JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE KINGDOM OF CAMBODIA
PHNOM PENH WATER SUPPLY AUTHORITY

THE STUDY
ON
PHNOM PENH WATER SUPPLY SYSTEM
IN
THE KINGDOM OF CAMBODIA

FINAL REPORT

VOLUME [illegible]
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NOVEMBER [illegible]

NIHON SUIDO CONSULTANTS CO., LTD.
in association with
TOKYO ENGINEERING CONSULTANTS CO., LTD.

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FINAL REPORT

VOLUME 3 : URGENT REHABILITATION PROJECT PORTION

NOVEMBER 1993

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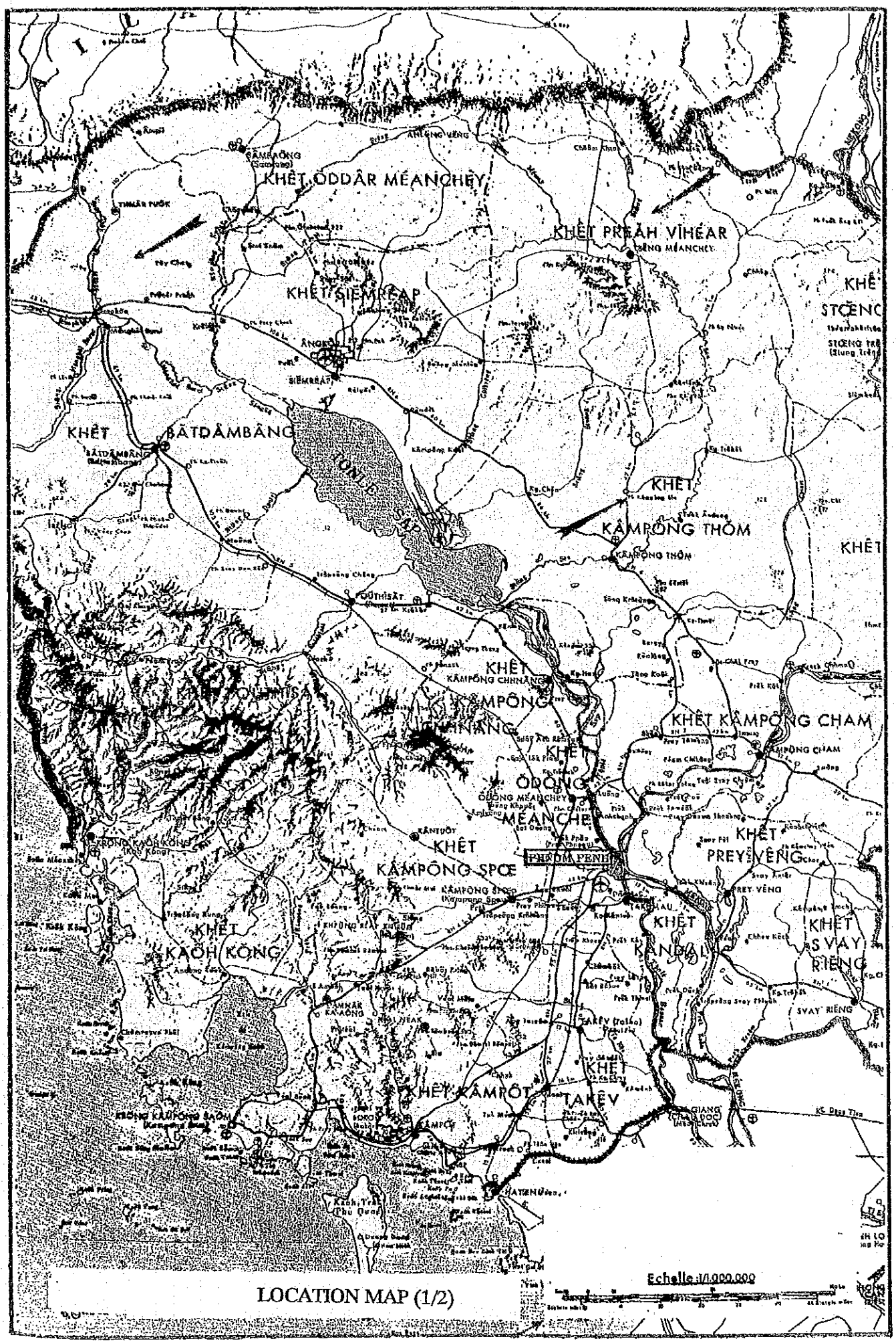
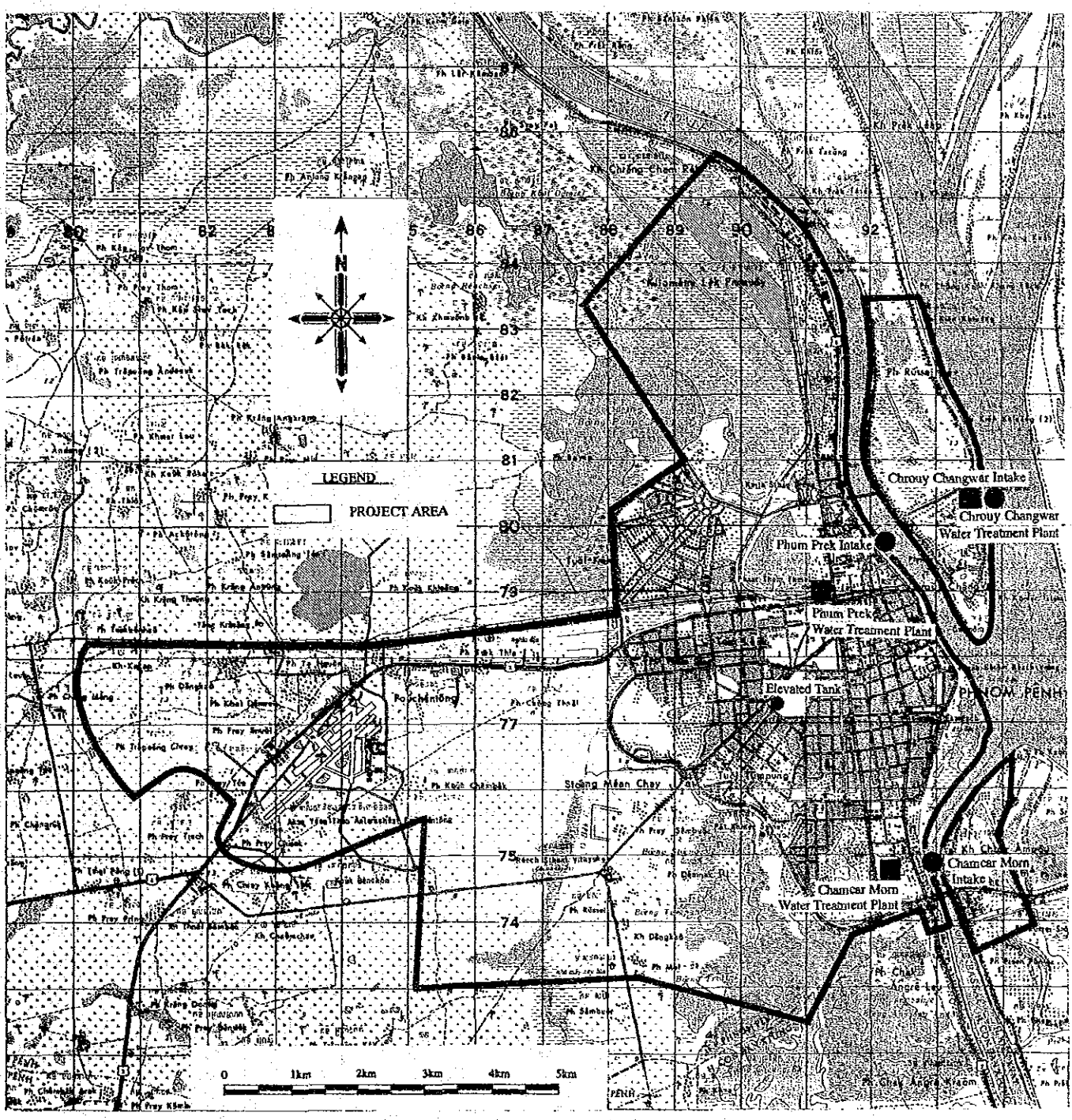


LOCATION MAP (1/2)



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SUMMARY

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The peace negotiations held in Paris in October, 1991 put an end to the long years of dispute in Cambodia and the country made a new start at that time. Since then, Cambodia has held a democratic election under the guidance of the United Nations Transitional Authority in Cambodia (UNTAC), set up a new government, and established a new constitution. In parallel with these political transformations, quick restoration of damaged social infrastructures is desired.

The city of Phnom Penh which is covered by this project is the capital of Cambodia and has prospered as the political, economical, cultural and transportational center of the country for many years. Population of the city as of 1992 is estimated to be about 700,000.

The water supply system in Phnom Penh is already timeworn but has long been left as it is without undergoing appropriate maintenance. Because of this and also because of electric power shortage, the functioning of the system has remarkably deteriorated. Water delivered by water the system used to be 140,000 m^3/day but it is about 63,000 m^3/day now, causing constant water supply shortage and low pressure. Hence, people are inconvenienced; residents in the downtown area of the city must depend on water drawing or a water peddler for their water source, and people in a low pressure area can only receive intermittent water supply.

In order to improve these conditions and be well prepared for the increasing water demand in the future, the Cambodian government has requested the Japanese government to formulate the "Improvement Plan and Survey of Water Supply System in Phnom Penh City" and to provide grant aid to Phum Prek treatment plant. In reply to this request, the Japanese government decided to execute the Improvement Plan and Survey of Water Supply System in Phnom Penh City, and JICA dispatched a study team to the city from February 7 to May 19 in 1993. The study team conducted a series of surveys to confirm the request made by the Cambodian government and this also included the investigation of the functioning of the existing facilities, and collection of various data and materials. These surveys have revealed that the water supply condition of the city is very serious and quick actions must be taken. People have resorted to their own means of using water such as storing the water supplied occasionaly in the pits, or installing pumps but the water is not

sanitary. In the rainy season, rain water and sewerage are stagnant in the downtown area and enter into the water pipes or pits. In order to improve the current situation, the study team conducted further investigation including selection of an urgent rehabilitation project with the examination of the effect and appropriateness of the project.

After returning to Japan, the study team analyzed details of the facilities and equipment included in the request and have determined which can be used as they are and which should require urgent rehabilitation and hence be included in the study for the Japan's Grant Aid. The following table shows the result.

