4.6 Institutional Development

4.6.1 Introduction

The first water supply system in Siem Reap was established on the right bank of the Siem Reap River in the core of Siem Reap District by the then French colonial government in the 1930s. Almost all facilities constructed in the colonial days, however, do not exist presently with any records and drawings.

The second system of the water supply for the Siem Reap was constructed in the 1960s with the American government aid within the old French system premises. This second American system also got the raw water from the Siem Reap River and the treated water was distributed to the limited service area with capacity 300 m^3/day. This American system was operated until March 1995 and its operation was ceased because of deteriorated raw water quality originating mainly from the discharge of wastewater.

To recover the condition, the Ministry of Industry, Mine and Energy (MIME) constructed a new water supply system abstracting the groundwater from two deep wells in the treatment plant premises, financed by the French government in 1995 with 1,440 m^3/day capacity. Although this system was completed by September 1998, the system was not operated because of unaffordable electric charge till 28 July 1999. MIME and the Siem Reap Waterworks (the Waterworks) had been sounding an adequate solution for the well operation, and concluded eventually with the authority concerned.

4.6.2 MIME and the Waterworks

The Cambodian central government is controlled by the Prime Ministers and two Deputy Prime Ministers in cooperation with the Council of Ministries. The government consists of 20 Ministries and National Bank of Cambodia. MIME is controlling Industry, Mine and Energy sectors at present. The Water Supplies which are included in the "Industry" sector are under supervision of MIME. Organization chart of the MIME Headquarters in shown on Figure 4.6.1. On the other hand, water supplies for rural areas are responsible for Ministry of Rural Development. Phnom Penh Water Supply Authority is under control of Municipality of Phnom Penh.

MIME Provincial Office in Siem Reap supervises the Waterworks with Local Industry, Mine Recourse, Energy, and Commodity Control/Measurement sectors. Organization chart of MIME Provincial Office in Siem Reap is shown on Figure 4.6.2. The financial matters of the Waterworks in Siem Reap are also controlled

by the local provincial governor.

During the stoppage of the Waterworks operation, many damages which seemed mainly occurring along the pipelines were found, and every efforts have been taken into the recovery works by the staff. In reward for the ceaseless efforts, the system operation was commenced, as the cost negotiation of power supply was concluded between the electric supply authority and MIME. The Waterworks planned the revised water charge system, and asked the approval of the revised charge for MIME and Financial Department. The revising proposal was accepted officially on 29 June 1999.

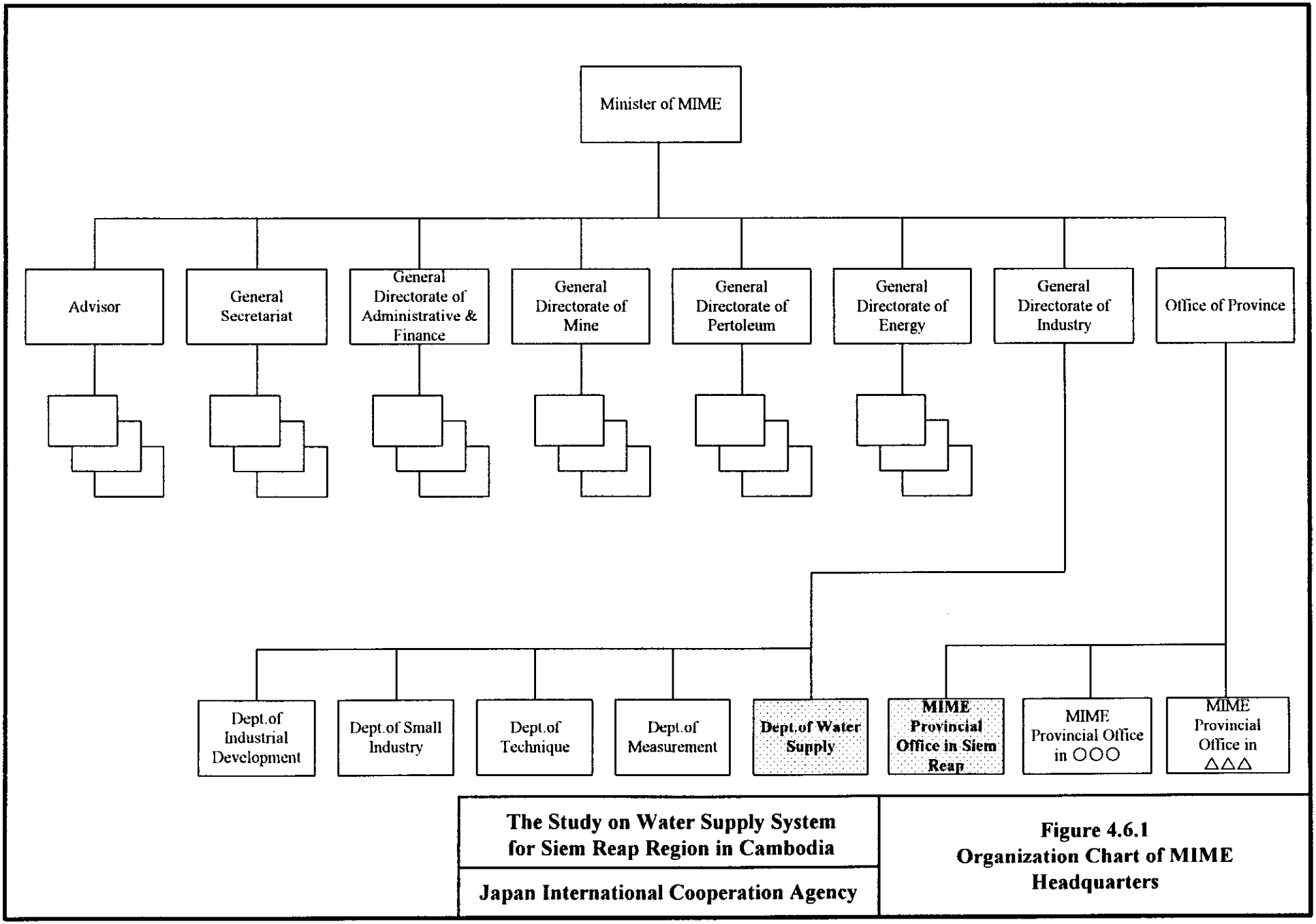
Nowadays the Waterworks has been managing by the above-mentioned 9 members, including one director as shown on Figure 4.6.3. The Technical Division members consist of one electric worker and two technical members, and all of them are engaging in the repair works in the networks of the service area. The Waterworks is planning to add 15 new employee, with commencement of the system operation.

4.6.3 Proposed Organization and Job Description

(1) System Productivity

The waterworks must be operated systematically and efficiently. From the standpoint of the functional waterworks operation, the productivity of the waterworks is considered from the number of employees as follows:

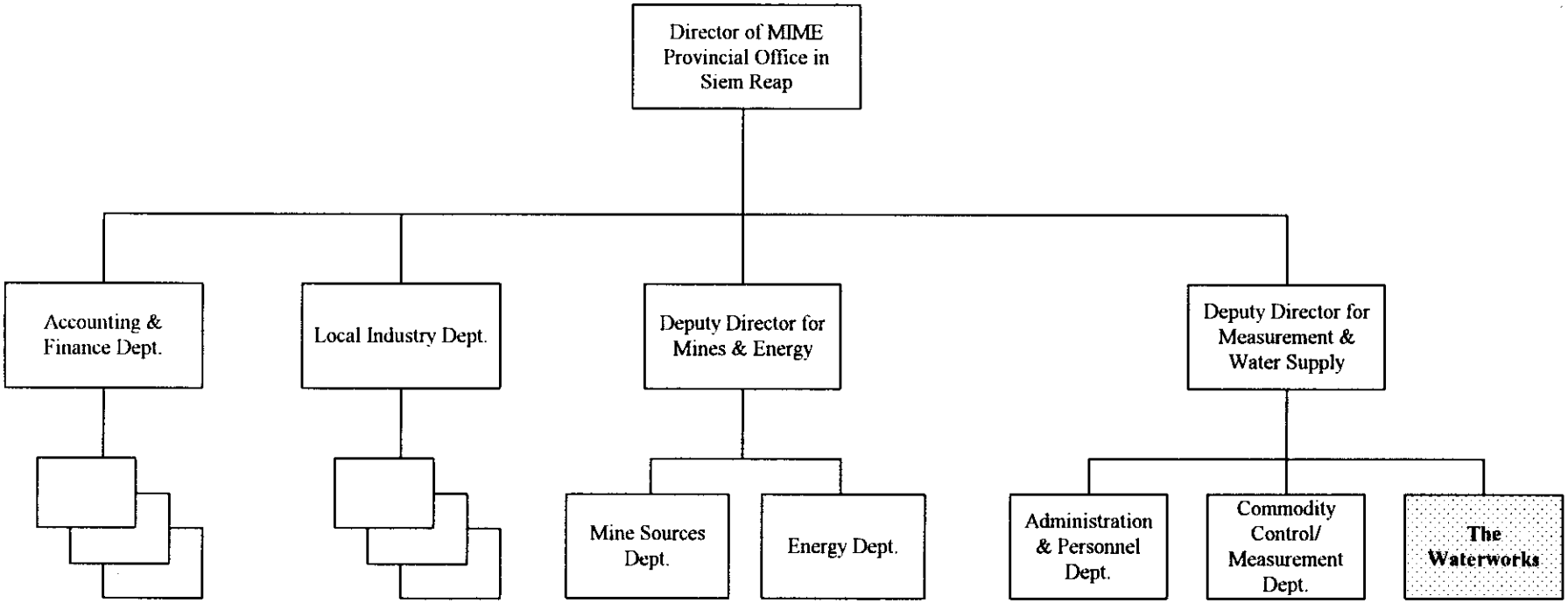
The Waterworks capacity will be increased 8,000 m^3/day in 2006, and 12,000 m^3/day in 2010, respectively, as studied in the previous chapters. The present employees for the system operation have to be strengthened with an additional employment along with the capacity increasing. To estimate an adequate the system employee number, several samples are shown below for the comparison:



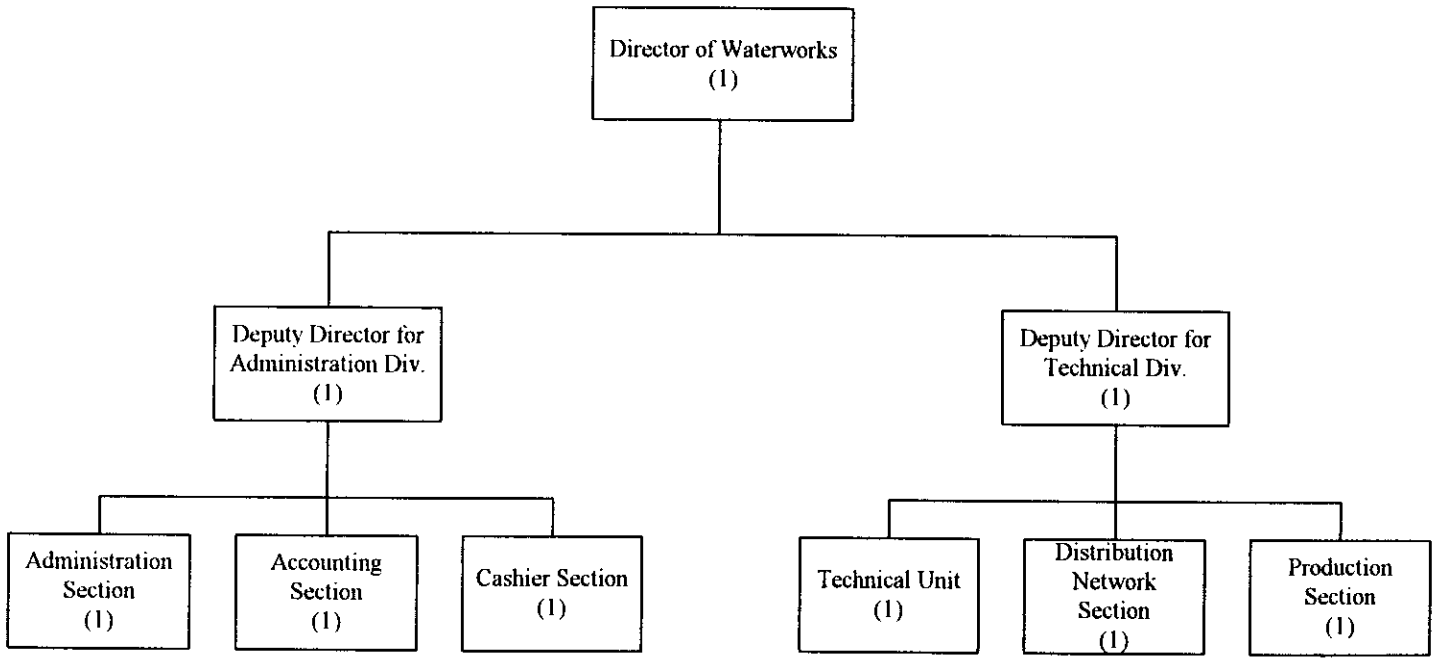
The Study on Water Supply System for Siem Reap Region in Cambodia

Japan International Cooperation Agency

Figure 4.6.1
Organization Chart of MIME Headquarters



The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 4.6.2 Organization Chart of MIME Provincial Office**
Japan International Cooperation Agency	



(Note) Bracketed figures denote the number of employees.

The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 4.6.3**
Japan International Cooperation Agency	**Organization Chart of the Waterworks**

System Productivity

Name	Unit	Siem Reap	Siem Reap	Phnom Penh	Sihanou-kville	Vientiane	Savan-nakhet
Country	–	Cambo-dia	Cambo-dia	Cambo-dia	Cambo-dia	Laos	Laos
Production (A)	m^3/day	1,440 (1995)	1,440 (1999)	121,000	2,800	80,000	15,000
No.of Employees in Production (B)	person			213		48	
No. of Total Employees (C)	person	7	9	417	35		73
Productivity (A/B)	m^3/day/ person			568		1,667	
Productivity (A/C)	m^3/day/ person	206	160	290	80		205

As shown on the table above, an index of "Productivity (Production/No. of Total Employee) varies from 80 to 290 m^3/day/person. The maximum productivity, 290, is found in Phnom Penh Water Supply Authority (PPWSA). Although the PPWSA shows the highest productivity, it was pointed out that the PPWSA was rather over-staffed by the previous JICA Study in 1993, "Master Plan and Feasibility Study for Phnom Penh Water Supply". It may mean that the productivity which will be realized in Cambodia will be more than 290 m^3/day/person.

