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 G-6 and G-7. 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
Kong Tang Town (G-1)	No Lineament	No Lineament
Nhon Hoa Commune (G-2)	No Lineament	No Lineament
Chu Ty Town (G-3)	No Lineament	No Lineament
Thang Hung Commune (G-4)	No Lineament	No Lineament
Nghia Hoa Commune (G-5)	No Lineament	No Lineament

In the communes/towns of Kong Tang town (G-1), Nhon Hoa commune (G-2), Chu Ty town (G-3), Thang Hung commune (G-4) and Nghia Hoa commune (G-5) no lineament can be detected.

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)

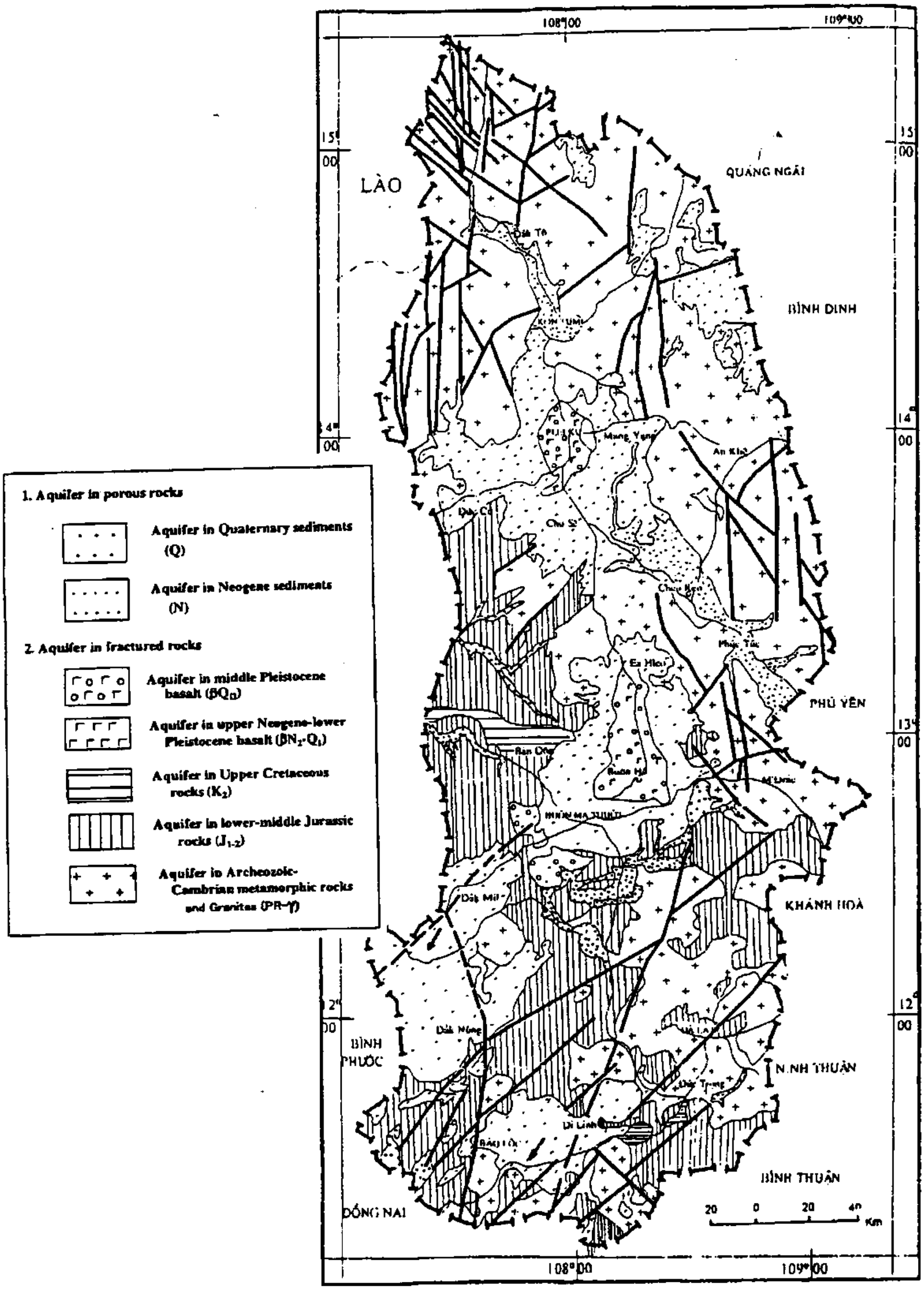

Figure 1.1 Hydro Geological Map of Central Highlands

Chapter 2 Geophysical Prospecting

For the purpose of selection of exploratory (test) drilling sites in the proposed 7 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
Gia Lai	Kong Tang	4	-
	Nhon Hoa	3	7
	Chu Ty	-	51
	Thang Hung	4	-
	Nghia Hoa	-	49
	Ia Rsiom	4	-
	Kong Yang	4	-
Total		19	107

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 107 points were made along 11 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 7 exploratory (test) wells were planned and 7 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 7 exploratory (test) wells were drilled at the 7 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			
G1	Kong Tang	1554896	202592	736	150	112
G2	Nhon Hoa	1499742	185766	421	170	110
G3	Chu Ty	1528374	791729	417	150	85
G4	Thang Hung	1630373	813129	633	180	150
G5	Nghia Hoa	1562211	814529	682	160	135
G6	Ia Rsion	1474169	238141	140	180	158
G7	Kong Yang	1531378	234391	472	160	110

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
G1	Kong Tang	Basalt (β N_2-Q_1)
G2	Nhon Hoa	Basalt (β N_2-Q_1)
G3	Chu Ty	Basalt (β N_2-Q_1)
G4	Thang Hung	Basalt (β N_2-Q_1)
G5	Nghia Hoa	Basalt (β N_2-Q_1)
G6	Ia Rsiom	Quaternary sediment (Q), Jurassic sandstone (N)
G7	Kong Yang	Basalt (β N_2-Q_1)

The geology and well structure of each well are shown in Figures 3.1 to 3.7 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.