Facilities and Equipment	Quantity	Remarks
1. Raw water intake facilities (Phum Prek treatment plant system)		
1.1 Water intake tower	1 No.	Use as it is.
1.2 Water intake pump	4 units	Use as it is.
1.3 Water intake electric equipment (power receiving equipment, power units)	1 lot	Replace.
1.4 Water intake site electric room 6m × 11m = 66m^2	1 No.	Construct newly.
1.5 Water conveyance pipeline 700mm dia. × 1.3 km	2 lines	Use as it is.
2. Water treatment facilities (Phum Prek treatment plant)		
2.1 Receiving well	1 No.	Use as it is.
2.2 Mixing basin	2 Nos.	Use as it is.
2.3 Flocculation basin	6 Nos.	Use as it is.
2.4 Sedimentation basin	6 Nos.	Use as it is.
2.5 Filter basin	12 Nos.	Repair (by France)
2.6 Chemicals dosing equipment		
(1) Aluminium Sulphate	1 lot	Use as it is.
(2) Lime	1 lot	Use as it is.
(3) Chlorine	1 lot	Use as it is.
2.7 Electric equipment	1 lot	Replace.
3. Transmission and distribution facilities		
3.1 Clear water reservoir (Phum Prek treatment plant)		
(1) Existing one (11,000m^3/day)	1 No.	Use as it is.
(2) New one (10,000 m^3/day)	1 No.	Construct newly.
3.2 Pump well (Phum Prek treatment plant)		
(1) Existing one (by France)	1 No.	Use as it is.
(2) New one	1 No.	Construct additionally.

Facilities and Equipment	Quantity	Remarks
3.3 Pump house (Phum Prek treatment plant)		
(1) Existing one (by Japan)	1 No.	Improve into electric room
(2) Existing one (by France)	1 No.	Use as it is.
(3) New one	1 No.	Construct additionally.
3.4 Transmission pump		
17.5 m^3 /min × 42 m × 180 kw	2 Units	Install new one.
3.5 Distribution pump	2	
(1) 17.5 m^3 /min × 42 m × 180 kw	2 Units	Install new one.
(2) 35.0 m^3 /min × 42 m × 325 kw (by France)	4 Units	Repair.
(3) 15.0 m^3 /min × 28 m × 132 kw (by Japan)	4 Units	Move.
3.6 Transmission pipeline 500 mm dia.	2,410 m	Install new one.
3.7 Elevated tank 2,000 m^3	1 No.	Improve.
3.8 Distribution pipeline		
(1) Existing one, 60 mm to 800 mm dia.	276,850 m	Use as it is. (One in Don Penh area is under repair by France.)
(2) 250 mm dia.	1,340 m	Install new one.
(3) 200 mm dia.	1,310 m	Install new one.
3.9 Isolating valves in southern area of elevated tank, 80 mm to 300 mm dia.	114 Sets	Install new one.
3.10 Distribution pressure control isolating valves, 150 mm to 400 mm dia.	52 Sets	Install new one.
3.11 Cover jonts (bands) for repair, 80 mm to 250 mm dia.	420 Sets	Supply.
3.12 Water meters 30 mm to 50 mm dia.	3,000 Sets	Supply.

This project is to improve, extend and newly install part of the Phum Prek treatment plant and transmission and distribution facilities in the city for the purpose of improving its original capacity of 100,000 m^3/day and improving the function of its distribution facilities.

It is intended in the project to effectively utilize the existing facilities, standardize supplied/installed machines and equipment so as to reduce types of necessary spare parts, enable easier operation of the facilities, effectively utilize local materials, and divide the stage of works in two stages judging from the execution conditions at the site. Included in the first stage of the works are the construction of additional transmission and distribution pump house installation of one set of transmission pump, construction of additional transmission pipeline, improvement of elevated tank, installation of distribution pressure control isolating valves. The rest are included in the second stage.

Phum Prek water treatment plant now operates only 13 hours a day but, as a result of improved power supply condition, it will be able to operate 24 hours a day and their treated water volume will be improved from 56,000 m^3/day to 100,000 m^3/day. In addition, reliability in operation increases as a result of replacing facilities which have worn out with time. Because the pressure increases after the improvement, it becomes possible for people to receive water through service taps inside the houses and the problem of distributed water contamination during the rainy season will be solved. It also becomes possible to supply water to an area of about 54.5 km^2 (about 190,000 persons) where no water supply is available now and accordingly the water supply per person increases. Ratio of water charges collection will increase as more and more water meters are installed.

After this project is complete, the water supply condition in Phnom Penh city will improve considerably and consequently the financial condition of the Water Supply Authority will also improve. Since the planned improvement of Phum Prek water treatment plant in this project is solely for improving the function of the plant, it will not require remarkable change of organization or additional staff members for maintenance and operation of the rehabilitated plant.

Since this project not only brings about the remarkable effects as mentioned above but contributes to the improved and stable life of Phnom Penh citizens, it must be justifiable to execute this project under Japan's Grant Aid. Better project management can be expected in

joint effort with other on-going collaboration programs like the one by UNDP. However, this project can be executed much more smoothly and effectively if the following recommendations are put into practice.

(1) It becomes possible as a result of this project for Phnom Penh City to secure supply water at the required minimum level. This situation will allow them to get started towards a new style of water supply business. Cambodians should devote their best to this project so that they can maintain a satisfactory service level of the water supply on a self-paying basis by collecting water charges consistently and so that they can expect further development of the water supply facilities.

(2) After the project is complete, Cambodia needs to increase the water charges in the nearfuture, but within a payable limit of beneficiaries, so that both ends on the balance sheet of the water supply business can be met by the income from water charges.

(3) In order to ensure water charge collection, Cambodia should complete necessary installation of the service pipeline to an individual user as soon as possible using a concrete organization such as by forming a special team to engage in the installation of water meters.

(4) In view of improving the balance sheet, it is essential for them to collect water charges also from faucets installed for the public. For this purpose, Cambodia should determine another charge system and a method of collection.

(5) It is very likely that water leakage occurs when the distributed water pressure is improved after the completion of this project. Therefore, Cambodia should form a repair team consisting of well-trained skilled workers so that they can be ready to cope with the leakage problem by controlling the pressure with isolating valves and repairing breakage.

(6) This project is planned to cope with the current minimum demand of water. Since the total demand is increasing, water shortage is unavoidable. Therefore, Cambodia needs to promptly prepare the extension project as specified in the master plan.

(7) For preventing contamination of water resources of the service water, Cambodia needs to plan out and implement a sewerage program.

(8) It is advisable to dispatch specialists from Japan and enter a technical collaboration with them for the purpose of efficient and effective operation, maintenance and control of the facilities as well as for maintaining a sound water supply business after the completion of this project.

(9) The water tariff should be increased for maintaining sound financial condition, and the increase shall be sufficient enough to be able to clear the accumulated nonpayment of the power rates.

(10) In order to clear the nonpayment of the water charge of the government organizations, the authority should take a decisive action including stoppage of water service against those organizations whose accumulated nonpayment is considerably high.

(11) They must employ a depreciation accounting of the facilities so that they can manage to raise a fund for renewing the facilities. Accordingly, it is necessary for them to increase the water charges to a certain level which allows them to depreciate the facilities and yet to make both ends meet on the balance sheet.

(12) In order to effectively utilize the insufficient water supply, the tariff should rise in proportion to the increase of consumption so that the system may give users an incentive to water saving.

(13) In order to keep close contact and promote efficient cooperation between the relevant supporting organizations including UNDP, France and Japan, the Cambodian side should organize a periodic meeting at least once a month of the persons in charge.

CONTENTS

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

The peace negotiations held in Paris in October 1991 put an end to the long years of disputes in Cambodia at last. It is very important for the future development of Cambodia that they set up a new government through a democratic election under the guidance of the United Nations Transitional Authority in Cambodia (UNTAC), establish a constitution, and make a new start independently. However, in parallel with these political transformations, it is necessary to quickly restore the damaged social infrastructures.

The water supply system in Phnom Penh city, the capital of Cambodia has long been left as it is without undergoing appropriate maintenance, resulting in the deterioration of the functioning of the system. As a result, the water supply system cannot satisfy the demand and a number of citizens depend on water drawing or water peddlers for their water source. Even those in the area where the water supply service is available suffer from inconvenience because the pressure is low or because they can only receive intermittent water supply. In order to improve these conditions and be well prepared for the increasing water demand in the future, thereby contributing to the development of the city, Cambodian government requested the Japanese government to formulate the "Improvement Plan and Survey of Water Supply System in Phnom Penh City" and provide grant aid to Phum Prek water treatment plant.

The Japanese government decided to execute the "Investigation of Master Plan for Improvement Plan of Water Supply System in Phnom Penh City", and JICA dispatched a study team headed by Heiichiro Makino of Tokyo Engineering Consultants to the city from February 7 to May 19, 1993. As a part of the study, the study team investigated level of the basic design necessary on the assumption that the grant aid is to be provided to Phum Prek water treatment plant. The study team conducted a series of surveys to confirme the request made by the Cambodian government, to investigate the functioning of the existing facilities, and to collect various data and materials. All subjects that were discussed and agreed upon with the Cambodian government during the investigation at the site were documented in the proceedings and both parties signed the proceedings them.

After returning to Japan, the study team examined the suitablity of this project as per the result of the survey. They have prepared a separate report on an urgent rehabilitation project

for "Improvement Plan of Water Supply System in Phnom Penh City" after careful consideration of the basic design of facilities (for which the urgent rehabilitation project must be executed as a part of the master plan), selection of materials and equipment, estimated cost of the project, and operation and maintenance plan.

The works covered by the study report on the urgent rehabilitation project include all the urgent rehabilitation works proposed in "the Master Plan" excluding the extension of the Phum Prek treatment plant.

JICA dispatched the study team again to Cambodia from November 10 to November 20, 1993 to explain the report to the Cambodian government. After explaining it to relevant persons in the government and discussing it, the study team documented the result into the agreed proceedings and to have it signed by both parties.

CHAPTER 2

BACKGROUND OF THE PROJECT

CHAPTER 2 BACKGROUND OF THE PROJECT

2.1 BACKGROUND OF THE PROJECT

Amongst all the water supply businesses in Cambodia, the one in Phnom Penh is administrated directly by the municipality.

The water supply in Phnom Penh city is supposed to be operated on a self-supporting accounting system with the water charges collected by the Phnom Penh Water Supply Authority. With increasing demand for water, however, the Water Supply Authority cannot supply enough water because of critical circumstances such as facilities worn out with time, shortage of spare parts for repair, lack of skilled workers, and financial difficulties. Thus, beneficiaries feel strongly dissatisfied with their services. What is worse, because only a few water meters have been installed on water taps in homes of individuals and the water charges collection system is very poor, water charges have never been collected fairly and properly. As a result, their water supply business is no longer profitable and hence it is operated with a subsidy from the municipality.

Phum Prek treatment plant is the newest facility in the Phnom Penh city water supply system and was constructed about 30 years ago in 1966. Since the 1970's were the age of confusion, neither any improvement or extension in the water supply facilities was achieved nor any medium or long-term plan ever set up. In the early 1990's after the peace negotiations, there arose a tendency to make medium and long-term plans for Phnom Penh water supply system. On receiving a request from the Cambodian government to form a "Master Plan", JICA dispatched a pre-study team to Cambodia in August and October 1992. Following the recommendation by the pre-study team, JICA dispatched a study team to Cambodia in February 1993. After the investigation which lasted until May of this year, the study team analyzed the results until September and then set up a master plan. Major points in the master plan are as follows.

