

Water consumption records of each property are accumulated in MWWA, although statistical preparation is remained.

2) Groundwater Use

According to MWWA (Review of Bangkok Water Supply Improvement, 1977), 30% of total demand is supplied from 140 deep wells, about 30% of which are unmetered. However, the data were not collected by visiting Mineral Resources Department, MOI, and Bureau of Public Health, BMA, because of lack of data.

3) Domestic Wastewater

Per capita wastewater flow and loadings have been estimated previous studies of sewerage system planning as shown in Table A-3-1:

Table A-3-1 Per Capita Wastewater Flow and Loading in Bangkok
(Design Values of Previous Studies)

	LEP ¹⁾	HBR ²⁾	CDM ³⁾
Waste Flow (l/c.d)	246	220	238
BOD (g/c.d)	-	-	85

- 1) Litchfield Plan
- 2) Husband Report
- 3) Camp, Dresser & McKee Plan

The values of per capita wastewater flow and BOD loading based on field survey are 109 l/c.d and 32 BOD g/c.d respectively, which were made by CDM (1967).

Mahidol University carried out a wastewater survey in Rattanakosin Island area in 1979 (Data No. 8.1.1). The newest wastewater survey was made by the Survey Team at Huay Kwang Housing Estate, in which

separate sewerage system had been applied. The findings are described in Section C-3; Dry Weather Wastewater Survey, of this report.

The data mentioned above are still not enough to estimate quantity and characteristics of domestic wastewater generated in Bangkok. It is, therefore, expected that further field survey be made in the Coming Study.

4) Commercial & Institutional Wastewater

The findings of the "Rattanakosin Island Survey" mentioned above are only information concerning to wastewater discharged from commercial and institutional area.

It would be necessary to make field survey to estimate "trade wastes allowance" in the Coming Study.

5) Industrial Wastewater

According to City Planning Division, BMA, there is no industrial estate in Survey Area at present and in the future. Therefore, industrial wastewater should be considered on factory-by-factory, if necessary.

The number of factories by each type of industry (1977) was provided by Bureau of Public Health (Data No. 4.2.2). BOD loadings discharged from selected factories have been surveyed by Department of Industry (Data No. 4.2.1).

The Data indicate the necessity of consideration about industrial wastewater discharged from factories scattering in the Study Area because it is supposed that harmful or toxic matter might be included in the wastes from some categories of industry listed up. For the purpose, it would be required to provide further informations, i.e. location, volume, quality etc. of selected factories.

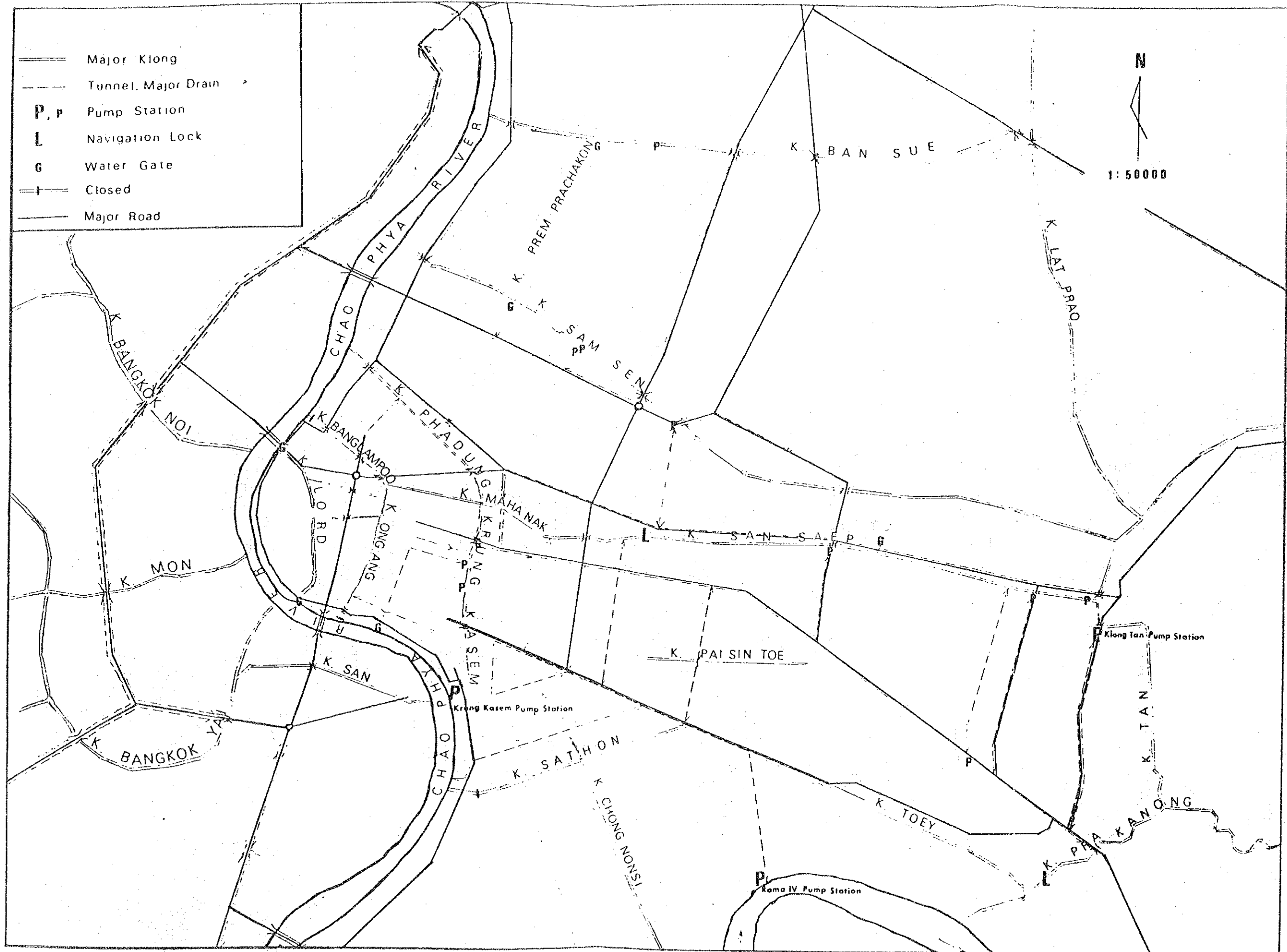


FIG. A-5-1 MAJOR DRAINAGE SYSTEM IN BANGKOK

A-4. Storm Waters

The necessary data for estimating storm water runoff are available in Master Plan Report (CDM). It is considered, these design criteria can be used in the coming study.

However, the record of rainfall event with the duration time and rain depth is required for estimating the amount of pollutant loads overflowed from a combined sewerage system. The record of rainfall in these ten years has been copied and included in the data file.

A-5. Existing Sewerage and Drainage Systems

1) Drainage System

i) Major Drain System

The major drainage system in central Bangkok is summarized in Figure A-5-1. The existing drainage system comprises klongs as the trunk drain, underground conduits as the sub-main or branch, two major pumping stations of Krung Kasaem ($5 \text{ m}^3/\text{sec.} \times 5$) and Rama IV ($5 \text{ m}^3/\text{sec} \times 4$), temporary lift stations with various capacities (from two \varnothing 200 mm. pumps in Sapan Prom to four \varnothing 600 mm. pumps in Klong Tan) in eleven critical points, and many mobile pumps equipped on trucks. The mobile pumps are distributed in response to the local requirements emerged at the time of storms.

All of klongs, big and small, and major sewers in Bangkok belong to BDS, and are maintained by the agency.

Drainage plan in Bangkok is established and implemented by BDS, which basically follows to CDM Report. Construction of drains for local needs is made by each district office. In 1979, some 32 bigger drains constructed by district offices were taken over to BDS.

ii) House Connection System

The evaluation of existing house connection system would be necessary in the Coming Study.

iii) Design Criteria (or Approval Guideline)

Design practice on Pipe slope is shown in Table A-5-1.

This is used by BDS as a approval guideline of pipes.

Table A-5-1. Pipe Slope as Design Practice (BDS)

Diameter (m)	Slope
0.4	0.0015 - 0.0020
0.6	0.0012 *- 0.0015
0.8	0.0008 - 0.0012
tunnel	0.0004

* in special case, 0.0010 be approved.

iv) Materials Used

Developers can select and use any material for drain construction of their development area. They usually use pre-cast concretes, which at least six local companies provide by their own standards, they say, market standards. According to information of BDS, the market standards are unified in size, but different in quality.

2) Sewerage System

i) Municipal Sewerage System

Existing public sewers serve for sullage water together with together with storm water, and BDS is responsible for their construction and maintenance.

There is no wastewater treatment system belonging to BDS.

ii) Communal Sewerage System

There are communal sewerage systems attached to housing estates constructed by NHA. These are basically designed as a separate system. However, some systems receive a part of storm water to protect from flooding of lower land in the served area.

The sewerage systems have communal treatment facilities, of which treatment methods are septic tank, oxidation pond, activated sludge, or extended aeration system.

In the housing areas developed by private developers, there is no sewerage system which has communal treatment facilities.

iii) Design Standards on Sewerage System

3) Nightsoil Collection & Disposal

i) Toilet System

Toilet system in Survey Area is usually water closet system connecting to permeation tank through septic tank, which is called cesspool or storage tank. Therefore, effluent is, in principle, not discharged to any drain nor surface waters. However, it is seen as a matter of fact that the septic tank effluents (or flush water even if it is rare case) are, here and there, discharged to public sewers or open waters. Common styles of toilet system are mentioned in CDM report. Standard styles of toilet system are in a file of data collected (Data No. 7.1.1).

ii) Collection and Disposal

Collection and disposal of septic tank sludge are carried out by Bureau of Sanitation (BOS), BMA, in entire Bangkok area, 24 districts.

Septic tank sludges are collected and conveyed to suburban area of Bangkok, Nong Khaem and On-nooch. The treatment methods of them are lagooning and activated sludge aeration respectively. As of November, 1979, the latter is under construction.

Number of collection vehicles provided in BOS is as follows:

Suction vehicle (capacity 5 m ³)	20
Suction vehicle (capacity 2 m ³)	21
Carriage vehicle (capacity 5 m ³)	24

350-400 m³ of sludge in daily average is collected by 7 days work in a week.

Government budget for collection and disposal is Baht 31,234,200 for the fiscal year 1980.

Collection charge is Baht 50 per cubicmeter.

Achievement records on collection effort and flow-sheet of On-nooch treatment plant are in a file of data collected (Data No. 7.1.2)

Activities of private firms for collection and disposal of septic tank sludge were not informed from BOS. They say many unregislated private firms contribute desludging services in fact. No. information has been obtained about their disposal site of collected sludge.

For evaluation of present toilet system in Bangkok, it is required to know the fact on existing services for collection and disposal of septic tank sludge.

A-6. Meteorological, Hydrological and Hydraulic Data

As climatic condition data, rainfall, temperature, relative humidity and wind were collected from Meteorological Department, Ministry of Communications.

The Chao Phya River's estimated flow rate is available in the report of "Chao Phya-Meklong Basin Study" from RID, Ministry of Agriculture and Cooperatives, and "Mathematical Optimization Model for Regional Water Quality Management: A Case Study of Chao Phya River (Phase 1)" from NEB.

The water level in several points of the Chao Phya River is indicated in "Tide Tables" published from Hydrographic Department, Royal Thai Navy.

A-7. Geological Data

Records of boring tests are available for some 15 points in the study Area. Those records and boring points are filed in the collected data. As other data of subsoil conditions, the 13 boring logs are presented in the Master Plan by CDM.

Concerning to the subsurface conditions, it should be kept in mind that as foundation of rather old buildings, wood piles are used and the significant changes in ground water level is considered to effect adversely to them.

A-8. Institutional Data

The authority which governs the Bangkok Metropolis is Bangkok Metropolitan Administration (BMA). BMA is positioned under the Minister of Interior and comprises 13 bureaus and an Office of the Under Secretary of