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 7.4 to 56 m^2/day. The Quaternary sediments and Jurassic sandstone aquifers of G6 (Ia Rsiom) have higher 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 0.08 to 0.31 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 G4 (Thang Hung) is 0.0018 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.

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
Gia Lai province						
G1	Kong Tang	Basalt	40	34.00	3.0E+1	8.2E-8
G2	Nhon Hoa	Basalt	34	21.00	7.4E+0	2.1E-8
G3	Chu Ty	Basalt	22	22.40	2.2E+1	6.2E-4
G4	Thang Hung	Basalt	50	34.10	6.5E+1	1.8E-3
G5	Nghia Hoa	Basalt	52	32.50	8.9E+0	2.5E-4
G6	Ia Rsiom	Quaternary sediments and Jurassic sandstone	38	24.15	5.6E+1	1.6E-7
G7	Kong Yang	Basalt and granite	34	10.80	2.6E+1	7.2E-4

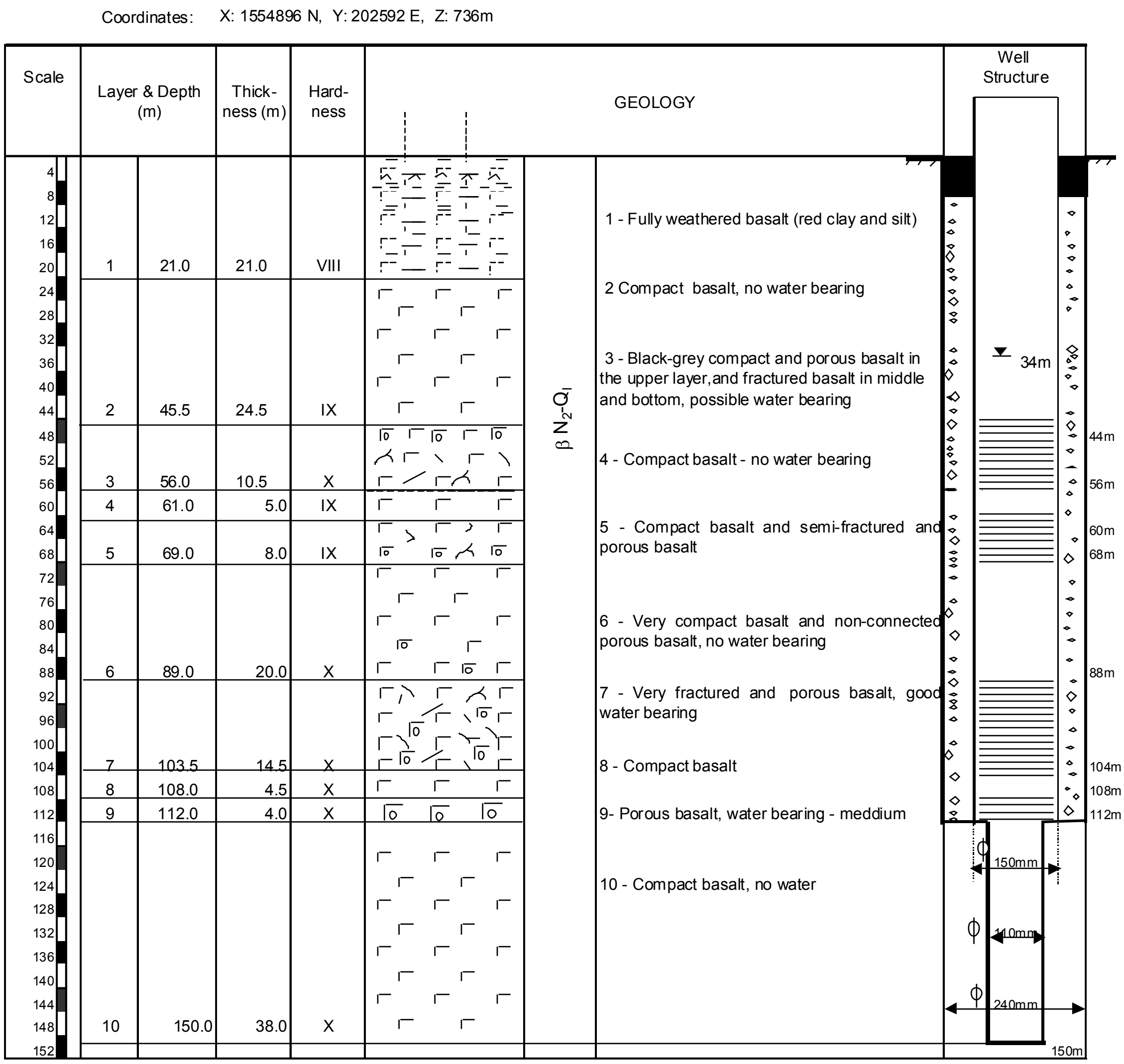

Figure 3.1 Geology and Well Structure of Test Well at Kong Tang Town (G1)

