Chapter 4
Selection of Master Plan Projects

CHAPTER 4 SELECTION OF MASTER PLAN PROJECTS

4.1 GENERAL PRINCIPLES

The review of the existing water supply system reveals that total capacity of available water sources is not sufficient against users' demand, especially in dry season. It results in chronic water rationing and accidental water failures especially in dry season. It is apparently necessary to develop additional water sources in order to meet the water demand. Only with adequate capacity of water sources the efficient water supply system can be established.

In addition, the review of the existing condition shows that the existing leakage amount is estimated about 30 % of distributed water. The master plan should give high priority to leakage control from the viewpoint of saving not only precious water resource but also resource input on production processes.

Tegucigalpa is the capital of Honduras and the present water supply service coverage exceeds 90 %. Considering these facts, the following general goals were set for the master plan proposed in the Study.

- Stable water supply service with 99 % reliability against draught, which is equivalent to the driest month in 10 years.
- 24-hour continuous water supply service with adequate quantity and quality.

The Study analyzed available water supply capacity in the study area based on the 99% reliable yield capacity of each water source. Then, the master plan components, which will enable to achieve the above goals, were selected based on a cost benefit analysis. They should be able to satisfy the future required water production rate of 267,494 m^3/day (3,096 l/s) on average daily base. It should be noted that groundwater was excluded from the discussion because the present share of groundwater to the total water supply is merely 1.4% and less possibility of further development was identified in the Study.

4.2 WATER PRODUCTION RATE OF EXISTING SYSTEM

The Study assumed that the water supply capacity after the aforementioned on-going projects could be considered as the existing conditions, because the fact that their implementation has already been committed endorsed their necessity, justification, and work contents. The 99 % reliable yield capacities before and after the on-going projects are summarized in *Table 4.1*.

Table 4.1 Yield Capacity after On-going Projects

Subsystem	Before the on-going projects (l/s)	After the on-going projects (l/s)
Picacho	200	350
Los Laureles	540	540
Concepcion	1,000	1,310
Miraflores	0	50
Total	1,740	2,260

The purpose of this section is to estimate the deficit of available production rate of the existing system to the required production rate in 2015. Therefore, the existing production rate is discussed base on the average daily value nevertheless the currently treatment plants may work at almost full design capacity, which is normally equivalent to the maximum daily value.

4.2.1 PICACHO SUBSYSTEM

After the on-going rehabilitation project, capacities of conduction, and treatment facilities of Picacho subsystem will be as shown in *Table 4.2*.

Table 4.2 Design Capacity of Picacho Subsystem

Facility	Design capacity (m^3/day)	Equivalent average daily value (m^3/day)
Intake yield	30,240 (350 l/s)	26,266 (304 l/s)
Conduction	90,720 (900 l/s)	67,570 (782 l/s)
Treatment plant	90,720 (900 l/s)	67,570 (782 l/s)

The available water production rate is limited by the yield capacity at the source. The water sources of Picacho subsystem are small creeks without storage capacity, thus the yield capacity is equivalent to the maximum daily value.

The available production rate of Picacho subsystem is estimated at 24,689 m^3/day (286 l/s) on average daily base. Operation loss is assumed to be 6 % of intake rate.

4.2.2 LOS LAURELES SUBSYSTEM

The present capacities of conduction and treatment facilities of Los Laureles subsystem are as shown in *Table 4.3*.

Table 4.3 Design Capacity of Los Laureles Subsystem

Facility	Design capacity (m^3/day)	Equivalent average daily value (m^3/day)
Intake yield	46,656 (540 l/s)	*46,656 (540 l/s)
Conduction	57,900 (670 l/s)	50,300 (582 l/s)
Treatment plant	57,900 (670 l/s)	50,300 (582 l/s)

*: The yield capacity will decrease approximately 430 m^3/day (5 l/s) a year due to sedimentation.

The yield capacity is equivalent to the average daily value because Los Laureles reservoir has enough storage capacity to absorb fluctuation of the required intake rate. The table shows that the available water production rate is limited by the yield capacity at the source. By deduction of 6% of operation loss, the available production rate of Los Laureles subsystem is estimated at 43,856 m^3/day (508 l/s) on average daily base. It should be noted that the yield capacity of Los Laureles reservoir is decreasing 5 l/s a year due to sedimentation. Therefore, the available production rate of Los Laureles subsystem decreases 406 m^3/day a year.

