CHAPTER 7

WATER SUPPLY PLANNING

FOR PILOT PROJECT

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7.1 General

In the pilot project, public faucet type water supply facilities were constructed at four communities where the test well had been drilled. However, since these facilities were mainly constructed for the purpose of operation and maintenance education and sanitation education, they are inadequate as full-fledged facilities for future use. The objective of this chapter is to plan domestic water supply systems of a higher degree of completion for the 4 communities based on the information obtained from the pilot project and to examine the feasibility for executing the groundwater development project.

The water supply plans make the most use of the existing facilities and the facilities constructed in the pilot project. If it is possible to distribute water to the surrounding communities with gravity, the water diversion scheme shall be included in the combined water supply planning. However, the feasibility of the project shall be examined on the case where it was assumed that there are no existing facilities.

7.2 Water Supply Facility Plans

7.2.1 Campo Leon (Chuquisaca)

1) Outline of the Existing Facilities

There were no water supply facilities prior to the execution of the pilot project.

In the pilot project, a deep well was constructed, a submersible motor pump and electric generator were installed, and a non-elevated water tank and a generator house were constructed, and public faucets were installed at one location.

The safe yield of the test well was 194 cubic meters per day, the static water level was 190 m, and the dynamic water level was 283 meters. The water consumption in this community can be covered satisfactorily with this well alone.

2) Water Supply District and Planned Water Consumption

Table 7-2-1 shows the planned domestic water consumption. Although the water consumption will be twice that shown if water for livestock is included, the plan will be aimed only at domestic water here.

3) Facility Plan

If an elevated tank is installed near the test well and a distributing pipe is laid, the water can be distributed to the water supply districts by gravity flow. Since the lift pump installed in the pilot project has an adequate head, water is pumped directly to the elevated tank. The water

supply plan diagram is shown in Figure 7-2-1.

Table 7-2-1 Planned Water Consumption in Campo Leon

Current population	237 persons
Planned population	273 persons
Planned mean water consumption per head per day	90 l/person·day
Planned daily mean water consumption	25 m^3/day
Planned daily maximum water consumption	30 m^3/day
Planned hourly maximum water consumption	5 m^3/hour

Note : Hourly maximum ratio: 4.0

4) Required Facilities

① Well Existing

② Lift pump Existing; submersible motor pump, ϕ 50mm X 120l/min X 290m X 11kW)

③ Electric generator Existing; 35kVA

④ Elevated tank Structure : Reinforced concrete

Capacity : $20m^3$

(equivalent to 16 hours of planned daily maximum water consumption)

⑤ Distributing pipe Specifications: PVC pipe, diameter ~50mm

Extension: approx. 4km

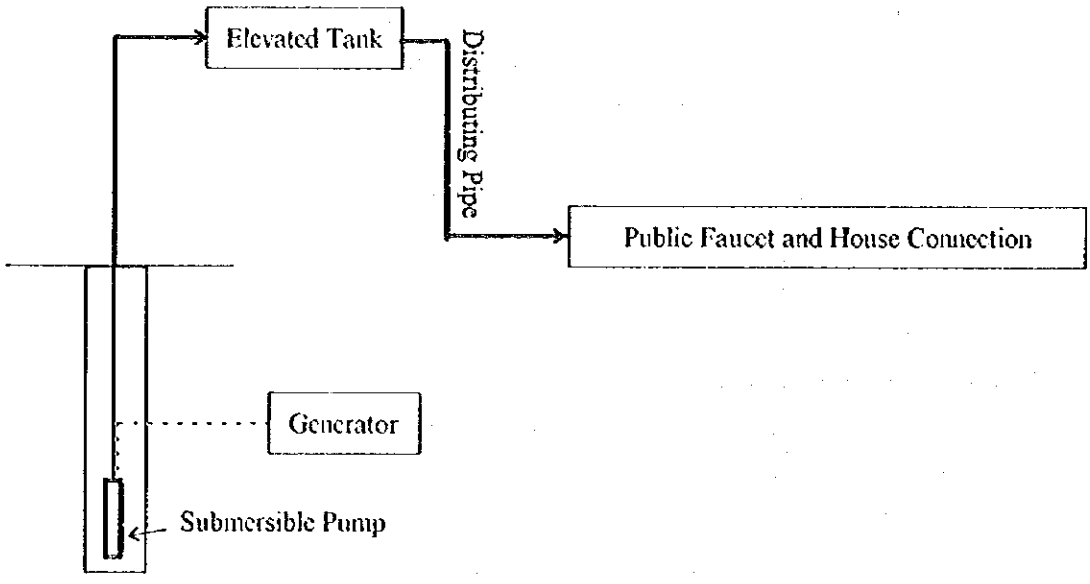

Figure 7-2-1 Water Supply Plan Diagram (Campo Leon)

7.2.2 Corque (Oruro)

1) Outline of the Existing Facilities

This community has a water supply system using a spring, located approximately 18 km north of the community, as a water source. A reinforced concrete distributing tank is installed at the hill side of the community and distributing pipes are laid to the community from this tank. However, although water can be obtained from the water source of the existing facility during the rainy season, the inflowing water quantity drops nearly to zero and water shortage occurs during the dry season.

In the pilot project, a deep well was constructed approximately 1 km east of the community, a submersible motor pump and electric generator were installed, and a waterpipe was laid to the existing distributing tank.

The safe yield of the test well was 173 cubic meters per day, the static water level was 7 m, and the dynamic water level was 29 meters. The water consumption can be covered with this well alone if the lift pump is operated 24 hours a day.

2) Water Supply District and Planned Water Consumption

Table 7-2-2 shows the planned domestic water consumption.

Table 7-2-2 Planned Water Consumption in Corque

Current population	1,558 persons
Planned population	1,792 persons
Planned mean water consumption per head per day	70 l/person·day
Planned daily mean water consumption	125m^3/day
Planned daily maximum water consumption	151 m^3/day
Planned hourly maximum water consumption	15.7 m^3/hour

Note : Hourly maximum ratio: 2.5

3) Facility Plan

Since the submersible pump installed in the pilot project is insufficient in capacity, a water tank shall be constructed near the tank and a conveying pump shall be installed to pump up water from this water tank to the existing distributing tank. With regard to the distributing tank and the distributing pipe, the existing facilities shall be used. Figure 7-2-2 shows the water supply plan diagram.

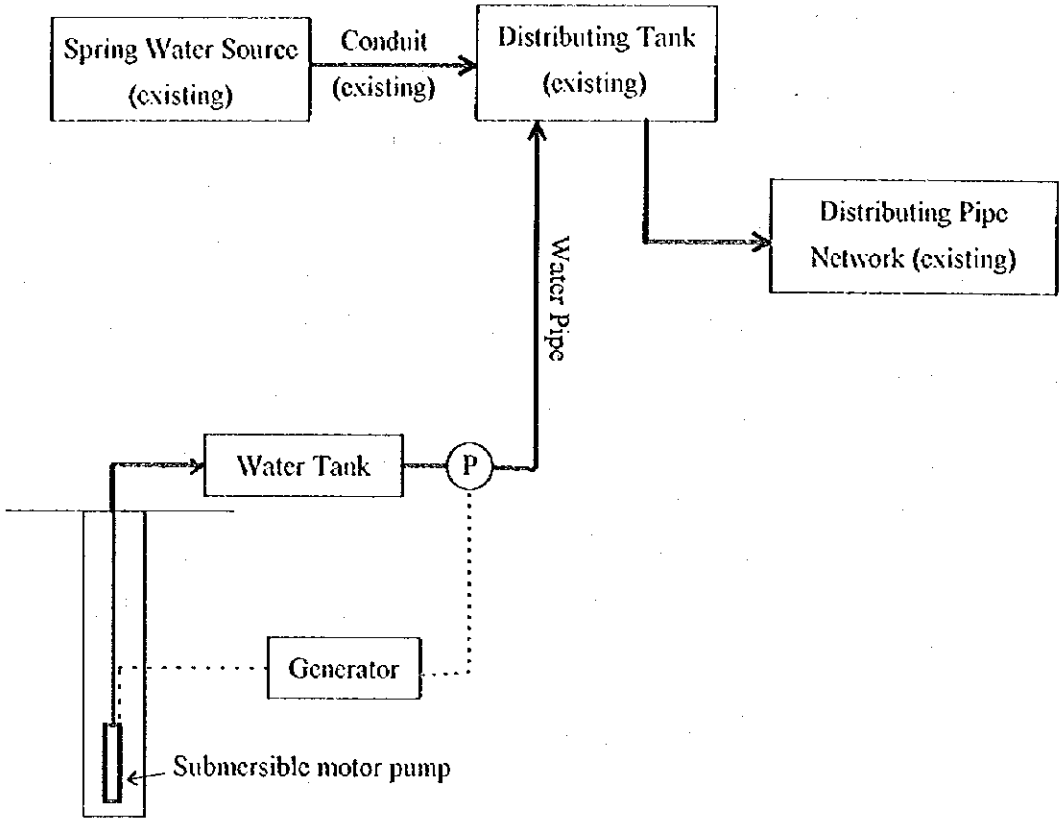

Figure 7-2-2 Water Supply Plan Diagram (Corque)

4) Required Facilities

① Well	Existing	
② Lift pump	Existing	ϕ 40mm X 140l/min X 35m X 1.5kW
③ Electric generator	Existing	10kVA
	Addition:	15kVA
④ Water tank	Structure :	Reinforced concrete
	Capacity :	approx.16 m^3
⑤ Conveying pump	Model:	Volute pump
	Specifications :	ϕ 50mm X 265l/min X 50m X 7.5kW
		(operated 24 hours a day)
⑥ Waterpipe	Existing	ϕ 100mm X 1,300m
⑦ Distributing tank	Existing	30 m^3
	Addition:	30 m^3
	Total :	60 m^3
	(equivalent to 10 hours of planned daily maximum water consumption)	
⑧ Distributing pipe	Existing	

7.2.3 La Chosa (Tarija)

1) Outline of the Existing Facilities

On the premise that water will be diverted from the neighboring village of San Isidro, a distributing tank was installed on a hill at the western side of the Pan American Highway and a distributing pipe was laid from this tank. However, due to a shortage of the water source quantity in San Isidro, the distribution of water has become impossible and the water could not be supplied.

In the pilot project, a deep well was constructed, a submersible motor pump and electric generator were installed, and a non-elevated water tank, a generator house, and public faucets were constructed.

The test well is 120 m deep and one from which water flows out naturally. The artesian yield was 7.6 liters per second (655 cubic meters per day).

2) Water Supply District and Planned Water Consumption

Since the artesian yield is high and the water can be diverted by gravity flow to 3 neighboring villages, the water supply block shall be comprised of the 4 villages of La Chosa, Ventolera, Angostura, and Sanchu Waykho. Table 7-2-3 shows the planned water consumption.

Table 7-2-3 Water Consumption in La Chosa and Other Districts

	La Chosa	Ventolera	Angostura	S. Waykho	Total
Current population (persons)	371	177	200	196	944
Planned population (persons)	425	200	225	220	1,070
Planned mean water consumption per head per day (l/day.person)	70	70	70	70	70
Planned daily mean water consumption (m^3/day)	30	14	16	15	75
Planned daily maximum water consumption (m^3/day)	36	17	19	18	90
Hourly maximum ratio	3.5	5.0	5.0	5.0	-
Planned hourly maximum water consumption (m^3/hour)	5.3	3.5	4.0	3.8	16.6
Distance from La Chosa	-	approx. 3.5 km	approx. 6 km	approx. 3 km	-

3) Facility Plan

The water tank installed in the pilot project shall be used as a relay tank, a conveying pump shall be installed to lift water to the existing distributing tank, and water shall be distributed within the La Chosa community from this tank using the existing distributing pipe.

Also, conduits to the three villages of Ventolera, Angostura, and Sanchu Waykho shall be installed anew and water shall be diverted by means of a gravity flow system. Figure 7-2-3 shows the water supply plan diagram.

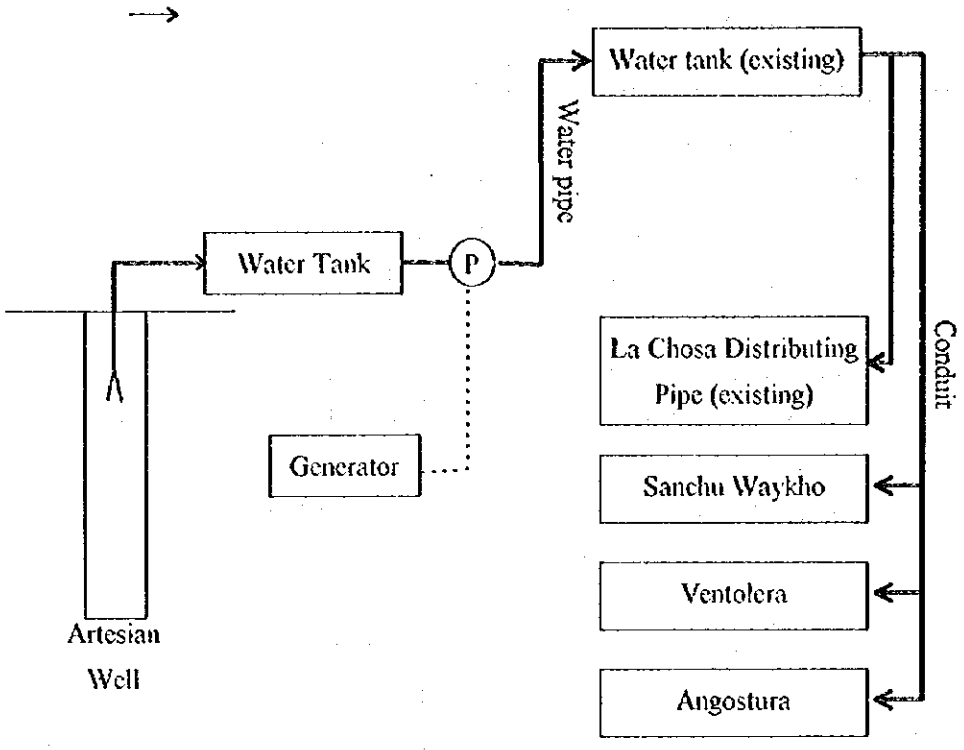

Figure 7-2-3 Water Supply Plan Diagram (La Chosa)

4) Required Facilities

① Well	Existing	
② Water tank	Existing	$8m^3$
③ Conveying pump	Model:	Volute pump
	Specifications :	ϕ 40mm X 280l/min X 50m X 3.7kW
④ Electric generator	Existing	10kVA
⑤ Waterpipe (from water tank to distributing tank)		
	Specifications :	PVC, ϕ 100mm
	Extension:	approx.300m
⑥ Distributing tank	Existing	30 m^3
	Addition	23 m^3
	Total :	53 m^3
	(equivalent to 14 hours of planned daily maximum water consumption)	
⑦ Distributing pipe	Existing	approx. 1km
⑧ Conduits (from distributing tank to neighboring 3 villages)		
	Specifications :	Steel pipe, ϕ 50-75mm
	Extension :	approx. 9km

7.2.4 San Carlos (Santa Cruz)

1) Outline of the Existing Facilities

There were no water supply facilities prior to the execution of the pilot project.

In the pilot project, a deep well was constructed, a submersible motor pump and electric generator were installed, and a non-elevated water tank, a generator house, and a public faucets were constructed.

The safe yield of the test well was 36.0 cubic meters per hour, the static water level was 58 m, and the dynamic water level was 93 meters. The planned water consumption can be covered satisfactorily with this well alone.

2) Water Supply District and Planned Water Consumption

Since the well has an abundant yield and the water can be diverted by gravity flow to 2 neighboring villages, the water supply block shall be comprised of the 3 villages of San Carlos, San Juan, and Villa Rosario. Table 7-2-4 shows the planned consumption.

Table 7-2-4 Planned Water Consumption in San Carlos and Other Districts

	San Carlos	San Juan	Villa Rosario	Total
Current population (persons)	480	100	250	830
Planned population (persons)	552	115	288	955
Planned mean water consumption per head per day (l/person·day)	110	90	90	90
Planned daily mean water consumption (m^3/day)	61	10	26	97
Planned daily maximum water consumption (m^3/day)	73	12	31	116
Hourly maximum ratio	3.5	5.0	4.0	
Planned hourly maximum water consumption (m^3/hour)	10.6	2.5	5.2	18.3
Distance from San Carlos	-	approx. 3km	approx. 3km	

3) Facility Plan

A distributing tank shall be installed anew at the hilltop part of San Carlos, a conveying pump for lifting water shall be newly installed next to the water tank installed in the pilot project, and a distributing pipe shall be laid for distribution of water by gravity within the community of San Carlos.

Also, a connection shall be made with distributing pipes and conduits shall be laid to divert water to the two villages of San Juan and Villa Rosario. Figure 7-2-4 shows the water supply plan diagram.