Proposed number of employees for the Siem Reap Waterworks is calculated based on the requirement from the proposed organization structure as discussed below and prospective productivity of the Siem Reap Waterworks will be as shown on the table below.

Proposed Number of Employees

Item	Year / Unit	1995	2002	2006	2010
Production (A)	m^3/day	1,440	3,000	8,000	12,000
No. of Total Employees (C)	person	7	14	19	25
Productivity (A/C)	m^3/day/perso n	206	214	421	480

(2) Proposed Organization

The production capacities of the Waterworks are 8,000 m^3/day in 2006, and 12,000 m^3/day in 2010, as stated above. The numbers of production wells are 10 wells (2006) and 15 wells (2010), as studied previously. The raw water uplifted by

submersible pumps is conveyed to the receiving well and the underground reservoirs constructed about 10 km eastwards away from the well field. The disinfected raw water is transmitted to the existing pipe networks through the newly installed transmission line.

The waterworks has to be operated for 24 hours all day long from its characters. Therefore, the staff engaging in the Production Section of the Waterworks have to work in four shifts, that is, 8 hour operation per one group by 3 groups a day, and one another group is rest, so 4 shifts a day system is employed. In addition, as the Distribution Section will engage in the bill collection works, the staff for the bill collector have to be strengthened. Considering these conditions, the proposed organization for the Waterworks is estimated succeedingly.

1) Proposed Organization for Well Capacity 8,000 m^3/day

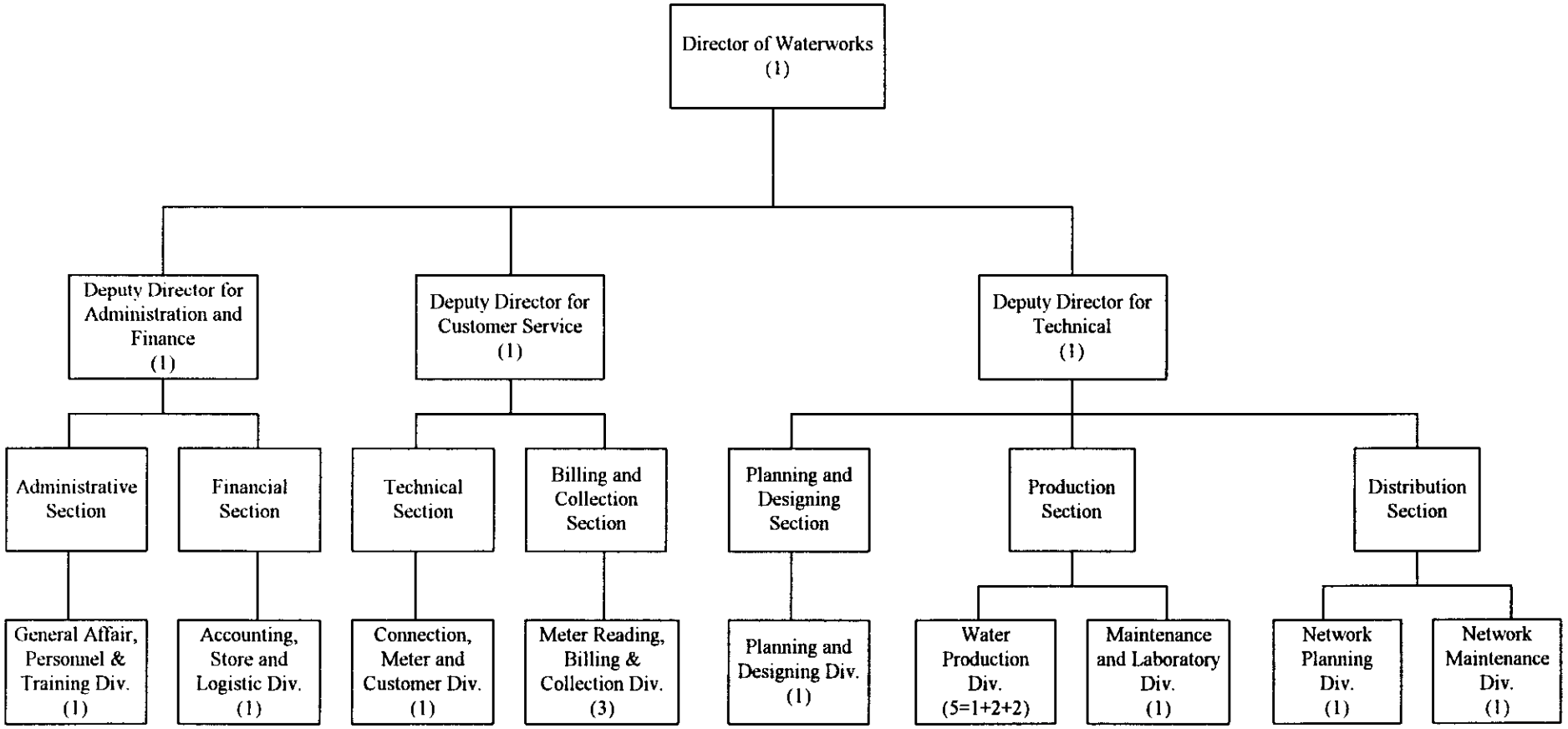
The Stage 1 Waterworks consisting of 10 production wells will supply 8,000 m^3 a day from 2002. The Waterworks is operated by one Director, three Deputy Directors, one engineer, and others. These Deputy Directors are composed of two qualified administrators/accountants and one engineer. As the Production Section members have to engage in 24-hour continuous operation, they work in 4 shifts. Positioning of every staff should be arranged on the basis of their required capacities, positions, and responsibilities in the Waterworks. The number of the System employees is 19 in total as shown on Figure 4.6.4.

2) Proposed Organization for Well Capacity 12,000 m^3/day

The Stage 2 Waterworks will be operated with 15 production wells and the capacity is expected as 12,000 m^3 a day. The targeted year is scheduled 2010. All wells will be arranged with some 400 m distance each along the National Road No. 6 near the Siem Reap Airport. For the 24-hour continuous operation of the Waterworks, two parties of the 4-shift group for the well operation will become necessary. Together with the increasing production, the business capacity will inevitably become expanded with increasing customer services. The strengthened sections are as follows:

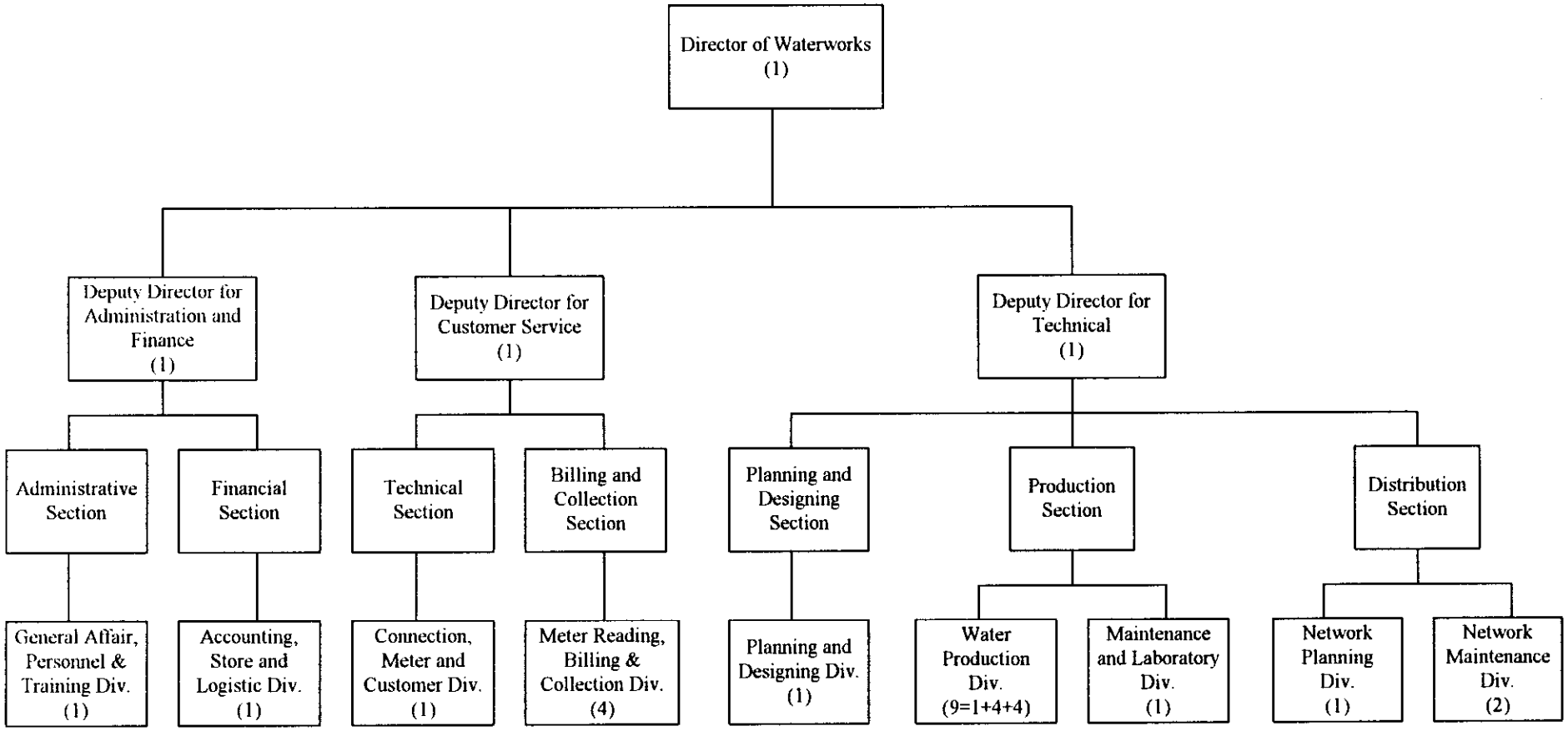
Billing and Collection Section ..... 1 person
Production Section ..... 4 persons
Distribution Section ..... 1 person

The number of the Waterworks employees is 25 in total as shown on Figure 4.6.5.



(Note) Bracketed figures denote the number of employees.

The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 4.6.4 Organization Chart of the Waterworks for Well Capacity 8,000 m3/day**
Japan International Cooperation Agency	



(Note) Bracketed figures denote the number of employees.

The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 4.6.5 Organization Chart of the Waterworks for Well Capacity 12,000 m3/day**
Japan International Cooperation Agency	

(3) Job Description

The Director and Deputy Directors directs their subordinates to manage the Waterworks, and takes the responsibility for their activities. The roles and activities of each section in the Waterworks are described below:

a) Administrative Section
- General affairs with communication and correspondence works
- Legal matters with communication and reporting to authorities concerned
- Personnel affairs including recruitment, position and salary improvement, rewards and penalties, holiday and rest control,

b) Financial Section
- Store keeping, purchasing materials and spare parts with ledger recordings
- Accounting with contacting authorities and banks concerned
- Tender arrangement, and contract works

c) Technical Section
- House connection (customer appreciation, design, connection materials, branch work supervision)
- Meter management (meter checking, installation and changing, repair)
- Leakage control (leakage repair, leakage detecting, leakage reducing, promotion and campaign)

d) Billing and Collection Section
- Meter reading (reporting read amount to customers, ledger recording)
- Billing (water charge calculation, bill making, aggregating and reporting)
- Bill collection

e) Planning and Designing Section
- Planning of waterworks (criteria of design/planning, system expansion plan of waterworks, unit cost study)
- Design of waterworks (preliminary and detail design of expansion works)

f) Water Production Section
- Operation and maintenance of facilities for intake, transmission, disinfection and distribution system.
- Leakage reducing works, and quality control

g) Distribution Section
- Distribution planning and designing, tendering, tender evaluation, construction supervision, records keeping of the System including design data and related drawings, and all ledgers keeping
- Leakage repair works

(4) Recommendable Roles of the Waterworks

One of the most important actions for the sound financial condition in the water-works management will be to reduce the unaccounted-for-water ratio, in other words, to reduce leakage and illegal connections as far as possible. It is well-known facts that almost all leakage occur from service pipe areas after branch of main pipelines. In Japan, around 60 to 70% of leakage is arising from the service pipe. Therefore, reducing leakage from service pipe is one of the most important activities of accounted-for-water increasing program.

To reduce the leakage from the service pipe and install the service pipe with high technique, the following are to be taken:

- To improve installation technique of service pipe.
- To use reliable service pipe materials for installation.
- To find leaking sites and repair them.

1) Licensed Plumber and Contractor for Service Pipe Installation Works

After the completion of the capacity improvement (8,000 – 12,000 m^3/day), a number of connection works will be proposed by consumers. Improvement of installation skill will be indispensable, because leakage is in many cases caused from joints connected by unskilled manners, especially from service pipe areas. To promote and develop the pipe installing technique for plumber's skill, the Waterworks is recommended to establish a system on "Licensed Plumber and Licensed Contractor" as an ordinance of the Waterworks.

The Waterworks should regulate the following in the ordinance:

- The Waterworks carries out the qualifying examination for Licensed Plumber and Licensed Contractor once a year.
- Pipe installation works shall exclusively be worked by Licensed Contractor.
- Licensed Contractors who want to execute any pipe installation works shall employ at least one Licensed Plumber to make him install pipe installation works.

2) Utilization of Reliable Materials for Pipe Installation

Property limit between the Waterworks and private utilities usually is the service meter. The pipe materials between service main branch and service meter, therefore, belong to the Waterworks, and materials after the meter to consumer concerned. As the installation works after the meter are carried out by the consumer himself, the quality of pipe materials is responsible to

him.

From the standpoint of carrying out installation works with reliable materials, the Waterworks should recommend in the ordinance as follows:

- All materials which will be installed in the premises of consumer shall be materials approved by the Waterworks.
- Pipe materials should be installed by the Licensed Plumber.
- All installation works of pipe materials should be inspected by inspector nominated by the Waterworks.

3) Leakage Finding/Detecting and Repair

Whenever pipe installation is carried out at every site, an inspector dispatched from the Waterworks will attend at the site to inspect the related works. The inspector may find leakage during his inspection adjacent to the work site, and in some cases illegal connections. Such cases should be reported to the Waterworks to repair.