4.2.3 CONCEPCION SUBSYSTEM

After the on-going rehabilitation project, capacities of conduction, and treatment facilities of Concepcion subsystem will be as shown in *Table 4.4*.

Table 4.4 Design Capacity of Concepcion Subsystem

Facility	Design capacity (m^3/day)	Equivalent average daily value (m^3/day)
Intake yield	113,120 (1,310 l/s)	113,120 (1,310 l/s)
Conduction	129,600 (1,500 l/s)	112,579 (1,303 l/s)
Treatment plant	129,600 (1,500 l/s)	112,579 (1,303 l/s)

The yield capacity is equivalent to the average daily value because Concepcion reservoir has enough storage capacity to absorb fluctuation of the required intake rate. The table shows that the available water production rate is limited by the capacities of conduction and treatment facilities. By deduction of 6% of operation loss, the available production rate of Concepcion subsystem is estimated at 105,824 m^3/day (1,225 l/s) on average daily base.

4.2.4 MIRAFLORES SUBSYSTEM

After the on-going rehabilitation project, capacities of conduction, and treatment facilities of Miraflores subsystem will be as shown in *Table 4.5*.

Table 4.5 Design Capacity of Miraflores Subsystem

Facility	Design capacity (m^3/day)	Equivalent average daily value (m^3/day)
Intake yield	4,320 (50 l/s)	3,752 (43 l/s)
Conduction	8,640 (100 l/s)	7,500 (87 l/s)
Treatment plant	4,320 (50 l/s)	3,752 (43 l/s)

The available water production rate is limited by both the yield capacity at the source and the treatment capacity. The water sources of Miraflores subsystem are rivers without storage capacity, thus the yield capacity is equivalent to the maximum daily value. By deduction of 6% of operation loss, the available production rate of Miraflores subsystem is estimated at 3,527 m^3/day (41 l/s) on average daily base.

4.2.5 EXISTING PRODUCTION RATE

As a result of the above analysis, the existing water production rate based on the 99% reliable yield capacity is estimated at 177,896 m^3/day (2,059 l/s) on daily average base, as shown in *Table 4.6*. This production rate will decrease 406 m^3/day (4.7 l/s) every year, due to sedimentation of Los Laureles reservoir.

Table 4.6 Existing Available Water Production Rate

Subsystem	Available water production rate with 99% reliability (m^3/day)	
Picacho	24,689	(286 l/s)
Los Laureles	*43,856	(*508 l/s)
Concepcion	105,824	(1,225 l/s)
Miraflores	3,527	(41 l/s)
Total	*177,896	(*2,059 l/s)

*: The production rate in 2000. It will decrease 406 m^3/day (4.7 l/s) a year.

The existing deficit of production rate to the required production rate in 2015, 267,494 m^3/day (3,096 l/s), is 89,598 m^3/day (1,037 l/s).

4.3 CANDIDATE PROJECTS

The following projects were studied as the candidate master plan projects.

- Los Laureles reservoir dredging project,
- Los Laureles II project, consisting of construction of Los Laureles II dam and necessary water supply facilities, and excavation of the existing Los Laureles reservoir,

- Quiebra Montes project, consisting of construction of Quiebra Montes dam and necessary water supply facilities,
- Sabacuante project, consisting of construction of Sabacuante dam and necessary water supply facilities,
- Tatumbla project, consisting of construction of Tatumbla dam and necessary water supply facilities, and
- Water leakage reduction project.

The location of each project site is shown in *Figure 4.1*.

Benefit of each candidate project was evaluated based on the available production rate with maximizing the use of the estimated yield capacity of water sources.

Required cost for each candidate project consists of the investment cost of facilities required for the said available production rate and required for primary transmission.

4.3.1 LOS LAURELES RESERVOIR DREDGING PROJECT

This project aims to increase the yield capacity of the existing Los Laureles reservoir by dredging sediments. Dredging of all the existing sediments of 3,000,000 m^3 will increase the effective storage volume of Los Laureles reservoir by 1,000,000 m^3, which is equivalent to an increase of yield capacity by 50 l/s. After the dredging, the yield capacity of Los Laureles reservoir will be 590 l/s.

In order to maximize the use of the water yield of Los Laureles reservoir of 590 l/s, it is necessary to expand Los Laureles WTP by 780 m^3/day (9 l/s). The existing conduction facility of Los Laureles WTP has enough capacity to deal with the increased intake flow. Since Los Laureles WTP is located in its distribution area, no primary transmission is required.