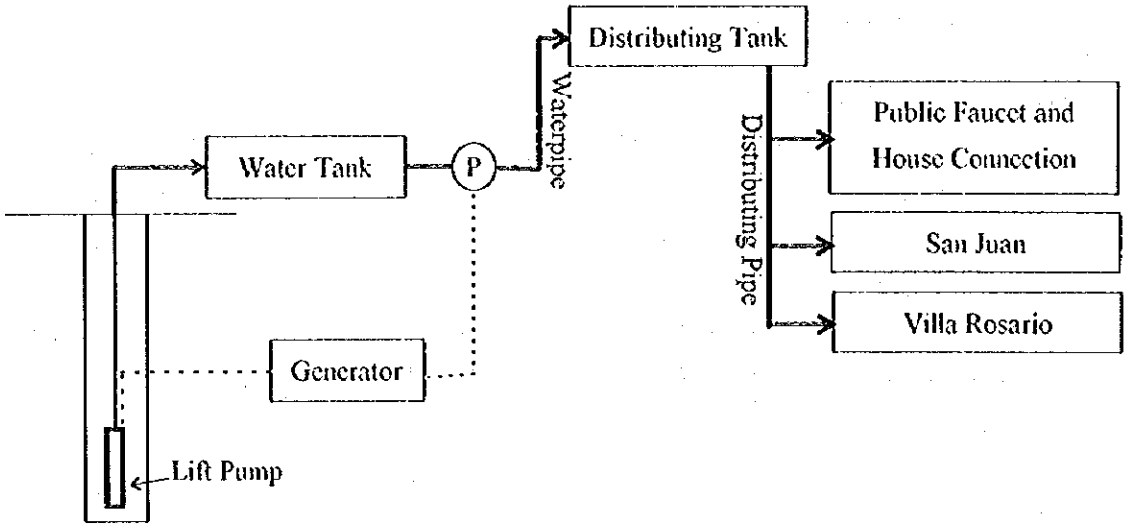

Figure 7-2-4 Water Supply Plan Diagram (San Carlos)

4) Required Facilities

① Well	Existing	
② Lift pump	Existing	ϕ 32mm X 105l/min X 100m X 3.7kW)
③ Water tank	Existing	15m^3
④ Conveying pump	Model:	Volute pump
	Specifications :	ϕ 50mm X 305l/min X 80m X 7.5kW
⑤ Electric generator	Existing	15kVA
	Addition	20kVA
	Total	35kVA
⑥ Waterpipe (from water tank to distributing tank)		
	Specifications :	PVC, ϕ 40mm
	Extension:	approx. 0.5km
⑦ Distributing tank	Structure :	Reinforced concrete
	Capacity:	approx. 70 m^3
	(equivalent to 16 hours of planned daily maximum water consumption)	
⑧ Distributing pipe	Specifications:	Steel pipe, ϕ 75-125mm
	Extension:	approx. 2km
⑨ Conduits (from distributing tank to neighboring 2 villages)		
	Specifications:	Steel pipe, ϕ 75mm
	Extension:	approx. 5km

7.3 Cost Estimation and Feasibility of the Project

7.3.1 Project Cost

Initial investment of the groundwater development and water supply project is composed of well drilling cost, construction cost of water supply facilities, land acquisition cost, and engineering cost for investigation, design and supervision. Among these, many beneficiary communities might carry the land acquisition cost and the labor cost for the facility construction.

The project costs for construction of water supply facilities are shown in Table 7-3-1, estimated according to the facility planning in the section 7.2 and the following conditions.

a. Well construction costs were estimated for the operation of drilling equipment, the procurement and installation for casing and strainer, and the field examination, excluding depreciation costs of the equipment and physical contingencies.

b. Construction costs for water supply facilities were estimated as far as distribution pipes and public water faucets, based on the contracts with private constructor.

c. Each costs were estimated upon multiplying the quantity of each facility and the unit prices of market, excluding reserve funds. To verify the total costs, the cost for construction of the existing facilities were also estimated on the current price bases.

d. Engineering and consulting costs were estimated at five percent of the total direct costs.

Table 7-3-1 Construction Costs

(Unit: dollar)

	Campo Leon	Corque	La Chosa	San Carlos
Well Drilling	48,100	11,100	13,400 (13,400)	24,000 (24,000)
Facility Construction				
Submersible Motor Pump	12,000	3,100	–	5,600 (5,600)
Lifting Pump	–	2,500	1,300 (1,300)	2,500 (2,500)
Transit Tank	–	3,000	1,200 (900)	2,300 (1,500)
Distribution Tank	4,500	9,000	7,500 (3,600)	10,500 (4,500)
Lifting Pipes	–	22,000	3,000 (3,000)	1,000 (1,000)
Distribution Pipes	25,000	82,000	10,000 (10,000)	20,000 (20,000)
Conduit Pipes to Other Communities	–	–	90,000 (0)	50,000 (0)
Distribution Pipes to Others	–	–	15,000 (0)	17,000 (0)
Generator	28,000	22,500	11,000 (11,000)	22,500 (22,500)
Generator House	3,000	3,000	3,000 (3,000)	3,000 (3,000)
Sub-total	120,600	158,200	155,400 (46,200)	158,400 (84,600)
Consulting Engineering	6,000	7,900	7,800 (2,300)	7,900 (4,200)
Total	126,600	166,100	163,200 (48,500)	166,300 (88,800)
Per Capita	464	93	153 (114)	174 (161)

Note: Figures in ( ) show the case of the individual planning.

Estimated construction costs of the facilities vary widely from $93 to $464 per person. Campo Leon is such a dispersed community with small population and deep groundwater level that the construction cost is comparatively high. The costs of Corque is the lowest because of greater population scale and shallow groundwater level. At La Chosa and San Carlos, the individual water supply planning costs lower than the combined planning with neighboring communities as a result of long distances.

7.3.2 Operation and Maintenance Cost

Operation and maintenance costs cover the energy costs for fuel, electricity and chemicals, the personnel expenses, the procurement expenses for expendables, the cost of materials and labor wages for repairing, and the depreciation expenses for facilities.

Table 7-3-2 shows the operation and maintenance costs in the pilot project communities, estimated upon the following conditions.

a. Fuel costs were estimated upon multiplying the average working hours of generator, fuel consumption rate and unit price.
b. Personnel expenses vary from the number of staff and the daily wages. Monthly expenditure were estimated for three days of daily allowance at Campo Leon, 20 days at Corque, and 10 days at La Chosa and San Carlos.
c. Annual repairing costs were estimated at 0.2 percent of the construction cost of facilities.
d. Depreciation costs of facilities and equipment were excluded in the cost estimation here.

Table 7-3-2 Operation and Maintenance Costs

(Unit: dollar/month)

	Campo Leon	Corque	La Chosa		San Carlos	
Fuel Consumption	132	248	56	(23)	376	(201)
Personnel Expenses	20	140	70	(70)	70	(70)
Repairing Cost	20	26	26	(8)	26	(14)
Total	172	414	152	(101)	472	(285)
Per Capita	0.63	0.23	0.14	(0.24)	0.49	(0.52)
Per Household	Bs 16	Bs 6	Bs 4	(6)	Bs 12	(13)

Note: Figures in ( ) show the case of the individual planning.

Estimated operation and maintenance costs ranges from Bs.4 to Bs.16 per household per month. Campo Leon is the most expensive, while Corque and La Chosa is comparatively inexpensive. Fuel costs account for 60 to 80 percent of the total operation and maintenance cost except for La Chosa where groundwater spouts to the ground with its pressure.

7.3.3 Feasibility for Water Supply Planning

1) Average monthly income is assumed to be around $40 to $100 per household in rural communities, which means the construction cost is equivalent to the income of all households for one year at Corque and five years at Campo Leon. The construction of water supply facilities should be charged to public investment because the project cost is far beyond the limit of the community's financial capacity.

2) Operation and maintenance cost was estimated at Bs.16 per household per month at Campo Leon, accounting for around eight percent of the monthly income. However, average monthly expenditure amounts to around Bs.10, some households charge up to Bs.20 per month for purchasing drinking water of tanker and many inhabitants said they could barely pay up to Bs.20 per month according to the questionnaire surveys. Therefore, it might be possible to charge the communities water tariff for operation and maintenance of water supply services.

3) The implementation of water supply projects planned in this Chapter will realize a stable water supply and improve the living condition of beneficiary communities. As the communities are considered to have strong wills and abilities to operate and maintain the water supply systems independently from the points of view in the pilot projects, the project is concluded to be viable after realization of an initial investment.

4) The simple technology employed in water supply planning must be adapted for rural communities to operate and maintain the system. However, supporting system should be constructed by the Prefectures, the Municipalities and private dealers to cope with the case of incident or disorder of the equipment.

CHAPTER 8

PROJECT IMPLEMENTATION PLAN

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8.1 Outline of the Project

1) The planned project aims at developing groundwater for domestic use and supplying and distributing water for domestic use to 98 communities in Chuquisaca, 46 communities in the southern part of La Paz, 72 communities in Oruro, 85 communities in Tarija, and 155 communities in Santa Cruz, or a total of 456 communities which face serious shortage of domestic water due to delays of water resource development.

2) International aid shall be depended on for the procurement of the well drilling equipment (rigs) necessary to execute the present plan. In order to serve the additional purpose of guidance on equipment operation skills, the well drilling work for the first year shall be carried out in cooperation with engineers of each Prefecture, which are the project executing bodies and agencies to which the equipment are to be provided.

3) The respective Prefectures shall be fully responsible for carrying out the well drilling work from the second year onwards and all of the water supply system construction work while making adjustments with the relevant agencies in the central government, Prefecture, city, targeted community, etc.

4) The term of execution of the project is considered to be restricted by the project financing conditions, the financial circumstances of the central government and the respective Prefectures. Although it may take approximately half a year to a year for the equipment procurement formalities to be completed if international cooperation is to be depended on for part of the financing, plans were formulated so that the planning targets will be achieved in 5 years in view of the urgency of execution of the project.

8.2 Execution Schedule

Figure 8-2-1 shows the execution schedule for the project. In the first year, drilling equipment shall be procured, the project execution system shall be established, and preliminary field surveys, selection of applicable projects, and detailed field surveys shall be carried out. The drilling work for the first year shall be performed in an on-the-job training form for the acquisition of skills.

The water supply system construction work shall be performed upon making facility plans that take the population, water consumption, site conditions, groundwater level, yield, etc. into consideration.

	1st Year	2nd Year	3rd Year	4th Year	5th Year	Remarks
Project preparation						
Procurement of drilling equipment						
Selection of drilling points						Field survey
Well drilling work						Annual inspection
Detailed design of water supply facilities						
Construction of water supply facilities						

Figure 8-2-1 Project Execution Schedule

8.3 Water Supply Plan

8.3.1 Basic Policies

The procedures for water supply plan formulation are shown in Figure 8-3-1.

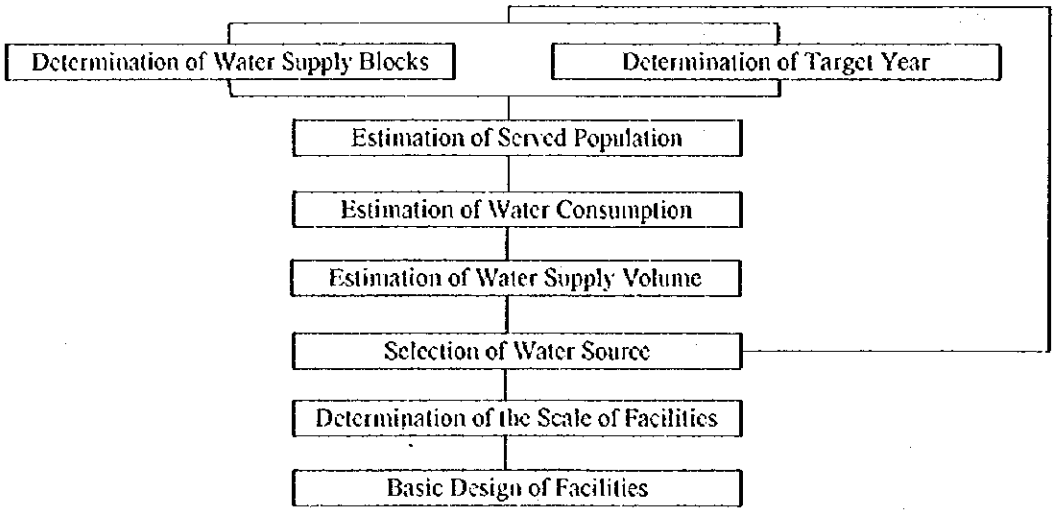

Figure 8-3-1 Procedures for Water Supply Plan Formulation

The water supply facility plan shall be formulated in accordance with the following basic policies.

① The planning and design of water supply facilities shall be carried out on the basis of the circumstances of existing water supply systems and the Design Standard of Water Supply Facility Design Standards in Bolivia.

② The scale of facilities and the improvement/expansion plan for existing systems shall be planned on the basis of the planned population for 10 years after the time of planning.

③ With regard to water sources, groundwater development by means of wells shall be given first consideration.

④ This development plan shall be planned for major facilities such as the water source facility, water conveying facility, distribution reservoir, distributing main, pipe.

⑤ In cases where the sustainable yield exceeds the water demand of the corresponding block, diversion of water to nearby blocks shall be considered.

⑥ In cases where water supply facilities exist already, improvement and expansion work shall be carried out to enable effective utilization of such facilities.

⑦ The capacities of each facility shall be designed for 8 hours of operation a day as standard.

8.3.2 Planned Water Volume

The mean water consumption per head per day have been set as shown in Table 8-3-1 based on the Water Supply Facility Design Standards in Bolivia and in accordance with the population of each water supply district and the zonal division.

Table 8-3-1 Planned Mean Water Consumption per Head per Day

(unit: l/person·day)

Zonal Division	Population of the Community			
	<=500	501~2,000	2,001~5,000	5,001~20,000
Altiplano	30~50	30~70	50~80	80~100
Valley	50~70	50~90	70~100	120~150
Plain	70~90	70~110	90~120	150~200

Table 8-3-2 shows the total water demand for the projects. Planned mean water consumption amounts to 24,116 cubic meters per day in total.

Table 8-3-2 Total Planned Water Volume in Each Department

(unit: m^3/day)

Item	Chuquisaca	South of La Paz	Oruro	Tarija	Santa Cruz	Total
Number of targeted blocks	98	46	72	85	155	456
Planned daily mean water consumption	5,073	1,176	1,867	2,815	1,3185	24,116
Planned daily maximum water consumption	6,088	1,411	2,240	3,378	15,822	28,939
Planned groundwater yield	6,696	1,552	2,464	3,716	17,404	31,832

Note Planned daily maximum water consumption = [Planned daily mean water consumption] X 1.2

Planned groundwater yield = [Planned daily maximum water consumption] X 1.1

8.3.3 Facility Plan

1) Water Supply System

Water supply systems using groundwater as the water source can be classified into the following four types according to the water intake method, the population of the targeted community, and the form of the community (Figure 8-3-2). Motorized pump system is applied for the water supply systems in this Project.

① Hand Pump System

This type of system can be adopted for shallow wells and deep wells with a water level at about 40 m or shallower and is applicable to districts where the number of households is about 20 or less. This type of system is the most inexpensive in terms of construction cost and operation and maintenance cost.

② Gravity Flow System

This type of system can be adopted in cases where spring water can be collected from an area that is higher in altitude than the targeted district. Since power will not be required if water intake facilities and conduits are constructed, the operation and maintenance cost will be inexpensive.

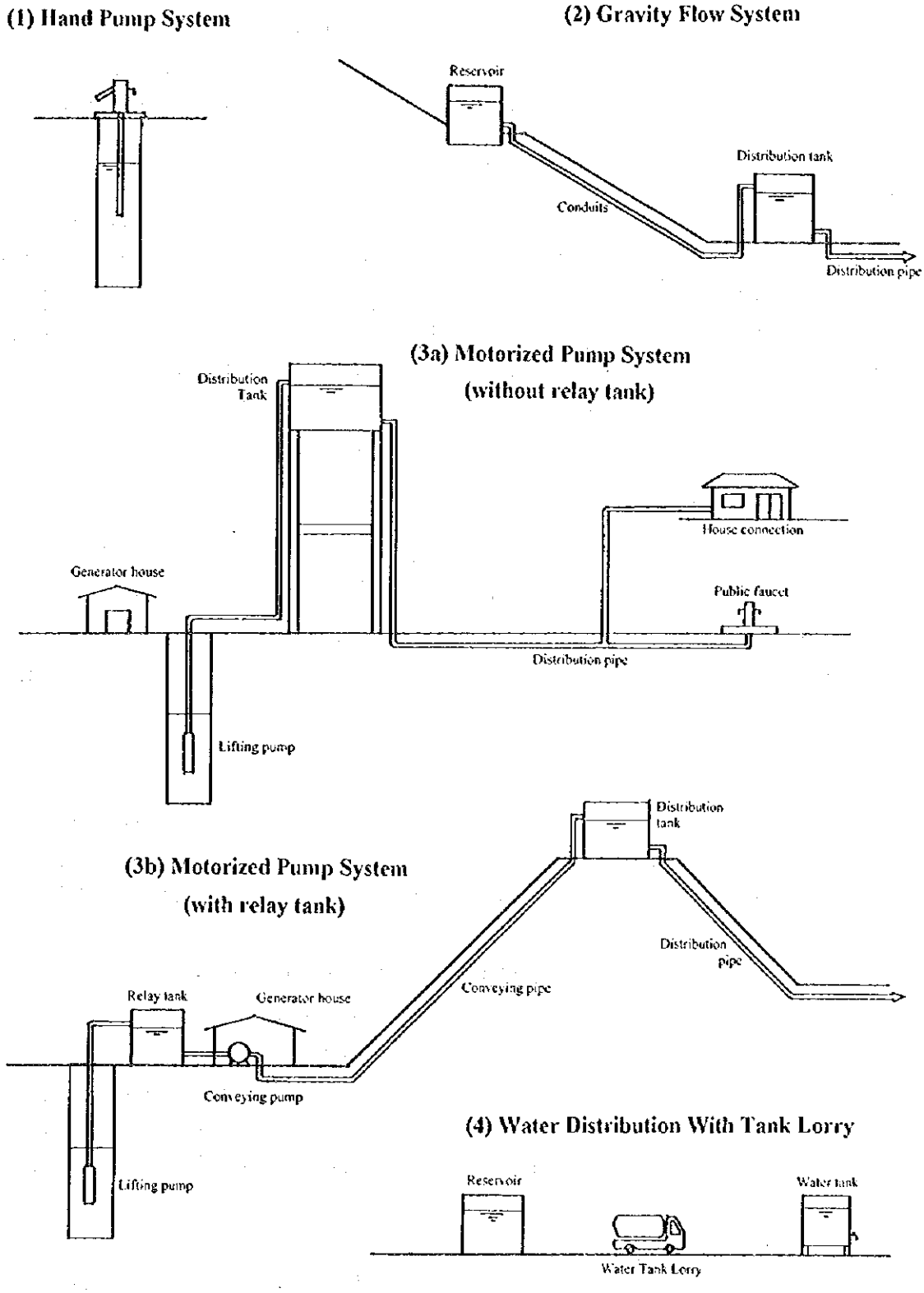

Figure 8-3-2 Basic Water Supply Systems

③ Motorized System

In this type of system, a power pump is used to pump up water from the well to a distribution tank (elevated water tank) where it is stored and then distributed by gravity. For the lift pump of a deep well, a submersible motor pump shall be used upon installing in a casing. In the case of a shallow well, operation and maintenance will be easier if a non-elevated centrifugal pump is used.

