7.11 Water Meters

Bulk Water Meters:

- ♦ Bulk water meters are important for monitoring overall water production and Unaccounted-For Water (UFW) through district meters throughout the water supply system.

- Location to be installed the meter are in front of each village/hamlet of the main distribution pipeline, and/or in front of branch (secondary) pipeline.
- Raw Water Meters: Equipped at all Deep wells in order to record water production.
- Clean Water Meters are recommended installed at all reservoir outlets.
- If necessary bulk water meters could be equipped together with an upstream screening filter in order to avoid larger particles in the water flow from damaging the meter rotor mechanism. If necessary, a by-pass could be installed at the meter in order to facilitate the cleaning of the screen and maintenance of the meter.
- The diameter of the water meter should be designed according to the range of flows and the manufacturer's specifications.

Household Meters:

- Household meters installed in house connections are for the accurate collection of water tariffs.
- The theoretical lifetime of a user household water meter should be at least 10 years, however, this depends on the quality of the meter, water quality and the general maintenance carried out on the meter. Unless the standards of these are high, the life span of the meter becomes much less.
- Meters should be calibrated regularly (internationally every 3 to 5 years depending on the meter quality and maintenance level). This requires that reliable meter calibrating facilities are available in the province (or neighboring provinces) and that spare parts are readily available.
- If users discover that the meters are inaccurate, they will eventually lose faith that they are paying a "fair" price for the water supplied. A common problem is that users will then attempt to "cheat" the meters, by manipulating them in various ways. The user may possibly go as far as sabotaging the meter.
- Metering each of the households increases the administrative workload. Meters need to be read and recorded regularly by trained staff. The recorded data needs to be processed, with water bills sent out to users and money collected.
- Policies for metering should be decided by water supply unit (WSU) and the board who are to operate the systems. Possible solutions should be presented to each village in order for them to make well-informed choices.

- The water meter installation is important for quantitative control for whole water supply to manage proper consumption and to establish fair water charge collection system.

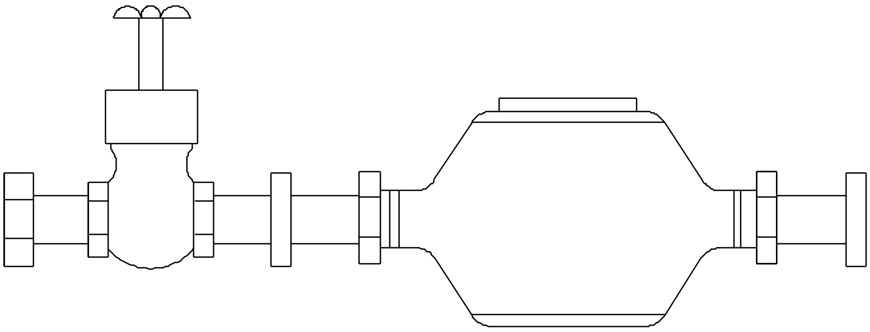


Figure 1.12 Standard design for House connection Meter

1.8 Cost Estimate for Construction

1.8.1 Conditions and Assumptions for Cost Estimate

The conditions and assumptions for construction cost estimates are as follows:

- Costs are calculated at the value in the year 2001.
- Exchange rate is US$ 1.0 = VND 15,000
- The unit costs applied for the cost estimates are tabulated in Table1.12.
- The estimates were reviewed following the updated master plan and the standard design of the systems.
- The estimates were reviewed on a financial basis with the cost composition and conditions as given in the table below.

Table 1.10 Composition of Project Cost

	Project Cost Item	Parameters
A	Direct construction cost	
B	VAT (Value Added Tax)	10 % of A
C	Cost for construction works	A+B
D	Land acquisition and compensation cost	
E	Engineering services expenses	15 % of C
F	Base cost	C+D+E
G	Price contingency	10 % of F
H	Physical contingency	10 % of F+G
I	Project cost	F+G+H

1.8.2 Total Project Costs

The project costs were updated during the F/S and reflected in the following table. The total project costs are US$ 2.7 million in total at Phase 1 (2010 for service coverage of 86 %). The summary of the construction costs is shown in Table 1.11.

Table 1.11 Summary of Construction Cost

Province	Phase1 (2010)	
	No. of Priority Systems	Project Cost (US$ million)
Kon Tum	5	2.7

Table 1 Unit Construction Cost

Unit Construction Costs

US$ 1.0=JY 120.0=VD 15,000.0 (Dec./01)

No.	Work Items	Unit	Unit Const Cost FC+LC (US$)	Allocation of Unit Construction Cost					
				Local Currency Portion			Foreign Currency Portion		
				Material (US$)	Installation (US$)	Amount (US$)	Material (US$)	Installation (US$)	Amount (US$)
1	Deep well								
	1.1 Deep well with casing and screen	well	40,000	1,000	19,000	20,000	20,000	0	20,000
2	Submersible Pump								
	Submersible pump, 1.0 m3/hr - 22 m3/hr, lifts 50 -110 m	set	6,000	0	1,000	1,000	5,000	0	5,000
	powered by local grid with motor protection, pipe								
	and accessaries (B-system)								
3	Well head arrangements	head	1,900	1,200	200	1,400	500	0	500
4	Control panel, incl. Motor protection	panel	2,200	0	200	200	2,000	0	2,000
5	Power supply for well pumping station	item	4,300	4,000	300	4,300	0	0	0
	from national grid,single phase, 1.5 - 15kW								
6	Power supply for booster station	item	4,800	4,000	800	4,800	0	0	0
	from national grid, 3 phases								
7	Well head house, 12 m2 (US$ 150/m2)	house	1,800	1,500	300	1,800	0	0	0
8	Storage Reservoir								
	8.1 Ground reservoir, 50 m3 capacity	cu.m	107	70	37	107	0	0	0
	8.2 Elevated reservoir	cu.m	330	200	130	330	0	0	0
	8.3 Bulk water meter equipped with the reservoir	each	1,000	0	0	0	1,000	0	1,000
9	Treatment plant								
	9.1 Aeration and reaction basin (per storage m3 basis)	cu.m	400	270	130	400	0	0	0
	9.2 Rapid sand filters (per m2 filter area basis)	sq.m	2,000	1,500	500	2,000	0	0	0
	9.3 Roughing filter and slow sand filter	sq.m	1,500	1,200	300	1,500	0	0	0
	(per m2 filter area basis)								
	9.4 Chlorination, semi-manual operation type for	item	4,400	4,200	200	4,400	0	0	0
	purely rural area								
	9.5 Chlorination, automatic advanced system type	item	6,000	300	200	500	5,000	500	5,500
10	Booster pump stations								
	10.1 10 m3/hr, station with booster pump	m3/hr	520	100	120	220	300	0	300
	10.2 20 m3/hr, station with booster pump	m3/hr	570	100	120	220	350	0	350
	10.3 50 m3/hr, station with booster pump	m3/hr	620	100	120	220	400	0	400
11	Raw water lines				2				
	GI pipe 80-150 mm, including 2 gate valves per line,	lin.m	16	12	4	16	0	0	0
	fittings, couplings, clearing of pipe route, pressure testing								
	and disinfection								
12	Distribution lines, PE or PVC pipes including valves,								
	fittings, valve chambers, clearing of pipe route, pressure								
	testing, disinfection								
	12.1 HDPE 25-65 mm	lin.m	6	2.5	3.5	6	0	0	0
	12.2 HDPE 80-125 mm	lin.m	10	6	3.5	9.5	0	0	0
	12.3 HDPE 150-200 mm	lin.m	17	11.5	5.5	17	0	0	0
13	Public taps								
	13.1 Public taps	tap	500	450	50	500	0	0	0

*Breakdown of the deep well construction cost, 40,000US$ is as followings;
10,000US$:Drilling cost (based on the construction cost carried out by the Study Team)
20,000US$:Casing pipe cost
10,000US$:Automatic switch on/off equipment

Table 2 Project Cost for 5 Piped Systems

No.	System No.	Year 2010, service coverage 86 %			
		Option	Construction Cost	Base Cost	Project Cost
		proposed	(US$)	(US$)	(US$)
Kon Tum			**2,140,805**	**2,461,926**	**2,708,118**
1	K1-1	option 1	875,885	1,007,268	1,107,995
2	K2-1	option 1	156,290	179,734	197,707
3	K2-3	option 1	443,742	510,303	561,334
4	**K3-1**	option 1	205,461	236,280	259,908
5	**K4-1**	option 1	459,427	528,341	581,175

Chapter 2 Organizational Settings

2.1 Organization of Operation and Maintenance

2.1.1 Principles

The operation and maintenance of the water supply facilities in the project will be organized along the following principles, based on the NRWSS and the lessons learnt from rural water supply in other countries:

- ☐ organization of operation and management arrangements of the facilities prior to construction of facilities (could not be fully applied in the pilot schemes due to time constraints),
- ☐ **integration of the responsibilities** for implementation, management and operation and maintenance, including major rehabilitation, extension and re-investment,
- ☐ retaining at least the majority of the ownership of the system with the commune or users,
- ☐ relative **autonomy** of the O&M organization, meaning its ability to operate with minimum control from any governmental body, but with necessary oversight and regulation,
- ☐ a **business-like approach**, meaning the water supply operator, although public, operates just as if it was a private business, in terms of its efficient system of billing and collecting revenues, financial self-sustainability, planning and budgeting, and treatment of the users of its services as true users, and
- ☐ provision of services related to O&M of the schemes by the private sector, to the extent reasonable and possible.

2.1.2 Organization of O&M

The NRWSS recommends that users (communes) decide how they wish to organize O&M. However, as rural piped schemes are a novelty in most project communes, an organizational model has been developed as a basis for discussion in communes. The model is based on the above principles, lessons learned from Vietnam and other countries, and extensive discussions with stakeholders ranging from CERWASS and PCERWASS to commune leaders and user representatives.

This model is considered realistic at this stage of development in the Central Highlands.

Proposed Organizations

For the O&M of the facilities implemented in the pilot models, following organizations are proposed.

- ☐ **Board of Water Supply Unit** will be established under **CPC/TPC** for piped water supply.
- ☐ This organizations will be materialized through representation of users in the Board of the WSU.
- ☐ **Water Supply Unit** (WSU) will be established under the Board of Water Supply Unit.
- ☐ **Representation of the users** will be included in the management structure of the WSU.

The chart of the organizations for piped water supply is shown in the following figure.

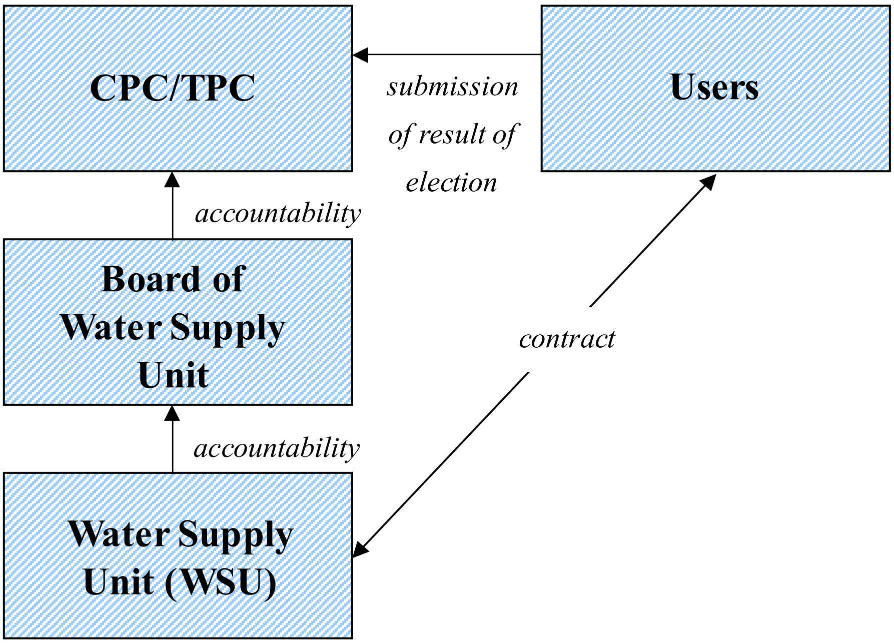


Figure 2.1 Organization for piped water supply

Board of Water Supply Unit Scheme

The purpose of the Board is to have a rigid and responsible body to supervise the WSU. The Board of WSU will be established based on following procedures;

- ☐ The Board comprises of five members appointed by the People’s Committee of the commune or town for a two years period,
- ☐ At least two of the five members of the Board should be elected by the users as their representatives. This election could take place for instance in an annual meeting of registered users of the WSU,
- ☐ The chairperson of the Board, on behalf of the Board, is accountable to the CPC/TPC,
- ☐ The People’s Committee appoints the members of the Board and adopts the tariff and other relevant decisions of the Board, and
- ☐ The Board convenes meetings according to the schedule decided by them, however at least once a month.

WSU Scheme

In order to achieve sufficient autonomy and separate the accounts of the WSU, it should have a staff of its own. The WSU will be established based on following procedures;

- ☐ Board appoints the Manager of the WSU,
- ☐ Board appoints other staff members of the WSU on the basis of the proposal of the Manager, and
- ☐ It is estimated that the proposed piped schemes will have the following staff;

- **manager,**
- **accountant,**
- **pump operator/treatment plant operator,**
- **network inspector/ meter readers, and**
- **water charge collectors.**

Duties and Responsibilities of CPC/TPC

Functions and duties of CPC/TPC on this O&M model shall be includes followings;

- CPC/TPC is in charge of resolving problems on sabotage, damaging the safety of the water supply system, and enforcing the measures against the violators of the general regulations and other relevant rules and misconduct of the staff of the WSU and the members of the Board,
- CPC/TPC provides support to the Board and the WSU in their duties, especially in training, and
- If CPC/TPC refuses to adopt the new tariffs decided by the Board and accepted by the representatives of the users in the Board, CPC/TPC should reimburse the WSU losses incurred due, or related to, the CPC/TPC's decision of not adopting the required tariff.

Functions of Board of WSU

The main duties of the Board are to **monitor and supervise the financial and technical performance** of the WSU, and to **approve the annual plans** and **decide upon the water tariff** and other payments and fines related to water supply services provided by the WSU.

- **Responsibilities**

Responsibilities of Board for WSU shall be includes followings;

- decisions on the salaries and possible performance incentives of the Manager and other staff members of the WSU,
- decision of the general regulation of the WSU and the conditions of contracts between the users and the WSU,
- decisions on protection of the water source and the water supply system,
- approval of annual (financial) plans proposed by the WSU, (if the Board is not satisfied with the WSU's proposal, it requests WSU to submit a new plan that takes into account the guidance provided by the Board), and
- decisions on water tariff, connection fees, meter rents, reconnection fees, fines etc.

- **Duties**

Duties of Board of WSU shall be includes followings;

- close and timely monitoring of the balance of costs and revenues against the financial plan and taking measures to ensure the sustainability in the case of possible deficit (either by reducing costs or increasing revenues),

- monitoring of the efficiency and performance of the WSU,
- provision of transparent information of the performance and accounts of the WSU to CPC/TPC and users,
- promotion of water use in collaboration of health and educational authorities and mass organizations,
- settlement of disputes between the users and the WSU,
- reporting to CPC/TPC and submission of tariff decisions and other decisions to CPC/TPC for adoption, and
- support to the WSU in the enforcement of the General Regulations and requesting support from relevant authorities if necessary.

Functions of WSU

Duties and responsibilities of each staff on the WSU shall be includes followings.

❑ **Manager**

- The manager will have the overall responsibility of the utility and he/she will be accountable for his work to the Board.
- Consequently, the duties of the manager would include planning and budgeting, monitoring of the performance of the utility, reporting, personnel management, liaison with relevant stakeholders, user relations, material management, contract management and supervision and control of his/her staff.

❑ **Accountant**

- The duties of the accountant are self-explanatory. In addition to accounting the accountant will also be responsible for preparing monthly water bills, based on the data provided by network inspectors, and maintaining user ledgers.

❑

❑ **Pump operator/Treatment plant operator**

- The main tasks of the pump/treatment plant operator are the operation and control of well pumps, including recording flow, pressure and power use measurements in the operation record of the intake, general control of the volume and quality of inflow and outflow at the treatment plant.
- The operator is, in the first place, responsible for the water quality, and in

general for the technical performance, operational and financial efficiency of the plant, reporting about the purchase needs (chemicals, spare parts, etc.) to the manager, and technical condition and housekeeping at the plant.

The operator would also be the recommended person to be responsible for the sanitary inspection of the well/intake facilities and their cleaning when necessary.

- ☐ Network inspector/meter reader

- ▪ The main tasks of the network inspector cover the overall network operation including general monitoring of the performance of distribution, based on readings of the master meters and user meters, observation of any irregularities (pressure, power consumption, etc.), detection of potential leaks and illegal connections, consequent repair, and installation, possible disconnection and reconnection of house connections.
- ▪ When the number of users in on the increase, the network inspector's main duty is the provision of house connections. The installation work can be outsourced to a contractor but the inspector has to assume the responsibility for quality control.
- ▪ The network inspector is, in the first place, responsible for the supply of water to the users in adequate quantity and with adequate pressure, and in general for the technical performance, operational and financial efficiency of the wells and distribution system (paying particular attention on minimizing the unaccounted-for water) and their technical condition.
- ▪ In this aspect, s/he will be responsible for the implementation of the maintenance plan in the network, including public water points, testing of water quality in the system, reporting about the purchase needs (pipes, fittings, etc.) to the manager.
- ▪ The network inspector/meter reader shall carry out monthly reading of user meters, distribution of water bills.
- ▪ The network inspector/meter reader reports the readings to the accountant

- ☐ **Water charge collector**

- ▪ The main tasks of water charge collector are to collect the water charge based on the bill prepared by the accountant, and to inspect the functioning and condition of the meter as well as its seal.

- The water charge collector receives the bills from the accountant.
- He/she is accountable for his/her work and the collected payments to the manager. He/she also reports about his/her work and any observed irregularities to the manager.

Staffing of WSU

The salaries of WSU staff are paid from the revenues collected from the users. In the initial period of the water supply system operation, some staff members may not be paid at all if they perform their duties as an additional task associated with their previous duties.

As a general principle the manager and the Board should ensure that for each activity of the WSU there are always at least two staff members who are familiar with this activity. This means that although there have to be clear responsibilities with one person having the responsibility for the task there is a need to develop overlapping skills. This will ensure uninterrupted operation and performance if a staff member is temporarily or permanently out of service.

Proposed staffing scheme of WSU includes followings.

- ☐ **Manager/Accountant**

It is assumed that there would be one manager and one accountant in every WSU. It is assumed that as long as the number of connections is less than 750 the manager can work on a half-time basis. In larger schemes there would be a full-time manager. Respectively, an accountant is assumed to be able to work on a half-time basis in schemes serving less than 1,000 connections.

- ☐ **Pump/treatment plant operators**

The number of pump/treatment plant operators depends on the type of treatment, the number of hours of operation per day and the volume of the treated water reservoir. Because pump operation has been designed to be manual, the pump operator needs to be available during the pumping hours,

It is assumed that there will be one full-time pump operator in each scheme but s/he can assume other responsibilities as well. For example, it is assumed the pump operator could manage to assume the responsibility for simple water treatment. It is estimated that initially water treatment can be undertaken in one eight-hour shift (until 2005) but, as the water use increases, plant operators will work in two shifts (2006-2009) and three shifts (tentatively since 2010).

- **Network inspector/meter reader**

It is estimated that generally one network inspector/meter reader will work in one shift except in large systems with a network exceeding 40 km and/or the number of connections exceeding 2,000. Thereafter, there would be two network inspector/meter reader. It is estimated that each meter reader can manage 300 connections, including meter reading. The number of meter readers will vary, consequently, from one half time reader of the smallest scheme in until 2005 to 11.5 readers of the largest scheme in 2020. The number of meter readers have been estimated at the accuracy of 0.5 full time worker.