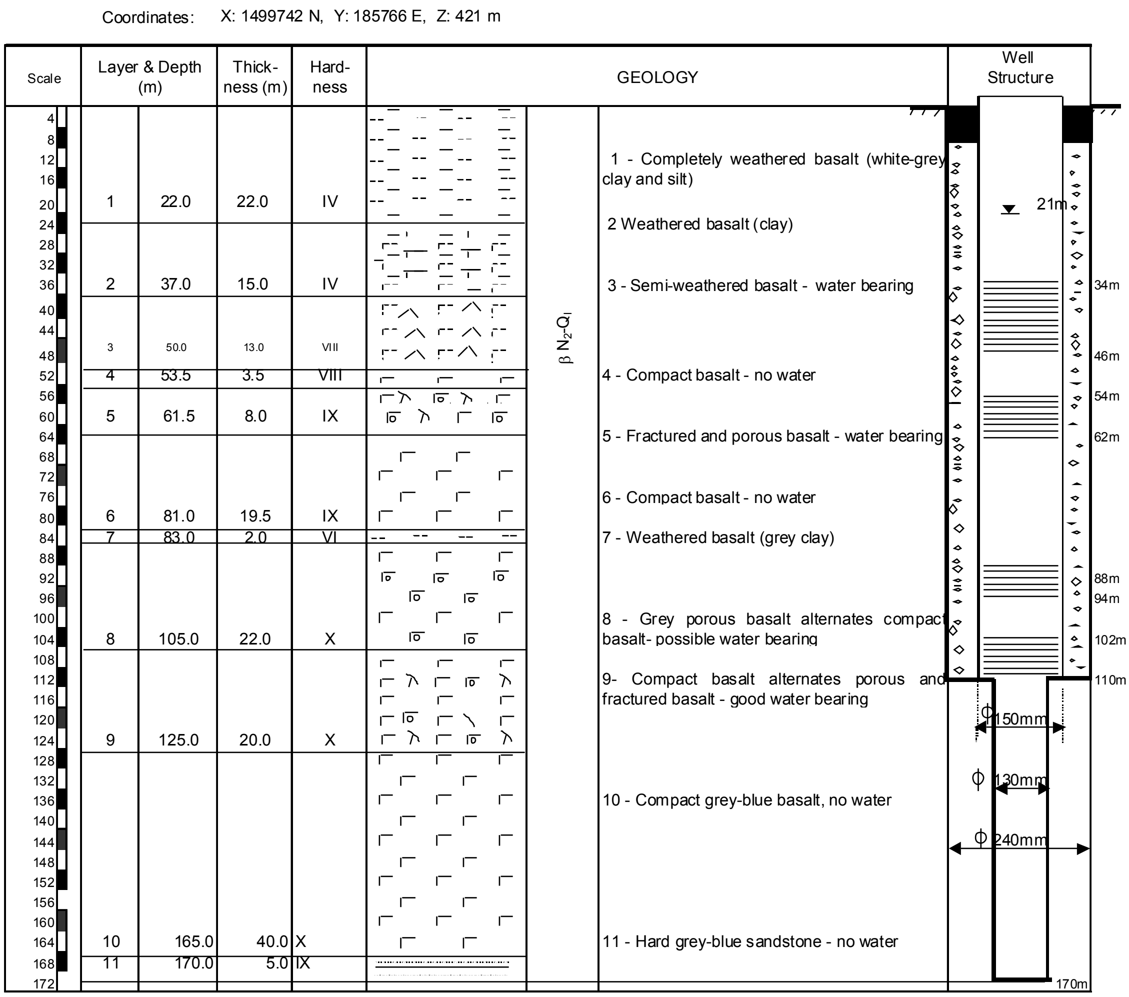

Figure 3.2 Geology and Well Structure of Test Well at Nhon Hoa Commune (G2)

Coordinates: X: 1528374 N, Y: 791729 E, Z; 417m

Layer	Depth (m)	Thickness (m)	Hardness	Age	Geology
1	10.3	10.3	IV	$\beta N_2\text{-}Q_I$	1 - Completely weathered basalt (white-grey clay and silt)
2	26.0	15.7	VIII		2 - Medium-compact basalt, and weathered basalt (red-brown soil) - possible water bearing
3	42.0	16.0	IX		3 - Compact grey basalt - no water bearing
4	48.5	6.5	IX		4 - Porous basalt , small size of pores in the lower part
5	54.2	5.7	X		5 - Very compact basalt - no water bearing
6	68.0	13.8	X		6 - Porous basalt - very small size of pores in the upper part - good water bearing
7	90.5	22.5	X		7 - Compact grey basalt alternates porous basalt
8	119.9	29.4	X		8 - Porous grey basalt
9	124.8	4.9	X		9- Very compact basalt - no water bearing
10	134.7	9.9	VIII		10 - Compact basalt and semi-weathered basalt (red-brown soil)
11	144.0	9.3	X		11 - Porous basalt
12	150.0	6.0	X		12- Compact basalt - no water

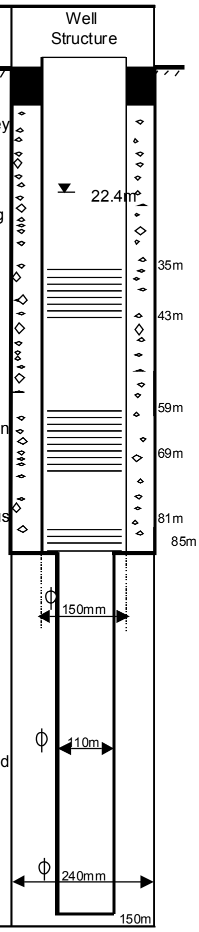

Figure 3.3 Geology and Well Structure of Test Well at Chu Ty Town (G3)

