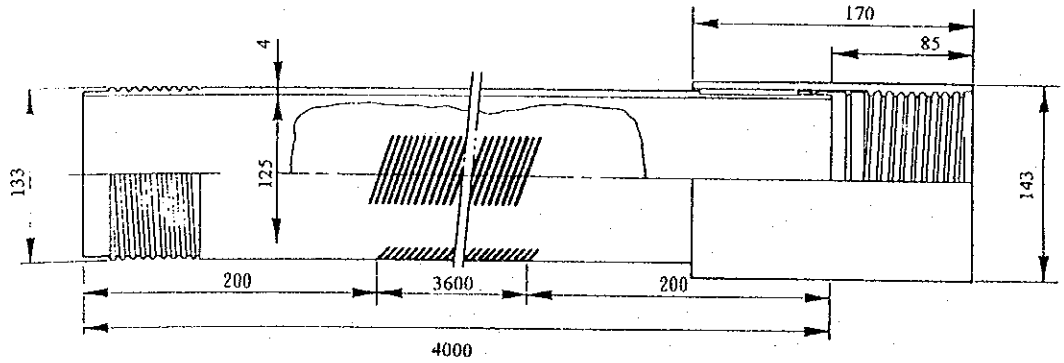
Hand Pump Well



Motor Pump Well

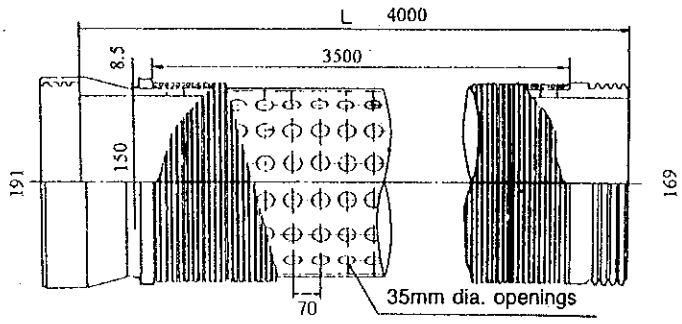


Figure 8.3.3 : Standard Design of Well Screen

CHAPTER 9 WATER SUPPLY PROGRAM

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CHAPTER 9 WATER SUPPLY PROGRAM

9.1 Frame and Design Criteria

9.1.1 Standard Water Consumption

Actual water consumption of the 20 test wells ranges from 28 to 42 lpcd. Therefore, the standard water consumption for the rural water supply program is set at 35 lpcd in year1995.

In the future, the water demand will increase , particularly for washing and bathing needs. Therefore, the target standard water consumption in year 2005 was set at 40 lpcd.

Note that the WHO indicates the relation between the distance to water source and typical values for domestic water consumption as follows:

Water source > 1000 m	----------	5-10 lpcd
Water source 500m-1000m	----------	10-15 lpcd
Village Well > 250 m	----------	15-25 lpcd
Village Well <250 m	----------	20-40 lpcd
Hydrant Tap	----------	50 lpcd

9.1.2 Water Demand Projection

(1) Population growth in the Study Area

According to the population growth projection, the population of the 200 villages in the Study Area will reach to about 131,789 in year-2005 (Refer to Table 3.3.1d, Chapter 3). The projection of each village is presented in Table 9.1.1.

(2) Rural Water Demand Projection

Based on the standard water consumption, the water demand in year-2005 will reach to 5,272 m^3/day at the standard water consumption of 40 lpcd.

9.1.3 Capacity of Hand Pump

(1) Handpump Selection

In order to meet the specified duties and operating conditions of the water supply program in Champasak and Saravan, the hand pump must be selected from various types of hand pumps presently being operated in Laos. The hand pump requirement of the program is as follows:

Discharge rate: 20-30 l/min
Ranges of pumping lift: 20-30 m
Ease of operation: Easy operation for woman and children

Ease of maintenance: Village-level or area-mechanic maintenance is possible
Material: Corrosion and abrasion resistance

Considering the above requirements, the pumping lift, the price, durability (corrosion and abrasion resistance) and ease of operation and maintenance are compared as shown in the following table.

Table 9.1.3 Comparison of Hand Pumps

Type	Pumping Lift	Price US$	Corrosion Resistance	Abrasion Resistance	Ease of Maintenance	Evaluation
India M3	15-45 m	300- 400	C	B	Village level	Suited
Dempster	8-25 m	200-300	C	B	Area mechanic	Adequate
Tara	7-12 m	less than 100	B	B	Village level	Inadequate
Lucky	2-6 m	less than 100	C	C	Village level	Inadequate
Sankyo (Japan)	15-45 m	over 1,000	A	A	Central or Foreign	Not suited

Interpretation of the rating of corrosion resistance is:

A: All downhole components are manufactured from non-corroding materials, such as stainless steel or plastic cylinder.
B: Most downhole components are corrosion resistant, but some small, inexpensive and easily replaced component may corrode.
C: Downhole components are susceptible to corrosion (e.g. mild steel or galvanized rods, rising main).

The rating of the abrasion is classified into:

A: The design minimizes the damage from abrasion
B: Adequate abrasion resistance
C: Inadequate abrasion resistance

The ease of maintenance is judged as follows:

- the Village level caretaker can replace spares, if he has minimal training and simple tools
- the Area mechanics must come to replace spares
- the Centralized maintenance is necessary
- the pump must be repaired in the Foreign country

These pumps are imported from India, Bangladesh, Thailand, USA and Japan. Since the UNICEF provides India Mark III and Tara for their rural water supply program, these pumps are

recently standardized in Laos and their spares are stored in the Provincial Health Department. Considering the above mentioned situations , the India Mark III is the best option for the hand pump water supply. However, material of this pump should be changed to stainless steel, considering the corrosive groundwater quality in the Study Area.

(2) Pumping Capacity of India Mark III

The results of the pumping test of the 20 test wells showed that the maximum pumping discharge was 3,800 m^3/day (B.Beng) and the lowest was 9 m^3/day (B.Nongphai). The groundwater level fluctuates seasonally. For instance, it changes from 7 m to13 m at B.Nakasao and from18 m to 33 m in B.Houn-Tai. The maximum total head of well is estimated to be less than 35 m. The pumping discharge of India Mark III within this head ranges is estimated at 15-20 liter/min in average.

Accordingly, the daily pumping capacity Qc is calculated as follows:

Time of pumping operation=8 hours

Qc=(15-20) liter x 60 min x 8 hours = 7.2 -9.6 m^3/day
(average 8.4 m^3/day)

(3) Water Supply Population per India Mark III Handpump

As mentioned above, the average pumping capacity of India MarkIII is 8.4 m^3/day. A served population by single India Mark III at a design water consumption of 35 lpcd is calculated as follows:

8,400 liter/day ÷ 35 lpcd = 240 persons in year-1995

and

8,400 liter/day ÷ 40 lpcd= 210 persons in year-2005

9.1.4 Number of Hand Pumps Required

(1) Supply Capacity of Existing Water Source

Almost all villages in the Study Area are presently not served by piped water or hand pump water supply systems. Unserved people traditionally uses rivers, spring, shallow dug wells and ponds for their domestic water needs.Table 9.1.3 (a) shows the coverage by existing traditional water sources in two provinces. Table 9.1.3 (b) also shows the number of existing hand pumps installed in the villages of two provinces. Although many Lucky hand pump is seen, the capacity of this pump is very small. Other hand pumps, such as India Mark III, Dempster and Tara, are still few. Present supply capacity of these water sources can be estimated as follows:

(a) Handpump

- India Mark 3 = 140-220 persons, pumping discharge 10-16 liter/min
- Dempster = 110-160 persons, pumping discharge 8-12 liter/min

- Tara = 70-110 persons, pumping discharge 5-10 liter/min
- Lucky = 15 persons (about 2 families)

(b) River

- Villages located along the big river (Mekong and Xedon)

River water can serve mainly for washing and bathing. About 50% of total domestic use can be served by river water.

- Villages located along tributaries

Small river or stream, the tributaries of Mekong and Xedon, can serve about 20% of total domestic use.

(c) Dug wells and other source

These water sources are neglected from the supply capacity, since water source is unstable and inferior in water quality.

(2) Distance to Handpump

The distance to the hand pump well is set at 250m according to the WHO standard, which is widely used in the rural water supply programs.

(3) Example Calculation of Number of Hand Pumps Needed

Based on the above mentioned design criteria, the number of the hand pumps to be installed in the candidate 200 villages of Champasak and Saravan provinces are calculated and presented in Table 9.1.4. The followings show the example calculation of the number of hand pumps.

(a) C-1 B.Nakham, Champasak Province

Population = 863 in year-1994, Population = 1,115 in year-2005
Existing water source = Xedon river, Village length = about 1,000 m
Number of pumps needed from the distance = 2 pumps
863 x (1 - 50% river served) ÷ 240/persons/pump = 2 pumps in year- 1995
(1,115 - 863) ÷ 210/persons/pump x 50% = 1 additional pump in year-2005

(b) C-29 B. Naxon Champasak Province

Population = 1,398 in year-1994, Population = 1,807 in year-2005, Existing water source = Lucky pump (55) and Tara pump (2), Village length = about 1,000 m
(1,398 - 825 - 180) ÷ 240 = 2 pumps in-year1995
(1,807 - 1,398) ÷ 210 = 2 additional pumps in 2005

(c) C-71 B. Tomo-Nak Champasak Province

Population = 620 in year-1994, Population = 801 in year-2005, Existing water source = Stream, Village length = about 1,000 m
620 x (1 - 20% stream served) ÷ 240 = 2 pumps
In this village, additional two pumps are needed for a hospital and a school. Therefore, 4 pumps are required in total in year-1995.
(801 - 620) ÷ 210 x 80% = 1 additional pumps in year-2005

(d) S-1 B.Nonsavang Saravan Province

Population = 522 in year-1994, Population = 720 in year-2005, Existing water source = Stream and Lucky pump (6), Village length = about 800 m
(522 - 90) x (1 - 20%) ÷ 240 = 2 pumps in year-1995
(720 - 522) x (1 - 20%) ÷ 210 = 1 additional pump in year-2005

(e) S-56 B.Chong Saravan Province

Population = 183 in year-1995, Population = 253 in year-2005, Existing water source = Stream and dug wells, Village length = about 200 m
183 - 240 (JICA test well) x (1 - 20%) = 0 pump in year-1995
253 - 183 x (1 - 20%) ÷ 210 = 1 additional pump in year-2005

(f) S-64 B.Phonphai

Population = 1,034 in year-1994, Population = 1,426 in year-2005, Existing water source = Stream, Village length = about 800 m
{1,034 - 240 (JICA test well)} x (1 - 20%) ÷ 240 = 3 pumps in year-1995
(1,426 - 1,034) x (1 - 20%) ÷ 210 = 2 additional pumps in year-2005

(4) Total Number of Handpumps Requirement in the Program

In the proposed water supply program, number of hand pumps in year-1995 and 2005 is calculated as follows:

Table 9.1.4 Number of Hand Pumps Required

Province	Population		No. of Pump	
	1995	2005	1995	2005
Champasak	53,297	68,886	159	241
Saravan	45,588	62,903	154	244
Total	98,885	131,789	313	485

9.2 Facilities

Two types of water supply facilities were planned. One is a hand pump system, the other is a motor pump system.

9.2.1 Hand Pump System

The system is composed of a deep well, a hand pump (India Mark III), a platform and a roof which were used in the pilot water supply systems.

(1) Platform

The platform is designed at 0.15 m thickness and 3 m x 3 m area of reinforcement concrete for suitable use of pumping, washing, bathing and water carrying, and protecting waste water from infiltration to the well. The drain is also designed to discharge waste water, feeding water for livestock and garden watering.

(2) Roof and Support

The roof is designed to protect pump and people from direct sunshine and rain. This roof design also aims to symbolize the well as the center of the community. A hook is put on the main beam. This can be used for suspending the riser pipe, plunger rod and valve unit at the time of pump maintenance. The design maximum loading is 2.8 t.

9.2.2 Motor Pump System

The system is composed of a deep well equipped with a submersible pump, an elevated water tank, a distribution pipe and a communal faucet.

(1) Water Tank

The capacity of the water tank is designed considering the following parameters:

(a) designed daily average water demand (Qn)
(b) designed maximum daily water demand (Qmax)
(c) designed hourly maximum water demand (Qhmax)

Example calculation in Ban Houaxe

Qn = Water supply population x Water consumption (35 lit./persons/day) x loss coefficient (1.2) = 628 x 35 x 1.2 = 26.4 m3/day

Qmax = 26.4 m3 x kd (peak coefficient 1.1) = 29m3/day
Qhmax = Qmax x kh (peak hourly peak coefficient 1.5) = 43.5 m3/day

It is necessary to make the storage volume large enough to enable adjustment of the accumulation of the difference between the pump amount and the demand for water. This accumulation of the difference is 20-40% of the total daily maximum water demand. Assuming that 30% of difference, the volume of the water tank must be about $9m^3$.

(2) Submersible Motor Pump

The capacity of submersible motor pump can be selected from the performance curves considering the total head and the discharge rate. Required total head is 50 m and discharge rate is 160 l/min. The pump drive power of 2.2 kw is required.

9.2.3 Maintenance Center

Two maintenance centers are planned to construct in Champasak and Saravan in order to facilitate maintenance works of the rural water supply program. A conceptual illustration of the maintenance center is presented in Figure 9.2.1.

9.3 Cost Estimation

The project cost necessary for the construction of water supply systems in 200 villages in Champasak and Saravan provinces were estimated. The following factors were taken into consideration.

a. Construction period
b. Well drilling method and procurement of foreign contractors
c. Construction materials and their transportation
d. Labor source
e. Equipment availability and rental cost
f. Supply of equipment for provincial health department
g. Well operation and maintenance (O & M) facilities,
h. Detailed Design (D/D) and supervision,
i. Foreign currency exchange rate.

The equipment supply includes vehicles and consumables. The O & M facilities includes office building, warehouse ,workshop and garages with necessary tools and handpump spares. The design and supervision is an expense of the consultant service for the project. A project cost in-year 2005 is estimated as follows:

Estimation conditions

a. Price level: Market prices in July 1995
b. Foreign currency exchange rate : 1 US $ = 85.55 Yen = 820 Kips
c. Project implementation period : 4 months + 2 years = 28 months
d. Contractors : Foreign contractors for well drilling works, construction of facilities and supply of equipment and material

The result of estimation are presented as follows:

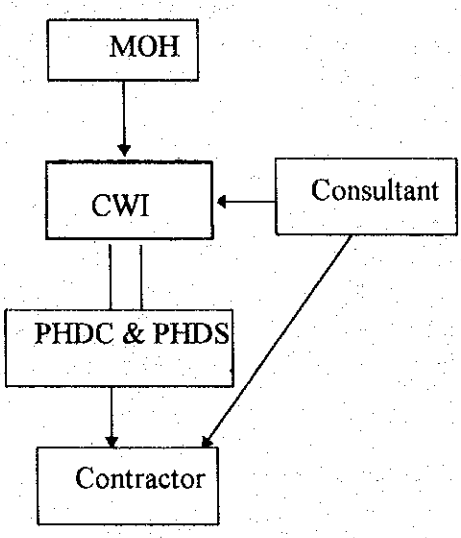
Table 9.3.1 Summary of the Project Costs

Cost Items	Cost in million Yen
Well Construction	1,247
O&M Facilities	89
Equipment & Materials	62
Engineering Fee	112
Contingency	216
Total	1,726

9.4 Organization

The Ministry of Health (MOH) is main responsible ministry for the health care and rural water supply in Lao PDR. The MOH controls rural water supply through its subordinate office, the National Institute of Hygiene and Epidemiology (NIHE). The NIHE also has its own subordinate office, the Clean Water Institute (CWI). The CWI is counterpart agency of the present JICA Study. The CWI is implementing for the rural water supply programs which are being supported by UNICEF in the whole country. The CWI, Champasak and Saravan provincial Health Department (PHDC, PHDS) will be principal implementing body of this rural water supply project. The PHD's Clean Water Supply Section is responsible for the well construction and maintenance with supported and materials provided under the CWI.

The organization of the project implementation is as below.



The CWI is responsible for the execution of this project. It manages of the construction budgets, PHDC and PHDS and contractors, as well as with cooperation of the consultant.

The consultant is responsible for the project detailed design, planning related to the procurement of the equipment and materials, the preparation of the tender document and tendering, the evaluation of the bids and the supervision of the project construction.

9.5 Implementation Schedule

The detailed of construction schedule will be prepared in the detailed design (D/D) stage. The tentative implementation schedule is shown below.

(1) D/D Stage

The activity of the detailed design stage is setting up of well construction number and sites, detailed design of facilities, planning of equipment and procurement schedule, detail of construction schedule, preparation of tender documents, tender calling, selection of contractors. The detailed design stage will require about 4 months.

(2) Construction Stage

Construction of the well and water supply facilities and procurement of equipment and materials will be executed in the project site. The duration of the construction stage is estimated about 2 years.

D/D Stage

Selection of Well Sites
Facilities D/D
Equipment D/D and Planning
O & M Facilities D/D
Calculation of Project Cost
Tender Document, Tendering

Construction Stage

Well Drilling, Well Logging
Water Supply Facilities construction
O & M Facilities Construction
Equipment Supply and Training
Test Run Facilities
Completion of Construction

A tentative implementation schedule is shown in Figure 9.5.1.

9.6 Operation and Maintenance Program

9.6.1 Policy

In the proposed water supply program, a hand pump and a motorized pump systems will be constructed. Operating problems are likely to be less important than maintenance problems in a hand pump system, while a motor pump system has a more significant operating and maintenance problems since it requires higher mechanical skill and operating cost. It is usually difficult to repair the submersible pump in Laos, once it has been broken.

In Laos, urban water supplies are run by Nam Papa and all the consumer pay the cost. On the other hand, in the rural water supplies, the village pay for the cost of well drilling and hand pump installation to the government, however, there is no maintenance arrangement by the government after completion of the systems. Even if it were possible, the government do not afford to run maintenance work without revenue. Most importantly, the community usually do not have an understanding of what maintenance is. Obviously, at present, there is no clear understanding between the the community and the government about who is to do what in maintenance.

Unless proper maintenance, the water supply system will be deteriorated and eventually becomes unworkable within a few years. The only possible solution is that the village people should maintain the system themselves. The responsibility of maintenance must be felt by them. However, it is unrealistic to expect the community to take over all maintenance duties. Though the India Mark III hand pump was designed under the concept of VLOM (Village Level Operation and Maintenance), it is still difficult for village people to repair even a minor trouble without skilled technician and necessary tools and spares. Maintenance must therefore be a shared responsibility of the government and the community, and the government must provide a reliable technical support to them.

9.6.2 Organization

(1) Village Level

Every community must establish "the water user's association" composed of the users of the water supply system. These associations were actually established in the villages where the test wells were drilled during the Study.

The association is managed by the village head, the caretaker and the accountant. The village head's role is to manage the association, to monitor the state of the system and to instruct the people to carry out routine maintenance and cleaning of well environs.

Under the village head, the caretaker carries out a daily inspection of handle motion, quantity , color and taste of water of hand pump. He sometimes dismantles the pump head and lubricates the chain and nuts. In motor pump system, he must check the water tank , pipes, valves and electricity meter. If he is well trained, all minor repairs of the hand pump are carried out by himself. If the damage beyond his knowledge and skill, he consultant with the village head and notifies the district health section indicating the the component causing the trouble.

The accountant's job is collection of water rate every month, posting up and keeping of them. The operating and maintenance costs are borned by them.

(2) Province Level

The role of the provincial health department is to monitor the state of the system, to encourage and motivate the community to carry out maintenance tasks, to ensure that spares are available, and to carry out major repairs beyond the capacity of the community.