The estimated staffing needs of each scheme in the years 2005, 2010 and 2020 are shown in the following table;

Table 2.1 Staffing Requirements

Commune	Manager			Accountant			Pump/treatment plant operator			Network inspector Meter reader			Water charge collector		
	2005	2010	2020	2005	2010	2020	2005	2010	2020	2005	2010	2020	2005	2010	2020
K1 Bo Y	½	½	1	½	½	1	1	3	3	1	1	1	1	1½	3½
K2-1 Dak Su	0	0	0	0	0	0	1	3	3	1	1	1	0	0	1
K2-3 Dak Su	½	½	½	½	½	½	1	3	3	1	1	1	½	1	2
K3 Dak Ui	½	½	½	½	½	½	1	3	3	1	1	1	½	1	2
K4 Dak Hring	½	½	1	½	½	½	1	3	3	1	1	1	1	1	2½

For the meaningful financial management of the utility it is extremely important to apply cost/profit center accounting even if this requires additional work in comparison or in addition to the administrative accounting practiced by organizations accountable to CPC/TPC. The accountant should have appropriate education and preferably some relevant experience,

2.1.3 Guideline for Operation and Maintenance

(1) Model documentation for O & M

Prior to and during the second field work period guidelines for operation and maintenance were developed. **Model documentation** was developed and designed especially to help the establishment and mobilization of WSUs and the Boards in the two pilot communes and to support them to develop working modalities. This model documentation includes *General Regulations of Services* and an *Application for a Connection to Piped Water Supply* (Supporting Report B, Appendix 8), a *Contract for Water Supply between the user and the WS*U (Supporting Report B, Appendix 9) and a form for *Daily Operations Record* (Supporting Report B, Appendix 10). These documents can be revised and further developed on the basis of experience from the two pilot schemes to be applied in other project schemes.

General regulations

The *General Regulations* define the mission statement, service area and organization of the WSU, the rights and responsibilities of the users, the WSU, the Board and the People's Committee, the responsibilities of the staff of the WSU, and implications of the violations of the regulations.

Contract document

The *Application for a Connection to Piped Water Supply* and the *Contract for Water Supply* are based on the *General Regulations* and they define the rights and responsibilities of the contracting parties and conditions of the contract.

Operation records

The *Daily Operations Record* provides a format for collection and recording of the most necessary technical data.

Operating manuals

The comprehensive O&M guidelines will need to be prepared at the time of implementation of each scheme. The operating instructions will include all the **manuals** provided by the suppliers of the pumps, switchboards and other installations. As the schemes are based on manual pump operation, the pump operators need hands-on training on the spot in order to be able to develop pumping patterns for their respective schemes. The pump operators need to apply an iterative method, learning from their experience, to optimize pumping to supply sufficiently water 24 hours a day and simultaneously avoiding overflows at the reservoir and consequent waste of water, energy and possibly chemicals. **Role of CERWASS / PCERWASS**

According to the role based on the NRWSS, PCERWASS will focus on supporting and facilitating functions. They include initial capacity building of the utility staff, the Board, DPC/TPC and users, development and distribution of model procedures, contracts, ledgers, guidelines, etc., maintaining lists of suppliers and service providers, facilitation of cross-fertilization and learning from others' experience: successes as well as failures. PCERWASS could also support the utilities in performance evaluation and, in association with this, maintain benchmarking data bases.

It is unlikely that small water utilities would be able to have spare or stand-by pumps. PCERWASS could possibly have a couple of spare pumps to be borrowed or leased by utilities in the case of emergency as long as there is a healthy market and, consequently, private enterprise who can provide emergency service.

In the course of time at least some of the supporting functions of PCERWASS will be decentralized to the districts (Units for Agriculture and Rural Development), at the pace of their increased capacity. It is anticipated that by the time of the completion of the schemes under this pilot model, at least in some of the project districts UARD could possess capacity to provide advisory services to rural water utilities, although their role is likely to be more vital in smaller scale water supply applying lower cost technologies and directly owned and managed by users or user groups.

Guidelines, model procedures etc. that are widely applicable in the country, will be developed by CERWASS or jointly between CERWASS and at least some PCERWASS and possibly some advanced utilities, in order to incorporate hands-on experience. CERWASS could also take the leading role in the development of performance indicators and benchmarking.

(2) Spare parts

Repair of pumps and electric appliances as well as meter testing and calibration are functions, in which small rural utilities are likely to rely on services provided by private (or state-owned) companies. The availability of spare parts and prompt repair of pumps and other equipment should be one major criterion in the selection of technology. For meter testing and calibration a realistic alternative seems to be signing a contract with an urban water utility in the center of the province or in another major town at a reasonable distance.

2.2 Implementing Organizations

2.2.1 Principles

The implementation of the project will be organized along the following principles, mainly based on the NRWSS:

- building, to the greatest extent possible, on existing organizations and their mandates and present roles, avoiding the establishment of parallel institutions and project-specific administration and bureaucracy;
- decentralization of implementation to the lowest appropriate level, which in the case of piped water supply schemes is the commune level;
- extension of the responsibility for water supply schemes to the communes while provision of support by the government (government bodies only carry out their state management responsibility and provide advisory guidance);
- organization of operation and management arrangements for the facilities prior to construction of facilities,
- integration of the responsibilities for initial implementation, management and O&M, including the financial and technical responsibility for rehabilitation and reinvestment, to the ownership of the schemes; and
- provision of services related to implementation and O&M of the schemes by the private sector, as far as is reasonably possible.
- An actual implementation organization is shown in Figure 2.2.

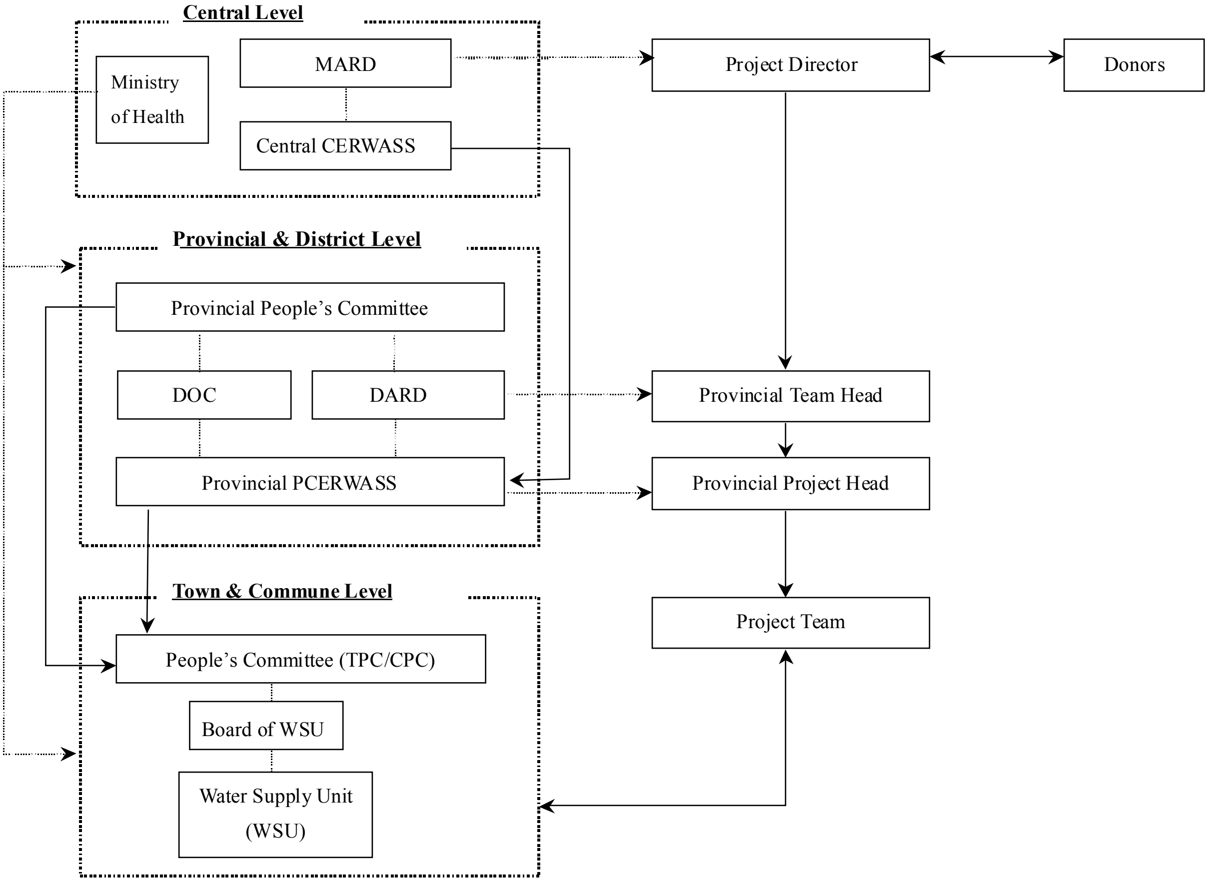


Figure 2.2 Organization charts of Project Implementation

2.2.2 National Level

The **Ministry of Agriculture and Rural Development**, particularly through **CERWASS**, is the focal body responsible for project coordination at the central level. In the implementation of the project, MARD/CERWASS will ensure the compliance of the project with NRWSS, provide capacity building for IEC and HRD and the respective PCERWASS in Dac Lac, Gia Lai and Kon Tum provinces, coordination of inter-provincial cooperation, and monitoring of the progress in the provinces. MARD/CERWASS will also ensure that the respective PCERWASS will have adequate budgetary, human and material resources to support the communes in project implementation. The implementation of water supply systems in the three provinces will be in accordance with the policies of NRWSS. These systems will build on the achievements of CERWASS and other stakeholders, particularly DANIDA, prior to project implementation.

Guidelines and model procedures that are widely applicable in the country will be developed by CERWASS or jointly between CERWASS, PCERWASS and possibly some advanced WSUs, to incorporate hands-on experience. CERWASS can also take the leading role in the development of performance indicators and benchmarking.

It is recommended that MARD/CERWASS appoint a **Project Director** to be accountable to MARD/CERWASS for the progress of the project and the efficient and transparent use of the allocated resources. MARD/CERWASS may also appoint other staff to be accountable to the Project Director for specific project tasks.

Joint meetings of representatives of the donor and relevant Vietnamese authorities will be held, at least quarterly. The topics of these meetings will include supervision of the implementation of the project, monitoring and regular review of the progress, recommendations for action to be taken if necessary, and decisions on the commencement of project implementation in communes that have shown commitment and fulfilled the preconditions. The Project Director and Team Leader of the Project Team will also participate in the joint meetings as non-voting members.

The **Ministry of Health** will have a key role in capacity building of the provincial and lower level health authorities in IEC and water quality monitoring.

2.2.3 Provincial and District Levels

The key sector organization at the provincial level is **PCERWASS**. According to NRWSS, PCERWASS will focus on supporting and facilitating functions. PCERWASS is also responsible for project coordination and monitoring.

PCERWASS in each project province will be the focal point of IEC, institutional strengthening of organizations at lower level, and support to communes in project implementation and O&M. This support includes initial capacity building of the WSU staff, the Board, DPC/TPC and users, development and distribution of model procedures, contracts, ledgers, guidelines, maintaining lists of suppliers and service providers, facilitation of cross-fertilization, and learning from others' experience: successes as well as failures. PCERWASS can also support the Boards in performance evaluation and in association with this, maintain benchmarking databases.

It is unlikely that small water supply systems would be able to have spare or stand-by pumps. PCERWASS could possibly have a small number of spare pumps to be borrowed or leased by WSUs in case of emergency until there is a healthy market and, consequently, private enterprises that can provide an emergency service.

DARD/PCERWASS will appoint a **Provincial Project Head**, accountable to MARD/CERWASS for the progress of the project and the efficient and transparent use of resources. DARD/PCERWASS may also appoint other staff to be accountable to the Provincial Project Head for specific tasks of the project.

There will be a **Provincial Team Head** (PTH), responsible for technical assistance in each of the project provinces. He/she will have other long and short-term experts/consultants under his/her responsibility. One PTH will assume the role of **Team Leader**, who is responsible for the entire international team and will also liaise with and provide necessary support to CERWASS.

The role of **Department of Construction (DOC)**, together with PCERWASS, will be important in the quality assurance of construction and protection of the users (communes) as clients of contractors and suppliers. This will call for substantial strengthening of the regulatory framework at the central level and capacity building of and support to communes and Water Supply Units.

According to NRWSS, government support to rural water supply should be decentralized to the district level. However, the implementation of NRWSS and the related capacity building is at an initial stage. Consequently, the capacity of the **Units of Agriculture and Rural Development** will not allow them to assume a major role in project implementation by 2010.

Mass organizations, particularly Women’s Union of each commune will have a major role in IEC activities at the district and commune level and in capacity building of the user/users in the project area.

2.2.4 Commune/Town Level

The proposed water supply systems involve quite complicated technology, deep boreholes with motorized pumping, and piped supply. Therefore, it is not likely that these schemes would be initiated, implemented and managed by cooperatives or other user-based organizations. Instead, it is expected that the scheme implementation and management will be organized under respective **CPC/TPC**.

It is recommended that a specific body, **Water Supply Unit** (WSU), will be established under CPC/TPC for piped water supply. It is also recommended that key staff members will be recruited prior to project implementation, in order to train the staff during the construction and involve them in project supervision. A **Board** would be a distinct body to supervise unit management and staff. Boards will need substantial training and follow-up support to become efficient and effective, focusing on strategic decisions, monitoring of the performance, and supervision. It is also recommended that representation of **users** will be included on the Board.

In the post-implementation management, the Board will generally monitor and control the financial and technical performance of the WSU, monitor user satisfaction, agree upon resetting of tariffs, support the WSU management and staff in enforcement of rules and regulations, and take strategic decisions, such as promotion to increase water sales when necessary, demand management measures (tariff adjustment, regulation of water use) if necessary and investment in expansion/upgrading and rehabilitation. It is important that the Board does not interfere in the day-to-day management and operation.

2.2.5 Competitive Sector

Services provided by the **competitive sector** - public and private companies - will be utilized in project implementation and O&M. Private and state construction companies will be invited to bid for construction of schemes in selected communes. The communes will be encouraged to take as much responsibility as possible for construction management and supervision. They will need substantial support for this undertaking. This support is a key area of technical assistance.

Private and public institutions can also be involved in capacity building and IEC in addition to government agencies and mass organizations. The assignments should be tendered and managed in a transparent and competitive manner. Local consultants will be assigned by the Project team to undertake customer surveys and assess the demand for improved water supply in communes.

Repair of pumps and electrical appliances as well as meter testing and calibration are functions in which small rural water supply systems are likely to rely on services provided by private (or state-owned) companies. The availability of spare parts and prompt repair of pumps and other equipment should be a major criterion in the selection of technology. For meter testing and calibration an option may be to negotiate a contract with an urban water utility in the center of the province or in another major town within a reasonable distance.

2.3 Coordination with Relevant Donors

To strengthen the executing agencies, the study team has held a seriese of meetings to discuss about the possible coordination, especially, with DANIDA, UNICEF, and ADB.

The concept paper was prepared in Figure 2.3 for coordination with the relevant donors and agencies at the F/S phase. The paper illustrates the present and possible coordination activities for the relevant donors.

DANIDA

At the national level, DANIDA started the Water Sector Program Support (WaterSPS) to cover the water sector in Vietnam including national capacity building, and rural water supply and sanitation (RWSS). DANIDA helped formulate the NRWSS for the strategy of rural water supply and sanitation in Vietnam. MARD revised the draft NRWSS submitted by DANIDA, and authorized the revised NRWSS in 2001. The present JICA study is in line with the NRWSS (the target years and goals and the basic approach) formulated by DANIDA.

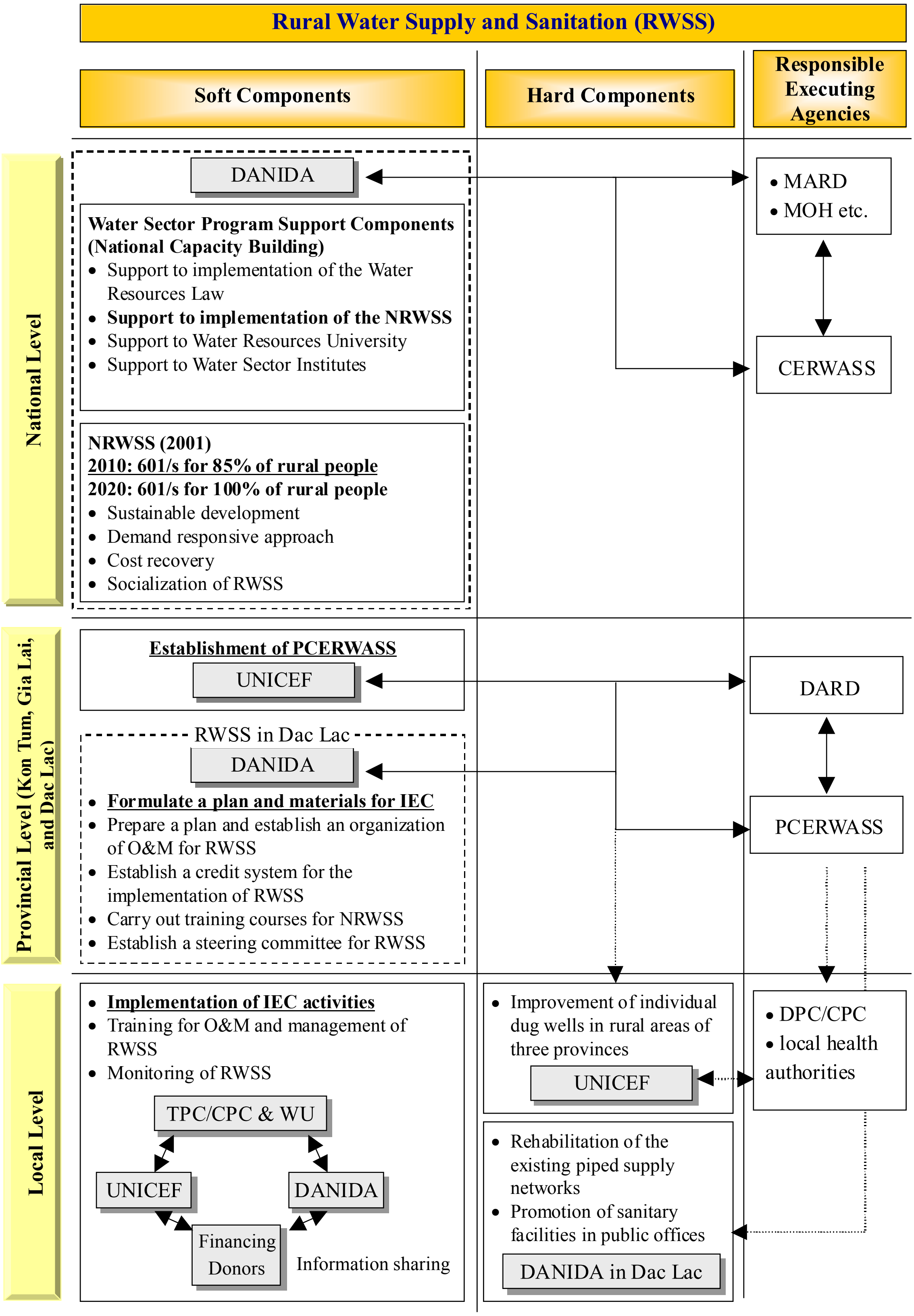
At the local level, DANIDA initiated the RWSS component of WaterSPS in Dac Lac in 2001 to support the implementation of NRWSS by applying the demand responsive approach up to 2005. The program aims to establish guidelines for the rural water supply systems in 3 districts of Dac Lac province (different from the JICA's target districts), considering financial, institutional and social sustainability and focusing on the rehabilitation of piped water supply systems. The RWSS component focuses on IEC, and the establishment of the local organizations for effective O&M and management, and the rehabilitation of the existing piped water systems. DANIDA agreed to the JICA study team that they can provide their IEC materials used for the WaterSPS program for 3 districts in Dac Lac province.

UNICEF

UNICEF has been the principal donor in the field of rural water supply and sanitation through the WATSAN Program in cooperation with CERWASS and MOH since 1982. The WATSAN Program focuses on the implementation of IEC activities by developing appropriate approaches and methods, promotion of coordination with the relevant international and national agencies, and the capacity building of the sector related organizations. The present master plan study is based on the IEC documents prepared by UNICEF.

UNICEF tries to help poor people by introducing shallow hand pump wells and sanitary latrines in the Central Highlands since the 1990s. However, most hand pump wells do not function due to the shortage of spare parts and lack of administration. Taking into account the situation of hand pump wells, especially for public use, UNICEF has adjusted its program to support individual households by dug well construction and sanitation. The present master plan recommends that the improvement of individual dug wells be supported by UNICEF.

In the course of the discussions with UNICEF, they were interested in monitoring the piped systems prioritized by the present study. The cooperation by UNICEF shall be integrated at the implementation stage if possible with regard to the monitoring.