- Targeted year of completion : 2010
- Supplied area of the plan : 77.75 km^2
- Population supplied by the plan : 1,254 thousand
- Planned average water consumption par capita : 200 l/day

- Planned average water supply par capita : 250 l/day
- Planned water supply : 313,536 m3/day
- Project cost : US$575.56 million
  - Urgent rehabilitation project : US$36.830 million
  - Project in the first term : US$259.98 million
  - Project in the second term : US$278.75 million
- Internal earning rate : 4.3%

The investigation of the urgent rehabilitation project together with that of the master plan were done concurrently. The scope of the investigation of the proposed urgent rehabilitation project covers rehabilitation of the existing facilities as described under the title "Urgent rehabilitation project" proposed by the master plan, except for the extension to the Phum Prek water treatment plant.

2.2 OUTLINE OF THE REQUEST

Water supply facilities in Phnom Penh city were extended to 140,000 m3/day in 1966 but no extension has ever been made since then. They were damaged or ruined during the civil war. Even at present, Water Supply Authority is operating the water supply business using the old facilities.

The operating hours of the plant were limited to about 17 hours a day because of poor power supply condition, and hence the plant could not satisfy the demand of all the citizens. Even at an area located near the treatment plant, where the supply condition is better than in other areas, the water delivered cannot reach the second floor or higher level or even the first floor. Therefore, many people cut open the service pipes to receive and store the water in pits.

As a result of the aforementioned measures by the citizens, pressure in the distribution pipelines decreases considerably and the water cannot reach anywhere but the area adjacent to the treatment plant. Further, the water stored in pits frequently flows out of them. These situations make it difficult to evenly distribute the water to every citizen. Thus, many people suffer from inconvenience and have no other alternative other than buying water from water peddlers or bringing in water for themselves.

In order to solve these problems and supply good and stable water to the citizens, the Cambodian government requested the Japanese government for grant aid.

Outline of the request is as follows.

(1) Rehabilitation of Phum Prek water treatment plant

Mixing basin

Flocculation basin

Horizontal flow sedimentation basin

Rapid sand filter

Chemicals dosing equipment

Distribution pump

Generator

(2) Installation of new transmission pipeline (from Phum Prek plant to the elevated tank)

CHAPTER 3

OUTLINE OF THE PROJECT

CHAPTER 3 OUTLINE OF THE PROJECT

3.1 OBJECTIVE

Cambodia has long been striving for peace from the age of chaos up to the current age of recovery. However, most of the functions that were lost during the post-war confusion have not been recovered yet, and the condition of their water supply is still very poor.

Water supply facilities in the city of Phnom Penh are not exceptional. The facilities which were constructed from 1859 up to 1960 are considerably timeworn by now and, what is worse is that they went out of order and remained so during the civil war. Some minimal measured were taken to restore functioning of these facilities under the aid by the Ex-Soviet Union and NGO in the 1980's, but there was a limitation to the amount of restoration that was carried out.

The poor condition of the power supply has worsened and the current supply capacity is about a half of the capacity of 140,000 m^3/day before the civil war. This has resulted in reduced service area and a number of citizens are compelled to use unsanitary water such as sold water, river water, rain water, or pond water. Additionally, reduction of the supply capacity has caused considerable reduction in the water supply pressure. In order to cope with this situation, people frequently cut open a pipeline or drill a hole in it and let the water flow into a pit for their use.

In order to rehabilitate the almost ruined water supply facilities and improve them in a medium and long term plan, Cambodia requested Japanese government to formulate a master plan "Improvement of Water Supply in Phnom Penh City and a Plan" and to provide grant aid. In response to this, the Japanese government prepared a master plan and presented it to the Cambodian government. In addition to the requirement of water specified in the master plan, it is also necessary to take a urgent action to supply the minimum level of water to the people until the plan is put into effect.

In order to fulfill this urgent need, it will be most effective to rehabilitate the existing water supply facilities which are in a very bad condition.

Phum Prek treatment plant has the largest purification capacity among the three existing plants in the city. Therefore, rehabilitating the plant and its distribution facilities as well as rehabilitating the transmission facilities from the treatment plant to the elevated tank located in the center of the city will help improve the water supply condition. Furthermore, these rehabilitation works will serve the purpose of the master plan as the first step toward the goal.

3.2 STUDY AND EXAMINATION ON THE REQUEST

3.2.1 APPROPRIATENESS AND NECESSITY OF THE PROJECT

In order to achieve the aforementioned objective, it is necessary to first improve the functions of Phum Prek treatment plant and Chamcar Morn treatment plant, neither of which have been functioning well. When both plants are working to their full capacity, they can restore the purified water volume to 110,000 m^3, which seems to meet the current minimum demand. For improving the functioning of these plans, the following rehabilitation of facilities and equipment is needed.

- Replacing the existing electric equipment
- Constructing additional clear water reservoir
- Installing additional transmission and distribution pumps
- Repairing the filter basins (This is excluded from this project because the basins are supposed to be repaired under aid given by French government.)

This project does not cover any facility in Chamcar Morn treatment plant. This is because when the electricity supply is restored with an improvement project planned separately, the plant will be able to operate for 24 hours and the functions of the plant will be restored.

Rehabilitation of the aforementioned facilities and equipment will increase the volume of treated water to a level to be able to fill the present minimum demand. In order to urgently improve the water supply condition, however, it is necessary to distribute the treated water. Since distribution pipelines have almost deteriorated, rehabilitation of the pipelines must be achieved together with rehabilitation of the water treatment facilities. From an idealistic viewpoint, replacing all the distribution pipes could serve the purpose. It is, however, is not

practical in an urgent rehabilitation considering the cost and the time required for the work. A more realistic method of increasing the area while is supplied would involve the construction of an exclusive pipeline up to the elevated tank located in the center of the city. Then clean water can be distributed from the tank to the city.

As a fundamental measure for improving the distribution pipelines, repair will be made also on a great number of leaking distribution and service pipes in parallel with the above work. As explained before, taking this action all over the city is not realistic for the specific purpose of the project but completing the repair for one area after another will be more realistic. In fact, repair work has already started at Don Penh area in the old downtown. Here the repair work could bring about remarkable effect because the old distribution and service pipes are installed there. Since distribution and service pipes in other areas were all installed around the same time in late 1950's, a similar effect could be expected. However, in this project, repair of leaking pipes in the area adjacent to the elevated tank where leakage may be caused as a result of increased water pressure will be initiated. Upon completion of that repair, entry of sewerage into the distribution pipeline during the rainy season can be eliminated and an increase in the service water quality can be expected.

Even after the project is over, it is necessary to continue repairing the leaking pipes in each area to improve the overall water supply condition in the city. To do so, the financial condition of the Water Supply Authority must be improved and a fund for leakage detection must be established. It is expected that the financial condition should considerably improve by installing water meters and collecting water charges according to the actual consumption. Due to this, larger size meters will be supplied in this project at higher cost.

The urgent rehabilitation works in the master plan call for the extension of Phum Prek water treatment plant by 50,000 m^3/day. Moreover, this is excluded from this project because it was not requested by Cambodia and also because it is largely felt that Cambodia is still not ready financialy and lacks human rescurces to satisfy the staff requirements and hence cannot implement the extension works yet.

3.2.2 PLAN OF OPERATION

Since the main subject of this project is the rehabilitation of Phum Prek treatment plant including the renewal of electric equipment and the replacement of transmission and distribution pumps, all rehabilitated facilities and equipment can be operated in the same way as the existing facilities. This project also includes installation of an additional clear water reservoir in the plant, an additional transmission pipeline from the plant to the elevated tank, and additional distribution pipelines in two areas of the city. All these installations can be operated in the same way as the existing ones because of the following reasons.

Maintenance and operation of the new clear water reservoir will not require additional operation staff because it can be performed together with the maintenance and operation of the existing clear water reservoir. Also, the new transmission and distribution pipelines will not require additional staff because the extension is as short as 5 km, being a minimal portion as compared to the total length of 277 km of the existing pipelines.

However, setting up new staff is necessary for installing 3,000 sets of water meters and repairing 420 portions of broken distribution pipes. It is proper that the following divisions handle of these works.

- Installation of 3,000 water meters : Connection Div. and Meter Div. of Technical Department (consisting of 50 persons in three divisions)
- Repair of 420 broken distribution pipes : Major Overhauls Div. and House Connection Div. of Chief Engineering Office (consisting of 35 persons in three divisions)

Provided that the above work is to be completed within a year (240 working days), installation and repair per day are as follows. This cannot be achieved by the existing staff members.

- Installation of 3,000 water meters : 12.5 sets per day
- Repair of 420 broken distribution pipes : 1.75 portions per day

A staff of eighteen employees in six teams, each consisting of six members (one driver, two plumbers, and three unskilled labors) is to be added to complete the work detailed above.

As the capacity of Phum Prek treatment plant increases by about 80% (from 56,000 m^3/day to 100,000 m^3/day), cost of chemicals and electrical power required for the operation, exclusive of labor cost, increases also by about 80% in proportion to the above. Maintenance and operation cost of Phnom Penh water supply system after completion of the project is expected to be as follows.

1) Chemicals cost	: US$533,987/year
2) Electric power cost	: 2,732 million Riel/year
3) Employees cost	: 144 million Riel/year
4) Maintenance and inspection cost	: US$4,500/year

3.2.3 EXAMINATION OF THE RELATION WITH OTHER SIMILAR PROJECTS AND OTHER AID PROJECTS

Until recently, OXFAM, a non-governmental organization had been engaged in the rehabilitation of Phum Prek treatment plant by providing aid to the Phnom Penh water supply system. However, they terminated it when France, Japan and UNDP offered aid.

1) Repair of distribution and service pipes in Don Penh area

France gave aid in 1992. In that year, they surveyed connections of service pipes and the condition of water charges collection in Don Penh area which is located in the main part of the city. Both distribution and service pipes in the area were installed in 1895 and are the oldest in the city. It is expected that pipes that are 100 years old had deteriorated causing frequent leakage. In addition, the service pipes in the area had been cut open to lead the supply water into a pit. Under this circumstance, it is very likely that, when the treatment facilities are rehabilitated and their expected functionality is regained by replacing the distribution and service pipes, the water pressure increases and the supply water flows out on the streets. In order to prevent this, the French project will identify and repair cut-open pipes and leaking points in Don Penh area in parallel with this project.

In practice, they have supplied distribution and service pipes for the repair. It is the Water Supply Authority's responsibility to replace the old pipes with the supplied ones.

2) Improvement of water charges collection in Don Penh area

Since there are only 2,300 water meters installed in the city, a fixed water charge system applies in practice. Besides, they fail to collect the charge in many cases. In order to improve the situation and increase the collection of water charges, the French government also supplied water meters in addition to the aforementioned supplies. The Water Supply Authority will be engaged in installing those meters.

3) Rehabilitation of Phum Prek water treatment plant

The French government plans to improve the filtration basin in Phum Prek treatment plant in 1993. Filtration basin as well as flocculation and sedimentation basins play an important roll in the treatment plant, but it is not satisfactorily functioning due to the lack of filter material. After the improvement, raw water taken from the rivers can be purified in the plant and sanitary water can be supplied to the city.