For this role, the provincial health department must set up a maintenance organization with an appropriate budget and full-time staff. A maintenance center will be constructed in the proposed water supply program. Maintenance offices and stores must be set up at this center.

A mobile maintenance team must be appointed to carry out periodical preventive maintenance according to a specified schedule and curative maintenance upon request from the village. The team members, maintenance technicians, should be selected from among the experienced field technicians or urgently be grown up by training.

It is therefore desirable to train a technician of the provincial health department to carry out some of the maintenance and repair functions. He should work as an assistant during the construction of the water supply system so that he can become familiar with the hand pump and learn the skills required to repair and replace spares.

9.6.3 Notification System and Maintenance Record

The target villages of the water supply program in Champasak and Saravan provinces are mostly located along the main road. However, the villagers have no means of communication even if the break down occurred due to trouble in the system. They have neither a vehicle nor a bicycle. However, there is a bus service along the main road. One method is to deliver a notification card by bus (Figure 9.6.1).

The provincial health department should issue a set of prepaid and preaddressed post cards illustrating their water supply, or various components of it. To report breakdown, the villagers mark the component causing the trouble and deliver the card to the district health section. Then, the district office communicate it to the mobile team in the maintenance center.

The mobile maintenance team should have a record of each village with their conditions and what maintenance was performed before. This report will record any trouble that have occurred and been repaired as well as any spares that have been used. These records then form a useful data of the causes of breakdowns, which can be used for future evaluations and design improvement (Table 9.6.1).

9.6.4 Spares and Tools

It may be recommended to leave standard sets of tools and supplies in the village, if the village has a skilled caretaker. A village-level maintenance of the so-called VLOM hand pump may be feasible.

However, as mentioned earlier, the village level maintenance is still not adaptable considering the circumstances of the village in Champasak and Saravan, though several developed villages can undertake maintenance works (refer to Chapter 7.4). It is therefore needed that the provincial health department ensures the maintenance service and store of tools and spares in its maintenance center.

All of equipment and materials for water supply system are presently imported from foreign countries. Local manufacture in Laos is limited to PVC pipe, yet able to produce hand pumps, reliable electric motors, replacement parts. This situation complicates the maintenance function. Several countries have tried to standardize equipment by limiting the imported brands for use or developing their own designs for local manufacture. In Laos, recently, the hand pump brands are limited to Tara and India Mark III. They are mostly supported by UNICEF. It may lighten the maintenance problems. It is also desirable that Laos grow manufacturer of hand pumps and its outlet in the future.

9.6.5 Operation and Maintenance Cost

Operation and maintenance cost can be estimated considering the following factors.

Operating cost

-Electric power consumption for operation in the motor pump system and power rate

Maintenance cost

-the size and wage of maintenance staff
-the flow of replacement parts and supplies consumed annually
-the size and use of the maintenance organization's vehicle fleet

The annual operation and maintenance cost is presented in Table 9.6.2.

In the hand pump system, the operation and maintenance cost is estimated to be 65,000 Kip/ year. Dividing by the average service population (210), it makes 26 Kip/person/month. Accordingly, the average family (6.7 persons) shall pay about 174 kip/month. The motor pump system (served population 2,300) become about 112 kip/month/family.

Table 9.1.1a Champasak Province Population Growth

(Growth Ratio = 2.36 %/ year) Champasak-1

Village Name	Villa. No.	1994 May	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Sanasomboon Dist.													
B.Nakham	C. 1	863	883	904	926	947	970	993	1,016	1,040	1,065	1,090	1,115
B.Phonthat	C. 2	135	138	141	145	148	152	155	159	163	167	170	174
B.Nonsavan	C. 3	615	630	644	660	675	691	707	724	741	759	777	795
B.Nonghai	C. 4	553	566	579	593	607	621	636	651	666	682	698	715
B.Souvannakihli	C. 5	839	859	879	900	921	943	965	988	1,011	1,035	1,059	1,084
B.Nanai	C. 6	629	644	659	676	691	707	723	741	758	776	794	813
B.Nongdou	C. 7	378	387	396	405	415	425	435	445	456	466	477	489
B.Houaxe	C. 8	628	643	658	674	689	706	722	739	757	775	793	812
B.Pongsan	C. 9	337	345	353	361	370	379	388	397	406	416	426	436
B.Dong	C.10	311	318	326	334	341	349	358	366	375	384	393	402
B.Hangam	C.11	354	362	371	380	389	398	407	417	427	437	447	458
B.Nongkham	C.12	419	429	439	449	460	471	482	493	505	517	529	542
B.Khampeng	C.13	987	1,010	1,034	1,059	1,084	1,109	1,135	1,162	1,189	1,218	1,246	1,276
B.Khamngoua	C.14	256	262	268	275	281	288	294	301	309	316	323	331
B.Nongkhen	C.15	256	262	268	275	281	288	294	301	309	316	323	331
B.Louy	C.16	150	154	157	161	166	169	173	177	181	185	189	194
B.Solo-Gnai	C.17	1,025	1,049	1,074	1,099	1,125	1,152	1,179	1,207	1,235	1,264	1,294	1,325
B.Solo-Noy	C.18	635	650	665	681	697	714	730	748	765	783	802	821
B.Xonphak	C.19	1,230	1,259	1,289	1,319	1,350	1,382	1,415	1,448	1,482	1,517	1,553	1,590
B.Khamlouang	C.20	266	272	279	286	292	299	306	313	321	328	336	344
B.Sithouan	C.21	422	432	442	453	463	474	485	497	509	521	533	545
B.Houang	C.22	1,285	1,315	1,346	1,378	1,411	1,444	1,478	1,513	1,549	1,585	1,623	1,661
B.Okumuana	C.23	1,117	1,143	1,170	1,198	1,226	1,256	1,285	1,315	1,346	1,378	1,410	1,444
B.Boungkha	C.24	1,010	1,034	1,058	1,083	1,109	1,135	1,162	1,189	1,217	1,246	1,275	1,305
B.Latsua(Kongmek)	C.25	317	324	332	340	348	356	365	373	382	391	400	410
B.Nalak	C.26	1,376	1,408	1,442	1,476	1,511	1,546	1,583	1,620	1,658	1,697	1,737	1,778
B.Dongkalong	C.27	374	383	392	401	411	420	430	440	451	461	472	483
B.Nalong	C.28	1,696	1,736	1,777	1,819	1,862	1,906	1,951	1,997	2,044	2,092	2,142	2,192
B.Naxon	C.29	1,398	1,431	1,465	1,499	1,535	1,571	1,608	1,646	1,685	1,725	1,766	1,807
B.Thangbengsivilai	C.30	310	317	325	332	340	348	357	365	374	382	391	401
B.Nonxat	C.31	293	300	307	314	322	329	337	345	353	361	370	379
B.Donphek	C.32	412	422	432	442	452	463	474	485	497	508	520	533
B.Dua-Hua	C.33	856	876	897	918	940	962	985	1,008	1,032	1,056	1,081	1,106
B.Kengkeo	C.34	498	510	522	534	547	560	573	586	600	614	629	644
B.Ngouadeng	C.35	1,053	1,078	1,103	1,129	1,155	1,183	1,211	1,240	1,269	1,299	1,330	1,361
B.Paxxon	C.36	1,497	1,532	1,568	1,606	1,643	1,682	1,722	1,763	1,804	1,847	1,890	1,935
	sub-total	24,780	25,365	25,963	26,576	27,203	27,845	28,503	29,175	29,864	30,568	31,290	32,028
Bachiang Dist.													
B.Nongsai	C.37	368	377	386	395	404	414	423	433	443	454	465	476
B.Bachiang	C.38	278	285	291	298	305	312	320	327	335	343	351	359
B.Makngeo	C.39	259	265	271	278	284	291	298	305	312	320	327	335
B.Nongbok-Noy	C.40	576	592	606	620	635	650	665	681	697	713	730	747
B.Nongbok-Gnai	C.41	646	661	677	693	709	726	743	761	779	797	816	835
B.Thongkim	C.42	510	522	534	547	560	573	587	600	615	629	644	659
B.Kenggnao	C.43	300	307	314	322	329	337	345	353	362	370	379	388
B.Thongsala	C.44	368	377	386	395	404	414	423	433	443	454	465	476
B.Mouangkhai	C.45	394	403	413	423	433	443	453	464	475	486	498	509
B.Pakonay	C.46	270	276	283	290	296	303	311	318	325	333	341	349
B.Oudomsouk	C.47	256	262	268	275	281	288	294	301	309	316	323	331
B.Phasouam	C.48	157	161	164	168	172	176	181	185	189	194	198	203
B.Lak-21	C.49	567	580	594	608	622	637	652	668	683	699	716	733
B.Phin	C.50	467	478	489	501	513	525	537	550	563	576	590	604
B.Lek-23	C.51	391	400	410	419	429	439	450	460	471	482	494	505
B.Lak-25	C.52	379	388	397	406	416	426	436	446	457	468	479	490
B.Nongkhamkhao	C.53	117	120	123	125	128	131	135	138	141	144	148	151
B.Senkeo	C.54	136	139	142	146	149	153	156	160	164	168	172	176
B.Houayten	C.55	320	328	335	343	351	360	368	377	386	396	404	414
B.Talen(Lak 17)	C.56	195	200	204	209	214	219	224	230	235	241	246	252
B.Nonsaat	C.57	218	223	228	234	239	245	251	257	263	269	275	282
B.Nongsak-Euk	C.58	184	188	193	197	202	207	212	217	222	227	232	238
B.Lak-13	C.59	120	123	126	129	132	135	138	141	145	148	152	155
B.Nonhouaydua	C.60	334	342	350	358	367	375	384	393	403	412	422	432
B.Kagno	C.61	283	290	297	304	311	318	326	333	341	349	357	366
	sub-total	8,095	8,286	8,482	8,682	8,887	9,096	9,311	9,531	9,756	9,986	10,222	10,463

Table 9.1.1b

Champasak-2

Village Name	Villa. No.	1994 May	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Pathoomphone Dist.													
B.Lak-19	C.62	451	462	473	484	495	507	519	531	544	556	569	583
B.Lak-20	C.63	178	182	187	191	195	200	205	210	215	220	225	230
B.Nephou	C.64	881	902	923	945	967	990	1,013	1,037	1,062	1,087	1,112	1,139
B.Lak-24	C.65	448	459	469	480	492	503	515	527	540	553	566	579
B.Sanamxaysouk(L25)	C.66	309	316	324	331	339	347	355	364	372	381	390	399
B.Houakhoua(L-29)	C.67	270	276	283	290	296	303	311	318	325	333	341	349
B.Lak-31	C.68	289	296	303	310	317	325	332	340	348	357	365	374
B.Lak-34	C.69	256	262	268	275	281	288	294	301	309	316	323	331
B.Khouatouay(L-36)	C.70	759	777	795	814	833	853	873	894	915	936	958	981
B.Tomo-Nak	C.71	620	635	650	665	681	697	713	730	747	765	783	801
B.Tao-Tai	C.72	629	644	659	675	691	707	723	741	758	776	794	813
B.Nakham-Noy	C.73	250	256	262	268	274	281	288	294	301	308	316	323
B.Thangbeng	C.74	633	648	663	679	695	711	728	745	763	781	799	818
B.Nongkhe	C.75	468	479	490	502	514	526	538	551	564	577	591	605
B.Napho	C.76	667	683	699	715	732	750	767	785	804	823	842	862
	sub-total	7,108	7,275	7,447	7,623	7,803	7,987	8,176	8,369	8,566	8,768	8,975	9,187
Sukhuma Dist.													
B.Chikthangngo	C.77	397	406	416	426	436	446	457	467	478	490	501	513
B.Bak	C.78	230	235	241	247	252	258	265	271	277	284	290	297
B.Samkhanabqua	C.79	682	698	715	731	749	766	784	803	822	841	861	881
B.Phonpheung	C.80	726	743	761	779	797	816	835	855	875	896	917	938
B.Pako	C.81	595	610	624	639	654	670	686	702	718	735	753	770
B.Thapcham	C.82	793	812	831	850	871	891	912	934	956	978	1,001	1,025
B.Kouttaboun	C.83	526	538	551	564	577	591	605	619	634	649	664	680
	sub-total	3,950	4,043	4,139	4,236	4,336	4,439	4,543	4,651	4,760	4,873	4,988	5,105
Khong Dist.													
B.Boun-Tai	C.84	832	852	872	892	913	935	957	980	1,003	1,026	1,051	1,075
B.Keng	C.85	517	529	542	554	568	581	595	609	623	638	653	668
B.Phonsaat	C.86	856	876	897	918	940	962	985	1,008	1,032	1,056	1,081	1,106
B.Naveng	C.87	268	274	281	287	294	301	308	316	323	331	338	346
B.Maisivilai	C.88	366	375	383	393	402	411	421	431	441	451	462	473
B.Nasenphan	C.89	563	576	590	604	618	633	648	663	679	695	711	728
B.Naxuak(Hang)	C.90	496	508	520	532	545	557	571	584	598	612	626	641
B.Xongpuay	C.91	252	258	264	270	277	283	290	297	304	311	318	326
B.Nasomhong	C.92	657	673	688	705	721	738	756	774	792	810	830	849
B.Boung	C.93	415	425	435	445	456	466	477	489	500	512	524	536
B.Hatxaykhoum	C.94	1,150	1,177	1,205	1,233	1,262	1,292	1,323	1,354	1,386	1,419	1,452	1,486
B.Veunkhao	C.95	502	514	526	538	551	564	577	591	605	619	634	649
B.Phondeng	C.96	370	379	388	397	406	416	426	436	446	456	467	478
B.Kadam	C.97	856	876	897	918	940	962	985	1,008	1,032	1,056	1,081	1,106
B.Khinak	C.98	780	798	817	837	856	876	897	918	940	962	985	1,008
B.Settaolek	C.99	371	380	389	398	407	417	427	437	447	458	468	480
B.Tapusy	C.100	113	116	118	121	124	127	130	133	136	139	143	146
	sub-total	9,364	9,585	9,811	10,043	10,280	10,527	10,771	11,025	11,285	11,551	11,824	12,103
Champasak Province	Total	53,297	54,555	55,842	57,160	58,509	59,890	61,303	62,750	64,231	65,747	67,299	68,887

Table 9.1.1c

Saravan Province Population Growth

(Growth Ratio = 2.97 %/ year) Saravan-1

Village Name	Villa. No.	1994 May	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Lakhonepheng Dist.													
B.Nonsavang	S. 1	522	538	553	570	587	604	622	641	660	679	699	720
B.Nadou	S. 2	602	620	638	657	677	697	718	739	761	783	807	831
B.Nadoumai	S. 3	579	596	614	632	651	670	690	711	732	753	776	799
B.Houaykapo	S. 4	543	559	576	593	610	629	647	666	686	707	728	749
B.Lakhosi-Tai	S. 5	289	298	306	316	325	335	344	355	365	376	387	399
B.Lakhosi-Nua	S. 6	130	134	138	142	146	150	155	160	164	169	174	179
B.Khonsay	S. 7	134	138	142	146	151	155	160	164	169	174	180	185
B.Kenpadek	S. 8	366	377	388	400	411	424	436	449	463	476	490	505
B.Nondinxay	S. 9	456	470	483	498	513	528	544	560	576	593	611	629
B.Nathandai	S.10	322	332	341	352	362	373	384	395	407	419	431	444
B.Phoudaocheng-Noy	S.11	426	439	452	465	479	493	508	523	538	554	571	588
B.Nongsano	S.12	231	238	245	252	260	267	275	284	292	301	310	319
B.Phoudaocheng-Gnai	S.13	356	367	377	389	400	412	424	437	450	463	477	491
B.Thangbeng	S.14	316	325	335	345	355	366	377	388	399	411	423	436
B.Bouttaphan	S.15	310	319	329	338	349	359	370	380	392	403	416	428
B.Houaykhen	S.16	186	192	197	203	209	215	222	228	235	242	249	257
	sub-total	6,768	6,939	6,116	6,297	6,484	6,677	6,875	7,079	7,290	7,506	7,729	7,959
Khongxedon Dist.													
B.Napong	S.17	1,182	1,217	1,253	1,290	1,329	1,368	1,409	1,451	1,494	1,538	1,584	1,631
B.Vang Kan Hong	S.18	316	324	334	344	354	365	375	387	398	410	422	435
B.Napheng-Gnai	S.19	516	530	546	562	579	596	614	632	651	670	690	711
B.Khong- Noy	S.20	835	860	885	912	939	967	995	1,025	1,055	1,087	1,119	1,152
B.Nongsaphang	S.21	439	452	466	479	494	508	523	539	555	571	588	606
B.Nongkoxong	S.22	346	356	367	378	389	401	412	425	437	450	464	477
B.Nongboua	S.23	178	183	189	194	200	206	212	218	225	232	239	245
B.Donmutang	S.24	398	410	422	435	447	461	474	488	503	518	533	549
B.Hinxiou	S.25	502	517	532	548	564	581	598	616	634	653	673	693
B.Thakho	S.26	121	125	128	132	136	140	144	149	153	157	162	167
B.Khok-Houaxang	S.27	288	297	305	314	324	333	343	353	364	375	386	397
B.Namouang	S.28	625	644	663	682	703	723	745	767	790	813	838	862
B.Khamthong-Gnai	S.29	573	590	608	626	644	663	683	703	724	746	768	791
B.Nonsamlan	S.30	171	176	181	187	192	198	204	210	216	223	229	236
B.Nonghalou	S.31	152	157	161	166	171	176	181	187	192	198	204	210
B.Thalouang	S.32	268	276	284	293	301	310	319	329	339	349	359	370
B.Nongteng	S.33	327	337	347	357	368	379	390	401	413	426	438	451
B.Houayxao	S.34	495	510	525	540	556	573	590	608	626	644	663	683
B.Hatdou	S.35	400	412	424	437	450	463	477	491	506	521	536	552
B.Nakadao	S.36	806	830	855	880	906	933	961	989	1,019	1,049	1,080	1,112
B.Koutlamphong	S.37	418	430	443	456	470	484	498	513	528	544	560	577
B.Kuttabeng	S.38	525	541	557	573	590	608	626	644	664	683	704	724
	sub-total	9,879	10,172	10,475	10,786	11,106	11,436	11,775	12,125	12,485	12,856	13,238	13,631
Vapy Dist.													
B.Nongngong	S.39	466	480	494	509	524	539	555	572	589	606	624	643
B.Donkha	S.40	817	841	866	892	918	946	974	1,003	1,033	1,063	1,096	1,127
B.Naxat	S.41	501	516	531	547	563	580	597	615	633	652	671	691
B.Houaykhou	S.42	603	621	639	658	678	698	719	740	762	785	808	832
B.Vapy-Nua	S.43	586	603	621	640	659	678	698	719	741	763	785	809
B.Vapy-Tai	S.44	571	588	605	623	642	661	681	701	722	743	765	788
B.Nakang	S.45	118	122	125	129	133	137	141	145	149	154	158	163
B.Bangkha	S.46	383	394	406	418	431	443	457	470	484	498	513	528
B.Saphat	S.47	753	775	798	822	847	872	898	924	952	980	1,009	1,039
B.Mouang	S.48	885	911	938	966	995	1,024	1,055	1,086	1,118	1,152	1,186	1,221
B.Hat	S.49	459	483	497	512	527	543	559	576	593	610	628	647
B.Samia	S.50	893	920	947	975	1,004	1,034	1,064	1,096	1,129	1,162	1,197	1,232
B.Khousta-Lat	S.51	223	230	236	243	251	258	266	274	282	290	299	308
B.Nongpho	S.52	257	265	272	281	289	297	306	315	325	334	344	355
B.Bungkham	S.53	1,671	1,618	1,666	1,715	1,766	1,819	1,873	1,928	1,985	2,044	2,105	2,168
	sub-total	9,096	9,366	9,644	9,931	10,226	10,529	10,842	11,164	11,496	11,837	12,189	12,551

