PART IV FEASIBILITY STUDY

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Chapter 1 Feasibility Study for the Seven Priority Systems

1.1 Water Supply System for the Feasible Study

The study selected the high ranking 7 systems of Phase-1 for the Feasibility Study as shown below, as those are likely to be judged as feasible than the other 9 systems of Phase-2. The facts were also taken into consideration that there are many uncertainties in Phase-2 systems in conducting a feasibility study.

In the Master Plan Study, the estimated 16 water supply systems needed for the 7 communes were prioritised. The 16 systems were then devised into 2 phases in accordance with the NRWSS policy. The high ranking 7 water supply systems were categorised as Phase-1 and to be implemented by the year of 2010 and the other 9 systems as Phase-2 to be implemented by the year of 2020.

Table 1.1 Selected Priority Systems

System	Population			Phase 1	Phase 2
	2000	2010	2020		
G1 Kong Tang	5567	6988	8773	Piped network by well	Extension of distribution pipes
G2 Nhon Hoa	11084	13779	17128	Piped network by well	Extension of distribution pipes
G3 Chu Ty	6377	7698	9292	Piped network by well	Extension of distribution pipes
G4-1 Thang Hung	4292	5080	6013	Piped network by well	Extension of distribution pipes
G5-1 Nghia Hoa	3288	4008	4886	Piped network by well	Extension of distribution pipes
G6-1 Ia Rsion	3843	4685	5710	Piped network by well	Extension of distribution pipes
G7.1 Kong Yang	1507	1837	2239	Piped network by well	Extension of distribution pipes

1.2 Targets of Water Supply Program

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

Table 1.2 Targets of Water Supply Program

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

1.3 Water Demand Projection

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

Table 1.3 Calculated Water Demand

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

*1: Coverage means population served as percentage of total population
*2:l/c/d means litter per capita per day
**NRWSS targets, the coverage ratio of the year 2001 and 2005 were estimated by the Study Team.

1.4 Groundwater Development Plan

1.4.1 Present Groundwater Resources

The groundwater sources have been identified for the prioritized for the 7systems.

The safe well yields for the 7 wells explored by the study team are shown below.

Table 1.4 Safe Well Yields of Explored Wells

Prioritized System		Safe well yield (m^3/day) (liter/sec)		Geology	Remarks
G1	Kong Tang	322	3.7	Basalt (β N_2-Q_1)	Confined aquifer
G2	Nhon Hoa	173	2.0	Basalt (β N_2-Q_1)	Confined aquifer
G3	Chu Ty	317	3.7	Basalt (β N_2-Q_1)	Confined aquifer
G4-1	Thang Hung	259	3.0	Basalt (β N_2-Q_1)	Confined aquifer
G5-1	Nghia Hoa	173	2.0	Basalt (β N_2-Q_1)	Confined aquifer
G6-1	Ia Rsiom	406	4.7	Quaternary sediment (Q), Jurassic sandstone (N)	Confined aquifer
G7-1	Kong Yang	432	5.0	Basalt (β N_2-Q_1)	Confined aquifer

* (refer to PART II, Chapter 4)

Basalt covers most of the communes/towns in Gai Lai province, except for the target commune of G-6 (Ia Rsiom commune). The 7 wells explored by the study team have enough quantity of water for the initiation of the piped supply systems. However, in a number of systems more wells will be required.

1.4.2 Necessary Groundwater Development

The following table shows the numbers of wells which will be required by 2010 and 2020 based on the water supply plans and safe well yields of the wells used for piped supply. The present quantity of water in the wells of G2 will not satisfy the future water demand even in 2005. In G2 there is a need to explore 3 more wells up to 2010. The explored wells in G6-1, and G7-1 have enough water for water supply plans and will not require any additional wells up to 2010.

Table 1.5 Number of Required Wells

Prioritized system	Safe well yield (m^3/day)	Water Supply Plan (m^3/day)				Required wells		Existing Wells (to be used)
		2001	2005	2010	2020	2010	2020	
G1: Kong Tang	322	66.6	146.0	556.0	821.1	1	1	1
G2: Nhon Hoa	173	132.5	289.2	1096.2	1603.2	6	3	1
G3: Chu Ty	317	76.0	163.9	612.4	869.7	1	1	1
G4-1: Thang Hung	259	51.1	109.3	404.2	562.8	1	1	1
G5-1: Ngia Hoa	173	39.2	84.9	318.9	457.3	1	1	1
G6-1: Ia Rsion	406	45.9	99.3	372.7	534.5	0	1	1
G7-1: Kong Yang	432	18.0	38.9	146.2	209.6	0	0	1

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

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

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

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

1.5 Water Quality and Necessary Treatment

1.5.1 Review of Water Quality Analysis

Water quality analysis was carried out for 23 items shown in Chapter 2 in the first investigation and for 3 items (coliform, nitrate, and nitrite) in the F/S period.

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

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

- ♦ The iron content of groundwater was high in G1, G6-1 and G7-1. Iron and manganese in the water do not pose a health risk, but they leave colored deposits in installations or stains on clothes, and unpleasant taste.
- ♦ Some manganese content is found in G2, G4-1 and G7-1.
- ♦ The water is generally soft.
- ♦ Some of the groundwater samples have a certain level of coliform.
- ♦ Water taken from G7-1 has unpleasant smell.
- ♦ No treatment is necessary for arsenic and fluoride.
- ♦ Dioxin was not detected in the 3 analyzed samples (K1-1, G3, and D6).

1.5.2 Recommendations for Treatment

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

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

- **<u>Iron removal</u>** may be necessary in the systems of G1, G6-1 and G7-1.
- **<u>Manganese removal</u>** may be required in the communes G2, G4-1 and G7.
- The need for treatment should be reconfirmed by repeated water quality analysis before the detailed design.

Table 1.6 Recommended Treatment

System	Source	Treatment			
		Problem	Filtration	pH adjust. Recommended	Disinfection
G1	Deep well	Iron	Aeration + Slow sand filter	No	Chlorination
G2	Deep well	Mangan.	Aeration + Slow sand filter	No	Chlorination
G3	Deep well	None	No treatment	No	Chlorination
G4-1	Deep well	Mangan.	Aeration + Slow sand filter	No	Chlorination
G5-1	Deep well	None	No treatment	No	Chlorination
G6-1	Deep well	Iron	Aeration + Slow sand filter	No	Chlorination
G7-1	Deep well	Iron Mangan. Smell	Aeration + Slow sand filter	No	Chlorination

1.6 Design for Piped Schemes

1.6.1 Design Principles

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

- **Automatic or simple (or manual) pump controls** are recommended.
- As far as possible **gravity** will be used for transport of water.
- **Local materials** should preferably be used for construction in order to ensure the availability of spare parts.
- **Pipe material and fittings should be of good quality** in order to minimize pipe bursts and leakage.
- **Water meters are delicate equipment and only good quality meters should be used**, otherwise it will quickly break down or the accuracy will degrade.

- ♦ Pumps with good efficiency should be used in order to save operating costs.
- ♦ Installations should be properly performed. Poor pipe work will certainly increase leakage rates.

1.6.2 Design Criteria

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

Table 1.7 Design Criteria

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

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

1.6.3 Alternatives for the 7 Piped Schemes

The 7 prioritized systems are varying with regard to elevations and pressure, and the locations of the water supply facilities should be efficient. This section prepares the three main alternatives for economical centralized piped supply as described below:

(1) Alternative 1

This solution is proposed in systems with small variations in ground elevation. For example, where it is not possible to position a reservoir on high ground, and supply the distribution system by gravity. It can also be proposed in areas where there is no need for water treatment (excepting chlorination).

Water is pumped directly from a deep well submersible pump to a ground level reservoir for storage. From this reservoir, the booster pumps transfer water to an elevated tank (8 to 10 meters in height). From the elevated tank the water flows by gravity to the piped distribution network.

