APPENDIX G
DOMESTIC WATER SUPPLY SYSTEM

THE STUDY
ON
GROUNDWATER DEVELOPMENT
IN
WANGDUEPHODRANG DISTRICT OF BHUTAN

FINAL REPORT

VOLUME III: SUPPORTING REPORT

APPENDIX-G DOMESTIC WATER SUPPLY SYSTEM

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APPENDIX-G DOMESTIC WATER SUPPLY SYSTEM

G.1 General

The objectives of the study on the water supply systems are as follows:
1) to clarify the present situation of the water supply systems in both the Wangduephodrang town area and rural areas of the study area,
2) to work out the present and future domestic water demands for establishing the Water Resources Development Basic Plan of the Wangduephodrang District,
3) to establish the Urban Water Supply Plan of the Wangduephodrang town area.

In a series of field surveys and investigations which have been conducted so far, the available data and information necessary for fulfilling the above objectives were collected and reviewed, and some field surveys including interview surveys were also carried out. Based on such data and information collected through site investigations, etc., various studies and analyses were conducted in order:

- to estimate the present and the future water demands to examine the present and the future water balance studies,
- to find out the required future improvement of the present water supply systems in the study area on the preliminary basis, in order to resolve the problems and constraints of the present system,
- to establish the implementation schedule to achieve the projected effects as envisaged, and
- to estimate the project costs necessary for implementing the schemes including disbursement schedule.

G.2 Present Situation of Water Supply System

G.2.1 Urban Water Supply System for Wangduephodrang Town Area

(1) Wangduephodrang Town

Wangduephodrang town is located at the junction of the Chang Chhu and the Dang Chhu, and its population is estimated as about 8,350 consisting of about 6,030 residents and 2,320 visitors. The town area extends mainly on the hilly plain of about 100 m higher than both river beds as shown in Fig. G.2.1. Most of the plain lands are occupied by the RBA compounds and the government offices, and the residential areas extends on the sloped lands surrounding these plain lands. The main commercial area is at present temporarily located along the Tongsa road running at the center of the town. These temporary shops and restaurants are planned to be transferred to the sloped area located in the west of the town area near the Chang Chhu according to the future town plan proposed by PWD.

(2) Present Urban Water Supply System

Fig. G.2.2 shows the location and layout of the urban water supply system for the Wangduephodrang town area. The supply system was constructed in 1969 with the assistance of India diverting the river water from the Pe Chhu, a tributary of the Dang Chhu. The system consists mainly of intake facilities, conveyance pipelines, water distribution station and distribution networks in the town area. The details of each facility are explained below.

1) Intake Facilities

The intake is situated at right bank of the Pe Chhu, 1.6 km upstream from the Chhuzonsa, where the Pe Chhu flows into the Dang Chhu. The river water flows directly into the 1,000 mm (w) x 500 mm (d) of concrete open canal by gravity. The raw water for water supply is again diverted to 800 mm (w) x 400 mm (d) of open canal, and then is treated by a grit chamber with a capacity of 70 m^3 (R.T for 1.5 hr) to remove coarse sands and heavy suspended solids. The irrigation water flows in the open canal to the command area in Bajo.

2) Water Conveyance Pipelines

The Bajo irrigation canal was used for conveying the domestic water also, when the supply system was constructed in 1969. Due to deterioration of water quality, about nine (9) km of 4"-steel-made high density polyethylene (HDPE) pipeline was constructed along the national road between Chhuzonsa and Wangduephodrang in 1991 under the UNICEF cooperation. At present, the domestic water is conveyed mainly by the pipelines, and only in the irrigation period during the wet season, the canal water is diverted at the distribution station site to a certain extent to fulfil the present demand of domestic water.

At the most upstream portion, two (2) lines of 4" galvanised steel pipes (SGP) convey raw water with a flow rate of 8 l/sec (29 m^3/hr) in average to the distributing station. The middle portion of the conveyance pipeline is two (2) lines of 4" HDPE buried along the road to Wangduephodrang town. The last portion of the pipeline near the distributing station is 3" SGP.

3) Water Distribution Station

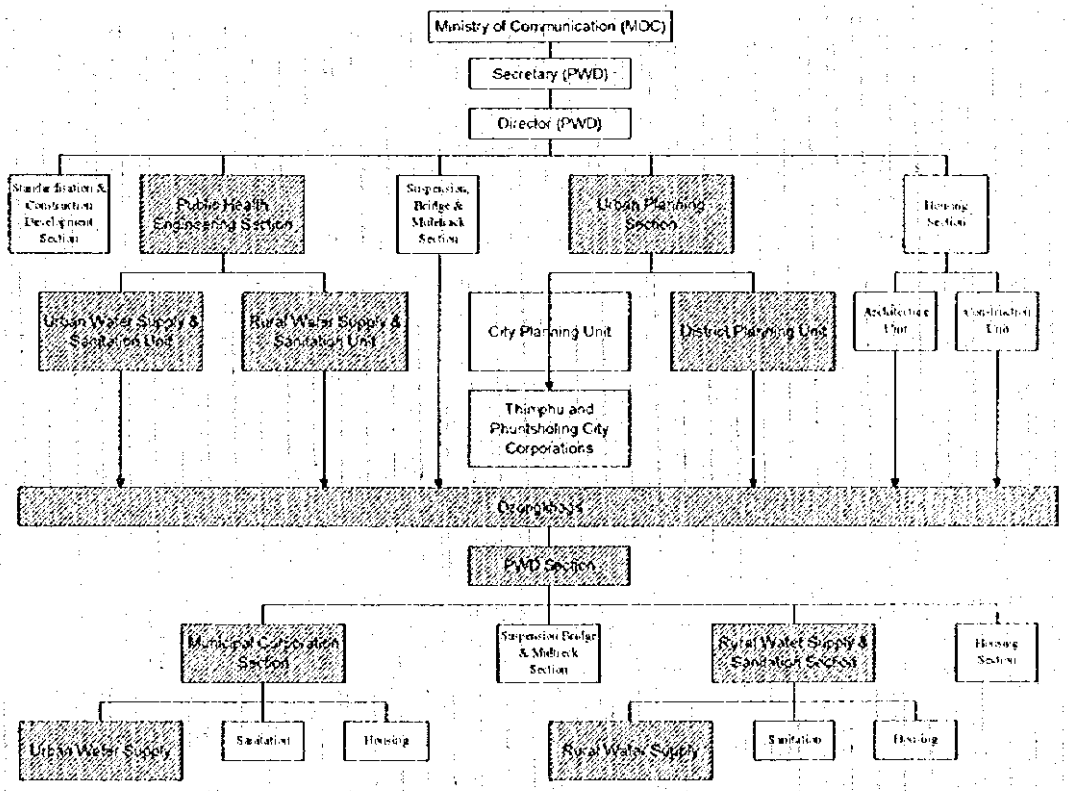
The water distribution station for the Wangduephodrang town area consists mainly of plain sedimentation tanks with a total capacity of 950 m^3, and water distribution tanks with a total capacity of 600 m^3. The raw water conveyed by the pipeline from the intake sites in the Pe Chhu is received at the distribution station, and flows into the sedimentation tanks through a 300 mm wide baffled open channel, and after removing sediments, it flows into distribution reservoirs as shown in Fig. G.2.3.

4) Water Distribution Network

According to the Dzongkhag PWD section, the pipeline network over 6,500m long was installed in 1969, which consists of 4" SGP for 900 m, 3" SGP for 1,500 m, 2" SGP for 800 m, 11/2" SGP for 220 m, 1" SGP for 1,000 m, 1/2" SGP for 2,000 m. The existing layout of such distribution networks are surveyed.

(3) Present Operation and Maintenance of Water Supply System

An intermittent water supply is conducted at present for operating the water supply system in the Wangduephodrang town area. Three (3) times of supply is made a day; three (3) hr in the morning, 2.5 hr for lunch time, and two (2) hr in the evening, totaling 7.5 hr a day. An operator of the Dzongkhag staff stays beside the distribution station to take care of the station including turning the valves in the station on and off. The operation and maintenance of the supply system is managed by the PWD section of the Wangduephodrang Dzongkhag as shown below.



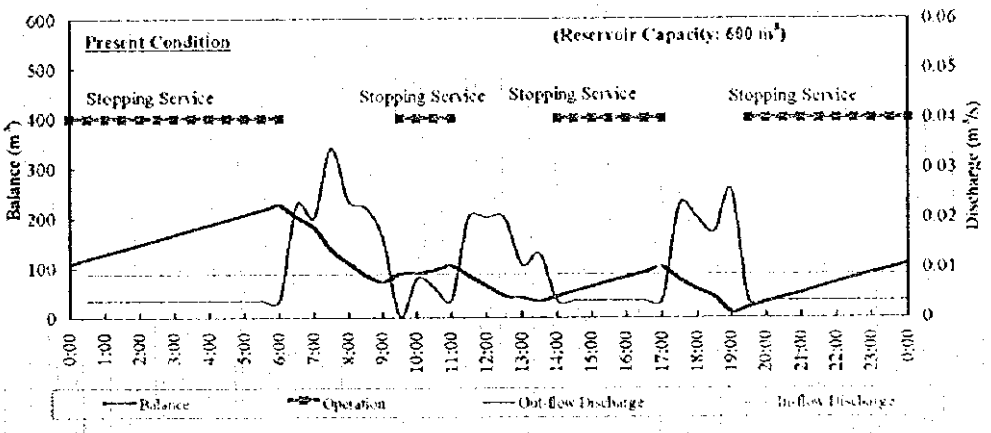
ORGANIZATION CHART OF CITY, URBAN AND RURAL WATER SUPPLY

(4) Present Water Consumption

1) Supplied Water

The variation of water level was observed at the distribution tank, to measure the actual water consumption. As a result, about 780 m^3/day of treated water is distributed to the town area by the distribution station with the maximum and minimum flow rates

of 110 m^3/hr and 53 m^3/hr. The water is distributed only for 7.5 hr a day intermittently. The water consumption per capita is calculated to be about 125 l/day considering the present population of 6,035 and day visitors also use some amount of water. The following figure shows the variation of water levels in the existing distribution tanks and the distributed water discharges observed during the field survey.



PRESENT WATER BALANCE OF DISTRIBUTION TANKS

2) Water Consumption

The supplied water volume is quite different from place to place depending on the topographic and hydraulic conditions of each location. The field survey on the actual water consumption was carried out in some selected areas where the supplied water is considered abundant in the Wangduephodrang town. The daily water consumption per capita is consequently estimated to be 75 l/day under the present life style as shown in the table.

Present Water Consumption per Capita

Description	Consumption
Cloth washing (Laundry)	30 l/c/d
Latrine	5 l/c/d
Bathing	30 l/c/d
Cooking	10 l/c/d
Total	75 l/c/d

The physical loss is calculated to be about 50 l/day per capita, deducting the above consumption per capita of 75 l/day from the observed consumption per capita of about 125 l/day.

G.2.2 Rural Water Supply System

(1) Villages and Communities Identified

Field surveys were conducted to identify the villages and communities located in each sub-area, and population, number of household and present situation of water supply in each villages/communities were also surveyed. As a result, total of 64 villages/communities were identified in the whole study area; 21, 8, 18 and 17 villages/communities in Lobeysa, Bajo, Phangyul and Rubeysa Sub-areas, respectively. The number of households and population were estimated as 627 and 6,684, respectively in the whole study area.

The locations and the households and population of the villages/communities are presented in Fig. G.2.4 and Table G.2.1, respectively. The gewog-wise number of households and population are summarized in the table shown below.

Summary of Identified Villages/Communities

Villages/Communities	Present Population		Villages/Communities	Present Population	
	Household	Population		Household	Population
Lobeysa Sub-area	177	3,086	Phangyul Sub-area	156	1,159
Babesa Gewog	134	2,604	Phangyul Gewog	156	1,159
Thetso Gewog	43	482			
Bajo Sub-area	115	983	Rubeysa Sub-area	179	1,456
Thetso Gewog	58	496	Rubeysa Gewog	102	744
Lingbukha Gewog	31	250	Jena Gewog	64	616
Babesa Gewog	26	237	Thetso Gewog	13	96
-	-	-	Total	627	6,684

(2) Present Rural Water Supply System

The present situation of the rural water supply is also surveyed village by village. The availability of supply system, source of water, households and population served, type of supply scheme, etc. of each village/community are presented in Table G.2.2.

As shown in the table, there are many villages which have the water supply systems constructed with the UNICEF's assistance. In the study area, 31 UNICEF's schemes are found, and most of them are generally considered to be operated well though some stand pipes are found to be out of order. The system consists of stream or spring intake, transmission pipeline with valves, break pressure tank, clear water reservoir, distribution system, tapstands, and sedimentation tanks. In Bhutan, the UNICEF's contribution to the rural water supply is remarkable and successful, and its assistance services are found to be active. Their assistance were commenced in the period of Fourth Five Year Plan (1977 - 1982), and about 1790 schemes have been completed so far under their assistance as shown in Table G.2.3.

The present situation of water supply in each sub-area is described below.

1) Lobeysa Sub-area

The Lobeysa Sub-area consisting of 21 villages/communities has a population of 3,086 and 177 households including schools and government offices. Out of these 21 villages/communities, there are schools and government offices in seven (7) villages. The average size of a household is calculated to be 8.7 persons based on the values counted for the rest of villages/communities.

It is observed that only two (2) villages do not have any water supply system carrying their water from the existing springs and irrigation canals available near their houses. There are eight (8) water supply schemes funded by UNICEF, and 12 villages/communities are provided with the scheme of UNICEF. The other communities which are provided with water supply systems are considered to be government offices, and they have the systems constructed by their respective government organization such as MOA, MOI, RBA, GREF, etc. Most of the existing system takes the water source in the springs in and around the sub-area. The population of 2,729 equivalent to 88 % of the total population is at present served by the present water supply systems in the sub-area as summarized in the table.

Present Water Supply Situation in Lobeysa Sub-area

Item	Total	Served by Existing System	Percent
Population	3,086	2,729	88
Household	177	149	-
No. of Villages/Communities	21	19	-

2) Bajo Sub-area

There are eight (8) villages/communities in the Bajo sub-area, and only one (1), DSC/AMC, is considered to be a government office. The average number of persons of a household is calculated to be 8.1 persons based on the population and the number of household of the villages of this sub-area.

Half of the villages/communities are considered to be left in the condition without any water supply system, and the villagers have to take their water from existing irrigation canals running near their houses. Out of the total population of 983, only 353 persons which is equivalent to about 36 % are at present served by the existing water supply schemes. There are three (3) water supply schemes constructed under the assistance of UNICEF; Proper Bajo, Wangjokha and Matalumchu. The DSC/AMC offices are provided with the supply system constructed by MOA. The present situation of water supply in the Bajo sub-area is summarized in the table.

Present Water Supply Situation in Bajo Sub-area

Item	Total	Served by Existing System	Percent
Population	983	353	36
Household	115	40	-
No. of Villages/Communities	8	4	-

3) Phangyul Sub-area

18 villages are identified in the Phangyul sub-area, and total population and total number of household are estimated as 1,159 and 156 with the average population per household of 7.4 persons. Most of the villages are located on the high hilly lands along the valley of the Dang Chhu.