Coordinates: X;1630373, Y: 813129, Z: 633m

Layer	Depth (m)	Thickness (m)	Hardness	Age	GEOLOGY
1	15.0	15.0	III	$\beta N_2\text{-}Q_1$	1 - Completely weathered basalt (red-brown clay and silt)
2	20.5	5.5	III		2 - Medium-compact basalt and weathered basalt (grey-brown clay)
3	31.0	10.5	III		3 - Completely weathered basalt (dark-grey clay)
4	40.5	9.5	X		4 - Compact and non-fractured basalt (dark-grey)
5	62.5	22.0	V		5 - Semi-weathered basalt - possible water bearing. Less weathered basalt in the upper part and the bottom.
6	69.0	6.5	X		6- Compact basalt
7	77.0	8.0	VI		7- Semi-weathered basalt (bright-grey)
8	85.0	8.0	IX		8 - Compact basalt alternates porous basalt - possible water bearing
9	100.0	15.0	X		9- Compact basalt (grey-blue). Some fractures in the upper part.
10	107.0	7.0	V		10 - Semi-weathered bright-grey basalt
11	127.0	20.0	IX		11- Porous and fractured basalt alternates compact basalt- possible water bearing
12	135.0	8.0	X		12- Compact and fractured basalt
13	152.0	17.0	VII		13 - Porous basalt and volcanic tuff - possible water bearing. Small pores in the upper part.
14	164	12.0	X		14 - Compact basalt
15	176	12	V	γ	15- Weathered granite (sand and clay) - possible water bearing
16	180	4	X		16- Granite

Well Structure

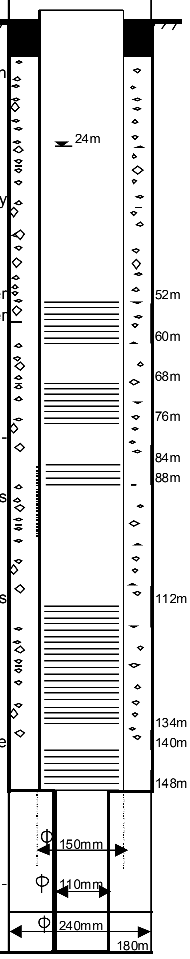

Figure 3.4 Geology and Well Structure of Test Well at Thanh Hung Commune (G4)

Coordinates: X;1562211, Y: 814529, Z: 682m

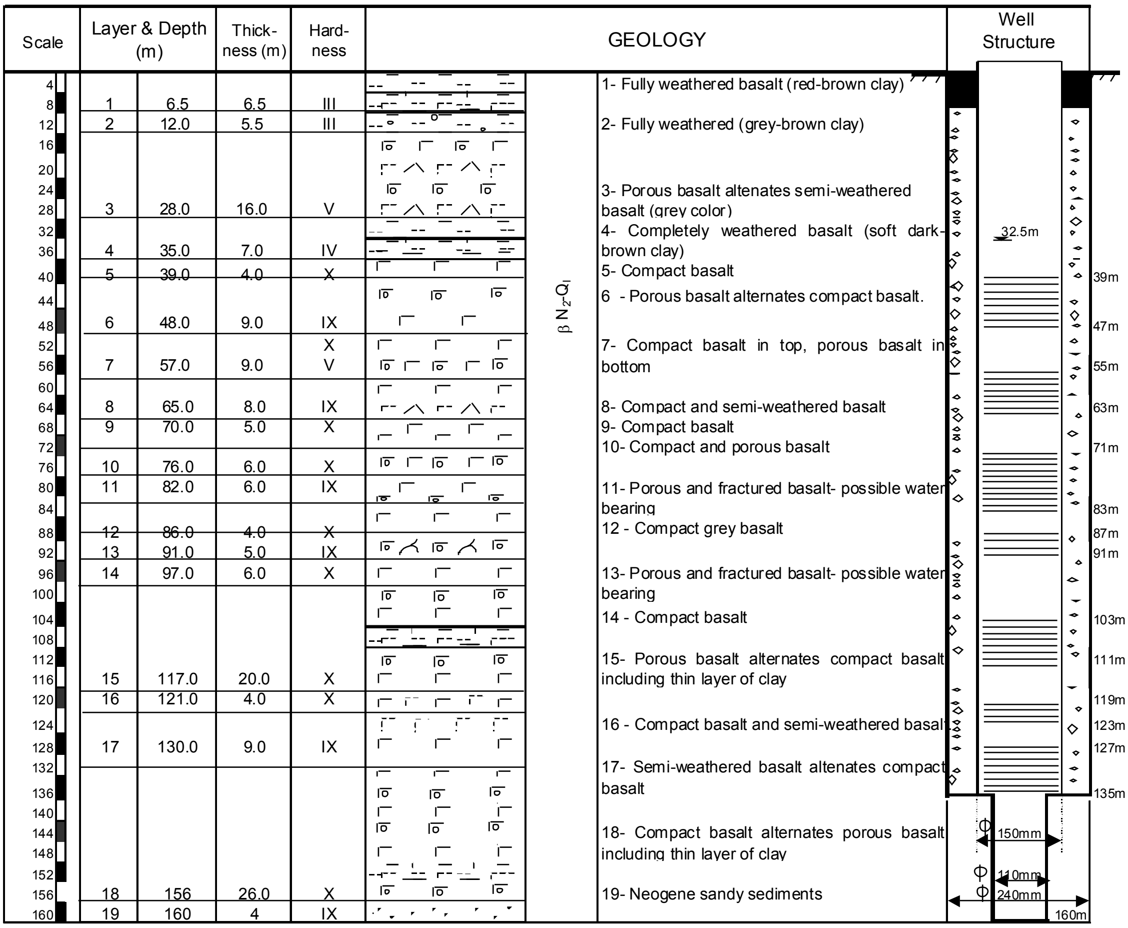

Figure 3.5 Geology and Well Structure of Test Well at Nghia Hoa Commune (G5)