4.6.4 Human Resource Development

(1) Training

Vocational training is essential to improve the employee's capability and eventually the performance of the organization. On-the-job vocational training has been employed for a long time in the Waterworks . Although this on-the-job training is still one of the considerably efficient methods and therefore it has been employed in every field widely, it will be necessary that the training is carried out with more systematic and premeditated planning. Phnom Penh Water Supply Authority (PPWSA) has enough capability to cooperate with the training program. Upon deliberation with PPWSA, an appropriate training methodology should be decided mutually. Key persons' training at National Waterworks Technology Training Institute, Bangkok, Thailand will be worthwhile for consideration.

The training programs for the Waterworks staff are shown below:

Training Programs

Field	Main Curriculum	Demonstration/Practice
Water Production	principle of groundwater and abstraction of groundwater	mechanism of groundwater, water level and observation
Water Processing	principle of deferrization/demanganization, disinfection, and filtration, pumping-up	chemical dosage, turbidity measurement, backwashing, residual chlorine measurement, pump operation an maintenance
Distribution Network maintenance	principle of distribution pipelines, appurtenance facilities	pipe installation, jointing, valve & air-release valve drain valve operation
Leakage Reduction	principles of pipeline flow and concept of the non-revenue water	pressure measurement, pipe laying valve control, leakage detection/repair, equipment operation
House Connection	underground utilities, public and private properties	tapping mains, plumbing, meter installation, detection of illegal connections
Customer Services	key matters of public relation, procedural matters	meter reading, calculation for billing, money handing, finding meter faults, reporting on leakage
Management	Administration and management, Public relation and public opinion	Analysis of management, Water rate and management, Budget & Settlement of accounts
Administration	matters on legislation and execution, personnel management, coordination on training	discussion on subjects in curricula, use of computer for administrative processing
Finance	matters on legislation and execution, budget planning and monitoring	discussion on subjects in curricula, use of computer for financial processing

(2) Management

1) Personnel

a) Salary

The Waterworks has 7 permanent national staff and no permanent station staff who are employed locally at present. Temporary staff is employed at the time when necessity arises, and during necessary period with contracted daily

wage. National staff is paid their salary based on the salary classification which is classified into three grades; A, B, and C. Every grade is divided into 10 degrees like A_1, A_2, A_3, ... A_{10}; B_1, B_2, B_3, ... B_{10}; C_1, C_2, C_3, ... C_{10}. The A grade is for leader classes, the B for normal staff like secretary, clerk and engineer, and the C for workers, all of which are employed for the national staff.

Average salary of MIME Siem Reap Provincial Office will be some 30,000 Riel/month, and a mainstay level of the Provincial Office (about 45 age) is paid 50,000 Riel per month for instance. (US$ 1.00 = 3,800 Riel as of July 1999)

Salary increase is periodically carried out every three years with one degree-up, and 10 times salary increase/degree-up is usually maximal. There is no bonus system, so additional payment at the vernal equinox or year-end is not paid. With the salary, family allowance for spouse and children is paid and number of children is without limit. For dependents, their parents and grandparents of employees are not included.

b) Working Conditions

The retirement age is 55 years. Only when specially requested by the Waterworks, a person can continue working after 55 within the limit of one year. After retirement at 55 years old, around 60% of the salary which has been paid at the retirement can be received as retirement money like a pension throughout the lifetime.

The national holidays are official holidays and red-letter days like Queen's Birthday also are generally regarded as payable-holidays. There are 24 such payable-holidays a year. When a national holiday falls on a Saturday or Sunday, the next Monday becomes a substituted holiday. When getting sick, employees can take sick-leave with a medical certificate within the limits of 7 days. In case that more than 7 consecutive days are necessary for sick-leave, an approval of Director/Regional Governor will become necessary, although such case has never occurred yet.

Working hours for weekday are from 7:30 am to 5:00 pm, and lunch time rest from 11:30 am to 2:00 pm. The portal-to-portal hours are 7 hours a day, and lunch time is actually 2.5 hours. Overtime pay is not considered. In a large system like PPWSA, every employee is required to sign four times a day to prove his presence. In case of the Waterworks, the system does not require such proving.

2) Administration

The fiscal year is same as the calendar year, 1st January to 31st December. The yearly budget of the Waterworks is drafted by the Waterworks staff concerned, and the drafted budget is sent to the Director of MIME Siem Reap Provincial Office. After obtaining the approval of the Director, it will be sent to Financial Office of Siem Reap and eventually to then Provincial Governor to get his approval. The financial matters are controlled by the Provincial Governor except for technical matters which are controlled by the MIME Provincial Office and the headquarters located in Phnom Penh directly.

To decide the Provincial policy, regular meeting has been held monthly in MIME Provincial Office with persons concerned, and also at the time when necessity arises. Regular attendants consist usually of every director and deputy director. When any special matters are to be discussed, necessary attendants are invited to the related meetings.

Regular meeting in the Waterworks has not been held up to now because of its limited structure at present, and matters to be solved also are limited. Therefore, whenever considered necessary, related persons are called together and discuss to get conclusion.

(3) Employment

Usually the method of employment/recruitment for national staff and station staff is different. In case of national staff employment, a request for new employment will be submitted to the Ministry of State for Social, Labor and Veteran Affairs through MIME Siem Reap Provincial Office. The Ministry will select the candidates from registered list or existing posts of offices, and inform to the Waterworks. So far the Waterworks has never collected members publicly by itself because of limited employment in number.

Employment of station staff is rather easy compared to the national staff. As station staff is usually a temporary staff who is employed as extra hands locally, employment term will generally be short and job contents will also be various. When any necessary cases occur, the Waterworks consults with the Financial Department of MIME Siem Reap Provincial Office and employs the temporary staff after obtaining the department's approval. Contact with the candidates and negotiation for working conditions are taken through acquaintance or neighbors.

4.6.5 Legislation System Required

(1) Legal Framework on Waterworks Operation

The Cambodian Government seems to have not even been able to provide funds adequately for the operation and maintenance of the systems of the waterworks already built. In this situation, it is almost impossible for the Government to allocate any funds for investment in the urban water sector. On the other hand, evidence from across the world shows that Private Sector Participation (PSP) leads to expanded coverage, improved productivity, higher efficiency, and better accountability. PSP is particularly opportune for Cambodia because private capital can substitute for public capital, which the Government is hardly in a position to provide.

So, the Government firstly issued the "Code on Public Enterprises and Public Participation" which covers the Law on Public Enterprises of June 1996 and its various implementation sub-decrees, regulations, and ministerial circulars. The second relevant law is the Provincial Budget Management Law (PBML, so-called as the Law on Decentralization) of February 1998. The PBML started being implemented in 1999 in phases.

The Phnom Penh Water Supply Authority (PPWSA) has been transformed into an autonomous public enterprise, and the water authority in Sihanoukville has already been granted a large measure of financial and operational autonomy by Ministerial Decree No. 524.

The Government, to date, have privatized water supply in three provincial towns: Banteay Meanchey, Kampong Speau, and Takeo. The main deficiencies in the privatization process are summarized as follows:

- Both the license given by MIME and the contract with MIME were ambiguous and non-specific on many issues.
- The formula for tariff setting is flawed both in concept and in applications.
- The process of PSP suffered from the absence of clear delineation of responsibilities between MIME and the provincial Governors.
- The license period of three years is too short for a concession. The Governors got around this by assuring the parties of almost automatic renewal of licenses for extended period ranging from 23 to 40 years. The basis for this assurance is uncertain.
- There is no legal framework for licensing private operations or for regulating their activities, along with the absence of clear guidelines

The present conditions of the urban water utilities are shown below in the attached table. From the last experiences for PSP, the most important arrangements to be

taken by the Government for the way forward of PSP will be :

- to prepare a framework for PSP
- to define the responsibilities
- to set up a Task Force
- to review the legal framework

At the same time, the waterworks should be supported by setting up an Institutional Framework, and the financial stability and viability is indispensable. The technical level for the operation and maintenance of the waterworks also should promote for a reliable system operation. Furthermore, the Government should actively encourage utilities/waterworks to progress toward autonomy by clearly enunciating the guidelines and procedures for attaining autonomy, accompanied by carefully planned training, guidance, and counseling. In short, the Government support should be provided for Private Sector Participation movements, as reported in "Urban Water Supply Policy and Institutional Framework", April 1999, IDA. It is considered, however, that the pace toward the PSP or autonomous utility of the Waterworks should be taken not hastily but steadily.

Details of Urban Water Utilities

No.	Town	Population	Staff No.	Production (m^3/day)	Tariff (Riel/m^3)	Connection Number	UFW (%)	Connection cost (US$)	Donor	Remarks
1	Battambang	70,321	67	3,000	1,400	3,100	47	60	EU/Social fund	
2	Banteymeanchey	44,517	18	800	1,300	950	32	100		Private
3	Kandal	10,554	13	500	550	415	38	50	World Bank	
4	Kompong Speu	27,890	5	300	1,500	1,100	35	60		Private
5	Kampong Chhang	33,000	15	1,000	1,000	200	30	50	Social Fund	
6	Kompong Thom	60,012	16	340	500	540	45	50		
7	Kompong Cham	16,000	24	700	550	778	37	50	World Bank	
8	Koh Kong	8,128	7	300	1,500	470	30	70		
9	Kep City	10,000	none	none	none	none				Treatment plant broken down
10	Kratie	23,069	11	1,000	1,000	500	33	60	Social Fund	
11	Kampot	30,392	21	2,000	800	900	37	50	World Bank	
12	Modolkiri	4,700	none	none	none	none				Nothing
13	Pursat	25,305	15	500	800	1,005	30	50	EU	
14	Preyveng	12,450	11	200	900	210	47	50	World Bank	
15	Prasvihear	12,000	none	none	none	none				Nothing
16	Rata-nakiri/Banlung	7,249	8	100	550			50	SAWA	
17	Svay Rieng	13,183	13	400	900	300	48	50	World Bank	
18	Stung Treng	13,000	12	500	1,200	320	50	50	YWAM	Repaid in full
19	Siem Reap	23,704	9	1,440	1,200/1,400	420	30	60	CFD/JICA	Not yet operating
20	Sihanoukville	47,000	30	2,000	700/900/1,100	940	27	80	WB/UNDP	
21	Takeo	28,071	12	150	1,800	400	45	50		Private
22	Phnom Penh	1,000,000	413	120,000	300 to 1,900	50,000	56	300 to 500	ADB,WB,JICA,UNDP	Autonomous
23	Pailin									Not yet surveyed
24	Odormeanchey									Not yet surveyed

Data Source : Urban Water Supply Policy and Institutional Framework, April 1999, IDA
(Note) : Tariff at Siem Reap was revised recently as 1,200 Riel for Domestic use, 1,400 Riel for Big users.

(2) Legislation to be Required

To operate the Waterworks as a technically stable and sound, financially balanced and viable, structurally stable, and legally supported utility, reasonable institutional and legal framework are indispensable as stated previously. In the present section, required legal items will be discussed. The Cambodian Government should take necessary actions for issuance of the related regulations.

1) Water Supply Ordinance

It is necessary for the Waterworks to stipulate the following conditions for water supply ordinance:

- Water tariff structure
- Boundary between private property and the Waterworks'
- Supply conditions of purified water

The stipulations as to (a) utilizing reliable materials for service pipes, and (b) execution of qualifying examinations for contractors and plumbers need to be specified clearly for minimizing unaccounted-for-water and protecting the Waterworks from illegal connections.

All the service connection works should be carried out with approval of the Waterworks for the application and drawings submitted prior to the works. After completion of service connection works by qualified contractor, the Waterworks must reserve the right to inspect the completed works in all private utilities to study the work level. Where any violations from the Ordinance were found in the works, the Waterworks has the right to order the owner/contractor to correct the violations.

The Ordinance should stipulate the following:

Where consumer(s) fail to pay his water charge in spite of several orders for payment, the Waterworks can cut his connection until being confirmed that he pays his charge to the Waterworks.

The procedure for the revision of the water tariff should be stated together with the announcement method for the public.

2) Byelaw on Business Consignment

The waterworks business should be efficiently carried out to meet consumers' requirement economically. The simple businesses such as meter-reading, billing/bill arrangement, bill collection, and so forth may be executed more effectively by business consignment than by the waterworks itself. Replacement of meter and performance test of meter also may be consigned to other parties in some cases, as far as the Waterworks eventually controls the work conditions. Consignment of the simple business will become effective for restraining staff number of the Waterworks, and making the staff themselves concentrate upon the original and important businesses of the water supply.

In the future stage, the Waterworks will be able to employ such consignment system, and therefore it seems worthwhile to study the system stated above. Consignment of such businesses should be stipulated in a bylaw provided that every services will never deteriorate in quality.

3) Law for Restriction for Groundwater Usage

Unrestricted groundwater abstractor can cause the water table to decline which can then cause land subsidence in a huge area. In addition, the quality of groundwater may deteriorate. Furthermore, wide spread land subsidence will have a serious impact on the Angkor heritage. Thus, it is very important to impose a law to restrict groundwater us age. In addition, the execution of the law will increase the rate of service pervasion on the public piped water.

This law is discussed in detail in section 5.8, Conclusions and Recommendations.

4) Water Pollution Control

It is necessary for Siem Reap area to control water permeating into the ground. In addition, the rate of service of the and/or water discharged from factories, hotels, business sites/offices, and institutions to protect water quality of public water bodies because the control against water pollution is one of problems to be solved. Considering the future condition and difficulty of solution, Siem Reap area will be in need of the arrangement of a law/decree prior to any occurrence of the pollution.

This matter also will be studied in the separated section.

4.6.6 Operation and Management of the Waterworks

As stated in the previous sections, the Waterworks must be supported by the Government, especially by MIME and Ministries concerned for its stable and efficient operations. In addition, the waterworks must endeavor to be self-helping/self-supporting by itself as discussed below:

(1) Self-Supporting Endeavor on Operation and Management

In order that the Waterworks will become a financially stable, economically viable, and technically reliable utility, it must in particular supply safe and reliable potable water continuously with appropriate pressure for every consumer faucet with reasonable water charge. When the Waterworks get an all-out reliance from every consumer, water charge would be able to be collected on schedule, and financially stable and economically viable conditions would become attainable for the Waterworks, as the results.

To supply safe potable water ceaselessly, the Waterworks will have to improve its technical situation through appropriate training for current employees recruiting and talented staff. Increasing the consumers willingness-to-pay is necessary for attaining economically stable condition of the Waterworks. Ceaseless supply of potable water is the one and only way to get a reliable utility for all the consumers.

Improvement and enhancement of the volition of employees for the operation and maintenance of the Waterworks will be obtained from the system of rewarding those to be rewarded and punishing those to be punished, in other words, employment of reasonable evaluation system for working manners. If employees who have worked their best are certainly guerdoned with improvement of salary/position, willingness for work execution will be remarkably improved and renovated.

