BASIC DESIGN STUDY REPORT
ON
VIENTIANE WATER SUPPLY SYSTEM
IMPROVEMENT PROJECT
IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

MAY 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Lao People's Democratic Republic, the Government of Japan decided to conduct a basic design study on the Improvement and Extension Project of Vientiane Water Supply System and entrusted the survey to the Japan International Cooperation Agency (JICA). The JICA sent to the Lao People's Democratic Republic a survey team headed by Mr. Minoru ISHIDA, Second Economic Cooperation Division, Economic Cooperation Bureau, Ministry of Foreign Affaires from January 12 to February 11, 1983.

The team had discussions with the officials concerned of the Government of the Lao People's Democratic Republic and conducted a field survey in Vientiane.

After the team returned to Japan, further studies were made and the present report has been prepared.

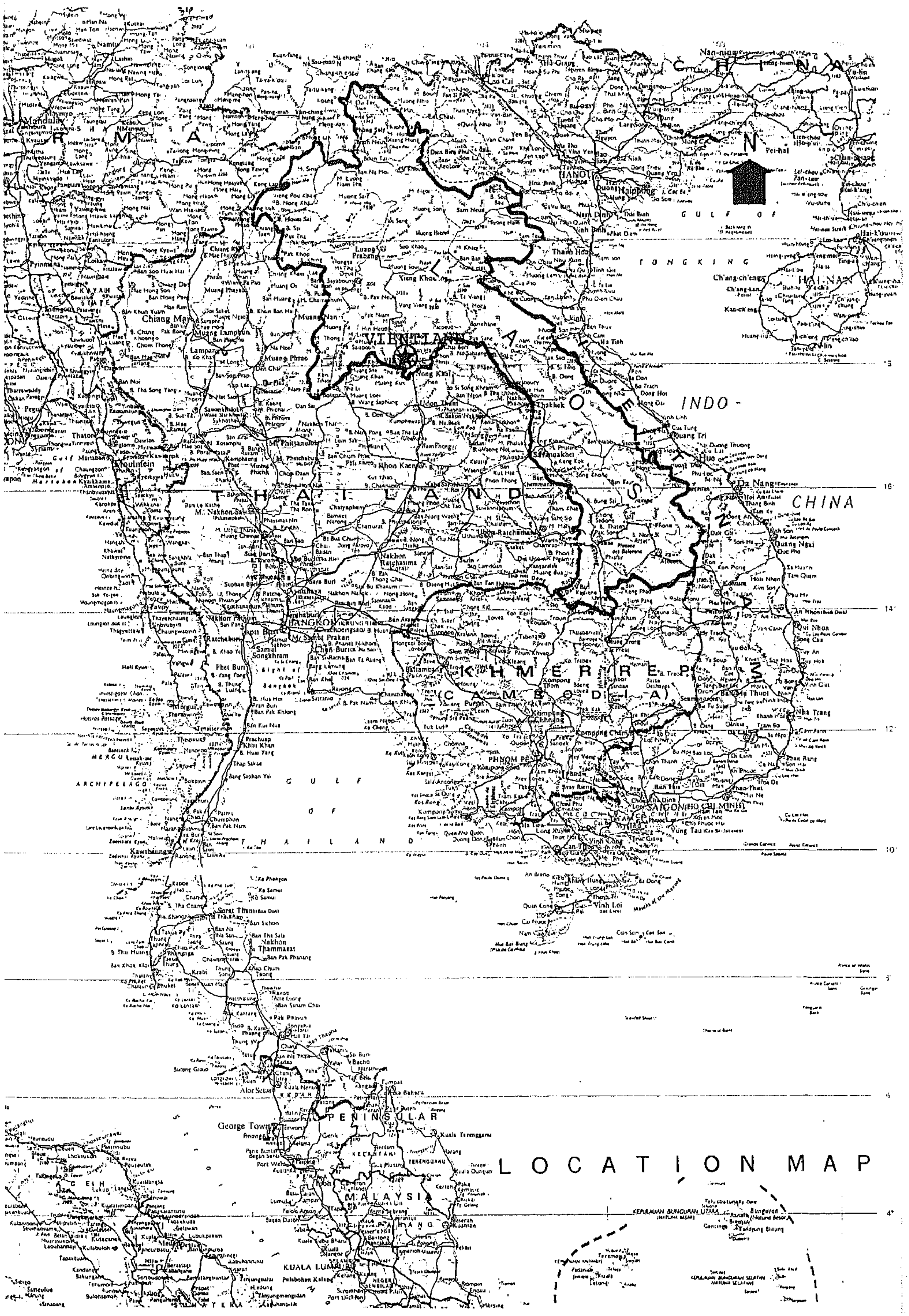
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Lao People's Democratic Republic for their close cooperation extended to the team.

May, 1983

Keisuke Arita

Keisuke Arita
President
Japan International
Cooperation Agency



LOCATION MAP
THAILAND
LAOS
VIENTIANE
KHMER REP. (CAMBODIA)
INDO-CHINA
GULF OF TONGKING
GULF OF THAILAND
HANOI
Haiphong
BANGKOK
PHNOM PENH
SAIGON (HO CHI MINH)
Da Nang
Hue
Qui Nhon
Nha Trang
Chiang Mai
Luang Prabang
Mandalay
Moulmein
George Town
KUALA LUMPUR
PENINSULAR MALAYSIA
HAI-NAN
MERGUI ARCHIPELAGO
N

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ABBREVIATIONS

millimeter	mm	milliampere	mA
centimeter	cm	ampere	A
meter	m	kiloampere	kA
kilometer	km	millivolt	mV
		volt	V
		kilovolt	kV
square millimeter	mm2	kilovolt-ampere	kVA
square centimeter	cm2	alternating current	AC
square meter	m2	direct current	DC
square kilometer	km2		
are	a		
hectare	ha	watt	W
		kilowatt	kW
cubic millimeter	mm3		
cubic centimeter	cm3	kilometers per hour	km/h
cubic meter	m3	revolutions per minute	rpm
		meters per second	m/sec
		meters per day	m/day
milligram	mg	cubic meters per minute	m3/min
gram	g	hour	hr
kilogram	kg	second	sec
metric ton	t		
liter	l	cubic meters per second	m3/sec
kiloliter	kl	cubic meters per day	m3/d
		liters per second	l/sec
		degree Celsius	°C

SUMMARY

This section briefly summarizes the principal findings of this study and describes conclusions and recommendations.

BACKGROUND OF THE PROJECT

The Project area is Vientiane City, the capital of Laos, and its environs, located on the left bank of the Mekong River. The city occupies 5,300 ha, and holds population of 185,000 (estimated in 1982).

Nam Papa Lao (hereinafter called "NPP") is the sole and financially independent organization which undertakes water supply in Vientiane.

The present served population of NPP is approximately 90,000 out of the total population 185,000. NPP operates two water treatment plants: Kaolieo Plant and Chi Naimo Plant; the current total production of the plants is estimated approximately 50,000 m3/day.

Kaolieo Plant (hereinafter called the "Plant"), commissioned in 1964, is malfunctioning due to lack of proper maintenance services; the Plant's average daily production is estimated 11,000 m3/day inspite of the designed capacity of 20,000 m3/day.

NPP is planning to expand its service area to the surroundings of Vientiane. Proposed expansion will increase NPP's served population from 90,000 in 1982 to 185,000 by 1990 and accommodate institutions and industries in the proposed area. The future water demand is estimated as about 60,900 m3/day in 1990 from current 41,000 m3/day. Thus the increase in production capacity and extension of the distribution networks are crucial for the development of the city.

THE PROJECT

The objective of the Project is to rehabilitate and improve the Kaolieo Plant to achieve the rated production capacity 20,000 m3/day, to provide bank and riverbed protection at the intake site, and to extend the distribution pipelines to the areas where piped water supply is urgently required, or to the additional served population of 12,000 by 1990.

The Improvement and Extension Project of the Vientiane Water Supply System is envisioned as follows:

Rehabilitation and Improvement of Kaolieo Water Treatment Plant

- Replacement of Pumps: three-intake pumps;
  four-distribution pumps; and
  three-backwash pumps (including one additional pump)
- Replacement of a Flash Mixer and four filter controllers;
- Replacement of Chemical Feeding Equipment;
- Replacement of Electrical Equipment of the Power Sub-station;
- Replacement of Instrumentation; and
- Repair of miscellaneous items.

Construction of Bank and Riverbed Protection

- Bank Protection: Height: 12 m
  Length: 40 m
  Surface Area: 700 m2
- Riverbed Protection: 550 m2

Extension of Distribution Pipeline

- Dong Dok Area: ϕ250 mm/5.7 km
- Phone Tong Area: ϕ400 mm/1.3 km and ϕ150 mm/2.1 km
- Thadua Road Area: ϕ250 mm/1.8 km and ϕ200 mm/1.7 km
- Thong Pong Area: ϕ150 mm/2.5 km and ϕ100 mm/2.3 km

IMPLEMENTATION OF THE PROJECT

- Executing Agency: Nam Papa Lao (NPP)
- Outset of the Project: May 1983
- Project Period: 10 months
- Outset of Construction Work: June 1983
- Construction Period: 9 months

OPERATION AND MAINTENANCE OF THE PROJECT

NPP is responsible for operation and maintenance of the rehabilitated Kaolieo Plant and extended distribution pipelines in addition to the other existing facilities of the Vientiane Water Supply System.

NPP, composed of five departments, is currently staffed with about 320 persons. On-the-job training of technical staff of the Kaolieo Plant, considering the present inadequate level of their competence, will be programmed along the progress of the Project.

FINANCIAL ASPECTS OF NAM PAPA LAO

Although NPP registered an unsubstantial deficit in the 1982 fiscal year, NPP is expected to generate sufficient revenues to cover the expenditure of operation and maintenance with the modest surplus from the current fiscal year because of the new water rates revised in October 1982 and the possible financial effects of the Project.

PROJECT EVALUATION

The Project, when implemented under the grant program by the Government of Japan, will help NPP to solve the urgent problems of the bank erosion and endangered treatment facilities at the Kaolieo Plant, and unhealthy conditions of the unserved areas.

Although some important returns such as health and other related benefits cannot be measured in monetary terms, economic and social benefits are significant by securing and providing safe drinking water supply to the population of the existing and proposed service areas in Vientiane and its environs. The impact of the Project is also substantial to the economic activities of Vientiane in providing industrial water to the industrial estates located in the extended service areas.

CONCLUSIONS AND RECOMMENDATIONS

The Project is, it is concluded, appropriate to be implemented under the grant aid program by the Government of Japan through its executing agency, the Japan International Cooperation Agency.

The basic design team is cognizant of urgent necessity to reformulate the master plan for the Vientiane Water Supply System, since no study was conducted after the review of the current master plan in 1975, and the current master plan established in 1972 is apparently out of date.

1. Introduction

The Japan International Cooperation Agency (hereinafter called "JICA") of the Government of Japan fielded a basic design team to Vientiane, the Lao People's Democratic Republic (hereinafter called "Laos") under the technical assistance agreement between both Governments for the site investigation of the Improvement and Extension Project of the Vientiane Water Supply System (hereinafter called the "Project") from 16 January to 15 February 1983.

The purpose of the team was to examine and assess the present situation of Nam Papa Lao (Vientiane Water Supply System), identify technical problems, recommend the Governments the actions deemed appropriate and prepare the detailed program for rehabilitation and improvement of the water supply system.

This study and report were prepared in compliance with the terms of reference executed on 7 January 1983 between JICA and the team composed as follows:

Ministry of Foreign Affairs, Government of Japan

Mr. Minoru Ishida,	Team Leader

Japan International Coorporation Agency

Mr. Naoki Kai,	Project Co-ordinator

Nihon Suido Consultant Co., Ltd.

Mr. Hiroshi Shinohe,	Chief Engineer
Mr. Takeshi Sakai,	Water Supply Engineer
Mr. Yoshiro Murase,	Mechanical/Electrical Engineer

2. Background of the Project

2.1 Vientiane City

Vientiane City, the capital of Laos, is located at 18 N and 104 E occupies 5,300 ha on the left bank of the Mekong River. The City has generally flat topographical feature ranging from +165 to +180 meters from mean sea level. The City measures 4 km from north to south and 14 km from west to east.

The local climate is characterized by two recognized seasons, one wet season from May to October and one dry season from November to April. The annual precipitation ranges from 1,500 to 1,800 mm. The temperature varies between 10 and 40 degrees centigrade and averages 25 degrees centigrade.

The City is administratively divided into four districts: namely, Sykhottabong, Chanthaboury, Saysettha and Sysattanak districts; and 14 subdistricts. (See Fig. 2.1.) The City has a plan to expand its administrative area and the expansion plan is currently being studied. Although no decision has been made on the plan yet, there is no piped water supply in all of the areas under the plan.

Only 40 % or some 80 km of the roads measured 190 km in total is asphalted in Vientiane, and heavy vehicles are allowed only in the main streets of the City. Although the public transportation by buses is somewhat available, people mostly rely upon bicycles or tricycles in the City.

The electricity power supply is sufficient at present due to the completion of Num Gum Hydro Power Development Project. However, the power distribution network does not yet cover the entire area of the City.

Three trunk roads passing through the City connect the City with Louang Prabang, Savanna Khet, Thadua and Thanaleng. Importants industrial estates and governmental institutions are located along these road.

The City serves as the economic center of Laos for such activities as agricultural, forestry, commercial, and small-scale industries. Such industries include tobacco, chemical fertilizer, plywood, textile, beverages, soap, flour and rice mills are located in the enviorns of the City along the above trunk roads. Since 1975, most business in the private sector of the country have been replaced by that of the state-owned enterprises.

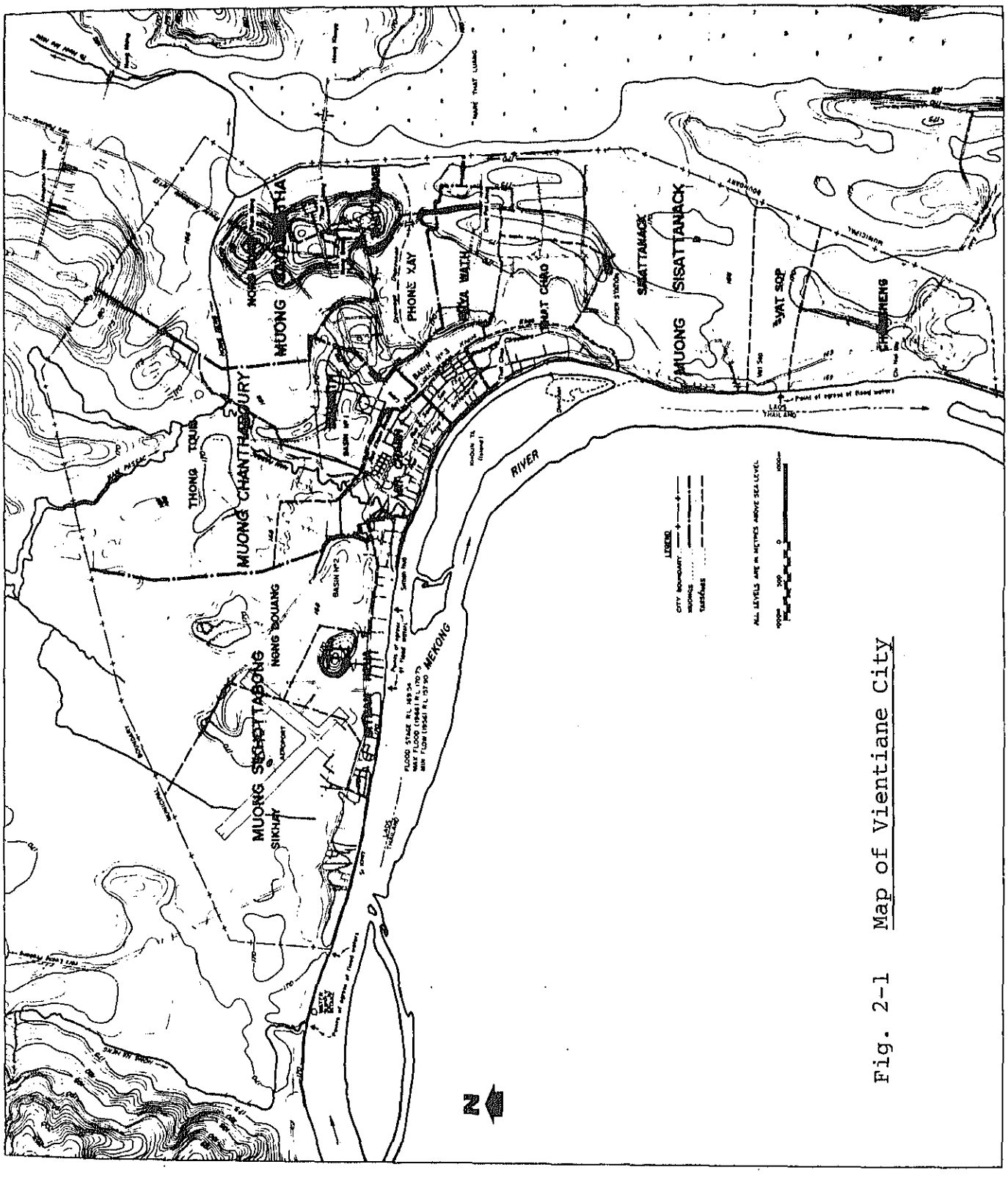
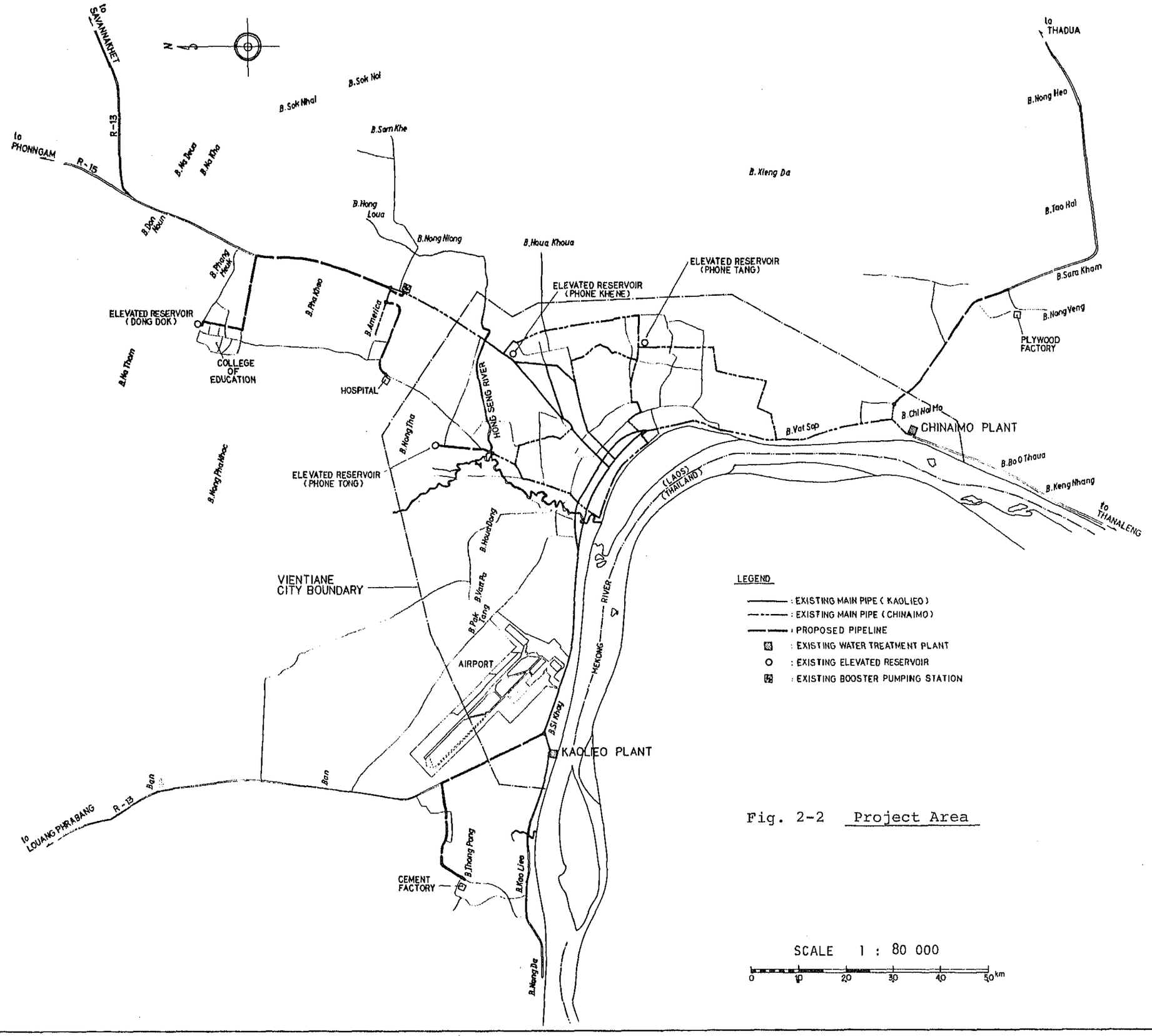


