CHAPTER 3 MASTER PLAN OF RURAL WATER SUPPLY

3.1 Groundwater Development

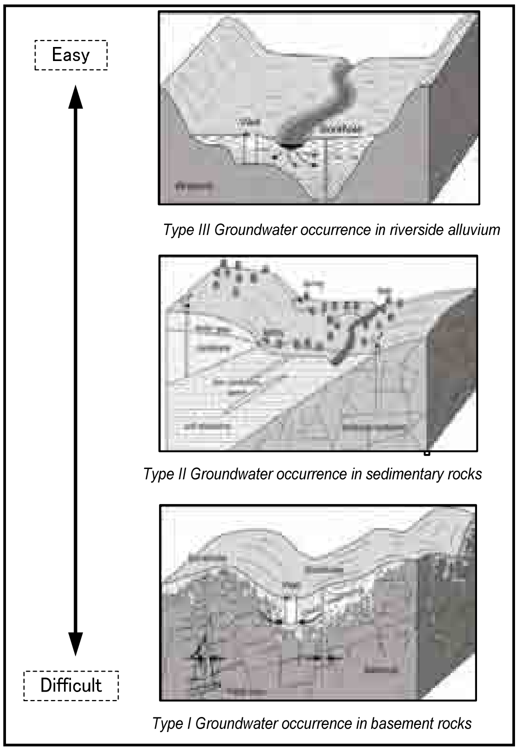
A master plan of groundwater development for rural water supply in the 24 target communes is worked out as described below based on the present conditions of groundwater as described in 2.6.

3.1.1 Groundwater Development Potential

(1) Introduction

Groundwater has several good characteristics for rural water supply as listed below, however it has some difficulties to exploit and develop the resources. For example, groundwater occurrence type or aquifer type is one of the most important items in consideration of the difficulties. Three typical types of groundwater occurrence types are shown in Figure 3.1.1 which means Type I is the most difficult case.

- Groundwater resources are often resistant to drought.
- Groundwater can generally be found close to the point of demand (if you look hard enough with appropriate expertise).
- Groundwater is generally of excellent natural quality and requires no prior treatment.
- Groundwater can be developed incrementally, and often accessed cheaply.
- Technology is often amenable to community operation and management.
- Groundwater is naturally protected from contamination.



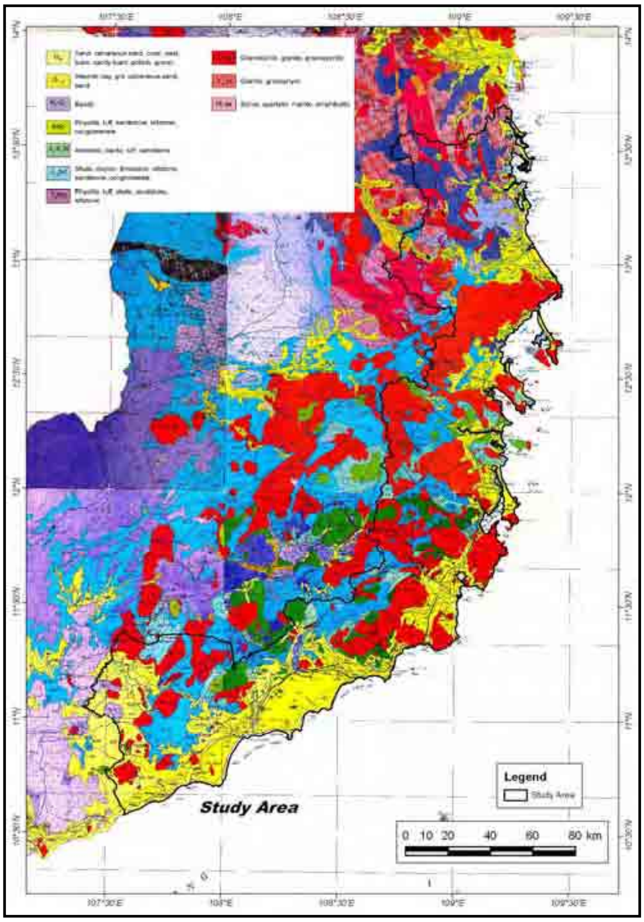
Source: International Association of Hydrogeologist: "Groundwater and Rural Water Supply in Africa"

Figure 3.1.1 Relative Difficulty of Groundwater Exploitation

Figure 3.1.2 shows the geology of the study area. In general, granitic rocks in reddish color, Mesozoic sedimentary rocks in bluish color and Quaternary in yellowish color are regarded as Type I, Type II and Type III respectively. Type I which is difficult to exploit and develop groundwater resources is dominant in the study area. Moreover, small catchment area and short river length because of topographical characteristics lead to insufficient water resources and serious shortage of them particularly in the dry season.

As for 24 target communes, some of them are classified to Type III which is relatively easy to exploit and develop groundwater resources, however there are water quality problems, for example, high salinity caused by seawater intrusion, fluoride contamination and so on.

In this study, the depth of target aquifer for groundwater development was decided to be shallower than 100 m as a practical exploitation depth from the economical and technical point of view. In the case of this unlike fossil water, infiltration or recharge by rain fall is the most important for the sustainable groundwater use. Therefore, the potential infiltration of each sub-catchment which was subdivided into 96 in and surrounding the study area was estimated by water balance analysis in order to evaluate their groundwater potentiality.



Source: MONRE (1987): "Geological Map of Vietnam"

Figure 3.1.2 Geology of the Study Area

(2) Estimation Methodology of Potential Infiltration

The water balance of the study area is expressed simply by the following equation.

$$P = E + R \pm I \qquad (1)$$

P: precipitation; E: evapotranspiration: R: runoff; and I: infiltration.

The primary goal of this analysis was to calculate the precipitation, evapotranspiration and runoff by using existing monitoring data and remote sensing data. Moreover, on the basis of these results, the infiltration which represents groundwater recharge was estimated by the equation (1). When applying the water balance analysis, a basic unit for analysis is "sub-catchment", and the 4 contents of water balance equation are compiled at each sub-catchment. The study area was subdivided automatically into 92 sub-catchments and 4 coastal planes by the hydrologic analysis of SRTM-3 data. The location map of sub-catchments and coastal planes extracted from SRTM-3 data is shown in Figure 3.1.3.

In the water balance analysis, meteorological data and hydrological data are utilized as the existing monitoring data. The location map of meteorological and hydrological stations is shown in Figure 3.1.3 and the list of used monitoring data is shown in Table 3.1.1.

Figure 3.1.3 Location of Sub-catchments, and Meteorological and Hydrological Stations

Table 3.1.1 List of Used Monitoring Data

Station				Meteorology				Hydrology
Name	Province	Period	*Source	M. Precipitation	M. Ave. Temp.	M. Total Sunshine Duration	M. Evaporation	M. Ave. Water Flow
Tuy Hoa	Phu Yen	1996 - 2005	HGSC	O	O	O	O	
Son Hoa	Phu Yen	1996 - 2005	HGSC	O	O		O	
Nha Trang	Khanh Hoa	1996 - 2005	HGSC	O	O	O	O	
Cam Rang	Khanh Hoa	1996 - 2005	HGSC	O	O		O	
Tan My	Ninh Thuan	1996 - 2005	HGSC	O				
Phan Rang	Ninh Thuan	1996 - 2005	HGSC	O	O	O	O	
Phan Thiet	Binh Thuan	1996 - 2005	HGSC	O	O	O	O	
Ta Pao	Binh Thuan	1996 - 2005	HGSC	O				
La Gi	Binh Thuan	1996 - 2005	HGSC	O	O		O	
Da Nang	Da Nang	2002 - 2005	GSO	O	O	O		
Playku	Gia Lai	2002 - 2005	GSO	O	O	O		
Quy Nhon	Binh Dinh	2002 - 2005	GSO	O	O	O		
Da Lat	Lam Dong	2002 - 2005	GSO	O	O	O		
Vung Tau	Ba Ria	2002 - 2005	GSO	O	O	O		
Cung Son	Phu Yen	1996 - 2005	HGSC					O
Dong Trang	Khanh Hoa	1996 - 2005	HGSC					O
Song Luy	Binh Thuan	1996 - 2005	HGSC					O
Ta Pao	Binh Thuan	1996 - 2005	HGSC					O

*HGSC: Hydrology and Geology Station Center, GSO: General Statistics Office

1) Precipitation

The annual and monthly precipitation map of the study area was made from the precipitation data of the published atlas in Vietnam and meteorological stations. Figure 3.1.4 shows the annual precipitation map of the study area.

The annual precipitation in most of the study area is greater than 1,500 mm. Especially the mountainous area in Khanh Hoa and Binh Thuan province reaches to greater than 2,500 mm. On the other hand, the annual precipitation of coastal lowland areas in Ninh Thuan province and the northern part of Binh Thuan province is less than 1,000 mm and the precipitation in the dry season is significantly low.

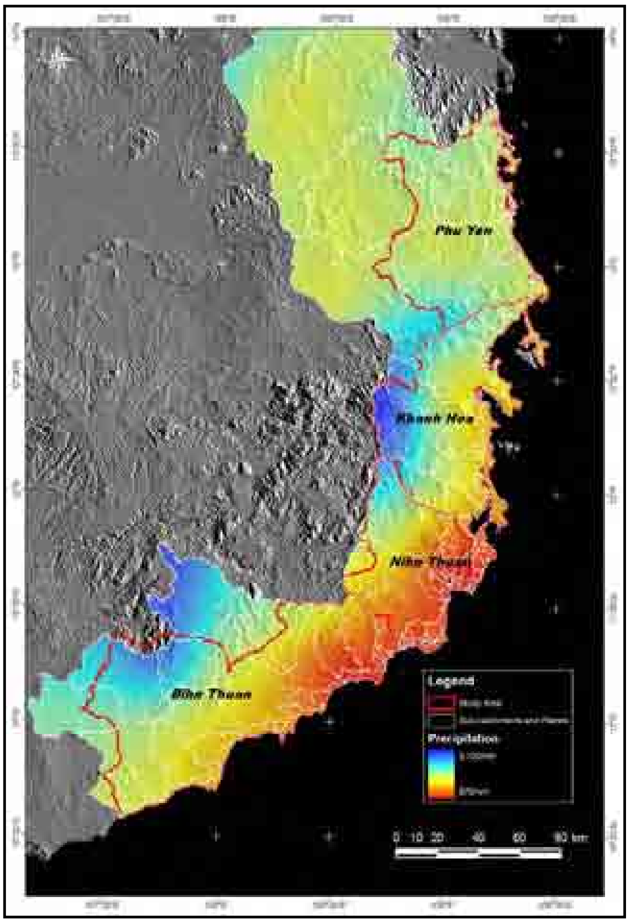


Figure 3.1.4 Annual Precipitation in the Study

2) Evapotranspiration

Makkink equation (Makkink, 1957) was adopted to estimate the annual and monthly potential evapotranspiration of the study area. The equation is defined as follows:

$$PET_{mak} = \frac{\Delta}{\Delta + \gamma}\frac{Rs}{\lambda}$$

PET_{mak} (mm/day):daily potential evapotranspiration at water surface;

Δ (hPa/°C): slope of saturation vapor pressure curve;

γ (hPa/°C): psychrometric constant;

Rs (MJ/cm^2/day): total solar radiation;

λ (MJ/kg): latent heat.

In addition, the following equation (Nagai, 1993, ERSDAC, 2005) was proposed to estimate the potential evapotranspiration related to different land cover classes except for water surface (ex. forest, grassland, soil, etc.) for consideration of albedo.

$$PET_{mak} = (a + 0.08 - A)\frac{\Delta}{\Delta + \gamma}\frac{Rs}{\lambda} + b$$

a and b: regional constant value;

A: albedo value of each land cover class.

Rs:calculated by the following equation.

$$Rs = Ra(0.18 + 0.55\frac{n}{N})$$

Ra (MJ/m^2/day): outer space solar radiation;

n/N: percentage of sunshine;

n (hour): observed monthly total sunshine duration

N (hour): monthly possible sunshine duration.

$\Delta / (\Delta + \gamma)$: dimensionless parameter

λ: determined by the following equations.

$$\frac{\Delta}{\Delta + \gamma} = \frac{1}{1.05 + 1.4 \times \exp(-0.0604T)}$$

$$\lambda = 2.5 - 0.0025 \times T$$

T (°C): observed temperature.

The distribution of calculated annual evapotranspiration is presented in Figure 3.1.5.

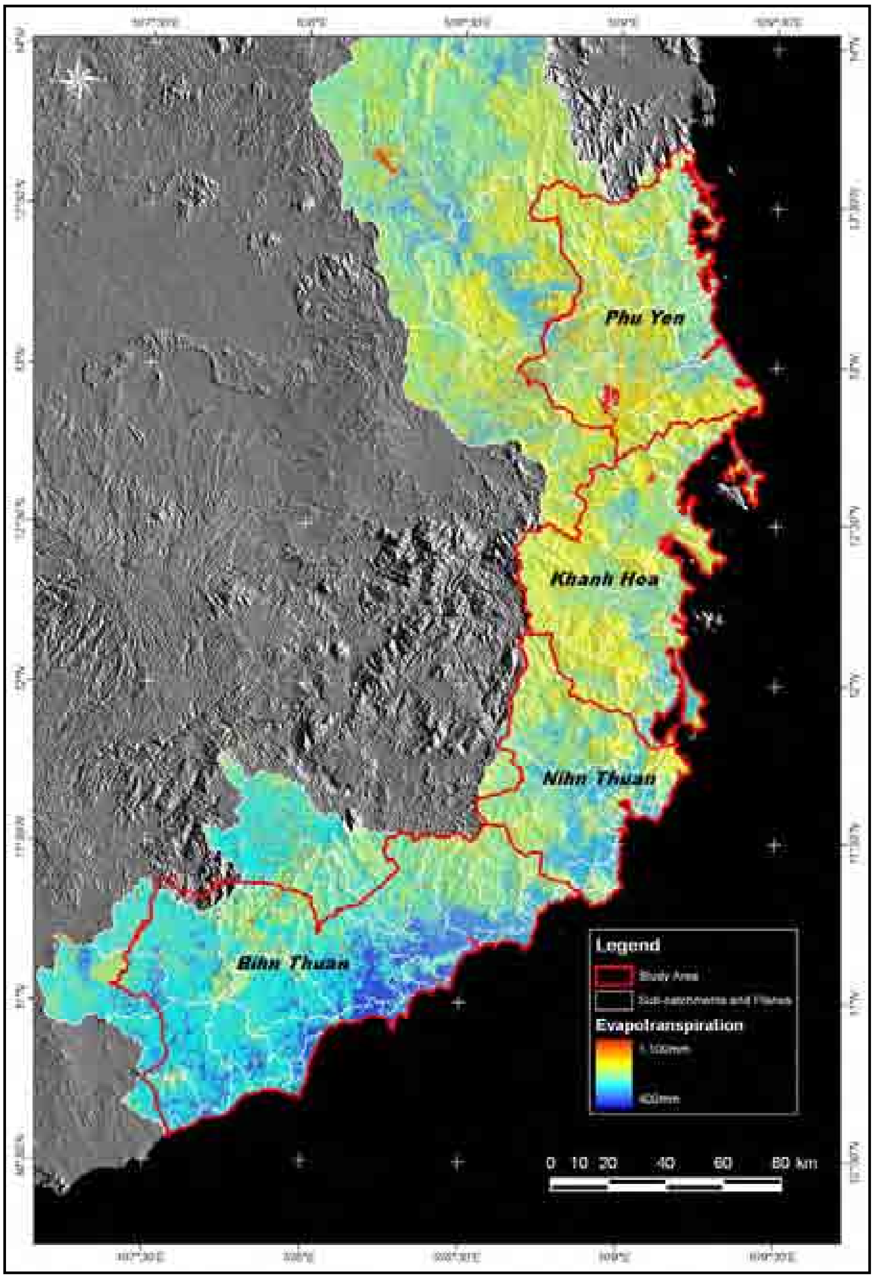


Figure 3.1.5 Distribution of Annual Evapotranspiration in the Study Area

3) Runoff

The ratio of runoff or river discharge was estimated by the techniques of geomorphometry. In order to examine the water flow on the land-surface, the SRTM-3 data based on geomorphometry was carried out at each sub-catchment.

There are four hydrological stations in the study area and the runoff ratio can be estimated by the monthly average water flow actually observed at these stations. In this study, the runoff ratio of the study area was estimated through the relationship between the actual runoff ratio of the stations and the result of geomorphometry in the station's sub-catchment.

The location map of the hydrological stations and its sub-catchments is shown in Figure 3.1.6 and the actual runoff ratio and the result of geomorphometry are shown in Table 3.1.2.

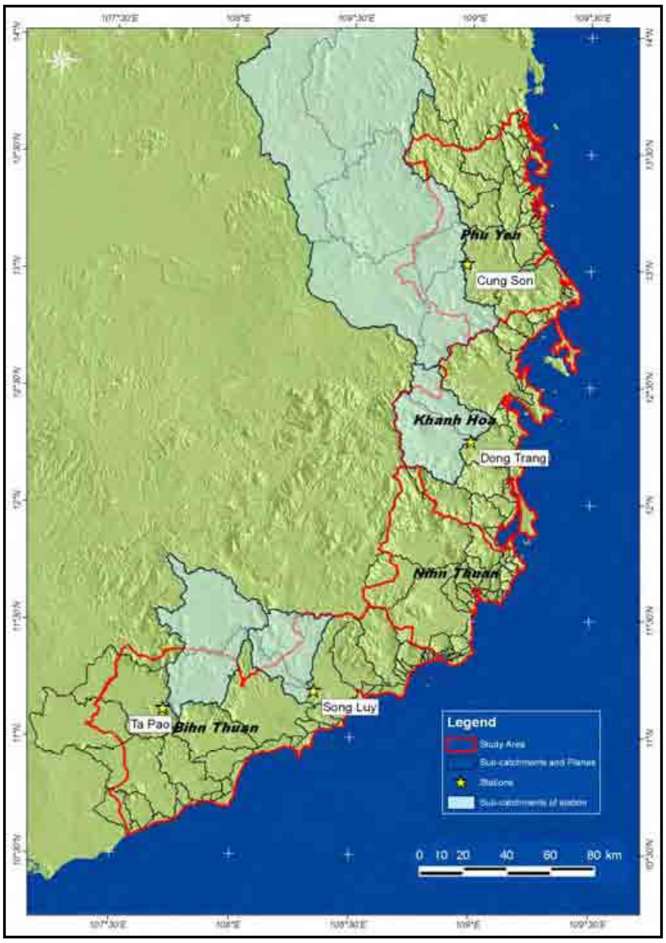


Figure 3.1.6 Location of Hydrological Stations and Catchment Area

Table 3.1.2 Relationship between Geomorphometry of Sub-catchments to where Hydrological Station's belong Runoff Ratio

Station		Geomorphometry and PCA				Observed Runoff Ratio of Stations
Name	Province	G_{PC1}	G_{PC2}	G_{PC3}	G_{runoff}	
Cung Son	Phu Yen	3	1	2	2.23	0.330
Dong Trang	Khanh Hoa	5	4	3	4.30	0.628
Phan Thiet	Binh Thuan	4	2	1	2.81	0.326
La Gi	Binh Thuan	4	1	2	2.74	0.511

PCA: Principal Component Analysis,

The scatter diagram of the G_{runoff} and the observed runoff ratio is shown in Figure 3.1.7. The correlation of them is strong ($R^2 = 0.71$), and then the G_{runoff} of all sub-catchment can be converted to the runoff ratio by the following equation from the linear regression equation of the scatter diagram.

$$R_{ratio} = 0.14 \times G_{runoff} + 0.03$$

R_{ratio}: runoff ratio of sub-catchment;

G_{runoff}: is grade of the runoff evaluation.

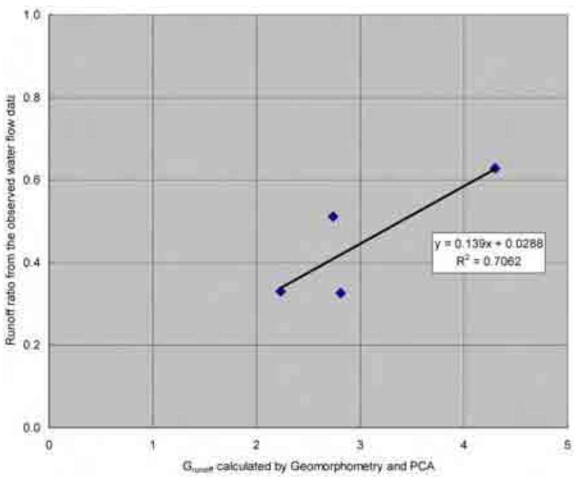


Figure 3.1.7 Scatter Diagram of G_{runoff} and Runoff Ratio at Hydrological Stations

4) Distribution of Potential Infiltration

On the basis of the precipitation, evapotranspiration and runoff ratio estimation, the potential infiltration reflecting the groundwater recharge can be expressed by the following equation.

$$I = P - AET_{mak} - P \times R_{ratio}$$

I (mm): amount of infiltration;

P (mm): amount of precipitation;

AET_{mak} (mm) is actual evapotranspiration value;

R_{ratio}: runoff ratio.

The infiltration map of the study area is shown in Figure 3.1.8. The water balance of each province is shown in Table 3.1.3.

Table 3.1.3 Water Balance of each Province

Province		Precipitation (P)	Evapotranspiration (E)	Runoff (R)	Infiltration (I)	I / A	I / P
Name	Area (A, km^2)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3/km^2)	(%)
Phu Yen	5,000	10,953,540,431	4,084,661,607	4,717,357,774	2,151,521,050	430,304	19.6
Khanh Hoa	4,610	9,538,991,944	3,492,193,853	4,919,180,766	1,127,617,324	244,602	11.8
Ninh Thuan	3,350	5,004,441,470	2,410,110,593	2,745,525,211	-151,194,334	-45,133	-3.0
Binh Thuan	7,810	15,151,919,461	5,347,714,746	5,837,280,230	3,966,924,485	507,929	26.2

The annual potential infiltration per unit area as shown in Figure 3.1.8 indicates dominant factor for groundwater potentiality. According to the figure, Ninh Thuan and the eastern part of Binh Thuan are low groundwater potential area; especially their coastal sub-catchments show the lowest potentiality. This is also related to poor groundwater quality and seawater intrusion in Ninh Thuan. (Refer to 2.6) On the other hand, Phu Yen and the western part of Binh Thuan have relatively high groundwater potentiality.

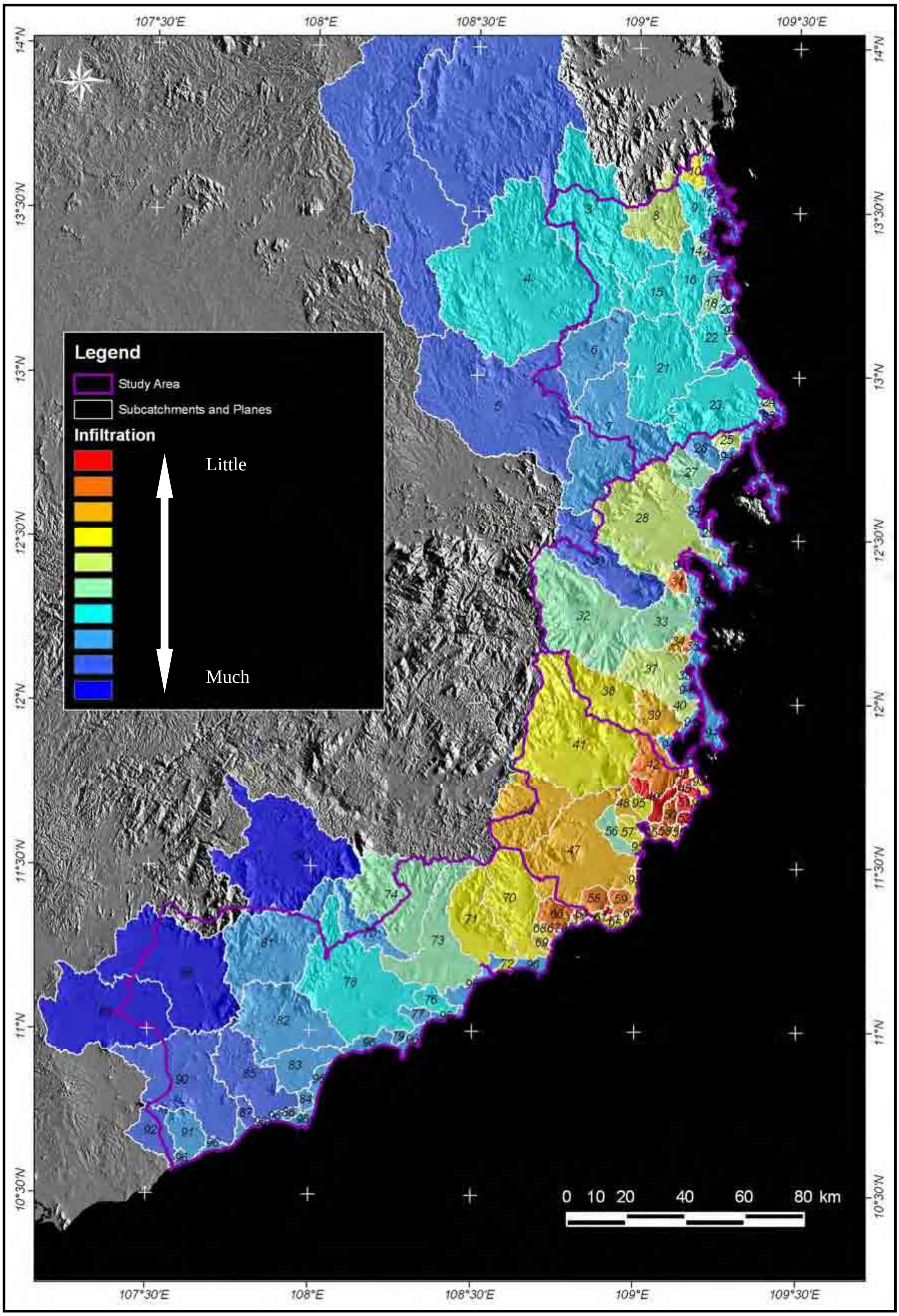


Figure 3.1.8 Annual Potential Infiltration in the Study Area

3.1.2 Groundwater Potential Evaluation of Target Communes

Groundwater potential for water resource development was evaluated on the basis of the results of the hydrogeological analysis mentioned in "Chapter 2.6 Groundwater Sources" and water balance analysis above mentioned. Five indices: namely; infiltration (recharge), yield, static water level, well depth and water quality (TDS) were selected in order to evaluate groundwater potentiality. Infiltration, which was estimated by water balance analysis, was regarded as potentiality of groundwater recharge, was selected from hydrological point of view.

(1) Potential Infiltration of each Commune

Potential infiltration of each commune by water balance analysis described in 3.1.1 is shown in Table 3.1.4. According to the ranking of commune in table, the communes of Binh Thuan are high-ranked but Ninh Thuan are low-ranked.

Table 3.1.4 Potential Infiltration of Target Communes

Commune			Area	Precipitation	Evapotranspiration	Runoff	Infiltration	I / P	I / A	Ranking
No.	Name	Province	A (km^2)	P (m^3)	E (m^3)	R (m^3)	I (m^3)	(%)	($10^3m^3/km^2$)	
P-1	Xuan Phuoc	Phu Yen	81	152,284,306	58,411,041	61,958,697	31,914,567	21.0	**394**	**12**
P-2	An Dinh	Phu Yen	18	33,158,801	12,356,861	15,109,438	5,692,502	17.2	**316**	**16**
P-3	An Tho	Phu Yen	44	78,619,040	30,124,474	33,304,048	15,190,518	19.3	**345**	**15**
P-4	An My	Phu Yen	14	24,725,234	9,636,067	9,985,904	5,103,263	20.6	**365**	**13**
P-5	Ea Cha Rang	Phu Yen	83	149,995,347	63,183,077	46,018,572	40,793,697	27.2	**491**	**8**
P-6	Son Phuoc	Phu Yen	79	143,964,216	59,847,559	44,168,222	39,948,436	27.7	**506**	**7**
P-7	Suoi Bac	Phu Yen	41	71,897,452	31,333,420	22,058,138	18,505,894	25.7	**451**	**9**
P-8	Son Thanh	Phu Yen	181	361,147,340	140,557,941	150,501,292	70,088,107	19.4	**387**	**14**
K-1	Cam An Bac	Khanh Hoa	21	32,259,896	14,202,876	15,319,224	2,737,795	8.5	**130**	**18**
K-2	Cam Hiep Nam	Khanh Hoa	19	29,818,444	12,786,974	14,159,855	2,871,616	9.6	**151**	**17**
K-3	Cam Hai Tay	Khanh Hoa	17	26,904,833	10,919,369	10,269,252	5,716,213	21.2	**336**	**11**
N-1	Nhon Hai	Ninh Thuan	40	35,207,161	24,473,589	15,695,352	-4,961,780	-14.1	**-124**	**22**
N-2	Cong Hai	Ninh Thuan	74	76,309,074	54,537,348	39,436,072	-17,664,345	-23.1	**-239**	**24**
N-3	Bac Son	Ninh Thuan	61	54,805,451	39,695,826	26,729,988	-11,620,364	-21.2	**-190**	**23**
N-4	Phuoc Minh	Ninh Thuan	75	75,702,092	44,930,597	38,896,189	-8,124,694	-10.7	**-108**	**20**
N-5	Phuoc Dinh	Ninh Thuan	33	31,352,483	18,952,822	15,197,740	-2,798,079	-8.9	**-85**	**19**
N-6	Phuoc Hai	Ninh Thuan	130	126,658,937	80,316,066	61,396,400	-15,053,529	-11.9	**-116**	**21**
B-1	Muong Man	Binh Thuan	18	28,608,358	10,498,083	10,808,066	7,302,208	25.5	**406**	**10**
B-2	Gia Huynh	Binh Thuan	158	333,962,936	93,666,136	112,167,797	128,129,003	38.4	**811**	**6**
B-3	Nghi Duc	Binh Thuan	38	101,584,292	23,775,279	34,119,015	43,689,999	43.0	**1,150**	**1**
B-4	Tan Duc	Binh Thuan	137	254,522,682	78,560,902	78,087,559	97,874,222	38.5	**714**	**5**
B-5	Me Pu	Binh Thuan	47	124,246,356	29,337,564	41,730,499	53,178,293	42.8	**1,131**	**2**
B-6	Sung Nhon	Binh Thuan	35	89,027,184	21,695,243	29,901,471	37,430,470	42.0	**1,069**	**4**
B-7	Da Kai	Binh Thuan	67	171,252,513	41,300,073	57,518,410	72,434,030	42.3	**1,081**	**3**

*Negative numbers in infiltration mean relatively very few infiltrations. Though negative value never happens theoretically, it causes analytical accuracy because of limited data.

(2) Safe Yield

A safe yield is fundamental data for planning water supply facility. To evaluate the well yield, relationship between well yield and scale of rural water supply facility was checked as Table 3.1.5. This provisional calculation was based on the following assumptions.

- Average Scale of Household = 5 people/household (Refer to "2.2 Socio-economic Conditions")
- Target Unit Water Consumption: 60L/day/person

Table 3.1.5 Water Demand for Evaluation of Well Yield

No. of Household	Population	Demand (m^3/day)	Evaluation
0 50	0 250	0 15	Poor
100	500	30	Fair
500	2,500	150	Good
1,000	5,000	300	Very Good
5,000	25,000	1,500	Excellent

Average Scale of Household: 5 people
Target Unit Water Consumption: 60L/day/person

(3) Static Water Level

The required pump capacity for withdrawal depends on the depth of the groundwater table from the ground surface in case of the same withdrawal volume. The depth of groundwater is also closely related to withdrawal cost: namely, operation cost of production wells. Data of static water level in the target communes is -43.5m for the maximum depth and +0.8m for the minimum depth which means artesian condition.

(4) Drilling Depth

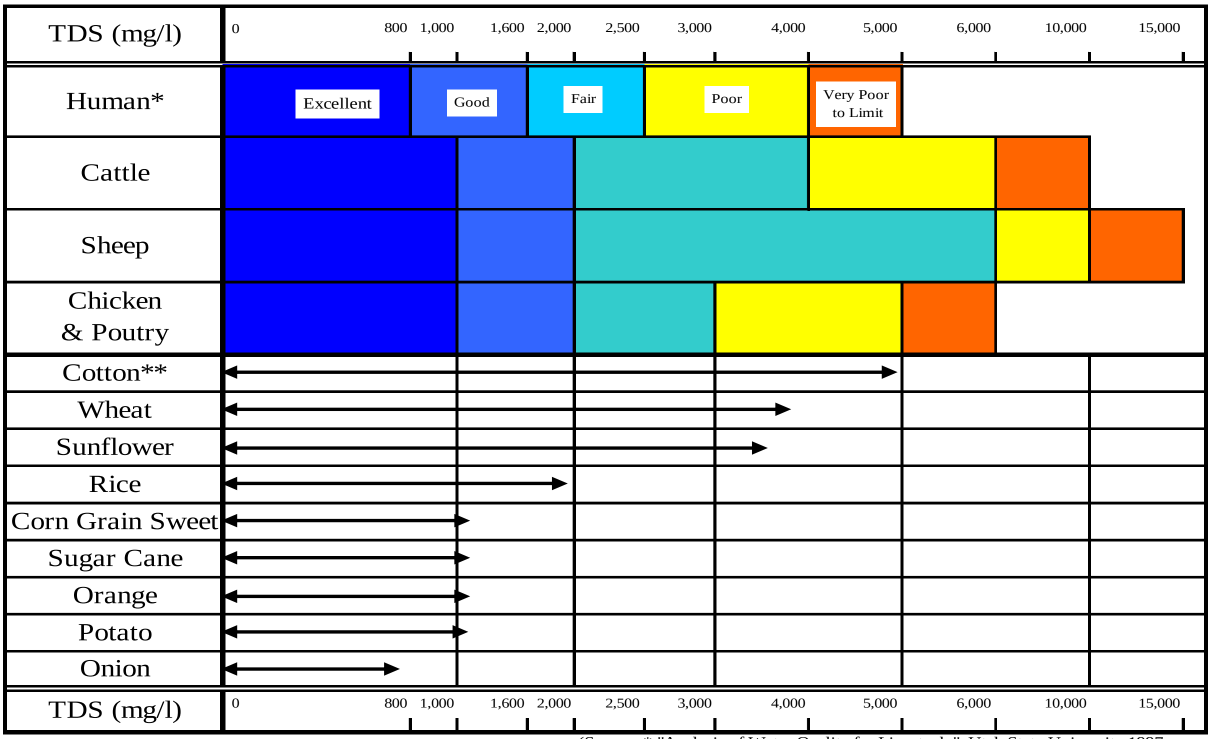
Drilling depth is a main factor of drilling cost as an initial cost of production well. Therefore, this value was selected as one of the indices for the evaluation of groundwater potential. Data of drilling depth is 75m for the maximum depth and 31m for the minimum depth. In the case of deep borehole, the drilling cost is directly proportional in general.

(5) Water Quality (TDS)

TDS is a representative index of salinity of groundwater. It is also important item on water quality standards and related to treatment cost for drinking water, productivity of livestocks and agricultural crops. Table 3.1.6 shows affection of TDS to animals and agricultural crops.

Above mentioned five indices for groundwater potential evaluation were given evaluation scores by the allocation manner shown in Table 3.1.7.

Table 3.1.6 Affection of TDS to Animals and Agricultural Crops
Table 3.1.7 Allocation of Evaluation Scores by Each Index



(Source: * "Analysis of Water Quality for Livestock ", Utah State University,1997
** Lenntech Water Treatment & Air Purification Holding B.V. Home Page)

Score		(1) Potential Infiltration ($10^3m^3/km^2$)		(2) Well Yield (m^3/day)		(3) Static Water Level (GLm)		(4) Well Depth (m)		(5) Water Quality [TDS] (mg/L)	
		Evaluation Index									
10	Better	1,000 <	exl.	500 <	exl.	0 <	exl.	< 30	exl.	0 - 400	exl.
9		800 - 1,000		300 - 500		-2.5 - 0		30 - 35		400 < 800	
8	↑	600 - 800	very good	200 - 300	very good	-5 - -3	very good	35 - 40	very good	800 - 1,200	good
7		400 - 600		100 - 200		-10 - -5		40 - 45		1,200 - 1,600	
6		200 - 400	good	80 - 100	good	-15 - -10	good	45 - 50	good	1,600 - 2,000	fair
5		100 - 200		60 - 80		-20 - -15		50 - 55		2,000 - 2,500	
4		0 - 100	fair	40 - 60	fair	-30 - -20	fair	55 - 60	fair	2,500 - 3,000	poor
3	↓	-100 - 0		20 - 40		-40 - -30		60 - 65		3,000 - 4,000	
2	Worse	-200 - -100	poor	10 - 20	poor	-50 - -40	poor	65 - 70	poor	4,000 - 5,000	Very poor
1		< -200		0 < 10		< -50		> 70		> 5,000	

(6) Aquifer Type

Difficulty of groundwater exploitation depends on not only potential infiltration but aquifer type as groundwater storage medium. Table 3.1.8 shows evaluation score of each commune by the hydrogeological investigation in this study. In the case of Binh Thuan province, the aquifer type of all target communes is classified into “fissure”, therefore, it reveals that groundwater exploitation is not easy in contradiction to superior potential infiltration in the north western part of the province.