The increment of production rate due to Los Laureles reservoir dredging is 4,057 m^3/day. The required cost is USD 48,800,000 as shown in *Table 4.7*.

Table 4.7 Cost of Los Laureles Reservoir Dredging Project

Facility	Cost (USD)	Specifications
Dredging	46,500,000	3,000,000 m^3
Treatment plant	2,300,000	780 m^3/day
Primary transmission	0	0 km
Total	48,800,000	

4.3.2 LOS LAURELES II PROJECT

Water balance analysis on Los Laureles II reservoir was made based on stream flow discharge records. The water yield of Los Laureles II reservoir in the driest month in 10 years was estimated at 130 l/s.

Los Laureles II reservoir is located about four (4) km upstream of the existing Los Laureles reservoir, and it is possible to utilize the existing Los Laureles WTP with expansion. The construction of Los Laureles II dam requires at least five (5) yeas, meanwhile the yield capacity of the existing Los Laureles reservoir decreases to 510 l/s due to sedimentation. Los Laureles II dam will facilitate to remove the sediments from the existing Los Laureles reservoir. In this case it is possible to restore the present yield capacity of 540 l/s by excavating 600,000 m^3 of sediments.

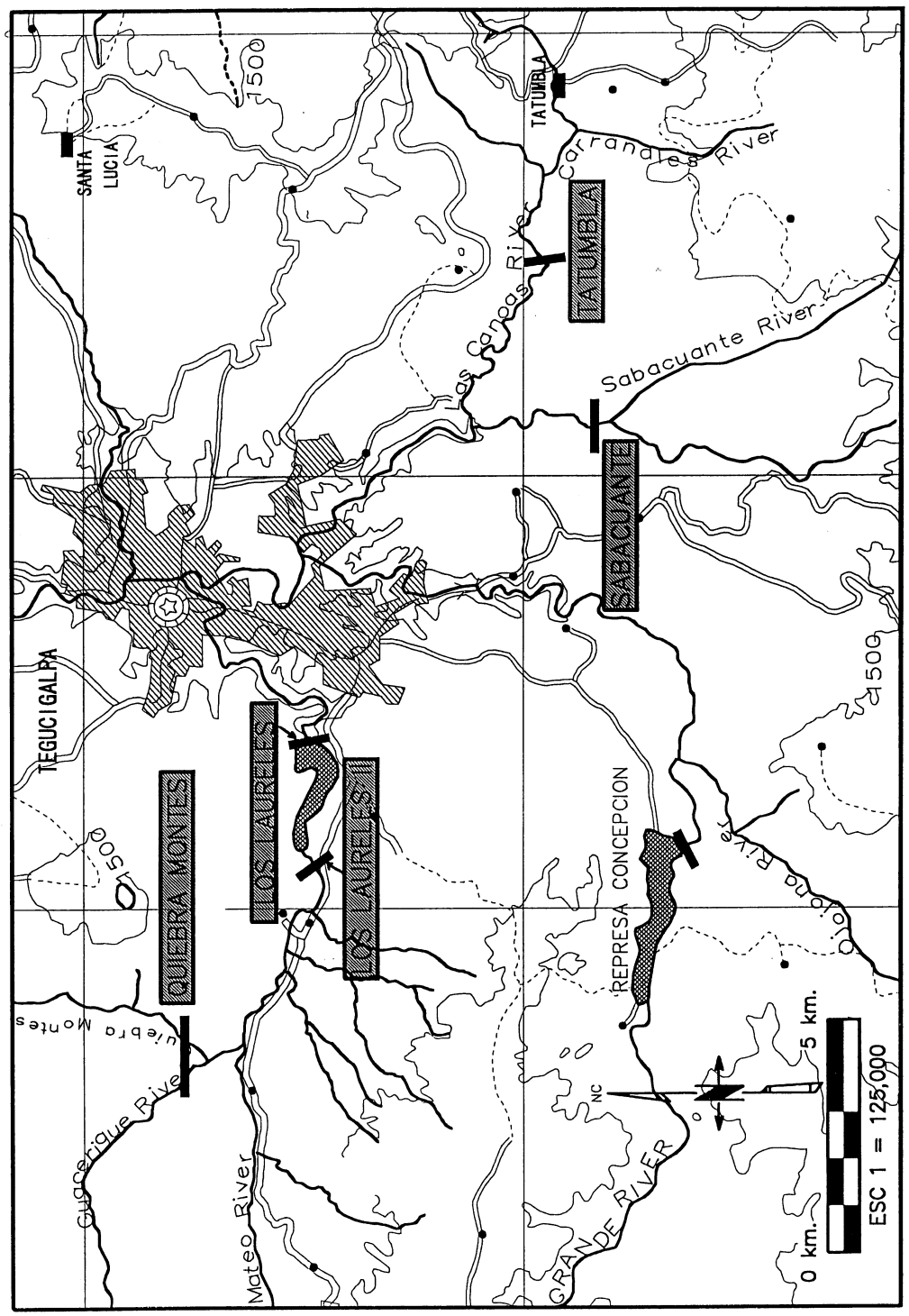

Figure 4.1	Location of Candidate Project Sites

The total yield capacity of Los Laureles II and the existing Los Laureles reservoirs will be 670 l/s. In order to maximize the use of this yield capacity, it is necessary to expand Los Laureles WTP by 8,760 m^3/day (101 l/s). Construction of conduction facilities is not necessary because the existing conduction facilities have enough capacity to deal with the increased intake flow. Since Los Laureles WTP is located in its distribution area, no primary transmission is required.

The increment of production rate due to Los Laureles II reservoir and excavation of Los Laureles reservoir is 12,995 m^3/day. The required cost is USD 28,300,000 as shown in *Table 4.8*.

Table 4.8 Cost of Los Laureles II Project

Facility	Cost (USD)	Specifications
Dam	14,800,000	Dam height : 31.0 m
Treatment plant	9,700,000	8,760 m^3/day
Primary transmission	0	0 km
Excavation of Los Laureles reservoir	3,800,000	600,000 m^3
Total	28,300,000	

4.3.3 QUIEBRA MONTES PROJECT