Depending on the location of the distribution tank, the water may be pumped up directly to an elevated tank by means of submersible pump or the water may be pumped up with a conveying pump to a distribution tank via a relay tank.

This type of system requires the appointment of a person responsible for management activities, including the operation of equipment, maintenance and inspection, prevention of excessive pumping, etc., and the provision of a support system for operation and maintenance. The operation and maintenance costs of this type of system are high.

④ Water Distribution with Tank Lorry

In this type of system, clean water collected from a water source in another district is transported by means of a water tanker and supplied to the targeted district. This type of system is applicable to districts in which satisfactory groundwater cannot be obtained or in which water supply facilities cannot be furnished due to high construction costs, operation and maintenance costs.

2) Required Facilities

The facilities required in each type of water supply system are shown in Table 8-3-3. Construction sites, access roads, and operation and maintenance facility, groundwater monitoring facility, and accessories are also required in addition to the items shown below.

Table 8-3-3 Required Facilities by Water Supply Systems

Water Supply System	Required Facilities
1) Hand pump system	Well, hand pump, foundation
2) Gravity flow of spring water	Catchment well, conduits, water storage tank, distribution pipe
3) Power pump system	Well, lift pump, electric generator, control house, distribution tank, distribution pipe (relay tank, conveying pump, conveying pipe)
4) Water distribution by transportation	Water tanker, water tank

Note: Depending on the water quality, disinfecting and filtration devices may also be necessary.

3) Planning Standards

The planning standards for motorized pump type water supply system are as follows.

① Well

The number of wells is determined based on the safe yield calculated based on the estimated water consumption and the pumping test results. The drilling method and well structure are described in section 8.4.

② Lift Pump

In the case of a deep well, a submersible motor pump shall be used. In the case of a shallow well or in the case where the water level is high, a non-elevated centrifugal pump shall be used and a low-level stoppage limit switch should be installed. Pumping pipes, submersible cables, control panel, power equipment, etc. will also be necessary. As a rule, the pump capacity should be calculated for 8 hours of operation a day. A pump room should be installed for housing the control panel.

③ Power Source

An engine generator should be installed in the case of a district without commercial power. Depending on the area, solar power generation may also be possible.

④ Distribution Tank

An elevated tank shall be installed at a location and height that would enable the continuous supplying by gravity of the necessary quantity of water at a certain pressure or more to the area to be supplied. Depending on topographical and site conditions, a lift pump ⇒ relay tank ⇒ conveying pump ⇒ distributing tank arrangement shall be used. The structure shall be of reinforced concrete and the effective volume of the tank shall be set to an equivalent of 10 to 18 hours of the estimated daily maximum water consumption.

⑤ Distribution Pipe

Distribution pipes should have adequate resistance against water pressure and earth pressure and should be one by which the water will not be polluted or will not leak. The minimum water pressure for a distribution pipe shall be 1.5kg/cm^2 or more as standard. In terms of material, the pipe should be a galvanized steel pipe or polyvinyl chloride pipe and freezing should be considered for cold areas. In cases where a distributing pipe network already exists, the connection positions should be examined.

Table 8-3-4 shows an example of water supply system specifications calculated based on the above planning standards for communities of representative population scales.

Table 8-3-4 Model Designs for Water Supply Facilities

Population scale of community	200 persons	300 persons	500 persons	1,000 persons	2,000 persons
Mean water consumption per head per day (l/person·day)	80	80	80	100	120
Planned daily mean water consumption (m^3/day)	16	24	40	100	240
Planned daily maximum water consumption (m^3/day)	19	29	48	120	280
Hourly maximum ratio	5.5	4.5	4.0	3.0	2.5
Planned hourly maximum water consumption (m^3/hour)	4.4	5.4	8.0	15.0	30.0
Planned yield (l/min.)	>=22	>=32	>=53	>=132	>=317
Capacity of lift pump (l/min.)	46	67	111	275	661
Capacity of distributing tank (m^3)	15	20	28	60	120
Capacity of conveying pump (l/min.)	74	90	133	250	500
Capacity of relay tank (m^3)	5	6	8	15	30

Note: 8 hours of operation a day was presumed for the lift pump. Depending on the topographical conditions, the conveying pump and relay tank may not be necessary.

8.3.4 Facility Construction Plan

1) Procurement of Equipment and Materials

Among the water supply equipment, foreign products must be imported for the lift pump (submersible motor pump) and the diesel engine generator since there are no manufacturing factories in Bolivia for these items. It is considered that the other equipment can be procured in the domestic market. Standards and specifications should be standardized in the procurement process.

2) Construction Works

The water supply facility construction work should be undertaken as contracted work by a domestic construction firm. With regard to the labor force for the construction work, the cooperation of the residents of the district should be sought as much as possible and employment opportunities should be increased.

The design, cost estimation, and execution control should be carried out under the responsibility of the Prefecture.

8.4 Well Construction Plan

8.4.1 Basic Policies

The basic policies for the well construction plan are as follows.

① Water source of this project shall be deep groundwater in an artesian aquifer.

② In order to determine the drilling depth and drilling method for a drilling point, detailed field surveys must be executed and the hydrogeological structure of the planned position must be checked prior to the execution of the project.

③ The yield should be set within the safe yield range upon confirming the yield of the well and confirming that there will be no influences on water utilization in the surroundings.

8.4.2 Well Drilling Plan

1) Well Drilling Procedures

The procedures for executing the survey and work for well drilling are shown in Figure 8-4-1. In order to secure stable intake of water, adequate studies, including the collection and organization of existing materials, hydrogeological surveys, geophysical prospecting, etc., must be conducted to seek out a favorable aquifer and the formulation of a drilling plan suited for such an aquifer, the installation of screens, and the selection of a pump with a capacity that matches the existing groundwater quantity must be carried out. The drilling point should be set in consideration of the position and height relationships with respect to the district to which the water is to be supplied.

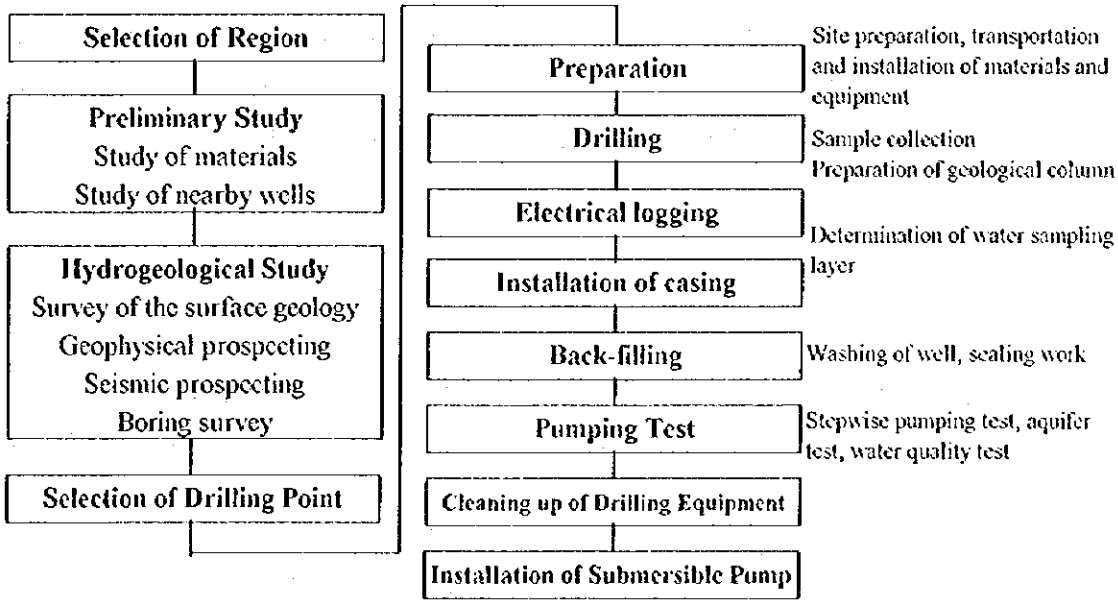

Figure 8-4-1 Flowchart of the Well Drilling Work

2) Drilling Method

Well drilling methods can be largely classified into open hole methods and cased hole methods. In open hole methods, the interior of the drilled hole is filled with slurry to prevent the collapsing of the hole and drilling is continued in the open hole condition up to a predetermined depth while making a mud wall. In cased hole methods, drilling is continued while inserting casings in order to prevent the collapsing of soft strata and using only clear water instead of slurry. Well drilling machines can be divided into the percussion type and the rotary type, and the type is selected according to the type of strata, the drilling depth, the site conditions, etc. With a percussion type well drilling machine, vertical motion is applied to a bit and the strata are crushed and drilled through by the impact force. Drilling is performed by applying a rotating force to the bit in a rotary type well drilling machine, which may be classified further into a spindle type, turntable type, reverse rotary type, etc.

The drilling method must be selected according to the type of strata, the drilling depth, the site conditions, etc.

3) Year-wise Drilling Plan

In consideration of the working and transport efficiency of the drilling equipment, the policy of starting the work from regions with high groundwater development potential and good access and then gradually expanding to peripheral areas shall be taken for the execution schedule for the well drilling work. Table 8-4-1 shows the number of locations drilled in each plan year in each Department.

4) Well Structure

The well structure must be determined in consideration of the planned depth, yield, and water level and water quality of the groundwater.

Figures 8-4-2 and 8-4-3 show standard cross sections of the well. As standard, the well drilling diameter shall be 10-12 inches and the casing diameter shall be 4-6 inches. Casings shall be made of steel and screens shall be made of stainless steel or FRP.

Table 8-4-1 Number of Locations Drilled in Each Plan Year in Each Department

Department	Drilling Year	Number of Drilling Wells by Planned Drilling Depth (m)							Drilling Extent (m)
		0~50	50~100	100~150	150~200	200~300	>=300	Total	
Chuquisaca	1st Year	15	1	3				19	1,300
	2nd Year	21	2	4	1			28	2,050
	3rd Year	2	10	8				20	2,300
	4th Year		1	18	1			20	3,000
	5th Year			1	5	2	3	11	2,950
	Total	38	14	34	7	2	3	98	11,600
South of La Paz	1st Year	6		1				7	450
	2nd Year	11		3				14	1,000
	3rd Year			9				9	1,350
	4th Year			7	2			9	1,450
	5th Year				7			7	1,200
	Total	17		20	9			46	5,450
Oruro	1st Year		12	5				17	1,950
	2nd Year	3	13	3				19	1,900
	3rd Year			16				16	2,400
	4th Year			11	2			13	2,050
	5th Year				3	5		8	2,100
	Total	3	25	35	5	5		73	10,400
Tarija	1st Year		11	3				14	1,550
	2nd Year		11	6		2		19	2,600
	3rd Year		15	5	1			21	2,450
	4th Year		3	8	1	4		16	2,900
	5th Year			5	5	5		15	3,250
	Total		40	27	7	11		85	12,750
Santa Cruz	1st Year		18	2				20	2,100
	2nd Year	4	22	13				39	4,350
	3rd Year		28	12				40	4,600
	4th Year		27	12				39	4,500
	5th Year				14	1	5	20	5,100
	Total	4	95	39	14	1	5	158	20,650
Total	1st Year	21	42	14				77	7,350
	2nd Year	39	48	29	1	2		119	11,900
	3rd Year	2	53	50	1			106	13,100
	4th Year		31	56	6	4		97	13,900
	5th Year			6	34	13	8	61	14,600
	Total	62	174	155	42	19	8	460	60,850

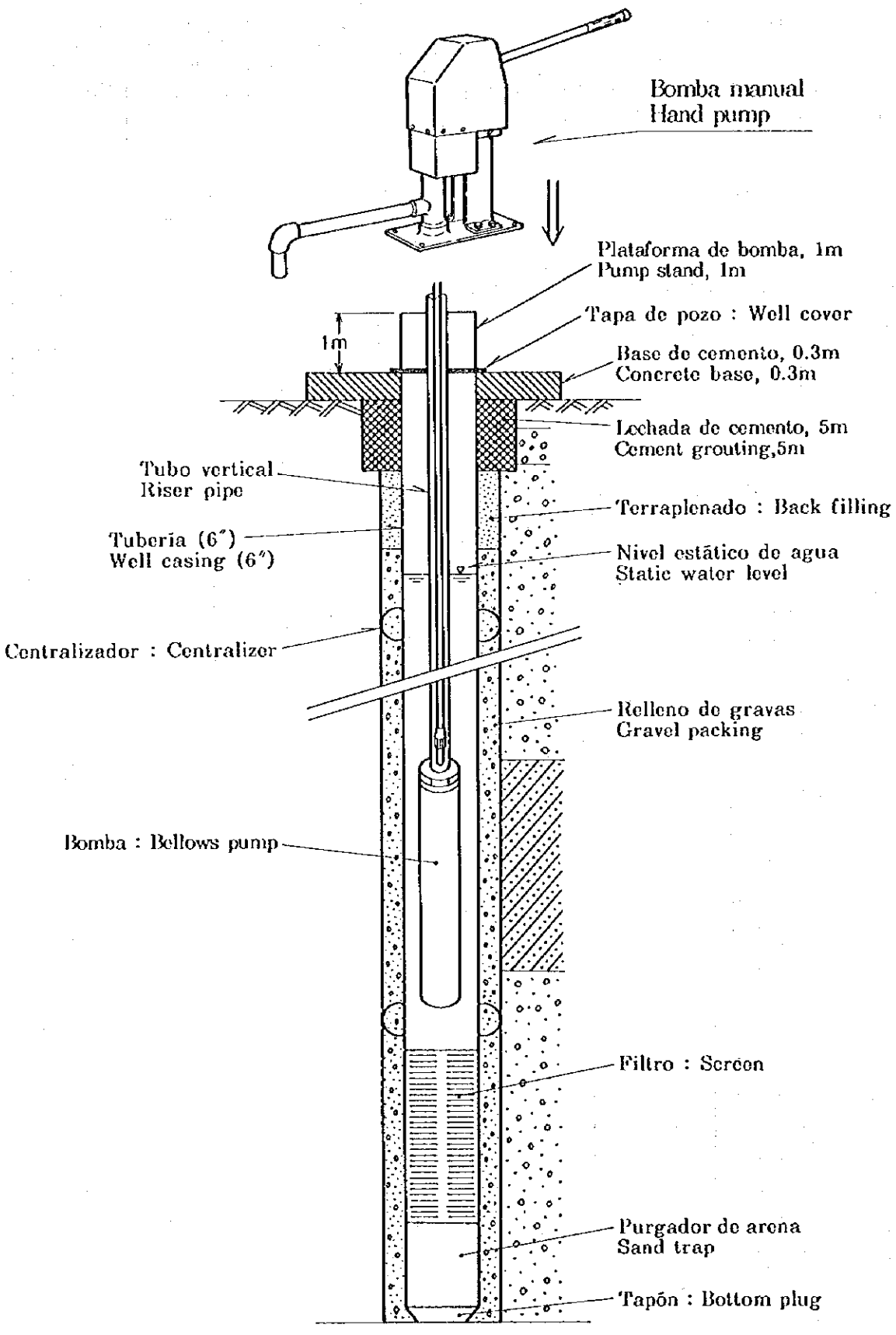

Figure 8-4-2 Designed Type of Well (in case of Hand Pump)

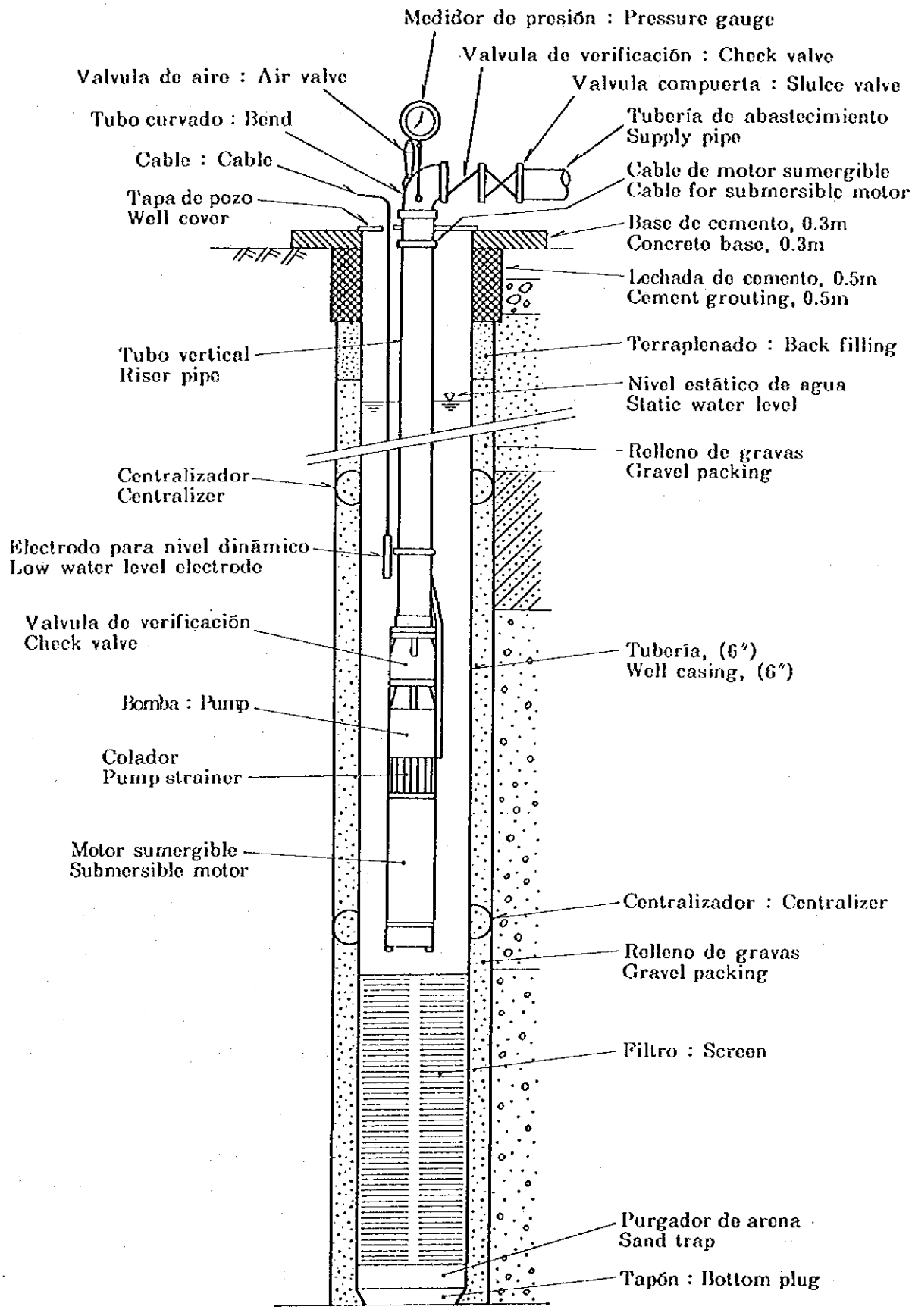

Figure 8-4-3 Designed Type of Well (in case of Submersible Pump)

8.4.3 Procurement of Well Drilling Equipment

1) Required Equipment and Materials

The materials and equipment necessary for well drilling are as listed below. Besides the items below, workshops (repair shop and storage room) for the well drilling machine and other equipment and materials will also be necessary.