Table 3.1.8 Evaluation of Aquifer Type for Groundwater Exploitation

Province	Commune Name		Target Aquifer Type of Groundwater					Total Score
			Sedimentary Deposit	Rocks				
				Weathered	Fissure	Fractured	Porus	
Phu Yen	P-1	Xuan Phuoc		x	x		x	8
	P-2	An Dinh	x		x		x	10
	P-3	An Tho		x	x		x	8
	P-4	An My		x	x			4
	P-5	Son Phuoc		x			x	8
	P-6	Ea Cha Rang		x			x	8
	P-7	Ea Cha Rang		x			x	8
	P-8	Son Thanh Dong		x			x	8
Khanh Hoa	K-1	Cam An Bac		x	x	x		6
	K-2	Cam Hiep Nam		x	x	x		6
	K-3	Cam Hai Tay		x	x			4
Ninh Thuan	N-1	Nhon Hai	x	x				8
	N-2	Cong Hai	x	x		x		10
	N-3	Bac Son			x	x		3
	N-4	Phuoc Minh			x			1
	N-5	Phuoc Dinh	x	x				8
	N-6	Phuoc Hai				x		2
Binh Thuan	B-1	Muong Man			x			1
	B-2	Gia Huynh			x			1
	B-3	Nghi Duc			x			1
	B-4	Tan Duc			x			1
	B-5	Me Pu			x			1
	B-6	Sung Nhon			x			1
	B-7	Da Kai			x			1
Evaluation Score			5	3	1	2	4	-

(7) Groundwater Potential Evaluation

Groundwater potential evaluation of each target commune was carried out by summing up scores from six indices in total. The results of the evaluation are shown in Table 3.1.9, which indicates high-ranked communes concentrate in Phu Yen and Khanh Hoa province, but low-ranked communes are mainly found in Ninh Thuan and Binh Thuan. Meanwhile, the score of aquifer type evaluation was weighted two times in comparison with other indices because of its importance for groundwater exploration.

Table 3.1.9 Results of Groundwater Potential Evaluation

Commune				1) Potential Infiltration		2) Safe Yield		3) Static Water Level		4) Borehole Depth		5) TDS		6) Aquifer Type	Total Evaluation	
No.	Name	Province	Area (km^2)	Value ($10^3m^3/km^2$)	Score	Value (m^3/day)	Score	Value (GL m)	Score	Value (m)	Score	Value (mg/L)	Score	Score	*Score	Ranking
P-1	Xuan Phuoc	Phu Yen	81	394	6	6	1	-2.0	9	55	4.5	136	10	8	46.5	7
P-2	An Dinh	Phu Yen	18	316	6	288	8	-3.0	8	50	5.5	2,328	5	10	52.5	1
P-3	An Tho	Phu Yen	44	345	6	115	7	-43.5	2	65	2.5	642	9	8	42.5	15
P-4	An My	Phu Yen	14	365	6	691	10	0.8	10	75	1	264	10	4	45.0	8
P-5	Ea Cha Rang	Phu Yen	83	491	7	6	1	-6.0	7	35	8.5	392	10	8	49.5	4
P-6	Son Phuoc	Phu Yen	79	506	7	22	3	-6.0	7	65	2.5	556	9	8	44.5	9
P-7	Suoi Bac	Phu Yen	41	451	7	7	1	-7.0	7	60	3.5	490	9	8	43.5	12
P-8	Son Thanh	Phu Yen	181	387	6	432	9	-12.7	6	62	3	156	10	8	50.0	3
K-1	Cam An Bac	Khanh Hoa	21	130	5	360	9	-1.6	9	52	5	394	9	6	49.0	5
K-2	Cam Hiep Nam	Khanh Hoa	19	151	5	58	4	-6.7	7	50	5.5	232	10	6	43.5	12
K-3	Cam Hai Tay	Khanh Hoa	17	336	6	288	8	0.6	10	45	6.5	411	9	4	47.5	6
N-1	Nhon Hai	Ninh Thuan	40	-124	3	130	7	-7.0	7	59	4	1,258	7	8	44.0	11
N-2	Cong Hai	Ninh Thuan	74	-239	1	50	4	-3.5	8	29	10	642	9	10	52.0	2
N-3	Bac Son	Ninh Thuan	61	-190	2	130	7	-2.5	9	31	9	3,802	3	3	36.0	20
N-4	Phuoc Minh	Ninh Thuan	75	-108	2	1	1	-4.0	8	40	7.5	1,766	6	1	26.5	24
N-5	Phuoc Dinh	Ninh Thuan	33	-85	3	86	6	-1.3	9	36	8	32,402	1	8	43.0	14
N-6	Phuoc Hai	Ninh Thuan	130	-116	2	50	4	-6.8	7	45	6.5	862	8	2	31.5	23
B-1	Muong Man	Binh Thuan	18	406	7	36	3	-5.3	7	40	7.5	626	9	1	35.5	21
B-2	Gia Huynh	Binh Thuan	158	811	9	43	4	-1.6	9	50	5.5	224	10	1	39.5	16
B-3	Nghi Duc	Binh Thuan	38	1,150	10	4	1	-1.1	9	45	6.5	260	10	1	38.5	17
B-4	Tan Duc	Binh Thuan	137	714	8	17	2	-2.5	9	50	5.5	528	9	1	35.5	21
B-5	Me Pu	Binh Thuan	47	1,131	10	65	5	-1.9	9	35	8.5	212	10	1	44.5	9
B-6	Sung Nhon	Binh Thuan	35	1,069	10	65	5	-0.8	9	67	2	134	10	1	38.0	18
B-7	Da Kai	Binh Thuan	67	1,081	10	7	1	-5.6	7	35	8.5	156	10	1	38.5	17

*Score= 1)+2)+3)+4)+5)+2*6)

3.1.3 Groundwater Development Plan for Rural Water Supply in Target Communes

Groundwater potential in each commune is affected by local conditions and besides, candidate drilling sites of borehole for the rural water supply schemes are considerably limited in the communes. Therefore, the groundwater development plan for rural water supply in the target communes should be based on the results of test borehole drilling survey in this study. The results of test borehole drilling survey for each commune are summarized in Table 3.1.10.

(1) Quantitative Aspect for Groundwater Development Plan

The test boreholes could detect groundwater at all target communes except for N-4 which had almost no water. However, the safe yield of each test borehole can not cover more or less entire water demand calculated in "3.2 Water Supply Plan". According to the results of the groundwater resources investigations through this study, an expected yield in addition to the test borehole was estimated as shown in Figure 3.1.9. The table indicates that four communes: namely, P-2, 4, 8 and K-1 will be able to cover their demands in the year of 2020 by groundwater resource development with construction of necessary number of boreholes.

Table 3.1.10 Summary of Test Borehole Drilling Survey

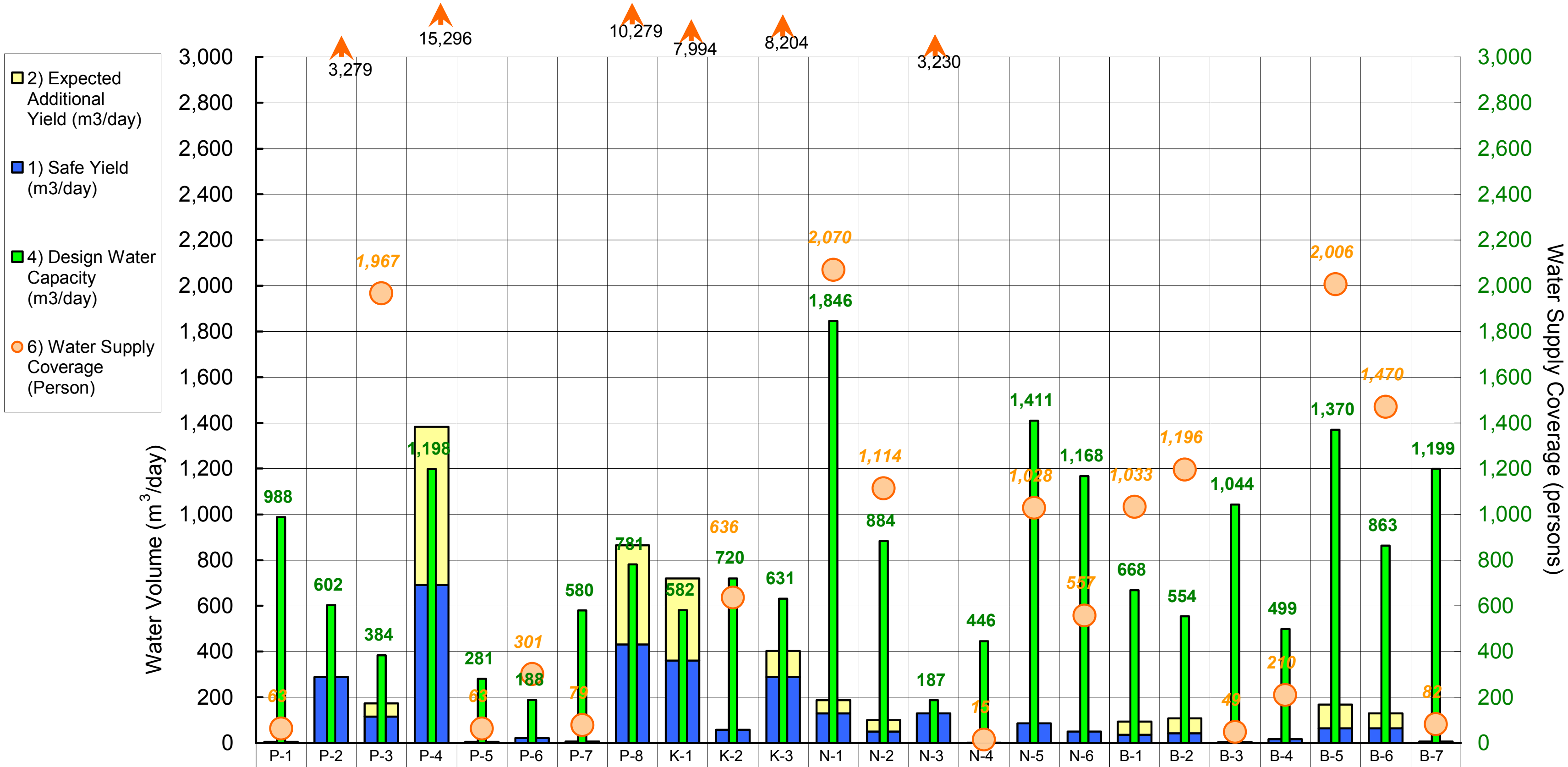
Province	Test well No.	Commune	Thickness of Alluvium (m)	Type* of Bedrock	Aquifer Type	Pumping Test Results				**Water Quality							
						Static Water Level (GL m)	Draw-down (m)	Safe Yield (l/min)	Safe Yield (m^3/day)	F	Cl^-	Fe	Mn	$KMnO_4$	$CaCo_3$	TDS	Zn
Phu Yen	P-1	Xuan Phuoc	10.0	Gr	Fracture	-2.00	-22.63	4.0	6								
	P-2	An Dinh	3.5	Gr	Alluvium, Fracture	-3.00	-9.30	200.0	288	M	X					X	
	P-3	An Tho	-	Ba, SR	Fracture	-43.50	-6.08	80.0	115					X			
	P-4	An My	8.0	Ba, SR	Fracture	0.80	-14.06	480.0	691								
	P-5	Son Phuoc	1.0	Ba, Gr	Fracture	-6.00	-17.00	4.0	6	X							
	P-6	Ea Cha Rang	4.0	Gr	Fracture	-6.00	-33.81	15.0	22				M				
	P-7	Suoi Bac	2.5	Gr	Fracture	-7.00	-30.10	5.0	7	X							
	P-8	Son Thanh Dong	-	Ba, An	Joint, Fracture	-12.70	-0.91	300.0	432								
Khanh Hoa	K-1	Cam An Bac	11.0	Gr	Weathering, Fracture	-1.60	-9.76	250.0	360			M	M				
	K-2	Cam Hiep Nam	15.0	Gr	Weathering, Fracture	-6.70	-25.17	40.0	58			X					X
	K-3	Cam Hai Tay	10.0	Gr	Intrusive, Fracture	0.60	-15.00	200.0	288								
Ninh Thuan	N-1	Nhon Hai	5.0	Gr	Fracture	-7.00	-29.62	90.0	130		X		M		X	X	
	N-2	Cong Hai	8.7	An	Fracture	-3.50	-11.37	35.0	50								
	N-3	Bac Son	5.0	Gr	Weathering, Fracture	-2.50	-14.10	90.0	130		X	X	X		X	X	
	N-4	Phuoc Minh	2.0	Gr	Fracture	-4.00	-36.00	1.0	1	M	X			M		X	
	N-5	Phuoc Hai	8.0	Gr	Weathering	-1.30	-13.65	60.0	86		X		X	X	X	X	
	N-6	Phuoc Dinh	15.0	Gr	Weathering	-6.80	-13.67	35.0	50	X				X			
Binh Thuan	B-1	Muong Man	10.0	SR	Fracture	-5.30	-7.47	25.0	36								
	B-2	Gia Huynh	5.7	Gr	Fracture	-1.64	-26.41	30.0	43								
	B-3	Nghi Duc	8.0	Gr	Fracture	-1.10	-10.03	3.0	4								
	B-4	Tan Duc	10.0	Gr	Weathering, Fracture	-2.50	-5.87	12.0	17						X		
	B-5	Me Pu	8.0	Gr	Weathering	-1.90	-21.30	45.0	65								
	B-6	Sung Nhon	8.0	Gr	Fracture	-0.80	-19.00	45.0	65								
	B-7	Da Kai	3.0	Ba, Gr	Alteration, Fracture	-5.60	-52.90	4.8	7								

* Gr: Granite, Ba: Basalt, SR: Sedimentary Rock, An: Andesite
** X:Dissatisfy Drinking Water Standards, M: Marginal of Drinking Water Standards

(2) Qualitative Aspect for Groundwater Development Plan

Table 3.1.10 also summaries qualitative aspects of groundwater in each commune based on the water quality analysis. It is clear that groundwater quality of Ninh Thuan province is bad but Binh Thuan is good. Since Fe, Mn and Zn can be removed practically, their dissatisfaction with the drinking water standards is not inhibitory matter to develop groundwater. On the other hands, it is difficult to remove Fluoride, TDS and Chloride. Then, some communes have to hang up groundwater development for drinking water supply, for example, target communes in Ninh Thuan except for N-2.

The groundwater development plan reflected both aspects are presented in Figure 3.1.9. The communes with no expected additional yield in the figure have no groundwater resources to develop or unsuitable quality for potable water. Slim bar charts present future demand volume of water supply for each commune in 2020 and thick bar charts mean groundwater development volume. Consequently, P-4, 8 and K-1 can cover their whole demands.



	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	K-1	K-2	K-3	N-1	N-2	N-3	N-4	N-5	N-6	B-1	B-2	B-3	B-4	B-5	B-6	B-7
2) Expected Additional Yield (m3/day)	0	0	58	691	0	0	0	432	360	0	115	58	50	0	0	0	0	58	65	0	0	104	65	0
1) Safe Yield (m3/day)	6	288	115	691	6	22	7	432	360	58	288	130	50	130	1	86	50	36	43	4	17	65	65	7
4) Design Water Capacity (m3/day)	988	602	384	1,198	281	188	580	781	582	720	631	1,846	884	187	446	1,411	1,168	668	554	1,044	499	1,370	863	1,199
6) Water Supply Coverage (Person)	63	3,279	1,967	15,296	63	301	79	10,279	7,994	636	8,204	2,070	1,114	3,230	15	1,028	557	1,033	1,196	49	210	2,006	1,470	82

Figure 3.1.9 Relationship between Water Supply Demand and Planning Borehole Yield for the Target Communes

3.1.4 Alternative Water Source

Due to the results of the hydrogeological investigation of the Study, only two communes (P-4 and 8) in Phu Yen Province and one commune (K-1) in Khanh Hoa Province have enough groundwater potential with good water quality. Accordingly, it becomes necessary to study alternative water sources (especially from surface water) for the rest of the twenty-one communes. Based on the estimated water demand and designed water capacity in 2020, the required water quantity of abstraction for the 21 communes from alternative water sources is shown below.

Table 3.1.11 Required Water Quantity for Abstraction from Alternative Water Sources

Code	Commune	Vave (m^3/month)	Qmax (l/sec)	Code	Commune	Vave (m^3/month)	Qmax (l/sec)
Phu Yen Province				**Ninh Thuan Province**			
P-1	Xuan Phuoc	24,400	11.3	N-1	Nhon Hai	45,700	21.1
P-2	An Dinh	14,900	6.9	N-2	Cong Hai	21,900	10.1
P-3	An Tho	9,500	4.4	N-3	Bac Son	10,400	4.8
P-4	An My	From groundwater		N-4	Phuoc Minh	11,000	5.1
P-5	Son Phuoc	6,900	3.2	N-5	Phuoc Hai	34,900	16.2
P-6	Ea Cha Rang	5,700	2.6	N-6	Phuoc Dinh	28,900	13.4
P-7	Suoi Bac	14,300	6.6	**Binh Thuan Province**			
P-8	Son Thanh Don	From groundwater		B-1	Muong Man	16,500	7.6
Khanh Hoa Province				B-2	Gia Huynh	13,700	6.4
K-1	Cam An Bac	From groundwater		B-3	Nghi Duc	25,800	12.0
K-2	Cam Hiep Nam	17,800	8.2	B-4	Tan Duc	13,200	6.1
K-3	Cam Hay Tay	28,700	13.3	B-5	Me Pu	33,900	15.7
-				B-6	Sung Nhon	21,300	9.9
				B-7	Da Kai	29,700	13.7

Vave: Monthly average required volume for abstraction
Qmax.: Daily maximum quantity for abstraction

(1) Method of Selecting Candidate Sites for Alternative Water Source

Possible alternative water sources around the target communes with distance of less than 16 km are classified into three. They are 1) rivers, 2) reservoirs or ponds and 3) existing urban water supply systems. The survey on alternative water sources was conducted mainly focusing on surface water sources composed of rivers and reservoirs or ponds. Candidate sites were firstly identified based on topographic maps, satellite images and information from P-CERWASS and DARD (in case of Phu Yen). Composition of the candidate sites is shown in table below.

Table 3.1.12 Number of the Candidate Sites

Province	River	Reservoir / Pond
Phu Yen	6	2
Khanh Hoa	1	2
Ninh Thuan	2	1
Binh Thuan	4	3

(2) Alternative Water Source with Possibility for Water Supply

Each candidate site was mainly studied in terms of water quantity and water quality, intake condition, distance and elevation between intake places and target communes. The water quality was firstly estimated with ocular observation, EC and pH at the sites. Then the laboratory test was implemented for the selected sites with high possibility (eight sites) and marginal possibility but has other backup water sources (one site).

Figure 3.1.10 and Figure 3.1.11 show the investigated candidate sites for alternative water sources. The survey results are summarized in Table 3.1.13 and Table 3.1.14. The tables also show the possibilities of the candidate sites as water supply source, which are classified into four categories: namely, “High possibility”, “Marginal possibility”, “Low possibility” and “No possibility”. The conclusion is as follows.

- There are total eight sites with high possibility and three sites with marginal possibility of surface water sources in and around the target communes.

- In case of developing surface water sources at the above sites with high possibility, total 20 communes will be able to be supplied sufficient drinking water. Numbers of these communes are five (Phu Yen), two (Khanh Hoa), six (Ninh Thuan) and seven (Binh Thuan).

- The water supply to P-3 should be done from urban water supply system of Tuy Hoa City, because of no good surface water source either groundwater source in and around P-3. As a provisional solution, it is better to consider supplying water to P-3 by using the test well (only 80 litter/min), even if the available water supply is done with limited time or smaller quantity than the target future water demand of 60 litter/day/person.

- Together with the three communes, which have sufficient groundwater potential, in case of using surface water sources, total 23 communes can have enough water sources for water supply.

- PS-4 site: Dong Tron Reservoir (PS-4 site) has line pipe with 300 mm diameter for drinking water supply already installed in the dam. Water quality of the reservoir is good; however it has odour of sulfide near the drinking water supply pipe. There is a possibility of production of hydrogen sulphide under anaerobic condition near the bottom of the reservoir. It may be better to adopt “selective withdrawal method” to take water from selected depth under aerobic condition in the reservoir.

- PS-6 site (Ba River): The Urban Water Supply Agency in Phu Yen said that during the dry season relatively high concentration of cyanide can be sometimes measured due to illegal gold mining activities in the upstream basin of Ba River. Cyanide was not detected by laboratory test of water quality in this study.

- KS-3 site: Cam Ranh Reservoir (KS-3 site) has marginal possibility for surface water source to K-2 and 3 due to the possibility of unreliable water supply during the dry season. Therefore, in case of using Cam Ranh Reservoir for surface water source, it is better to consider revision of water allocation rule of Cam Ranh Reservoir and prepare back-up supply system from Suoi Dau Reservoir or groundwater wells to increase the reliability for water supply in drought year.

- BS-2 site: Cam Hang Reservoir (BS-2) is the lower reservoir of Song Quao Reservoir and they are connected with an open channel. Average minimum effective storage volume of Song Quao Reservoir from 1997 to 2007 is 11.02 million m^3 with 15 % of design effective storage volume. The minimum effective storage volume became very small in 1998, 2001 and 2002, but its tendency has been slightly improved from 2003 to 2007. Although the percentage of the minimum effective storage volume is only 15 % of the design effective volume, the average minimum effective storage volume of Song Quao Reservoir is sufficient. Furthermore, for the water supply to B-1 commune, the water supply capacity 1,000 m^3/day from Cam Hang Reservoir is ensured by an Irrigation Company that is responsible for the operation and maintenance of Cam Hang and Song Quao Reservoirs, and water quality in Cam Hang Reservoir is good. Therefore, Cam Hang Reservoir has a high possibility of surface water source for B-1.

- BS-4 site: BS-4 site (La Nga River) locates in flooding area; therefore it is necessary to set the structures with equipment as well as the access road to be sufficient height over flood water level around the site. In addition to that, it is also necessary for the access road to have drainage channels to avoid destruction with overflowing during floods.

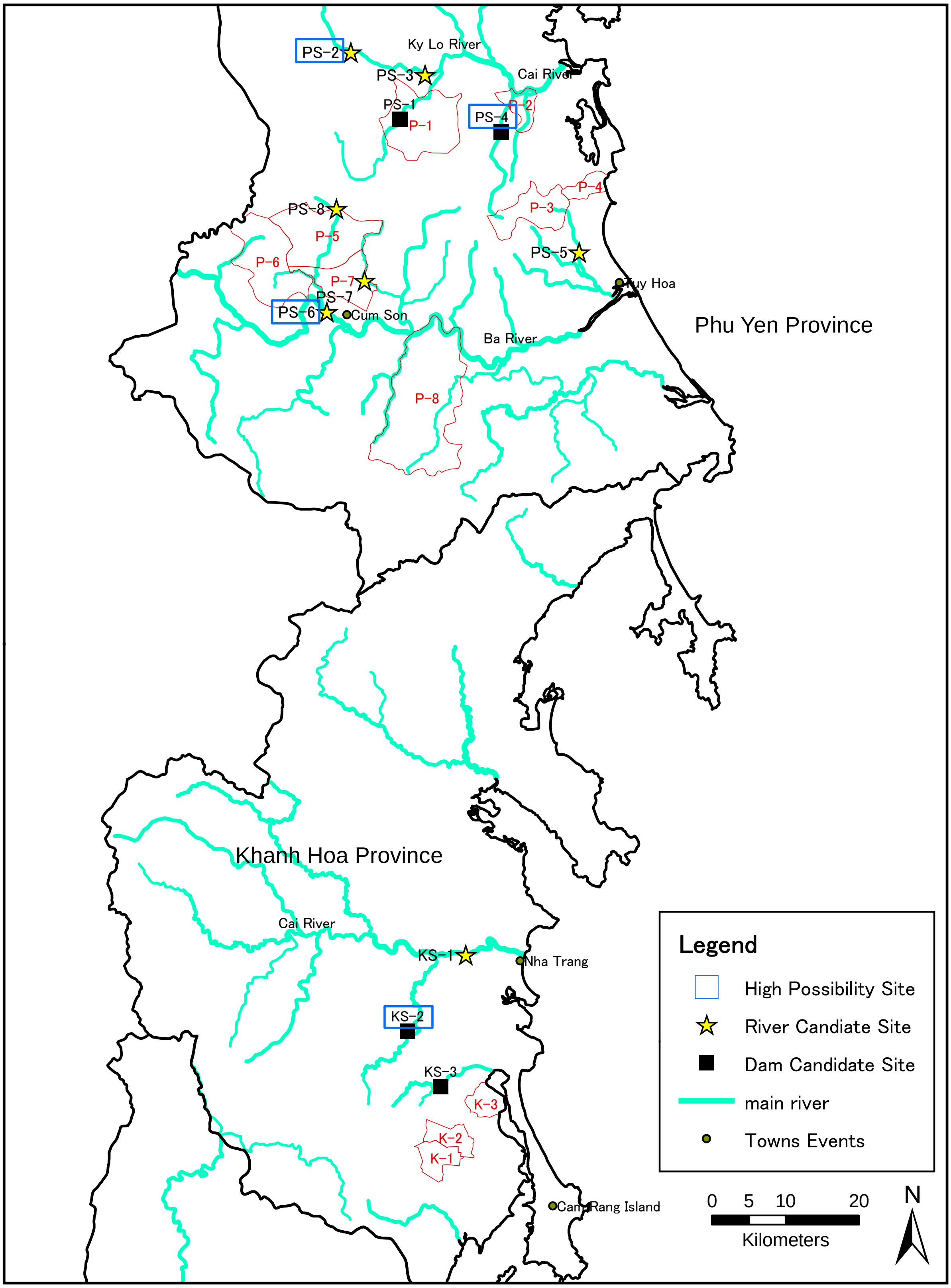


Figure 3.1.10 Locations of Candidate Sites and High Possibility Sites for Surface Water Sources (1/2)

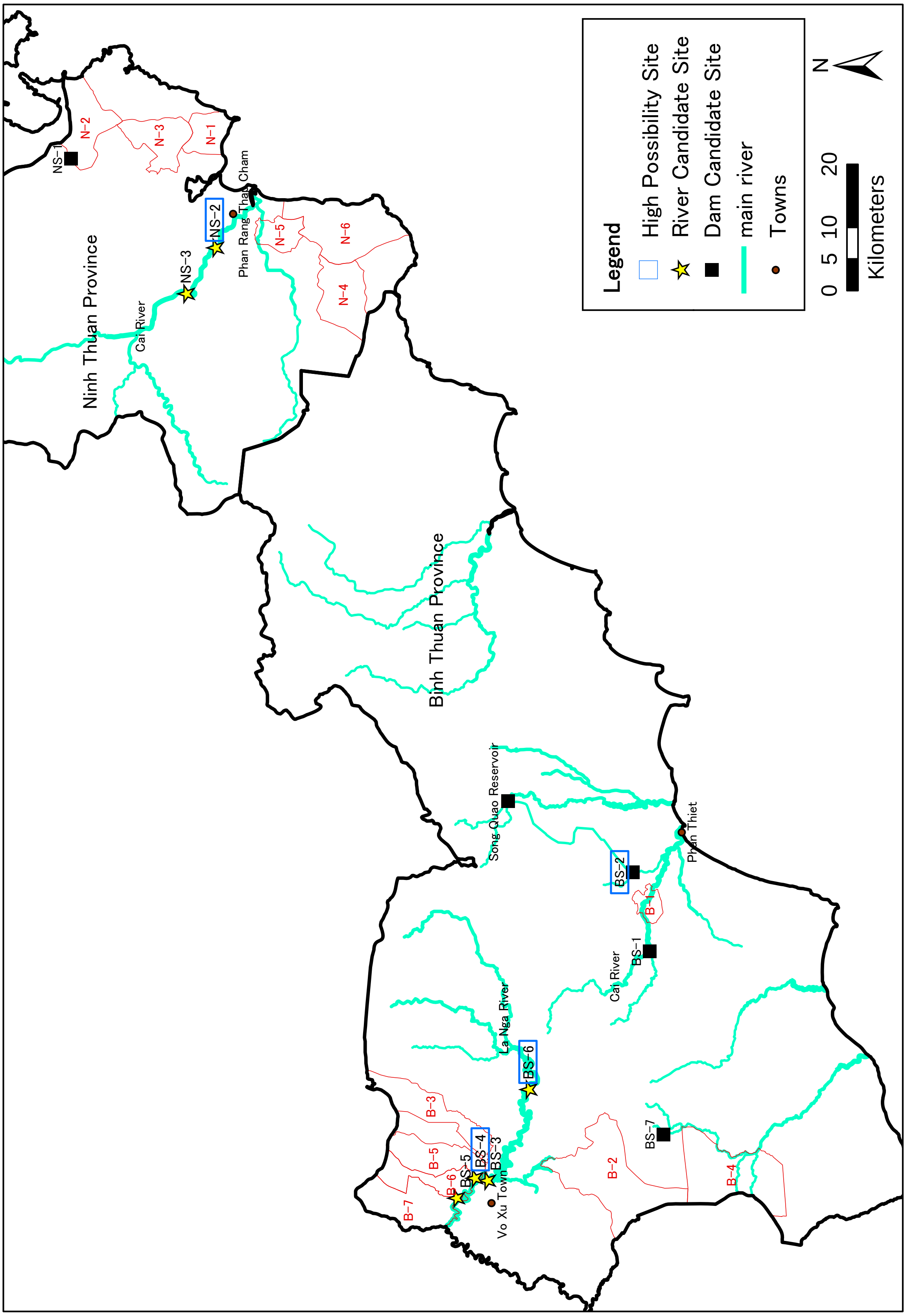


Figure 3.1.11 Locations of Candidate Sites and High Possibility Sites for Surface Water Sources (2/2)

Table 3.1.13 Summary of the Possible Surface Water Sources (1/2)

Site No.	River / Reservoir	Coordinates (at observed site)	Target Commune	Distance (Item 2 to 4)	Difference of Elevation (Item 2 – 4)	Water Quantity during dry season	Water Quality		Possibility of Water Supply Source
							Ocular observation	Laboratory test Excess standard.	
1	2	3	4	5	6	7	8	9	10
1. Phu Yen Province									
PS-1	Phu Xuan Reservoir	13.29053 ºN 109.03555 ºE	P-1	About 3 km	10 m	Not enough	Not so bad	--	Low possibility
PS-2	Ky Lo River (Upstream reach)	13.37263 ºN 108.97303 ºE	P-1	About 13 km	10 m	Enough	Very good	Turbidity, Fe, Total coli, E-coli	**High possibility**
PS-3	Ky Lo River (Midstream reach)	13.34549 ºN 109.06671 ºE	P-1	About 5 km	-5 m	Enough	Not so good	--	**Marginal possibility**
PS-4	Dong Tron Reservoir	13.27567 ºN 109.16115 ºE	P-2	About 5 km	15 m	Enough	Probably good	Turbidity, Fe, H_2S, Total coli, E-coli	**High possibility**
PS-5	Small river	13.12818 ºN 109.26200 ºE	P-3	--	--	Not enough	--	--	No possibility
PS-6	Ba River	13.05220 ºN 108.94560 ºE	P-5, P-6 and P-7	About 4 to 10 km	-120 to -40 m	Enough	Good but in case of no cyanide pollution	Turbidity, Fe, Total coli, E-coli	**High possibility** (but in case of no cyanide pollution)
PS-7	Suoi Bac River (tributary Ba R.)	13.09116 ºN 108.99264 ºE	P-7	About 2.5 km	36 m	Not enough	Good	--	No possibility
PS-8	River in P-5 (tributary Ba R.)	13.17042 ºN 108.95661 ºE	P-5 and P-6	About 4 to 12 km	-10 to 15 m	Not enough	Not so good	--	No possibility
2. Khanh Hoa Province									
KS-1	Cai River (in Nha Trang)	12.26101 ºN 109.12584 ºE	--	About 21 to 26 km	--	Enough	Good	--	-- (Reference site)
KS-2	Suoi Dau Reservoir	12.16636 ºN 109.05357 ºE	K-2 and K-3	About 16 to 18 km	0 to 20 m	Enough	Good	Turbidity, Fe, Total coli, E-coli	**High possibility**
KS-3	Cam Ranh Reservoir	12.09826 ºN 109.09554 ºE	K-2 and K-3	About 8 to 9 km	-10 to 10 m	Not enough (Water supply with 1,230 m^3/day ensured)	Good	Turbidity, Fe, Total coli, E-coli	**Marginal possibility** (better to use with other water source)

Table 3.1.14 Summary of the Possible Surface Water Sources (2/2)

Site No.	River / Reservoir	Coordinates (at observed site)	Target Commune	Distance (Item 2 to 4)	Difference of Elevation (Item 2 – 4)	Water Quantity during dry season	Water Quality		Possibility of Water Supply Source
							Ocular observation	Laboratory test Excess standard.	
1	2	3	4	5	6	7	8	9	10
3. Ninh Thuan Province									
NS-1	Song Trau Reservoir	11.80315 °N 109.06749 °E	N-1, N-2 and N-3	About 3 to 25 km	45 m	Not enough	Bad		Low possibility
NS-2	Cai River at Lam Cam Weir	11.59657 °N 108.93936 °E	N-1to 3, N-4 to 6	About 8 to 26 km	0 m	Enough	Good, but slightly high NH3	Turbidity, Fe, Total coli, E-coli	**High possibility**
NS-3	Cai River at Nha Trinh Weir	11.63788 °N 108.87256 °E	--	About 16 to 29 km	--	Enough	Good	--	-- (Reference site)
4. Binh Thuan Province									
BS-1	Bao Bau Reservoir	10.96631 °N 107.92632 °E	B-1	About 9 km	25 m	Enough	Bad	--	Low possibility
BS-2	Cam Hang Reservoir	10.99128 °N 108.04044 °E	B-1	About 5 km	10 m	Enough (Water supply with 1,000 m^3/day ensured)	Good	Turbidity, Fe, Total coli, E-coli	**High possibility**
BS-3	La Nga River (Left Bank near Vo Xu Town)	11.19543 °N 107.59187 °E	B-3, B-5, B-6 and B-7	About 6 to 10 km	0 to 5 m	Enough	Good	--	-- (Reference site)
BS-4	La Nga River (Right Bank near B-6)	11.21343 °N 107.59513 °E	B-3, B-5, B-6 and B-7	About 4 to 9 km	-20 m	Enough	Good	Turbidity, Fe, Total coli, E-coli	**High possibility**
BS-5	La Nga River (Right Bank near B-7)	11.23943 °N 107.56582 °E	B-3, B-5, B-6 and B-7	About 3 to 12 km	-10 m	Enough	Good	--	**Marginal possibility**
BS-6	La Nga River (around Dong Kho Town)	11.13765 °N 107.72428 °E	B-2 and B-4	About 16 to 36 km	20 to 70 m	Enough	Good	Turbidity, Fe, Total coli, E-coli	**High possibility**
BS-7	Irrigation Pond near B-2	10.94367 °N 107.66137 °E	B-2 and B-4	About 10 km	0 to 50 m	Not enough	Not so good	--	No possibility

Note: Elevation is mainly measured by simple GPS.

3.2 Water Supply Plan

3.2.1 Study Area

The study area is located in twenty four (24) communes of four (4) provinces including Phu Yen, Khanh Hoa, Ninh Thuan and Binh Thuan. The target communes in the Study area are listed in Table 3.2.1. The water supply Master Plan is formulated on consideration for plan conditions to be confirmed through site survey in these communes.

Table 3.2.1 Target Communes in the Study Area

Province	Code	Commune	Area (km^2)	Province	Code	Commune	Area (km^2)
Phu Yen	P-1	Xuan Phuoc	80.5	Ninh Thuan	N-1	Nhon Hai	34.1
	P-2	An Dinh	17.9		N-2	Cong Hai	73.6
	P-3	An Tho	43.0		N-3	Bac Son	60.3
	P-4	An My	13.8		N-4	Phuoc Minh	75.0
	P-5	Son Phuoc	83.1		N-5	Phuoc Hai	32.5
	P-6	Ea Cha Rang	78.4		N-6	Phuoc Dinh	130.1
	P-7	Suoi Bac	40.5	Binh Thuan	B-1	Muong Man	18.3
	P-8	Son Thanh Dong	179.7		B-2	Gia Huynh	158.3
Khanh Hoa	K-1	Cam An Bac	20.5		B-3	Nghi Duc	74.7
	K-2	Cam Hiep Nam	18.8		B-4	Tan Duc	137.4
	K-3	Cam Hai Tay	15.4		B-5	Me Pu	64.3
					B-6	Sung Nhon	49.5
					B-7	Da Kai	87.3

3.2.2 Objectives of the Study

The target year of the Master Plan (MP) is 2020. The prime aim of the preparation of MP is to achieve improvement in living standards and promotion of healthy socio-economic activities through suitable project for providing clean water to the people in the study area.

The service level is considered to be 24 hours uninterrupted water supply with house connections. The rate of population served is to be 100% under the condition of sufficient water supply in 2020.

3.2.3 Water Demand

(1) Population

Table 3.2.2 summarizes the population forecast for the year 2007, 2012, 2017 and 2020. Population in the Study area until 2020 is projected on the basis of the past population records and foreseen social and economic changes. As mentioned earlier in the description of population in Chapter 2, the population of Ninh Thuan is forecasted considering slightly higher growth rate than other provinces due to its accelerating trend of economic development, although the scale itself is still limited.

On the other hand, the government has been promoting family planning for more than ten years now nationwide[6], and its effect has been observed to pervade in the Study area as well. Hence, the

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[6] The resolution of the fourth conference (No 04-NQ/HNTW on 14/1/1993) of the Party Central Committee, term VII about policy of population and family planning is as follows:
- Goal: each family has 1 or 2 children up to 2015 on average; each family (each couple) should have 2 children at the maximum.
- Results as of 2007: "Vietnam Women's Union" evaluated the results; after over 10 years since the Resolution came into effect, one or

population growth rate is judged to be basically stable recently. Considering these points, population estimates have been made and result is presented in Table below.