Reduction of leakage is one of the important actions. Finding invisible leakage is quite difficult and special techniques and equipment are necessary. On the contrary, leakage visible on the ground can be comparably easily repaired because of the visibility. As already known widely, visible leakage is counted as some 70% of total leakage. Therefore, incentive system for leakage reporters must be quite effective to reduce leakage and increase counted-for-water ratio.

(2) Characteristics of Operation and Management

1) Water Quality Control

The commission of the waterworks is to offer plenty and safe water constantly with adequate pressure to the consumers. To meet such objectives, water quality control for the raw water and the treated water should be conducted by the Waterworks at all times. The water quality analyses are necessary for periodical laboratory tests not only at the wells and reservoirs but at consumer taps located at the farthest service area. The proposed frequency, test items, locations for sampling are:

Test Frequency	:	daily, monthly, every three months, yearly,
Location of Sampling	:	all wells, reservoirs, consumer taps,
Test Items	:	as stated
Sites/Laboratory	:	as stated

The details to be tested are shown below.

Laboratory Test Items for Water Supply

Frequency	Test Item
Daily	: Climate, Atmospheric Temperature, Water Temperature, Turbidity, Color, Residual Chlorine, pH Value, Odor, Taste, Potassium Permanganate Consumption, Electric Conductivity,
Monthly	: Climate, Atmospheric Temperature, Water Temperature,Nitrate Nitrogen, Nitrite Nitrogen, Chlorite Ion, Ammonium Nitrogen, Standard Plate Count Bacteria, Total Coliforms, Chlorine Demand, Iron, Manganese, Free Carbon Dioxide,
Every 3 Months	: Climate, Atmospheric Temperature, Water Temperature, Total Hardness (Calcium Hardness), Evaporated Residue (Total Solids), Alkalinity, Iron Bacteria,
Yearly	: All Items Necessary

(Note) Hens which cannot be tested by the Waterworks should be done at Phnom Penh.

2) Inventory Management

The Waterworks has to keep a lot of official documents, correspondence, records and data. As the durations for their storage are set documents by documents, they will be preserved in accordance with their duration to keep, and all documents which are over duration to be kept will be thrown out.

Documents to be kept for ever should be preserved carefully. Records on water quality analyses and well observation have to also be kept for future reference and expansion works.

The Waterworks should name a staff for storekeeper to make him engage in store keeping exclusively. All spare parts, pipe materials for repair, and disinfectant and chemicals should be kept in well ventilated store house with appropriate record book/ ledger.

3) Ledger of Facilities

All records of pipe networks, valves, fire hydrants, and so forth should be preserved as the ledger of facilities. Facility drawings as well should be kept with their design data and structural calculations. In addition, pipe networks and other related facilities are to be improved yearly. Improved data should be recorded in the ledger and revised with up-to-date records. All drawings of service pipes in every private premises should be kept for improvement or expansion works.

4.7 Financial and Economic Analysis

4.7.1 Introduction

The financial status of the present waterworks and presents economic and financial evaluation of the proposed project are describe here. The proposed project is selected through the least-cost method among several alternatives. The viability of the proposed project is evaluated from three socioeconomic viewpoints. The project evaluation is conducted from the three points of view: (1) economic aspect, (2) financial aspect, and (3) social aspect in the Study area. The economic aspect is to evaluate viability of social investment in the national economy. The financial aspect is to evaluate the earning capacity and fund management. The social aspect describes socio-economic issues and recommendations for agencies concerned and people in the areas of the proposed project.

4.7.2 Financial Status of Waterworks

(1) Present Situation of Water Supply

As mentioned in the "Provincial Development Plan of Siem Reap for 1999-2000", the new water supply system in the core part of Siem Reap Town was completed in 1998, although some parts of the distribution piping network are still being fixed because of the long interval since 1995. In July 1999, the PDIME got approval of a new water tariff from MIME head office, and started operation of water supply facilities to consumers in the town. As of July, the number of water connections was expected to around 110.

In outside areas from water supply services, the people still get drinking water from wells or surface waters such as rivers, ponds, and lakes. Even in the town proper, most of them rely on unprotected dug wells. The present situation of water sources for drinking water in the project area is analyzed as follows: (1) 98% of the total households get water through wells; (2) out of these households, 78% have installed protected tube-wells and 20% have unprotected open wells; (3) 2% get from surface water sources. After introducing the new water supply system, around 400 households are going to switch their potable water sources from present systems to the new piped system. Most hotels, guesthouses, and restaurants in the service areas of the new water system are also going to switch their individual water source procurement systems to the new piped system as well.

(2) Water Tariffs

In July 1999, the PDIME launched the new water supply system. It provided a new tariff shown in Table 4.7.1. The water tariff was simplified into two categories only: (1) normal consumers and (2) big consumers. The former mainly includes domestic consumers, expected to account for about 85% of the total demand. The latter includes hotels and large restaurants, expected to account for about 15%. This time, The PDIME provided water meters for the respective connections. Therefore, the tariff is based on measured service system. Incidentally, it does not impose any standing charges.

Table 4.7.1 Water Tariff in 1999

Category	Rate
Water Charge (Unit: Riels/m^3)	
Category 1 (Normal Consumers, 85% of total water supply volume)	1,200
Category 2 (Big Consumers, 15% of total water supply volume)	1,400
Connection Charge Including water meter, connection pipes and installation costs (Unit: US$) (Charged at the first connection to a new consumer)	137.75

Source: Water Supply Station in Siem Reap

In addition to water charge, the PDIME imposes "connection charge" for a new connection. Its rate is US$ 137.75 per connection. A new consumer has to pay for this charge, when he applies for the water supply services. The charge includes water meter, connection pipes, and installation costs. At present, the PDIME provides a half-inch diameter's water meter only. In case that a big consumer needs a bigger water meter than a half-inch, he has to procure the big meter by himself.

The water supply system has a capacity of 262,800 m^3 per year. Of this total volume, 30% or 78,840 m^3 per year might be lost due to technical losses, so 70% or 183,900 m^3 per year could be sold to the water consumers. The total production cost was estimated at US$ 62,772 per annum. So the, a unit production cost of water was calculated at 1,292 Riels per m^3. Accordingly, the selling price of water was calculated at 1,372 Riels per m^3, added 5% for profit and 1.25% for business tax on the total production cost. Finally, the water rates were set up as shown in Table 4.7.1.

(3) Financial Performance of New Waterworks

At the end of July 1999 the water station started operation of the water supply system to consumers in the central part of Siem Reap Town. As of July, the water station expected that around 400 water connections in the service area would be registered after the inauguration. In reality, the number of connections and

monthly volume of water sold for the first three months was reported as follows: 113 connections and 1,329 m^3 in August; 189 connections and 4,272 m^3 in September; and 211 connections and 6,060 m^3 in October.

After starting the water supply, it turned out that the water leakage losses through the piping-network were more serious than the water station had considered. Although they have repaired the spoiled pipes, the leakage is still considerable as compared with the other existing water supply systems in Cambodia. The losses for the three months are shown in Table 4.7.2.

Table 4.7.2 Operation Losses of New Waterworks

Month	Intake (m^3)	Production (m^3)	Sold (m^3)	Losses (m^3)	Loss Rate (%)
August	9,054	8,604	1,329	7,725	85.5
September	14,639	14,190	4,272	10,367	70.8
October	15,620	15,170	6,060	9,560	61.2

Before the inauguration of the water supply system, the water station laid two kinds of obligations to the consumers: (1) deposit of water consumption, i.e., 10 m^3 or 12,000 Riels in the case of category 1 or domestic use, and (2) maintenance charge (US$ 20.00) of connection pipes and water meter which were already installed between the water service pipe and inside consumer's site.

Every month a meter reader visits all water consumers and measures their monthly consumption volume. The water station invoices to the consumers through the meter reader. After receiving the invoice, the consumer has to pay the water charge in a week in principle. After some negotiations regarding payment of water charge, The water station stops supplying potable water to the consumer in the case that he does not pay for the charge. However, there have been no unpaid consumers so far since the water station started the supply services in July.

According to the financial information for the last three months, the balance of income statement in each month resulted in considerable deficit as follows: US$ 2,354 in August, US$ 1,336 in September, and US$ 1,649 in October. The income includes security deposit equivalent to 10m^3 and maintenance fee in addition to water charges. The installation charges are not regular income but one-off payment at the time when the consumers enter into the agreement. In terms of expenditure, the depreciation of plant system and piping network mainly caused these deficits. Then, to simplify the financial situation of the water supply service, a net operation profit/loss is calculated by means of eliminating both depreciation and installation charges from the income statement. The net operation profit/loss between water sales and water production was summarized in Table 4.7.3.

Table 4.7.3 Net Operation Loss of New Waterworks

(Unit: US Dollars)

Item	August	September	October
Income from Water Sales	436	1,446	2,058
Expenditures for Water Production	2,601	2,478	3,018
Balance (Net Profit/Loss)	-2,165	-1,032	-960

Note: * The amount did not include expenses of office supplies and communication.

As far as this balance shows, the management of the water supply services seems to be improved month by month, although the balance recorded a deficit for the three months. If this tendency keeps on hereafter and when the water station attains the target connections in the service areas, the nominal cash balance may turn into profit in single year. In the future, the management of the water station may get rid of the cumulative deficit and turn to the black, if the depreciation of plants and other facilities are left out of consideration.

4.7.3 Financial Analysis

(1) Overview of Financial Analysis

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 projects are examined in financial efficiency and evaluated taking into account of financial situation. Financial viability of the proposed project is examined by means of an evaluation indicator of "financial internal rate of return (FIRR)". If the FIRR were not good to implement from the point of financial view, financial difficulties would be analyzed and identified, and some countermeasures would be proposed in this stage.

In addition to supply side analysis above, the project management is also evaluated from the viewpoint of demand side. Affordability of the proposed project from water consumers is important constraint for the project to be accepted by the consumers. Through these analyses, this financial study proposes financial solutions and recommendations in the sectoral conclusion.

(2) Revenue from Water Supply Services

In the water demand study, the average unit volume of water consumption in the year 2002 was estimated and the consumption volumes were already calculated in forms of monthly and annual figures. The details of water demand are explained in Section 4.1. The unit revenue is calculated as a product of unit rate (Riels/m^3) and an average volume of water consumption by consumer types. Table 4.7.4

shows the annual unit revenue of the respective consumers.

Table 4.7.4 Average Water Consumption and Water Charge

Type of Consumer	Unit	Domestic User (per Household)	Hotel User (per Hotel)
I. Monthly Consumption			
Consumption Volume	m^3	17.1	480.0
Monthly Charge	1000 Riels	20.5	672.0
II. Annual Consumption			
Consumption Volume	m^3	208.1	5,840.0
Annual Charge	1000 Riels	246.2	8,176.0

Note: *1 A family size is set up as 5.7 persons, the average number of household member.
*2 A hotel has 40 guestrooms, the average number of hotels in Siem Reap.

As mentioned before, the total revenue of the proposed project is estimated as a product of unit rate of the water tariff and total volume of the water supply scheme. The unit rate is assumed to be constant during the evaluation period, which was set up in July 1999. The total annual revenue from water supply services is summarized in Table 4.7.5.

Table 4.7.5 Annual Revenue of Water Supply Services: 2002 and 2010

Item	2002	2010
I. Water Demand (1000 m^3/Year)		
Normal Consumers	364	1,821
Big Consumers	269	992
Total	633	2,814
II. Revenue (Million Riels/Year)		
Normal Consumers	437	2,185
Big Consumers	377	1,389
Total	814	3,574
Total in US$1000	214	941

In addition to water sales, the PDIME can receive the connection charges from new consumers. The number of the new consumers is estimated at 7,050 between 2002 and 2010. The PDIME, therefore, will collect the connection charge of US$ 971,000 in total at 1999 prices.

(3) Cost for Water Production

The financial construction costs were estimated at US$ 18.973 million in total, as mentioned in Section 4.5. The costs of the proposed project were divided into US$ 16.192 million in the Stage 1 and US$ 2.781 million in the Stage 2. The construction costs are annually disbursed in compliance with the construction schedule of two years in the Stage 1 and one year in the Stage 2. In addition to these main works, the installation costs of connection works such as service pipes and water meter are invested in accordance with the increase of new consumers. The new consumers pay for these costs as connection charges at the time when they apply water supply to the waterworks.

The cost of operation and maintenance (O&M) must be paid annually during the economic life of the proposed project. The O&M cost was estimated at US$ 0.135 per m^3 during the Stage 1 and US$ 0.115 per m^3 at 1999 price level.

(4) Financial Efficiency

The indices of financial evaluation were –2.2% of FIRR (Financial Internal Rate of Return), 0.34 of B/C (Benefit-Cost Ratio) and minus US$ 12.0 million of NPV (Net Present Value). The latter two indices were the results applying 10% discount rate. From the financial point of view, accordingly, the proposed project is not viable, because the FIRR is much lower than the opportunity cost of capital of 10%.

The proposed project is not financially viable because the revenue is too small as compared with the investment and O&M costs. If it is wished by means of only revenue increase that the proposed project was made to have the FIRR of more than 10%, the water rates for all consumers would have to be increased 3.2 times more than the present rate. On the other hand, it would be possible to make the project viable by subsidizing for the investment costs. A FIRR of more than 10% could be obtained by subsidizing almost 81% of the capital investment.

The two countermeasures could be combined to make the proposed project financially viable. If 62% of investment costs were subsidized and 50% higher water rates than the present ones were introduced in the water supply management, the proposed project could be viable financially. The combination of these countermeasures has many variations. For example, the combination case of 70% of the subsidy and 30% of rate hike also makes the proposed project viable financially. Furthermore, the following combination makes the project viable from the financial viewpoint: (a) 100% of construction costs of the Stage 1 are procured through subsidy; (b) 100% of construction costs of the Stage 2 are procured through the international finance; and (c) 25% of water rate is reduced. Among these countermeasures, 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. On the other hand, the water rates should be considered referring to household economy and affordability of the project from water consumers.

4.7.4 Economic Analysis

(1) Overview of Economic Analysis

The project evaluation is conducted in accordance with the conventional methodology that is commonly applied for evaluation of development project under finance of the World Bank and other international agencies concerning to

technical and economic corporation. The proposed project is condensed into evaluation factors on the basis of costs and benefits. The factors are Economic Internal Rate of Return (EIRR) for a main index, and Net Present Value (NPV) and Benefit-Cost Ratio (B/C) for supplementary indices.