At the survey stage of this project, it was decided after consultation with the Water Supply Authority and the French government to exclude the improvement work described above from our project. Phum Prek water treatment plant can regain its expected functionality only after both the improvement work and the work described in our project as well as the reconstruction of electric equipment and the replacement of distribution pumps is completed.

4) Rehabilitation and extension of Chamcar Morn water treatment plant

Chamcar Morn plant, whose current nominal capacity is as small as 10,000 m^3/day as compared to the capacity 100,000 m^3/day of Phum Prek plant, is a treatment plant responsible for supplying water to the southern part of the city. Rehabilitation of this plant began in the late 1980's under aid from the Ex-Soviet Union but the aid was suspended after the dissolution of the Ex-Soviet Union. France plans to complete this rehabilitation and also extend the plant by the capacity of 10,000 m^3/day making it 20,000 m^3/day in total.

This and the rehabilitation of Phum Prek treatment plant will increase the total purification capacity of the city to 120,000 m^3/day. However, this is still lower than the current demand.

5) Qualitative improvement of employees of Water Supply Authority

Various influences of the long civil war could be seen everywhere and the Water Supply Authority is not an exception. Besides the facilities, management, operation and maintenance are also important for waterworks, but there are very few experienced and skilled employees. To improve the staff, UNDP will dispatche specialists to the Water Supply Authority and to provide necessary guidance for three years starting in 1993. The guidance includes training of engineers and education of financial, accounting and management staff members.

3.2.4 CONSTITUENTS OF THE PROJECT

Main constituents of this project are a) rehabilitation of Phum Prek treatment plant, b) construction of transmission pipeline from the plant to the elevated tank, c) construction of the distribution pipeline, and d) installation of isolating valves. As a result of a) rehabilitation of Phum Prek treatment plant, the water supply condition of the city should significantly improve because the rehabilitation not only makes it possible to restore the specified capacity of the facilities but also to distribute and supply the extra water resulting from the increased capacity to the areas suffering from insufficient volume and pressure.

However, because leakage from distribution pipeline is anticipated, the measure (b) shall be taken for ensuring water supply to the center of the city and (c) for improving the water supply condition to the areas where the condition is worse due to the narrow distribution pipeline.

Measure (b) above is a temporary action for improving the water supply condition all over the city by means of controlling the water pressure. In order to completely prevent the water leakage, it is necessary to take drastic action and replace distribution and service pipes worn out with time by new pipes like France has done in the Don Penh area.

3.2.5 OUTLINE OF REQUESTED FACILITIES AND EQUIPMENT

We have examined the details of facilities and the equipment requested by Cambodia and found that most of the facilities in Phum Prek treatment plant are usable as they are as shown in Table 3.1. Thus, the study team have decided not to include these usable ones in the scope of this project. Although it has not been requested, the study team have included the improvement of distribution and supply systems in the project because it is essential for improving the water supply condition.

Table 3.1 Phum Prek Water Treatment Plant System

Name of Facility	Whether to Rehabilitate	Description and Reason
1. Phum Prek water treatment plant		
Mixing basin	Excluded	Use as it is.
Flocculation basin	Excluded	Use as it is.
Side flow type chemical sedimentation basin	Excluded	Use as it is.
Rapid filtration basin	Excluded	Requires some repair, but is excluded because an aid by French government will carry out the repair.
Chemical feeding equipment	Excluded	Use as it is.
Stand-by power supply	Excluded	Power supply is expected to become stable after the power supply improvement project planned separately. Thus, no stand-by generator is necessary.
Electric equipment	Included	Is badly timeworn. Essential for restoring functionality of intake, filtration, transmission and distribution facilities.
2. Transmission and distribution facilities		
Clear water reservoir	Included	To increase the supply capacity for satisfying fluctuating needs.
Transmission and distribution pumps	Accepted	Inclusive of pump well and pump house.
Transmission pipeline	Accepted	Pipeline connecting between Phum Prek treatment plant and elevated tank.
Elevated tank	Included	Execute waterproofing and connecting works so that it may serve as a base for water distribution.
Distribution pipeline	Included	Construct new pipelines up to two areas of the city for optimizing the distribution water pressure.
Distribution pressure control isolating valves	Included	To control pressure and prevent leakage from unrepaired distribution pipes at the areas where the urgent rehabilitation project results in increased supply water preassure.
3. Supply of materials and equipment for distribution and supply facilities		
Cover joints (bands) for repair	Included	For repairing broken portions of distribution pipes in order to reduce leakage, regulate distribution pressure,and supply water effectively.
Water meters	Included	For allowing to collect water charges fairly according to the consumption and increase income of the water supply business.

The appropriateness and necessity of the project is discussed below in relation to each of the above items.

1) Rehabilitation of electric equipment in Phum Prek water treatment plant

Phum Prek water treatment plant has been operating under insufficient management because of a lack of skilled engineers and shortage of spare parts due to an insufficient budget. As a result, electric equipment in the plant is in a critical condition. Furthermore, electric system of the plant has been deteriorating at an increasing speed because for example, the switchboard is an open type. Under the existing conditions, operators are forced to perform the daily operation under dangerous circumstances. The present problem with the electric equipment is not so minor that it can be rehabilitated by partial repairs but so critical that the entire plant may be shut down due to electrical failures. Rehabilitating the electric equipment in the treatment plant is essential for enabling reliable and stable operation of the equipment and for securing the safety of the operators.

Items that require repairs in the plant are as follows.

a) High-tension electric system
b) Low-tension electric system
c) In-plant high-tension power line

2) Construction of additional clear water reservoir

The supply capacity of the existing water treatment facilities is far lower than required. Constructing an additional clear water reservoir will not only allow to effectively utilize the existing facilities and increase the capacity but will also promote the sound operation of the plant. The present status is outlined below.

The plant is operating at its full capacity for 13 hours in the daytime (5:00 AM to 6:00 PM) but is compelled to reduce its night-time water supply to about 1/4 of the daytime supply because of pressing power shortage. Water supply from the plant to the clear water pipeline during the night-time is less than raw water intake into the plant by about 1,300 m^3/hour. This difference is caused by the difference in the capacities of the intake and clear water pumps. The excessively treated water of 1,300 m^3/hour during the night is not used but

discharged out of the plant.

It will be possible to increase the water delivery by the same volume if this treated water which is unused and discharged out of the plant during the night-time is stored and then distributed in the daytime. In order to increase the water delivery, a clear water reservoir for storing the treated water must be constructed in the plant. Required capacity of the clear water reservoir will be 10,000 m^3, which is calculated as follows.

The increase in volume of the water delivery is determined by the operation sequence of the pumps and it is about 500 m^3/hour in this case. Distributing this 500 m^3/hour volume during the daytime operating hours, that is 500 × 13, makes a total volume of 6,500 m^3. By adding the washing water volume 3,500 m^3 of the filter basin of the plant to this volume, required capacity of the clear water reservoir is 10,000 m^3. Capacity of the existing clear water reservoir in the Phum Prek treatment plant is about 11,000 m^3, which is equivalent nearly to the treated water volume in 2.6 hours. With an addition of 10,000 m^3, the total capacity of the plant turns our to be equivalent to the treated water volume in 5.0 hours. Consequently, the plant becomes capable of storing the treated water in a volume sufficient for washing in the filter basin.

3) Installation of additional transmission pipeline and transmission pump

Generally, the pressure at a tap needs to have 3 to 5 m of the water head at the lowest. However, the supply water head is lower than 3 m at more than 90% of the supplied area in the city.

Head of the distribution pump in Phum Prek water treatment plant was 42 m from the beginning, and the supply water head at each tap was 15 to 20 m at the lowest when the distribution pipelines were in good order. In order to secure the pumping volume for distribution, however, a pump with 28-m low head that was installed for other applications has been employed in combination with the above. This has resulted in overall lower supply pressure. To improve the pressure, it is necessry to replace the 28-m low head pump with a 42-m head pump.

Replacing a pump as described above would suffice for increasing the supply pressure in

general cases. In the case of Phnom Penh, however, replacement of pump will only bring about limited results because people have cut open the water pipes and led the water into pits to cope with the low supply pressure for many years. To take drastic action against this situation would be to repair the cut-open portions of the pipes. However, it will take longer time to locate the cut-open portions and repair them because there are too many such portions. This repair has begun in one part of the city with aid given by France, but it will take a minimum of five to ten years to complete the repair all over the city.

On the other hand, it is necessary to increase the supply pressure while the repair is under way. Thus, it was decided to feed the pumped water directly into the elevated tank until the repair work is complete. The elevated tank is located in the center of the city and it is expected that a pressure increase will be created in a wide area around the tank.

4) Installation of isolating valves on the distribution pipeline

Repairing the cut-open distribution pipelines in parallel with the above measure is important, however, it will take a long time. In order to prevent leakage of valuable water and maintain sufficient supply pressure, a system has to be designed to divide the distribution pipelines into blocks and to let the water be distributed into each block after the repair work of the distribution pipelines is completed in that block. Isolating valves shall be installed for this purpose, and these valves will be effecture even after the repair work is completed. That is, after many years of operation, leakage from the distribution pipelines may by caused by broken or loosen joints resulting from surface pressure, or holes resulting from electrolytic corrosion. To prevent this leakage, distribution pipes must be monitored and replaced as required. Closing up specific isolating valves will make it possible to isolate a specific block for monitor and replacement. If no isolating valve is installed, water supply must be stopped not only in the required block but in the entire city for repair.

5) Construction of additional distribution pipelines in the city

Installation of additional transmission pipelines and utilization of the existing elevated tank will significantly improve the water pressure in the supplied area, however, there still remain two areas where the condition is not improved because of the insufficient capacity of the distribution pipeline. These areas constitute former political offenders' concentration camps

and an located in a central and northem part of the city as shown in Figure 4.1. For these areas, it is possible to improve the supply pressure by installing relatively small size pipes as shown in Figure 3.1. Total extension of the pipes is about 2.7 km, detail of which is as follows.

a) DIP 250 mm diameter × 1,340 m long (northern area)
b) DIP 200 mm diameter × 1,310 m long (central city)

6) Installation of water meters

One of the urgent matters the city of Phnom Penh must deal with is the improvement of its financial condition. Installing water meters is essential for them to increase collection of water charges and decrease non-payment. Water meters necessary to be used as service meters in the specified area and their ancillary equipment will be supplied.

Detail of the water meters and ancillary equipment are as follows.

Size	Quantity	Remarks
50 mm	500	including accessories
40 mm	1,000	including accessories
30 mm	1,500	including accessories
Total	3,000	

7) Cover joints (band) for repairing broken pipe

Cover joints necessary for repairing broken portions of distribution pipes will be supplied. The Water Supply Authority will take charge of the repair work using these cover joints. The repair work shall be done in low pressure areas of below 5 m, excluding the Don Penh area where France has started its aid activity. It is suspected that most of the leaking portions on the distribution pipelines are holes drilled for connecting service pipes. Since most service pipes connected to the distribution pipelines are 250 mm diameter or less, cover joints of this size and below will be supplied.