Table 3.2.2 Population Forecast in 2007, 2012, 2017 and 2020

Province	Code	Commune	Growth Rate (%)	Population (Persons)				
				2006 (Actual)	2007	2012	2017	2020
Phu Yen	P-1	Xuan Phuoc	1.30	9,059	9,182	9,816	10,495	10,927
	P-2	An Dinh	1.00	5,964	6,022	6,326	6,654	6,856
	P-3	An Tho	2.18	3,242	3,312	3,684	4,101	4,373
	P-4	An My	1.10	11,427	11,549	12,178	12,840	13,256
	P-5	Son Phuoc	1.60	3,261	3,313	3,585	3,882	4,071
	P-6	Ea Cha Rang	1.25	2,583	2,616	2,782	2,959	3,072
	P-7	Suoi Bac	0.94	5,626	5,678	5,946	6,232	6,411
	P-8	Son Thanh Don	0.86	8,240	8,309	8,674	9,056	9,292
	Sub-total		1.20	49,402	49,981	52,991	56,219	58,258
Khanh Hoa	K-1	Cam An Bac	2.02	6,316	6,440	7,109	7,861	8,355
	K-2	Cam Hiep Nam	1.91	6,113	6,226	6,832	7,513	7,962
	K-3	Cam Hay Tay	1.40	10,620	5,825	6,245	6,693	6,978
	Sub-total		1.70	23,049	18,491	20,186	22,067	23,295
Ninh Thuan	N-1	Nhon Hai	2.30	14,896	15,234	17,048	19,079	20,413
	N-2	Cong Hai	2.00	7,381	7,530	8,324	9,203	9,776
	N-3	Bac Son	1.95	5,809	5,922	6,523	7,182	7,609
	N-4	Phuoc Minh	2.48	3,509	3,596	4,061	4,585	4,934
	N-5	Phuoc Hai	1.90	12,881	13,126	14,430	15,869	16,804
	N-6	Phuoc Dinh	4.20	8,549	8,912	10,766	12,061	12,911
	Sub-total		2.40	53,025	54,320	61,152	67,979	72,447
Binh Thuan	B-1	Muong Man	1.50	5,977	6,067	6,540	7,052	7,378
	B-2	Gia Huynh	1.13	5,246	5,305	5,611	5,936	6,139
	B-3	Nghi Duc	1.10	10,192	10,303	10,878	11,487	11,869
	B-4	Tan Duc	1.42	4,981	5,052	5,421	5,817	6,068
	B-5	Me Pu	1.50	13,250	13,449	14,488	15,603	16,315
	B-6	Suong Nhon	1.30	8,175	8,282	8,833	9,422	9,794
	B-7	Da Kai	1.60	11,436	11,615	12,556	13,590	14,263
	Sub-total		1.40	59,257	60,073	64,327	68,907	71,826
Total			1.60	184,733	182,865	198,656	215,172	225,826

(2) Water Usage

The water usage is classified into two categories as described below:

1) Domestic Water

The domestic water is used for living purposes such as for drinking, cooking, bathing and laundry mainly consumed by the Residential areas.

According to National Rural Water Supply and Sanitation Strategy (NRWSSS), per capita consumption is estimated to be 60 liters up to 2020. Towards achieving the target of NTP II, the ratio of population served in the target communes and per capita water consumption are defined as follows.

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two-child family is widely accepted.
Actually, Vietnam’s population growth rate dropped to 1.26% in 2006 from 2.1% in 1989, and the average number of children being born to one woman decreased from 3.8 in 1989 to 2.33 in 1999 when the last study was conducted.
- In addition, although the government promotes the resolution’s effect, there are no penalties when families have more than 2 children.

Year	2010	2020
Rate of population served (%)	85	100
Water demand per capita (l/ c /d)	60	60

Source: National Target Program on Rural Clean Water Supply and Sanitation (NRWSSS)

As a result of the socio-economic survey, average of per capita consumption for domestic sector is estimated to be 120 liters. Specifically for drinking, cooking and shower purposes only, the consumption is generally observed to be around 20 to 30 l/person/day. As described in “2.2 (6) Local needs regarding water supply” and “2.3.3 Condition of water use”, the demands on water use for drinking, cooking, and bathing has been increasing significantly compared to the present demand.

The lifestyle of people in Study area has been changing at accelerated pace in the past decade and has spread to most of the area. It has been observed that the practice of more frequent bathing is followed by more people. Therefore, the target of water consumption should be increased definitely, taking into consideration their growing demands based on changes in lifestyle. In addition, in the Study area, the practice of using toilets is also gaining momentum and being practiced by higher population than it used to be in the past and therefore has resulted into increase of volume of water consumption.

Considering these factors and conditions, the governmental target of the supply volume to be increased from the present 20-30 liter/person/day (in case of limiting to drinking, cooking and bathing) to 60 liter/person/day is judged to be appropriate and in accordance with the increased demands. Consequently, per capita consumption in this Study is considered as 60 liters/day.

2) Non-Domestic Water

As a result of the socio-economic survey, the non-domestic water in the study area is classified into two categories including consumption by commercial and public facilities.

From the results of field survey, the ratio of non-domestic water consumption varies from 3% to 43%. The average rate of non-domestic water is approx. 12% in case when the rate of domestic water is 100%. In order to assemble raw water data of socio-economic study, the estimation of rate of non-domestic water is carried out considering its classification into three quartiles. The range of classification is shown in Table 3.2.3.

Table 3.2.3 Classification of the Adopted Rate of Non-Domestic Water

Adopted value for calculation of commercial water supply (%)	Range of the actual rate of non-domestic water (%)
5%	Less than 5%
10%	Between 5% and 10%
13%	More than 10%

Based on the classification of non-domestic water consumption rate mentioned above, rate of non-domestic water in each commune is shown in Table 3.2.4 where the whole domestic water is 100%.

Table 3.2.4 Rate of Non-Domestic Water

Province/Commune			Non-domestic water	Province/Commune			Non-domestic water
Phu Yen	P-1	Xuan Phuoc	13%	Ninh Thuan	N-1	Nhon Hai	13%
	P-2	An Dinh	10%		N-2	Cong Hai	13%
	P-3	An Tho	10%		N-3	Bac Son	13%
	P-4	An My	13%		N-4	Phuoc Minh	13%
	P-5	Son Phuoc	13%		N-5	Phuoc Hai	5%
	P-6	Ea Cha Rang	10%		N-6	Phuoc Dinh	13%
	P-7	Suoi Bac	13%	Binh Thuan	B-1	Muong Man	13%
	P-8	Son Thanh Dong	5%		B-2	Gia Huynh	13%
Khanh Hon	K-1	Cam An Bac	10%		B-3	Nghi Duc	10%
	K-2	Cam Hiep Nam	13%		B-4	Tan Duc	10%
	K-3	Cam Hai Tay	13%		B-5	Me Pu	5%
					B-6	Sung Nhon	10%
					B-7	Da Kai	5%

3) Leakage Water

The water demand forecast shall be including leakage water as a fixed percentage per day. On the basis of the adopted values in past projects of Vietnam such as the groundwater development in rural part of central highlands provinces and Northern provinces financed by JICA Grant Aid, each percentage of the leakage water was to be 10%. Furthermore, the water supply system in the project will be constructed newly build. 10% leakage water is considered reasonable and proper. Therefore, the rate of leakage water is determined as 10% in the project. The formulation of water demand including leakage water is shown as below:

$$W1/(1-r) = W2$$

Where,

W1: water consumption (domestic water +non domestic water: m^3/d)

W2: water demand (m^3/d)

r: rate of leakage water (%)

(3) Water Demand Forecast

The water demand is estimated on the bases of the water consumption, non-domestic water and leakage water. The water demand forecast is summarized in Table 3.2.5.

Table 3.2.5 Water Demand Forecast

	Code	Commune	Water demand (Domestic, non-domestic, leakage water, m^3/d)				
			2006	2007	2012	2017	2020
Phu Yen	P-1	Xuan Phuoc	683	692	740	791	823
	P-2	An Dinh	438	441	464	488	502
	P-3	An Tho	239	243	270	301	320
	P-4	An My	861	870	918	967	998
	P-5	Son Phuoc	246	250	270	292	307
	P-6	Ea Cha Rang	190	192	204	218	224
	P-7	Suoi Bac	424	428	448	470	483
	P-8	Son Thanh Don	577	582	607	633	651
Khanh Hoa	K-1	Cam An Bac	463	472	522	577	612
	K-2	Cam Hiep Nam	461	470	514	567	600
	K-3	Cam Hay Tay	800	440	471	504	526
Ninh Thuan	N-1	Nhon Hai	1,122	1,148	1,284	1,438	1,538
	N-2	Cong Hai	557	568	627	693	737
	N-3	Bac Son	438	446	491	541	573
	N-4	Phuoc Minh	264	271	307	346	371
	N-5	Phuoc Hai	902	919	1,010	1,111	1,176
	N-6	Phuoc Dinh	644	672	811	909	973
Binh Thuan	B-1	Muong Man	451	457	492	531	557
	B-2	Gia Huynh	396	399	423	447	462
	B-3	Nghi Duc	748	756	798	842	870
	B-4	Tan Duc	366	370	398	427	444
	B-5	Me Pu	928	941	1,013	1,092	1,142
	B-6	Suong Nhon	600	608	648	691	719
	B-7	Da Kai	800	813	879	951	999
Total			13,598	13,448	14,609	15,827	16,607

3.2.4 Water Supply Plan

(1) Determination of Project Scope for Master Plan

The water source for the supply system formulated in the Master Plan is basically groundwater. However, as a result of groundwater study, it is observed that in case of only 4 communes, the availability of groundwater sources is sufficient in terms of quality and quantity and hence could be used for design of water supply systems. Therefore, additional studies have been carried out to locate the alternative water sources such as river or irrigation reservoir.

Furthermore, there are some areas that are supplied water by existing piped water in 24 target communes and some areas are overlapped by water supply plan of other Donor. Analyzing the current conditions, project area for MP formulation has been determined and the concept for this determination is presented in Figure 3.2.1.

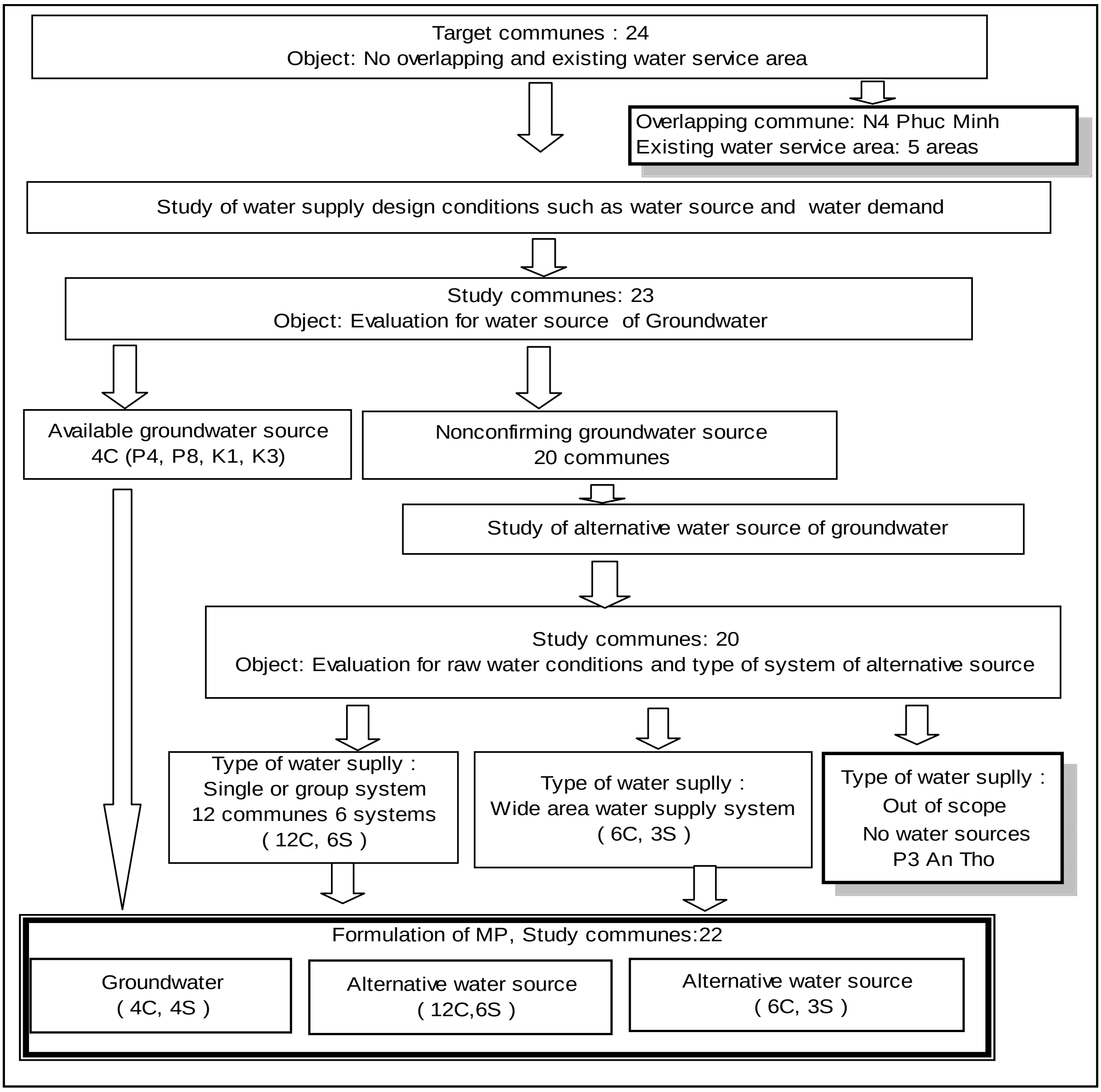


Figure 3.2.1 Confirmation of Commune for Master Plan

Based on the result of site investigation, pertinent area with following conditions is excluded from the selected commune under this Master Plan.

(2) Areas with Existing Water Supply System and covered by Projects of Other Donor

There are 10 existing water supply systems in the target commune and Phuoc Minh commune is now carrying out tendering for the construction financed by ADB loan.

According to the evaluation of the existing system in Chapter 2, 5 areas out of 10 have got good sources of water availability. For the estimation of the design population, the population supplied by existing water supply is deducted from the total population in communes. Considering present conditions, the deducted population in 2006 is summarized in Table 3.2.6.

Table 3.2.6 Deducted Population in 2006

Province	Commune code	Commune	Total population of commune	Existing population served	Percentage of existing population served
Deducted area					
Phu Yen	P-5	Son Phuoc	3,261	777	24
	P-6	Ea Cha Rang	2,583	772	30
Khanh Hoa	K-1	Cam An Bac	6,316	1305	21
Ninh Thuan	N-3	Bac Son	5,809	4,226	73
Binh Thuan	B-4	Tan Duc	4,981	314	6
Deducted commune					
Ninh Thuan	N-4	Phuoc Minh	3,509	3,509	100

On the basis of population, water demand forecast in 2020 and percentage of existing population served in Table 3.2.6, deducted population and water demand in 2020 is estimated as given below:

Table 3.2.7 Deducted Population and Water Demand in 2020

Province	Commune code	Commune	Deducted population	Deducted water demand (m^3/d)
Deducted area				
Phu Yen	P-5	Son Phuoc	969	73
	P-6	Ea Cha Rang	919	67
Khanh Hoa	K-1	Cam An Bac	1,729	127
Ninh Thuan	N-3	Bac Son	5,532	417
Binh Thuan	B-4	Tan Duc	382	28
Deducted commune				
Ninh Thuan	N-4	Phuoc Minh	4,934	371
Total			**14,465**	**1,083**

(3) Non Water Source

According to the result of the groundwater and surface water sources study, the water sources can be available for 23 communes. However, in case of P-3 commune (Phu Yen province), there is no possibility to take water from the water sources in adjacent area. Hence, it is proposed to consider supplying water from the Urban Water Supply System of Thy Hoa City to P-3 commune. This commune is close to the city and therefore has not been considered for comparison of alternative water sources. Hence, P-3 commune is not included in the Master Plan. As a consequence, the deduction population and water demand in 2020 is to be 14,465 and 1,083 m^3/d, respectively.

(4) Projected Communes and Water Demand in 2020

Considering the mentioned above, 22 out of 24 communes have been included for preparation of MP in this Study and projected communes and their water demand in 2020 are shown in Table 3.2.8.

Table 3.2.8 Projected Communes and Water Demand in 2020

Province	Code	Commune	Population	Water Demand (m^3/d)	Province	Code	Commune	Population	Water Demand (m^3/d)
Phu Yen	P-1	Xuan Phuoc	10,927	823	Ninh Thuan	N-1	Nhon Hai	20,413	1,538
	P-2	An Dinh	6,856	502		N-2	Cong Hai	9776	737
	P-4	An My	13,256	998		N-3	Bac Son	2,077	156
	P-5	Son Phuoc	3,102	234		N-5	Phuoc Hai	16,804	1,176
	P-6	Ea Cha Rang	2,153	157		N-6	Phuoc Dinh	12,911	973
	P-7	Suoi Bac	6,411	483	Binh Thuan	B-1	Muong Man	7,378	557
	P-8	Son Thanh Don	9,292	651		B-2	Gia Huynh	6,139	462
Khanh Hoa	K-1	Cam An Bac	6,626	485		B-3	Nghi Duc	11,869	870
	K-2	Cam Hiep Nam	7,962	600		B-4	Tan Duc	5,686	416
	K-3	Cam Hay Tay	6,978	526		B-5	Me Pu	16,315	1,142
						B-6	Suong Nhon	9,794	719
						B-7	Da Kai	14,263	999
					Total			206,988	15,204

3.2.5 Water Supply System

(1) Pattern of Water Supply System

In 3 communes out of 22 communes, groundwater sources have been evaluated as good conditions in terms of water flow capacity.

The design capacity of water supply for commune with codes K-3 have been decided based on the expected yield of groundwater in accordance with results of the test borehole drilling. The differences between design capacity and the yield for these communes shall be covered by alternative water sources.

According to the result of the alternative water sources study, in case of 19 communes including K-3 surface water sources can be utilized. Water supply system for these communes is planned considering site conditions as described below.

Where there is the water source nearby water service area, the water supply system will be constructed and operated by single facility. These systems will be applied to communes with codes P-1, P-2, K-3, B-1, refer to Figure 3.2.2, (1).

In case of water supply system with intake from surface water, the transmission pipeline, between water source and service area, is longer than groundwater intake. Thus, the system has advantage to be in conjunction with some nearby communes with view point of economical and technical aspects because of shared transmission pipe and intake facility. The system could be defined as "group water supply system" and applicable communes are P-5, 6, 7, N-5, 6, B-3, 5, 6, 7, refer to Figure 3.2.2, (2).

In addition, it is possible that there are some communes (not included among target communes) which are still lacking water supply along transmission main. It is better that future water supply plan include these communes too. The system could be termed as "wide area water supply". The system shall be designed considering current water supply situation in these districts in a comprehensive manner. In the Master Plan, the study area is limited to target commune so the system will be provisionally designed to pick up target communes only in the wide area. For communes with codes K-2, N-1, N-2, N-3, B-2 and B-4 facilities will be planned considering it as wide area water supply system, refer to Figure 3.2.2, (3).

The schematic diagram illustrating pattern of the system is shown in Figure 3.2.2.

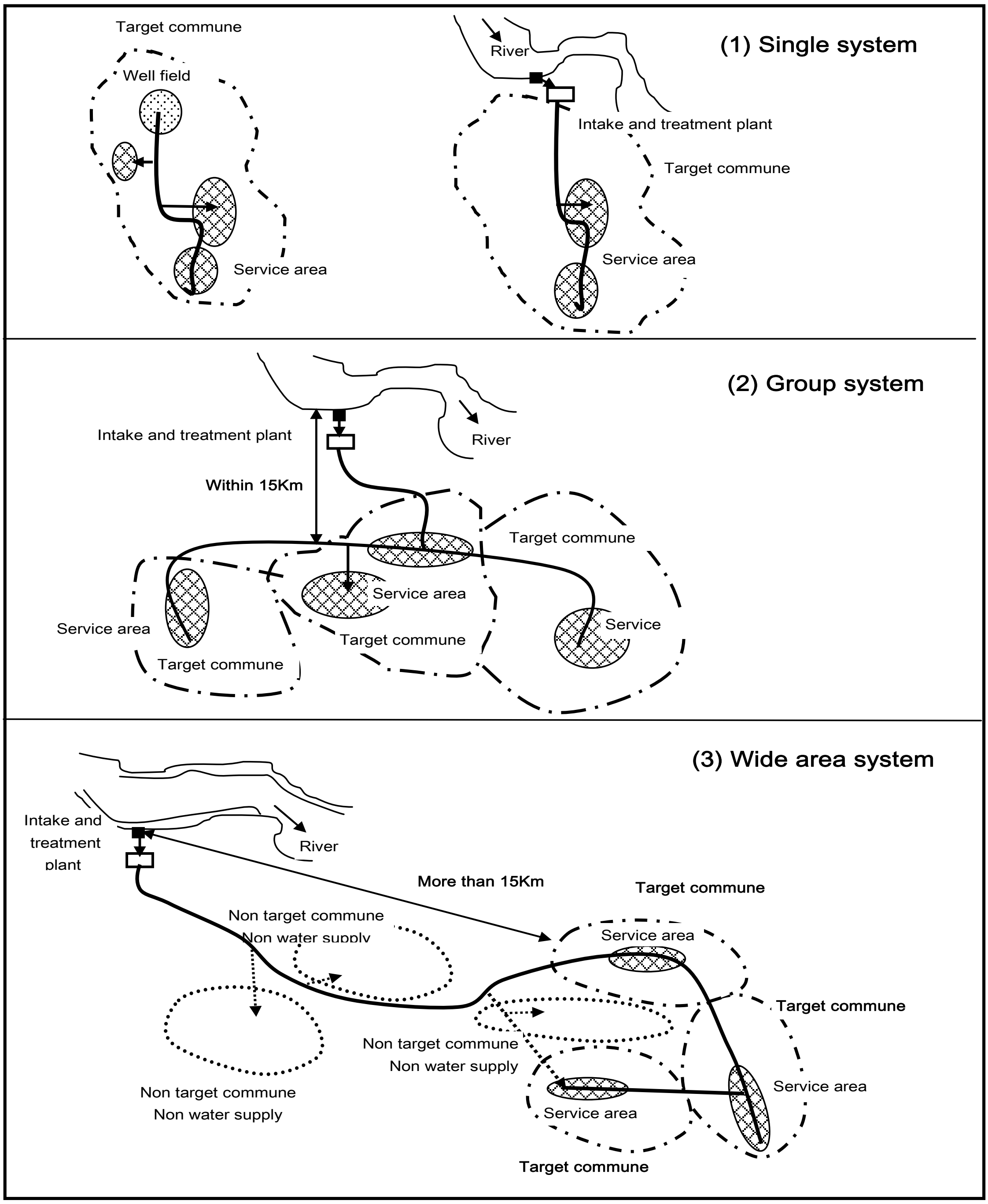


Figure 3.2.2 System Pattern

The basic conditions for water supply system, including groundwater sources and alternative water sources (surface water sources), are summarized in Table 3.2.9.

Table 3.2.9 System Pattern and Basic Conditions

Commune		System		Population in 2020	Water demand in 2020(m^3/d)	Raw water source	Transmission interval（km）
		No.	Pattern				
Xuan Phuoc	P-1	FPS-1	Single	10,927	823	Ky Lo river (PS-2)	18.1
An Dinh	P-2	FPS-2	Single	6,856	502	Dong Tron reservoir (PS-4)	5.5
An My	P-4	FPS-3	Single	13,256	998	**Groundwater**	1
Son Phuoc	P-5	FPG-4	Group	11,666	874	Ba river (PS-6)	4.5
Ea Cha Rang	P-6						
Suoi Bac	P-7						
Son Thanh Don	P-8	FPS-5	Single	9,292	651	**Groundwater**	1.9
Cam An Bac	K-1	FKS-6	Single	6,626	485	**Groundwater**	0.5
Cam Hiep Nam	K-2	FKW-7	Wide area	7,962	600	Suoi Dau river (KS-2)	9.6
Cam Hay Tay	K-3	FKS-8	Single	6,978	526	**Groundwater** + Cam Ranh reservoir (KS-3)	1+8=9 9
Nhon Hai	N-1	FNW-9	Wide area	32,266	2,431	Cai river at Lam Com Weir (NS-2)	22,8
Cong Hai	N-2						
Bac Son	N-3						
Phuoc Hai	N-5	FNG-10	Group	29,715	2,149	Cai river at Lam Com Weir (NS-2)	14.5
Phuoc Dinh	N-6						
Muong Man	B-1	FBS-11	Single	7,378	557	Com Hang reservoir (BS-2)	4.7
Gia Huynh	B-2	FBW-12	Wide area	11,825	878	La Nga river (BS-6)	21.4
Tan Duc	B-4						
Nghi Duc	B-3	FBG-13	Group	52,241	3,730	La Nga river (BS-4)	4.5
Me Pu	B-5						
Suong Nhon	B-6						
Da Kai	B-7						
22		13		206,988	15,204		95.2

(2) Design Capacity

The design capacity such as daily maximum and hourly maximum water demand is calculated, based on water demand including domestic, non-domestic and leakage water. The process of calculation is shown in Figure 3.2.3.

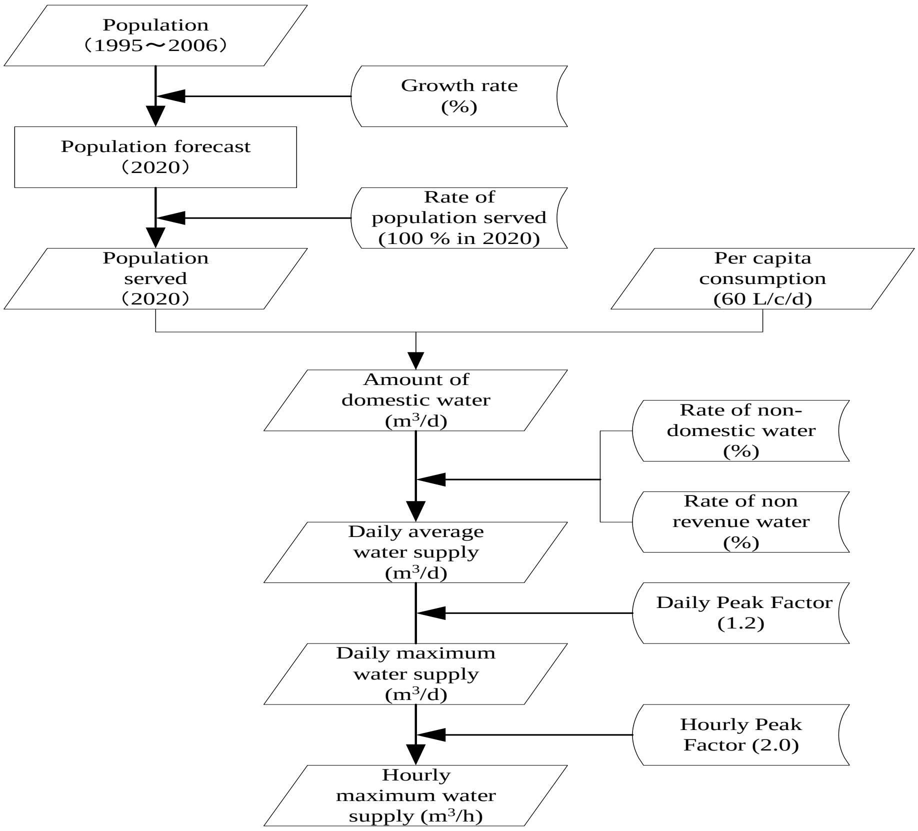


Figure 3.2.3 Calculation Process of Design Capacity

(3) Design Criteria

In order to calculate Design capacity, the values of peak factors are required. The peak factor should be compared with the Vietnamese standards, other examples and determined by existing condition of the target area. Comparison of design criteria between past record and Vietnamese standard is shown in Table 3.2.10.

Table 3.2.10 Comparison between Past Project and Vietnamese Standard

Item to be compared	Northern province and Central Highland*1	Vietnamese Standard*2
Peak factor for daily maximum	1.3 to 1.35	1.2~1.4
Peak factor for hourly maximum	2.0	This value is calculated by size of the served population

Source: *1; Basic Design study on the Project for the Groundwater Development in Rural Part of Central Highlands Provinces in the Socialist Republic of Vietnam, *2; Vietnam Construction Standard (TCXDVN 33: 2006 issued by Ministry of Construction)

In the project of Northern provinces and Central highlands, daily peak factor of 1.3 to 1.35 was used. However, the target area of this Project is located in southern coastal areas of temperate region. In the Project area, the seasonal variation is very low, and therefore, daily peak factor of 1.2 is considered in this Project. Based on the adopted values in past projects of Vietnam, hourly peak factor is considered to be 2.0 in this Project.

Adopted values of peak factors are as follows;

Daily peak factor : 1.2 Hourly peak factor : 2.0

(4) Design Water Capacity

The design capacity in 2020 is calculated as shown in Table 3.2.11.

Table 3.2.11 Design Water Capacity in Year 2020

Province	System	Commune	Design Water Capacity		
			(1) Daily Average (m^3/d)	(2) Daily Maximum (m^3/d)	(3) Hourly Maximum (m^3/hr)
Phu Yen	FPS-1	P-1	823	1,000	82
	FPS-2	P-2	502	600	50
	FPS-3	P-4	998	1,200	100
	FPG-4	P-5,6,7	874	1,000	83
	FPS-5	P-8	651	800	67
Khanh Hoa	FKS-6	K-1	485	600	50
	FKW-7	K-2	600	700	60
	FKS-8	K-3	526	600	50
Ninh Thuan	FNW-9	N-1,2,3	2,431	3,000	243
	FNG-10	N-5,6	2,149	2,600	217
Binh Thuan	FBS-11	B-1	557	700	58
	FBW-12	B-2,4	878	1,000	88
	FBG-13	B-3,5,6,7	3,730	4,500	375
Total			15,204	18,300	

1) Daily Average Water Capacity

The daily average water capacity means average water consumption in year. The capacity consist domestic water, non-domestic water and leakage.

2) Daily Maximum Water Capacity

This capacity means peak consumption through all seasons. Meanwhile, from the design criteria, a peak factor is given as 1.2 in accordance with the design criteria. Therefore, the daily average water capacity multiplied by the peak factor comes to daily maximum water capacity. It is round each calculation value to the nearest 100. However the error for these approximate numbers shall be considered within plus or minus 5% of daily average capacity.

3) Hourly Maximum Water Capacity

In order to design for the distribution facility, hourly maximum water capacity is required. The daily maximum multiplied by the hourly peak factor (2.0) comes to hourly maximum water capacity.

(5) Process of the System

When groundwater is used as source of water supply, there are two kinds of process that may be adopted including treatment for iron and manganese removal, defined as category 2, and without treatment process, defined as category 1. All systems are planned to have disinfection facility. If the raw water is drawn from surface water, treatment process includes system to remove turbidity in raw water, defined as category 3. The schematic diagram for each category is indicated in Figure 3.2.4.

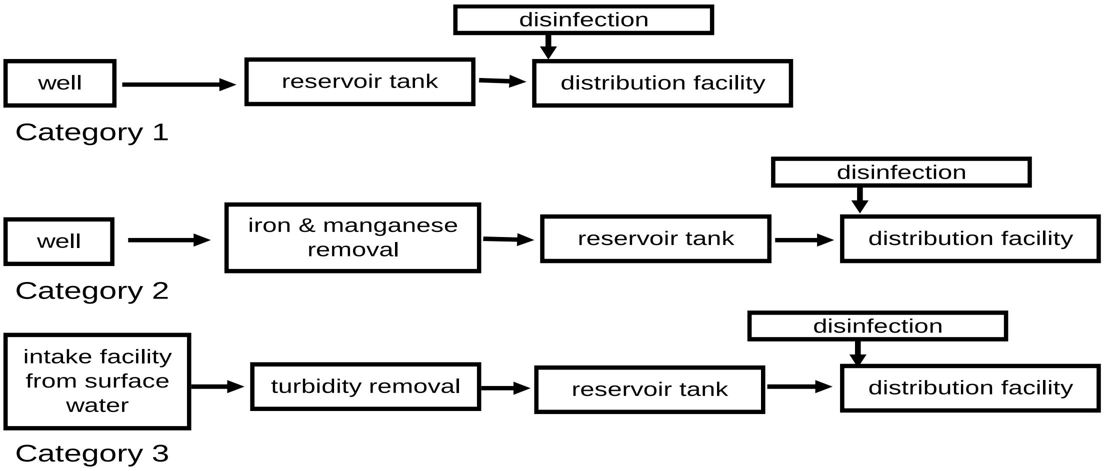


Figure 3.2.4 Category of Water Supply System

In case of category 1 and 2, the groundwater is pumped up from well by submersible pump. Based on the result of groundwater quality analysis for system FPS-3, FPS-5 and FKS-8, it is observed that the value of all parameters is within drinking water quality standards. Therefore, water supply system defined as category 1 is proposed to apply for these cases.

The raw water of system FKS-6 is observed to include iron amount slightly higher than drinking water standard. Therefore, in this case water supply system defined in category 2 is proposed to be applied. In this case, Iron shall be removed by means of biological treatment process with slow sand filter considering economical and technical aspects compared to aeration process. This is attributed to the reason that the construction and O & M cost of the slow sand filter is lower than aeration process which consists of aeration tower, contact tank and rapid sand filter with back wash pumps.

In case of the system using surface water source, high concentration of turbidity has been detected. During and after rainfall the turbidity level in surface water is very high and it is necessary to bring turbidity within permissible level of palatable water. Therefore, it is appropriate to conduct the turbidity removal by coagulation, sedimentation and rapid sand filter. This concept has been applied in case of category 3.

There are 3 types of intake facility that could be applied in case of category 3 depending on the situation of each commune and are listed as follows:

- Direct intake from river: the intake channel is constructed by open cut method and relevant systems are FPS-1, FPG-4, FKW-7, FNW-9, FNG-10, FBW-12 and FBG-13.
- Connecting existing irrigation channel: the intake channel constructed to connect existing concrete channel and relevant systems are FKS-8 and FBS-11.
- Connecting existing pipe: Since the irrigation department prepared the pipe for drinking water through embankment of reservoir, the raw water pipe is connected. Relevant system is FPS-2.

In order to disinfect water, the chlorinator facility is proposed for all of the systems.

The distribution facilities consist of the distribution reservoir, distribution pump (if necessary), and distribution pipeline. To make it economic, normally the water distribution is by gravity flow wherever possible. The capacity of distribution reservoir is for about 8 hours of the maximum daily water flow considering the purposes mentioned above. The capacity of the reservoir will include water required for fire control too.

The facilities for water supply system are summarized in Table 3.2.12.

Table 3.2.12 Facility for Water Supply System

System	Facilities							
	Well	Intake from river	Non treatment	Iron removal	Turbidity removal	Reservoir tank	Distribution	Process category
FPS-1		**x**			**x**	**x**	**x**	**3**
FPS-2		**x**			**x**	**x**	**x**	**3**
FPS-3	**x**		**x**			**x**	**x**	**1**
FPG-4		**x**			**x**	**x**	**x**	**3**
FPS-5	**x**		**x**			**x**	**x**	**1**
FKS-6	**x**			**x**		**x**	**x**	**2**
FKW-7		**x**			**x**	**x**	**x**	**3**
FKS-8		**x**			**x**	**x**	**x**	**3**
FNW-9		**x**			**x**	**x**	**x**	**3**
FNG-10		**x**			**x**	**x**	**x**	**3**
FBS-11		**x**			**x**	**x**	**x**	**3**
FBW-12		**x**			**x**	**x**	**x**	**3**
FBG-13		**x**			**x**	**x**	**x**	**3**

3.3 Institutional Framework and Management Plan

3.3.1 Implementation System

The implementation system for the construction phase should follow the approach adopted for the "Project for the Groundwater Development in Rural Part of Northern Provinces" (hereinafter described in "Northern Project") as grant aid project and will establish the institutional setup illustrated in Figure 3.3.1. The Project Management Unit (PMU) will be organized under the N-CERWASS, same as the one for the Northern Project, to serve as a core organization to lead implementation-related activities on the Vietnamese side. More precisely, the PMU will be responsible for coordination with the Vietnamese government and related organizations, the securing of government approvals and permits required for construction, while serving as the counterpart of the Japanese study team.

As a core of the PMU, steering committee shall be a sort of collective entity which is composed of the concerned organizations such as N-CERWASS, MARD and PPC, and should hold a periodic meeting to monitor the implementation of the Project.

On the one hand, primary responsibilities of P-CERWASS at this stage are to solve problems relating to acquisition of the construction site, in cooperation of the PPC, DPC and CPC, to establish a facility operation and maintenance system after completion, to promote capacity building of staffs who will be engaged in facility operation, and to construct water supply facilities to individual households.

As for financial assistance, aid projects targeting communes in the country are entitled to the Counterpart (C/P) Fund, which is provided to the implementation body as subsidy to cover the project cost to be borne by the Vietnamese counterpart. As shown in Figure 3.3.1, the C/P Fund is distributed by the Ministry of Planning and Investment (MPI), after project approval by the Ministry of Finance (MOF), to the PPC or N-CERWASS in some cases. Finally P-CERWASSs receive the fund through either of the two channels. In general, the fund is expected to cover around 10% of the total project cost and is mainly allocated to the construction cost.