Water Sector Program Support Components (National Capacity Building)
- Support to implementation of the Water Resources Law
- **Support to implementation of the NRWSS**
- Support to Water Resources University
- Support to Water Sector Institutes

NRWSS (2001)
2010: 601/s for 85% of rural people
2020: 601/s for 100% of rural people
- Sustainable development
- Demand responsive approach
- Cost recovery
- Socialization of RWSS

Establishment of PCERWASS

- **Formulate a plan and materials for IEC**
- Prepare a plan and establish an organization of O&M for RWSS
- Establish a credit system for the implementation of RWSS
- Carry out training courses for NRWSS
- Establish a steering committee for RWSS

- **Implementation of IEC activities**
- Training for O&M and management of RWSS
- Monitoring of RWSS

- Improvement of individual dug wells in rural areas of three provinces

- Rehabilitation of the existing piped supply networks
- Promotion of sanitary facilities in public offices

Figure 2.3 Concept Paper for Coordination

Chapter 3 Environmental Impact Assessment (EIA)

3.1 Scope of EIA

The main objective of environmental impact assessment (EIA) is to ensure that rural water supply systems will not cause significant negative impacts. EIA aims not only to protect the nature but also to alleviate expecting negative impacts on the human society as a result of development activities.

3.1.1 Institutional Setting for EIA

The EIA system in Vietnam is implemented through Article 18 of the Law on Environmental Protection (LEP) and a series of implementing regulations, particularly the Decree on Providing Guidance for the Implementation of LEP (Govt. Decree No. 175-CP, 1994) and the Decree on Sanctions against Administrative Violations in Environmental Protection (Govt. Decree No. 26-CP, 1996). In addition, the Circular Letter of Guidance on Setting Up and Appraising the Environmental Impact Assessment (EIA) Report for Investment Projects (No. 490/1998/TT-BKHCNMT) is informative.

The Law of Water (LAW) states that "the investors, project owners or directors of public offices and enterprises must evaluate the environmental effect of the projects invested or funded by foreign organizations or individuals, or international organizations, or built with loans from them or as joint ventures with them on the Vietnamese territory."

According to the Circular Letter, rural groundwater development is classified into a project in Category II, which "shall be required to prepare and submit the registration for securing environmental standards to the government management agencies of environmental protection for evaluation", the contents of which are provided in the Circular Letter.

Small-scale projects are appraised at the provincial level. In some cases, competent DOSTE officials have to give advice to the investors formulating the EIA reports, and then appraise the reports themselves.

The process of IEE and EIA basically follows the guideline on EIA for groundwater development formulated by JICA in 1994. The process was agreed by CERWASS.

3.1.2 Necessary Items for EIA

Initially, twenty-three (23) items listed in Table 3.1 were examined as the initial environmental examination (IEE). As a result, possible impacts were identified, and environmental impact assessment (EIA) was decided to be carried out further to ensure the process during the feasibility study (F/S). Especially, five (5) items are considered to be analyzed and monitored before and after the construction of water supply facilities: water level fluctuations, water right, land acquisition, water quality, and wastewater disposal. Each item is outlined below:

(1) Water level fluctuations

The pumping tests in the wells explored by the study team showed that the water level was lowered in the existing shallow wells in some communes. Although, the impact is very small (around 0.5 m), this indicates that the water is related to the water in the shallow dug wells already there.

(2) Water right

Water level fluctuations in the existing shallow dug wells will raise the issues relevant to water right in the communities. Water right issues need to be solved before the construction of water supply systems. If the owners of the shallow wells agree to connect to the piped scheme, water right will not become an issue. This issue is discussed together with the water fluctuations.

(3) Land acquisition

Resettlement is not necessary, but land should be acquired by the local governments for water supply facilities, before the construction works. The facilities should be built up on public land, and private land should be avoided as much as possible.

(4) Water quality

Water quality analysis was conducted for 25 parameters by the publicly authorized institutions during the M/P and F/S periods. No poisonous chemicals such as arsenic and dioxin were identified, though the level of iron might cause little health risk, but washing inconvenience, in some water samples if not treated well.

(5) Wastewater disposal

Wastewater derived from the use of piped water supply should be treated. Especially, the towns included in the study area are relatively densely populated and need appropriate wastewater treatment to protect the quality of the shallow groundwater.

Table 3.1 Screening Checklist*

	No.	Item	Evaluation**	Reasoning
Social Environment	**1**	**Resettlement and land acquisition**	**C**	**No resettlement is incurred. However, land acquisition problems are to be solved by CPC/TPC in negotiation with private landowners if necessary.**
	2	Economic activities	D	Positive impact on future economic development. Insufficient water quantity especially in the dry season in the target areas has adversely affected public health and economic conditions of the local people.
	3	Transportation and infrastructure	D	No intervention on existing transportation and infrastructure. The main pipelines will be located along the main roads.
	4	Community division	D	No division will be brought.
	5	Historical heritages	D	No historical heritages exist near the project's wells and groundwater development sites.
	6	**Water right**	**C**	**Lowering of shallow groundwater level will have very minor impact on those who use dug wells near the wells explored by the study team. They can also use the water taken from the wells through the piped supply systems.**
	7	**Public health (water quality)**	**C**	**Water quality of newly developed groundwater should be analyzed before the construction of water supply facilities. No poisonous chemicals such as arsenic and dioxin were identified. The level of iron might cause some washing problems in some water systems if not treated well. One needs to pay attention to microorganisms contamination.**
Natural Environemnt	8	Solid waste disposal	D	No negative impact is anticipated if the contractors should pay attention to solid waste disposal at the time of the construction of the piped systems.
	9	Risk in construction sites	D	Construction sites are exclusively limited to those who work for the systems.
	10	Geography and geology	D	No major geographical and geological impact will be seen.
	11	Erosion	D	No deforestation is planned.
	12	**Groundwater level**	**B**	**As a result of the pumping tests, it was observed that the water level was lowered in the existing shallow wells near some wells developed by the study team. Although, the impact is very small (0.5 m at most), further analysis will become necessary at the implementation stage.**
	13	Lake and river	D	No impact on lakes and rivers is expected.
	14	Coastal effect	D	The target areas are located far away from the seacoast.
	15	Fauna and flora	D	No major impact on fauna and flora is expected.
	16	Meteorology	D	No effect is anticipated.
	17	Landscape	D	Little effect is anticipated.
Public Hazard	18	Air pollution	D	No air pollution activity is followed.
	19	**Water pollution**	**C**	**Water pollution should be alleviated by appropriate wastewater disposal.**
	20	Soil pollution	D	No chemicals causing soil pollution will be used.
	21	Noise and vibration	D	Noise and vibration might cause just a little intermittent nuisance to the local people living near the construction sites, which could be avoided if the contractors will need to inform the local people before the construction works.
	22	Land subsidence	D	Land subsidence will hardly occur due to the aquifers in basalt lavas and gravelly alluvial deposits.
	23	Bad smell	D	No possibility of bad smell.

*The screening checklist is based on the guideline on EIA for groundwater development formulated by JICA in 1994.

**Evaluation:

A= Significant impact is anticipated.

B= Due considerations will be necessary before the implementation stage.

C= Not obvious at present, but needs further EIA study.

D= No or little negative impact or positive impact is anticipated, and requires no further detailed assessment

3.2 Environmental Impact Assessment and Countermeasures

As we have seen, some communes/towns have different pending issues to be solved. This section clarifies the items necessary to be focused on in the study area. There are issues related to 1) groundwater level lowering and water right, 2) land acquisition, 3) water quality, 4) wastewater disposal, and 5) other issues.

3.2.1 Groundwater Level Lowering and Water Right

The pumping tests showed that the water levels in the existing shallow wells near the explored wells in K3-1 (depth of the well is 40 m) were lowered, although the effect was very small (0.5 m at most). Therefore, the water sources taken from these wells are estimated to be the shallow unconfined aquifers.

The shallow wells near these explored wells in K3-1 are affected by the pumping, and need some considerations for water right issues especially in the dry season (the pumping tests were carried out in the wet season). It is recommended to monitor the groundwater levels in the shallow dug wells in K3-1 where the pilot model has been operating. The operation results of the pilot model will be reflected in the Final Report.

3.2.2 Land Acquisition

Resettlement and relocation are not required for the construction of the proposed water supply facilities in the study area. The design of the water facilities was conducted based on the availability of the land.

However, it is a prerequisite that the people's committees and PCERWASS take the responsibility for acquiring the land for water supply facilities, i.e. wells, treatment plants, reservoirs, elevated tanks, main pipes, etc. Public land is in this sense ideal for the water facilities. If private land acquisition is needed, the people's committee is responsible for the land acquisition.

It is difficult to completely avoid placing water supply facilities on private land considering their optimum locations. Probably, part of the water works might occupy private land in K4-1.

The drawings prepared by the study team will need to be checked by the people's committees, and updated if construction sites, either publicly or privately owned, are not available.

3.2.3 Water Quality

The water quality analysis carried out by the publicly authorized institutes in 2001 includes the analysis of the water samples in the 18 systems out of the 21 prioritized systems (3 systems are planned by surface water sources) in the three provinces.

As a result of the water quality analysis, it was found that there was no fear for toxic substances listed in the analysis items. Dioxin was not identified in the tested samples (K1-1), and arsenic was within the limit specified in the national water quality standard (Standard 505, Ministry of Health) in all the 18 samples. Physical and chemical substances, i.e. TDS, sodium, chloride, sulfate, ammonium, COD, fluoride were within the national standard.

Iron was above the limited level (0.5 mg/l) in the water samples taken from K1-1, K2-3, K3-1, K4-1. Iron causes stains when washing clothes, and the local users of the existing dug wells are concerned about the issue. These water samples need treatment by aeration and filtration.

Manganese is also somewhat of a problem.These water samples need treatment by aeration and filtration.

The re-tests for coliform was reexamined by the Institute of Hygiene and Epidemiology (in Buon Ma Thout) during the F/S period, and the water samples taken from the explored wells contained lower levels of coliform than that from the river in K4-1 (130 MPN/100 ml). Therefore, it is needed to install a water treatment plant for the surface water resource in K4-1.

3.2.4 Wastewater Disposal

As a result of the water quality analysis, it was found that the water in the existing shallow dug wells was generally polluted by human and animal waste. In many cases, hygienic latrines are not appropriately installed and used by the local people, and the shallow wells are not appropriately protected from possible contamination.

The wastewater needs to be treated before sewage, especially the communities near production wells. The public buildings, e.g. people’s committees, health centers, hospitals, public schools, markets, should be equipped with septic tanks or more advanced technology if financially viable. The installations of septic tanks need to be financially supported by the provincial and/or district governments in the poor communes. Especially, the water is taken from the unconfined aquifers in the K1-1, K2-3, and K3-1 systems, and the groundwater sources should be protected.

The average cost for a semi-septic or septic tank system is VND 1 to 4 million, and it is rather expensive even for the richest families in the study area. The communities in the densely populated and rather richer areas are recommended to install individual septic tanks during phase 1 (up to 2010), which might be upgraded to more intensive wastewater treatment systems in future. Areas where population density is low and far from the groundwater sources may install cheaper hygienic latrines instead of expensive hygienic latrines.

It is recommended that the local governments prepare a credit system for the local users to install a hygienic latrine. The health centers should intensify IEC activities to motivate the use of hygienic latrines for richer families.

3.2.5 Other Issues

Other issues concerning environmental assessment include traffic control in the course of the construction of the proposed water supply facilities and access to the militarily protected area.

The construction of main pipes along the busy roads, i.e. national roads, will bring traffic nuisance if traffic control is not effective. Constructors will need to distribute appropriate information to the local communities, i.e. time schedule of construction, places, types of construction, etc. Appropriate traffic control on the national roads will alleviate the negative environmental impact.

In the Cambodian/Laotian border area in K1-1 and K2-1, the military has been stationed and access to the area is very complicated and affects the smooth construction works. It is necessary to confirm to the local governments that constructors can work at the site before the detailed design

3.3 Environmental Impact Assessment of Each Priority System

Environmental impact assessment (EIA) was carried out for 4 communes/towns prioritized during the F/S phase to check the items to be focused as a result of IEE. The Communes K-5 and K-6 were excluded from the assessment. The system of K2-3 was also excluded because of absence of exploratory well.

K1-1, Bo Y commune

The study team has explored a single well with a yield of 1.0 l/s (86 m^3/d) in K1-1. The deep well has a rather high content of iron (3.55 mg/l) and the water should consequently be treated by filtration.

As the depth of the explored well is only 50 m long with a screen 24 m in length, the water source of the well is a shallow aquifer. Therefore, the well has a concrete protection 10 m deep at the top and the possibility of microorganism contamination from surrounding soil is alleviated. To protect the quality of the water in the well, the environment near the well should be clean.

The construction of the water supply system in K1-1 will become very complicated because of the presence of the military stationed near the Cambodian/Laotian border. Especially, foreign workers will need permission to enter the commune, and it will take more time to construct the proposed water supply facilities.

K2-1, Dak Su commune

The study team has explored a well in K2-1. The permissible yield is 147 m3/day. Water quality analysis shows that pH is very low, and the content of iron is relatively high (2.64

mg/l). Water should be treated by aeration and slow sand filtration.

Since the depth of the well is only 50 m with a screen 32 m in length, the water of the well is probably taken from a shallow aquifer.

K3-1, Dak Ui commune

The pilot model has been constructed in K3-1. The study team has drilled a well with a yield of 268 m3/d on the public land near the health center. The water has high content of iron (3.49 mg/l) and should be treated by aeration and filtration.

The depth of the well is only 38 m with a screen 28 m in length. As a result of the pumping test in K3, it was observed that the water level of the neighboring shallow dug wells was lowered. Therefore, the water is from an unconfined aquifer. The health center needs a hygienic latrine (septic tank) to protect the groundwater resource.

K4-1, Dak Hring commune

The well drilled by the study team was dry and water must be taken from the river. The water quality analysis of the river water showed a high level of coliform, and needs treatment of prefiltration, slow sand filtration, and subsequent chlorination.

3.4 Conclusion

In conclusion, none of the priority systems is environmentally unfeasible.

As a result of the pumping tests in the rainy season, the water level was lowered in the shallow dug wells in K3-1 near the well explored by the study team (evaluated as B in Table 3.2). Therefore, in the system, water right for the households with affected dug wells should be investigated by PCERWASS before the detailed design.

The wells are structured to take water from an unconfined aquifer in K1-1, K2-1 and K3-1 (evaluated as C in Table 3.2). The environment around the wells should be protected from possible contamination in these systems.

The water taken from the river in K4-1 needs treatment (aeration, roughing filter, and slow sand filtration), and this process needs management skills to operate and maintain the system.

Construction of water supply facilities (reservoir, treatment plant, elevated tower, main pipes, raw water pipes, management station) on private land should be basically avoided. Land acquisition issues might be a problem in K4-1. If compensation is necessary, negotiations shall be arranged by the people’s committee and PCERWASS prior to the detailed design.

Table 3.2 EIA Matrix

Priority System	**District Name**	**Commune/Town Name**	**Depth of the Well (m)**	**Water Source (Shallow or Deep Aquifer)**	**Water Level Lowering and Water Right ***	**Water Quality (Public Health)**	**Wastewater Disposal**	**Land Acquisition***	**Environmental Feasibility**
K1-1	**Ngoc Hoi**	**Bo Y**	50	Shallow	D	High Fe (3.55 mg/l)	C	D	**Feasible**
K2-1	**Ngoc Hoi**	**Dak Su**	50	Shallow	D	High Fe (2.64 mg/l)	C	D	**Feasible**
K2-3	**Ngoc Hoi**	**Dak Su**	-	-	-	-	C	D	**Minor issue**
K3-1	**Dac Ha**	**Dak Ui**	38	Shallow	**B**	High Fe (3.49 mg/l)	C	D	**Pilot Model**
K4-1	**Dac Ha**	**Dak Hring**	-	River	D	**High coliform (130 MPN/100 ml)** High Fe (1.88 mg/l)	D	C	**Minor issue**
G1	**Mang Yang**	**Kong Tang**	112	Deep	D	Little high Fe (0.82 mg/l)	C	D	**Feasible**
G2	**Chu Se**	**Nhon Hoa**	110	Deep	D	Little high Mn (0.19 mg/l)	C	D	**Pilot Model**
G3	**Duc Co**	**Chu Ty**	85	Deep	D	No problem	C	D	**Feasible**
G4	**Chu Prong**	**Thang Hung**	150	Deep	D	Little high Mn (0.17 mg/l)	D	D	**Feasible**
G5-1	**Chu Pau**	**Nghia Hoa**	135	Deep	D	No problem	D	C	**Feasible**
G6-1	**Krong Pa**	**Ir Simon**	158	Deep	D	High Fe (3.10 mg/l)	D	C	**Feasible**
G7-1	**Krong Chro**	**Kong Yang**	110	Deep	D	High Fe (2.07 mg/l) High Mn (0.29 mg/l) **Unpleasant smell**	D	D	**Pending**
D1	**Krong Nang**	**Kron Nang**	100	Deep	D	No problem	C	C	**Feasible**
D2	**Ea Hleo**	**Ea Drang**	120	Deep	D	No problem	C	C	**Feasible**
D3-1	**Krong Puk**	**Kron Buk**	70	Deep	D	Little high NO_3^- (10.2 mg/l)	D	C	**Feasible**
D3-2	**Krong Puk**	**Kron Buk**	-	-	-	-	D	D	**Minor issue**
D4-1	**Krong Buk**	**Ea Drong**	116	Deep	D	High Fe (3.76 mg/l)	D	C	**Feasible**
D4-2	**Krong Buk**	**Ea Drong**	-	-	-	-	D	D	**Minor issue**
D5-1	**Buon Don**	**Ea Wer**	35	Shallow	**B**	High Mn (1.11 mg/l) Little high Fe (0.82 mg/l)	C	C	**Feasible**
D6	**Dac Rlap**	**Kien Duc**	120	Deep	D	Little high Fe (0.65 mg/l)	C	C	**Feasible**
D7	**Krong Bong**	**Krong Kmar**	39	Shallow	D	High Fe (4.09 mg/l) High Mn (0.36 mg/l)	C	C	**Feasible**

*Evaluation:

A= Significant impact is anticipated.

B= Some measures will be necessary before the implementation stage.

C= Needs further detailed analysis in the course of the implementation stage.

D= No or little negative impact or positive impact is anticipated, and requires no further assessment.

Chapter 4 Feasibility Evaluation

The five priority systems are based on centralized piped type schemes. The feasibility and sustainability of the five priority systems were evaluated from financial, economic, technical, institutional (operation and maintenance) and environmental viewpoints.

Prior to project evaluation, a questionnaire was sent to each commune/town to clarify the current issues. The evaluation is partly based on that information.

Table 4.1 Questionnaire and Answer from PCERWASS and Interpretation

System	Question	Answer	Interpretation and Recommendable Solution
K1-1	In these poor communes, How much subsidy/ year?	1,500,000VND (=US$100/year)	The existing public taps by a gravity system in K1-1 are not operating. Although people heavily rely on subsidy, the amount of it is too small. The population in K2-1 is only 1,460 in 2001. A sustained IEC campaign is needed over several years. These areas are military controlled and have bad access.
K2-1		US$100–150/year	
K2-3	How about integrating to an ADB project is planned in the neighboring town?	Impossible to combine with ADB project. Subsidy of some US$30/year.	This system is very small and expects very limited number of users. The system has long pipelines which complicates O&M. When the ADB project is combined with the K2-3 system, O/M will be more reliable. A sustained IEC campaign is needed over several years.

4.1 Financial Analysis

4.1.1 General Principles

As a general principle embodied in the NRWSS, **users will be responsible for all construction costs and all operating costs for RWSS facilities**. There are, however, cases, when the government will provide financial support in the form of grants to certain types of users and certain types of technologies. For example,

- the poor, the very poor and the social policy which targets households who suffer difficulties;
- full piped water supply schemes, which are promoted by the government, and
- a number of special cases.

Water supply systems described in this project fall under the category of full piped schemes. Even when accepting investment grants, NRWSS states that in all cases users shall fund all operation costs and shall control the actual payment for construction, and O&M. The NRWSS assumes that in the future an **average rural household could pay between 3% and 5% of its total income for clean water and sanitation**. However, the tariff, including the initial investment cost may be more than five times the tariff excluding the initial investment cost. Consequently, it is judged to be impossible to refund the initial cost by the users themselves with heavy water charges. Therefore, the initial investment cost is assumed to be a grant. Also, it has been assumed that there will be no second round of grant for rehabilitation, upgrading and other similar reinvestments. Therefore, the financial analysis involves an element of **reinvestment**. Also, the communes/users will be responsible for their connections, including water meters.