Nine (9) villages in the sub-area do not have any water supply system, and 745 persons are left without any supply system. Such villagers who do not have proper supply system have to take water from irrigation canals or existing springs. There are seven (7) UNICEF schemes, and two (2) private schemes in the sub-area. Only 414 persons are served by these existing supply schemes at present, and this value is considered equivalent to only 36 % as shown in the above table.

Present Water Supply Situation in Phangyul Sub-area

Item	Total	Served by Existing System	Percent
Population	1,159	414	36
Household	156	57	-
No. of Villages/Communities	9	9	-

4) Rubeysa Sub-area

In the Rubeysa sub-area, there are 17 villages/communities identified, and out of them 13 villages are provided with the UNICEF's water supply scheme. The population and the number of households are estimated as 1,456 and 179, respectively, and the average population per household is calculated to be 8.1 persons. As shown in the table, a population of 1,006 is considered to be provided with proper water supply system out of the total population of 1,456.

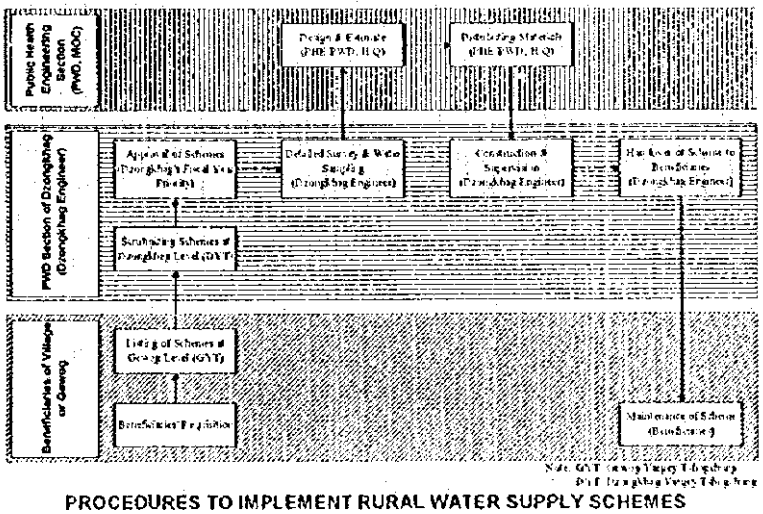
Present Water Supply Situation in Rubeysa Sub-area

Item	Total	Served by Existing System	Percent
Population	1,456	1,006	69
Household	179	143	-
No. of Villages/Communities	17	13	-

(3) Present Operation and Maintenance of Water Supply System

The services of national level such as planning, etc. are taken up by the Public Health Engineering Section of PWD of MOC, while the Rural Water Supply & Sanitation Section of each Dzongkhag takes care of the implementation.

The above figure schematically presents the procedures to implement the rural water supply schemes. The beneficiaries consisting of more than five (5) households present their requisition for the necessary water supply system, and such submitted requisition are scrutinized by the Dzongkhag Engineer for selecting and prioritizing



PROCEDURES TO IMPLEMENT RURAL WATER SUPPLY SCHEMES

of water supply. The detailed survey and sampling of the raw water are conducted by the Dzongkhag Engineer. The design is transferred to the Public Health Engineering Section of PWD in MOC Head Quarter for further detailed design and cost estimate. The procurement and delivery of the necessary materials are controlled by PHE/PWD of MOC Head Quarters. The construction of the supply system is conducted under the supervision of the Dzongkhag Engineer with the materials delivered at the site. The common labors necessary for the construction works have to be prepared by the beneficiaries themselves. After the completion of the construction, the system is handed over to the beneficiaries for the operation by them. The operation and maintenance of the water supply system handed over have to be conducted by the beneficiaries themselves under the supervision of the Dzongkhag Engineer.

(5) Present Water Consumption

Some field surveys were conducted to grasp the actual water consumption in the rural areas. As shown in the right table, the total consumption per capita is observed to be 45 l/day.

Surveyed Water Consumption in Rural Areas

Description	Consumption
Cloth washing (Laundry)	20 l/c/d
Latrine	5 l/c/d
Bathing	10 l/c/d
Cooking	10 l/c/d
Total	45 l/c/d

According to the UNICEF's guideline, the water supply system to be constructed in rural areas should be designed based on the water demand per capita of 67 l/day, which is obtained multiplying the consumption of 45 l/day with 1.5 considering the further increase of population. This increase is translated to an annual population increase of about 3.4 % as shown in the above table.

Population Increase in Rural Areas

Present Population (1995)	2002	2007
1.0	1.26	1.50

G.3 Population Projection and Water Demand

G.3.1 Wangduephodrang Town Area

(1) Present Population Served and Service Area

The present water supply system covers the whole town area of about 110 ha, and all of the population therein is considered to be served by the present system with an intermittent operation. The field survey was conducted during the field survey period to roughly grasp the actual population in these areas, and consequently the present population was estimated as 8,355 for 1995 including the day time visitors of 2,320 as summarized in the table. The details of the population is presented in Table G.3.1.

Construction of a junior high school is going on in the north to the existing AMC yard in the Bajo area, and its completion is scheduled for 1997. The present junior high school is planned to be transferred to the new school when its construction is completed.

Summary of Population Surveyed in Wangduephodrang Town Area

Category	Population in 1995	
	Residents	Day Visitors
Township Area	1,820	0
Commercial and Shopping Area	520	400
Monk Body	65	0
Administrative Organization	60	150
RBA Complex and Outer Quarters	3,140	370
RBA Hospital	175	200
Primary and Junior High School	30	1,200
RNRRC Office	225	0
Total	6,035	2,320

(2) Wangduephodrang Town Planning

According to PWD of MOC, the expansion of the present township is considered with some alternatives at present, but any final decision has not yet been made so far due to the limited land resources in the surrounding areas of the township. There are two (2) alternative plans being considered as shown in Fig. G.3.1, and both plans aim mainly to transfer the existing shopping and commercial areas located at the center of the township to the other areas by:

- newly expanding the town area to include the experimental farm yards of RNRRC for the further development, or
- developing the present residential areas extending on rather steep slope lands west to the town center along the Chang Chhu.

In planning the future water supply system, it is proposed to adopt the former plan, since it seems to be more possible to reserve such lands for development in the present township than out of it considering that the present experimental farm yards in RNRRC are being utilized to the full extent and there is not any alternative sites for relocation at present.

(3) Future Population Projection

The NUDC conducted the population survey of the Wangduephodrang town area in 1989 for the Seven Towns Water Supply Study, and estimated that resident and day time population are 3,800 and in 800, respectively. Comparing with the present population for 1995 and those for 1989, the population growth rate of six (6) years from

Projected Population in the Expanded Service Area

Category	2002		2007	
	Residents	Day Visitors	Residents	Day Visitors
Junior High School in Bajothang	10	220	165	435
Agricultural Machinery Center (AMC)	0	7	0	7
Druk Seed Corporation (DSC)	37	6	37	6
Total	47	233	202	448

1989 to 1995 is calculated as high as eight (8) % per year. Since this growth rate is considered extremely high, more realistic value of two (2) % per year is applied for projecting the population in 2002 and 2007 considering the Wangduephodrang Dzongkhag's expectation.

As described in the previous Sub-section (2), the town development will be made in the present town area in their town plan, and then no expansion is necessary to be considered. However, some extent of development such as construction of residential houses, etc. is expected to be made in the lands of existing AMC and DSC yards along the Chang Chhu towards the new school site, because such areas are considered to become high potential areas in development when the development is realized in future based on the said town plan. The service area is, therefore, proposed to be expanded so as to include such areas which are located north to the present township along the Chang Chhu. The expected population increase in such areas to be newly included in the future service area is summarized in the table, and its breakdown is presented in Table G.3.2.

The future population increase projected for the target year of 2002 and 2007 is set as shown in the table based on the above discussions.

The number of day visitors shares 38 % of the resident population, and the total population is projected at 9,847 (consisting of 6,979 residents and 2,293 day visitors) and 11,212 (consisting of 7,856 residents and 3,356 day visitors) for 2002 and 2007, respectively including those in the present and the future extended service areas. This projected population increase is illustrated in Fig. G.3.2.

Projected Population in Wangduephodrang Town Area

Categories	1995	2002	2007
1. Present Service Area			
Resident	6,035	6,932	7,654
Growth Rate (%)	-	(2.00)	(2.00)
Day Visitors (38%)	2,293	2,634	2,908
Sub-total	8,328	9,567	10,562
2. Extended Service Area			
Resident	0	47	202
Day Visitors	0	233	448
Sub-total	0	280	650
3. Total Population			
Resident	6,035	6,979	7,856
Day Visitors	2,293	2,867	3,356
Total	8,328	9,847	11,212

(4) Future Water Demand

1) Water Demand per Capita

As aforesaid, the present water consumption per capita is measured to be 125 l/day, which consists of the net consumption of 75 l/day and the physical loss of 50 l/day (40 % of the total demand). Based on this measured value, the future demand is estimated as stated below.

- The consumption of laundry and cooking water will be gradually increased as the living standard of the dwelling people rises, and they will reach 40 l/day and 20 l/day in the target year of 2007, respectively.

- The latrine water will become four (4) times of the present one in 2007, because the flush toilet is considered to be introduced in some advanced households in the town in near future.

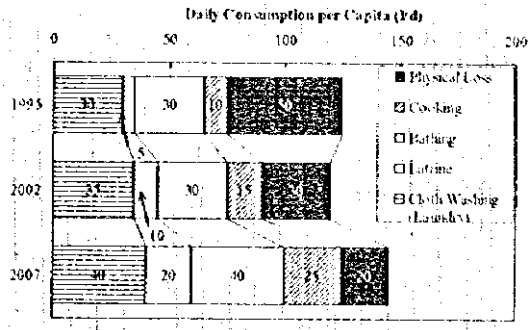
- The consumption of bathing water will not be increased substantially, but will rise to 40 l/day in 2007.

- The present physical loss of 40 % will be applied at the initial time, but it will be decreased substantially to 25 % and 14 % in 2002 and in 2007, respectively, since the moral to save water consumption will prevail among the dwellers in the town as an effect of introducing the metered supply system.

Present and Future Water Consumption per Capita

Description	Present 1995	Future 2002	Future 2007
Cloth Washing (Laundry)	30	35	40
Latrine	5	10	20
Bathing	30	30	40
Cooking	10	15	25
Consumptive Demand	75	90	125
Physical Loss	50	30	20
(% to Total Demand)	(40)	(25)	(14)
Total Water Demand	125	120	145

As a result, the consumptive demand per capita is increased from present 75 l/day to 125 l/day in 2007. The total demand per capita will be once decreased from present 125 l/day to 120 l/day in 2002 and will be increased to 145 l/day in 2007 as shown in the table and figure.



PRESENT AND FUTURE WATER CONSUMPTION PER CAPITA

2) Total Water Demand

Considering the above discussion on the future population and the future water demand per capita, the total water demand for the whole of the served area is calculated. The average daily demand and the maximum daily demand are calculated. The average daily demand is calculated by multiplying the estimated water demand per capita by the served population, and the 25 % - increased value of the average demand is taken for the maximum daily demand. The estimated daily water demands are presented in the table, and are illustrated in Fig. G.3.3.

Estimated Water Demand

Year	Average Daily Demand (m^3/day)	Max. Daily Demand (m^3/day)
1995	812	1,015
2002	906	1,133
2007	1,236	1,546

(5) Block-wise Population and Water Demand

The service area of the water supply system is divided into six (6) blocks as shown in Fig. G.3.4. The block-wise population is calculated based on the results of the population survey which was conducted during the field survey period, as shown in the table.

The average and maximum daily demands for each divided block are also calculated taking proportional values of the above calculated block-wise population as shown in the above table. The details of the above estimated values are tabulated in Table G.3.3.

Block-wise Population in the Wangduephodrang Town Area

Year	Blocks						
	1	2	3	4	5	6	Total
1995	2,935	1,555	950	2,743	145	-	8,328
2002	3,372	1,786	1,618	1,926	166	978	9,847
2007	3,723	1,972	2,368	1,545	183	1,421	11,212

Block-wise Water Demand for the Wangduephodrang Town Area (m^3/day)

Year	Blocks						
	1	2	3	4	5	6	Total
Average Daily Demand							
1995	286	152	93	267	14	-	812
2002	310	164	149	177	15	90	906
2007	411	217	261	170	20	157	1,236
Maximum Daily Demand							
1995	358	189	116	334	18	-	1,015
2002	388	206	186	222	19	113	1,133
2007	513	272	326	213	25	196	1,546

G.3.2 Rural Areas

(1) Population and Population Served

As mentioned in the previous chapter, the present population and those served by the present water supply schemes are summarized in the table.

Population and Population Served in the Study Area

Sub-areas	Population	Population Served	Service Ratio (%)
Lobeysa	3,086	2,729	88
Bajo	983	353	36
Phangyul	1,159	414	36
Rubeysa	1,456	1,006	69
Total	6,684	4,502	67

The population of the Study area is 6,684 and 4,502 persons, which are equivalent to 67 % of the total population are served by the present water supply schemes. The rest of the population of 2,182 persons which are equivalent to 33 % are left without any supply system, and they have to consume their domestic water from rivers, streams or irrigation canals near their houses facing the risks to be bacteriologically infected.

According to the Dzongkhag administration, the population growth rate in rural areas have gradually increased for these ten (10) years in all villages, and it is considered that the population in these rural villages looks like reaching the saturation in the near future because of the limited land resources available and the poor possibility to maintain self-sufficient economy. However, the rural population is considered to increase for the further 10 years at least. Therefore, in this study, it is proposed to apply two (2) % of annual increase, a rather conservative value of increase, for estimating the future population. The projected population in 2002 and 2007 is summarized for each sub-area as shown in the table.

Projected Future Population in the Study Area

Sub-areas	Population		
	1995	2002	2007
Lobeysa	3,086	3,545	3,914
Bajo	983	1,129	1,247
Phangyul	1,159	1,331	1,470
Rubeysa	1,456	1,672	1,847
Total	6,684	7,677	8,478

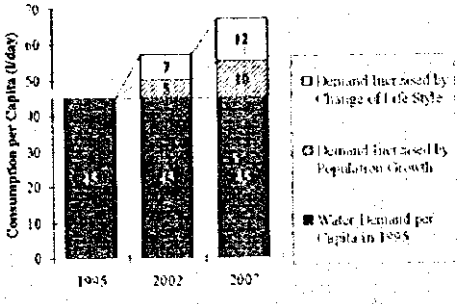
(2) Water Demand

As described in the previous chapter, the present water consumption per capita as measured through the field surveys is 45 l/day and this consumption meets that recommended in the UNICEF's guideline. According to the UNICEF's guideline, it is further recommended to apply the 50 % - increased value for estimating the future water consumption per capita. The increased value is calculated to be 67 l/day. In case that the rural population increases with the growth rate of two (2) % as projected, it is translated that the 45 l/day of consumption per capita would be increased to 57 l/day (45 l/day x 1.02^{12}) against the same present population. Therefore, if the value of 67 l/day is applied as recommended by UNICEF, the balance of 10 l/day (67 l/day - 57 l/day) is considered as the value increased due to leveling up of villagers' living standards. This value is equivalent to about 22 % of the present consumption per capita, and is considered quite reasonable taking into account of their present life styles. It is, therefore, proposed to apply the same values as the UNICEF's guideline for planning rural water supply systems in the Study area as shown in the table.