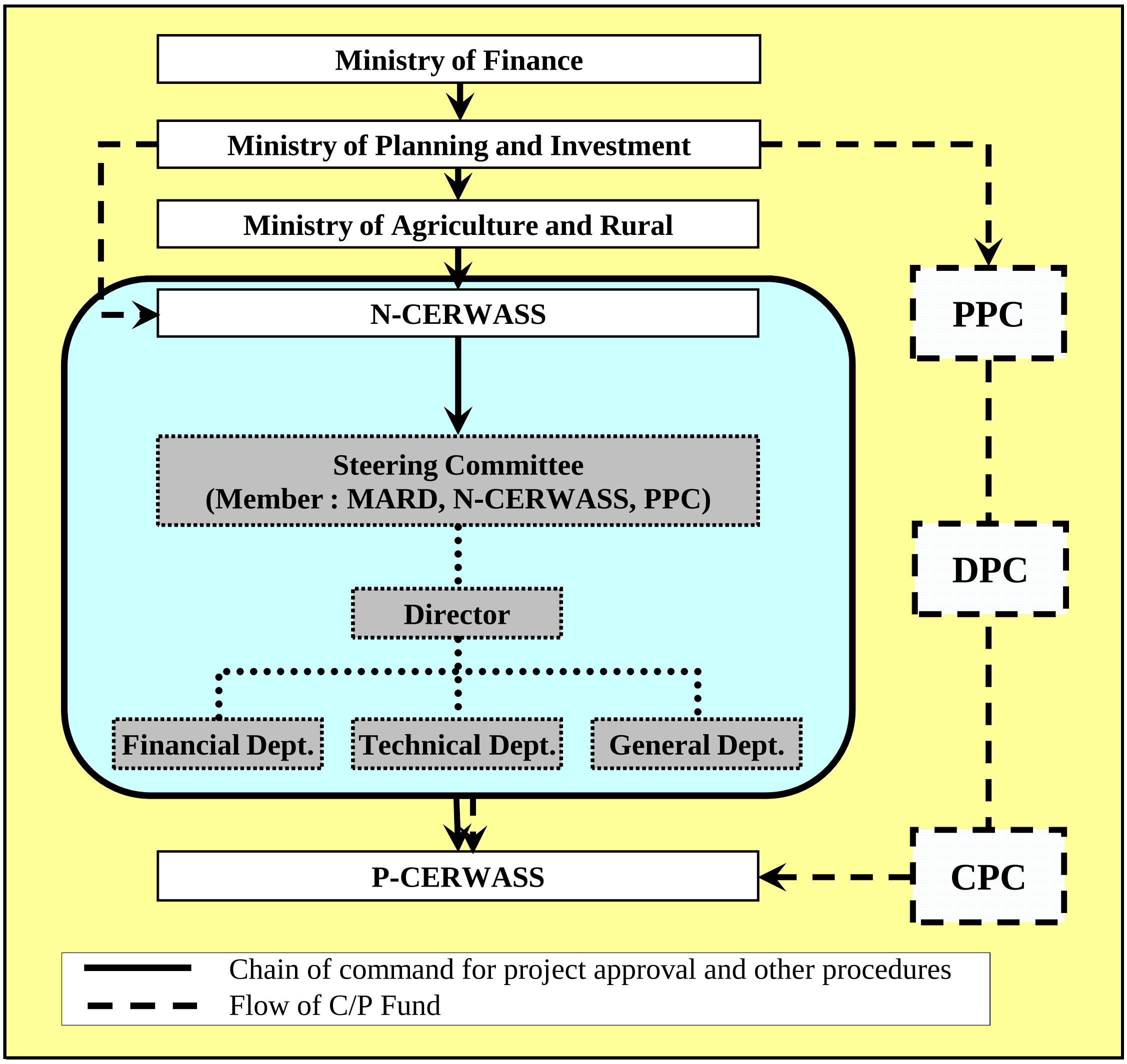


Figure 3.3.1 Proposed Implementation System during the Construction Period

3.3.2 Operation & Maintenance (O&M)

(1) Current state of O&M of Existing Water Supply Facilities

As shown in Table 3.3.1 , in Vietnam, about 45% of total rural water supply systems (4,433 piped schemes in 39 Provinces/cities, capacity from 50 to 1,000 m³/day serving for 500 to 10,000 inhabitants) are operated and maintained by P-CERWASS, and regional communes and cooperative unions also directly manage the water supply systems (28.4%) after the completion of facilities.

In the targeted Provinces of the Study, P-CERWASSs directly manage water supply facilities in Ninh Thuan and Binh Thuan Provinces. In the meanwhile, rural wafer supply facilities in Phu Yen and Khanh Hoa Provinces, after the completion, are transferred to the ownership of the CPC or other local community organization, which entrusts operation and management to local residents under the technical assistance of P-CERWASS.

Table 3.3.1 O&M Structures of Rural Water Supply

Organization	Number	(%)
P-CERWASS	**1,996**	**45.0**
Commune/Village	**1,105**	**24.9**
Cooperative Union	153	3.5
Company	36	0.8
Proprietary	140	3.2
Other form	1,033	22.6
Total	**4,433**	**(100.0)**

Source: N-CERWASS

Table 3.3.2, for reference, indicates the result of an independent investigation conducted by N-CERWASS, there are operational problems in 13% of the facilities managed by P-CERWASS, whereas 6.5% of the facilities operated by communes and villages have some problems. Note that the water supply facilities local managed by communities are, in general, small-scale water-supply system such as hand-pumps and simplified pipelines sourced spring water, and thus it is impossible to determine the merits of each O & M structure from the result of the survey. In the meanwhile, the table shows that 61.9% of the facilities managed by P-CERWASS performed well. To compare with the management by other managerial organizations, it seems to be the most effective management and operation model.

Table 3.3.2 Current Situation of Rural Water Supply by Management Organization

(A) Facilities operated by P-CERWASS

Result	Number	(%)
Good	1,235	61.9
No Problem	502	25.2
Some Problems	**190**	**9.5**
No Operation	**69**	**3.5**

(B) Facilities operated by Commune/Village

Result	Number	(%)
Good	416	37.6
No Problem	617	55.8
Some Problems	**24**	**2.2**
No Operation	**48**	**4.3**

Source：N-CERWASS

3.3.3 Capacity Assessment

(1) Outline

The rural water supply sector is, in general, characterized by institutional weakness, inefficient O&M, insufficient infrastructure, and severe financial constraints. As a result, the rate of population served by water supply services in the targeted Provinces is still confined to 42 to 60 percents. Among the factors of the low level and poor quality of rural water supply services, institutional issues should be immediately improved to manage O&M for water supply and sanitation in an appropriate manner. For instance, as indicated in the previous sub-clause 3.3.2, some water supply facilities have not been managed properly due to the lack of budget and human resources for O&M. In a sense, capacity development must be the task of pressing urgency.

In this clause, capacities of the targeted P-CERWASSs, which play a key role of rural water supply in the four Provinces, will be examined by means of generally-accepted analytical tools such as SWOT analysis and checklist of the comprehensive capacity assessment.

The results of the two assessments should be the basis of capacity development for the concerned organizations in the Study.

(2) SWOT Analysis

To fully examine the current state of the targeted P-CERWASSs, SWOT analysis approach is conducted in each P-CERWASS. SWOT analysis is a simple framework for generating strategic alternatives from a situation analysis, and it is often applied to institutional and corporate analysis as a strategic analysis tools. As indicated in Figure 3.3.2, it involves specifying the goal of the organization and identifying the internal and external factors that are favorable and unfavorable to achieve the goal, and it will also enable the targeted organization to highlight problems to be solved thoroughly.

For example, the internal analysis is a comprehensive evaluation of the internal environment's potential strengths and weakness. Internal factors should be evaluated across the P-CERWASSs in area such as:

- Organizational culture
- Organizational structure
- Organization's technical level
- Access to water resources
- Operational capacity and efficiency
- Financial and human resources, etc.

On the other hand, an opportunity is the chance to develop water supply services if the P-CERWASSs effectively exploit the opportunity. Opportunities can arise when changes occur in the external environment. However, many of these changes can also be perceived as threats to the organizations and may necessitate a change in the organizational environment and the development of their services in order for the P-CERWASSs to achieve the goal. Changes in the external environment may be related to:

- Population
- Customer trend
- Social changes
- Economic environment
- Political and regulatory environment
- Natural disaster and terrorism, etc.

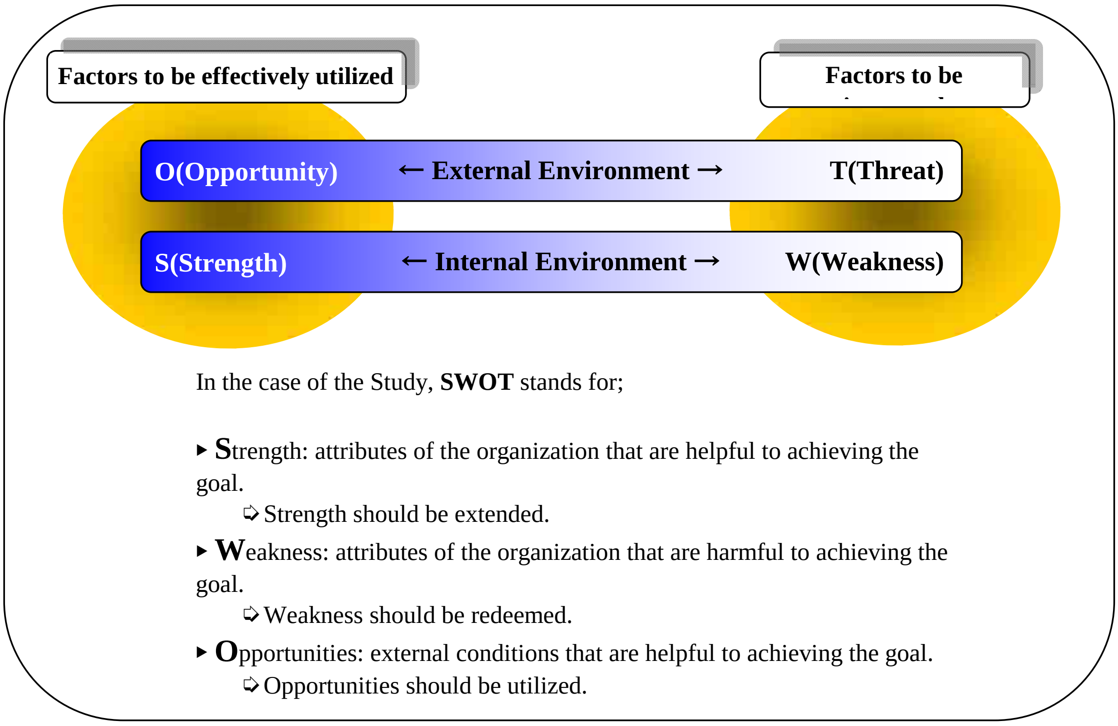


Figure 3.3.2 Concept of SWOT Analysis

On the basis of the principles as indicated above, SWOT analysis was carried out in the targeted four P-CERWASSs respectively. Results of the analysis are as follows;

Table 3.3.3 SWOT Analysis of Phu Yen P-CERWASS

	Plus Factors (+)	**Minus Factors (-)**
Internal Environment	**Strength** • Technical skills and experience on designing and construction of small water supply facilities • There is a of training course for O&M in the P-CERWASS • Operation manual for water supply facilities was elaborated by the P-CERWASS	**Weakness** • Shortage of manpower (only fourteen employees) • Shortage of budget • Low motivation of employees • No experience to cooperate with foreign donors • No communication tools such as ICT • No skills and experience to manage water supply facilities
External Environment	**Opportunity** • PPC is quite cooperative to the Project • Phu Yen is one of the targeted Provinces in the NTP II, and TA is planning to implement • Anticipation toward safe and stable water supply • Urban Water and Sewerage Company in Tuy Hoa is cooperative • Construction Technical College No.3 is locate in Tuy Hoa and is cooperative • DARD has an intention to transfer the management of water supply facilities to P-CERWASS	**Threat** • Some CPCs intend to manage water supply facilities by themselves • CPC's passive attitude towards the Project • The proposed O&M structure may not be approved. • No strict regulation of water charge non-payment • Water users may use dug well water during the rainy season • IEC activities will be inevitable in the Province entirely • Some customer may not be able to pay water charge due to the poor • Prospective project sites are scattered

Table 3.3.4 SWOT Analysis of Khan Hoa P-CERWASS

	Plus Factors (+)	**Minus Factors (-)**
Internal Environment	**Strength** • A wide range of technical skills and experience on designing and construction of small water supply facilities • Good communication between the P-CERWASS and DARD • The P-CERWASS has an intension to manage water supply facilities by themselves from the Project	**Weakness** • Shortage of manpower (only twenty employees, including construction department) • Shortage of budget • Low motivation of employees • No experience to cooperate with foreign donors • No communication tools such as ICT • No skills and experience to manage water supply facilities
External Environment	**Opportunity** • Good access (by air, train and road) • Procurement of goods is comparably easy (since Nha Trang is the capital city of South Coastal Provinces) • Anticipation toward safe and stable water supply • Urban Water and Sewerage Company in Nha Trang is cooperative	**Threat** • Groundwater development is difficult due to the geographical condition • CPC's passive attitude towards the Project • The proposed O&M structure may not approved. • DARD is not cooperative to the Project • No Strict regulation of water charge non-payment • Water users may use dug well water during the rainy season • IEC activities will be inevitable in the Province entirely

Table 3.3.5 SWOT Analysis of Ninh Thuan P-CERWASS

	Plus Factors (+)	**Minus Factors (-)**
Internal Environment	**Strength** • A wealth of human resources (46 employees) • A wide range of technical skills and experience on management of small water supply facilities • Good relationship with Binh Thuan P-CERWASS (which is the most advanced organization in the South Coastal Provinces) • There is a training course for O&M in the P-CERWASS	**Weakness** • Employees' technical skill and knowledge about water supply is insufficient • Relatively bureaucratic organization • Inefficient communication procedures (eg. Every requirement shall be documented well in advance) • Opaque procedure during the water charge collecting
External Environment	**Opportunity** • Ninh Thuan is one of the targeted Provinces in the NTP II, and TA is planning to implement • Anticipation toward safe and stable water supply • Strict regulation of water charge non-payment • Water charge collection ratio is high	**Threat** • Minority tribes share relatively high percentage of the total population in the Province • Groundwater development is difficult due to the geographical condition such as salt-water intrusion • CPC's passive attitude towards the Project • Conservative environment for foreigners • Prospective project sites are scattered

Table 3.3.6 SWOT Analysis of Binh Thuan P-CERWASS

	Plus Factors (+)	Minus Factors (-)
Internal Environment	**Strength** • Motivation of employees is high • A wealth of human resources (172 employees) • Effective personnel performance evaluation system that leads to individual incentive • Internal educational system is also effective • Strong leadership of the director of P-CERWASS • Computerization is relatively advanced • A wide range of technical skills and experience on management of small water supply facilities • Good communication between the P-CERWASS and DARD • GIS data is processing by their own efforts	**Weakness** • Sanitary services is not so actively • Corruption during the water charge collecting
External Environment	**Opportunity** • Anticipation toward safe and stable water supply • Strict regulation of water charge non-payment • Water charge collecting ratio is high • Clear demarcation of water supply in Province	**Threat** • Groundwater development is difficult due to the geographical condition • CPC's passive attitude towards the Project • DARD is not cooperative to the Project • Water supply facilities under control are scattered and are difficult to manage intensively • Project sites are far from P-CERWASS headquarters

(3) Checklist for the Capacity Development

In parallel with the SWOT analysis, the Following checklist is also confirmed by the Study Team.

In order to assess the each level - Individual, organizational, and Institutional and Social level - comprehensively, survey items should be compiled in systematic order. In this sense, as shown in Table 3.3.7, capacity assessment checklist specifically for the country, provinces and the concerned organizations provides useful information and direction as a standardization tool. The items in this checklist provide valuable directions for assessing the capacities of each P-CERWASS at the social, organizational and individual levels.

Note that the form and check items are based on “CAPACITY DEVELOPMENT (CD)” issued by the JICA in 2006 and are partially modified by the Study Team to suit the survey for rural water supply development.

Table 3.3.7 Capacity Assessment Checklist

Higher-order item	Middle-order item	Lower-order item	Binh Thuan P-CERWASS	Phu Yen P-CERWASS	Khanh Hoa P-CERWASS	Ninh Thuan P-CERWASS
(Prerequisite)	Existing factors for considering water supply management and aid	Population	Refer to sub-clause 2.1	Refer to sub-clause 2.1	Refer to sub-clause 2.1	Refer to sub-clause 2.1
		Area, land use	Agricultural land	Agricultural land	Agricultural land	Agricultural land
		Natural condition	Refer to sub-clause 2.1	Refer to sub-clause 2.1	Refer to sub-clause 2.1	Refer to sub-clause 2.1
		Economy, main industry	Rice, dragon fruits	Rice, processing industry	Rice, mango, casava, tourism	Rice, grapes
		Other donors' activities	UNICEF provided rain water collection tanks in some communes in the past	Not particulaly	UNICEF provided technical assistance.	Some NGOs worked for agricultural production.
Capacities of individuals	Capacities of individuals in implementing	Knowledge, skill	24 piped water supply systems are managed.	No experience in water supply management	No experience in water supply management	22 piped water supply systems are managed.
		Language	Vietnamese. English language education is also encouraged.	Vietnamese	Vietnamese	Vietnamese
		Intention, awareness	Staff shows discipline under leadership of director	Staff shows discipline but nore positive action is desired.	Staff shows discipline but nore positive action is desired.	Staff shows discipline but nore positive action is desired.
Capacities of organisations	Organisational structures and human resources of implementing agencies	Organisational structure	172 staffs (largest # of employees among the four P-CERWASSs)	14 staffs	21 staffs	46 staffs
		Decision-making mechanism	Director class personnel are appointed by PPC. Budget is approved by PPC. New project is approved and financed by PPC.	Director class personnel are appointed by PPC. Budget is approved by PPC. New project is approved and financed by PPC.	Director class personnel are appointed by PPC. Budget is approved by PPC. New project is approved and financed by PPC.	Director class personnel are appointed by PPC. Budget is approved by PPC. New project is approved and financed by PPC.
		Coordinating ability	Coordination ability seems to be fair	Coordination ability seems to be fair	Coordination ability seems to be fair	Coordination ability seems to be fair
		# of staffs	University (52), Highschool (50) Staff seldom chenge job for high loyalty	University (5), Highschool (7), Junior Highschool (2) Staff seldom chenge job for high loyalty	University (8), Highschool (13) Staff seldom chenge job for high loyalty	University (7), Highschool (35), Junior Highschool (4) Staff seldom chenge job for high loyalty
		Human resource management	All operators are trained regularly. Two grades are classified according to knowledge level. Office staffs are trained. Performance rating of personnel is introduced. Staff rated high performance may be awarded with prize.	Office staff are trained through on-the-job training and training course of CERWASS.	Office staff are trained through on-the-job training and training course of CERWASS.	Office staff are trained through on-the-job training and training course of CERWASS.
	Finance	Financial management	Refer to sub-clause 3.7.	Refer to sub-clause 3.7.	Refer to sub-clause 3.7.	Refer to sub-clause 3.7.
		Water charge collection	Fee-setting is approved by the PPC.	Not applicable	Not applicable	Fee-setting is approved by the PPC.
	Physical assets	Water supply equipment	Regular O&M seems well performed. Spareparts are properly provided.	Not applicable	Not applicable	Some dificulty in water treatment after rainfall when water source become high turbidity.
		Maintenance	Laboratory is scheduled	No equipment	No equipment	No equipment
		Land acquisition	Yes. Mostly public land is considered.	Yes. Mostly public land is considered.	Yes. Mostly public land is considered.	Yes. Mostly public land is considered.
	Intellectual assets	Equipment maintenance	Repair can be carried out by P-CERWASS	Not applicable	Not applicable	Repair can be performed by P-CERWASS but there are not sufficient spare parts.
		Statistical information	Monthly monitored and recorded properly	Not applicable	Not applicable	Regular monitoring data is not available.
		Manual/literature	Documents are properly stored	Documents are properly stored	Documents are properly stored	Documents are properly stored
Capacities of institutions and societies	Institutions	National water policies	NRWSSS up to 2020, NTP II for RWSS	NRWSSS up to 2020, NTP II for RWSS	NRWSSS up to 2020, NTP II for RWSS	NRWSSS up to 2020, NTP II for RWSS
		Laws and ordinances concerning rural water supply	No laws particularly on RWSS.	No laws particularly on RWSS.	No laws particularly on RWSS.	No laws particularly on RWSS.
		Environmental impact assessment (EIA)	EIA is not required for water supply capacity.	EIA is not required for water supply capacity.	EIA is not required for water supply capacity.	EIA is not required for water supply capacity.
		Land acquisition and compensation processes	In accordance with Vietnamese Law.	In accordance with Vietnamese Law.	In accordance with Vietnamese Law.	In accordance with Vietnamese Law.
		Standards regarding environmental impact	Not applicable	Not applicable	Circular No 490/1998/TT-BKHCNMT dated 29/04/1998	Not applicable
		Law enforcement mechanism	Penal regulation exists that P-CERWASS executes water cut-off after 2 months non-payment	Not applicable	Not applicable	No clear mechanism.
	Whether there are positive or negative social norms; how deeply they are rooted in society	Customs	Most people have the custom to drink water after boiling, even if it is piped water supply, and have have their own dugwells in households. Rain water is also stored in jar when available and used as potable water. Only a few ethnic minority prefer to riv	Most people have the custom to drink water after boiling, even if it is piped water supply, and have have their own dugwells in households. Rain water is also stored in jar when available and used as potable water. Only a few ethnic minority prefer to riv	Most people have the custom to drink water after boiling, even if it is piped water supply, and have have their own dugwells in households. Rain water is also stored in jar when available and used as potable water. Only a few ethnic minority prefer to riv	Most people have the custom to drink water after boiling, even if it is piped water supply, and have have their own dugwells in households. Rain water is also stored in jar when available and used as potable water. Only a few ethnic minority prefer to riv
		Ethnic groups; classes	Income level of ethnic minority is generally low. They are financially supported by state program 134 and 135. Social grades are not observed	Income level of ethnic minority is generally low. They are financially supported by state program 134 and 135. Social grades are not observed	Income level of ethnic minority is generally low. They are financially supported by state program 134 and 135. Social grades are not observed	There is a number of minority traibes in the Province and income level of ethnic minority is generally low. They are financially supported by state program 134 and 135. Social grades are not
		Religious implication(If any)	Not observed	Not observed	Not observed	Not observed but may exist in minority groups.
	Capacities of civil society	Awareness of water	Most people seem to have willingness to pay for water supply.	Most people seem to have willingness to pay for water supply but some customers may not be able to pay water charge due to the poor.	Most people seem to have willingness to pay for water supply but some customers may use dug-well water during the rainy season.	Some people who access to existing piped water system without water charge may have low willingness to pay. Some poor ethnic minority may have little affordability and needs remedial measures.
		Information, education and communication (IEC)	Sanitary education is provided in school. IEC campaigns are occasionally taken place in commune by P-CERWASS and DOH, though they don't seem effective enough	Sanitary education is provided in school. IEC campaigns are occasionally taken place in commune by P-CERWASS and DOH, though they don't seem effective enough	Sanitary education is provided in school. IEC campaigns are occasionally taken place in commune by P-CERWASS and DOH, though they don't seem effective enough	Sanitary education is provided in school. IEC campaigns are occasionally taken place in commune by P-CERWASS and DOH, though they don't seem effective enough
	The state of relevant actors	Informal sector	Few informal sector exist.	Few informal sector exist.	Informal private water venders are common in provinces.	Informal private water venders are common in provinces.
		Social organisations	Few activities are reported	No activities are reported.	No activities are reported.	No activities are reported.
		Private service providers	No private service providers exist.	No private service providers exist.	Two provate service provider is confirmed.	No private service providers exist.
	Partnership	Partnership among civil society, business and government	People's high demands for public water supply system are gathered by CPC to request to PPC through DPC. However, budget allocation is hardly realized.	People's high demands for public water supply system are gathered by CPC to request to PPC through DPC. However, budget allocation is hardly realized.	People's high demands for public water supply system are gathered by CPC to request to PPC through DPC. However, budget allocation is hardly realized.	People's high demands for public water supply system are gathered by CPC to request to PPC through DPC. However, budget allocation is hardly realized.
		Reflection of input from communities in policies, systems and services	Complaints can be lodged to P-CERWASS through the existing water systems. They are monthly reported to and monitored by P-CERWASS.	DPC and PPC/P-CERWASS usually hold liaison conference at least twice in a year and discuss the water-related issues.	DPC and PPC/P-CERWASS usually hold liaison conference at least twice in a year and discuss the water-related issues.	Complaints can be lodged to P-CERWASS through the existing water systems. However, there seems no functionable monitoring system in P-CERWASS.
	Basic infrastructure	Road traffic network	Seven target communes are far from center city	Some target communes are far from center city	All target communes are not far from center city and accessible by paved road.	All target communes are not far from center city and accessible by paved road.
		Communication network and	Telephone and postal service are main communication tools	Telephone and postal service are main communication tools	Telephone and postal service are main communication tools	Telephone and postal service are main communication tools
		Electricity	Electricity coverage is generally high. There is a case of planned power cut.	Electricity coverage is generally high. There is a case of planned power cut.	Electricity coverage is generally high. There is a case of planned power cut.	Electricity coverage is generally high. There is a case of planned power cut.

3.3.4 Major issues on Operation & Maintenance (O&M)

Based on the analysis of the present facility operation and maintenance system in the previous sub-clause and the results of the past analogous projects in Northern and Central Highland Provinces, the following problems should be pointed out.

1) Especially in Phu Yen and Khan Hoa Provinces, there is no modern water supply facility in the project area. As a result, the two P-CERWASSs and local organizations such as CPC have little experience in operation and maintenance of the water supply facilities.

2) In addition to 1), each P-CERWASS lacks of enough experience and know-how of the management of water supply facilities, since the existing rural water supply facilities in the two Provinces are transferred to and operated by communes.

3) In general, CPCs lacks expertise and experience in water supply service although it is responsible for actual facility operation and periodical inspection, since most water sources in rural areas are shallow wells owned by private households.

4) Since the ownership of the rural water supply system has been transferred from Ministry of Labuor, War Invalids and Social Affars (MOLISA) to MARD only ten years ago, neither N-CERWASS or P-CERWASS (the core organization responsible for facility operation and maintenance) has a sufficient number of personnel who has expertise in the field. Also, while MARD has expertise in groundwater resource development since its original jurisdiction includes geological exploration, it does not have a sufficient resource to provide education and training for personnel who is engaged in water supply service.

5) N-CERWASS covers all rural water supply services throughout the country with limited staff and budget, and is not in a position to understand water supply conditions accurately at commune levels.

6) In some communes, IEC activity is not fully carried out and there is the lack of awareness of importance of water supply among residents.

7) As for financial aspect, production cost of water varies in each water supply facility since it heavily depends on circumstances surrounding facilities such as distance between water source and water supply facilities, length of distribution pipelines, and treatment method, etc. On the other hand, water charge in each facility is, generally, in the same price level ranged from 2,000 to 4,000 VND/M^3. Accordingly, there may be water supply facilities that income exceeds their operation costs, and others that needs to spend more than their current income allows. It is, therefore, quite hard for the deficit-ridden facilities, where water production cost is much higher, to move into the black unless water charges are increased substantially. (For the detailed information, please refer to

the sidebar “BOX 1”.)

BOX 1: Revenue and expenditure of water supply facilities in Binh Thuan Province

Table 3.3.8 shows income and expenditure in the 23 existing water supply facilities managed by Binh Thuan P-CERWASS in the past three years, 2004 to 2006. There is a tendency that some facilities, such as #2, 14, 17, 18, 19, stay mired in the red. Table 3.3.9 also indicates that the minus factor is mainly stemmed from the negative balance between income and production cost.

Table 3.3.8 Income and Expenditure in the Respective Water Supply Facilities

#	Commune	Income			Expenditure			Balance		
		2004	2005	2006	2004	2005	2006	2004	2005	2006
1	Hong Liem	32,348.8	82,035.2	148,966.4	26,829.6	68,692.7	156,921.9	5,519.2	13,342.5	-7,955.5
2	Hong Son	50,588.8	49,968.0	62,652.8	38,469.5	62,352.2	77,153.3	12,119.3	-12,384.2	-14,500.5
3	Ham Duc	165,974.4	284,652.8	365,977.6	150,860.2	262,074.6	316,748.4	15,114.2	22,578.2	49,229.2
4	Ham Nhon	207,379.2	307,475.2	410,137.6	197,924.9	314,816.0	344,156.5	9,454.3	-7,340.8	65,981.1
5	Ham Tien	167,660.8	187,814.4	218,870.4	162,954.1	205,888.8	180,359.0	4,706.7	-18,074.4	38,511.4
6	Mui Ne	335,446.4	417,574.4	415,673.6	282,335.3	390,996.5	331,138.3	53,111.1	26,577.9	84,535.3
7	Ham My	185,056.0	191,072.0	272,800.0	140,060.4	180,668.5	226,641.2	44,995.6	10,403.5	46,158.8
8	Ham Kiem	110,768.0	148,585.6	194,393.6	102,850.2	139,546.4	201,522.2	7,917.8	9,039.2	-7,128.6
9	Song Phan	75,274.2	76,805.1	81,376.7	59,059.4	70,682.9	75,624.0	16,214.8	6,122.2	5,752.7
10	Tan Ha	20,551.5	29,686.7	48,009.6	24,172.3	26,678.4	35,347.8	-3,620.8	3,008.3	12,661.8
11	Lac Tanh	48,220.8	89,936.0	129,283.2	113,183.1	82,876.7	127,243.5	-64,962.3	7,059.3	2,039.7
12	Tien Loy	205,014.4	265,862.4	336,985.6	184,497.7	254,992.7	323,982.0	20,516.7	10,869.7	13,003.6
13	Ham Phu	7,747.2	17,616.0	44,969.6	11,509.4	17,042.3	33,381.1	-3,762.2	573.7	11,588.5
14	Ham Tanh	2,246.2	7,823.2	8,425.6	8,605.0	9,150.5	11,143.8	-6,358.8	-1,327.3	-2,718.2
15	H.T. Bac	129,785.6	322,115.2	414,355.2	154,537.6	308,549.4	513,413.2	-24,752.0	13,565.8	-99,058.0
16	H.T. Nam	21,561.6	260,755.2	362,780.8	96,680.2	257,938.6	337,248.5	-75,118.6	2,816.6	25,532.3
17	Hong Phong	6,579.2	58,435.2	78,624.0	17,415.3	88,104.4	162,602.0	-10,836.1	-29,669.2	-83,978.0
18	Tan Minh	-	80,812.8	179,836.8	-	108,203.9	205,649.1	-	-27,391.1	-25,812.3
19	Son My	-	3,036.8	43,017.6	-	21,414.7	60,123.7	-	-18,377.9	-17,106.1
20	Tan Hai	-	-	13,171.2	-	-	98,171.3	-	-	-85,000.1
21	Dong Giang	-	-	0.0	-	-	6,961.5	-	-	-6,961.5
22	Ba bau	-	-	187.5	-	-	22,751.0	-	-	-22,563.5
23	Vo Xu	-	-	0.0	-	-	10,436.0	-	-	-10,436.0
Total Amount		**1,774,207.1**	**2,884,067.2**	**3,832,501.4**	**1,773,948.2**	**2,872,675.2**	**3,860,725.3**	**258.9**	**11,392.0**	**-28,223.9**

Table 3.3.9 Comparison of Income and Production cost

#	Commune	Income (2006)	Capacity (M^3/Year)	Income/M^3	Expenditure (2006)	Capacity (M^3/Year)	Production cost/M^3	Balance (2006)
1*	Hong Liem/ Hong Son	211,619.2	131,400	1,610	234,075.2	131,400	1,781	-22,456.0
3	Ham Duc	365,977.6	73,000	5,013	316,748.4	73,000	4,339	49,229.2
4	Ham Nhon	410,137.6	182,500	2,247	344,156.5	182,500	1,886	65,981.1
5	Ham Tien	218,870.4	292,000	750	180,359.0	292,000	618	38,511.4
6	Mui Ne	415,673.6	109,500	3,796	331,138.3	109,500	3,024	84,535.3
7	Ham My	272,800.0	146,000	1,868	226,641.2	146,000	1,552	46,158.8
8	Ham Kiem	194,393.6	138,700	1,402	201,522.2	138,700	1,453	-7,128.6
9	Song Phan	81,376.7	65,700	1,239	75,624.0	65,700	1,151	5,752.7
10	Tan Ha	48,009.6	54,750	877	35,347.8	54,750	646	12,661.8
11	Lac Tanh	129,283.2	73,000	1,771	127,243.5	73,000	1,743	2,039.7
12	Tien Loy	336,985.6	116,800	2,885	323,982.0	116,800	2,774	13,003.6
13	Ham Phu	44,969.6	91,250	493	33,381.1	91,250	366	11,588.5
14	Ham Tanh	8,425.6	36,500	231	11,143.8	36,500	305	-2,718.2
15	H.T. Bac	414,355.2	292,000	1,419	513,413.2	292,000	1,758	-99,058.0
16	H.T. Nam	362,780.8	255,500	1,420	337,248.5	255,500	1,320	25,532.3
17	Hong Phong	78,624.0	73,000	1,077	162,602.0	73,000	2,227	-83,978.0
18	Tan Minh	179,836.8	241,995	743	205,649.1	241,995	850	-25,812.3
19	Son My	43,017.6	102,200	421	60,123.7	102,200	588	-17,106.1
20	Tan Hai	13,171.2	135,050	98	98,171.3	135,050	727	-85,000.1
21	Dong Giang	N.A	N.A	N.A	N.A	N.A	N.A	N.A
22	Ba bau	N.A	N.A	N.A	N.A	N.A	N.A	N.A
23	Vo Xu	N.A	N.A	N.A	N.A	N.A	N.A	N.A
Total Amount		**3,830,307.9**	**2,610,845.0**	**1,545.3**	**3,818,570.8**	**2,610,845.0**	**1,532.0**	

*Remark: Data of Hong Liem and Hong Son Commune were combined in table.

To deal with the above issues, it is important for the targeted P-CERWASSs to establish cooperative ties not only with N-CERWASS, DARD and CPC, but also with other water-related organizations such as urban water supply and sewerage cooperation in each capital city. As for the details, refer to the next sub-clause.

3.3.5 Proposed O&M Structure

To ensure smooth operation and maintenance of new water supply facilities, a new organization and system should be established to allow self-supporting operation based on revenue from water charges.

Basically the NRWSSS and its subordinate document NTP Ⅱ recommend that new water supply facilities are operated and maintained by a commune-led organization or a local community. Indeed the communes appear to have high levels of solidifying and organizing ability as judged from activities of various local cooperatives and organizations. As pointed out earlier, however, the results of the site survey indicate that it is very difficult for local communes to operate and maintain a modern water supply system by themselves due to the shortage of human and financial resources. Thus, as shown in Figure 3.3.3, the study team recommends the establishment of the new and multi-organizational interrelated O&M system with the P-CERWASS being at the core of the structure. This arrangement is modeled after the organization adopted for the Northern and Central Highland Projects but the proposal newly adds an advisory group.

The advisory group has been conceived in reflection of a major lesson learned from the past project, where P-CERWASS was unable to provide effective support for commune staff who faced an unforeseen accident in the course of the O&M, due to the lack of knowledge and experience to manage the modern water supply system. Then, the advisory group is expected to act as “technical guide” that P-CERWASS can access easily and can ask for advice relating to day-to-day operation and maintenance of the water supply system. In a sense, prospective members of advisory group will be highly experienced organization in the water supply management. For instance, urban water supply and sewerage corporations under the MOC, which are located in provincial capitals and other urban areas and are engaged in operation and maintenance of modern water supply systems including water treatment plants and pipeline networks, can be prime candidate. Also, in some provinces, DRAD, which supervises P-CERWASS, directly manages large-scale water supply facilities. More exceptionally, water supply facilities that have been constructed by the PPC or DPC under the finance of the central government’s rural development fund are operated and maintained by water management division in DPC.

As expertise and experience in operation and maintenance of these water supply systems and organizations can be adopted by the proposed O&M structure, it is important for the structure to establish communication channels with these organizations in order to allow it to deal with any problem encountered in the course of operation promptly.

In addition, in order to correct the profit disparities among water supply facilities, the proposed O&M structure could be effective and durable resolution as P-CERWASS will be able to divert surplus of income stemmed from some facilities to deficit-ridden facilities for making up lost money. Study Team strongly recommends establishing such an integrated administration system with P-CERWASS as a core organization. Otherwise, an adverse balance of payment in loss-making facilities may be continued perpetually.

As explained in sub-clause 3.4.2, in Binh Thuan and Ninh Thuan Provinces, P-CERWASSs have already managed all work supply facilities by taking into account the needs for streamlining facility operation and maintenance and ensuring a uniform water quality standard. Their current O&M structures and the one proposed by the Study Team differ only slightly, on the other hand, in Phu Yen and Khan Hoa Provinces, where CPCs manage water supply facilities at present, the two P-CERWASSs are required to change the internal structure drastically.

In the first and second site survey, the Study Team confirmed that the four targeted P-CERWASS and the N-CERWASS agreed to establish the proposed O&M structure in the near future.

In the second year of the Study, Phu Yen P-CERWASS, in fact, newly established “Operation and Maintenance Department” in the organization to prepare the direct management proposed by the Study Team, and have already been embarked on the operation and maintenance of a water supply facility at Xuan Tho Commune on a trial basis. In addition, for the preparation, the P-CERWASS, in cooperation with the DARD, employs six new graduates from Universities and also plans to expansion of the office building next year.

Khan Hoa P-CERWASS also continuously discusses with the DARD to adjust their organization to the proposed organizational structure.