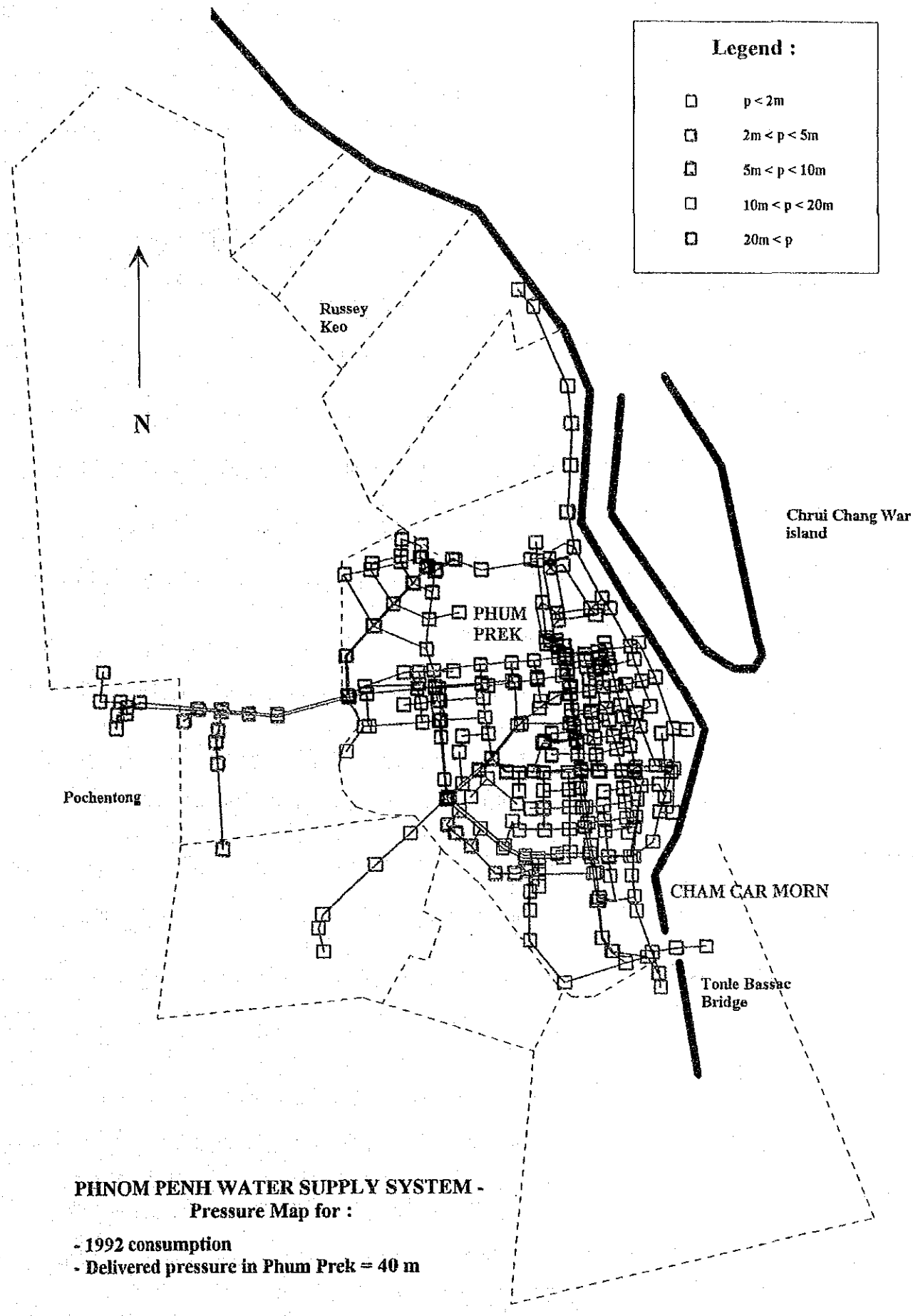

Figure 3.1 Pressure Map for Phnom Penh Water Supply System

3.2.6 NECESSITY OF TECHNICAL COOPERATION

The Water Supply Authority has to perform many tasks after rehabilitation of the water treatment plants as covered in this project before they can become self sufficient. These tasks include the operation and maintenance of the plants, prevention of leakage after the replacement of distribution and service pipes, and improvement of efficiency in collecting water charges. In this sense, technical cooperation with international organizations for the purpose of personnel training and technical improvement is also an important aspect of this project.

UNDP's aid project for the coming three years started in July 1993 as explained before. The scope of their project covers all fields of management in the water supply business. In addition, aid by the French government covers installation of pipelines and preparation of customer files.

Consequently, it is expected that the quality of the Water Supply Authority's employees should remarkably improve in the coming years. Therefore, it may be assured at this stage that the project will be executed satisfactorily, as a matter of course, and even the activities which must be performed continuously after the completion of the project such as installation of water meters, improvement of collection in water charges, and prevention of leakage would be go on smoothly. However, because the term of the project is as short as three years, it seems very difficult to achieve the goal completely. Continuous technical cooperation is necessary for facilitating more smooth management.

3.2.7 BASIC POLICY IN GRANTING COOPERATION

The effect of this project and the reality as it is now have been checked and confirmed. Further, it has been verified that the other party is capable of executing it and there is no overlap with aid programs of other international organizations. This project has been found to conform to our grant aid program. As a result, it is judged proper to execute this project under a grant aid from Japan. Therefore the outline of the project is examined in the succeeding paragraphs on the basis of Japan's Grant Aid and the basic design will be established. However, as it was explained in the sections entitled "Constituents of the Project" and "Outline of the requested facilities and equipment", it is possible to modify a

portion of the requests contained in the project.

3.3 PROJECT DESCRIPTION

3.3.1 IMPLEMENTING ORGANIZATION AND OPERATIONAL STRUCTURE

The implementing body of this project is the Phnom Penh Water Supply Authority. The Water Supply Authority became an independent organization on and after January 1, 1988 according to a decision by the Ministry Council. However, it failed financially even though necessary financial measures including increase in water charges were taken. As a result, the Water Supply Authority has been put under administration by the Phnom Penh municipality since January 1991.

From the point of view of activities required after completion of the project including prevention of leakage, installation of water meters, and stringent adjustment and collection of water charges, the number of staff members in the relevant divisions shall be increased and the organization of the Water Supply Authority shall be strengthened and re-organized. The proposed organization of the Authority is explained in the master plan which has been worked out together with this project. That is, the existing organization is re-organized into three bureaus of Technical Matter, Customer Service, and Finance and Administration as shown in Figure 3.2. The Chief Engineer's Office will be in charge of repairing broken pipes and Distribution Department will be in charge of installing water meters. These two departments will be newly added and the number of employees shall be increased by 44 for the two departments. The number of total employees increases from the existing 300 to 344. The following lists the number of employees in each department after the completion of the rehabilitation.

Since UNDP is now offering know-how on the management of the water supply business, it is supposed that the Water Supply Authority will become an independent organization again and adopt a self-supporting accounting system by around 1996 when this project is supposed to be complete. As transfer of the know-how helps improve the quality of the employees, it is expected that the existing employees can smoothly perform various activities that are required during and after the execution of this project such as operation of the water

treatment plants, prevention of leakage, installation of water meters, and adjustment and collection of water charges.

Name of department	Number of employees after completion of rehabilitation
Director/Deputy director/Assistant director	13
Technical Matters Bureau	
Production Department	78
Distribution Department	42
Chief Engineer's Office	35
Customer Service Bureau	
Technical Department	50
Billing Department	28
Collection Department	34
Finance and Administration Bureau	
Accounting Department	17
Stores Department	12
Administration Department	20
Personnel Department	15
Total	344

3.3.2 PLAN OF OPERATION

This projects aims at urgent improvement of the water supply condition. Accordingly,major project specifications are equivalent to the potential demand specified in the master plan which was worked out at the same time as this project.

- Supplied area : the city of Phnom Penh of 29 km^2 in area
- Population supplied : 700,000
- Per capital water consumption : 200 l per person per day (inclusive of 100 l of leaking water)
- Quantity of water supply : 140,000 m^3/day in average
- Supply pressure : 3 to 5 m water head at consumer's tap
- Water treatment plan : treated water volume of 110,000 m^3/day(100,000 m^3/day in Phum Prek treatment plant, 10,000 m^3/day in Chamcar Morn treatment plant)
- Distribution plan : water delivery is 1.3 times as much as the above.
- Water charges adjustment and collection plan:
  water meters shall be installed at large consumer's with a targeted collection ratio of 70%.

3.3.3 LOCATION AND CONDITION OF PROJECT SITE

Facilities and equipment covered in this project will be installed at the following locations. (See Figure 4.1)

- Phum Prek water treatment plant

  Location : in a northern part of the city, about 1 km north of Sap river

  Topography : flat, 10 m above the sea level

  Environment : Western side of the plant faces Boeng Kak lake which serves as one of the retention ponds for the drain. Northern side faces Phnom Penh Medical University, and eastern side faces Achar mean Street, the main street of the city. Southern side faces Phnom Penh railway station. Major governmental offices are located along the USSR street running south of the station from west to east. A

commercial center including the central market is also located near the plant.

Electric power and telephone:

Main distribution line from the power station located about 1.5 km north of the plant runs along Achar mean Street, and a private line is also led into the plant.

• Transmission pipeline

Location : Its extension is about 2.4 km, connecting Phum Prek plant and the elevated tank.

Topography : flat, 10 m above the sea level

Environment : in a commercial area with a number of 3 to 5-storied apartment houses.

• Elevated tank

Location : beside the Olympic Sports Complex. In the center of the southern half of the city.

Topography : flat, 10 m above the sea level.

Environment : in the neighborhood of residential area.

• Distribution pipelines

Location : one near Chrouy Changwar bridge over Sap river in the north of the city and one along a street near Olympic Sports Complex in a southern part of the city.

Topography : flat

Environments : The northern pipeline is located near a power station, and the southern pipeline is located in the residential area.

• Distribution pressure control sluice valves

Location : all over the city

Topography : flat

• Cover joints (bands) for repair

Location : all over the city (exclusive of Don Penh area)

Topography : flat

• Water meters

Location : all over the town area of the city

Topography : flat

3.3.4 OUTLINE OF FACILITIES AND EQUIPMENT

Provided tthe project is executed under grant aid from Japan, an outline of the facilities and equipment which are judged proper to be included in the scope of the project (on the basis of the aformentioned study and investgation of the request from the Cambodian government) is given as follows. For reference, this list also includes items which will not be rehabilitated but used as they are.