Present and Future Water Consumption per Capita

(l/day)

Present	Future	
1995	2002	2007
45	57	67



INCREASE OF CONSUMPTION PER CAPITA

Present and Future Water Demand

(m^3/day)

Sub-areas	Water Demand		
	1995	2002	2007
Lobeysa	139	176	207
Bajo	44	56	66
Phangyul	52	66	78
Rubeysa	66	83	98
Total	301	381	449

Based on the above discussion, the future water demand in each sub-area is calculated as shown in the table. The total demands of the target years of 2002 and 2007 are estimated as 381 m^3/day and 449 m^3/day , respectively.

G.3.3 Constraints in Present Water Supply

A series of field surveys and investigations have been carried out so far, and some constraints and problems which are considered to be solved were found as stated below.

(1) Urban Water Supply System in Wangduephodrang Town Area

1) Supply Capacity

Since the quantity delivered from the Pe Chhu is not sufficient, the water distribution is made intermittently at present and the irrigation water conveyed by the Bajo canal is also sometimes used for the urban water supply. The capacity of the present water supply system is considered to be as small as 780 m^3/day, which is caused by the insufficient conveyance capacity of pipeline from the Pe Chhu to the distribution station. Taking into account that the water demand of the town area would increase in

future as mentioned in the Section G.3.2, it is necessary to increase the supply capacity of the present system.

2) Distribution Networks

The present distribution networks were constructed in 1969. Since then some main lines have been renovated and many branch lines have been added and expanded at random resulting in the present inadequate and unbalanced distribution of networks as stated below.

- It is impossible to maintain even water supply over the service area because of uneven load distribution of water demand.
- It is difficult to achieve proper operation and maintenance due to lack of necessary facilities such as valves, meters, etc.
- Inadequate construction makes proper maintenance of the distribution networks impossible; pipe materials are not buried to the proper depth to keep them safe and in good condition.

3) Water Quality

The irrigation water of the Bajo canal is frequently used for the urban water supply during the irrigation season, and such irrigation water is apt to be bacteriologically contaminated by the animal waste and land slide mud. It is, therefore, necessary to increase the capacity of the conveyance pipeline from the Pe Chhu. In addition, no treatment is conducted in the present distribution system except for simple sedimentation at present. Considering that the turbidity of the raw water from the Pe Chhu becomes higher than 20 frequently during the rainy season, it is necessary to reinforce such facility which reduces turbidity and remove color substances. Chlorination is also necessary to keep the distributed water free from infection.

(2) Rural Area

In rural areas, the service ratio of the existing water supply schemes reaches only 67 %, and the remaining 33 % of dwellers have to take water from irrigation canals, river streams or small spring pools for their domestic use. Such water is easily infected by animal waste, etc. and is unstable without any protection. In order to supply safe water to the dwellers in rural areas, it is necessary to provide adequate water supply systems with stable and protected water sources.

G.4 Proposed Basic Water Resources Development Plan for Urban and Rural Water Supply

G.4.1 Basic Concepts

(1) Objectives of Basic Development Plan and Factors to be Considered

As aforesaid, the inhabitants in the Wangduephodrang town is at present facing the shortage of water due to the limited capacity of the present water supply system. According to the Dzongkhag Administration, the population of the town area is forecasted to increase with a rather high growth rate rushing towards the saturation in the coming decade, since more rapid urbanization and population concentration are expected to take place in the near future as same as the other similar scale of towns in the country.

To supplement the shortage of raw water, the irrigation water of the Bajo canal is often taken, and such irrigation water conveyed with open canal systems is considered usually to be infected by animal wastes, land slide soils, etc.

These situations mentioned above are found in the other towns and urban areas in the country, and it is desired to provide the adequate water supply facilities as soon as possible. Therefore, the GOB recently commenced to introduce new water supply systems to improve existing schemes giving them the high priority in their national development plans in order to cope up with such increasing water demand in the country.

As for the rural areas, though the implementation of rural water supply schemes has progressed so far reaching the service ratio of 67 % in the Study area, the remaining population of over 2,000 are left in the situation with neither stable nor safe water supply. It is, therefore, considered essential to provide proper water supply systems enough to supply safe and stable domestic water for such rural inhabitants.

In the context mentioned above, the basic water resources development plan for the rural and urban water supply is to be established and formulated with the following objectives:

- to provide safe domestic water free from any infection for as many rural and urban inhabitants as possible by providing proper water treatment facilities in the sustainable manners,
- to realize the stable and reliable water supply throughout a day as well as a year by providing the inhabitants in rural and urban areas in the Study area with the adequate capacity and quality of water supply systems, and
- to improve and raise the lives of urban and rural inhabitants for creating the improved social conditions through sustainable and balanced development methods considering the constraints found and the present situation of the Study area as well.

In formulating and establishing the basic water resources development plan for the rural and urban water supply, particular attentions are to be paid for the following items.

- Considering the present situation that many inhabitants both in urban and rural areas are suffering from shortage of water, the highest priority will be given in the plan to reserve enough volume of domestic water to meet the increasing demand.

- The level of the improved and/or introduced water supply systems should be of the quality and level as same as those being implemented in the other similar areas in the country in order to avoid uneven development.

- It is necessary and essential to consider the existing plans related to the water resources development in the Study area as well as the municipality and town development plans in order to formulate such basic plans in a most realistic and suitable way.

(2) Target Year

The target year has to be set considering the implementation period; hence the final target year is set as 2007 taking into account of the implementation period of about 15 years and the period covered by a regular five year plan of the country. If the future five year plans are prepared with the regular five (5) years of interval, the 9th Five Year Plan will cover the five (5) year period from 2002 to 2007. The final target year is, therefore, set at 2007 adjusting the time frame of the basic plan to that to be covered by such five year plans. In addition, the year of 2002 is also taken as a milestone for implementing the basic plan for about 10 years later and five (5) years before the final target year.

The water resources development basic plan for the rural and urban water supply is prepared in accordance with this basic time frame. The whole plan is first figured out for the final target year of 2007, and then it is divided into some steps of implementation considering priority, importance, urgency, etc.

G.4.2 Urban Water Supply System in Wangduephodrang Town Area

(1) Service Area and Required Capacity of Water Supply System

1) Service Area

The present urban water supply system covers an area of about 110 ha consisting of the RBA complex and quarters, the Dzongkhag and administrative areas, the commercial and shopping areas, the residential areas, etc. Any extension of the present town area is scheduled at present according to the Town Planning Section of PWD except for the areas where some internal shuffling of land use is scheduled. However, the areas of about 23 ha located between the present DSC/AMC yards and the construction sites of the junior high school are recommended to be included, and then the total service area of the water supply system will be 133 ha.

2) Required Capacity of Urban Water Supply System

As mentioned in the previous sections, the present productivity of the existing water supply system is considered to be 780 m^3/day mainly because of the limited conveyance capacity of the existing conveyance pipeline from the Pe Chhu.

Estimated Water Demand and Required Additional Capacity

Year	Average Daily Demand (m^3/day)	Max. Daily Demand (m^3/day)	Required Additional Capacity (m^3/day)
1995	812	1,015	-
2002	906	1,133	363
2007	1,236	1,546	776

The domestic water demand, on the other hand, is estimated based on the projected future population and the estimated demand per capita as shown in the table. It is, therefore, necessary to increase the water supply capacity from 780 m^3/day to 1,133 m^3/day and 1,546 m^3/day in 2002 and 2007, respectively. The capacity to be increased is calculated to be 363 m^3/day and 776 m^3/day in 2002 and 2007, respectively. The future demand and the capacity to be increased in future are illustrated in Fig. A.4.1.

Therefore, the proposed capacity of the conveyance pipeline from the Pe Chhu and the proposed daily productivity of the distribution station are set at the values as stated below, considering the internal requirement of five (5) % for washing tanks.

- Conveyance capacity of the proposed conveyance pipeline: 1,700 m^3/day
  (including 5 % of the internal requirement for washing, etc.)
- Productivity of the proposed water distribution station: 1,700 m^3/day
- Distribution capacity of the distribution networks: 1,600 m^3/day

(2) Water Source

1) Possible Water Resources for Urban Water Supply

The present water supply system diverts its raw water from the Pe Chhu, and the diverted water is conveyed to the distribution station through the conveyance pipelines. After a simple treatment, the water is distributed by the distribution networks extending over the town area. No other kind of water resource is utilized for the present urban water supply.

The following water sources are considered possible to be developed to supplement the present resource of the Pe Chhu for the urban water supply system in the Wangduephodrang town area.

- Surface water in the Chang Chhu and the Dang Chhu
- Groundwater in the south of the Bajo
- Sub-surface water in the areas along the Chang Chhu

Spring water is not considered for the urban water supply in the Study, because its potential is expected to be quite less comparing with the estimated demand of water supply and possible source sites are scarce.

The surface water of the Chang Chhu and the Dang Chhu is found to be abundant, but its utilization is judged to be quite difficult, because of the following reasons.

- Since the velocity and depth of river flow in these rivers are fast and shallow in the reaches near the town, it is necessary to provide the intake facilities with sufficient capacity of suction pits which require difficult underwater construction.

- The inlet structure constructed beside the river is easily clogged by the sediment loads of the river, and it is difficult to conduct necessary sediment removal works for the Dzongkhag administration due to the limited budget allocation for it.

- A large lift of pumping facility is required to lift the diverted water up to the existing water distribution station; the necessary height of the lift is measured over 140 m.

- If the supplemental volume to meet the estimated future demand (about 1,000 m^3/day) is served by the river water, a huge capacity of distribution reservoir is required to be constructed since the operation hour of the pumping station is limited.

Furthermore, it is recommended to utilize neither groundwater in the south of the Bajo sub-area nor sub-surface water in the areas along the Chang Chhu for supplementing whole of the future incremental demand of the urban water supply in the following aspects.

- Considering that the present distribution reservoir tank is located at the highest point in the town area over 1,300 m and the both sites of tubewells and shallow wells are in quite low areas in the south of the Bajo sub-area, it is considered necessary to apply the pumping system to lift the raw water up to the distribution station. However, it is recommended to reduce such application of pumping facilities as much as possible which requires expensive related facilities such as electric supply in order to realize the liable water supply and to achieve an easy operation and maintenance.

- If the whole of the future incremental volume is served by the newly developed groundwater or sub-surface water resources, the pumping facilities are necessary as explained above. Then, a large capacity of distribution tanks is necessary since such pumping facilities are not be able to be operated throughout a day. However, taking into account that the present yard of the existing distribution station is quite limited being situated on the top of hill, it is judged to be difficult to extend the present yard for constructing the additional reservoir tanks.

2) Alternative Measures to Develop the Supplemental Water Resources for Urban Water Supply for Wangduephodrang Town Area

Based on the discussion made in the above section, in this Study, the alternatives for establishing the most appropriate water resources development plan are to be set so as to consider only the optional plan to cover the extended areas between the school yards being constructed and the DSC/AMC yards in the Bajo sub-area (Block 6) from the following considerations.

- As discussed in the above section, it is recommended to apply the development of neither groundwater nor sub-surface water for supplementing whole of the incremental demand.

- Since the existing water supply network covers whole of the town area as its service area at present, and only the areas along the Chang Chhu in the Bajo sub-area are not covered.

The following three (3) alternatives are consequently considered in this Study to supplement the shortage of supply capacity of the urban water supply system.

Alternative 1 ➡ Increase the present diversion water from the Pe Chhu

The present urban water supply system is basically utilized with some extent of improvement that meets whole of the incremental demand including that for Block 6 which is proposed to be extended. The proposed improvement consists of the following items:

- construction of the conveyance pipeline from the Pe Chhu to the distribution station,

- improvement of the present treatment facilities adding raw water receiving tank, flocculator, rapid water filter, etc. and increasing the capacity of distribution reservoir, and

- improvement of the existing distribution networks with metered system.

Alternative 2 ➡ Develop the groundwater resources available in the south of the Bajo sub-area

The groundwater resources available in the farm yards of RNRRC are developed for the additional demand of the extended area (Block 6), and the incremental demand of the other blocks are served by utilizing the existing water supply system. In this case, an isolated supply system is provided for only the Block 6. The present system for the Blocks 1 to 6 has to be improved by increasing its supply capacity. The proposed improvement is composed of the following items:

- construction of deep tubewells of about 50 m depth in the RNRRC farm yards with the distribution networks and reservoir tanks for supplying the water to the inhabitants in Block 6,

- construction of new conveyance pipeline from the Pe Chhu to the existing water distribution station in the town area, whose capacity has to meet the increased demand of the Blocks 1 to 5,

- improvement of the present treatment facilities adding raw water receiving tank, flocculator, rapid water filter, etc. and increasing the capacity of distribution reservoir, and

- improvement of the existing distribution networks with metered system.

Alternative 3 ➡ Develop the sub-surface water resources available in the area along the Chang Chhu in the Bajo sub-area

The sub-surface water resources expected to be available in the areas along the Chang Chhu are developed for the additional demand of the extended area (Block 6), and the incremental demand of the other blocks are served by utilizing the existing water supply system. In this case, an isolated supply system is provided for only the Block 6 as same as Alternative 2. The present system for the Blocks 1 to 6 has to be improved increasing its supply capacity. The proposed improvement consists of the following items:

- construction of shallow tubewells of about eight (8) m depth in the areas along the Chang Chhu between the school yard under construction and the DSC/AMC yards with the distribution networks and reservoir tanks for supplying the water for Block 6,

- construction of new conveyance pipeline from the Pe Chhu to the existing water distribution station in the town area, whose capacity has to meet the increased demand of the Blocks 1 to 5,

- improvement of the present treatment facilities adding raw water receiving tank, flocculator, rapid water filter, etc. and increasing the capacity of distribution reservoir, and

- improvement of the existing distribution networks with metered system.

The above-stated alternatives, presented in Fig. G.4.2, are scrutinized and compared with each other, and consequently it is concluded that the Alternative 1 is considered the most appropriate for supplying the water to the Block 6 as stated below.

- The capacity of the present water supply system is considered to be 780 m^3/day as a whole mainly because of the limited conveyance capacity of the pipeline from the Pe Chhu, and hence if such limited conveyance capacity is increased by improving or replacing it, the supply capacity is expected to be increased to the substantial

extent with a little modification of the existing reservoir tanks in the distribution station.

- As discussed in the previous section on the block-wise demand, the daily demand of about 200 m^3/day is estimated for the target year of 2002 sharing only 12.5 % of the whole estimated demand of 1,600 m^3/day. The scale of the necessary facilities for the present service area such as conveyance pipeline, distribution and treatment facilities, etc. are not reduced even if the planned supply capacity is decreased from 1,600 m^3/day to 1,400 m^3/day (1,600 m^3/day - 200 m^3/day) considering standard sizes of the materials to be used for the construction. This means that the construction costs for the Alternative 1 are not decreased by such small decrease of supply capacity.

- In case that the Alternative 2 or 3 is applied, the total construction costs for the Alternative 1 is rather increased with those for the additional facilities to be constructed to supply water to the Block 6 such as shallow or deep wells reservoir tank, pumping facilities, etc.

- The Alternative 1 is considered to be the most appropriate from the view point of operation and maintenance aspects also, since it is considered that the operation and maintenance works for the uniform system are able to be conducted more easily than those for the complicated and mixed system like Alternatives 2 and 3.