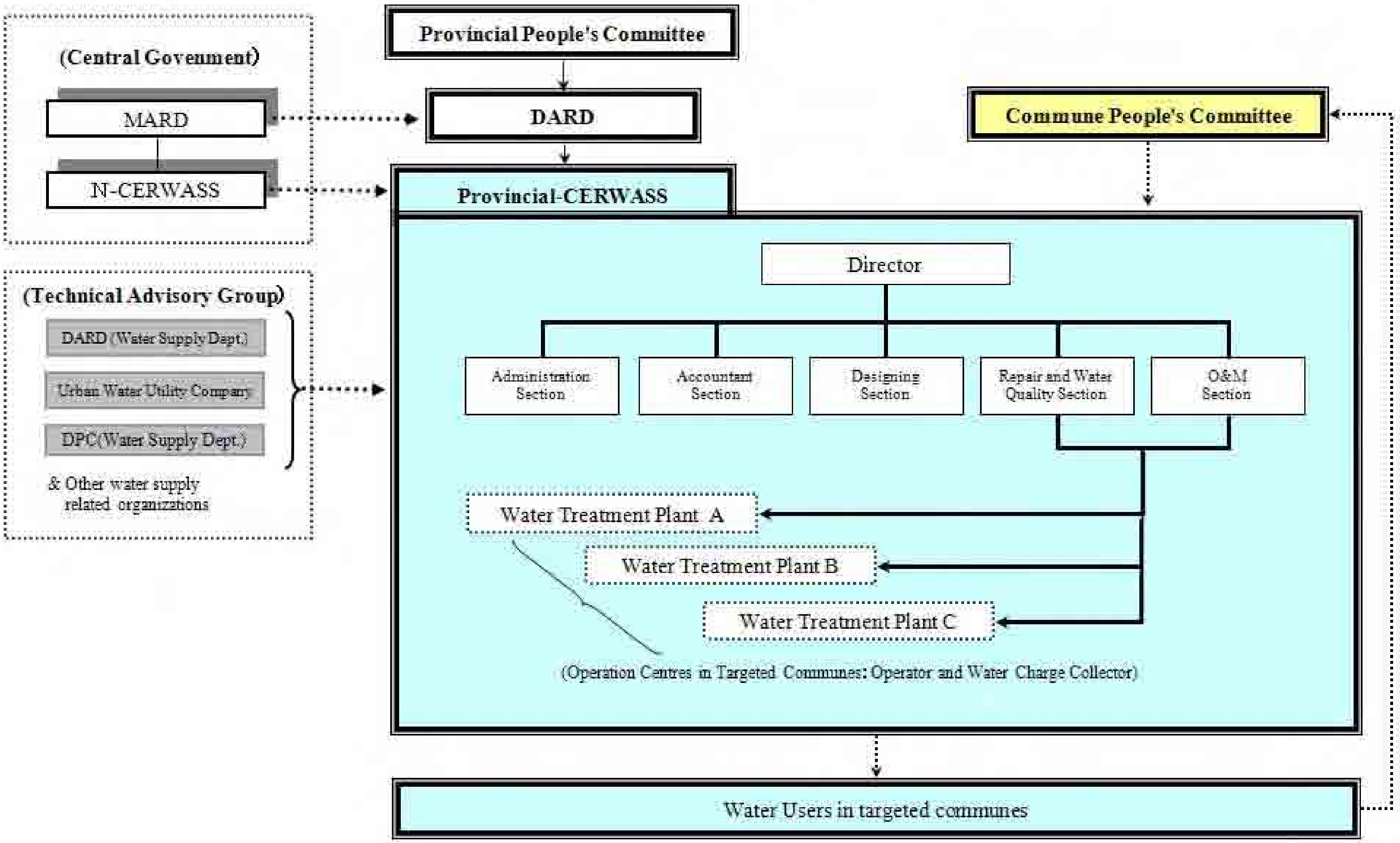


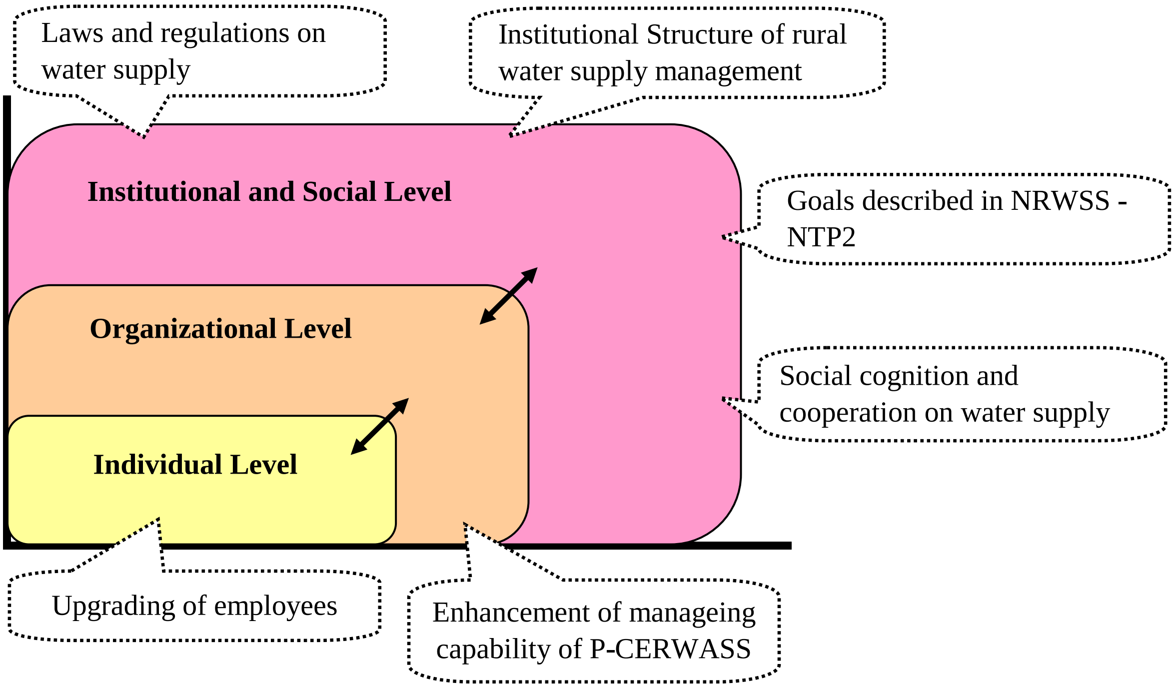
Figure 3.3.3 Proposed Organizational Structure of O&M of Water Supply Systems

3.3.6 Capacity Development Plan

(1) Background of Capacity Development

According to the UNDP, Capacity Development (CD) is the process by which individuals, organizations, institutions, and societies develop “abilities” (individually and collectively) to perform functions, solve problems, and set and achieve objectives.

With in the general CD framework, there are three layers, individual, organizational and institutional or social levels. These layers are not mutually exclusive, but rather each level is interconnected in a systematic way.



Source: JICA and modified by the Study Team

Figure 3.3.4 Three Layers of Capacity Development

As shown in the above table, in the case of the Study, development of ability of parties concerned could be the main theme. Upgrading the individual level directly conduce to the enhancement of managing capability at the organizational level, for instance P-CERWASS, that is the complex entities of individuals. Finally, the organizational level interrelates with institutional and social level such as laws, regulations, policies and institutional structure regarding the rural water supply. In addition to that, public acceptance and cooperation toward water supply are absolutely imperative.

In general, the CD process takes a long time to achieve the tangible results since strategic elements that form an integral part of the CD process such as sense of trust, motivation, awareness, commonsense, creativeness and cooperativeness would require to much work to learn. Table 3.3.10 describes the key elements that constitute the CD process

Table 3.3.10 Key Capacity Features and Elements to be developed in the Three CD Levels

Levels of capacity	Key capacity features to be developed	Elements on which the capacity is based at the three levels
Individual	The will and ability to set objectives and achieve them using one's own knowledge and skills	Knowledge, skills, will/stance, health, awareness
Organization	The decisions-making processes and management systems, organizational culture, and frameworks required to achieve a specific objective.	Human assets (capacities of individuals comprising organizations)
		Physical assets (facilities, equipment1, materials, raw materials) and capital
		Intellectual assets (organizational strategy, management and business know-how, manuals, statistical information, production technology, survey and research reports, household precepts, etc.)
		Form of organization that can optimally utilize assets (human, intellectual, physical), management methods (flat organizations, TQC (total quality control), KM (Knowledge management), personnel systems, etc.)
		Leadership
Institution Society	The environment and conditions necessary for demonstrating capabilities at the individual or organizational level, and the decision-making processes, and systems and frameworks necessary for the formation/implication of policies and strategies that are over and above an individual organization.	Capacities of individuals or organizations comprising a society
		Formal institutions (laws, policies, decrees/ordinances, membership rules, etc.)
		Informal institutions (customs, norms)
		Social capitals, social infrastructure

Source: JICA

On the basis of the above concept of the CD, all the stakeholders involving in the rural water supply need to be upgraded comprehensively. In the four targeted Provinces, especially in the proposed project sites, there are small-scaled water supply facilities utilizing the water source of dug well and natural springs. However, most of the communes have no experience and skill of operating the large-scale water supply facilities with modern equipment. In addition, water charge system has not yet fully established in some communes since the large majority of inhabitant use their private wells. As for the administrative organization, as stated in sub-clause 3.4.2, Phu Yen and Khan Hoa P-CERWASSs have never experienced to manage water supply facilities.

In consideration of the current situation surrounding the rural water supply in the four Provinces, CD shall be divided into the three phases for each target group such as management, working level and water user group in the Study.

Table 3.3.11 Proposed Schedule of Capacity Development in the Study

Target Group	Phase 1	Phase 2	Phase 3	
Management Group	(Main Object) Acquisition of management skill and knowledge for organizations	Sustainable continuation	Sustainable continuation	*Comprehensive Capacity Development*
Working-level Group		(Main Object) Upgrading of O & M skill and technique of facilites	Sustainable continuation	
Water User Group			(Main Object) Understanding of water supply and water supply management	

The summary of program (draft) in each phase is shown below, it is, however, necessary to add or modify it in response to the changing situation of rural water supply in the targeted Provinces.

1) Phase 1 - Improvement of Management Group

In this stage, CD should be focused on the management class such as directors of P-CERWASS and managers of N-CERWASS to establish the foundation of O&M. For smooth and efficient management of water supply, it is imperative for managers to acquire management skill and knowledge. Following programs are expected to implement at phase 1;

- Training course in Japan (already carried out in December 2007)
- Technical group meeting and workshop

Throughout the programs, the targeted group will learn and fully understand;

- Effective management of rural water supply
- Advantageous effect on the improvement of water supply facilities
- Merits of integration management of water supply
- Facility management by a self-supporting accounting system

It is also expected to establish a communication channel among the four P-CERWASSs as well as between the four P-CERWASSs and the N-CERWASS.

BOX 2: Training course in Japan (December 2007)

As stated above, Training course in Japan (Official title: The Seminar on Administration of Small Scale Water Supply Services Management focused on Vietnam) was held under the auspices of JICA and was implemented by Japan International Cooperation of Welfare Services (JICWELS) on December 2007. Three directors from Khan Hoa, Ninh Thuan and Binh Thuan P-CERWASSs and a manager in charge of rural water supply from N-CERWASS were invited to the course. The main purpose of the program is to learn much about business operation and facility management of small scale water works in Japan, and to abstract some useful and applicable factors to their management task in Vietnam. For reference, the program includes the following lectures;

- Background and role of public administration on the improvement for water supply in Japan
- Public health and water supply (living and water)
- Financial framework of rural water supply and water charge
- Water quality control and its operation in rural water supply
- Technology of rural water supply (Construction and its cost saving)
- Site visit to small scale water supply facility and organization in Saitama prefecture
  (Main themes of the site visit)
  - The balance between O&M cost and revenue from water charge
  - The measures of facility for polluted raw water
  - Conservation of water quality
  - Development of human resource

As an output of the training course, "Action Plan" that envisions future organizational management including activities to be carried out, monitoring performance, estimated costs, inputs and resources required, and due date was elaborated by the four participants respectively. The "Action Plan" was attached in the ANNEX 4.

2) Phase 2 - Improvement of Working-level Group

At Phase 2, CD will mainly cover working-level group or employees in practical level such as operators, accountants, and administrators of P-CERWASS. "Spillover effect" from Phase 1 is also expected. The followings are the prospective options during the phase;

- Technical group meeting and workshop
- On-the-job training in the urban water supply and sewerage corporation nearby
- Training course in Construction Technical College No.3 in Tuy Hoa
- Training course in Construction Technical College No.2 in Ho Chi Ming City
- Dispatch of lecturers from the above two College to the training courses held at each P-CERWASS

In this phase, the main objective is to enhance executive ability for O&M of water supply facilities. Expecting outputs from the programs in Phase 2 are as follows;

- Concerned employees will have, practically and technically, acquire the necessary knowledge and skill to operate and manage water supply
- The role, organization structure, management method and operation policy are specified, codified and publicly announced
- Upgrading of individual technical skills of employees
- O&M manual is drawn up for each facilities in the light of treatment process
- Establishment of registration system of customers
- Establishment of water charge and water charge collection system

In order to acquire the expecting outputs above mentioned, the four P-CERWASSs conducted or will conduct the following technical work shop or training course at their own expenses.

Table 3.3.12 Conducted or Planned Capacity Development (Phase-2)

P-CERWASS	Schedule	Contents
Phu Yen	June 30 – July 2 and July 3 – July 5	- Technical Seminar for employees of P-CERWASS and commune representatives - No. of Participants: 61 (1st session-30, 2nd session-31) - Lecturer: P-CERWASS, Urban water Company, and Construction Technical College No.3 *Programme of the seminar is attached in the ANNEX5
Khan Hoa	(Not yet decided)	In case of Khan Hoa, the training session for water sectors is usually carried out by DPCs once or twice a year.
Ninh Thuan	November (Duration: 27days)	- Technical Seminar for employees of P-CERWASS and commune representatives - No. of Participants: 70 (planned) - Lecturer: P-CERWASS
Binh Thuan	June 26 and 28	- Technical Seminar for employees of P-CERWASS and commune representatives - No. of Participants: 264 (26: 114, 27: 150) - Lecturer: P-CERWASS, Water supply facility manufactures

As shown in table, most of the training seminars are intended for employees of P-CERWASS and representatives from communes who engage in operation and management of small-scale water supply facilities. The main objectives of the seminars commonly include;

- ✓ Description of the basic mechanism of water supply system
- ✓ Operation and maintenance of water supply facilities such as treatment plant, pump, valve, flow meter, and pipeline, etc.
- ✓ Management and administration of waterworks
- ✓ Regulations and laws on water supply

The main lecturers of the seminars are technical staffs from each P-CERWASS, however, outside technical experts from technical colleges, private companies and other concerned organization are also invited to disseminate more detailed expertise for participants.

In addition to the above training sessions, the four P-CERWASSs, voluntarily, promote technical cooperation one another. For instance, Phu Yen and Khan Hoa P-CERWASSs that have no experience to manage water supply facilities plan to send their engineers to Binh Thuan and Ninh Thuan P-CERWASSs respectively for the preparation of direct management on water supply systems. Binh Thuan and Ninh Thuan P-CERWASSs, who have broad experience on the direct O&M of water supply systems, have already agreed to accept the required training sessions for the two inexperienced P-CERWASSs.

BOX 3: Training courses in Construction Technical College No.2 in Ho Chi Ming City

The Water Sector Training Center in the South of the Construction Technical College No.2, which is under the Ministry of Construction, offers a wide variety of training courses mainly for employees of water sectors.

The Training Center owns full-equipped laboratories and facilities, such as leakage detection, plumbing, water meter adjustment, for practical trainings that are funded by JICA, and still receives technical assistance from the Tokyo metropolitan government bureau of waterworks and Yokohama waterworks bureau in Japan.

The standard courses in the Training Center are as follows;

- Operation and Maintenance : Water Treatment Plant
- Operation and Maintenance : Water Distribution Network
- Operation and Maintenance : Electric and Mechanical Equipment
- Water Loss Prevention (Leakage detection)

Syllabus of the standard courses is attached in the ANNEX 6, however, the Training Centre can also arrange the customized lectures to meet the request and technical level of participants, and the dispatch of the lecturers to rural water sectors such as P-CERWASS who can not afford to send their employees to HCMC due to financial and time constraints can also be available on demand.

As for the tuition fee, a rough estimate for one session (45 minutes) is about US$30, and the fee is divided into the number of participants. Normally, minimum number of the unit is 30.

College dormitory is available for participants at the cost of US$6 per day.

Construction Technical College No.3 in Tuy Hoa can also provide similar training courses and temp services of lecturers for water supply sectors. In fact, Phu Yen P-CERWASS invited some lecturers from the College to their technical seminar held in June and July 2008.

In addition, the targeted four P-CERWASSs constantly hire graduates of the above two colleges.

3) Phase 3 – Improvement of Water User Group

Finally, the targeted group of Phase 3 is shifted down to water users including CPC and its inhabitants. The contents of the phase may consist of the Information, Education and Communication (IEC) activities and trainings targeted to local operators in O&M for small-scaled water supply scheme managed by both of P-CERWASSs and CPCs. The main objectives of this phase are;

- Enlightenment of the public health and sanitation.
- Understanding the outline of water supply facilities
- To recognize of the cost of operation and maintenance of the facilities (in case of small scaled water supply system located at very remote area)
- To work up cooperation and understanding of the O&M of the facilities from local communities

As for the IEC, in particularly in Phu Yen and Ninh Thuan Provinces, DANIDA has already launched IEC activities in some communes under the framework of NTPⅡ. It is, therefore, essential to fully discuss the content and schedule of the IEC with the DANIDA in order to generate synergetic effect from the both scheme.

The trainings for local operators should be provided by P-CERWASSs or other concerned organizations by means of knowledge and skills acquired from phase 1 and 2. In the sense, same as phase 2, spillover effect from phase 1 and 2 is expected to encourage counterparts' initiative.

3.4 Water Supply Development

(1) Project cost

Investment plan is prepared and proposed for the water supply system for 22 communes excluding overlapping commune (Phuoc Minh: N-4) and commune (An Tho: P-3) with no water source. The systems will be classified in 3 Packages as follows;

1) Single type water supply system for groundwater source
2) Single and group type water supply system for surface water source
3) Wide-area water supply system for surface water source

Each package includes following commune and facility.

Package	Water source and system pattern	Commune code and system No.
1	Groundwater Single	P-4 (FPS-3), P-8 (FPS-5), K-1(FKS-6)
2	Surface water Single and Group water supply	P-1(FPS-1), P-2(FPS-2), P-5,6,7(FPG-4), K-3(FKS-8), N-5,6 (FNG-10), B-1(FBS-11), B-3,5,6,7(FBG13)
3	Surface water Wide-area water supply	K-2(FKW-7), N-1,2,3(FNW-9), B-2,4(FBW-12)

In single type water supply system, considering the objective of the Study, and on the basis of the result of the groundwater study as potential sources of water supply, the water supply systems for 4 communes using groundwater sources are designated as high-priority communes.

Wide-area water supply system shall be investigated and designed including surrounding communes which are non water supply and non target commune in future from technical and economical viewpoints.

The estimated project cost for 13 water supply systems including 22 communes are summarized in Table 3.4.1

Table 3.4.1 The Estimated Project Cost for each System

Package	Direct cost (x1000US$)				Indirect cost (x1000US$)		**Project cost (X1000US$)**
	Construction cost	Engineering service fee	Cost to be borne by Vietnam	Base cost	Contingency	VAT	
Package 1	3,742	374	411	4,527	453	412	**5,392**
Package 2	24,712	2,469	2,717	29,898	2,962	2,718	**35,578**
Package 3	11,853	1,185	1,304	14,342	1,304	1,304	**16,950**
Total in thousand US$	**40,307**	**4,029**	**4,432**	**48,767**	**4,719**	**4,434**	**57,920**
Total in million VND	679,253	6,789	74,682	760,724	79,519	74,716	914,959

Note: Exchange Rate: 1US$=VND16, 852=JY106.17 (as of July 2008)

However, the cost of package 3 is for reference only. Because the water service areas are within the target communes only and it is uncompleted system as wide-area water supply.
The project cost is estimated based on the conditions and assumptions explained below.

1) Construction Cost

The cost under this head comprises direct cost required for construction of the facilities such as concrete structure, architecture, pipe, mechanical and electrical. The water meter and fitting pipe (10 m per one house) is supplied only and installation cost is paid by consumer. Project cost for the water supply systems are estimated based on described in item 5.2.1: Project cost.

For FS target communes; namely, 9 systems out of 13 systems, some cost is employed as FS.

For the other communes, the cost is estimated by using proportional ratio according to system capacity of FS cost.

2) Engineering Services

This cost includes expenditure on site survey, detailed design, preparation of tender document, supervision during construction stage, and assistance provided during tender stage by the consultants. The cost is considered as 10% of construction cost 1).

3) Cost to be borne by Vietnam

This cost includes costs on land acquisition and clearing, fencing of the facilities, establishment of primary electric power line and access road to the facilities. These costs are estimated based on past experience and data of Japanese grant aid projects and the cost is borne by recipient country in general.

4) Base Cost

This cost is the total of costs in items 1), 2) and 3).

5) Contingency

This cost is 10% of 4) base cost.

6) VAT (Value Added Tax)

The tax is calculated as 10% of total in items 1) and 2).

7) Project Cost

The project cost is calculated as total of items 4), 5) and 6).

(2) Schedule

The implementation schedule for 3 Packages is shown in Figure 3.4.1.

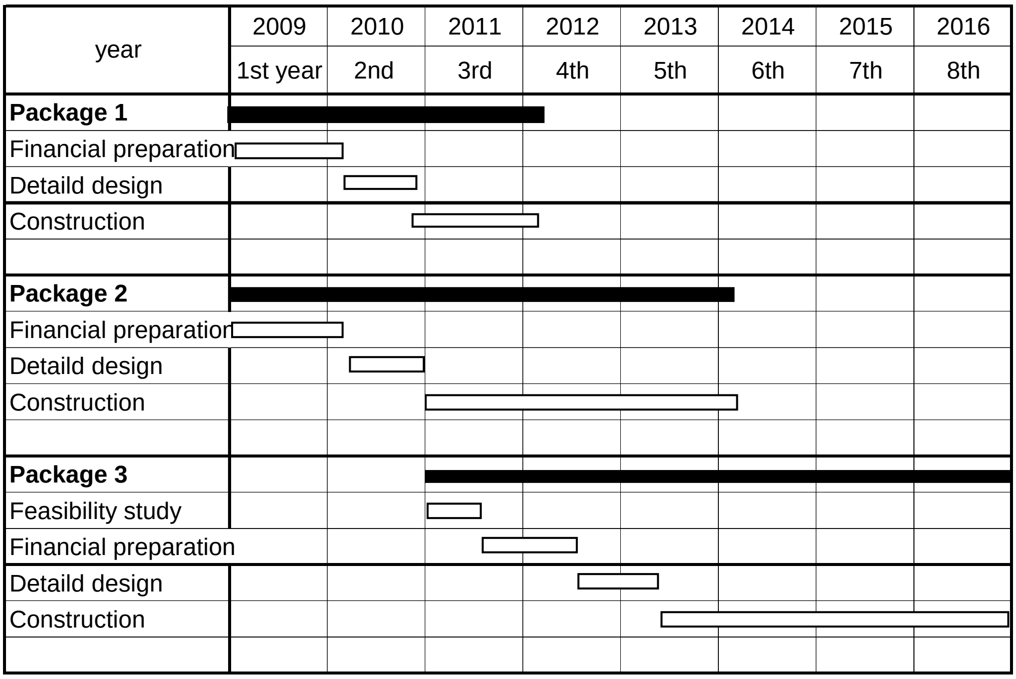


Figure 3.4.1 Implementation Schedule

The schedule is prepared and proposed based on the following conditions.

- Since total cost of Package 1 is small amount, the schedule of Package 1 and 2 is considered concurrence work schedule.
- The project size of Package 3 is tentative and it includes Feasibility Study due to required comprehensive study including neighboring communes which are non service area by piped water.
- Package 3 is scheduled after finished construction work for Package 2 due to avoid concentration of the investment.

The year indicated in time schedule in Figure 3.4.1 is tentative.

3.5 Selection of Priority Project

(1) Basic concept of selection

Based on communes included under Master Plan, the selection procedure of target commune for FS is shown in Figure 3.5.1.

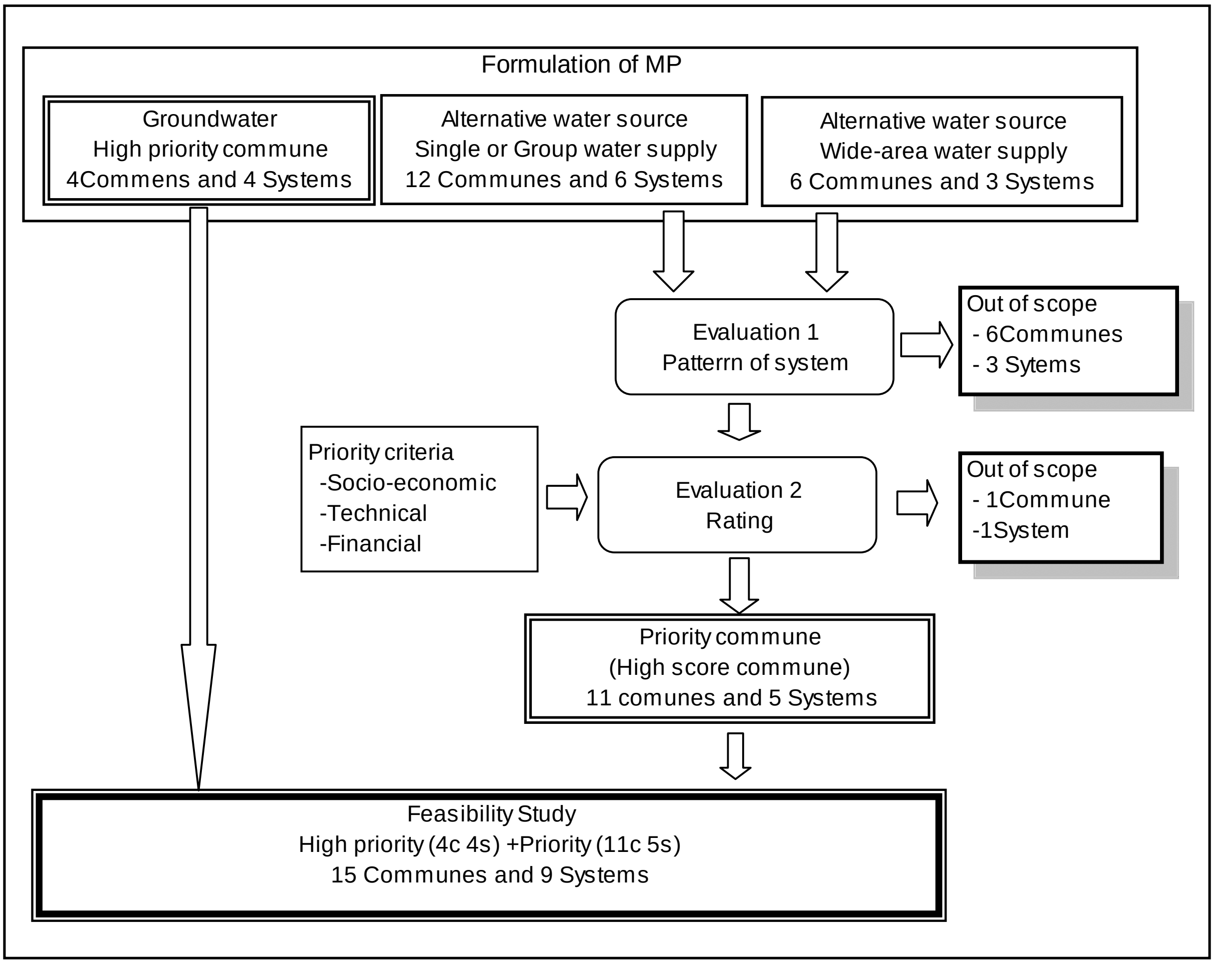


Figure 3.5.1 Selection Procedure for Priority Project

Considering the objective of the Study, the water supply systems for 4 communes using groundwater sources are designated as high-priority communes. These 4 communes are ranked as the priority communes without comparison of the commune applied by alternative water sources.

(2) Selection of the Priority Commune

For 18 communes, study is carried out for alternative water sources. The priority commune is formulated based on the following 2 evaluations.

Evaluation 1

- There is high possibility of availability of surface water sources in and around the target communes. Water supply systems can be constructed near the water source considering Single or Group system pattern.
- Although these communes also have high possibility of availability of surface water sources,

it is better to construct water supply system including other many communes out of target communes as Wide-Area water supply from the view point of economical and technical aspects. These communes shall not be included as a part of FS.

Evaluation 2

12 communes and 6 systems are evaluated based on the priority criteria. The substitute criteria for each of the six criteria are proposed. The content of criteria is shown in Table 3.5.1.

Table 3.5.1 Priority Criteria

Socio-economic	(A) Scarcity of potable water
	(B) Effectiveness to poverty reduction
	(C) Active participation of the community
	(D) Technical rationality to install house connection using groundwater
Technical	(E) Technical conditions
Financial	(F) Financial conditions

Significance of each criterion is weighted with reference to and in view of five indices of Project Evaluation prepared by the Development Assistance Committee (DAC) of the Organization for Economic Cooperation and Development (OECD). Each index is defined as follows:

(i) Relevance: Relevance to national policy
(ii) Effectiveness: Effectiveness of the Project
(iii) Efficiency: Efficiency of the Project (Input and accomplishment)
(iv) Impact: Positive and negative impact on socio-economic aspect by the project
(v) Sustainability: Sustainability of water supply system and management

The estimated magnitude of criteria on the basis of DAC indices is shown in Table 3.5.2. According to the estimated magnitude of criteria, the assessment score is defined. In most cases, the assessment score of criteria is classified into three (3) by quartile range. However, since the collected data for some items are not quantitative, the qualitative evaluation has been adopted for those criteria. In case when criteria related to 3 out of DAC's 5 indices, they are weighted 5 points and others are weighted 3 points. Based on the criteria and magnitude, assessment score is summarized in Table 3.5.3.

Table 3.5.2 Estimated Magnitude of Criteria by DAC Indices

Criteria	(i) Relevance	(ii) Effectiveness	(iii) Efficiency	(iv) Impact	(v) Sustainability	Magnitude
A Scarcity of Potable water						**11**
A1 Fetching water in dry season	X	X		X		5
A2 Rate of population served	X					3
A3 Satisfaction level of available water		X		X		3
B Effectiveness to poverty reduction						**6**
B1 Rate of poverty	X	X				3
B2 Rate of ethnic minorities	X	X				3

Criteria	(i) Relevance	(ii) Effectiveness	(iii) Efficiency	(iv) Impact	(v) Sustainability	Magnitude
C Active participation of the community						**6**
C1 Willingness to pay / Affordability					X	3
C2 Project ownership					X	3
D Technical rationality to install house connection						**11**
D1 Total population served	X	X	X	X		5
D2 Affordability to connection fee					X	3
D3 Rate of households having toilet					X	3
E Technical conditions for water supply system (alternative source)						**25**
E1 Raw water flow capacity	X	X	X	X	X	5
E2 Raw water quality	X	X	X	X	X	5
E3 difficulty in intake construction	X	X	X	X	X	5
E4 Distance between intake and service area	X	X	X	X	X	5
E5 Difficulty in transmission pipe construction	X	X	X	X	X	5
F Financial conditions						**5**
F1 Construction cost per m3 (VND)	X	X	X	X	X	5

Table 3.5.3 Assessment Score for the Criteria

Assessment criteria			Assessment Point		
A	Scarcity of Potable Water				
	A-1	Fetching water in dry season	5 pts more than 15 minutes	3 pts from 10 to 15 minutes	1 pt less than 10 minutes
	A-2	Rate of population served	3 pts 0%	2 pts from 1 % to 20 %	1 pt More than 21 %
	A-3	Satisfaction level of available water	3 pts more than 2.0	2 pts from 1.0 to 2.0	1 pt less than 1.0
B	Effectiveness to poverty reduction				
	B-1	Rate of poverty	3 pts more than 25 %	2 pts from 10 % to 25 %	1 pt less than 10 %
	B-2	Rate of ethnic minorities	3 pts more than 15 %	2 pts from 5 % to 15 %	1 pt less than 5 %
C	Active participation of the community				
	C-1	Willingness to pay / Affordability	3 pts more than 33,000 VND	2 pts from 20,000 VND to 33,000 VND	1 pt less than 20,000 VND
	C-2	Project ownership	3 pts Commune has an organization or experiences for O&M of water supply system.	2 pts Commune doesn't have any organization for O&M. However, Commune has planned to establish organization.	1 pt Commune doesn't have any organization for O&M and so far has no plans to establish organization.
D	Technical rationality to install house connection using groundwater				
	D-1	Total population served	5 pts more than 10,000	3 pts from 6,000 to 10,000	1 pt less than 6,000

	D-2	Affordability to connection fee	3 pts more than 400,000 VND	2 pts from 300,000 VND to 400,000 VND	1 pt less than 300,000 VND
	D-3	Rate of households having toilet	3 pts more than 50 %	2 pts from 15 % to 50 %	1 pt less than 15 %
E Technical conditions for alternative water sources					
	E-1	Water capacity	5pts Enough	3pts marginal in dry season	1pt not enough
	E-2	Water quality	5pts No treatment Including disinfection)	3pts Requires normal treatment (Removal of Iron and Turbidity)	1pt High risk of contaminated by heavy metal or pesticide
	E-3	Difficulty in intake construction	5pts Connection with existing pipe	3pts Connection with irrigation channel	1pt River intake
	E-4	Distance between intake and service area	5 pts Less than 10km	3 pts from 10 km to 15km	1 pt more than 15km
	E-5	Difficulty in transmission pipe construction	5pts No facility	3pts Crossing of small river or provincial road	1pt Crossing of big river or national road
F	F1 Financial conditions				
	F-1	Construction cost per m^3 (VND)	5 pts Less than 2 million	3 pts from 2 to 5million	1 pt more than 5 million

3.5.1 Estimated Score and Prioritization of the Target Communes

The estimated scores of the system in cases of alternative source are shown in Table 3.5.4.

Table 3.5.4 Evaluation for Water Supply System

System No.	Commune	(1) Socio-economic	(2) Technical	(3) Construction cost	(4) Total Score (4)=(1)+(2)+(3)
FPS-1	P-1	21	11	1	33
FPS-2	P-2	23	21	3	47
FPG-4	P-5,6,7	28	15	5	48
FNG-10	N-5,6	24	13	3	40
FBS-11	B-1	24	19	3	46
FBG-13	B-3,5,6,7	23	19	5	47

On the basis of result of evaluation, system Number FPS-1 is not included in the FS. This is because of the reason that the total score of the system is low compared to other systems that have points greater than 40. Especially pertaining to both condition technical and financial are low at a time. It means that transmission interval is long and degree of difficulty for construction is high. Therefore cost per cubic meter is comparatively high on price. It is decided that Feasibility Study be conducted on priority basis for 6 systems.

The details on priority system including 4 high priority systems to be included in Feasibility Study are summarized in Table 3.5.5.

Table 3.5.5 System and Commune for FS

Province	Commune code No.	Commune Name	No. of commune	System No.	Population in 2020 (persons)	Water Demand in 2020 (m^3/d)
Phu Yen	P-2	An Dinh	1	FPS-2	6,859	502
	P-4	An My	1	FPS-3	13,256	998
	P-5,6,7	Son Phuoc, Ea Cha Rang, Suoi Bac	3	FPG--4	12,136	874
	P-8	Son Thanh Don	1	FPS-5	9,292	651
Khan Hoa	K-1	Cam An Bac	1	FKS-6	6,462	485
	K-3	Cam hay Tay	1	FKS-8	6,978	526
Ninh Thuan	N-5,6	Phuoc Hai, Phuoc Dinh	2	FNG-10	29,715	2,149
Binh Thuan	B-1	Muong Man	1	FBS-11	7,378	557
	B-3,5,6,7	Nghi Duc, Me Pu, Sung Nhon, Da Kai	4	FBG-13	52,241	3,730
4 Provinces	15 communes			9 facilities	144,317	10,472

CHAPTER 4 SANITATION IMPROVEMENT PLAN

4.1 Introduction

Sustainable approach for sanitation improvement in rural areas of Vietnam is discussed in this chapter, based upon findings on current situation of rural sanitation as described in Chapter 2 and lessons learned obtained through the Model Sanitation Program under the Study (ANNEX 1). This chapter consists of the following sub-sections and Annexes. The results of the program are incorporated into the “Follow Up Report”.

(1) Issues on environmental sanitation in rural Vietnam
(2) Recommendable approach toward sustainable improvement of environmental sanitation
(3) Probable implementation scheme
(4) Model Sanitation Program under the JICA Study (ANNEX 1)
(5) Case Study on Septic tank sludge Treatment Facility (ANNEX 2)

4.2 Issues on Environmental Sanitation in Rural Vietnam

The problems on environmental sanitation are presented by using the logical problem tree as shown in Figure 4.2.1. In the Problem Tree, the core problem is given as “Sustainability of environmental sanitation in rural areas is low”. And the following seven issues are identified as the main issues.

(1) Sanitation Coverage in Rural Area is Much Lower than the National Target

Sanitation coverage in rural area of Vietnam is estimated to be 56%. (2006, “WHO/UNICEF Joint Monitoring Programme for Water and Sanitation”) However, serious situation is presumed in the report “Rural Environmental Sanitation Survey in Vietnam, MOH, 2007”. It reports only 22.5% of total households surveyed have latrines which meet hygienic standards. Considering the national target set by RWSS NTP II is 70% in 2010, it is so difficult to accomplish the target within the remaining time, since sanitation promotion requires long time to change peoples’ awareness.