Water balance analysis on Quiebra Montes reservoir was made based on stream flow discharge records. The water yield of Quiebra Montes reservoir in the driest month in 10 years was estimated at 1,040 l/s.

In order to maximize the use of this water yield, it is necessary to construct the conduction facilities and a water treatment plant with design capacity of 103,450 m^3/day (1,197 l/s). Quiebra Montes WTP requires eight (8) km primary transmission line.

The available production rate is 84,464 m^3/day. The required cost is USD 212,000,000 as shown in *Table 4.9*.

Table 4.9 Required Cost for Quiebra Montes Project

Facility	Cost (USD)	Specifications
Dam	143,900,000	Dam height : 66.0 m
Conduction	1,600,000	Diameter 1.2 m × 1 km
Treatment plant	42,200,000	103,450 m^3/day
Primary transmission	24,300,000	8 km
Total	212,000,000	

4.3.4 SABACUANTE PROJECT

Water balance analysis on Sabacuante reservoir was made based on stream flow discharge records. The water yield of Sabacuante reservoir in the driest month in 10 years was estimated at 250 l/s.

In order to maximize the use of this water yield, it is necessary to construct the conduction facilities and a water treatment plant with design capacity of 24,900 m^3/day (288 l/s). Sabacuante WTP requires three (3) km primary transmission line.

The available production rate is 20,332 m^3/day. The required cost is USD 93,000,000 as shown in *Table 4.10*.

Table 4.10 Required Cost for Sabacuante Project

Facility	Cost (USD)	Specifications
Dam	68,900,000	Dam height : 76.5 m
Conduction	4,000,000	Diameter 0.8 m × 5.2 km
Treatment plant	17,800,000	24,900 m^3/day
Primary transmission	2,300,000	3 km
Total	93,000,000	

4.3.5 TATUMBLA PROJECT

Water balance analysis on Tatumbla reservoir was made based on stream flow discharge records. The water yield of Tatumbla reservoir in the driest month in 10 years was estimated at 220 l/s.

In order to maximize the use of this water yield, it is necessary to construct the conduction facilities and a water treatment plant with design capacity of 21,900 m^3/day (253 l/s). Tatumbla WTP requires three (3) km primary transmission line.

The available production rate is 17,882 m^3/day. The required cost is USD 115,000,000 as shown in *Table 4.11*.