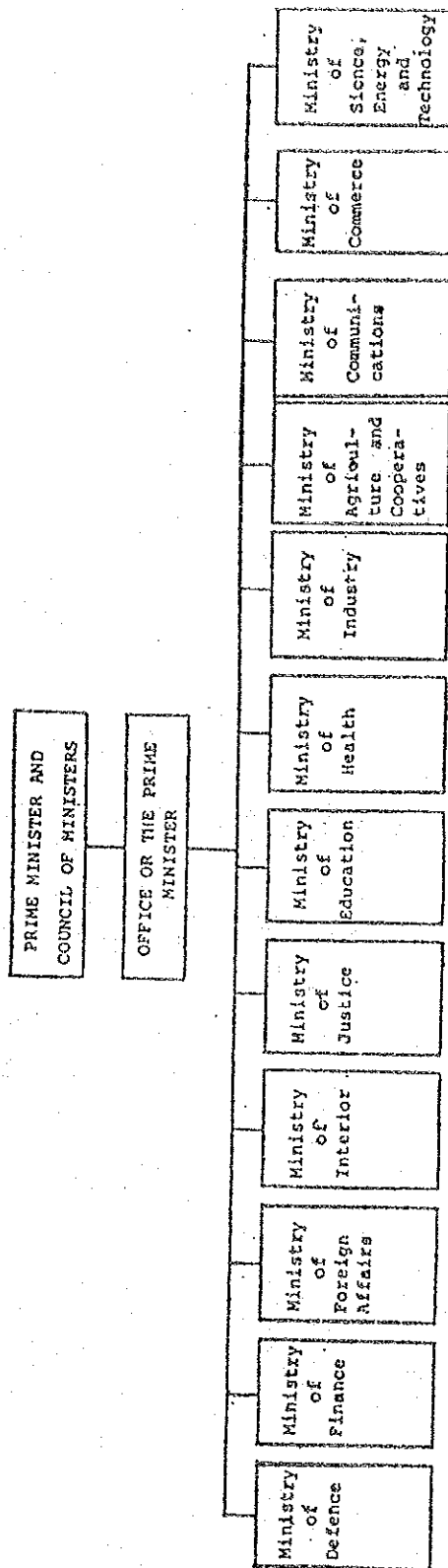


Figure A-8-1 ADMINISTRATIVE ORGANIZATION OF THE GOVERNMENT OF THAILAND

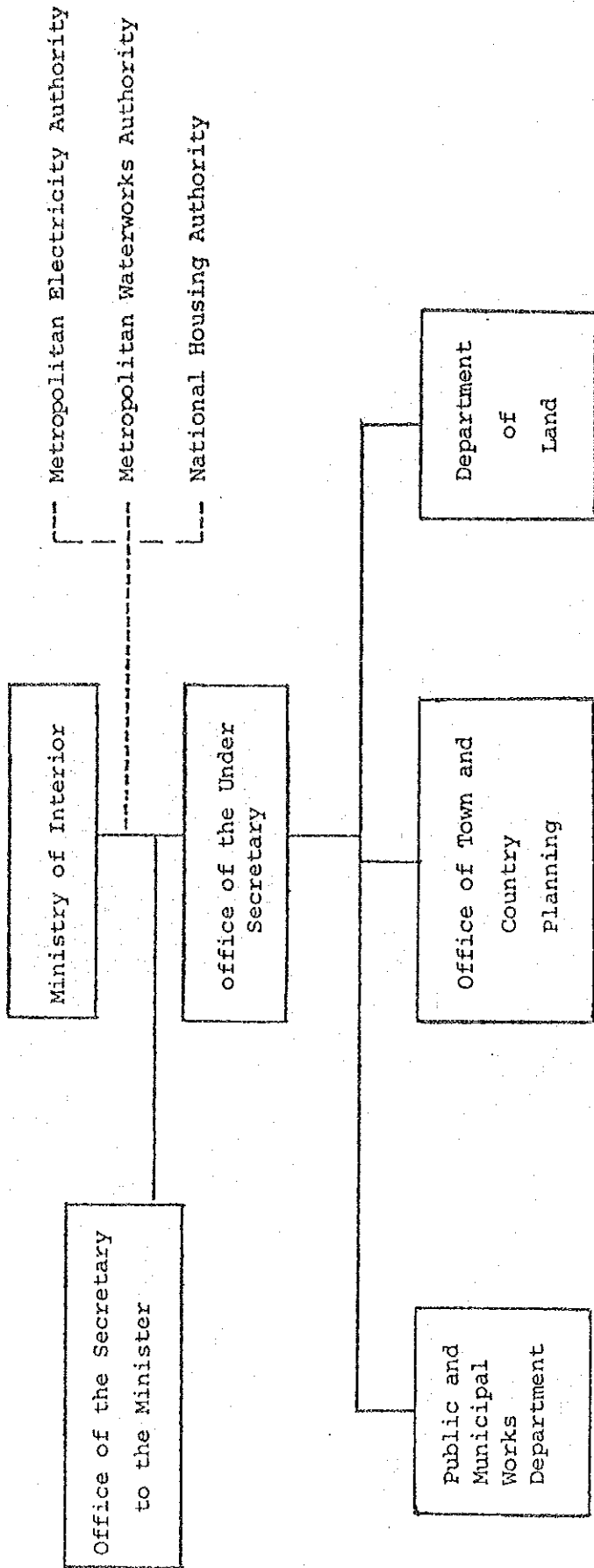


Figure A-8-2 ORGANIZATION OF MINISTRY OF INTERIOR

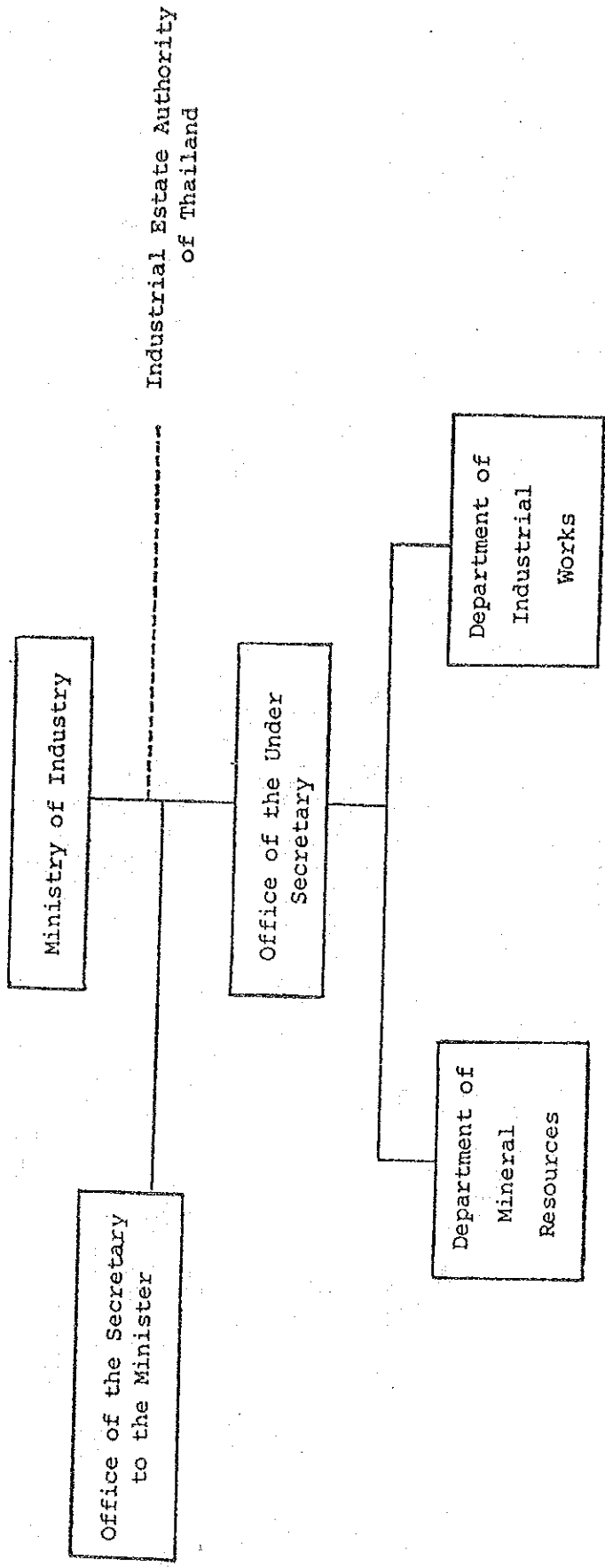


Figure A-8-3 ORGANIZATION OF MINISTRY OF INDUSTRY

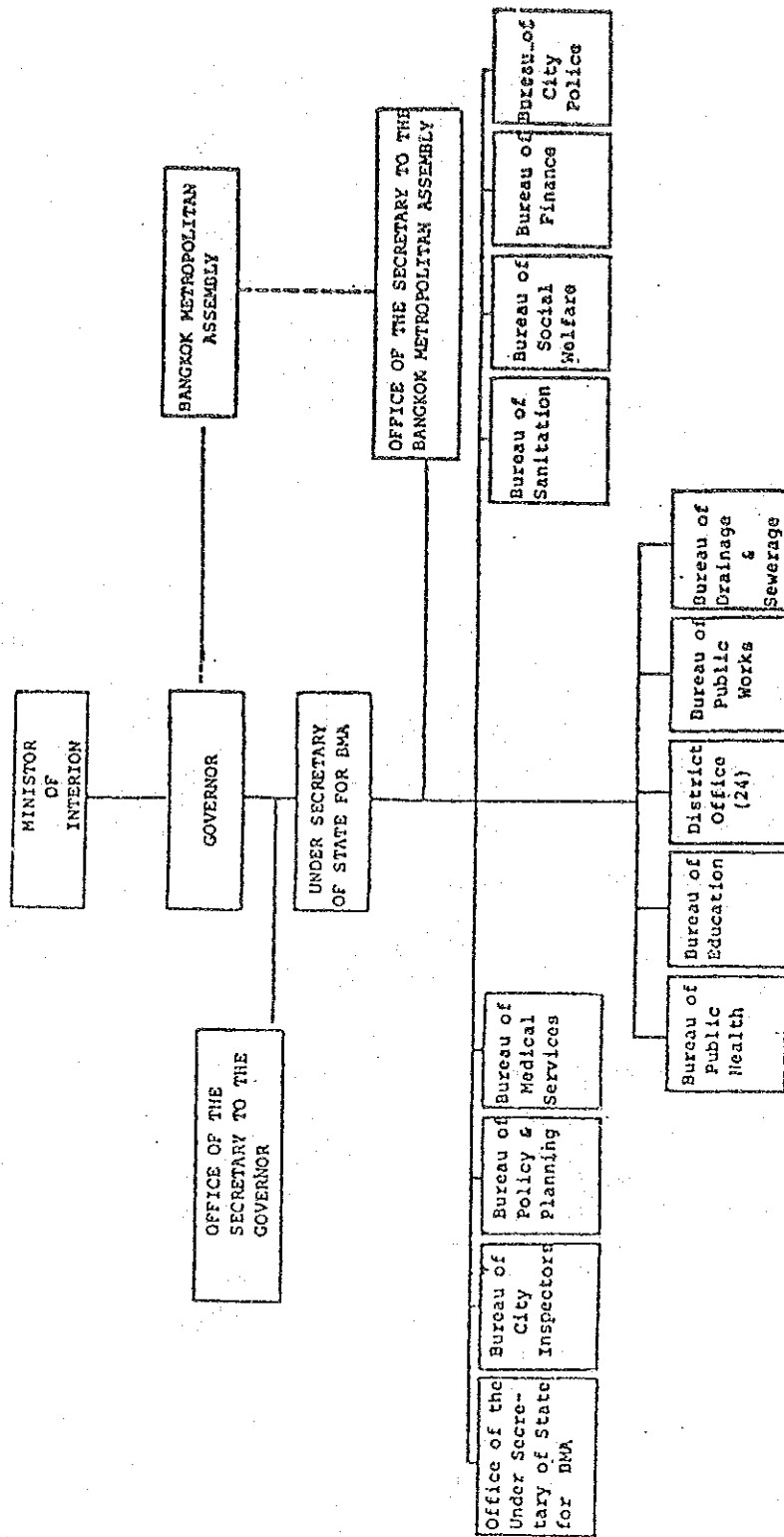


Figure A-8-4 ADMINISTRATIVE ORGANIZATION OF THE BANGKOK METROPOLITAN ADMINISTRATION

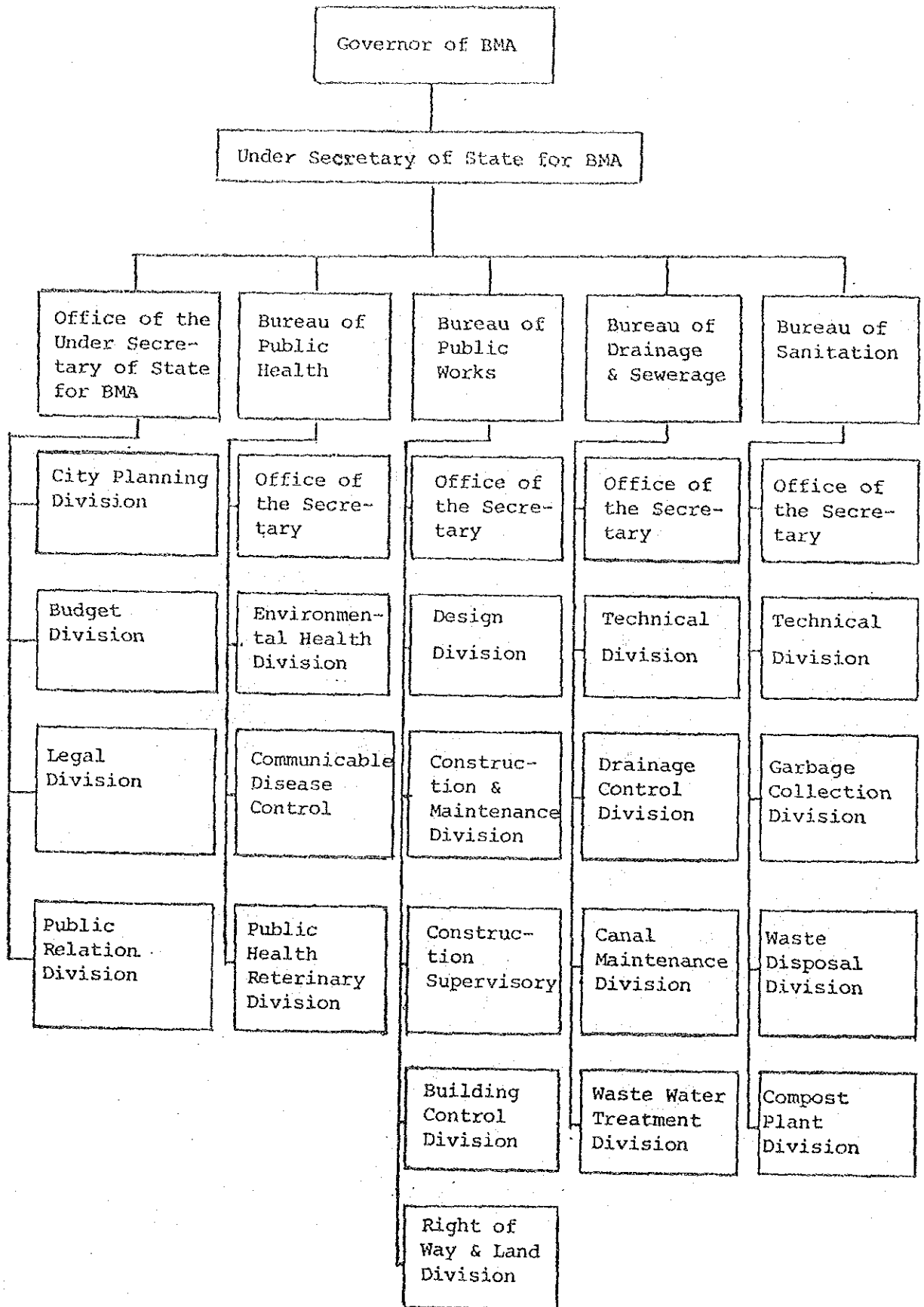


Figure A-8-5 EXTRACTION OF BMA ORGANIZATION CONCERNED TO DRAINAGE & SEWERAGE

State for BMA. Of the 13 bureaus, Bureau of Drainage and Sewerage has responsibility for the management of wastewater except industrial wastes which are controlled by Ministry of Industry. The nightsoil of septic tank sludge collection is managed by Bureau of Sanitation which also is responsible for the collection and disposal of solid wastes.

Other agencies concerned with drainage and sewerage are Bureau of Public Works which buried sewer at the time of road construction. For the road belongs to the Central Government, Department of Highway, Ministry of Communications furnished pipes for drainage.

For BMA area the construction and maintenance of trunk drains are carried out by BDS, however, branches of drainage system are taken care by district office respectively. The boundary of the responsibility of BDS and district offices is indicated in data of "Existing Drainage System".

At the time of Master Plan study, it is necessary to carry out the further investigation for the organization concerned in terms of their respective responsibility or role and activity together with manpower, finance and legislative constraint. BMA's organization is said to be changed in near future, therefore, it would be necessary to collect data of a new structure.

Legal and financial data have been collected and included in the data files. These data should be analysed for the study of Master Plan and further pursuit should be conducted, if necessary.

A-9. Chronological Records on Flooding.

The flooding records are available in BDS and have been collected as can be seen in the data files. The data indicate flood prone area and are helpful to investigate inadequate portion of existing piping system.