- Taking into consideration that the electric supply condition is not considered well in the area, the system requiring continuous and stable electric supply is not recommended. In case of the Alternative 1, the conveyance and distribution of the supplied water depends only on the gravity flow.

As explained above, the Alternative 1 is judged to be the most appropriate to supplement the supplied water to cope up with the increasing demand of the urban water supply system for the Wangduephodrang town area.

(3) Proposed Water Supply System

The proposed water supply system for the urban water supply of the Wangduephodrang town area consists of:

- the intake and conveyance facilities,
- the water treatment and distribution station, and
- the distribution networks and house meters.

The types, capacities, scales and dimensions of these facilities are proposed as explained below.

1) Intake and Conveyance Facilities

a) Intake and Sediment Removal Facilities

The raw water is diverted directly from the Pe Chhu at present with 1,000 mm (w) x 500 mm (d) open channel by gravity on the right bank of the river, and the diverted water is conveyed through the open channel together with irrigation water. The water for the urban water supply is separated at the point of 65 m downstream from the intake structure, and the separated water flows into the sediment removal structure made of a grit chamber of 70 m^3 capacity located beside the open channel for irrigation.

The design discharge of the conveyance pipeline is calculated to be 20 l/sec for the target year of 2002 on the condition that the raw water is diverted continuously from the river for a day (1,700 m^3/day / 86,400 sec = 20 l/sec). The existing open channel is judged to have enough capacity to flow this discharge, even if the irrigation water requirement of the Bajo canal is considered.

The existing sediment tank made of reinforced concrete is found to be functioning well at present, and is considered well functional in the future plan also although some extent of cleaning is required.

Therefore, it is proposed to utilize the existing intake and sediment removal facilities as they are utilized now.

b) Conveyance Pipeline

As described in the previous chapter on the present condition of the urban water supply, the diverted raw water is conveyed by the pipelines to the existing water distribution station at present. The existing pipelines run mainly along the national road for Tongsa, and their distance is measured to be 8,336 m according to the results of the topographic survey.

The flow capacity of the existing pipelines is estimated as eight (8) l/sec, which is quite smaller than the design discharge of 20 l/sec. The pipelines are made of galvanized steel at the most upstream and downstream portions only, while the middle portion is of 4" HDPE pipes and partly broken causing leakage of water. Therefore, it is recommended to replace the existing one in this Study.

Route of New Conveyance Pipeline

There are two (2) routes which are considered as options for the new conveyance pipeline. One is the route along the existing Bajo canal and the other is along the national road for Tongsa. The existing pipelines run along the latter route. Both routes are scrutinized and compared in detail, and the latter route is recommended to be considered for the new conveyance pipeline considering the following findings.

- The former route has a mild and constant slope to reach the distribution station, resulting in rather moderate pressure variation, while the latter route's profile reveals sudden and frequent changes of pressure due to its topography.

- The latter route runs geologically more stable zones than the former one, and many gullies are formed along the route. Hence the latter route looks to be safer, and less construction costs are expected.

- There is no space for construction and placing the piping materials along the existing Bajo canal. Therefore, the latter route is recommended to enable easy operation and maintenance as well as easy and smooth construction.

Type of Piping Materials

The following three (3) types of piping materials are considered as options for materials of the new conveyance pipelines.

- PVC pipe

- Steel pipe

- Ductile iron pipe

Among the above piping materials, the ductile iron pipe is judged to be the most suitable for the construction of new conveyance pipeline after the following considerations.

- The geological situation in the Study area like Himalayan region is considered as still unstable. In the areas along the proposed route, many land sliding are found, and many efforts have been taken to prevent the national road from damages induced by such land sliding. According to the results obtained through the geological hazards assessment, the vulnerability in this area is the highest. It is, therefore, necessary and essential to adopt such materials which are considered as strong and bearable against excessive pressures and stresses caused by unstable geological conditions.

- In order to proceed with the construction works smoothly as scheduled under the condition that the availability of construction equipment is limited and skilled laborers are found scarce, it is necessary to apply the materials that make joint works easy, because such pipe joints are considered to be the most important to avoid unexpected leakage of water, etc.

- The materials which are strong and bearable against the deterioration and weathering are recommended to be adopted in order to reduce the replacement costs after the completion of construction as much as possible.

- The PVC materials are considered to last a long time, but are weak in bearing the inner and outer stresses and pressures. The steel pipe is rather strong and

bearable, but the welding work requiring skilled welders is essential to joint these materials. The ductile iron pipe is considered stronger against such stresses and pressures and easily jointed and last for a long time.

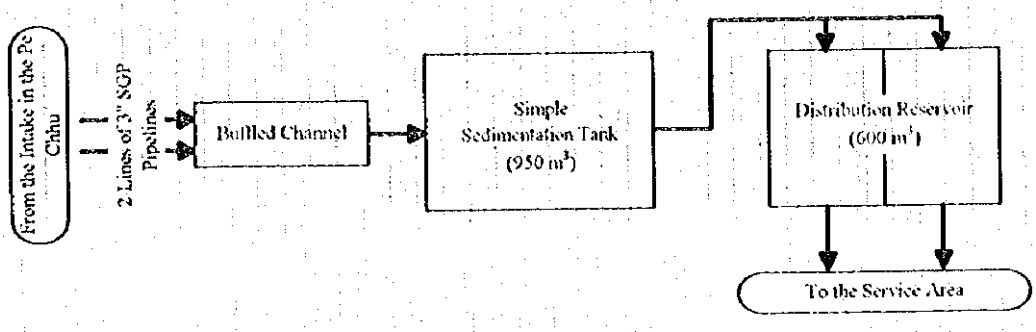
The principal features of the proposed new conveyance pipeline are summarized below.

- Design discharge: 1,700 m^3/day (20 l/sec)
- Design water levels: Grit Chamber LWL: 1,428 m, HWL: 1,430.5 m)
  Raw water receiving tank 1,344 m
- Total distance: Approximately 8.4 km
- Diameter: 8 inch
- Type of piping materials: Ductile iron pipe

The longitudinal profile of the proposed conveyance pipeline is presented in Fig. G.4.3.

2) Treatment Facility

As shown in the following flow chart, only simple sedimentation is performed in the present water distribution station.



FLOW CHART OF EXISTING WATER DISTRIBUTION STATION

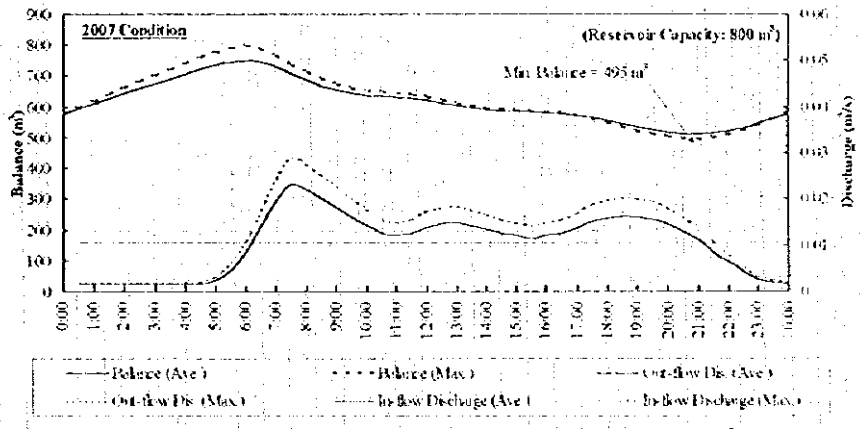
The water is delivered from the existing intake through two (2) lines of the conveyance pipelines with a maximum discharge of 8 l/sec, and received water passes the baffled channel to the simple sedimentation tank, of about 950 m^3 capacity. The distribution reservoir of about 600 m^3 capacity is located adjacent to the sedimentation tank. The flow of treated water is regulated in this tank and distributed to the service area in the town.

The present distribution station is scrutinized to find out the necessary items of improvement as stated below.

a) Daily Productivity of Distribution Station

The daily productivity of the proposed distribution station is set at 1,700 m^3/day as aforesaid. The capacity of the existing sedimentation tank (950 m^3) is considered to be so sufficient that about 13 hr of retarding time is considered enough to allow the required sediment settlement. However, the capacity of distribution reservoir measured to be 600 m^3 is considered insufficient considering that this capacity is translated to only about eight (8) hr of retarding time.

Therefore, it is proposed to increase the capacity of distribution reservoir from present 600 m^3 to 800 m^3 so as to reserve the capacity for storing 11 hr of distribution water. The variation of water levels in the reservoir tanks are illustrated in the following graph.



WATER BALANCE IN DISTRIBUTION TANKS (800 M^3)

An amount of 495 m^3 of water is stored even in case of the minimum water level, and this volume is translated to about seven (7) hr of water storage is considered possible.

b) Water Treatment

The results of the water quality examination reveal that no serious bacteriological infection is detected, but turbidity frequently raises over 20 particularly during and after the flood in the Pe Chhu especially in the wet season from June to September. Therefore, it is recommended to apply some water treatment for improving such high turvidity and reducing bad color content.

Based on the above discussions, the existing distribution station is proposed to be improved as itemized below.

- The high turbidity should be resolved by improving and enhancing the present treatment system. A rapid filtration system is applied to improve the station, taking into account that there are only limited areas where the system expansion is able to be allowed as shown in Fig. G.4.4.

- To facilitate the effects of rapid filtering, a flocculator should be provided before sedimentation tank, and some coagulant materials like aluminum surfeit should be applied to accelerate such coagulation effects as expected.

- Chlorination is recommended to distribute safe and clean water to the service area. It is given at the last stage of treatment.

- The existing water reservoir tanks are proposed to be expanded to some extent, because the present capacity of 600 m^3 is considered rather short to meet the requirement.

- Sludge and drain water treatment systems should also be provided in order to make the sludge dry for disposal and to process the washing water for draining out of the station yard within a permissible level of water quality.

- A piping galley is proposed to be provided to spare the space necessary for smooth operation of valves.

The flow chart of the proposed improved distribution station is illustrated in Fig. G.4.5, and the elevation of each component is confirmed since some of the additional processes require much fall of water head as presented in Fig. G.4.6.

The details of such proposed system components are summarized below as a principal features of the water treatment works.

- Raw water receiving pit: 5.5 m (L) x 1.5 m (W) x 1.5 m (H) of reinforced concrete box with V-shape notch, butterfly type valves, flow meter and turbidity meter.

- Flocculator: 0.7 m (W) x 10.0 m (L) x 4 Nos. of concrete canal with baffles.

- Aluminum dosing system: 1,5 m (W) x 1.5 m (L) x 1.2 m (D) reinforced concrete solution tank with diaphragm constant injection pump (1,400 cc/min.).

- Sedimentation tanks: The existing tanks whose capacity is measured to be 950 m^3 is utilized with some extent of reinforcement and supporting with frames and tapers

- Rapid sand filter: Gravity Type Rapid Filter of 24 m^2 filter area with filtered water transfer pumps of 1.2 m^3/min (Filtered water basin is attached to the rapid filter).

- Distribution reservoirs: The present capacity of 600 m^3 is proposed to be increased by about 200 m^3 and the piping galley is proposed to be attached to the tank.
- Chlorination: 0.8 m dia. x 1.0 m (D) of tank made of plastics with a diaphragm constant injection pump (1,400 cc/min.) and the necessary equipment such as level gauge, drain pipe, etc.
- Operation house: Wooden operation houses of 90 m^2 area
- Approach road: About 80 m of approach road from the national road to Tongsa.
- Other miscellaneous works: Wet masonry walls, fencing works, electricity connection works, etc.

3) Distribution Networks and House Connection

The present distribution networks cover most of the whole service areas in the township, and house connections are made partly to the government offices and the offices and quarters in the RBA complex, without any metered system. The following improvement works are proposed to be made for the present distribution networks.

a) Main Pipelines

The present distribution networks were constructed in 1969, and since then no substantial improvement has been made so far. Then, the pipe material is deteriorated in many parts of the networks, resulting in continuous leakage of water. Many extension pipelines have also been placed at random with HDPE pipe materials as the town area expands. Such HDPE pipes are easily connected to the illegal supply lines, which causes unbalanced load of demand.

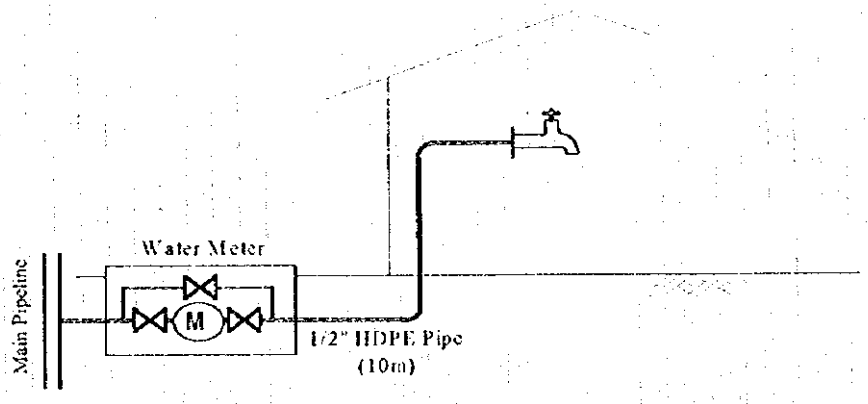
Therefore, it is proposed to replace such HDPE pipe materials with galvanized steel pipes to avoid illegal connection and reduce the leakage. To mitigate such unbalanced load of demand by traversing long main pipelines, etc., it is proposed to construct new main lines.

Since the service area is scheduled to be extended in the Bajo sub-area, a new main line is proposed to be constructed to distribute the water to such extended areas also.

The existing main pipelines and the proposed new pipelines are presented in Fig. G.4.7.

b) House Connections

To introduce the metered system, the house connection pipeline should be constructed as illustrated below.



TYPICAL HOUSE CONNECTION

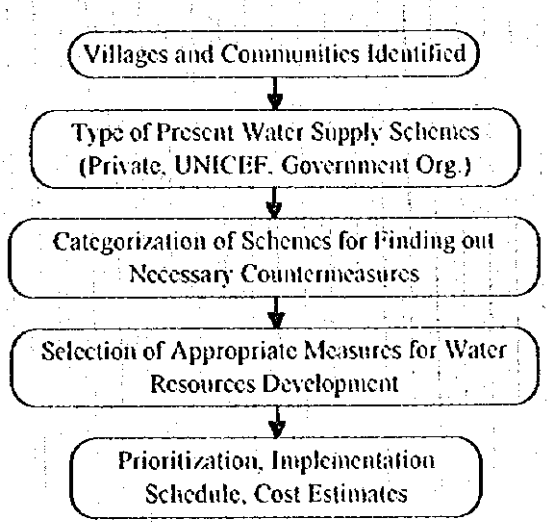
G.4.3 Rural Water Supply System

(1) Planning Methodology

As mentioned in the previous chapters on the present conditions of rural areas, there exist 64 villages/communities found in the sub-areas; 21 in the Lobeysa, 8 in the Bajo, 18 in the Phangyul, and 17 in the Rubeysa sub-areas. Among these villages, some villages have water supply systems provided either by the Dzongkhag with the assistance of UNICEF or by the government organizations such as RBA, MOA, etc. The service ratio of the rural water supply reaches 67 % in average for whole the Study area; 88 % for the Lobeysa, 36 % for the Bajo, 36 % for the Phangyul, and 69 % for the Rubeysa sub-areas.