Table 4.11 Required Cost for Tatumbla Project

Facility	Cost (USD)	Specifications
Dam	92,300,000	Dam height : 81.0 m
Conduction	5,000,000	Diameter 0.8 m × 6.5 km
Treatment plant	15,400,000	21,900 m^3/day
Primary transmission	2,300,000	3 km
Total	115,000,000	

4.3.6 WATER LEAKAGE REDUCTION PROJECT

Leakage can be regarded as potential water source because a reduction of leakage enables the water supply users by pipe to increase available water. The present amount of leakage in the driest month during 10 years was estimated at 41,757 m^3/day (483 l/s), which is equivalent to 30 % of the available production rate of 139,190 m^3/day (1,611 l/s) before the on-going projects.

According to the results of leakage survey conducted in the Study, leakage scattered all over the network and it is necessary to replace pipelines for the reduction of leakage amount. SANAA repair records show that 97.3 % of leakage occurred at pipes with 8-inch diameter or less, among which 33.5% occurred at house connection pipes with 3/4-inch diameter or less. Based on these facts, the following two (2) alternatives of leakage reduction measures were studied.

- To replace all pipes with 8-inch diameter or less, and
- To replace all house connection pipes with 3/4-inch diameter or less.

Although it is difficult to estimate the benefits of leakage reduction quantitatively, the benefits of both alternatives were empirically assumed as follows.

- Replacement of pipes with 8-inch diameter or less will reduce the leakage ratio from 30 % to 10 %. Then, the production rate is estimated at 27,833 m^3/day (322 l/s).
- The effect of replacement of house connection pipes with 3/4-inch diameter or less will be 8 % of that of the replacement of pipes with 8-inch or less, based on the assumption that the leakage volume will be in proportion to the number of leakage occurrences and pipe diameter. Then, the production rate is estimated at 2,227 m^3/day (26 l/s).

The required investment costs are summarized in *Table 4.12*.

Table 4.12 Required Cost for Water Leakage Reduction Project

Activity	Pipe with 8-inch or less		Pipe with 3/4-inch or less	
	Cost (USD)	Specifications	Cost (USD)	Specifications
Replacement of pipe	160,000,000	1,870 km	22,800,000	120,000 contracts × 3 m

4.4 SELECTION OF MASTER PLAN PROJECTS

4.4.1 COST BENEFIT ANALYSIS

Table 4.13 shows the result of cost benefit analysis. From the viewpoint of cost efficiency, projects with lower specific cost were given higher priority.

Table 4.13 Result of Cost Benefit Analysis

Project	Developed production rate (m^3/day)	Required investment cost (USD)	Specific cost (USD/m^3/day)
Los Laureles reservoir dredging project	4,057	48,800,000	12,029
Los Laureles II project	12,995	28,300,000	2,178
Quiebra Montes dam	84,464	212,000,000	2,510
Sabacuante dam	20,332	93,000,000	4,574
Tatumbla dam	17,882	115,000,000	6,431
Water leakage reduction (8-inch or less)	27,833	160,000,000	5,749
Water leakage reduction (3/4-inch or less)	2,227	22,800,000	10,238

4.4.2 WATER SUPPLY CAPACITY BUILD-UP

Based on the priority given by the cost benefit analysis, required water supply capacity build-up was studied. As shown in *Table 4.14*, two (2) projects with lower specific cost, *i.e.* Los Laureles II project and Quiebra Montes project satisfy the required production rate of 267,494 m^3/day. These two (2) projects were selected as the master plan projects.

Table 4.14 Water Supply Capacity Build-up

Project	Developed production rate	Cumulative production rate	Deficit to requirement
(Existing condition)	-	*175,459	92,035
Los Laureles II project	12,995	188,454	79,040
Quiebra Montes project	84,464	272,918	(-5,424)

*: The production rate in the year 2006 when Los Laureles II project will be completed. (Unit: m^3/day)

4.4.3 MEASURES FOR WATER LEAKAGE CONTROL

Though the water leakage reduction projects were given lower priority as a result of cost benefit analysis, necessity of leakage control is still high from the viewpoint of saving not only precious water resource but also resource input on production processes.

Currently lack of data concerning leakage and low coverage of working micrometers make it difficult to prepare effective and efficient leakage reduction program. At this moment since it is impossible to measure actual water consumption due to lack of insufficient micrometer, even an amount of leakage is not clear. It is essential for implementation of leakage reduction program to understand actual situation of leakage by monitoring both outflow of distribution reservoirs and water consumption of each user. Therefore, as a measure of leakage control installation of micrometers to all users and flow meters to all distribution reservoirs is proposed as one of master plan projects.