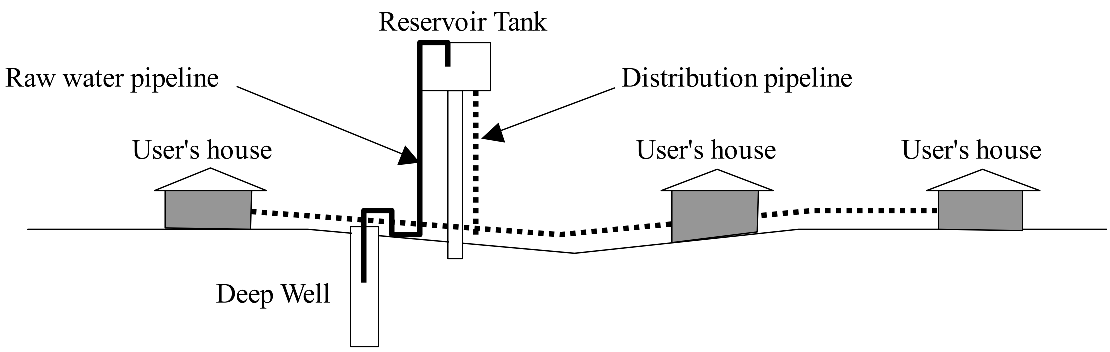

Figure 1.1 Typical Layout of Alternative 1

(2) Alternative 2

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

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

(3) Alternative 2a

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

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

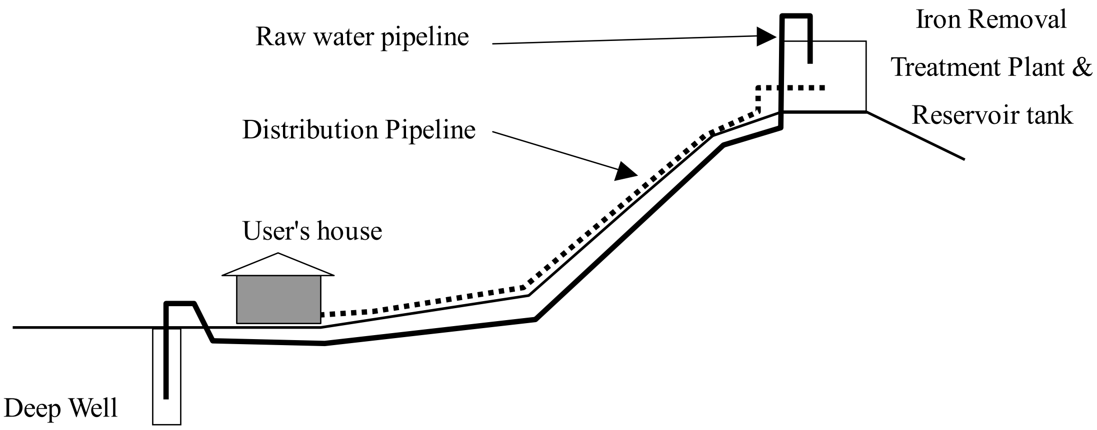

Figure 1.2 Typical Layout of Alternative 2a

(4) Alternative 2b

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

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

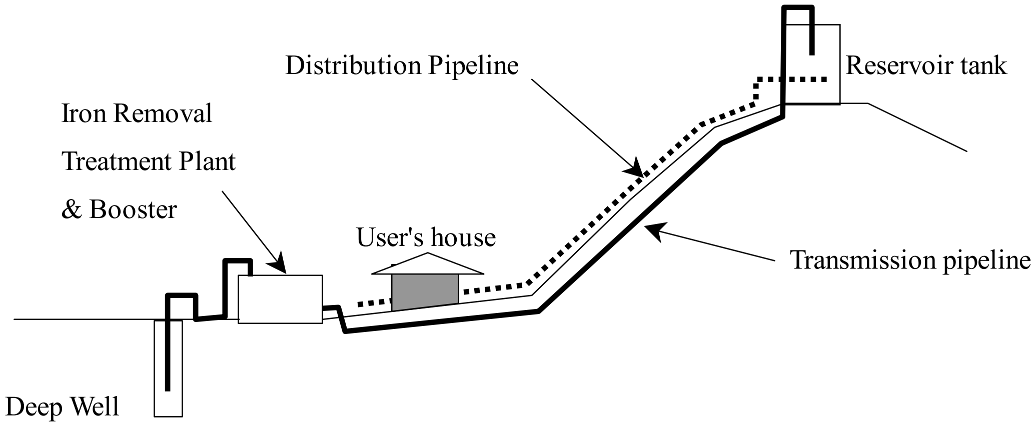

Figure 1.3 Typical Layout of Alternative 2b

(5) Alternative 4

This is the proposed simple solution in areas where there is no need for water treatment (apart from optional chlorination), and where the topography allows for a ground level reservoir to be placed at a site of high ground elevation. Direct pumping from a deep well to a reservoir located on a high ground.

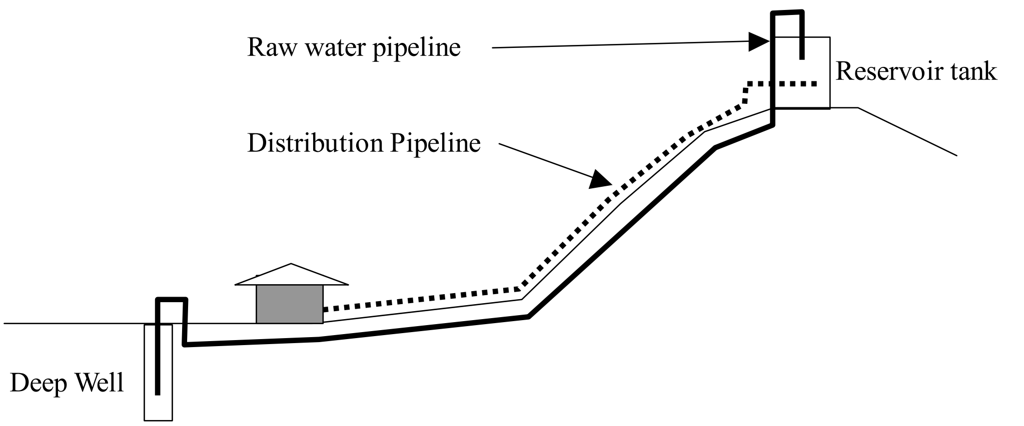

Figure 1.4 Typical Layout of Alternative 4

Table 1.8 shows the overview of proposed water supply systems.

Table 1.8 Overview of Proposed Water Supply Systems

Prioritized System	Alterna-tive	Description and Comments
G1 Kong Tang	**2**	• Water pumped directly from deep wells through the treatment plant to the ground level reservoir (both placed at the highest point of the villages). • Iron removal treatment by aeration and slow sand filtration. • Treated water is boosted to an elevated reservoir and gravitates to the villages.
G2 Nhon Hoa	**2a**	• Water is pumped directly from deep wells through the treatment plant to the ground level reservoir (both placed at the highest point of the villages). • Treatment: manganese removal by aeration and slow filtration. • Treated water is boosted to an elevated reservoir and gravitates to the villages. • Note: the content of manganese is to be confirmed.
G3 Chu Ty	**4**	• Water is pumped directly from the deep well to the ground level reservoir placed at high location. Water gravitates to the network.
G4-1 Thang Hung	**2**	• Water is pumped directly from deep wells through the treatment plant to the ground level reservoir. • Treatment: manganese removal by aeration and slow sand filtration. • Treated water is boosted to an elevated reservoir (placed at the highest point in the villages) and gravitates to the villages. • Note: the content of manganese is to be confirmed
G5-1 Nghia Hoa	**1**	• Water is pumped directly from the deep well to the ground level reservoir. Water is boosted to an elevated tower from where the water gravitates to the villages.
G6-1 Ia Rsion	**2**	• Water is pumped directly from deep wells through the treatment plant to the ground level reservoir. • Treatment: iron and manganese removal by aeration and slow sand filtration. • Treated water is boosted to an elevated reservoir (placed at the highest point in the villages) and gravitates to the villages.
G7-1 Kong Yang	**2**	• Water is pumped directly from deep wells through the treatment plant to the ground level reservoir. • Treatment: iron and manganese removal by aeration and slow sand filtration. • Treated water is boosted to an elevated reservoir (placed at the highest point in the villages) and gravitates to the villages.

1.6.4 Layout of the Water Supply Systems

This section provides a general description of the contents of the drawings. Layout drawings were required to take construction quantities and cost estimate on the proposed water supply systems. A layout drawings for the prioritized 5 systems has been provided indicating a proposed water supply networks in the feasibility study level that changes and additions from the 16 systems in the master plan.

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

- ♦ Newly decided intake location and raw water pipe line route,
- ♦ Addition of some main distribution pipes,

- Change in pipe lengths and diameters of several main distribution pipes,
- The proposed location of water treatment plants,
- Change of location of elevated reservoirs (G4).

(1) Deep Wells

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

(2) Raw Water Pipes

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

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

(3) Main Distribution Pipes

The main distribution pipes are shown in the drawings with diameter and approximate length indicated. The diameters of the pipes were designed for year 2010/2020, based on hydraulic calculations described in the next section.

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

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

(4) Secondary Distribution Pipelines

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

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

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

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

(5) Proposed location of Treatment Plants and Reservoirs

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

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

(6) Water Meter

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

1.6.5 Hydraulic Calculations

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

(1) Analysis Guidelines

The following guidelines were applied for the analysis:

- ♦ The maximum hourly supply in year 2020 was used for dimensioning the pipes. This provided a conservative calculation for the design in all periods up to year 2020.
- ♦ A number of the systems were further analyzed in order to determine and view how flow and pressure varied during the course of an average day.
- ♦ A pipe roughness factor of 0.1 mm was used. This is a conservative value, which takes into account the possibility of deposits on the pipe wall over time (a typical value for new pipes is 0.01 to 0.05).
- ♦ All main distribution pipelines in the system were included in the analysis. Some secondary pipelines were also included for several systems.
- ♦ Pumping mains were generally not included in the analysis as the design of a single pumping pipe is relatively simple and does not require computer analysis. Design of pumping mains with multiple pumps networked together may be more complicated, however as the locations and details on future deep wells are not yet known, the multiple pump case cannot be analyzed at this stage.
- ♦ Water supply quantities were distributed amongst network nodes on the basis of water demands and knowledge gained from inspections during the field surveys. The supply quantities were distributed in a conservative manner by, for example, placing half (or a third) of the consumption at the farthest point of the pipe.
- ♦ The criterion for minimum pipe pressure was 6 meters head at all locations, but preferably up to 7 meters, so as to take into account friction losses in secondary pipes.
- ♦ Alternatively, it is sound practice to maintain minimum flow velocities in the pipes (preferably above 0.2 m/s). This is in order to avoid stagnant water and to achieve a self-cleaning effect within the pipes.
- ♦ Accurate pipe invert levels are of high importance towards accurate results of the analysis. Surface levels have been obtained during the field visits

with the use of altimeters and by the study of topographic maps (1:50.000). Several critical lines were subject to carry out a topographic survey, in order to confirm the levels of the main areas for supply. However, elevations of some secondary pipe routes may still not be sufficiently accurate and should be confirmed during detailed design.

(2) The Results of the Analysis

The results of the analysis are included in the Data Book, Chapter 7, together with print outs of the results in the form of network maps. The results are graphically shown on the maps, featuring pressures for the nodes and flow velocities for the pipes (values are shown underneath the respective nodes and pipes, with node numbers and pipe numbers also shown). Tables of the analysis results are included after each network map, detailing complete information on the water supply system flows and pressures.

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

The following significant results of the analysis can be seen:

- ♦ Generally, there were no problems in achieving the required pressures throughout most areas in the network. However, there were isolated areas where it was difficult to reach sufficient pressure during maximum hourly supply times. During times outside the maximum hourly supply periods (usually lasting only a few hours per day) there was no difficulty for all areas in obtaining sufficient pressure.
- ♦ A maximum height limit for elevated reservoirs of 10 meters was used in the analysis. Higher pressures can be achieved by increasing the height of these towers.
- ♦ Water Supply networks can be adjusted to optimal pressures and supply flows with the aid of computer software calculations. The resulting output often lists many different pipe dimensions and numerous changes in dimensions along pipes. Some such results are not desirable with regards to operations and maintenance, so repeated changes to pipe dimensions were subsequently avoided and the results altered accordingly.
- ♦ One particular result of the computer analysis was that the outskirts of systems only required very small pipe diameters. However, allowing for

future water supply system expansion, these very small dimensions (below 65 mm) were avoided at pipe ends in most networks.

- The analysis results formed, in part, the basis for the estimation of pipe quantities. However, most secondary pipes will only be correctly evaluated after detailed survey maps are completed and detailed design has been performed. At this stage, lengths of such secondary pipes have been only approximately estimated from information gathered during site visits.