A-10. Sea and River Water Quality

1) Water Quality Data

To obtain available data on water quality of klongs, Chao Phya River, and groundwater, questionnaires were sent to DOI, NEB, BPH, BDS, and other institutes. Collected data and informations are as follows:

- a) Findings of Chao Phya River Water Quality Survey (1978),
(Data No. 6.2.4)
- b) DO Concentration in Chao Phya River (1979-1980)
(Data No. 4.2.1)
- c) Water Pollution Survey in Bangkok Metropolitan Area (1978)
(Data No. 6.1.1)
- d) Distribution of Heavy Metals,in Chao Phya River
Estuary (1978) (Data No. 6.1.2)
- e) Findings of Klongs Water Quality Survey (1979)
(Data No. 6.1.3)
- f) Abstracts of reports concerning to environmental technology
were also collected from Chulalongkorn University and Asian
Institute of Technology. Some of them present informations
concerning to water pollution. (Data No. 10.2 - 10.8)

Any record on long-term monitoring of water quality was not collected from any agencies visited. At present, DO monitoring of Chao Phya River is being carried out by DOI once or twice a week interval. Water quality of selected klongs in Bangkok has been monitored by BDS, but unperiodically.

While water pollution of Chao Phya River and klongs in town area has become already severe, data on water pollution are not enough to describe the present acute condition. It is therefore expected

that a comprehensive water pollution survey be made in near future,

There was no data concerning groundwater pollution in the agencies visited.

Data on sea water quality were not collected. Because, sea water pollution control study requires all sort of data concerning to pollutants' loads together with their sources which are located through the Chao Phya Basin, i.e. for wider than the Coming Study Area, and therefore it is clear that the study could not cover all those wider areas. It is also apparent the wider area comprise several municipal government areas which are beyond the reach of BMA authority.

2) Water-System Analysis

Considering water-system analysis on flow and water quality of the Chao Phya River, following materials were collected.

- a) "Chao Phya Meklong Basin Study" (RID, 1977)
(Data No. 6.2.1)
- b) "Mathematical Optomization Model-----: A Case Study of Chao Phya River (Phase I)" (NEB, 1978), (Data No. 6.2.4)
- c) "Mathematical Optomization Model-----: A Case Study of Chao Phya River (Phase II) (NEB, in progress) (This will be published by the end of June, 1980)

The model described in the Phase I study (Data No. 6.2.4) would be applicable to the study on effects of sewerage system to be proposed on the Chao Phya River, if required.

3) Aspects on Pollution Control

The Chao Phya River is a big river, about 200 m wide and about 20 m deep. of which reaches from the river mouth up to around 160 km are tidal area. The tidal flow velocity is around 1m/sec. in maximum near the Memorial Bridge. The minimum and average runoff rate of the river are approximately $75 \text{ m}^3/\text{sec.}$, and $200 \text{ m}^3/\text{sec.}$ respectively (Data No. 6.2.1).

BOD loadings generated in the lower basin from the Rama VI Bridge were estimated that about 60% of total were contributed by domestic wastewater, and remains were industrial wastes (Data No. 4.2.1). But, the amount of BOD reaching to the river was dominated by industrial wastes rather than domestics (Data No. 6.2.4), because most of domestic wastewaters are discharged through klongs which are like a anaerobic pond or a sedimentation tank, while a lot of industrial wastes are directly discharged to the river.

As the results of wastes discharge mentioned above the klongs in the town area have been heavily polluted as mentioned in Section B-3: Water Pollution, and organic pollution (i.e. DO extinction) of the Chao Phya River has been going to a catastrophic stage year by year.

The Government of Thailand has established "National Environmental Quality Act, B.E. 2518 and B.E. 2522" (Data No. 1.3.2 and 1.3.3), and established NEB promoting pollution control, especially about air pollution and water pollution.

Guidelines of water pollution control have been made by place-by-place. the Chao Phya River is one of the places put emphasis on pollution control.

NEB has an intention to require preparation of environmental impact statement (EIS) to every proposed project. For the purpose, "Manual of NEB Guideline for Preparation of Environmental Impact Evaluations" (Data No. 6.3.4) has been published. Guideline for

sewerage project is not concretely described in the material.

Ministry of Industry (MOI) directs to regulate industrial wastewater discharge to open receiving waters by means of "Allowable Trade Effluent Standard" (Data No. 1.3.8). As of 1979, only BOD loading is picked up as an item to be controlled in the first step.

A-11. Price Data Including Material, Labour and Land

The price data concerning to material, labour and land have been collected from the government agencies and included in the data files.

A-12. Water Borne Disease

Data on water borne disease were collected from Ministry of Health and Bureau of Public Health, BMA:

- a) Table of "Reported Communicable Diseases in Various Provinces, Thailand" (MOH, 1971-1977),
- b) "Epidemiological Surveillance Report, Bangkok Metropolis for 1965-1978" (BPH).

There is no report discussing relationship between water borne disease and water pollution/unhygienic condition. The collected data, however, indicate that some water borne diseases outbreak in Bangkok at intervals of several years. It may be considered that the outbreaks because to poor sanitary sewerage system.

B. Survey for Existing Conditions of Sewerage,
Drainage and Natural Water Course .

B-1. Sewerage System

The existing conditions of sewer system, sewage treatment plants and nightsoil treatment and disposal system have been surveyed. The result of the survey is described below:

1) Sewer System

The domestic, commercial industrial wastewater are collected by underground conduits and discharged to klongs or the Chao Phya River.

In major part of the urbanized area, it has been observed that the wastewater discharging from living environment is satisfactorily achieved. In some areas, however, it was seen that wastewater had come up on roads and ponded. It might be due to backing up of klong's water resulted from high tide level or clogging of pipes. The investigation of causes of those floods would be necessary.

The existing sewer system is consisted of concrete pipes, concrete box culverts and manholes installed in every 6.0 m- 30.m. The system had been constucted, with the "U" shape open channels, along with the development of the existing town area. As the town had been populated more densely, the open channel system has gradually converted to underground one which presently serves for both wastewater and storm water.

The concrete pipes of the system are of vertically casted with steel bar reinforcement at factories. The joints of the pipe are bell-and-spigot type fixed rigidly by cement mortal. Although the pipes are buried with scant earth coverages considerable parts of the sewer system are thought to be under the high ground water level. The situation which is composed the rigid pipe joint, too many manholes and the high grond water table might result in not a little amount of extraneous flows. The evaluation of existing system , therefore, would be desirable in the coming study.

2) Sewage Treatment

At present, there is no sewage treatment plant constructed by BMA. NHA, however, has constructed eight sewage treatment plants in its housing estates. Some of these plants and AIT sewage treatment plant have been

surveyed by the Survey Team and the result is described hereafter.

i) Huay Kwang Sewage Treatment Plant

The standard activated sludge method is applied for this plant together with anaerobic sludge digestion method. The flow sheet of this plant is shown in Figure B-1-1. The Capacity and design criteria of main facilities are shown in Table B-1-1. The sewerage system here is composed of principally separate and partially combined system, the plant is designed so that the six time DWF is subject to the primary treatment and the three time DWF is secondary one.

Raw sewage comprise nightsoil which have passed through the individual septic tank, sullage water and storm water.

The complete mixing system by means of surface aeration is applied for the aeration tank.

Sludges are digested by anaerobic system without heating. The digested sludges are dewatered by a mechanical process which is operated usually twice a week, and sludge cakes are disposed within NHA estate as a fertilizer for plants. The quality of treated water is observed to be in satisfactory range. It is considered that the unheated anaerobic digestion system for sludge treatment would be one of proposable alternatives in hot climate country.

It was reported that bulking of activated sludge have been occurred in this plant once or twice a year.

Table B-1-1 Capacity and Design Criteria of Main Facilities in Huay Kwang Sewage Treatment Plant

Facility Name	Number of Tank	Total Volume	Retention Time
Primary Sedimentation Tank	2	648 m ³	5.4 hours
Aeration Tand	2	580 m ³	4 hours
Final Sedimentation Tank	2	566 m ³	4.75 hours
Digestion Tank	1	900 m ³	16 days
Belt press Filter		2 sets	

Population : 25,000 persons (Design),

Dry Weather Flow : 2,850 m³/day (Design).

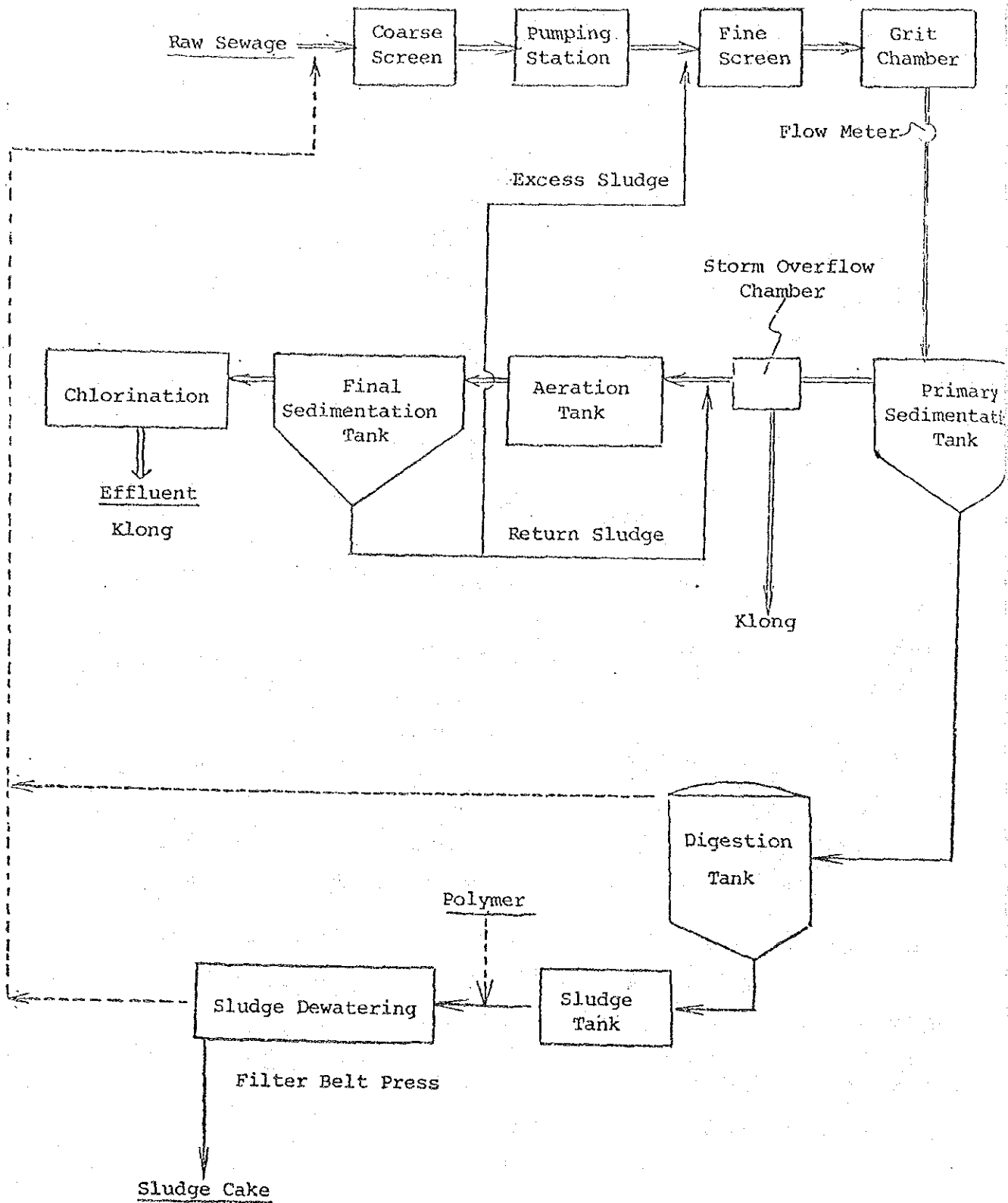


Figure B-1-1 FLOW DIAGRAM OF HUAY KWANG SEWADE TREATMENT PLANT

ii) Klong Jan Sewage Treatment Plant

The extended aeration system without the primary sedimentation tank is applied for the plant. The excess sludges are conveyed from a storage tank to sand beds directly and dried. The flow sheet of this process is shown in Figure B-1-2, the capacity and estimated design criteria are show in Table B-1-2.

It took 300 days for the construction and the plant has been operated for one and half year. During the period, the excess sludges have been extracted in every three days and poured on the sand bed, however, the removal of sludge cakes from the beds has never been carried out so far.

Table B-1-2 Capacity and Design Criteria of Main Facilities in Klong Jan Sewage Treatment Plant

Facility Name	Number of Tank	Total Volume	Retention Time (Design)	Time (Present)	Over Flow Rate (Design)	Flow Rate (Present)
Aeration Tank	2	7,560 m ³	1.5 days	2.5 days	-	-
Final Sedimentation Tank	2	544 m ³	2.7 hrs.	4.4 hrs.	20m ³ /m ² day	12m ³ /m ² day
Drying Bed	10	300 m ²	-	-	-	-

Aerator : Surface Aeration Facility 4 sets.