Table 9.1.1d

Saravan-2

Village Name	Villa. No.	1994 May	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Saravan Dist.													
B.Nongsai	S.54	1,250	1,287	1,326	1,365	1,405	1,447	1,490	1,534	1,580	1,627	1,675	1,725
B.Bungxai	S.55	1,691	1,741	1,793	1,846	1,901	1,957	2,016	2,076	2,137	2,201	2,266	2,333
B.Chong	S.56	183	188	194	200	206	212	218	226	231	238	245	253
B.Phonkham	S.57	72	74	76	79	81	83	86	88	91	94	96	99
B.Koutmoung	S.58	117	120	124	128	132	136	139	144	148	152	157	161
B.Nongdou-Noy	S.59	90	93	95	98	101	104	107	110	114	117	121	124
B.Dong- Nong	S.60	315	324	334	344	354	365	375	387	398	410	422	435
B.May-Sivilai	S.61	131	136	139	143	147	152	156	161	166	170	176	181
B.Nakathian	S.62	556	573	590	607	626	644	663	682	703	724	745	767
B.Nathon	S.63	628	647	666	686	706	727	749	771	794	817	842	867
B.Phonphai	S.64	1,034	1,065	1,096	1,129	1,162	1,197	1,232	1,269	1,307	1,346	1,386	1,427
B.Nadon	S.65	116	118	122	126	129	133	137	141	145	150	154	159
B.Nadonkhoang	S.66	224	231	238	245	252	259	267	275	283	292	300	309
B.Thamuang-Kao	S.67	452	465	479	493	508	523	539	555	571	588	606	624
B.Napheng-Gnai	S.68	510	525	541	557	573	590	608	626	645	664	683	704
B.Napheng-Noy	S.69	117	120	124	128	132	136	139	144	148	152	157	161
B.Saokadi-Tai	S.70	460	463	477	491	506	521	536	552	569	586	603	621
B.Dan-Gnai	S.71	739	761	784	807	831	855	881	907	934	962	990	1,020
B.Kengaiw-Tai	S.72	365	376	387	398	410	423	435	448	461	475	489	504
B.Nobon-Tai	S.73	212	218	226	231	238	245	253	260	268	276	284	293
B.That-Noy	S.74	260	267	265	273	281	289	298	307	316	325	335	345
B.Nakasao	S.75	717	738	760	783	806	830	855	880	906	933	961	989
B.Ko	S.76	326	336	346	356	366	377	389	400	412	424	437	450
B.Phao-Gnai	S.77	884	910	937	965	994	1,023	1,054	1,085	1,117	1,150	1,185	1,220
B.Soung	S.78	780	803	827	852	877	903	930	957	986	1,015	1,045	1,076
B.Thongkapok	S.79	112	116	119	122	126	130	134	137	142	146	150	155
B.Naxai-Gnai	S.80	396	408	420	432	445	458	472	486	500	515	531	546
B.Naxai-Noy	S.81	471	485	499	514	529	545	561	578	595	613	631	650
B.Naknao	S.82	178	183	189	194	200	206	212	218	225	232	239	246
B.Dongko-Nua	S.83	318	327	337	347	357	368	379	390	402	414	426	439
B.Beng	S.84	580	597	615	633	652	671	691	712	733	755	777	800
B.Khiangphoukhong	S.85	385	396	408	420	433	446	459	473	487	501	516	531
B.Kadap	S.86	613	631	650	669	689	710	731	752	775	798	821	845
B.Lavang	S.87	549	565	582	599	617	636	654	674	694	714	736	758
B.Senvang-Noy	S.88	368	379	390	402	414	426	439	452	465	479	493	508
B.Houakhoua	S.89	256	264	271	279	288	296	305	314	324	333	343	353
	sub-total	16,434	16,922	17,425	17,942	18,475	19,024	19,589	20,171	20,770	21,386	22,022	22,676
Lao ngam Dist.													
B.Kiangtat	S.90	287	296	304	313	323	332	342	352	363	373	385	396
B.Xanuw	S.91	237	244	251	259	266	274	282	291	300	308	318	327
B.Xanumnok	S.92	171	176	181	187	192	198	204	210	216	223	229	236
B.Baktheung	S.93	237	244	251	259	266	274	282	291	300	308	318	327
B.Yangpuay	S.94	300	309	318	328	337	347	358	368	379	390	402	414
B.Sangthong-Noy	S.95	125	129	133	136	141	145	149	153	158	163	168	172
B.Sangthong-Gnai	S.96	410	422	435	448	461	475	489	503	518	534	549	566
B.Lao ngam	S.97	1,140	1,174	1,209	1,245	1,282	1,320	1,359	1,399	1,441	1,484	1,528	1,573
B.Nokong	S.98	655	674	694	715	736	758	781	804	828	852	878	904
B.Beng	S.99	411	423	436	449	462	476	490	504	519	535	551	567
B.Houm-Tai	S.100	438	451	464	478	492	507	522	538	554	570	587	604
	sub-total	4,411	4,542	4,677	4,816	4,959	5,106	5,258	5,414	5,575	5,740	5,911	6,086
Saravan Province	Total	46,588	46,942	48,336	49,772	51,250	52,772	54,339	55,953	57,615	59,326	61,088	62,903

Population Growth in Study Area

	1994 May	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Total Popuration in Champasak	53,297	54,555	55,842	57,160	58,509	59,890	61,303	62,750	64,231	65,747	67,299	68,887
Total Popuration in Saravan	45,588	46,942	48,336	49,772	51,250	52,772	54,339	55,953	57,615	59,326	61,088	62,903
Ground Total	98,885	101,497	104,178	106,932	109,759	112,662	115,643	118,703	121,846	125,073	128,387	131,789

Table 9.1.2 Water Demand Projection in 200 Villages

Province District	Population 1995	Water Demand 35 l/p/d	Population 2000	Water Demand 38 l/p/d	Popu- lation 2005	Water Demand 40 l/p/d
Champasak						
Sanasomboon	25,365	888	28,503	1,083	32,028	1,281
Bachiang	8,286	290	9,311	354	10,463	419
Pathoomphone	7,276	255	8,176	311	9,187	367
Sukhuma	4,043	142	4,543	173	5,105	204
Khong	9,585	335	10,771	409	12,103	484
Sub-total	54,555	1,909	61,304	2,330	68,886	2,755
Saravan						
Lakhonepheng	5,939	208	6,875	261	7,959	318
Kongxedon	10,172	356	11,775	447	13,631	545
Vapy	9,366	328	10,842	412	12,551	502
Saravan	16,922	592	19,589	744	22,676	907
Lao ngam	4,542	159	5,258	200	6,086	243
Sub-total	46,941	1,643	54,339	2,065	62,903	2,516
		m3/d		m3/d		m3/d
Total	101,496	3,552	115,643	4,394	131,789	5,272

Table 9.1.3a Served for Existing Water Sources in the Study Area

Province Districts	Popu-lation 1994	Served Population from Water Sources							
		River Stream	%	Hand Pumps	%	Dugwell	%	Others	%
Champasak									
1. Sanasomboon	24,780	13,747	55	6,988	28	4,045	16	0	0
2. Bachiang	8,095	6,582	81	111	1	512	6	890	11
3. Pathoomphone	7,108	3,909	55	220	3	2,680	38	299	4
4. Sukhuma	3,950	621	16	2,254	57	310	8	765	19
5. Khong	9,364	7,509	80	647	7	1,208	13	0	0
sub-total	53,297	32,368	58	10,220	19	8,755	16	1,954	7
Saravan									
1. Lakhonepheng	5,768	1,764	31	3,374	58	495	9	135	2
2. Khongxedon	9,879	5,715	58	3,705	38	26	0	433	4
3. Vapy	12,499	10,444	84	1,129	9	421	3	505	4
4. Saravan	13,031	9,229	71	725	6	1,142	9	1,935	15
5. Lao ngam	4,411	2,674	61	1,083	25	0	0	654	15
sub-total	45,588	29,826	61	10,016	27	2,084	4	3,662	8
			%		%		%		%
Total	98,885	62,194	59	20,236	23	10,839	10	5,616	8

Remarks : Others = Pond, Spring, Irrigation Canal

Table 9.1.3b Existing Water Supply Facilities in May 1994

Province District	No.of Handpumps							No.of Dugwells			
	W-W	Mot	Ind	Dmp	Tar	Lky	total	C-R	W-R	N-R	total
Champasak											
1. Sanasomboon	0	11	10	10	3	105	139	8	31	11	50
2. Bachiang	0	0	0	0	1	0	1	4	4	0	8
3. Pathoomphone	0	1	2	2	0	4	9	15	65	19	99
4. Sukhuma	0	0	0	1	0	88	89	0	18	0	18
5. Khong	0	0	2	2	0	0	4	3	11	0	14
sub-total	0	12	14	15	4	197	242	30	129	30	189
Saravan											
1. Lakhonepheng	0	0	3	0	0	102	105	2	12	3	17
2. Khongxedon	0	0	5	1	0	89	95	0	0	0	0
3. Vapy	0	0	2	0	0	1	3	2	12	1	15
4. Saravan	0	0	2	0	0	3	5	1	7	1	9
5. Lao ngam	1	0	0	0	0	0	1	0	0	0	0
sub-total	1	0	12	1	0	195	209	5	31	5	41
Total	1	12	26	16	4	392	451	35	160	35	230

Remarks: W-W = Water works, Mot= Motor pump, Ind = India Mark 3,
Dmp = Dempster, Tar = Tara, Lky = Lucky, C-R =Concrete Ring
W-R = Wooden Ring, N-R = None Ring

Table 9.1.4 (1) Champasak Province New Handpump Requirement

Champasak-1

Water Demand in 1995 = 35 litter/day/person, Served of 240 persons/1 Well
Water Demand in 2005 = 40 litter/day/person, Served of 210 persons/1 Well

District & Village Name	Village No.	1994 May	Population 1995 T/Well	Population 2005 Estimate	Existing H/pump 1995	Hand pump Requirement 1995	Hand pump Requirement 2005	Construction Accessibility
Sanasomboon								
B.Nakham	C. 1	863		1,115	0	2	3	V.Difficult
B.Phonthat	C. 2	135		174	1	1	2	Easy
B.Nonsavan	C. 3	615		795	2	1	2	Easy
B.Nonghai	C. 4	553	557	715	2	1	2	Easy
B.Souvannakihli	C. 5	839		1,084	0	2	3	Usual
B.Nanai	C. 6	629		813	0	2	3	Usual
B.Nongdou	C. 7	378		489	0	2	3	Easy
B.Houaxe	C. 8	628	630	812	S/pump	0	1	Easy
B.Pongsan	C. 9	337		436	0	2	2	Easy
B.Dong	C.10	311		402	0	1	2	Usual
B.Hangam	C.11	354		458	0	H/tap	H/tap	Easy
B.Nongkham	C.12	419		542	1	H/tap	H/tap	Easy
B.Khampeng	C.13	987		1,276	3	S/pump	H/tap	Easy
B.Khamngoua	C.14	256		331	0	1	2	Usual
B.Nongkhen	C.15	256		331	0	1	2	Easy
B.Louy	C.16	150	150	194	1	0	0	Easy
B.Solo-Gnai	C.17	1,025		1,325	2	2	3	V.Difficult
B.Solo-Noy	C.18	635		821	0	2	3	Difficult
B.Xonphak	C.19	1,230		1,590	4	4	6	Easy
B.Khamlouang	C.20	266		344	0	1	2	Difficult
B.Sithouan	C.21	422		545	16	2	3	Usual
B.Mouang	C.22	1,285		1,661	0	2	3	V.Difficult
B.Okumuana	C.23	1,117		1,443	2	3	4	V.Difficult
B.Boungkha	C.24	1,010		1,305	4	3	4	Usual
B.Latsua(Nongmek)	C.25	317		410	0	1	1	V.Difficult
B.Nalak	C.26	1,376		1,778	2	3	5	V.Difficult
B.Dongkalong	C.27	374		483	3	2	3	Easy
B.Nalong	C.28	1,696		2,192	16	2	4	Usual
B.Naxon	C.29	1,398		1,807	57	2	4	Difficult
B.Thangbengsivilai	C.30	310		401	11	1	1	Easy
B.Nomat	C.31	293		379	1	1	2	V.Difficult
B.Donphek	C.32	412		533	2	2	3	Usual
B.Dua-Nua	C.33	856		1,105	1	2	3	Difficult
B.Kengkeo	C.34	498		644	0	2	3	V.Difficult
B.Ngouadeng	C.35	1,053		1,361	0	2	3	V.Difficult
B.Paksxon	C.36	1,497		1,934	7	2	3	Usual
sub-total		24,780	1,337	32,028	138	58	90	
Bachiang Dist.								
B.Nongsai	C.37	368		476	0	1	2	V.Difficult
B.Bachiang	C.38	278		359	1	2	2	Easy
B.Makngeo	C.39	259		335	0	1	2	Easy
B.Nongbok-Noy	C.40	578		747	0	2	3	Easy
B.Nongbok-Gnai	C.41	646		835	0	1	2	Difficult
B.Thongkim	C.42	510		659	0	2	3	Easy
B.Kenggnao	C.43	300		388	0	1	1	Usual
B.Thongsala	C.44	368	383	476	1	1	2	Easy
B.Mouangkhai	C.45	394		509	0	2	3	Easy
B.Pakonay	C.46	270		349	0	2	2	Easy
B.Oudomsouk	C.47	256		331	0	1	2	Easy
B.Phasouam	C.48	157		203	0	1	1	Easy
B.Lak-21	C.49	567	562	732	1	1	2	Usual
B.Phin	C.50	467		603	0	2	3	Easy
B.Lak-23	C.51	391		505	0	2	3	Easy
B.Lak-25	C.52	379		490	0	1	2	Easy
B.Nongkhamkhao	C.53	117		151	0	1	1	Easy
B.Senkeo	C.54	136		176	0	1	1	Easy
B.Houayten	C.55	320		414	0	1	1	Easy
B.Talan(Lak 17)	C.56	195		252	0	1	1	Easy
B.Nonsaat	C.57	218		282	0	1	1	Easy
B.Nongmak-Euk	C.58	184		238	0	1	1	Easy
B.Lak-13	C.59	120		155	0	1	1	Easy
B.Nonhouaydua	C.60	334		432	0	2	2	Easy
B.Kagno	C.61	283		366	0	1	2	Easy
sub-total		8,095	945	10,463	3	33	46	

Table 9.1.4 (2)

Pathoomphone Dist.								
B.Lak-19	C.62	451		583	0	2	3	Easy
B.Lak-20	C.63	178		230	0	1	1	Easy
B.Mophou	C.64	881		1,139	1	2	3	V.Difficult
B.Lak-24	C.65	448	445	579	1	1	2	Easy
B.Sanamxaysouk(L25)	C.66	309		399	1	1	2	Easy
B.Houakhoua(L-29)	C.67	270		349	0	1	2	Usual
B.Lak-31	C.68	289		374	1	1	2	Difficult
B.Lak-34	C.69	256		331	0	1	2	Easy
B.Khouatouay(L-36)	C.70	759		981	0	3	4	Easy
B.Tomo-Nak	C.71	620		801	0	4	5	Easy
B.Tao-Tai	C.72	629		813	2	2	3	Easy
B.Nakham-Noy	C.73	250		323	0	1	2	Easy
B.Thangbeng	C.74	633		818	2	2	3	Easy
B.Nongkhe	C.75	468	481	605	3	0	1	Easy
B.Napho	C.76	667		862	0	2	3	V.Difficult
sub-total		7,108	926	9,187	11	24	38	
Sukhuma Dist.								
B.Chikthangngo	C.77	397		513	13	2	3	Easy
B.Bak	C.78	230		297	2	1	2	Usual
B.Samkhanaboua	C.79	682	631	881	8	2	3	Easy
B.Phonpheung	C.80	726		938	24	2	3	V.Difficult
B.Pako	C.81	596		770	4	2	3	V.Difficult
B.Thapcham	C.82	793		1,026	29	2	3	V.Difficult
B.Kouttaboun	C.83	526		680	10	2	3	V.Difficult
sub-total		3,950	631	5,105	90	13	20	
Khong Dist.								
B.Boun-Tai	C.84	832		1,075	0	3	4	V.Difficult
B.Keng	C.85	517		668	0	1	2	V.Difficult
B.Phonsaat	C.86	856		1,106	1	3	4	Easy
B.Naveng	C.87	268		346	0	1	2	V.Difficult
B.Maisivilai	C.88	366	300	473	1	1	2	Usual
B.Nasenphan	C.89	563	595	728	2	2	3	Easy
B.Naxuak(Hang)	C.90	496		641	1	1	2	V.Difficult
B.Xongpuay	C.91	252		326	0	1	1	V.Difficult
B.Nasomhong	C.92	657		849	0	2	3	V.Difficult
B.Boung	C.93	415		536	0	1	2	Difficult
B.Hatxaykhoum	C.94	1,150		1,486	1	3	5	Easy
B.Veunkhao	C.95	502		649	0	2	3	Usual
B.Phondong	C.96	370		478	0	1	2	Easy
B.Kadam	C.97	856		1,107	0	3	4	Easy
B.Khinak	C.98	780		1,008	0	3	4	Easy
B.Settaolek	C.99	371		481	0	2	3	Usual
B.Tapusy	C.100	113		146	0	1	1	Usual
sub-total		9,364	895	12,103	6	31	47	
Champasak Total		53,297	4,734	68,886	248	159	241	

Remark : T/Well = JICA Test Well, S pump = Submersible Pump,
W work = Water works, H/pump = Handpump, H/tap = Hydrant tap

Table 9.1.4 (3)

Saravan Province New Handpump Requirement **Saravan-1**

Water Demand in 1995 = 35 litter/day/person, Served of 240 persons/1 Well
Water Demand in 2005 = 40 litter/day/person, Served of 210 persons/1 Well