Facilities and Equipment	Quantity	Remarks
1. Raw water intake facilites (Phum Prek treatment plant system)		
1.1 Water intake tower	1 No.	Use as it is.
1.2 Water intake pump	4 Units	Use as it is.
1.3 Water intake plant electric equipment (power receiving equipment, power units)	1 lot	Replace .
1.4 Water intake plant electric room 6m × 11m = 66m^2	1 No.	Construct newly.
1.5 Water conveyance pipeline 700mm dia.× 1.3 km	2 Lines	Use as it is.
2. Water treatment facilities (Phum Prek treatment plant)		
2.1 Receiving well	1 No.	Use as it is.
2.2 Mixing basin	2 Nos.	Use as it is.
2.3 Flocculation basin	6 Nos.	Use as it is.
2.4 Sedimentation basin	6 Nos.	Use as it is.
2.5 Filter basin	12 Nos.	Repair (by France)
2.6 Chemicals dosing equipment		
(1) Aluminium Sulphate	1 lot	Use as it is.
(2) Lime	1 lot	Use as it is.
(3) Chlorine	1 lot	Use as it is.
2.7 Electric equipment	1 lot	Replace.
3. Transmission and distribution facilities		
3.1 Clear water reservoir (Phum Prek treatment plant)		
(1) Existing one (11,000m^3/day)	1 No.	Use as it is.
(2) New one (10,000 m^3/day)	1 No.	Construct newly.

Facilities and Equipment	Quantity	Remarks
3.2 Pump Suction Pit (Phum Prek treatment plant)		
(1) Existing one (by France)	1 No.	Use as it is.
(2) New one	1 No.	Construct additionally.
3.3 Pump house (Phum Prek treatment plant)		
(1) Existing one (by Japan)	1 No.	Improve into electric room
(2) Existing one (by France)	1 No.	Use as it is.
(3) New one	1 No.	Construct additionally.
3.4 Transmission pump		
17.5 m^3/min × 42 m× 180 kw	2 Units	Install new one.
3.5 Distribution pump		
(1) 17.5 m^3/min ×42 m× 180 kw	2 Units	Install new one.
(2) 35.0 m^3/min ×42 m× 325 kw (by France)	4 Units	Repair.
(3) 15.0 m^3/min×28 m× 132 kw (by Japan)	4 Units	Move
3.6 Transmission pipeline 500 mm dia.	2,410 m	Construct new one
3.7 Elevated tank 2,000 m^3	1 No.	Improve.
3.8 Distribution pipeline		
(1) Existing one 60 mm to 800 mm dia.	276,850 m	Use as it is. (One in Don Penh area is under repair by France.)
(2) 250 mm dia.	1,340 m	Install new one.
(3) 200 mm dia.	1,310 m	Install new one.
3.9 Isolating valves in southern area of elevated tank, 80mm to 300 mm dia.	114 sets	Install new one.
3.10 Distribution pressure control isolating valves, 150 mm to 400 mm dia.	52 sets	Install new one.
3.11 Cover joints (bands) for repair, 80 mm to 250 mm dia.	420 sets	Supply.
3.12 Water meters 30 mm to 50 mm dia.	3,000 sets	Supply.

3.3.5 OPERATION AND MAINTENANCE PLAN

1) Operation of facilities

While Phum Prek water treatment plant has the capacity of 4,000 m^3 per hour and can operate at its full capacity in the daytime, it is forced to lower the capacity at night because of unstable power supply. Operational control of the plant is performed by the staff of the Production Department of the Technical Matters Bureau in three shifts. When the plant becomes capable of operating at its full capacity for 24 hours a day and consequently the treatment volume restores from about 56,000 m^3/day to 100,000 m^3/day after the completion of this project, current operational control can apply. Since the existing facilities and the extended ones do not differ much, it is basically thought unnecessary to change the qualitative level of the employees. At present, however, it is hard to say that the employees are engaged in the operation with a full understanding of the function of the plant. Thus, it is necessary to provide the employees with education and training irrespective of whether this project is executed or not.

2) Maintenance and repair of facilities

Functioning of the water supply facilities deteriorates after a few years. Therefore, it is necessary to conduct routine maintenance and inspection (such as inspection of dust prevention and lubrication), of the following equipment and devices and make prompt repairs whenever any failure is found.

- Intake pump and motor
- Mechanical mixer (flush mixer) and motor of mixing basin
- Mechanical mixer (flocculator) and motor of flocculation basin
- Inlet gate and flow controller of filter
- Pump and blower for back washing of filter
- Chemicals (Aluminum sulphate and lime) dosing equipment
- Chlorine dosing equipment
- Distribution pump and motor
- Electric equipment (such as power receiving/transforming equipment, power distribution equipment, power equipment, and DC power supply)

3) Water quality control

At present, they check the water quality three times a day in a laboratory in the Phum Prek water treatment plant, measuring temperature, pH value, and turbidity of the raw and the filtered water. Since the raw water is taken from the Sap river with plenty of stream flow and therefore there is no rapid change of the quality with time, jar tests are not performed as frequently as three times a day but from time to time. Depending on the water quality test result, operators are instructed withthe required dosing rate of chemicals such as aluminium sulphate and lime. However, because they are short of chemicals due to the lack of funds and because the filter basin is not functioning satisfactorily, the quality of the treated water does not conform to the WHO guide line.

It is necessary in the near future for them to add measurement items such as alkalinity and total coliform and measure the quality in the Chamcar Morn treatment plant where measurement has been neglected up to now.

4) Leakage prevention and installation of water meters

Despite the low supply pressure, the present rate of leakage is assumed to be as high as 50%. It is anticipated that the supply pressure will increase after this project and consequently the rate of leakage will become considerably higher.

It is required now and after completion of this project that a leakage prevention team be established for lowering the rate of leakage and making effective use of the water. As the supply water increases, it becomes possible for people to receive the water through a tap at each house. Thus, use of pits shall be terminated and holes in the distribution pipelines shall be closed up. At the same time, the team shall proceed to replace timeworn distribution pipes, or repairing broken portions of pipes in different areas of the city as is currently being done at a part of the town area of the city.

Leakage prevention work should be handled by the Chief Engineer's Office (35 employees) of the Technical Matters Bureau, but the staff should be increased because this is a new service for the Water Supply Authority. It is necessary to add 18 employees in three teams, each consisting of six members (one driver, two plumbers, and three

unskilled labourers).

5) Control of materials and equipment

After completion of this project, it will be highly necessary to reduce water leakage by replacing timeworn distribution and service pipes in the city and repairing broken portions of those pipes. It will become also necessary to install water meters and try to collect water charges according to the consumption. For these purposes, it is required that necessary materials including pipes, joints, valves and water meters as well as excavation machines, transportation machines and connecting machines should be purchased according to a plan so that this work can be achieved smoothly. In order to achieve the work without delay, it is effective to prepare a materials and equipment inventory and understand the available stock in addition to planning out a work schedule.

3.3.6 MANAGEMENT PLAN

(1) Estimated Revenue and Expenditure

The estimated revenue and expenditure following the completion of the urgent repair and modification are discussed here for a period of 5 years from 1996 to 2000.

(2) Basic Conditions

The following conditions are used to estimate the revenue and expenditure for the above period.

1) Foreign Exchange Rates
   (a) 1 US$ = 2,500 riels
   (b) 1 US$ = 118.41 yen
   (c) 1 yen = 21.113 riels

2) Inflation
   No inflation factor is included in the estimate which is based on 1993 prices.

3) Water Charge

The applicable water charge of 166 Riels/m^3 is uniform.

4) Supply Volume

The water supply volume of Phum Prek Water Supply System and Chamcar Morn Water Supply System will be restored to 110,000 m^3/day with the successful completion of the Project.

Phum Prek Water Supply System	: 100,000 m^3/day
Chamber Morn Water Supply System	: 10,000 m^3/day
Total Supply Volume	: 110,000 m^3/day

5) Water Leakage Rate

The current water leakage rate is estimated to be 50%. Replacement of old distribution pipelines and improvement of water service facilities are underway in the Don Pen District with French assistance. As water leakage prevention work using cover joints will be conducted by the Water Supply Authority following the completion of the Project, the leakage rate is expected to decline to 40% by the year 2000. A 2% annual reduction of the water leakage rate is assumed for 5 years commencing in 1996.

6) Issue of Bills

Twenty-four thousand households formerly received water bills. This number has been increasing with UNDP assistance which commenced in 1993 and the 100% issue of water bills vis-a-vis the effective supply volume is expected by 1996, the final year of the Project.

7) Water Charge Collection Rate

The water charge collection rate is currently as low as 20% due to the facts that bills can only be issued to those living in the central city area served with relatively good water pressure and that non-payment by those living on the first or higher floors is the result of inadequate service. (These people must arrange and pay for their own water pumps to compensate for the low water pressure and also pay the electricity charge for pump operation). However, these problems will be alleviated with the

completion of the Project and a collection rate of 40% - 80% is considered for the present estimation purposes.

8) Water Meter Installation

Three thousand water meters for a supply pipeline diameter of 30 mm and 50 mm will be installed in the 5 years from 1996. The installation cost will be paid by the beneficiaries.

9) Cover Joints (Bands)

Four hundred and twenty sets of cover joints (diameter ranging from 80 mm to 250 mm) will be installed in 1996 and 1997.

10) Personnel Cost

The Water Supply Authority currently employs 300 people and this figure is expected to increase to 344 in the final year of this Project. The personnel cost of these 344 employees is taken into account in the estimate. The monthly salary of a civil servant is approximately 20 US$/person.

11) Administration Cost

Based on past results, the administration cost for the increased staff is estimated.

12) Chemical Cost

The chemical cost to treat the planned water quantity is estimated based on the following unit costs.

(a) Aluminum Sulphate : 219.0 US$/ton
(b) Lime : 140.0 US$/ton
(c) chlorine gas : 572.0 US$/ton

Water Supply System	Intake (m^3/day)	Treated (m^3/day)	Supplied (m^3/day)
Phum Prek	105,600	105,600	100,000
Chamcar Morn	11,000	11,000	10,000
Total	116,600	116,600	110,000

13) Electricity Cost

The electricity cost to support the treatment of the planned water quantity is estimated based on the following unit cost.

- unit electricity charge: 170 Riels/kwH

(See Appendix 3 for the detailed power load requirements and costs.)

14) Repair Cost

Due to the very small repair cost in the past, a standard 10% is adopted in addition to the cost of the bands which will be installed in 1996 and 1997 as mentioned earlier.

15) Depreciation Cost

The depreciation cost of the existing facilities/equipment is not included in the estimate as their residual values are unknown. The following lives are assumed for the equipment and buildings to be provided under the Project.

(a) mechanical and electrical equipment : 15 years
(b) buildings : 40 years
(c) water supply pipelines : 40 years

(3) Optional Cases for Examination

The various combinations of optional cases under each item shown in Table 3-3 are examined to estimate the financial balance of the water service operation.

Table 3-3 Optional Cases for Examination

Water Supply (m^3/day)	Leakage Rate (%)	Depreciation	Water Charge Collection Rate (%)	Water Charge (Riels/m^3)
110,000	40	1) None 2) Mechanical and Electrical Equipment only 3) Total Cost	1) 40 2) 50 3) 60 4) 70 5) 80	1) 166 2) 300 3) 400 4) 500 5) 600 6) 700

(4) Results of the Examination

1) Depreciation Cost

Assuming that the present water charge collection rate of 20% continues, a unit water charge of 1,800 Riels/m^3 (see Table 3-4), which is 11 times higher than the present unit water charge of 166 Riels/m^3, will be required to depreciate the entire project cost. The renewal of mechanical and electrical equipment is the most important factor in the case of the production of domestic water. The depreciation of only mechanical and electrical equipment, which is the minimum depreciation, still results in a unit water charge of 1,600 Riels/m^3 (see Table 3-5), 10 times higher than the present charge. The water charge collection rate must be improved in order to accumulate sufficient funds for the minimum replacement of equipment (or to support the minimum depreciation cost) and to prevent a sharp increase in the water charge.