Fig. 2-1 Map of Vientiane City



LEGEND

- ——— : EXISTING MAIN PIPE (KAOLIEO)
- —·—·— : EXISTING MAIN PIPE (CHINAIMO)
- ——— : PROPOSED PIPELINE
- ▨ : EXISTING WATER TREATMENT PLANT
- ○ : EXISTING ELEVATED RESERVOIR
- ▨ : EXISTING BOOSTER PUMPING STATION

Fig. 2-2 Project Area

SCALE 1 : 80 000

0 10 20 30 40 50 km

2.2 Existing Water Supply System

The Vientiane Water Supply System consists of the Kaolieo and the Chinaimo Water Treatment Plants, the raw water intake facilities at the Mekong River, and the distribution networks including three elevated reservoirs: Phong Keng, Phone Tong, and Phone Tang reservoirs. Average daily production of the system is about 36,000 m3/day in 1982, while the current plant capacity is estimated as about 10,000 m3/day at the Kaolieo Plant and some 40,000 m3/day at the Chinaimo Plant respectively. Table 2-1 shows the monthly production records of the system in 1979, 1980 and 1982.

i) Water Source

The entire supply of water is derived from the Mekong River at the intake tower located near the Kaolieo Plant and at the intake bay of the Chinaimo Plant.

The minimum river flow is estimated as about 700 m3/sec at Wat Sop Station located about 2.5 km upstream of Chinaimo Treatment Plant. This estimate is in far excess of demand of the system.

The water level of the Mekong River considerably fluctuates:

- From January to April: about +160 m or less;
- From July to September: about +163 m or more; and
- Other period: approximately between +160 and +163 m.

Appendix-1 represents the record of water level of the Mekong River at Wat Sop from 1965 through 1982.

The raw water quality is acceptable for drinking water supply. The raw water temperature is about 19 degrees centigrade throughout the year. Turbidity of the River is high and peaks in July through October. Turbidity fluctuates with an apparent seasonal pattern. Alkalinity ranges from 70 to 100 ppm or more.

ii) Kaolieo Water Treatment Plant

The Kaolieo Water Treatment Plant, constructed in 1964 under the Japanese Government aid, was designed to supply the City with 20,000 m3/day but the current production is reduced to 11,000 m3/day due to insufficient maintenance services. The Plant is located on the left bank of the Mekong River, about 7 km upstream of the City center. (See Fig. 3-2 for the general plan of the Plant.)

TABLE 2-1 Supply Record of Vientiane Water Supply System

Month	Kaolieo Plant		Chimaimo Plant		Total	
	m3/month	m3/day	m3/month	m3/day	m3/month	m3/day
SEP/1979	578,510	19,280	-	-	578,510	19,280
OCT	575,300	18,560	-	-	575,300	18,560
NOV	589,980	19,670	-	-	589,980	19,670
DEC	594,250	19,670	-	-	594,250	19,670
JAN/1980	566,340	18,270	-	-	566,340	18,270
FEB	562,260	20,080	-	-	562,260	20,080
MAR	561,490	18,110	-	-	561,490	18,110
APR	615,960	20,530	-	-	615,960	20,530
MAY	581,820	18,770	-	-	581,820	18,770
JUN	615,370	20,510	-	-	615,370	20,510
JUL	597,110	19,260	-	-	597,110	19,260
AUG	551,350	17,790	-	-	551,350	17,790
JAN/1982	341,640	11,020	503,930	16,260	845,570	27,280
FEB	423,540	15,130	623,480	22,270	1,047,020	37,400
MAR	477,240	15,390	567,550	18,310	1,044,790	33,700
APR	445,270	14,840	733,590	24,450	1,178,860	39,290
MAY	410,210	13,230	802,800	25,900	1,213,010	39,130
JUN	400,760	13,360	820,940	27,360	1,221,700	40,720
JUL	295,500	9,530	914,790	29,510	1,210,290	39,040
AUG	315,950	10,190	789,240	25,460	1,105,190	35,650
SEP	207,600	6,920	845,210	28,170	1,052,810	35,090
OCT	311,880	10,060	743,140	23,970	1,055,020	34,030
NOV	319,180	10,640	794,270	26,480	1,113,450	37,120
DEC	167,230	5,390	856,850	27,640	1,024,080	33,030
1982 Annual Production (m3/year)	4,116,000		8,995,790		13,111,790	
1982 Average Daily Production (m3/day)	11,280		24,650		35,930	

The Plant comprises the following:

- Raw water intake tower including 3 intake pumps, a raw water transmission main and a flow meter (500 mm in dia.);
- Mixing basin;
- 2 flocculation and sedimentation basins;
- 4 rapid sand filters;
- Chemical feeding facilities (alum and hypochlorite);
- Clear water distribution facilities consisting:
  - . 2 clear water reservoirs
  - . 4 distribution pumps

Since Plant was so designed to operate on manual basis, the existing instrumentation equipment was provided at the minimum level.

The system operates as follows:

Raw water is abstracted from the Mekong River by 3 vertical turbine pumps in the intake tower and conveyed to the mixing basin through the ϕ500 mm raw water transmission main. After the dose of alum at the mixing basin, water flows into two flocculation basins and then to two sedimentation basins for coagulation and settling. Clarified water is roughed out by gravel filters equipped to the end of the sedimentation basins. Water is, then, filtered through four rapid sand filters at 122 m/day in average rate. Filtered water is disinfected by hypochlorite solution and stored in the reservoirs (4,000 m3 in total capacity). Finished water is metered and pumped to the distribution networks through ϕ450 mm distribution main.

The current problems of the Plant are, among others, malfunctioning water treatment equipment, the erosion of the bank and riverbed, cracks on reinforced concrete walls, and the drainage in the rainy season.

The present conditions of the treatment equipment is discussed in Chapter 3 and recommendations for rehabilitation and improvement of equipment is presented in the same chapter.

The bank protection is in urgent need. Since there is no protection of the bank near the Plant, the bank erosion by river flow is advancing to almost the perimeter of the Plant. Unless proper protection is provided, some facilities of the Plant will be destroyed by the progressive bank erosion. The details of the protection work will be discussed in Chapter 5.

Many cracks in various depth and length are observed on walls of reinforced concrete structures of the Plant. Particularly the sedimentation basins and the connection channel from the basins to the filters show a lot of cracks. Although cracks hardly cause serious obstacle to treatment, repair work is needed.

The office and the Laboratory are always flooded during the rainy season because of the elevation of the building and insufficient drainage facilities. The countermeasures are discussed in section 5.

Table 2-1 shows the production record of the Kaolieo and Chinaimo Treatment Plants.

iii) Chinaimo Water Treatment Plant

The Chinaimo Plant was completed in 1980 under the financial assistance by the Asian Development Bank (hereinafter called "ADB"). The current production of the Plant is contained to the level of about 30,000 m3/day, while the designed capacity is 40,000 m3/day. The difference is due to the lack of storage capacity of the distribution system to meet the peak demand. The Plant is located on the left bank of the Mekong River, about 7.5 km downstream of the City center.

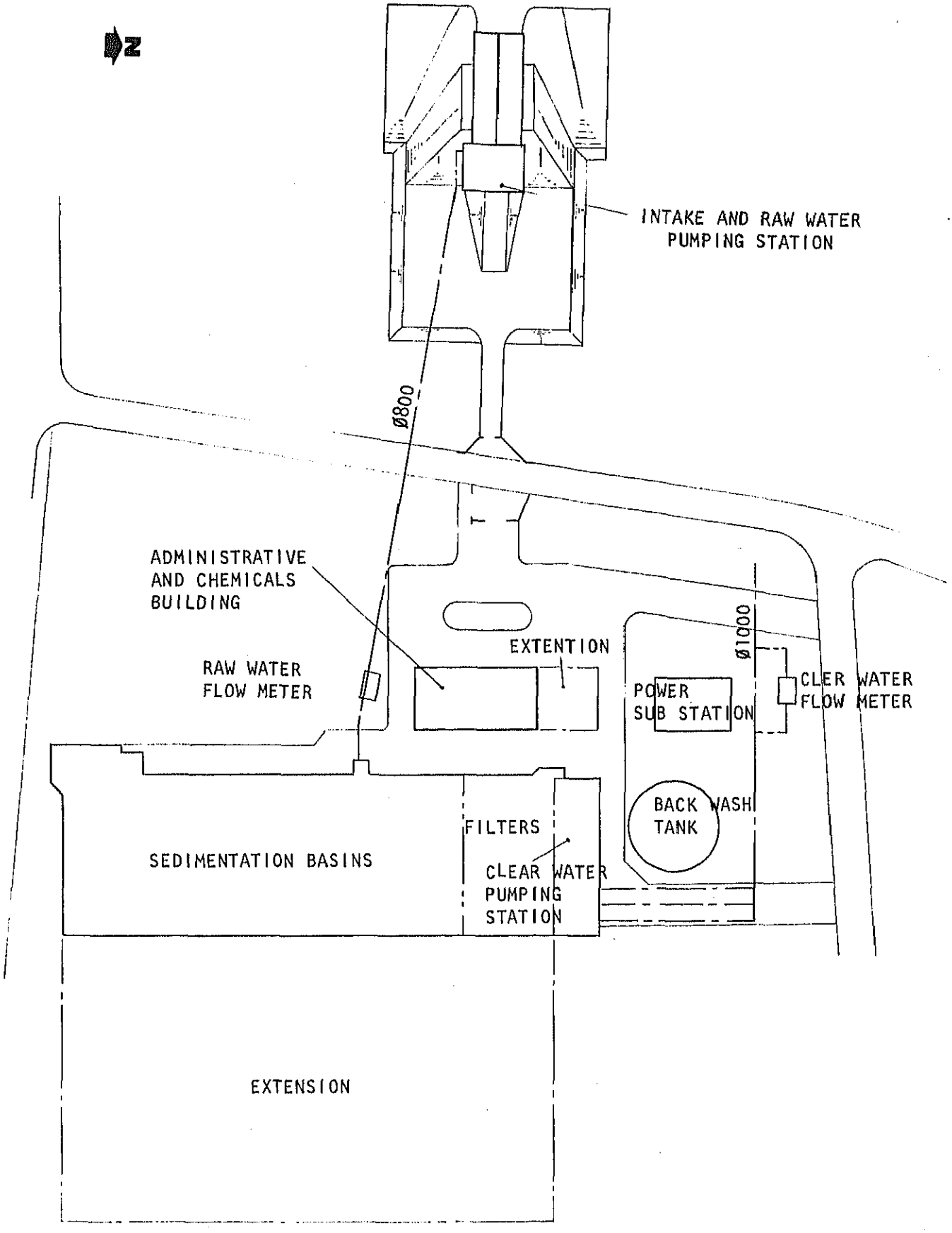
The Plant comprises the following:

- Raw water intake bay;
- Raw water pump well including 3 intake pumps;
- Raw water transmission main with a flow meter (800 mm in dia.);
- Treatment facilities consisting of:
  - . Receiving well;
  - . 2 mixing basins;
  - . 2 flocculation and sedimentation basins;
  - . 4 rapid sand filters; and
  - . Chemical feeding facilities.
- Distribution facilities including:
  - . Clear water reservoir;
  - . Clear water pump well; and
  - . 3 distribution pumps.

The treatment processes of the Plant are as follows:

Raw water is taken from the Mekong River by 3 pumps at the intake bay and transmitted to the receiving well through the ϕ800 mm raw water transmission main. Water is then conveyed by raw water transmission conduit to the mixing basins, where coagulant, alum is fed.

Fig. 2-3 General Layout of The Chinaimo Treatment Plant



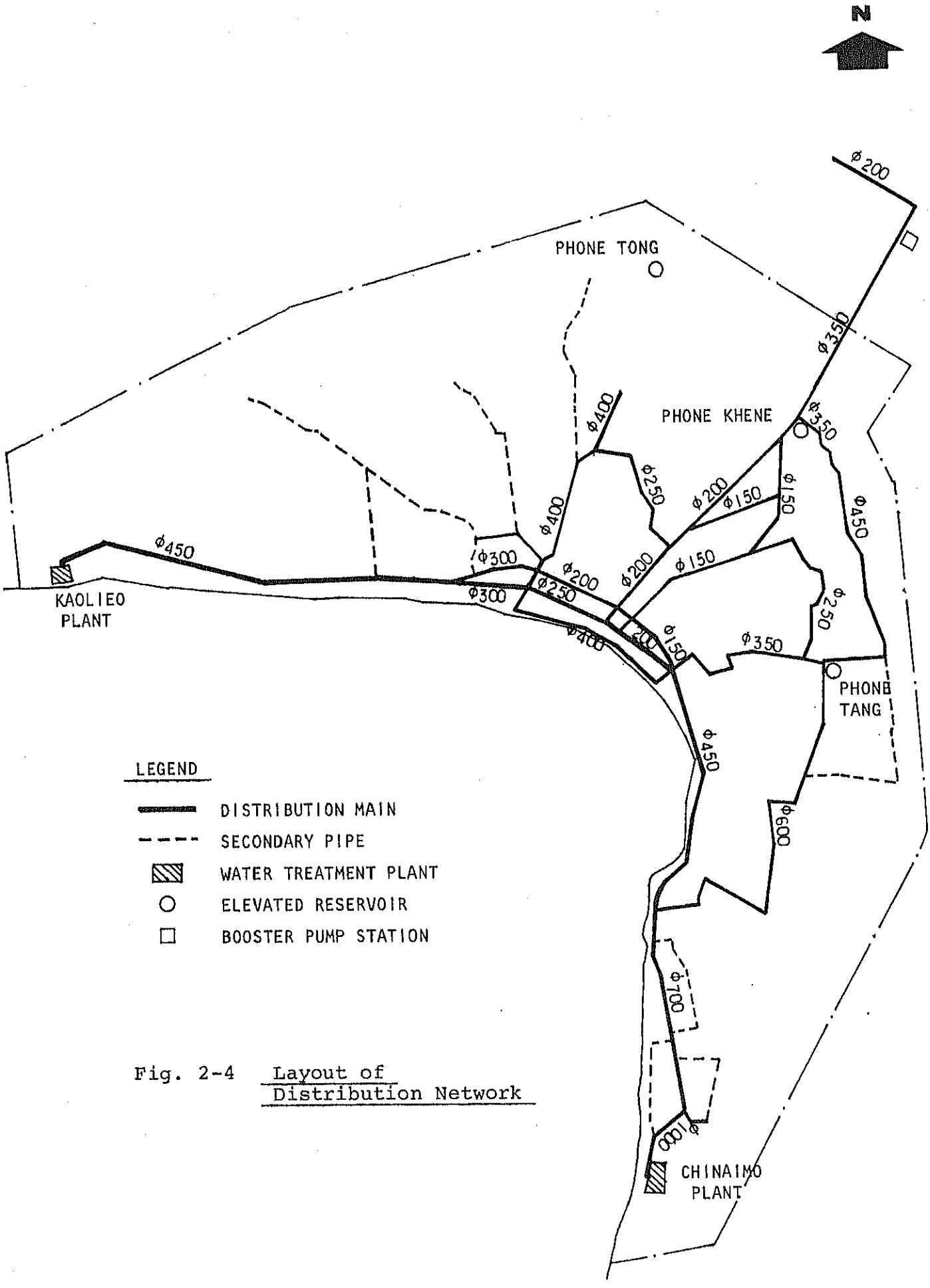


Fig. 2-4 Layout of Distribution Network

Table 2-2 Distribution Main of Vientiane Water Supply System

Diameter (mm)	Length (km)	Material	Installed
1,000	0.51	SP	1980
700	2.52	SP	1980
600	4.26	SP	1980
450	4.44	DIP	1964
	6.98	SP	1980
Sub-total	11.42		
400	4.98	SP	1980
350	3.98	SP	1980
300	1.87	CIP	1964
250	1.19	CIP	1964
	3.90	ACP	1980
Sub-total	5.09		
200	6.99	CIP	1964
	2.39	DIP	1973
	1.13	ACP	1980
Sub-total	10.51		
150	14.67	CIP	1964
	1.97	DIP	1973
	5.12	PVC	1973
	3.92	ACP	1980
Sub-total	25.68		
100	7.02	CIP	1964
	2.05	GI	1971
	4.51	PVC	1973
	6.20	ACP	1980
Sub-total	19.78		
75	11.47	CIP	1964
	9.15	GI	1971
	9.33	ACP	1980
Sub-total	29.95		
Total Length	120.55		

Notes: DIP: Ductile Iron ACP: Asbestos Cement
CIP: Cast Iron PVC: Polyvinyl Chloride
SP : Steel GI : Galvanized Steel

Coagulation and settling are achieved in two flocculation basins and two sedimentation basins. Clarified water is filtered through rapid sand filters at 130 m/day in average rate. After disinfection by hypochlorite solution, finished water is stored in the reservoirs and is supplied to the distribution networks by 3 pumps and ϕ1,000 mm distribution main.