District & Village Name	Village No.	Population 1994 May	Population 1995 T/Well	Population 2005 Estimate	Existing H/pump 1995	Handpump Requirement 1995	Handpump Requirement 2005	Construction Accessibility
Lakhonepheng Dist.								
B.Nonsavang	S. 1	522		720	6	2	3	Easy
B.Nadou	S. 2	602		831	24	2	3	Easy
B.Nadoumai	S. 3	579		799	19	2	3	V.Difficult
B.Houaykapo	S. 4	543	613	749	9	1	2	Easy
B.Lakhosi-Tai	S. 5	289		399	8	1	2	Easy
B.Lakhosi-Nua	S. 6	130		179	0	1	1	Easy
B.Khonsay	S. 7	134		185	1	1	1	Easy
B.Kenpadek	S. 8	366		505	3	2	3	Easy
B.Nondinxay	S. 9	456		629	1	1	2	Easy
B.Nakhandai	S.10	322		444	2	1	2	V.Difficult
B.Phoudaocheng-Noy	S.11	426		588	5	2	3	Easy
B.Nongsano	S.12	231	235	319	6	0	1	Easy
B.Phoudaocheng-Gnai	S.13	356		491	1	1	2	Easy
B.Thangbeng	S.14	316		436	0	2	3	Easy
B.Bouttaphan	S.15	310		428	4	1	2	Easy
B.Houaykhen	S.16	186		257	18	1	2	Easy
sub-total		5,768	848	7,959	107	21	35	
Khongxedon Dist.								
B.Napoug	S.17	1,182		1,631	63	2	4	Easy
B.Vang Kan Hong	S.18	315		435	12	1	2	Easy
B.Napheng-Gnai	S.19	515		711	9	1	2	Difficult
B.Khong- Noy	S.20	835		1,152	0	2	4	Easy
B.Nongsaphang	S.21	439		606	1	1	2	V.Difficult
B.Nongkoxong	S.22	346		477	0	1	2	V.Difficult
B.Nongboua	S.23	178		246	0	0	0	None Access
B.Donmuang	S.24	398	410	549	1	1	2	Easy
B.Hinxiou	S.25	502		693	1	2	3	Easy
B.Thakho	S.26	121		167	0	1	1	V.Difficult
B.Khok-Houaxang	S.27	288		397	1	1	2	Usual
B.Namouang	S.28	625		862	1	2	3	Usual
B.Khamthong-Gnai	S.29	573		791	0	2	3	Usual
B.Nonsamlan	S.30	171		236	0	1	1	Easy
B.Nonghalou	S.31	152		210	0	1	1	Easy
B.Thalouang	S.32	268		370	0	1	2	Usual
B.Nongteng	S.33	327		451	0	1	2	Usual
B.Houayxao	S.34	495		683	0	2	3	Usual
B.Haidou	S.35	400		552	0	2	3	Difficult
B.Nakadao	S.36	806		1,112	7	3	4	Easy
B.Xoutiamphong	S.37	418		576	0	1	2	V.Difficult
B.Kuttabeng	S.38	525		724	1	2	3	Easy
sub-total		9,879	410	13,631	97	31	51	
Vapy Dist.								
B.Nongngong	S.39	466	478	643	1	1	2	Usual
B.Donkha	S.40	817		1,127	1	2	3	Difficult
B.Naxat	S.41	501		691	1	1	2	V.Difficult
B.Houaykhou	S.42	603		832	0	2	3	Difficult
B.Vapy-Nua	S.43	586		809	0	2	3	Easy
B.Vapy-Tai	S.44	571		788	0	2	3	Easy
B.Nakang	S.45	118		163	0	1	1	V.Difficult
B.Bangkha	S.46	383		528	0	1	2	Easy
B.Saphat	S.47	753		1,039	0	3	4	Easy
B.Mouang	S.48	885		1,221	0	3	5	Easy
B.Hat	S.49	469		647	0	2	3	Easy
B.Samia	S.50	893	893	1,232	1	3	5	Easy
B.Khoumta-Lat	S.51	223		308	0	2	2	Easy
B.Nongpho	S.52	257		355	0	1	2	Easy
sub-total		7,525	1,371	10,383	4	26	40	

Table 9.1.4 (4)

Saravam-2

Saravan Dist.								
B.Bungkham	S.53	1,571		2,168	0	3	6	Easy
B.Nongsai	S.54	1,250		1,725	1	3	5	Easy
B.Bungxai	S.55	1,691		2,333	0	4	6	Easy
B.Chong	S.56	183	191	253	1	0	1	Difficult
B.Phonkham	S.57	72		99	0	0	0	None Access
B.Koutmoung	S.58	117		161	0	1	1	Easy
B.Nongdou-Noy	S.59	90		124	0	1	1	Easy
B.Dong- Nong	S.60	315		435	0	2	3	V.Difficult
B.May-Sivilai	S.61	131		181	0	1	1	Easy
B.Nakathian	S.62	556		767	0	2	3	Usual
B.Nathon	S.63	628		867	0	2	3	Difficult
B.Phonphai	S.64	1,034	1,071	1,426	1	3	5	Easy
B.Nadon	S.65	115		159	0	1	1	Easy
B.Nadonkhoang	S.66	224		309	1	1	2	Easy
B.Thamuang-Kao	S.67	452		624	1	1	2	Difficult
B.Napheng-Gnai	S.68	510		704	0	2	3	Easy
B.Napheng-Noy	S.69	117		161	0	1	1	Easy
B.Saokadi-Tai	S.70	450		621	0	2	3	Difficult
B.Dan-Gnai	S.71	739		1,019	0	3	4	Difficult
B.Kengsim-Tai	S.72	365		504	0	1	2	V.Difficult
B.Nobon-Tai	S.73	212		293	0	1	2	V.Difficult
B.That-Noy	S.74	250		345	0	1	2	Easy
B.Nakasao	S.75	717	725	989	2	2	3	Easy
B.Ko	S.76	326		450	0	1	2	Usual
B.Phao-Gnai	S.77	884		1,219	0	3	5	Difficult
B.Soung	S.78	780		1,075	0	2	3	Usual
B.Thongkapok	S.79	112		155	0	1	1	Easy
B.Naxai-Gnai	S.80	396		546	1	2	3	Easy
B.Naxai-Noy	S.81	471		650	0	2	3	Easy
B.Maknao	S.82	178		246	0	1	1	Difficult
B.Dongko-Nua	S.83	318		439	0	2	3	Easy
B.Beng	S.84	580	600	800	S/pump	0	H/Tap	Easy
B.Khiangphoukhong	S.85	385		531	0	2	3	Easy
B.Kadap	S.86	613		846	0	2	3	Easy
B.Lavang	S.87	549		758	0	2	3	Easy
B.Senvang-Noy	S.88	368		509	0	2	3	Easy
B.Houakhoua	S.89	256		353	0	1	1	Easy
sub-total		18,005	2,587	24,844	8	61	94	
Lao ngam Dist.								
B.Kiangtat	S.90	287		396	0	1	2	Easy
B.Xanum	S.91	237		327	0	1	2	Easy
B.Xanumnok	S.92	171		236	0	1	1	Usual
B.Baktheung	S.93	237		327	0	1	2	Usual
B.Vangpuay	S.94	300		414	0	2	3	Easy
B.Sangthong-Noy	S.95	125		172	0	1	1	Easy
B.Sangthong-Gnai	S.96	410		566	0	2	3	Easy
B.Lao ngam	S.97	1,140		1,573	W/work	1	2	Usual
B.Hokong	S.98	655		904	0	2	3	Usual
B.Beng	S.99	411		567	0	2	3	Usual
B.Houm-Tai	S.100	438	450	604	1	1	2	Easy
sub-total		4,411	450	6,086	1	15	24	
Saravan Total		45,588	5,666	62,903	217	154	244	
Ground Total in Study Area		98,885	10,400	131,789	465	313	485	

Remark : T/Well = JICA Test Well, S pump = Submersible Pump,
W work = Water works, H/pump = Handpump, H/tap = Hydrant tap

Table 9.6.2 Annual Operation and Maintenance Cost

Unit: Kip

System	Item	Unit Cost	Quantity	Amount	Remarks
Hand Pump (1 unit)	Periodical Maintenance	10,000	2 times	20,000	2 times/year by mobile team
	Repair	45,000	1 set	45,000	15% of pump cost
	Sub total			65,000	
Submersible pump (1 unit)	Electricity	25	4,200kw	80,000	350kw/month
	Repair	380,000	1 set	380,000	10% of pump cost
	Sub total			460,000	
Maintenance Center	Salary	30,000	96	2,880,000	8personx12months =96
	Electricity	25	12,000	300,000	1000kw/month
	Fuel	250	36,000	9,000,000	10km/l 30,000km
	Spare parts	330,000	1 set	330,000	10% of supplied spares
	Sub total			12,510,000	

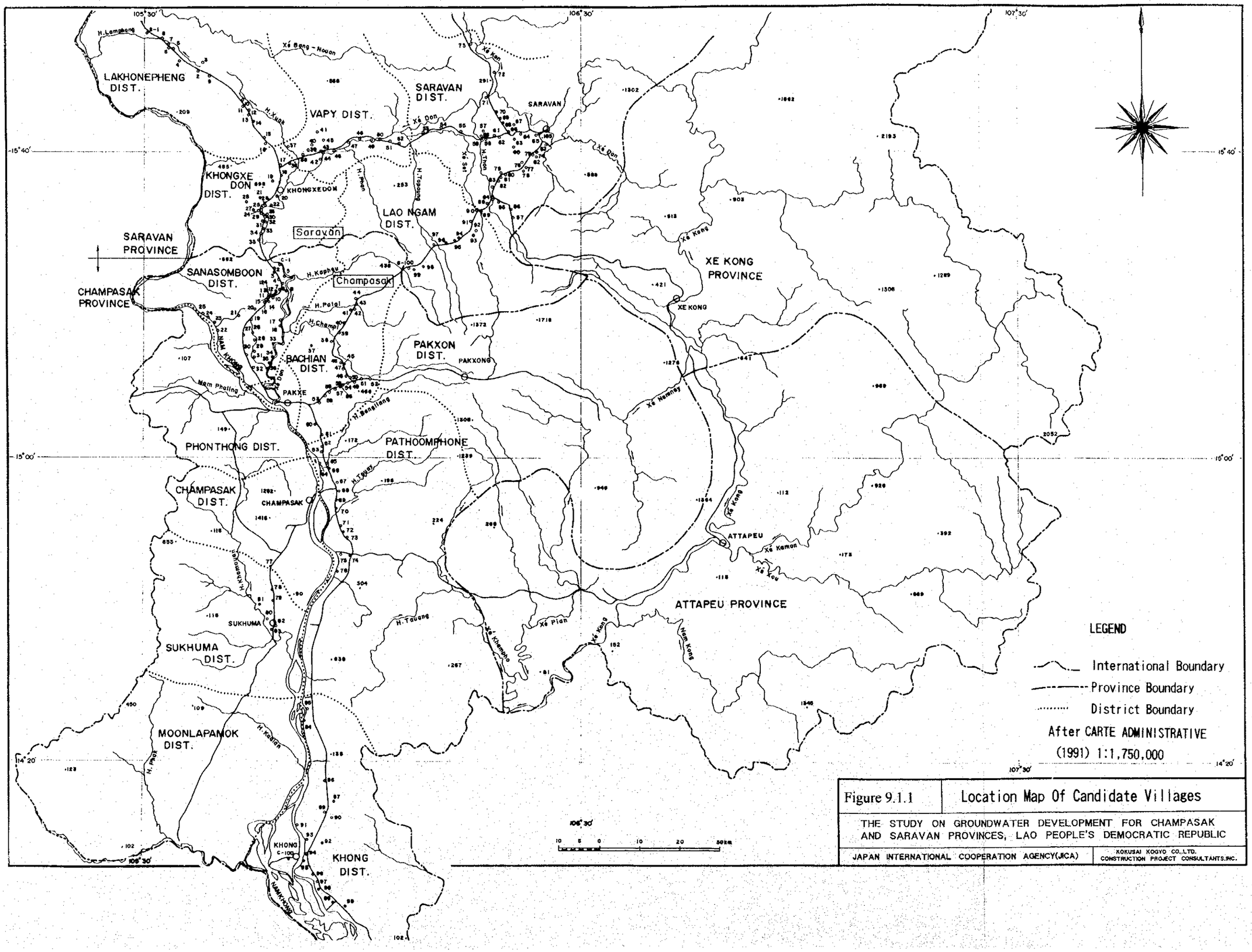


Figure 9.1.1	Location Map Of Candidate Villages
THE STUDY ON GROUNDWATER DEVELOPMENT FOR CHAMPASAK AND SARAVAN PROVINCES, LAO PEOPLE'S DEMOCRATIC REPUBLIC	
JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)	KOKUSAI KOGYO CO.,LTD. CONSTRUCTION PROJECT CONSULTANTS,INC.