1.7 Standard Designs of Water Supply Facilities

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

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

Table 1.9 Summary of the Water Supply Facilities

Commune/ Town Name		Number of Villages	Population 2010	Water demand 2010 Qav (m^3/day)	Number of Bulk meter	Number of existing wells (yield;m^3/day)	Number of required wells till 2010	Number of Pump till 2010	Number of reservoir tank (Cap.;m^3)	Elevated tower	Treatment plant	Raw water pipeline (km)	Distribution pipeline (km)	Number of Public tap
G1:Kong Tang T.		**11**	**6988**	**428**	**17**	**1(300)**	**1**	**2**	**1**	**1**	**1**	**3.0**	**48**	**15**
G2: Nhon Hoa C.		**15**	**13779**	**843**	**15**	**1(200)**	**6**	**7**	**1**	**1**	**1**	**2.0**	**44**	**18**
G3: Chu Ty T.		**8**	**7698**	**471**	**17**	**1(350)**	**1**	**2**	**1**	**1**	**1**	**3.0**	**44**	**9**
G4:Thang Hung C.	**G4-1**	**5**	**5080**	**311**	**5**	**1(250)**	**1**	**2**	**1**	**1**	**1**	**3.0**	**16**	**7**
	G4-2	1	295	18	1	Household systems								
	G4-3	1	385	24	1									
	G4-4	3	1742	107	3									
G5:Nghia Hoa	**G5-1**	**5**	**4008**	**245**	**6**	**1(200)**	**1**	**2**	**1**	**1**	**1**	**3.0**	**21**	**8**
	G5-2	1	441	27	1	Household systems								
G6: Ia Rsion	**G6-1**	**7**	**4685**	**287**	**6**	**1(400)**	**0**	**1**	**1**	**1**	**1**	**1.5**	**10**	**7**
	G6-2	2	839	51	2	Household systems								
G7: Kong Yang	**G7-1**	**5**	**1837**	**112**	**6**	**1(400)**	**0**	**1**	**1**	**1**	**1**	**1.5**	**15**	**7**
	G7-2	1	258	16	1	Household systems								
	G7-3	1	161	10	1									
	G7-4	2	667	41	1									
	G7-5	1	156	10	1									

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

The following Standard Drawings are included:

- Typical deep well structure,

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

1.7.1 Well Structure and Well Head

Standard design for well structure is shown in the Figure 1.5. Dimension of the proposed well in Gia Lai province is as following;

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

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

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

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

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

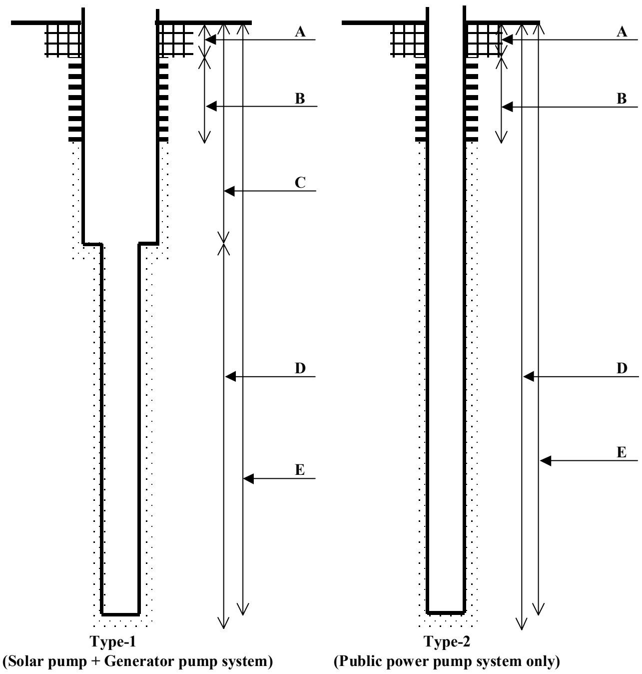

Figure 1.5 Standard design for well structure

1.7.2 Iron and Manganese Removal

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

- **Manganese removal can be performed by means of aeration and slow sand filtration.** This process requires very effective aeration and careful operation of the filter, which should never become dry and should preferably receive a constant flow of water.
- The purpose of aeration is to provide sufficient time for the iron and manganese oxidization reaction processes to complete. The hydraulic retention time should be approximately 40 minutes.
- The aeration system consists of a series of small water pipes (25 mm dia.) perforated with outlet holes (3 - 5 mm dia. at approximately 50 mm spacing), from where the outflow of water falls down upon a series of plates in turn, and finally on to the surface of the reaction tank. Some maintenance is

necessary because the pipe outlet holes may become blocked with iron deposits over time.

- Proper ventilation is necessary to enable the supply of sufficient oxygen, as well as assisting in the removal of possible dissolved gases in the water, such as hydrogen sulphide.
- Removing the products created during the iron and manganese oxidization processes is achieved by the use of a filter, consisting of several sand layers of differing particle size. The maximum hydraulic filter speed should be 5 m/day for slow sand filtration.
- Iron removal can be performed by means of aeration and slow sand filtration. The periodical washing or replace of the surface layer (10cm) in slow sand filter is approximately 3 to 6 months intervals, depending upon its water treated volume and size of sand filtration.

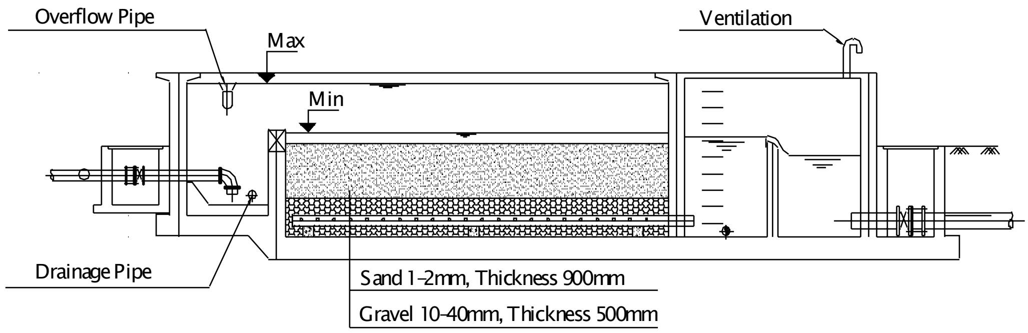

Figure 1.6 Standard design for Slow Sand Filter

1.7.3 Surface Water Treatment

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

The following is the main points of surface water treatment:

- The process of surface water treatment follows roughing filter, followed by slow sand filter.

- Complete removal of turbidity may present a problem during the rainy season, however this can only be verified after testing the water quality following heavy rain.
- The water quality analysis showed that the surface water had high iron content. The roughing and slow sand filters are together able to remove the iron.
- The purpose of the roughing filter is to remove the bulk of the turbidity content and also some of the iron content contained in the raw water. The filter shall be equipped with drains. From the roughing filter the water flows by gravity to the slow sand filter.
- The slow sand filter is a simpler alternative to the slow sand filter, and contains very fine sand, requiring a larger filter area.
- Slow sand filters do not require backwashing or the operation of backwash pumps, however the filter sand needs to be periodically removed, washed and replaced. Washing of the filters should be performed every 3 months, however washing may need to be more frequent during the rainy season.
- In order to guarantee the fulfillment of all water supply quality standards, it may be necessary to employ flocculation, sedimentation and filtration processes followed by disinfection. Such full-scale treatment complicates the operation and maintenance procedures and increases the costs.

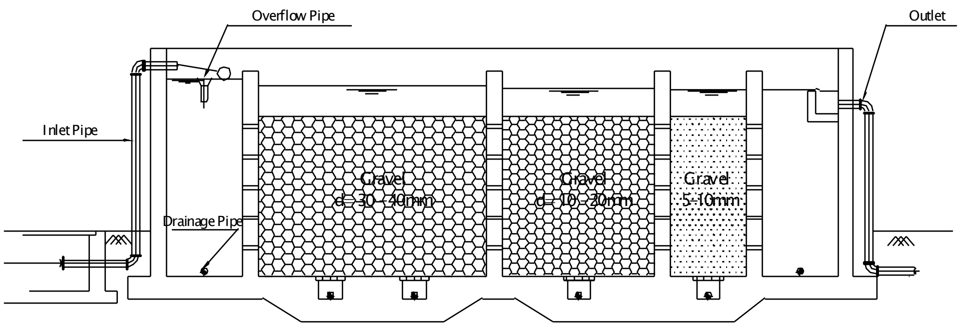

Figure 1.7 Standard design for Roughing Filter

1.7.4 Chlorination

Deep groundwater does not normally require a disinfection process by chlorination, provided that the deep well and installation works were properly installed and constructed, and the required safety zone has been established around the deep well.

The need for disinfection will also depend on how well the deep aquifer has been protected from possible seepage from upper aquifers. For several systems there exists this risk of contamination of the unconfined aquifer from above.

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

- ♦ As an option, the chlorination equipment of chlorine gas shall be installed where a large reservoir tank and long retention time are expecting and/or shallow groundwater sources. For smaller rural villages in case of a few hours retention time, chlorination can be installed later during phase 2 (2010 – 2020).
- ♦ Surface water that has been treated by roughing filter and slow sand filter normally also becomes bacteriological clean, however this cannot be guaranteed. Therefore, the water should, in theory, be disinfected by chlorination.
- ♦ The disadvantages of the chlorination process are that it complicates the treatment process; particularly in the way the chlorine should be continually and correctly dosed against measured water flow, and should be well mixed, which is sometimes difficult to achieve. The efficiency of disinfection also depends on the content of other substances in the water.
- ♦ The cost of delivering chlorine to the plant needs to be added to the overall operations and maintenance cost. Chlorine is also a dangerous chemical substance that requires careful handling and storage.
- ♦ An alternative chlorination system is presently being used in treatment plants for several water schemes in Vietnam. This particular disinfection process produces chlorine from salt (NaCl) through electrolysis. This eliminates the risk of handling and storing chlorine, however the risk of the system breaking down and requiring spare parts is increased.

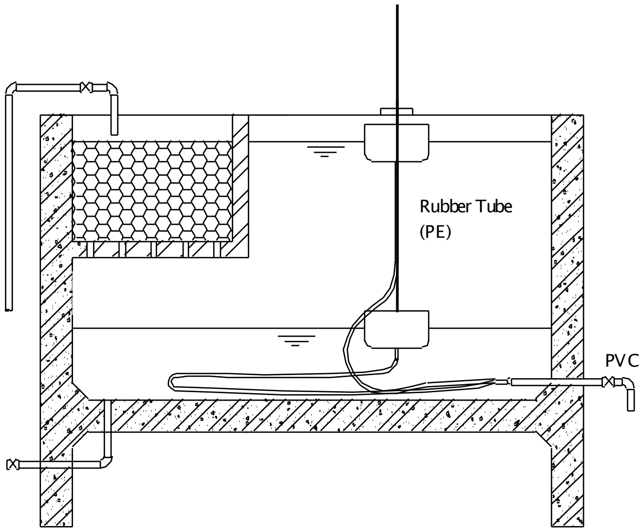

Figure 1.8 Standard design for Chlorination System

1.7.5 Sand Washing Basins (Alternative3 and K4.1)

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

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

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

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

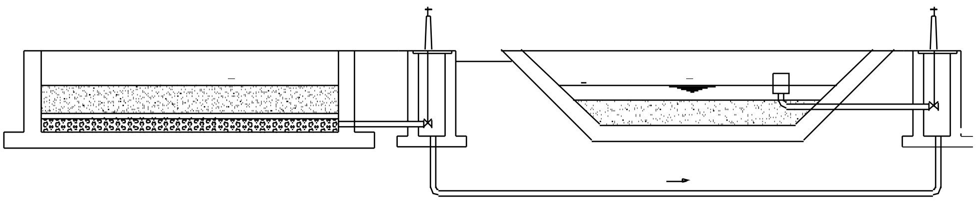

Figure 1.9 Standard design for Sand Washing Basins

1.7.6 Reservoirs

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

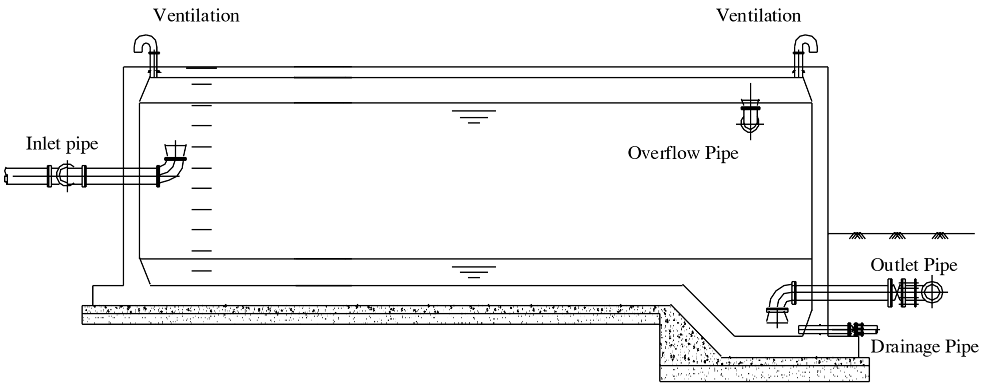

Figure 1.10 Standard design for Reservoir

1.7.7 Pumping Stations

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

Submersible pumps:

- ♦ These are the most commonly used, for pumping from the deep wells to surface reservoirs or treatment plants.
- ♦ The submersible pumps proposed fall within a relatively narrow range for flow yields and lifting heads. The maximum proposed yields vary between 6 m3/hr and 22 m3/hr.
- ♦ The lifting heads vary between 60 and 110 meters.

- Most pumps could be operated from power supplied from a one-phase power grid.
- Only in perhaps 0 to 3 instances would 3 –phase power supply be required.

Booster Pumps:

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

Control of Pumping:

- Control of pumping is proposed to be manual to the highest extent possible. For example, a pump may be started manually in order to fill up a reservoir, and stopped manually when full.
- A pumping schedule should be prepared from the experience gained during operation, and by considering the water consumption.
- Another simple way of controlling start and stop operations of pumps is by using float control switches in the reservoirs. When the reservoir is full, the float lever becomes horizontal and trips a switch that signals the pump to stop. After the water level drops, the float lever will hang vertically, tripping a switch that signals for the pump to start. This method may require the installation of cables over relatively long distances to carry signals from the float control switch to the deep well pump panel, which results in the risk of possible damage to cabling.

Motor Protection:

- Motor control panels, as recommended by the pump supplier, shall be included in the installation of pumps.

- Control panels shall include necessary pump protection devices to protect against, e.g.: dry running, voltage surge, under/over voltage, lightning transient surge protection, thermal overload protection, phase failure protection shall be included for three phase pumps.

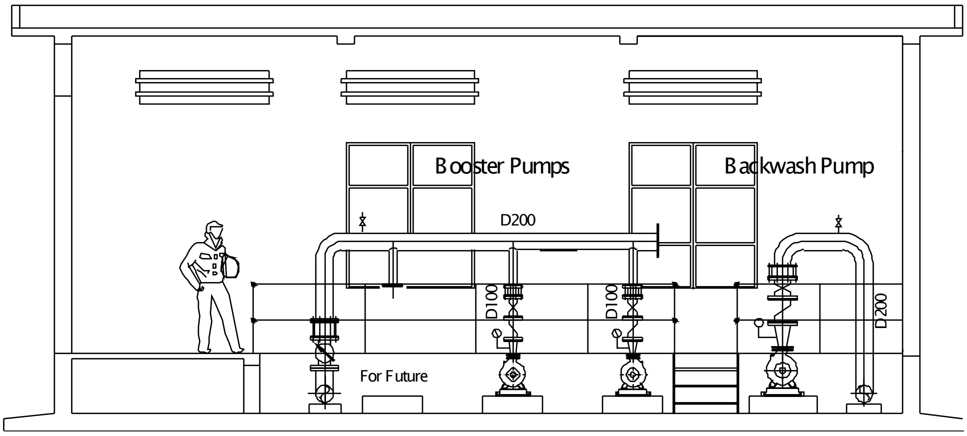

Figure 1.11 Standard design for Pumping Station

1.7.8 Pipelines

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

Raw Water Pipelines:

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

Distribution Pipelines

- Galvanized iron (GI) pipes have traditionally been used for water distribution mains in Vietnam. In places where it may be necessary to construct the mains either above ground or at shallow depths, GI pipes should be used.

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

Pressure Testing:

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

Disinfection:

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

1.7.9 Valve Chambers

Isolation Valves

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

Air Valves, Washouts and Thrust Blocks:

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

1.7.10 Public Taps

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

- Alternative 1 uses a tap for dispensing water directly from the distribution main. The tap is installed on a concrete slab, with a slight slope for drainage.
- Alternative 2 uses 3 taps for dispensing water, and a small storage volume (1 m3) as a back-up supply, during periods of the maximum amount served, times of power failure or during reduced pumping times. There is a single tap on a sloping concrete slab.

- Alternative3 includes a small storage as a back-up supplying, bathing rooms for men and for women, with 3 taps for supplying water. This type is suited to very poor villages.
- Pipes and taps shall be manufactured from metal, such as GI or bronze. Plastic pipes must not be used to prevent damages by hunging the water vessels on the pipe.

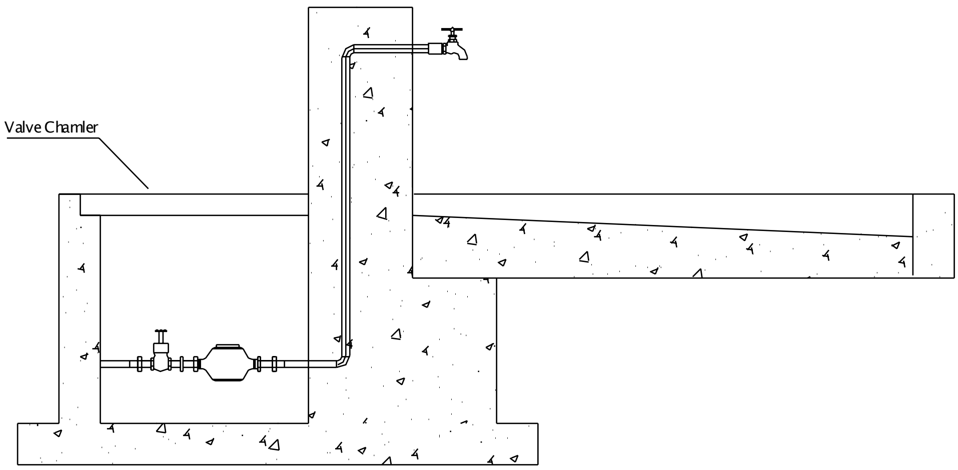

Figure 1.12 Standard design for Public Tap

1.7.11 Water Meters

Bulk Water Meters:

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

Household Meters:

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

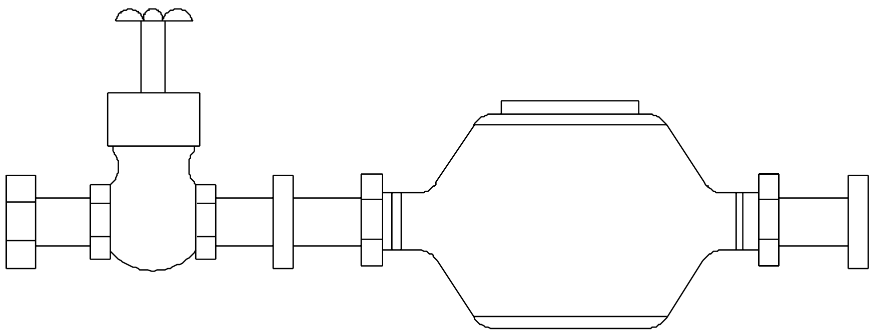

Figure 1.13 Standard design for House connection Meter

1.8 Cost Estimate for Construction

1.8.1 Conditions and Assumptions for Cost Estimate

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

- Costs are calculated at the value in the year 2001.
- Exchange rate is US$ 1.0 = VND 15,000
- The unit costs applied for the cost estimates are tabulated in Table 1.12.
- The estimates were reviewed following the updated master plan and the standard design of the systems.
- The estimates were reviewed on a financial basis with the cost composition and conditions as given in the table below.

Table 1.10 Composition of Project Cost

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

1.8.2 Total Project Costs

The project costs were updated during the F/S and reflected in the following table. The total project costs are US$ 4.3 million in total at Phase 1 (2010 for service coverage of 86 %). The summary of the construction costs is shown in Table 1.11.

Table 1.11 Summary of Construction Cost

Province	Phase1 (2010)	
	No. of Priority Systems	Project Cost (US$ million)
Gia Lai	7	4.3

Table 1.12 Unit Construction Cost

Unit Construction Costs

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

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

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

Table1.13 Project Cost for 7 Piped Systems

No.	System No.	Year 2010, service coverage 86 %: Option	Construction Cost	Base Cost	Project Cost
		proposed	(US$)	(US$)	(US$)
Gia Lai			**3,392,611**	**3,901,503**	**4,291,653**
1	**G1**	option 1	607,639	698,785	768,663
2	**G2**	option 1	1,064,964	1,224,709	1,347,179
3	**G3-1**	option 1	593,946	683,038	751,342
4	**G4-1**	option 1	345,588	397,426	437,169
5	**G5-1**	option 1	340,560	391,644	430,808
6	**G6-1**	option 1	212,663	244,562	269,019
7	G7-1	option 1	227,251	261,339	287,473