After the commissioning in 1980, the Plant has been in successful operation.

iv) Distribution System

About 120 km of water mains (75 mm in dia. and above) are laid in the service area. Table 2-2 shows the breakdown of mains by diameter and material. Refer to Fig. 2-4 for the layout of the networks. Pipe material is steel and cast iron for 300 mm in dia. or above, and asbestos and polyvinylchloride for 250 mm in dia. or below.

According to NPP, water supply conditions have been improved after commissioning the Chinaimo Treatment Plant and reinforcement of distribution mains, as far as the present service area is concerned. There are, however, a number of areas adjacent to the served area where various establishments have been built and potable water is urgently needed.

On the other hand, commissioning of the Chinaimo Plant increased unaccounted-for water to about 40 % as estimated in 1982, while the 1973 estimate was as low as 26 %. This percentage is due to the increased leakage and wastage from the obsolete distribution mains and service connections caused by increased supply pressure throughout the service area.

The present storage capacity of the system is about 7,000 m3 including the reservoirs in the Plants: 4,000 m3 in Kaolieo and 1,000 m3 in Chinaimo. Two elevated reservoirs of 1,500 m3 each are currently under construction. The total storage capacity, therefore, will be about 10,000 m3 after the completion of the construction work in March 1983. The capacity of 10,000 m3 is considered sufficient to meet the peak demand of the service area.

v) Service Connections

NPP keeps metering system of every service connection and charges customers on a quantity basis. No public hydrant is currently practiced in the service area. The number of registered service connections totaled to 11,040 at the end of 1982.

The registration record of service connections is shown below:

Table 2-3 Registered Service Connections

Year	No. of Registered Service Connections
1977	5,450
1978	7,560
1979	8,120
1980	8,920
1981	9,890
1982	11,040

No data is available on breakdown by categolies of customers such as domestic, commercial/industrial, and institutional.

2.3 Population and Water Demand

1) Population

The Vientiane city held the population of approximately 185,000 in 1982, while the proposed extended service area is estimated to have 60,000 population in 1982. The populations are estimated to increase 227,000 and 74,000 respectively and total to 301,000 by 1990.

As the basic information for population estimate, population census data of the Vientiane City are available for 1964 and 1973. In addition, recent population data also available for 1981 and 1982 which are estimated by the City office. However, no population data between the above two periods was obtained during the survey period.

Considering the political and economic stability of the country, the City office is estimating the annual population increase up to 1990 at 2.6 percent. Afterward, the tentative estimate of the growth rate shows gradual increase to 3.5 percent per annum by the year 2000. This rate is almost same as experienced between 1964 and 1973 in Vientiane City.

On the other hand, the Vientiane City is planning to extend its boundary as mentioned in the previous section. Some 60,000 of population will be added to the present population in 1982 on the assumption that the areas shown in Fig. 2.2 include the additional extension area of the Vientiane City. The 1982 population of the additional area is estimated by household counting based on the photomap prepared in 1968 with the population growth rate discussed above. Table 2.4 shows the population projection of the Vientiane City including the additional extension area.

2) Population Served

The present population served is estimated by NPP as about 90,000, which was derived from the numbers of service connections and average number of consumers per connection. Average consumers per connection was obtained from the sample survey done by NPP in 1982. Past population served is also estimated on the same basis and the result is shown in Table 2-5.

The future population served is projected as shown in Table 2-5 on the following assumptions:

a. The service ratio of the present Vientiane City will be increased gradually from the present ratio of about 49 percent to 90 percent by 2000.

b. The service ratio of the additional extension area will be 23 percent in 1985 and will gradually increase to 80 percent by the year of 2000.

   The estimated service ratio of 23 percent was derived from the population in the area along the trunk roads and proposed the served area by the Project.

Table 2-4 Past Population Trend and Future Population Projection, Vientiane

Year	Present City Area	Extension Area	Total	Annual Growth Rate (%)
1964	132,253	-	132,253	-
1973	179,000	-	179,000	3.4
1981	181,000	-	181,000	0.1
1982	185,000	(60,000)	185,000	2.2
1985	200,000	65,000	265,000	2.6
1990	227,000	74,000	301,000	2.6
1995	263,000	86,000	349,000	3.0
2000	312,000	102,000	414,000	3.5

Table 2-5 Past Population Served and Projected Population Served
(In 1,000)

Year	Total Population			Population Served			Service Ratio (%)		
	Present City Area	Extension Area	Total	Present City Area	Extension Area	Total	Present City Area	Extension Area	Average
1977	179	-	179	44	-	44	25	-	25
1978	180	-	180	60	-	60	33	-	33
1979	180	-	180	65	-	65	36	-	36
1980	180	-	180	71	-	71	39	-	39
1981	181	-	181	79	-	79	44	-	44
1982	185	(60)	185	90	-	90	49	-	49
1985	200	65	265	112	15	127	56	23	48
1990	227	74	301	159	26	185	70	35	61
1995	263	86	349	210	43	253	80	50	72
2000	312	102	414	281	82	363	90	80	88

3) Water Demand Projection

The water demand is projected as the sum of net consumption by domestic and non-domestic users, and unaccounted-for water. The domestic consumption is projected on the basis of the population served and net per capita consumption, while non-domestic consumption is projected on the basis of the unit consumption by category.

Non-domestic users are categolized as commercial, industrial, hospital, school, institutional and governmental users. However, breakdown of water consumption by each category of non-domestic users was not available during the survey period. Thus, average per capita consumption (total consumption divided by population served) is applied for the base of the estimation for the future water demand.

Unaccounted-for water consists of such as leakage, wastage, and unauthorized connections. Some 40 percent of unaccounted-for water is estimated at present according to the information from NPP. It is projected that unaccounted-for water will be reduced gradually to 10 percent by the year of 2000 by the effort of NPP implementing leakage and wastage control.

Present average per capita consumption is estimated as about 240 lpcd. It is expected to increase gradually to 280 lpcd by the year 2000. Also, the average per capital consumption of the additional extension area is estimated as 150 lpcd at present and to increase to 280 lpcd by 2000 considering the current trend of urbanization in the area. Table 2-6 shows projected average per capita consumption for every five year up to the year 2000.

Water demand in the future of the Vientiane City is, thus obtained and presented in Table 2-7.

2.4 Identification and Justification of the Project

The country has been steadily recovering from the chaotic condition after the government reform in 1975. However, the reconstruction of the Vientiane City is still retarded because of the Government's financial constraint.

One of the most essential infrastructure of which development are urgently needed, is water supply of the City which provides the citizens with drinking water and the industries with water essential for their operation and production. In Vientiane where all the important establishments are centered, water supply is the more important and its construction is urgent.

In this connection, the Lao Government requested the Government of Japan to extend its financial assistance (a grant aid) in 1982, for construction of two elevated reservoirs. The construction work of the reservoirs is currently in progress and scheduled to be completed in March 1983.

Table 2-6 Average Per Capita Consumption

Year	Per Capita Consumption		Unaccounted-for Water	
	Present City Area (lpcd)	Extension Area (lpcd)	Present City Area (%)	Extension Area (%)
1982	240	150	40	10
1985	250	170	35	10
1990	260	200	25	10
1995	270	230	15	10
2000	280	280	10	10

Table 2-7 Water Demand Projection, Vientiane

Year	Present City Area				Extension Area				Day Maximum Water Demand ('000 m3)
	Population Served ('000)	* (lpcd)	Unaccounted-for Water (%)	Day Ave. Demand ('000 m3)	Population Served ('000)	* (lpcd)	Unaccounted-for Water (%)	Day Ave. Demand ('000 m3)	
1982	90	240	40	36.0	-	-	-	-	40.7
1985	112	250	35	43.1	15	170	10	2.8	52.8
1990	159	260	25	55.1	26	200	10	5.8	70.0
1995	210	270	15	66.7	43	230	10	11.0	89.4
2000	281	280	10	87.4	82	280	10	25.5	129.8

Day Maximum Water Demand = 1.15 x Day Average Water Demand

* Per Capita Consumption

This undertaking is, without saying, most beneficial for the public in terms of the supply conditions. However, further problems have arisen such as the deterioration of the Kaolieo Plant and unserved population in the surrounding areas of the City. The Government, however, is still in the same financial condition as the first request was made one year earlier. Hence the present request of economic assistance has been made to the Government of Japan.

1) Identification of the Project

The water demand of the Vientiane City will reach about 53,000 and 70,000 m3/day by the year of 1985 and 1990 respectively. On the other hand, the current production capacity of the Vientiane Water Supply System is estimated as approx. 50,000 m3/day in total (Kaolieo: 10,000 m3/day, Chinaimo: 40,000 m3/day), while the rated capacity of the Kaolieo Plant was 20,000 m3/day and the total design capacity of the system was 60,000 m3/day.

This deficiency at the Kaolioe Plant is due to the lack of proper maintenance over the last two decades because of difficulties to replace damaged or worn out equipment. The present condition of the Plant is threatening stoppage, partial or whole, of the operation of the Plant at any moment. In addition, the bank the Plant bounds and the riverbed around the intake tower have progressively been eroded and scoured by floods, and it is feared that part of the treatment facilities and the intake tower might be washed away by floods. All these require some immediate remedial measures to be taken.

Most of the industrial enterprises and some of institutions are located outside of the present city boundary and mainly along the trunk roads mentioned in the previous section. They use ground-water taken from shallow wells and suffering from the inadequate water quality and shortage of water during dry season. The areas are Dong Dok and Dong Noun located along route 13 at the north-west of the City, Tadua Road area located at the south-west of the City and Thong Pong area located along route 13 at the north-east of the City. In addition, in Phone Tong area, a hospital is under construction and some industrial enterprises are planned to be established by the Government together with housing for the above staff and their families. This area is located at the vicinity of the north-west boundary of the City where no water supply pipe is installed.

Water supply for the above mentioned areas is urgently required for industrial and institutional usage together with domestic use for nearby villages.

The project required urgently thus identified and summarized as follows:

a) Rehabilitation and Improvement of the mechanical and electrical equipment of the Kaolieo Treatment Plant;

b) Bank and riverbed protection work for the intake site of the Kaolieo Treatment Plant; and

c) The extension work of distribution mains for the following areas:

    1. Dong Dok area

    2. Phone Tong area

    3. Thadua Road area

    4. Thong Pong area

Further detailed discussions on the above project will be made in the following chapter "Description of the Project."

2) Need for Grant Aid

The Kaolieo Plant was constructed as a grant aid by the Government of Japan in 1964. On the other hand, the Chinaimo Plant was constructed by financing of ADB. The ADB-financed project included all facilities from the intake at Chinaimo through distribution facilities, but due to the acute price hike after the consecutive energy crises, elevated reservoirs and a large portion of distribution mains were inevitably cut off the construction program. Under such circumstances, the construction of two elevated reservoirs have been granted by the Government of Japan.

The social conditions in Vientiane have gradually been stabilized since the governmental reform of Laos, and water demand has been steadily increasing, whereas the productin of the Kaolieo Plant is declining due to the previously described reasons, as well as the production of the Chinaimo Plant has so far been curtailed due to the lack of reservoirs.

Presently, NPP is financially self-supporting owing to the improved social conditions and the resulting increase of consumption and revenue, but NPP still remains in the condition where it cannot afford to generate own funds required for implementation of the proposed project. Moreover the scheduled debt service of NPP will be a financial burden to NPP; the grace period of the ADB loan will soon terminate and the repayment will be subsequently started. The team therefore recommends that NPP request an external aid on grant basis to improve the aforementioned crucial situation.

3. Description of the Project

The Project is aimed at rehabilitating and improving the Kaolieo Plant to recover its rated capacity of 20,000 m3/day, providing bank and riverbed protection at the intake site, and extending the distribution pipelines to the environs of the Vientiane City, which are currently located outside the City administrative area.

The future daily maximum demands are estimated as 53,000 m3/day in 1985 and 70,000 m3/day in 1990 respectively. As regards the capacities of the Plants, the rated capacity is 60,000 m3/day with the Chinaimo Plant of 40,000 m3/day and the Kaolieo Plant of 20,000 m3/day. As described earlier, the maximum production of the Kaolieo Plant is currently about 10,000 m3/day but it can be restored to its original designed capacity of 20,000 m3/day by rehabilitation of all deteriorated equipment. This capacity of 60,000 m3/day can meet the daily maximum demand until 1987, which is 3 years earlier than the reservoirs and the distribution mains are fully loaded to their capacities. Therefore some counter-measures must be considered in the near future, such as an expansion of any of the Plants, or regulation of water distribution.

On the other hand, the existing distribution system is capable to deliver 70,000 m3/day as the daily maximum demand to the present served area and the commencement of operation of the two elevated reservoirs will enable the existing distribution system to meet the peak demand until 1990. However the demand of water supply is acute in the nearby areas of the present served area, since such areas hold industries and governmental institutions and are significant in the economic development of the country. Therefore, the extension of the distribution pipelines will be undertaken considering the trend of urbanization in the proposed areas.

The bank and the riverbed around the intake site is to be protected by gabions and by riprapping respectively. Such protection work is urgently needed since some of the water treatment facilities are endangered by advancing bank erosion. The river flow also scours the riverbed around the intake tower.

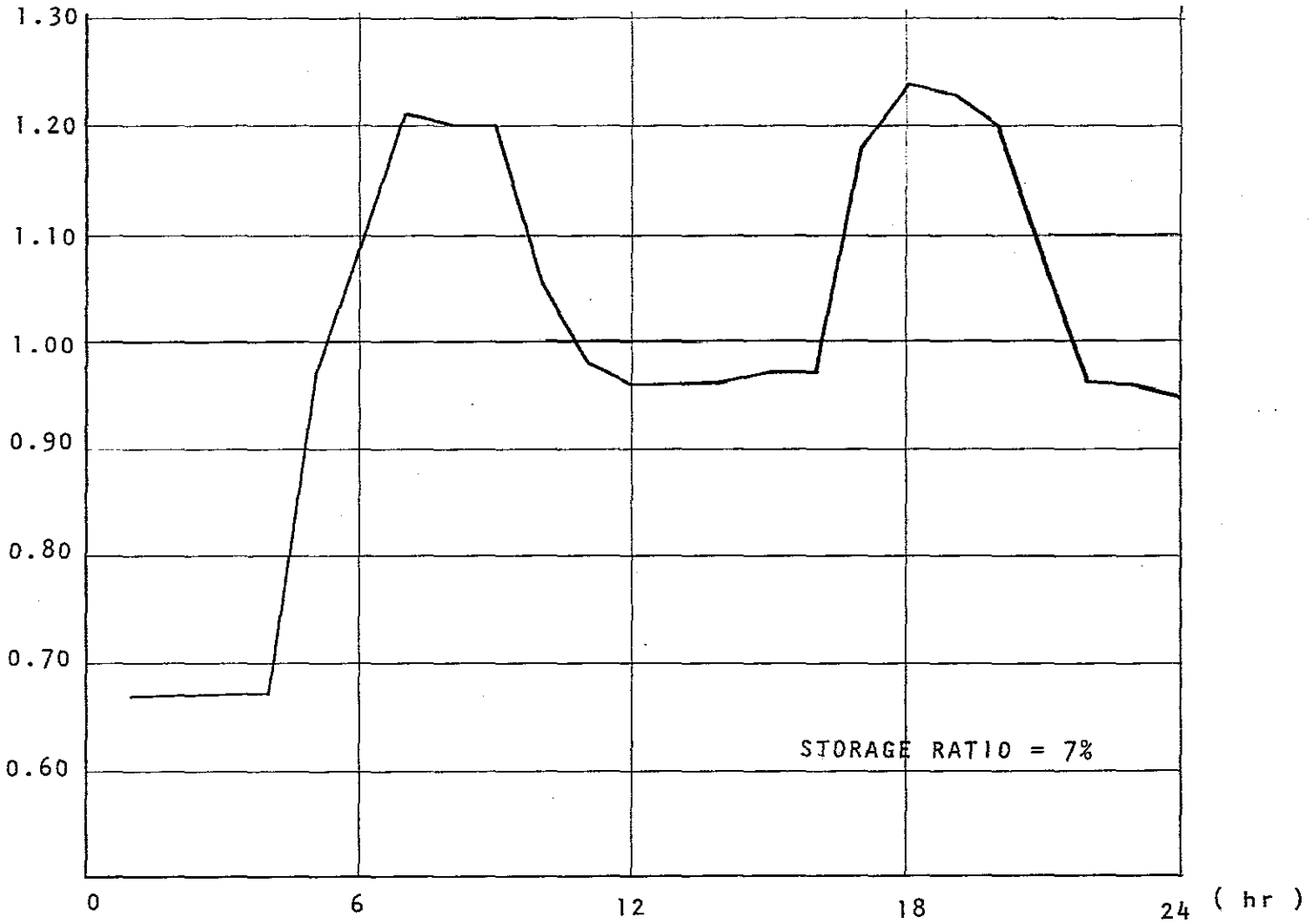


Fig. 3-1 Present Hourly Consumption Curve

3.1 Rehabilitation and Improvement of the Kaolieo Treatment Plant

1) Existing Facilities

The Kaolieo Treatment Plant consists of the intake facilities, the treatment facilities, the distribution facilities and the buildings such as the office, the laboratory, the pump house and warehouses. Major facilities and equipment of the Plant and the present conditions are described in detail in this section. The general layout is shown on Fig. 3-2 and its hydraulic profile is also shown on Fig. 3-3.

The intake facilities consists of an intake tower, an intake pump house, three intake pumps, Ø500 mm transmission pipe with flow meter (orifice plate), an inspection bridge and other miscellaneous appurtenances. Capacity of the intake facilities was designed at 22,000 m3/day and designed water levels are +171.50 and +159.50 as high and low water levels respectively.

The treatment facilities was designed in a conventional type with designed capacity of 22,000 m3/day including 2,000 m3/day for plant operation use, consisting of a mixing basin, two units of flocculation and sedimentation basins, two units of gravel filters and four rapid sand filters. Water flows by gravity from the mixing basin to the reservoir, of which water levels are +176.00 and +170.60 respectively. The gravel filter is of upflow type and located at the outlet of each sedimentation basin which supplements the filtration especially during high turbid period of raw water to avoid the heavy load on the rapid sand filter.