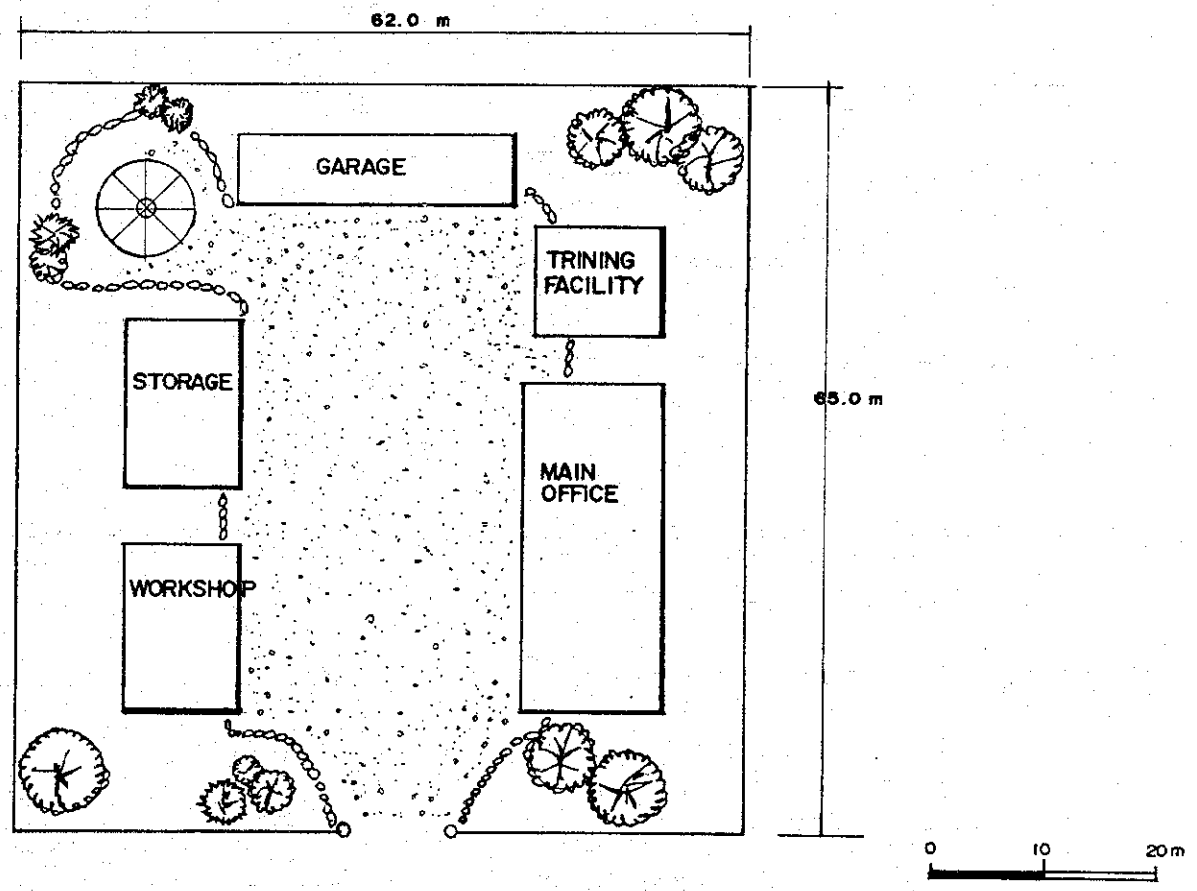


Figure 9.2.1(1) Rural Water Supply Operation and Maintenance Center

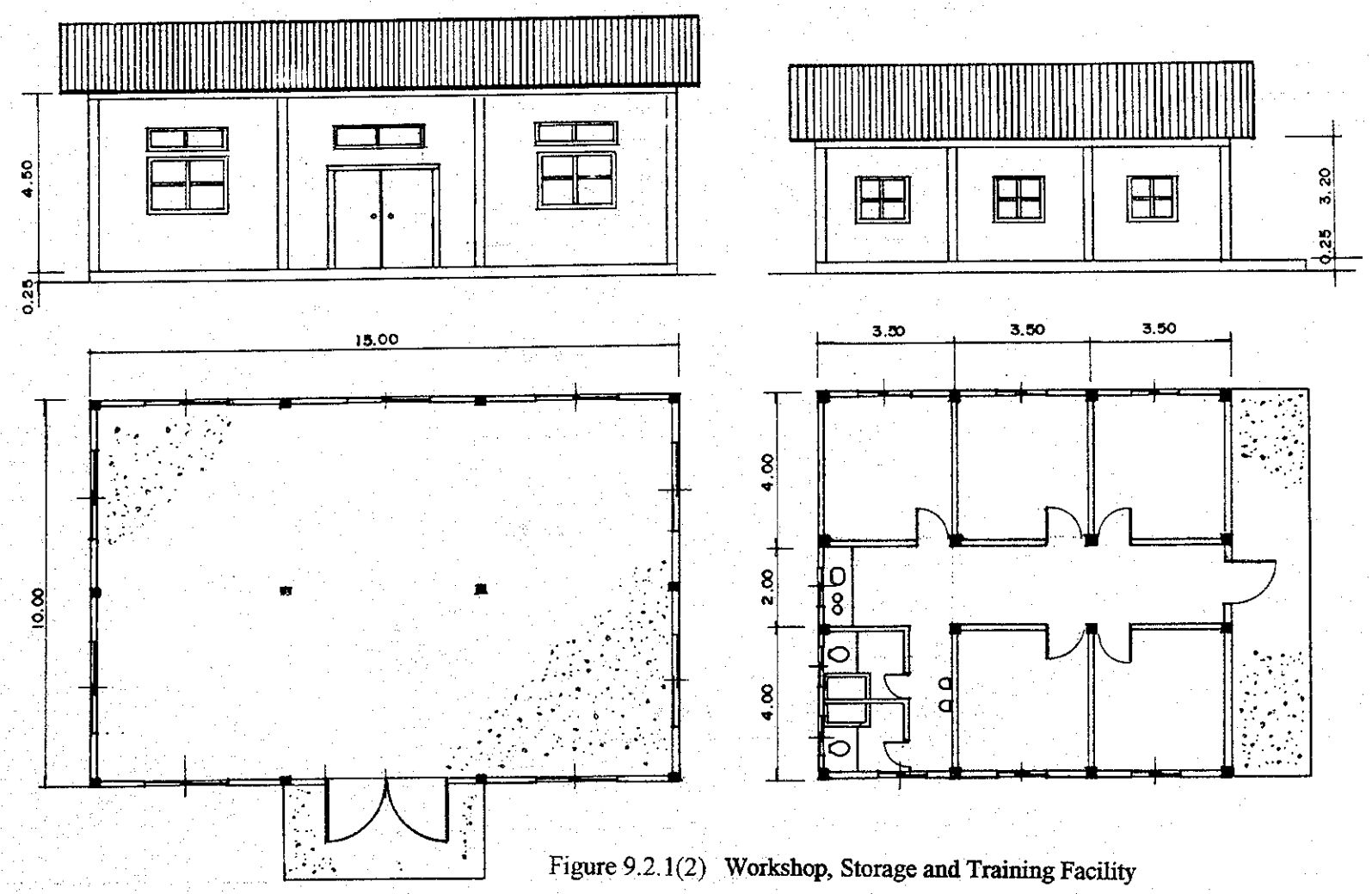


Figure 9.2.1(2) **Workshop, Storage and Training Facility**

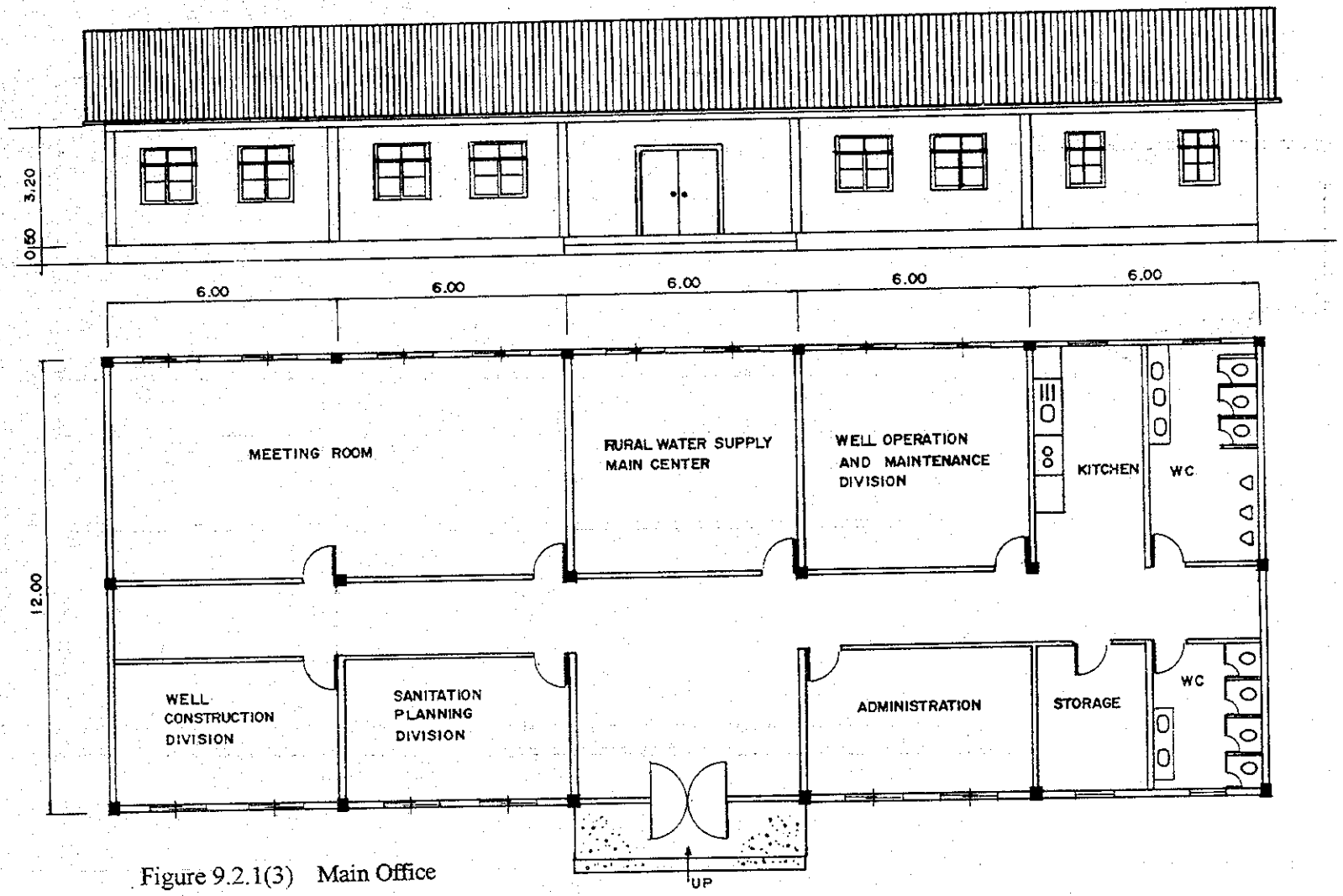


Figure 9.2.1(3) Main Office

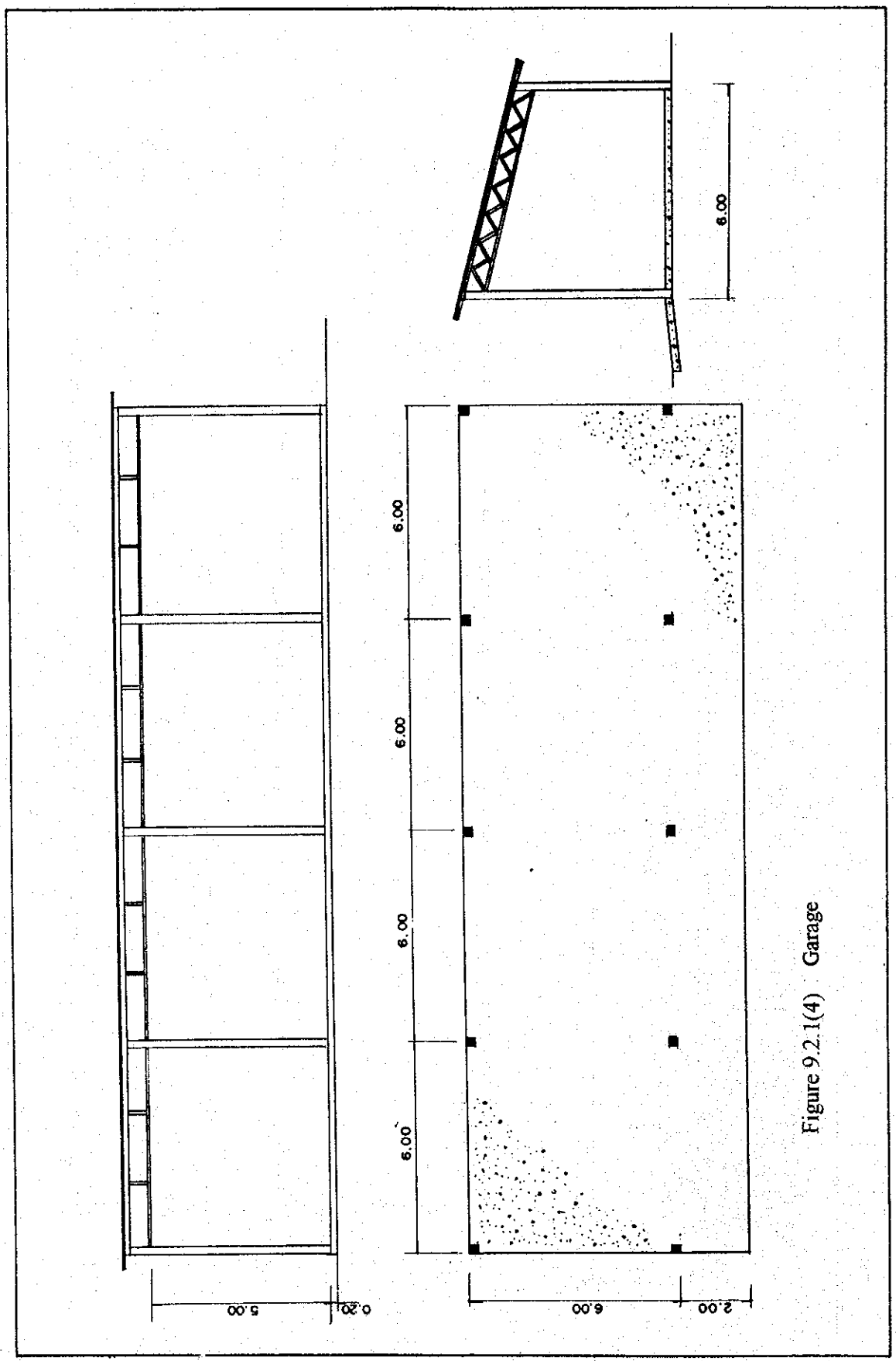


Figure 9.2.1(4) Garage

Figure 9.5.1 **Tentativie Implementation Schedule**

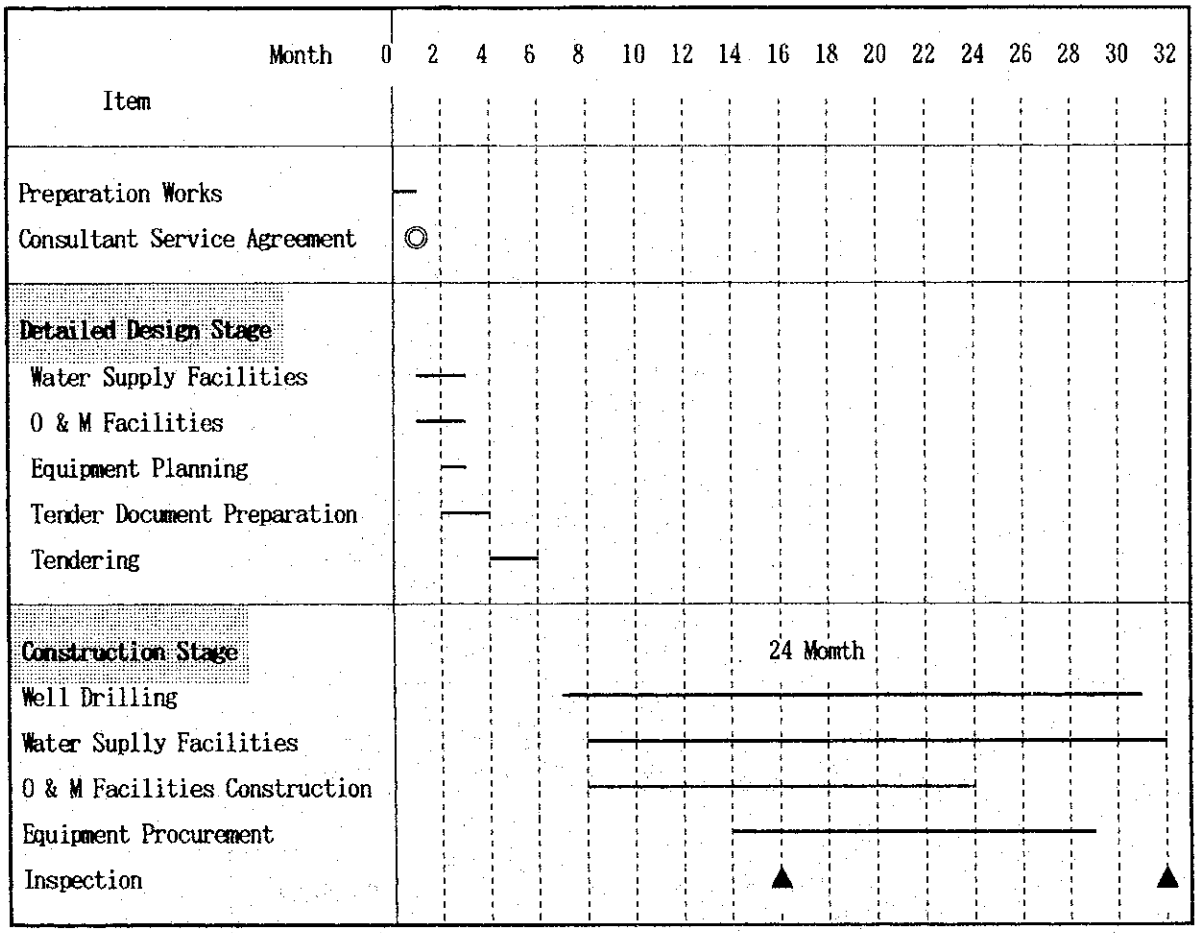


Figure 9.6.1 **MAINTENANCE POLICY AND ORGANIZATIONS**

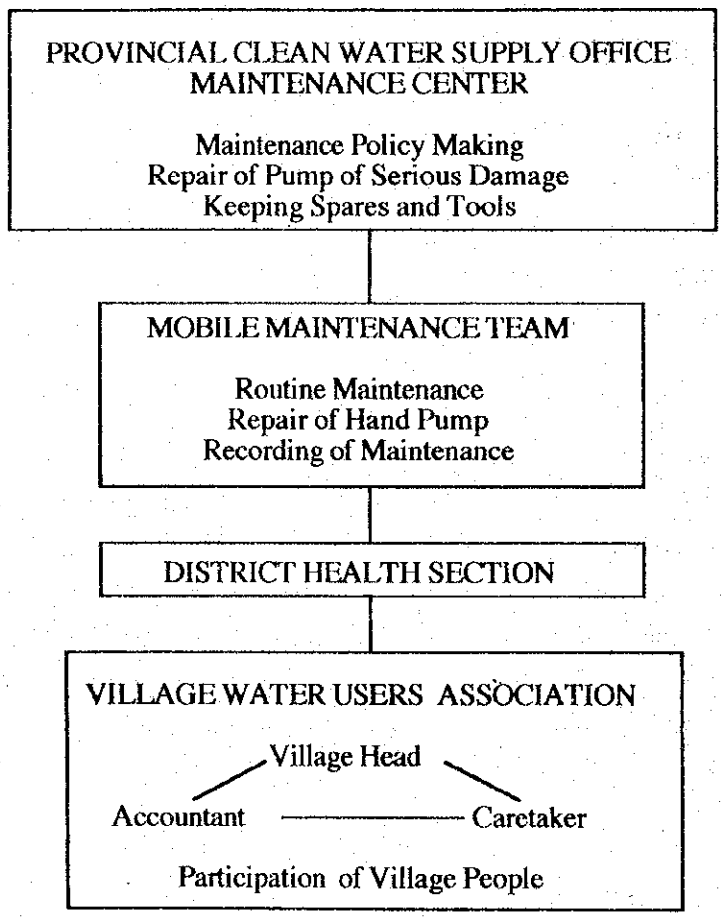


Figure 9.6.1 **RECORD OF MAINTENANCE**

Name of Village.....District.....
Province.....Caretaker.....
Name of Maintenance Team.....

Date of occurrence of fault	Date of repair	Cost of repair	Type of fault	By whom repaired	Remarks

CHAPTER 10 PROJECT EVALUATION

CONTENTS

LIST OF TABLES

CHAPTER 10 PROJECT EVALUATION

10.1 Overall Benefits

10.1.1 Beneficiaries of the Project

The Study Area covers 200 villages in Champasak and Saravan Provinces with a total population of 98,885 in 1994. The population in the Study Area is projected to grow at an annual rate of 2.65%, reaching 131,789 persons in 2005.

During the course of the Study, 20 test wells were drilled and 18 units of handpump systems and 2 units of motor pump systems were constructed. In all these villages, water users' associations have been organized. As of April 1995, 1,636 households or 90% of the total population of 20 villages participated in these associations. Although the water supplied by the test wells is not enough to meet all the demand of these population, most people are enjoying better access to clean water.

In addition to the 20 test wells mentioned above, the Project include the construction of another 485 handpump systems and a motor pump system to cover the whole villages in the Study Area. The total beneficiaries will be 131,789 persons in the target year of 2005. (Refer to Table 10.1.1)

10.1.2 Improvement in Health Conditions

(1) Provision of Clean Water and Human Health Improvements

In order to improve health conditions in rural areas, PHDC and PHDS are promoting the Rural Water Supply Program in Champasak and Saravan Provinces. This program is basically aimed at reducing the incidence of waterborne diseases in rural areas of the two Provinces.

The proposed Project is also designed to reduce the incidence of waterborne diseases through provision of improved water quality and increased water use.

After implementation of the Project, residents in the Study Area, particularly women and children, no longer have to spend a lot of time fetching water from traditional water sources. This saved time can be used for different activities such as food preparation, agricultural work, child care and leisure. Moreover, the ready availability of water nearby the house may change personal hygiene habits, promoting increased bathing and clothes washing. Increased water use for bathing, washing and food preparation can lead to a reduction in water-washed diseases. Improved water quality can be expected to reduce the incidence of waterborne diseases. In addition, spending more time on child care and food preparation may lead to a reduction of child mortality and morbidity.

(2) Health Conditions in the Study Area

It is evident from the result of the Village Survey conducted in April 1994 that malaria and diarrhea are the main causes of morbidity in the Study Area. The number of patients who are suffering from diarrhea account for 3,270 persons (6%) in Champasak Province (100 villages)

and 3,563 persons (8%) in Saravan Province (100 villages), averaging 6.91% of the total population. The percentage of patients is highest in Sukhuma District (13%), followed by Lakhongpheng District (12%). The villages with higher percentage of diarrhea diseases are located at a long distance from reliable water sources. (Refer to Tables 10.1.2a and 10.1.2b).

(3) Effect of Clean Water Supply on Reduction of Diarrhea Diseases

Unclean water and poor sanitation are a major cause of ill-health for the rural population. Provision of clean water supply facilities will reduce the incidence of water related diseases.

The extent of the effects which provision of clean water will give to water users in their health conditions can be estimated from the result of analyses conducted by USAID and WHO. (Refer to World Development Report, 1992). It is estimated that out of the total reduction in the incidence of diarrhea diseases due to provision of clean water and improvement in sanitation, 78% is attributable to provision of clean water and the remaining is attributable to improvement in sanitation. It is also reported that incidence of diarrhea has been reduced by 22% due to provision of clean water and improvement in sanitation. It can be concluded from these analyses that provision of clean water alone can reduce the incidence of diarrhea diseases at least by 17%.

The average medical expenses in the Study Area amounted to Kip 53,000 per person in 1994, of which about 50% is estimated to be spent on diarrhea diseases. It is roughly estimated that provision of clean water will lead to a reduction of Kip 4,500 per person in medical expenses.

10.1.3 Time Saving for Water Collection

One of the main objectives of water supply project is to reduce the workload of the residents, particularly women and children, for water collection. By providing water supply facilities within the village, access to water sources will be greatly improved. Saved time may be used for social, educational, agricultural or commercial activities.

Data on time saving in the Study Area have been collected from 100 water users in 10 villages where JICA test wells were installed. (Refer to Section 7.6 in Chapter 7). The result of interview survey indicated that hauling distance of water has been reduced from 494 m to 72 m in 5 villages in Champasak Province, thus reducing water collection time from 4.29 hours to 1.01 hours. Likewise, hauling distance of water has been reduced from 1,026 m to 114 m in 5 villages in Saravan Province, thus reducing water collection time from 3.37 hours to 1.09 hours. Time saving averages 2.78 hours per household per day which is equivalent to the unskilled labor cost of Kip 868.75 (Kip 312.50 x 2.78 hours).

10.1.4 Opportunities for Better Farming

There is no community which can exist without a source of water. The proposed Project will give additional water source for the communities. Therefore, these communities will have surplus water either from traditional water sources or from the new water supply systems which can be used for irrigating food and tree crops grown in the backyard gardens. Many farmers who spent a long time to collect water from streams or dug wells nearby the village for irrigating such crops no longer have to spend a lot of time fetching water for their crops. Saved time for water

collection by men or women can be utilized also for additional work for farming activities which will give more chance for them to increase their agricultural production.

10.1.5 Improvement in Operation and Maintenance System

Under the Project, two maintenance centers are planned to be constructed in Champasak and Saravan Provinces. The main functions of the center are; (i) policy making on operation and maintenance work; (ii) repair of pumps in case of serious damages; and (iii) storage of spares and tools for operation and maintenance work. Provision of maintenance centers will certainly improve the operation and maintenance services provided by the WESs.

10.2 Financial Analysis

10.2.1 Financial Project Cost

Financial Project costs have been estimated on the basis of the market prices as of July 1995. The Project costs comprise the costs for well construction, maintenance centers, operation and maintenance equipment, engineering services, physical and price contingencies, and taxes.

Base costs of the Project at the price level of July 1995 amount to Kip 13,995 million, and the total Project costs including physical and price contingencies and taxes amount to Kip 15,998 million or Yen 1,725.6 million (refer to Table 10.2.1).

Financial Project Costs

Unit: Million Kips

	Foreign Portion	Local Portion	Total
A. Well Construction	10,262.5	1,296.3	11,558.9
B. Maintenance Center	423.9	400.8	824.8
C. O/M Facilities	295.4	279.3	574.7
D. Engineering Services	1,036.7	0	1,036.7
Sub-total	12,018.5	1,976.4	13,994.9
E. Physical Contingency	1,201.9	197.6	1,399.5
F. Price Contingency	524.7	78.4	603.1
Total	13,745.1	2,252.4	15,997.5

10.2.2 Finance Plan

The total Project costs comprise foreign currency portion of Kip 13,745.1 million (86%) and local currecny portion of Kip 2,252.4 million (14%). In consideration of the investment costs and financial status of the government of Lao PDR, financial assistance from foreign sources will be indispensable. External assistance in terms of grant aid will be necessary to cover the entire foreign currency portion and a part of local currency portion of the Project costs.

10.2.3 Recovery of Capital Cost and Recurrent Cost

(1) Basic Concept

It is the policy of the government of Lao PDR that beneficiaries are responsible for covering a part of the investment costs in water supply project. Under the proposed Project, all the construction works including drilling of boreholes, installation of handpumps and motor pumps, and construction of standpipes will be conducted by the implementing agency. After the completion of the Project facilities, the residents in the beneficiary villages will organize water users' associations to collect water charge and to conduct periodical works for operation and maintenance of the facilities.