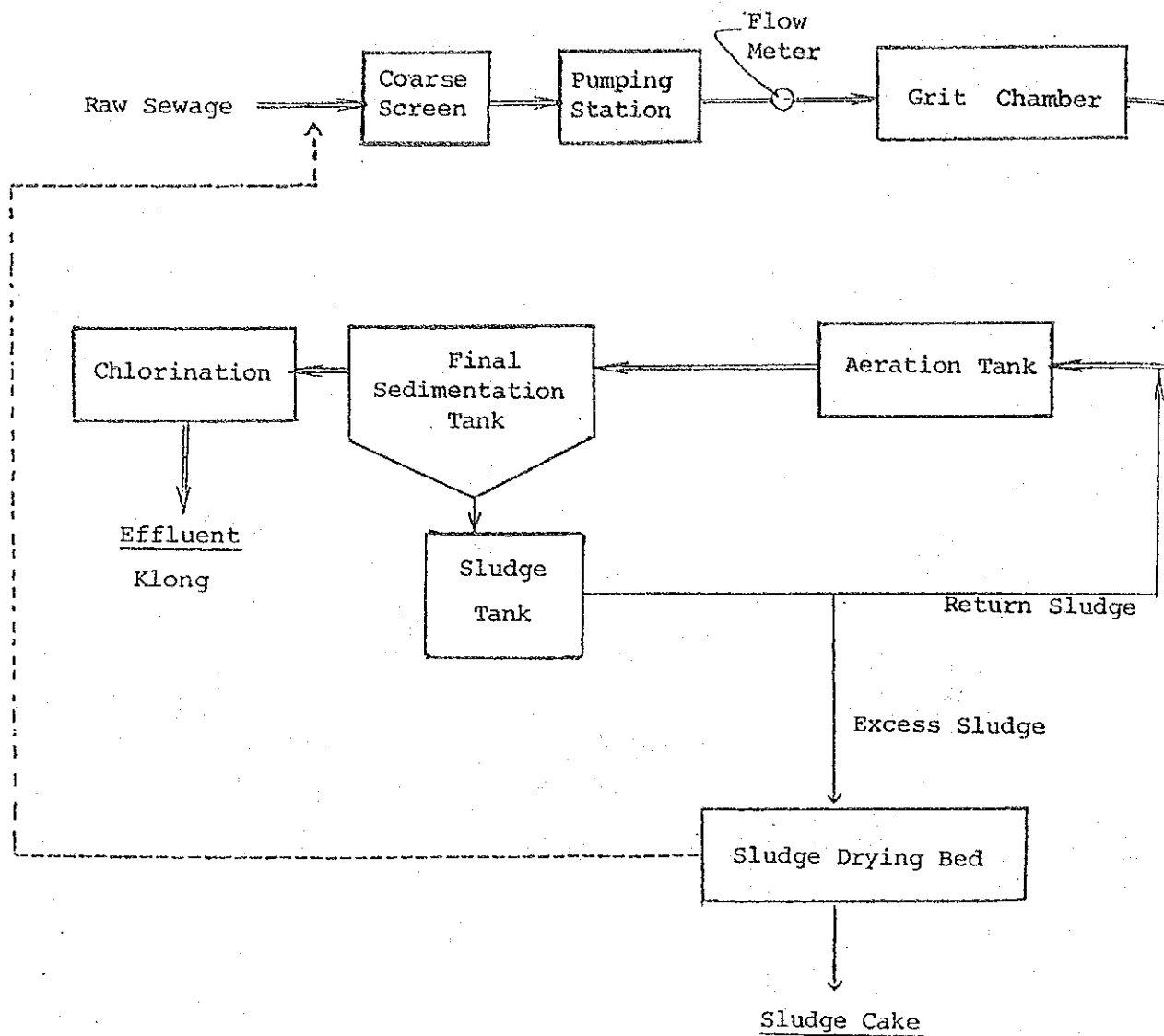
D.W.F. : (Design) 5,000 m³/day, (present) 3,000 m³/day

Estimated population : 29,000 persons

iii) Septic Tank and Other Processes

Septic tank, oxidation pond and oxidation ditch in NHA housing estates also have been surveyed.

Most houses in NHA housing estate have septic tank. Some of the NHA estates are served by communal sewerage system comprising pipe collection system and treatment plant to which effluent of the septic tank is connected. In this case, the inflow to the treatment plant is consisted of the effluent of septic tank and sullage water.



Figur B-1-2 FLOW DIAGRAM OF KLONG JAN SEWAGE TREATMENT PLANT
(EXTENDED AERATION SYSTEM)

Septic tanks are usually small size, so each building which accommodate about 100 units have numbers of tanks under the ground.

Klong Jan oxidation pond is constructed in the part of a klong in the area. The pond seems to be in good condition, but pumps are used for discharging effluents, which is considered to cause the carry-over of sediments. The outlet divide with overflow-weir would be appropriate mean for this type of pond.

Prachanives II located outside of BMA have two oxidation ditches followed by sedimentation tanks and sand beds. Presently BOD loading as inflow are still in low level compared with the design value, so only one series of the plant is operated without returning of sludge.

vi) Sewage Treatment facility in AIT.

Wastewaters discharged from the campus of AIT are treated by an oxidation pond system. The flow sheet of the system is shown in Figure B-1-3. The plant was operated successfully and no scum floating could be observed even in a facultative pond. There are many fishes (*terapia*) in the present condition of both ponds, facultative and oxidation.

3) Nightsoil Treatment and Disposal

The Nong Khaem nightsoil sludge dumping site and On Nooch Nightsoil treatment plant have been surveyed.

A description of both facilities is given below:

i) Nong Khaem

The nightsoils are dumped into a pond existed within a wide solid wastes disposal site, and covered by solid wastes later on. The overflow of nightsoils from the site is likely to happen during the rain season and klong waters nearby are jeopardized to be polluted.

ii) On Nooch

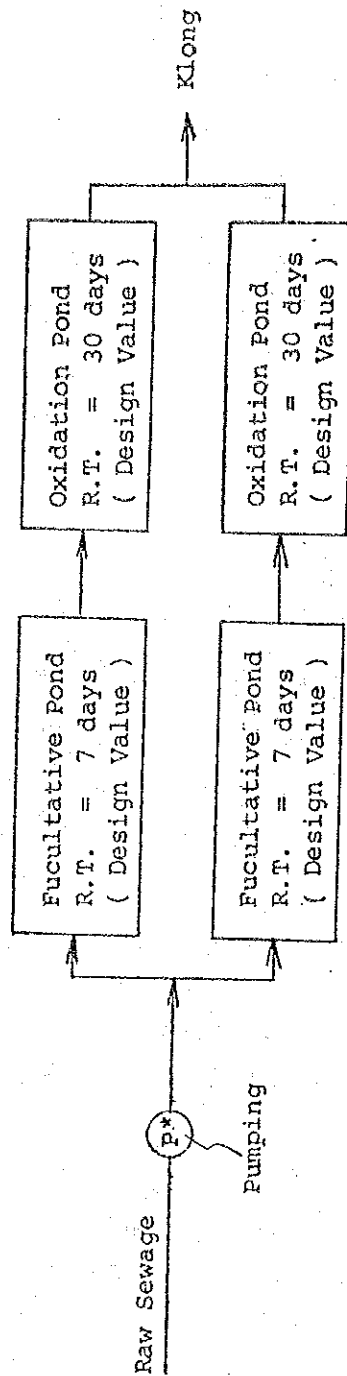


FIGURE B-1-3 FLOW DIAGRAM OF AIT SEWAGE TREATMENT PLANT

Septic tank sludge is stored in the receiving tank, and is sent to a chemical treatment process followed by the activated sludge process for secondary treatment. The capacity of the plant is 600 kl/d. With the capacity, it is possible for this plant to accommodate daily average quantity to be collected with the present nightsoil collection capacity of BOS. Flow sheet of this plant is shown in Figure B-1-4. The leachate treatment plant for the garbage dumping site in On Nooch has already been constructed and are waiting for its operation. The capacity of the plant is relatively small and the flow sheet is shown in Figure B-1-5.

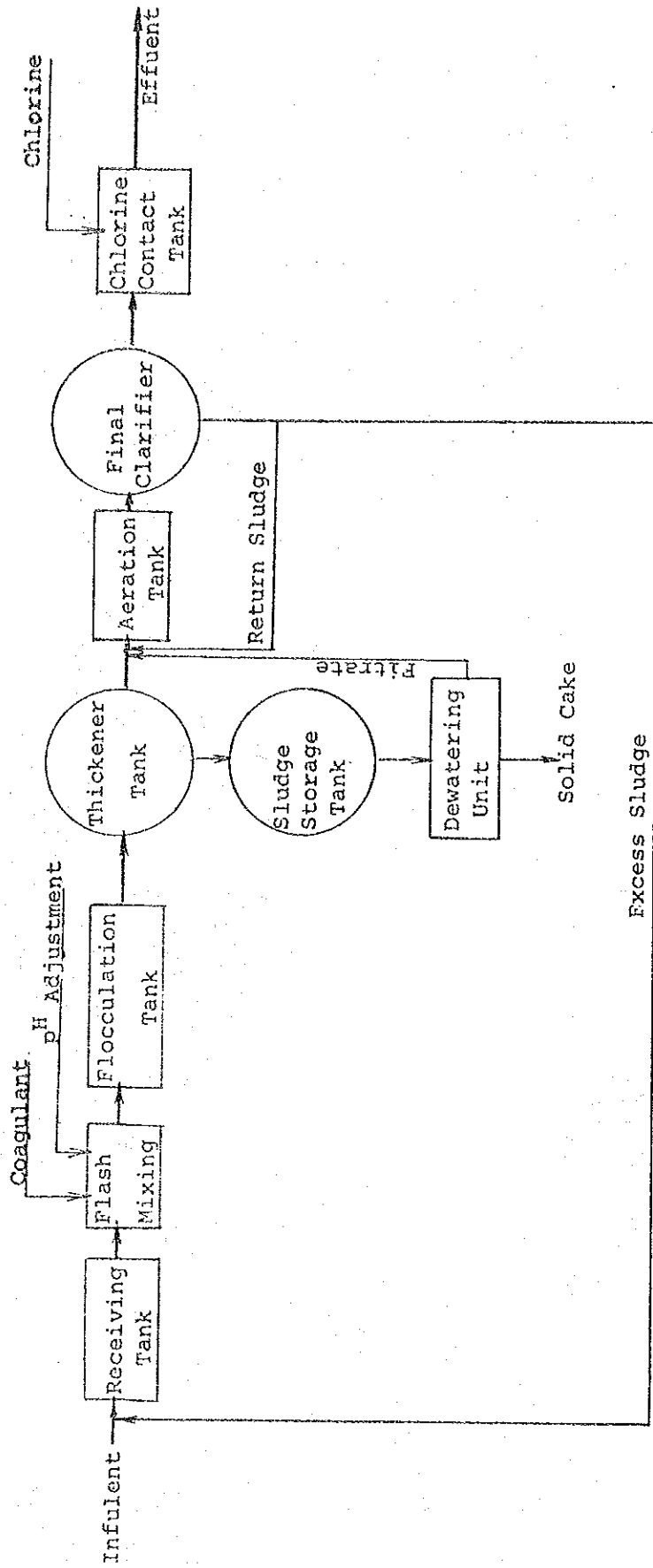
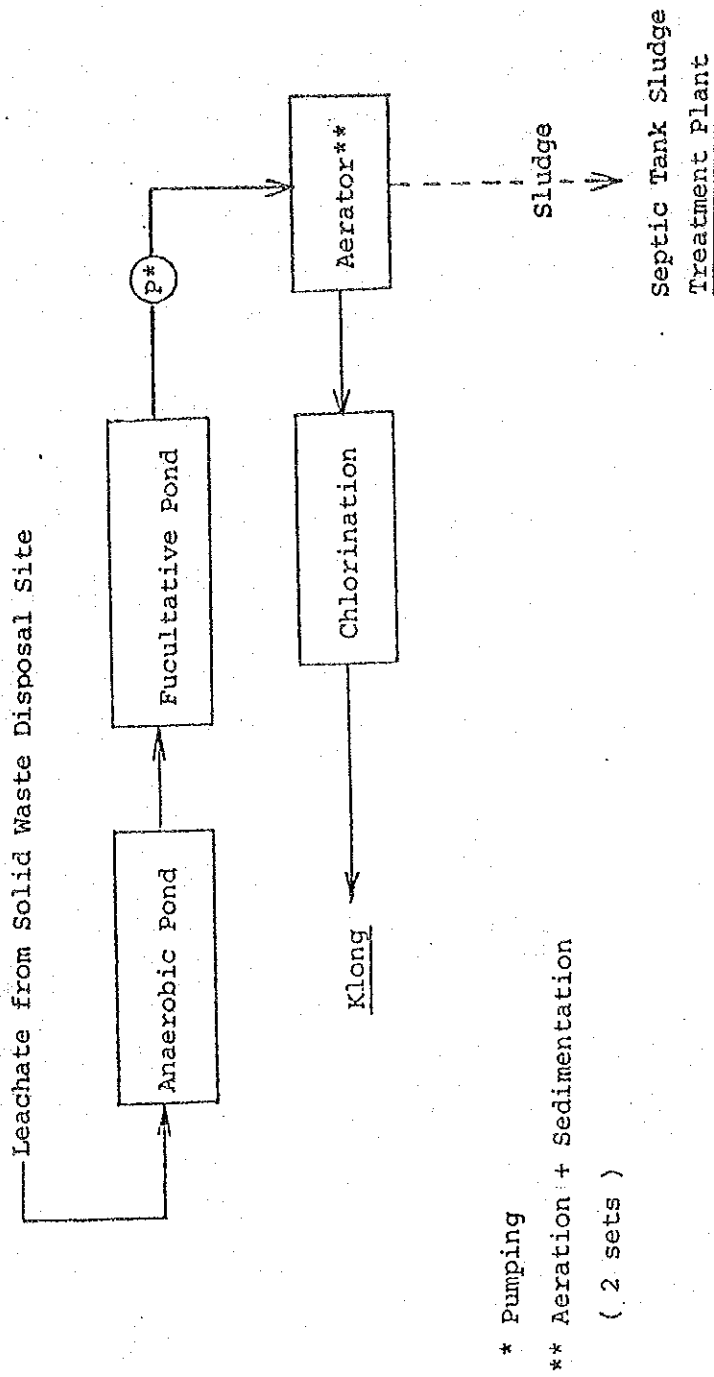


Figure B-1-4 FLOW DIAGRAM OF SEPTIC TANK SLUDGE TREATMENT PLANT

(ON NOOCH, BMA)



* Pumping

** Aeration + Sedimentation

(2 sets)

Figure B-1-5 FLOW DIAGRAM OF LEACHATE TREATMENT PLANT

B-2 Drainage System

The klongs, lined or unlined, are of various sizes of 1.0 m-30.0 m in width and receive all surface runoffs and convey them to the Chao Phya River. Because the Bangkok is low-lying and flat, the flow in klongs is effected by backing up of the Chao Phya River at the time of the hightide. Under the conditions mentioned above, almost all under ground piping systems are simultaneously influenced by back waters. During rain season, however, klongs located in central area are usually closed by existing gates or sand bags and stormwaters are drained by pumps. The flood protection and drainage project is under consideration by BMA, which will significantly improve the drainage conditions by constructing new major pumping stations and water gates as well as dredging and widening existing klongs.

The people's inherent habit of disposing of their garbages into nearby channels or underground conduits from manholes, frequently produce intorelable situations in terms of hydraulic capacity of exsiting collection and conveyance system for surface waters. The efforts to cope with this unacceptable and trouble making situations, which have conti-
nuously carried out by BMA comprise administrative and engineering components respectively. As administrative countermeasures, anti litter campaign through mass media, education and notice boards, is now carried out together with the enforcement of law concerned. BDS as responsible agency for flood protection and drainage, has been changing the manhole cover to a garbage proof type on the one hand and cleaned piping system continuously on the other hand. Although there still remains various problems, those efforts would gradually improve the drainage condition. It is considered to that the survey of existing capacity of under ground conduits are necessary for clarifying the limit beyond which those present activities could not encounter.

The survey mentioned above is also needed for establishing the sewerage improvement programme while taking into consideration the maximum absorption of existing system to the new one.

B-3. Water Pollution

Present condition of water pollution of the major klongs in Survey Area were observed through field trips in parallel with other activities.

The findings are summarised in Figures B-3-1 and B-3-2. Any chemical analysis was not carried out, therefore, the check on water pollution were made on the view of aesthetic, that is, color, odor, and floatables.

