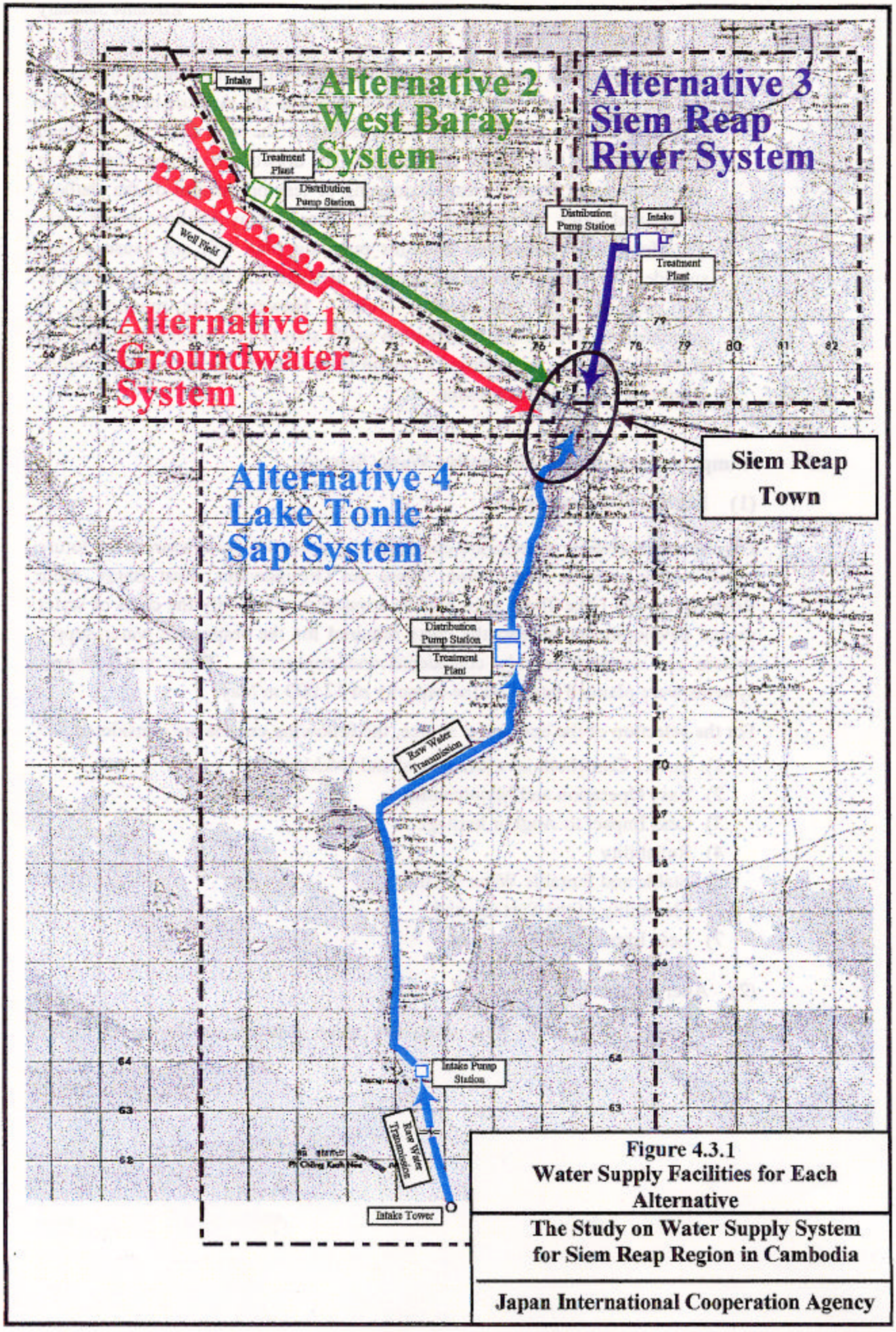

Figure 4.3.1
Water Supply Facilities for Each Alternative

The Study on Water Supply System for Siem Reap Region in Cambodia

Japan International Cooperation Agency

(3) Cost Comparative Study

Detail analysis shows that the direct construction cost including land acquisition cost for the four water supply systems are 6.3, 10.0, 13.1, and 13.3 million US$ for groundwater, West Baray, Siem Reap River, and Lake Tonle Sap System, respectively. Base year for cost estimation is 1999. The yearly operation and maintenance cost for the same four systems in that order are 0.26, 0.30, 0.32, and 0.36 million US$, respectively. For both cases, groundwater system is most economical. For a system lifetime of 30 years, the net present value of the systems in same order are 7.5, 11.3, 14.3, and 14.6 million US$, respectively. This also strongly indicates that groundwater system is most economic over the life span.