In consideration of the present income level of the residents in the Study Area, it is suggested that water charge should be maintained at levels to ensure recovery of the full cost of operation and maintenance.

(2) Recovery of Operation and Maintenance Costs

Annual operation and maintenance costs of the Project will consist of the costs for operation and maintenance of water supply facilities and those of the maintenance centers. It is the policy of the government of Lao PDR that the former costs will be borne by the beneciciaries.

Annual operation and maintenance costs for the water supply facilities are estimated at Kip 33.9 million, comprising Kip 32.5 million for 500 units of handpump systems (including 18 test wells) and Kip 1.38 million for 3 units of motor pump systems (including 2 test wells). It is recommended that water charge will be Kip 174 per month per household for a handpump system and Kip 112 per month per household for a motor pump system. The water charge, which account for about 0.9 % of the net income of a household for handpump system and 0.6% of the same for a motor pump system, are considerd to be within the capacity to pay of the residents in the Study Area.

10.3 Economic Evaluation

10.3.1 Basic Assumptions

The economic analysis has been undertaken on the basis of the following assumptions:

(1) The official exchange rate as of July 1995 has been applied:
US$1.00 = Kip 820.00 = Yen 88.45
(2) Project life has been assumed as 30 years. Service life of handpumps, motor pumps, and operation and maintenance equipment is assumed to be 10 years. That of other facilities is assumed to be 30 years.
(3) Only direct tangible benefits have been quantified for the calculation of the EIRR.
(4) Opportunity cost of capital (or discount rate) is assumed to be 10 %.
(5) Transfer payments such as interest and taxes, and price escalation are not included in the calculation.

10.3.2 Economic Project Costs

Economic Project costs are composed of the investment costs and recurrent costs as mentioned below.

(1) Investment Costs for the Project

Economic investment costs comprise the costs for well construction, construction of maintenance centers, operation and maintenance equipment, engineering services and physical contingency. Taxes and price contingency are not included in the economic costs. Conversion factors to convert the financial prices into economic prices have not been applied in this analysis due to lower percentage of local currency portion. Investment costs are summarized below. (Refer to Table 10.3.1.)

Economic Project Costs

Unit: Million Kips

	Foreign Portion	Local Portion	Total
A. Well Construction	10,262.5	540.1	1,0802.7
B. Maintenance Center	423.9	346.9	770.8
C. O/M Facilities	295.4	241.7	537.1
D. Engineering Services	968.8	0	968.0
Sub-total	11,950.7	1,128.7	13,079.4
E. Physical Contingency	1,195.1	112.9	1,307.9
Total	13,145.8	1,241.6	14,387.4

(2) Recurrent costs

Recurrent costs consist of annual operation and maintenance costs and replacement costs for the equipment and facilities.

1) The annual operation and maintenance costs are estimated at Kip 46.4 million, comprising Kip 33.9 million for water supply facilities and Kip 12.5 million for maintenance centers.

2) Service life of mechanical equipment such as handpumps, motor pumps and operation and maintenance equipment is estimated at 10 years and that of other facilities such as tubewells, pump houses, and maintenance centers is estimated at 30 years. Replacement costs of these euipment and facilities have been conisidered in the calculation of economic internal rate of return.

The economic project costs thus estimated amount to Kip 14,387.4 million and the annual disbursement schedule of the same is presented in Table 10.3.1.

10.3.3 Economic Benefits

Economic benefits of the Project will arise immediately after implementation of the Project. Annual benefits have been calculated as the total of saved time benefits and health improvement benefits.

(1) Saved Time Benefits

Saved time benefits are derived as a result of shorter distance to water sources after implementation of the Project. Saved time is the difference between water collection time without installation of water

supply systems and water collection time with installation of the same. Water collection time consists of travel time, queue time and fill time. Saved time value is measured by multiplying average saved time by economic labor cost for water collection. Distance to water source, therefore, is the major factor to determine the saved time benefits.

Data on water collection time are based on the interview survey conducted in 100 households of 10 villages as explained in the preceding section (10.1.3 Time Saving for Water Collection).

(a)	Average time spent for water collection without installation of water supply systems:	3.83 hours per day
(b)	Average time spent for water collection with installation of water supply systems:	1.05 hours per day
(c)	Saved time:	2.78 hours per day
(d)	Unskilled labor cost per hour at markert prices:	Kip 312.50
(e)	Economic labor cost per hour: (assummed to be 50% of unskilled labor cost at market prices)	Kip 156.25
(f)	Saved time value in terms of economic labor cost:	Kip 434 per day
(g)	Saved time value per year (365 days per year)	Kip 158,410
(h)	Saved time value for 15,538 households in 1997 :	Kip 2,461.4 million
	Saved time value for 23,810 households in 2005 :	Kip 3,771.7 million

Saved time benefits wll arise from the second year after commencement of the Project and will increase at the annual rate of 2.6457 %, reaching Kip 3,771.7 million in 2005.

(2) Health Improvement Benefits

Health improvement benefits are derived as a result of improvement in water quality and increased supply of water. The benefits can be measured from the difference of medical expenses without installation of water supply systems and medical expenses with installation of the same.

(a)	Medical expenses for a diarrhea patient without installation of water supply systems:	Kip 26,534
(b)	Medical expenses for a diarrhea patient with installation of water supply systems: (Reduction in incidence of diarrhea by 17%)	Kip 22,023
(c)	Difference in medical expenses per patient:	Kip 4,510
(d)	Saved medical expenses per year: (Average morbidity rate at 6.91%)	Kip 4,510 x served population x 0.0691
(e)	Saved costs in 1997:	Kip 33.3 million
	Saved costs in 2005:	Kip 41.1 million

Based on the above calculation, health improvement benefits are estimated at Kip 33.3 million in 1997 and Kip 41.1 million in 2005.

10.3.4 Cost and Benefit Analysis

Economic analysis has been conducted on the basis of annual costs and benefits stream as estimated in the preceding sections. The result of economic analysis of the proposed Project in terms of Economic Internal Rate of Return (EIRR), Net Present Value (NPV) and Benefit Cost Ratio (B/C) is presented below. (Refer to Table 10.3.4).

EIRR:	20.1 %
NPV:	Kip 13,804.0 million
B/C:	1.98

It can be concluded from the above result that the Project is economically feasible as the EIRR exceeds 10% (opportunity cost of capital), NPV is positive and B/C is more than 1.

10.4 Project Evaluation

10.4.1 Rationale

The Project has been designed to satisfy basic human needs of the people residing in rural areas of Chamapsak and Saravan Provinces. The implementation of the Project is expected to yield various kinds of benefits as mentioned in the preceding sections. These benefits include not only quantifiable benefits such as health improvement and time saving benefits, but also non-quanifiable benefits such as consumer satisfaction and improved quality of life of the people in general. The Project is also expected to yield indirect benefits such as employment generation as a result of time saving, reduction in morbidity and mortality of children as a result of increased time of women for child care, increased activities of rural population for community development as a result of time saving and so on.

10.4.2 Financial Source

Financing sources of the Project will be derived from the government budget, water charge collection from the beneficiaries and assistance from foreign countries including international organizations. Although financial source of the government will not be enough to support major part of the Project costs, local population are expected to contribute significantly to the Project in the form of water charge and in the form of labor as in the case of the existing water supply program now underway in Champasak and Saravan Provinces.

10.4.3 Sustainability

Due attention has been paid to the sustainability of the Project during the course of the Study. In order to make the Project sustainable, establishment of two maintenance centers has been included as one of the components of the Project. The center will have such functions as: (i) policy making on operation and maintenance work; (ii) repair of pumps in case of serious damages; and (iii) storage of spares and tools for operation and maintenance work. Opration and maintenance work of the PHDC and PHDS will be greatly improved under the Project.

For the maintenance of the Project facilities, periodical cleaning and inspection of the equipment and facilities are necessary. In this regard, participation of people in the beneficiary villages is indispensable. From the beginning of the Study work, due attention has been paid to the importance of full participation of local population. During the course of the Study, water users' associations have been organized in 20 villages where JICA test wells were constructed. Their activities include collection of water charge, periodical inspection of handpumps, and periodical cleaning of pump houses and its surroundings. Their activities proved to be considerably satisfactory. It is expected that water users' associations will be organized in every village where new water supply systems will be constructed. Thus it can be assured that the Porject will be well operated and maintained by the beneficiaries.

10.4.4 Consideration for Women

(1) Position of Women in the Study Area

According to the Village Survey in April 1994, women in the Study Area represent 53.4% of the total population. Percentage of women is higher (53.7%) in Saravan province. Therefore, role of women in agricultural as well as domestic works is considerably important in the Study Area.

In agriculture, women perform planting, weeding and harvesting. Heavy and dangerous tasks such as clearing forest and land preparation are generally performed by men. The daily tasks of cooking, water collection, cleaning the house and washing clothes are usually conducted by women. However, it has been observed that men in the Study Area often share in some household tasks such as water and fuelwood collection and child care.

Women in the Study Area are considered to enjoy a more egalitarian status than women in other regions. This is mainly due to its matrilineal way of life in Lao Loum society. Lao Loum ethnic group accounts for 90% in Champasak Province and more than 60% in Saravan Province. In Lao Loum society, the yougest daughter and her husband will commonly stay with her parents and will inherit the house and a share of the farm land. Major family decisions are jointly taken by the couple under the guidance of the parents (UNICEF, 1992). Even in the villages where Lao Theung group is dominant, men usually share in some household tasks such as water and fuelwood collection and child care.

(2) Project Impact on Women

Although the Project has been formulated to benefit all the people in the Study Area regardless of sex, the Project will give greater impact on women and children who are playing a major role in water hauling. As mentioned in the preceding section (10.1.3 Time Saving for Water Collection), time saving for water collection is estimated at 2.78 hours per day which can be used for social, educational, agricultural and commercial activities.

Women are usually responsible for the daily tasks of feeding the pigs and poultry, taking care of the vegetables and spice gardens and checking the fruit trees in the home gardens or in the backyard gardens. Many women spend a lot of time to haul water for the cultivation of vegetables and young fruit trees grown in the backyard gardens. Installation of handpumps within the village will lead to a significant reduction in workload of women in water hauling for

agricultural activities during absence of their husbands who are working outside .

In addition to time saving for water collection, significant effect on health improvement for women is expected to arise as a result of improved water quality and increased use of water. Improved water quality will reduce the incidence of waterborne diseases. Increased water use for bathing, washing and food preparation will lead to a reduction in water-washed diseases for women.

(3) Consideration for Women

In onsideration of the role that women and children are playing in water hauling, due attention has been paid in the design of the Project facilities.

1) Platform has been designed to have a enough space for pumping, washing, bathing and water hauling.

2) Pump house consisting of a roof and support has been designed to protect pump and people from direct sunshine and rain water. The pump house and its surrounding will become a social meeting place for villagers, especially for women.

3) Height of pump has been designed taking into consideration the average height of women and children for their easier operation of handpumps.

4) Handpump manuals with illustrations have been prepared for women to understand the importance of periodic inspection of handpumps and periodic cleaning of pump houses. Imporance of hygine practice has been particularly emphasized.

Table 10.1.1 Beneficiaries of the Project

Year	Total Population		Served by Handpumps		Served by Motor Pumps	
	Household	Population	Household	Population	Household	Population
1994	17,865	98,885	3,080	17,070	216	1,208
1995	18,338	101,501	3,161	17,522	222	1,240
1996	18,823	104,187	3,245	17,985	228	1,273
1997	19,321	106,943	11,252	62,240	567	3,210
1998	19,832	109,772	19,250	106,478	582	3,295
1999	20,357	112,677	19,759	109,295	597	3,382
2000	20,895	115,658	20,282	112,186	613	3,472
2001	21,448	118,718	20,819	115,154	629	3,563
2002	22,016	121,859	21,369	118,201	646	3,658
2003	22,598	125,083	21,935	121,328	663	3,754
2004	23,196	128,392	22,515	124,538	681	3,854
2005	23,810	131,789	23,111	127,833	699	3,956

Note:

(1) Number of households and population in 1994 are based on the Village Survey, 19
(2) Population is assumed to increase at 2.6457% per year.
(3) Number of households is assumed to increase at 2.6457% per year.
(4) Villages served by motor pump systems are Beng (S-84), Huaxe, Khampeng, Hangam and Nongkham.

Table 10.1.2a Health Conditions in the Study Area (Champesak Province)

Village Code	Village Name	District Name	House-hold	Popul-ation	Male	Female	Sex Ratio	Main Disease 1/ Malaria	Main Disease 1/ Diarrhea	Ratio of WBD Patients 2/	Medical Expenses 3/	Distance to Hosp./Clinic (km)	Toilet
C-1	B.Nakham	Sanasomboon	153	863	405	458	0.88	20	30	3%	50,000	7	2
C-2	B.Phonthat	Sanasomboon	28	135	67	68	0.99	20	15	11%	30,000	7	0
C-3	B.Nonsavan	Sanasomboon	122	615	279	336	0.83	20	10	2%	50,000	6	0
C-4	B.Nongphai	Sanasomboon	98	553	273	280	0.98	20	15	3%	100,000	5	1
C-5	B.Souvannakidl	Sanasomboon	170	839	366	473	0.77	50	40	5%	100,000	6	0
C-6	B.Nanai	Sanasomboon	118	629	304	325	0.94	20	10	2%	50,000	4	0
C-7	B.Nongdou	Sanasomboon	74	378	173	205	0.84	10	20	5%	15,000	2	0
C-8	B.Houaxe	Sanasomboon	109	628	313	315	0.99	50	40	6%	15,000	0	4
C-9	B.Pongsan	Sanasomboon	70	337	167	170	0.98	30	40	12%	25,000	3	1
C-10	B.Dong	Sanasomboon	63	311	145	166	0.87	10	20	6%	20,000	3	0
C-11	B.Hangam	Sanasomboon	62	354	176	178	0.99	30	30	8%	20,000	5	0
C-12	B.Nongkham	Sanasomboon	93	419	187	232	0.81	50	20	5%	15,000	7	0
C-13	B.Khampeng	Sanasomboon	153	987	450	537	0.84	100	30	3%	100,000	6	3
C-14	B.Khamngoua	Sanasomboon	39	256	86	170	0.51	20	30	12%	30,000	5	0
C-15	B.Nongkhen	Sanasomboon	55	256	116	140	0.83	20	20	8%	30,000	7	0
C-16	B.Louy	Sanasomboon	32	150	65	85	0.76	10	10	7%	60,000	9	0
C-17	B.Solo-Gnai	Sanasomboon	225	1025	375	650	0.58	60	40	4%	200,000	34	0
C-18	B.Solo-Noy	Sanasomboon	116	635	310	325	0.95	50	20	3%	100,000	31	0
C-19	B.Xonphak	Sanasomboon	226	1230	578	652	0.89	60	40	3%	200,000	14	0
C-20	B.Khamlouang	Sanasomboon	52	266	128	138	0.93	50	20	8%	50,000	27	0
C-21	B.Sithouan	Sanasomboon	82	422	200	222	0.90	20	20	5%	100,000	27	1
C-22	B.Mouang	Sanasomboon	210	1285	636	649	0.98	40	30	2%	10,000	1	4
C-23	B.Okumuana	Sanasomboon	180	1117	588	529	1.11	200	100	9%	300,000	9	0
C-24	B.Boungkha	Sanasomboon	150	1010	223	787	0.28	20	30	3%	100,000	30	0
C-25	B.Latsua (Nong	Sanasomboon	58	317	161	156	1.03	30	20	6%	100,000	39	0
C-26	B.Nalak	Sanasomboon	250	1376	660	716	0.92	100	60	4%	100,000	20	0
C-27	B.Dongkalong	Sanasomboon	59	374	189	185	1.02	15	15	4%	40,000	18	0
C-28	B.Nalong	Sanasomboon	287	1696	922	774	1.19	60	60	4%	100,000	0	0
C-29	B.Naxon	Sanasomboon	219	1398	676	722	0.94	30	50	4%	20,000	18	0
C-30	B.Thangbengsiv	Sanasomboon	85	310	90	220	0.41	40	50	16%	20,000	3	6
C-31	B.Nonxat	Sanasomboon	51	293	148	145	1.02	10	10	3%	20,000	13	2
C-32	B.Donphek	Sanasomboon	68	412	119	293	0.41	40	40	10%	30,000	6	2
C-33	B.Dua-Nua	Sanasomboon	155	856	426	430	0.99	20	20	2%	100,000	30	0
C-34	B.Kengkeo	Sanasomboon	96	498	246	252	0.98	50	40	8%	200,000	24	0
C-35	B.Nguuadeng	Sanasomboon	183	1053	518	535	0.97	30	110	10%	50,000	15	0
C-36	B.Pakxon	Sanasomboon	255	1497	704	793	0.89	20	15	1%	10,000	15	7
	36 Villages Sub-Total		4,446	24,780	11,469	13,311	0.86	1,425	1,170	5%	71,111	13	36
C-37	B.Nongsai	Bachiang	70	368	152	216	0.70	20	30	8%	100,000	10	1
C-38	B.Bachiang	Bachiang	52	278	163	115	1.42	40	30	11%	30,000	0	0
C-39	B.Makngeo	Bachiang	57	259	124	135	0.92	30	20	8%	30,000	2	0
C-40	B.Nongbok-Noy	Bachiang	105	578	263	315	0.83	20	30	5%	30,000	6	1
C-41	B.Nongbok-Gna	Bachiang	117	646	271	375	0.72	60	30	5%	100,000	14	0
C-42	B.Thongkim	Bachiang	70	510	301	209	1.44	30	20	4%	60,000	8	1
C-43	B.Kenggnao	Bachiang	54	300	138	162	0.85	20	20	7%	30,000	9	0
C-44	B.Thongsala	Bachiang	72	368	170	198	0.86	50	30	8%	40,000	10	0
C-45	B.Mouangkhai	Bachiang	63	394	119	275	0.43	20	30	8%	20,000	5	0
C-46	B.Pakonay	Bachiang	42	270	144	126	1.14	20	20	7%	40,000	6	0
C-47	B.Oudomsouk	Bachiang	65	256	98	158	0.62	30	20	8%	30,000	7	0
C-48	B.Phasouam	Bachiang	37	157	70	87	0.80	20	20	13%	50,000	23	1
C-49	B.Lak-21	Bachiang	127	567	332	235	1.41	20	20	4%	100,000	21	0
C-50	B.Phin	Bachiang	99	467	216	251	0.86	30	60	13%	50,000	22	0
C-51	B.Lak-23	Bachiang	71	391	166	225	0.74	30	50	13%	50,000	23	0
C-52	B.Lak-25	Bachiang	81	379	172	207	0.83	40	30	8%	50,000	25	0
C-53	B.Nonakhamkh	Bachiang	33	117	43	74	0.58	30	30	26%	60,000	11	0
C-54	B.Senkeo	Bachiang	24	136	61	75	0.81	10	10	7%	30,000	20	0
C-55	B.Houayten	Bachiang	65	320	125	195	0.64	10	10	3%	40,000	19	0
C-56	B.Talan (B.Lak-	Bachiang	32	195	100	95	1.05	10	20	10%	30,000	17	0
C-57	B.Nonsaat	Bachiang	36	218	105	113	0.93	20	20	9%	30,000	15	0
C-58	B.Nongmak-Eut	Bachiang	35	184	83	101	0.82	10	10	5%	30,000	15	0
C-59	B.Lak-13	Bachiang	23	120	63	57	1.11	5	5	4%	30,000	13	0
C-60	B.Nonhouaydua	Bachiang	58	334	178	156	1.14	10	10	3%	30,000	14	0
C-61	B.Kagno	Bachiang	58	283	135	148	0.91	30	20	7%	100,000	16	2
	25 Villages Sub-Total		1,546	8,095	3,792	4,303	0.88	635	595	7%	47,600	13	6
C-62	B.Lak-19	Pathoomphone	80	451	217	234	0.93	100	70	16%	100,000	18	17
C-63	B.Lak-20	Pathoomphone	36	178	100	78	1.28	10	10	6%	50,000	20	0
C-64	B.Mophou	Pathoomphone	179	881	420	461	0.91	30	30	3%	100,000	24	1
C-65	B.Lak-24	Pathoomphone	99	448	205	243	0.84	27	40	9%	40,000	24	0
C-66	B.Sanamxaysou	Pathoomphone	59	309	159	150	1.06	20	30	10%	100,000	25	0
C-67	B.Houakhoua (L	Pathoomphone	53	270	133	137	0.97	15	15	6%	60,000	30	0
C-68	B.Lak-31	Pathoomphone	61	289	140	149	0.94	10	30	10%	40,000	32	0
C-69	B.Lak-34	Pathoomphone	44	256	131	125	1.05	10	10	4%	50,000	6	4
C-70	B.Khouatouay (I	Pathoomphone	148	759	411	348	1.18	80	40	5%	40,000	4	0
C-71	B.Tomo-Nak	Pathoomphone	117	620	235	385	0.61	150	40	6%	50,000	0	0
C-72	B.Tao-Tai	Pathoomphene	156	629	240	389	0.62	30	40	6%	30,000	1	1
C-73	B.Nakham-Noy	Pathoomphone	43	250	115	135	0.85	20	30	12%	40,000	4	1
C-74	B.Thangbeng	Pathoomphone	110	633	312	321	0.97	30	40	6%	50,000	8	0
C-75	B.Nongkhe	Pathoomphone	85	468	218	250	0.87	15	15	3%	40,000	11	0
C-76	B.Napho	Pathoomphone	112	667	307	360	0.85	60	40	6%	30,000	18	3
	15 Villages Sub-Total		1,382	7,108	3,343	3,765	0.89	607	480	7%	54,667	15	26
C-77	B.Chukthangngo	Sukhuma	61	397	197	200	0.99	10	10	3%	60,000	4	0
C-78	B.Bak	Sukhuma	43	230	115	115	1.00	20	100	43%	50,000	8	0
C-79	B.Samkhanabou	Sukhuma	123	682	337	345	0.98	10	110	16%	70,000	6	0
C-80	B.Phompheung	Sukhuma	111	726	351	375	0.94	50	100	14%	50,000	2	0
C-81	B.Pako	Sukhuma	108	596	263	333	0.79	60	60	10%	50,000	13	0
C-82	B.Thapcham	Sukhuma	146	793	388	405	0.96	50	100	13%	50,000	2	0
C-83	B.Kouttaboun	Sukhuma	109	526	272	254	1.07	65	30	6%	100,000	2	0
	7Villages Sub-Total		701	3,950	1,923	2,027	0.95	265	510	13%	61,429	5	0
C-84	B.Boun-Tai	Khong	132	832	340	492	0.69	30	40	5%	100,000	35	0
C-85	B.Keng	Khong	89	517	267	250	1.07	15	20	4%	100,000	91	0
C-86	B.Phonsaat	Khong	128	856	331	525	0.63	70	100	12%	70,000	20	0
C-87	B.Naveng	Khong	45	268	132	136	0.97	15	15	6%	50,000	14	0
C-88	B.Maisivilai	Khong	50	366	211	155	1.36	10	10	3%	50,000	15	0
C-89	B.Nasenphan	Khong	112	563	264	299	0.88	50	30	5%	50,000	12	0
C-90	B.Nayuak (Hang	Khong	97	496	220	276	0.80	30	30	6%	30,000	13	6
C-91	B.Xongpuay	Khong	46	252	122	130	0.94	20	20	8%	50,000	8	45
C-92	B.Nasomhong	Khong	105	657	325	332	0.98	15	15	2%	50,000	8	2
C-93	B.Boung	Khong	80	415	189	226	0.84	20	20	5%	30,000	4	30
C-94	B.Hatxaykhoun	Khong	175	1,150	610	540	1.13	25	25	2%	100,000	1	0
C-95	B.Veunkhao	Khong	92	502	252	250	1.01	5	5	1%	50,000	2	0
C-96	B.Phondeng	Khong	63	370	167	203	0.82	80	70	19%	100,000	5	0
C-97	B.Kadan	Khong	130	856	418	438	0.95	15	15	2%	50,000	7	30
C-98	B.Khinak	Khong	135	780	370	410	0.90	15	15	2%	50,000	8	0
C-99	B.Settaolek	Khong	65	371	189	182	1.04	150	80	22%	50,000	21	0
C-100	B.Tapusy	Khong	18	113	57	56	1.02	5	5	4%	30,000	4	0
	17 Villages Sub-Total		1,562	9,364	4,464	4,900	0.91	570	515	5%	58,235	16	113
	100 Villages Total/Average		9,637	53,297	24,991	28,306	0.88	61,167	3,270	6%	58,608	12	181