(1) Well drilling machine (rig) and accessory equipment, such as slurry pump, air compressor, etc.

(2) Support vehicle (water tank vehicle, crane, station wagon, etc.)

(3) Logging equipment and pumping test equipment

(4) Geophysical prospecting equipment

(5) Communication equipment

(6) Workshop vehicle

(7) Casings and strainers

(8) Submersible motor pump

2) Required Number of Well Drilling Machines

A truck-mounted type of well drilling machine will be suitable since it can cope with the various geological, drilling depth, and site conditions of the Study Areas. Both percussion type and rotary type machines should be used and a reverse circulation function must be provided for talus material.

A total of 9 well drilling machines, 2 units for Chuquisaca, 1 unit for the southern part of La Paz, 1 unit for Oruro, 2 units for Tarija, and 3 units for Santa Cruz, are necessary in order to achieve the targets of the project in five years.

Three models of well drilling machine are being considered depending on the major estimated drilling depths. The breakdown of the required number of well drilling machines by model are shown in Table 8-4-2. Since there are many blocks with a planned drilling depth of 300 m or more in the two Departments of Chuquisaca and Santa Cruz, type C equipment are necessary for these Departments. Type B equipment will be suitable for the three Departments of La Paz, Oruro, and Tarija. Although there are many water supply blocks in all Departments for which type A equipment will be sufficient, upper-grade models should be procured in order to accommodate for blocks with deep drilling as well.

Table 8-4-2 Required Number of Well Drilling Machines

	Chuquisaca	South of La Paz	Oruro	Tarija	Santa Cruz	Total
A (100-150m class)				1	1	2
B (200-300m class)	1	1	1	1	1	5
C (400-500m class)	1				1	2
Total	2	1	1	2	3	9

2) Procurement Method

When the supporting vehicle, logging and pumping test equipment, communication equipment, geophysical prospecting equipment, and other accessory equipment and materials are included, the well drilling equipment procurement cost will come to comprise approximately half of the total project cost. Procurement by the domestic funds of Bolivia will thus be difficult and international cooperation (direct overseas investment) is anticipated for the necessary funds. Furthermore, upon procuring the equipment, it is necessary to provide technical transfer on the operation, maintenance and repairing of the equipment to the engineers of each Prefecture for a term of half a year to a year or more.

While well casings can be procured in Bolivia, stainless steel or FRP strainers must be imported.

8.5 Organizational Arrangement Program

8.5.1 Basic Policy

1)Each Prefecture shall be the implementation organization in charge of rural groundwater development projects. Basic sanitation Unit (UNASBA) shall be responsible for the execution of the well drilling works and the management of drilling machines.

2)Construction works of water supply systems shall be implemented mainly under the control of the Prefecture. The Municipality might be organization in charge of the projects depending on the conditions at local communities. Community participation shall be promoted on the progress of the projects.

3)Daily operation and maintenance of the facilities shall be performed independently by the beneficiary communities. The Prefecture and/or the Municipality shall provide the communities with technical and financial supports required for sustainability of water supply services.

8.5.2 Implementation Organization

1) Establishment of Implementation Organization

Figure 8-5-1 shows a model of groundwater development project implementation flow. Beneficiary communities should perform the operation and maintenance of water supply systems, while the construction should be realized on the responsibility of the government.

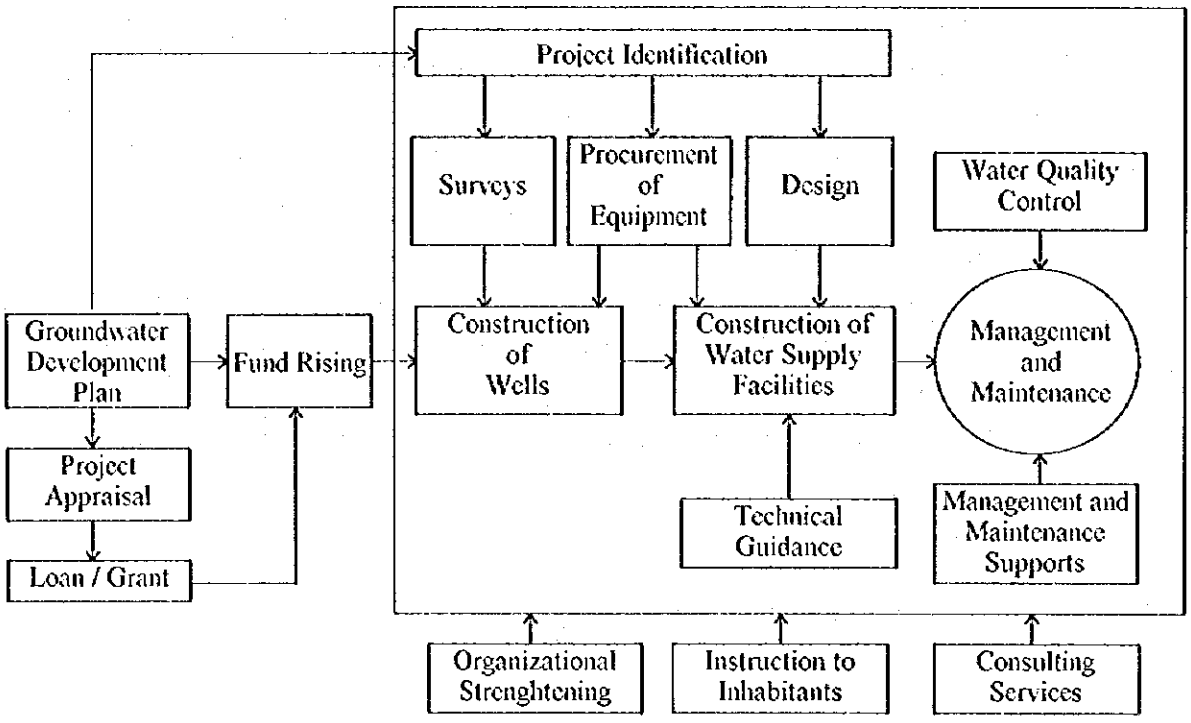

Figure 8-5-1 Groundwater Development Implementation Flow

Administration system in Bolivia consists of the central government, the Prefectures, the Municipalities and communities from the top and the decentralization is promoted currently. While ex-CORDES was most informed about the actual situation of rural water supply and accumulated technical information through the performance of water supply projects, they were integrated and reorganized to the Prefectures. However, as the ability of the Municipalities is still yet settled, the Prefectures must be worthy of the organizations for responsible for implementation of rural groundwater development projects. The Prefectures shall be responsible for well drilling works, management of well drilling equipment and enforcement of construction works of water supply system. In case of medium-scale cities, the Municipality could be the organization in charge of constructing the water supply facilities.

Table 8-5-1 shows an arrangement of organizational responsibilities among the central government, the Prefectures, the Municipalities and the private engineering services in the progress of groundwater development and water supply projects.

Table 8-5-1 Organizational Arrangement for the Projects

	Government	Prefecture	Municipal-ity	Community	Private Services
Planning	△	○	○		
Procurement of Rig	○	○			
Investigation/Design		○	○		△
Well Drilling		○			
Construction of Facilities		○	○	△	○
Operation and Maintenance				○	
Technical Support		○	○		△
Procurement of Funds	○	○	○	○	
Institutional Arrangement	○	○	○		
Education and Training	○	○			

2)Responsibility of the Prefectures

Rural groundwater development projects shall be executed under the responsibility of each Prefecture including the following works.

a. Procurement of finance for the proposed projects
b. Formulation of implementation program
c. Operation and maintenance of well drilling equipment
d. Detailed design of required facilities
e. Planning and supervision of the construction works
f. Land acquisition, and other required matters and procedures for the commencement of the construction works
g. Procurement and supply of main materials and equipment
h. Coordination with the authorities concerned
i. Establishment of organizational arrangement
j. Provision and training of the staff

The Prefecture shall perform the projects through the Basic Sanitation Unit (UNASBA) of the Department of Popular Participation. UNASBA shall organize the project team to establish the project implementation system.

It is proposed to establish the coordinating committee, composed of the Prefecture, the Municipalities, health center and school to secure smooth and effective implementation of the project.

8.5.3 Institutional Arrangement

1) Legal Backgrounds:

The organization of the Basic Sanitation Sector obviously should be put within the planned legal mechanisms, having its institutional structure respond with major efficiency for the fulfilness of policies, plans and projects programmed or in execution. Therefore, its institutional and organizational structure of the Basic Sanitation Sector, from 1996, should respond to the changes and modifications emanating from the following legislations:

- Popular Participation Law No.1551 of April 20th, 1994.
- Supreme Decree No.23792 about the creation of National Secretariat of Popular Participation of May 30th, 1994.
- Supreme Decree No.23813 which regulates the Popular Participation of June 30th, 1994.
- Administrative Decentralization Law No.1654 of July 28th, 1995.
- Supreme Decree No.24113 of transfer of the National Secretariat of Popular Participation to the Ministry of Human Development, of September 2nd, 1995.
- Supreme Decree No.24134 which disposes the restructuring of the Ministry of Human Development, of October 2nd, 1995.
- Supreme Decree No.24206 which disposes and regulates the organization of the Executive Power at prefectural level, through the Prefectures, promulgated on December 29th, 1995.

2) Institutional Ordination of the Basic Sanitation Sector

The organizational chart in Figure 8-5-2 shows the organizational structure of the Basic Sanitation Sector in 1996 taking into consideration the latest legal mechanisms.

There are 3 levels:

- National level constituted by DINASBA.

- Prefectural level constituted by Prefectural Secretariat of Popular Participation in each one of the prefectures of the Study Area (Chuquisaca, La Paz, Oruro, Santa Cruz and Tarija).

Among those Secretariats, depending on the Prefecture, the Units of Basic Sanitation, Prefectural UNASBAs, will be located, which in turn are within the Bureau of Municipal Strengthening.

In case of donation of equipment, prefectural UNASBAs will be the obligatory operators and administrators of the equipment through a Special Section of Well Perforation.

- Local level constituted by Municipal UNASBAs which are formed in the Sectional Municipalities, executors of basic sanitation, now definitively strengthened by the Popular Participation.

At local level, there is a sub-level formed by the operating and administrative entities of drinking water services (Municipal Enterprises of Drinking Water, cooperative of Services,

Water Committee or directly the proper Municipality) and those activities are formed according to the size and complexity of the service in the cities, cantons, communities and blocks located in the territory of the Municipality.

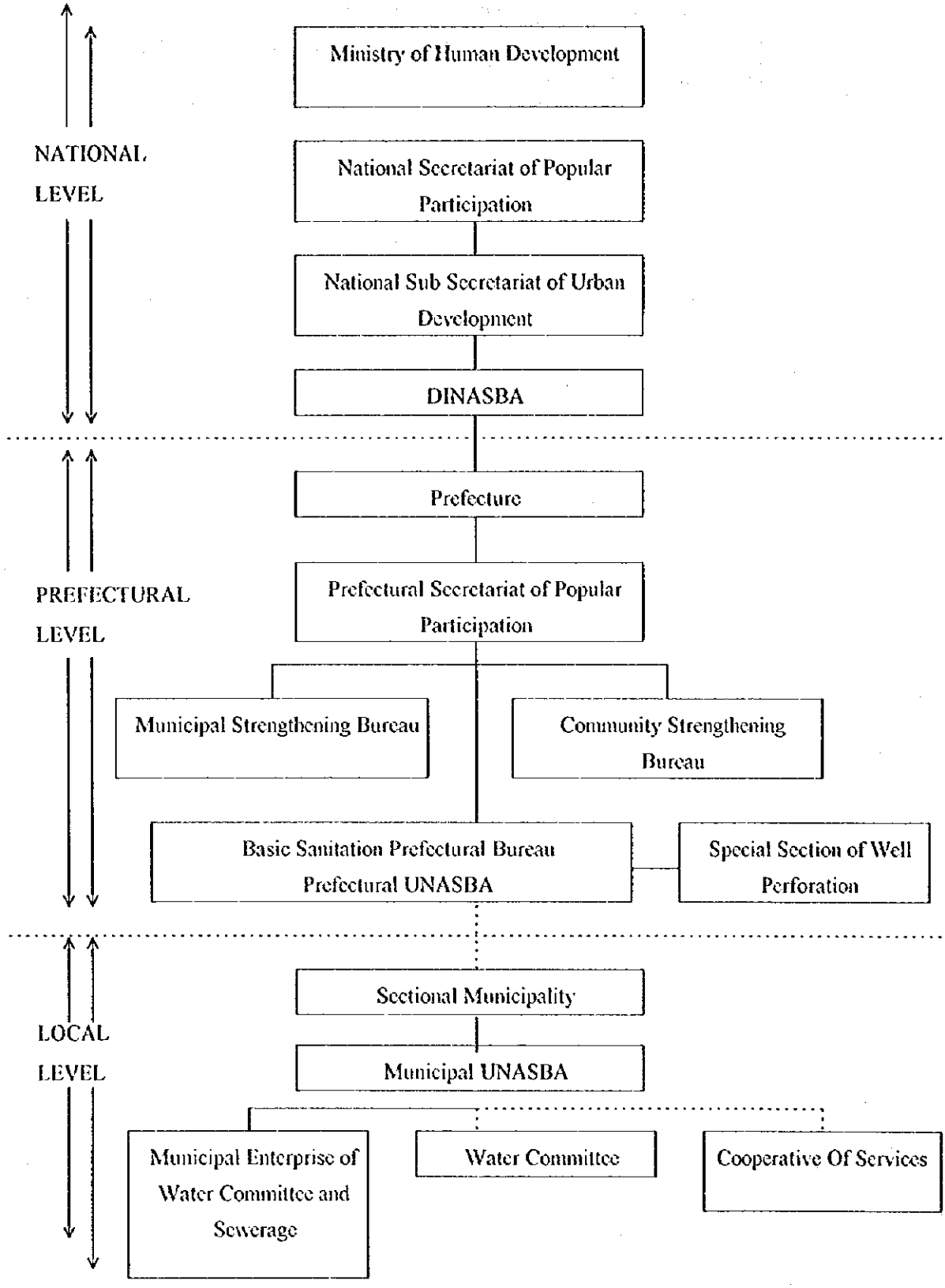

Figure 8-5-2 Institutional Ordination Of The Basic Sanitation Sector

Consequently in the Study Area, there is a Prefectural UNASBA in each Prefecture. Table 8-5-2 shows the Number of Municipalities in every Prefecture of the Study Area. Theoretically, in the Study Area, the Maximum number Municipal UNASBAs will reach 134, but due to administrative, economic and development reasons, this will not be possible in the short period.

Table 8-5-2 Number Of Sections In Study Area

PREFECTURE	NO.OF PROVINCES	NO. OF SECTIONS (MUNICIPALITIES)
CHUQUISACA	10	27
LA PAZ(※)	4	20
ORURO	16	30
SANTA CRUZ	15	46
TARIJA	6	11
TOTAL	51	134

※ *South of La Paz only as Aroma, G.Villarroel and J.M.PANDO.*

The attribution of this organization is functional and not administrative. However, between DINASBA and PREFECTURAL-UNASBA, there is a line of technical and normative authority, now that the latter is a decentralized organism of the Executive Power, of which head at national level is DINASBA.

The Municipal UNASBA will belong to the Municipality, which is the local autonomous government. Also, Water Committees should have autonomous administration, though they should be assisted, advised and supervised by the municipal UNASBAs.

3) Organizational Scheme of DINASBA

Figure 8-5-3 shows the organizational chart of DINASBA, which keeps to be head of the sector, maintaining its rank among the Structure of the Ministry of Human Development and Its coordination and technical assistance is fundamental for the basic sanitation, and furthermore for the implementation of the present project of development of groundwater.