(4) Comprehensive Comparison and Selection of the Best Alternative

Cost is one of the most important criteria for the comparative study. However, for the selection of the most suitable water source, the other criteria have also been taken into consideration.

From the results of evaluation, the Groundwater System has been concluded to be the most suitable alternative and recommendable as a water source for the Siem Reap Water Supply System.

4.4 Past and Present Public Water Supply System

(1) Production

Public piped water supply system in Siem Reap Town is under responsibility of the Siem Reap Waterworks, which is one of the waterworks controlled by the Ministry of Industry, Mines, and Energy (MIME).

The first public piped water supply system was established in the 1930s by French aid. The so-called “Old French System” consisted of treatment plant taking its raw water from the Siem Reap River and small-scale distribution system.

The second system was constructed in the 1960s by American aid, abandoning the Old French System. This “American System” also took its raw water from the Siem Reap River. Distribution system was expanded to cover the central part of the Siem Reap Town. This system had been operated until March 1995. Water treatment was terminated and the Waterworks stopped its public water supply services because of deterioration of raw water quality of the Siem Reap River and deterioration of the facilities.

MIME commenced construction of a new water supply system using groundwater in 1995 financed by French aid. Two deep wells were dug in the existing treatment plant. However, groundwater from these two deep wells contains high iron and it was not suitable for direct drinking. To remove the high iron contents,

aeration facility and pressure filters were additionally installed. This "New French System" was completed in September 1998, and finally the Siem Reap Waterworks started its water supply services from the end of July 1999.

(2) Distribution

Range of diameter of the existing distribution network, which was constructed in the 1960s, is 100 mm to 250 mm and the dominant material of the distribution pipeline is ACP. PVC material was used in very limited pipeline that was recently installed by AFD in 1995.

When the New French System was constructed, AFD checked all distribution network pipeline. Although AFD repaired some pipelines, the condition of distribution network is still not good according to the information from the Waterworks.

It is apparent that rehabilitation of the existing distribution network is required considering current situation. Pipe replacement is recommended under the present Study.

For the selection of the pipelines to be replaced, the following data and information were considered.

1. Results of leakage survey conducted by AFD
2. Record of location of leak repaired by the Waterworks
3. Record of location of house connection repaired by the Waterworks
4. Density of house connection
5. Pipelines where Waterworks experienced difficult maintenance

Based on the detail analysis, final selection of pipeline to be replaced is proposed. This covers around 50% of the existing pipelines.

4.5 System Expansion Program on Siem Reap Water Supply

(1) Stage-wised Development Policy

Service area will be expanded in the end of year 2006 to cover new housing area located in southeastern area. In this Master Plan, stage-wised development policy is introduced to meet such expansion of service area and increase of water demand. As shown on Figure 4.5.1, after the first implementation in year 2002 as Stage 1, system capacity will be increased again in year 2006 as Stage 2.

Increase of water supply capacity is shown in Table 4.5.1.

Table 4.5.1 Increase of Supply Capacity

Stage	Incremental Capacity (m^3/day)	Total Supply Capacity (m^3/day)
Existing		1,440
Stage 1	8,000	9,440
Stage 2	4,000	12,000

At the end of the Stage 1, the existing system of 1,440 m^3/day capacity is supposed to be abandoned because of its life time. Therefore the total capacity of the Stage 2 will be 9,440 + 4,000 – 1,440 = 12,000 m^3/day