Source: Village Survey, April, 1994 Note: 1/ Number of patients per year 2/ WBD= water-borne diseases 3/ annual average in Kip per person

Table 10.1.2b **Health Conditions in the Study Area (Saravan Province)**

Village Code	Village Name	District Name	House-hold	Popul-ation	Male	Female	Sex Ratio	Main Diseases 1/ Malaria	Diarrhoea	Ratio of WBD Patients 2/	Medical Expenses 3/	Distance to Hosp./Clinic (km)	Toilet
S-1	B.NonSavang	Lakhonpheng	105	522	267	255	1.05	20	40	8%	50,000	50	0
S-2	B.Nadou	Lakhonpheng	113	602	301	301	1.00	10	40	7%	40,000	36	0
S-3	B.Nadoumsi	Lakhonpheng	109	579	246	333	0.74	100	60	10%	50,000	38	0
S-4	B.Houaykapho	Lakhonpheng	160	543	241	302	0.80	20	40	7%	50,000	3	0
S-5	B.Lakhosi-Tai	Lakhonpheng	50	289	122	167	0.73	60	80	28%	-	2	0
S-6	B.Lakhosi-Nua	Lakhonpheng	29	130	58	72	0.81	20	30	23%	30,000	1	0
S-7	B.Khonsay	Lakhonpheng	24	134	59	75	0.79	5	5	4%	50,000	3	0
S-8	B.Kengpadek	Lakhonpheng	68	366	148	218	0.68	5	20	5%	50,000	4	0
S-9	B.Nondinxay	Lakhonpheng	85	456	233	223	1.04	20	50	11%	20,000	3	0
S-10	B.Nakhandai	Lakhonpheng	53	322	167	155	1.08	30	40	12%	50,000	30	0
S-11	B.Phoudaocheng-Noy	Lakhonpheng	85	426	213	213	1.00	30	30	7%	50,000	29	0
S-12	B.Nongsano	Lakhonpheng	42	231	115	116	0.99	15	15	6%	50,000	23	0
S-13	B.Phoudaocheng-Gna	Lakhonpheng	73	356	169	187	0.90	40	100	28%	50,000	24	0
S-14	B.Thangbeng	Lakhonpheng	73	316	95	221	0.43	30	40	13%	50,000	22	0
S-15	B.Bouttaphan	Lakhonpheng	62	310	125	185	0.68	40	50	16%	50,000	14	1
S-16	B.Houaykhen	Lakhonpheng	38	186	92	94	0.98	30	40	22%	50,000	13	0
	16 Villages Sub-Total		1,169	5,768	2,651	3,117	0.85	475	680	12%	43,125	18	1
S-17	B.Napong	Khongxedon	198	1182	571	611	0.93	20	30	3%	30,000	6	5
S-18	B.Vang Kan Hong	Khongxedon	54	315	160	155	1.03	10	30	10%	30,000	3	0
S-19	B.Napheng-Gnai	Khongxedon	103	515	237	278	0.85	20	60	12%	50,000	5	0
S-20	B.Khong-Noy	Khongxedon	158	835	397	438	0.91	20	80	10%	20,000	1	28
S-21	B.Nongsaphang	Khongxedon	90	439	203	236	0.86	55	70	16%	40,000	5	0
S-22	B.Nongkoxong	Khongxedon	63	346	154	192	0.80	20	20	6%	50,000	5	0
S-23	B.Nongboua	Khongxedon	34	178	86	92	0.93	5	5	3%	100,000	8	0
S-24	B.Donmuang	Khongxedon	80	398	174	224	0.78	28	30	8%	50,000	7	2
S-25	B.Hinxiou	Khongxedon	100	502	236	266	0.90	15	15	3%	50,000	6	0
S-26	B.Thakho	Khongxedon	28	121	54	67	0.81	10	10	8%	50,000	5	0
S-27	B.Khok-Houaxang	Khongxedon	53	288	135	153	0.88	10	50	17%	50,000	8	2
S-28	B.Namouang	Khongxedon	121	625	285	340	0.84	20	100	16%	60,000	10	0
S-29	B.Khamthong-Gnai	Khongxedon	102	573	271	302	0.90	20	10	2%	100,000	7	0
S-30	B.Nonsamlan	Khongxedon	26	171	82	89	0.92	5	10	6%	40,000	8	0
S-31	B.Nonghalou	Khongxedon	24	152	68	84	0.81	10	20	13%	100,000	10	0
S-32	B.Thalouang	Khongxedon	47	268	128	140	0.91	10	10	4%	60,000	11	1
S-33	B.Nongteng	Khongxedon	43	327	153	174	0.88	10	10	3%	50,000	13	0
S-34	B.Houayxao	Khongxedon	85	495	222	273	0.81	10	10	2%	50,000	14	1
S-35	B.Hatodou	Khongxedon	77	400	183	217	0.84	15	30	8%	50,000	16	1
S-36	B.Nakadao	Khongxedon	162	806	378	428	0.88	30	60	7%	60,000	10	1
S-37	B.Koutlamphong	Khongxedon	70	418	180	238	0.76	20	20	5%	40,000	14	0
S-38	B.Kouttabeng	Khongxedon	89	525	247	278	0.89	50	50	10%	100,000	72	1
	22 Villages Sub-Total		1,798	9,879	4,604	5,275	0.87	413	730	7%	55,909	11	42
S-39	B.Nongngong	Vapy	74	466	231	235	0.98	45	50	11%	100,000	70	0
S-40	B.Donkha	Vapy	128	817	395	422	0.94	100	50	6%	60,000	6	3
S-41	B.Naxat	Vapy	78	501	206	295	0.70	20	30	6%	50,000	6	0
S-42	B.Houaykhou	Vapy	116	603	211	392	0.54	60	50	8%	90,000	1	2
S-43	B.Vapy-Nua	Vapy	121	586	265	321	0.83	60	40	7%	85,000	0	16
S-44	B.Vapy-Tai	Vapy	116	571	283	288	0.98	40	30	5%	50,000	0	16
S-45	B.Nakang	Vapy	19	118	49	69	0.71	10	20	17%	40,000	5	0
S-46	B.Bangkha	Vapy	69	383	167	216	0.77	10	20	5%	20,000	4	0
S-47	B.Saphat	Vapy	139	753	336	417	0.81	110	100	13%	15,000	8	1
S-48	B.Mouang	Vapy	159	885	419	466	0.90	200	20	2%	50,000	11	1
S-49	B.Hat	Vapy	85	469	198	271	0.73	10	20	4%	30,000	13	1
S-50	B.Samia	Vapy	156	893	449	444	1.01	50	30	3%	50,000	16	2
S-51	B.Khoumta-Lat	Vapy	49	223	105	118	0.89	20	30	13%	30,000	0	1
S-52	B.Nongpho	Vapy	49	257	131	126	1.04	20	20	8%	30,000	20	0
S-53	B.Bungkhem	Vapy	235	1,571	751	820	0.92	40	50	3%	100,000	35	1
S-54	B.Nongsai	Vapy	130	1,250	510	740	0.69	30	60	5%	50,000	30	1
S-55	B.Bungxai	Vapy	300	1,691	810	881	0.92	20	30	2%	30,000	24	1
S-56	B.Chong	Vapy	31	183	83	100	0.83	12	8	4%	100,000	19	0
S-57	B.Phonkham	Vapy	13	72	34	38	0.89	10	10	14%	30,000	21	0
S-58	B.Koutvoung	Vapy	21	117	61	56	1.09	10	15	13%	20,000	19	0
S-59	B.Nongbou-Noy	Vapy	13	90	41	49	0.84	15	10	11%	20,000	18	0
	21 Villages Sub-Total		2,101	12,499	5,735	6,764	0.85	892	693	6%	50,000	16	46
S-60	B.Dong-Nong	Saravan	64	315	151	164	0.92	30	50	16%	50,000	14	0
S-61	B.May-Sivilai	Saravan	23	131	62	69	0.90	15	10	8%	50,000	15	0
S-62	B.Nakathian	Saravan	92	556	256	300	0.85	20	15	3%	30,000	3	0
S-63	B.Nathon	Saravan	100	628	287	341	0.84	10	30	5%	40,000	13	0
S-64	B.Phonphai	Saravan	147	1034	510	524	0.97	100	300	29%	20,000	8	0
S-65	B.Nadon	Saravan	27	115	53	62	0.85	5	10	9%	20,000	4	0
S-66	B.Nadonkhoang	Saravan	39	224	100	124	0.81	10	30	13%	30,000	12	0
S-67	B.Thamuang-Kao	Saravan	75	452	212	240	0.88	20	40	9%	30,000	10	0
S-68	B.Napheng-Gnai	Saravan	70	510	215	295	0.73	20	20	4%	50,000	15	0
S-69	B.Napheng-Noy	Saravan	18	117	55	62	0.89	5	10	9%	30,000	16	0
S-70	B.Saokadi-Tai	Saravan	66	450	190	260	0.73	30	40	9%	50,000	18	0
S-71	B.Dan-Gnai	Saravan	113	739	298	441	0.68	20	30	4%	50,000	21	0
S-72	B.Kengtim-Tai	Saravan	56	365	185	180	1.03	15	20	5%	50,000	31	0
S-73	B.Nobon-Tai	Saravan	42	212	101	111	0.91	15	20	9%	30,000	33	0
S-74	B.That-Noy	Saravan	46	250	110	140	0.79	10	10	4%	50,000	6	0
S-75	B.Nakasao	Saravan	99	717	382	335	1.14	40	50	7%	30,000	8	0
S-76	B.Ko	Saravan	63	326	161	165	0.98	10	20	6%	50,000	11	0
S-77	B.Phao-Gnai	Saravan	164	884	372	512	0.73	20	30	3%	50,000	13	0
S-78	B.Soung	Saravan	120	780	365	415	0.88	30	20	3%	50,000	13	1
S-79	B.Thongkapok	Saravan	14	112	52	60	0.87	10	10	9%	50,000	16	0
S-80	B.Naxai-Gnai	Saravan	60	396	190	206	0.92	20	30	8%	60,000	17	0
S-81	B.Naxai-Noy	Saravan	88	471	224	247	0.91	20	30	6%	50,000	19	1
S-82	B.Maknao	Saravan	30	178	91	87	1.05	30	20	11%	30,000	9	0
S-83	B.Dongko-Nua	Saravan	62	318	149	169	0.88	20	10	3%	40,000	3	0
S-84	B.Beng	Saravan	107	580	230	350	0.66	50	30	5%	50,000	24	0
S-85	B.Khiangphoukhong	Saravan	76	385	220	165	1.33	60	20	5%	50,000	26	0
S-86	B.Kadap	Saravan	120	613	301	312	0.96	100	60	10%	-	30	0
S-87	B.Lavang	Saravan	107	549	278	271	1.03	30	40	7%	50,000	33	0
S-88	B.Senvang-Noy	Saravan	76	368	208	160	1.30	40	30	8%	50,000	26	0
S-89	B.Houakhoua	Saravan	47	256	119	137	0.87	20	30	12%	50,000	29	1
	30 Villages Sub-Total		2,211	13,031	6,127	6,904	0.89	825	1,065	8%	41,333	16	3
S-90	B.Kiangtat	Lao ngam	68	287	144	143	1.01	20	15	5%	50,000	30	0
S-91	B.Xanum	Lao ngam	40	237	110	127	0.87	15	20	8%	50,000	28	0
S-92	B.Xanumnok	Lao ngam	31	171	80	91	0.88	35	30	18%	50,000	35	0
S-93	B.Baktheung	Lao ngam	56	237	120	117	1.03	40	30	13%	50,000	9	0
S-94	B.Vengpuay	Lao ngam	60	300	125	175	0.71	70	30	10%	50,000	6	0
S-95	B.Sangthong-Noy	Lao ngam	24	125	56	69	0.81	10	30	24%	40,000	5	0
S-96	B.Sangthong-Gnai	Lao ngam	86	410	188	222	0.85	20	40	10%	30,000	3	0
S-97	B.Laongam	Lao ngam	250	1140	465	675	0.69	60	40	4%	50,000	9	60
S-98	B.Hokong	Lao ngam	179	655	308	347	0.89	60	40	6%	50,000	8	0
S-99	B.Beng	Lao ngam	82	411	214	197	1.09	50	40	10%	50,000	9	0
S-100	B.Houn-Tai	Lao ngam	73	438	172	266	0.65	100	80	18%	50,000	9	0
	11 Villages Sub-Total		949	4,411	1,982	2,429	0.82	480	395	9%	47,273	13	60
	100 Villages Total/Average		8,228	45,588	21,099	24,489	0.86	3,085	3,563	8%	47,528	15	152

Source: Village Survey, April, 1994 Note: 1/ Number of patients per year 2/ WBD= water-borne diseases 3/ annual average in Kip per person

Table 10.2.1 Financial Project Costs

Unit: Million Kips

Item	Foreign Currency Portion	Ratio	Local Currency Portion	Ratio	Total
1. Well Construction	10,262.5	89%	1,296.3	11%	11,558.9
2. Maintenance Center	423.9	51%	400.8	49%	824.8
3. O&M Equipment	295.4	51%	279.3	49%	574.7
4. Engineering Services	1,036.7	100%	0.0	0%	1,036.7
Total Base Cost 1/	12,018.5	86%	1,976.4	14%	13,994.9
Physical Contingency 2/	1,201.9	86%	197.6	14%	1,399.5
Price Contingency 3/	524.7	87%	78.4	13%	603.1
Total Project Cost	13,745.1	86%	2,252.4	14%	15,997.5
Yen Equivalent (million):	1,482.6	86%	243.0	14%	1,725.6

Note: 1/ including value added tax of 7%

2/ Physical contingency at 10% for total base cost

3/ Price contingency at 3% p.a. for foreign portion and 10% p.a. for local portion.