The klongs surveyed are classified to 3 categories as follows:

- 1) Closed Klong : Klongs Ong Ang, Ban Lam Poo (rainy season), Teptida, Rachaborpid, Krung Kasem, Mahanak, lower San Saep, inner Sam Sen, inner Bang Sue, inner Prem Prachakon, Sathon, Chong Nonsi, Klong Tan, Lat Prao, and Klong San.
- 2) Flushing Klongs : Klongs Lord, lower Sam Sen, lower Bang Sue, Ban Lam Poo (dry season)
- 3) Long Klong : Klongs Prakanong, upper San Saep, upper Prem Prachakon, Bang Khen, Bangkok Noi, Bangkok Yai, and Bang Pakaeo

The closed klongs are regulated in water flow by gate, dum, and/or navigation lock for flood protection, so that the klongs in this category are almost closed. As seen in Figures B-3-1 and B-3-2, the closed klongs located in town area such as Klongs Ong Ang, Mahanak, Krung Kasem, San Saep, etc, are heavily polluted through both season, rainy and dry, and have made nuisance for people living along and passing through the klongs. The nuisance are not only anaesthetics caused to a lot of floatables but also foul odor and even hydrogen sulphide in high concentration which is toxic for human body and erosive for city structures.

The flushing klongs such as Klongs Lord, lower Sam Sen, etc, are, either artificially or naturally, flushed out by the river water to follow tidal movements. Having a glance, therefore, these klongs are not severe on water pollution problem, however, on the view of pollution control for Chao Phya River, flush-out of klongs is not admirable way.

The long klongs, which are originated from out of Bangkok, such as Klongs Prakanong, upper San Saep, Bangkok Noi, etc, are comparatively

better in water quality although, in dry season, their water quality are low down by decreasing flow rate, ie. decrease of dilution and/or flush-out rate.

The water pollution of the klongs mentioned above are considered to be mainly originated to domestic wastewater including commercial wastes, and solid wastes disposed illegally. The pollutant sources both wastewater and solid wastes, could not be controlled without proper services and facilities provided by government agencies concerned.

A control-project of illegal disposal of solid wastes has been started by BOS and BDS, ie. solid waste collection service is strongly improving, while domestic wastewater disposal is remained on unchanged way, ie. no-treatment disposal into nearby klong.

Considering present water pollution problem, further development and improvement of city life, and increase of organic loads accompanying them, it seems that a system which consists of collection, treatment, and disposal facilities is required in central Bangkok area.

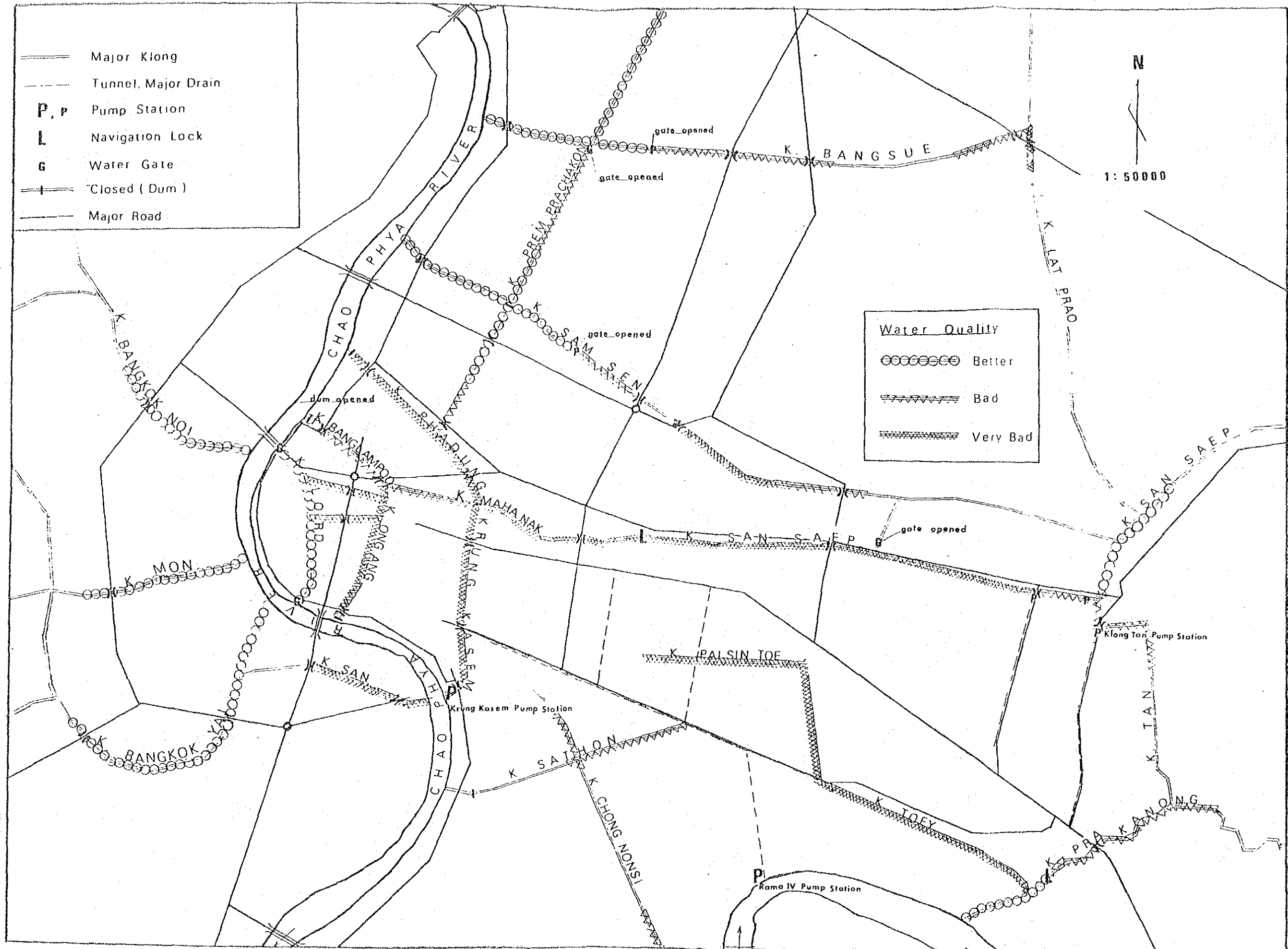


FIG. B-3-2 PRESENT CONDITION OF WATER POLLUTION
(DECEMBER, 1979 - JANUARY, 1980)

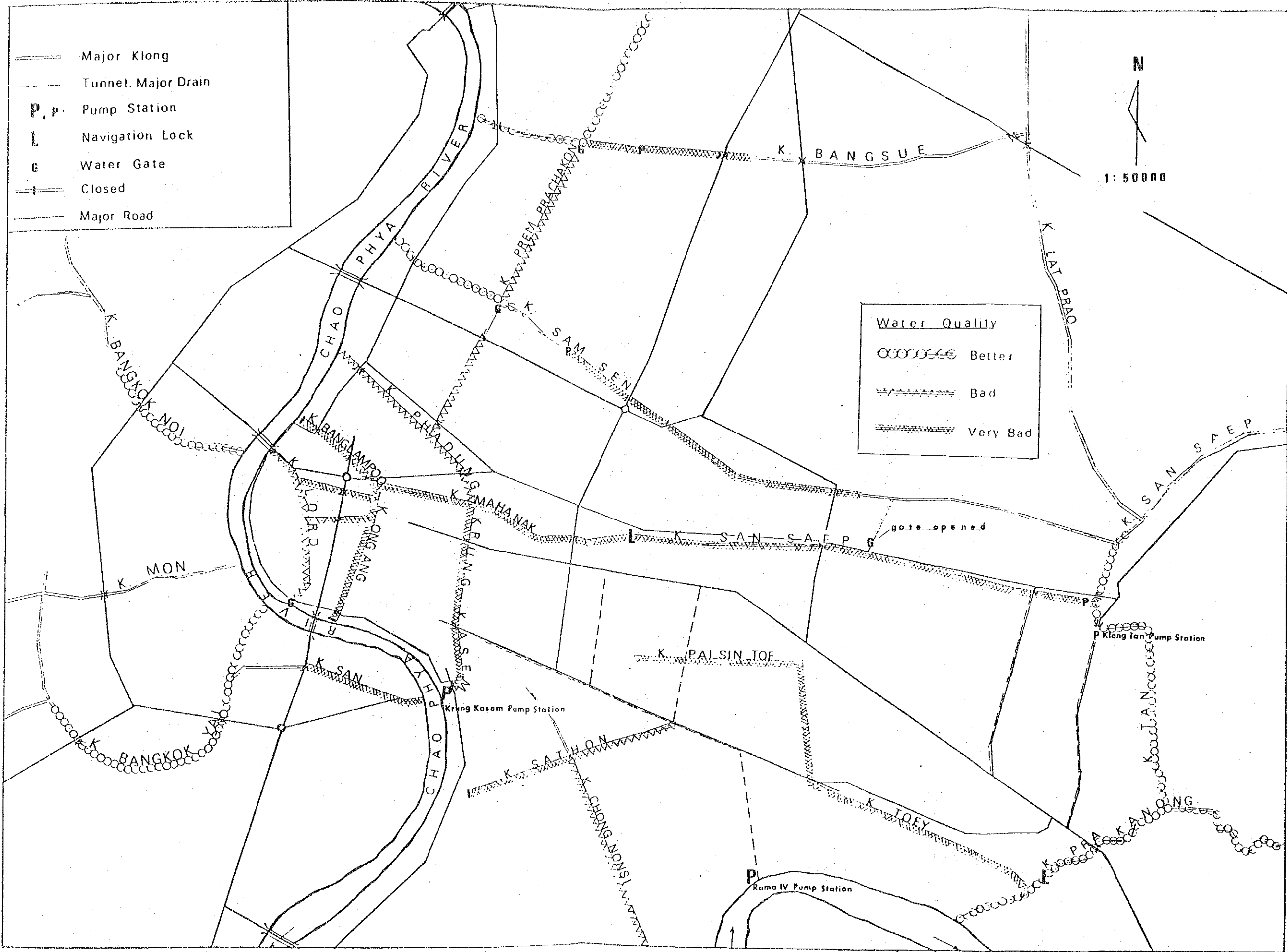


FIG. B-3-1 PRESENT CONDITION OF WATER POLLUTION (AUGUST - OCTOBER, 1979)

C. Survey for "Combined vs Separate System"
and "Zoning for Sewerage System"

C-1. Combined vs Separate System

To obtain sub-information for consideration of "Combined vs Separate System", during this survey duration, field reconnaissance was carried out in two ways; (1) observation of whole area by car, and (2) check up of the selected areas on foot, for the purpose of collecting data on existing urban characteristics where were selected on the base of typical or model land use at present.

The selected areas are as follows:

Sri Yan ----- middle income residential
Bangrak ----- commercial and residential
China Town ----- congregated commercial
Rattanakosin ----- public area
Klong Tan ----- new developing

Based on the field reconnaissance, following comments are summerized for "Combined vs Separate System":

- i) The topography of the area is low-lying and totally flat. This specific characteristics would effect substantially to the initial and running cost of the respective system, combined or separate.
- ii) It would be necessary to utilize the existing sewer system as much as possible because the system has been quite widely constructed as previously mentioned.
- iii) In built - up central parts of the city, roads are filled with all kind of vehicles and the serious traffic jam appears to be one of the biggest social problems in Bangkok. Under the roads, there are structures of utilities including water supply pipes, telephone cables

and surface water drains.

In these congested areas, if the construction of another new sewer system were attempted, inestimable inconveniences for urban activities would be expected. The public opinion in the city seems to be that these enormous obstructions would not be acceptable.

- iv) The surrounding areas with moderate population density are still open to any alternative consideration. Therefore, the study of "Combined vs Separate system" in the coming stage is expected to take into conditions of various areas.
- v) In the central areas, as spaces for the trunk sewers, klongs seem to be the only available spaces. On the other hand, the storm water drainage system has been and will be improved in accordance with "the Master Plan" (CDM, 1968) on the basis of the separate system in which klongs are used as trunk drains. It is, therefore, required for the combined system, if applied, to consider carefully the relation with the storm water drainage system.
- vi) The effect on an abatement of existing water pollution in klongs and the Chao Phya River is an essential factor to be considered in the improvement programme of the sewerage system. Whatever the system is, therefore, the applied one should be of fundamental counter measure to clean up the receiving waters.
- vii) In the combined system, wastewaters including toilet and sullage waters would be collected and conveyed together with storm waters by a single piping system. Flooding under the system would cause not only physical damages to properties and inconveniences to people but also public health problems by spreading coliform bacteria. In the case that the combined system is adopted as the new one and the majority of the existing system is incorporated in

it, it should be necessary to consider an elimination of floods from the view point of hygienics as well as physical damage. And on the basis of this new concept for flood protection, an improvement programme for the existing sewer system have to be developed.

C-2. Wet Weather Wastewater Survey

The survey is carried out to obtain the data on loadings flushed out by initial runoff of stormwater.

Klong Tan Pump Station and Ta-num Rachawong sewer outlet were selected for the survey points, which were selected by the survey team based on the following check points:

- a) To be independant from the other drainage areas,
- b) To have only one outlet drain from the area,
- c) To receive all stormwater fallen in the area,
- d) To be free from tidal water,
- e) Not to be special in land use of the area.

As of end of December, 1979, only one sampling has been carried out at Klong Tan Pump Station because of very seldom rains caused by quite short rainy season of this year.

Rainfall intensity and variation of flow rate and water quality of wet weather wastewater were measured at Klong Tan.

Rainfall intensity was measured by a rain gauge connected to automatical recorder, which was set up by the survey team near by the station.

Flow rates were calculated by means of pump-out-rates, which were computed on the bases of mean pump-capacity and running duration of the attached pumps. The mean pump-capacity was estimated by using pump-characteristic-curves and mean head. The running duration and mean head were recorded by a water level gauge set up the pump pit by the survey team.

The water samples are taken at 10 to 18 minutes interval during initial runoff, and stored in ice packed cooler and refrigerator until analysed. The chemical analysis is carried out at the laboratory of Chulalongkorn University and/or BDS for following items:

BOD ----- Biochemical Oxygen Demand
COD ----- Chemical Oxygen Demand
SS ----- Suspended Solids
Cl ----- Chloride Ions

Findings of the survey are shown in Table C-2-1.

Comments on the findings of the wet weather wastewater survey are as follow:

- 1) Background condition of Klong Tan area is developing as a commercial and residential area, which may be classified to higher middle income class. Undeveloped empty lands are still remained in the area.
- 2) As shown in Table C-2-1, initial runoff was approximately 5 times of dry weather flow during 10.5 mm. of rain for 30 minutes. This increase of flow rate means that of average running period of pump, so that, this does not reflect increase of flush-out energy in the same ratio.
- 3) Water quality of initial runoff water did not show any speciality comparing to other samples as a result of only one experience in the survey duration. Further survey should be made to get more real data.