2) Water Charge Collection Rate

To achieve a 100% water charge collection rate is extremely difficult due to the reasons given below. The recovery of the water distribution pressure by implementing this project, will eradicate the main source of user complaints regarding the present water supply service, and priority collection efforts vis-a-vis large users may well achieve a 70% collection rate.

(a) A long time will be required to establish and enforce a proper collection system over a wide area.

(b) A long time will be required to provide sufficient water with adequate water pressure to those people living on the second and higher floors.

3) Water Charge

The required unit water charge is 600 Riels/m^3 if a collection rate of 70% is achieved. This represents 4.3% of the income as calculated below and will constitute a heavy burden on low income families. For reference, the average water bill in ordinary Japanese households is 0.6% of the income which is less than one-seventh of the level of the required charge in the present case. A unit water charge of 600 Riels/m^3 may not appear exorbitant compared to the 500 - 800 Riels/m^3 charged

by water vendors. From the viewpoint of providing relief for low income people, the present uniform charge system should be replaced by the progressive charge system.

$$\frac{100 \text{ liters/person} \times 6 \text{ persons} \times 30 \text{ days} \times 600 \text{ Riels/m}^3}{100 \text{ US\$} \times 2{,}500 \text{ Riels/US\$}} \times \frac{100}{1{,}000} = 4.3\%$$

- water consumption per capita : 100 liters/person/day
- average number of people/household : 6
- minimum monthly income/household : 100 US$

Table 3-4 Estimated Revenue and Expenditure

(Unit : 100 million Riels)

Item	Year					Remarks
	1996	1997	1998	1999	2000	
Revenue						
Water Charge	75.2	78.1	81.0	84.0	86.7	
Other Income	13.1	13.1	13.1	13.1	13.1	meter installation
Total	88.3	91.2	94.1	97.1	99.8	
Expenditure						
• Operating Cost	2.1	2.1	2.1	2.1	2.1	
Personnel	0.4	0.4	0.4	0.4	0.4	
Administration	13.3	13.3	13.3	13.3	13.3	
Chemicals	27.3	27.3	27.3	27.3	27.3	
Electricity	9.3	9.3	9.2	9.2	9.2	
Repair	0.9	0.9				
Bands						
Depreciation						
Mechanical & Electrical Equipment	18.6	18.6	18.6	18.6	18.6	
Buildings	2.7	2.7	2.7	2.7	2.7	
Supply Pipe Lines	5.3	5.3	5.3	5.3	5.3	
Miscellaneous	13.1	13.1	13.1	13.1	13.1	meter installation
Sub-Total	93.0	93.0	92.0	92.0	92.0	
• Non-Operating Cost						
Interest Paid	0.0	0.0	0.0	0.0	0.0	
Others	0.0	0.0	0.0	0.0	0.0	
Sub-Total	0.0	0.0	0.0	0.0	0.0	
• Total	93.0	93.0	92.0	92.0	92.0	
Net Profit or Loss	-4.7	-1.8	2.1	5.1	7.8	
Accumulated Profit or Loss	-4.7	-6.5	-4.4	0.7	8.5	

Notes
1. Unit Water Charge : 1,800 Riels/m^3
2. Depreciation : total project cost
3. Collection Rate : 20% (present rate)

Table 3-5 Estimated Revenue and Expenditure

(Unit : 100 million Riels)

Item	Year					Remarks
	1996	1997	1998	1999	2000	
Revenue						
Water Charge	66.8	69.4	72.0	75.0	77.1	
Other Income	13.1	13.1	13.1	13.1	13.1	meter installation
Total	79.9	85.1	85.1	88.1	90.2	
Expenditure						
• Operating Cost	2.1	2.1	2.1	2.1	2.1	
Personnel	0.4	0.4	0.4	0.4	0.4	
Administration	13.3	13.3	13.3	13.3	13.3	
Chemicals	27.3	27.3	27.3	27.3	27.3	
Electricity	8.4	8.4	8.3	8.3	8.3	
Repair	0.9	0.9				
Bands						
Depreciation						
Mechanical & Electrical Equipment	18.6	18.6	18.6	18.6	18.6	
Buildings	0.0	0.0	0.0	0.0	0.0	
Supply Pipe Lines	0.0	0.0	0.0	0.0	0.0	
Miscellaneous	13.1	13.1	13.1	13.1	13.1	meter installation
Sub-Total	84.1	84.1	83.1	83.1	83.1	
• Non-Operating Cost						
Interest Paid	0.0	0.0	0.0	0.0	0.0	
Others	0.0	0.0	0.0	0.0	0.0	
Sub-Total	0.0	0.0	0.0	0.0	0.0	
• Total	84.1	84.1	83.1	83.1	83.1	
Net Profit or Loss	-4.2	-1.6	2.0	5.0	7.1	
Accumulated Profit or Loss	-4.2	-5.8	-3.8	1.2	8.2	

Notes
1. Unit Water Charge : 1,600 Riels/m^3
2. Depreciation : mechanical and electrical equipment only
3. Collection Rate : 20% (present rate)

Table 3-6 Estimated Revenue and Expenditure

(Unit : 100 million Riels)

Item	Year					Remarks
	1996	1997	1998	1999	2000	
Revenue						
Water Charge	56.4	66.7	77.6	89.1	101.2	
Other Income	13.1	13.1	13.1	13.1	13.1	meter installation
Total	69.5	79.8	90.7	102.2	114.3	
Expenditure						
• Operaring Cost	2.1	2.1	2.1	2.1	2.1	
Personnel	0.4	0.4	0.4	0.4	0.4	
Administration	13.3	13.3	13.3	13.3	13.3	
Chemicals	27.3	27.3	27.3	27.3	27.3	
Electricity	8.4	8.4	8.3	8.3	8.3	
Repair	0.9	0.9				
Bands						
Depreciation						
Mechanical & Electrical Equipment	18.6	18.6	18.6	18.6	18.6	
Buildings	0.0	0.0	0.0	0.0	0.0	
Supply Pipe Lines	0.0	0.0	0.0	0.0	0.0	
Miscellaneous	13.1	13.1	13.1	13.1	13.1	meter installation
Sub-Total	84.1	84.1	83.1	83.1	83.1	
• Non-Operating Cost						
Interest Paid	0.0	0.0	0.0	0.0	0.0	
Others	0.0	0.0	0.0	0.0	0.0	
Sub-Total	0.0	0.0	0.0	0.0	0.0	
• Total	84.1	84.1	83.1	83.1	83.1	
Net Profit or Loss	-14.6	-4.3	7.6	19.1	31.2	
Accumulated Profit or Loss	-14.6	-18.9	-11.3	7.8	39.0	

Notes
1. Unit Water Charge : 600 Riels/m^3
2. Depreciation : mechanical and electrical equipment only
3. Collection Rate : 70% (present rate)

CHAPTER 4

BASIC DESIGN

CHAPTER 4 BASIC DESIGN

4.1 DESIGN POLICY

In planning out a basic design for this project, which aims to resolve the insufficient water supply problem in the city of Phnom Penh, careful consideration have been given to various factors such as the natural environment of the city, its social circumstances, present situation of the construction, availability of material supply, and latest condition of maintenance services.

It is necessary to design a plant which should be a) easy to repair and maintain, b) the most effective to help improve the sanitary and hygienic environment of the city, while also being cost-effective to the Phnom Penh Water Supply Authority and c) suitable to their technical level in water treatment, and d) capable of supplying treated water consistently. Given below are the important design considerations which can be summed up as the basic design policy for such a plant.

1) Effective Utilization of Existing Facilities

Many of the facilities and equipment in Phum Prek treatment plant are badly timeworn, requiring repair or replacement. In addition, some of the existing facilities do not seem to be functioning well enough to ensure stable quality of the treated water and some should preferably be improve for achieving simplified maintenance of the plant. In making repair and improvment plans, the greatest importance has been attached to utilizing the existing facilities to the maximum extent possible. Whether these timeworn facilities should be replaced with new installations or retrofitted will be decided based on the technical level required for the maintainance of such facilities and also with the prive aim of trying to use existing facilities as far as possible.

2) Standardization of Mechanical Equipment

One of the problems the Phnom Penh water supply system has encountered is the difficulty in obtaining necessary spare parts for mechanical and electrical equipment. The main reason is that the Water Supply Authority is financially vulnerable and thus has no room to purchase such parts. Complicated equipment requires a lot of spare parts, while the spare parts

available in Cambodia are limited and most of them need to be imported. This causes delay in purchasing such parts. In many cases, when a piece of equipment has failed, it is forced to stop operation for a long period. If the failed equipment is an essential component in the water treatment system, the situation becomes critical and the water can no longer be supplied. With the above situation in mind, equipment of the same type and size is to be purchased so that spare parts can be made available between units in case of failure.

3) Upgrading Operation and Handling of Facilities

Because the technical level of the operators engaged in the Phnom Penh water supply system is low, adopting a system that requires high technical capability may adversely affect operation management and efficiency of the treatment plant. Since the quality of raw water varies from time to time, appropriate operation is necessary to cope with this variation. If the system is not easily operable, operators can hardly take necessary steps to cope with the varying condition. As a result, it is possible that extra electricity is consumed, overdosing or underdosing of chemicals takes place, or raw water is uselessly discharged back in the river. Low operability can bring about problems. In order to avoid possible waste and trouble, the system will be designed by giving consideration to the operability of each facility.

4) Effective Utilization of Local Materials

Utilizing local materials makes it possible to lower the total project cost and also to expect an economical ripple effect in Cambodia. Although only a limited number of locally available materials are acceptable, utilization of as many of them as possible is advantageous for Cambodia particularly in the maintenance or repair of the facilities. In view of the above, the basic design will be prepared by giving due consideration to utilizing local materials effectively.

5) Policy on the Stage of Works

This project is divided into two stages of works by considering (1) the scale of the works; (2) natural conditions including temperature, precipitation, and rainfall patterns; (3) specific local requirement that, when digging a public road or sidewalk, drawings of the works must be submitted to the Road Authority via the Water Supply Authority, with a request for

necessary traffic control stating the time and place, and (4) an authorization must be obtained prior to the start of the works; and the level of labor.

Since the facilities included in this project are to be constructed using grant aid from Japan, it is necessary to complete the construction within a certain period of time regulated by Japan's accounting system. It is also necessary that Japan and Cambodia shall accomplish each of their share of the project with good cooperation between all parties concerned and that the construction should move ahead efficiently and functionally.

4.2 STUDY AND EXAMINATION ON DESIGN CONDITIONS

This project is to improve, extend or newly construct parts of water treatment, transmission and distribution facilities so that Phum Prek Water Treatment Plant will regain its original capacity of 100,000 m³/day. The design conditions is for this project are examined below.