Table 10.2.2 Annual Disbursement Schedule of Financial Costs

Unit: Million Kips

	Item	1996		1997		Total		Grand
		Foreign	Local	Foreign	Local	Foreign	Local	Total
A.	Well Construction							
	Mobilization	671.1	35.3	612.7	32.2	1,283.8	67.6	1,351.4
	Drilling	2,394.0	126.0	2,185.8	115.0	4,579.7	241.0	4,820.8
	Geophysical Logging	559.5	29.4	510.8	26.9	1,070.3	56.3	1,126.7
	Well Development	895.0	47.1	817.2	43.0	1,712.2	90.1	1,802.4
	Handpumps Installation	435.3	22.9	397.4	20.9	832.8	43.8	876.6
	Submersible Pumps Facilities	6.2	1.1	5.7	1.0	11.8	2.1	13.9
	Casing and Screen	402.7	21.2	367.7	19.4	770.4	40.5	811.0
	Sub-total:	5,364.5	282.3	4,898.0	257.8	10,262.5	540.1	10,802.7
	Tax 1/	0.0	395.3	0.0	360.9	0.0	756.2	756.2
	A. Sub-total	5,364.5	677.6 0.0	4,898.0	618.7	10,262.5	1,296.3	11,558.9
B.	Maintenance Center							
	Land Leveling	20.7	17.0	0.0	0.0	20.7	17.0	37.7
	Main Office	202.0	165.3	0.0	0.0	202.0	165.3	367.4
	Workshop	64.0	52.4	0.0	0.0	64.0	52.4	116.4
	Garage	36.5	29.9	0.0	0.0	36.5	29.9	66.4
	Storage	49.2	40.2	0.0	0.0	49.2	40.2	89.4
	Training Facilities	51.4	42.1	0.0	0.0	51.4	42.1	93.5
	Sub-total:	423.9	346.9	0.0	0.0	423.9	346.9	770.8
	Tax 1/	0.0	54.0	0.0	0.0	0.0	54.0	54.0
	B. Sub-total	423.9	400.8 0.0	0.0	0.0	423.9	400.8	824.8
C.	O&M Equipment							
	Truck Crane	55.9	45.8	0.0	0.0	55.9	45.8	101.7
	Motorcycle	18.5	15.1	0.0	0.0	18.5	15.1	33.6
	Pickup	57.3	46.9	0.0	0.0	57.3	46.9	104.1
	Workshop Tools	63.1	51.7	0.0	0.0	63.1	51.7	114.8
	Handpumps	64.0	52.4	0.0	0.0	64.0	52.4	116.4
	Spareparts	22.6	18.5	0.0	0.0	22.6	18.5	41.0
	Miscellaneous	14.0	11.4	0.0	0.0	14.0	11.4	25.4
	Sub-total:	295.4	241.7	0.0	0.0	295.4	241.7	537.1
	Tax 1/	0.0	37.6	0.0	0.0	0.0	37.6	37.6
	C. Sub-total	295.4	279.3	0.0	0.0	295.4	279.3	574.7
	Sub-total (A+B+C)	6,083.9	1,357.7	4,898.0	618.7	10,981.9	1,976.4	12,958.3
D.	Engineering Services	622.0	0.0	414.7	0.0	1,036.7	0.0	1,036.7
E.	Total Base Costs	6,705.9	1,357.7	5,312.7	618.7	12,018.5	1,976.4	13,995.0
F.	Physical Contingency 2/	670.6	135.8	531.3	61.9	1,201.9	197.6	1,399.5
G.	Sub-total (E + F)	7,376.4	1,493.5	5,844.0	680.6	13,220.4	2,174.1	15,394.5
H.	Price Contingency 3/	201.2	40.7	323.5	37.7	524.7	78.4	603.1
Total Project Cost		7,578	1,534	6,168	718	13,745	2,252	15,997.6
Yen Equivalent (million):		817.4	165.5	665.3	77.5	1,482.6	243.0	1,725.6

Note: 1/ Value added tax at 7%

2/ Physical contingency at 10% for total base cost

3/ Price contingency at 10% p.a. for local portion and 3% for foreign portion

Table 10.3.1 **Annual Disbursement Schedule of Economic Costs**

Unit: Million Kips

	Item	1996		1997		Total		Grand Total
		Foreign	Local	Foreign	Local	Foreign	Local	
A.	Well Construction							
	Mobilization	654.8	34.5	597.8	31.5	1,252.6	65.9	1,318.6
	Drilling	2,785.3	146.6	2,543.1	133.8	5,328.4	280.4	5,608.8
	Geophysical Logging	557.1	29.3	508.6	26.8	1,065.7	56.1	1,121.8
	Well Development	891.4	46.9	813.9	42.8	1,705.2	89.7	1,795.0
	Handpumps Installation	432.5	22.8	394.8	20.8	827.3	43.5	870.8
	Submersible Pumps Facilities	12.4	2.2	11.3	2.0	23.7	4.2	27.9
	Sub-total:	5,333.3	282.2	4,869.6	257.7	10,202.9	539.9	10,742.8
B.	Maintenance Center							
	Land Leveling	10.4	8.5	0.0	0.0	10.4	8.5	18.9
	Main Office	202.0	165.3	0.0	0.0	202.0	165.3	367.4
	Workshop	64.0	52.4	0.0	0.0	64.0	52.4	116.4
	Garage	36.5	29.9	0.0	0.0	36.5	29.9	66.4
	Storage	49.2	40.2	0.0	0.0	49.2	40.2	89.4
	Training Facilities	51.4	42.1	0.0	0.0	51.4	42.1	93.5
	Sub-total:	413.6	338.4	0.0	0.0	413.6	338.4	751.9
C.	O&M Equipment							
	Drilling Rig and Tools	163.3	133.6	0.0	0.0	163.3	133.6	296.8
	Air Compresser	40.6	33.2	0.0	0.0	40.6	33.2	73.8
	Drilling Materials	55.9	45.8	0.0	0.0	55.9	45.8	101.7
	Truck Crane	24.4	19.9	0.0	0.0	24.4	19.9	44.3
	Tank Lorry	33.8	27.7	0.0	0.0	33.8	27.7	61.5
	Pick-up	26.6	21.8	0.0	0.0	26.6	21.8	48.4
	Workshop Tools	63.1	51.7	0.0	0.0	63.1	51.7	114.8
	Handpumps	64.0	52.4	0.0	0.0	64.0	52.4	116.4
	Spareparts	11.3	9.2	0.0	0.0	11.3	9.2	20.5
	Miscellaneous	72.6	59.4	0.0	0.0	72.6	59.4	132.0
	Sub-total:	555.6	454.6	0.0	0.0	555.6	454.6	1,010.2
	Sub-total (A+B+C)	6,302.5	1,075.2	4,869.6	257.7	11,172.1	1,332.9	12,505.0
D.	Engineering Services	602.2	0.0	401.5	0.0	1,003.7	0.0	1,003.7
E.	Total Base Costs	6,904.7	1,075.2	5,271.0	257.7	12,175.8	1,332.9	13,508.7
F.	Physical Contingency 1/	690.5	107.5	527.1	25.8	1,217.6	133.3	1,350.9
G.	Sub-total (E + F)	7,595.2	1,182.7	5,798.1	283.5	13,393.3	1,466.2	14,859.5
H.	Price Contingency 2/	0.0	0.0	0.0	0.0	0.0	0.0	0.0
I.	Taxes 3/	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total Project Cost	7,595	1,183	5,798	283	13,393.3	1,466.2	14,859.5
	Yen Equivalent (million):	819.3	127.6	625.4	30.6	1,444.7	158.2	1,602.8

Note: 1/ Physical contingency at 10% for total base cost

2/ Price contingency is not considered in economic costs.

3/ Value added taxes are not considered in the economic costs.

Table 10.3.4 Economic Analysis

Unit: Million Kips

Year	Incremental Net Benefit	Incremental Costs				Net Cash Flow	Discount Factor	Present Value of Benefits	Present Value of Total Costs	Net Present Value
		Investment Cost	Replacement Cost	O & M Cost	Total Cost		at 10%	---------- discounted at 10% ----------		
						20%				
1996	0.0	8,289.7	0.0	0.0	8,289.7	-8,289.7	0.91	0.0	7,536.1	-7,536.1
1997	1,121.8	6,097.7	0.0	33.4	6,131.1	-5,489.2	0.83	927.1	5,067.0	-4,139.9
1998	1,904.9	0.0	0.0	46.4	46.4	1,758.5	0.75	1,431.2	34.8	1,396.4
1999	3,258.1	0.0	0.0	46.4	46.4	3,108.0	0.68	2,225.3	31.7	2,193.6
2000	3,343.3	0.0	0.0	46.4	46.4	3,193.1	0.62	2,075.9	28.8	2,047.1
2001	3,430.9	0.0	0.0	46.4	46.4	3,280.4	0.56	1,936.7	26.2	1,910.5
2002	3,520.9	0.0	0.0	46.4	46.4	3,370.0	0.51	1,806.8	23.8	1,783.0
2003	3,613.1	0.0	0.0	46.4	46.4	3,462.1	0.47	1,685.5	21.6	1,663.9
2004	4,331.1	0.0	0.0	46.4	46.4	3,556.5	0.42	1,836.8	19.7	1,817.1
2005	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.39	1,467.0	17.9	1,449.1
2006	3,805.1	0.0	1,379.7	46.4	1,426.1	3,568.6	0.35	1,333.7	499.8	833.8
2007	3,805.1	0.0	1,014.9	46.4	1,061.3	3,596.9	0.32	1,212.4	338.2	874.3
2008	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.29	1,102.2	13.4	1,088.8
2009	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.26	1,002.0	12.2	989.8
2010	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.24	910.9	11.1	899.8
2011	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.22	828.1	10.1	818.0
2012	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.20	752.8	9.2	743.6
2013	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.18	684.4	8.3	676.0
2014	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.16	622.2	7.6	614.6
2015	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.15	565.6	6.9	558.7
2016	3,805.1	0.0	1,379.7	46.4	1,426.1	3,568.6	0.14	514.2	192.7	321.5
2017	3,805.1	0.0	1,014.9	46.4	1,061.3	3,596.9	0.12	467.4	130.4	337.1
2018	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.11	424.9	5.2	419.8
2019	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.10	386.3	4.7	381.6
2020	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.09	351.2	4.3	346.9
2021	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.08	319.3	3.9	315.4
2022	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.08	290.2	3.5	286.7
2023	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.07	263.9	3.2	260.6
2024	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.06	239.9	2.9	236.9
2025	3,805.1	0.0	0.0	46.4	46.4	3,653.5	0.06	218.1	2.7	215.4
	104,430.6	14,387.4	4,789.2	1,332.0	20,508.6	0.20		27,881.9	14,077.9	13,804.0

EIRR: 20.1 %
NPV: 13,804.0 million Kips
B/C: 1.98

CHAPTER 11 ENVIRONMENTAL IMPACT ASSESSMENT

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CHAPTER 11 ENVIRONMENTAL IMPACT ASSESSMENT

Over exploitation of groundwater often causes environmental problems such as decline of water levels, land subsidence and groundwater contamination. The Study establishes a groundwater development plan for rural water supply. Compared with large groundwater development for agricultural and industrial purposes, groundwater pumpage for rural water supply is smaller and has lesser impact on the environment. However small, it still has an impact on the environment since the natural water cycle may change due to groundwater withdrawal.

11.1 National Aspect

The Environmental Action Plan of Lao PDR describes the key environmental issues and actions to be taken by the Government within the next three to five years:

- Define environmental guidelines and standards for the industrial and mining sectors;
- Expand water supply and provision of sanitation;
- Streamline and improve environmental data collection system, including land resource mapping.

With regards to rural water supply, the Government will undertake the following measures:

- Develop and implement a national rural water supply sanitation strategy focussing on communities, demands, ensuring community participation to assume, where appropriate, responsibility for proper operation and maintenance.

The Organization for Science, Technology and Environment (OSTE) of the Prime Minister's office is responsible for overall coordination of environmental activities. The Ministry of Health (MOH) is a line agency to implement environmental activities related with its own project in coordination with OSTE. However, the present status of its activities are limited shown in Table 11.1.

Legal and regulatory framework, governing processes used in environmental planning and management has not been given major priority in Lao PDR. Because Lao PDR's legal system is nascent, only a limited number of environmental aspects have so far been addressed, mainly in the areas of natural resource management. Therefore, development of a regulatory framework and procedures is a key action the Government must implement.

11.2 Main Points of Environmental Consideration

JICA , in its guideline, presents the main points of environmental impact caused by the groundwater development project as follows:

Groundwater

Excessive groundwater withdrawals from aquifers causes declinning of water levels and exhaustion of groundwater resource. It finally affects springs and existing wells in the vicinity of the project area. Particularly, in the coastal area, groundwater may be contaminated due to sea water intrusion accompanied by the declinning of water levels. Therefore, groundwater withdrawals must be planned considering the areal extent and productivity of aquifers.

Land Subsidence

Land subsidence occurs due to compaction or consolidation of clayey beds accompanied by the declinning of groundwater levels. Land subsidence results in flooding of the land and failure of surface structures , buckling of pipelines and protrusion of well casing etc. These damages finally interferes social and economic activities and increases development cost. Therefore, present situation of land subsidence and land use must be considered in the implementation of the project.

11.3 Qualitative Assessment

The following environmental items were examined from the view points of groundwater development in Champasak and Saravan provinces according to JICA guideline.

11.3.1 Groundwater

Groundwater withdrawals from the well for domestic use in the village will be small comparing with that for industrial and agricultural use. Most of wells will be equipped with hand pumps. Maximum capacity of deep well hand pump is less than $10m^3$/day per well. Total pumpage of the project area will be less than the amount of natural recharge. Groundwater can be withdrawn without causing annual declinning of groundwater levels. However, water balance of the project area shall be analyzed and the impact of pumping shall be assessed quantitatively.

Existing wells in the vicinity may be influenced locally. However, it greatly depends on aquifer characteristics. Particularly, in the area where aquifer composed of Jurassic shale and basalt lava , shallow existing well may be dried up because groundwater is essentially poor and contained in the fissure. New well shall be located considering the distance from existing wells.

11.3.2 Land Subsidence

Land subsidence will not occur in the project area. Hydrogeological survey result shows that the Aluvial sediment (Qal) is mainly distributed in the downstream of the Xedon River and the right bank of the Mekong River with 4 to 30m thick and consits of fine sand with gravel and silt partly intercalating clay bed. Land subsidence depends on the thickness of soft unconsolidated clay bed and the declinning of water level. Considering these factors, the possibility of land subsidence is very low.

11.3.3 Groundwater Contamination

The disposal of domestic waste water may contaminate groundwater through newly constructed well if it is not properly sealed. If an aquifer of inferior water quality , abundant in

Fe or Cl^- for example, is not properly sealed during well construction, it may contaminate another aquifer. As was explained in the previous chapter, the test wells drilled at two villages located in the hydrogeologic unit Ba1, namely Ban Lak 21 (C-49) and Ban Hountai (S-100), yielded reddish brown turbid groundwater. The groundwater of basaltic aquifer may be contaminated by intrusion of water abundant in Fe and Mn from overlying thick red clay. This does not affect neighboring wells, however, it contaminates itself and finally groundwater can not be used.

Surface geological survey shows that evaporite or salt bed is not outcropped in the Study Area. However, the test well drilled at B.Houaxe (C-8) encountered salinized sandstone-mudstone aquifers at depth from 109m to 134m and 153m to 182m. This fact indicates the existence of evaporite and/or salt bed in upper Jurrasic or lower Cretaceous formations in the underground.

Drawing up of salty water, a phenomenon known as "upconing", may occur in these area by a well pumping from an overlying fresh water zone. These factors shall be considered in the designning and construction of the well.

11.4 Quantitative Assessment

11.4.1 Basin-Wide Water Balance

Under natural conditions, an aquifer is usually in a state of dynamic equilibrium. A volume of water recharges the aquifer and an equal volume is discharged. When a well begins to pump water from an aquifer, the water is withdrawn from storage around the well and from vertical leakage. The area around the well where the hydraulic head in the aquifer is lowered by pumping is called pumping cone or cone of depression..

When the pumping cone reaches a discharge area, the amount of natural discharge is proportionally reduced. If the pumping cone reaches the recharge area, it may induce additional recharge of water. It can take many years for the cone of depression to influence recharge or discharge areas sufficiently for an aquifer to regain dynamic equilibrium.

As was mentioned in the previous chapter, the water balance calculation indicated the total volume of the recharge is about 210-500 mm/year (575-1,370 m^3/day/km^2). This volume is discharged as the groundwater outflow in natural aquifer. The groundwater development program proposed in this study also assumes approximately 5,300 m^3/day of withdrawals through the hand pump wells and the motor pump wells. It is only 10 km2 of the natural recharge area in the entire basin, and the same amount of discharge (groundwater outflow) will be reduced in many years. However, the groundwater level in the aquifer is not declined annually.

The groundwater outflow is naturally composed of the flow from spring, the base flow in dry season and the outflow to adjacent aquifers. It is considered that this amount of discharge reduction does not affect practical water use in the spring and river.

11.4.2 Drawdown and Influence Circle

A pumping cone is grown up around the well when the groundwater is pumped from an aquifer. The drawdown and the radius of influence circle during well pumpage can be estimated by using Theis equation:

$$h_0-h=QW(u)/4\pi T \qquad (11.1)$$

$$u=r^2S/4tT \qquad (11.2)$$

where Q : the constant pumping rate
h : the hydraulic head at time t since pumping began
h_0: the hydraulic head before the start of pumping
r : the radial distance from the pumping well to the observation well
T : the aquifer transmissivity
S : the aquifer storativity
"h_0-h" is the drawdown and W(u) is the well function.

Assuming that a well is located in Jurrasic aquifer in the hydrogeologic unit Ep or Eh and pumped at a rate of $10m^3$/day, the drawdown after 12 hours of pumping is calculated as follows:

A logarithmic average of transimissivity in Jurassic aquifer is $11m^2$/day. The storativity is assumed at 0.05 (a minimum value obtained at the pumping test). The radial distance to the pumping well is a half of the well diameter (4 inch=0.1m). These assumptions yield:

$$u= (0.1/2m)^2x0.05/(4x11m^2/dayx12/24day)=5.68x10^{-6}$$

From the table of W(u) and u, we obtain W(u)=11.51

$$h_0-h=10m^3/dayx11.51/4x3.14x11m^2/day$$
$$=0.83\ m$$

The radial distance of the influence circle at 0.01 meter of the drawdown is also estimated by using Equation (11.1) and (11.2)

$$W(u)=4\pi T(h_0-h)/Q=4x3.14x11m^2/dayx0.01m/10m^3/day=0.1386$$

From the table of W(u) and u, we obtain u=1.47

$$r^2=4Ttu/S=4x11m^2/dayx0.5dayx1.47/0.05=646.8$$
$$r=25.4\ m$$

As is understood from the above calculation, the size of the pumping cone is small and it does not affect neighboring existing wells if the new well is constructed at more than 25 m distant from them in the Jurassic aquifer. The cone of depression will not grow more and reach a state of equilibrium under this pumping condition. However, the size of the cone of depression obviously depends on the transmissivity and the storativity values.

The equation also indicates that the pumping rate may be reduced or the well dried up in the aquifer of poor transmissivity, particularly in the dry season. Actually the reduction of the pumping rate was observed at Ban Nongphai (C-4), in the dry season of 1995. The transmissvity of Jurassic sandstone aquifer in this village shows 0.78 m^2/day and a drawdown was 27.5m at a pumping rate of 20 liters/min.

The average drawdown and the radius of the influence circle of each hydrogeologic unit were calculated and presented in Table 11.2. This table also presents the summary of environmental impact assessment qualitatively and quantitatively.

The calculated radius of influence circle is a theoretical value. Groundwater occurs in the fissure of sandstone and shale in Jurassic aquifer and basalt. In many cases, groundwater behavior is not governed by Theis theory since it assumes a radial, homogeneous and isotropic groundwater flow in the confined aquifer of an uniform thickness in an infinite areal extent. Therefore, practically, a new well should empirically be located at least 150m distant from the existing well.

Table 11.1 Summary Environmental Planning and Management Activities

Primary Environment Activities to Date	- Draft General Hygiene Law Prepared - Identified priority areas as sanitation/waste water in urban and rural areas, solid waste treatment however limited implementation program
Extent of integration of environmental planning and management process into operations	All activities have environmental quality focus , however to date little operational focus
Environmental policy guidelines incorporated into investment plannning	NP investment planning has completed to date
Legal and regulatory framework for Public Health	General Hygiene Law Prepared under WHO auspices
Public Health	No Regulation in place
Compliance/Monitoring	Minimal due to lack of resource

Source: Environmental Action Plan, OSTE (1993)