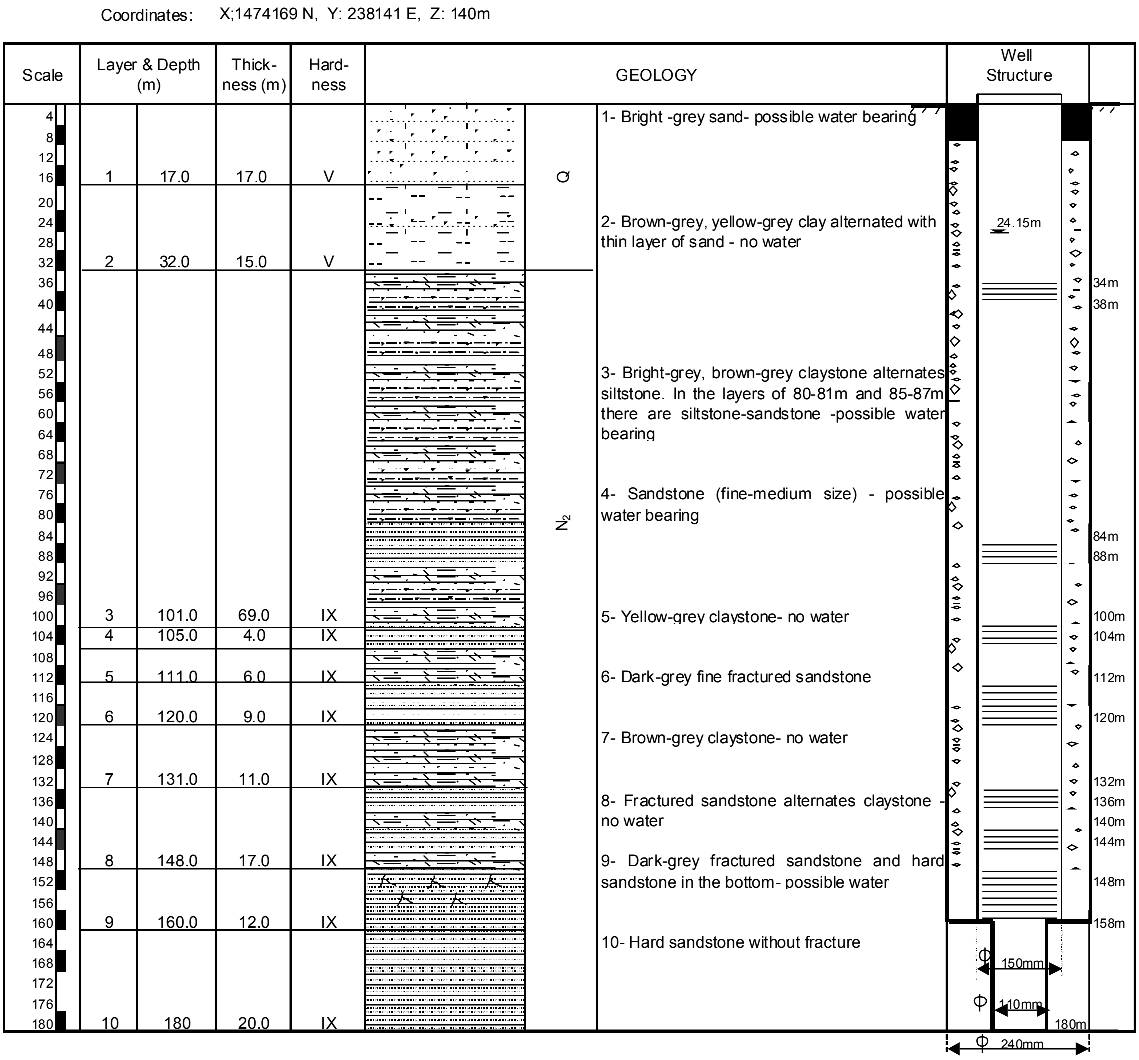

Figure 3.6 Geology and Well Structure of Test Well at Ea Rsuom Commune (G6)