Distribution facilities consists of the clear water reservoir, four distribution pumps and Ø450 mm distribution main with a flow meter (venturi tube). Filtered water is stored in the reservoir after disinfection and distributed by the pumps through Ø450 mm of distribution main. The total rated capacity of pumps is 27,000 m3/day.

Alum and Hypochlorite are presently used for coagulation and Hypochlorite is for disinfection, respectively.

The electric equipment consists of power sub-station, motor control panels for pumps and other mechanical equipment, lighting and instrumentation. Capacity of the power sub-station is 750 kVA at 15 kV, at which the National Power Company supplies power to the plant through the company's transformer from 22 kV power line. After the completion of the Num Gum Power Development Project, 22 kV high voltage supply is practiced instead of 15 kV supply.

15 kV is dropped to 380/220 V through the main transformer at the power sub-station.

There are 8 buildings in the Plant which include an office, a laboratory, a distribution pump house, an electric room, four warehouses, and a hall. The office and the laboratory are in the same building.

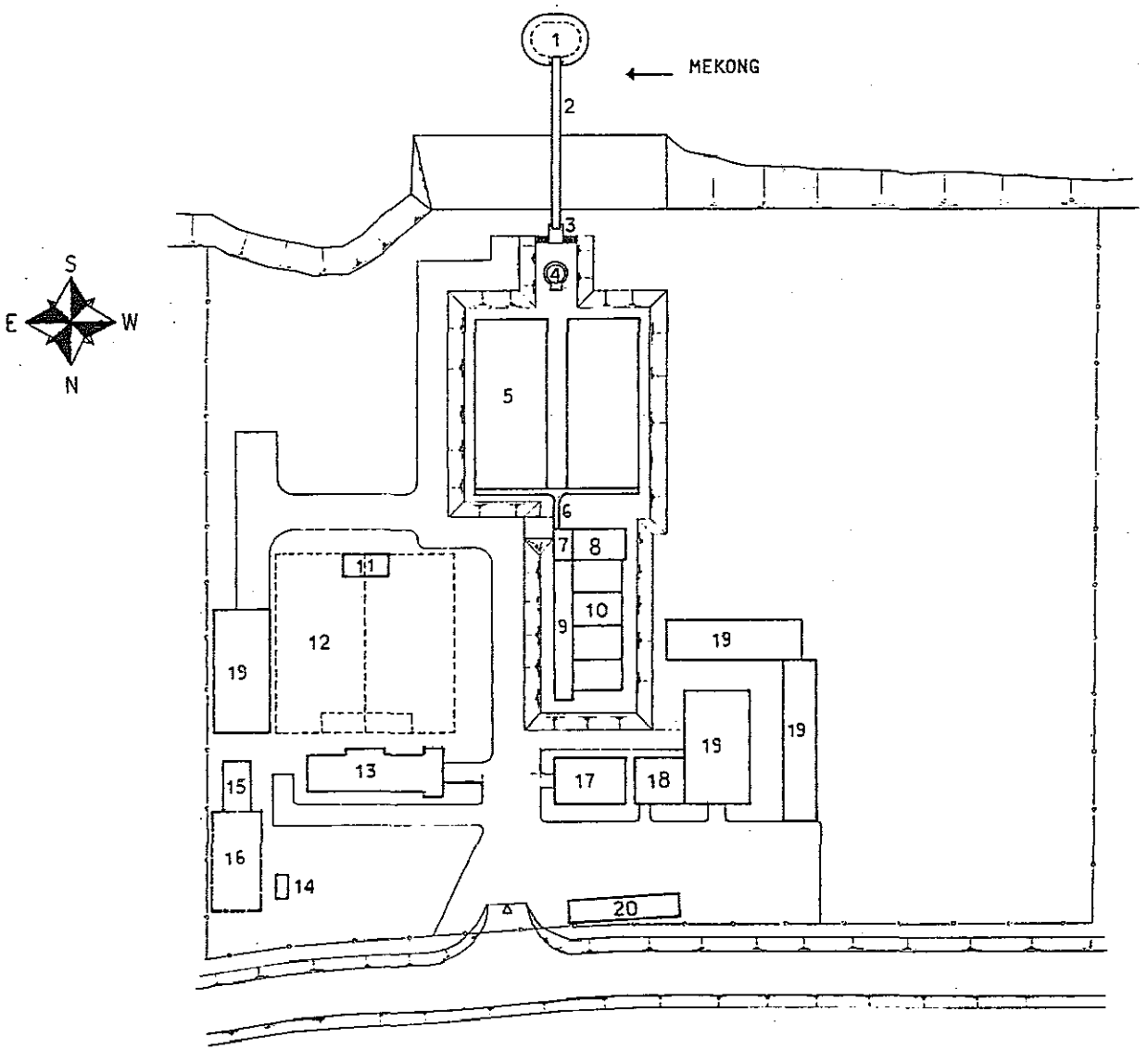
The results of the site investigation on the facilities and equipment of the Kaolieo Plant is listed in Appendix -3.

2) Rehabilitation and Improvement of the Kaolieo Treatment Plant

The Plant has been operating for about 20 years from 1965 and most of mechanical and electrical equipment have reduced their functions and some of them are out of order. Almost all of the instrumentation equipment especially are in no working condition, causes the difficulty of the proper plant operation.

Accordingly, actual production has reduced to about a half of the rated capacity and the plant operation is not satisfactory. However, almost all structures such as the Intake Tower, Basins and Buildings are still in function except minor defect.

Table 3-1 shows the summary of the improvement measures of major facilities/equipment based on the site investigation.



1 INTAKE TOWER
2 INSPECTION BRIDGE (RAW WATER TRANSMISSION PIPE)
3 RAW WATER FLOW METER
4 MIXING BASIN
5 FLOCCULATION AND SEDIMENTATION BASIN
6 CLARIFIED WATER CONDUIT
7 CONTROL CENTER/ALUM STORAGE
8 ALUM FEEDING ROOM/STORAGE
9 FILTER OPERATION GALLERY
10 FILTER
11 CHLORINATION ROOM
12 CLEAR WATER RESERVOIR
13 DISTRIBUTION PUMP HOUSE
14 DISTRIBUTION FLOW METER
15 ELECTRIC ROOM
16 POWER SUBSTATION
17 OFFICE AND LABORATORY
18 HALL
19 STORAGE
20 GARAGE

Fig. 3-2 General Layout of The Kaolieo Treatment Plant

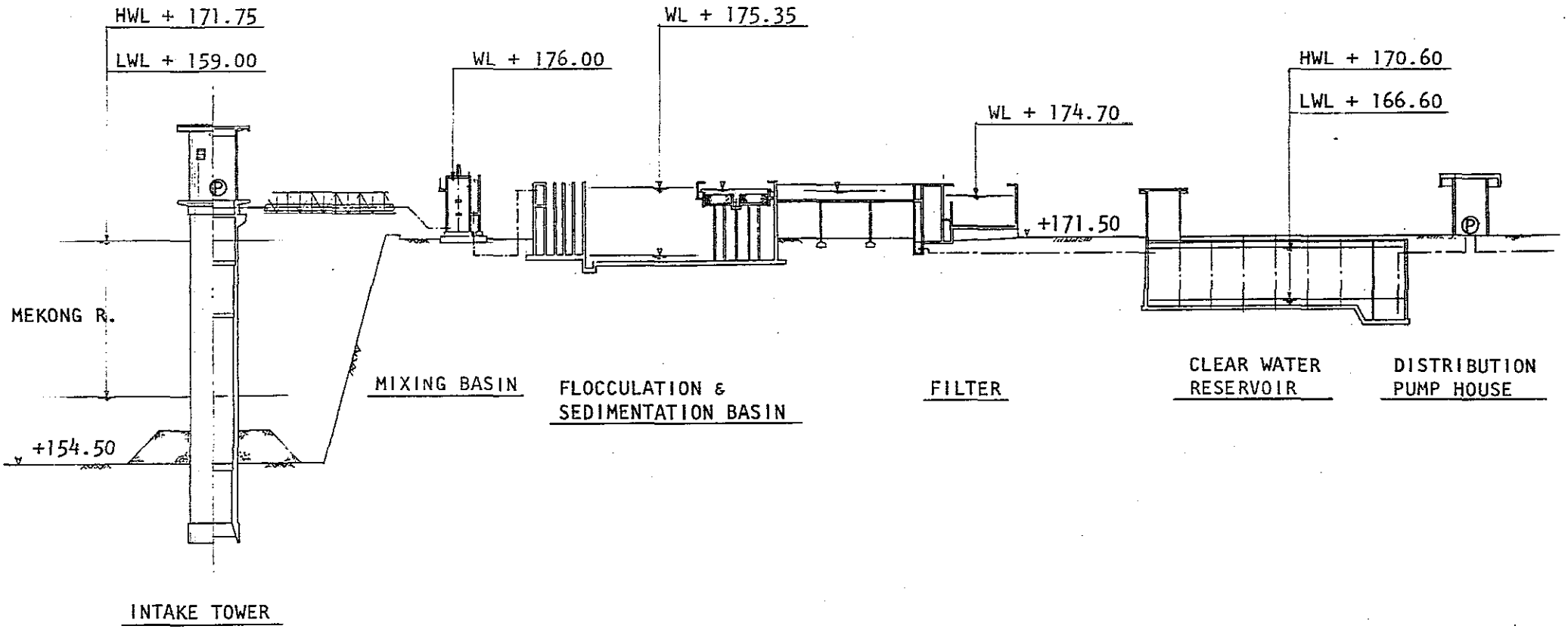


Fig. 3-3 Hydraulic Profile of The Kaolieo Treatment Plant

Table 3-1 Measures of Facilities/Equipment of the Kaolieo Treatment Plant

Facilities/Equipment	Qty	Measures
A. Intake Facilities		
Intake Tower		
Structure (R.C.)	1	--
Influent Gate (Ø700mm)	3	two gates located lower place to be replaced
Drain Pump	1	--
Chain Blocks	2	--
Intake Pump		
Pump (Ø250mm x Q7.65 x H19.5 x 37 kW)	3	to be replaced
Check Valve (Ø250mm)	3	to be replaced
Gate Valve (Ø250mm)	3	to be replaced
Pipe Support (steel)	1	to be replaced
Delivery Pipes (S.P.)	1	to be replaced
Pump House		
Structure (R.C.)	1	--
Transmission Pipe		
Pipe (Ø500mm x L30m)	1	exterior surfaces to be painted
Orifice Plate (Ø500mm)	1	to be replaced
Flow Controller (Ø500mm)	1	to be insta-led newly
Inspection Bridge		
Structure (steel)	1	all ferrous surfaces to be painted
B. TREATMENT FACILITIES		
Mixing Basin		
Structure (R.C.)	1	--
Flash Mixer	1	mixer and hatch way cover to be replaced
Flocculation Basin		
Structure (R.C.)	2	leakage to be repaired

Facilities/Equipment	Qty	Measures
Sedimentation Basin		
Structure (R.C.)	2	leakage to be repaired
Overflow Pipe (Ø150mm)	4	leakage to be repaired
Gravel Filter		
Structure (R.C.)	2	--
Washing Pipe (Ø150mm)	4	leakage to be repaired
Clarified Water Conduit		
Structure (R.C.)	1	leakage to be repaired
Rapid Sand Filter		
Structure (R.C.)	4	leakage to be repaired
Controller (Ø250mm)	4	to be replaced
Manometer (float type)	4	to be replaced
Washwater Trough (B400 x H600mm, steel)	8	to be replaced
Washwater Drain Pipe	1	capacity of pipe to be increased
Pipes		
influent pipe (Ø300mm)	4	--
filtered pipe (Ø250mm)	4	outlet to be raised
backwash pipe (Ø400mm)	4	--
surfacewash pipe (Ø200mm)	4	leakage to be repaired
washwater drain pipe (Ø450mm)	8	--
drain pipe (Ø100-0/600)		--
overflow pipe (Ø200mm)	4	--
Valves		
influent valve (Ø300mm)	4	--
filtered valve (Ø250mm)	4	leakage from grand to be repaired
backwash valve (Ø400mm)	4	leakage from grand to be repaired
surfacewash valve (Ø200mm)	4	--
washwater drain valve (Ø450mm)	8	--
drain valve (Ø100mm)	4	--
Operation Gallery	1	defect of roof to be repaired
Inspection Passage	1	to be replaced
Backwash Controller (Ø450mm)	1	to be installed newly on the existing backwash main
Surfacewash Controller (Ø200mm)	1	to be installed newly on the existing surfacewash main

Facilities/Equipment	Qty	Measures
C. DISTRIBUTION FACILITIES		
Clear Water Reservoir		
Structure (R.C.)	2	--
Valves		
gate valve (Ø350mm)	4	two valves to be replaced and the rest valves to be abandoned
gate valve (Ø300mm)	8	to be replaced
Water Level oeter (float type)	2	to be replaced
Ventulator	1	to be replaced
Distribution Pump		
Pump (Ø200mm x Q6.3 x H67 x 110 kW)	4	to be replaced
Suction Pipe (Ø250mm)	4	--
Delivery Pipe (Ø200mm)	4	to be replaced
Foot Valve (Ø250mm)	4	to be replaced by bell mouth
Check Valve (Ø200mm)	4	to be replaced
Gate Valve (Ø200mm)	4	to be replaced
Backwash Pump		
Pump (Ø350 x Q14.5 x H16 x 60 kW)	2	to be replaced and additional one pump to be installed
Suction Pipe (Ø350mm)	2	pipe for additional pump to be installed
Delivery Pipe (Ø350mm)	2	to be replaced and pipe for additional pump to be installed
Foot Valve (Ø350mm)	2	to be replaced by bell mouth
Check Valve (Ø350mm)	2	to be replaced and additional one to be installed
Gate Valve (Ø350mm)	2	to be replaced and additional one to be installed
Priming System		
Vaccum Pump	2	to be replaced
Pipes and Valves	1	to be replaced
By-pass Pipe of Distribution Main	1	to be installed newly for protection of distribution pump

Facilities/Equipment	Qty	Measures
D. CHEMICAL FEEDING SYSTEM		
Alum Feeding System	1	to be replaced with new system
Hypochlorite Feeding System	1	to be replaced with new system
E. ELECTRICAL EQUIPMENT		
Power Sub-staion	1	whole equipment to be replaced except frame (steel)
Electric Room	1	whole equipment to be replaced
Motor Control Panel		
Intake Pump	1	to be replaced
Distribution Pump	1	--
Backwash Pump	1	panel for additional pump to be installed
Flash Mixer	1	to be replaced
Center Control Panel	1	to be replaced
Instrumentation	1	all equipment to be replaced including transmitters of flow meters and water level meters
Power Cable	1	all cables for power distribution and instrumentation to be replaced
Lighting	1	to be replaced
F. BUILDINGS		
Alum Storage	1	
Structure (R.C.)	1	floor to be elevated
Winch	1	to be replaced with new system for Alum transportation
Alum Feeding Room and Control Center	1	to be divided by partition wall
Hypochlorite Feeding Room	1	--
Distribution Pump House	1	--
Hall	1	--
Warehouses	4	--

3.2 Bank and Riverbed Protection

The Kaolieo Treatment Plant faces the Mekong River. The ground elevation of the Plant is +171.5 m and all the site of the Plant is protected by the bank from flood of the Mekong River which elevation is +172.0 m. A total length of the bank faced to the Mekong River is about 158 m where about 97 m is the upstream of the intake tower. The rest 61 m is the downstream of the Intake Tower.

The bank protection was already made by NPP which length is about 45 m centered by the intake tower. The existing bank protection is made of gabion armour where further erosion is proceeding. The height of the existing bank protection is about 12 m with slope of 45 degrees. Severe erosion upstream of the existing bank protection was not observed during site survey, however, the downstream bank of the existing bank protection is eroded severely by the flow. As a result of the present survey, the bank shoulder on downstream was found to have receded about five (5) m over last eight (8) years up to the plant perimeter due to the erosion. Also the slope has become as steep as about 25 degrees which was about 45 degrees in 1975.

The bank protection to this area is crucial. The length of the bank protection to be made is about 40 m from the existing bank protection to the boundary of the Plant, while, the bank protection on upstream from the existing one will not be necessary considering the current conditions.

The riverbed around the Intake Tower also has been scoured by the strong turbulent flow caused by the Intake Tower and the rapid stream in the high water period. The riverbed has lowered by about 3 m at the most eroded parts according to the survey result and compared with the river contours at the time of completion of the intake tower. The riverbed protection work is also urgently required. The area of the riverbed to be protected is estimated as about 550 m2 around the Intake Tower.

3.3 Extension of Distribution Pipeline

Areas for the extension of water supply requested by the Government of Laos are listed in the priority order as follows:

(1) Dong Dok Area - 1
(2) Phone Tong Area - 1
(3) Thadua Road Area - 1
(4) Thong Pong Area
(5) Thadua Road Area - 2
(6) Phone Tong Area - 2
(7) Dong Dok Area - 2

All areas above are located outside of the city boundary except Phone Tong Area (See Fig. 3-4).
Most of the above areas have important governmental institutions and/or industrial enterprises along the trunk roads from Vientiane City to Luan Phraban, Thadua and Thanalane. However, areas (1) to (4) were selected for immediate implementation considering the importance and urgency need of water supply of each area.

1) Dong Dok Area - 1

The Dong Dok Area - 1 is located about 6-9 km northwest from the city center.

The total population of the area is estimated as 5,800 by 1990 and 70 percent of the population, or 4,100 is assumed as population to be served. The current total population is estimated by NPP as 4,700.

About 4,100 population will compose consumers in the area in addition to non-domestic consumers such as the Educational College, Institute of Politics, and Institute of Forestry. Daily maximum water demand of Dong Dok area is estimated as about 2,500 m3/day by 1990 (refer to Appendix-4).

A total length of the distribution main for the area will be about 5.7 km in length and Ø250 mm in diameter.

2) Phone Tong Area - 1

The Phone Tong Area - 1 is located in the vicinity of the southeast boundary of the City (see Fig. 3-3).
The main objective of the pipeline is water supply to the hospital under construction.

The total population of the area is estimated as 2,400 by 1990 and 70 percent of the population or 1,600 is assumed as population to be served. The current total population is estimated by NPP as 2,000.

About 1,600 population will compose consumers in the area in addition to the hospital. Daily maximum water demand is estimated as about 700 m3 including water supply to the hospital (refer to Appendix-4).

The length of the distribution mains in the area, will be about 1.3 km of ϕ400 mm and 2.1 km of ϕ150 mm.

3) Thadua Road Area - 1

The location of Thadua Road Area - 1 is about 7-11 km southeast from the city center. The total population to be served in 1990 is estimated as about 5,200 or 70 percent of the total population of about 7,400, while NPP estimates the present population of five villages is about 6,000 in total.

Daily maximum water demand is estimated as about 1,800 m3/day in 1990 (refer to Appendix-4).
The pipeline will be about 3.5 km in length and Ø250/Ø200 mm in diameter.