In the case that this EIRR exceeds the opportunity cost of capital, the proposed project could be judged as viable economically. The NPV shows the magnitude of project incremental benefit. The B/C indicates the gap between the project efficiency and the opportunity cost of capital.

(2) Assumptions for Economic Evaluation

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. The economic values are converted from the financial values basically applying conversion factors. For the economic evaluation, the following criteria and assumptions are applied to calculate economic values and evaluation indicators in this study.

1) Basic Conditions and Assumptions

(a) Conversion Factor: All the costs have to be measured as economic costs, i.e., the real costs or "opportunity costs". In particular, market values are usually distorted by transfer payments such as taxes and subsidies. These have to be eliminated from the market values of cost and benefit as a whole. In the master plan stage, the economic values are assumed to be 90% of the financial costs.

(b) Shadow Wage: Prevailing wages of skilled workers are considered to reflect an opportunity cost of labor, because there is usually a shortage of workers skilled in the labor markets. Therefore, the shadow wage rate of skilled workers is set up as 1.0. On the other hand, unskilled workers are in excess in the labor markets. Thus, the shadow wage rate of unskilled workers is assumed at 0.6 of legislated wage rate.

(c) Land Value: Land areas expropriated for distribution pump station of 1.00 ha and wells of 200 m^2 in total for the Stage 1 are purchased from the landowners. In the estimate of investment cost, the purchased values of the land areas are figured out in market prices for private land and in no purchased value for public lands. In economic evaluation, however, lands should generally be evaluated on the basis of productivity of the lands for productive plots such as crop cultivation.

In the proposed project, most land areas are used for paddy production with irrigation system. Since the land areas are converted to the plant and well sites, the ceased paddy production is considered as negative benefit for the

proposed project. This negative benefit is quantified through values of paddy production for the economic life of the proposed project. An annual net income from paddy cultivation is calculated as a product of paddy yield and net income for a year. During 30 years of the economic life, the total production value is calculated at US$ 3,000 at present value, which was discounted at 10% per annum. This value is negligible small as compared with the total construction cost and accruing benefits from the proposed project.

2) Schedule and Evaluation Period

(a)	Base Year	The year 2000
(b)	Construction Period	Two years (2000 and 2001) for the Stage 1 and one year (2006) for the Stage 2
(c)	Economic Life and Evaluation Period	30 years after the completion of the Stage 1
(d)	Timing of Accruing Benefits	The benefits will appear after the completion of the project. The matured benefit is attained in the target year 2010.
(e)	Price Level	Cost and benefit of the project are set in 1999.
(f)	Prevailing Exchange Rate	3,800 Riels per US$ 1.00 and ¥120 per US$ 1.00
(g)	Opportunity Cost of Capital	10% per annum

(3) Economic Benefits

1) Benefits of Proposed Project

One important main goal of a water supply project is to improve public health and well-being. In particular, the urban poor would receive benefit from the project. They rely on contaminated groundwater or polluted streams, rivers and lakes in the project site. Besides these basic benefits, the water supply project gives various advantages to the people and the regional economy in and around the project areas. Table 4.7.6 lists the benefits accruing from the water supply project.

Table 4.7.6 Benefits Accruing from Water Supply Project

(i) Improvement of Public Health	(a) Elimination of poor quality water source
	(b) Reduction of water related diseases
	(c) Reduction of medical expenses
(ii) Enhancement of Amenity and Well-being	(a) Elimination of equipment for procuring water source
	(b) Time-savings associated with procuring water source
	(c) Energy-savings associated with boiling water for disinfection
	(d) Reduction of absence from work because of water related illness
(iii) Social Issues Related to Water Supply	(a) Effective use of alternative water resources
	(b) Efficient operation of water supply equipment
	(c) Stimulation of the project investment to regional economy
	(d) Prevention of urban disaster by means of fire hydrant
	(e) Improvement of degree of freedom for urban planning
	(f) Increase of land values

Among these benefits, benefits in lines (i) and (ii) are considered as direct benefits, which the proposed project directly brings about those benefits to the beneficiaries. Benefits in line (iii) are considered as indirect benefits. The project has ripple effects on people or regional environment in relation to the project. On the other hand, the proposed project may bring about negative effects to the people and the regional socio-economy. These impacts will be discussed later.

2) Quantifiable Direct Benefits

The benefits listed in the table above are furthermore classified into two categories. They are quantifiable or tangible, and non-quantifiable or intangible. To calculate evaluation indicators for economic evaluation, only tangible benefits are quantified as project benefit. In this Study, the following benefits are chosen as tangible benefit, and they are bound into three components.

A)	Benefits of (ii)-(a), (b) and (c)	Water source saving benefit for residents
B)	Benefits of (i)-(b) & (c) and (ii)-(d)	Public health improvement benefit for residents
C)	Benefit of (ii)-(a)	Water source saving benefit for hotels and other big water consumers

Benefit of water supply project is generally captured on the basis of willingness-to-pay of beneficiaries. The willingness-to-pay is said as monetary term of usefulness that the beneficiaries consider for procurement of water in their lives. Thus, it includes various factors not only tangible

benefits but also intangible ones. The tangible benefits selected above are only some parts of their willingness-to-pay. Anyhow, it is difficult to find out the real willingness-to-pay. In this Study, thus, the willingness-to-pay is estimated on the basis of the tangible benefits above.

Benefits are classified into two main categories, i.e., (a) domestic water for residential use and (b) water for hotel business. The water consumption volume of these categories accounts for more than 90% of the total consumption in the project areas. In this evaluation study, then, these main categories are considered to stand for other consumers.

The willingness-to-pay of residents is assumed as a sum of (i) water source saving benefit, (ii) public health improvement benefit and (iii) other intangible direct benefits. Hence, other intangible direct benefits are assumed as 10% of the sum of benefit (i) and (ii). The willingness-to-pay of hotels is assumed as a sum of (i) water source saving benefit and (ii) other direct benefits. In the same manner, other direct benefits are assumed as 10% of the sum of benefit (i).

3) Estimate of Unit Economic Benefits

(a) Benefits of Domestic Water

The water source saving benefit is estimated based on the facts how the people in the project areas procure water source at present. According to the JICA "Public Awareness and Water Use Survey" in 1997, procurement ways of water source in Siem Reap are classified into four types. They are (1) deep well with pump (Type A); (2) well with hand pump (Type B); (3) shallow open well (Type C); and (4) surface water intake (Type D).

The water source costs consist of two main factors: investment cost and operation cost. In the case of Type A, for instance, the investment cost includes deep wells, pumps, elevated tanks, and connection pipes linking these facilities. The operation cost composes electric power, liquefied petroleum gas (LPG) for boiling to disinfect groundwater water, and some maintenance cost. On the other hand, Type D has no investment cost. However, it needs family labor to procure water source to their house from the source place. It also needs firewood for boiling to disinfect source water. The water source costs were estimated as follows: US$ 1.20 per m^3 for Type A; US$ 0.46 per m^3 for Type B; US$ 0.41 per m^3 for Type C; and US$0.31 per m^3 for Type D, as illustrated in Figure 4.7.1.

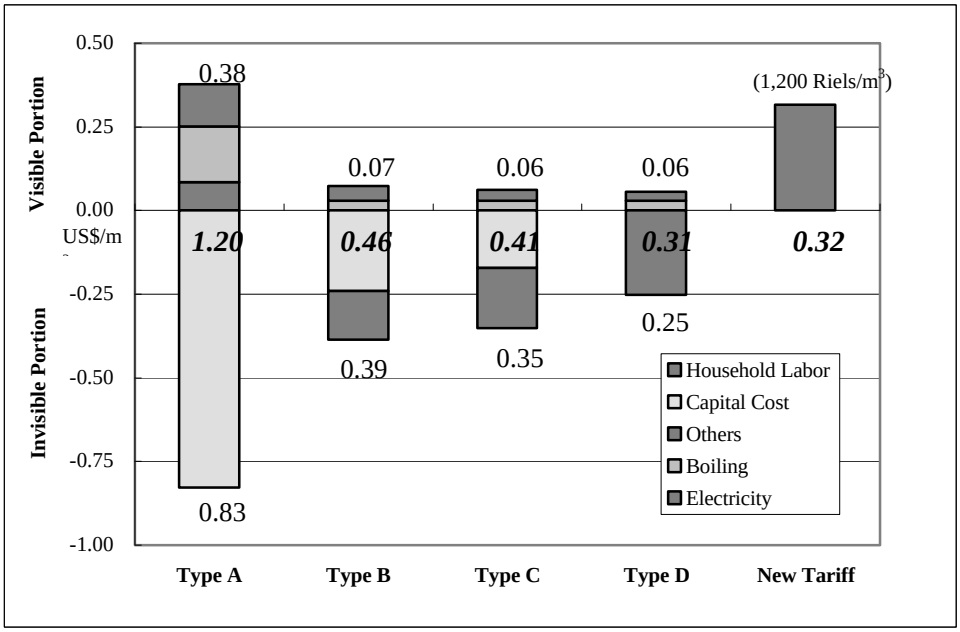


Figure 4.7.1 Water Unit Cost of Domestic Use by Type

The cost components are furthermore classified into two parts: visible portion and invisible portion. The operation costs such as electric power and LP gas for boiling are paid every month. The family realizes these costs usually. These costs are perceived as visible portion. On the other hand, the capital cost is paid at the first investment time, so it is not conceived as monthly charges. However, it should be counted as a part of water source costs. These costs are perceived as invisible portion. These cost components are estimated as shown in Figure 4.7.1. These water source costs could be eliminated once the water supply project is introduced in the project site.

According to the social survey in 1997, these types are composed as follows: 28% for Type A, 50% for Type B, 20% for Type C and 2% for Type D. Applying this components' composition, the weighted average water source cost was estimated as US$ 0.66 per m^3. However, the water source value was estimated in market prices. In economic evaluation, these values are converted to economic value. Applying conversion factors of 0.9 for general cost items and 0.6 only for unskilled labor cost item, the economic source water value was converted to US$ 0.57 per m^3 in economic terms.

In addition to water source saving benefit, the public health improvement benefit was estimated as reduction of medical expenses by beneficiaries and as the same time reduction of labor opportunity losses due to illness. The amounts of these losses are estimated on the basis of medical data which were provided by "Socio-Economic Survey 1997, National Institute of

Statistics and UNDP" and which came from Ministry of Health, Headquarters and Provincial Department of Health in Siem Reap. The medical annual expenses were estimated at around 108,000 Riels per household in 1999. The annual labor losses were estimated at around 30,000 Riels per household. Then, the total annual losses due to ill conditions were estimated at 138,000 Riels or equivalent US$ 36 per household. The losses were re-calculated at US$ 0.17 per m^3, because a household consumed 208 m^3 per year. Finally, it was converted to US$ 0.16 per m^3 per year in economic terms.

Accordingly, the water cost of domestic use in Siem Reap was estimated as at least US$ 0.73 per m^3, which includes not only visible portion but also invisible portion. In other words, the people in Siem Reap pay for around US$ 0.73 per m^3 on average to procure water.

Once the people recognize the water resource cost and conceive intangible benefits shown in the benefit table, the willingness-to-pay could become more than this estimated value of US$ 0.73 per m^3. In this study, it was assumed from the economic point of view that this willingness-to-pay might be 10% more than the estimated value, taking intangible direct benefits into consideration. Thus, it resulted in US$ 0.80 per m^3.

(b) Benefits from Hotel Water

The tourism is one of the most important industries in Siem Reap. More than 20% of the total water demand is occupied by hotel service sector. In this sector, thus, the water source saving benefit is considered to be one of the most important tangible benefits.

In this Study, two recent hotels were investigated in terms of water source procurement system and water supply facilities. The water source cost of the hotel is estimated in the same manner of the calculation for the domestic water. The water cost in the water system's installation is estimated at US$ 1.97 per m^3 for the example A and US$ 2.07 per m^3 for the example B. However, the water source cost is a part of the water costs. Then, the water source cost is US$ 1.35 per m^3 for the example A and US$ 1.00 per m^3 for the example B, as illustrated in Figure 4.7.2. Thus, the unit benefit of water source saving was estimated at US$ 1.18 per m^3 as an average of these examples.

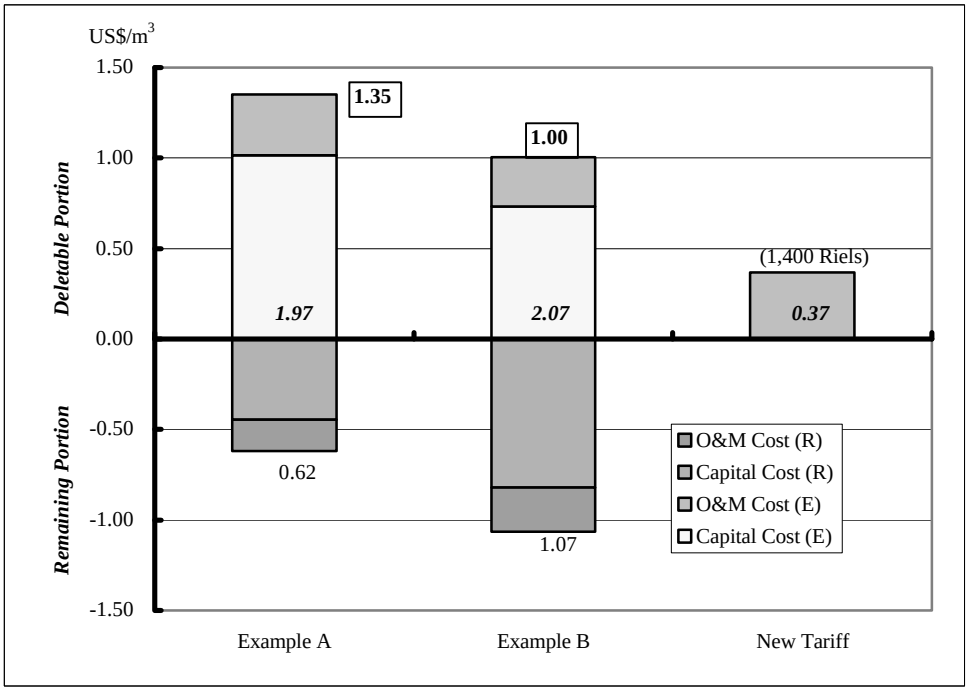


Figure 4.7.2 Water Source Costs of Hotels

Yet, the average water source value of US$ 1.18 per m^3 was estimated in market prices, so it was converted to US$ 1.06 per m^3 in economic terms, applying the conversion factor of 0.9. Furthermore, it was assumed from the economic point of view that the willingness-to-pay might be 10% more than the estimated value, taking consideration of intangible benefits in Siem Reap. Thus, it resulted in US$ 1.16 per m^3.