Table C-2-1

Findings of Wastewater Survey

(at Klong Tan)

Date & Time	Flow Rate (m ³ /min.)	Water Quality (mg/l)				Remarks
		BOD	COD	SS	CL	
17 Oct. 11:17	8.8	20	-	-	129	** Fine weather
24 Oct. 11:36	7.9	43	-	107	-	** -"-
21:55	42.4	19	51	78	69	* Wet weather flow
28	23.6	23	53	61	74	* -"-
41	16.3	24	55	65	74	* -"-
53	21.6	28	69	58	69	* -"-
23.05	20.7	23	53	54	69	* -"-
17	19.9	24	63	82	69	* -"-
28	21.7	24	63	74	78	* -"-
42	18.9	23	59	60	78	* -"-
58	16.1	19	51	48	69	* -"-
24:16	12.1	21	55	74	69	* -"-
1 Nov. 10:19	8.1	33	-	85	111	** Fine weather
7 Nov. 10:15	8.1	32	73	29	83	* -"-
		30	-	-	140	** -"-

* Analysed by Chulalongkorn University

** Analysed by BDS

Note : The rain started at 21:55, 24 Oct. , and stopped around 22:50.

c-3. Dry Weather Wastewater Survey

This survey was made as one of wastewater survey to be made in the Coming Study. The wet weather wastewater survey mentioned in the Inception Report had been, in a part, changed over to a dry weather wastewater survey because the rainy season of this year was unexpectedly short so that very seldom rains were experienced by the end of year 1979.

The findings of this survey would make for field surveys to be made in the Coming Study to estimate per capita wastewater flow and loadings.

The values of per capita flows and loadings to be estimated would be different depending on living conditions, for example, residential or commercial, income level, etc. while, in Bangkok, there are numerous kinds of classes in living conditions, therefore, in the Coming Study, it is expected that some number of per capita wastewater survey would be made.

Huay Kwang Housing Estate were selected as the survey area because in the area background informations i.e. piping system, population, water supply, etc. could be more correctly obtained than in the other areas.

The outline of the estate is as follows (Data No. 3.1.10):

- Served Area : about 13 ha
- Population : 25,000 persons
- Number of Units : 3,360 units (38 buildings)
- Super Market : 1
- School : 1 (number of pupils 2,700)
- Government Offices : 3

The sewerage system is described in the Section B; Existing Conditions of Sewerage, Drainage and Natural Water Courses.

The wastewater samples were collected at the point of an inlet flow gauge of the sewage treatment plant at 2 hours interval for 2 days, 27-29 January, 1980. The flow rate were continuously recorded by the flow gauge (Parshall flume) attached to the plant.

The samples collected were stored in an ice packed cooler, and analyzed at the laboratory of Chulalongkorn University as soon as possible.

The items of analysis are as follows:

- PH
- SS
- BOD
- COD
- CL

Water temperature was measured at the sampling site every sampling time.

To obtain the background informations, a home visiting survey was carried out during the sample collection. A random sampling were made for selection of houses visited, and data on family composition, mean water consumption rate, mean monthly income, etc. were collected.

The findings of this survey are shown in Table C-3-1 - C-3-3.

Comments on the findings of the dry weather wastewater survey are shown below:

- 1) In the Huay Kwang, a portion of washing wastes are discharged to storm sewers in the cause of a habit washing and discharging at veranda attached to their houses. And the sinks of veranda are connected to storm sewers which are separated from sewage pipes.
- 2) As seen in Table C-3-1, flow peaks were not sharp. This indicates that retention volume of the sewage collection system may be large.
- 3) The minimum flow rates of daily inflow would not represent the extraneous flow of this collection system, which further consideration would be necessary to estimate it.
- 4) To estimate per capita wastewater flow and loadings from the findings, some allowance would be required for activities of market, government offices of which workers are about 150 persons in total, and of which dormitories have about 400 habitants, and a school which consists of 2768 pupils and about 120 teaching staffs.

Table C-3-1 Findings of Dry Weather Wastewater Survey at Huay Kwang Sewage Treatment Plant

Date	Time	Flow Rate l/sec	WT °C	pH	SS mg/l	BOD mg/l	COD mg/l	Cl mg/l
29 Jan. (Sun)	9:00	40	29.0	7.49	339	303	627	16
	11:00	50	30.0	7.49	213	160	360	31
	13:00	45	30.0	7.15	168	136	284	38
	15:30	40	29.5	7.58	144	123	254	36
	17:00	40	29.0	7.60	114	137	284	40
	19:00	40	29.0	7.50	160	164	341	40
	21:00	45	29.0	7.65	148	152	330	42
	23:00	41	29.0	7.80	140	136	231	36
28 Jan. (Mon)	1:00	37	29.0	7.70	71	98	191	38
	3:00	32	29.0	7.80	74	69	141	44
	5:00	32	28.0	7.80	62	68	138	42
	7:00	36	29.0	7.90	269	280	561	55
	9:00	40	29.0	7.60	208	220	428	36
	11:00	42	30.0	7.50	154	159	337	35
	13:00	40	30.0	7.55	141	126	302	31
	15:00*	38	29.0	7.40	3560*	3360*	3727*	49
	17:00	39	30.0	7.60	148	137	307	45
	19:00	40	30.0	7.65	152	157	331	42
	21:00	42	30.0	7.80	170	154	334	33
23:00	40	29.5	7.85	118	117	246	41	
29 Jan. (Tue)	1:00	37	30.0	7.80	78	103	194	36
	3:00	32	30.0	7.85	50	63	133	42
	5:00	29	29.0	7.95	68	77	162	40
	7:00	32	29.0	8.50	292	294	619	45
	9:00	40	29.0	7.80	172	165	390	38

* Excess sludge was mixed from 14:00 to 15:00.

Table C-3-2 Findings of Home Visiting Survey in Huay Kwang Housing Estate
(Household Population and Monthly Income)

Flat No.	Surveyed				Monthly Income	
		Units	Persons	Persons/Unit	Bahts/Month.Unit	Bahts/Month.Capita
5	20	108	5.40	4635	858	
7	8	50	6.25	3363	538	
12	21	123	5.86	3824	653	
13	21	142	6.76	4367	646	
22	20	145	7.25	3470	479	
26	23	119	5.17	2665	515	
31	6	41	6.83	3783	554	
34	21	104	4.95	3476	702	
	140	832	5.94	3700	623	

Date : 1980.1.28

Table C-3-3 Findings of Home Visiting Survey in Huay Kwang Housing Estate
 (Water Expenditure and Water Consumption)

Flat No.	Surveyed	Water Expenditure			Water Consumption		
		Units	Persons	Bahts/Month.Unit	Bahts/Month.Capita	M ³ /Month.Unit	l/d.c
5	-	-	-	-	-	-	-
7	6	39	44.0	6.77	28.8	148	
12	16	102	45.7	7.16	36.0	188	
13	18	127	47.7	6.75	41.0	193	
22	13	80	37.4	6.08	33.1	179	
26	2	7	22.8	6.50	25.3	240	
31	-	-	-	-	-	-	-
34	2	7	18.3	5.21	15.8	150	
57		362	42.2	6.64	35.1	184	

Date : 1980.1.28

C - 4 Zoning for Sewerage System

As a conceptual idea for the sewerage system in Bangkok, to separate the considered area into some sewerage districts, has been suggested by both sides, Thai and Japan. It is, therefore, included in the scope of work in this preliminary survey to collect data required for the zoning study.

As basic data, following were collected.

- I) Population distribution
(see Section A., II-2)
- II) Land use
(see Section A., II-2)
- III) Drainage Master Plan and existing layout of klongs.
(see Section A., II-2)
- IV) Proposable treatment plant sites

Proposable treatment plant sites were picked up after looking for the open land spaces on topographical map and aerial photograph, discussions with counterparts about availability and visiting the marked points for observing general conditions in and around there.

In Table C-4-1 proposable treatment plant sites are shown. The every site selected is located near klongs or the Chao Phya River so as to be convenient for effluent discharge. The area (in ha) mentioned in the table, is approximate figure which was measured on the aerial photograph (as of 1974). These information should be considered as the first approach to the theme. In the coming study, therefore, an elaborate survey of their location, area and necessary number, should be carried out in parallel with the study of zoning. Wide fruit gardens lie in the outside of BMA. Those areas are in the zone along the klong Bang Ken of Nontaburi (about 100 ha), Northeast part of the Prapadean City (about 500 ha) and Northeast portion of the Prapadean City (about 1,000 ha), these areas could be considered as supplemental ones to those mentioned in the table.

On the basic of these data, zoning for sewerage system would be discussed through comparative study of various alternatives.

Table C-4-1 Proposable Treatment Plant Sites

Location of the land	Area (ha)	Present Condition	Land Owner	Receiving Stream
<u>A. Central area</u>				
1. The mouth of Klong Bang Lan Poo	2	Landing stage Housing area	Royalty 0.2 ha Private 2 "	Chao Phya River
2. The pond of Makassan	20	Pond	Royal Railway	Klong Sam Sen
3. Huay Kwang	100	Rice field	Private	Klong Sam Sen
4. The pond of Tobacco-monopory	20	pond	Tobacco monopoly	Klong toey
5. The space of Port Authority	50	Waste land	Port Authority	Klong Pra Kanong or Chao Phya River
6. The mouth of Klong Chog Nonsi	130	Fruit garden outside of the road inside of the road	BMA. - 5 ha Private - 25 " Private -100 "	Chao Phya River
<u>B. Tonburi area</u>				
7. Bang Prad	4.5	Fruit garden	Private	Chao Phya River
8. Phetcha Kasem	11	Fruit garden	Private	Klong Bangkok Yai
9. Raja Burana	30	Fruit garden	Private	Klong Bang Boon or Chao Phya River

to be continued

Proposable Treatment Plant Sites (continued)

Location of the land	Area (Ha)	Present Condition	Landowner	Receiving Stream
<u>C. Surrounding area</u>				
10. Soi Lat Phrao 28	6	Waste land including some house	Private	Klong Bang Sue
11. The land along the Klong Bang Khen	30	Fruit garden	Private	Klong Bang Khen
12. The land along the Klong Lat Phrao	200	Fruit garden	Private	Klong Lat Phrao
13. The land along Soi Suan Luang	200	Vegetable garden, including owners' house	Private	Klong Tan or Klong Pra Kanong
14. Bang Na	45	Rice field and Waste Land	NHA?	Klong Bang Na

* Area is depended on the photomap (s=1:5,000) in 1974

D. Survey for Treatment Methods of Wastewater and Sludge.

What kind of treatment method or methods would be engineeringly and economically feasible and applicable for Bangkok ? This is one of the substantial components to be studied in the coming study (Master Plan).

In the Preliminary Engineering Survey, it has been intended to collect fundamental data and informations as the basis of the study.

D-1 Collection of Data Available

Seeking data and informations on treatment technology, the Survey Team visited two notable institutions in the data collection. The helpfull cooperation was presented from two institutions, which enabled the team to gather quite, an amount of experimental study reports.

Titles and summary of researches for environmental technology were collected.

- i) AIT
 - * Title of Research (1967 - 1979)
Division of Environmental Engineering (Master Course Theses)
 - * Research Summary (1969 - 1978)
Division of Environmental Engineering
- ii) Chulalongkorn University
 - * Research Topics of the Institute of Environmental Research
(1975 - 1978)

After reviewing titles and summaries of about 300 study reports, it was understood that 70 reports of them were the data related to wastewater treatment. These data can be classified into 4 categories; three for wastewater treatment and one for sludge, as follows:

Wastewater Treatment

- i) Lagoon processes including anaerobic pond, facultative pond, oxidation pond and aerated lagoon.
- ii) Other suspended processes including activated sludge process, pure oxygen system and oxidation ditch.
- iii) Bio-film processes including trickling filter and rotating biological contactor..

Sludge Treatment

iv) Anaerobic Digestion, and Sludge Dewatering.

Summaries of the 70 reports have been read and investigated whether they contained substances which would be useful for practical plan and design. Finally 16 of the 70 reports have been selected. Six of them are domestic wastewater treatment and two, sand beds and eight, comparison of treatment methods. The copies of these reports have been prepared. The title of those reports are shown below.

i) Reports related with domestic waste treatment.

1. Factors affecting algal yields from high-rate oxidation ponds treating sewage (1970)
2. Effects of COD loading and detention time on anaerobic pond performance (1971)
3. Anaerobic and facultative ponds for tropical waste treatment (1974)
4. Optimization sewage treatment and fish propagation in ponds. (1976)
5. Effects of some operating variables on biological filtration of domestic wastewater in the tropics (1974)
6. Substrate and nitrogen conversion in rotating biological filters (1974)

ii) Reports related with sludge treatment

1. Pricipal factors affecting sludge drying on sand beds (1968)
2. Effects of the Bangkok climate on sludge dewatering (1968)

iii) Other reports related with waste treatment.

1. A study of high-rate aerobic stabilization pond. (1968)
2. Effect of detention time on aerobic stabilization pond performance in Southeast Asia (1968)
3. General reviwie of oxidation ponds and oxidation ditches (1974)
4. Performance of rotation drum filter in treatment of wastewater in the tropics (1975)
5. Performance of oxidation ditches in Thailand (1975)

6. Comparison of activated sludge, trickling filter and anaerobic contact processes (1976)
7. Aerobic treatment of liquid wastes from the fruit processing industry (1976)
8. Rapid estimation of waste treatment (1978)

D-2. Interview to Experts in Thailand

The philosophy or conceptual idea of experts in Thailand who have been engaged in the fields of water pollution control, wastewater treatment, and sludge disposal, have been inquired by means of interview to them. The interview has been made to leading institutions and government agencies concerned, including AIT, Chulalongkorn University and Mahidol University in association with the recommendation of BDS.

The experts met by the survey team are; (in the order of interview)

* Assist. Prof. Suvit Shommumsirivath

Department of Sanitary Engineering, Faculty of Public Health,
Mahidol University.

* Prof. Sudchai Champa

Department of Sanitary Engineering, Faculty of Engineering,
Chulalongkorn University.

* Assist. Prof. Samorn Muttamara

Environmental Engineering Division,
Asian Institute of Technology.

*

The philosophy of the experts are as follows:

- 1) Present Problems derived from Existing Wastewater Disposal Practices and the Necessity of Improvement

* Bangkok citizens have used septic tank with percolation system

for disposing of nightsoil. This system, however, doesn't work properly because of subsoil condition of clay and high ground water table which has recently become even higher due to ground settlement. In practical, the percolation can not be done and effluents of septic tank, in almost cases, are discharged to nearest public sewers or water sources by connecting tanks with pipes to them directly.