According to NRWSS, methods of tariff formulation and recommendation should meet five key objectives. These are:

- economic - to ensure that charges for water are related to economic costs, thus achieving efficiency of resource allocation in the water sector;
- financial - to ensure each Water Supply Company (WSC) has sufficient revenue to cover all its operating costs, debt servicing, taxes, and a proportion of capital expenditure;
- social - to ensure that the poorer members of the community have access to a safe water supply at a price which they can afford;
- conservation - that the tariff plays a role in managing the demand for water and the conservation of resources; and
- administrative - to ensure that recommendations are capable of being implemented by each WSC in terms of metering, billing, and revenue collection, and that the tariffs are readily comprehensible to users.

4.1.2 Estimation of Operation and Maintenance, and Re-Investment Costs

The O&M costs include direct costs and fixed costs. Power and chemical costs are the most notable direct costs. Personnel costs, which are quite substantial in the case of small utilities in spite of generally low personnel costs in Vietnam, are a combination of direct and fixed costs. Within the scale of these small utilities a certain number of staff are mandatory irrespective of the number of users and volume of water sales. In some activities however, the number of staff depend on the number of users, for example meter readers. The maintenance costs are largely fixed; scheduled maintenance has to be performed irrespective of the volume of business.

This financial analysis recognizes power and chemical costs, personnel costs, and maintenance costs. In the earlier stages of this study, maintenance costs were considered to be included in the reinvestment cost. The present analysis is more detailed and it has been matched with the recommendations of the international consultants providing support to CERWASS in the implementation of NRWSS.

The **direct costs** per cubic meter produced, including power and chemical costs, have been calculated on the following assumptions:

- ☐ pumping efficiency of 50%;
- ☐ cost of electricity VND 750/kWh; and
- ☐ chemical cost (cost of chlorine) VND 25/m^3.

The estimation of **personnel costs** is based on the estimated staffing requirements and monthly personnel costs in various categories. These monthly costs reflect the Vietnamese salary level and the requirements of the positions to be created.

In the case of communes where two piped schemes have been recommended, it has been assumed that the minor system (K2-1, D3-2) does not need to employ a manager and an accountant. In practice, the division of the cost implications of shared staff is to be agreed upon case by case.

The **maintenance costs** have been estimated following the principles recommended in the implementation of NRWSS. They have been calculated on an appropriate percentage basis of the capital costs of the works; 1.0% for building and civil works and 3.0% for electrical and mechanical works. However, the maintenance cost in the year of respective investment (2003 and 2013) is estimated at 50% of the above figures, taking into account warranties provided by contractors and suppliers.

The initial investments are assumed to take place in 2003 and 2013. It is anticipated that the **re-investments** will be implemented by user's contribution or local contractors using locally available materials and equipment. Based on experience from Vietnamese construction costs, the reinvestment cost have been estimated at 50% of the costs presented in cost estimates. The estimated life times of 12 years for electro-mechanical installations and 30 years for civil works and pipelines have been adopted from recommendations of international consultants providing support to

CERWASS in the implementation of NRWSS. The lifetime of boreholes is estimated at more than 28 years. The estimate of **water sales** has been reduced from that applied in the previous study, which was based on the design estimates. To be on the safe side, design figures need to be excessive rather than too low. However, financial viability analyses need to be based on conservatively moderate water sale projections rather than overly optimistic figures. Therefore the initial percentage of water users through house connections is estimated at 35% in 2003 and the initial per capita water use through house connections 35 litres per capita per day (lpcd). In the tariff calculations for the pilot models the initial water use per capita was 35 lpcd for house connections and 15 lpcd for public taps. With the exception of K3, the water use from relatively few public taps will remain very low in comparison with water sold through house connections. Moreover, the public tap water use will decrease over the time as house connections increase. Therefore, in order to simplify calculations, only house connections are included in the cost calculations. In comparison with other uncertain parameters the impact of public taps is negligible.

The annual growth of served population through house connections (including population increase and connection rate) is estimated at 8% and the annual growth of per capita water use at 3%, respectively. The latter growth calculated on the initial water use of 35 lpcd will result in 60 lpcd by 2021.

It is estimated that the **non-revenue water** (including physical leakage, bad debts and administrative losses) represents 20% of water production. Consequently, water production is estimated to include water sales and non-revenue water. Direct costs have been calculated for produced water.

For longer term cash flow analyses the **analysis period** is from 2003 until 2030. However, the population figures and other parameters are constant between 2021 and 2030 in order to avoid bias of the inaccuracy of estimated growth beyond the design period.

Cost projections have been made separately for O&M costs excluding re-investment financing. These costs are the basis of the cash flow analysis together with projected revenues. The re-investment needs have been taken into account by calculating annual and cumulative **saving targets** for financing of re-investments. In financial terms this is equal to annual and cumulative **operation margin**.

The **tariff** analysis has been made on the basis of four principles. Firstly, operation margin has to be positive, although sometimes only marginally, every single year.

Secondly, actual cumulative savings (for re-investments) have to account to at least 63% of the cumulative saving targets by 2020. Thirdly, the break-even point between the actual cumulative savings and saving targets has to be reached within 25 years from the initial investment (by 2028). Fourthly, the tariffs are estimated to be constant from 2003 until 2012 and again from 2013 until the end of the analysis period (2030). The tariff increase in 2013 is easily justified by the second tier of investments.The affordability analysis compares the annual expenditure on water of one user of the scheme (based on estimated per capita water use and assumed tariff) with the average annual income within the respective commune/town. To be on the safe side the income has been assumed to stay constant throughout the period. Therefore, the actual ability to pay (ATP) in 2020 is likely to be much higher than in this analysis.

4.1.3 Ability of Payment for Estimated Tariff

The annual costs of each scheme, including O&M cost and annualized re-investment costs in three cross-sectional years (2005, 2010 and 2020) are tabulated in Table 4.2. As power and chemical costs are direct costs, they are fully dependent on the operational volume, i.e., the amount of water pumped and treated. Consequently, there is a considerable variation between the utilities and between the years.

The personnel costs, especially during the first years when the water sales will remain substantially below the system capacity, are quite similar to fixed costs because of the relative influence of managers and accountants. The variation between utilities is quite limited in 2005 but it increases along with the number of operational staff and meter readers as the business volume increases.

The annual re-investment saving needs have a significant impact on annual costs, especially in the early years of operation when water sales remain relatively low. The re-investment saving increases the O&M cost in 2005 by about 140%-300% and in 2020 by about 90%-220%.

Table 4.2 Annual costs in Million VND

Commune	Annual cost (MillionVND)																
	Power and chemicals			Personnel			Maintenance cost			Reinvestment		Grand total w/o re-investment			Grand total		
	2005	**2010**	**2020**	**2005**	**2010**	**2020**	**2005**	**2010**	**2020**	**-2012**	**2014-**	**2005**	**2010**	**2020**	**2005**	**2010**	**2020**
Kon Tum																	
K1:Bo Y	7.776	13.246	38.431	19.200	30.900	44.700	62.472	62.472	82.830	265.768	357.280	89.448	106.617	165.961	355.216	372.385	523.242
K2-1:Dak Su	1.699	2.895	8.399	9.600	19.200	23.400	14.767	14.767	20.704	51.296	79.577	26.066	36.862	52.503	77.362	88.157	132.080
K2-3	5.128	8.734	25.342	17.100	28.800	33.000	31.046	31.046	42.354	129.363	177.033	53.273	68.580	100.696	182.637	197.943	277.729
K3:Dak Ui	6.052	10.309	29.910	17.100	28.800	33.000	21.830	21.830	32.680	61.058	95.397	44.982	60.938	95.591	106.039	121.996	190.988
K4:Dak Hring	4.335	7.384	21.423	19.200	28.800	38.100	42.064	42.064	53.084	137.166	178.367	65.599	78.248	112.607	202.766	215.414	290.974
Gia Lai																	
G1:Kong Tang	13.559	23.096	67.011	26.100	37.800	55.800	53.347	53.347	67.356	192.944	248.658	93.006	114.243	190.168	285.950	307.187	438.825
G2:Nhon Hoa	32.887	56.019	162.534	30.300	49.500	71.100	85.085	85.085	113.114	334.583	451.615	148.272	190.604	346.749	482.855	525.186	798.364
G3:Chu Ty	22.275	37.942	110.086	28.200	45.000	69.000	49.401	49.401	62.314	183.583	236.386	99.875	132.343	241.400	283.459	315.926	477.786
G4:Thang Hung	7.707	13.128	38.090	19.200	30.900	44.700	31.667	31.667	42.463	115.038	159.376	58.574	75.695	125.253	173.611	190.732	284.629
G5:Nghia Hoa	8.959	15.261	44.277	19.200	28.800	38.100	28.309	28.309	36.528	105.829	141.882	56.468	72.370	118.905	162.297	178.199	260.787
G6:Ia Rsion	8.110	13.814	40.081	19.200	30.900	42.300	22.916	22.916	32.884	76.368	117.697	50.226	67.630	115.265	126.594	143.998	232.962
G7:Kong Yang	3.966	6.755	19.598	17.100	26.700	30.900	21.597	21.597	24.370	74.529	84.537	42.662	55.051	74.868	117.191	129.581	159.405
Dac Lac																	
D1:Krong Nang	18.623	31.722	92.040	28.500	46.800	70.500	53.689	53.689	70.191	202.161	273.722	100.813	132.212	232.731	302.974	334.373	506.453
D2:Ea Drang	38.382	65.379	189.691	35.100	53.100	83.100	61.669	61.669	84.365	253.857	354.120	135.151	180.148	357.156	389.008	434.004	711.276
D3-1:Krong Buk	12.587	21.441	62.209	21.300	35.100	51.000	30.413	30.413	41.459	110.425	155.669	64.301	86.954	154.667	174.725	197.379	310.336
D3-2	6.567	11.185	32.453	13.800	20.700	27.000	25.794	25.794	36.948	97.949	145.069	46.160	57.679	96.401	144.110	155.628	241.470
D4-1:Ea Drong	15.120	25.755	74.727	21.300	35.100	53.100	47.036	47.036	58.176	176.205	221.967	83.456	107.891	186.003	259.661	284.096	407.970
D4-2	3.955	6.736	19.545	11.700	23.400	27.600	19.413	19.413	23.734	74.768	90.115	35.068	49.550	70.879	109.836	124.317	160.994
D5:Ea Wer	6.300	10.732	31.137	21.300	33.000	46.800	49.455	49.455	65.984	183.862	247.580	77.055	93.186	143.922	260.917	277.048	391.501
D6:Kien Duc	27.471	46.793	135.765	23.400	40.200	57.300	44.454	44.454	59.286	175.983	235.957	95.325	131.447	252.351	271.308	307.430	488.307
D7:Krong Kmar	12.839	21.869	63.451	21.300	35.100	51.000	34.223	34.223	46.112	121.742	162.694	68.361	91.192	160.563	190.104	212.934	323.258

Note: 1 US$ = 15,000 VND (June 2001)

The water costs per cubic meter are presented in Table 4.3. These unit costs are more applicable for comparison between schemes.

The basic O&M costs per cubic meter vary between VND 1,600/m^3 and VND 6,300/m^3 in 2005 and between VND 700/m^3 and VND 2,600/m^3 in 2020. The re-investment costs per cubic meter increase the costs dramatically, varying between VND 4,600/m^3 and VND 18,600/m^3 in 2005 and between VND 1,600/m^3 and VND 6,400/m^3 in 2020.

The unit costs in the early years are extremely high, due to high impact of fixed costs and very low water sales. The tariffs do not need to include in these critical years any substantial part for re-investment saving. The critical issue is to have a cash flow (operation margin) that is positive.

The unit costs in 2020 that include re-investment saving are much closer to the long term tariff requirements, although the tariffs have to be somewhat higher to fill the financing gaps of earlier years.

The lowest viable tariff in 2005 is VND 1,850/m^3 (D2) and the highest required tariff in that year is VND 8,000/m^3 (K2-1). The tariff requirements in 2020 vary between VND 2,200/m^3 and VND 8,250/m^3.

The calculated tariffs look relatively high in the Vietnamese context. For example, the Provincial People's Committee in Dac Lac has set a ceiling of VND 1,800/m^3 for rural water tariffs. On the other hand the calculated tariffs do not seem to involve problems with the average affordability, except in all schemes in Kon Tum and possibly in D5, as can be seen in Table 4.3. Instead of the ability to pay, the calculated tariffs may be a political issue.

The willingness to pay was surveyed during the first field work. The willingness to pay for water was lower than the ability, the willingness ranging between 20% and 90% of the ability. While the ability to pay is really a critical issue for sustainability, the willingness to pay is a more dynamic parameter. The willingness may be raised up to the ability to pay through effective IEC.

Table 4.3 Cost of Water per cubic meter, Tariff Requirement and Affordability

Commune	Annual unit costs (VND/m^3)						Tariff (VND/m^3)		Affordability (%)*	
	Cost excl. reinvestment			Cost incl. reinvestment						
	2005	2010	2020	2005	2010	2020	Up to 2012	After 2013-	2005	2020
K1-1	**4,438**	**3,106**	**1,666**	**17,625**	**10,847**	**5,253**	**6,750**	**7,000**	**4.8**	**7.8**
K2-1	**6,258**	**5,195**	**2,550**	**18,573**	**12,425**	**6,416**	**8,000**	**8,250**	**10.9**	**17.5**
K2-3	**4,239**	**3,204**	**1,621**	**14,532**	**9,246**	**4,471**	**5,750**	**6,000**	**7.8**	**12.7**
K3-1	**3,455**	**2,748**	**1,486**	**8,146**	**5,502**	**2,969**	**3,750**	**3,800**	**4.8**	**7.5**
K4	**4,680**	**3,277**	**1,626**	**14,466**	**9,022**	**4,200**	**5,500**	**5,600**	**4.7**	**7.4**
G1	2,952	2,129	1,221	9,075	5,723	2,818	3,400	3,750	1.5	2.7
G2	2,363	1,784	1,118	7,697	4,915	2,575	2,850	3,350	0.7	1.3
G3	2,767	2,153	1,353	7,853	5,139	2,678	3,100	3,500	1.0	1.7
G4-1	2,411	1,829	1,043	7,146	4,609	2,371	2,800	3,100	1.9	3.3
G5-1	3,034	2,283	1,293	8,721	5,621	2,835	3,300	3,800	1.4	2.5
G6-1	2,309	1,825	1,072	5,820	3,886	2,167	2,500	2,800	1.3	2.3
G7-1	5,002	3,789	1,776	13,739	8,919	3,781	5,300	5,400	2.7	4.3
D1	1,658	1,277	774	4,983	3,229	1,685	1,950	2,200	0.6	1.1
D2	1,609	1,259	860	4,632	3,034	1,714	1,850	2,200	0.8	1.5
D3-1	1,711	1,359	833	4,650	3,084	1,671	1,900	2,200	0.9	1.6
D3-2	2,355	1,727	995	7,352	4,661	2,493	2,700	3,250	1.3	2.4
D4-1	2,160	1,639	974	6,720	4,316	2,136	2,650	2,800	1.2	2.0
D4-2	3,470	2,878	1,419	10,868	7,221	3,223	4,000	4,500	1.8	3.1
D5-1	2,536	1,801	959	8,588	5,353	2,607	3,100	3,500	3.2	5.7
D6	1,956	1,584	1,048	5,568	3,704	2,028	2,300	2,600	0.7	1.2
D7	2,084	1,632	990	5,794	3,810	1,994	2,150	2,700	0.9	1.7

*Water tariffs more than ATP (5% of income) are shadowed.

4.1.4 Willingness to Pay

Willingness to pay was investigated through the socio-economic investigation of the Study. The results indicate that the calculated water tariffs are higher than the amount which people are willing to pay in all the systems (year 2005).

Table 4.4 Willingness to Pay

Unit VND

Town/ Commune	Average annual income per capita	Willingness To Pay for piped system (VND, %)		3% of income	5% of income
K-1:Bo Y C.	1,892,804	41,000	2.2%	56,784	94,640
K-2:Dak Su C.	993,836	35,000	3.5%	29,815	49,692
K-3:Dak Ui C.	1,067,566	25,700	2.4%	32,027	53,378
K-4:Dak Hring	1,589,087	26,800	1.7%	47,673	79,454
K-5: Sa Nghia C.	2,783,730	39,000	1.4%	83,512	139,187
K-6:Chu Hreng C.	1,988,042	40,000	2.0%	59,641	99,402

Source: Household survey results

4.1.5 Financial Cash Flow Analysis

The cash flow of each scheme has been estimated separately. The main requirement in cash flow projections is to ensure that there is a positive cash flow every single year, and that every scheme is able to generate sufficient savings for reinvestment in 25 years from the initial investment. The assumptions of the cash flow analysis are presented in Section 3.11.1 above. While the costs have been calculated along the same principles for every scheme, the tariffs have been set on an iterative basis to facilitate a healthy cash flow. The financial performance charts, based on operation margin and the charts showing the cumulative savings, are in Appendix 3.

On the basis of the above, the outcome of the cash flow analysis is not the critical criterion for the assessment of scheme sustainability (see Table 4.5 "Financial Cash Flow Analysis"). Because a healthy cash flow has been a basis for tariff calculation, the critical criterion is the ability and willingness to pay the required tariff. In this connection one has to bear in mind that **WSUs are not intended to generate profit or surplus in excess of financing reinvestment requirements.**

In practice WSUs and their boards have the responsibility for financial management and ensuring healthy cash flows. When a WSU encounters financial problems it has three principal alternatives: to raise tariffs, increase sales volume or reduce costs, or a combination of the three. Experience has shown that although water is a basic need of human beings, the price to pay for water has a strong impact on water use. Economists call this price elasticity and it implies that the total revenue may not be increased by a tariff raise.

4.2 Economic Evaluation

To supplement the financial analysis, an economic analysis was first quantitatively carried out using the economic internal rate of return (EIRR) method.

4.2.1 Identification of Economic Merits and Demerits

The estimated economic merits from rural water supply projects will be:

B-1. Improvement of public health due to decrease in water-borne diseases
B-2. Increase in work time or study time by reducing water transportation and time
B-3. Improvement of gender issues by B-1 to B-2.

B-4. Decrease in medical expenditure
B-5. Increase in employment opportunities by the construction of the systems and the need for O/M
B-6. Increase in business activities to provide local materials for the systems
B-7. Improvement of awareness on hygiene and sanitation through IEC
B-8. Higher living standard and longer life expectancy by the use of clean and safe water

However, there might be some economic demerits as follows:

D-1. Decrease in vendor business by the systems in some areas
D-2. Environmental impact of groundwater lowering on shallow wells raising water rights issues
D-3. Land acquisition issues that might be raised if not solved at the initial stage.

According to the social survey, households that take water from vendors are limited. Furthermore, the business for vendors is very limited both spatially and seasonally. This economic demerit is considered to be of a very limited nature.

As concluded in the EIA analysis, the water level was lowered in the existing shallow wells in K3 and D5 as a result of the pumping tests. The water rights issues should be taken into consideration before implementation. This issue will raise a social conflict between villages that use piped water and dug wells, and damage the economic foundation of the local communities. In K3-1, the pilot model has been monitored if there is such an issue.

4.2.2 Economic Cash Flow Analysis

General

Cash flow analysis by the use of economic internal rate of return (EIRR) method was calculated based on the estimated economic merits, and demerits. Most of these identified in the previous section have qualitative effects; only merits in B1, B2 have quantifiable effects.

The quantifiable effect related to B1 is cost reduction of medical care, and that for B2 is cost saving of water collection. Vendors will experience reduced benefits related to their businesses.

Assumptions

Assumptions of the quantifiable analysis are as follows:

- ATP (3% of the annual income) will be used if the necessary water tariff exceeds 3% of the annual income;
- Instances of water-borne diseases collected by the social survey are used for the analysis;
- Reduction in water-borne diseases is estimated as high as 50 % for typhoid, cholera, dysentery, and diarrhea;
- Annual costs saved by reducing the diseases is estimated as high as VND 250,000 (average medical cost) for treatment for typhoid, cholera, dysentery, diarrhea, and trachoma. Cost saving by disease reduction is thus calculated as follows:
- Total saving by water collection = 250,000 VND/household x no. of households suffering from each disease
- Reduction of time for water collection will accrue to households taking water from the springs, which is estimated to take up to 1 hour;
- Time saved for water collection is valued at the average VND 1,000 using the household incomes per hour of farmers collected by the social survey. The annual saving is thus calculated as follows:
- Total saving by water collection = 500 VND/hour x 1 hour/day x 365 days x % of using springs/rivers x no. of households; and
- Demerits associated with the reduction in the vending business are offset by merits derived by the cost reduction for water bought from vendors. In a closed society, net demerits are zero. So the economic analysis excluded the vending business.