Incidentally, the water tariff for big consumers is 1,400 Riels per m^3 in the new tariff approved in 1999. This is equivalent to US$ 0.37 per m^3. This unit price is quite small, as compared with the water source costs discussed above. The water source costs seem to be much higher than the present tariff. These phenomena might result in a good economic performance in the future.

4) Estimate of Economic Benefits

The benefit of water supply services is calculated as a product of water volume consumed and unit economic benefit. As discussed above, unit benefits are US$ 0.80 per m^3 for domestic water and US$ 1.16 per m^3 for hotel water. Hence, a unit benefit of non-residential consumer other than hotel is assumed to be the same as that of hotel, i.e., US$ 1.16 per m^3. The total economic benefits were estimated at US$ 0.612 million in 2002 and US$ 2.626 million in 2010. The details are shown in Table 4.7.7.

Table 4.7.7 Estimate of Economic Benefits

Item	2002	2010
I. Water Demand (1000 m^3/Year)		
Domestic Demand	341	1,746
Non-residential Demand*1	292	1,068
Total	633	2,814
II. Benefit (US$1000/Year)		
Domestic Demand	273	1,397
Non-residential Demand	340	1,242
Total	613	2,639

Note: *1 Special use is included in this category in economic analysis.

(4) Economic Costs

The estimate of the proposed project was already described in Section 4.7.3-(3). The estimate, however, was enumerated in market prices, what is called "financial value". In economic evaluation, the financial value has to be converted into economic value. The procedure of this conversion was already discussed in 4.7.2-(2). The total economic cost of the proposed project was calculated at US$ 15.521 million, which was broken down to US$ 13.213 million in the Stage 1 and US$ 2.308 million in the Stage 2. In addition to these investment costs, the installation costs of connection works such as service pipes and water meter are invested in accordance with the increase of new consumers.

The construction costs are disbursed in compliance with the construction schedule of two years in the Stage 1. Then, the disbursement of construction costs is as follows: US$ 1.530 million in 2000 and US$ 11.683 million in 2001 for the Stage 1. In the Stage 2, US$ 2.3084 million is disbursed in 2006.

The pipeline facilities of the respective projects are considered to last 30 years long. So, the evaluation period is set up as 30 years. On the other hand, the machinery such as submersible pump and booster pump is considered to last 15 years. These machines have to be replaced during the system's life. In the disbursement schedule, the replacement costs of these machines are appropriated every 15 years. Thus, these replacement costs were estimated in economic terms as follows: US$ 1.599 million in 2016 and US$ 0.376 million in 2021

After the evaluation period of 30 years, the replaced machines will still be able to work well, because they are in their durable period after the replacement. In the evaluation procedure, however, these residual values were neglected because they were quite small at the end of evaluation period.

The O&M cost is annually paid during the economic life of the proposed project. The O&M unit cost in economic terms was estimated at US$ 0.122 per m^3 during the Stage 1 and US$ 0.104 after the completion of the Stage 2.

(5) Economic Efficiency

The indices of economic evaluation were calculated as follows: 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%.

4.7.5 Socioeconomic Impacts

(1) Impact on Regional Economy

It is obvious that commencement of construction works such as water supply project induces regional economy to activate in the sectors related to construction works as well as construction sector itself. In general, one unit of construction work could induce 1.50 to 2.00 units of economic effects in the national and regional economy. In other words, a construction work would bring about 50% to 100% ripple effect on related works in various economic sectors in monetary terms in addition to the said construction work. This effect could stimulate the regional economy in Siem Reap.

According to "Siem Reap 1998, Provincial Development Plan", about a hundred thousand people were not unemployed, accounting for 22% of the labor force. The investment of the proposed project would activate the regional economy and at the same time create opportunities for temporary jobs during the construction period. Accordingly, it would be clear that the investment proposes new labor opportunities for the people unemployed and underemployed in the regions.

(2) Impact on Public Finance

The total investment cost was estimated at US$ 16.2 million in the Stage 1 and US$ 2.8 million in the Stage 2, or 61.5 billion Riels and 10.6 billion Riels. The total amount of 72.1 billion Riels in these 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 heavy burden for the government. The capital expenditure of the central government has relied on the foreign project assistance generally so far. For implementation of this proposed project, there would be no other way that the capital cost would depend on foreign financial assistance.

Even so, the water supply business has to be managed as independent autonomous entity, after the project is implemented. To put this policy into practice, the following basic management principle should be carried out in the management of water supply business.

1) The revenue from water sales at least covers the O&M costs of water production during the initial operating period. In the future, it covers the whole water production costs.
2) Working fund is procured by the water supply entity not through public finance but through private self-financial options.
3) Taking into consideration of re-investment and replacement in the near future, surplus has to be reserved as much as possible in water supply management.

(3) Impact on Household Economy

According to "Cambodia Socio-Economic Survey 1997", the water charge of a family accounted for 1.4% of the total household expenditure in urban areas excluding Phnom Penh. The annual amount of the water charge was estimated at around 67,600 Riels on average, since the monthly amount was reported as 5,631 Riels. On the other hand, the annual total expenditure was also estimated at 4,839,000 Riels on average. Although the total income was not reported in the survey, it could be assumed as almost the same amount as the expenditure.

As of September 1999, the water rate of domestic use is 1,200 Riels per m^3. Annual consumption of domestic water is estimated at 208 m^3 per household, so annual charge is calculated as 246,200 Riels per household. An annual family income in 1999 is estimated at 5,855,000 Riels, which come from 4,839,000 Riels of annual income in 1997 mentioned in the previous paragraph and price increase rate of 10% per annum, a water charge of a household is estimated to account for 4.2% on average. This rate is much higher than that of 1.4% in the survey above. The rate is almost three times of the survey result of 1.4%. Thus, it might be a controversial issue that every domestic consumer within the service areas of water supply system could afford to accept this water tariff.

Yet, the World Bank report of "Investing in Development, 1985" described that the price of the minimum block of water is commonly set at 3 to 5 percent of household income, which experience suggests is affordable. This of 4.2% seems to be within the block, although it is on the high side. Anyhow, the actual income of an average household is reported not to be more than the household expenditure, so the present tariff might appear to be expensive for the domestic consumers in water supply service areas. As discussed in "Financial Evaluation", the water rate of domestic water might be increased to 3.2 times more than the present one, if the capital investment is not subsidized by the public sectors and moreover if the water supply is managed on the basis of independent autonomy. In this case, a water charge of a household is estimated to account for 13% of the total household expenditure on average. Almost all households could not afford to accept water supplied by the water supply system.

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 outlined a future wastewater disposal plan.

4.8.1 Initial Environmental Examinations (IEE)

(1) Objectives and Methodology

1) Objectives

The IEE focuses on determination of 1) Existing environmental conditions and problems of the study area in accordance with their relevance to urban water supply planning, and 2) Potential environmental impacts and mitigation measures.

This would enable environmental concerns related to water supply to be incorporated in the formulation of a development strategy for water supply in the Siem Reap Region in Phase II: Master Plan of the study. This would determine the important factors to be considered from the environmental point of view for Feasibility Study in Phase III of this study.

In water supply planning, the most important guideline in selecting a source is that it must be of the highest quality that is technically and economically feasible. Consequently, determination of water quality of all water sources considered from the point of their suitability for drinking purposes is also important.

The health status of a population is determined by an interaction of factors including water quality and quantity, socioeconomic status of population, housing, local ethnic or religious customs, community organization and education, sanitation facilities and hygiene practices. The IEE would relate

the health state of the population with the sources of the problems and determine focal points of interventions.

2) Methodology

Environmental guidelines related to drinking water supply and groundwater development prepared by JICA**,** World Health Organization (WHO)**,** and the World Bank (WB) were referred to determine important environmental components and the methodology to be adopted for the IEE. A two step methodology is used for the IEE:

i. Description of existing environmental conditions

Existing conditions of the Study area with respect to key environmental factors, water quality, sanitation and wastewater disposal and treatment, health and water borne diseases, as well as institutional and sociological factors were determined. Various documents, data, field visits, interviews and discussions with government agency personnel and local people provided the baseline data. A comprehensive environmental investigation is presented in Section 3.6.3.

Although water quality data were accumulated during the Study period to enable characterization of existing water sources in terms of their appropriateness of use for drinking water, additional examination of water is still preferable. Therefore, in Phase III of the study, water samples at proposed new well sites were tested for their quality.

ii. Impact evaluation and recommendation of interventions

This step relates various inter-related environmental factors with respect to water supply and groundwater development. The sources of the problems and type of project interventions are to be identified.

(2) IEE for the Selected Alternative

1) The Selected Alternative

The details of selected alternative are explained in Section 4.5. The main components of the system are:

Deep Tube Wells:	Depth 50 m X Dia 430 mm X 15 Wells
Connecting Pipelines:	Length 6.9 km X Dia 150 to 250 mm
Receiving Well:	Area 14 m^2 X Depth 3 m
Clear Water Reservoir:	Area 375 m^2 X Depth 3.5 m X 3 Reservoirs

Distribution Pumps:	8 Pumps
Distribution Main:	Length 7.45 km X Dia 500 mm
Chrination Facility:	Liquid chlorine gas in chlorination house
Generators:	Diesel Generators
Distribution Network:	Existing pipelines with partial improvement

The wells will be located in northwest part of the town near airport along the National Road No. 6 and south of West Baray. For each well, a land area of $50m^2$ is required. All wells will be housed in an independent well house. There will be a separate treatment and distribution center. About 1 ha land area will be required to house the well, receiving well, chlorination house, clear water reservoir, generators, distribution pumps and other related facilities. Connecting pipeline and distribution main will be placed along the National Road No. 6. Other distribution pipelines will be laid out in the town roads.

2) Environmental Screening

Environmental screening is defined as 'a process of judgement on whether a development project requires an environmental impact study or not' (JICA, 1988). 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. The result of the screening is given in Table 4.8.1. There are 23 items considered involving social environment, natural environment and pollution aspects.

Table 4.8.1 Environmental Screening for the Selected Alternative

No.	Environmental Item	Description	Impact Evaluation	Remarks
Social Environment				
1	Resettlement	Resettlement by land occupation (transfer of rights of residence, land ownership)	Negative	– –
2	Economic Activities	Loss of production base (land, etc.) and change of economic structure	Indecisive	?
3	Traffic and Public Facilities	Impacts on existing traffic, schools hospitals, etc. (e.g., traffic jam, accidents)	Negative	–
4	Split of Communities	Separation of regional communities by hindrance of regional traffic	No Impact	0
5	Cultural Property	Loss or deterioration of cultural properties, such as temples, shrines, archaeological assets, etc.	Indecisive	?
6	Water Rights and Rights of Common	Obstruction of fishing rights, irrigation and water rights	No Impact	0
7	Public Health Condition	Worsening of health and sanitary condition due to generation of garbage and appearance of harmful insects	Positive	+ + +
8	Waste	Generation of construction waste, surplus soils, sludge, domestic waste, etc.	Negative	– –
9	Hazards (Risk)	Increase in risk of cave-ins, ground failure and accidents	No Impact	0
Natural Environment				
10	Topography and Geology	Change of valuable topography and geology due to excavation and earthfill	No Impact	0
11	Soil Erosion	Topsoil erosion by rainfall after land reclamation or deforestation	No Impact	0
12	Groundwater	Lowering of groundwater table due to overdraft and turbid water caused by construction work	Negative	– – –
13	Hydrological Situation	Change of discharge and water quality due to reclamation and drainage	Negative	–
14	Coastal Zone	Coastal erosion and sedimentation due to change of littoral drift and reclamation	No Impact	0
15	Fauna and Flora	Interruption of reproduction or extinction of species due to change of habitat condition	No Impact	0
16	Meteorology	Change of micro-climate, such as temperature, wind, etc., due to large scale reclamation and construction	No Impact	0
17	Landscape	Deterioration of aesthetic harmony by structures and topographic change by reclamation	No Impact	0
Pollution				
18	Air Pollution	Pollution caused by exhaust gas or toxic gas from vehicles and factories	Negative	–
19	Water Pollution	Water pollution of river and groundwater caused by drilling mud and oil	Negative	–
20	Soil Contamination	Contamination caused by discharge or diffusion of sewage or toxic substances	Negative	–
21	Noise and Vibration	Generation of noise and vibration due to drilling and operation of pumping machines	Negative	–
22	Land Subsidence	Deformatin of the land and land subsidence due to lewering of groundwater table	Negative	– – –
23	Offensive Odor	Generation of offensive odor and exhaust gases	Negative	–

3) Positive Impacts

The Project will significantly improve the public heath condition. Beneficiaries are presently depends on shallow wells for the domestic water demand. Since there is no wastewater disposal system available in the town, organic and fecal pollution of the well water is highly possible. As stated in the previous sections, water-related disease constitutes major health problem in Siem Reap. In addition, the Project will contribute to the public health for the section of population depending on surface water for their water demand. 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.

4) Negative Impacts

A number of negative impacts are anticipated due to implementation of the Project. In the screening process as shown in Table 4.8.1, 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 to resettlement and land acquisition and generation of wastewater. The land requirement includes one plot of 10,000 m^2 land area and 15 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. If not disposed properly, benefits from safe water supply may disappear and may constitute a threat to public health.

There are some minor negative impacts, but these are either temporary or with insignificant impact. During the construction of pipelines, some traffic jam and accidents can be possible. During the construction, generation of construction waste will occur. Also some change in underground water flow and hydrological pattern may be possible. During the construction, air, water, soil and noise pollution is expected from the drilling rigs, generators, pumps and other construction vehicles.

5) Indecisive Impacts

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. Easy access to water is, on one hand, a benefit to the economy by reduced mortality and morbidity and increase of economic time. On the other hand, water tariff may put some pressure on personal economic condition. Also, persons involved in shallow well digging and maintenance may have to change their profession. With the easy water availability, tourism potential will increase. This may put extra pressure on the precious cultural property of Angkor heritage although increase in tourism will benefit the local economy.