- * Septic tank is expected to decrease some pathogenic organism if sufficient retention time is provided. However, in Bangkok it is usual that the volume of tank is inadequate and the retention time is insufficient as a result, the function of the tank is just a pit through which nightsoil passes to somewhere. In this context, the inspection and control of the responsible government agencies should be more strict.
- * There are cholera incidents in summer season in Bangkok region especially in the area along the Chao Phya River in which population density is high with mainly workers for industry. Origin of cholera organism is not clear.
- * In May 1979, the Chao Phya River was seriously polluted until the water color became black due to organic matter, therefore water pollution abatement in the river is urgently needed.

2. Sewage Treatment Method

- * The sewage treatment method suitable here should be selected with the consideration of; 1) Who will have responsibility for operation and maintenance, 2) How much expenditure is requested for O & M, 3) What kind of expertise is required for O & M. From the view of physical sense for Bangkok Metropolis which is large, congested and less availability of land spaces for the sewage treatment plant, how can you avoid the use of Activated Sludge Process? The process has been applied in many developed countries

and compiled much experiences until it achieved successful consequences. The new technology with less experiences should be careful to be applied here.

- * Domestic sewage, compared with industrial waste, is easily treated, accordingly many kinds of treatment method could be applied in the pure sense of treatment technology.

- * If land space is available, pond system is desirable as the treatment method. However, available land can't be found in the central area of Bangkok.

- * Training of operator is needed if Activated Sludge system is applied.

3) Sludge Treatment and Disposal

- * Digestion

Depend on the availability of land either anaerobic or aerobic digestion method can be applied. Both have their merits and demerits, for example, in case of anaerobic the gass yield from the process could be used as the part of energy required for the plant, however the process needs wider space than aerobic one.

- * Dewatering

Sand bed is acceptable as a method of dewatering. However, the use of mechanical dewatering process can not be avoided in the practical phase in Bangkok due to the land problem.

- * Disposal

It is advisable to use the sludge for a fertilizer, however, it should kept in mind that there are problems such as transportation of the sludge.

4) Other

* How to collect wastewaters is more difficult problem than how to treat them. Most of existing pipes are not proper because of the insufficient slope of them.

As an alternative it could be possible to consider to use some parts of klongs for the collection and treatment of wastewaters.

* The policy which moves existing factories of relatively small scale and located in the central part of Bangkok should be considered for the purpose of avoiding troubles expected at the time of sewage treatment.

* If the construction of the new system is considered for the central area of Bangkok, problems including obstruction to traffic and high construction cost, will be occurred.

III. Data Requiring Further Augmentation

As a result of the Preliminary Engineering Survey, it was found that some fundamental data were presently inadequate or totally lacking. The data should be augmented or newly collected in the coming study under the cooperated works of Thai government agencies concerned and Japanese Mission.

The data underlined are described below.

1. Data on Water Pollution

Since May, 1979, BDS established a laboratory in the bureau and started field surveys and chemical analysis for various waters including klongs' water, leachate from solid wastes disposal sites.

The data on existing water quality obtained by systematical and comprehensive surveys are one of the most important and basic information for wastewater management, ie, sewerage system planning.

It is recommended that monitoring survey on klong water pollution be systematically made in various seasons, in each of which BDS annually re-arranges drainage facilities to make them the most functionable for discharging inland waters.

As an example, a survey plan for major klongs located in the Study Area to be proposed has been made by the survey team and submitted to BDS as a memorandum, which includes sampling points, frequency and ways of sampling, and items to be analysed and recorded.

2. Data on Industrial Wastewater

Some kinds of industrial wastewater, sometimes, make unanticipated influences to sewerage system, i.e. to sewers and treatment plants.

To make good management of sewerage system and measures for preventing the unanticipated influences, following data and informations should be filed in the BDS library :

- a) The list of big water consumers including trades together with location, consumption volume, and their sources.
- b) Effluent quality discharged from selected industries, such as food processing, brewery, electric plating, dyeing, chemicals, etc. together with location and effluent volume.
- c) Existing and/or planned facilities for waste treatment of the selected industries together with outline of the facilities, and

operational data including personnel and O & M costs.

3. Data on Nightsoil Collection & Disposal

"Septic tank system" with flush toilet and percolation tank is applied to most of toilet in Bangkok. Once or twice a year, desludging are usually required for maintenance of the system, for which services are carried out by BOS or private firms. Data and information for the activities of the private firms are very limited because they are out of control of any government agency.

They say a large number of septic tanks are connected to drainage sewers for discharging the effluent. Actual data of connection and its influences to hygienic condition are necessary to be evaluated for applying proper measures for wastewater management.

Collection of following data and information is expected:

- 1) List of large volume septic tanks together with their location, volume and structure.
- 2) Data on function of existing percolation tanks
- 3) Data on activities of private firms for desludging
 - a) Number of the firms together with vehicles
 - b) Collection volume
 - c) Place and methods of sludge disposal
- 4) Data on water pollution
 - a) Coliforms in surface and groundwater
 - b) Effluent BOD of septic tank

4. Dry Weather Wastewater Quantity and Characteristics.

Few data are available for the estimation of quantity and characteristics of dry weather flow. The survey team itself has carried out the sampling for dry weather and wet weather wastewater. However, with all those data, it is considered to be inadequate for the estimation of present wastewater quantity and characteristics. In the coming study the further data have to be collected through field sampling or any other measures.

5. Ground Survey

Data concerning to ground elevation and other physical structures related to the sewerage system planning are presently inadequate. In the

coming study it is necessary to carry out ground survey to some extent in association with the necessity of informations for the study.

6. Conditions of Existing Underground Sewer System.

Existing sewer system furnished in almost entire urbanized area, should be surveyed in terms of general condition and invert elevation in the critical points required for the design of a new system. The fitness for integration of existing facilities to the new system, should be evaluated.

7. Map in which Proposed Sewerage System is drawn.

Map with considerably large scale, in which proposed sewerage system would be drawn is presently unavailable. The preparation of the map is necessary for the coming study as well as the project implementation itself.

IV Transfer of Knowledge to Counterparts

Since the initiation of the survey, the Japanese Survey Team and Thai counterparts have worked together. Through the series of activities for data collection, explanations and discussions on the object or necessity of each required information, have been carried out.

In addition to the discussions related to actual survey works, the explanations on existing situations together with problems of the sewerage system in Osaka City which functions comprehensively for flood protection, drainage and sewerage treatment, were presented. The sewer user charge system Osaka City, also outlined and the description named with "Sewer User Charge System in Osaka City" was handed over to BDS.

The laboratory of BDS was established only several months ago. Considering the stage of the BDS laboratory, a part of laboratory works concerning to sewerage management was discussed among the survey team members, counterparts and BDS laboratory technicians on every chance encountered. The subject of discussions includes field survey planning, improvement of analytical technic, and data accumulation as a library.

The establishment of a library was planned by BDS and the Japanese Survey team promised to cooperate for the plan. The collected data was screened and copied in order to be reserved in the library.

In accordance with request of BDS, a meeting was held among survey team members, counterparts, and laboratory technicians, of which subjects were general concepts of wastewater survey, and an example of klongs' water survey plan for Bangkok.

As a practical field survey following the meeting, a dry weather wastewater survey was planned and conducted by the survey team, and carried out by BDS staffs at Huay Kwang Sewage Treatment Plant.

v. Recommendation of the Scope of Work
for the Master Plan Study

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1. Introduction

Bangkok with the population of 4.8 millions, one of the largest city in Southeast Asia and it still is growing by 4 per cent yearly in its population. In this Metropolis there is no sewerage system which properly disposes of wastewaters generated from million of population and numerous factories. As the result, the public health and water pollution problems have become serious. It is apparent that as the Metropolis is further urbanizing and industrializing, the problems would even more be deteriorated. In order to improve the existing intorelable situation as well as to meet further requirement, the comprehensive sewerage programme is needed to be prepared at this crucial time.

Since two decades ago the study for an improvement of wastewater management has already been carried out and four reports submitted to BMA. Of those plans, only a part of the newest one (prepared by CDM) has been implemented so far for the improvement of flood protection and drainage. BMA intends to proceed the drainage project in accordance with the plan mentioned above. The sewerage system plan is also included in the CDM plan, however, intorelable obstructions to be imposed to traffic and city life by the construction works of the proposed separate system and enormous capital costs required for the implementation makes it unacceptalbe to carry out the project for BMA.

Therefore, the review of sewerage project and the preparation of the master plan has been called for. It should be kept in mind this is the sixth attempt in seeking for suitable measures of wastewater management for the Metropolis. The new plan will apparently be requested to be reflected by the lesson learned from the previous attempts and their consequences.

The Government is now conducting number of projects including water supply, roads, various public buildings and telephone whcih are imminent for the Metropolis. It is also pointed out that the city is served with inadequate stormwater drainage system and suffered by frequent floods during annual rain season. The Government is now planning to start the project of " Flood Mitigation and Drainage " based on the CDM plan, which is considered to have higher priority for the city than the sewerage.

It is unlikely for the Government to embark on any large scale program to remedy environmental problems unless the program is justified to be beneficial in social and economical aspects. It is, therefore, necessary for the new program to take into consideration the social and economical requirements for the project. In addition to that the scale of the project and strategy to be applied are of in the balance with other social investments and of flexible one by which the Government could improve situation gradually and properly.

As the first step, the Preliminary Engineering Survey has been carried out for collecting available data and surveying existing general conditions in Bangkok. Data and informations collected as well as finding are accumulated in the Preliminary Engineering Survey Report.

2. Study Area & Target Year for Planning

2.1 Target Year for Planning

The Target year of the sewerage planning is set to year of 2000, with due consideration on other projects of infrastructures including drainage, flood protection and water supply system. The Master plan has to be prepared to meet the requirement around the year.

2.2 Study Area for Planning

The study Area is the central part of Bangkok Metropolis. The area comprises densely built-up area and its fringe untill where developments are expected to reach in the foreseeable future. The area is about 370 km² and shown in the map attached.

3. Survey of Existing Conditions

As the basic requirement for the Planning existing conditions of various aspects in the Study Area should be surveyed and investigated.

Following articles will be covered:

3.1 Topography and Geology

The Study Area lies in the lower deltaic area of the Chao Phya River. The area is low and extremely flat terrain. The data of ground elevation are not available. Although it is flat area, the ground elevation survey will be requested to some extent in order to find the minimum elevation to be used for the planning.

Geological data are available and included in the collected data file. Investigation of those informations is necessary.

3-2. Population and Land Use

The present population together with its distribution be investigated on the basis of the collected data and additional survey if necessary. The same request is attached to land use to the area.

3-3. Evaluation of Existing Wastewater Disposal Practices

The urbanized parts are furnished with underground drains for removing sullages and storm waters from the living environment. The drains are of concrete pipes with rigid connection of cement mortar and connected with manholes installed in every 6.0 m - 30.0 m.

The existing pipes are principally designed to conduct storm waters and the part of piping system may be insufficient for keeping self cleaning velocity.

Whatever the system would be proposed, it is necessary to consider the integration of the existing pipes to the new system as much as possible with due evaluation for them. Items to be evaluated are house connection practice, pipe materials and strength, the method of connection together with resulted extraneous flow, the structured of manhole as well as its cover, and others.

The existing toilet system should also be investigated for making proper recommendations how to connect them to the new system. At the same time, the discussions for the improvement of present septic tank system might become necessary depending upon the measures to be applied for the Study Area.

The operation and maintenance practice together with organization have to be investigated, too.

3-4. Environmental Water Pollution

Environmental water pollution control is one of the greatest purposes of sewerage system construction.

As mentioned previously (Section B-3), klongs in Bangkok town area have been heavily polluted, and its improvement are strongly expected. For the pollution control, Chao Phya River has been studied under the NEB's promotion since establishment of NEB in 1975. On the other hand, klongs' water quality survey was just started for the selected klongs by BDS in 1979.

To look over, comprehensively, environmental water pollution a field survey should be systematically made on the klongs located in the Study Area.

4. Future situation set for the Study Area

4-1. Population & Land Use

Future population to be used for the plan should be projected on the basis of collected data. The projected population should be adjusted with the existing other plans including the water supply master plan or any.

Future land use should also be investigated as the basic data for the planning.

4-2. Drainage System to be expected in the Future.

The drainage system envisaged for the future which has direct relation with the sewerage plan is required to be taken into consideration. The drainage system will be improved in accordance with the " Master Plan for Drainage and Flood Protection " prepared by CDM. The implementation schedule for the system is necessary to be learned from BMA.

4-3. Water Supply

" A Review of the Bangkok Water Supply Improvement - Phase 2 Project " was prepared by MWWA in 1977. The report is the review of the "Master Plan" prepared by CDM in 1970. The water supply plan in these two reports is considered to be essential for the wastewater management planning.

4-4. Transportation, Electric Power and Telephone

The plans of these infrastructures are needed to be learned for the sewerage system planning in order to get idea of future situation of the city and to avoid competition for land spaces with other utility plans.

5. Wastewater Quantity and Characteristics

For estimation of design wastewater quantity, peaking factor and loadings, following studies and surveys would be required :

1) Domestic Wastewater

Quantity and characteristics of domestic wastewater should be estimated by means of considering water supply plan, field survey data on actual wastewater generation and so on.

For water supply improvement plan in Bangkok, MWWA has established Water Supply Master Plan (prepared by CDM, 1970) and its Review (1977), of which reports have been collected (Data No.2.3.1 and 2.3.2).

Per capita wastewater productions were estimated more than 10 years ago by CDM and others (see Sec. A-3). Therefore, these per capita values should be re-studied.

To obtain data on present per capita wastewater production (flow and loadings), it is recommended that field surveys be made at typical areas such as residential, commercial, etc. by using existing piping systems. Further, it is expected that data on extraneous flow into the existing pipes are also obtained from the surveys.

2) Industrial Wastewater

In the Study Area recommended, as mentioned previously (Sec. A-3), there is no industrial estate. It is, however, expected to check quantity and characteristics of wastewaters discharge from factories scattered in the Study Area.

If necessary, water supply records for individuals could be collected from MWWA, and/or questionnaire survey on trade waste would be made.

It is also expected that effluent standards to be discharged into the sewers to be proposed be considered if necessary.

3) Extraneous Waters

Flow rate of extraneous waters should be studied on existing pipes.

6. Estimation of Future Water Quality in the Chao Phya River due to Wastewater Disposal System

Since 1975, water pollution control of Chao Phya River is one of major subjects of NEB, and the Study including computer analysis of river pollution is being carried out by government agencies concerned. At present, the Phase I report on mathematical analysis of water pollution had been published, and the Phase II Report will be published by June, 1980. The mathematical model of Chao Phya River covers quite wide area along the river comparing with the Bangkok town area to be studied in the sewerage Master Plan. It is expected that the consideration of the effects mentioned above will be made on the base of the NEB's model.