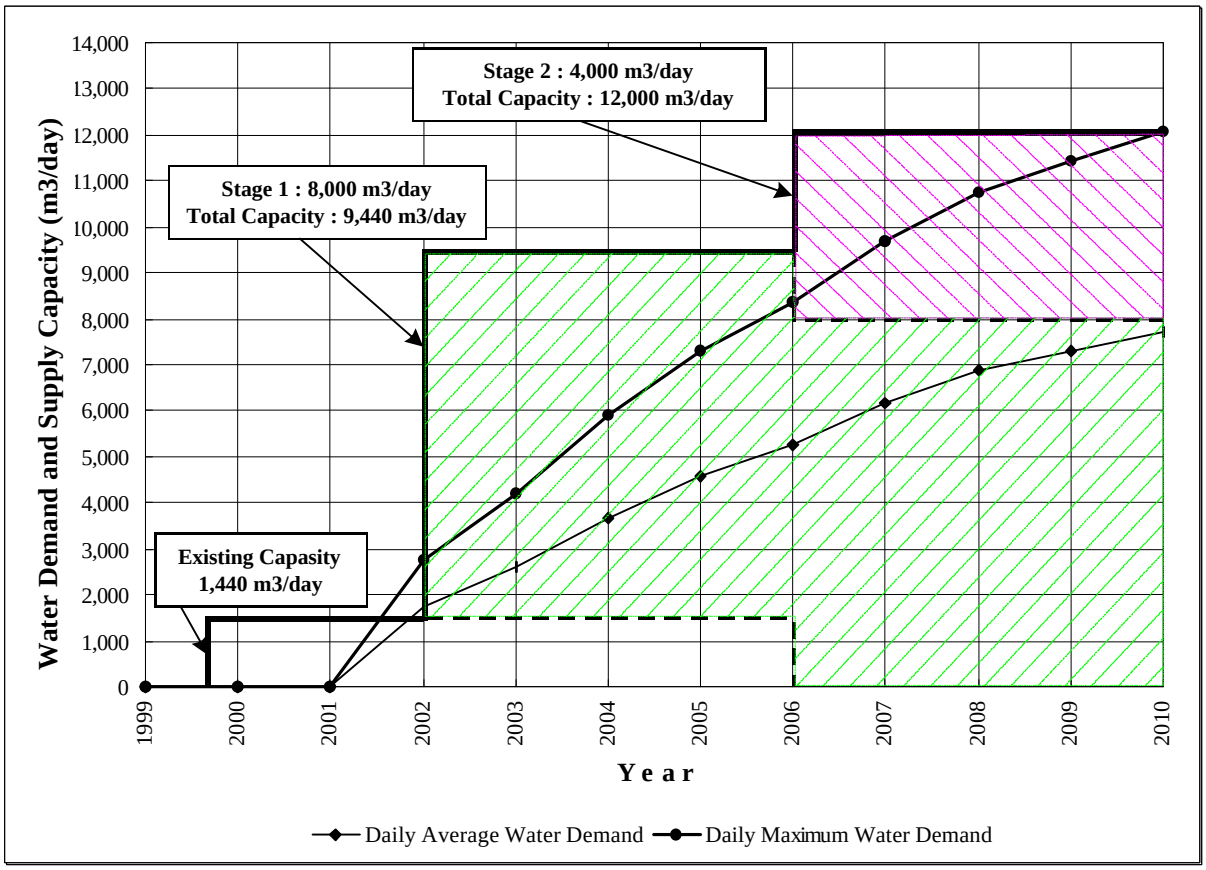

Figure 4.5.1 Stagewised Capacity Increase and Future Water Demand

(2) Future Water Supply System

1) System Flow

Groundwater abstracted from each well will be sent to a receiving well through a connecting pipeline. Liquid chlorine will be dosed for disinfection in the receiving well. Disinfected groundwater will be stored in the clear water reservoir to buffer hourly peak water demand. After measurement by the main water meter, water will be pumped to distribution network. Method of water distribution is direct pumping, hence new or additional elevated tank will not be constructed.

Water production facilities such as wells, receiving well, clear water reservoir, and disinfection facilities will be designed based on the Daily Maximum Water Demand. Distribution system such as distribution pumping station and distribution network will be designed based on the Hourly Maximum Water Demand.

2) Production facilities

There will be 10 wells constructed under Stage 1 located along the National Road No. 6. Additional 5 wells to be constructed under Stage 2 will be located along the branch road from the National Road No. 6 to the West Baray. Each well will have a capacity of 800 m^3/day. Depth of each well will be 50 m.

This M/P stage also proposed directions to construct well connecting pipes, receiving wells, disinfection facilities, and clear water reservoir for the entire system.