4) Thong Pong Area

The Thong Pong Area is located about 6-9 km away from the city center along the Route 13 leading to Luang Prabang. The total population to be served of the area in 1990 is estimated as about 1,100, or about 70 percent of the total population of 1,600, while the present population of three villages is about 1,300 in total according to NPP's estimate.
Daily maximum water demand in 1990 is estimated as about 500 m3/day (refer to Appendix-4).

The distribution main will be of about 4.8 km in length and Ø150/Ø100 mm in diameter.

Table 3-2 shows the summary of consumers of villages and non-domestic consumers.

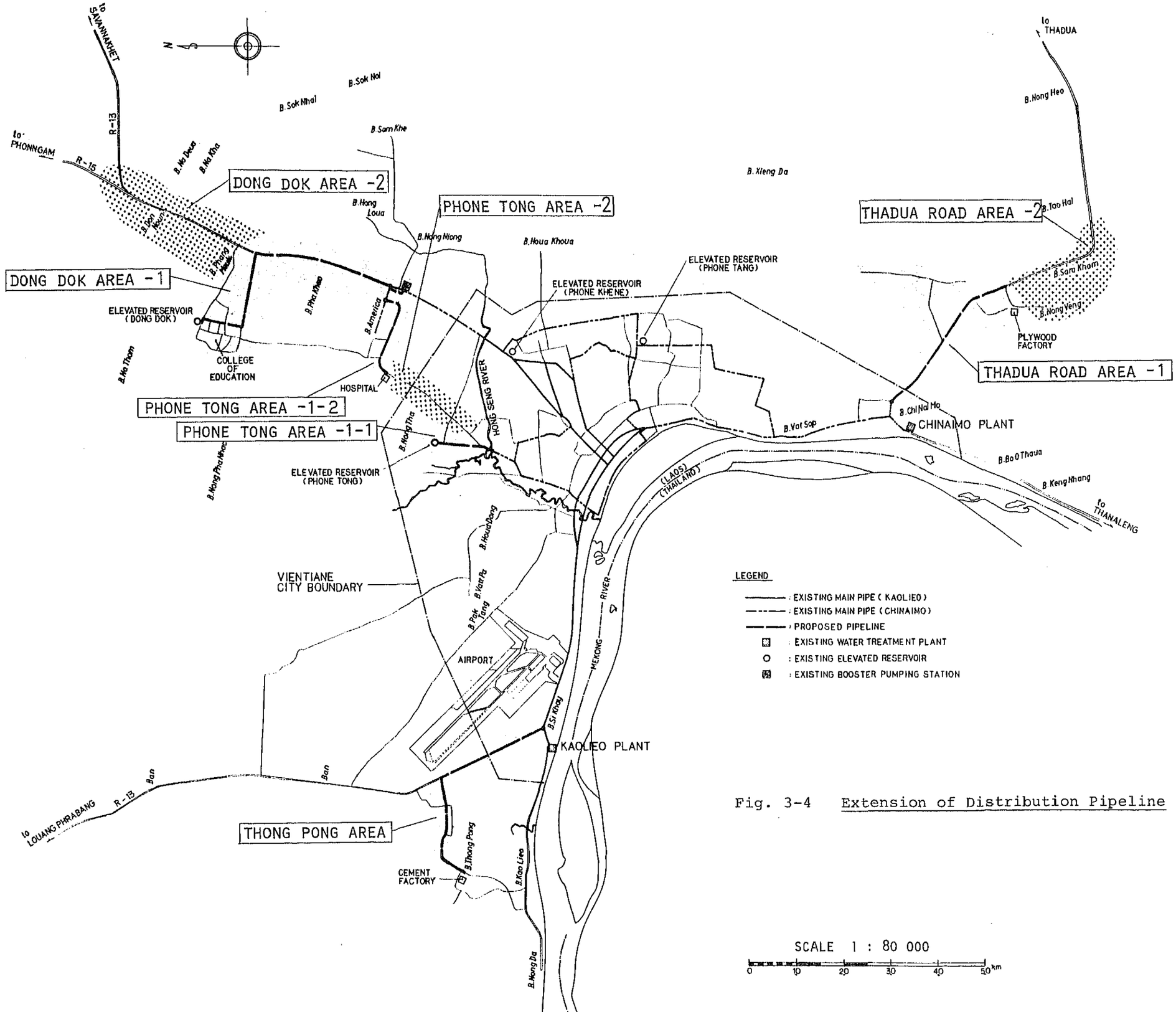


Fig. 3-4 Extension of Distribution Pipeline

Table 3-2 Summary of Consumer

Consumer	Served Population/Number	
(Dong Dok Area-1)		
Domestic		
Sa Phang Muk Village	560	
Pha Khao Muk Village	1,470	
Sang Khau Village	630	
Civilay Village	490	
Tane Mixay Village	910	
	4,060	= 4,100
Non-domestic		
Educational College	1	
Institute of Politics	1	
Institute of Forestry	1	
Repair Shop	1	
Saw Mill	2	
(Thone Pong-1)		
Domestic		
Thone Pong Village	800	
Nong Tha Village	800	
	1,600	
Non-domestic		
Hospital	1	
(Thadua Road Area-1)		
Domestic		
Song Veng Village	2,590	
Sone Sanouk Village	1,050	
Nong Hai Village	840	
Samg Village	700	
	5,180	= 5,200
Non-domestic		
Tabacco Factory	1	
Fertilizer Factory	1	
Soap Factory	1	
Petroleum Transportation Station	1	
Provincial Irrigation Office	1	
Technical School	1	
Acetilen Factory	1	

Consumer	Population/Number
Textile Factory	1
Plywood Factory	3
	Served
(Thong Pong Area)	
Domestic	
Nakham Village	490
Thong Pong Village	630
	1,120 = 1,100
Non-Domestic	
Market	1
Saw Mill	4
Repair Shop	1
Cement Factory	1

4. Design Criteria

1) Kaolieo Treatment Plant

The rehabilitation work is aimed at restoring the designed production capacity of 20,000 m3/day (22,000 m3/day for intake and treatment capacity including 2,000 m3/day for the plant use.)

The field investigation disclosed that the required rehabilitation work of the plant is limited to replacing the obsolete, damaged or worn out equipment so that the original design concept of the plant is principally maintained and no major revision is made to the current unit processes.

2) Bank and Riverbed Protection at the Intake Site

The following water levels at the intake site of the Mekong River are indicated for design and cost estimate purposes:

- HWL +171.75 m
- LWL +159.00 m

3) Distribution Pipelines in the Extended Service Area

The following criteria are applied to the proposed pipelines in the extended service area proposed in the Project:

- Population served in 1990: 12,000 (70% of the total population)
- Daily average water demand: 5,800 m3/day
- Daily max. demand: 6,670 m3/day (115% of daily average water demand)
- Hourly max. demand: 314 m3/hr or 7,540 m3/day (130% of daily max. water demand)
- Per capita water consumption of domestic use: 136 lpcd in 1990
- Hydraulic conditions:
  The water pressure at each branch from the existing main is as follows:
  - Dong Dock Area:
    +202.0 m (at the Phone Keng Reservoir)
  - Phone Tong Area:
    +200.8 m (at the Phone Tong Reservoir)
    +202.0 m (at the Phone Keng Reservoir)

- Thadua Road Area:
  +225.4 m (at the branch from the ϕ1,000 mm distribution main from the Chinaimo Treatment Plant)
- Thong Pong Area:
  +229.3 m (at the branch from the ϕ450 mm distribution main from the Kaolieo Treatment Plant)

5. Design of Major Facilities

The Kaolieo intake, treatment plant, distribution facilities necessary to be improved, and distribution pipeline system to be extended are designed to incorporate the best technical and economical measures.

The size or capacity of the equipment to be repaired, improved or replaced is determined in principle, same as originally designed and to meet the requirement of producing potable water of the design capacity.

Major facilities and equipment to be improved are described in the following paragraphs:

5.1 Rehabilitation and Improvement of Kaolieo Treatment Plant

1) Intake Facilities

Conditions for Design

Capacity of Intake	22,000 m3/day
Water Levels	Intake: HWL +171.75 LWL +159.0
	Mixing Basin: +176.0

Design of Intake Pump

Number of Pumps

Three (3) units including one stand-by installed in the existing intake pump house on the intake tower.

Pump Drive	Motor output: 37 kW Type of motor: squirrel cage type induction motor Vertical mixed flow type
Specification	Ø250 x Q7.65m3/min x H19.5m x 37kW Higher resistivity is required on the materials against wear-off caused by suspended materes such as sand and silt in intake water.

Flow Control

Flow control valve, Ø500mm butterfly valve, is installed on the existing raw water main to control raw water intake and to maintain the pump operation at rated point. Flow control will be made by the combination of the gate valve on discharge line of intake pump and control valve.

2) Treatment Facilities

Conditions for Design

Capacity of Treatment	22,000 m3/day	
Water levels	Mixing basin:	+176.0
	Reservoir:	+170.6

Design of Mixing Basin

Base floor of the mixing basin is to be raised to reduce detention time for better coagulation and direction of raw water influent is changed upflow for better mixing.

Rapid Sand Filter

Backwashing: Additional one unit of backwash pump is to be installed as stand-by, existing two pumps are operating at the same time currently to keep about 60 cm/min of backwash rate as the minimum rate.

Flow control valve, butterfly valve, is to be installed on backwash main where no control device is currently provided.

Increase pump head to 18 m from 16 m considering the capacity of backwash main, Ø450 mm in diameter.

Surfacewashing: Flow control valve, butterfly valve, is to be installed on surfacewash main to regulate surfacewash rate as 15-20 cm/min. There is no control device to reduce pressure from the distribution main.

Washwater Trough: Washwater trough is to be replaced by new one at the higher position from the existing trough.

Flow Controller: Existing flow controller are to be replaced with the same type of controller. Flow rate of controller is 8,000 m3/day as a maximum rate. Effluent of filtered pipe is to be up-side-down to avoid pertial flow in controller.

Additional washwater drain pipe is to be installed to increase the capacity of the drain system.

The differential pressure gauge is to be installed to observe loss head of filter media.

3) Distribution Facilities

Conditions for Design

Capacity of Distribution	27,000 m3/day
Water Level of Clear	HWL +170.6
Water Reservoir	LWL +166.6

Design of Distribution Pump

Number of Pumps

Four (4) units including one stand-by in the existing pump house.

Pump Drive

Motor output; 110 kW
Type of motor; drip-proof squirrel cage induction motor

Specification

Horizontal double suction volute type
Ø250mm x Q6.3 m3/min x H67m x 110kW

Pump Operation

Manual operation by changing the number of pumps according to delivery pressure and discharge flow which shall be in the range of 50-120% of rated flow of pump.

By-pass pipe is to be provided on the distribution main to the reservoir to maintain pump operation at normal condition. The pressure release valve will be installed on the by-pass line.

Design of Backwash Pump

Number of Pumps

Three (3) units including one stand-by are to be installed in existing pump house.

Pump Drive

Motor Output; 60 kW
Type of Motor; drip proof squirrel cage induction motor

Specification

Horizontal double suction volute type
Ø350mm x Q14.5 m3/min x H18m x 60kW

Priming system

Priming system for distribution and backwash pump is furnished providing vacuum pumps and piping.

4) Chemical Feeding System

Conditions for Design

Chemical for Coagulation	Alum ($Al_2(SO_4)_3.18H_2O$)
Alum Feeding Rate	Maximum: 100 ppm Minimum: 30 ppm Average: 50 ppm
Alum Feeding Point	at mixing basin
Mixing	Flash mixer
Chemical for Disinfection	Calcium Hypochlorite
Hypochlorite Feeding Rate	Maximum: 1.0 ppm average: 0.5 ppm
Hypochlorite Feeding Point	at the effluent of filtered water

Design of Alum Feeding System

Required Alum Solution

Aluminum sulphate: 2,200 kg/day in maximum feeding rate
Alum solution: 16 l/min by 10% alum solution in maximum feeding rate

Alum Solution Storage Tank

Capacity: one-day equivalent at average feeding rate
Number: three tanks with capacity of 5.5 m3 each including one stand-by.
Construction: Cylindrical type, fiber reinforced polyvinyl structure with mixer.

Feeding System

Alum solution is fed by gravity flow using constant water level head tank, flow meter and control valve.

Alum Circulation Pump

Two (2) units including one stand-by.
The pump is made of stainless steel,
Q100 l/min x H8m x 0.75kW

Constant Water Level Head Tank

One unit with capacity of 100 l, rectangular with over flow weir, stainless steel made.

Design of Flash Mixer

Energy Dissipation

300 sec^{-1} or more

Type of Mixer

Vertical mixer, suspended type, directly coupled with motor and speed-reducing drive unit, tip velocity of impeller blade is to be more than 1.5 m/sec.

Design of Hypochlorite Feeding System

Hypochlorite Solution

Effective Chlorine:	60 % of Hypochlorite in weight.
Max. Dosage:	33 kg/day of Hypochlorite or 1,600 l/day in 2 % Hypochlorite solution.
Storage:	2 tanks of 800 l each (1,600 l in total), cylindrical type of FRP made.

Feeding System

Hypochlorite solution is fed by gravity flow using constant water level head tank, flow meter and control valve.

Solution Circulation Pump

Number: 2 units including one stand-by.
Material: PVC
Capacity: Q60 l/min x H8 m x 0.75 kW

Constant Water Level Head Tank

One unit with capacity of 50 l, rectangular with over flow weir, PVC made

5) Electric Equipment

Design of Power Sub-station

Same as present power receiving capacity, 750 kVA.

Power is to be received from 2 kV transmission line.

Generator will not be prepared considering present stable power supply condition.

Design of Motor Control Panel

Basically present equipment will be replaced except panels for distribution and backwash pumps.

Design of Instrumentation

The following instrumentation will be furnished:

Intake water flowrate measuring system
Distribution flowrate measuring system
Reservoir water level measuring system
Alarm for LWL of intake and HWL and LWL of reservoir

5.2 Bank and Riverbed Protection

To select the construction method for the bank protection, the following conditions are examined.

- topographical feature of the site
- construction period due to the seasonal fluctuation of water level (see Appendix-1)
- economical construction
- materials locally available
- the existing bank protection method

Considering the height of the bank, economical construction and construction period, rigid structure such as retaining wall will not be adequate method. Stone or concrete block maisonry is also not adequate considering height of the bank and narrow working space. The bank protection by gabion armour is considered as the most suitable method which was also applied for the existing one. Stone is used for gabion armour in general, but concrete block will be used in this project due to the difficulties to obtain big enough size of stone locally. One of the advantage to apply the gabion armour for the bank protection is the easiness of construction and no necessity of big construction machines and equipment.

To select the construction method for riverbed protection, the following conditions are also examined.

- size of the river and water depth around the intake tower.
- construction period due to the seasonal fluctuation of water level
- economical construction
- materials locally available

Considering the above conditions, installation of concrete blocks around the intake tower is considered as the most applicable method for the riverbed protection. The size of the concrete block is to be examined considering transportation and installation thereof.

General plan for both bank and riverbed protection are illustrated in Fig. 5-1 and 5-2 in addition with the typical section of them.