Results

The EIRR for each system proposed is calculated as shown Table 4.6. The following are the results of the economic cash flow analysis:

- The EIRRs of K3-1 are relatively large (+5 to 15%). These systems are economically feasible;
- The EIRRs of K1-1, K2-1, K2-3 could not be calculated, or had large negative values (–6% to -27%). These systems are economically unfeasible; and
- The EIRR of the other systems varies between –4 to 4%.

Table 4.5 Financial Cash Flow Analysis

	1			2			3			4			5			6			7			8			9			10			11		
Commune	K1-1			K2-1			K2-3			**K3-1**			**K4-1**			**G1**			**G2**			**G3-1**			**G4-1**			**G5-1**			**G6-1**		
Option	1			1			1			**1**			**1**			**1**			**1**			**1**			**1**			**1**			**1**		
Phase 1	578,218			151,059			350,210			181,568			406,601			601,322			965,360			591,512			344,955			337,704			227,066		
Phase 2	206,762			17,820			72,480			92,120			126,247			168,673			352,676			143,199			136,717			117,396			29,894		
Population	7,797			1,612			4,862			2,819			3,136			6,988			13,779			7,698			5,080			4,008			4,685		
Year	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance
1	322	110	(213)	70	27	(43)	164	58	(106)	92	39	(52)	177	62	(114)	257	87	(170)	432	144	(287)	250	90	(159)	156	55	(101)	144	50	(95)	114	44	(70)
2	354	122	(232)	77	30	(47)	182	65	(117)	105	44	(62)	202	69	(133)	285	96	(188)	477	161	(317)	276	101	(176)	173	61	(112)	161	55	(106)	126	49	(77)
3	355	136	(219)	77	33	(44)	183	72	(110)	106	49	(57)	203	77	(126)	286	107	(179)	483	179	(304)	283	112	(172)	174	68	(106)	162	61	(101)	127	54	(72)
4	356	151	(205)	78	37	(40)	183	80	(103)	107	54	(52)	203	86	(117)	287	119	(168)	490	199	(291)	288	124	(164)	177	76	(101)	163	68	(95)	128	60	(67)
5	**364**	168	(196)	**83**	41	(41)	**189**	89	(99)	**112**	60	(52)	**209**	95	(113)	**296**	133	(163)	**501**	221	(279)	**299**	138	(160)	**182**	84	(98)	**169**	76	(93)	**133**	67	(66)
6	**365**	187	(178)	**83**	46	(37)	**189**	99	(90)	**113**	67	(46)	**209**	106	(103)	298	147	(150)	505	246	(259)	302	154	(148)	183	94	(90)	170	85	(86)	137	75	(62)
7	**366**	208	(158)	**83**	51	(32)	**192**	111	(82)	**116**	75	(41)	**210**	118	(92)	300	164	(136)	512	274	(239)	307	171	(136)	185	104	(80)	172	94	(78)	138	83	(55)
8	**372**	232	(141)	**88**	57	(31)	**198**	123	(75)	**122**	83	(39)	**215**	131	(84)	307	182	(125)	525	305	(221)	316	191	(125)	191	116	(75)	178	105	(74)	144	93	(51)
9	**376**	258	(118)	**88**	63	(25)	**199**	137	(62)	**123**	92	(31)	**218**	146	(72)	312	203	(109)	534	339	(195)	325	212	(113)	194	129	(65)	182	116	(66)	146	103	(43)
10	378	287	(91)	89	70	(19)	200	152	(48)	124	103	(22)	219	162	(57)	318	226	(92)	541	377	(164)	329	236	(94)	196	143	(53)	184	129	(54)	149	115	(35)
11	481	331	(150)	123	81	(42)	255	177	(78)	166	116	(50)	267	184	(83)	386	277	(109)	682	493	(189)	396	296	(100)	248	177	(71)	226	166	(60)	198	143	(55)
12	493	368	(125)	126	90	(36)	262	197	(65)	173	129	(44)	274	205	(69)	396	308	(88)	706	548	(158)	410	330	(81)	257	196	(61)	233	184	(48)	205	159	(46)
13	498	409	(88)	127	100	(27)	263	219	(44)	174	144	(31)	277	228	(49)	402	343	(60)	716	610	(106)	417	367	(50)	262	219	(44)	237	205	(32)	209	177	(33)
14	503	455	(48)	127	111	(16)	267	243	(23)	179	160	(19)	278	253	(25)	409	381	(28)	729	678	(50)	426	408	(19)	265	243	(22)	240	228	(12)	212	197	(15)
15	508	507	(2)	128	123	(4)	269	271	2	181	178	(3)	280	282	2	416	424	8	743	755	12	437	454	17	270	270	1	244	254	10	218	219	1
16	511	563	52	130	137	7	271	301	30	183	198	14	282	313	32	422	472	50	758	839	81	448	505	57	273	301	28	249	282	33	223	243	20
17	517	627	110	131	153	21	273	335	62	186	220	34	286	349	63	430	525	95	780	934	154	460	561	101	281	335	54	253	314	61	227	271	44
18	523	697	174	132	170	38	278	373	95	191	244	53	291	388	97	439	584	145	798	1,039	240	478	624	147	285	372	88	261	350	89	233	301	68
19	530	776	246	133	189	56	281	415	134	194	272	78	295	432	136	446	650	203	819	1,155	337	492	695	202	291	414	123	268	389	121	240	335	95
20	530	776	246	133	189	56	281	415	134	194	272	78	295	432	136	446	650	203	819	1,155	337	492	695	202	291	414	123	268	389	121	240	335	95
FIRR			**-8%**			**-9%**			**-7%**			**-7%**			**-8%**			**-7%**			**-8%**			**-7%**			**-8%**			**-7%**			**-7%**
NPV	US$(=15000VND)		**-1,153**			**-228**			**-566**			**-275**			**-618**			**-919**			**-1,556**			**-854**			**-546**			**-507**			**-370**

	12			13			14			15			16			17			18			19			20			21					
Commune	G7-1			**D1**			**D2**			**D3-1**			D3-2			**D4-1**			D4-2			D5-1			**D6**			D7			**Total**		
Option	1			**1**			**1**			**1**			1			**1**			1			1			**1**			1					
Phase 1	227,066			640,632			926,850			337,039			297,530			500,457			250,341			460,679			469,229			363,980			**9,209,378**		
Phase 2	29,894			233,064			375,219			141,311			133,328			165,608			127,854			176,027			104,813			130,138			**3,081,240**		
Population	1,837			12,903			18,464			8,556			4,463			7,775			2,034			8,920			10,619			7,484			**145,519**		
Year	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance			
1	104	37	(67)	270	96	(174)	346	126	(221)	157	58	(99)	128	43	(85)	233	83	(150)	99	33	(67)	233	76	(157)	242	91	(151)	171	57	(114)			
2	115	41	(74)	301	107	(195)	383	140	(243)	173	64	(109)	143	48	(81)	258	92	(166)	109	36	(73)	258	85	(174)	269	101	(168)	189	63	(125)			
3	117	45	(72)	303	119	(184)	389	155	(234)	175	71	(103)	144	53	(77)	260	102	(157)	110	40	(69)	261	94	(167)	271	112	(159)	190	71	(120)			
4	118	50	(67)	307	132	(175)	395	173	(223)	178	79	(99)	145	59	(74)	263	114	(150)	110	45	(65)	262	105	(157)	274	125	(150)	192	78	(113)			
5	**123**	56	(67)	**314**	**147**	(168)	**405**	**192**	(213)	**185**	**88**	(96)	**146**	**65**	(70)	**270**	127	(143)	**116**	50	(66)	**267**	**117**	(151)	**285**	**139**	(146)	**200**	**87**	(113)			
6	123	62	(61)	321	163	(158)	412	214	(199)	186	98	(88)	147	73	(66)	272	141	(131)	116	56	(60)	268	130	(138)	292	154	(137)	202	97	(105)			
7	124	69	(55)	324	182	(143)	420	238	(183)	188	109	(79)	148	81	(62)	277	157	(120)	119	62	(57)	271	144	(127)	298	172	(126)	204	108	(96)			
8	130	77	(53)	334	202	(132)	434	265	(169)	197	122	(76)	156	90	(58)	284	174	(110)	124	69	(55)	277	160	(117)	307	191	(117)	213	120	(93)			
9	132	86	(47)	340	225	(115)	441	294	(147)	203	135	(68)	157	100	(54)	290	194	(96)	125	77	(48)	278	178	(100)	313	212	(100)	218	134	(85)			
10	133	95	(38)	344	250	(94)	452	328	(124)	208	150	(57)	158	112	(47)	295	216	(79)	126	85	(41)	280	199	(81)	323	236	(87)	221	149	(72)			
11	146	108	(38)	430	314	(117)	579	433	(146)	261	194	(67)	213	149	(63)	350	254	(97)	144	107	(38)	355	249	(106)	399	297	(102)	273	208	(65)			
12	148	120	(28)	446	349	(97)	603	482	(121)	270	216	(55)	220	166	(54)	364	282	(82)	148	119	(29)	368	277	(91)	414	330	(83)	282	231	(51)			
13	149	134	(16)	453	388	(65)	616	536	(80)	278	240	(39)	224	185	(39)	369	314	(55)	151	132	(19)	372	309	(64)	424	368	(56)	291	257	(34)			
14	151	149	(2)	461	432	(30)	633	596	(37)	285	267	(18)	226	206	(20)	376	349	(27)	152	147	(5)	374	343	(31)	433	409	(24)	295	286	(9)			
15	154	165	11	475	480	5	649	663	15	289	297	8	228	229	0	383	388	5	154	163	10	378	382	3	445	455	10	302	318	16			
16	156	184	28	485	534	50	666	738	71	296	330	34	233	254	21	389	432	43	155	182	26	383	425	41	458	506	48	309	354	45			
17	157	205	47	495	594	99	688	821	133	304	367	63	236	283	47	398	481	82	157	202	45	388	472	84	472	563	90	315	394	79			
18	159	228	68	506	661	155	711	913	202	310	409	98	241	315	73	408	535	127	161	225	64	392	526	134	488	626	138	323	438	115			
19	162	253	92	521	735	214	737	1,016	279	319	454	135	245	350	105	418	595	176	163	250	87	397	585	188	510	697	186	332	487	155			
20	162	253	92	521	735	214	737	1,016	279	319	454	135	245	350	105	418	595	176	163	250	87	397	585	188	510	697	186	332	487	155			
FIRR			-6%			**-7%**			**-7%**			**-6%**			-7%			-8%			-6%			-8%			**-7%**			-6%			

Table 4.6 EIRR Cash Flow

	1				2				3				4			
Commune	K1-1				K2-1				K2-3				K3-1			
Option	1				1				1				1			
Phase 1	578,218				151,059				350,210				181,568			
Phase 2	206,762				17,820				72,480				92,120			
Population	7,797				1,612				4,862				2,819			
Year	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL
2003	322	68	36	(219)	70	7	5	(57)	164	22	10	(131)	92	25	24	(42)
2004	354	75	39	(240)	77	8	6	(63)	182	25	11	(146)	105	28	26	(51)
2005	355	84	42	(230)	77	9	6	(62)	183	28	12	(143)	106	31	29	(46)
2006	356	93	45	(218)	78	10	7	(61)	183	31	13	(139)	107	35	31	(41)
2007	364	103	49	(212)	83	11	7	(64)	189	34	14	(140)	112	39	33	(40)
2008	365	115	53	(197)	83	13	8	(63)	189	38	15	(136)	113	43	36	(34)
2009	366	128	57	(181)	83	14	8	(61)	192	42	16	(134)	116	48	39	(29)
2010	372	142	61	(168)	88	16	9	(64)	198	47	18	(133)	122	53	42	(27)
2011	376	158	66	(151)	88	17	10	(62)	199	52	19	(127)	123	59	45	(19)
2012	378	176	72	(130)	89	19	10	(59)	200	58	21	(121)	124	66	49	(10)
2013	481	196	77	(208)	123	21	11	(90)	255	177	22	(56)	166	114	53	2
2014	493	218	84	(192)	126	24	12	(90)	262	197	24	(41)	173	127	57	12
2015	498	243	90	(165)	127	27	13	(87)	263	219	26	(18)	174	142	62	29
2016	503	270	98	(136)	127	30	14	(83)	267	243	28	5	179	158	67	46
2017	508	300	105	(103)	128	33	15	(80)	269	271	30	32	181	175	72	66
2018	511	334	114	(63)	130	37	16	(77)	271	301	33	63	183	195	78	89
2019	517	372	123	(22)	131	41	18	(73)	273	335	35	97	186	217	84	115
2020	523	413	133	23	132	45	19	(68)	278	373	38	133	191	241	91	141
2021	530	460	143	74	133	50	21	(62)	281	415	41	175	194	268	98	172
2022	530	460	143	74	133	50	21	(62)	281	415	41	175	194	268	98	172
EIRR				-27%				#DIV/0!				-6%				7%
NPV	US$(=15000VND)			-1,287				-380				-700				-161

	5				6				7				8			
Commune	K4-1				G1				G2				G3-1			
Option	1				1				1				1			
Phase 1	406,601				601,322				965,360				591,512			
Phase 2	126,247				168,673				352,676				143,199			
Population	3,136				6,988				13,779				7,698			
Year	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL
2003	177	62	22	(93)	257	87	31	(139)	432	144	21	(267)	250	90	30	(129)
2004	202	69	23	(110)	285	96	33	(155)	477	161	22	(294)	276	101	32	(144)
2005	203	77	25	(100)	286	107	36	(143)	483	179	24	(280)	283	112	35	(137)
2006	203	86	27	(90)	287	119	39	(130)	490	199	26	(264)	288	124	38	(126)
2007	209	95	30	(84)	296	133	42	(122)	501	221	28	(251)	299	138	41	(120)
2008	209	106	32	(71)	298	147	45	(105)	505	246	31	(228)	302	154	44	(104)
2009	210	118	34	(57)	300	164	49	(87)	512	274	33	(205)	307	171	47	(89)
2010	215	131	37	(47)	307	182	53	(72)	525	305	36	(185)	316	191	51	(74)
2011	218	146	40	(32)	312	203	57	(52)	534	339	39	(156)	325	212	55	(58)
2012	219	162	43	(13)	318	226	61	(31)	541	377	42	(122)	329	236	60	(34)
2013	267	184	47	(36)	386	277	66	(42)	682	493	45	(144)	396	296	64	(36)
2014	274	205	51	(18)	396	308	72	(17)	706	548	49	(110)	410	330	69	(12)
2015	277	228	55	5	402	343	77	18	716	610	52	(54)	417	367	75	25
2016	278	253	59	34	409	381	84	56	729	678	57	6	426	408	81	62
2017	280	282	64	66	416	424	90	98	743	755	61	73	437	454	87	104
2018	282	313	69	101	422	472	97	148	758	839	66	147	448	505	94	151
2019	286	349	74	137	430	525	105	200	780	934	71	225	460	561	102	204
2020	291	388	80	177	439	584	114	259	798	1,039	77	317	478	624	110	257
2021	295	432	87	223	446	650	123	326	819	1,155	83	420	492	695	119	321
2022	295	432	87	223	446	650	123	326	819	1,155	83	420	492	695	119	321
EIRR				2%				2%				-4%				2%
NPV				-439				-665				-1,384				-608

	9				10				11			
Commune	G4-1				G5-1				G6-1			
Option	1				1				1			
Phase 1	344,955				337,704				227,066			
Phase 2	136,717				117,396				29,894			
Population	5,080				4,008				4,685			
Year	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL
2003	156	55	19	(82)	144	50	8	(86)	114	45	24	(45)
2004	173	61	21	(91)	161	56	9	(97)	126	50	25	(50)
2005	174	68	22	(83)	162	62	10	(90)	127	55	27	(44)
2006	177	76	24	(77)	163	69	10	(84)	128	62	30	(36)
2007	182	84	26	(72)	169	77	11	(81)	133	69	32	(33)
2008	183	94	28	(61)	170	86	12	(73)	137	76	35	(26)
2009	185	104	31	(50)	172	95	13	(63)	138	85	37	(15)
2010	191	116	33	(42)	178	106	14	(58)	144	94	40	(9)
2011	194	129	36	(30)	182	118	15	(49)	146	105	44	3
2012	196	143	39	(14)	184	131	16	(36)	149	117	47	15
2013	248	177	42	(29)	226	166	18	(43)	198	143	51	(4)
2014	257	196	45	(16)	233	184	19	(29)	205	159	55	9
2015	262	219	49	5	237	205	21	(12)	209	177	59	27
2016	265	243	52	31	240	228	22	10	212	197	64	49
2017	270	270	57	57	244	254	24	34	218	219	69	70
2018	273	301	61	89	249	282	26	59	223	243	75	95
2019	281	335	66	120	253	314	28	89	227	271	81	124
2020	285	372	71	159	261	350	30	119	233	301	87	155
2021	291	414	77	200	268	389	33	154	240	335	94	189
2022	291	414	77	200	268	389	33	154	240	335	94	189
EIRR				2%				-2%				10%
NPV				-387				-435				-170

	12				13				14				15			
Commune	G7-1				D1				D2				D3-1			
Option	1				1				1				1			
Phase 1	227,066				640,632				926,850				337,039			
Phase 2	29,894				233,064				375,219				141,311			
Population	1,837				12,903				18,464				8,556			
Year	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL
2003	104	37	11	(56)	270	96	24	(150)	346	126	50	(170)	157	58	33	(67)
2004	115	41	12	(62)	301	107	25	(169)	383	140	54	(189)	173	64	35	(74)
2005	117	45	13	(59)	303	119	28	(157)	389	155	59	(175)	175	71	38	(65)
2006	118	50	14	(54)	307	132	30	(146)	395	173	64	(159)	178	79	41	(57)
2007	123	56	15	(52)	314	147	32	(135)	405	192	69	(144)	185	88	45	(52)
2008	123	62	16	(45)	321	163	35	(124)	412	214	74	(125)	186	98	48	(40)
2009	124	69	17	(37)	324	182	37	(105)	420	238	80	(103)	188	109	52	(27)
2010	130	77	19	(34)	334	202	40	(92)	434	265	86	(83)	197	122	56	(19)
2011	132	86	20	(26)	340	225	44	(72)	441	294	93	(54)	203	135	61	(7)
2012	133	95	22	(16)	344	250	47	(47)	452	328	101	(23)	208	150	66	9
2013	146	108	24	(14)	430	314	51	(66)	579	433	109	(37)	261	194	71	3
2014	148	120	26	(2)	446	349	55	(42)	603	482	118	(3)	270	216	77	22
2015	149	134	28	12	453	388	59	(6)	616	536	127	47	278	240	83	44
2016	151	149	30	28	461	432	64	35	633	596	137	101	285	267	89	72
2017	154	165	32	44	475	480	69	75	649	663	148	163	289	297	97	104
2018	156	184	35	63	485	534	75	125	666	738	160	231	296	330	104	138
2019	157	205	38	85	495	594	81	180	688	821	173	306	304	367	113	176
2020	159	228	41	109	506	661	87	242	711	913	187	388	310	409	122	220
2021	162	253	44	135	521	735	94	309	737	1,016	201	480	319	454	131	266
2022	162	253	44	135	521	735	94	309	737	1,016	201	480	319	454	131	266
EIRR				2%				0%				4%				9%
NPV	US$(=15000VND)			-265				-740				-768				-257

	16				17				18				19			
Commune	D3-2				D4-1				D4-2				D5-1			
Option	1				1				1				1			
Phase 1	297,530				500,457				250,341				460,679			
Phase 2	133,328				165,608				127,854				176,027			
Population	4,463				7,775				2,034				8,920			
Year	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL
2003	128	43	18	(67)	233	83	22	(129)	99	33	8	(59)	233	71	15	(146)
2004	143	48	19	(77)	258	92	24	(143)	109	36	8	(65)	258	79	16	(163)
2005	144	53	21	(71)	260	102	25	(132)	110	40	9	(61)	261	88	18	(155)
2006	145	59	22	(64)	263	114	27	(122)	110	45	10	(56)	262	98	19	(144)
2007	146	65	24	(56)	270	127	30	(114)	116	50	10	(55)	267	109	21	(137)
2008	147	73	26	(48)	272	141	32	(99)	116	56	11	(49)	268	121	22	(124)
2009	148	81	28	(39)	277	157	35	(85)	119	62	12	(45)	271	135	24	(112)
2010	156	90	30	(35)	284	174	37	(72)	124	69	13	(43)	277	150	26	(101)
2011	157	100	33	(24)	290	194	40	(56)	125	77	14	(35)	278	167	28	(83)
2012	158	112	35	(11)	295	216	44	(36)	126	85	15	(26)	280	186	30	(63)
2013	213	149	38	(25)	350	254	47	(50)	144	107	16	(21)	355	207	33	(116)
2014	220	166	41	(13)	364	282	51	(31)	148	119	18	(11)	368	230	36	(103)
2015	224	185	44	5	369	314	55	0	151	132	19	0	372	256	38	(78)
2016	226	206	48	28	376	349	59	33	152	147	21	15	374	284	41	(48)
2017	228	229	52	52	383	388	64	69	154	163	22	32	378	316	45	(17)
2018	233	254	56	77	389	432	69	112	155	182	24	50	383	352	48	17
2019	236	283	60	107	398	481	75	157	157	202	26	71	388	391	52	55
2020	241	315	65	139	408	535	81	207	161	225	28	92	392	435	56	100
2021	245	350	70	176	418	595	87	263	163	250	30	117	397	484	61	148
2022	245	350	70	176	418	595	87	263	163	250	30	117	397	484	61	148
EIRR				3%				0%				0%				-10%
NPV				-312				-635				-294				-806

	20				21							
Commune	D6				D7				Total			
Option	1				1							
Phase 1	469,229				363,980				9,209,378			
Phase 2	104,813				130,138				3,081,240			
Population	10,619				7,484				145,519			
Year	EXP	REV	E/B	BAL	EXP	REV	E/B	BAL				
2003	242	91	20	(132)	171	57	0	(114)				
2004	269	101	21	(147)	189	63	0	(125)				
2005	271	112	23	(136)	190	71	0	(120)				
2006	274	125	25	(125)	192	78	0	(113)				
2007	285	139	27	(119)	200	87	0	(113)				
2008	292	154	29	(109)	202	97	0	(105)				
2009	298	172	31	(95)	204	108	0	(96)				
2010	307	191	34	(83)	213	120	0	(93)				
2011	313	212	36	(64)	218	134	0	(85)				
2012	323	236	39	(48)	221	149	0	(72)				
2013	399	297	42	(60)	273	208	0	(65)				
2014	414	330	46	(38)	282	231	0	(51)				
2015	424	368	49	(7)	291	257	0	(34)				
2016	433	409	53	29	295	286	0	(9)				
2017	445	455	58	68	302	318	0	16				
2018	458	506	62	110	309	354	0	45				
2019	472	563	67	157	315	394	0	79				
2020	488	626	72	210	323	438	0	115				
2021	510	697	78	264	332	487	0	155				
2022	510	697	78	264	332	487	0	155				
EIRR				0%				-6%				
NPV				-652				-603				

4.3 Technical Feasibility

All five priority systems are feasible from a technical viewpoint, provided that institutional, financial, economic, and social considerations are satisfied.