3) Distribution Facilities

Distribution pumping station will be constructed to store distribution pumps, which will transmit water to distribution system in Siem Reap Town area through distribution trunk main. Power for these distribution pumps will be supplied by in-plant generators.

From the distribution pumping station, water will be transmitted to the town through distribution trunk main, which will be installed along the National Road No. 6. Hotels which are located along the National Road No. 6 will be supplied from branches on the trunk main. Water supply system for the new hotel development area will be a separated system from the town water supply, although it will get water from proposed Siem Reap Water Supply.

Future distribution network is established taking into account all possible technical factors including pipe replacement. Most of the new pipeline will be installed under the Stage 1, additional pipeline will be installed under the Stage 2 to cover newly expanded service area. Service area is separated by the Siem Reap River and eastern and western service area will be connected by two new pipe bridges.

Length of the proposed distribution network is as shown in Table 4.5.2.

Table 4.5.2 Length of Distribution Pipeline by Diameter

Dia (mm)	Stage 1		State 2	Remaining Existing Pipelines (m)	Total (m)
	New Installation (m)	Replacement (m)	New Installation (m)		
500	7,450	-	-	-	7,450
450	710	-	-	-	710
400	-	166	-	-	166
350	-	254	-	-	254
300	-	230	-	-	230
250	360	900	-	509	1,769
200	2,630	92	-	354	3,076
150	765	1,169	410	1,964	4,308
100	1,860	3,499	1,100	3,005	9,464
75	3,250	-	1,800	-	5,050
Total	**17,025**	**6,310**	**3,310**	**5,832**	**32,477**

DIP is recommended as pipe material for the trunk main of which diameter is more than 200 mm. For the secondary main, PVC or PE is recommended.

It is recommended that tapping for connection is allowed only from distribution pipe of which diameter is smaller than 150 mm. It will require parallel pipe installation along with larger diameter (more than 200 mm) to install connection. Total length of service main will be about 6,200 m and diameter will be 50 mm and 75 mm.

Future increase of house connection is estimated on a per year basis for different types of connections. The total estimated connection are 1,744, 4,797, and 7,442 in 2002, 2006, and 2010, respectively.

(3) Preliminary Cost Estimates

Base year for the cost estimation is 1999 and all costs are shown in US$.

1) Construction Costs

A survey concerning unit costs of labor, materials, machines and equipment in Siem Reap Town and Phnom Penh is carried out. Based on the results of the survey, construction costs are preliminary estimated as shown in Table 4.5.3.

Table 4.5.3 Summary of Project Cost

(Unit: US$1,000)

	Description	Stage 1	Stage 2	Total
A	**Construction Costs**	11,242	1,963	13,205
	• Well Facilities(Deep Wells, Connecting Pipelines and Well House)	2,432	1,218	3,650
	• Disinfection, Reservoir, Power Facilities and Pumping Station	2,669	489	3,158
	• Pipelines (Distribution Mains, Service Mains, Rehabilitation of Existing Pipe)	6,141	256	6,397
B	Land Acquisition Cost	250	-	250
C	Administration Cost (2% of A)	225	40	265
D	Engineering Services (15% of A)	1,687	295	1,982
E	Physical Contingency (10% of A+C+D)	1,316	230	1,546
F	Price Contingency (10% of A to E)	1,472	253	1,725
	Total	**16,192**	**2,781**	**18,973**

2) Operation and Maintenance Costs

Operation and maintenance costs are calculated as unit cost per m^3 of water production. This is 0.135 US$/$m^3$ for Stage 1 and 0.115 US$/$m^3$ for Stage 2.

(4) Implementation Schedule

Project implementation is divided into two stages. A proposed time schedule is shown in the following Figure 4.5.2.