Fig. 5-1 Bank Protection

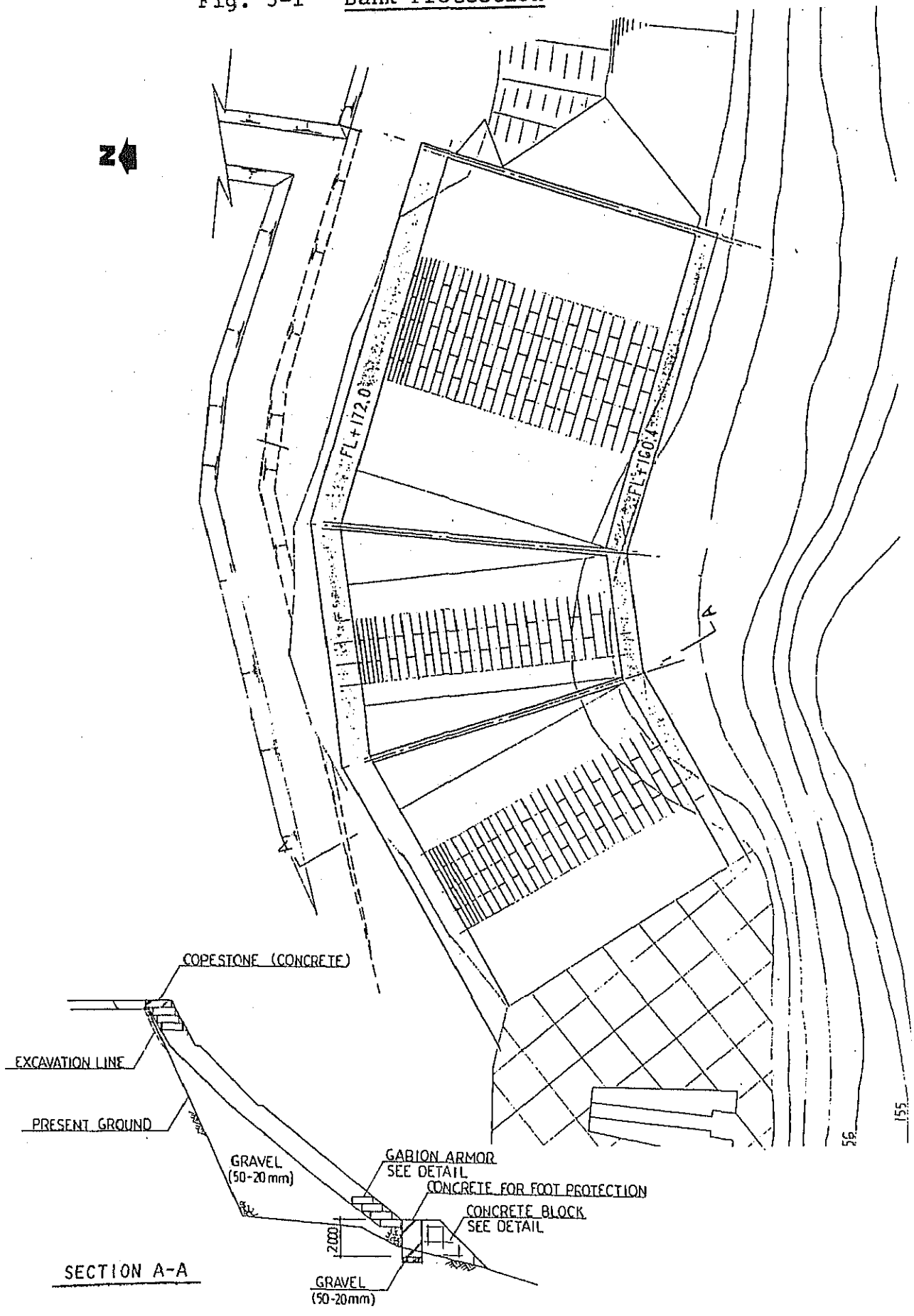
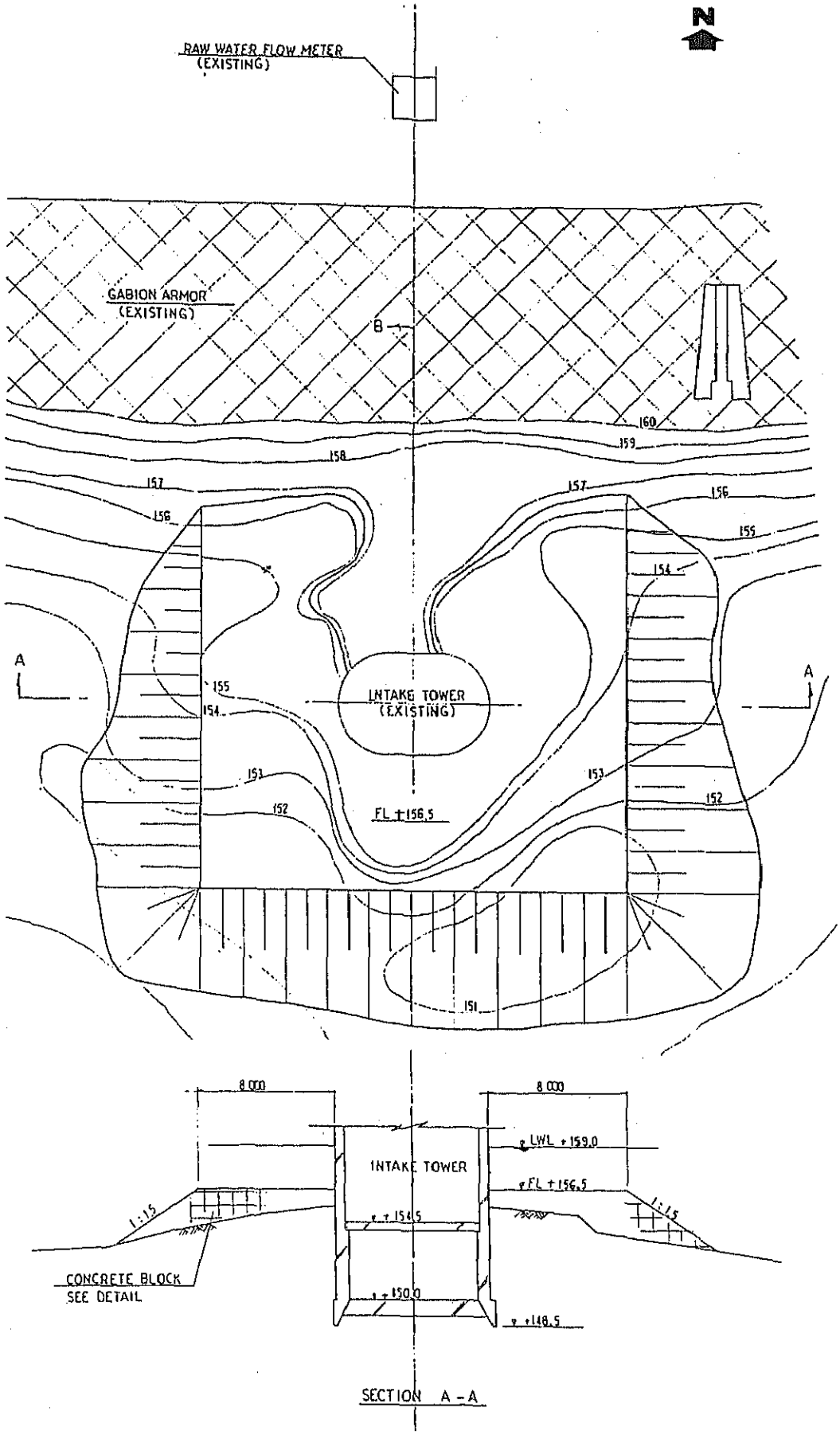


Fig. 5-2 Riverbed Protection



SECTION A-A

5.3 Installation of Distribution Pipeline

1) Pipeline Route

The following list shows the pipeline routes for the extension areas by the Project, and these routes are illustrated in Fig. 5-3 to 5-7.

Pipeline	Route	Extension Area
R - A	B/P station - E/R at Dong Dok	Dong Dok Area - 1
R - B	Hong Seng R. - E/R at Phone Tong	Phone Tong Area 1-1
R - C	B. America - Hospital 150	Phone Tong Area 1-2
R - D	Chinaimo - Plywood Factory	Thadua Road Area - 1
R - E	B.Si Khay - Cement Factory	Thong Pong Area

Note: B/P: Booster Pump Station
E/R: Elevated Reservoir
R : River

Route-A
The pipeline extends from the existing valve installed at the end of pipeline of Ø250 mm in diameter, about 100m downstream of the Booster Pump Station, and reaches to the existing elevated reservoir located beside the College of Education at Dong Dok. A shallow well supplies water to the College and its peripheral area through the elevated reservoir. The water of the shallow well contains high iron according to the information obtained. The elevated reservoir has a capacity of 550 m3 and is constructed on the top of a hill where the ground elevation is about +191 m. The height of the reservoir is 31.5 m to the high water level.

For future extension to Dong Dok Area-2, Na Than Village area and Nong Pha Nhae Village area, the branches will be provided as shown on Fig. 5-3.
The existing pipeline, Ø200 mm ACP, for B. America will be connected to the upstream of the Booster Pump Station to prevent the damage of the existing pipes caused by the high water pressure when the pump is operated for water supply to Dong Dok Areas.

The length of pipeline is about 5.7 km and its diameter is Ø250 mm.

Route-B
The pipeline extends from the end of Ø400 mm pipeline, and after crossing Hong Seng River reaches to the reservoir at Phone Tong, at present under construction, as shown on Fig. 5-4.
The pipeline provides two braches, one is Ø350 mm in diameter for future extention to the trunk main from the existing elevated reservoir at Phone Keng. Another branch is for extention to the hospital at Phong Tong.

The length of the pipeline is about 1.3 km including about 20m in length of the Hong Seng River crossing, and its diameter is Ø400 mm.

Route-C
The pipeline extends from the existing pipe, Ø200 mm ACP, to Hospital. Two branches are provided on the line for future extention to pipelines of routes A and B as shown on Fig. 5-5.

Route-D
The pipeline extends from existing valve at the end of Ø250 mm pipeline, branched from Ø1,000 mm trunk main from the Chinaimo Treatment Plant, to the Plywood Factory at Nong Beng Village. A branch is provided on the pipeline for future extension to Thadua Road Area-2 as shown on Fig.5-6.

The pipeline consists of Ø250 mm and Ø200 mm in diameter and a total length is about 3.5 km.

Route-E
The pipeline extends from the existing trunk main Ø450 mm in diameter from the Kaolieo Treatment Plant to the Cement Factory at Thong Pong Village. Two branches, to the area along route 13 and Kaolieo Village, for future extension as shown on Fig. 5-7.

The pipeline consists of Ø200 mm and Ø150 mm in diameter and a total length is about 4.8 km.