The design must take into account the appropriate technical level of the local contractors, efficient location of facilities, and the availability of equipment and materials necessary for the construction. Emphasis is given below to certain issues, such as appropriateness of technology, efficient designing, and local construction skills.

4.3.1 Appropriateness of Technology

The Study team referred to, and followed, the documents related to design standards for rural water supply facility specified by CERWASS, and "Water Supply Options Catalogue" published by The World Bank and the Ministry of Health.

The design is generally uncomplicated, but should be undertaken by qualified engineers. Some areas that may complicate the design are listed below.

- In treatment of surface water in K4-1, the proposed filter arrangement (roughing filter and slow sand filter) will remove most turbidity, biological contamination, and high iron content, but may present a problem during the rainy season.,
- Iron and manganese removal can be performed effectively by means of aeration and slow sand filtration. The iron removal process is not complicated by regular replacement and washing the sand filter.
- The process for the removal of manganese is more complicated than iron removal. This process requires very effective aeration and careful operation of the filter, which should never become dry and should preferably receive a constant flow of water.
- The chlorination process has a complex operation and maintenance aspect.

The following considerations were made to solve the above issues:

- In the removal of iron and manganese, local technology was applied to the piped systems; and
- As an option, the treatment plants may be initially installed only in the larger villages during the first phase. In the smaller, more rural villages, such equipment can be installed later, during phase 2 (2010 – 2020).

4.3.2 Efficient Designing

The proposed location of water supply facilities (e.g., treatment plants, reservoirs, and pipes) was determined considering the need for efficient and economical designs. These included the following:

- For the four systems of K1 (Bo Y), K2-1 and K2-3 (Dak Su), and k3 (Dak Ui), water is pumped by submersible pumps directly to treatment plants (if needed) and by gravity to the reservoirs, in order to avoid secondary pumping;
- Reservoirs for the four systems should be located at high elevations, so that the water can be gravity fed to the system;
- The layout of raw water pipelines was determined so that the pipeline would always run alongside a road for ease of identification, simpler location and to facilitate maintenance;
- The main distribution pipes along the main roads will supply all main areas with water at sufficient pressure, so that the secondary network (which will be designed during the detailed design phase) can be connected to the mains and supply all households;
- Space for the construction of treatment plants and reservoirs should be readily available; and
- The water works (e.g. distribution pipes, treatment plants) should preferably be placed on public ground, in order to avoid compensation to private landowners.

There are several issues to be addressed from the technical viewpoint. These are:

- In some systems, the achievement of satisfactory service pressure during the hours of maximum demand will need careful optimization by hydraulic calculations during the detailed design aspects of the network for location of reservoirs and size of pumps; and
- Removal of some remote villages out of the centralised piped systems should be considered from an economic point of view: K2-3 (villages Dak Giao, Dak Long, Dak Pil and Phi Phap).

The operation and maintenance manual has been formulated for the rural water supply systems as proposed in the master plan.

4.3.3 Local Construction Skills and Materials

Generally, the construction of the schemes will not be complicated, provided construction is done by qualified local contractors and is properly supervised. However, some activities may have to be carefully planned. These are:

- Pipe laying in town centers should be planned carefully to avoid traffic obstruction. Construction of reservoirs on hills will need access roads, but this is not considered a problem.
- Generally, for optimum durability, it is proposed to use unplasticized polyvinyl chloride (uPVC) Class 6 bar pressure for pipes 100 mm diameter and above, and high density polyethylene (HDPE) for pipes below 100 mm diameter.

4.4 Operation and Maintenance

O&M efficiency is the most important factor determining the feasibility of the water supply schemes. Appropriate O&M of the schemes will be possible provided that the necessary training and institutional settings are provided. Access to spare parts to continue O&M should also be available.

4.4.1 Training Method for O&M

Pump operation, maintenance for the plant of iron and manganese removal by the WSU in K1, K2-1 and K2-3 shall be well learned from the WSU staff of the pilot model plant of K3-1. The training shall be also introduced through consultant engineers and constructor during the implementation stage.

Surface water treatment for K4-1 involves only simple technology. Regular washing of the filter sand (maybe once a month or once every second month, depending on the season) is necessary. Treatment by flocculation, and sedimentation followed by filtration highly complicates O&M, and this alternative has not been recommended.

Maintenance of the pipe network is of particular interest. Long pipelines and few users increase the risk of a relatively high percentage of ‘unaccounted for water’ (UFW) and illegal connections. An extensive network of pipes may require intensive maintenance after some years, even if high quality material and high quality construction has been undertaken. This will be needed to solve through the monitoring of the K3-1 pilot model.

4.4.2 Evaluation of O&M Skills

During the study, it was identified that the O&M resource, considering the issues explained above, was rather low in a number of systems, i.e., K1-1 (Bo Y), K2-1 (Dak Su) and K2-3.

Long pipelines and few users in K1-1, K2-1, and K2-3. will increase the risk of a relatively high percentage of UFW. In these systems, the potential of the managers of the WSU seem to be limited, and training of the pump operator, network inspector, and meter reader will be a challenge.

Having two systems in one commune will make O&M more complicated. There are two systems recommended in the commune of K2. As the main systems will become K2-3 in each commune, the management of the subsystems of K2-1 will be very complex, considering the present O&M potential.

4.5 Environmental Concerns

There are environmental issues related to 1) lowering of groundwater level and water rights, 2) land acquisition, 3) water quality, 4) wastewater disposal, and 5) other issues. The more important are explained below:

Water rights issues may be a problem in K3 where the water level fell in the shallow dug wells near the explored wells. In the pilot model of K3-1, water rights of the households with affected dug wells should be carefully investigated, and the results should be reflected in the Draft Final Report.

Acquisition of private land may be necessary, probably, in K4-1. Resettlement and relocation are not required in any of the systems. It is a prerequisite that the people's committees and PCERWASS take the responsibility for acquiring the land for water supply facilities.

Wastewater disposal is crucial in some of the systems, especially the communities near the explored groundwater resources in the K1-1, K2-3, and K3-1 systems. The public buildings should be equipped with septic tanks or more advanced technology if funding is available. Communities in the densely populated areas are advised to install individual septic tanks during phase 1 (up to 2010), which can be upgraded to more intensive wastewater treatment systems in the future.

4.6 Result of Feasibility Evaluation

The feasibility evaluation for the study should be regarded as a prioritization of 21 systems to achieve the national target that 85% of the population is to be provided with water within the Phase-1 period. The result of feasibility evaluation is summarized in Table 4.7.

Table 4.7 Summary of Feasibility Evaluation

No.		1	2	3	4	5	6	Description	Feasibility
Item		Financial		Economical -EIRR-	Technical	O&M	Environ mental		
		WTP	ATP						
Kon Tum									
K1: Bo Y C.	K1-1	**C**	**C**	**C**	**B**	**B**	**B**		**C**
K2: Dak Su C.	K2-1	**B**	**C**	**C**	**B**	**B**	**B**		**C**
	K2-3	**B**	**C**	**C**	**B**	**C**	**A**	ADB connection	**C**
K3: Dak Ui C.	K3-1	**C**	**C**	**B**	**B**	**B**	**C**	Pilot	**C**
K4: Dak Hring C.	K4-1	**C**	**C**	**B**	**B**	**B**	**B**	Surface water	**B**
Gia Lai									
G1:Kong Tang T.		**C**	**A**	**B**	**B**	**B**	**A**		**A**
G2: Nhon Hoa C.		**C**	**A**	**C**	**B**	**B**	**A**	Pilot	**B**
G3: Chu Ty T.	G3-1	**C**	**A**	**B**	**B**	**B**	**A**		**A**
G4:Thang Hung C.	G4-1	**B**	**B**	**B**	**B**	**B**	**A**		**B**
G5:Nghia Hoa	G5-1	**C**	**A**	**C**	**A**	**B**	**B**		**B**
G6: Ia Rsion	G6-1	**C**	**A**	**B**	**B**	**B**	**B**		**B**
G7: Kong Yang	G7-1	**B**	**B**	**B**	**B**	**C**	**C**	Bad smell	**B**
Dac Lac									
D1: Krong Nang T.		**C**	**A**	**B**	**A**	**B**	**B**		**A**
D2: Ea Drang C.		**C**	**A**	**B**	**A**	**A**	**B**		**A**
D3: Krong Buk C.	D3-1	**C**	**A**	**B**	**A**	**B**	**B**		**A**
	D3-2	**C**	**A**	**B**	**B**	**B**	**A**	No well	**B**
D4: Ea Drong C.	D4-1	**C**	**A**	**B**	**B**	**B**	**B**		**B**
	D4-2	**C**	**B**	**B**	**B**	**B**	**A**	No well	**B**
D5: Ea Wer C.	D5-1	**C**	**C**	**C**	**B**	**B**	**C**		**C**
D6: Kien Duc T.		**B**	**A**	**B**	**B**	**A**	**B**		**A**
D7:Krong Kmar T.		**C**	**A**	**C**	**B**	**B**	**C**		**B**

Explanation of “A”, “B” and “C” is determined by following criterion.

No.	1	2	3	4	5	6
Item	Financial		Economic -EIRR (%)-	Technical	O&M -Potential of PC-	Environment
	WTP (%)	ATP (%)				
A	> 5.0	< 3.0	> 10	No treatment plant	Good	No concerns
B	5.0 - 3.0	3.0 - 5.0	10 - 0	Iron, Mn treatment	Fair	Some concerns
C	< 3.0	> 5.0	< 0	Specific issue	Poor	Much concerns

As mentioned, not all of the projects are financially justifiable. Financial subsidy will be required to maintain the project as being financially viable. Provided that this financial subsidy is available, financial aspects are not critical to the feasibility evaluation.

Feasibility of each system largely depends on ‘soft component aspects’ or ‘preparedness’ such as O&M capability, organizational capability etc. If sufficient preparedness is confirmed for some communes, the project can be judged feasible and can be implemented immediately. Otherwise, the project likely remains unfeasible.

‘Soft component aspects’ can be improved through IEC campaigns though it may require a long time. Some communes with little preparedness (unfeasible) can be raised to sufficient preparedness level (feasible) through an IEC campaign within the Phase-1 period.

Chapter 5 Pilot Models Construction

5.1 Purposes of Pilot Models

Two pilot systems were constructed in the communes under typical different social situation in the Central Highlands. One is a commune with poverty issues (K3-1) and the other is minority-dominated commune (G2). The main purpose of the pilot models in K3-1 and G2 are to assess the feasibility and sustainability of the piped water supply systems with regard to the following issues:

- financial sustainability,
- local management skills,
- monitoring of house connection rate and water charge collection,
- effectiveness of IEC, and
- local construction skills.

(1) Financial sustainability

In K3-1, the majority of the population are of the ethnic minority, the economic conditions are generally poor, and the financial sustainability of the piped supply systems has been unclear. The project cannot achieve its goal without financial subsidy.

(2) Local management skills

At G2, there are issues between the two major ethnic groups (the Kinh and Gia Rai). The people's committee has been expected to solve the issues by themselves to ensure the harmonious management of the water supply system.

(3) House connection rate, water charges collection and IEC

The collection of water charges from users of house connections is most important for sustainable O/M. To achieve successful O/M, effective IEC activities promoting safe and clean water in both communes are essential. IEC activities have been carried out prior to the construction of the water supply facilities, and their effectiveness needs to be checked and reviewed.

(4) Local construction skills

Piped supply systems are still not common in the rural areas in Vietnam. The level and reliability of the construction contractors need to be technically evaluated to ensure quality of the construction works. Materials are procured from the local markets and the availability of spare parts needs to be considered. The skill to keep to the construction schedule and to prepare the design drawings to meet the construction program is also one of the important key factors.

5.2 Background Information for Dak Ui Commune (K3-1)

Background information includes the target population, ethnicity, economic conditions, present water supply, health, groundwater potential, water quality, future water demands in each target area.

(1) General Background

It takes one and half hours by car from the provincial capital, Kon Tum city to reach Dak Ui. The target area is located along a minor dirt (not asphalt) road, via a turnoff at Dak Ha from the national road No. 14.

The target area (K3-1) includes 5 villages, i.e. nos. 1A, 1B, 5B, 6, and 7, with the total population of about 2,164 (412 households). The biggest village is village No. 7 with a population of 1,044, followed by villages 1B (361), 1A (355), 5B (275), and 6 (129).

The target area is inhabited by various ethnic minority people. Xe Dang and Xo Dra people live in villages 1A, 1B, 5B, and 6, and a few Roman households also live in village No. 7. The Kinh people dwell in villages 1B, 5B, 6, and 7.

The poverty ratio, 33 %, is reported only for the commune level, although the specific data for K3-1 is unavailable.

There are some public buildings in the area, a CPC, secondary school, and the commune health center in village 1B, and primary schools in villages 1A and 7.

(2) Existing Water Supply

Most of the existing water supply is in the form of shallow dug wells, and many people still believe that spring water is clean and drinkable.

There are 2 bamboo piped systems where spring water gravitates to villages Nos. 5B and 7. Maintenance of the bamboo systems is of local responsibility, and both Kinh and ethnic minority people have managed the systems very successfully. The inside of the bamboo pipes has been reinforced by plastic pipes contributed by the local users of the existing systems.

According to the social survey, 49% of the respondents were reportedly unsatisfied with the quantity of water in the dry season, and only 7% were unsatisfied with the quality of the existing water supply. There is therefore much potential in the target area for urgent development.

(3) Piped System

The study team has explored a well with a safety yield of 259 m^3/day near the commune health center in 1B. The depth of the well is only 38 m with a screen 28 m in length. The water taken from the well has high contents of iron (3.49 mg/l) and manganese (0.12 mg/l), and water treatment by aeration and filtration would be necessary.

The estimated water demands (maximum daily demands) are 27.5 m^3/day in 2001, 59.7 m^3/day in 2005, 224.3 m^3/day in 2010, and 322.6 m^3/day in 2020. One more well with the same capacity as the explored well will be necessary to meet the water demand in 2020.

Alternative 2a is recommended for the system in K3-1. Water is pumped from the drilled well to a treatment plant on the hill in village No. 7 from where the water runs to a ground level reservoir. The target area will be supplied from the proposed reservoir.

5.3 Overall Progress of Pilot Model

5.3.1 General

The pilot model plants in Dak Ui commune (K3-1) and Nhon Hoa commune (G2) were constructed by the end of January 2002. The selected local contractor carried out the construction works under the contract agreed between the JICA study team and the contractor on 31st October 2001. The construction period took 3 months starting at the beginning of November 2001. The monitoring of the actual and realistic operation and maintenance activities by the users will be continuing after the completion of model plants for about 3 months from February to April 2002. The actual schedule of the construction works is presented in Figure 5.1.

The basic parameters for the construction works are as follows:

Table 5.1 Basic parameters for the Construction Works

Items	**Dak Ui (K3-1)**
A. Water resource	
1. Permissible yield of JICA`s deep well	3.0 l/sec
2. Altitude of JICA`s deep well	El 687 m
3. Elevation of reservoir tank	El 750 m
B Water demand	
1. Number of villages	5
2. Number of households	412
3. Number of population, 2001	2,164
4. Maximum hourly demand, 2001	2.0 m3/h
5. Maximum daily demand, 2001	20.0 m3/d
6. Maximum hourly demand, 2020	26.0 m3/h
7. Maximum daily demand, 2020	238.0 m3/day
8. Minimum pressure at tapping point	3.0 m

5.3.2 Construction Works

The scope of the construction works of the pilot models are summarized as follows.

- Design of water supply facilities
- Land clearing
- Installation of submersible pumps with appurtenances
- Installation of electric panels and their protection
- Connection of electric power lines to public power lines
- Construction of well heads
- Installation of raw-water pipelines
- Construction of provisional reservoirs
- Installation of distribution pipelines
- Construction of public taps
- Water pressure tests
- Disinfection

(1) Water Intake

The profiles of the wells explored by the JICA study team in K3-1 in 2001 are as follows:

Table 5.2 Profiles of the Wells

Description	K3-1
Well diameter	150 mm
Well depth (reamed)	38 m
Dynamic water level	18 m
Permissible yield	3 l/s
Ground elevation (m)	685

The deep well head was constructed to meet the water demand for the year 2020. The well head consists of a pressure gauge, gate valve, water meters, non-return valve and all necessary couplings and fittings. A protective housing was constructed. The following type of submersible pumps was installed in K3-1 system.

Table 5.3 Type of Submersible Pump

	Description	K3-1
Pump	Type	Calpeda submersible pump, Italy
	Model	4SD 10/17N N 021525
	Performance	H max. 114 m, Q min. 1.5 m3/h H min. 35 m, Q max. 12 m3/h
Motor	Type	Franklin Electric, Germany
	Model	3 kW, 3-Phase, 380 V

(2) Power Supply

The power required for the operation of submersible pumps and lightning is supplied from the national grid. The line connections and installation of control panels have been completed in K3-1 and G2.

(3) Raw Water Mains

The raw water main laid 60 cm below the ground transports the water from the wellhead to the reservoir. The raw water pipe is made from Galvanized Iron (GI) and is 100 mm in diameter for both K3-1 (Dak Ui) and G2 (Nhon Hoa).

(4) Distribution Lines

The distribution pipes were designed and constructed for the maximum hourly demand in year 2020. The distribution pipes are High Density Polyethylene (HDPE) for secondary and small pipelines and Poly-vinyl Chloride (PVC) for the main pipelines. The distribution pipe lengths and diameters are shown in the following:

Table 5.4 Type of Distribution Pipe

Pipe Material	K3-1	
	Dia. (mm)	Length (m)
PVC (for mains)	100	600
PVC (for mains)	75	-
HDPE (for secondary pipes)	75	500
HDPE (for secondary pipes)	63	1,600
HDPE (for secondary pipes)	50	3,200
HDPE (for secondary pipes)	32	4,500

(5) Iron Removal Plant

A treatment plant (aeration and slow sand filtration) was constructed at the hill top of the K3-1 system to reduce the iron content from 3.49 mg/l to less than 0.5 mg/l (the Vietnamese standard).