Coordinates: X:1531378 N, Y: 234391 E, Z: 472m

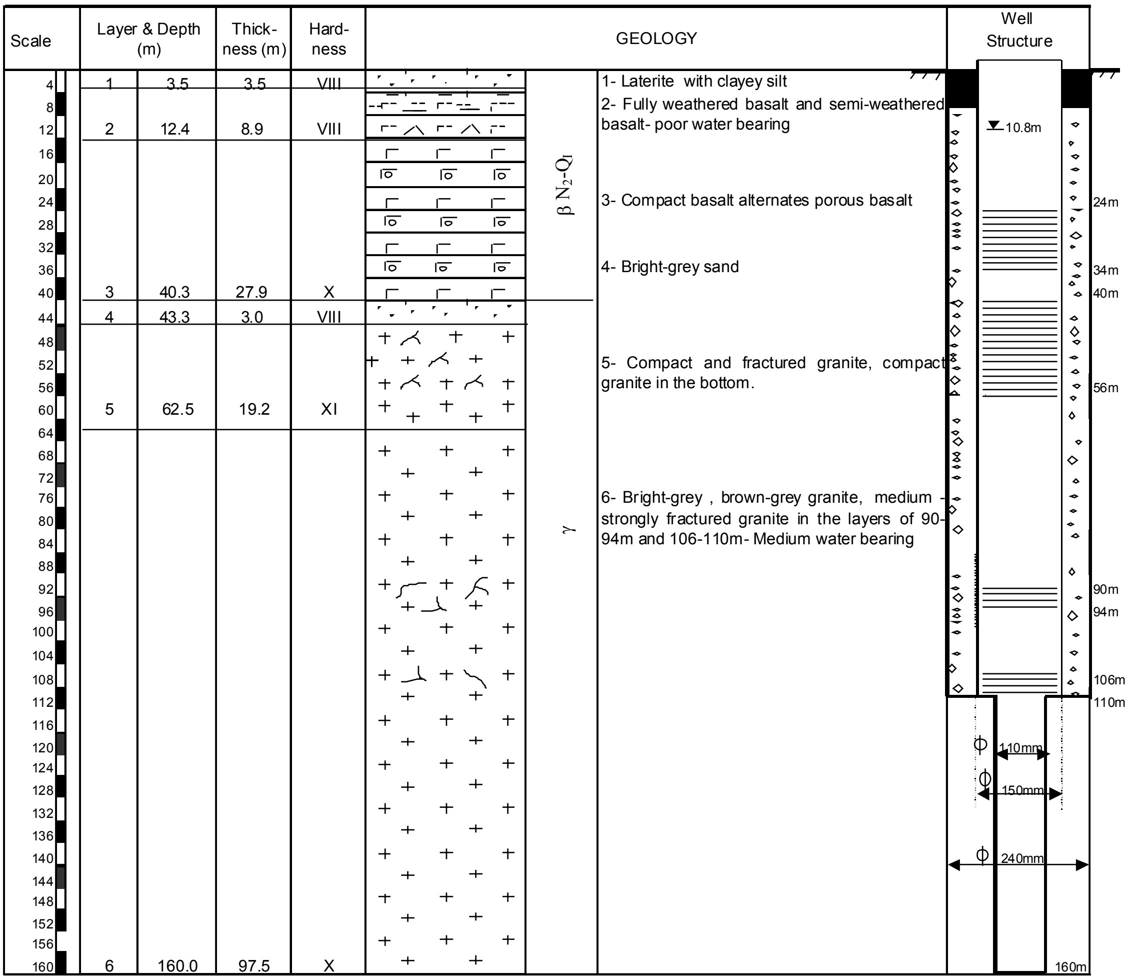

Figure 3.7 Geology and Well Structure of Test Well at Kong Yang Commune (G7)

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)	
Gia Lai province				
G1	Kong Tang	322	3.7	57
G2	Nhon Hoa	173	2.0	71
G3	Chu Ty	317	3.7	62
G4	Thang Hung	259	3.0	54
G5	Nghia Hoa	173	2.0	62
G6	Ia Rsiom	406	4.7	50
G7	Kong Yang	432	5.0	44

*: 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.

The following monitoring wells exist within and in the vicinity of the target communes/towns.

Table 4.2 Existing Monitoring Wells within and in the Vicinity of the Target Communes

Commune/town	Monitoring well	Aquifer	Screen (m)
G2, Nhon Hoa	LK67T	Basalt (βN_2-Q_1)	0 - 20
G5, Nghia Hoa	C2a	Basalt (βN_2-Q_1)	0 - 22.7
	C2b	Basalt (βN_2-Q_1)	33 - 58.5
	C2c	Basalt (βN_2-Q_1)	62 - 75
	C2o	Basalt (βN_2-Q_1)	89.6 - 190.8

The LK67T and C2 monitoring wells are located within the target communes of Nhon Hoa (G2) and Nghia Hoa (G5), respectively. The aquifers of these monitoring wells are composed of basalt and the groundwater level measurement has been carried out. The monitoring data do not show lowering of groundwater level at these monitoring.

It can be recognized that groundwater exploitation from the deep aquifers has just started recently in the rural area according to the field survey. 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.

Automatic groundwater level recorders were installed for the 7 successful test wells at June 2001. Gia Lai 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. The data acquisition work by PCERWASS will be continued around one year more from June 2002 by using the remaining recording paper.

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 by the publicly authorized laboratory, i.e., for 18 items by the Institute Hygiene and Epidemiology Institute, the Ministry of Health as shown in Table 5.1. For Dioxin analysis a water samples (G3) was taken and analyzed by Hanoi National University.

For the samples taken from the test wells explored by the study team as shown in Table 5.1, no harmful substances, i.e. arsenic and dioxin, were found. However, the iron content was relatively high in G6 (Ia Rsiom, 3.10 mg/l) and G7 (Kong Yang, 2.07 mg/l). Iron removal treatment will be needed for domestic use of the groundwater.

The content of manganese was also relatively high in G2 (Nhon Hoa, 0.1950 mg/l), G4 (Thang Hung, 0.1740 mg/l) and G7 (Kong Yang, 0.2860 mg/l).

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. If coliform is found in the water it should be treated by disinfection.