Chapter 2 Organizational Settings

2.1 Organization of Operation and Maintenance

2.1.1 Principles

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

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

2.1.2 Organization of O&M

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

Proposed Organizations

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

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

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

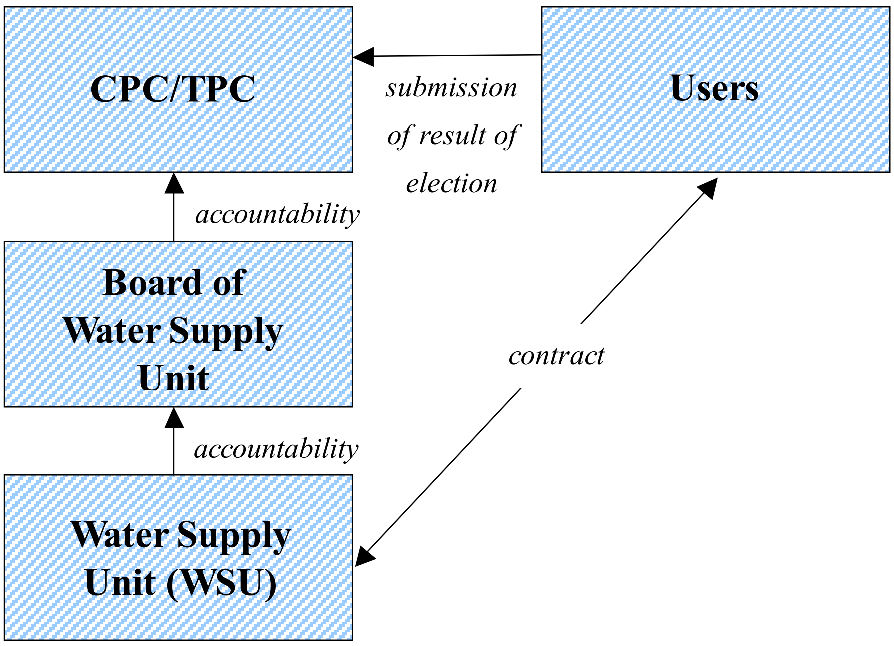

Figure 2.1 Organization for piped water supply

Board of Water Supply Unit Scheme

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

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

WSU Scheme

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

- Board appoints the Manager of the WSU,
- Board appoints other staff members of the WSU on the basis of the proposal of the Manager, and
- It is estimated that the proposed piped schemes will have the following staff;
  - **manager,**
  - **accountant,**
  - **pump operator/treatment plant operator,**
  - **network inspector/ meter readers, and**
  - **water charge collectors.**

Duties and Responsibilities of CPC/TPC

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

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

Functions of Board of WSU

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

- **Responsibilities**

Responsibilities of Board for WSU shall be includes followings;

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

- **Duties**

Duties of Board of WSU shall be includes followings;

- close and timely monitoring of the balance of costs and revenues against the financial plan and taking measures to ensure the sustainability in the case of possible deficit (either by reducing costs or increasing revenues),
- monitoring of the efficiency and performance of the WSU,
- provision of transparent information of the performance and accounts of the WSU to CPC/TPC and users,
- promotion of water use in collaboration of health and educational authorities and mass organizations,
- settlement of disputes between the users and the WSU,
- reporting to CPC/TPCand submission of tariff decisions and other decisions to CPC/TPC for adoption, and
- support to the WSU in the enforcement of the General Regulations and requesting support from relevant authorities if necessary.

Functions of WSU

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

- **Manager**

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

- **Accountant**

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

- **Pump operator/Treatment plant operator**

- The main tasks of the pump/treatment plant operator are the operation and control of well pumps, including recording flow, pressure and power use measurements in the operation record of the intake, general control of the volume and quality of inflow and outflow at the treatment plant.
- The operator is, in the first place, responsible for the water quality, and in general for the technical performance, operational and financial efficiency of the plant, reporting about the purchase needs (chemicals, spare parts, etc.) to the manager, and technical condition and housekeeping at the plant.
- The operator would also be the recommended person to be responsible for the sanitary inspection of the well/intake facilities and their cleaning when necessary.

- **Network inspector/meter reader**

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

- **Water charge collector**

- The main tasks of water charge collector are to collect the water charge based on the bill prepared by the accountant, and to inspect the functioning and condition of the meter as well as its seal.
- The water charge collector receives the bills from the accountant.
- He/she is accountable for his/her work and the collected payments to the manager. He/she also reports about his/her work and any observed irregularities to the manager.

Staffing of WSU

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

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

Proposed staffing scheme of WSU includes followings.

- **Manager/Accountant**

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

- **Pump/treatment plant operators**

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

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

- **Network inspector/meter reader**

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

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

Table 2.1 Staffing Requirements

Commune	Manager			Accountant			Pump/treatment plant operator			Network inspector Meter reader			Water charge collector		
	2005	2010	2020	2005	2010	2020	2005	2010	2020	2005	2010	2020	2005	2010	2020
G1 Kong Tang	½	½	1	½	½	1	1	3	3	2	2	2	1½	2	5
G2 Nhon Hoa	½	1	1	½	1	1	1	3	3	2	2	2	2½	3½	7½
G3 Chu Ty	½	1	1	½	½	1	1	3	3	½	½	1	2	3	7
G4 Thang Hung	½	½	1	½	½	1	1	3	3	1	1	1	1	1½	3½
G5 Nghia Hoa	½	½	1	½	½	½	1	3	3	1	1	1	1	1	2½
G6 Ia Rsion	½	½	1	½	½	½	1	3	3	1	1	1	1	1½	3½
G7 Kong Yang	½	½	½	½	½	½	1	3	3	1	1	1	½	½	1½

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

2.1.3 Guideline for Operation and Maintenance

(1) Model documentation for O & M

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

General regulations

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

Contract document

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

Operation records

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

Operating manuals

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

(2) Role of CERWASS / PCERWASS

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

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

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

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

(3) Spare parts

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

2.2 Implementing Organizations

2.2.1 Principles

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

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

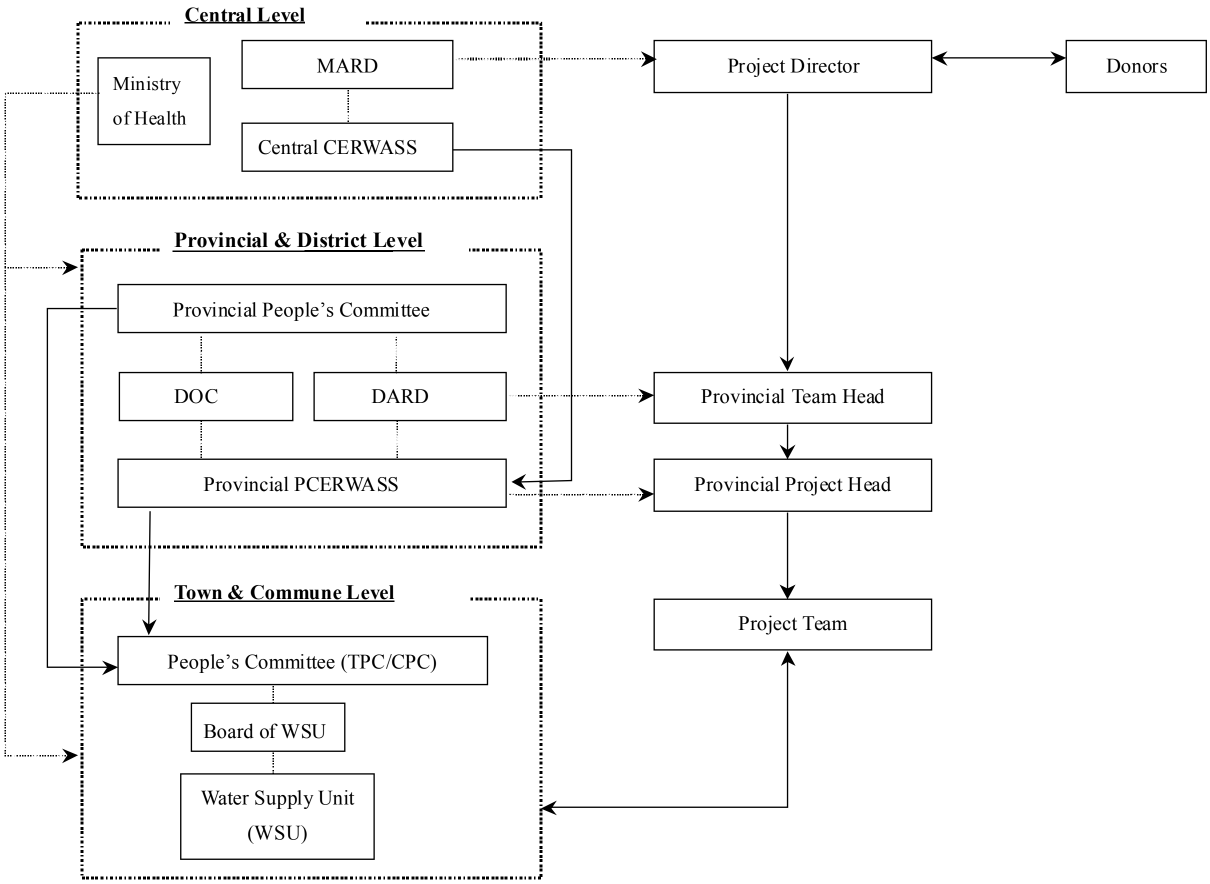

Figure 2.2 Organisation charts of Project Implementation

2.2.2 National Level

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

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

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

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

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

2.2.3 Provincial and District Levels

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

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

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

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

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

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

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

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

2.2.4 Commune/Town Level

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

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

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

2.2.5 Competitive Sector

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

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

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

2.3 Coordination with Relevant Donors

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

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

DANIDA

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

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

UNICEF

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

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

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

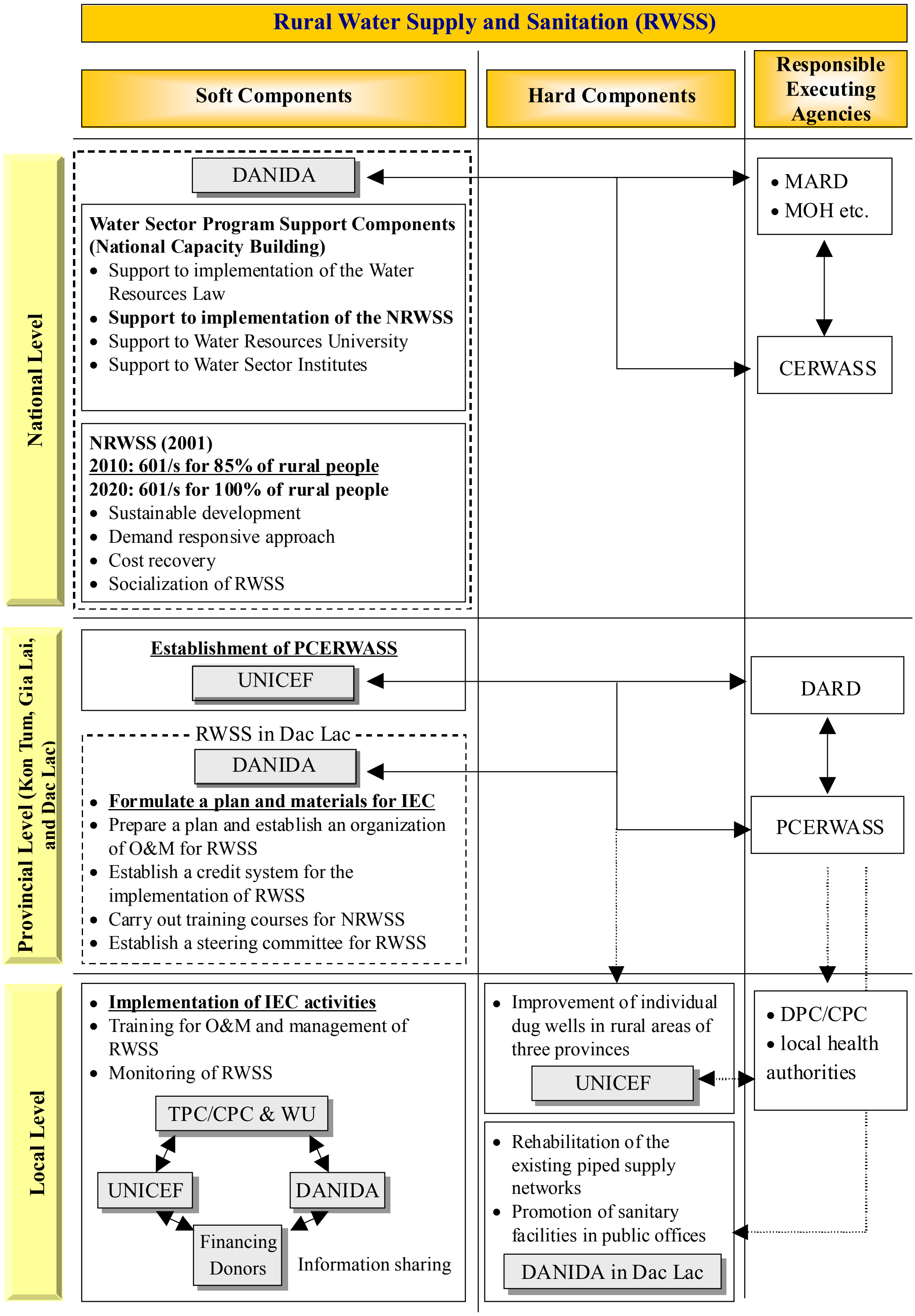

Figure 2.3 Concept Paper for Coordination

Chapter 3 Environmental Impact Assessment (EIA)