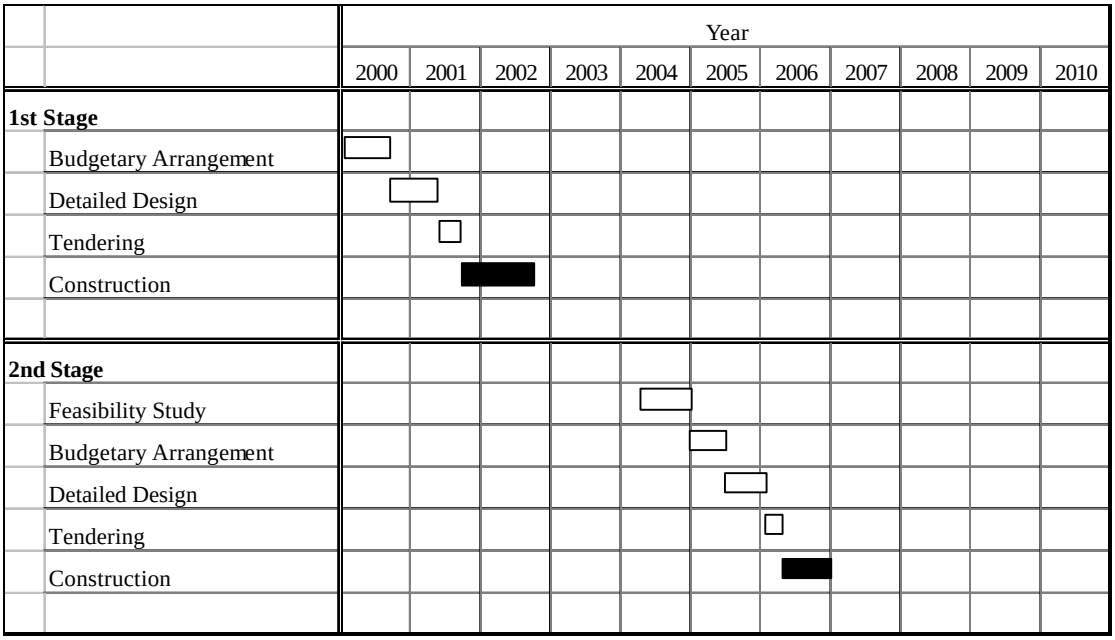

Figure 4.5.2 Implementation Schedule

4.6 Institutional Development

(1) Organizational Structure

The Study elaborately examined the existing institutional and organizational structure of Ministry of Industry, Mines and Energy (MIME) and the Siem Reap Waterworks, and their inter-relationship. At present, the Waterworks is managed by 9 persons and is comprised of two divisions, namely administration and technical.

To make the waterworks operate systematically and efficiently, this Study proposed a new organization with specific job description. From the standpoint of the functional waterworks operation, the productivity of waterworks is referred to in various cities of Cambodia and Laos as the neighboring country. Based on this analysis, the numbers of employees for the Siem Reap Waterworks are proposed as 14, 19, and 25 in the year 2002, 2006, and 2010, respectively. The new proposed organization took into account the operational condition of the proposed water supply system. Three divisions are proposed, namely, administration and finance, customer service, and technical. A detail job description for each position is also proposed.

(2) Recommendations for institutional improvement

One of the most important actions for the sound financial condition in the waterworks management will be to reduce an unaccounted-for-water ratio, in other words, to reduce leakage and illegal connections as far as possible. An elaborate program for this action is proposed in the Study.

Human resources development is another important avenue. The vocational training is essential to improve the employee's capability and eventually the performance of the organization. This Study proposes detail training program for the employees to be held both domestically and internationally.

To operate the Waterworks as technically stable and sound, financially balanced and viable, structurally stable, and legally perfect, reasonable institutional and legal framework are indispensable. After analyzing existing legal framework, potential of private sector participation and anticipated operational constraints, the Study proposes the following laws to be enacted as soon as possible.

1) Water Supply Ordinance
2) By-law on Business Consignment
3) Law for Restriction for Groundwater Usage
4) Law for Water Pollution Control

(3) Operation and Management

For smooth operation, Waterworks must supply safe and reliable potable water continuously with appropriate pressure for every consumer faucet with reasonable water charge. If the Waterworks can get an all-out reliance from every consumer, water charge could be collected on schedule, and financially stable condition would become attainable for the Waterworks.

To supply safe potable water ceaselessly, the Waterworks will have to improve its technical situation through appropriate operation and management practice. The Study proposed the following strategies:

1) Improvement and enhancement of the volition of employees,
2) System of reward,
3) Continuous monitoring for water quality,
4) Inventory management, and
5) Ledger of facilities.

4.7 Economic and Financial Analysis

(1) Introduction

The project evaluation is conducted from three points of view: (1) economic aspect, that is, viability of social investment in the national economy (2) financial aspect, that is, tests of earning capacity and fund management and (3) socioeconomic aspect of the Study area.