6) Intervention Measures for Negative Impacts

Appropriate intervention measures to reduce the effects of negative impacts was determined in the EIA stage. A brief outline of the intervention measures for the major and notable negative impacts are given in the following. For the minor negative impacts, extra care should be given in construction and operation stage. No major intervention is required for the minor negative impacts. For the indecisive impacts, actual effect was determined and if required, possible remedial steps would be proposed in the EIA stage.

i. Lowering of Groundwater Level

In the computer simulation, allowable limit for the groundwater level drawdown was set as 2.0m in the well field and 0.3m in Angkor area. Continuous monitoring has to be done to check these allowable limits. A stepwise implementation is preferable so as to allow evaluating the impacts. All deep wells and most of the shallow wells should stop groundwater withdrawal in the town area. Some recommendations in this regard are made in Section 5.8.

ii. Land Subsidence

Continuous monitoring should be done for land subsidence. The maximum allowable limit for the land subsidence in Angkor area is set at 1 mm. In case the land subsidence tends to be higher than this limit, proper remedial measure should be taken. One of the possible options can be an artificial recharge of groundwater subject to further study. Surface water from West Baray may be used for recharge. The location of the recharge zone will be northeastern side of the well field to act as a barrier between well field and Angkor area.

iii. Generation of Wastewater

Proper arrangement for wastewater disposal is essential to get maximum health benefit from a water supply project. A brief future wastewater disposal plan is proposed in Section 4.8.3.

iv. Land Acquisition

Along the National Road No.6, a 15 meter shoulder zone is available on both sides of the road. This government land is under jurisdiction of Ministry of Transport. Department of Electric Supply now uses some portion of land for their transformers. Steps should be taken in selecting well locations so that, wells can be located in this public land. An agreement should be made with the Ministry of Transport in this regard. However, 10,000m^2 of land area required for disinfection and distribution facilities cannot be obtained from this public land. The location for this facility should be selected in such a way that impact remains minimum. In the vicinity of the proposed well field, major land use is paddy cultivation and small housing and business. The location should be selected within paddy cultivation land to eliminate the impact of resettlement. Proper compensation should be paid for land acquisition.

4.8.2 Scope for Environmental Impact Assessment (EIA)

Scoping is defined as ‘a process of identification of the critical environmental impacts out of the possible environmental impacts of a development project. Through the scoping process, the priority fields or items of an environmental impact assessment are also identified (JICA, 1988). The matrix of the scoping is given in Table 4.8.2. The matrix shows that six items are scoped for EIA in the feasibility study stage.

Table 4.8.2 Matrix for Scoping

Major facilities / Activities / Activities which may cause impacts / Environmental Items			Pumping facilities / Conveyance facilities / Transmission facilities Treatment facilities / Distribution facilities				
			Overall Evaluation	Before Operation		After Operation	
				Reclamation and Spatial Occupancy	Operation of Construction Equipment and Vehicles	Spatial Occupancy	Operation of Facilities and Pumping
Social Environment	1	Resettlement	○	○			
	2	Economic Activity	?	?	?		?
	3	Traffic and Public Facility					
	4	Split of Communities					
	5	Cultural Property	?				?
	6	Water Rights/Rights of Common					
	7	Public Health Condition					
	8	Waste	○		○		○
	9	Hazards (Risk)					
Natural Environment	10	Topography and Geology					
	11	Soil Erosion					
	12	Groundwater	◎				◎
	13	Hydrological Situation					
	14	Coastal Zone					
	15	Fauna and Flora					
	16	Meteorology					
Pollution	17	Landscape					
	18	Air Pollution					
	19	Water Pollution					
	20	Soil Contamination					
	21	Noise and Vibration					
	22	Land Subsidence	◎				◎
	23	Offensive Odor					

Note: ◎ : The environmental items to which special attention has to be paid. They might cause serious impacts that may affect the project formulatio depending on the magnitude of the impacts and the possibility of the measures.

○ : The environmental items which may have a significant impact depending on the scale of the project and site conditions

? : Environmental Impact is not possible to anticipate without further study

No mark : The environmental items requiring no impact assessment since the anticipated impacts are negligible from the site conditions

4.8.3 Future Wastewater Disposal Plan

(1) Introduction

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 existing condition related to wastewater disposal and storm drainage is provided in the following section. Based on this, a basic outline for future wastewater disposal and drainage plan is provided taken into consideration the introduction of piped water supply in near future to the Siem Reap Town.

(2) Existing Condition

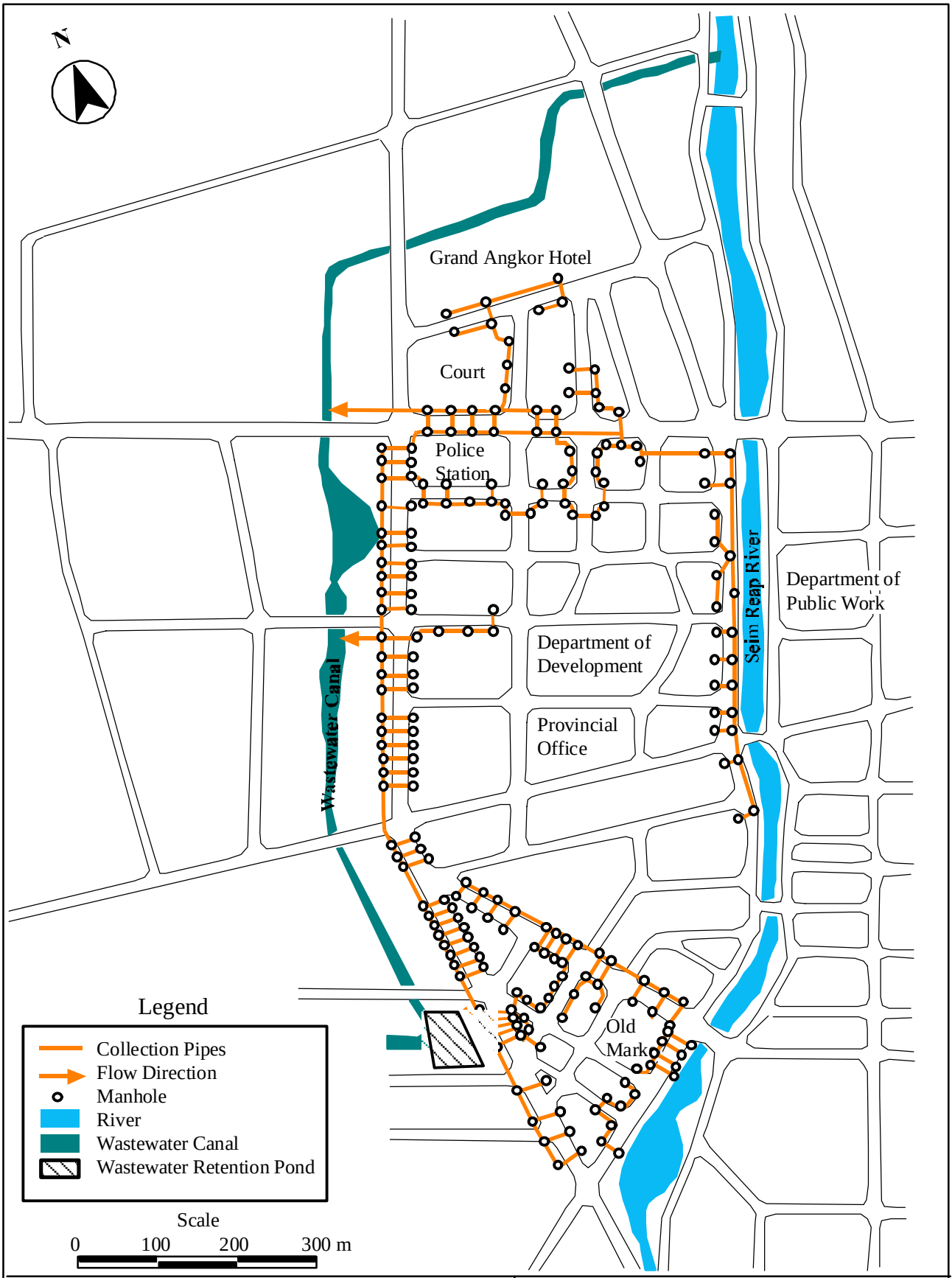
There was a piped wastewater collection system in the central core of the town. However, the service is now not working properly. There is no wastewater treatment plant at Siem Reap or nearby regions. There is no sewage project currently under consideration. Acceptable individual sanitation methods are available in the town centers while outskirt areas lack proper sanitation methods.

According to the District Office, 30% of the households are covered by the septic tank system, while only 10% use pit latrines. The rest uses open defecation. Some of them use overhang latrine while others use open field. In most cases, there is no permanent structure for overhang latrines. Overhang toilets are frequently seen in the southern part of the town along the river course. District Office also mentioned that in the town central area 100% households have septic tanks. However, a survey by the Study Team found that the septic tanks are not well maintained. In most cases, wastewater was seen overflowing from the soakaway. The appearance of the over flowing liquid suggests that proper treatment is not taking place in the septic tank. It is reported to the Study Team that tank sludge was removed once only in about 20 years. This overflowing liquid is going to, in most cases, nearby ditches, which may cause groundwater pollution especially in the shallow aquifers. No information available about the treatment or disposal of septic tank sludge. In many cases the river is used as a disposal point for the sludge. There is no public toilet available in Siem Reap.

There is a limited sewerage pipelines in the town center. This was constructed in 1930 in French colonial period. The total length of the pipeline is around 4 km. There are three types of diameter namely, 0.5, 0.8 and 1.0 m. Pipeline layout is shown in Figure. 4.8.1. However, there is no exact map available for the pipeline layout. The service is free for the users. All wastewater collected by the sewer lines is disposed in a canal. The location of the canal is also shown in the Figure.

4.8.1. The wastewater gradually reduces in the canal due to gradual flow into rice fields. The remaining flow is ultimately discharged into Lake Tonle Sap. However, this canal is found to be blocked by many water plants. Also there are illegal constructions in many places. A hotel was found to be under construction over the canal. These illegal constructors often encroach the canal completely even a pipe or culvert is provided under the building. This causes serious problem in the flow of wastewater in the canal. In one portion, flow is almost clogged due to such construction. Many low-lying areas around the canal are overflowed by wastewater posing serious public health threat.

There is a drainage system for the disposal of rainwater in Siem Reap Town (Figure. 4.8.2). The storm drainage system consists of cisterns placed in many places connected to two sets of canals for each side of the river, which discharge into rivers, canals, rice fields or to a low lying place called New Lake. In town center all runoff to cisterns are through surface. The natural overland flow direction is shown in Figure. 4.8.3.



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

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Figure 4.8.1
Collection Pipe Network in Siem Reap Town