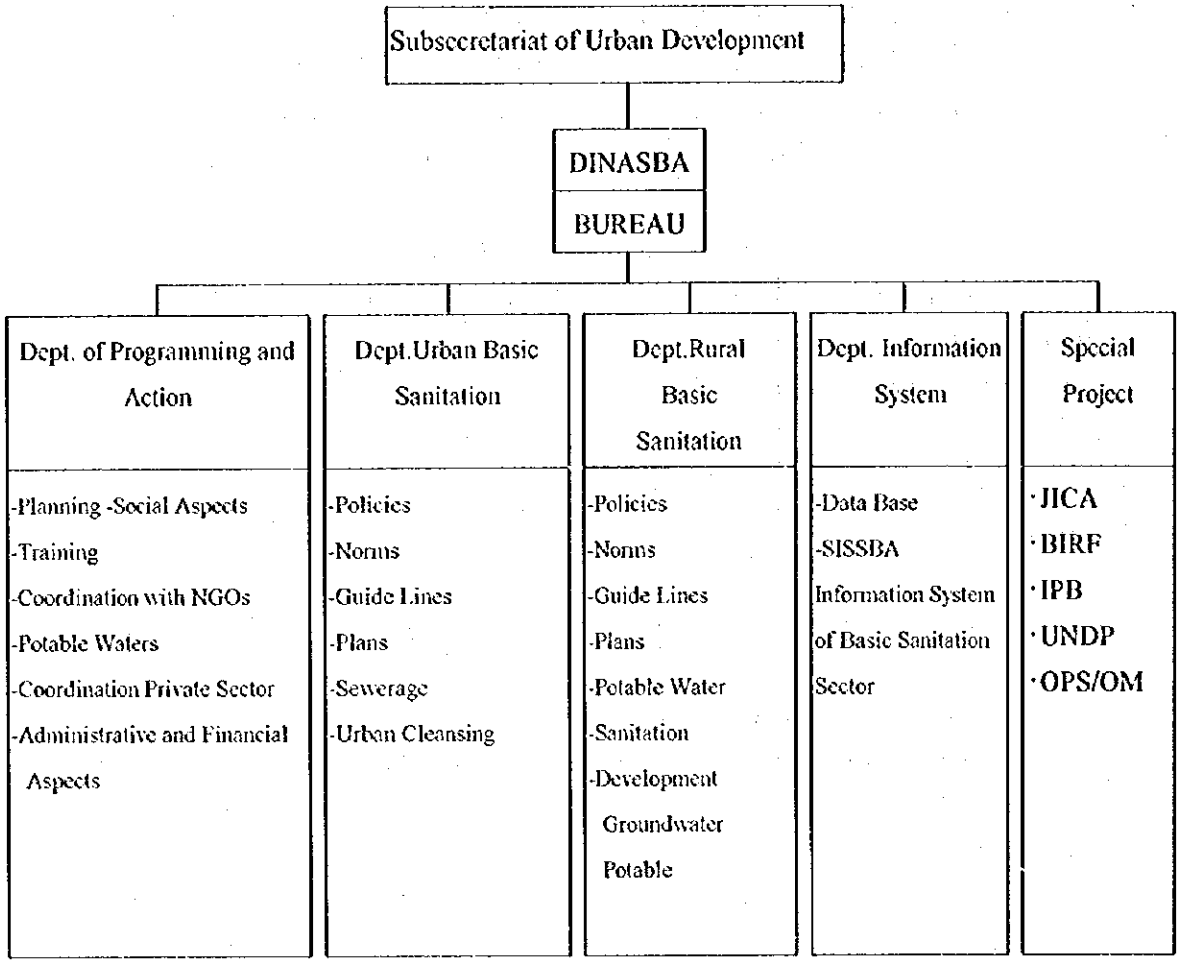

Figure 8-5-3 Functional Organization chart of DINASBA

4) Organizational Scheme of Prefectural UNASBA

Figure 8-5-4 shows the functional organization chart of Prefecture UNASBA, located in the Municipal Strengthening Bureau of the Prefectural Secretariat of Popular Participation of Prefecture. Its fundamental function will be to strengthen Sectional Municipalities of Prefecture and concretely Municipal UNASBAs advising and training in technical and administrative aspects of basic sanitation.

The organization of a Special Section of Well Perforation is included, which can be implemented in short or medium period in the prefectures of Santa Cruz, Tarija and La Paz, since in Oruro and Chuquisaca. They have been operating, and have only to be reinforce in case of receiving the donation of equipment of perforation.

It is expected that Prefectures organize their UNASBAs as having had in CORDEs with the same or higher rank, since their function is very import in the prefectural level.

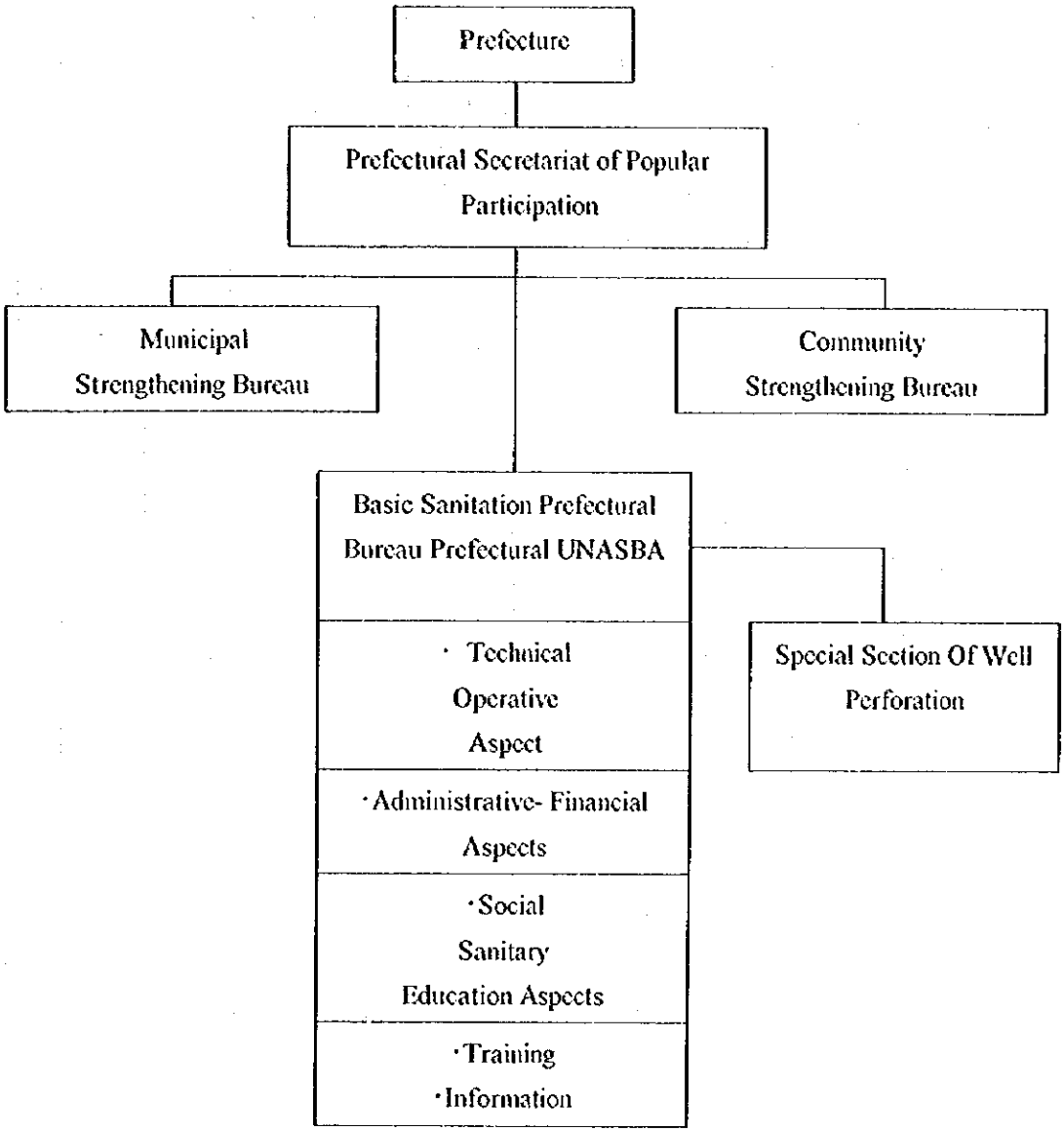

Figure 8-5-4 Functional Organization Chart of Prefectural UNASBAs

5) Functional Scheme of Operative Organisms of Drinking Water Systems at Local Level

Table 8-5-3 classifies the Operative and Administrative Organism of Drinking Water according to the size of block, which in turn generally determines the administrative and operative complexity of the service.

3 classes are defined:

Class A: For cities with more than 10,000 inhabitants, which correspond to organizational types of Municipal Enterprises, Cooperative or Concession of Service.

Class B: Localities with population between 2,000 and 10,000 inhabitants, with alternatives of Municipal Direct Administration, Cooperative of Service or Water Committee. There are 50 localities of Class B in the Study Area.

Class C: Rural communities or blocks less than 2,000 inhabitants, with organizational alternatives of Municipal Direct Administration, Water Committee or Cooperative of Service. 4,208 blocks of the Study Area (98.6% of total blocks) are included in this Class C.

Table 8-5-3 Classes of Operative Organisms of Drinking Water According to the Size of Block

Classes	Size of Block	Type of Organization (Alternatives)	Number of Blocks in Study Area					
			CH	LA	OR	SA	TA	TOTAL
A	More than 10,000 inhabitants	-Municipal enterprise -Cooperative of Service -Concession of Service	0	0	1	6	3	10
B	Between 10,000 to 2,000 inhabitants	-Municipal Direct Administration -Cooperative of Service -Water Committee	2	2	7	35	2	50
C	≦2,000 inhabitants	-Municipal Direct Administration -Water Committee -Cooperative Service	1,222	759	536	1,184	507	4,208

Figure 8-5-5 shows the Functional Scheme of Municipal Enterprises of Drinking Water and Sewerage.

Municipal enterprise is autonomous and functions on the base of organizational systems: Planning, Operational Systems, Commercial system, Administrative system and Financial system.

It is a basic organism of the Sector which administrates drinking water services in intermediate cities. There Enterprises depend on the Municipality which controls, supervises and evaluates the movement of the Enterprise. The Board of Directors of the Enterprise is presided by the Municipal Mayor. The role of DINASBA is to issue policies, norms and guidelines, to prepare plans and programs, to deliver and receive information, to support the training of the professional personnel and to coordinate and promote the international support to the Municipal Enterprises. DINASBA communicates directly with the Enterprise.

ANESAPA (Association Nacional de Empresas de Servicio de Agua Portable y Alcantarillado-National Association of Enterprises of Service of Drinking Water and Sewerage)is the non governmental entity which gives advice, disseminates information, trains personnel and coordinates horizontal collaboration among enterprises.

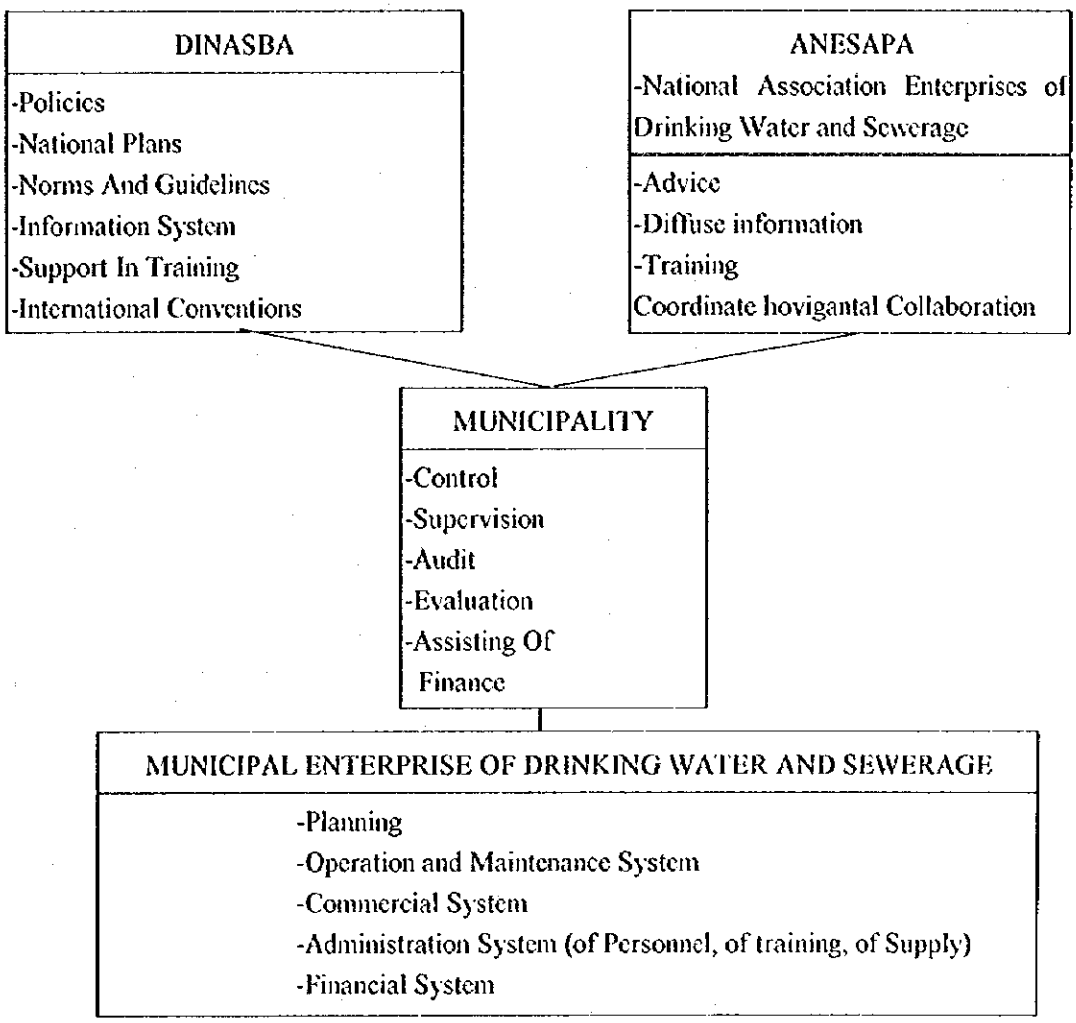

Figure 8-5-5 Functional Scheme of Municipal Enterprises of Drinking Water and Sewerage (Class A)

Figure 8-5-6 shows the functional organization chart of Rural Basic Sanitation which can be applied to the services of Class B as well as of Class C, because organizational, administrative, operation and maintenance problems are similar in those two classes.

The fundamental difference is in the obligations of recovery of investment and in the composition of the Tariff, which are described in (4) Sustainability of Services.

The organizations which administer the services of classes C and B in the Study Area can be: Municipal Direct Administration, Cooperative of Service or Water Committee.

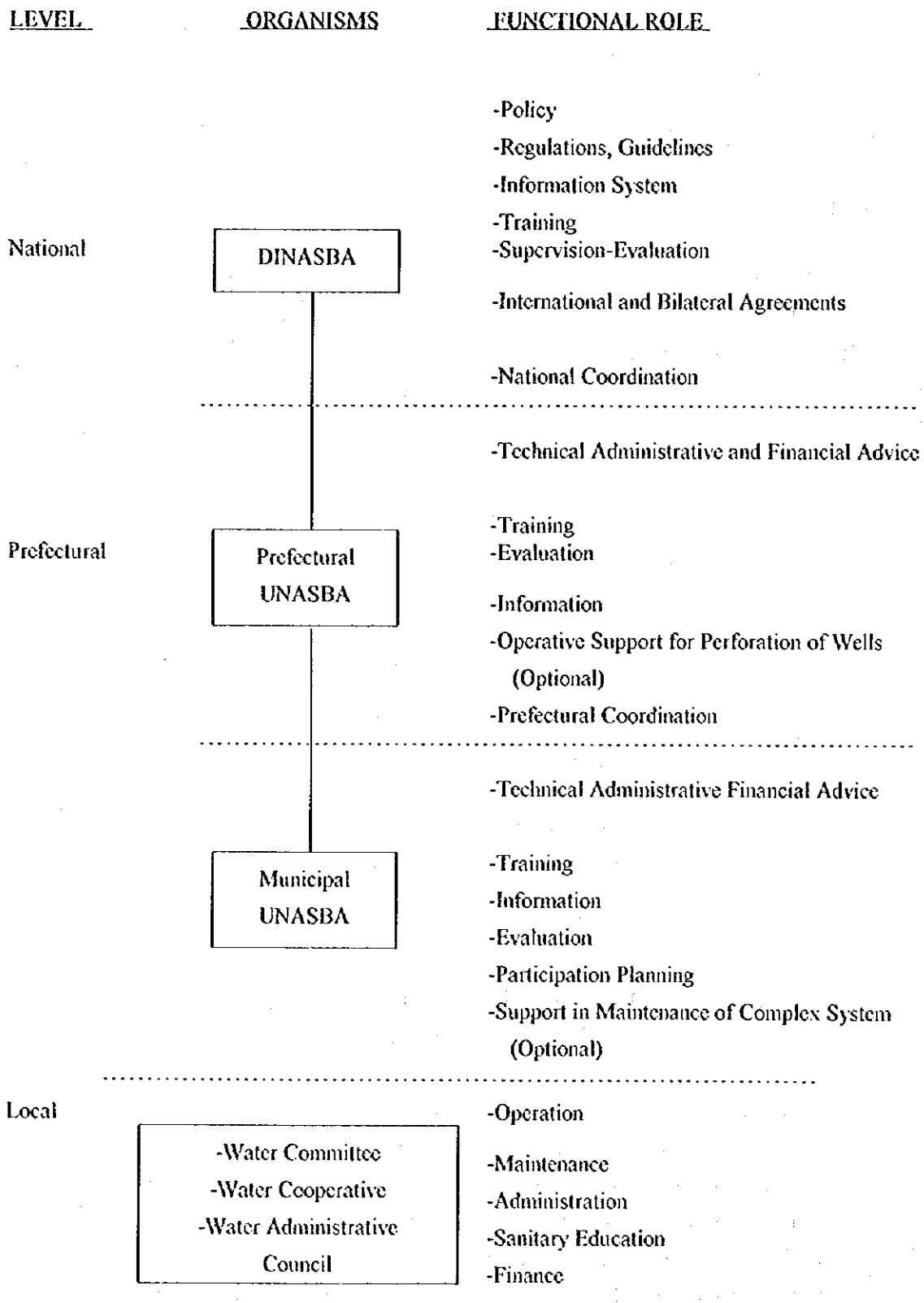

Figure 8-5-6 Functional Organization Scheme Of Rural Basic Sanitation
(applicable to services of class B and class C)

6) Sustainability of the Services

The monthly payment of tariffs of drinking water is the single guarantee for the sustainability of the services. Table 8-5-4 shows the local aspects for investments in drinking water, as well as the tariff policy in the 3 classes of administrative organisms of drinking water.

These policies and norms have been established by legal mechanism in force: Supreme Decree No.22627 of Financial Policies of the Basic Sanitation Sector of October 24th, 1990 and of Ministry Resolution No.120 of February 20th, 1990 of then Ministry of Urban Affairs which approved the new Tariff policy of water system and sewerage.