The conditions such as topography, available water resources, village population served and not-served, present water supply systems, etc. were surveyed for each village/community during the field surveys as summarized in Table A.2.2. As a result, it is found, that such villages have different conditions varying village by village, and consequently it is difficult to prepare such plans which are required for each village one by one in this level of the study for the basic planning.

Therefore, as shown in the flow chart presented in the figure, the villages and communities identified during the field survey are categorized depending upon some factors which are considered



FLOW CHART FOR SELECTING METHODS OF WATER RESOURCES DEVELOPMENT

important in order to find out the constraints and necessary and suitable measures to be taken for respective sub-areas. Some typical scale of villages are, then, assumed for each selected category to facilitate further studies on appropriate measures to be proposed. These assumed villages have the typical constraints. The countermeasures are proposed for these assumed villages including alternative studies, if necessary.

(2) Categorization of Villages/Communities and Necessity of Further Water Resources Development

1) Factors to be Considered

Before categorizing the villages/communities identified, the types of the present water supply schemes are considered according to the kind of organization which implemented such water supply schemes; private, UNICEF and other government organizations such as RBA, MOA, MOC, etc. Out of the villages whose type of scheme is confirmed, those schemes which are implemented by UNICEF and any private sectors and those village which do not have any scheme are considered for further categorization, taking into account of the following factors which are consideredto be important for finding out constraints and countermeasures.

a) Present Service Ratio

The service ratio which is considered to best describe the water supply situation of a village is taken up as one of the factors for categorizing the villages identified. The ratio is expressed as a value obtained by dividing the population served by total population of the village. The less the ratio indicates, the more and urgent implementation of water supply scheme is desired.

b) Liability of Water Source

Getting liable water source is one of the important factors in planning the water supply scheme particularly in rural areas. The stable water supply may not be achieved unless any reliable water source is obtained. In case that such present water source is judged to be unreliable in quantity or quality, the other kinds of resources should be seeked and developed as required.

c) Water Quality

Most of the existing water supply schemes in the rural areas like the Rubeysa sub-area, the Phangyul sub-area, Lobeysa sub-area, and a part of the Bajo sub-area, the existing spring water sources are utilized for the domestic use, and hence its water quality is considered good enough except some of those villages in the Rubeysa sub-areas. The results of the water quality analyses indicate that iron contents exceed the recommended value in the guideline requiring some extent of iron removal treatment. In the villages where there is no water supply scheme, villagers take their water from existing irrigation canals resulting in the risk of biological infection. It is, therefore, considered urgent to provide the necessary water supply system in these villages to provide safe water for the villagers.

d) Number of Households to be Involved

The size of scheme, in other words, the number of households involved in such scheme, should be set so as to make scheme's performance properly efficient. According to the UNICEF's guideline, five (5) households are required to be involved in a proposed scheme as a minimum requirement. Therefore, the number of households to be involved is also taken up as one of the factors for categorizing the villages identified. The scheme involving more than six (6) households is given higher priority than those less than five (5) households.

The general flow of the above procedures are schematically illustrated in Fig. G.4.8.

2) Categorized Villages/Communities

Following the above-described procedures, the villages/communities identified in the field survey are categorized and evaluated as shown in Table G.4.1. The categories considered in the Study are as follows:

i) the villages requiring some new schemes involving more than six (6) households (New Scheme (A)),

ii) the villages requiring some new schemes involving more than six (6) households, since there are private water supply schemes but do not function well as expected (New Scheme (B)),

iii) the villages requiring some new schemes involving less than five (5) households (New Scheme (C)),

iv) the villages requiring some additional schemes, since the existing UNICEF's schemes do not satisfy the requirement in some viewpoints of service ratio, liability of water source or water quality (Additional Scheme),

v) the villages requiring some water treatment schemes, because the present raw water does not clear the recommended standard values (Water Treatment Scheme),

vi) the villages requiring some extension schemes involving more than six (6) households to increase the served population (Extension Scheme (A)),

vii) the villages requiring some extension schemes involving less than five (5) households (Extension Scheme (B)), and

viii) the villages requiring both extension and water treatment schemes (Extension with Treatment Schemes).

In the above categories, the first four (4) items from i) to iv) are considered to be the group requiring new water resources development and the last four (4) items from v)

to viii) require some improvement or rehabilitation works such as water quality treatment, expansion of present water supply system, etc. as shown in Fig. G.4.8.

The results of categorization are summarized below.

Population and Number of Villages to be Served by New and Extension Schemes

Sub-areas	Item	New Scheme (A)	New Scheme (B)	New Scheme (C)	Addition-al Scheme	Extension Scheme (A)	Extension Scheme (B)	Extension with Treat-ment	Water Treat-ment Scheme
Lobeysa	No. of Villages	1	0	2	0	0	1	0	0
	Average Population	250	0	29	0	0	67	0	0
Bajo	No. of Villages	3	0	1	1	0	0	0	0
	Average Population	128	0	61	185	0	0	0	0
Phangyul	No. of Villages	3	1	7	0	3	0	0	0
	Average Population	120	49	18	0	76	0	0	0
Rubeysa	No. of Villages	2	0	2	0	1	2	0	1
	Average Population	93	0	21	0	169	27	0	123
Whole Area	Total No. of Villages	9	1	12	1	4	3	0	1
	Average Population	131	49	24	185	99	40	0	123

Number of villages, total population, and average population of these villages which are categorized into ones which require the implementation of any type of water supply scheme are mentioned in the above table.

(3) Selection of Appropriate Methods for Water Resources Development

1) Procedure of Selection

To select the most appropriate method of water resources development for the rural water supply, the categorized villages are further simplified and re-arranged considering the available water resources in each sub-area as presented in Fig. G.4.9. The water resources available in the Study area are considered and evaluated as stated below.

a) Spring Water

Spring water resources are available predominantly in the hilly areas such as the Phangyul and the Rubeysa sub-areas and some parts of the Bajo and the Lobeysa areas along hilly areas. Many springs have been developed for the rural water supply schemes so far mainly by UNICEF, and villagers who do not have their water supply schemes also take water from such springs available nearby their houses. This source is considered as the most liable one in the Study area for rural water supply.

b) Sub-surface Water

Sub-surface water resources are available in low lands such as alluvial terraces along the Chang Chhu in the Bajo and the Lobeysa sub-areas. A shallow well has to be constructed on the low lands to utilize this water source. According to the results of the monitoring conducted during the field survey, 8 l/sec of yield is expected in a 3.5 m diameter of well with 1.6 m of drawdown in the Bajo sub-area.

c) Groundwater

The groundwater resource is also considered as one of the most promising sources in the low lands like the Bajo and the Lobeysa sub-areas. According to the results of test boring conducted during the field survey, an yield of 150 l/sec is expected for a 10" diameter of borehole with 50 m and 80 m depths in the Bajo and the Lobeysa sub-areas, respectively.

d) Stream/River Water

There are many streams and rivers available in the Study area. Among others, perennial streams are found to be a quite few in the Study area except for the Chang Chhu and the Dang Chhu, and such surface water may be infected and contaminated by animal wastes and land sliding soils. If this source is utilized for the use of domestic water supply, it is essential to provide the supply system with treatment facilities to the extent that enables to supply safe water. Therefore, this water source is not recommended for rural water supply.

Considering the above discussions, the following cases are extracted for the further study.

Cases to be Considered in the Study

Case	Description	Remarks
Case S-1	Spring Development - New (Large)	New spring development for large group of households of more than six (6) mainly applied for the hilly areas like the Phangyul and the Rubeysa sub-areas
Case S-2	Spring Development - New (Small)	New spring development for small group of households of less than five (5) mainly applied for the hilly areas like the Phangyul and the Rubeysa sub-areas
Case S-3	Spring Development - Extension (Large)	Extension or additional spring development for large group of households of more than six (6) mainly applied for the hilly areas like the Phangyul and the Rubeysa sub-areas
Case S-4	Spring Development - Extension (Small)	Extension or additional spring development for large group of households of less than five (5) mainly applied for the hilly areas like the Phangyul and the Rubeysa sub-areas
Case T-1	Water Treatment	Water treatment scheme of iron removal for the Rubeysa sub-area
Case B-1	Groundwater vs. Sub-surface Development (Large)	Groundwater or Sub-surface water development scheme for large group of households of more than six (6) applied for the Bajo sub-area (Construction costs are compared with each other to determine which resource is to be applied.)
Case B-2	Groundwater vs. Sub-surface Development (Small)	Groundwater or Sub-surface water development scheme for large group of households of less than five (5) applied for the Bajo sub-area (Construction costs are compared with each other to determine which resource is to be applied.)
Case L-1	Spring vs. Groundwater Development (Large)	Spring or groundwater development scheme for large group of households of more than six (6) for the Lobeysa sub-area (Construction costs are compared with each other to determine which resource is to be applied.)
Case L-2	Spring vs. Groundwater Development (Small)	Spring or groundwater development scheme for large group of households of less than five (5) for the Lobeysa sub-area (Construction costs are compared with each other to determine which resource is to be applied.)

The sizes and scales of the typical villages for the study are tabulated below.

Summary of Sizes and Population of Typical Villages for the Study

Case	Water Source	Type of Scheme	Population to be Served	Present Population Served	Required No. of Tap Stands	Distance from Source (m)	Existing Storage Tank Vol (m3)	Distance to Standpipe (m)	Slope Condition
Case S-1	Spring Water	New	103	-	15	1,000	-	1,500	Steep
Case S-2	Spring Water	New	19	-	3	1,000	-	1,500	Steep
Case S-3	Spring Water	Extension	99	120	15	1,000	3	1,500	Steep
Case S-4	Spring Water	Extension	27	22	3	1,000	No Tank	1,500	Steep
Case T-1	-	Deiton	123	-	-	-	4	-	-
Case B-1	Groundwater	New	147	-	29	500	-	1,000	Mild
	Sub-surface Water	New	147	-	29	500	-	1,000	Mild
Case B-2	Groundwater	New	61	-	5	500	-	1,000	Mild
	Sub-surface Water	New	61	-	5	500	-	1,000	Mild
Case L-1	Groundwater	New	250	-	26	1,000	-	1,500	Steep
	Spring Water	New	250	-	20	1,000	-	1,500	Steep
Case L-2	Groundwater	New	29	-	3	1,000	-	1,500	Steep

2) Selected Methods of Development

a) Lobeysa Sub-area

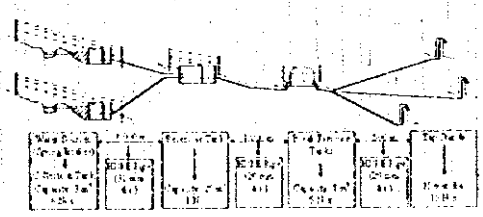
In the Lobeysa sub-area, there are development schemes required to be implemented as shown in the table. Two (2) New Schemes (A) and (C) are considered as Case L-1 and Case L-2, respectively taking into account of the available water resources in this sub-areas. The last Extension Scheme (B) is regarded as Case S-4 because the present scheme depends on the spring water resource.

As for Cases L-1 and L-2, there are two (2) options to be considered; the construction costs are compared for utilizing spring water and groundwater resources. The following typical schemes are considered for the comparative study of Cases L-1 and L-2.

Development Schemes Required in the Lobeysa Sub-area

Item	New Scheme (A)	New Scheme (C)	Ext'sion Scheme (B)
Population	250	58	67
No. of Villages	1	2	1
Average Pop.	250	29	67
Case →	L-1	L-2	S-4

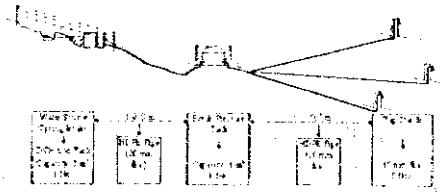
Case L-1



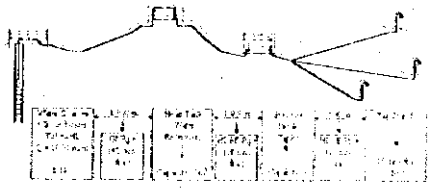
OPTION-1 (SPRING WATER)

OPTION-2 (GROUNDWATER)

Case L-2



OPTION-1 (SPRING WATER)



OPTION-2 (GROUNDWATER)

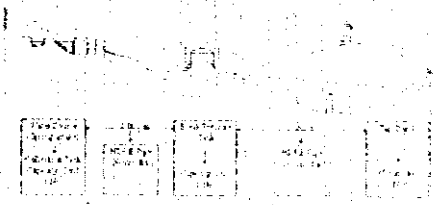
The construction costs are calculated for the above options, and the costs for the Option-1: Utilization of Spring Water are considered lower than those of Option-2: Utilization of Groundwater as summarized in the right table. Therefore, utilization of the spring water resources is recommended for Cases L-1 and L-2.

Comparison of Construction Costs for Cases L-1 and L-2

(Unit: 1,000 Nu.)

Case	Option-1 (Spring Water)	Option-2 (Groundwater)
L-1	2,418	3,838
L-2	657	2,608

As for Case S-4: Extension Scheme of the Present Spring Water Source, the water supply system consisting of collection tank, reservoir tank, break pressure tank, etc. is recommended to be applied as shown in the right figure.



CASE S-4: EXTENSION OF SPRING WATER SCHEME

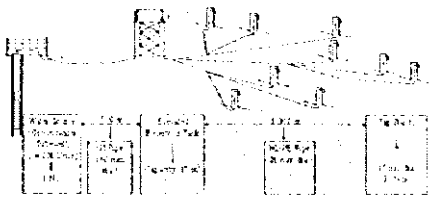
b) Bajo Sub-area

There are three (3) schemes to be implemented for water resources development as summarized in the table. Out of the three (3) New Schemes (A), one (1) scheme is located away from the potential area of groundwater and sub-surface water, and hence it is considered as Case S-1: the new development scheme of spring water. The other schemes are located in the potential areas of either groundwater or sub-surface water, and then are regarded as Cases B-1 or B-2, which include two (2) optional water sources of groundwater and sub-surface water. The necessary construction costs of these two (2) options are compared with each other to determine which option is more suitable and appropriate for the basic plan. The following two (2) typical schemes are considered for the comparative study.