Fig 5-3 Pipeline Route - A

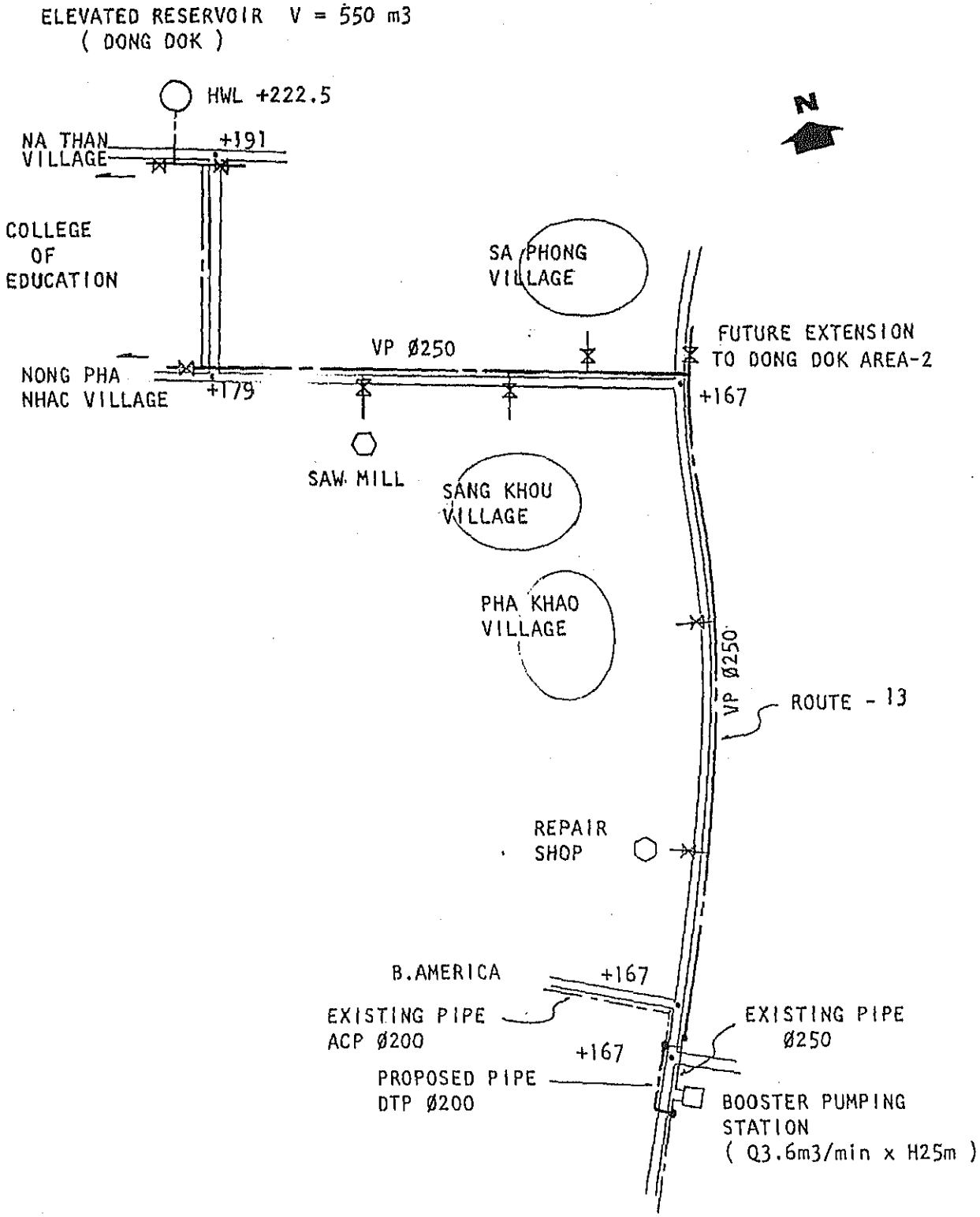


Fig 5-4 Pipeline Route - B

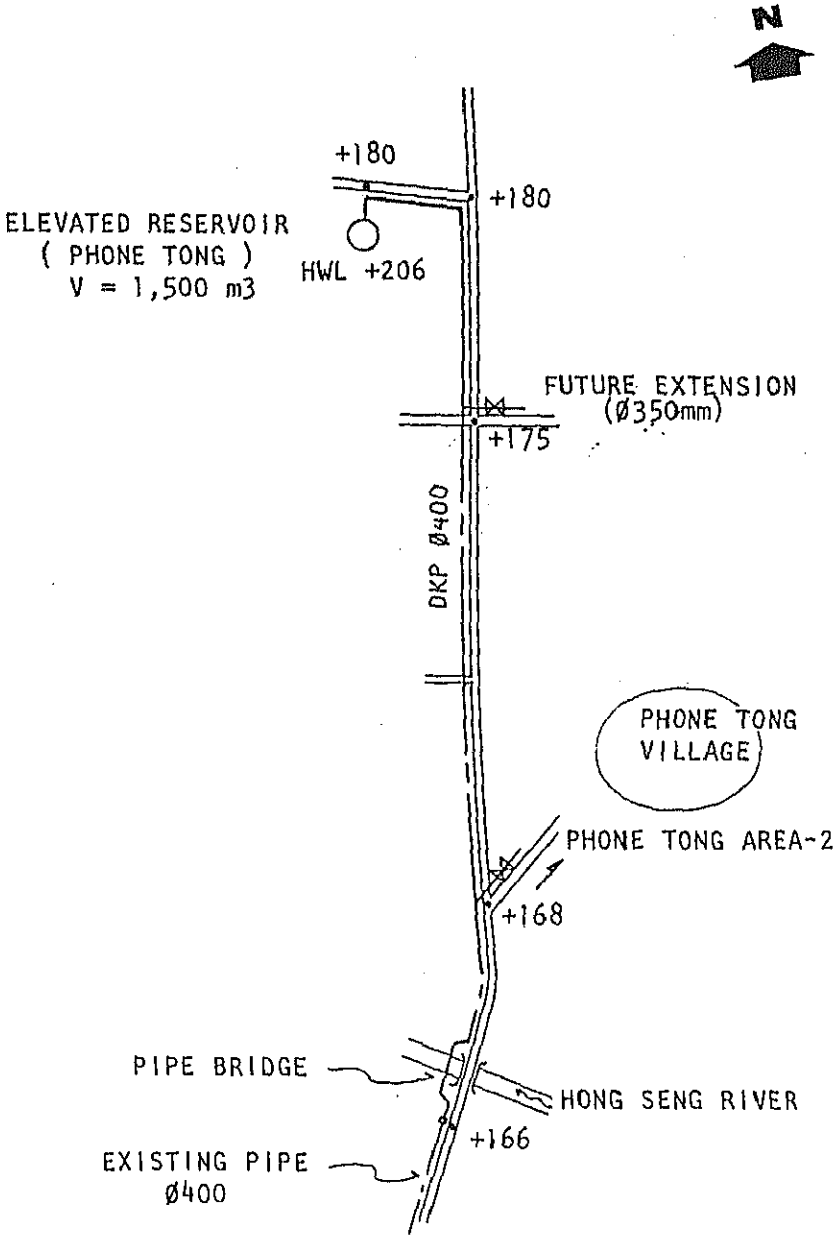


Fig 5-5 Pipeline Route - C

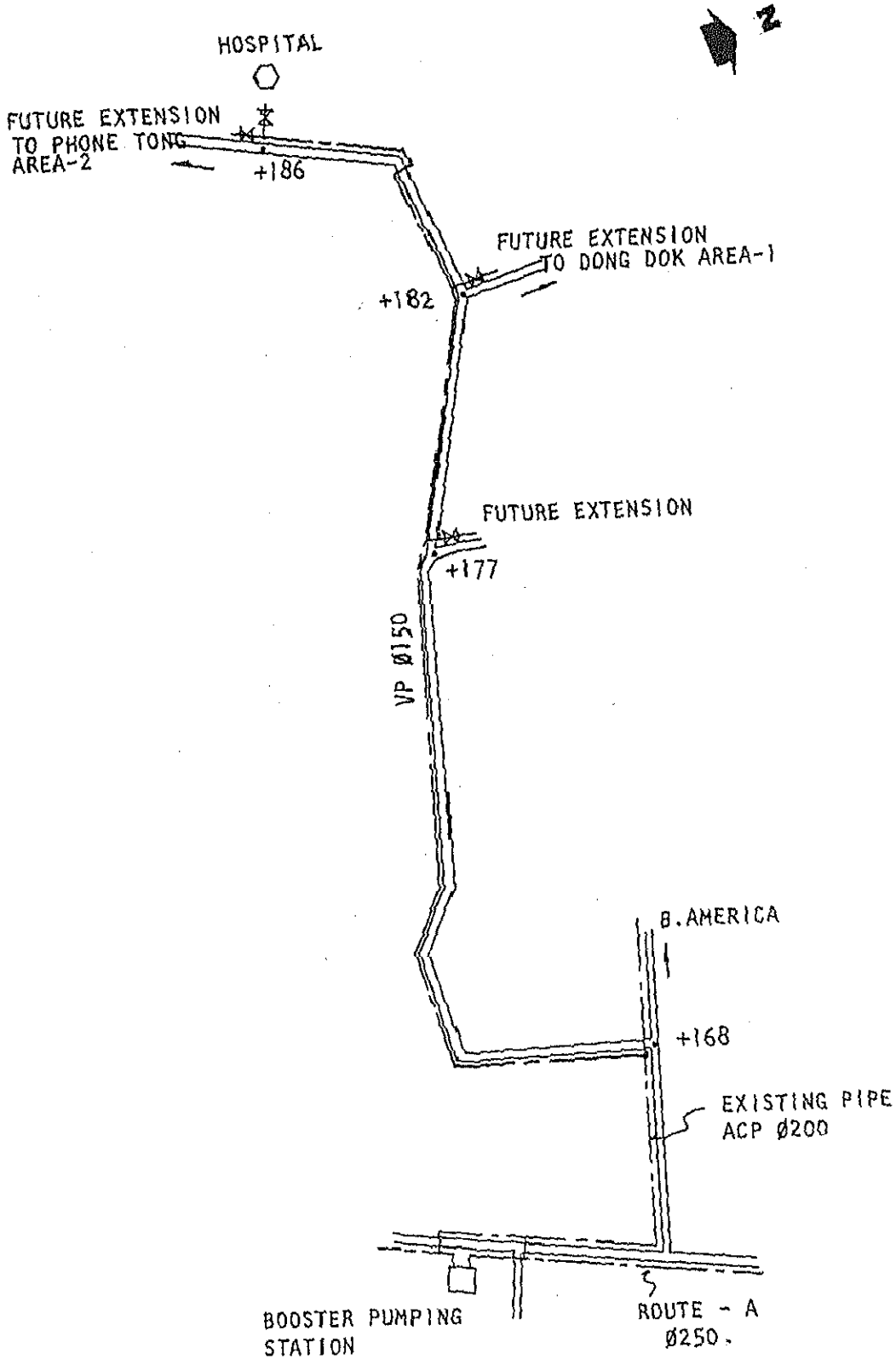


Fig 5-6 Pipeline Route - D

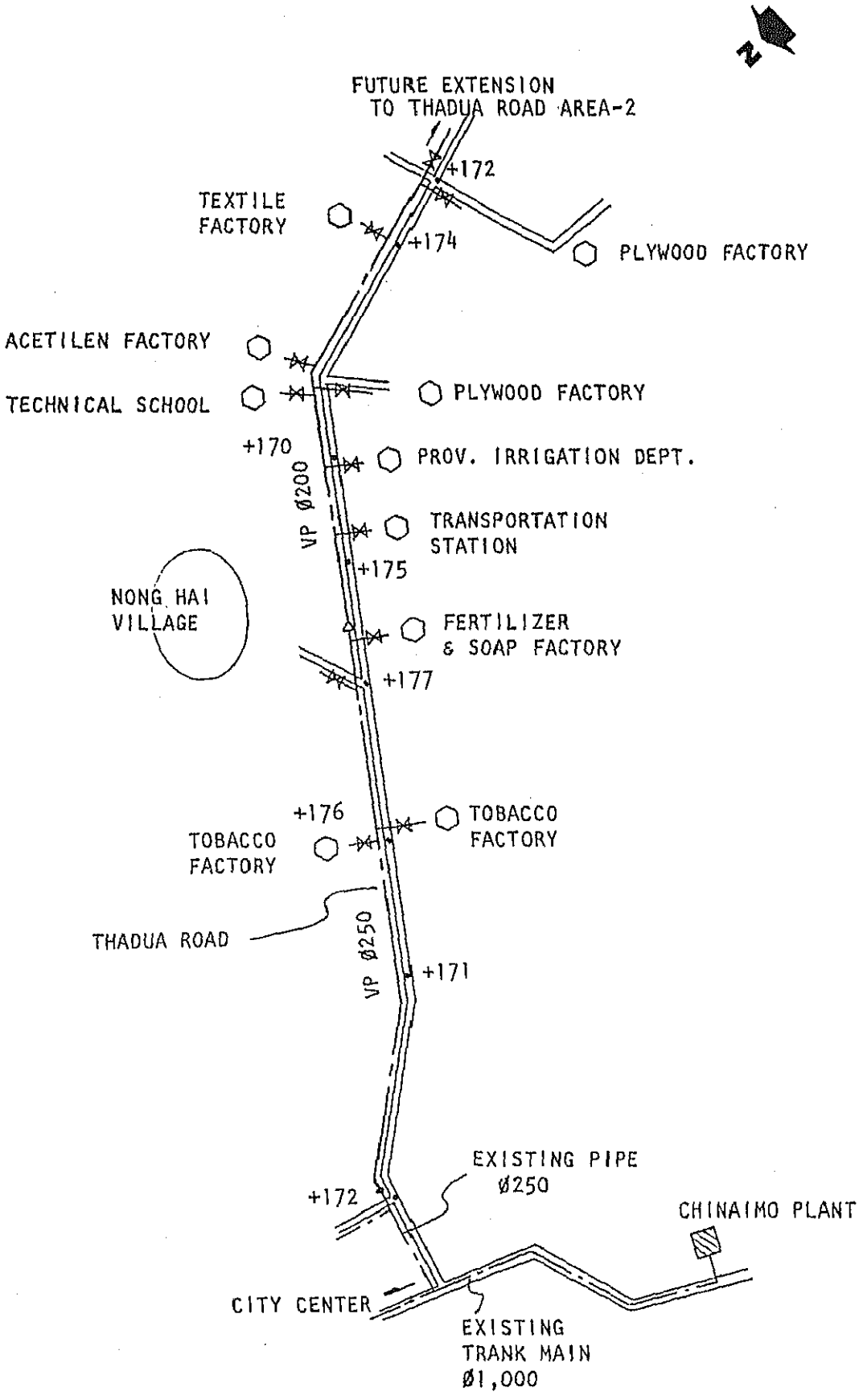
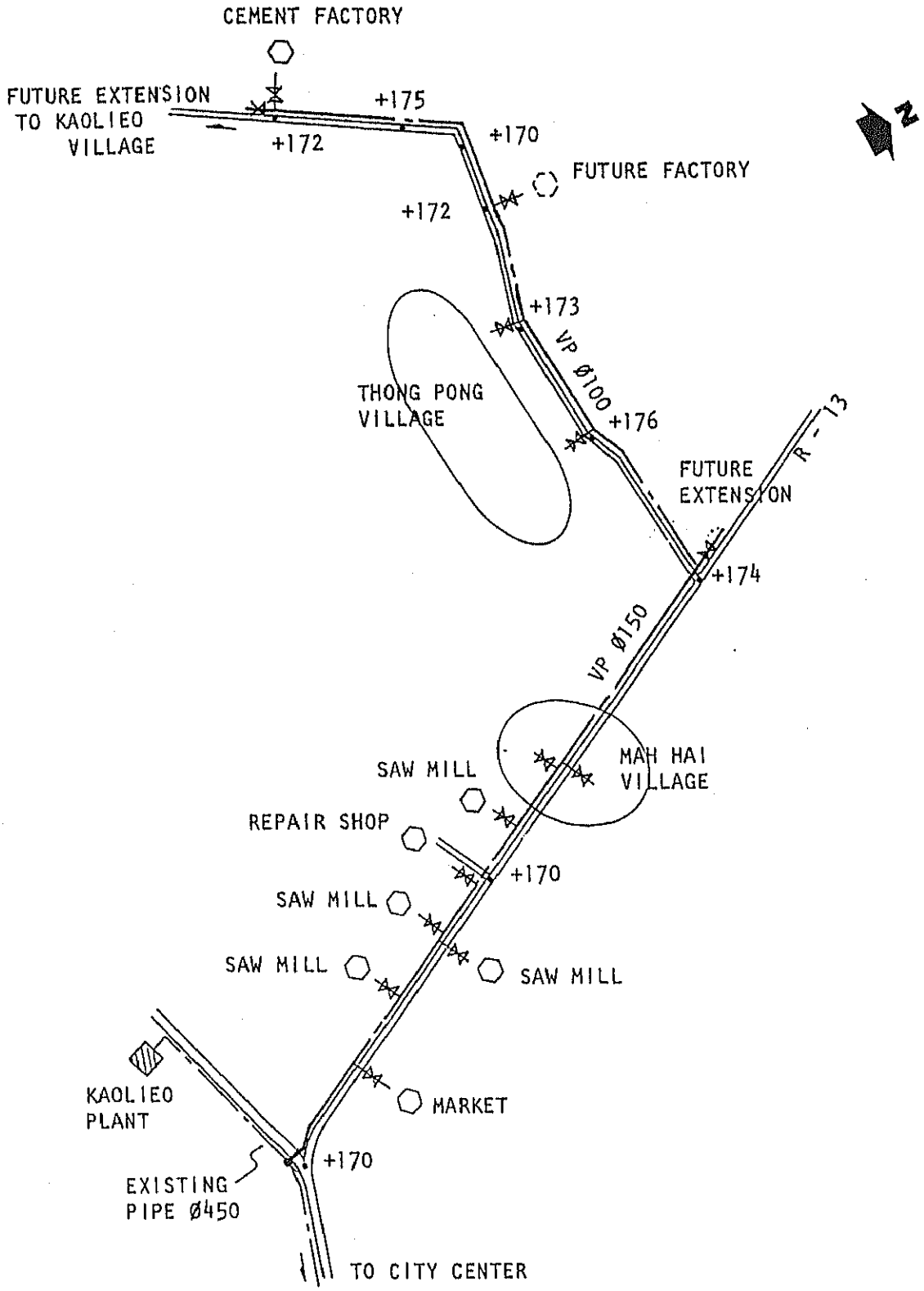


Fig 5-7 Pipeline Route - E



2) Hydraulic Analysis

Hydraulic analysis for each pipeline is made in this section including its size under the following conditions;

- Water pressure for each starting point of pipeline is as follows: (refer to Appendix-5)

Route - A	+202.0 m	at the Phone Keng Reservoir
Route - C	+202.0 m	at the Phone Keng Reservoir
Route - D	+225.4 m	at the the branch from Ø1,000mm trunk main from the Chinaimo Treatment Plant
Route - E	+229.3 m	at the the branch from Ø450mm trunk main from the Kaolieo Treatment Plant

  Route - B is already confirmed that water will reach to the reservoir through Ø400 mm pipeline as shown in Appendix-5.

  Head of booster pump is 25 m at rated capacity of 3.6 m3/min.

- Hydraulic analysis for routes A and C are made based on the daily maximum water demand because hourly maximum water demand of these area will be covered by elevated reservoirs at Phone Keng, Phone Tong and Dong Dok.

- Hydraulic analysis for route D and E are made based on the hourly maximum water demand.

- For friction coefficient for hydraulic analysis are employed 110 and 120 for DIP and PVC respectively.

- Water demands of areas for Dong Dok-2, Phone Tong-2 and Thadua Road-2 are considered for the hydraulic analysis of pipeline routes A, C, and D (refer to Appendix-6).

Results of the hydraulic analysis of each pipeline route are tabulated in Appendix-6.

3) Pipe Materials and Pipe Laying Work

Pipe Materials

Considering current prices, durability of materials and installation practice, the following pipe materials are recommended for each pipe diameter.

Diameter of Pipe	Materials
Ø 75 - Ø250 mm	Polyvynil chloride (PVC) pipe of push-on joint type, 10 kg/m2 1/
Ø300 - Ø400 mm	Ductile iron pipe (DIP) of mechanical joint type, 7.5 kg/m2

Note: 1) DIP is used specially for such as road crossing, ditch crossing and other crossings.

2) Pipe materials for river crossing (Hong Seng River) is steel pipe.

Pipe Laying Work

Earth coverings for pipe are 1.2 m for Ø75 mm - Ø250 mm in diameter and 1.5 m for Ø300 mm in diameter or larger.
At the portion where pipe is crossing other pipes or culvert, the minimum clearance to the others is 30 cm or more and is to be filled with sand compacted.

PVC is to be laid on the bedding sand and compacted around the pipe to 200 mm depth over the pipe with backfill sand.
Backfilling for DIP is allowed to be made by selected excavated soil not contained rock and solid matter.

Concrete encasement will be employed for such specific portion as ditch crossing.

The main valve will be located in a maximum interval of 1,000 m to allow isolation of any pipeline at breaks or washout work.
The branch valves are to be installed at every branches.

Air valve is installed at the crest points along the pipeline.
The standard sizes of air valves are as shown below:

Diameter of Main Pipe	Air Valve
Ø100 - Ø300 mm	Ø13 mm single orifice
Ø350 mm or larger	Ø50 mm double orifice

Blow-off is installed at low points or depression on the pipeline at rivers or ditches in maximum interval of 1,000 to 2,000 m.

Fire hydrants will be installed at points where housing areas and factories and institutions are located along the pipeline. The sizes of fire hydrant to be installed are as shown below:

Diameter of Main Pipe	Fire Hydrant
Ø150 - Ø250 mm	Ø 75 mm single outlet
Ø300 mm or larger	Ø100 mm double outlet

6. Implementation of the Project

6.1 Executing Agency and organization

NPP will be the executing agency of the Project under the control of the Ministry of Construction. NPP belongs to the Bureau of Construction of Building and Industrial Plant, Ministry of Construction. Fig. 6-1 shows the organization chart of the Ministry of Construction.

NPP was established to deal with operation and maintenance activities for Water Supply System of Vientiane City. NPP is acting as an executing agency for the construction of elevated reservoirs at Phone Tong and Phone Tane under the grant aid from the Japanese Government and the work is scheduled to be completed in March 1983. NPP consists of five departments with 321 personel in total.

The construction work of the Project will be undertaken by a Japanese contractor selected through competitive bidding by NPP with assistance of the Consultants. The contractor will perform the work in cooperation with a local sub-contractor and will carry out technology transfer in construction and installation during the execution of the Project. NPP will join in the Project as the sub-contractor because almost all other private local contractors have limited capability to accomplish the Project considering their technical ability and scale of the work to be undertaken.

In order accomplish the satisfactory plant operation, the training of the staff from NPP will be necessary. The contractor will take care of NPP for such purpose during the construction work under the supervision of the Consultants. The training includes handling and maintenance of equipment and apparatus to be furnished. Fig. 6-2 shows the organization chart for execution of the Project.

Fig. 6-1 Organization Chart of The Ministry of Construction

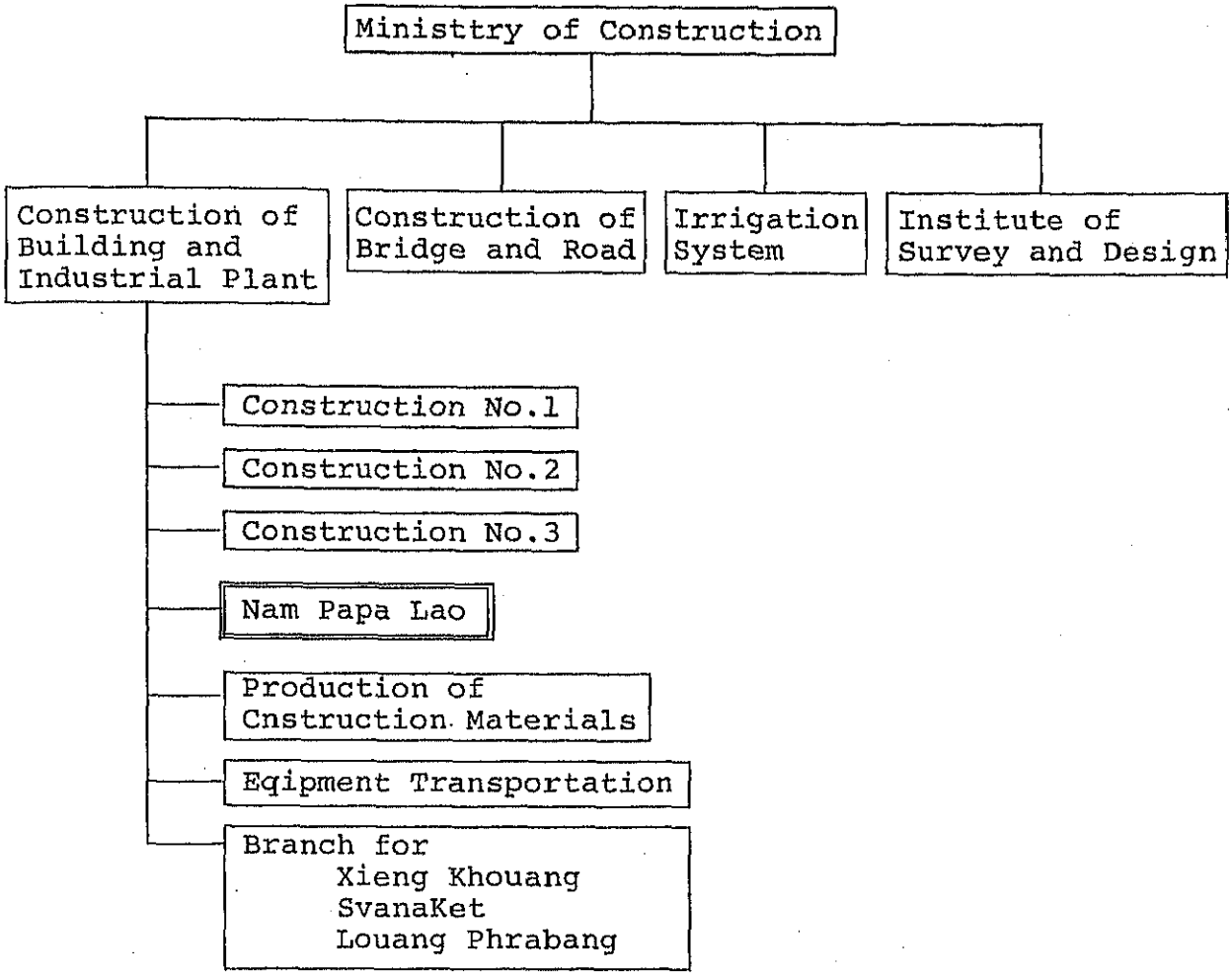
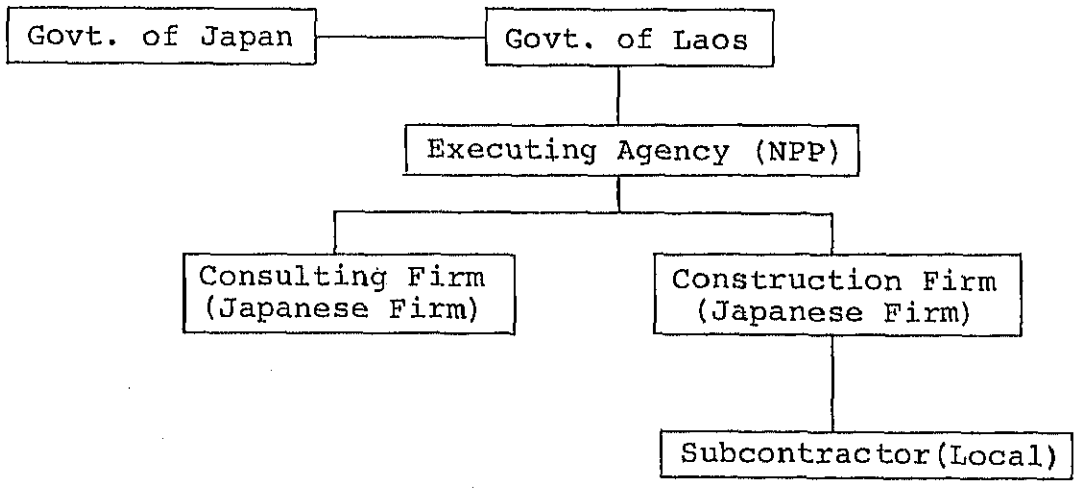


Fig. 6-2 Organization Chart of Execution of The Project



6.2 Implementation Program

The Project will require nine (9) months from June 1983 to March 1984 including period for manufacturing of equipment and materials and shipment/transportation.

Fig. 6-3 shows the recommended implementation schedule considering tender procedure, scale of the works, periods for manufacturing of equipment/materials imported and for transportation and local weather condition.