Table 8-5-4 Local Contributions for Investments and Tariff Policy in the 3 classes A, B and C

Class	Local Contributions for investment and Tariff Policies
A (Intermediate cities with more than 10,000 inhabitants)	·Criteria of payability of services ·Tariffs cover costs of administration, operation, maintenance, depreciation of equipment and capital cost. ·The local contribution and of use 's should reach 15% of the investment
B (Blocks between 2,000 and 10,000 inhabitants)	·Criteria of semi-payability of services ·Tariffs cover costs of administration, operation, maintenance and renovation of equipment of short life. ·The local contribution and of user's should reach 10% of the investment
C (Blocks less than 2,000 inhabitants)	·Criteria of semi-payability of services. ·Tariffs cover costs of administration, operation and maintenance. ·Capital cost is financed by national Government, Prefecture of funds from Popular Participation. · In financing of the investment, the contribution of labor by the community is evaluated as 15% of investment.

8.5.4 Human Resources Development

1) Central Government

The Government shall take the leadership for smooth promotion of international cooperation, coordination among the Prefectures, financial assistance of project funds, and supervision and evaluation of the projects. For these purposes, DINASBA is required to increase the engineers and staff by three or five at least.

Table 8-5-5 shows the demand and technical qualification proposed for DINASBA. The training of personnel in all the technical branches can be obtained in Bolivian Universities.

Table 8-5-5 DINASBA: Table of professional personnel proposed and technical qualifications.

Operative Areas	NO.of Professionals	Technical Qualifications
Bureau	1	Civil/Sanitary/Geologist Mechanical Engineer(1)
DEPT.of Programming and Action	5	Architect(1) Administration of Enterprises(1) Sociologist(1) Economist(1) Financial analyst(1)
DEPT.of Urban Basic Sanitation	3	Sanitary engineer(1) Civil engineer(1) Architect(1)
DEPT.of Rural Basic Sanitation	4	Sanitary engineer(1) Geologist(1) Civil engineer(1) Mechanical engineer(1)
DEPT.of Information system	3	System engineer(1) System analyst(1)
Special Project	Variable	Professional personnel qualified according to the project. Variable number of professional to be contracted according to project

Table 8-5-6 shows the movement of personnel of DINASBA in the last 3 years,

Table 8-5-6 Movement of Personnel of DINASBA in the last 3 years

Year	Personnel	Increase(%)
1993(Before the Popular Participation Law)	17	
1994(After the Popular Participation Law)	13	(-)24%
1996(Proposed)	16	23%

The increase of personnel in 1996 is due to, above all, the fact that the Department of Rural Basic Sanitation of DINASBA should be strengthened to cover the new functions to carry out in the Development of Groundwater and also due to the increasing activity of the Department of Information System.

The special projects with international finance of BIRF and IDB, as well as PROSABAR, PROPPAAL and GAPS, have Bolivian professional personnel specially contracted for those projects in variable member.

It is reiterated that JST should recommend with emphasis that the technical personnel of the counterpart of the project JICA-DINASBA continue their functions because they are trained human resources who have received training and technical Transfer in service and their staying on will guarantee the future implementation of the project.

2) Prefectures

UNASBA of each Prefecture shall organize groundwater exploration team, drilling team, water supply planning and design team, and community strengthening team. The groundwater exploration team shall perform hydrogeological field survey and geophysical prospecting. Well drilling team shall perform drilling work and management of rigs. Required number of a team is estimated over five, consisting of hydrogeologist, mechanical engineers and technicians. As the drilling works are to continue for 24 hours a day, the back-up system shall be also established. Water supply planning and design team shall be in charge of technical support to the beneficiary communities and operation and maintenance education as well as planning and design. Community strengthening team shall be responsible for sanitary education, guidance for the establishing the Water Committee and the management, and patrol of the existing water supply systems in rural area.

Each Prefecture shall establish the project team and the inspection committee for supervision of the project. Facility design, preliminary works and supervision of construction works could be carried out through consultant engineering services.

Table 8-5-7 shows the table of personnel proposed and technical qualifications for prefectural UNASBAs of each prefecture of the Study Area.

This proposal is based on the following criteria.

1. Because of the importance of Prefectural UNASBAs as an entity for advising, training and promoting basic sanitation in the municipalities of the prefecture and in order o constitute the link between national level and local level, which is the Operator of the drinking water service, the assigned personnel should not be less in number than UNASBAs of ex-CORDEs.

2. In order to guarantee the future implementation of the project; including the operation of a possible section of well perforation for rural water supply in charge of Prefecture, it is indispensable to keep the personnel of counterpart of the project JICA transferring its all relative personnel of ex-CORDEs to new prefectural UNASBAs, because those personnel have been trained and received technical transfer in service.

3. As the function of UNASBAs will be to strengthening of Municipalities advising and training them in basic sanitation, the areas of assistance and cooperation are:

- Technical, Operative aspects
- Administrative, financial aspects including commercial system, planning, having relation with NGO and private sector.
- Social aspects including sanitary education, community participation, involvement of women.
- Information system

4. The personnel of possible operation of a section of well perforation will be detailed in other Chapter of this Report. Units of perforation of Oruro and Chuquisaca of ex-CORDEs have already been operating, and so all those personnel should he transferred and keep operating

among prefectural UNASBAs.

5. Furthermore, because prefectural UNASBAs have as object the strengthening of Municipalities, the following have been taken into account to design the table of personnel:

a) Based on Table 8-5-7 showing the number of municipalities in each prefecture, the criteria is 1 professional for each 4 municipalities without considering the coordinator.

b) Minimum 1 professional for each Area of Assistance and Cooperation of the column of the table.

c) The Municipality of the prefectural capital is not considered for the calculation.

d) Taking into account all the indicated parameters, including above 2)-1, assign the larger number of personnel.

e) In case of Oruro, 14 persons of the Section of Well Perforation are included.

f) In the prefecture of La Paz, the calculation is considered only for the municipalities of the Study Area.(20 municipalities of 4 provinces of the south of the prefecture).

Table 8-5-7 Table of Personnel of Prefectural UNASBAs in Prefecture of Study Area and technical qualifications

PREFECTURAL UNASBAs						
Areas of Assistance Cooperation	Professional Qualification	Number of Professionals				
		Chuquisaca	La Paz (4Prov)	Oruro	Santa Cruz	Tarija
Coordination	Eng. Civil/Sanit/Geol/Mech	1	1	1	1	1
Technical operative Aspects	-Civil Eng. -Sanitary Eng.. -Geology Eng. -Mechanic Eng.	3	2	2	4	3
Administrative, financial, commercial, participation planning, relating private sector aspects	-Economist -Administration of enterprises -Accountant -Planner	2	1	2	3	2
Social aspects,	-Sociologist -Educator -Sanitation technician	2	1	2	3	1
System information	-Saint./civil/system Eng.	1	1	1	1	1
Section well Perforation(1)	Depending on the type and number of equipment of perforation and the well construction program. Oruro has 14 persons working in the Section of Well perforation.					
Total		10	7	23	13	10

1) Section which can be implemented in a short of medium period.

The Table 8-5-8 shows the movement of personnel of UNASBAs of ex-CORDES and what are proposed for the Prefectures

Table 8-5-8 Movement of Personnel of Prefectural UNASBA in the last years

Year	CORDECH		CORDEPAZ		CORDEOR		CODETAR		CORDE CRUZ	
	Total	UNASBA	Total	UNASBA	Total	UNASBA	Total	UNASBA	Total	UNASBA
1993 (Before Popular Participation Law)	1007		700		398	20	824		492	
1994 (After Popular Participation Law)	576	10	329	12	436	23	303	10	346	10
1996 (Proposal to Prefectures)	-	10	-	7	-	23	-	10	-	13

As seen only in case of Santa Cruz, it is proposed to increase personnel of UNASBA by 30% from ex-CORDECRUZ.

In case of La Paz, the proposed personnel correspond only to the 4 provinces of the South of La Paz, in the Study Area.

The human resources required in Prefectural UNASBAs are trained in universities and technical Institutes in Bolivia.

3) Municipality

Though it is a slow process, the constitution of Units of Municipal Basic Sanitation, Municipal UNASBA, in charge of giving advice, assistance and technical cooperation to all cooperatives and Water Committees located in the Municipality is irreversible, if it is required to achieve the goals of coverage and above all the sustainability of the services.

Theoretically in the Study Area, 130 Municipal UNASBAs had to be organized reducing the Municipalities of the capital of 4 prefectures as indicated in the Table 8-5-2.

This process is still slow by economic, administrative, political reasons and of transition to a full decentralization. However, this process should be accelerated for the benefit of basic sanitation and consequently for the inhabitants, above all, of the rural areas.

In fact, DINASBA has begun promoting the formation of these municipal UNASBAs in various prefectures in the country.

Owing to the indicated reasons, it is not possible to calculate necessary personnel in Municipal UNASBAs, since each Municipality has different characteristics.

However, the Table 8-5-9 indicates the principal guideline of organization of those

UNASBAs and of Qualification of Technicians, as well as criteria to determine the number of technician required for this labor in each Municipality.

Table 8-5-9 Guidelines For Organization And Personnel Of Municipal UNASBAs

UNASBAs	Municipal UNASBAs	
Areas of Assistance and Cooperation to water Committees	Qualification of Technical persons	Criteria for N° and qualification of Technical persons
1)Technical and Operative aspects 2)Social aspects (Training, Sanitary education Information, Women participation Evaluation 3)Administrative, financial and participation planning aspects	- Civil/Sanit. Eng. - Sanitary - Educator - Technician of installation of water and sanitation - Master of Civil Work	- One technician for each 10 water Committees, and as Minimum, one multivalent technician (who is trained in 3 areas) - The level of qualification of technical persons to be contracted will depend on financial capacity of Municipality

The number and qualification of technical persons of Municipal UNASBAs will be fixed consequently by the number of Water Committees and by the resources which Municipality rely on to organize those UNASBAs.

There are Municipalities having economic power which may be able to contract engineers, and there are other very modest municipalities which can contract with only one master of works.

The criteria of one technician for every 10 Water committees, is due to the reason that this personnel can visit each Water Committee at least one time per month.

The concept of "multivalent technician" is that only one person is trained or has knowledge in the 3 works:

Technical-Operating aspects, Social aspects of Training and Sanitary Education, and administration-Finance and Planning.

For example, one Municipality having 18 Water Committees needs 2 technicians for its UNASBA.

4) Beneficiary Communities

The success of the proposed projects will be realized with the appropriate operation and maintenance practices in the constructed water supply systems, including dairy maintenance of the facilities, collection of water tariff and other miscellaneous works. Proposed personnel organization of the beneficiary communities is as follows.

a.Urban city with a population of over 10,000 : 10 or more full-time staff shall be employed.

b.Urban city with a population from 2,000 to 10,000 : Several number of full-time staff shall be employed.

c.Rural community with a population from 500 to 2,000 : One or more full-time staff shall be employed for maintaining the system with part-time members of the Water Committee.

d.Rural community with a population from 50 to 500 : Part-time members of the Water Committee shall maintain the system by turns.

The Prefecture shall make the communities of the proposed projects to organize the Water Committee for independent operation and maintenance of the water supply systems. The Water Committee shall appoint the manager and operator responsible for operation and maintenance of the equipment.

As indicated in the last instance, those also operate and administer drinking water services are local organisms, such as Municipal Enterprises, Municipalities themselves, Cooperative of Services or Water Committees, and those whom we have categorized in Classes A, B and C according to the size of population.

Obviously, the remunerated personnel is particular for each operative local organism, therefore, the necessity of this personnel can not be presented in detail.

However, for the preliminary estimate of the required personnel in each organism, the following criteria will be utilized, deducing from "Manual from the Development of Human Resources" published by WHO in 1987:

a) To consider 3.5 officials in the basic sanitation services for every 1,000 home connections of drinking water.

b) The technical qualification of their personnel will be able to use the following criteria for distribution:

Sanitary engineers	4%
Other professionals	7%
Superior technician	10%
Administrative support	25%
Qualified workers	30%
No qualified workers	24%

c) Obviously in the class B and furthermore in the C, the personnel is varying because the personnel of Water Committee, of Cooperative of Service and of Sub-Committee of Sanitary Education is voluntary, and remunerated personnel is very limited or does not exist.

Table 8-5-10 shows an example of personnel and technical qualification in organisms of Class A, B and C attending the functions and complexity of each one of the classes.

For the simulation, following guidelines are considered:

Class A: Cities with 5,000 home connections and approximately 25,000 inhabitants.

Class B: Block with 1,500 home connections and approximately 7,500 inhabitants.

Class C: Rural block with 120 home connections and approximately 600 inhabitants.

Table 8-5-10 Personnel In Operative Personnel Of Classes A, B And C (Example)

CLASS	FUNCTIONS	REMUNERATED PERSONNEL TECHNICAL QUALIFICATION	NO.
A	- Planning	·Sanitary engineer	1
	- Operation	·Accountant	1
	- Maintenance	·Superior technicians	2
	- Administration	·Administrative support	5
	- Accounting	·Qualified workers	5
	- Financial Administration	·Non qualified workers	4
	- User's registration	Total:	18
	- Invoicing/collection of Tariffs		
	- Information system/Data Base		
B	- Operation	·Technician	1
	- Maintenance	·Accounting helper	1
	- Administration	·Qualified workers	2
	- Accounting and Finance	·Non qualified workers	2
	- User's register and tariffs	Total	6
	- System Information		
C	- Operation	·Qualified worker	1
	- Maintenance(Simple system)	Total	1
	- Administration		
	- Tariffs		

8.5.5 Planning and Engineering

The Regional Water Supply Department (expected to be centered around UNASBA of the CORDES), which is to be newly installed in the Departomento office as part of decentralization, should take the initiative in the preparation of plans and the engineering relevant to regional water supplying.

The activities of this new organization can be largely divided into the following:

- Management of community information with the database
- Preparation, modification, and improvement of the regional water supply master plan
- Execution of individual projects (in cases where requests are made by a community and in cases where a project is proposed by a Departomento)

8.5.6 Development Priority by Department

The priority for groundwater development projects by Department was evaluated in the progress of the Study. The results are summarized in Table 8-5-11. As for La Paz, the evaluation focuses to not total Department but four Provinces in the Study Area.

a.Urgency of the Project

Santa Cruz and Chuquisaca have twice as much population unserved as other three Departments. Especially, Chuquisaca has first priority of groundwater development because many communities have no alternative water sources. Many communities in Oruro also has few alternatives and the groundwater development is required.

b.Difficulty of Well Drilling Works

Chuquisaca is disadvantageous for implementation of the groundwater development project because most part is located in the arid valley area with bad traffic condition. The drilling works is expected easy in Oruro but the concentration of salts in groundwater might be so high due to dry climate that the advanced technology is required for groundwater exploration. Santa Cruz includes some area difficult to access the communities in rainy season.

c.Organizational Aspect

Among five Departments, Santa Cruz has gotten the most achievement of water supply projects in the period of ex-CORDES and retains a financial ability, followed by Tarija and Oruro. have as much performance of investment per capita as Santa Cruz. Chuquisaca has uncertain factors in the organizational aspects in the course of recent decentralization process.

d.Technical Level

Santa Cruz and Tarija employ so many high-level engineers to perform the water supply projects and accumulate considerable amount of planning technologies. Chuquisaca and Oruro, which own an old-type rig respectively, continue to perform well drilling works little by little but the technologies are outdated at present compared with the international level. La Paz has few examples of groundwater development projects.

e.Sustainability of the System

It might be more difficult to sustain the operation and maintenance of the system for small-scale communities than larger ones. Oruro and the southern part of La Paz include such communities so much. In Chuquisaca, the traffic conditions and the distances from the departmental capital will be disadvantage factors for establishing the supporting system. Santa Cruz is expected to establish the local station for supporting system because of extensive area.

f.Expectation for Future Use of Equipment

Santa Cruz and Tarija are expected to make the most use of well drilling equipment because the organizations are reliable with strong wills for promoting the groundwater development projects. Although Chuquisaca has a iron will for the project, the organization is unsettled at present. As the Study Area in La Paz covers only four Provinces, the comprehensive plan on groundwater development is expected to establish for the total area of the

Department.

Table 8-5-11 Development Priority by Department

	Chuquisaca	S.of La Paz	Oruro	Tarija	Santa Cruz
Project Urgency	A	B	B	B	A
Drilling Difficulty	C	B	C	B	B
Organization	C	C	B	B	A
Technical Level	B	C	B	A	A
Sustainability	B	B	B	A	A
Future Use of Equipment	B	B	A	A	A

The departmental priority for rural groundwater development can be arranged Santa Cruz, Chuquisaca, Oruro, Tarija and the southern part of La Paz in order named from the view point of the urgency of the projects. And the order of Santa Cruz, Tarija, Oruro, Chuquisaca and the southern part of La Paz are another line-up from the view point of the reliability.

8.6 Operation and Maintenance Program

8.6.1 Basic Policy

The function of the water supply facilities depends on operation and maintenance practices, which shall be in accordance with the following basic policies.

1)Daily operation and maintenance works of the facilities and groundwater pumping practices shall be performed independently by the beneficiary communities.
2)Each Prefecture shall guide the communities to organize the Water Committee and support them to promote the operation and maintenance by the communities.
3)In principle, operation and maintenance costs shall be burdened by the beneficiaries, including the expenses for exchange of spare parts and easy repairing of broken equipment.
4)The Prefectures shall perform the training on operation and maintenance practices and work managements for the members of beneficiary communities.
5)The drilling equipment shall be managed under the responsibility of the Prefectures.
6)The Prefectures shall establish the groundwater monitoring and well management system to promote groundwater conservation.