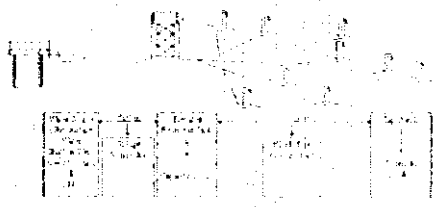
Development Schemes Required in the Bajo Sub-area

Item	New Scheme (A)	New Scheme (C)	Additional Scheme
Population	384	61	185
No. of Villages	3	1	1
Average Pop.	128	61	185
Case →	B-1 & S-1	B-2	B-1

Case B-1

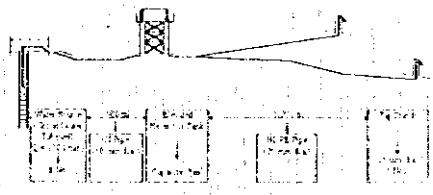


OPTION-1 (GROUNDWATER)

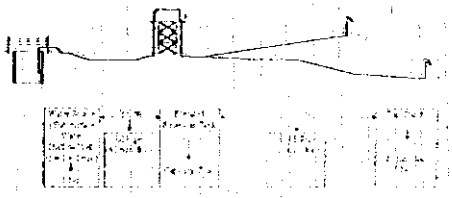


OPTION-2 (SUB-SURFACE WATER)

Case B-2



OPTION-1 (GROUNDWATER)



OPTION-2 (SUB-SURFACE WATER)

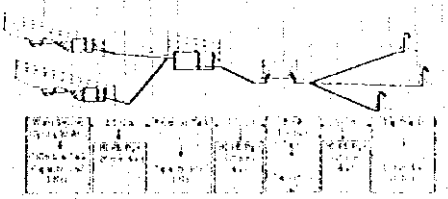
The construction costs are calculated for the above options, and the costs for the Option-1: Utilization of Groundwater are considered lower than those of Option-2: Utilization of Sub-surface Water as summarized in the table. Therefore, the groundwater resources are recommended to be utilized for Cases B-1 and B-2.

Comparison of Construction Costs for Cases B-1 and B-2

(Unit: 1,000 Nu.)

Case	Option-1 (Groundwater)	Option-2 (Sub-surface Water)
B-1	4,275	4,341
B-2	3,066	3,317

As for Case S-1: New Scheme of the Spring Water Source, the water supply system consisting of collection tank, reservoir tank, break pressure tank, etc. is recommended to be applied as shown in the figure.



CASE S-1: NEW SPRING WATER SCHEME

c) Phangyul Sub-area

In the Lobeysa sub-area, there are the development schemes required to be implemented as shown in the table. Two (2) New Schemes (A) and (B) are considered as Case S-1, and New Scheme (C) is considered as Case S-2 taking into account that the available water resource is only spring water in

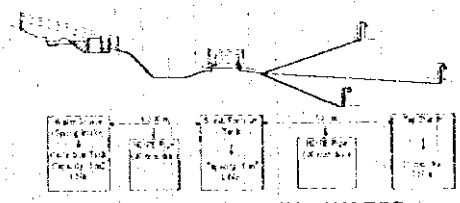
Development Schemes Required in the Phangyul Sub-area

Item	New Scheme (A)	New Scheme (B)	New Scheme (C)	Ext'sion Scheme (A)
Population	361	49	128	227
No. of Villages	3	1	7	3
Average Pop.	120	49	18	76
Case →	S-1		S-2	S-3

this sub-area. The Extension Scheme (A) is regarded as Case S-3 because the present scheme fully depends on the spring water resource.

As for Cases L-1 and L-2, there are two (2) options to be considered; the construction costs are compared for utilizing spring water and groundwater resources. The following typical schemes are considered for the comparative study of Cases L-1 and L-2.

CASE S-1 NEW SPRING WATER SCHEME (LARGE)



CASE S-2 NEW SPRING WATER SCHEME (SMALL)

CASE S-3 EXTENSION OF SPRING WATER SCHEME (LARGE)

It is considered as unnecessary to conduct any cost comparison between different water sources, because only the spring water source is available for the rural water supply in this sub-area. The water supply systems indicated in the above figures consisting of collection tank of spring water, reservoir tank, break pressure tank, etc. are recommended to be applied for the spring water development schemes in this sub-area.

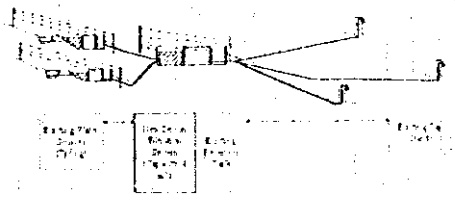
d) Rubeysa Sub-area

In the Rubeysa sub-area, there are development schemes required to be implemented as shown in the table. Two (2) New Schemes (A) and (C) and two (2) Extension Schemes (A) and (B) are considered as Cases from S-1 to S-4 taking into account that the available water resource is only spring water in this sub-area. Water Treatment Scheme is considered as Case T-1, because this scheme includes only the component of water treatment for iron removal.

Development Schemes Required
In the Rubeysa Sub-area

Item	New Scheme (A)	New Scheme (C)	Ext. Scheme (A)	Ext. Scheme (B)	Water Treat. Scheme
Population	186	42	169	53	123
No. of Villages	2	2	1	2	1
Average Pop.	93	21	169	27	123
Case →	S-1	S-2	S-3	S-4	T-1

It is considered as unnecessary to conduct any cost comparison between different water sources, because only the spring water source is available for the rural water supply in this sub-area. The water supply systems indicated



CASE T-1 WATER TREATMENT SCHEME

in the previous sub-section consisting of collection tank of spring water, reservoir tank, break pressure tank, etc. are recommended to be applied for the spring water development schemes in this sub-area. The treatment scheme proposed to be implemented is considered only for one (1) existing scheme in this sub-area, and it is recommended to be composed of a iron removal tank beside the existing tank as shown in the figure in previous page.

G.5 Implementation Schedule and Cost Estimate

G.5.1 Implementation Schedule

(1) Basic Consideration

Prior to setting up the implementation schedules for the Basic Water Resources Development Plan both for the urban and the rural water supplies in the Study area, the following items are considered in order to make the implementation schedule more effective and more suitable for the Study area taking into account of the matters and factors discussed in the beginning of Chapter G.4 of this Appendix.

Urban Water Supply Plan

- The present urban water supply system faces the constraints both in quantity and quality of the supplied water as aforesaid. To achieve the maximum effects of the project implementation, the quantity of supplied water should be increased as soon as possible in accordance with the projected future demand.

- The planned scale of the water supply system is set at 1,700 m^3/sec only, which is considered so small that it is difficult to construct the proposed water distribution station and the conveyance pipeline separately baed on efficiency and economic aspects.

- Therefore, the construction of the proposed conveyance pipeline and distribution station is recommended to be implemented by the first target year of 2002, and the improvement works of distribution networks and the introduction of metered system are implemented later by the final target year of 2007.

Rural Water Supply Plan

- The present service ratios of the sub-areas are considered to be one of the important factors to determine the priorities for implementing the schemes in each sub-area. The priority of the area-wise implementation is proposed to be set i) Phangyul sub-area, ii) Bajo sub-area, iii) Rubeysa and iv) Lobeysa, according to the present service ratios of the respective sub-areas; 88 %, 36 %, 36 % and 69 % for the Lobeysa, the Bajo, the Phangyul and the Rubeysa sub-areas, respectively.

- There are eight (8) categories of schemes proposed to be implemented. Among these schemes, the first priority is recommended to be given to the schemes for villages

which are considered to have no supply system at present and more population to be served.

- Water treatment scheme is proposed to be given the last priority, because the quantity of supplied water is judged to be the most important and essential in planning.

- Extension schemes are proposed to be implemented after the new schemes which are proposed to be implemented in the villages having no supply system.

(2) Urban Water Supply Plan

The urban water supply system for the Wangduephodrang town area is proposed to be implemented as shown below based on the above-mentioned items.

Work Items	Year										
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Detailed Design and Administrative Arrangements											
Conveyance Pipeline											
Water Treatment and Distribution Station											
Distribution Networks and House Meters											

IMPLEMENTATION SHCEDULE OF URBAN WATER SUPPLY SYSTEM

(3) Rural Water Supply Plan

The rural water supply systems for the sub-areas are proposed to be implemented as shown below taking into account of the above-mentioned items.

Sub-area/Scheme	Type	Priority	Year										
			1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Lobeysa Sub-area		❶											
New Scheme (A)	L-1	❶-1											
New Scheme (C)	L-2	❶-2											
Extension Scheme (B)	S-4	❶-3											
Bajo Sub-area		❷											
New Scheme (A)	B-1 S-1	❷-1											
New Scheme (C)	B-2	❷-3											
Additional Scheme	B-1	❷-2											
Phangyul Sub-area		❶											
New Scheme (A)	S-1	❶-1											
New Scheme (B)	S-1	❶-2											
New Scheme (C)	S-2	❶-4											
Extension Scheme (A)	S-3	❶-3											
Rubeysa Sub-area		❸											
New Scheme (A)	S-1	❸-1											
New Scheme (C)	S-2	❸-4											
Extension Scheme (A)	S-3	❸-2											
Extension Scheme (B)	S-4	❸-3											
Water Treatment Scheme	T-1	❸-5											

IMPLEMENTATION SHCEDULE OF RURAL WATER SUPPLY SYSTEM

G.5.2 Cost Estimate

(1) Project Costs

The project costs for implementing both rural and urban water supply schemes are estimated based on the above implementation schedules as shown in the table presented in the next page. The total costs consisting of direct costs, engineering fees, administration fees, and physical contingency are estimated as Nu. 231,100,000 for the urban water supply system for Wangduephodrang town area, and Nu. 44,200,000 for the rural water supply schemes. The total project costs account to Nu. 275,300,000. The details of estimated costs are explained in Appendix-J including the proportion between the local and foreign costs.

Summary of Project Costs

(Unit: Nu.1,000,000)

Description	Costs	Description	Costs
I. Urban Water Supply System for Wangduephodrang Town Area		II. Rural Water Supply Systems	
1. Direct Costs	172.6	1. Lobeysa Sub-area	4.2
1.1 Conveyance Pipeline	60.1	2. Bajo Sub-area	18.1
1.2 Treatment and Water Distribution Station	95.4	3. Phangyul Sub-area	14.9
1.3 Distribution Networks and House Meters	17.1	4. Rubeysa Sub-area	6.9
2. Engineering Service	35.9	Total	44.1
3. Administration Costs	6.2		
Sub-total	213.9		
4. Physical Contingency	17.3		
Total	231.2	Grand Total	275.3

The above estimates are made based on the prices in July 1995, with the exchange rates of 30.85 Nu./US$ and 100 yen/US$.

(2) Annual Disbursement Schedule

The annual disbursement schedule is also set as shown below based on the implementation schedules prepared in the previous section.

Annual Disbursement Schedule for Implementing Urban Water Supply Scheme

(Unit: Nu.1,000,000)

Work Items	Year										
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Direct Construction Costs	0.0	0	60.1	95.4	9.3	0	0	0	3.9	3.9	0
1.1 Conveyance Pipeline			60.1								
1.2 Water Treatment and Distribution Station				95.4							
1.3 Distribution Networks and House Meters					9.3				3.9	3.9	
2. Engineering Service		10.4	9.8	9.8	4.9						
3. Administration Costs		0.3	2.1	3.2	0.4				0.1	0.1	
Sub-total	0.0	10.7	72.0	108.4	14.6	0.0	0.0	0.0	4.0	4.0	0.0
4. Physical Contingency			6.0	9.5	0.9				0.4	0.4	
Total	0.0	10.7	78.0	117.9	15.5	0.0	0.0	0.0	4.4	4.4	0.0

Annual Disbursement for Implementing Rural Water Supply Schemes

(Unit: Nu.1,000,000)

Sub-area Scheme	Year										
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Lobeysa Sub-area											
New Scheme (A)									2.5		
New Scheme (C)										1.4	
Extension Scheme (B)										0.4	
Baja Sub-area											
New Scheme (A)				10.6							
New Scheme (C)					3.2						
Additional Scheme					4.4						
Phangyul Sub-area											
New Scheme (A)	5.3										
New Scheme (B)		1.8									
New Scheme (C)			2.5								
Extension Scheme (A)		5.3									
Rubeysa Sub-area											
New Scheme (A)						3.5					
New Scheme (C)								0.7			
Extension Scheme (A)							1.8				
Extension Scheme (B)								0.7			
Water Treatment Scheme										0.1	
Total	5.3	7.1	2.5	10.6	7.6	3.5	1.8	1.5	2.5	1.9	40.0

G.6 Institutional and Organizational Aspects

G.6.1 Constraints of Present Operation and Management

According to the Dzongkhag's administration, the water supply system for the urban water supply is operated and managed fully with the Dzongkhag's responsibility. The PWD Section (the Municipal Corporation Section) of the Dzongkhag is responsible for the actual operation and management of such supply system from the intake to the lateral distribution pipelines for house connections.

Rural Water Supply and Sanitation Section of the Dzongkhag's PWD Section takes care of the rural water supply system. They conduct the maintenance services for only the defects and troubles which the beneficial farmers are not able to repair or fix by their own efforts.

The following constraints were found in the present operation and management of the urban and the rural water supply systems through the field surveys.

- Shortage of skilled and experienced staff numbers for the operation and maintenance.
- Lack of technical knowledge and know-how as well as tools and equipment to detect and fix leakage in the distribution networks.
- Shortage of the budget allocated to the operation and management of the water supply systems.
- Illegal connection to the distribution system found in the distribution station and networks.
- Low morality of the beneficiaries on water usage particularly in the town areas; many water taps are found to be left opened throughout a day even during the periods when the

water is not supplied under the present intermittent supply system, resulting in the huge volume of physical loss.

It is considered to be necessary and important to improve the above-mentioned situation urgently. If the new supply system is introduced as proposed in the aforesaid section, the operation and maintenance is considered to become more complicated and more numbers of skilled and experienced staff and engineers are essentially required to achieve the objectives to realize the stable 24-hour supply of safe water in the town area.

G.6.2 Proposed Organization and Staffing

(1) Necessity of Introducing Metered System in Urban Water Supply System

Water charge is not collected at present for the urban water supply except a service charge of Nu. 9 - 40 a month depending on the class of beneficiary's house, and most of the expenditures necessary for operation and maintenance of the present urban water supply system have been managed by the Dzongkhag's own budget allocated by the government so far.

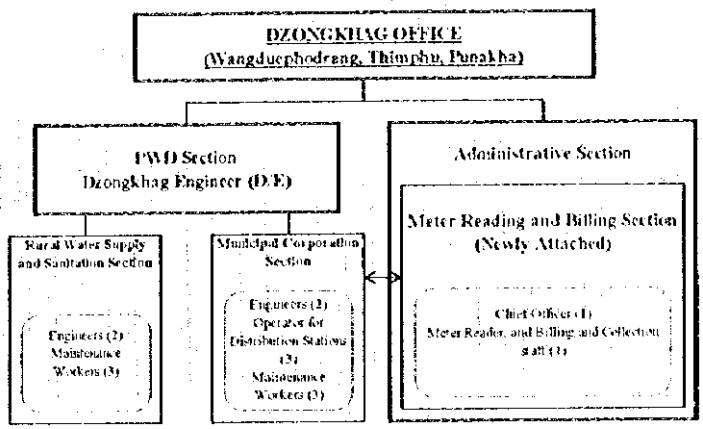
The operation and management costs for the future supply system is considered to increase comparing with the present ones, because more number of staff and engineers as well as tools and equipment are required to manage such systems in the future. In addition, the present low morality of the beneficiaries should also be improved at least to reduce such high rate of physical losses. It is, therefore, proposed to introduce a systematic water collection system with a proper water tariff before the water production reaches to the full stage as proposed. The metered system is also required to be introduced the new water supply system in order to measure collectly the volume of water used by a beneficiary. The tariff rate should be set considering those being applied to the other cities such as Thimphu, Phuntholing, etc.