(6) Storage Reservoirs

Temporary storage reservoirs with a capacity of 5 m^3 were constructed in order to ensure supply during the pilot period. In K3-1 a concrete reservoir equipped with the iron removal plant will be constructed later.

(7) Public Taps

The number of public taps installed was 50 in K3-1 and 4 in G2. Two shower rooms are equipped with public taps in K3-1 in accordance with the requirements of local customs.

(8) Pressure Testing and Disinfection

In K3-1 system, pressure testing of every 300 m length at 1.5 times the design pressure was carried out from between 29th December 2001 to 11th January 2002 in the presence of PCERWASS and the JICA study team. Following the pressure testing, disinfecting was undertaken in the G2 and K3-1 system subjecting all the relevant parts of the pipelines to a 50-mg/l solution for 24 hours. After disinfecting the system the residual chlorine content was reduced to below 1 mg/l.

(9) Preliminary Design and Actual Construction

The following table shows major technical design changes or modification during the construction period of the 2 model plants compared with the preliminary design of the study team.

Table 5.5 Preliminary Design and Actual Construction

System	Work Item	K3-1			
		Content	Original	Actual	Reason
K3-1	Public tap	Quantity	45 sets	50 sets	Request from CPC and villagers
	Distribution pipe	Material, spec.	PE D75 and D50	HDPE D75 and D50	Stronger than PE
	Distribution pipe	Material, spec.	PE D65	HDPE D63	Stronger than PE and local availability
	Distribution pipe	Material, spec	PE D25	HDPE D32	Stronger than PE and local availability
	Iron treatment plant	Item	None	Aeration & slow sand	Remove iron contents
	Distribution pipe	Material, spec.	PE D40	HDPE D50	Local availability & hydraulic calculation

5.3.3 Water Tariff and Financial Sustainability

The water tariffs were initially set by the study team consulting with CPC/TPC. The situation as at December 2001 was as follows:

Table 5.6 Water Tariff

System	**Estimated users**	**Average water use (lpcd)**	**Water sales volume (m^3/day)**	**Water Tariff (VND/ m^3)**	**Total annual revenue (MVND/y)**	**Estimated annual expenditure (MVND/y)**	**Annual balance (MVND/y)**
K3-1	2164: 25% HC and PT 75%	35 for HC 15 for PT	38	2000	27.5	26.6	**0.97MVND**

HC: house connection
PT: public tap

While the calculated annual balance for the K3-1 system is positive, that for the G2 system is negative. In order to meet the balance between the revenue and expenditure including the re-investment cost, the rate of house connections should be increased for the G2 system. Unless the 50 public taps are properly managed and water tariffs are collected by the local people in K3-1, the water supply systems account will fall into deficit.

The present house connections of the K3-1 and G2 systems are reportedly 2 and 26, respectively. The calculations for the estimated water tariffs will become 2000 VND/m3 for K3-1, and 3000 VND/m3 at these house connection levels.

The study team has strongly emphasized, to WSUs and PCERWASS, the necessity for more house connections to maintain sustainable management. IEC activities are the most important method of achieving the target number of house connections.

The monitoring of the management of WSU will continue in order to improve the economic evaluation.

5.3.4 Water Supply Management Unit

After the discussions with CERWASS Hanoi and CPC, the Water Supply Unit (WSU) was established for the management of the water supply facilities during the construction stage.

The job positions and their duties were decided in the presence of JICA study team at the pilot model construction stage as follows.

Water Supply Unit of K3-1

Board of WSU: - two persons selected from users
- three persons selected from CPC

- Manager	Half day work only
- Accountant	Half day work only
- Operator	Full time work
- Inspector	Half day work only

Transfer of technology and know-how of O/M to the WSU staff was carried out by the contractor and the JICA study team. The O/M manual and monitoring forms are provided in Appendix 8-9 in Supporting Report-B. The training for periodical water quality checks using portable kits was introduced to the operator of each WSU.

5.3.5 On-going IEC Activities

The IEC activities are undertaken by Gia Lai PCERWASS in K3-1 and G2.

The following personnel who can speak both the Kinh and the ethnic minority languages are engaged in IEC:

K3-1: Doctors and nurses in the health center
G2: Former vice-chairman of CPC

The information to be distributed included:

1) the objectives of the piped supply system,
2) the master plan drawings,
3) the implementation schedule,

4) the results of the water quality analysis,
5) the benefits of safe and clean water,
6) the costs for house connections and the water tariff,
7) how to reduce the cost for the management of the water supply system
8) how to keep the environment clean, and
9) the responsibilities of the local people.

5.4 Percentage of House Connections

The most crucial issue is how to increase the number of house connections. The willingness to pay in the social survey is relatively positive.

As a result of IEC activities in the two pilot model areas, the number of house connections have increased, which will raise the revenue level. It is recommended that the Vietnam government pay for the IEC promoters. It is strongly recommended that PCERWASS be involved in more IEC activities.

There are two two households in K3-1 which already had house connections as at 29 January 2002. The installation of 5 additional public taps was requested by the study team from CPC because the target area is mostly composed of poor and very poor minority households. Some additional houses were willing to connect to the piped system in K3-1 system, but as at the end of Jan. 2002 no progress had been made. Three were connected by the end of May 2002.

In the G2 area, there were twenty-six households which already had house connections on 29 January 2002 (out of 138 houses, i.e. 19%). This grew to 38 households by the end of May 2002 (27%). The planned coverage for the house connections is 70%. According to the social survey and interviews in the model areas, high willingness for the house connections was reported and designs for as many as 100 house connections have been completed. More intensive IEC activities are imperative in G2.

The capacity building of PCERWASS with regard to financial sustainability, O/M, and IEC is urgent. Regular training at CERWASS Hanoi for PCERWASS, and more involvement by PCERWASS for IEC and technical issues is recommended.

5.5 Local Construction Skills and Materials

In Vietnam, a numbers of construction companies exist as listed below:

1) General construction companies located in Hanoi and Ho Chi Minh - 9

2) Medium sized construction companies in Da Nan, Nya Tran and Da Rat cities - 7
3) Construction companies for water supply systems in the target provinces which have experience of similar projects:
   - Construction Enterprise for Water Supply (Buon Ma Thout city)
   - Tan Viet Groundwater construction company (Buon Ma Thout city)
   - Thien Trung construction company (Buon Ma Thout city)
   - Gia Lai State Enterprise in Mechanical Services (Pleiku)
   - Subdivision No. 709 (Pleiku)
   - Gia Lai Construction and Electric Assembly Company (Pleiku)

The pilot model plants were constructed by local contractor, Gia Lai Construction and Electric Assembly Company (from Pleiku City, Gia Lai Province). The following table summarizes an evaluation of the local contractor in the course of construction and supervision of the pilot models from November 2001 to December 2001:

Table 5.7 Results of Evaluation

Evaluation items	Evaluation
Understanding of contract	Still needs experience
Cost proposal	On-time, acceptable
Document preparation	Speedy, acceptable but needs English up-skilling
Construction material preparation	Speedy and acceptable
Worker organization skill	Speedy and acceptable
Construction schedule	Followed the target schedule, acceptable
Understanding of progress meeting	Clearly understood
Quality control	Understand, but needs more attention at site

It is considered that a simple system for rural water supply could be constructed by the local contractors. Almost all of the construction materials for the rural water supply facilities are available in the local markets of Vietnam, except the submersible pump motors and control panels. Water meters are also available from Assembly Company in line with the licensed production of a qualified French Company. Popular water meters for house connection are made in China and India. Both meters were installed in G2 and K3-1 systems.

5.6 Necessary Monitoring Items

Necessary documents for monitoring items are shown Appendix 8-1. The monitoring will be continued by WSU with the help of PCERWASS. The main items are listed below.

Daily operation records

- Pump operation time, production water volume, and meter reading, water loss, conventional water quality test etc. (Form-c1)
- Maintenance records (Form-c2)
- List of summarized pump operation and water production (Form-c3)

Monthly records

- Monthly report for new user registrations and remarkable O/M topics
- Records of every user (water meter reading)
- Records of water charge collections
- Account records (revenues and expenditures)
- Diseases and number of patients

5.7 Results of the Monitoring of O&M

5.7.1 Purpose and Methodology

A follow-up mission to collect management and operation experience from the pilot models in Dak Ui (K3-1) and Nhon Hoa (G2) was undertaken by Mr. Pham Anh Dung (CERWASS) and the Study Team Member (Mr. Hannu Vikamn) in the period 4 - 8 May 2002. The mission collected records and documents from the two Water Supply Units (WSUs) interviewed the managers and staff of the WSUs as well as customers, and visited sites, including pumping stations, treatment plant (in K3-1), public taps and private connections. The operation data was summarised in Table 5.8 for K3-1 system.

5.7.2 Progress and Status

Both pilot models came into operation by the end of January 2002. Along with official handing-over, a water quality kit and a set of manuals, model reports, records and documents were distributed to the WSUs.

The institutional capacity of both WSUs needs further building. Both WSUs have managed to operate and maintain the system and collect revenues.

A problem was exacerbated by the status of PCERWASS of Kon Tum. The experience and capacity of PCERWASS is not up to the level of its counterpart in Gia Lai. Furthermore, PCERWASS of Gia Lai was involved in the implementation of the pilot model at Dak Ui, which has probably resulted in some confusion and misinterpretation of the responsibilities by PCERWASS of Kon Tum. The mission tried to clarify the situation and requested Kon Tum PCERWASS to closely follow-up and support the WSU and the People's Committee in Dak Ui.

The total number of house connections in G2 is 38 as at 8 May. There also three public taps at schools and a "public" tap at the market managed and operated by a vendor. The estimated number of beneficiaries, i.e., people using water from the scheme in G2 (excluding customers of the vendor) is about 170.

As shown Table 3.8, both schemes have been operated more or less on a daily basis. Interviewed customers reported to have benefited from almost uninterrupted service in both communes. Interruptions in K3-1 were explained as having resulted from power failures (one power failure occurred during a site visit) and few interruptions in G2 arose from the installation of new customer connections.

Since the beginning, the total pumped water volumein K3-1 until May 07 has been about 4,500 m^3. Meters have been read twice. Based on very limited and partly questionable data from the end of March, "sold" water (so far unbilled but metered) was about 930 m^3 against the total pumping of about 1700 m^3. This suggests that non-revenue water is some 45%. The most significant single reason for high losses was substantial overflow from the treatment plant, due to long pumping periods. Communication has now been improved and there has been no overflowing since June 2002.

The total pumping from the beginning until May 08 in G2 has been about 1,800 m^3. WSU has maintained quite reliable monthly records. According to these records, the water use between January 27 and April 30 totalled 1,355 m^3 while the metered water use in the same period was 1,182 m^3, a difference of 13%.

The tariff in G2 is VND 2,000 per m^3 and in K3-1 1,500 per m^3. The tariff in G2 could provide sustainable financial status if the number of house connections and the volume of sold water increased closer to the capacity of the system. The tariff of VND 1,500/ m^3 in K3-1 and its water sales are almost equal to the original estimate for the first year due to high water consumption volume, though the house connection number is limited at present. IEC activities are important to increase the house connection.

According to the water analysis reports the water quality in both schemes is in compliance with the Vietnamese and international water quality standards. However, users in G2 have complained about water quality. Although some nitrites were identified at the beginning of the operation, repeated sampling and analysis managed by PCERWASS showed that no further occurrence. After boiling, a small volume of white/greyish sedimentation can be observed at the bottom of vessels. It is possible and even likely that the problem is mainly aesthetic and does not involve any risks. The most probable cause is calcium.The mission took samples to be analysed in Buon Ma Thuot, Hanoi and Tokyo. The result is shown in Data Book "Water Quality". The water quality in G2 as perceived by the customers is, however, restricting the interest of existing customers to use water and potential new customers to register. The results have confirmed that the water quality in G2, on the basis of the analysed parameters; i) does not constitute any risk for human health, ii) is in compliance with Vietnamese water quality standards (Standard 5050 of MOH) as well as international standards and guidelines (WHO, EU, EPA of USA, etc), and iii) is not affected by high iron concentrations of any substances that could explain the white/greyish sedimentation. Similar problems are often caused by high hardness, but analysed hardness (about 50 mg/l) and concentration of calcium (about 5 mg/l) in G2 are not sufficient to explain the cause of sedimentation. It is very likely that the problem is mainly aesthetic and does not involve any risk.

The mission did not observe any wastage of water by users. For example, there were no taps of public water points left opened. In K3-1, some civil works of public water points have been partly damaged.

Issues

The issues at G2 include water quality , lack of potential customers along pipelines (designed to serve minority population), manual pump operation (resulting in overflows) and pending action on establishment of rules, proper accounting, and more detailed data base on customers.

There are more issues in K3-1. The most serious are related to low level of system management.

There is rubbish (leaves and small branches from nearby trees) in the filter basin of the treatment plant. The WSU constructed a cover after obtaining the necessary money at the beginning of June 2002. Manual pump operation in K3-1 is not practical due to the location of treatment plant some distance from the pumping station. The percentage of water losses and excessive pumping suggest that there is an urgent need to improve cost-consciousness by the WSU. JICA Study Team donated a set of transceivers recently (June 2002) to WSU of K3-1 system as a communication tool between the reservoir tank (iron removal treatment) and pump station.

The time frame for information, education and communication (IEC) has been too short to achieve good results. For example, customers of K3-1 said that the water quality is very good, yet some of them (even teachers) preferred to drink water from shallow wells, due to the taste that they were used to (saying that the piped water "did not taste sweet"). Further IEC is definitely needed. This will take time whereas the capacity building of WSUs is a more urgent matter.

5.8 Lessons Learned

5.8.1 Institutional Aspects

Some of the communes in the area selected for the Study, (Dak Ui - K3-1), have been generously supported by the Government of Vietnam through free or highly subsidized investments and services.

The problems encountered in K3-1 may partly be explained by the limited capacity of Kon Tum PCERWASS.

It is obvious that in a situation where both extensive infrastructure building and changing of inhabitant's attitudes are still required at the provincial level, it is difficult to expect that the district level could have substantial role in supporting communes, WSUs and users. It will take time, probably several years, before the Units of Agriculture and Rural Development in the district will be developed enough and prepared to play the role suggested in the NRWSS. It is strongly recommended that CERWASS shall technically support to PCERWASS, and PCERWASS should train to WSU for the both aspects of technical and managerial viewpoints.

5.8.2 Financial Aspects

The tariff of VND 2,000/m^3 in G2 is sufficient for financial sustainability even for the financing of re-investment in longer term even though the number of house connections is still less than half of the estimated average of the first year. The tariff of VND 1,500/m^3 in K3-1 is enough for salary, electrical charges payment and small amount of repair. Excessive pumping, the very low number of metered house connections and extremely low start in billing and collection make the situation even worse, and the sustainability is at risk. The short period of operation of the pilot models also does not provide for sufficient information. In future, People's Committee should support to WSU for sudden requirement of replacement for submersible pump etc.

5.8.3 Technical Aspects

One of the most serious technical problems is the vulnerability of power supply. The unreliability of power supply is an external factor. Its impacts can be reduced, however, by taking its impacts into account in the design of the water supply schemes.

Experience from the first few months of operation shows that pumps can be operated manually reasonably well (in G2). On the other hand, operation practice in K3-1 has ignored wastage of water and energy, even though the volume of the reservoir in K3-1 is significant and should allow more accurate optimization of pumping than in G2. The study team supplied the transceiver for proper pump operation to the both WSUs. An automatic pump switch on/off device may be required for other systems.

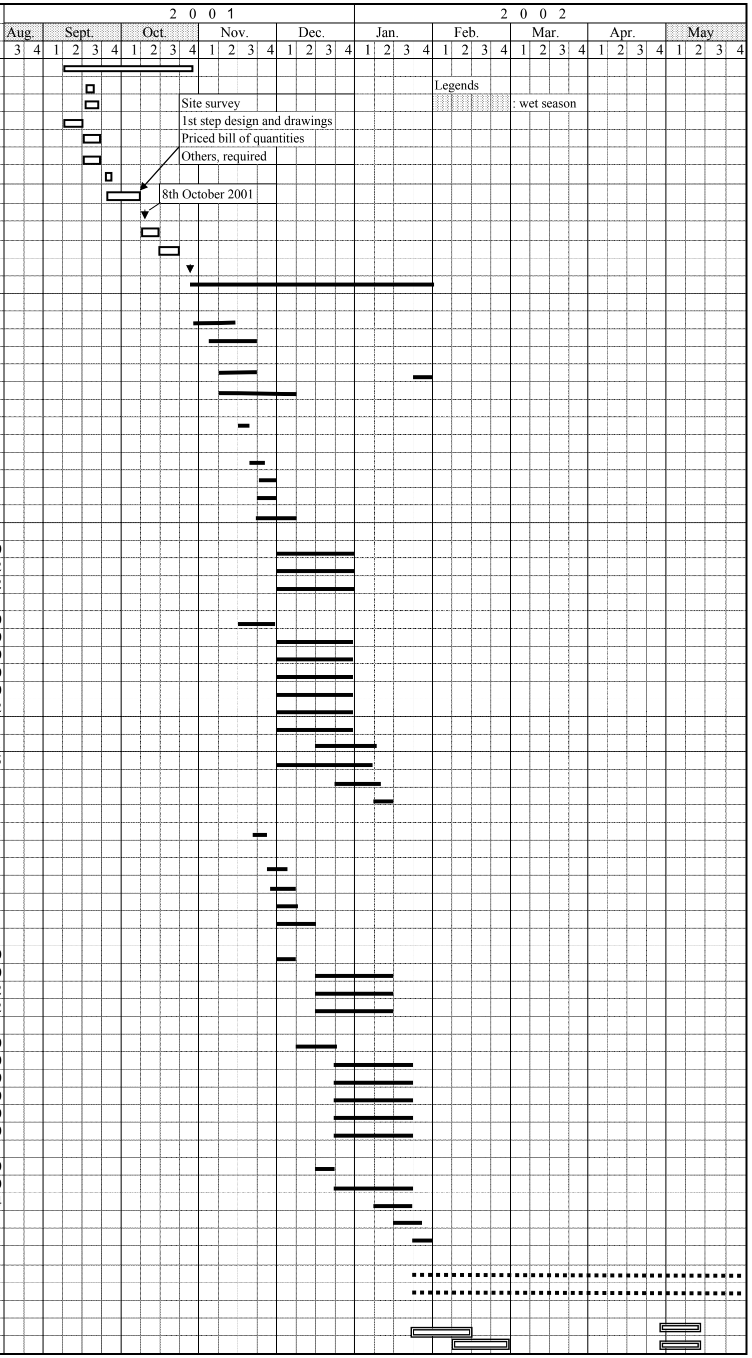
It is vital that the WSU is able to make connections and repair broken pipelines.