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

Sampl. No.	Type	Temp. (℃)	pH	EC (μS/cm)	DO (mg/l)	TDS (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)	Na^{+} (mg/l)	K^{+} (mg/l)	HCO_3^- (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	Total Fe (mg/l)	NO_2^-N (mg/l)	NO_3^-N (mg/l)	NH_4^+ (mg/l)	PO_4^{3-} (mg/l)	COD/$KMnO_4$ (mg/l)	F (mg/l)	As (mg/l)	Mn^{2+} (mg/l)	Coliform* MPN/100r
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

PART III MASTER PLAN STUDY

Chapter 1 Water Supply Master Plan GIII1-1

Chapter 2 Selection of Priority Projects GIII2-1

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 Coverage of the Service

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 Gia Lai province, 16 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 fugures in each commune/town.

Table 1.3 Projected Populations

Commune	No. of Villages	No. of Household	Growth Rate (%)*	Growth Rate (%)*	Population	Projection			
			2001-2005	2006-2020	2000	2001	2005	2010	2020
G1:Kong Tang	11	1163	**2.30**	**2.30**	5567	**5695**	**6237**	**6988**	**8773**
G2: Nhon Hoa	15	1906	**2.20**	**2.20**	11084	**11328**	**12358**	**13779**	**17128**
G3: Chu Ty	8	1481	**1.90**	**1.90**	6377	**6498**	**7006**	**7698**	**9292**
G4-1: Thang Hung	5	858	**1.70**	**1.70**	4292	**4365**	**4669**	**5080**	**6013**
G4-2: Thang Hung	1	51	**1.70**	**1.70**	249	**253**	**271**	**295**	**349**
G4-3: Thang Hung	1	66	**1.70**	**1.70**	325	**331**	**354**	**385**	**455**
G4-4: Thang Hung	3	338	**1.70**	**1.70**	1472	**1497**	**1601**	**1742**	**2062**
G5-1: Ngia Hoa	5	696	**2.00**	**2.00**	3288	**3354**	**3630**	**4008**	**4886**
G5-2: Ngia Hoa	1	66	**2.00**	**2.00**	362	**369**	**400**	**441**	**538**
G6-1: Ia Rsion	9	710	**2.00**	**2.00**	3843	**3920**	**4243**	**4685**	**5710**
G6-2: Ia Rsion	2	134	**2.00**	**2.00**	688	**702**	**760**	**839**	**1022**
G7-1: Kong Yang	5	374	**2.00**	**2.00**	1507	**1537**	**1664**	**1837**	**2239**
G7-2: Kong Yang	1	48	**2.00**	**2.00**	212	**216**	**234**	**258**	**315**
G7-3: Kong Yang	1	26	**2.00**	**2.00**	132	**135**	**146**	**161**	**196**
G7-4: Kong Yang	2	109	**2.00**	**2.00**	547	**558**	**604**	**667**	**813**
G7-5: Kong Yang	1	50	**2.00**	**2.00**	128	**131**	**141**	**156**	**190**

*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 Coverage percentages of 25% in the year 2001 and 50% in the year 2005 was estimated based on the site condition.

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 by 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: Gia Lai 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		
System	Qav	Qmax	qmax	Qav	Qmax	qmax	Qav	Qmax	qmax	Qav	Qmax	qmax
G1:Kong Tang	51.3	**66.6**	**5.55**	112.3	**146.0**	**12.16**	427.7	**556.0**	**46.33**	631.6	**821.1**	**68.43**
G2: Nhon Hoa	102.0	**132.5**	**11.04**	222.4	**289.2**	**24.10**	843.3	**1096.2**	**91.35**	1233.2	**1603.2**	**133.60**
G3: Chu Ty	58.5	**76.0**	**6.34**	126.1	**163.9**	**13.66**	471.1	**612.4**	**51.04**	669.0	**869.7**	**72.48**
G4-1: Thang Hung	39.3	**51.1**	**4.26**	84.0	**109.3**	**9.11**	310.9	**404.2**	**33.68**	432.9	**562.8**	**46.90**
G4-2: Thang Hung	2.3	**3.0**	**0.25**	4.9	**6.3**	**0.53**	18.0	**23.4**	**1.95**	25.1	**32.7**	**2.72**
G4-3: Thang Hung	3.0	**3.9**	**0.32**	6.4	**8.3**	**0.69**	23.5	**30.6**	**2.55**	32.8	**42.6**	**3.55**
G4-4: Thang Hung	13.5	**17.5**	**1.46**	28.8	**37.5**	**3.12**	106.6	**138.6**	**11.55**	148.5	**193.0**	**16.09**
G5-1: Ngia Hoa	30.2	**39.2**	**3.27**	65.3	**84.9**	**7.08**	245.3	**318.9**	**26.57**	351.8	**457.3**	**38.11**
G5-2: Ngia Hoa	3.3	**4.3**	**0.36**	7.2	**9.4**	**0.78**	27.0	**35.1**	**2.93**	38.7	**50.3**	**4.20**
G6-1: Ia Rsion	35.3	**45.9**	**3.82**	76.4	**99.3**	**8.27**	286.7	**372.7**	**31.06**	411.2	**534.5**	**44.54**
G6-2: Ia Rsion	6.3	**8.2**	**0.63**	13.7	**17.8**	**1.37**	51.3	**66.7**	**5.13**	73.6	**95.7**	**4.42**
G7-1: Kong Yang	13.8	**18.0**	**1.50**	29.9	**38.9**	**3.24**	112.4	**146.2**	**12.18**	161.2	**209.6**	**17.47**
G7-2: Kong Yang	1.9	**2.5**	**0.21**	4.2	**5.5**	**0.46**	15.8	**20.6**	**1.71**	22.7	**29.5**	**2.46**
G7-3: Kong Yang	1.2	**1.6**	**0.13**	2.6	**3.4**	**0.28**	9.8	**12.8**	**1.07**	14.1	**18.4**	**1.53**
G7-4: Kong Yang	5.0	**6.5**	**0.54**	10.9	**14.1**	**1.18**	40.8	**53.0**	**4.42**	58.5	**76.1**	**6.34**
G7-5: Kong Yang	1.2	**1.5**	**0.13**	2.5	**3.3**	**0.28**	9.5	**12.4**	**1.03**	13.7	**17.8**	**1.48**