(2) Proposed Future Organization

No new organization is recommended to be established to implement the proposed urban and rural water supply schemes, because it is consequently judged as follows:

- the present Dzongkhag's organization is considered to have functioned so far well enough to proceed with its implementation of various schemes as well as operation and maintenance services at least in view of the rural water supply, since most of the daily and routine maintenance works are basically to be managed by the beneficiaries themselves,

- on the other hand, it is considered to involve some constraints in operating and managing the urban water supply system as stated in the above sub-chapter, which requires some extent of the reinforcement and enhancement of the present organization particularly in the human and material resources aspects, and



PROPOSED ORGANIZATION CHART

- taking into account of the scale of town and the served population, it is not necessary to establish such new independent organization only for operating and managing the water supply system to reduce the costs and expenditures necessary for such management.

Therefore, it is proposed to maintain the present Dzongkhag's organization with a little enhancement and reinforcement in human and material resources, and the organization presented in the figure is proposed for the operation and management of the future urban water supply system.

Only a sub-section for meter reading and billing is proposed to be attached to the Administrative Section of the Dzongkhag Office in order to enhance and facilitate the services connected to the beneficiaries.

G.6.3 Operation and Maintenance Costs

The operation and maintenance costs consist of the following items:

- the salary and other necessary expenditures for the operation and maintenance staff,
- the costs for electric charge to operate the distribution station,
- costs for such chemicals that are applied for treating the distributed water such as chlorine and coagulant, and
- repairing and replacement costs for the distribution station and networks.

The calculated operation and maintenance costs are summarized below, and the details of these costs are explained in Appendix-J.

Annual Operation and Maintenance Costs

(Unit: NU.1,000)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Rural Water Supply	282.0	335.1	405.9	431.3	582.7	704.0	739.4	757.1	771.6	796.5	815.1
Urban Water Supply	526.2	526.2	526.2	526.2	2,219.5	2,312.4	2,312.4	2,312.4	2,312.4	2,628.0	2,667.0
Total	808.2	861.3	932.1	957.5	2,802.2	3,016.4	3,051.8	3,069.5	3,084.0	3,424.5	3,482.1

G.7 Recommendation

The recent growth of the country's economic activities are remarkable and significant both in municipalities and cities in the country. In Wangduephodrang district also, the tendency is considered as same as the other towns, and many people gather to the town area resulting in sharp increase of the population in the town. In the rural areas surrounding the town, the population growth is believed to be faster than the previous decades, because the mortality is expected to be improved significantly due to the recent growth of BHU networks, etc.

Under these situation, it is considered to be quite important to provide the inhabitants with safe water by stable water supply system in order to give the nationals the fair opportunities for improving their life standards. Especially in rural areas, it is essential to provide the villagers with safe water to maintain their lives in safe and stable conditions considering that the present service ratio remains as low as 67 % in average in the Study area. The town inhabitants are at present facing the shortage of water getting water intermittently. It is, therefore, recommended to implement the proposed schemes as basic human needs without delay in order to realize the safe and stable lives both in rural and urban societies in a satisfactory manner.

APPENDIX G
TABLES

Table G.2.1 Identified Villages/Communities in the Study Area

Lobeysa Sub-area			Bajo Sub-area			Phangyul Sub-area			Rubeysa Sub-area		
	Present Population			Present Population			Present Population			Present Population	
Village/Community	Household	Population	Village/Community	Household	Population	Village/Community	Household	Population	Village/Community	Household	Population
BABESA GEWOG			THETSO GEWOG			PHANGYUL GEWOG			RUBEYSA GEWOG		
1 Mitshina	18	250	1 Proper Bajo	33	251	1 Proper Phangyul	24	188	1 Nyizergang Gompa	20	156
2 Sopsokha	9	70	2 Bajothang	5	61	2 Phangyul Gompa	2	5	2 Rumina	19	123
3 Yuwakha	15	85	3 DSC/AMC	1	50	3 Jemkhelo	1	6	3 Nyalakha	10	74
4 Chimi Lhakhang	1	105	4 Thangu	11	59	4 Yangcheytawa	1	5	4 Ruteokha	16	107
5 Gomji	2	20	5 Matalumchu	8	75	5 Chumey Gompa	4	45	5 Tshemcho	9	59
6 Baywokha	5	40	Sub-total	58	496	6 Chungsekha	26	175	6 Jasukha	5	45
7 Yusakha	13	105	LINGBUKHA GEWOG			7 Domkhar	14	123	7 Awakha	3	22
8 Pachekha	2	25	6 Umtekha	31	250	8 Paropselsa	1	9	8 Maphekha	8	71
9 Jangsapo	4	49	Sub-total	31	250	9 Vegopara	1	5	9 Umtekha	4	33
10 Tshokona	12	80	BABESA GEWOG			10 Rabuna inc. PWD	4	70	10 Nyegapara	7	45
11 NRTI***	1	630	7 Wangjokha	14	177	11 Geonkhar	27	192	11 Tashidingkha	1	9
12 Gangkha	8	41	8 Matalumchu	12	60	12 Lenkhena	1	5	Sub-total	102	744
13 Power Station	1	30	Sub-total	26	237	13 Omchuphunasa	1	22	JENA GEWOG		
14 Pry School***	1	510				14 Kumchi	21	146	12 Balakha	7	56
15 Jamripang	9	100				15 Damina	1	10	13 Themakha	37	319
16 PWD Camp (Maint.)	19	100				16 Ribana	19	92	14 Phuntshogang	9	100
17 Motokha	2	18				17 Pachekha	1	12	15 Tashi Tokha	11	141
18 Pangnang	10	65				18 Chuzomsa	7	49	Sub-total	64	616
19 PWD Camp (Const.)	1	75							THETSO GEWOG		
20 RBA Firing Range**	1	206							16 Nyechegeykha	10	68
Sub-total	134	2,604							17 Nalabji	3	28
THETSO GEWOG									Sub-total	13	96
21 Rinchengang	43	482									
Sub-total	43	482									
Total	177	3,086	Total	115	983	Total	156	1,159	Total	179	1,456
									Total Household and Population in the Study Area:	627	6684

Note: The population and household in the Wangduephodrang Town area are discussed in the sub-sections for the urban water supply plan.

Table G.2.2 Present Conditions of the Identified Villages/Communities in the Study Area (1/4)

(Lobeysa Sub-area)

Village/Community	Present Population		Existing Water Supply System							
	Household	Population	Year of Construction	Water Source	Name of Source	Tank Capacity (m3)	Discharge (l/s)	Household	Population Served	Type of Scheme
BABESA GEWOG										
1 Mitshina	18	250	-	Irri./Spring	Misina Chhu	-	-	-	-	No Scheme
2 Sopsokha	9	70	1981	Spring	Chuzana Chhu	No Tank	0.4	9	70	UNICEF**
3 Yuwakha	15	85	1981	Spring	Chuzana Chhu	No Tank	-	15	85	UNICEF**
4 Chimi Lhakhang	1	105	1986	Spring	Misina Chhu	No Tank	-	1	105	UNICEF
5 Gomji	2	20	1981	Spring	Chuzana Chhu	No Tank	-	2	20	UNICEF**
6 Baywokha	5	40	-	Spring	Zakha Chhu	-	-	-	-	No Scheme
7 Yusakha	13	105	1982	Spring	Pep Chhu	No Tank	-	13	105	UNICEF
8 Pachekha	2	25	1978	Spring	Zakha Chhu	No Tank	-	2	25	UNICEF
9 Jangsapo	4	49	1981	Spring	Nyeshi Chhu	No Tank	-	4	49	UNICEF
10 Tshokona	12	80	1982	Spring	Nyeshi Chhu	No Tank	-	12	80	UNICEF
11 NRTI***	1	630	1987	Stream	Tobe Rongchhu	8.0	-	1	630	MOA
12 Gangkha	8	41	1982	Spring	Pep Chhu	No Tank	-	8	41	UNICEF
13 Power Station	1	30	1988	Spring	Pep Chhu	No Tank	-	1	30	MOI
14 Pry School***	1	510	1987	Spring	Gamalum Chhu	2.5	3.0	1	510	UNICEF
15 Jamripang	9	100	1981	Spring	Chuzana Chhu	No Tank	-	9	100	UNICEF**
16 PWD Camp (Maint.)	19	100	1976	Spring	Pep Chhu	No Tank	-	19	100	GREF*
17 Motokha	2	18	-	Spring	Men Chhu	-	-	2	18	Private
18 Pangnang	10	65	1981	Spring	Chuzana Chhu	No Tank	-	10	65	UNICEF**
19 PWD Camp (Const.)	1	75	1982	Spring	Chuchelukha Chhu	No Tank	-	1	75	MOC
20 RBA Firing Range***	1	206	1994	Spring	Pep Chhu	No Tank	-	1	206	RBA
Sub-total	134	2,604	-	-	-	-	-	111	2,314	-
THETSO GEWOG										
21 Rinchengang	43	482	1978	Stream	Chaugedema	5.0	0.5	38	415	UNICEF
Sub-total	43	482	-	-	-	-	-	38	415	-
Total	177	3,086	-	-	-	-	-	149	2,729	-

Note:

*: General Reserved Engineering Force of India (Dantak)

**: Covered by one (1) UNICEF scheme.

***: The population includes temporary visitors such as students, trainees, etc.

Table G.2.2 Present Conditions of the Identified Villages/Communities in the Study Area (2/4)

(Bajo Sub-area)

Village/Community	Present Population		Existing Water Supply System							
	Household	Population	Year of Construction	Water Source	Name of Source	Tank Capacity (m3)	Discharge (l/s)	Household	Population Served	Type of Scheme
THETSO GEWOG										
1 Proper Bajo	33	251	1982	Stream	Bajo Chhu	3.0	-	13	66	UNICEF
2 Bajothang	5	61	-	River	Chang Chhu	-	-	-	-	No Scheme
3 DSC/AMC	1	50	1992	Subsurface	Chang Chhu	6.0	-	1	50	MOA
4 Thangu	11	59	-	Spring	-	-	-	-	-	No Scheme
5 Matalumchu	8	75	-	Spring	-	-	-	-	-	No Scheme
Sub-total	58	496	-	-	-	-	-	14	116	-
LINGBUKHA GEWOG										
6 Umtekha	31	250	-	Spring	-	-	-	-	-	No Scheme
Sub-total	31	250	-	-	-	-	-	-	-	-
BABESA GEWOG										
7 Wangjokha	14	177	1982	Spring	-	1.4	-	14	177	UNICEF
8 Matalumchu	12	60	1985	Spring	-	1.5	0.3	12	60	UNICEF
Sub-total	26	237	-	-	-	-	-	26	237	-
Total	115	983	-	-	-	-	-	40	353	-

Note: Wangduephodrang Town is not included in the above list.

Table G.2.2 Present Conditions of the Identified Villages/Communities in the Study Area (3/4)

(Phangyul Sub-area)

Village/Community	Present Population		Existing Water Supply System							
	Household	Population	Year of Construction	Water Source	Name of Source	Tank Capacity (m3)	Discharge (l/s)	Household	Population Served	Type of Scheme
PHANGYUL GEWOG										
1 Proper Phangyul	24	188	1982	Spring	Ominga	4.0	0.3	9	70	UNICEF
2 Phangyul Gompa	2	5	-	Spring	-	-	-	-	-	No Scheme
3 Jemkhelo	1	6	1985	Spring	Lamching	1.4	0.8	1	6	UNICEF
4 Yangcheytawa	1	5	1987	Spring	-	-	-	1	5	UNICEF
5 Chumey Gompa	4	45	1982	Spring	Sichukakha	2.0	0.3	4	45	UNICEF
6 Chungsekha	26	175	1985	Spring	Damtejakha	2.5	1.0	16	103	UNICEF
7 Domkhar	14	123	-	Irrigation	-	-	-	-	-	No Scheme
8 Paropselsa	1	9	-	Irrigation	-	-	-	-	-	No Scheme
9 Vegopara	1	5	-	Spring	-	-	-	1	5	Private
10 Rabuna inc. PWD	4	70	-	Spr./Irr.	-	-	-	-	-	No Scheme
11 Geonkhar	27	192	1988	Stream	Egikha Chhu	4.0	1.0	21	155	UNICEF
12 Lenkhena	1	5	-	Irrigation	-	-	-	-	-	No Scheme
13 Omchuphunasa	1	22	-	Irrigation	-	-	-	-	-	No Scheme
14 Kumchi	21	146	-	Spring	-	-	-	-	-	No Scheme
15 Damina	1	10	1984	Spring	Janglum	3.5	0.5	1	10	UNICEF
16 Ribana	19	92	-	Spring	Gong Chhu	-	-	-	-	No Scheme
17 Pachekha	1	12	-	Spring	-	-	-	-	-	No Scheme
18 Chuzomsa	7	49	-	Spr./Riv./Irr	-	-	-	3	15	Private
Total	156	1,159	-	-	-	-	-	57	414	-

Table G.2.2 Present Conditions of the Identified Villages/Communities in the Study Area (4/4)

(Rubeysa Sub-area)

Village/Community	Present Population		Existing Water Supply System							
	Household	Population	Year of Construction	Water Source	Name of Source	Tank Capacity (m3)	Discharge (l/s)	Household	Population Served	Type of Scheme
RUBEYSA GEWOG										
1 Nyizergang Gompa	20	156	1970	Spring	Kingathang Chhu	1.5	0.8	20	156	UNICEF
2 Rumina	19	123	1985	Spring	Men Chhu	4.0	1.0	19	123	UNICEF
3 Nyalakha	10	74	1989	Spr./Irr.	Ju Chhu	1.5	0.3	6	33	UNICEF
4 Rutcokha	16	107	1982	Spring	Ja Chhu	2.5	0.5	16	107	UNICEF
5 Tshemcho	9	59	1991	Spring	Sagami Chhu	1.5	0.3	9	59	UNICEF
6 Jasukha	5	45	1991	Spring	Jigi Chhu	No Tank	0.3	5	45	UNICEF
7 Awakha	3	22	1995	Spring	-	No Tank	0.1	2	10	UNICEF
8 Maphekha	8	71	1990	Stream	Dango hupakha	1.5	0.5	8	71	UNICEF
9 Umtekha	4	33	-	Spring	-	-	-	-	-	No Scheme
10 Nyegapara	7	45	-	Stream	-	-	-	-	-	No Scheme
11 Tashidingkha	1	9	-	Spring	-	-	-	-	-	No Scheme
Sub-total	102	744	-	-	-	-	-	85	604	-
JENA GEWOG										
12 Balakha	7	56	1984	Stream	Ya Chhu	5.0	2.0	7	56	UNICEF
13 Themakha	37	319	1982	Spring	Hog Chhu	3.3	-	29	150	UNICEF
14 Phuntshogang	9	100	1989	Stream	Sasaba Chhu	No Tank	1.0	9	100	UNICEF
15 Tashi Tokha	11	141	-	Spring	-	-	-	-	-	No Scheme
Sub-total	64	616	-	-	-	-	-	45	306	-
THETSO GEWOG										
16 Nyechegeykha	10	68	1990	Spring	Yelzam	No Tank	0.4	10	68	UNICEF
17 Nalabji	3	28	1985	Stream	Temchiling	1.5	0.2	3	28	UNICEF
Sub-total	13	96	-	-	-	-	-	13	96	-
Total	179	1,456	-	-	-	-	-	143	1,006	-