3.1 Scope of EIA

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

3.1.1 Institutional Setting for EIA

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

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

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

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

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

3.1.2 Necessary Items for EIA

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

Each item is outlined below:

(1) Water level fluctuations

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

(2) Water right

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

(3) Land acquisition

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

(4) Water quality

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

(5) Wastewater disposal

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

Table 3.1 Screening Checklist*

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

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

**Evaluation:

A= Significant impact is anticipated.

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

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

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

3.2 Environmental Impact Assessment and Countermeasures

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

3.2.1 Land Acquisition

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

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

It is difficult to completely avoid placing water supply facilities on private land considering their optimum locations. Probably, part of the water works might occupy private land in G5-1 and G6-1.

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

3.2.2 Water Quality

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

As a result of the water quality analysis, it was found that there was no fear for toxic substances listed in the analysis items. Dioxin was not identified in the tested samples (G3), and arsenic was within the limit specified in the national water quality standard (Standard 505, Ministry of Health) in all the 18 samples. Physical and chemical substances, i.e. TDS, sodium, chloride, sulfate, ammonium, COD, fluoride were within the national standard.

However, unpleasant smell in G7-1 is a problem. If the smell of the water taken from the explored well in G7-1 cannot be treated by slow sand filtration, it is difficult to apply the water to the piped system. The cause of the smell has not been identified and no possible substances are found in the results of the water quality analysis.

Iron was above the limited level (0.5 mg/l) in the water samples taken from G1, G6-1, G7-1. Iron causes stains when washing clothes, and the local users of the existing dug wells are concerned about the issue. The highest level was from the explored well in G6- (3.10 mg/l) and G7-1(2.07 mg/l). hese water samples need treatment by aeration and filtration.

Manganese is also somewhat of a problem. The highest value is from the explored well in G7-1 (0.29 mg/l). These water samples need treatment by aeration and filtration.

The re-tests for coliform was reexamined by the Institute of Hygiene and Epidemiology (in Buon Ma Thout) during the F/S period.

3.2.3 Wastewater Disposal

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

The wastewater needs to be treated before sewage, especially the communities near production wells. The public buildings, e.g. people's committees, health centers, hospitals, public schools, markets, should be equipped with septic tanks or more advanced technology if financially viable. The installations of septic tanks need to be financially supported by the provincial and/or district governments in the poor communes.

The average cost for a semi-septic or septic tank system is VND 1 to 4 million, and it is rather expensive even for the richest families in the study area. The communities in the densely populated and rather richer areas, i.e. G1, G2, and G3, are recommended to install individual septic tanks during phase 1 (up to 2010), which might be upgraded to more intensive wastewater treatment systems in future. Areas where population density is low and far from the groundwater sources may install cheaper hygienic latrines instead of expensive hygienic latrines.

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

3.2.4 Other Issues

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

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

3.3 Environmental Impact Assessment of Each Priority System

Environmental impact assessment (EIA) was carried out for 7 communes/towns prioritized during the F/S phase to check the items to be focused as a result of IEE.

G-1, Kong Tang town

The study team has explored a deep well with a yield of approximately 320 m3/day. And treatment (rapid filtration) may be necessary.

The drilled deep well is 112 m long with a screen 40 m in length. As a result of the pumping test, no impact was found in the existing shallow dug wells near the deep well.

However, the construction works along the national road no. 9 from Pleiku to Quang Ngai will require careful traffic management to avoid traffic nuisance in the neighboring communities. For the secondary roads in the development area, the construction works will not become an issue.

G-2, Nhon Hoa commune

The pilot model has been constructed in this commune. The study team has drilled a deep well with a yield of 259 m3/d. The water has a somewhat high content of manganese (0.195 mg/l), for which the treatment is optional.

The drilled deep well is 110 m long with a screen 34 m in length. As a result of the pumping test, no relations were identified between the existing shallow dug wells and the deep well.

The construction works along the national road no. 14 from Pleiku to Buon Ma Thout will require careful traffic management to avoid traffic nuisance in the neighboring communities. To lay two main pipes along the busy national road, it may be necessary to control traffic causing traffic jam.

G-3, Chu Ty town

The study team has drilled a deep well with a yield of 328 m3/day. Dioxin was not detected in the water sample of this town. The overall quality is also satisfactory without any treatment.

The drilled deep well is 85 m long with a screen 22 m in length. The water is taken from the deep aquifer. There are no shallow wells near the drilled well, and the impact is negligible.

G4-1, Thang Hung commune

The deep well drilled by the study team in G4-1 has a yield of approximately 250 m3/d. The content of manganese in the water (0.174 mg/l) is slightly high. Manganese treatment is recommended.

The drilled deep well is 150 m long (one of the deepest wells among the explored wells) with a screen 50 m in length. As a result of the pumping test, no negative impact was found in the neighboring shallow dug wells.

G5-1, Nghia Hoa commune

The study team has explored a deep well with an estimated yield of 173 m3/day. The water quality analysis indicates that the quality is satisfactory and no treatment is necessary.

The explored deep well is 135 m long with a screen 52 m in length. As a result of the pumping test, no negative impact was identified in the neighboring shallow dug wells.

G6-1, Ir Simon commune

The deep well constructed by the study team has a permissible yield of 328 m3/day. The water has a relatively high content of iron (3.10 mg/l) and requires a treatment plant with aeration and slow sand filtration.

The drilled deep well is 158 m long (the deepest well among the explored wells) with a screen 38 m long. As a result of the pumping test, no negative impact was found in the existing shallow wells.

G7-1, Kong Yang commune

The study team has drilled a deep well with a yield of 346 m3/d. The water has a high content of iron (2.07 mg/l) and should consequently be treated. In addition, the water has an unpleasant smell, and if not solved by treatment this may be serious.

The drilled deep well is 110 m long with a screen 34 m in length. As a result of the pumping test, no negative impact was found in the existing shallow dug wells near the deep well.

3.4 Conclusion

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

Water quality is, overall, not a problem except that bad smell was identified in G7-1 during the F/S period. If the smell is not taken away from the water by treatment, the system in G7-1 could not be feasible. The water taken from the deep wells in G1, G2, G3, G4-1, G5-1, and G6-1 is safe and clean if necessary treatment is added (e.g. iron and/or manganese removal).

Construction of water supply facilities (reservoir, treatment plant, elevated tower, main pipes, raw water pipes, management station) on private land should be basically avoided. Land acquisition issues might be a problem in G5-1, and G6-1. If compensation is necessary, negotiations shall be arranged by the people's committee and PCERWASS rior to the detailed design.

Table 3.2 EIA Matrix

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

*Evaluation:

A= Significant impact is anticipated.
B= Some measures will be necessary before the implementation stage.
C= Needs further detailed analysis in the course of the implementation stage.
D= No or little negative impact or positive impact is anticipated, and requires no further assessment.

Chapter 4 Feasibility Evaluation

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

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

Table 4.1 Questionnaire and Answer from PCERWASS and Interpretation

System	Question	Answer	Interpretation and Recommendable Solution
G7	How about bad smell in groundwater?	Residential claimed the water smell	Treatment will increase the tariff. Sustainable O&M is doubtful by a small population of 1,664 in 2001. Many poor houses are not electrified due to poverty.

4.1 Financial Analysis

4.1.1 General Principles

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

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

Water supply systems described in this project fall under the category of full piped schemes. Even when accepting investment grants, NRWSS states that in all cases users shall fund all operation costs and shall control the actual payment for construction, and O&M. The NRWSS assumes that in the future an **average rural household could pay between 3% and 5% of its total income for clean water and sanitation**. However, the tariff, including the initial investment cost may be more than five times the tariff excluding the initial investment cost. Consequently, it is judged to be impossible to refund the initial cost by the users themselves with heavy water charges. Therefore, the initial investment cost is assumed to be a grant.

Also, it has been assumed that there will be no second round of grant for rehabilitation, upgrading and other similar reinvestments. Therefore, the financial analysis involves an element of **reinvestment**. Also, the communes/users will be responsible for their connections, including water meters.

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

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

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

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

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

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

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

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

In the case of communes where two piped schemes have been recommended, it has been assumed that the minor system (K2-1, D3-2 and D4-2) does not need to employ a manager and an accountant. In practice, the division of the cost implications of shared staff is to be agreed upon case by case.

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

The initial investments are assumed to take place in 2003 and 2013. It is anticipated that the re-investments will be implemented by user's contribution or local contractors using locally available materials and equipment. Based on experience from Vietnamese construction costs, the reinvestment cost have been estimated at 50% of the costs presented in cost estimates. The estimated life times of 12 years for electro-mechanical installations and 30 years for civil works and pipelines have been adopted from recommendations of international consultants providing support to CERWASS in the implementation of NRWSS. The life-time of boreholes is estimated at more than 28 years.

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

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

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

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

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

The tariff analysis has been made on the basis of four principles. Firstly, operation margin has to be positive, although sometimes only marginally, every single year. Secondly, actual cumulative savings (for re-investments) have to account to at least 63% of the cumulative saving targets by 2020. Thirdly, the break-even point between the actual cumulative savings and saving targets has to be reached within 25 years from the initial investment (by 2028). Fourthly, the tariffs are estimated to be constant from 2003 until 2012 and again from 2013 until the end of the analysis period (2030). The tariff increase in 2013 is easily justified by the second tier of investments.