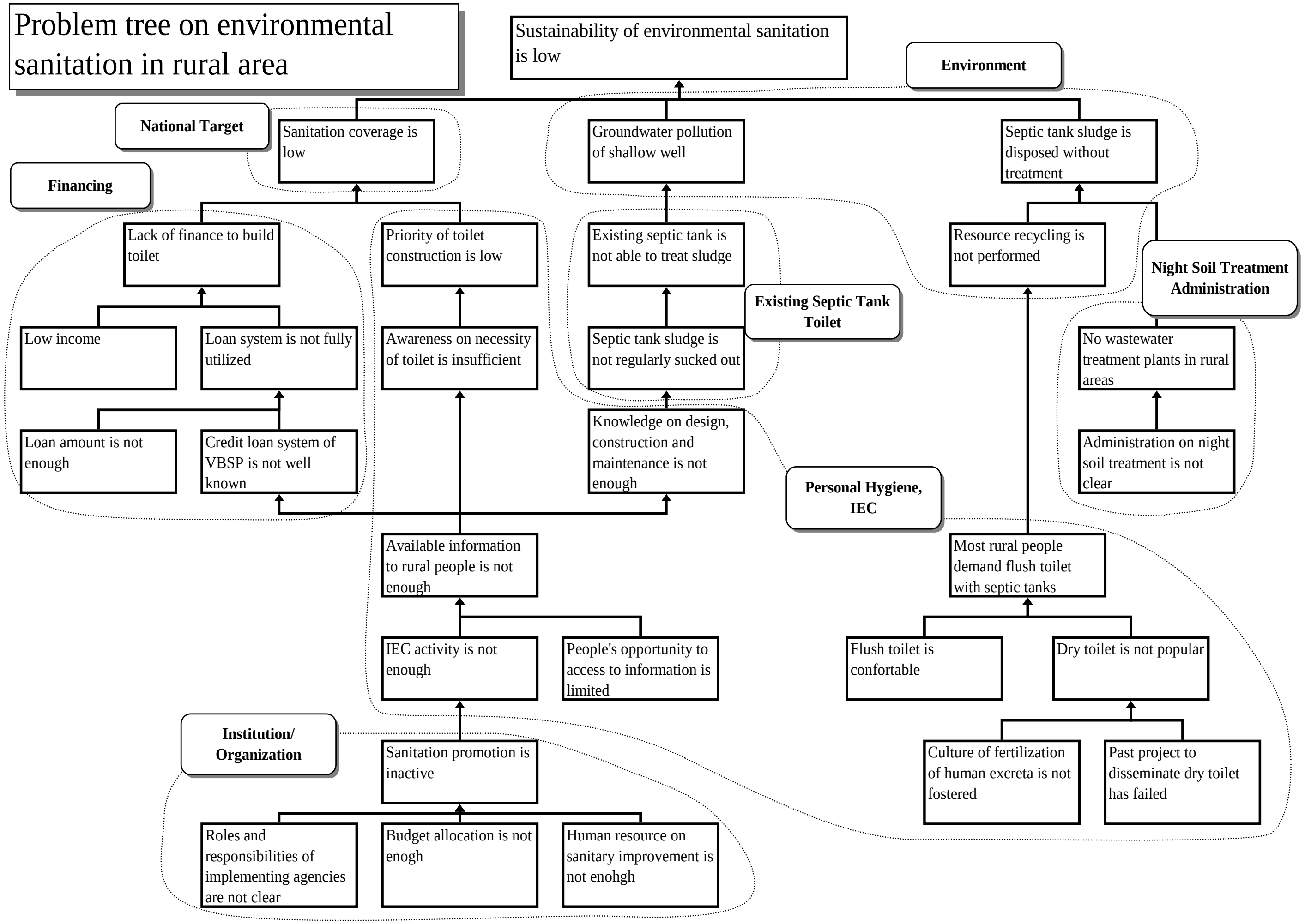


Figure 4.2.1 Problem Tree on Environmental Sanitation in Rural Area

(2) Institution and Organization for Sanitation Promotion in Provincial Level is Weak

In the central level, the leading administration agency for RWSS is MARD. And N-CERWASS, as the implementing entity under MARD, provides technical guidance to related organizations, such as P-CERWASS, in terms of construction of sanitation facilities, etc. MOH also plays important role in sanitation promotion, since MOH provides health education, formulates hygienic standards of latrines and has nationwide network in every commune through clinics and health workers. MOET is in charge of building school toilets and also provides hygiene education in school curriculum. The Government of Vietnam recognizes importance of cooperation among the three ministries and promulgated Joint Circular No. 93/2007 (MARD/MOH/MOET) which expresses roles of each ministry and principles of their cooperation.

However, according to the observation through the Model Sanitation Program in the study area, these activities at the provincial level don't seem active enough because of little awareness of RWSS NTP II which results in less budget allocation and personnel mobilization for sanitation promotion, and little cooperation among the related organizations.

(3) Personal Hygiene is Insufficient due to Lack of IEC

Personal hygiene of rural residence is reportedly insufficient from the survey results of MOH (2007). Among the surveyed households which have no toilet, only 43% of them showed willingness to have their own toilets.

In order to raise personal hygiene, it is essential to provide IEC effectively and continuously. Although importance of IEC is recognized well in central level and many IEC materials have been produced, implementing framework to provide IEC systematically has not been established in local level.

Under the Model Sanitation Program, sanitation education was also provided in order to raise personal hygiene and teach how to use and maintain toilets. The effects, however, were limited within the small number of target group and didn't last for a long period.

(4) Lack of Funds to Build Sanitation Facility

According to survey by MOH (2007), lack of household finance is the foremost reason for rural residents who don't have toilet. The Government of Vietnam promotes a financial supporting policy through an unsecured loan by VBSP (Vietnam Bank for Social Policies) to build WSS facilities. Yet, several issues are pointed out; e.g. loan amount is not enough to cover construction cost and little involvement of MARD/N-CERWASS who provides technical guidance to the borrowers.

(5) Groundwater Pollution by Effluent from Septic Tank

In the Model Sanitation Program, water quality analysis was carried out for effluent (overflow) and sediment sludge of the existing septic tank toilets (septic tank sludge). The water quality analysis results are presented in Table 4.2.1 with referential value of Japanese wastewater quality standard. The values of fecal coliforms, BOD, COD, SS and Nitrogen, as parameters of contamination, exceeds the standard value in both sludge and effluent.

This result shows that the existing septic tanks have few effects to reduce pollution loads and a risk of groundwater pollution of shallow wells is progressing by the effluent of septic tanks, which is the most popular among rural residents.

Table 4.2.1 Water Quality Analysis Result of Septic Tank[#1)]

	Sludge in Septic Tank Bottom	Effluent from Septic Tank	Wastewater effluent quality standard (Japan)
Fecal coliform	93 x 10^5 nos/100mL	2,100 x 10^5 nos/100mL	3.0 x 10^5 nos/100mL[#2)]
BOD	1,387 mg/L	691 mg/L	20 mg/L[#3)]
COD	1,900 mg/L	965 mg/L	120 mg/L[#2)]
SS	2,371 mg/L	326 mg/L	150 mg/L[#2)]
Nitrogen	829 mg/L	795 mg/L	60 mg/L[#2)]

(Note)
[#1)] Nguyen Tri Secondary School – Cam An Bac Commune, Khanh Hoa Province
[#2)] Water pollution control law, Japan
[#3)] Law on Johkasou (advanced domestic wastewater treatment tank), Japan

(6) Administration for Night Soil Treatment

Night soil treatment in rural areas is supposed to be on-site system, which requires septic tank sludge collection and treatment. However, administrative structure for night soil treatment is not established in rural area, whereas it is clearly defined to be MOC for urban area.

(7) Environmental Issues Caused by Disposal of Untreated Septic Tank Sludge

Sediment sludge in septic tank (septic tank sludge) is sucked out by vacuum cars. The collected sludge is currently disposed in the mountainous fields without treatment which causes degradation of natural environment.

Since serious environmental problems are presumed with increase use of septic tank toilet in future, treatment facilities should be planned and developed.

<< BOX Septic tank toilet and environmental issues>>

Besides low sanitation coverage rate, environmental issues should be pointed out in regard to septic tank toilet, which is the most desired by rural people. As shown in Figure 4.2.2, septic tank toilets possibly cause two environmental issues. They are: groundwater pollution by effluent and environmental degradation by untreated sludge disposal.

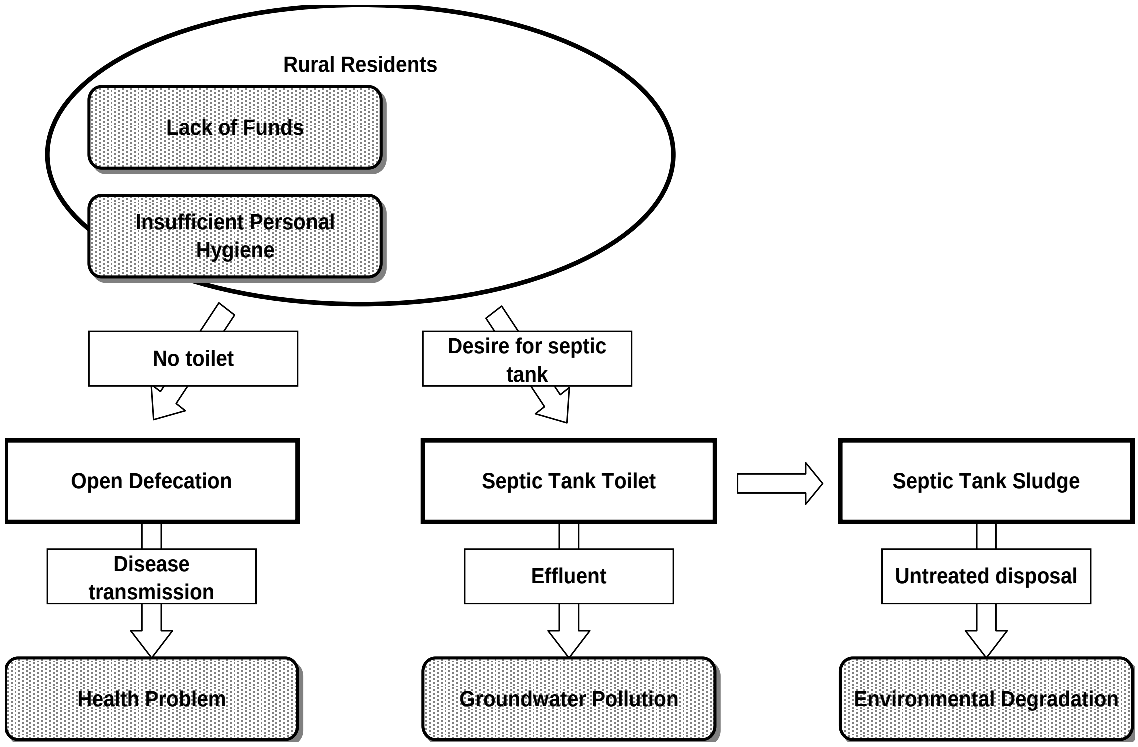


Figure 4.2.2 Environmental Issues related to Septic Tank Toilet

4.3 Recommendable approach toward sustainable improvement of environmental sanitation

Based on aforementioned recognition, recommendable approaches are presented to address sustainable improvement of environmental sanitation. It is envisaged that not only target oriented approach to increase access rate of sanitation facility but also continuous efforts to maintain environment are required.

(1) Establishment of Provincial Taskforce for Sanitation Promotion

In order to enhance implementation organization in provincial level, information sharing and consolidated policy formation is recommended by forming a cross-sectoral workgroup; e.g. "Provincial Taskforce for Sanitation Promotion" as shown in Table 4.3.1:

Table 4.3.1 Recommended Taskforce for Sanitation Promotion

Member	DARD(leading agency), P-CERWASS, DOH, DOET, DONRE, DPC, etc.
Main functions	(1) Policy formation: through discussion of priority subject and decision making (2) Needs identification and analysis: by surveying and monitoring knowledge, attitude and practice (KAP) related to sanitation (3) Cooperation with local authorities: by information sharing with DPC and CPC (4) Implementation of pilot project (5) Support to grass-roots activity

The Project Design Matrix (PDM, a project summary sheet with logical framework) for the taskforce formation is presented as below:

Table 4.3.2 PDM for Taskforce Formation

Summary	Indicator	Means of verification	Important Assumption
Overall Goal: - Sustainability of environmental sanitation in rural area is improved.	- Sanitation coverage (%) - Night soil treatment volume (m^3/year)	- DOH Statistics - Operation record of treatment plant	
Project Purpose: - Taskforce for sanitation promotion is functioning	- Preparation of policy paper - Preparation of budget plan	- Existence of the policy paper - Existence of budget plan	- Budget is allocated to implement the plans
Outputs: - Information on taskforce activity is shared and supported by provincial organization	- List of participants/ organization - Preparation of policy paper	- Minutes of the taskforce meetings - Existence of the policy paper	- Taskforce activity will continue and be monitored by the provincial government
Activities: - Information sharing on sanitation promotion of the related organizations - Needs identification and analysis by surveying and monitoring KAP on sanitation - Policy formation through discussion of priority subject and decision making	**Inputs:** - Top of provincial administrative organization understands importance of the taskforce and commit to support the activity - Active participation of the related organizations - Budget for taskforce activity is allocated - Taskforce for sanitation promotion is established under PPC led by DARD		- The Government’s policy on RWSS NTP II will continue

(2) Raising Personal Hygiene through Enhancement of IEC channels

It is identified that IEC is the key factor to approach sanitation promotion. Although a lot of IEC materials have been prepared by N-CERWASS as well as MOH, they are not fully utilized in promotion activities in local level.

The reasons of ineffective use in provincial level are presumed as listed below:

- Shortage of IEC staff in P-CERWASS, DOH and other organizations involved in IEC. In most P-CERWASS, IEC is assigned as an additional task for already employed staff. The local collaborators mainly work on a voluntary basis.
- Little knowledge and experience of IEC staff.
- Information is provided in instructive way with little dialogues and explanation on background information so that rural people can make their own decision.
- IEC materials are not necessarily attractive for all target groups. Sometimes they are less attention to differences in customs, traditions, socio-economic conditions, literacy, etc.
- Inadequate budget allocation to IEC activities. The budget for IEC is very small compared to construction budget. And the available budget tends to be spent for large meetings and training, rather than creating communication opportunity with local people.

In the Model Sanitation Program, IEC materials have also been prepared, such as; posters for sanitation education, booklets for how to build toilet, DVD video to promote urine-feces separation toilets with instruction of how to build toilet, etc. However, due to limited period of the activities, remarkable effects in raising personal hygiene have not been observed.

Since behavioural change takes long time, long term intervention through diversified communication channels should be taken into account in addition to short term and single activity. And IEC should be performed through every possible ways of communication, by improving delivery of information. For this purpose, the existing community-based local network, such as women’s union, farmers’ union, etc. shall be utilized. In this case, local motivators, who can influence and motivate people by using their grass-roots networks, should be developed. The concept of delivery of information to residents by using local motivators is illustrated in Figure 4.3.1.

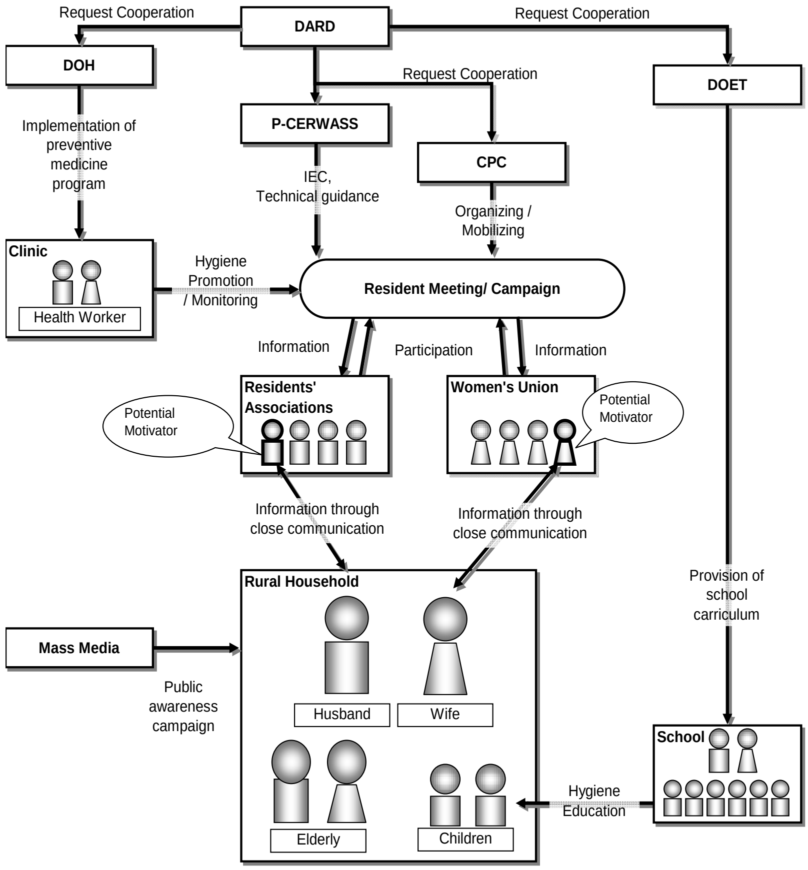


Figure 4.3.1 Delivery of Information to Residents by using Local Motivators

As the actions to be taken by the implementing organizations, the following activities are recommended to improve IEC for raising personal hygiene in rural area.

- P-CERWASS fosters IEC specialists (through training by N-CERWASS)
- The IEC specialists provide IEC to local motivators (training in commune by using training package to be prepared by N-CERWASS)
- Involvement of related organizations to the IEC activity (Collaboration with DOH, health workers, schools, mass media, etc.)
- Supportive working conditions will be ensured to mobilize IEC participants
- Diversified IEC media/ methodology (Production of visual media, use of mass media, local campaign event, etc.)

The PDM for IEC enhancement is presented as below:

Table 4.3.3 PDM for Raising Personal Hygiene through Enhancement of IEC channels

Summary	Indicator	Means of verification	Important Assumption
Overall Goal: - Sustainability of environmental	- Sanitation coverage (%)	- DOH statistics - Operation record of	

sanitation in rural area is improved.	- Night soil treatment volume (m^3/year)	treatment plant	
Project Purpose: - Personal hygiene is raised through enhancement of IEC channels	- KAP (Knowledge, Attitude, Practice) survey - Sanitation coverage (%)	- DOH survey - DOH statistics	
Outputs: - IEC activities are enhanced	- Number of IEC Specialists who completed IEC training course - Number of local motivators fostered	- P-CERWASS annual report - P-CERWASS annual report	- IEC activity will continue
Activities: - P-CERWASS fosters IEC specialist - P-CERWASS provides training for local motivators - Ensuring supportive working conditions for IEC motivators - Public announcement through mass media - Public awareness campaign event	**Inputs:** - DARD/ P-CERWASS/ DOH commit to support the policy of IEC enhancement - Training course for IEC specialists by N-CERWASS - Preparation of training package for local motivators - Participation of DOH, health workers, etc. to IEC activities - Participation of school teachers to IEC activities - Budget for IEC activity		- The Government’s policy on RWSS NTP II will continue

(3) Dissemination of New Design of Urine-Feces Separation Toilet

It is pointed out that the existing pour flush latrine with septic tank, which is the most popular in the study area, may cause groundwater pollution since the septic tank has few effects to treat the excrement. On the other hand, DVCL toilet is not popularly accepted by the rural residents in southern provinces, although the JICA Study Team recommends it from the ecological point of view.

In the Model Sanitation Program, the Team introduced urine-feces separation type with chair type stool for both dry and septic tank toilet. They are designed in consideration of the above mentioned issues of the existing toilets. The design concept of the new urine-feces separation toilet is given as below and illustrated in Figure 4.3.2.

- To be ecological by resource recycling of excreta as fertilizer and by mitigating groundwater pollution from septic tank effluent: Urine-feces separation type
- To be comfortable and friendly for any users, especially for aged and handicapped persons: Chair type stool
- To provide options to be chosen by customers: Dry and pour flush with septic tank types
- To be reasonable price: Locally manufactured (production cost of prototype: VND 700,000.- per stool)

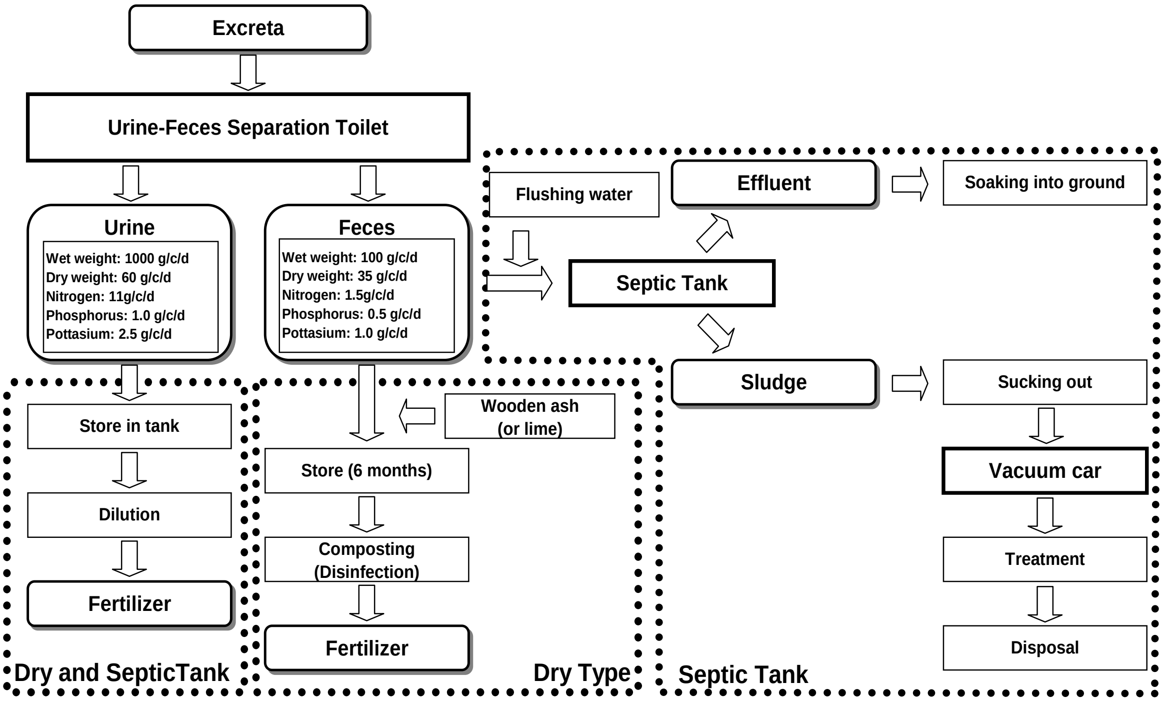


Figure 4.3.2 Concept of Urine-Feces Separation Toilet (Dry and Septic Tank Types)

The characteristics of the existing and the new designs of both dry and septic tank toilets are summarized in Table 4.3.4.

Table 4.3.4 Comparison between Existing and New Design Urine-Feces Separation Toilet

<< Dry Type>>

Item	Existing Design (DVCL)	New Design Toilet
Comfortable	Squat type is difficult for aged or handicapped users Little bad smell (if properly constructed and used)	Chair type stool is comfortable Little bad smell
Groundwater pollution	No	No
Resources recycling	Urine and feces are recycled	Urine and feces are recycled
Water supply	No need (except hand washing water)	No need (except hand washing water)
Economy	Approx. USD 400 [#1)]	Approx. USD 500 [#2)]
O&M	Wooden ash or lime should be used after defecation for disinfection. Water can not be used. Two feces chambers should be alternately used after every 6 months. Feces should be kept in dry condition for more than 6 months.	Wooden ash or lime should be used after defecation for disinfection. Water can not be used. (but small amount of mist water can be used for cleaning feces hole) Some containers for feces storage should be prepared for removable cartridge which is placed in the single feces chamber. Feces should be kept in dry condition for more than 6 months.
Other risk	Water intrusion into feces chamber in rainy season may not suitable	To date, the new type stool is not sold on the market

<< Pour Flush with Septic Tank Type>>

Item	Existing Design	New Design Toilet
Comfortable	Chair type stool is comfortable Little bad smell	Chair type stool is comfortable Little bad smell
Groundwater pollution	Effluent from septic tank may pollute groundwater	Pollution load is mitigated by separating urine. (Approx. 88%[#3)] of nitrogen is reduced)
Resources recycling	Urine and feces are not recycled	Urine is recycled as fertilizer
Water supply	Necessary	Necessary, but less water consumption
Economy	Approx. USD 400 – 600 [#1)]	Approx. USD 600 [#2)]
O&M	Septic tank sludge shall be sucked out by vacuum track	Septic tank sludge shall be sucked out by vacuum truck Urine tank shall be removed to spray in the field. (urine discharge pipe by using gravity flow can be optionally installed)
Other risk	Environmental degradation due to disposal of untreated sludge	To date, the new type stool is not sold on the market

(Note)
[#1)] Research by the Study Team, 2007
[#2)] Actual cost of the Model Sanitation Program (2007), including toilet stool cost of VND 700,000.
[#3)] "A Proposal of Advanced Sanitation System and Attempts to Improve Vietnamese Sanitation, Hidenori Harada, 2007"

In the Model Sanitation Program under the Study, the new model toilets have been introduced and effects are monitored. The design drawings and monitoring results are presented in ANNEX 1 "Activity Report on Model Sanitation Program". As a result of monitoring, new design of urine-feces separation toilets is accepted and properly used by most users, even it is of dry or flush toilets. It seems that rural people in the Study Area possibly accept this model. Therefore, it is highly recommendable to disseminate this new design toilet from environmental point of view.

In disseminating the new design toilet, the following issues should be taken into account.

・Design approval by MOH: The new design is in progress for approval by MOH (as of November 2008). MOH basically agrees and enough hygienic and environmental effects should be verified with demonstration data. MOH has policy to increase types of the hygienic latrine standards to be diversified and applicable for different climate, culture, etc.

・Commercialization of the new design stool: Since it is newly introduced in Vietnam, the new stool is produced as a prototype and not on sale in market. Manufacturing and market system should be developed.

・Price of the stool: The prototype model was manufactured at the cost of VND 700,000.- per stool. It doesn't include cost and profit margin of distributors. But the production cost could be reduced by mass production and distribution. Policy to provide preferential conditions for ecological benefits of the urine-feces separation type should also be considered, e.g. financial subsidy for people who buy the urine-feces type stool.

・Advertisement and public information: Since it is new model introduced in Vietnam, advertisement is important for dissemination. Technical guidance should be provided to rural people, including information about hygienic and ecological benefits, how to build, use and maintain toilet. In this connection, booklets and DVD video for teaching how to build toilet were produced and provided in the Model Sanitation Program.

・Long time to disseminate: It takes a long time to disseminate this model widely for rural people.

Taking into account of the aforementioned, the PDM for disseminating urine-feces separation type toilet is presented as below:

Table 4.3.5 PDM for Further Dissemination of Urine-Feces Separation Type Toilet

Summary	Indicator	Means of verification	Important Assumption
Overall Goal: - Sustainability of environmental sanitation in rural area is improved.	- Sanitation coverage (%) - Night soil treatment volume (m^3/year)	- DOH statistics - Operation record of treatment plant	
Project Purpose: - Urine-feces separation toilet is disseminated	- Rate of rural households using urine-feces separation toilet (%)	- DOH statistics	- Pollution load to groundwater is reduced - Resources recycling is performed
Outputs: - Rural people understand benefits of urine-feces separation toilet - Rural people have willingness for the toilet	- Rate of rural households having willingness for urine-feces separation toilet (%)	- KAP survey (DOH)	- Leading policy for resources recycling is promoted - Socialization of the new type toilet proceeds
Activities: - New design urine-feces separation toilet is approved by MOH - Urine-feces separation type toilet stool is sold on the market at reasonable price - Leading policy is promoted, such as preferential subsidy for urine-feces separation toilet - Advertisement, public information and technical guidance is provided	**Inputs:** - Design documents and drawings for approval - Participation of private sectors for manufacturing and distribution - Budget for disseminating the new design toilet		- Urine-feces separation type toilet is recognized and supported by the Government and related organizations

(4) Enhancement of Financial Support and Incentive Mechanism

The preferential loan offered by VBSP (Vietnam Bank for Social Policies) seems attractive for rural households to construct water supply and sanitation facilities. Some constraints are identified in the Study. For example, the loan system is not widely known by rural people, depending on involvement of commune having branch office. Technical standard and evaluation system is not established, which may fail in design failure, etc., due to little involvement of P-CERWASS. And loan amount is sometimes insufficient.

As the measures against these constraints, maximum utilization of VBSP loan is recommended, through promoting measures as described below:

- More advertisement and public information to rural people: More information about how to apply loans and actual case should be provided to public through aforementioned IEC activities. Information should be easy enough and accessible to any people.
- Increasing loan amount: Current loan amount of maximum VND 4 million is not enough to cover entire construction cost, while it is assumed that approx. VND 6-8 million is required in many cases.
- Sufficient technical guidance: People should have sufficient information on appropriate technical options and necessary knowledge and skills for construction, how to use and maintenance, that would be provided by P-CERWASS.
- Incentive strategy: For example, premium financial support for urine-feces separation toilet, which contributes ecology as above mentioned, would give motivation.
- Cost reduction: Construction cost would be reduced by standardization of toilet design and/or package purchase of construction materials, which would be done by any group of beneficiaries. In this regard, local residential groups, such as Women's Union, would be potential motivator.
- Technical evaluation and monitoring: To ensure transparency and sustainability, technical evaluation and monitoring of constructed facility should be programmed in the financial mechanism.

The PDM for enhancing financial support is presented as below:

Table 4.3.6 PDM for Enhancing Financial Support

Summary	Indicator	Means of verification	Important Assumption
Overall Goal: - Sustainability of environmental sanitation in rural area is improved.	- Sanitation coverage (%) - Night soil treatment volume (m^3/year)	- DOH statistics - Operation record of treatment plant	
Project Purpose: - Financial support is effectively utilized for toilet construction	- Access rate of hygienic latrine (%) - Number of borrower of VBSP loan (borrowers/year) - Loan amount per year (VND/year)	- DOH statistics - VBSP's annual report - VBSP's annual report	- Technical evaluation and monitoring is performed to ensure transparency and sustainability
Outputs: - Enhancement of preferential loan for toilet construction	- Number of borrower of VBSP loan (borrowers/year) - Loan amount per year (VND/year)	- VBSP's annual report - VBSP's annual report	- Good practice is advertised in commune - Policy of preferential loan continues

Summary	Indicator	Means of verification	Important Assumption
Activities: -More advertisement and public information - Increasing loan amount - Sufficient technical guidance by P-CERWASS - Incentive strategy for toilet construction - Explanatory meeting to introduce cost reduction method by standardization and package purchase	**Inputs:** - Strategic policy to disseminate VBSP loan - More budget allocation to support VBSP loan - More involvement of P-CERWASS and local organization		- Inflation doesn't rapidly increase

(5) Environmental Administration and Night Soil Treatment

It is envisaged that MONRE would be the administration body responsible for night soil treatment and sludge disposal in rural area, although legal framework has not been formulated yet. As multi-sectoral organizations are currently involved in rural sanitation, it is recommended to establish single administrative organization which is responsible for dissemination of hygienic latrines as well as for collection and treatment of sediment sludge from septic tank in order to promote sanitation with conscious of environmental conservation. Provision of regulation is also recommended to collection, treatment and disposal of septic tank sludge.

In this regards, a case study is conducted for septic tank sludge treatment system in a rural province, which aims to examine technical solution, preliminary design and cost estimations. The result of the case study is presented in ANNEX 2.

The PDM for wastewater treatment is presented as below:

Table 4.3.7 PDM for Night Soil Treatment

Summary	Indicator	Means of verification	Important Assumption
Overall Goal: - Sustainability of environmental sanitation in rural area is improved.	- Sanitation coverage (%) - Night soil treatment volume (m^3/year)	- DOH statistics - Operation record of treatment plant	
Project Purpose: - Wastewater is treated by night soil treatment plan	- Night soil treatment volume (m^3/year)	- Operation record of treatment plant	- Hygienic latrines are disseminated in rural area - Residents pays fee for waste water collection and treatment
Outputs: - Construction of night soil treatment plant - Procurement of vacuum cars	- Existence of night soil treatment plant - Number of vacuum cars	- As-built drawings - Contract document/ commissioning report	- Operating staff is engaged - Operating expenses are secured
Activities:	**Inputs:**		

Summary	Indicator	Means of verification	Important Assumption
- Construction of night soil treatment plant - Procurement of vacuum cars	- Funds for construction and procurement - Facility design - Land acquisition - Training for operators		- Legal frame for septic tank sludge treatment is formulated

4.4 Probable Implementation Scheme

The approaches discussed in the previous section are rather challenging, since they require extensive efforts of all the related organizations of central and local levels. Therefore, it is recommended to implement with assistance from foreign donors. In addition to the currently supporting donors, such as UNICEF and TPBS, this section discusses about probable implementation scheme for further promotion.

(1) Grass-Roots Assistance

As sanitation promotion should be carried out continuously at local level, grass-roots assistance by NGOs is envisaged to be suitable to support public relations and technical instruction for toilet construction in commune level.

In this scheme, the target group is envisaged to be local residents who need hygienic latrines. They are to be assisted by NGOs for choosing appropriate technology, designing, construction and maintenance. Information on finding fund sources is also to be provided. Transmitted effect by the residents who construct toilets with the assistance should be considered in the program. Namely, they are expected to be local motivators to disseminate their experience through their grass-roots network in commune.

As an idea, the grant aid for grass-roots group funded by the Government of Japan would be applicable to follow-up the Model Sanitation Program commenced under the Study. Since target communes and implementation organization have been formulated, smooth project implementation with quick impact is expected through adequate understandings and cooperation by the organizations, such as CPC, schools, etc. The monitoring of the program is also to be followed-up to verify their behavioral effect and personal hygiene.

Table 4.4.1 Outline of Grass-Roots Assistance Program (Provisional)

Objectives:	- To provide information on appropriate technology for hygienic latrines and resources recycling to be chosen by the residents. - To assist designing, preparation of work plan, procurement and construction of toilets - To provide the new urine-feces toilet stool - To monitor behavioral effect and personal hygiene
Target group:	- CPC and Residents of target communes of the Model Sanitation Program under JICA Study
Counterpart:	- N-CERWASS, DOH, DARD, DOET, CPC
Period:	- One year

(2) Technical Cooperation for Capacity Development on Environmental Administration in Rural Area

To cope with the environmental issues pointed out in this report, such as groundwater pollution and septic tank sludge disposal, institutional and administrative capacity should be developed through technical cooperation by international donor agency, since institutional framework has not been formed yet in Vietnam.

In that case, a pilot project should be considered to construct a pilot plant for septic tank sludge treatment.

Table 4.4.2 Outline of Technical Cooperation Project (Provisional)

Objective:	- To formulate institutional framework on wastewater discharge and sludge disposal in rural area - To develop capacity of the administrative organization - To carry out a pilot project to examine effects of septic tank sludge treatment plant
Target group	- Related government organizations; MARD, MOH, MONRE, etc.
Period	- 3 years (including construction and operation of the pilot plant)

(Note) This outline is provisionally prepared, which isn't based on any commitment by donors and NGO's.

(3) Septic Tank Sludge Treatment Plant Project by CDM Scheme

In the "Case Study on Septic Tank Sludge Treatment" presented in ANNEX 2, GHG reduction is expected by combustion of methane gas which is to be collected through septic tank sludge treatment.

This implies a possibility of project implementation by CDM (Clean Development Mechanism) which is an international arrangement to execute commitment for GHG reduction. Namely under CDM scheme, industrialized countries, including Japan, who commit reduction of GHG invest in project that reduce GHG emissions in development countries to get emission reduction credits provided by the project.

By implementation of the project, technologies and fund for project implementation can be introduced to Vietnam, as the host country. And groundwater pollution and environmental degradation would be mitigated through treatment plant operation. At the same time, for the investing countries are able to execute commitment to reduce GHG emission by the carbon credit. Thus, CDM is an incentive scheme for both of host and industrialized countries.

In order to implement CDM project, a lot of procedures for project approval by the authorized agency are required. Also the project effect must be monitored annually by the agency. In order to apply CDM to this case, technical issues identified in the case study should be cleared. And the project implementation organization should be established to prepare detailed project implementation plan, in order to get approval by both of government of Vietnam as well as the authorized operational entity registered by the Executive Board of CDM.

4.5 Conclusions

In this chapter, recognitions and issues on rural sanitation are described based on findings through the Model Sanitation Program. It is identified that further efforts to increase sanitation coverage is necessary. It should be stressed that needs of environmental measures are potentially growing, including administration for septic tank sludge disposal.

Recommendable approaches are also presented for sustainable improvement of environmental sanitation. Then, probable implementation scheme is preliminarily examined. To proceed to further technical examination, a case study on septic tank sludge treatment is carried out as ANNEX 2, which presents technical and financial examination.

It is desirable that these contents would help for the Vietnamese Government to strength the efforts toward sanitation improvement with environmental consideration.

CHAPTER 5 FEASIBILITY STUDY

5.1 Preliminary Design of Water Supply System

5.1.1 Objective of the Project

In this part, Feasibility Study (FS) is carried out for the priority projects selected through the Master Plan study. Based on the national strategy of NRWSSS, the target year of Feasibility Study is year 2020. It is considered reasonable and proper from view point of technical and economical aspects, because the average growth rate of water demand in all target area from year 2006 to year 2020 is estimated as 18% only.

The aim of the study is to achieve improvement in living standards and promotion of sound socio-economic activities through the project by providing sufficient water to the people in the study area. The rate of population served in the area is considered to reach 100% by means of house connections by the year 2020.

5.1.2 Outline of the Project Area

(1) Project Area

According to the selection of priority project in the Master Plan, study areas include 15 communes with 9 water supply systems.

(2) Outline of the Project Area

The project area includes 9 water supply systems located in 15 communes of 4 provinces. The relation between the system and commune and outline of the project area are summarized in Table 5.1.1.