(2) Economic Analysis

In economic evaluation, the costs and benefits are estimated on the basis of economic values instead of market values, which were applied for financial analysis. For the economic evaluation, certain criteria and assumptions are applied to calculate economic values in this Study. The base year was selected as 2000 and 10% opportunity cost was applied for 30-year economic life.

One of important main benefits of water supply project is to improve public health and well being. Besides this, all other benefits like enhancement of amenity and social issues were considered in this Study. An elaborate economic approach was taken to find out economic benefits of both domestic and hotel water use. In economic evaluation, the financial cost was converted into economic value. Finally, the project is examined for economic efficiency.

The indices of economic evaluation were calculated as 10.5% of EIRR, 1.04 of B/C, and US$ 0.56 million of NPV. Thus, the proposed project could be viable from the economic point of view, because its EIRR exceeded the opportunity cost of capital, 10%.

(3) Financial Analysis

Financial analysis started with examination of financial status of Waterworks. This included present situation of water supply, category-wise water tariff with connection charge, and financial performance of new Waterworks for the month of August, September, and October 1999.

Financial analysis is carried out on the basis of market values of project costs and incomes from the proposed projects. The project costs are estimated in Section 4.5. The revenue of water sales is calculated as a product of a volume of water sold and water rates lay down by the PDIME. Finally, the project is examined for financial efficiency.

The indices of financial evaluation were –2.2% of FIRR, 0.34 of B/C, and minus US$ 12.0 million of NPV. The latter two indices were the results applying 10% discount rate. From the financial point of view, accordingly, the proposed project is not viable, as the FIRR is lower than the 10% opportunity cost.

The reason why the proposed project is not financially viable is too small revenue as compared with the investment and O&M costs. The project can be made financially viable by either increasing the water tariff 3.2 times or by covering 81% of the capital investment by subsidy. The two countermeasures mentioned here could be combined to make the proposed project financially viable.

(4) Socioeconomic Impacts

It is obvious that commencement of construction work for water supply project induces regional economy to activate and create job opportunity. The total investment cost of 72.1 billion Riels in two stages accounts for 3.4% of the total expenditure of the central government in 1999. It also accounts for 19.0% of the capital expenditure. Although this amount is not disbursed within a year, it is still a big investment.

4.8 Environmental Considerations

Environmental consideration represents the study whether a development project will have serious environmental impacts on the project site and its surrounding areas, analyzes the study results, and establishes necessary measures for avoiding or alleviating any adverse environmental impacts. In order to support sustainable development in developing countries, it is of great importance to give sufficient consideration to the environment in the planning and implementation of development programs.

For the present Study, an environmental investigation was conducted during the initial phase of the Study. This investigation is regarded as a preparatory stage for the Initial Environmental Examination (IEE). The IEE has been carried out in Master Plan Phase to determine the environmental impacts that may be created by the Project based on existing information and data, and judgement and experience. Primary objective of IEE is to scope Environmental Impact Assessment (EIA). Because of its extreme need and importance, this chapter also outlines a future wastewater disposal plan.

(1) Initial Environmental Examinations (IEE)

The IEE was carried out for the selected alternative only. Since there is no Cambodian Law available for the environmental screening, principally JICA format is applied making reference to ADB and WB guidelines. The Project is a water supply project involving groundwater development. So JICA guidelines for both groundwater development and water supply were applied for the Project. There are 23 items considered involving social environment, natural environment and pollution aspects.

The Project will significantly improve the public heath condition. Beneficiaries are presently depending on shallow wells for the domestic water demand. Since there is no wastewater disposal system in the town, organic and fecal pollution of the well water is highly possible. A house or yard supply will reduce the water fetching and storing time thereby contributing in more economic time availability. Hotels can also save a great amount of energy for independent water withdrawal and treatment.

A number of negative impacts are anticipated due to implementation of the Project. In the screening process, all negative impacts are classified into three categories, major negative impacts, notable negative impacts and minor negative impacts.

The possible major negative impacts can be the excessive lowering of groundwater table and more than expected land subsidence. Excessive lowering of groundwater table may reduce the yield of other wells operating nearby and may ultimately reduce the yield of the wells under the Project if the recharge is less than abstraction. A land subsidence may cause structural damage to buildings, airport and Angkor heritage.