The affordability analysis compares the annual expenditure on water of one user of the scheme (based on estimated per capita water use and assumed tariff) with the average annual income within the respective commune/town. To be on the safe side the income has been assumed to stay constant throughout the period. Therefore, the actual ability to pay (ATP) in 2020 is likely to be much higher than in this analysis.

4.1.3 Ability of Payment for Estimated Tariff

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

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

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

Table 4.2 Annual costs MVND/a

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

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

The annual costs per cubic meter are presented in Table 4.2. These unit costs are more applicable for comparison between schemes.

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

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

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

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

The calculated tariffs look relatively high in the Vietnamese context. For example, the Provincial People's Committee in Dak Lac has set a ceiling of VND 1,800/m3 for rural water tariffs. On the other hand the calculated tariffs do not seem to involve problems with the average affordability, except in all schemes in Kon Tum and possibly in D5, as can be seen in Table 4.3. Instead of the ability to pay, the calculated tariffs may be a political issue.

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

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

Commu-ne	Annual unit costs (VND/m³)						Tariff (VND/m³)		Affordability (%)*	
	Cost excl. re-investment			Cost incl. re-investment						
	2005	2010	2020	2005	2010	2020	Up to 2012	After 2013-	2005	2020
K1-1	4,438	3,106	1,666	17,625	10,847	5,253	6,750	7,000	4.8	7.8
K2-1	6,258	5,195	2,550	18,573	12,425	6,416	8,000	8,250	10.9	17.5
K2-3	4,239	3,204	1,621	14,532	9,246	4,471	5,750	6,000	7.8	12.7
K3-1	3,455	2,748	1,486	8,146	5,502	2,969	3,750	3,800	4.8	7.5
K4	4,680	3,277	1,626	14,466	9,022	4,200	5,500	5,600	4.7	7.4
G1	**2,952**	**2,129**	**1,221**	**9,075**	**5,723**	**2,818**	**3,400**	**3,750**	**1.5**	**2.7**
G2	**2,363**	**1,784**	**1,118**	**7,697**	**4,915**	**2,575**	**2,850**	**3,350**	**0.7**	**1.3**
G3	**2,767**	**2,153**	**1,353**	**7,853**	**5,139**	**2,678**	**3,100**	**3,500**	**1.0**	**1.7**
G4-1	**2,411**	**1,829**	**1,043**	**7,146**	**4,609**	**2,371**	**2,800**	**3,100**	**1.9**	**3.3**
G5-1	**3,034**	**2,283**	**1,293**	**8,721**	**5,621**	**2,835**	**3,300**	**3,800**	**1.4**	**2.5**
G6-1	**2,309**	**1,825**	**1,072**	**5,820**	**3,886**	**2,167**	**2,500**	**2,800**	**1.3**	**2.3**
G7-1	**5,002**	**3,789**	**1,776**	**13,739**	**8,919**	**3,781**	**5,300**	**5,400**	**2.7**	**4.3**
D1	1,658	1,277	774	4,983	3,229	1,685	1,950	2,200	0.6	1.1
D2	1,609	1,259	860	4,632	3,034	1,714	1,850	2,200	0.8	1.5
D3-1	1,711	1,359	833	4,650	3,084	1,671	1,900	2,200	0.9	1.6
D3-2	2,355	1,727	995	7,352	4,661	2,493	2,700	3,250	1.3	2.4
D4-1	2,160	1,639	974	6,720	4,316	2,136	2,650	2,800	1.2	2.0
D4-2	3,470	2,878	1,419	10,868	7,221	3,223	4,000	4,500	1.8	3.1
D5-1	2,536	1,801	959	8,588	5,353	2,607	3,100	3,500	3.2	5.7
D6	1,956	1,584	1,048	5,568	3,704	2,028	2,300	2,600	0.7	1.2
D7	2,084	1,632	990	5,794	3,810	1,994	2,150	2,700	0.9	1.7

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

4.1.4 Willingness to Pay

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

Table 4.4 Willingness to Pay

Town/ Commune	Average annual income per capita	Willingness To Pay for piped system (VND, %)		3% of income	5% of income
Kong Tang T.	2,973,520	64,600	2.2%	89,206	148,676
Nhon Hoa C.	5,350,492	55,700	1.0%	160,515	267,525
Chu Ty T.	4,403,992	47,300	1.1%	132,120	220,200
Thang Hung C.	1,960,873	81,700	4.2%	58,826	98,044
Nghia Hoa C.	3,253,095	63,700	2.0%	97,593	162,655
Ia Rsiom C.	2,527,044	63,100	2.5%	75,811	126,352
Kong Yang C.	2,635,858	94,100	3.6%	79,076	131,793
Kien Duc T.	4,668,492	209,500	4.5%	140,055	233,425
Krong Kmar T.	3,287,566	62,900	1.9%	98,627	164,378

4.1.5 Financial Cash Flow Analysis

The cash flow of each scheme has been estimated separately. The main requirement in cash flow projections is to ensure that there is a positive cash flow every single year and that every scheme is able to generate sufficient saving for re-investment in 25 year from the initial investment. The assumptions of the cash flow analysis are presented in Section 4.1 above. While the costs have been calculated along the same principles for every scheme the tariffs have been set on an iterative basis to facilitate a healthy cash flow. The financial performance charts, based on operation margin and the charts showing the cumulative savings, are attached in Appendix 3.

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

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

4.2 Economic Evaluation

To supplement the financial analysis, the economic analysis was first quantitatively carried out using the EIRR analysis.

4.2.1 Identification of Economic Benefits and Demerits

The estimated economic benefits to be derived from rural water supply projects will become:

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

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

However, there might be some economic demerits as follows:

D-1. Decrease in vendor businesses by the systems in some areas
D-2. Environmental impact of groundwater lowering on shallow wells raising water right issues
D-3. Land acquisition problems that might be raised if solved properly.

According to the social survey, households who take water from venders are limited. Furthermore, the business for venders is very limited both spatially and seasonally. This economic demerit is considered very limited.

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

4.2.2 Economic Cash Flow Analysis

General

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

The quantifiable effect related to B1 is cost reduction for medical care, and that for B2 is cost saving of water collection. Venders will reduce the benefits related to vending business.

Assumptions

Assumptions of the quantifiable analysis are as follows:

- ATP (3% of the annual income) will be used if the necessary water tariff exceeds 3% of the annual income.
- Incidences of water-borne diseases collected by the social survey are used for the analysis.
- Reduction in water-borne diseases is estimated as high as 50 % for typhoid, cholera, dysentery, and diarrhea.
- Annual cost saved by reducing the diseases is estimated as high as VND 250,000 (average medical cost) for treatment for typhoid, cholera, dysentery, diarrhea, and trachoma. Cost saving by disease reduction is thus calculated as follows:
- Total saving by water collection = 250,000 VND/household x no. of households suffering from each disease
- Reduction of time for water collection is due to the households taking water from the springs, and is estimated as long as 1 hour.
- Time saved for water collection is valued at the average VND 1,000 using the household incomes per hour for farmers collected by the social survey. The annual saving is thus calculated as follows:
- Total saving by water collection = 500 VND/hour x 1 hour/day x 365 days x % of using springs/rivers x no. of households
- Demerits associated with the reduction in vending business are offset by benefits derived by the cost reduction for water bought from venders. In a closed society, net demerits are zero, so the economic analysis omitted did not take any calculations for vending business.

Results

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

- The EIRRs of G6-1 is relatively large (+5 to 15%). These systems are economically feasible.
- The EIRR of the other systems varies between –4 to 4%.

Table 4.5 Financial Cash Flow Analysis

	1			2			3			4		
Commune	K1-1			K2-1			K2-3			**K3-1**		
Option	1			1			1			**1**		
Phase 1	578,218			151,059			350,210			181,568		
Phase 2	206,762			17,820			72,480			92,120		
Population	7,797			1,612			4,862			2,819		
Year	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance
1	322	110	(213)	70	27	(43)	164	58	(106)	92	39	(52)
2	354	122	(232)	77	30	(47)	182	65	(117)	105	44	(62)
3	355	136	(219)	77	33	(44)	183	72	(110)	106	49	(57)
4	356	151	(205)	78	37	(40)	183	80	(103)	107	54	(52)
5	**364**	168	(196)	**83**	41	(41)	**189**	89	(99)	**112**	60	(52)
6	**365**	187	(178)	**83**	46	(37)	**189**	99	(90)	**113**	67	(46)
7	**366**	208	(158)	**83**	51	(32)	**192**	111	(82)	**116**	75	(41)
8	**372**	232	(141)	**88**	57	(31)	**198**	123	(75)	**122**	83	(39)
9	**376**	258	(118)	**88**	63	(25)	**199**	137	(62)	**123**	92	(31)
10	378	287	(91)	89	70	(19)	200	152	(48)	124	103	(22)
11	481	331	(150)	123	81	(42)	255	177	(78)	166	116	(50)
12	493	368	(125)	126	90	(36)	262	197	(65)	173	129	(44)
13	498	409	(88)	127	100	(27)	263	219	(44)	174	144	(31)
14	503	455	(48)	127	111	(16)	267	243	(23)	179	160	(19)
15	508	507	(2)	128	123	(4)	269	271	2	181	178	(3)
16	511	563	52	130	137	7	271	301	30	183	198	14
17	517	627	110	131	153	21	273	335	62	186	220	34
18	523	697	174	132	170	38	278	373	95	191	244	53
19	530	776	246	133	189	56	281	415	134	194	272	78
20	530	776	246	133	189	56	281	415	134	194	272	78
FIRR			**-8%**			**-9%**			**-7%**			**-7%**
NPV	US$(=15000VND)		**-1,153**			**-228**			**-566**			**-275**

	5			6			7			8		
Commune	**K4-1**			**G1**			**G2**			**G3-1**		
Option	**1**			**1**			**1**			**1**		
Phase 1	406,601			601,322			965,360			591,512		
Phase 2	126,247			168,673			352,676			143,199		
Population	3,136			6,988			13,779			7,698		
Year	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance
1	177	62	(114)	257	87	(170)	432	144	(287)	250	90	(159)
2	202	69	(133)	285	96	(188)	477	161	(317)	276	101	(176)
3	203	77	(126)	286	107	(179)	483	179	(304)	283	112	(172)
4	203	86	(117)	287	119	(168)	490	199	(291)	288	124	(164)
5	**209**	95	(113)	**296**	133	(163)	**501**	221	(279)	**299**	138	(160)
6	**209**	106	(103)	298	147	(150)	505	246	(259)	302	154	(148)
7	**210**	118	(92)	300	164	(136)	512	274	(239)	307	171	(136)
8	**215**	131	(84)	307	182	(125)	525	305	(221)	316	191	(125)
9	**218**	146	(72)	312	203	(109)	534	339	(195)	325	212	(113)
10	219	162	(57)	318	226	(92)	541	377	(164)	329	236	(94)
11	267	184	(83)	386	277	(109)	682	493	(189)	396	296	(100)
12	274	205	(69)	396	308	(88)	706	548	(158)	410	330	(81)
13	277	228	(49)	402	343	(60)	716	610	(106)	417	367	(50)
14	278	253	(25)	409	381	(28)	729	678	(50)	426	408	(19)
15	280	282	2	416	424	8	743	755	12	437	454	17
16	282	313	32	422	472	50	758	839	81	448	505	57
17	286	349	63	430	525	95	780	934	154	460	561	101
18	291	388	97	439	584	145	798	1,039	240	478	624	147
19	295	432	136	446	650	203	819	1,155	337	492	695	202
20	295	432	136	446	650	203	819	1,155	337	492	695	202
FIRR			**-8%**			**-7%**			**-8%**			**-7%**
NPV			**-618**			**-919**			**-1,556**			**-854**