Table 5.1.1 Outline for the FS commune

Province	Commune		System No.	System Pattern	Population in 2020	Water demand in 2020 (m^3/d)	Raw water source	Distance between intake and commune（km）
Phu Yen	An Dinh	P-2	FPS-2	Single	6,856	502	Dong Tron reservoir (PS-4)	5.5
	An My	P-4	FPS-3	Single	13,256	998	Groundwater	1.0
	Son Phuoc	P-5	FPG-4	Group	11,666	874	Ba river (PS-6)	4.5
	Ea Cha Rang	P-6						
	Suoi Bac	P-7						
	Son Thanh Don	P-8	FPS-5	Single	9,292	651	Groundwater	1.9
Khanh Hoa	Cam An Bac	K-1	FKS-6	Single	6,626	485	Groundwater	0.5
	Cam Hay Tay	K-3	FKS-8	Single	6,978	526	Groundwater + Cam Ranh reservoir (KS-3)	1.0 8.0
Ninh Thuan	Phuoc Hai	N-5	FNG-10	Group	29,715	2,149	Cai river at Lam Com Weir (NS-2)	14.5
	Phuoc Dinh,	N-6						
Binh Thuan	Muong Man	B-1	FBS-11	Single	7,378	557	Com Hang reservoir (BS-2)	4.7
	Nghi Duc	B-3	FBG-13	Group	52,241	3,730	La Nga river (BS-4)	4.5
	Me Pu	B-5						
	Suong Nhon	B-6						
	Da Kai	B-7						
15 communes			9 systems		144,008	10,472		46.1

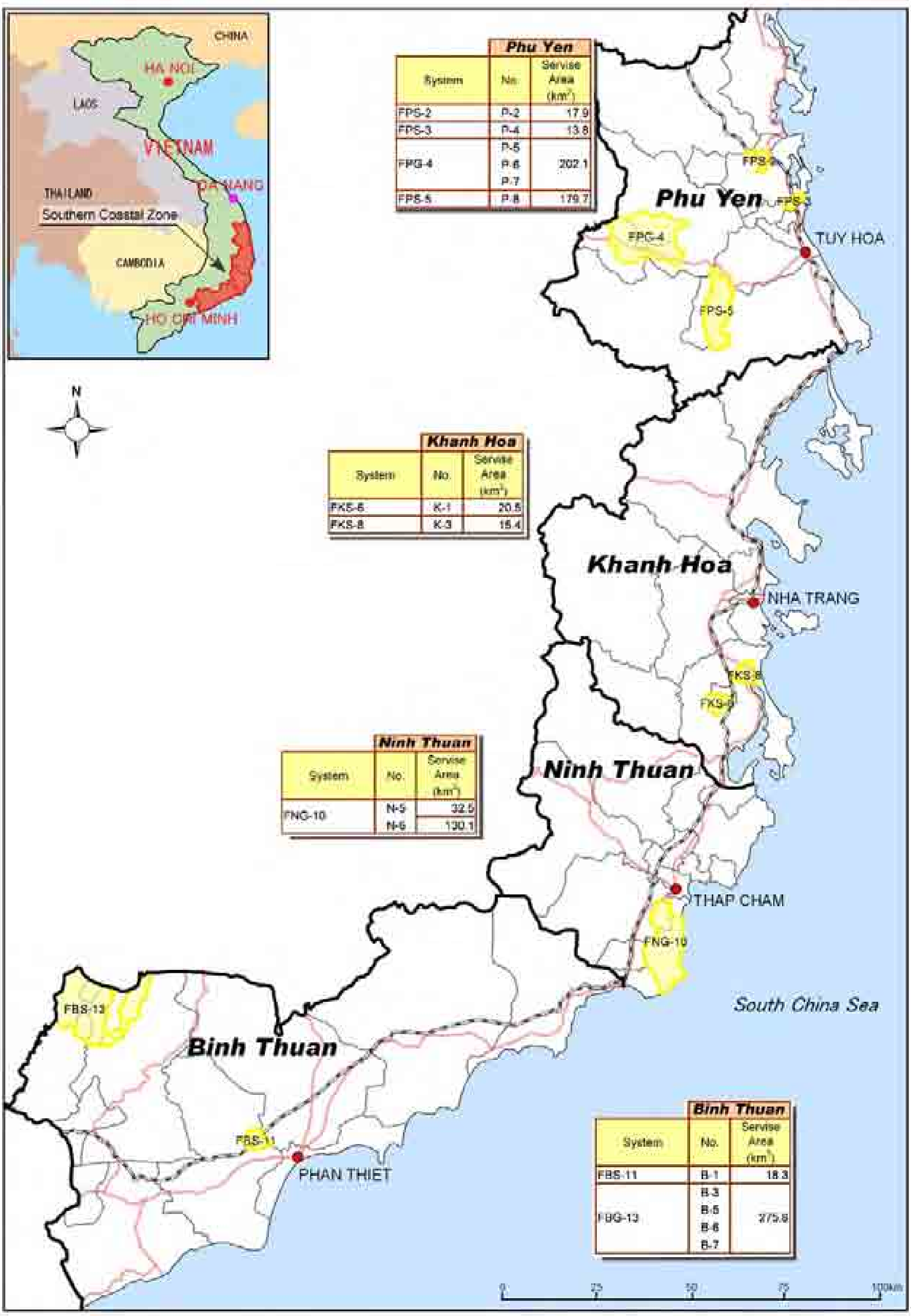


Figure 5.1.1 Location of Water Supply System considered in FS

5.1.3 Water Sources

Water sources of the selected 9 facilities for 15 communes in total are planned as follows.

(1) Groundwater

Groundwater development plan of three facilities for three communes based on the results of this study including test well drilling survey is described as follows.

1) P-4 (An My)

Three production wells can be developed apart from 500m each other upstream of the valley where the test well is located. Since they have to develop fissure water in fault zone, it is not easy to exploit sufficient groundwater. Therefore, it is assumed that the safety yields of two wells which will be newly developed are 50% of the test well and the total withdrawal volume (691× (1+0.5×2) = 1,382m^3/day) is expected to cover the design water capacity: 1,198m^3/day for the water supply facility plan in An My Commune.

2) P-8 (Son Thanh Don)

It is possible to develop another well whose safety yield is the same as the test well. The total volume of them becomes 864m^3/day (432×2=864m^3/day) and can cover the design water capacity: 781m^3/day.

3) K-1 (Cam An Bac)

K-1 is also possible to set another well having the same yield as the test well. The total safety yield is expected to be 720m^3/day (360×2=720m^3/day) which can cover the design water capacity: 582m^3/day.

(2) Combination of Groundwater and Surface Water

1) K-3 (Cam Hay Tay)

Since this commune faces to the ocean and is generally located in low-lying area, an affection of the seawater intrusion is detected along shoreline. Therefore, the test well was constructed to exploit fissure water in the basement rocks which is difficult to strike water but has no influence of seawater intrusion. In this plan, approximately 40 % of the test well's safety yield in K-3 is regarded as an additional yield by another well. Total volume of groundwater by the wells is 403m^3/day (288×(1.0+0.4)=403m^3/day). On the other hand, it is expected to add 250 m^3/day of surface water from Cam Ranh Reservoir where is located about four kilometer west of K-3. Therefore, such a combination of groundwater and surface water can cover the design intake water capacity: 650m^3/day.

As to water quality of above-mentioned groundwater sources, all of them except K1 satisfy the drinking water standards. An appropriate facility is needed to remove total iron and manganese for K-1.

(3) Surface Water

According to the alternative water source survey which was conducted to look for other water sources for the communes having inadequate groundwater sources, it is possible to develop surface water for 5 water supply facilities in 11 communes as described below.

1) P-2 (An Dinh)

Surface water of Dong Tron Reservoir located about five kilometers south-southwest from P-2 is taken to the water supply facility to cover water demand of P-2 commune. The intake water volume is 700m^3/day.

2) P-5,6,7 (Son Phuoc, Ea Cha Rang, Suoi Bac)

The water source of the water supply facility for P-5, 6 and 7 comes from the Ba River about four to ten kilometers away from their communes. The intake water volume is 1,100m^3/day.

3) N-5, 6 (Phuoc Hai, Phuoc Dinh)

The intake facility of the water supply facility for N-5 and 6 communes is located about ten kilometers away from the river mouth of the Cai River. The intake water volume is designed to be 2,900m^3/day.

4) B-1 (Muong Man)

The water source of the water supply facility for B-1 commune is Cam Hang Reservoir about five kilometers away from there. The intake water volume is designed to be 800m^3/day.

5) B-3, 5, 6, 7 (Nghi Duc, Me Pu, Sung Nhon, Da)

The intake facility of the water supply facility for B-3, 5, 6 and 7 communes is located about four kilometers away from the center of B-6. The intake water volume designed to be 5,000m^3/day.

As to water quality of above-mentioned surface water sources, turbidity, ferric oxide and coli form of them dissatisfy the drinking water standards because they are not groundwater but surface water. Water treatment facilities should be set into the water supply systems.

5.1.4 Design Conditions

(1) Design Water Capacity

The design capacity of all the facilities in each water supply system considered for FS has been determined based on “Design water capacity” of Chapter 3 and the result is presented in Table 5.1.2.

Table 5.1.2 Design Water Capacity for FS

System	(1) Daily average (m^3/d)	(2) Daily Max. (m^3/d)	(3) Intake water flow (m^3/d)	(4) Hourly max. (m^3/hr.)
FPS-2	502	600	700	50
FPS-3	998	1,200	1,200	100
FPG-4	874	1000	1,100	83
FPS-5	651	800	800	67
FKS-6	485	600	600	50
FKS-8	526 *GW :403 *SW:123	600	650 GW:400 SW:250	50
FNG-10	2,149	2,600	2,900	217
FBS-11	557	700	800	58
FBG-13	3,730	4,500	5,000	375
9	10,472	12,600	13,750	

Note: * GW: Groundwater, SW: Surface Water
Capacity used to design following facility.
Daily Max.: Transmission pipeline and reservoir tank, Intake water flow: intake facility and treatment plant, Hourly max.: distribution pipeline

Intake water flow capacity includes system utility water. The volume of utility water is considered as 10% of daily max. The utility water means wash water for filter bed and cleaning water for each facility. In case of groundwater without treatment plant, the utility water is not required. For system FKS-6 with slow sand filter, utility water has been neglected due to a drop in the bucket.

The nominal capacity of the treatment plant means daily maximum capacity which is amount of water produced.

(2) Design Conditions and Criteria

All water supply systems are designed considering the following design conditions.

1) Design Raw Water Quality

The system is designed based on drinking water quality standards of Vietnam. If the level of water quality parameters in raw water is not in accordance with the standard, the removal of these parameters shall be considered by treatment plant. According to the water quality analysis test, the design raw water quality before treatment is defined by each water source as shown in Table 5.1.3.

Table 5.1.3 Design Water Quality of Raw Water

Water source	System	Paragraph for treatment			
		Total Iron (mg/L)	Manganese (mg/L)	Turbidity (NTU)	
				Max.	Average
Groundwater (A)	FPS-3, FPS-5, FKS-8	less than 0.5	less than 0.5	less than 2	less than 2
Groundwater (B)	FKS-6	0.7	0.6	less than 2	less than 2
Surface water (River)	FPG-4, FNG-10, FBG-13	less than 0.5	less than 0.5	300	100
Surface water (Irrigation reservoir)	FPS-2, FKS-8,FBS-11	less than 0.5	less than 0.5	100	50
Drinking water hygienic standard* (Treated water quality)		0.5	0.5	2	2

Note: * Drinking water hygienic standards (Standard No. 1329/2002/BYT/QD, MOH)

2) Intake Facility

a. Spare Well

According to the design criteria* of Vietnam issued by MOC, in case of groundwater source, the spare well is required based on the water supply project size and the number of wells needed is shown in Table 5.1.4. (Note *: Ministry of Construction TCXDVN33:2006 Distribution system and facilities Design Criteria Hanoi 3/2006) The spare well is not included in pump set.

Table 5.1.4 Required Number of Spare Well

No. of operating well	Spare well
1 to 2	0
3 to 9	1

The spare well is applied for each system that is proposed to make use of the groundwater sources based on Table 5.1.4.

b. Well Structure

The test wells constructed by the study are used for production well in the Project. The new wells are required to construct depending on the conditions of the water demand. The drilling depth of new wells is determined considering the result of existing boring data and the electrical sounding. The length of screen is determined based on the result of the existing boring data and considering the inflow velocity. The conceptual diagram of well structure is shown in Figure 5.1.2.

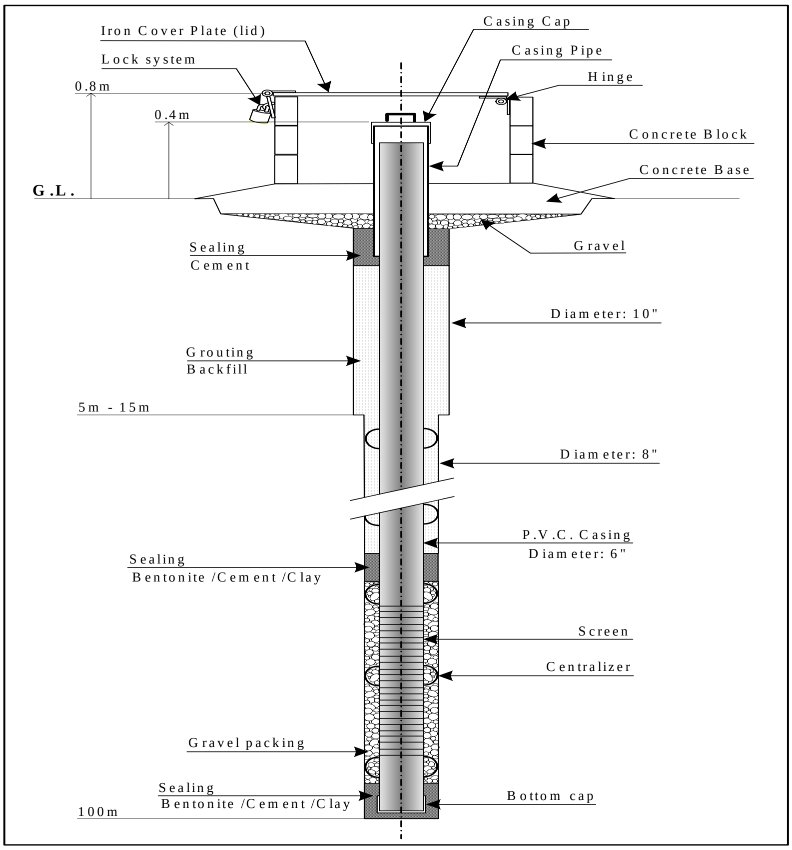


Figure 5.1.2 Conceptual Diagram of Well Structure

c. Intake Structure for River Water

The intake facility is located by the side of river. The configuration of the intake is constructed open channel system. The stop-log and bar screen is designed in the channel. In order to protect corrosion by the flowing water, a part of upstream and downstream of the intake is protected by gabion mat or concrete wall and intake base is constructed by piling for protection against scouring. The intake structure of each system is shown in the preliminary design.

d. Intake Pump

In case of intake from river, submersible motor pump is proposed as intake pump due to protection against flood. The use of submersible motor pump is also proposed for deep well.

3) Transmission Main

In principle, the materials for pipeline between intake, treatment plant and distribution reservoir is PVC pipe. However, in cases when the pipelines are to be laid for long distance and has big diameter or require laying along the national road, the pipe materials are Ductile Cast Iron Pipe (DCI) in order to protect external pressure on these pipe. These pipelines are applied for system in case of FPG-4, FNG-10 and FBG-13. For the part of pipelines crossing railway or river, pipe materials are Steel pipe with concrete pipe as protection.

4) Distribution Facility

a. Capacity of Distribution Reservoir

The distribution reservoir has the function of regulating the fluctuation in daily consumption especially hourly maximum water demand. According to the water consumption pattern in Figure 5.1.3, the consumption during day time is high compared to night time. Therefore, the reservoir tank charges water in the night time in order to prepare for peak consumption. The storage water in the reservoir can be equal to demand in the peak consumption time. The capacity needs to have storage for 6 hours of daily maximum water.

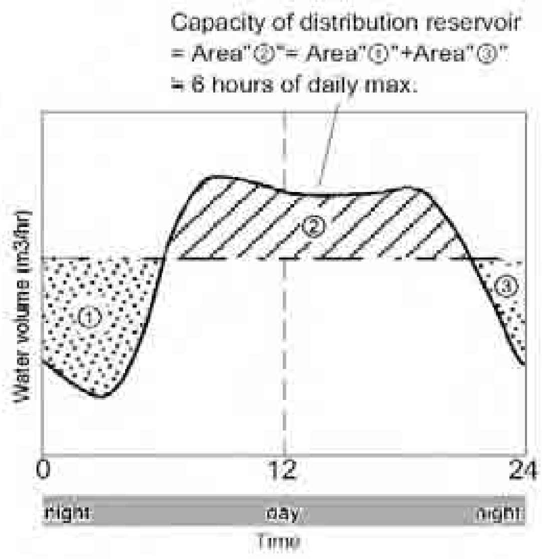


Figure 5.1.3 Pattern of Daily Water Consumption

It also facilitates the water supply for certain duration in case of emergency such as occurrence of facilities failure or in case of suspension of intake facilities and water treatment facilities due to some unavoidable reasons.

Therefore, it is better to have some allowance in the capacity. Taking this into consideration, the retention time or capacity of each reservoir is to have storage for 8 hours of daily maximum water in the design.

b. Distribution to the Service Area

In principle, distribution system from the reservoir to service area is recommended by gravity flow. However, when the gravity flow system is impossible due to geological conditions, it uses booster pump system. The residual pressure of distribution pipe end is designed as more then 5m

c. Pipe Diameter

The diameter of the distribution pipe network is calculated by “Hazen Williams” formula as follows;

$$H=10.666C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$$

Where;

H: Friction loss (m)

C: Velocity factor

D: Inner diameter (m)

Q: Flow capacity (m^3/sec.)

L: Pipe length (m)

5) Monitoring Method within the System.

The monitoring of the system is proposed considering fixed-line phone or mobile phone.

However, in case of the systems located far from each other or for systems having big capacity, such as FPG-4, FNG-10 and FBG-13, the communication is proposed through dedicated wireless system.

The transmission pump in the water treatment plant shall be manually controlled by the conditions of water level in remote area reservoir. The monitoring system by GPR (Global Packet Radio) is proposed. Although the distance between treatment plant and reservoir is large, the transmission pump is required to be controlled more promptly.

The water level of a distribution reservoir is measured using pressure type water level meter. Measured analog signal with 4 to 20mm Ampere gets converted to digital signal by GPR and the signal is transmitted to water treatment plant by packet radio system through frequency band of mobile phone. Thereby, the pump operator in the treatment plant can monitor water level of the reservoir. Required components for this purpose are listed below:

- Water level meter with transmitter: pressure type
- GPR routers
- Water level indicator with alarm for monitoring

6) Water Treatment Plant

Thap Cham water treatment plant in Ninh Thuan (capacity: 20,000m^3/d)

a. Process

In order to remove turbidity including silt and Iron as ferric, the process consists of function such as coagulation, sedimentation and filtration. The fabrication of each tank is RC structure. The structure of system FKS-8 is fabricated steel plate due to its small capacity.

b. Operation Method

The treatment plant in system of FPS-2, FKS-6, FKS-8 and FBS-11 with relatively small capacity is recommended to be operated by manually considering their capacity. However, the filter operation for big capacity systems is designed by automatic washing system on the filter console for easy operation and maintenance. Therefore, the type of each filter valve for big capacity system is automatic operation.

c. Flocculation Basin

The detention time is from 20 to 40 minutes for appropriate formation of the flocks. The mixing method of coagulation chemical is baffling type without mechanical and electrical equipments.

d. Sedimentation Basin

In case of sedimentation basin, the detention time is from 3 to 5 hrs, in order to secure sufficient volume of sedimentation. The type of sedimentation is horizontal-flow. The length of the tank is more than 3 times the width of basin.

e. Filter

The type is rapid sand filter. The filter speed is from 120 to 150m/day. The washing is considered to be carried out through surface and back wash system by manual operation. The type of FKS-6 is slow sand filter in order to remove iron and manganese by means of biological filter and the filter speed is 5m/day.

f. Clear Water Tank

The capacity of clear water tank is more than 2 hrs of design filtration flow to secure water consumed in treatment process, such as washing water.

g. Transmission Pump

Clear water is pumped up to distribution reservoir. The design operating time of transmission pump is considered as 20 hrs.

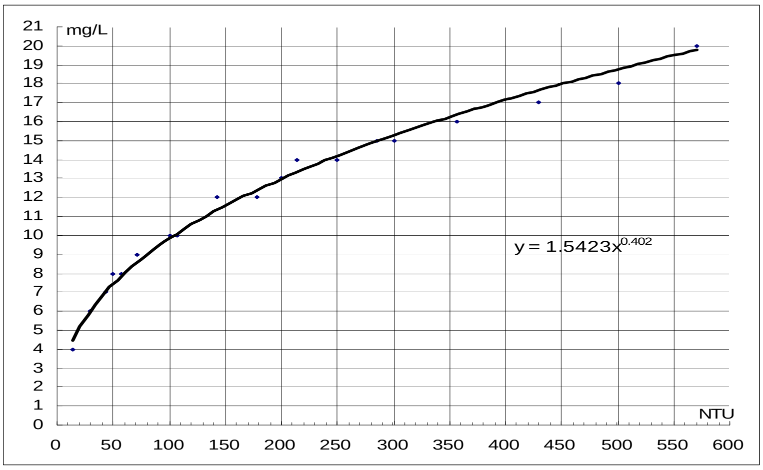
h. Chemical Dosing

h-1. Coagulation Chemical

The chemical dosing facility is required in the treatment process for coagulation. It is also needed to include pH control facility to balance reduced pH as a result of dosing coagulation chemical. Upon the addition of coagulant in raw water, the alkalinity with pH in the treated water is consumed then, its pH value is lowered.

PAC as 30% Al_2O_3
Xuan Phong water treatment plant in Khanh Hoa

The coagulation chemicals are powdered PAC (Poly-Aluminum-Chloride). These chemicals are generally used for existing water supply systems also. It is proposed to use PAC. The efficiency of coagulant to form floc is closely related to Alumina（Al_2O_3）contents and PAC as 30% Al_2O_3 has twice of Alumina compared to alumina content in Alum. Therefore the size of PAC dosing facility can be designed smaller than the Alum dosing facility. The related curve for dosing rate of PAC and turbidity is shown in Figure 5.1.4.



Source: Refer to the data as 10% PAC in Technical Guideline of Water Supply Facility in Japan

Figure 5.1.4 Dosing Rate and Turbidity

Lime as 70% Ca $(OH)_2$ is recommended as the chemical for pH control This is attributed to the facts that the cost of Lime is cheaper and it is easily available in local market.

According to Figure 5.1.4, The PAC dosing rate can be estimated. Table 5.1.5 shows the chemical dosing rate.

h-2. pH control (powdered Lime)

- The consumption volume of Alkalinity ($CaCo_3$) to dosing of 1mg/L PAC as 30% of Al_2O_3 is to be 0.45mg/L from experiment.
- The lime dosing rate for increase Alkalinity with 1mg/L is 0.74mg/L (74/100, where 74: molar weight of Lime, 100: molar weight of Alkalinity)
- The purity of Lime is 70%
- The factor of difference between experiment and theoretical formula is 0.8
- Based on above conditions, the dosing rate of Lime is calculated as follows; The dosing rate of Lime is shown in Table 5.1.5.

In case of 12mg/L dosing as PAC (Max. turbidity at irrigation channel)
12 mg/L x 0.45= 5.4 mg/L
5.4 mg/L x 0.74 x (100/70) = 5.7 mg/L
5.7 mg/L x 0.8= 4.6 mg/L

In case of 17mg/L dosing as PAC (Max. turbidity at river)
17 mg/L x 0.45= 7.65 mg/L
7.65 mg/L x 0.74 x (100/70) = 8.1 mg/L
8.1 mg/L x 0.8 = 6.5 mg/L

Table 5.1.5 Design Chemical Dosing Rate

Chemical	Max. (mg/L) as 100NTU of Turbidity (Irrigation reservoir)	Max. (mg/L) as 300NTU of Turbidity (River)
PAC	12	17
Lime	4.6mg/L	6.5mg/L

i. Disinfection Facility

i-1. Chemical

The chlorine disinfection chemicals are liquid chlorine（Cl2）, sodium hypochlorite（NaClO）, bleaching powder（$CaCl_2 \cdot Ca(OCl)_2 \cdot 2H2O$）, and chlorine dioxide. Liquid chlorine and sodium hypochlorite are commonly used as disinfectant.

Small type gas chlorinator (Binh Thuan province)

The liquid chlorine is more effective as disinfectant than sodium hypochlorite. The main disadvantage of the sodium hypochlorite is decrease in volume of effective chlorine during its long storage. Effective chlorine in sodium hypochlorite with 15% initial concentration is reduced by half when it is stored for three months. Also, since the project area is far from hypochlorite production area such as Ho Chi Minh, the effective chlorine discharges to atmosphere gradually, and reduces in the process of being transported because of unstable behavior of NaClO.

Other method of producing chlorine is electrolytic process of pure salt or sea water. The comparison has been made for chlorine gas system and electrolysis chlorine system and the result is summarized in Table 5.1.6.

Other method of producing chlorine is electrolytic process of pure salt or sea water. The comparison has been made for chlorine gas system and electrolysis chlorine system and the result is summarized in Table 5.1.6.

Table 5.1.6 Comparison Table for Chlorination System

Evaluation Item	Chlorine gas system	Electrolysis chlorine system
Required component	Chlorine cylinder, chlorinator. Booster pump, leakage protection apparatus	Dissolution tank, saline water feeding pump, Electrolysis, Hypo-chlorate receiving tank, Measuring pump
Evaluation	Simple component	Complicated component
Operation and maintenance	Careful handing is required due to toxic gas.	Requires careful operation due to presence of hydrogen gas in the process.
Evaluation	Needs special skill	Needs special skill
Construction cost	Rate of incremental cost : 100%	Rate of incremental cost : 330%
Evaluation	Low cost	Costly
Running cost	Needs cost of chlorine gas Rate of incremental cost : 100%	Needs cost of electric consumption (kWh) and replacement of electrode Rate of incremental cost :140%
Evaluation	Low cost	A litle higher cost

Based on the above evaluation result, the electrolysis chlorine system as the latest technology in rural water supply has some risks such as respond to malfunctions. Therefore, chlorine gas system, which is popularly used for rural areas, is recommended.

1-2. Dosing Rate

Based on the experience of existing water treatment in the project area and raw water quality analysis, the chlorine dosing rate can be estimated. The chlorine dosing rate is shown in Table 5.1.7.

Table 5.1.7 Chlorine Dosing Rate

Disinfection: Chlorine gas	Ave. (mg/L)	Max. (mg/L)
	1.5	3.0

In case of river water, it is essential to include some ammoniacal compound. Therefore accurate dosing rate shall be determined on considering result of Break-point test before detailed design stage.

j. Building

Administration building is designed for operation and maintenance of treatment system. Building consists of staff working room, director room, small conference room, and basic water quality analysis room.

Chemical building is designed to install dosing equipment such as metering pumps, dissolution tanks and include chemical store spaces for requirements of 30 days operation.

The design for building is applied Vietnamese standard (TCVN 4450, 1987).

k. Discharge waste water

If treatment plant capacity is 5,000m^3/d as maximum capacity in the project; the volume of waste water is estimated to be less than 150m^3/d. However, considering the view point of environment, the waste water shall be treated by simple sedimentation lagoon. The lagoon is excavation without timbering and capacity has reserve for more than 4 hours. The waste water is separated into solid and liquid in the lagoon. The supernatant water is discharged back to river. The spare lagoon is considered.

5.1.5 Preliminary Design in Phu Yen Province

(1) Outline

The water supply systems are summarized in Table 5.1.8.

Table 5.1.8 Outline of the System

System	(1) Daily average (m^3/d)	(2) Daily Max. (m^3/d)	(3) Intake water flow (m^3/d)	(4) Hourly max. (m^3/hr.)
FPS-2	502	600	700	50
FPS-3	998	1,200	1,200	100
FPG-4	874	1000	1,100	83
FPS-5	651	800	800	67

(2) Water Supply Process

The contents of the process are categorized based on water source and topographical conditions as follows;

Table 5.1.9 Water Source and Facility

Water source	Facility	
	With treatment plant	Without treatment plant
Groundwater		FPS-3, FPS-5
Surface water	FPS-2, FPG-4	

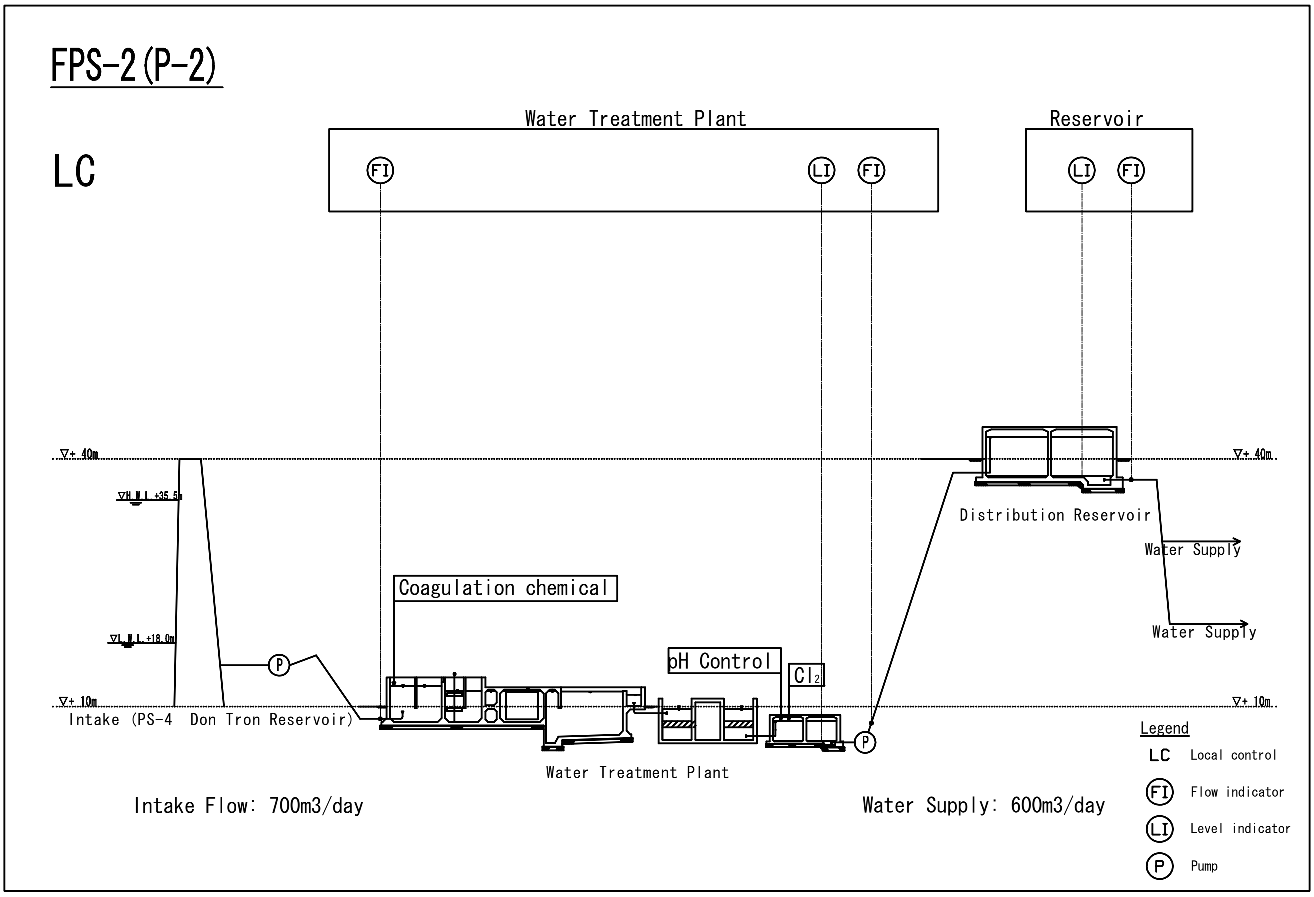
Table 5.1.10 Topograpghical Condition and Facility

system	Figure. No.	Facility		
		Intake	Transmission pump	Distribution pump
FPS-2	Figure 5.1.5	Booster pump	Transmission pump	Non (gravity flow)
FPS-3	Figure 5.1.5	Well pump	Non (from well pump)	Non (gravity flow)
FPG-4	Figure 5.1.6	Intake pump	Transmission pump	Distribution pump and gravity flow
FPS-5	Figure 5.1.6	Well pump	Non (from well pump)	Distribution pump

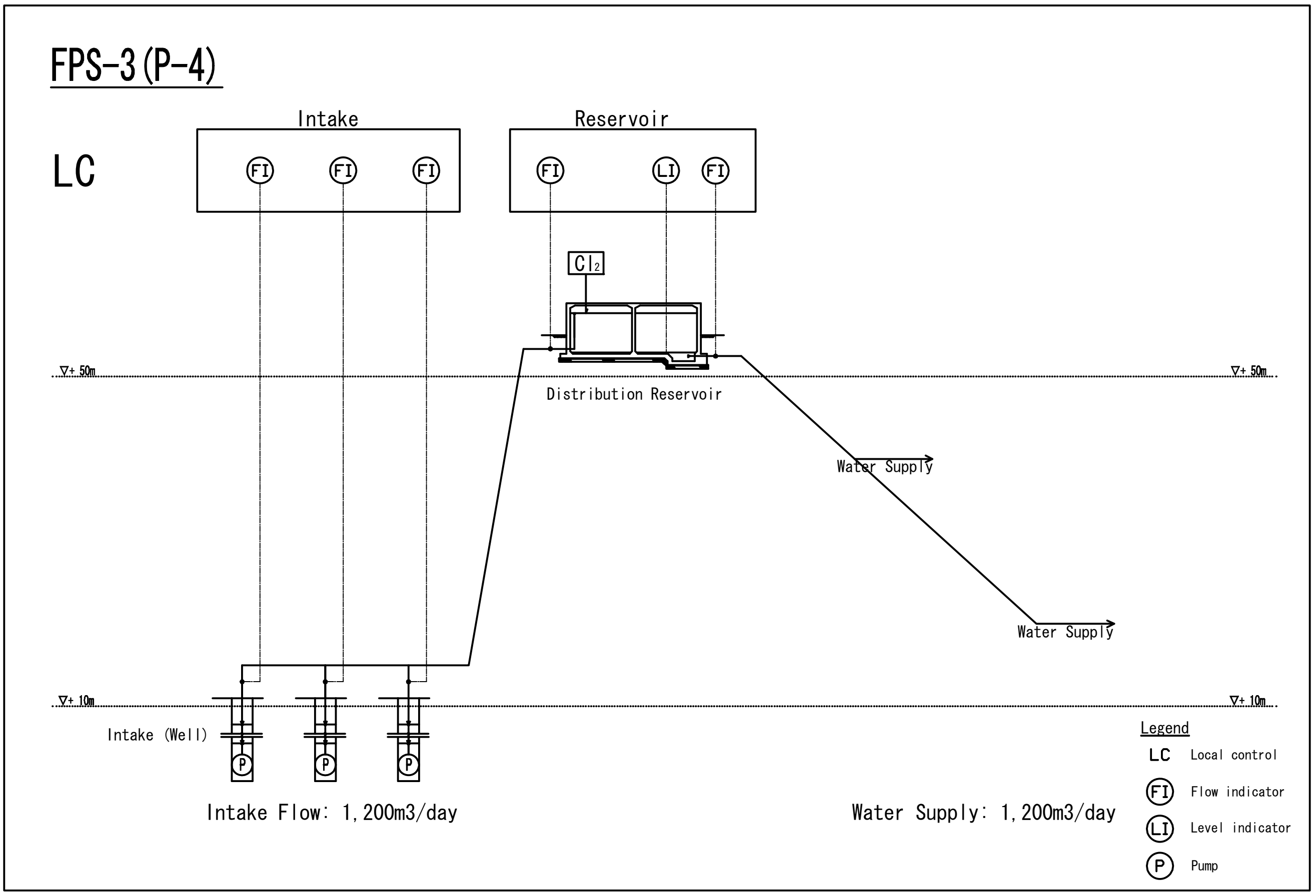
(3) System Layout Plan

Based on the result of meeting with P-CERWASS and CPC, the location and alignment of the facilities such as intake, transmission pipe, treatment plant, reservoir tank and distribution network pipe is arranged. The system layout plan is shown from Figure 5.1.7 to Figure 5.1.10.