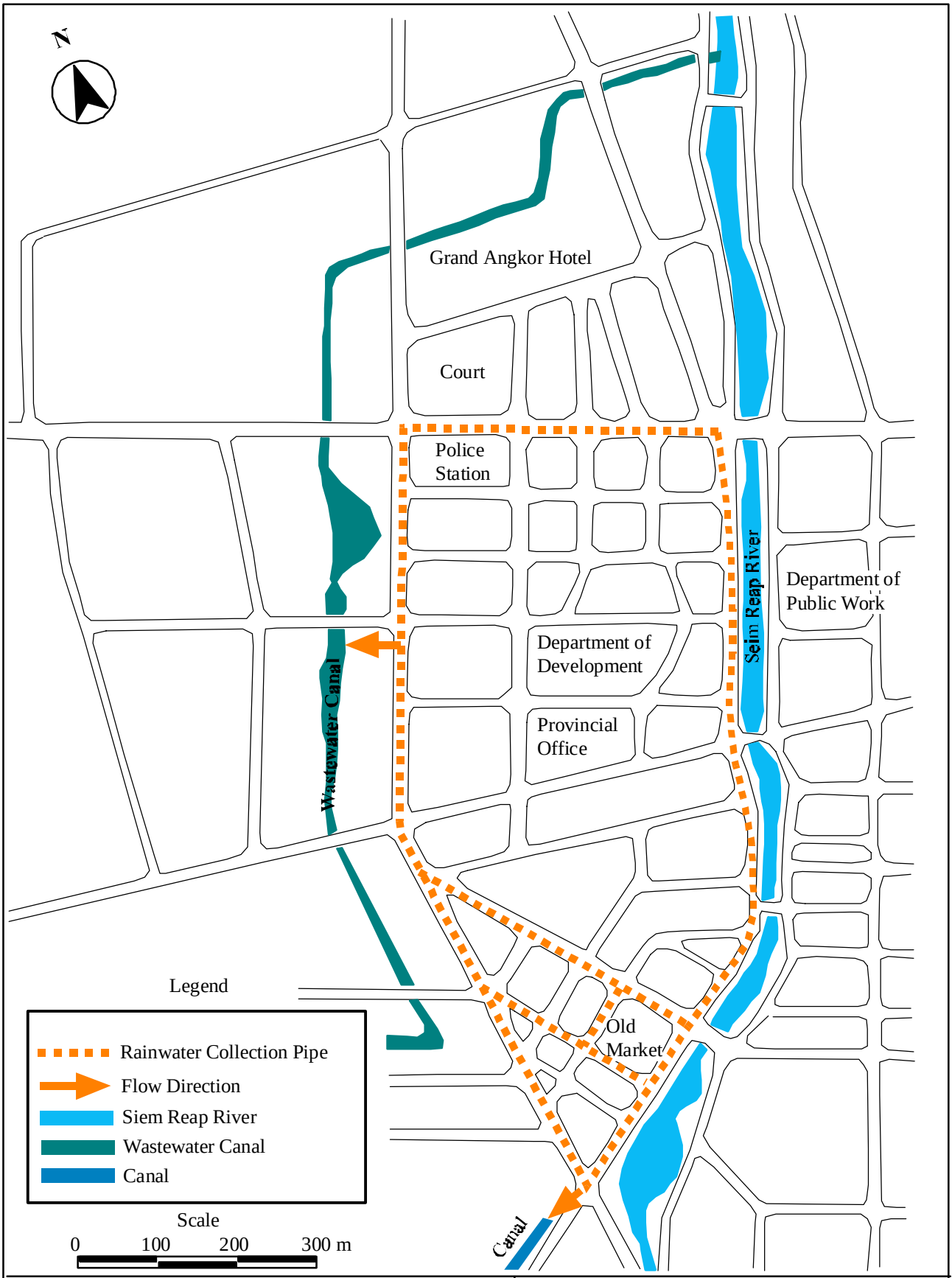

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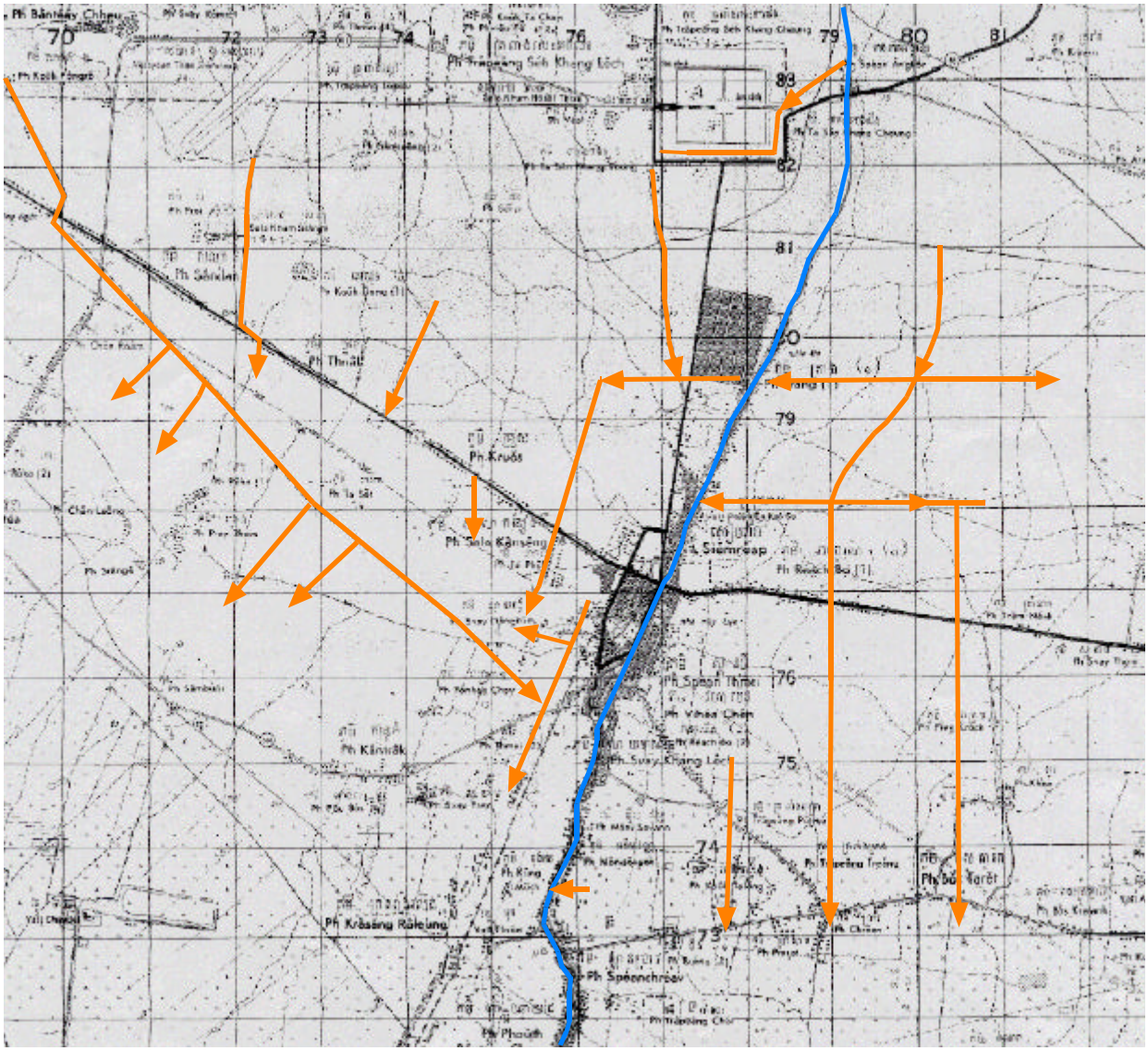
Figure 4.8.2
Drainage System for the Disposal of Rainwater in Siem Reap Town



The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 4.8.3 Direction of Natural Drainage around Siem Reap Town**
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(3) Future Plan

To avoid unnecessarily large quantities of wastewater, the preferred option for household sanitation will be pour flush latrine to septic tanks, or in suitable conditions, the ventilated pit latrine. Satisfactory methods of disposal of large quantities of wastewater obviously include the expensive option of piped gravity sewers. Due to resource constrains, these may be limited in the short or medium term to town centers and market areas.

A stepwise development plan is proposed. In addition, since piped sewer option can work economically efficiently only in places of high population concentration, zoning will be suitable option for future wastewater disposal plan. These are:

Zone 1: The town center.
Zone 2: Areas outside town center but within proposed water supply service area.
Zone 3: Other adjacent areas to be included in the water supply service area in future.

For the treatment option, waste stabilization pond system is proposed because,

a. It is a low cost option because of low cost land availability.
b. It requires little maintenance.
c. Operational cost is low.
d. Stepwise implementation is possible.
e. Suitable for tropical country.

Because the wastewater disposal requires high investment cost a stepwise improvement over a certain timeframe is proposed. A four-step plan is proposed. These are:

1. Immediate step (to be implemented as soon as possible)
2. Short term strategy (to be implemented by 2005)
3. Medium term strategy (to be implemented by 2010)
4. Long term strategy (to be implemented by 2015)

1) Immediate Step

Work in this step principally includes rehabilitation of canals and sewer lines. Illegal encroachment in, over and side of the canal should be removed. Since the sewer lines are very old, rehabilitation and replacement is urgently needed. A monitoring system should be formulated for septic tanks and septic tank sludge disposal. Septic tank should be promoted in Zone 1 and pour flush pit latrine in Zone 2.

2) Short Term Strategy

Lake Tonle Sap is a protected area and according to the Law for Environmental protection and Sub-decree for Water Pollution, no wastewater can be disposed without treatment. In this term, an anaerobic pond should be constructed as part of treatment process. The effluent is not of high quality, but it can reduce the BOD by 40 to 60%. Since all the influent is mostly septic tank overflow, effluent quality will meet the requirements. In this step, all parts of the town center should be brought under sewer service.

A legal enforcement should be placed for mandatory septic tank use or sewer connection in the zone 1. Septic tank should be promoted in Zone 2 and pit latrine in Zone 3.

A sewerage authority should be established independently or in conjunction with water supply authority. A sewage tariff should be placed to make the project financially solvent.

3) Medium Term Strategy

In this stage, Zone 2 will be brought under sewer service and strict use of septic tank or sewer connection will be enforced. Septic tank will be promoted in Zone 3.

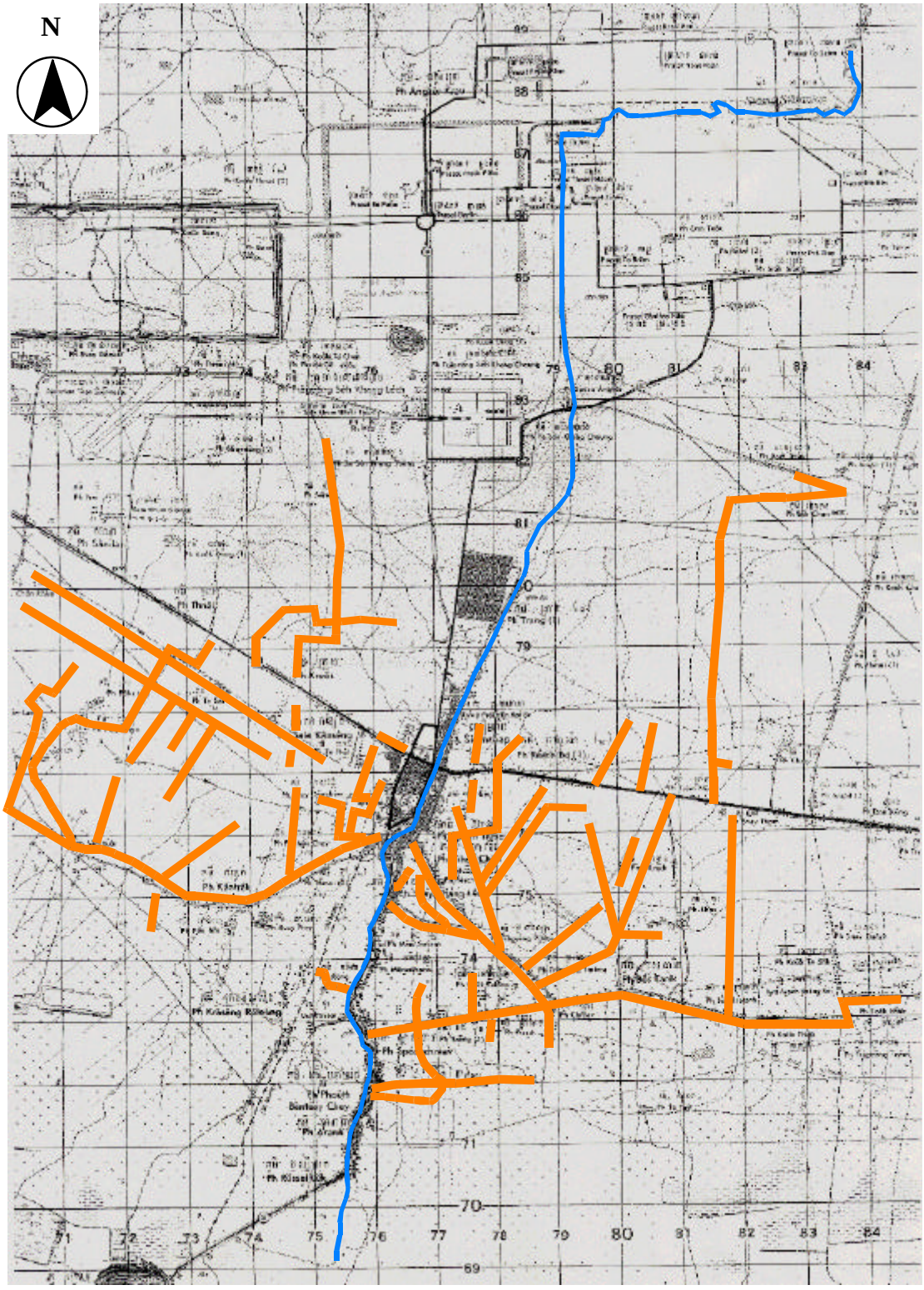
Facultative ponds should be added to the treatment process in this stage.

4) Long Term Strategy

All Siem Reap Town will be brought under sewer service by 2015. All people living in the town must have a septic tank in case not connected with sewer line. Maturation ponds and sludge treatment facilities will be added to the treatment plant.

Drainage

A drainage plan is proposed in APSARA development plan as shown in Figure 4.8.4. This plan should be implemented gradually. However, rehabilitation of the existing canal has the highest priority. In the town center underground drainage pipelines and culverts are highly recommended. New lake can be used for drainage disposal without many problems.



The Study on Water Supply System for Siem Reap Region in Cambodia	**Figure 4.8.4 Canal System around Siem Reap Town**
Japan International Cooperation Agency	

4.9 Evaluation of the Master Plan

4.9.1 Technical Evaluation

(1) Service Area

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 or 3.6 times large than the existing one.

Under the Stage 2, service area will be expanded again to supply water to the newly developed housing area located in the southeast area. Service area will be around 436 ha or 4.6 times 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 branch on northern end of the distribution network in bulk.

(2) Service Ratio

Population in the service area in 1999 is about 25,000 and number of house connection is about 400. Calculated served population from the number of the house connection in 1999 is only 2,300, therefore, 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 and 75% in year 2010. For the tourism water demand, 95% of hotels, guest houses and restaurants will be served by the new piped water supply. As service ratio increase, served population will increase to 25,500 in 2006 and 39,900 in 2010.

To supply water to meet future increasing water demand, system capacity will be expanded to 8,000 m^3/day in 2006 and 12,000 m^3/day in 2010 from the current capacity of 1,440 m^3/day.

(3) Stability of Service

Stable and reliable water supply will be realized hence system water source is a number of wells. Groundwater will be supplied from 8 wells in 2006 and 12 wells in 2010, which will be constructed in the well field. Even if one submergible pump in the well becouse out of order, other pumps will still operable. Therefore, total system down will not occur.

Power source of these well pumps and distribution pumps will be in-house generators. Several generators will be installed and will be operated alternately.

Having stand-by generator, power failure will be avoided.

(4) Water Quality

Water quality of the groundwater is confirmed suitable as a source of water supply. Abstracted groundwater will be supplied without any treatment except disinfection. Liquid chlorine is selected as a disinfectant. Chlorine solution will be dosed in the receiving well before the water entering clear water reservoir. Detention time of the clear water reservoir will be 8 hours, so sufficient contact time with dosed chlorine will be secured. Potable water supply will be materialized by the continuous disinfection.

(5) Adequate Technology

Not only for construction work but also for routine operation and maintenance, new water supply system will not require special technology. Current staff of the Waterworks has experience of pump and generator operation, disinfection using chlorine gas, repairing distribution pipes. Although an adequate level of technology is employed in this Master Plan, training for new staff and skillup training will be required.

4.9.2 Financial / Economic Evaluation

As mentioned in Section 4.7.3, the financial evaluation indices were as follows: -2.2% of FIRR, 0.34 of B/C and minus US$ 12.0 million of NPV. From the financial point of view, accordingly, the proposed project is not viable, because the FIRR is quite lower than the opportunity cost of capital of 10%.

The reason why the proposed project is not financially viable is too small revenue as compared with the capital investment and O&M costs. If it is wished by means of only revenue increase in order that the proposed project was made to have the FIRR of more than 10%, the water rates for all consumers would be increased to 3.2 times more than the present rates. On the other hand, it would be possible to make the projects viable by means of subsidy for the investment costs as well. The analysis says that the proposed project might be financially viable, if 81% of the capital investment cost would be covered by grant.

The two countermeasures mentioned above could be combined to make the proposed project financially viable. If 62% of investment costs were subsidized and 50% higher water rates than the present ones were introduced in the water supply management, the proposed project could be viable from the financial viewpoint. The combination of these countermeasures has many variations. For example, the combination case of 70% of the subsidy and 30% of rate hike 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.

On the other hand, the economic evaluation proved that the proposed project was viable. As mentioned in Section 4.7.4, the evaluation indices were 10.5% of EIRR, 1.04 of B/C and US$ 0.56 million of NPV, respectively. Since its EIRR exceeded the opportunity cost of capital (10%), the proposed project could be viable from the economic point of view.

4.9.3 Environmental Evaluation

An Initial Environmental Examination (IEE) was carried out as part of the master plan study and presented in Section 4.8. The investigation 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 and indirectly 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. The environmental screening carried out in the master plan study indicates that there can only two significant negative impacts. These are, (i) excessive lowering of groundwater table and (ii) higher than expected land subsidence. However, impact from both of these can be minimized with some efforts. An outline of remedial action was discussed and 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.