8.6.2 Management of Well Drilling Works

Well drilling shall be performed in accordance with the following advises.

a. To prepare implementation program of the drilling works

b.To conduct regular inspection of the drilling equipment at least once a year

c.To secure the repair shop and workshop of the drilling machine and other equipment

d.To prepare the report on the drilling works in each time and the annual report on the progress of the projects to present to the central government and authorities concerned

e.To execute the training of groundwater development technologies and the exchange of information

8.6.3 Operation and Maintenance of Water Supply Systems

1) Well Management

Constructed well shall be managed in accordance with the following advises.

a. To prevent over-drafting

b. To prevent the contamination of groundwater

c.To conduct daily inspection on voltage, pressure, fuel consumption and conveyance time of the motor pump

2) Operation and Maintenance of Equipment

Operation and maintenance of the water supply system shall be executed in accordance with the following advises.

a. To appoint an manager and operator responsible for daily works.

b.To prepare and store the catalogue and drawing of the facilities and equipment.

c. To conduct the inspection and cleaning regularly

d.To prepare the record on water volume, fuel consumption and operation costs and the account book

e. To observe the actual capacity to improve the declining facilities

f.To hold a general meeting of the Water Committee regularly to report the activities and accountings.

g. To receive an inspection of engineering specialist once a year

3) Reporting

With regard to the present water supply system, the weakness of recording and reporting is indirectly causing the lowering of the sustainability of water supply systems. The following reports should be established in the relevant organizations in the execution of operation and maintenance.

- Daily operation report : To be submitted to the director from operation staff. Should include records of daily inspections, fuel oil consumption conditions, records of operation times, etc.
- Monthly maintenance report : To be submitted to the director from maintenance staff. Should include operation records and failure/repair records of each equipment.

- Facility operation report : To be submitted to the Departomento Water Supply Section from Committee director once every 6 months. The facility operation conditions and an outline investment plan for revenues and expenditures should be reported.
- Regular patrol report : To be submitted to the director from the person responsible for the patrol team. Should provide advice on problems of the equipment, parts replacement, and early repairs.
- Parts stock report : To be submitted to the Departomento Water Supply Section from Committee director.

4) Technical Supporting System

Technical support is required for the sustainable operation and maintenance by the communities in the following matters.

a. Regular inspection for preventive maintenance

b. Repairing works of declined equipment

c. Operation and maintenance training and sanitary education for communities

The Prefectures shall establish the supporting system in cooperation with the municipal corporations of water supply and sewerage and/or private constructors.

The Figure below illustrates functional linkage among the resident organizations and other organization and agencies concerned in the execution of a project.

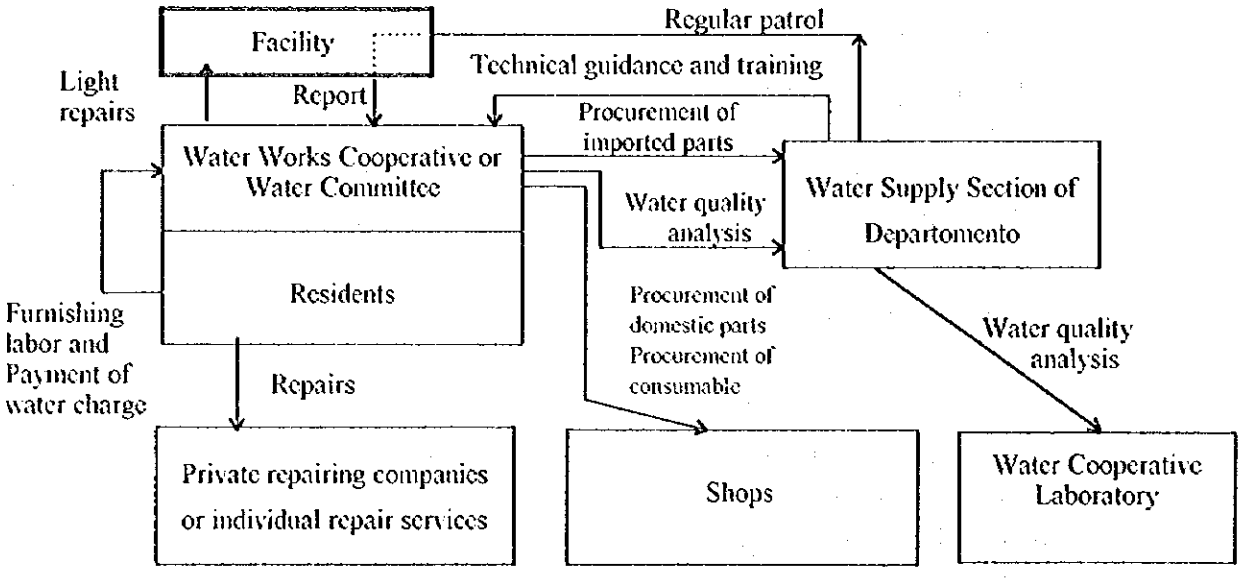

Figure 8-6-1 Relationship between Resident Organizations and External Support Agencies

8.6.4 Community Education Program

The objectives of operation and maintenance education are to train the personnel of the beneficiary communities and to promote sustainability of the water supply systems.

Major subjects consist of primary knowledge on well management and water supply systems, daily operation and maintenance practices, accounting practices and reporting manners. Each Prefectures shall systematically execute the training program in advance of the project implementation.

Sanitary education aims at improving sanitary habits of water utilization and public consciousness on water pollution, sanitation, and water tariff.

The personal training for operation and maintenance of rural water supply systems will be carried out in two stages. In the first stage, the training of trainers in Departamentos, and, in the second stage, the training of rural personnel in charge of operation and maintenance on the water supply sites.

Probably, it is the best for Water Supply Sections in the Departamentos to take a training responsibility.

1) Training for trainers

Training for trainers should be carried out constantly in a Departamento regardless of existing projects.

Prospective trainers will be recommended by Water Supply Section of Departamento and/or members of Water Works Cooperatives in cities. After attending technical seminars for around two weeks in Departamento Water Supply Sections, they will receive on the job training for around one month in Water Works Cooperatives.

Then, they will return to Departamento Water Supply Section to finish technical ability and learn various kinds of training methods. It is necessary that Departamento Water Supply Sections should prepare regular re-training system for trainers in service.

2) Training of personnel in charge of operation and maintenance

In each water supply block for which execution of the water supply plan has been determined, a Water Committee will be organized to talk with water supply planners as a representative of residents.

In this preparatory stage, the Water Committee should select and appoint one or two persons to be trained, and put them in the training course. Training has to complete prior to start of construction of facilities.

3) Subjects to be studies during training

It is desirable that subjects to be studied during training will be determined in the national level under guidance of DINASBA.

For quality of training of personnel necessary for operation and maintenance, emphasis will be put on practical knowledge and technique, and it is required to be immediately helpful in daily work. Although, details are omitted in this report.

4) Proposed number of trainees and trainers

The expected number of trainees in each Departamento is shown in the following table.

	Chuquisaca	La Paz	Oruro	Tarija	Santa Cruz
Number of trainees	150	78	159	160	1,222
Annual	30	39	32	32	244
Number of trainers	2	2	2	2	6

8.7 Investment Planning

1) Past Public Investment

Table 8-7-1 shows the performance of total public investment all over the country from 1991 to 1994. Average annual investment amounts to $496 million, $32 million (6.4%) of which is the investment for basic sanitation sector. External funds accounts for 58 percent of total investment to finance through FNDR and FIS.

Table 8-7-1 Total Public Investment (Whole Country)

(Unit: million dollars)

Year	1991	1992	1993	1994	Average (92-94)
Total Investment (T)	420.5	531.6	480.6	473.3	495.9
External Fund (E)	192.8	282.2	283.4	292.1	285.9
E/T	45.9%	53.1%	59.0%	61.7%	57.7%
Investment to Basic Sanitation (S)	12.9	31.6	34.2	29.4	31.7
External Fund (ES)	6.1	18.9	18.4	18.5	18.6
ES/S	47.3%	59.8%	53.8%	62.9%	58.7%
S/T	3.1%	5.9%	7.1%	6.2%	6.4%

Past public investment in the Study Area is shown in Table 8-7-2. Total annual investment amounted to $240 million, $20 million of which was for basic sanitation sector.

Table 8-7-2 Average Investment in the Study Area (1991-1994)

(Unit: thousand dollars)

Department	Chuqui-saca	South of La Paz	Oruro	Tarija	Santa Cruz	Total
Total Investment (A)	40,914	11,924	24,127	46,104	116,472	239,541
Per Capita	139	95	154	229	175	142
Investment to BS.(B)	3,352	1,345	3,472	3,415	8,720	20,304
B/A	8.2%	11.3%	14.4%	7.4%	7.5%	8.3%
Net Fund of ex-CORDES (C)	10,765	3,702	3,316	11,656	28,871	58,310
Per Capita	33	30	21	58	43	40
C/A	26.3%	31.0%	13.7%	25.3%	24.8%	25.7%
Net Fund of ex-CORDES to BS (D)	882	417	476	864	2,163	4,802

Note: The column of the south of La Paz is estimated from the performance all over Department by percentage of the population.

2) Financial Trends

The Popular Participation Law in 1994 has reorganized the flow of public investment from the central government to the communities. Regional investment funds are distributed to the municipality of each section depending on the population. Amount of money is $20 per person per year.

Ex-CORDES had been integrated to the Prefectures by the Administrative Decentralization Law and the responsibility for planning and implementation of regional development and public investment was transferred to the Prefectures.

3)Outline of the Project

Period	5 years
Total costs	$71.3 million ($279 per capita)
Domestic Fund	$31.8 million ($124 per capita)
External Fund	$39.5 million ($154 per capita)
Total population of the beneficiary:	255,785 (Year 2000)
Project costs except for rig procurement	$37.7 million ($148 per capita)

The breakdown of the project costs by year and works is shown in Table 8-7-3.

Table 8-7-3 Investment Plan for Groundwater Development Project Up To 2000 Year

(Unit: thousand dollars)

Items		1996		1997		1998		1999		2000		Total	
		External	Domestic	External	Domestic	External	Domestic	External	Domestic	External	Domestic	External	Domestic
Chuquisaca	Procurement of equipment	7,800										7,800	
	Drilling works	780			155		155		155		153	780	618
	Construction materials	380	90		665		665		665		665	380	2,750
	Construction works		140		680		680		680		685		2,865
	Personnel expenses		70		140		140		140		140		630
	Total	8,960	300	0	1,640	0	1,640	0	1,640	0	1,643	8,960	6,863
South of La Paz	Procurement of equipment	4,160										4,160	
	Drilling works	270			75		75		75		75	270	300
	Construction materials	140	45		315		315		315		320	140	1,310
	Construction works		50		235		235		235		243		998
	Personnel expenses		40		80		80		80		80		360
	Total	4,570	135	0	705	0	705	0	705	0	718	4,570	2,968
Oruro	Procurement of equipment	4,160										4,160	
	Drilling works	1,170			115		115		115		111	1,170	456
	Construction materials	340	65		490		490		490		485	340	2,020
	Construction works		75		365		365		365		380		1,550
	Personnel expenses		40		80		80		80		80		360
	Total	5,670	180	0	1,050	0	1,050	0	1,050	0	1,056	5,670	4,386
Tarija	Procurement of equipment	7,800										7,800	
	Drilling works	930			150		150		150		153	930	603
	Construction materials	280	80		585		585		585		575	280	2,410
	Construction works		85		415		415		415		426		1,756
	Personnel expenses		70		140		140		140		140		630
	Total	9,010	235	0	1,290	0	1,290	0	1,290	0	1,294	9,010	5,399
Santa Cruz	Procurement of equipment	9,600										9,600	
	Drilling works	1,260			280		280		280		273	1,260	1,113
	Construction materials	400	145		1,100		1,100		1,100		1,095	400	4,540
	Construction works		270		1,335		1,335		1,335		1,345		5,620
	Personnel expenses		100		200		200		200		200		900
	Total	11,260	515	0	2,915	0	2,915	0	2,915	0	2,913	11,260	12,173
Total	Procurement of equipment	33,520									0	33,520	
	Drilling works	4,410			775		775		775		765	4,410	3,090
	Construction materials	1,540	425		3,155		3,155		3,155		3,140	1,540	13,030
	Construction works		620		3,030		3,030		3,030		3,079		12,789
	Personnel expenses		320		640		640		640		640		2,880
	Total	39,470	1,365	0	7,600	0	7,600	0	7,600	0	7,624	39,470	31,789

4) Investment Plan

Table 8-7-4 shows the amount of investment by year and the organization calculated on the assumption of the following conditions.

a.Rig and other equipment required for well drilling will be prepared by grant aids of foreign country at the first year of the project in each Department.

b.The drilling works in the first year will be conducted by the donor country in cooperation with each Prefecture for technical transfer of groundwater development methods.

c.The Prefecture will take responsibility for the drilling works in each Department from the second year and burden all costs such as the expenses of investigation, purchasing costs of casing and strainer, and salary of staff.

d.Water supply facility will be constructed using domestic funds. The Prefecture will be in charge of technical aspects such as investigation, design and supervision.

e.The construction costs of the system except for procurement of the equipment will be charged by the Prefecture (10%), the Municipality (30%) and the central government (60%). The beneficiary community shall provide the manpower to be required for the construction works.

f.The funds for procurement of pump and generator will be borne by the finance of the government.

g.The constructed water supply system will be operated and maintained by the beneficiary community.

Table 8-7-4 Investment Amount by Year and Organization Concerned

(Unit: thousand dollars)

	1996	1997	1998	1999	2000	Total
Bilateral Cooperation	39,470	0	0	0	0	39,470
Central Government	656	3,921	3,921	3,921	3,940	16,359
Prefectural government						
Chuquisaca	114	585	585	585	583	2,452
La Paz	60	283	283	283	286	1,195
Oruro	69	395	395	395	395	1,645
Tarija	105	527	527	527	527	2,213
Santa Cruz	175	980	980	980	973	4,088
Sub Total	523	2,770	2,770	2,770	2,760	11,593
Municipalities	186	909	909	909	924	3,837
Grand Total	40,835	7,600	7,600	7,600	7,624	71,259

5) Financial Review

a. Procurement of well drilling equipment together with one-year drilling works is expected to bear in grant aids which accounts for 55.4 percent of the total project costs. This aids is a key factor to realize the groundwater development project in the Study Area.

b. Annual investment of the central government amounts to around $3.9 million, accounting for 51.5 percent of the required domestic funds. This investment accounts for 12 percent of the past budget to the basic sector all over the country or 19 percent of the past public investment for the Study Area. If the government takes top priority on the this project and leadership on the coordination with the authorities concerned, financial conditions can be overcome to realize implementation of the project.

c. Annual investment of the Prefectures accounts for 36.5% of the total domestic costs. Required investment for each Prefecture reaches 45 percent to 83 percent (57.7% on the average) of the past net budget for basic sanitation sector in ex-CORDES, although the rates depend on the Prefectures. However, the investments account for around five percent of their net budgets and are considered to stay within financial abilities.

d. The funds of investment of the Municipalities prepared by the provision of the Popular Participation Law account for 12.0% of the total domestic funds. The requirement per person amounts to US$15, which is equivalent to three fourth of an annual tax dividend from the government. While the amount of money must be a heavy burden for the Municipalities with the project community, it is possible to pay.

e. In conclusion, all burden shares is considered well under ceiling for each organization and the project can be viable with the grant aids depending on the policy of the donor.

CHAPTER 9

PROJECT EVALUATION

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9.1 Social Evaluation

There is a large difference of water supply service between urban and rural area in Bolivia. Rural communities without any water supply system occupy an overwhelming majority in the rural area where water scarcity is critical.

The greatest cause of delay of water supply service in the Study Area is the difficulty to develop water sources. Even existing water supply systems with traditional water sources such as river, pond, spring and shallow well suffer from the problems of insufficient volume to take and bad quality especially in dry season.

The new development of surface water in the rural area as the water resources has been impossible, because most surface water has been already exhausted and any development is difficult in respect of either finance or time. As a drastic solution, it cannot but to note the groundwater as the water resources.

On the other hand, groundwater is quite well with the bounds of potentiality to develop in the Study Area, it is expected to promote the groundwater development projects which have been delayed due to the lack of equipment, funds and technology.

In view of the background mentioned above, it can be said that the "groundwater development project" is an only means to provide stable supply of living water to the rural communities, and the role of this project is very large. And, implementing this project as promptly as possible will contribute much to the stabilization of people's life which is one of the major targets of the government of Bolivia.

Implementation of the proposed project will develop the safe water, extend the water supply services and benefit 57,295 inhabitants of 58 communities in Chuquisaca, 19,957 inhabitants of 46 communities in the southern part of La Paz, 31,009 inhabitants of 72 communities in Oruro, 35,128 inhabitants of 85 communities in Tarija, and 112,396 inhabitants of 155 communities in Santa Cruz. Beneficiary population is 255,785 in total or around 15.9% of the population in the Study Area by the target year 2000. The number of beneficiaries will be considerably larger if proper account is take, of people passing through the villages and of residents from nearby communities without water supply facilities.

Moreover, in Bolivia, it will be indispensable to promote groundwater development in the future, and therefore, learning the groundwater development technology through the implementation of this project will be very significant for the country in performing similar projects in any areas other than the Study Area.

9.2 Technical and Organizational Evaluation

According to the results of hydrogeological investigations, the groundwater development potential is evaluated extremely high to satisfy the water demand of rural communities in the Study Area. As for the water quality, it is evaluated possible to develop the groundwater satisfactory of domestic use without any treatment if only elaborate preliminary survey will be conducted.

The seasonal fluctuations will not occur if the groundwater is developed and the water quality will be secured constantly at all times.

The prefectural government which succeeded the authorities and functions of ex-CORDES are considered to be the most suitable organization for implementing groundwater development projects in the Study Area. Ex-CORDES has experienced many water supply projects and accumulated the staff, planning technologies and drilling skills even if it needs further development of technology and reinforcement of organization.

As for operation and maintenance, each beneficiary community should do its duty and it is regarded to be practicable for the motivated community to maintain the water supply system if only the supporting system are constructed and well managed.

The Prefecture in charge of implementing the projects is now proceeding with securing necessary organization and personnel, and learning of technology through the integration of regional development agencies. It is appreciated that the requirements for implementation of the projects can be fully expected for each Prefecture in cooperation with the national government.

Four pilot study, which consists of test well drilling, construction of the pilot project facility and educational program, was successfully carried out in cooperation of inhabitants and the water committee. On their own initiative, the communities made a decision to contribute 10 ~ 20 Bolivianos per family per month on the average for the water tariff. As the operation and maintenance costs of the water supply systems are estimated about 5 ~ 20 Bolivianos according to the sites, the contribution is, if it will be well managed, enough to cover not only the recurrent costs but also a part of the replacement costs.