4.2.1 BASIC DESIGN CONDITIONS

(1) Quality Standard of Treated Water

Since there are no applicable local standards available in Cambodia, WHO New Guideline is employed for this project.

(2) Design Criteria of Facilities

Design of the facilities shall conform to the following.

- Design Criteria for Waterworks Facilities : Japan Waterworks Association
- Building Basic Structure Design Criteria : Japan Architecture Association
- Standard Concreting Guideline : Japan Civil Engineering Association
- High-Tension Power Receiving Equipment Guideline : Japan Electrical Association
- Other design criteria an applicable to the facilities

(3) Applicable Standards

The following standards shall apply.

- Japan Waterworks Association (JWWA) Standard
- Japanese Industrial Standard (JIS)
- Japanese Electrotechnical Committee (JEC) Standard
- Japan Electro Machinery (JEM) Standard
- Other applicable standards including International Organization for Standardization (ISO) Standard and manufacture's standard

(4) System of Unit

The metric system shall be used.

(5) Operating hours of Treatment Plant, Transmission Pump and Distribution Pump

The treatment plant, transmission pump and distribution pump shall operate 24 hours a day in principle, however, the operating hours may vary depending upon the distribution.

4.2.2 FIRST STAGE OF WORKS

(1) Mechanical Equipment

1) Installation of transmission pump

Figure 3.5 illustrates the existing water pressure in the supply area. It indicates that the water head (head above the ground level) is lower than 2.5 m in about one-third of the entire supply area in Phnom Penh.

Provided that a transmission pipeline is installed from the Phum Prek treatment plant to the existing 2,000 m^3 elevated tank and the water is distributed from this tank, the water head will be improved as shown in Figure 4.0 which is obtained from the simulation model. The Figure clearly shows that the supply area having a water head below 2.5 m

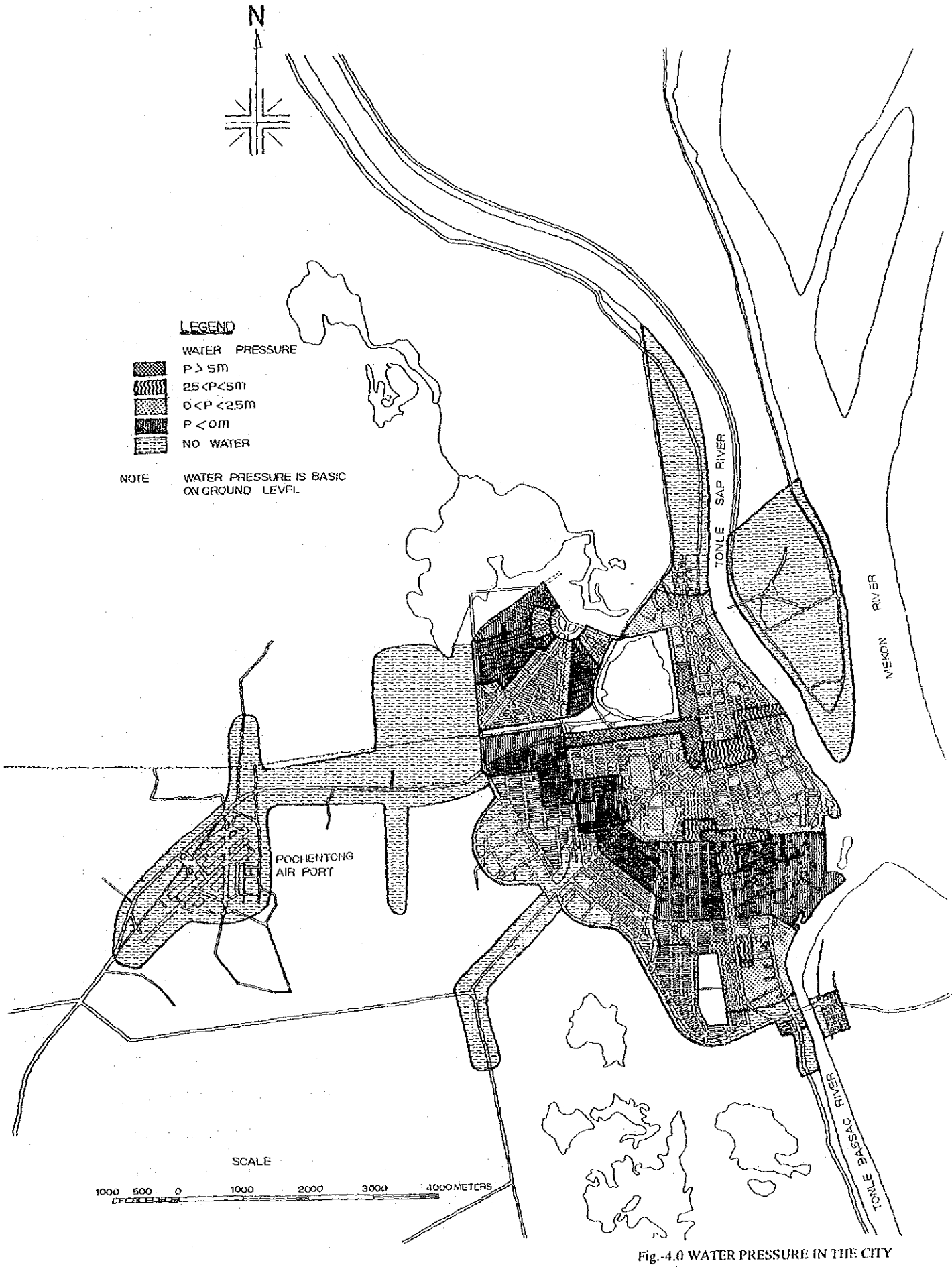

Fig.-4.0 WATER PRESSURE IN THE CITY

can be reduced drastically. The assumptions on which the simulation model is based are as follows.

- Per capita per day consumption : 100 litres/person/day (1993)
- Hourly fluctuation of demand : assumed to be none
- Transmission flow to the elevated tank : 1,000 m^3/hour
- Water pressure at the outlet of the tank : L.W.L. (above sea level + 30 m)

Specification of the transmission pump that meets the above requirement shall be 17.5 m^3/min. × 42.0 m × 3,000 V × 50 Hz × 180 kW. One such pump shall be installed during the first and second stage of the works and either of them can serve as a stand-by.

The transmission pump shall operate as follows. First, the water level of the elevated tank is sensed by a Flict type water level detector mounted in the tank, and then the level is transferred by the water level transmitter to the transmission pump control panel installed in Phum Prek treatment plant. The transmission pump is turned "ON" when an operation level signal is received and turned "OFF" when a stop level signal is received. Although the transmission pump is turned "ON" and "OFF" according to the water level of the elevated tank, the level setting to turn the pump on/off will be carefully adjusted through careful investigation and examination because it relates to the distribution pressure in the city. In addition, although only one of the two pumps is in service at a time, the sequence of alternate operation and the average operating hours of each unit shall be determined through careful consideration.

(2) Electric Equipment

1) Installation of electric equipment

Since renovation of the entire electric equipment in Phum Prek treatment plant is scheduled to commence in the second stage, only the secondary circuit breaker for the 15 kV/3 kV transformer shall be installed in this stage mainly for supplying power to the transmission pump motor. High-tension primary power (3 kV) to the main panel is supplied from the high-tension power panel located in the distribution pump house

which was constructed by Japan in 1959.

(3) Building Facilities

1) Extension of the transmission & distribution pump house (main distribution pump house)

From the point of view of convenient maintenance and operation, the existing pump house which was constructed by France in 1966 shall be extended and shall be used as a new transmission and distribution pump house annex.

The new pump house will be of the same height and width as the existing pump house, while the length shall be determined by considering the minimum space required for installing four sets of pumps and the ease of maintenance and operation.

In the new pump house, the pump suction pit shall be the same height and width as the existing pump house, and the length be the same as that of the proposed one.

(4) Civil Facilities

1) Installation of the interconnection pipeline in the Phum Prek Treatment Plant

A pipeline between the filtered water channel and the extended main distribution pump house is necessary for transmitting water to the elevated tank. Ductile cast-iron pipes (with mortar lining inside) of 700 mm and 800 mm diameter shall be used.

2) Installation of 500 mm diameter transmission pipeline

Design conditions are as follows.

(a) Formula employed for the hydraulic calculation of the pipeline

Williams & Hazen's formula:

$$H = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$$

where: H: loss of head (m)

C: coefficient of flow velocity (130)

D: diameter of pipe (m)

Q: flow rate (m^3/sec)

L: length of pipeline (m)

(b) Transmission flow and length of pipeline

The discharge of the transmission pump i.e. the transmission flow shall be 17.5 m^3/min. The length of the pipeline shall be 2,410 m from the starting point in the treatment plant up to the foundation of the elevated tank.

(c) Flow meter for transmission pipeline

Type	: venturi meter
Flow rate	: 17.5 m^3/min
Differential pressure	: 1,500 mm Aq
Velocity	: 2.3 to 2.4 m/sec

3) Improvement of the existing elevated tank

The existing elevated tank has an effective storage capacity of 2,000 m^3 and is designed for a one-way method, which uses a common pipe for both inlet and outlet. The water flows into the tank when the pressure around it increases and flows out when the pressure decreases. However, this method has never been functional and no water ever flowed into the tank because the pressure was always low.

The tank is converted to be suitable for the two-way method by installing separate inlet and outlet pipes. This enables water to be directly supplied from the Phum Prek treatment plant by the transmission pump. A connection piping from the elevated tank to

the existing distribution pipeline around the tank is also provided so that the water can be distributed to the area in the neighborhood of the elevated tank. Design flow rate of the inlet pipe, overflow pipe and bypass pipe shall be 17.5 m^3/min, the discharge of the transmission pump. The outlet pipe shall have a flow rate capable of coping with the time factor 1.3, that is, 17.5 m^3/min × 1.3 = 22.86 m^3/min.

4) Installation of pressure control isolating valves for the distribution networks

The water head in the city will improve from 2-5 m to 5-20 m after the improvement of the transmission/distribution pumps and the elevated tank are completed. This may result in leakage from or breakage of the distribution pipes. To prevent this, it is necessary to control water pressure in the distribution system. However, it is almost impossible to regulate the pressure in the city because the existing distribution pipeline system is has almost no isolating valves. Thus, isolating valves will be installed in the entire area of the city. It is possible to exclude the Don Penh area from this plan because the improvement of the distribution pipeline system and water supply devices in the area is being carried out by France and the Water Supply Authority. Nevertheless, it has been decided to include this area as the improvement work will take much more time to complete (it is scheduled to be completed in 1994 but a delay of a year or so is anticipated). The number of isolating valves in Don Penh area shall be kept to a minimum.

The valves shall be installed on the main and secondary lines in the distribution pipe network within the city and will serve to regulate the pressure in the areas where leakage may occur or distribution pipes may be broken due to the high pressure. No isolating valve shall be installed on a branch pipe of a diameter below 100 mm which branches out directly from a main of a diameter over 450 mm because the loss of head becomes greater.