FPS-2 (P-2)



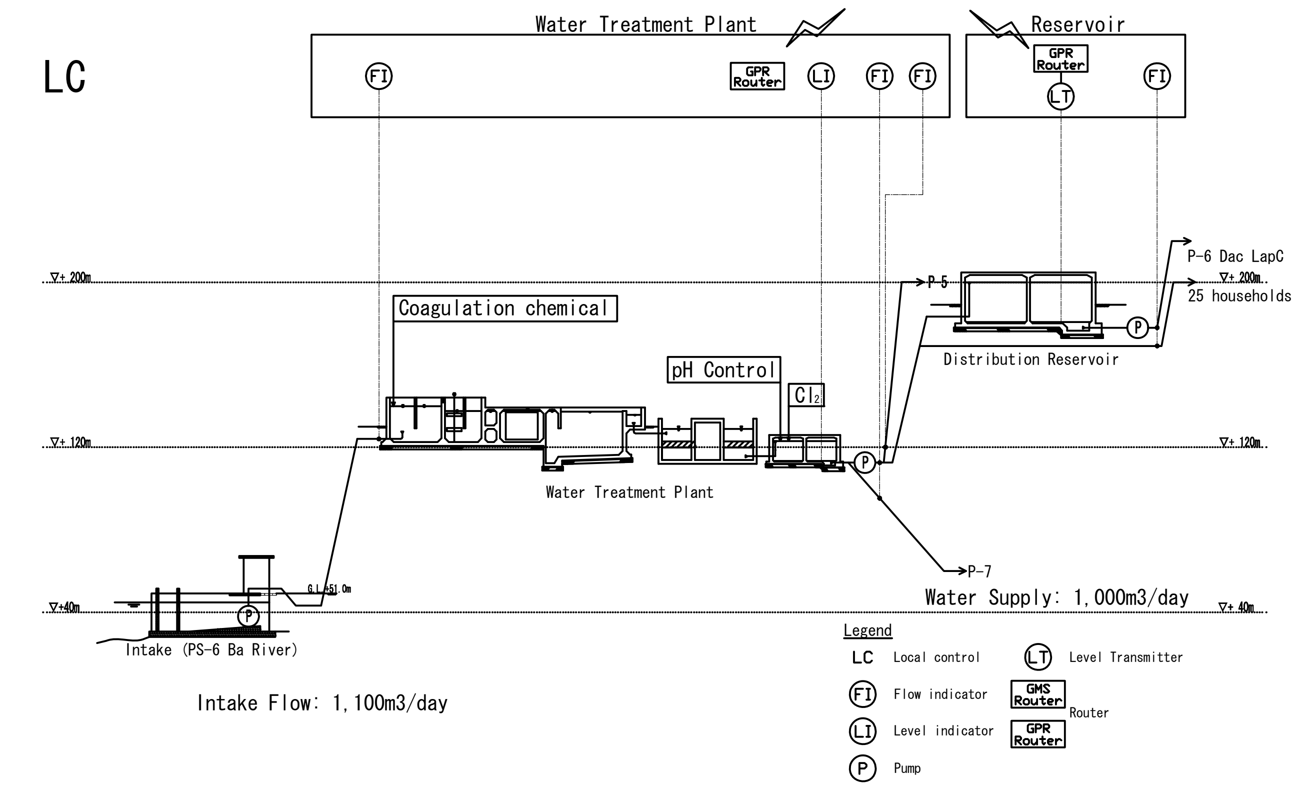
FPS-3 (P-4)



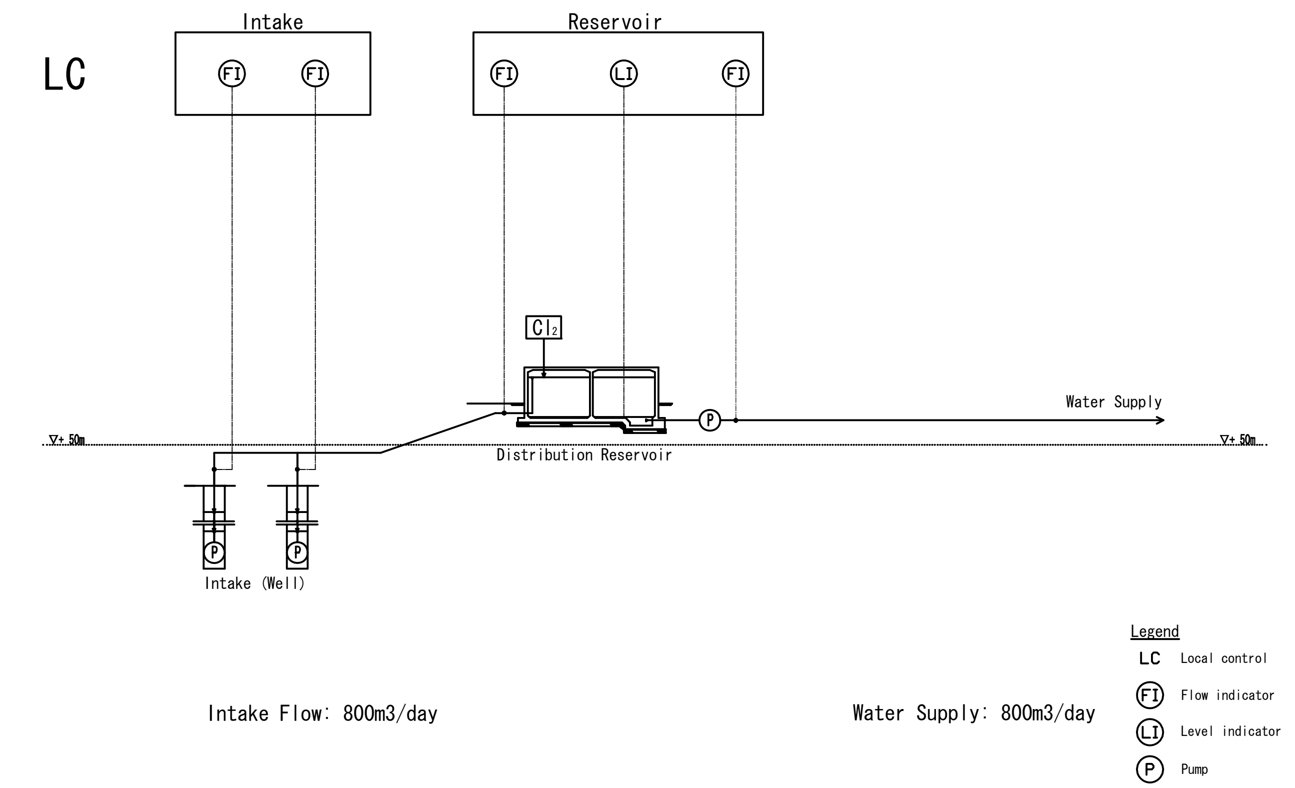
Preliminary

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF THE SOUTHERN COASTAL ZONE IN THE SOCIALIST REPUBLIC OF VIETNAM	Water Supply Process (FPS-2, FPS-3)	Scale : Non	Figure. 5.1.5

FPG-4 (P-5, 6, 7)

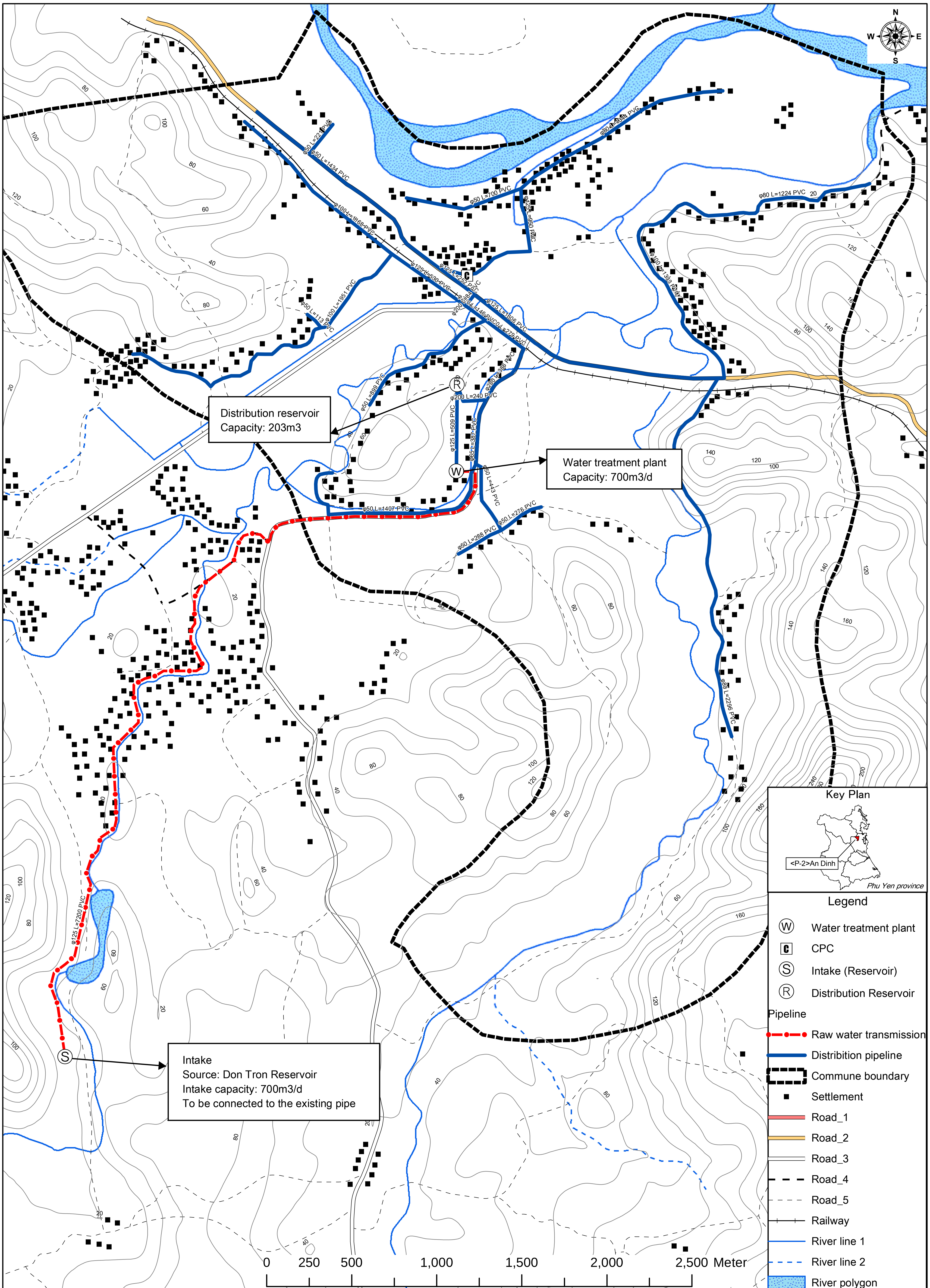


FPS-5 (P-8)



Preliminary

THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF THE SOUTHERN COASTAL ZONE IN THE SOCIALIST REPUBLIC OF VIETNAM	Water Supply Process (FPG-4, FPS-5)	Scale : Non	Figure. 5.1.6

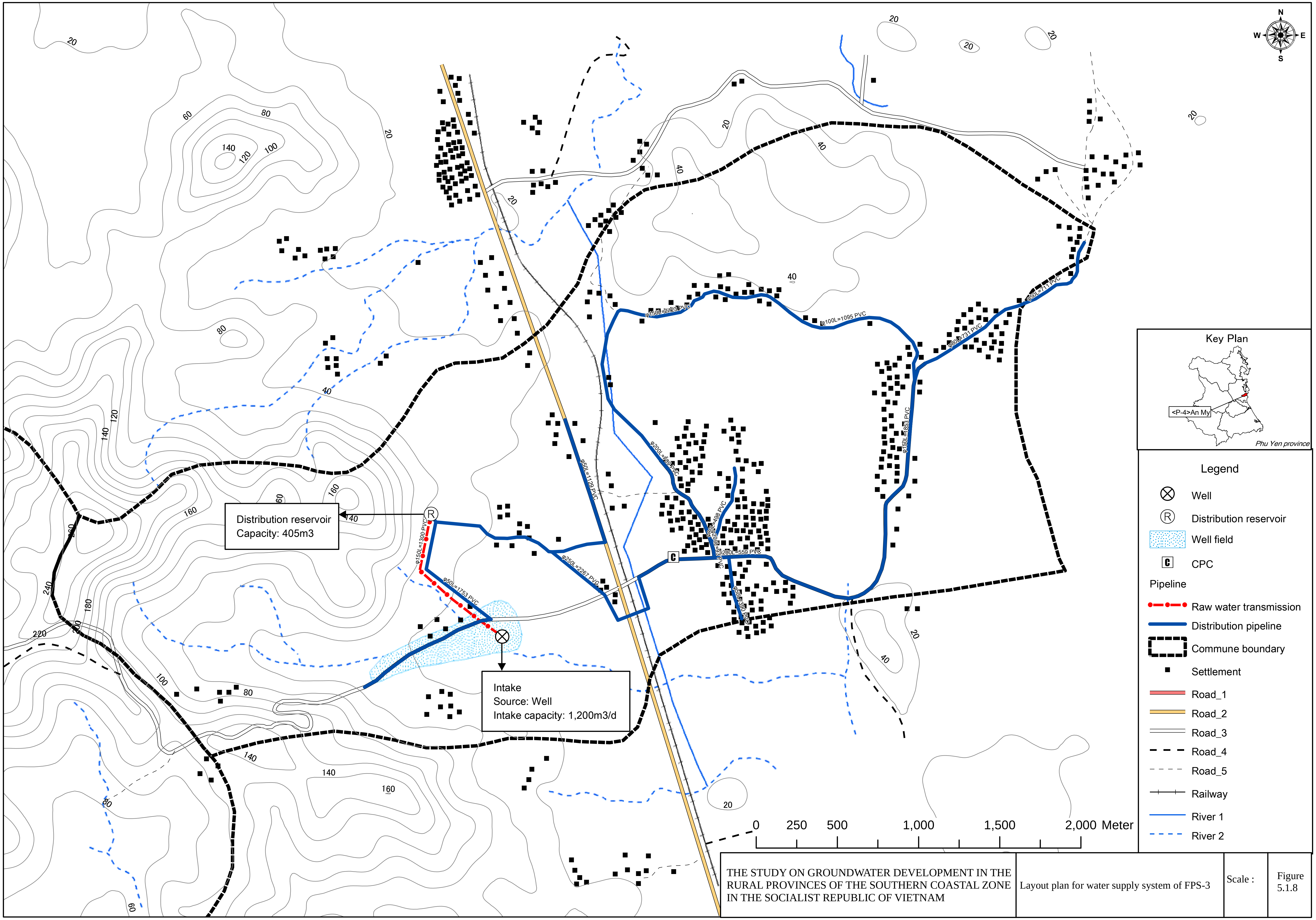


THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF THE SOUTHERN COASTAL ZONE IN THE SOCIALIST REPUBLIC OF VIETNAM

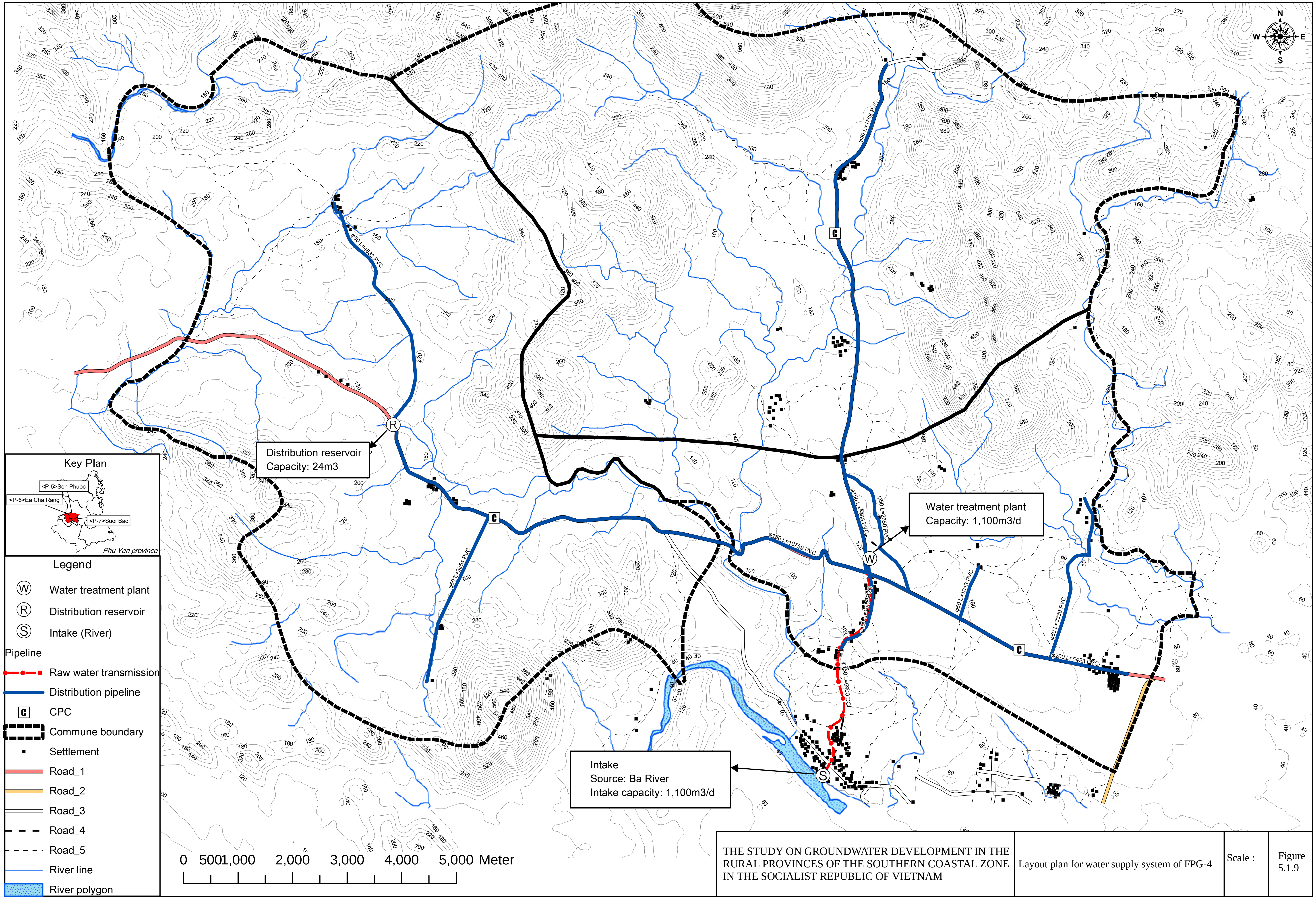
Layout plan for water supply system of FPS-2

Scale :

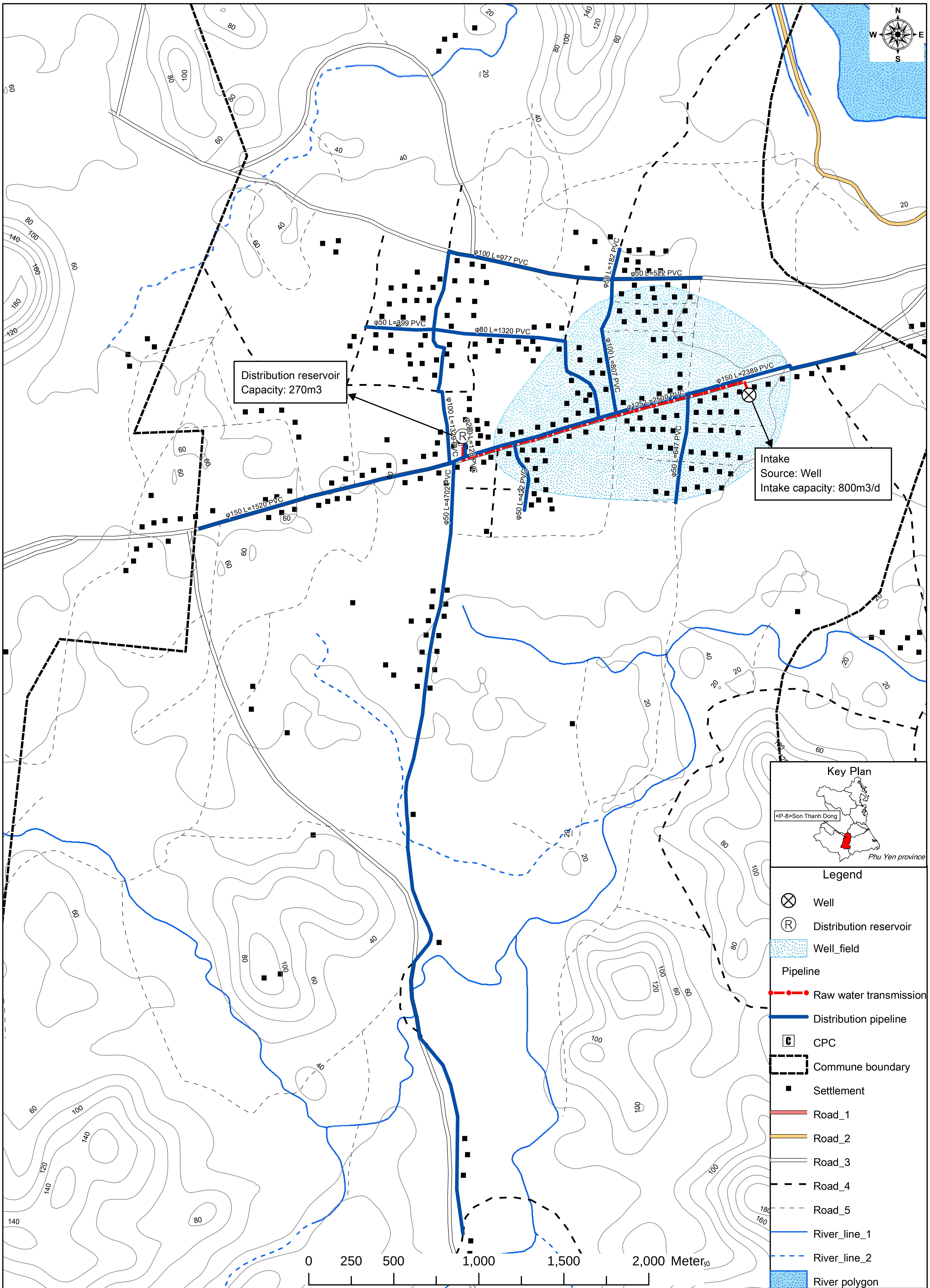
Figure 5.1.7



THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF THE SOUTHERN COASTAL ZONE IN THE SOCIALIST REPUBLIC OF VIETNAM	Layout plan for water supply system of FPS-3	Scale :	Figure 5.1.8



THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF THE SOUTHERN COASTAL ZONE IN THE SOCIALIST REPUBLIC OF VIETNAM	Layout plan for water supply system of FPG-4	Scale :	Figure 5.1.9



THE STUDY ON GROUNDWATER DEVELOPMENT IN THE RURAL PROVINCES OF THE SOUTHERN COASTAL ZONE IN THE SOCIALIST REPUBLIC OF VIETNAM	Layout plan for water supply system of FPS-5	Scale :	Figure 5.1.10

(4) Main Facility Plan

1) System FPS-2

a. Process Flow

The process flow chart is shown in Figure 5.1.11.

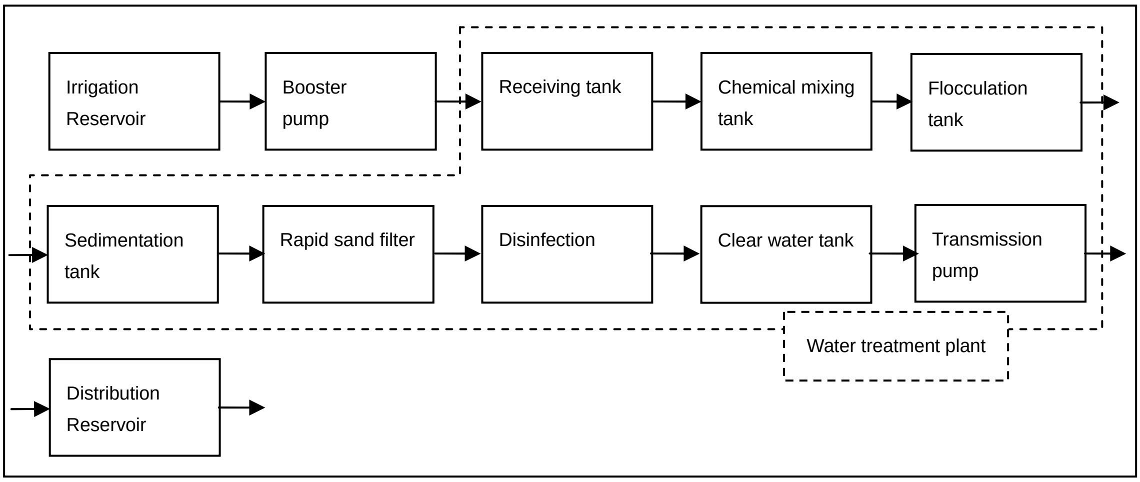


Figure 5.1.11 Process Flow Chart

b. Intake facility and transmission main

In this system, raw water will be secured from reservoir. The transmission pipe is connected to the existing pipe, which was installed in outlet of Don Tron reservoir and raw water is pumped up to water treatment plant by booster pumps. The operating time of intake pump is designed as 20 hrs in the day. Specification of intake facility and transmission main is shown in Table 5.1.11.

Table 5.1.11 Intake Facility and Transmission Main

Items	Specifications
Booster pump:	
Type	Centrifugal pump
Specification	0.29m^3/min X 16.0mH X 1.5kW
No. of pumps	3 nos
Transmission main:	
Material	PVC
Diameter	125mm
Length	7.2 km

c. Water treatment plant

c-1. Specification

Table 5.1.12 Water Treatment Plant

Items	Specifications
Flocculation tank:	
Structure	Reinforced concrete (RC)
Dimension	W 2.6 X L 1.8m X H 1.65m
No. of basins	2 basins
Capacity	15.4 m^3
Detention time	31.4 min

Sedimentation: Structure Dimension No. of basins Capacity Detention time	 Reinforced concrete (RC) W 2.6m X L 7.8m X H 2.6m 2 basins 105.4 m^3 3.6 hrs
Filter: Structure Type Dimension No. of basins Total filtration area Filtration rate Operation Washing Equipments	 Reinforced concrete (RC) Rapid sand filter W 1.4m X L 2.1m 2 basins 5.8 m^2 120.7m/d Manual Surface and back washing Valve, mild steel pipe, washing pump, under drain system and surface wash pipe
Clear water tank: Structure Dimension No. of basins Capacity Detention time	 Reinforced concrete (RC) W 2.5m X L 4.0m X H 3.0m 2 basins 60.0 m^3 2.1hrs
Transmission pump: Type Specification No. of pumps	 Centrifugal pump 0.25m^3/min X 39.0mH X 3.7kW 3 nos
Chemical dosing PAC (Al_2O_3, 30%): Dosing rate (Max.) Dosing capacity Pump Total capacity of Dissolution tank No. of tanks	 12.0 ml/L 152.7 L/day (0.11 L/min) Metering pump 1.5 m^3 2 tanks
Chemical dosing Lime ($Ca(OH)_2$, 70%): Dosing rate (Max.) Dosing volume (Max.) Pump Total capacity of Dissolution tank No. of tanks	 4.6 ml/L 29.1 L/day (0.02 L/min) Metering pump 0.5 m^3 2 tanks
Chemical dosing Chlorine gas (Cl_2): Dosing rate (Max.) Dosing capacity (Max.) Equipments	 3.0 ml/L 2.1 kg/day Chlorine cylinder, chlorination, booster pump (if necessary) and gas mask

c-3. Layout Plan

It is necessary to secure the area of 1,000 m^2 (25m X 40m) for water treatment plant. In the water treatment plant, it planned to place also pump station, chemical building, administration office and chlorinator building. Layout plan of water treatment plant is shown in the ANNEX 3.

d. Distribution Facility

The capacity of reservoir has reserve for 8 hrs. The material of distribution pipelines is considered to be PVC. The diameter of each pipe is determined based on the result of Analysis of hydraulic calculation. The network calculation is shown in Supporting report. The specification of distribution facility is shown in Table 5.1.13.

Table 5.1.13 Distribution Facility

Items	Specifications
Distribution reservoir:	
Dimension	W 4.5m X L 7.5m X H 3.0m
No. of basins	2 basins
Capacity	203 m^3
Detention time	8.1hrs
Distribution pipeline:	
Material	PVC with rubber joint
Length	ND 50mm L= 5,781m
	ND 65-80mm L= 6,582m
	ND 100-150mm L= 6,459m
	ND 200-300mm L= 1,135m
	Total length L= 19,957m

2) System FPS-3

a. Process Flow

The process flow is shown in Figure 5.1.12.

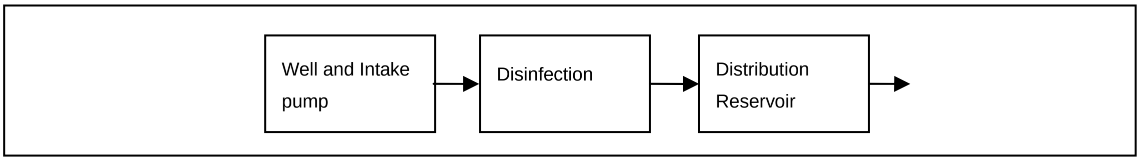


Figure 5.1.12 Process Flow Chart

b. Intake Facility and Transmission Main

In this system, raw water will be secured from wells. The total number of designed wells is three (3), submersible pump will be installed. The operating time of intake pump is designed as 20 hrs. According to Table 5.1.14, one spare well is required to install.

Specification of intake facility and transmission main is shown in Table below.

Table 5.1.14 Intake Facility and Transmission Main

Items	Specifications
Well:	
Drilling depth	100m
No. of wells	3 nos
Casing diameter	140mm
Casing material	Steel pipe
Screen diameter	140mm
Screen material	Steel pipe

Intake pump: Type Specification No. of pumps	 Submersible pump 0.33m^3/min X 61.0mH X 5.5kW 4 nos
Transmission main: Material Diameter Length	 PVC 150mm L= 1.3 km

c. Water Treatment Plant

c-1 Component

One set of chlorine gas system is required for disinfection.

c-2 Specification

The specification of chlorination facility is shown in Table 5.1.15.

Table 5.1.15 Chlorination

Items	Specifications
Disinfection Chlorine gas (Cl_2): Dosing rate (Max.) Dosing capacity Equipments	 3.0 ml/L 3.6 kg/day Chlorine cylinder, chlorination, booster pump (if necessary) and gas mask

d. Distribution facility

d-1. Hydraulic calculation

The hydraulic calculation is shown in Supporting report.

d-2. Specification

Table 5.1.16 Distribution Facility

Items	Specifications
Distribution reservoir: Dimension No. of basins Capacity Detention time	 W 4.5m X L 15.0m X H 3.0m 2 basins 405 m^3 8.1hrs
Distribution pipeline: Material Length	 PVC with rubber joint ND 50mm L= 2,854m ND 65-80mm L= 1,229m ND 100-150mm L= 5,006m ND 200-300mm L= 3,628m Total length L= 12,717m

3) System FPG-4

a. Process Flow

The process flow chart is shown in Figure 5.1.13.

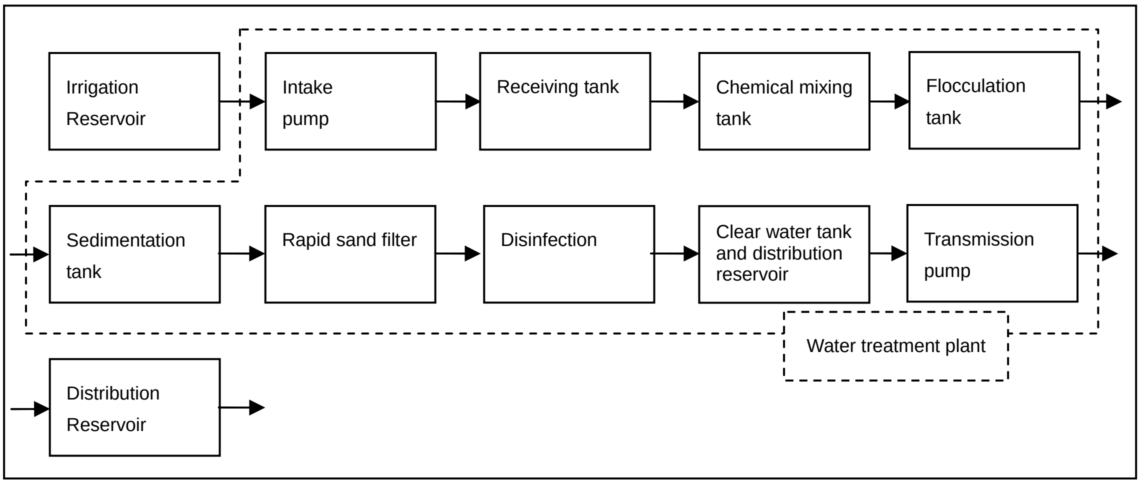


Figure 5.1.13 Process Flow Chart

b. Intake facility and Transmission Main

In this system, raw water will be secured from Ba River through submersible pump.

Specification of intake facility and transmission main is shown in Table below.

Table 5.1.17 Intake Facility and Transmission Main

Items	Specifications
Intake:	
Transmission canal	W1.5m X L10.2m X H4.0m
Pumping well	W3.0m X L 5.0m X H4.5m
Intake pump:	
Type	Submersible pump
Specification	0.46m^3/min X 99.0mH X 15.0kW
No. of pumps	3 nos
Transmission main:	
Material	DCI
Diameter	150mm
Length	L= 5.9 km

c. Water Treatment Plant

c-1 Specification

The specification of water treatment plant is presented in Table below.

Table 5.1.18 Water Treatment Plant

Items	Specifications
Flocculation tank:	
Structure	Reinforced concrete (RC)
Dimension	W 3.4m X L 2.4m X H 1.7m
No. of basins	2 basins
Capacity	27.7 m^3
Detention time	36.5 min
Sedimentation:	
Structure	Reinforced concrete (RC)
Dimension	W 3.4m X L 10.2m X H 2.5m

No. of basins Capacity Detention time	2 basins 173.4 m^3 3.8 hrs
Filter: Structure Type Dimension No. of basins Total filtration area Filtration rate Operation Washing Equipments	 Reinforced concrete (RC) Rapid sand filter W 1.8m X L 2.6m 2 basins 9.2 m^2 119.6 m/d Automatic washing system Surface and back washing Valve, mild steel pipe, washing pump, under drain system and surface wash pipe
Clear water tank and distribution reservoir: Structure Dimension No. of basins Capacity Detention time	 Reinforced concrete (RC) W 6.2m X L 11.0 m X H 3.0m 2 basins 409.0 m^3 (Clear water tank: 93m^3, Distribution reservoir: 316m^3) Clear water tank: 2.0hrs, Distribution reservoir: 8.1hrs
Distribution pump: Type Specification No. of pumps	 Centrifugal pump 0.23m^3/min X 85.0mH X 5.5kW 3 nos
Transmission pump: Type Specification No. of pumps	 Centrifugal pump 0.16m^3/min X 81.0mH X 3.7kW 3 nos
Chemical dosing PAC (Al_2O_3, 30%): Dosing rate (Max.) Dosing capacity Pump Total capacity of Dissolution tank No. of tanks	 17.0 ml/L 340.0 L/day (0.24 L/min) Metering pump 2.5 m^3 2 tanks
Chemical dosing Lime ($Ca(OH)_2$, 70%): Dosing rate (Max.) Dosing volume Pump Total capacity of Dissolution tank No. of tanks	 6.5 ml/L 65.5 L/day (0.05 L/min) Metering pump 0.5 m^3 2 tanks
Chemical dosing Chlorine gas (Cl_2): Dosing rate (Max.) Dosing capacity Equipment	 3.0 ml/L 3.3 kg/day Chlorine cylinder, chlorination, booster pump (if necessary) and gas mask

c-2. Layout plan

It is necessary to secure an area of 1,650 m^2 (30m X 55m) for water treatment plant. In the water treatment plant, it is planned to place also pump station, chemical building, administration office and chlorinator building in addition to the facilities for the water treatment process. Layout plan of water treatment plant is shown in ANNEX 3.

d. Distribution Facility

d-1. Hydraulic Calculation

The result of hydraulic analysis of distribution network is shown in Supporting report.

d-2. Specification

Table 5.1.19 Distribution Facility

Items	Specifications
Distribution reservoir: Dimension No. of basins Capacity Detention time	 W 2.0m X L 3.0m X H 2.0m 2 basins 24 m^3 9.9hrs
Distribution pump: Type Specification No. of pumps	 Centrifugal pump 0.07m^3/min X 51mH X 1.1kW 3 nos
Distribution pipeline: Material Length	 PVC with rubber joint ND 50mm L= 16,706m ND 100-150mm L= 21,913m ND 200-300mm L= 5,423m Total length L= 44,042m

4) System FPS-5

a. Process Flow

The process flow is shown in Figure 5.1.14.

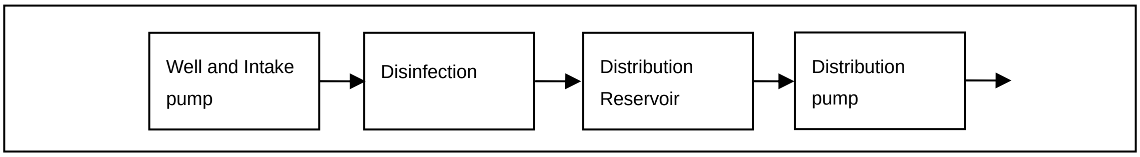


Figure 5.1.14 Process Flow Chart

b. Intake Facility and Transmission Main

In this system, raw water will be secured from wells. The total number of designed wells is two (2). In each well, submersible pump will be installed.

Specification of intake facility and transmission main is shown in Table below.

Table 5.1.20 Intake Facility and Transmission Main

Items	Specifications
Well: Drilling depth No. of wells Casing diameter Casing material	 85m 2 140mm Steel pipe

Screen diameter Screen material	140mm Steel pipe
Intake pump: Type Specification No. of pumps	 Submersible pump 0.22m^3/min X 29.0mH X 2.2kW 2 nos
Transmission main: Material Diameter Length	 PVC 125mm 2.5 km

c. Water Treatment Plant

The treatment process in this case shall include only disinfection facilities. Specification of these facilities is presented in Table below.

Table 5.1.21 Chlorination

Items	Specifications
Disinfection Chlorine gas (Cl_2): Dosing rate (Max.) Dosing capacity (Max.) Equipments	 3.0 ml/L 2.4 kg/day Chlorine cylinder, chlorination, booster pump (if necessary) and gas mask

d. Distribution Facility

d-1. Hydraulic Calculation

The result of hydraulic analysis of distribution network for this system is shown in Supporting report.

d-2. Specification

The specification of distribution facility is listed in Table below.

Table 5.1.22 Distribution Facility

Items	Specifications
Distribution reservoir: Dimension No. of basins Capacity Detention time	 W 4.5m X L 10.0m X H 3.0m 2 basins 270 m^3 8.1hrs
Distribution pump: Type Specification No. of pumps	 Centrifugal pump 0.67m^3/min X 12.0mH X 2.2kW 3 nos
Distribution pipeline: Material Length	 PVC with rubber joint ND 50mm L= 6,874m ND 65-80mm L= 1,320m ND 100-150mm L= 7,122m ND 200-300mm L= 128m Total length L= 15,444m