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. 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 7 systems prioritized for piped supply systems in Gia Lai 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 16 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		
G1 Kong Tang	5567	6988	8773	Piped network by well	Extension of distribution pipes
G2 Nhon Hoa	11084	13779	17128	Piped network by well	Extension of distribution pipes
G3 Chu Ty	6377	7698	9292	Piped network by well	Extension of distribution pipes
G4-1 Thang Hung	4292	5080	6013	Piped network by well	Extension of distribution pipes
G4-2	249	295	349	Household systems	Household systems by well
G4-3	325	385	455	Household systems	Household systems by well
G4-4#	1472	1742	2062	Household systems	Household systems by well
G5-1 Nghia Hoa	3288	4008	4886	Piped network by well	Extension of distribution pipes
G5-2	362	441	538	Household systems	Household systems by well
G6-1 Ia Rsion	3843	4685	5710	Piped network by well	Extension of distribution pipes
G6-2	688	839	1022	Household systems	Household systems by well
G7.1 Kong Yang	1507	1837	2239	Piped network by well	Extension of distribution pipes
G7-2	212	258	315	Household systems	Household systems by well
G7-3	132	161	196	Household system	Household systems by well
G7-4	547	667	813	Household system	Household systems by well
G7-5	128	156	190	Household system	Household systems by well

Note: The areas with shaded mark are correspondent with the priority systems.

#: Population of G4-4 exceeds 1000, however, the average pipeline length per household is over than 70m. It is economically not feasible apply piped network.

Table 1.10 Summary of the Selection of the Options

Phase	Option	Number of systems	Remarks
Phase 1	**Option 1**	**Gia Lai: 7**	• 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	**Gia Lai:9**	• 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**	**Gia Lai: 7**	• 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	**Gia Lai: 0**	• 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	**Gia Lai: 9**	• 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 16 systems were identified in the 7 target communes. 2 systems in G6 and G7 were integrated to the neighboring systems. Out of 16 systems, 7 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 16 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 G7 commune in Gia Lai province are unsatisfied with the present water quality.

As a result of the preliminary evaluation, the component of urgency and necessity was highly evaluated in G2 followed by G3.

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, G1, G2, G3, G4-1 and G5-1 were highly evaluated with regard to population density and infrastructure. All of these systems are 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.

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 G1, G3 and G4-1 were highly evaluated with regard to potential of groundwater resources. The well yields of these systems are 4.8, 4.0 and 3.l/s, respectively, and the quality is very good for both drinking and domestic water. The G2 system 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 systems of G2 (Nhon Hoa C.), , G3 (Chu Ty T.), and G6-1 (Ia Rsiom C.) were highly evaluated with regard to poverty and ethnic minority proportion, followed by G1.

There are a lot of ethnic minority populations living in G2 (Gia Rai), G3 (Gia Rai), and G6-1 (Gia Rai) where the poverty ratio 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 G3 systems was highly evaluated, followed by G2 and G5-1. The WTP in G3 and G2 is the highest among all the systems. 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 G2 and G3 where the leadership by the people's committee is generally very strong and the community organizations, i.e. WU, farmers' union, youth union are well organized so as to carry out community activities.

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 G7-2 to G7-5 were highly evaluated with regard to gender perspective. The Ba Na people often take water from springs in the remote villages in G7.

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. 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.

Bad smell was identified in G7-1, and needs additional considerations for treatment. The local people are also unsatisfied with the odor of the existing shallow dug wells.

As a result of the environmental evaluation, most of the proposed systems were highly evaluated.

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 16 systems in the study area 7 systems were selected as the prioritized systems as summarized in Table 2.18, and the water supply master plan will mainly focus on these systems.

The selected 7 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 (G2, G3 and G6-1) are included in the priorities.
- Most of the target communes/towns are included for the priority systems.
- All of the systems with the highest demand from poor and ethnic minority households (G2 and G3-1) are selected for the priorities.
- Most of the priority systems have a certain level of financial affordability.
-
- The small-sized piped water supply systems of G7 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. G4-2, G4-3, G4-4, G5-2, G6-2, G7-2, G7-3, G7-4 and G7-5. 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
GIA LAI	40073	
G1 Kong Tang	5567	Population served by piped systems at phase 1: 35,958 (90%)
G2 Nhon Hoa	11084	
G3 Chu Ty	6377	
G4-1 Thang Hung	4292	
G5-1 Nghia Hoa	3288	
G6-1 Ia Rsion	3843	
G7-1 Kong Yang	1507	
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		Infrastructure 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 (a)		Povety ratio (%) (b)		Ratio of ethnic minorities (%) (c)		Poverty 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 (a)		Leadership (b)		Understanding of RWSS issues (c)		Relevant experience (d)		O&M complexity (e)		O&M potential (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