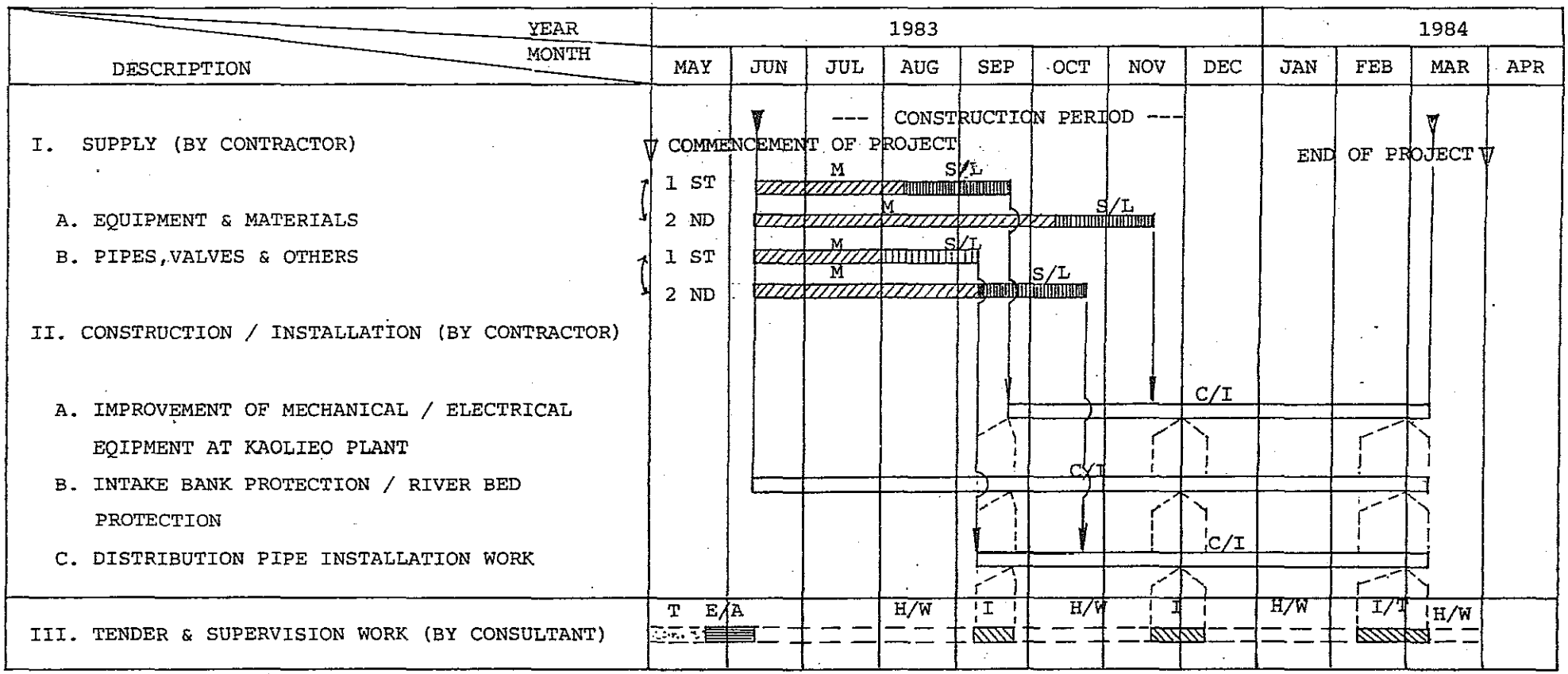
Period for manufacturing of equipment/materials imported for the Project estimated as two to four months. About 40 days will be required for shipment and transportation from the port of Japan to the job site. The procedure of shipment and transportation is shown in Appendix-7.

The construction of bank and riverbed protection at the intake site will starts in December at the earliest time because water level of the Mekong River is too high to allow the earlier commencement of the work before December. (refer to Appendix-2, "Frequency of Water Level of Mekong River"). However, fabrication of concrete blocks and preparation of other materials necessary are to be commenced at the outset of the Project because of the voluminous concrete block work to be provided.

Installation work for distribution pipelines will start from September, the end of rainy season after arrival of 1st shipment of pipe materials.

Installation of equipment for the improvement work for the Plant will start from September after arrival of 1st shipment of the equipment.

Fig. 6-3 Implementation Schedule of The Project



LEGEND

- TENDERING : INCLUDING TENDER CALLING ,PREPARATION / SUBMISSION (BY CONSULTANT)
- EVALUATION / AWARD OF CONTRACT : INCLUDING EVALUATION , CLARIFICATION , AWARD OF CONTRACT
- MANUFACTURING
- SHIPMENT / HANDLING / LOCAL TRANSPORTATION
- CONSTRUCTION / INSTALLATION
- I : INSPECTION , I/T : INSPECTION / TEST RUN (OPERATION)
- HOME WORK (PART TIME) FOR PREPARATION OF REPORTS,COMMUNICATION

7. Operation and Maintenance

7.1 Organization of Nam Papa Lao

Nam Papa Lao (NPP) consists of five departments with 321 personnel.

The production department is composed of three sections with 77 personnel, they are for operation and maintenance of the Kaolieo Treatment Plant and the Chinaimo Treatment Plant, and repair shop for the equipment and materials. The department will be able to operate and maintain the Kaolieo Treatment Plant by the present staff even after completion of the improvement work of the Plant. Since, no major alternation is made on the capacity, the treatment process and operation system of the Plant.

The financial department comprises four sections with 27 personnel; they are budget, account, expense and inventory sections.

The commercial department consists of three sections with 51 personnel; they are bill collection, unpaid bill control, and commercial sections.

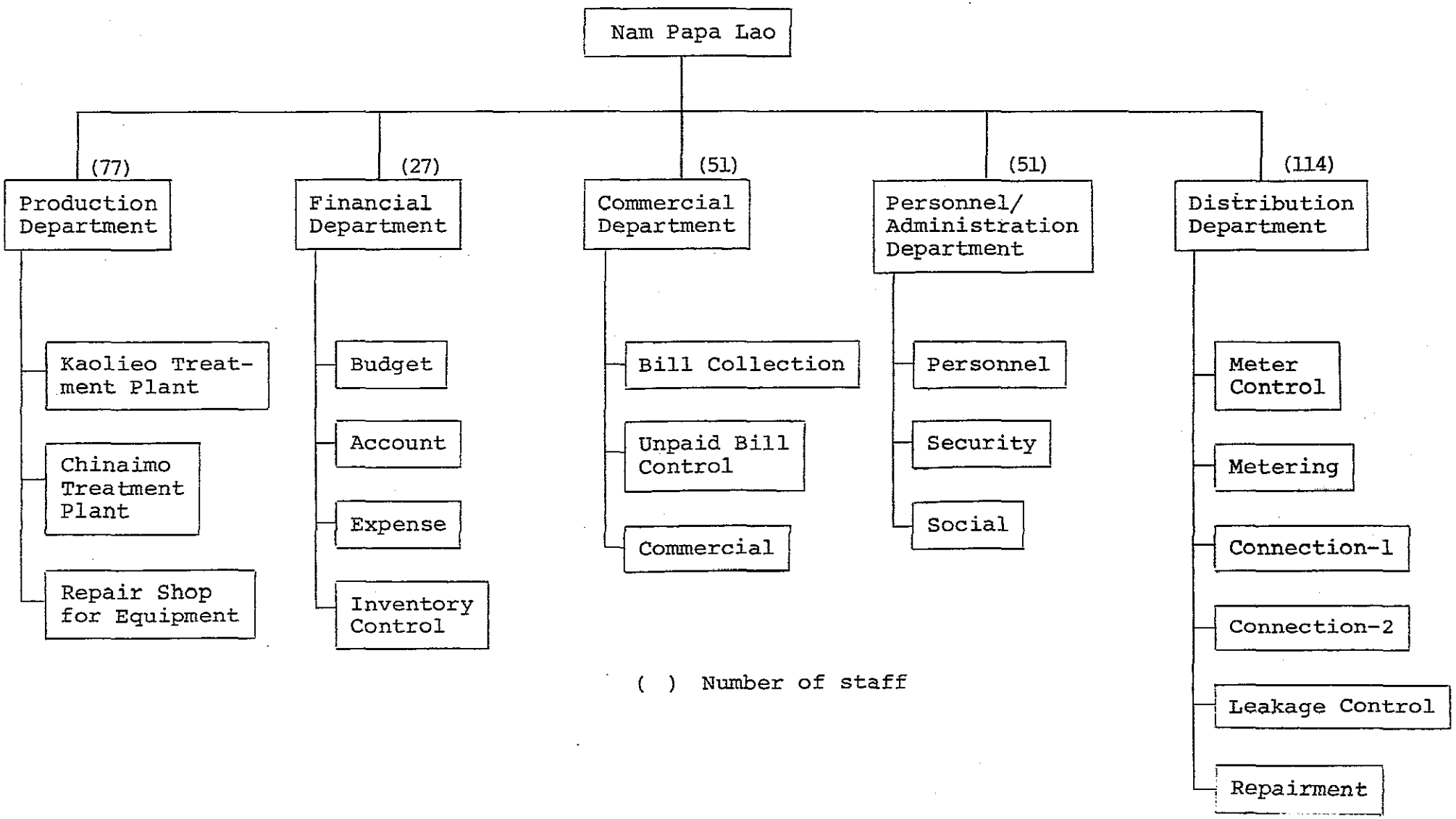
The personnel/administration department consists of three sections with 51 personnel; personnel, security and social sections.

The distribution department consists of five sections with 114 personnel, they are meter control, metering, connection-1, connection-2 and leakage control sections. The department installs and maintains distribution pipelines and service connections including leakage control and its repair work.

Slight increase of personnel might be required to maintain the pipelines and service connections to be installed by the Project, since a total length of pipeline installed by the Project is about 17 km which is about 15 percent of the existing distribution mains of 120 km. About 1,500 service connections are expected to be installed until year 1990 in the areas extended by NPP.

Fig. 7-1 shows the organization chart of NPP.

Fig. 7-1 Organization Chart of Nam Papa Lao



( ) Number of staff

7.2 Financial Aspect of Nam Papa Lao

Water tariff is levied on each consumer by the consumption basis through water meter on service connection. Water rate at present is Kip 3.5/m3 was increased from Kip 1.15/m3 in 1982.

Cost for all materials for service connections including water meter, pipes and other miscellaneous appurtenances are shouldered by consumers. Charges for a service connections is about Kip 2,500 in average including Ø13 mm water meter, Ø20 mm of pipes and other miscellaneous appurtenances at present.

The balance of revenue over expenditures in 1982 registered a deficit as shown in Table 7-1. Water Production was about 13,1000,000 m3 and sold water was 7,850,000 m3 on the other hand in 1982.

Present water rate was raised to Kip 3.5/m3 from Kip 1.15/m3 which was applied for water sales in 1982. The balance of revenue over expenditures will reveal a surplus, if Kip 3.5/m3 of water rate is applied on the above water sold of 7,850,000 m3/year. Moreover, NPP will gain the additional benefits to its budget, because it will receive additional revenue with minor expenditures such as operation and maintenance costs for the facilities provided by the Project granted by the Government of Japan.

Average monthly family income is estimated as about Kip 3,000/month according to the information obtained by NPP. Assuming that 4 to 5 % of family income is the payable amount which average residence can afford to pay for water, the amount payable is calculated at Kip 120 to 150/month. The average monthly consumption per family is estimated as about 36 m3/month for which water tariff is Kip 126, this amount is in between the above payable tariff per family.

Although NPP is not in a financial position to undertake the extension program of the water supply system without an external assistance, NPP is considered capable of keeping the services of the present system.

Table 7-1 Statement of Revenue and Expenditure of Nap Papa Lao in FY 1982

Revenue	Water Sales	Kip 10,941
	Customers Contribution 1/	Kip 3,183
	Total	Kip 14,124
Expenditures	Salary	Kip 1,864
	Electricity	Kip 665
	Chemicals	Kip 5,605
	Amortization	Kip 500
	Operation and 2/ Maintenance Cost	Kip 5,000
	Other 3/	Kip 1,609
	Total	Kip 15,243
Balance		Kip (1,119)

Note: FY: Fiscal Year from January through December

water rate: Kip 1.15/m3 up to September 1982
Kip 3.50/m3 after October 1982

1) charges for service connections paid by customers

2) including installation and repair cost of service connections

3) including office supply, spare parts, taxes and other miscellaneous expenditures

8. Evaluation of the Project

The benefits for NPP and consumers which are generated by the Project area as follows:

1) Revenue

NPP is able to receive additional revenue by the implementation of the Project. The benefit to NPP, revenue over expenditures, is estimated as about Kip 57 millions for seven years from 1984 to 1990 as shown in Table 8.1 based on prices in 1983.

2) Fire Prevention

Improvement water supply system will contribute to fire suppression activities not only in the existing but also in the extended served areas. This results in decrease of losses caused by fires.

3) Health Benefit

Water supply for extended areas by the Project will contribute to the improvement of health and sanitation conditions of the people in these areas by decreasing water borne diseases. People in these areas are currently obtaining drinking water from shallow wells, brooks and other polluted sources .

4) Impact on Economic Activities

Water supply will give the impact to the extended served areas which will promote economic development of the country. Important industrial estates and institutions are situated in these areas, and they are indispensable for the economic development of the City.

Table 8-1 Sales of NPP

Year	Water Sold ('000 m3) City Area	Exten. Area	Total	Sales ('000 Kip)	O/M Cost *1 ('000 Kip)	Gross Revenue *2 ('000 Kip)
1983	-	900	900	3,150	-	3,150
1985	700	900	1,600	5,600	1,770	3,830
1986	1,300	1,100	2,400	8,400	2,580	5,820
1987	2,000	1,100	3,200	11,200	3,450	7,750
1988	2,700	1,400	4,100	14,350	4,410	9,940
1989	3,500	1,600	5,100	17,850	5,430	12,420
1990	4,100	1,900	6,000	21,000	6,270	14,730
Total			23,300	81,550	23,910	57,640

Note: water rate: Kip 3.5/m3

For additional water sold and expenditure: See Table 8-2 and 8-3

Estimated at 1983 price level

*1 O/M cost including chemicals, electricity, and personnel costs.

*2 Before debt service and depreciation.

Table 8-2 Additional Water Sold by the Project

Year	Additional Water Production (m3/day)			Unaccounted-for Water (%)		Additional Water Sold ('000 m3/year)		
	City Area	Exten.Area	Total	City Area	Exten.Area	City Area	Exten.Area	Total
1984	-	2,600	2,600	37	10	-	900	900
1985	3,100	2,800	5,900	35	10	700	900	1,600
1986	5,400	3,200	8,600	33	10	1,300	1,100	2,400
1987	7,800	3,700	11,500	31	10	2,000	1,200	3,200
1988	10,400	4,300	14,700	29	10	2,700	1,400	4,100
1989	13,100	5,000	18,100	27	10	3,500	1,600	5,100
1990	15,100	5,800	20,900	25	10	4,100	1,900	6,000

Note: The Kaolieo Treatment Plant is expected to stop its operation unless improvement work is made.

Table 8-3 Operation and Maintenance Costs for Additional Production

Year	Additional Projection (m3/day)	Operation and maintenance cost ('000 Kip)
1984	-	-
1985	5,900	1,770
1986	8,600	2,580
1987	11,500	3,450
1988	14,700	4,410
1989	18,100	5,430
1990	20,900	6,270
Total		23,910

Note: Unit costs for operation and maintenance are estimated based on the present costs.

- Alum: Kip 128/m3.year
  (50 ppm x 1/1,000,000 x 365 x Kip 7kg)
- Hypochlorite: Kip 56/m3.year
  (0.5 ppm x 1/1,000,000 x 365 x Kip 50.75/kg)
- Electricity: Kip 4.3/m3.year
  (0.012 kWH x 24 x 365 x Kip 0.04/kWH)
- Personnel Cost: Kip 43/m3.year
  (75 x Kip 5,800/year x 1/10,000)
- Other Cost: Kip 68/m3.year
  (3,426,000 x 1/5 x 1/10,000)

Estimated unit production cost: Kip 300/m3/year

Table 8-4 Production and Water Demand

Year	Production ('000 m3/d)			Average Daily Demand ('000 m3/d)			Maximum Daily Demand ('000 m3/d)		
	Kaolieo	Chinaimo	Total	City Area	Ext. Area	Total	City Area	Ext. Area	Total
1982	10,000	40,000	50,000	36,000	-	36,000	40,700	-	40,700
1983	10,000	40,000	50,000	38,200	(2,400)	38,200	43,900	(2,800)	43,900
1984	20,000 1/	40,000	60,000	40,600	2,600	43,200	46,700	3,000	49,700
1985	20,000	40,000	60,000	43,100	2,800	45,900	49,600	3,200	52,800
1986	20,000	40,000	60,000	45,400	3,200	48,600	52,200	3,700	55,900
1987	20,000	40,000	60,000	47,800	3,700	51,500	55,000	4,200	59,200
1988	20,000	40,000	60,000	53,100	5,000	58,100	61,000	5,800	66,800
1990	20,000	40,000	60,000	55,100	5,800	60,900	63,300	6,700	70,100

Note: 1/ Production Capacity after proposed improvement.

9. Conclusion and Recommendation

Based on the site survey and intensive study for the Vientiane Water Supply System, the following works are recommended to be implemented:

- The improvement work of the Kaolieo Treatment Plant such as replacing and repairing of mechanical and electrical equipment;
- The intake bank and riverbed protection to prevent the further erosion; and
- Installation of the distribution pipelines for such areas as Dong Dok Area-1, Phone Tong Area-1, Thadua Road Area-1 and Thong Pong Area where important industrial estates and governmental institutions are situated.

The abovementioned works should be regarded as an interim measures to be followed by the next phase expansion program. The system to be improved by the Project will cover the water demand up to the year around 1990.

Water demands of the Vientiane City for every five years are estimated as follows:

Year	Daily Average Demand (m3/day)	Daily Maximum Demand (m3/day)
1985	45,900	52,800
1990	60,900	70,000
1995	89,400	77,700
2000	112,900	129,800

The rated production capacity of the system is 60,000 m3/day, 40,000 m3/day from the Chinaimo Treatment Plant and 20,000 m3/day from the Kaolieo Treatment Plant. However, actual production capacity at present is estimated as about 50,000 m3/day due to the deterioration of the equipment of the Kaolieo Treatment Plant. The present distribution system in the existing served area is considered to have a capacity which will meet the water demand up to the year 1990.

Intake bank and riverbed protection around the Intake Tower of the Kaolieo Treatment Plant is to be implemented by this project to avoid further erosions which may result in the suspension of the operation of the Plant.

Extension of the distribution pipelines for such areas as Dong Dok Area-1, Phone Tong Area-1, Thadua Road Area-1, and Thong Pong Area will serve water for about 12,000 people and 25 bulk users such as industrial estates and governmental institutions by 1990. Daily maximum water demand of these area is estimated as about 5,000 m3/day in 1990.

The Project will be implemented starting from June 1983 and all construction and installation works are expected to be completed at the beginning of May 1984. NPP is the executing agency of the Project and a Japanese contractor undertakes construction work. The Consultants will be employed for the construction supervision to assist NPP.

On-the-job training for operation and maintenance of the Kaolieo Treatment Plant is undertaken by the Contractor under the supervision of the Consultants.

The following benefits generated by the Project implementation are considered:

- To increase revenue of NPP which is estimated as Kip 57 millions for seven (7) years from 1984 to 1990 based on prices in 1983;
- To reduce the losses caused by fires;
- To improve health and sanitation conditions; and
- To give the impact on economic activities resulting in economic development of the City.

The team concludes the proposed project is most appropriate for the consideration of a grant aid by the external source from the history of the water supply of Vientiane.

Study for the next expansion program is recommended to start in the early stage, which includes such as the review of the served area and water demand projection, expansion of production facilities, planning for distribution system and its network analysis, leakage and wastage control program, organization of the system, and financial analysis.