Table G.2.3 List of Rural Water Supply Schemes Implemented by UNICEF

NO.	Name of Dzongkhag	Five Year Plan					Total
		IV Plan	V Plan	VI Plan	VII Plan	Additional	
WESTERN ZONE							
1	Thimphu	11	44	30	7	5	97
2	Paro	7	51	32	8	3	101
3	Haa	3	36	20	4	0	63
4	Chhukha	1	45	28	2	3	79
5	Samtshe	0	74	18	0	0	92
Sub-total		22	250	128	21	11	432
WEST CENTRAL ZONE							
1	Gasa	0	9	2	1	2	14
2	Punakha	13	48	30	9	6	106
3	Wangdue	6	68	55	7	5	141
4	Tshirang	28	41	15	0	3	87
5	dagana	5	36	14	1	2	58
Sub-total		52	202	116	18	18	406
CENTRAL ZONE							
1	Bumthang	2	35	23	6	1	67
2	Trongsa	8	23	29	13	3	76
3	Zhemgang	10	26	24	9	2	71
4	Sarpang	15	46	18	2	0	81
Sub-total		35	130	94	30	6	295
EASTERN ZONE							
1	Lhuntshe	11	29	30	12	7	89
2	Mongar	16	82	35	9	16	158
3	Trashigang	34	92	14	16	11	167
4	Trashi Yangtshe	23	23	15	3	9	73
5	Pemagatshel	13	24	28	10	4	79
6	Samdrupjongkhar	4	51	22	9	3	89
Sub-total		101	301	144	59	50	655
Total		210	883	482	128	85	1,788

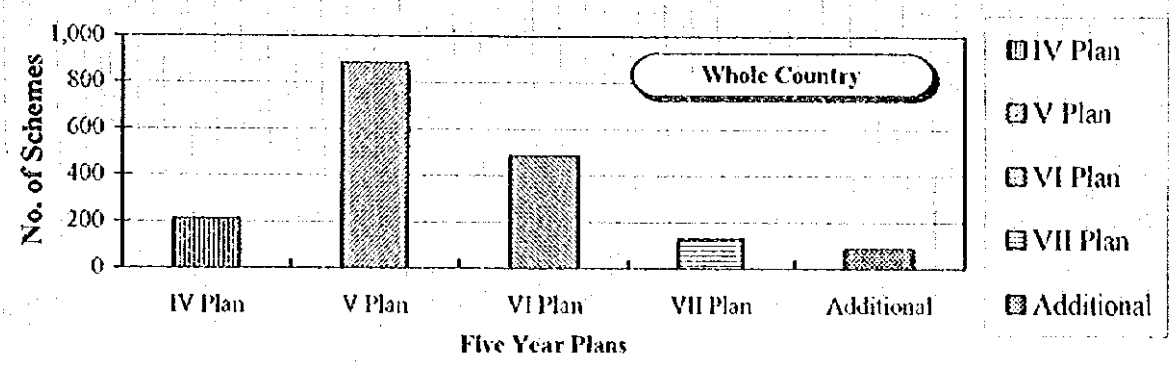


Table G.3.1 Surveyed Population of Wangduephodrang Town Area

Category of Population	1995	
	Residents	Dayvisitors
1. Township Area	1,820	0
Residents	1,820	0
2. Commercial and Shopping Area	520	400
Residents	520	0
Visitors	0	400
3. Monk Body (Dratshang)	65	0
Monks	65	0
4. Administrative Organization	60	150
Dzongkhag Officers	5	75
Other Public Organizations	55	75
5. RBA Complex	1,190	370
6. RBA Outer Quarters	1,950	0
7. RBA Hospital	175	200
Beds	50	0
Doctors and Staff	125	0
Outpatients	0	200
8. Primary School	20	600
Staff and Residents	20	0
Students	0	600
9. Junior High School	10	600
Staff and Residents	10	0
Students	0	600
10. RNRRC (CARD) Office	225	0
Residents	225	0
Grand Total	6,035	2,320

Table G.3.2 Estimated Population in Extended Service Area

Category of Population	2002		2007	
	Residents	Dayvisitors	Residents	Dayvisitors
1. Junior High School in Bajothang *	10	220	165	435
Students	0	200	0	400
Dormitory	0	0	150	0
Teachers and Staff	10	20	15	35
2. Agricultural Machinary Center (AMC)	0	7	0	7
Staff and Workers	0	7	0	7
3. Druk Seed Corporation (DSC)	37	6	37	6
Staff and Workers	37	6	37	6
Total	47	233	202	448

Note:
*: The operation of the junior high school being constructed at present in Proper Bajo will be commenced in 1997. The students of the present junior high school will be transferred to the new one when it is in operation in 1997. The enrolement of 1,000 students are scheduled, and the dormitory will also be constructed for 150 students.

Table G.3.3 Block-wise Population and Water Demand

(Population)

Categories of Population	Blocks 1	2	3	4	5	6	Total
1995							
Population in Present Service Area	2,935	1,555	950	2,743	145	0	8,328
Population in Extended Area	-	-	-	-	-	-	-
Total	2,935	1,555	950	2,743	145	0	8,328
2002							
Population in Present Service Area	3,372	1,786	1,618	1,926	166	698	9,567
Population in Extended Area	-	-	-	-	-	280	280
Total	3,372	1,786	1,618	1,926	166	978	9,847
2007							
Population in Present Service Area	3,723	1,972	2,368	1,545	183	771	10,562
Population in Extended Area	-	-	-	-	-	650	650
Total	3,723	1,972	2,368	1,545	183	1,421	11,212

(Water Demand) (Unit: m^3/d)

Year	Blocks 1	2	3	4	5	6	Total
1995							
Average Daily Demand	286	152	93	267	14	-	812
Maximum Daily Demand (x1.25)	358	189	116	334	18	-	1,015
2002							
Average Daily Demand	310	164	149	177	15	90	906
Maximum Daily Demand (x1.25)	388	206	186	222	19	113	1,133
2007							
Average Daily Demand	411	217	261	170	20	157	1,236
Maximum Daily Demand (x1.25)	513	272	326	213	25	196	1,546

Table G.4.1 Evaluation Sheet of Each Village/Community (1/4)

(Lobeysa Sub-area)

Village/Community	Implemented Scheme	Water Source					Water Quality	Present Service		Measures to be Taken	
		Type of Water Source	Liability of Water Source	Capacity per Capita (l/d)	Capacity > or < 67 l/s	Present Source Capacity		Service Ratio (%)	Number of Household Not Served	Proposed Measures	Population to be Served
BABESA GEWOG											
1 Mitshina	No Scheme	* Irri./Spring	Low	-	-	-	NG	0	18	X New Scheme (A)	250
2 Sopsokha	UNICEF**	Spring	High	102	OK	OK	OK	100	0		
3 Yuwakha	UNICEF**	Spring	High	102	OK	OK	OK	100	0		
4 Chimi Lhakhang	UNICEF	Spring	High	-	-	OK	OK	100	0		
5 Gomji	UNICEF**	Spring	High	102	OK	OK	OK	100	0		
6 Baywokha	No Scheme	* Spring	Low	-	-	-	OK	0	5	X New Scheme (C)	40
7 Yusakha	UNICEF	Spring	High	-	-	OK	OK	100	0		
8 Pachekha	UNICEF	Spring	High	-	-	OK	OK	100	0		
9 Jangsapo	UNICEF	Spring	High	-	-	OK	OK	100	0		
10 Tshokona	UNICEF	Spring	High	-	-	OK	OK	100	0		
11 NRTI***	MOA	Stream	High	-	-	-	OK	100	0		
12 Gangkha	UNICEF	Spring	High	-	-	OK	OK	100	0		
13 Power Station	MOI	Spring	Low	-	-	-	OK	100	0		
14 Pry School***	UNICEF	Spring	High	508	OK	OK	OK	100	0		
15 Jamripang	UNICEF**	Spring	High	102	OK	OK	OK	100	0		
16 PWD Camp (Maint.)	GREF*	Spring	Medium	-	-	-	OK	100	0		
17 Motokha	Private	Spring	Low	-	-	NG	OK	100	0	X New Scheme (C)	18
18 Pangnang	UNICEF**	Spring	Medium	102	OK	OK	OK	100	0		
19 PWD Camp (Const.)	MOC	Spring	Medium	-	-	-	OK	100	0		
20 RBA Firing Range**	RBA	Spring	Low	-	-	-	OK	100	0		
Sub-total	-	-	-	-	-	-	-	89	23	-	-
THETSO GEWOG											
21 Rinchengang	UNICEF	Stream	Medium	104	OK	OK	OK	86	5	X Extension Scheme (B)	67
Sub-total	-	-	-	-	-	-	-		5	-	-
Total	-	-	-	-	-	-	-	88	28	-	-

Table G.4.1 Evaluation Sheet of Each Village/Community (2/4)

(Bajo Sub-area)

Village/Community	Implemented Scheme	Water Source					Water Quality	Present Service		Measures to be Taken	
		Type of Water Source	Liability of Water Source	Capacity per Capita (l/d)	Capacity > or < 67 l/s	Present Source Capacity		Service Ratio (%)	Number of Household Not Served	Proposed Measures	Population to be Served
THETSO GEWOG											
1 Proper Bajo	UNICEF	Stream	Low	-	-	NG	OK	26	20	X Additional Scheme	185
2 Bajothang	No Scheme	* River	High	-	-	-	NG	0	5	X New Scheme (C)	61
3 DSC/AMC	MOA	Subsurface	High	-	-	-	OK	100	0		
4 Thangu	No Scheme	* Spring	Low	-	-	-	OK	0	11	X New Scheme (A)	59
5 Matalumchu	No Scheme	* Spring	Low	-	-	-	OK	0	8	X New Scheme (A)	75
Sub-total	-	-	-	-	-	-	-	23	44	-	-
LINGBUKHA GEWOG											
6 Umtekha	No Scheme	* Spring	Low	-	-	-	OK	0	31	X New Scheme (A)	250
Sub-total	-	-	-	-	-	-	-	0	31	-	-
BABESA GEWOG											
7 Wangjokha	UNICEF	Spring	High	-	-	OK	OK	100	0		
8 Matalumchu	UNICEF	Spring	High	432	OK	OK	OK	100	0		
Sub-total	-	-	-	-	-	-	-	100	0	-	-
Total	-	-	-	-	-	-	-	36	75	-	-

Table G.4.1 Evaluation Sheet of Each Village/Community (3/4)

(Phangyul Sub-area)

Village/Community	Implemented Scheme	Water Source					Water Quality	Present Service		Measures to be Taken	
		Type of Water Source	Liability of Water Source	Capacity per Capita (l/d)	Capacity > or < 67 l/s	Present Source Capacity		Service Ratio (%)	Number of Household Not Served	Proposed Measures	Population to be Served
PHANGYUL GEWOG											
1 Proper Phangyul	UNICEF	Spring	Medium	407	OK	OK	OK	37	15	X Extension Scheme (A)	118
2 Phangyul Gompa	No Scheme	* Spring	Medium	-	-	-	OK	0	2	X New Scheme (C)	5
3 Jemkhelo	UNICEF	Spring	High	-	-	OK	OK	100	0		
4 Yangcheytawa	UNICEF	Spring	High	-	-	OK	OK	100	0		
5 Chumey Gompa	UNICEF	Spring	Medium	-	-	OK	OK	100	0		
6 Chungsekha	UNICEF	Spring	High	839	OK	OK	OK	59	10	X Extension Scheme (A)	72
7 Domkhar	No Scheme	* Irrigation	High	-	-	-	NG	0	14	X New Scheme (A)	123
8 Paropselsa	No Scheme	* Irrigation	High	-	-	-	NG	0	1	X New Scheme (C)	9
9 Vegopara	Private	Spring	Medium	-	-	OK	OK	100	0	X New Scheme (C)	5
10 Rabuna inc. PWD	No Scheme	* Spr./Irr.	Medium	-	-	-	OK	0	4	X New Scheme (C)	70
11 Geonkhar	UNICEF	Stream	High	557	OK	OK	OK	81	6	X Extension Scheme (A)	37
12 Lenkhena	No Scheme	* Irrigation	High	-	-	-	NG	0	1	X New Scheme (C)	5
13 Omchuphunasa	No Scheme	* Irrigation	High	-	-	-	NG	0	1	X New Scheme (C)	22
14 Kumchi	No Scheme	* Spring	Low	-	-	-	OK	0	21	X New Scheme (A)	146
15 Damina	UNICEF	Spring	Medium	-	-	OK	OK	100	0		
16 Ribana	No Scheme	* Spring	Low	-	-	-	OK	0	19	X New Scheme (A)	92
17 Pachekha	No Scheme	* Spring	Low	-	-	-	OK	0	1	X New Scheme (C)	12
18 Chuzomsa	Private	Spr./Riv./Irr	High	-	-	OK	NG	31	4	X New Scheme (B)	49
Total	-	-	-	-	-	-	-	36	99	-	-

Table G.4.1 Evaluation Sheet of Each Village/Community (4/4)

(Rubeysa Sub-area)

Village/Community	Implemented Scheme	Water Source					Water Quality	Present Service		Measures to be Taken	
		Type of Water Source	Liability of Water Source	Capacity per Capita (l/d)	Capacity > or < 67 l/s	Present Source Capacity		Service Ratio (%)	Number of Household Not Served	Proposed Measures	Population to be Served
RUBEYSA GEWOG											
1 Nyizergang Gompa	UNICEF	Spring	Medium	415	OK	OK	OK	100	0		
2 Rumina	UNICEF	Spring	High	237	OK	OK	NG	100	0	X Treatment Scheme	123
3 Nyalakha	UNICEF	Spr./Irr.	High	237	OK	OK	OK	45	4	X Extension Scheme (B)	41
4 Rutcokha	UNICEF	Spring	Medium	404	OK	OK	OK	100	0		
5 Tshemcho	UNICEF	Spring	High	237	OK	OK	OK	100	0		
6 Jasukha	UNICEF	Spring	High	576	OK	OK	OK	100	0		
7 Awakha	UNICEF	Spring	High	518	OK	OK	OK	45	1	X Extension Scheme (B)	12
8 Maphekha	UNICEF	Stream	High	608	OK	OK	OK	100	0		
9 Umtekha	No Scheme	* Spring	Low	-	-	-	OK	0	4	X New Scheme (C)	33
10 Nyegapara	No Scheme	* Stream	High	-	-	-	OK	0	7	X New Scheme (A)	45
11 Tashidingkha	No Scheme	* Spring	Low	-	-	-	OK	0	1	X New Scheme (C)	9
Sub-total	-	-	-	-	-	-	-	81	17	-	-
JENA GEWOG											
12 Balakha	UNICEF	Stream	Medium	3,086	OK	OK	OK	100	0		
13 Themakha	UNICEF	Spring	Medium	237	OK	OK	OK	47	8	X Extension Scheme (A)	169
14 Phuntshogang	UNICEF	Stream	High	864	OK	OK	OK	100	0		
15 Tashi Tokha	No Scheme	* Spring	High	-	-	-	OK	0	11	X New Scheme (A)	141
Sub-total	-	-	-	-	-	-	-	50	19	-	-
THETSO											
16 Nyechegeykha	UNICEF	Spring	Medium	508	OK	OK	OK	100	0		
17 Nalabji	UNICEF	Stream	Medium	617	OK	OK	OK	100	0		
Sub-total	-	-	-	-	-	-	-	100	19	-	-
Total	-	-	-	-	-	-	-	69	36	-	-