The notable negative impacts may occur due land acquisition and generation of wastewater. The land requirement includes one plot of 10,000 m^2 land area and 12 plots of 50 m^2 land area. All pipelines will be placed under the road so no permanent land acquisition is necessary. Any water supply project increases the domestic wastewater, which should be disposed properly.

There are some aspects or impacts, which can not be ascertained in the Master Plan stage of the Project. One of these was impact on economic activities and the other was impact on cultural property.

(2) Scope for Environmental Impact Assessment (EIA)

From the matrix of the scoping, the following six items were scoped for EIA in the Feasibility Study stage: land acquisition, economic activities, cultural property, wastewater disposal, groundwater lowering, and land subsidence.

(3) Future Wastewater Disposal Plan

Piped water supply implies the production of increased wastewater. This has a potential for enhanced risk to health if on-site disposal is inadequate and off-site disposal is not provided. Hence, attention will need to be given to public hygiene education and the application of simple and effective wastewater disposal method. Community self-help can minimize cash costs, and should be encouraged.

A detailed study was conducted for the existing condition related to wastewater disposal and storm drainage. Based on this, a basic outline for future wastewater

disposal and drainage plan is provided taking into consideration the introduction of piped water supply in the near future to the Siem Reap Town.

4.9 Evaluation of the Master Plan

(1) Technical Evaluation

Existing service area covers only the central part of the Siem Reap Town. The area of the existing service area is about 90 ha. After implementation of the Stage 1 Project, service area will be expanded to about 345 ha and it will be 3.6 times wider than the existing one. Under the Stage 2, service area will be around 436 ha and it will be 4.6 times of the existing service area.

Although it will not be direct piped water supply, new hotel development area in northern part of Siem Reap Town will receive sufficient water for hotels, museum, and convention center from the proposed water supply system.

It is estimated that the current service ratio is about 9%. In this Master Plan, domestic service ratio is planned to increase 65% at the end of the Stage 1 (2006) and 75% in year 2010. For the tourism water demand, 95% of hotels, guesthouses and restaurants will be served by the new piped water supply. As service ratio increases, served population will increase to 25,500 in 2006 and 39,900 in 2010 from the present 2,300.

Stable and reliable water supply will be realized as system water source is a plural number of wells. Even if one submergible pump in the well goes out of order, the other pumps will still be operable. Power source of these well pumps and distribution pumps will be in-house generators. Two generators will be installed and will be operated alternately. Having stand-by generator, power failure will be avoided.

Water quality of the groundwater is confirmed suitable as a source of water supply. Potable water supply will be materialized by the continuous disinfection.

Not only for construction work but also for routine operation and maintenance, new water supply system will not require any special technology.

(2) Economic/Financial Evaluation

The economic evaluation proved that the proposed project was viable. The evaluation indices were 10.5% of EIRR, 1.04 of B/C, and US$ 0.56 million of NPV, respectively. Since its EIRR exceeds the opportunity cost of capital (10%), the proposed project could be viable from the economic point of view.

On the other hand, the financial evaluation indices were as follows: -2.2% of FIRR, 0.34 of B/C and NPV of minus US$ 12.0 million. From the financial point of view, therefore, the proposed project is not viable, because FIRR is lower than

the opportunity cost of capital of 10%. It would be possible to make the projects viable by means of subsidy for the 81% of the capital investment costs. Also, the combination case of 62% of the subsidy and 50% of hike in water tariff also makes the proposed project viable financially. What kind of combination is the most realistic is a policy matter. The available financial sources for the proposed project have to be found in the foreign and local financial markets.

(3) Environmental Evaluation

An Initial Environmental Examination (IEE) carried out as part of the Master Plan Study suggests that the Project will have a very significant positive impact in terms of public health condition. This Project will reduce the occurrence of water related diseases to a great extent, its medical cost and improve the economic condition of the town. Also this will support all tourist-related infrastructures and contribute to regional and national economy.

This Project will have minimum negative impacts compared with other development projects in developing countries. More elaborate strategy would be provided in EIA study under Feasibility Study.

Considering the benefit expected from the Project and relative ease in overcoming the negative impacts, it can be concluded that the Project is compliant with the environmental consideration.