However, some communities will be unable to cover the operation and maintenance costs. Technical or financial support, therefore, from the local government would be necessary.

9.3 Economic and Financial Evaluation

The proposed project has formulated on the assumption that well drilling equipment shall be procured by grant aids and the Bolivian side shall proceed the drilling works and construction of water supply facility of themselves. Examined the implementation program and investment plan by each Department, the projects are assessed feasible for the financial conditions of the central government, each prefectural government and beneficiary municipality based on the possibility of direct foreign aids.

9.4 Environmental Impact Assessment

The projects focus on mainly deep groundwater development to supply safe and domestic water to rural communities without water supply service. As a few groundwater is pumped up for domestic use and deep aquifer is not developed until now, the environmental impact is expected scarce.

9.5 Overall Evaluation

The proposed project is expected to have direct and indirect regional and national impacts. Expected main effects is summarized as follows:

(1) Human health improvement
(2) Water procurement labor and time saving
(3) Improvement of the living conditions
(4) Reduced expenses for purchasing water
(5) Strengthening water supply sectors
(6) Increase of employment opportunities during project periods

In summary, the various impacts lead to the conclusion that the proposed project is expected to have significant beneficial effects, therefore, it should be immediately implemented.

CHAPTER 10

CONCLUSIONS AND RECOMMENDATIONS

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10.1 Conclusions

10.1.1 Need for Water Development

1) The majority of the communities (water supply blocks) in the Study Area are isolated, scattered communities with small populations. The water supply coverage in rural area is only 23.3%. Living conditions, environment and economic situation is bad, and the shortage of water posing an extremely serious problem. 71% of total number of communities in the Study Area has not any water supply system. A large proportion of inhabitants can not obtain enough safe water for daily life, and has to depend on the unhygienic water sources such as raining water puddles. There is also the scarce shortage in water supply for farming and livestock grazing. Even communities with existing water supply systems have to face with inevitable supply restrictions in the dry season.
2) This lag of water supply service is due to a number of factors, including mainly: 1) the natural-geographic conditions, 2) the lag in the water resources development, 3) the lack or shortage of technology, manpower and funds for the water supply and the water resources development, 4) the lack of operation and maintenance for existing facilities.
3) Water development and water supply project in the rural areas of Bolivia have been pursued by the former Regional Development Corporations of each Department and the Public Service Authorities such as municipalities, with the cooperation of various countries, international agencies, and non-government organizations (NGO). These projects have included shallow wells, springs, and river-bed water. However, these projects are sporadically and located at some particular areas, so that the supply quantity is deficient in absolute terms.
4) There are only two departments, naming Chuquisaca and Oruro, who own a kind of well drilling equipments. In either case, however, the drilling equipments are old and obsolete and have a low performance. Other departments do not own any equipment, and have to depend on private constructors, and can not push forward the groundwater development projects continuously.
5) The inhabitants of many communities do not have the financial capability to cover the initial investments required for the execution of the groundwater development projects. But a majority of inhabitants strongly desires to have stable domestic water and shows a considerable awareness of the self-help efforts in the operation and maintenance of water resources and water supply facilities. In general, the inhabitants in many rural communities show the considerable willingness to pay tariffs required for the operation and maintenance of the water supply systems. Therefore, the daily operation and maintenance of the water supply system may be possible with the inhabitant self-help efforts, once the system had been constructed. Provided that the administrative organizations concerned are engaged in providing suitable education and guidance to the inhabitants and that the government offers

certain financial support or subsidies, there appears to be a high probability that the water development project will succeed. In the future, however, it is reasonable to anticipate a further reinforcement of these efforts, due to the effects of the decentralization process that now is ongoing in Bolivia.

6) To improve the water supply condition in Bolivian rural areas, it needs to put more efforts in the development of groundwater, as a stable water supply source whose the lack is the main cause of the shortage of drinking water in Bolivia. The groundwater, especially the ones of deep aquifer, has not been developed adequately yet, due to the lack of investment, technology, equipment, etc. But, this development should be carried out as soon, in order to improve the live conditions of the inhabitants and the public hygienic conditions in these rural communities.

10.1.2 Possibility of the Development of Groundwater

1) A large part of the Study Area, such as Altiplano area, Chaco Plain, etc. is dry area where the precipitation is very low. The main water sources in common used in Altiplano and in the plain in northern of Santa Cruz are wells, while the ones in mountainous areas are surface water sources.
2) Altiplano is a high plain closed off from other water basins, and therefore it has the big quantity of underground water preservation, though the precipitation here is not so high. The development of groundwater in this plain in the past is mainly based on the shallow wells, so then the development of deep underground water sources remains in high potential. The groundwater taken from the shallow aquifer here is becoming salty, but the ones from the deep aquifer contains low salt concentration relatively. The groundwater in the areas around the Lake of Poopo, the Uyuni Salt Flats, the Coipasa Salt Lake, Tredo City is likely to become salty, and therefore it needs to examine the possibility of the development of "fissure water" or "stratum water" at these areas.
3) In the hill zones, the surface water from the source such as rivers, springs is used widely, and the development of groundwater is not in adequate level. It assumed that there is a big quantity of groundwater under the ground of the valleys in these areas, thus the development potential in these areas is high. However, it has not easy access to many communities in these areas, and the drilling work may be difficult in some areas due to the existing of the hard rock stratum beneath them. These difficult conditions much be taken into consideration in the drilling plan applied to these areas.
4) In the northern humid area of Amazon river basin, the precipitation is high, and the groundwater can be obtained easily from relatively shallow wells. The groundwater development potential of the dry area in the southern part is also high, with the large and flat water basin, though the aquifer here is in deep location.
5) In the gently undulating plateau of Escudo Central area, there is a hard stratum under the ground, but the precipitation here is high relatively, and the groundwater development

potential is high with the weathering rock stratum that is rich in groundwater considerably.

6) In Chaco region, the groundwater preservation is small, due to its low precipitation and its location that is just at the watershed between the La Plata river basin and the Amazon river basin. However, since surface water is hard to obtain and adequate water quantities cannot be obtained with shallow wells either, there is a need to carry out active development of deep groundwater.

7) Until now, the development of deep groundwater has not been carried out adequately. Although the development of groundwater may not be easy depending on the geological characteristics of the area concerned, it is considerable that an adequate quantity of water with good quality as required by the inhabitants in rural communities for daily life, can be obtained with the appropriate groundwater development at these communities.

10.1.3 Regional Groundwater Development Strategies

1) The groundwater development strategies had been formulated to establish the basic policies to improve the water supply services in the Study Area. The strategy target year had been determined to be the 2000 Year (the fifth stage plan year). And base on the results of the case study on several project implementation strategies, the target water supply coverages had been determined separately for rural area and urban area of each Department. The target water supply coverages are given as 89% for the urban area and as 38% for the rural area, making an average of 54% for the Study Area in total. Given that the current average water supply coverage of the Study Area stands at 40.5%, this target water supply coverage marks a 13.5% increase.

2) To formulate the development strategies, the water supply blocks in the Study Area were classified by mean of the water supply database. At the same time, for each water supply block, the estimation of future population was made, and an evaluation was conducted to assess the supply ability of the existing water supply systems, and the numbers of projects (that is, the population benefiting from the projects) required to attain the target coverages were calculated. The next step was to conduct a series of evaluations for the three project implementation strategies in accordance with the development priorities in order to determine the time required for project completion, the effective of the investment, the structure of the executing organizations and the level of technology. Finally, a list of selected water supply blocks was made, listing the communities which were considered to be most appropriate for the implementation plan.

3) The number of selected water supply blocks and its total planned population are: 98 blocks, 57,295 persons for Department of Chuquisaca; 46 blocks, 19,957 persons for Southern Part of La Paz; 72 blocks, 31,009 persons for Department of Oruro; 85 blocks, 35,128 persons for Department of Tarija; and 155 blocks, 112,396 persons for Department of Santa Cruz. For all five departments, the selected number of blocks is 456 blocks, and the total planned population is 255,785 persons.

4) Rough facility planning was established to determine the specifications and quantities of facility and equipment and to make cost estimation. To complete the projects within five years as determined by the implementation plan, the required numbers of drilling rigs are 2 rigs for Chuquisaca, and Tarija, 3 rigs for Santa Cruz and 1 rig for Oruro and the Southern Part of La Paz.

5) The total project cost has been calculated to amount to US$ 71.26 million. 47% of this total project cost is for the procurement of well drilling equipments. The initial investment required for the implementation of projects may be obtained from the fiscal subsidy from central government according to the Law of Popular Participation. In this context, it has been assumed that the procurement of drilling equipments depends on the external financial aids, which accompanies with a cooperation in short-term drilling work to conduct the on-job technical transfer. The total external financial aids is assumed to be US$ 39.47 million, of which the cooperation by mean of conducting drilling work in one year period for each department is included.

10.1.4 Establishment of Project Implementation Plan

1) In recognition of the current serious shortage of drinking water, it has been concluded that the groundwater development plan should be implemented as soon as possible. It has been assumed that the procurement of the necessary drilling equipments, detailed studies, detailed surveys, detailed design, and all other preparations should be completed within five years period. On this basis, the work schedule has been established, and the project costs for each stage plan year has been calculated. In this context, the use of the bilateral financial cooperation in the initial stage plan year has been taken into consideration.

2) The project implementation plan has been established in such a manner that the project is started from the community with high possibility of successful groundwater development and with easy access conditions, and gradually extended to the surrounding areas.

3) It has been assumed that the individual prefectural governments (i.e. the UNASBAs in direct charge) should be the organizations responsible for the implementation of drilling works under this plan, and that the prefectural governments or the municipal authorities are responsible for the construction of water supply facilities. Furthermore, it has been assumed that once the water supply system had been completed, its operation and maintenance should be carried out by the cooperatives formed by the beneficiaries in the individual communities, under the jurisdiction and instructions of the competent prefectural governments.

4) It has been assumed that the prefectural governments have the ability to carry out the implementation plan by themselves after being provided with drilling equipments. However, the reorganization of local administrative institutions is under going, and we expect that the works will be transferred smoothly from the ex-CORDES to the prefectural agencies.

5) The objective of the groundwater development project is to assure a steady water supply as the

livelihood basis for the inhabitants in rural communities, who are suffering from a very scarce water supply shortage. The direct and indirect benefits of the investments, such as the improvements of the general health conditions of the inhabitants, the reduction of the working hours required to collect water, the cost savings in the acquisition of water, the activation of inhabitants' lives and communities' economic activities, etc. can be anticipated. Accordingly, the effects such as the improvement of inhabitants' living standards in long-term, the stabilization of civilian lives, the development of the communities' society and economy, etc. are the promising outcomes of the plan. Also, in terms of project operation, project maintenance and project management, etc. we can conclude that the execution of the project is totally reasonable.

10.2 Recommendations

10.2.1 Basic Policy for Project Implementation

1) The implementation of the groundwater development project is expected not only to fill the needs of rural inhabitants but also to improve their living standard and stabilize their public welfare. In order to implement the project quickly, the central government and the prefectural governments should confer with related agencies about the responsibility-sharing, the cooperation system and the raising funds.
2) Main targets of the project are the scattered communities in the rural areas; and the prefectural governments should take responsibility to carry out the project. In big and medium cities, the municipal authority can be the implementor of the water supply facilities construction project.
3) Investment funds necessary to implement the project should be basically recovered through tariff collection. However, central government should take responsibility to procure initial investments necessary for the project implementation. Prefectural governments should bear various expenses (including personnel expenses and traffic expenses) necessary to routine or temporary checkup and adjustment, technician training, renewals of facilities and equipments and etc. The central government and the prefectural governments should establish the financial foundation, consulting with related agencies on the strengthening of relevant organizations, ensuring personnel required, etc., in order to perform adequate and efficient operation and management for the sustainability of the system.
4) The communities should provide manpower in the construction of the water supply facilities, take the initiative in the operation of the water supply systems, and participate in the management and maintenance of these systems.
5) The selection of the water supply blocks for the project implementation were based on the data obtained from the water supply database, and on the results of a partial and rough questionnaire surveys. That means, the inhabitants' intentions and their will to participate in the project implementation have not been taken into consideration, and therefore, before the

implementation of the project, and after carrying out the field detailed surveys, this selection should be reviewed, and corrected.

6) However in determining the implementation of project, political interventions should be excluded to the utmost, and efforts should be made in order to obtain the appropriate and rational decision making from the neutral standpoint.

7) In planning and designing the facilities, an adequate and rational decision should be made, taking into consideration the social conditions, the water supply conditions, the environmental conditions, the topographical and geological conditions, the investment efficiency, the operation and maintenance ability, etc. of the targeted community.

10.2.2 Developments, Management of Groundwater Resources

1) Groundwater is a precious natural resource that should be developed and managed by the people who are living on that land, and based on their experiences and knowledge. During the implementing process of groundwater development project, in order to perform better measures for the development of groundwater source, the prefectural government concerned should instruct the beneficiary inhabitants on the use and the management of the groundwater source, motivate them to the formation and operation of the relevant organizations

2) The hydrologic and geological conditions in the Study Area are complicated and different by site of the project. Therefore, detailed hydrologic and geological surveys and geophysical prospectings should be carried out, and if it is necessary, test boring should be conducted previous to the well drilling works.

3) In implementing the water supply project, efforts should be made to establish the comprehensive planning which takes into consideration the organic linkage between the targeted community and the neighboring communities.

4) A composite technology, with wide knowledge and cross-sectorial experience are required for the development of groundwater source. Therefore, the engineers of groundwater development are required to acquire adequate technologies relating to groundwater prospecting, well drilling, well logging tests, quantitative assessments, groundwater monitoring, etc. Therefore, the prefectural governments should intentionally assign appropriate personnel in the phase of detailed design, planning of the project implementation, and enhance the levels of engineers through the on-job training. DINASBA should bear more efforts to train up technicians, conduct the technical exchanges, etc. in order to enhance their technical levels.

10.2.3 Community Commitment and Women Participation

1) Efforts should be made to conduct appropriate explanations to the inhabitants on the meaning of the project and on their considerable responsibility, to promote their participation

in the project implementation. The inhabitants are expected to contribute important labor force to the construction of the water supply facilities .

2) It is assumed that the operation and management of the water supply system are carried by the water committee or water cooperatives formed by the inhabitants, and with the financial fund formed by the inhabitants' payments.

3) The prefectural governments should conduct the educational programs on sanitation, and on the maintenance and management of water supply system at the beneficiary communities, with the cooperation of governmental agencies or non-governmental organizations concerned.
Efforts should be made to promote women's participation, utilize the surplus time that they might be obtained by the implementation of the project.

4) The active participation of women should be promoted in establishing the maintenance and management organization of the water supply systems. The life pattern and needs of women, as the end-users of the water supply services, should be considered in the water supply planning process.

10.2.4 Consideration of Environments and Public Health

1) For the sustainability of the wells, the organizations in charge of maintenance and management of the wells should pay adequate attention to prevent the over-pumping up of groundwater, and the inflow of polluted water into the wells. The water supply facilities should be managed carefully by daily checks, routine checks, and cleaned up always.

3) However, the improvement of consciousness of water supply and public health in whole community is the most important thing to be considered. Therefore, it is necessary to promote widely the sanitary education to any inhabitant, including the children and the housewives. Schools, public health centers, and other relevant regional agencies should perform the cooperative working programs to instruct the inhabitants on the public health and environmental preservation.

10.2.5 Planning, Implementation and Strengthening of Management Organizations

1) The National Secretariat of Popular Participation and DINASBA should be strengthened as the only organization in the central government which takes general control on the development project relating to water supply, public health, and basic sanitation.

2) Prefectural governments should establish and reinforce the system to operate and manage the drilling equipments, and bear following efforts to ensure the successful water supply services.
   (1) Increase the personnel required for the implementation of the development project.
   (2) Establish the education and training system in order to improve the technical levels of the staff members.

(3) Intensify the internal inspection system in the project implementation organization for the efficient operation and management of the project.

(4) Establish separated accounts, in order to obtain the efficiency in operating and managing of the development project.

(5) Establish the supply, custody and delivery system of water supply equipments and materials.

(6) Establish the survey methods and the standards for the selection of the targeted communities. Make the technical manuals.

(7) Conduct the educational programs on sanitation and maintenance and management of water supply system toward the inhabitants in the targeted communities.

(8) Follow-up the operating and managing circumstance of installed systems, and contribute technical and financial supports to ensure the appropriate operation and management of these systems.

3) All equipments used in this project, and all facilities completed by this project are public properties belonging to each prefecture. Therefore, the prefectures should bear responsibility for the management and maintenance of these equipments and facilities, and make efforts to perform technical support to the communities in order to ensure the adequate operation and management, the efficient use, the long life expectancy of these equipments and these facilities.

10.2.6 Information Management

1) The development of aquifers in deep location is the main target of this groundwater development project. But in Bolivia, the distribution and recharging mechanism of deep aquifers have not been known fully, due to the lack of data, and it is desirable that an overall study on groundwater should be conducted.

Moreover, in order to implement adequate and efficient management of the water supply facilities, and obtain necessary and effective data for the groundwater development project in the future, it is necessary to conduct groundwater monitoring, make the well inventory, collect, adjust and analyze the hydrometeorologic data, and also establish the system for the groundwater observation and maintenance and management of the groundwater using facilities.

2) The water supply database which was built up by this study, has the water supply blocks as the smallest unit, and is important and meaningful. In future, more efforts should be made to update the database, extend its use to the departments standing outside of the Study Area, utilize it in formulating the water supply plan, and in the management of groundwater development project in the whole nation.

3) In order to coordinate various water supply projects, which have individually carried out by the ex-CORDES, or by the foreign cooperation organization, or NGO etc., it is necessary to establish the information system to manage the informations on the contents, the implementing situation, etc. of these projects.

4) In consideration of the current water shortage in the areas outside of the Study Area, in order to be able to implement the same water supply project to remote mountain villages, and to the inhabitants who have not obtained water supply thought are living in the service area of a water supply system, the detailed surveys should be conducted immediately, in accompanying with the implementation of the development project.

5) More efforts should be made to conduct the follow-up surveys on the usage of the completed water supply systems, and to feed back the experienced lessons into the implementation of future project, and promote the interchange of technical knowledge between the persons in charge at the prefectural governments.