	9			10			11		
Commune	**G4-1**			**G5-1**			**G6-1**		
Option	**1**			**1**			**1**		
Phase 1	344,955			337,704			227,066		
Phase 2	136,717			117,396			29,894		
Population	5,080			4,008			4,685		
Year	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance
1	156	55	(101)	144	50	(95)	114	44	(70)
2	173	61	(112)	161	55	(106)	126	49	(77)
3	174	68	(106)	162	61	(101)	127	54	(72)
4	177	76	(101)	163	68	(95)	128	60	(67)
5	**182**	84	(98)	**169**	76	(93)	**133**	67	(66)
6	183	94	(90)	170	85	(86)	137	75	(62)
7	185	104	(80)	172	94	(78)	138	83	(55)
8	191	116	(75)	178	105	(74)	144	93	(51)
9	194	129	(65)	182	116	(66)	146	103	(43)
10	196	143	(53)	184	129	(54)	149	115	(35)
11	248	177	(71)	226	166	(60)	198	143	(55)
12	257	196	(61)	233	184	(48)	205	159	(46)
13	262	219	(44)	237	205	(32)	209	177	(33)
14	265	243	(22)	240	228	(12)	212	197	(15)
15	270	270	1	244	254	10	218	219	1
16	273	301	28	249	282	33	223	243	20
17	281	335	54	253	314	61	227	271	44
18	285	372	88	261	350	89	233	301	68
19	291	414	123	268	389	121	240	335	95
20	291	414	123	268	389	121	240	335	95
FIRR			**-8%**			**-7%**			**-7%**
NPV			**-546**			**-507**			**-370**

	12			13			14			15		
Commune	G7-1			**D1**			**D2**			**D3-1**		
Option	1			**1**			**1**			**1**		
Phase 1	227,066			640,632			926,850			337,039		
Phase 2	29,894			233,064			375,219			141,311		
Population	1,837			12,903			18,464			8,556		
Year	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance
1	104	37	(67)	270	96	(174)	346	126	(221)	157	58	(99)
2	115	41	(74)	301	107	(195)	383	140	(243)	173	64	(109)
3	117	45	(72)	303	119	(184)	389	155	(234)	175	71	(103)
4	118	50	(67)	307	132	(175)	395	173	(223)	178	79	(99)
5	**123**	56	(67)	**314**	**147**	(168)	**405**	**192**	(213)	**185**	**88**	(96)
6	123	62	(61)	321	163	(158)	412	214	(199)	186	98	(88)
7	124	69	(55)	324	182	(143)	420	238	(183)	188	109	(79)
8	130	77	(53)	334	202	(132)	434	265	(169)	197	122	(76)
9	132	86	(47)	340	225	(115)	441	294	(147)	203	135	(68)
10	133	95	(38)	344	250	(94)	452	328	(124)	208	150	(57)
11	146	108	(38)	430	314	(117)	579	433	(146)	261	194	(67)
12	148	120	(28)	446	349	(97)	603	482	(121)	270	216	(55)
13	149	134	(16)	453	388	(65)	616	536	(80)	278	240	(39)
14	151	149	(2)	461	432	(30)	633	596	(37)	285	267	(18)
15	154	165	11	475	480	5	649	663	15	289	297	8
16	156	184	28	485	534	50	666	738	71	296	330	34
17	157	205	47	495	594	99	688	821	133	304	367	63
18	159	228	68	506	661	155	711	913	202	310	409	98
19	162	253	92	521	735	214	737	1,016	279	319	454	135
20	162	253	92	521	735	214	737	1,016	279	319	454	135
FIRR			-6%			**-7%**			**-7%**			**-6%**

	16			17			18			19		
Commune	D3-2			**D4-1**			D4-2			D5-1		
Option	1			**1**			1			1		
Phase 1	297,530			500,457			250,341			460,679		
Phase 2	133,328			165,608			127,854			176,027		
Population	4,463			7,775			2,034			8,920		
Year	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance
1	128	43	(85)	233	83	(150)	99	33	(67)	233	76	(157)
2	143	48	(81)	258	92	(166)	109	36	(73)	258	85	(174)
3	144	53	(77)	260	102	(157)	110	40	(69)	261	94	(167)
4	145	59	(74)	263	114	(150)	110	45	(65)	262	105	(157)
5	**146**	**65**	(70)	**270**	127	(143)	**116**	50	(66)	**267**	**117**	(151)
6	147	73	(66)	272	141	(131)	116	56	(60)	268	130	(138)
7	148	81	(62)	277	157	(120)	119	62	(57)	271	144	(127)
8	156	90	(58)	284	174	(110)	124	69	(55)	277	160	(117)
9	157	100	(54)	290	194	(96)	125	77	(48)	278	178	(100)
10	158	112	(47)	295	216	(79)	126	85	(41)	280	199	(81)
11	213	149	(63)	350	254	(97)	144	107	(38)	355	249	(106)
12	220	166	(54)	364	282	(82)	148	119	(29)	368	277	(91)
13	224	185	(39)	369	314	(55)	151	132	(19)	372	309	(64)
14	226	206	(20)	376	349	(27)	152	147	(5)	374	343	(31)
15	228	229	0	383	388	5	154	163	10	378	382	3
16	233	254	21	389	432	43	155	182	26	383	425	41
17	236	283	47	398	481	82	157	202	45	388	472	84
18	241	315	73	408	535	127	161	225	64	392	526	134
19	245	350	105	418	595	176	163	250	87	397	585	188
20	245	350	105	418	595	176	163	250	87	397	585	188
FIRR			-7%			-8%			-6%			-8%

	20			21			
Commune	**D6**			D7			**Total**
Option	**1**			1			
Phase 1	469,229			363,980			**9,209,378**
Phase 2	104,813			130,138			**3,081,240**
Population	10,619			7,484			**145,519**
Year	Expenditure	Revenue	Balance	Expenditure	Revenue	Balance	
1	242	91	(151)	171	57	(114)	
2	269	101	(168)	189	63	(125)	
3	271	112	(159)	190	71	(120)	
4	274	125	(150)	192	78	(113)	
5	**285**	**139**	(146)	**200**	**87**	(113)	
6	292	154	(137)	202	97	(105)	
7	298	172	(126)	204	108	(96)	
8	307	191	(117)	213	120	(93)	
9	313	212	(100)	218	134	(85)	
10	323	236	(87)	221	149	(72)	
11	399	297	(102)	273	208	(65)	
12	414	330	(83)	282	231	(51)	
13	424	368	(56)	291	257	(34)	
14	433	409	(24)	295	286	(9)	
15	445	455	10	302	318	16	
16	458	506	48	309	354	45	
17	472	563	90	315	394	79	
18	488	626	138	323	438	115	
19	510	697	186	332	487	155	
20	510	697	186	332	487	155	
FIRR			**-7%**			-6%	

Table 4.6 EIRR Cash Flow

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

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

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

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

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

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

4.3 Technical Feasibility

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

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

4.3.1 Appropriateness of Technology

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

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

- Iron and manganese removal can be performed effectively by means of aeration and rapid sand filtration. The iron removal process is not complicated by regular replacement and washing the sand filter.
- The process for the removal of manganese is more complicated than iron removal. This process requires very effective aeration and careful operation of the filter, which should never become dry and should preferably receive a constant flow of water.
- The chlorination process has a complex operation and maintenance aspect.

The following considerations were made to solve the above issues:

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

4.3.2 Efficient Designing

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

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

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

- In some systems, the achievement of satisfactory service pressure during the hours of maximum demand will need careful optimization by hydraulic calculations during the detailed design aspects of the network for location of reservoirs and size of pumps; and
- Removal of some remote villages out of the centralised piped systems should be considered from an economic point of view: G2 Nhon Hoa (villages Ia Tung, Ong A, Thong Will, Hoa Tin, Tho Ga A and Tho Ga B), G5-1 (village 4) and G7-1 (village 1).

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

4.3.3 Local Construction Skills and Materials

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

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

4.4 Operation and Maintenance

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

4.4.1 Training Method for O & M

Pump operation, maintenance for the plant of iron and manganese removal by the WSU shall be well learned from the WSU staff of the pilot model plant of G2. The training shall be also introduced through consultant engineers and constructor during the implementation stage.

Maintenance of the pipe network is of particular interest. Long pipelines and few users increase the risk of a relatively high percentage of 'unaccounted for water' (UFW) and illegal connections. An extensive network of pipes may require intensive maintenance after some years, even if high quality material and high quality construction has been undertaken. This will be needed to solve through the monitoring of the G2 pilot model.

4.4.2 Evaluation of O&M Skills

It is recommended that a specific body, called Water Supply Unit (WSU), be established under CPC/TPC for the O&M of the piped water supply facilities. It is also recommended that the users be represented in the management structure of the WSU. This will materialize through representation of users on the Board of the WSU.

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

To achieve sufficient autonomy and separate the accounts of the WSU, it should have a staff of its own. It is also possible to outsource some functions to external personnel. It is estimated that the proposed WSU management will have a manager, an accountant, a pump operator/treatment plant operator, a network inspector, and meter readers.

During the study, it was evaluated that the O&M potential, considering the issues explained above, was rather low in a number of systems, i.e., G7-1.

4.5 Environmental Concerns

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

Acquisition of private land may be necessary, probably, in G5-1 and G6-1. Resettlement and relocation are not required in any of the systems. It is a prerequisite that the people's committees and PCERWASS take the responsibility for acquiring the land for water supply facilities.

Bad smell is identified in G7, and needs technical considerations for treatment. The local people are also unsatisfied with the odor of the existing shallow dug wells, and need technical solutions.

Wastewater disposal is crucial in some of the systems, especially, the communities near the explored groundwater resources in the G1, G2 and G3 systems. The public buildings should be equipped with septic tanks or more advanced technology if funding is available. Communities in the densely populated areas are advised to install individual septic tanks during phase 1 (up to 2010), which can be upgraded to more intensive wastewater treatment systems in the future.

4.6 Result of Feasibility Evaluation

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

Table 4.7 Summary of Feasibility Evaluation

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

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

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

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

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

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