Table 5.8 Daily operation record

Month	Date	Time (min)	F (s)	F (e)	F (m^3)	Power (s)	Power (e)	Power (kWh)	F (m^3/d)	Day	F (m^3/h)	E (kWh/m^3)
	26	710	1685	1793	108	251	292	41		Tue	9.1	0.38
	27	595	1793	1889	96	663	667	4		Wed	9.7	0.04
	28	650	1889	1819	-70	624	711	87		Thu	-6.5	-1.24
	29	0	1819	1819	0			0		Fri	0.0	#DIV/0!
	30	0	1819	1819	0			0		Sat	0.0	#DIV/0!
	31	615	1930	2020	90	729	772	43		Sun	8.8	0.48
Apr	1	660	2020	2124	104	772	791	19		Mon	9.5	0.18
	2	680	2124	2202	78	213	242	29		Tue	6.9	0.37
	3	715	2202	2324	122	281	294	13		Wed	10.2	0.11
	4	320	2324	2367	43	195	134	-61		Thu	8.1	-1.42
	5	665	2367	2422	55	934	952	18		Fri	5.0	0.33
	6	740	2422	2554	132	919	959	40		Sat	10.7	0.30
	7	0	2554	2554	0			0		Sun	0.0	#DIV/0!
	8	715	2554	2636	82	102	102	0		Mon	6.9	0.00
	9	0	2636	2636	0			0		Tue	0.0	#DIV/0!
	10	745	2636	2729	93	102	113	11		Wed	7.5	0.12
	11	660	2729	2801	72	111	114	3		Thu	6.5	0.04
	12	405	2801	2863	62	114	116	2		Fri	9.2	0.03
	13	450	2863	2928	65	116	119	3		Sat	8.7	0.05
	14	550	2928	3014	86	119	124	5		Sun	9.4	0.06
	15	670	3014	3123	109	124	129	5		Mon	9.8	0.05
	16	n.a.	3123	3123	0	129	132	3		Ti	0.0	#DIV/0!
	17	365	3123	3183	60	132	152	20		Wed	9.9	0.33
	18	0	3183	3183	0			0		Thu	0.0	#DIV/0!
	19	710	3183	3349	166	135	139	4		Fri	14.0	0.02
	20	310	3349	3396	47	139	142	3		Sat	9.1	0.06
	21	530	3396	3474	78	142	145	3		Sun	8.8	0.04
	22	0	3474	3474	0			0		Mon	0.0	#DIV/0!
	23	605	3474	3558	84	145	149	4		Tue	8.3	0.05
	24	580	3558	3639	81	149	153	4		Wed	8.4	0.05
	25	705	3639	3724	85	153	157	4		Thu	7.2	0.05
	26	510	3724	3787	63	157	160	3		Fri	7.4	0.05
	27	710	3787	3793	6	160	164	4		Sat	0.5	0.67
	28	710	3793	3883	90	164	168	4		Sun	7.6	0.04
	29	0	3883	3883	0			0		Mon	0.0	#DIV/0!
	30	465	3883	3966	83	168	171	3		Tue	10.7	0.04
May	1	450	3966	4040	74	171	174	3		Wed	9.9	0.04
	2	495	4040	4087	47	174	177	3		Thu	5.7	0.06
	3	0	4087	4087	0			0		Fri	0.0	#DIV/0!
	4	630	4087	4156	69	177	182	5		Sat	6.6	0.07
	5	1480	4156	4367	211	182	187	5		Sun	8.6	0.02
	6	740	4367	4476	109	187	1020	833		Mon	8.8	7.64

Figure 5.1 Schedule of Model Plants Construction in Dak Ui (K3-1) and Nhon Hoa (G2) Communes

			Activities / Construction Items / Work Items	Unit	Q`ty
A	**Pre-construction activities**				
	a)	Preparation of Candidate Subcontractor`s List		LS	1
	b)	Selection of Candidate Subcontractors		LS	1
	c)	Preparation of Sub-Contarct Agreement and Terms of Reference (TOR)		LS	1
	d)	Approval of JICA for Sub-Contract Agreement and TOR		LS	1
	e)	Review & Acknowledgement by CERWASS for Sub-Contract and TOR		LS	1
	f)	Distribution of TOR to Candidate Sub-Contractors		LS	1
	g)	Preparation of Proposals by the Candidate Sub-Contractors		LS	1
	h)	Closing Date of Submission of Proposals		LS	1
	i)	Assessment of Proposals / Recommendation to JICA		LS	1
	j)	JICA`s Concurrence and Approval		LS	1
	k)	Conclusion of Sub-Contract Agreement		LS	1
B	**Construction**				
	B1	Survey and design, K3-1 and G2			
		1)	Topographic survey	LS	1
		2)	2nd step design	LS	1
	B2	Mobilization, Demobilization and Procurement, K3-1 and G2			
		1)	Mobilization / Demobilization		
		2)	Procurement of pump, pipes, fittings and others		
	B3	K3-1 Dak Ui Commune (No. 1A, 1B, 5B, 6 and 7, Peak demand : 2.0 m3/h)			
		1)	Well head arrangements	LS	1
		2)	Raw water pump, furnishing and installation		
			- Submersible pump, 1.0 l/s x 70 m	no.	1
			- Control panel, motor protection, motor cable of 100 m	no.	1
		3)	Power supply from national grid	LS	1
		4)	Storage reservoir, 5 m3 tank, valves, bends & others	LS	1
		5)	Raw water main, furnishing and installation		
			- GI materials, 100 mm dia.	lin.m	1,400
			- Sector valves, 100 mm dia	no.	2
			- Valve chambers, bends 90 degrees, each	no.	2
		6)	Distribution pipes, furnishing and installation		
			- Clearing of piperoute	sq.m	12,000
			- PVC w/valves, 100 mm dia.	lin.m	600
			- PE w/valves, 90 mm dia.	lin.m	500
			- PE w/valves, 65 mm dia.	lin.m	1,600
			- PE w/valves, 50 mm dia.	lin.m	3,200
			- Valve chambers	no.	12
			- bends and tees	LS	1
		7)	Small distribution pipes and valves	LS	1
		8)	Public taps, type 3, w/meter	no.	45
		9)	Pressure testing	LS	1
		10)	Disinfection	LS	1
	B4	G2 Nhon Hoa Commune (Plei Kia & Hoa An Villeges, Peak demand : 1.1 m3/h)			
		1)	Well head arrangements	LS	1
		2)	Raw water pump, furnishing and installation		
			- Submersible pump, 1.0 l/s x 70 m	no.	1
			- Control panel, Motor protection, motor cable of 200 m	LS	1
		3)	Power supply from national grid	LS	1
		4)	Storage reservoir, 5 m3 tank, valves, bends & others	LS	1
		5)	Raw water main, furnishing and installation		
			- Clearing piproute	sq.m	1,000
			- GI materials, 100 mm dia.	lin.m	500
			- Sector valves, 100 mm dia	no.	2
			- Valve chambers, bends 90 degrees each	no.	2
		6)	Transmission pipes w/valves, bends and tees		
			- Clearing of pipe route	sq.m	7,000
			- PVC, 150 mm dia., furnishing and installation	lin.m	600
			- PE, 100 mm dia., furnishing and installation	lin.m	500
			- PE, 65 mm dia., furnishing and installation	lin.m	1,600
			- PE, 50 mm dia., furnishing and installation	lin.m	1,500
			- PE 40 mm dia., funishing and installation	lin.m	1,500
		7)	Distribution pipes		
			- Clearing of piperoute	sq.m	3,000
			- PE w/valves, bends 25 mm dia., furnishing and installation	lin.m	800
		8)	Public taps, type 3, w/meter	no.	4
		9)	Pressure testing	LS	1
		10)	Disinfection	LS	1
C	**Operation and Maintenance of Model Plants and Its Monitoring**				
	C1	K3-1 Dak Ui Commune		LS	1
	C2	G2 Nhon Hoa Commune		LS	1
D	**Intermediate Assessment of Model Plant**				
	D1	K3-1 Dak Ui Commune		LS	1
	D2	G2 Nhon Hoa Commune		LS	1



Chapter 6 Recommendations for Implementation Schedule and Method

6.1 Grouping of the Priority 21 Systems

In the feasibility study, the priority 21 systems were prioritised. Based on the prioritisation, two systems were selected for the Pilot Model Project in order to test the plan and to identify unknown problems during the study period.

The Pilot Model project suggested that careful consideration should be given to organisational aspects related to local entrenched habits that require changing

Another grouping of the 21 systems has been considered for the purpose of budgetary arrangement and consequently for the implementation priority. The following three aspects were taken into account for the grouping.

- Feasibility evaluation (Prioritisation)
- Results of the Pilot Model Project
- Equal opportunity for the targeted 3 provinces
- Requests from Vietnam Government

The 21 systems were grouped into 4 groups (A, B, C and D) as shown in the Table 6.1. The following explains the reasons for the grouping for each province:

In the previous Chapter 4.6 "Result of Feasibility Evaluation" for Kon Tum province, K4-1 system was ranked as the Group B, followed by K1-1, K2-1, K2-3 and K3-1 systems (ranked as the Group C). However, there is an opportunity for K2-3 to be combined with the ADB town water supply project in terms of WSU, water tariffs and O&M staff. The town water system will have a much higher sustainability than that of the small commune. Therefore, the K2-3 system will be advanced to top priority, from a sustainability point of view, ahead of K4-1, then K3-1, K1-1 and K2-1.

Table 6.1 Plan of Phased Implementation of 21 Systems

Table 6.1 Plan of Phased Implementation of 21 Systems

Step	Implementation period	Group	Kon Tum	Gia Lai	Dac Lac	Number
1	2002-2005	A	K2-3	G2, G3-1	D1, D2	5
2	2004-2006	B	K4-1	G1, G4-1	D3-1, D6	5
3	2005-2008	C	K3-1	G5-1, G6-1	D4-1	4
4	2007-2010	D	K1-1, K2-1	G7-1	D3-2, D4-2, D5-1, D7	7

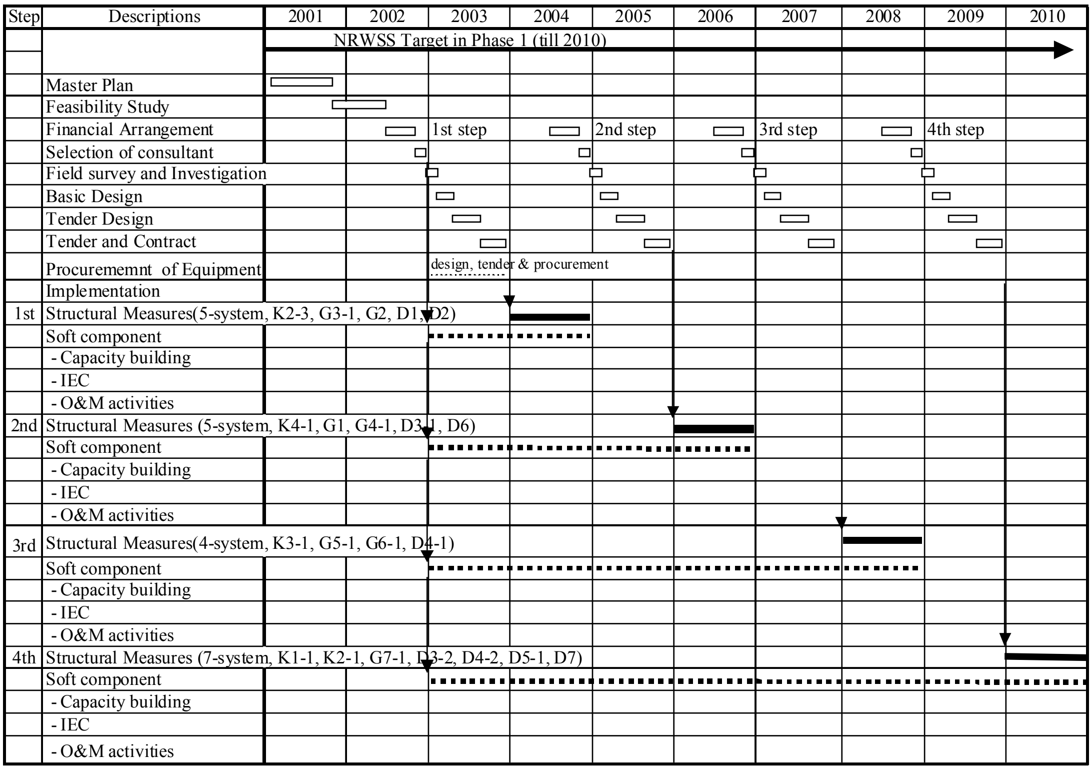
6.2 Implementation Plan

For the consideration of a phased implementation plan, three cases (implementation in 2 steps, 3 steps and 4 steps) were considered. Out of these three cases, implementation in 4 steps was considered to be most appropriate taking into account sustainability and preparedness of communes.

The phased implementation plan is presented in Table 6.2. With this implementation schedule, systems with a high preparedness of inhabitants can be implemented at early stages, while systems with low preparedness of inhabitants may be implemented at a later stage, after sufficient IEC campaign to raise preparedness to a sufficient level.

In case of Kon Tum province, the systems of K2-3, K4-1 and K3-1 were listed to be implemented with step 1, step 2 and step 3 in order, by the request from PCERWASS, Kon Tum. Because these systems have less sustainability for financial and technical points, K2-3 system in step 1 has been combined with the ADB town water supply project. The K4-1 and K3-1 systems in step 2 and step 3 should be financed (WSU's staff salaries and emergency expenditures for their operation) by consolidated subsidy from the Vietnamese government.

Table 6.2 Implementation Schedule for 21 systems



6.3 Collaboration with ADB Project

Though the systems in Kon Tum province were considered to be unsuitable for immediate implementation, the K2-3 system was selected with conditions. The system shall be combined with the on-going ADB town water supply project that will be constructed in the year 2003. The treated water reservoir tank of the ADB project will be connected to the K2-3 system and a distribution system then installed to the area. The O&M methods, including decisions on water tariff, billing, collection of water charge and accounting will strictly follow the ADB town WSU's procedures. The joint operation of the town system and the K2-3 system will continue until the full design capacity of the reservoir tank of the town water supply is reached. When the joint capacity of the reservoir tank is almost fully used, a decision will have to be made on whether to invest in additional capacity for the town system or to develop the K2-3 system independently. Transfer of knowledge and capacity building of PCERWASS in Kon Tum will be ensured through the ADB project (town water supply system) and the K3-1 pilot model. After reaching an adequate level of O&M, technology and financial management, the K3-1system can be implemented.

6.4 Allocation of the Project Cost

The construction cost for the development of the 5 prioritized systems has been estimated for a service coverage of 86 % of the population in the targeted communes and provinces of the Central Highlands.

The project cost is summarized in Table 6.3 and meets the 4-step proposed implementation up to the year 2010 in line with the NRWSS strategy.

Table 6.3 Cost of the 21 Piped Water Supply Schemes

US$ 1.0=VND 15,000.0=JY 120.0

No.	No.	System No.	Name of Commune	Construction Cost (US$)*1	Base Cost (US$)*2	Project Cost (US$) *3				
						1st step	2nd step	3rd step	4th step	step 1 to 4
						5-system	5-system	4-system	7-system	21-system
						2002-2004	2004-2006	2006-2008	2008-2010	2002-2010
		Kon Tum		**2,140,805**	**2,461,926**	**561,334**	**581,175**	**259,908**	**1,305,702**	**2,708,119**
1	1	K1-1	Bo Y	875,885	1,007,268				1,107,995	1,107,995
2	2	K2-1	Dak Su	156,290	179,734				197,707	197,707
3	3	K2-3	Dak Su	443,742	510,303	561,334				561,334
4	4	**K3-1**	Dak Ui	205,461	236,280			259,908		259,908
5	5	**K4-1**	Dak Hring	459,427	528,341		581,175			581,175
		Gia Lai		**3,392,611**	**3,901,503**	**2,098,521**	**1,205,832**	**699,827**	**287,473**	**4,291,653**
6	1	**G1**	Kong Tang	607,639	698,785		768,663			768,663
7	2	**G2**	Nhon Hoa	1,064,964	1,224,709	1,347,179				1,347,179
8	3	**G3-1**	Chu Ty	593,946	683,038	751,342				751,342
9	4	**G4-1**	Thang Hung	345,588	397,426		437,169			437,169
10	5	**G5-1**	Ngia Hoa	340,560	391,644			430,808		430,808
11	6	**G6-1**	Ia Rsiom	212,663	244,562			269,019		269,019
12	7	G7-1	Kong Yang	227,251	261,339				287,473	287,473
		Dac Lac		**4,515,889**	**5,193,272**	**1,982,864**	**1,153,380**	**688,513**	**1,887,841**	**5,712,598**
13	1	**D1**	Krong Nang	640,632	736,727	810,399				810,399
14	2	**D2**	Ea Drang	926,850	1,065,878	1,172,465				1,172,465
15	3	**D3-1**	Krong Buk	337,039	387,595		426,354			426,354
16	4	D3-2	Krong Buk	321,530	369,760				406,735	406,735
17	5	**D4-1**	Ea Drong	544,279	625,921			688,513		688,513
18	6	D4-2	Ea Drong	246,098	283,013				311,314	311,314
19	7	D5-1	Ea Wer	566,628	651,622				716,784	716,784
20	8	**D6**	Kien Duc	574,724	660,933		727,026			727,026
21	9	D7	Krong Kmar	358,109	411,825				453,008	453,008
		Total		**10,049,305**	**11,556,701**	**4,642,719**	**2,940,387**	**1,648,248**	**3,481,016**	**12,712,370**
		VAT (10 %)				**360,423**	**239,033**	**130,296**	**275,179**	**1,004,931**
		Total				**5,003,142**	**3,179,420**	**1,778,544**	**3,756,195**	**13,717,301**

Note: *1 Construction cost

*2 Base cost = Construction cost + Land acquisition cost + Engineering services cost (15 % of construction cost)

*3 Project cost = Base cost + Physical contingency (10 % of base cost), excluding price contingency

6.5 Procurement of Necessary Drilling Equipment

The drilling rigs and all equipment used for the study were old and were subject to many mechanical troubles. They have been used for more than 25 years and were donated by the former Soviet Union. Resuming work for well construction after core drilling took much time and effort. Although aquifers were found at approximate 200m depth in Gia Lai province, it was difficult to ream the full depth. The generator, air compressor and electrical logging instruments are old, have small capacity, and are in extremely poor condition.

The Vietnamese authorities considered the equipment would be suitable for the required drilling work provided repairs were undertaken promptly and the equipment was well maintained. In order to improve their drilling work, procurement of a new set of drilling equipment should be considered for the implementation stage. The equipment can be effectively utilized by the Vietnamese authorities after the first implementation, particularly for the financially and economically disadvantaged areas.

The procurement cost of one lot of drilling equipment in the first step was estimated at US$ 2.8 million by ex-go-down Yokohama Port basis.

Chapter 7 Project Evaluation

The project was evaluated from several points of view.

7.1 Contribution to the National Strategy

National Strategy for water supply (NRWSS) set up a target that 85% of the total population should be supplied with water by the year of 2010 (Phase-1). The project was programmed in accordance with the national strategy. Implementation of the project will contribute to the achievement of the target.

7.2 Demonstration Effects as Model Projects

The NRWSS also set up a target that the 100 % of the population should be water supplied by the year of 2020 (Phase-2). Although the study did not include Phase-2 in the feasibility study, implementation of Phase-1 will have positive impacts on the neighbouring communes. It is expected that the project could encourage the neighbouring inhabitants to increase their motivation and to prepare themselves for water supply projects. This could lead to the implementation of Phase-2 projects, which would contribute the full achievement of the national strategy.

7.3 Technical Aspects

Wherever possible, simplified designs were adopted for the water supply facilities to minimize operation and maintenance requirements. Locally available materials were also applied wherever possible. Therefore, the design and concept can also be introduced not only to the second stage (Phase-2) but also to the other unrelated projects. It is considered that the design concept of the project will contribute the technical development of the country. New technology using solar power and related pump systems can be introduced to reduce the running cost for the systems in the poor communes and improve the environmental effect by using clean energy.

7.4 Operation and Maintenance Aspects

The Study proposed organisational arrangement and introduction of comprehensive IEC campaigns. Through the implementation of the arrangement, organisational activities at various levels will be stimulated, clear role distinctions will be recognised and definite responsibility of personal can be realised. This positive effect is expected to spread to other fields of activities.

7.5 Environmental and Hygiene Aspects

In all three provinces, rather high ratios of water related diseases are reported. Implementation of the project will provide those inhabitants with clean water and contribute to a decrease in the population suffering from such diseases. In particular, infant mortality can be drastically reduced.

7.6 Social Equality (Help for Ethnic Minorities)

The special issues inherent to the Central Highlands of Vietnam are said to be poverty and minority. Servicing clean water to the poverty areas and minorities is one of the crucial matters for social stabilisation of the area. Equal allocation of natural resources such as water is essential from this point of view.

The issues of poverty and ethnic minorities were taken into account in the selection of the priority projects, and the social equity issues were duly considered;

- Out of the total 4989 poverty households, 74% (3691 households) will be covered by the priority projects selected by the Study in phase 1; and
- Out of the total 10,139 ethnic minority households, 71% (7,174 households) will be supplied by piped schemes in phase 1.

Implementation of the project will accelerate the establishment of a society where every level of population can enjoy equal opportunities.

7.7 Gender Issues

Presently drinking water is delivered from nearby water sources. In dry seasons, water sources are sometimes very far from individual household. Women and children are currently responsible for drawing water. The water drawing activities impose on them physically heavy work and occupy a significant amount of their time. The project will alleviate such heavy work from women and children and create spare time in which women can participate in social activities (such as IEC activity through women's union). Children can also devote more time to schooling.

The implementation of the project will greatly contribute to the gender aspects.

7.8 Total Evaluation

The project, because it is a water supply project for poverty and minority, is hardly justifiable from an economical and financial point of view. Financial subsidies will be required for sustainable operation and maintenance. The Government of Vietnam expresses their firm commitment to subsidies for poor communes when required.

Provided that the initial investment costs and governmental subsidies are available, various unpredictable positive effects are expected. Among those, increasing of the social equality to the poverty and minority, improvement of hygiene conditions, reducing of infant mortality and contributions to gender aspects are significant.

Implementation of the project will contribute to satisfy the basic human needs of the inhabitants of the Central Highlands of Vietnam.