7. Strategy for Wastewater Management

7-1. Long-range, Short-range and Interim Measures

The Study Area comprises built-up central core portion and surrounding areas which have partly been developed or are being developed. Because there is no comprehensive town or regional planning, the developments are of sprawl or ribbon developments. With the form mentioned above, the urban area is being expanded by a influx of population. The strategy to deal with variety of requirements should include following concepts;

Strategy proposed be of comprehensive on which includes a long-range perspective together with short-range proper steps.

It seems to be unrealistic to consider that the entire Study Area would be served with the public sewerage system by the final year of design period, year 200. Therefore, it is necessary to consider interim measures for the areas for which immediate action is required or the construction of public sewerage system cannot be expected for a time being. Alternatives as recommendable measures include an individual house or property treatment system such as improved septic tank system or other suitable methods and remedial means which eventually are converted or connected to the central public sewerage system.

Recommendable alternatives have to be studied in comparative manner involving engineering and economical aspects.

The Study Area can be zoned in association with and unique local requirement, topographical and other physical conditions of the area, the drainage system proposed and available land as wastewater treatment plant sites.

7-2. Combined vs Separate System

The study of "Combined vs Separate System" should be carried out taking into consideration various factors including engineering and economical components to be faced in construction and maintenance, obstruction to be imposed on the city life during construction, effects on water pollution abatement and others. As the parts of the study followings have to be included.

- a. Economical and engineering comparative study in typical areas to be selected in terms of land use characteristics.
- b. Decision of wet weather wastewater flow rate to be intercepted to the treatment plant under the combined system, should be carried out considering waste loads overflowed to the receiving water body. The investigation would include statistical analysis of rain fall during these ten years and field sampling of wet weather wastewater. The data of rain fall in recent ten years is available in data file collected.
- c. General condition of urban area, especially in terms of road condition together with buried utilities such as water supply pipes, telephone cables and power lines, should be surveyed for delineating physical restriction to be anticipated at the time of implementation.

7-3. Study of Treatment Methods for Wastewater and Sludge

- 1) Selection of recommendable sewage treatment processes.

Sewerage treatment methods recommendable for the Study Area should be studied and their respective merits and demerits have to be evaluated.

It is considered that one of the most influential factors for the selection of the treatment methods is the available

land spaces. The study and selection of recommendable treatment methods have also due correlation with zoning, required capital costs, consequences in maintenances and others. The flexibility to meet short-range as well as long-range requirements, have also been taken into consideration for the study and selection of treatment methods.

2) Selection of Recommendable Sludge, Grit and Screenings Treatment Processes and Disposals

Considering differences in quantity and quality of sludge resulted from various methods of sewage treatment, proper sludge treatment methods should be selected.

The suitable sludge disposal method should be recommended. As the part of the study following items be included;

- *To use sludges as fertilizer for agriculture purpose.

- *To use for land reclamation with recommendations of necessary measures for avoiding water pollution problem around sites of dumping.

3) Recommendation of Sewage and Sludge Treatment and Disposal Systems

7-4. Comparative Study of Alternative Sewerage Systems and zoning.

For the purpose of assessing the proper sewerage system. It is required to carry out comparative study for alternatives. Considerations have to be put on various factors including available land space, engineering consequences in constructions and maintenance and an economical superiority or any else. The study is interrelated with long-range strategy and short-range steps, treatment methods, zoning and an effect on environmental water pollution abatement. Therefore, it is necessary to evaluate alternative systems comprehensively, taking the essential components mentioned above into considerations. The proper system should be proposed.

7-5. Design Criteria and Design of Major Facilities of System Proposed

Technological design criteria to be applied for the sewerage planning have to be studied and recommended. The criterial should

be set in accordance with the unique situations in Bangkok and the recommended one would be used as standards hereafter. On the basis of recommended substances, the proposed sewerage system together with any other remedial measures have to be designed. Drawing of the designed major facilities have to be prepared.

8. Study on Availability of Construction Materials, Machinery and Man-power of Construction, Operation and Maintenance.

It is necessary to study an availability of materials, machinery, man-power to be required for the construction as well as operation and maintenance of the proposed sewerage system.

9. Consturction Methods and Materials

Construction methods should be discussed roughly as a basis of cost estimation. In relation with the methods the capability of local contractors have also been evaluated. Materials to be used for recommended facilities have also been studied and availability of required materials should be investigated.

10. Rough Estimation of Cost for Construction and Operation and Maintenance

Construction cost and O & M (Operation and Maintenance) costs of the proposed system should be estimated in broad bases.

11. Preparation of Implementation Programme

The implementaion programme have to be prepared, taking account of the order of priority of urgency of local requirements.

12. Study on Sewerage and its related Regulations including Acceptance of Trade Wastewater and Connection of Pipe from each House or Building.

It is necessary to recommend legislation required for controlling or administrating various concerned activities in wastewater management. The regulations to be prepared include as to acceptance of trade wastewater, connection of pipe from each house or building to the public sewer and others.

13. Study on Organization for Sewerage Work including Administration and Accounting.

The suitable organization for implementation and management should be recommended after investigation for existing organizations concerned. The Consideration should be put on not only administration but also accounting part of the organization.

14. Study of Charge System and Financial Plan

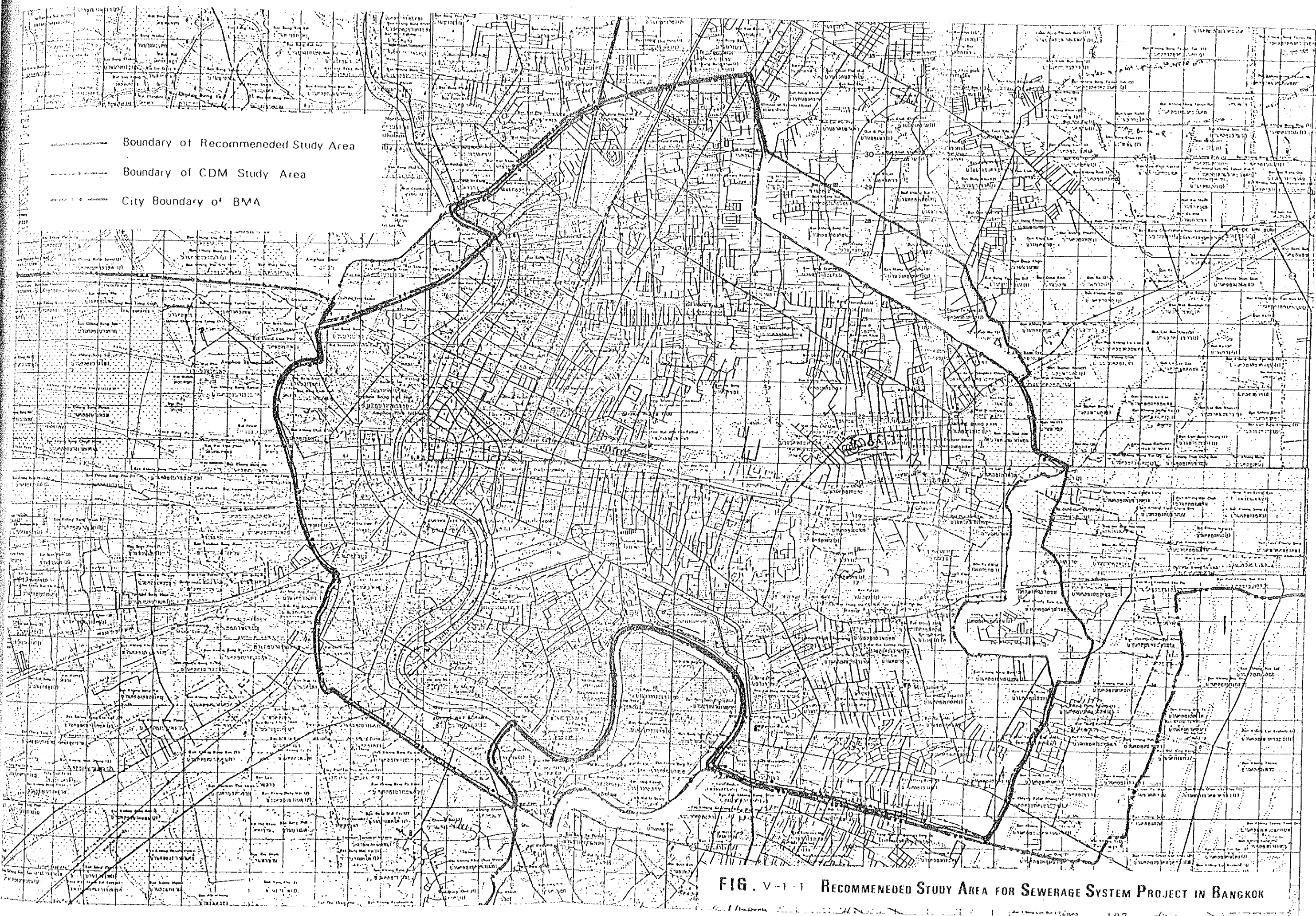
Financial requirement of the sewerage project which will be carried forward in accordance with the prepared programme, should be analyzed and suitable recommendation of revenue sources have to be done. In connection with the revenue, the charging system should be prepared and recommended.

15. Rough Estimation of Benefit

The benefit, derived from the executing of sewerage project, in quantifiable and unquantifiable aspects should be roughly estimated for the purpose of justifying the project.

16. Evaluation of the Project.

Taking account of the effect of the proposed project for improving existing water-related environmental situations and preparing the requirement in future, the project should be evaluated.



——— Boundary of Recommended Study Area
 - - - - - Boundary of CDM Study Area
 ····· City Boundary of BMA

FIG. V-1-1 RECOMMENDED STUDY AREA FOR SEWERAGE SYSTEM PROJECT IN BANGKOK

ANNEX 1. DESCRIPTION OF ACTIVITIES IN DIARY FORM

- Aug. 16. Arrival at Bangkok.
17. In order for courtesy call and discussing the scope of work, the survey team visited DTEC (Department of Technical and Economic Cooperation) and BMA (Bangkok Metropolitan Administration).
18. The field survey was made by the Japanese Team accompanied by Thai counterparts for the existing pumping stations, Krung Kasaem and Rama IV, and several points of polluted Klongs.
20. Discussions between BMA and the survey team were held for establishing the scope of work.
21. On the basis of the result of discussions held on previous day the scope of work was summarized.
22. The scope of work was agreed by BMA and JICA with the signature of Maj. - Gen. Charan Sammatat, Deputy Governor, BMA and Mr. Xujati Pramoolpol, Director - General, DTEC, and Dr. Mamoru Kashiwaya, Leader of the Japanese Survey Team.
23. Huay Kwang Sewerage Treatment Plant and China Town Area were visited in order to find sampling points of wet weather wastewater.
24. For checking topographic map available in Bangkok, Dr. Kashiwaya and Messrs. Nakatake and Mizutani accompanied by counterparts, Mr. Teeradej and Miss Injira, visited Royal Thai Survey Department, Ministry of Defence.
25. Dr. Kashiwaya and Mr. Kumagishi left for Tokyo.
27. The office was set up in BDS. General preparation for the survey work was initiated.
28. The machinery of government organization, central and municipal, was investigated. The agencies to which questionnaires would be sent were marked. The investigation was continued thereafter.

Aug. 29. Mr. Nakatake visited JICA office for being briefed on general affairs concerned.

30. The investigation on the government organization was continued.

The topographical map with a scale of 1:50,000 was received on this day.

31. Preparation of the Inception Report was started. Preparation of questionnaires to various government agencies requesting necessary data was also set forth.

Sep. 3. -----do-----

4. -----do-----

5. -----do-----

6. Messrs. Nakatake and Mizutani visited JICA office for processing visa extension.

7. Preparation of the Report was kept going.

10. -----do-----

11. -----do-----

12. -----do-----

13. Finalizing the Report including printing and binding was carried out.

Mr. Mizutani made field survey in order to observe present condition of Klongs.

14. The Inception Report had been prepared.

Messrs. Nakatake and Mizutani visited JICA office for notifying expected expenditures in each month during the survey. Mr. Takayanagi had arrived.

17. Mr. Takayanagi accompanied by Messrs. Nakatake and Mizutani visited Japan Embassy and JICA office for reporting his arrival and courtesy call. The Inception Report of 20 copies had been submitted to Bureau of Drainage and Sewerage, BMA.

Sep. 18. Briefing on the progress of survey work for Mr. Takayanagi had been done. After that the meeting between Mr. Anuchit, Deputy Director, BDS, and Japanese members as well as counterparts was held and general affairs concerned were discussed.

19. There was heavy rain on this day. Various parts of Bangkok were flooded. The Survey Team together with counterparts conducted a reconnaissance over the central part of the city.

20. By this time the questionnaires to be distributed to various government agencies had been prepared. In accordance with the recommendation of counterparts, it was decided that the questionnaires would be distributed under the name of Bureau of Drainage and Sewerage, BMA.

Field survey was carried out in order to find wet weather wastewater sampling sites and proposable treatment plant sites; Bangrak, Yannawa, Port Authority Area.

21. The monthly report had been submitted to JICA office. For the preview of proposable sites for sewage treatment plant, available land spaces were plotted on a map prepared on the basis of informations presented by counterparts. The availability of proposable sites are subject to further discussions.

24. It was scheduled to carry out further field survey for the purpose of selecting typical area of various land use types including residential, commercial, institutional and industrial. To observe each proposable treatment plant site was also integrated in the field survey schedule mentioned above.

25. All three members of the survey team together with two counterparts Mr. Chaiwat and Miss Injira visited areas along Klong Lord, the outlet point of Klong Bang Lum Poo to the Chao Phya River and Wang Saranlom Park beside Klong Lord.

- Sep. 26. The field survey group same as previous day, visited Sri Yan residential area and the zone referred to as China Town Area.
27. The group visited Klong Tan Pumping Station and the pond area belong to Tobacco Monopory.
28. The team visited Asian Institute of Technology (herein-after referred to as AIT) and met Dr. Tanbo (visiting professor from Hokkaido University), Dr. Watanabe (associate professor from Miyazaki University). The request for a cooperation in data collection needed for the study of proper sewage treatment method in Bangkok, was made to them. The request was accepted kindly by them.
- Oct. 1. Mr. Nakatake visited National Statistical Office and collected statistic data of general matters.
- Mr. Takayanagi and Mr. Mizutani made preparation for sampling of wet weather wastewater quality together with quantity.
2. A water level gauge was set at Klong Tan Pumping Station.
3. The survey team joined to the group of AIT professors from Japan and observed the Chao Phya River by boat from Bang-Pa-In, Ayuthaya Province to Bangkok City.
4. A place on which a rain gauge would have been set was searched.
5. A rain gauge was set in a private house plot beside the Klong Tan Pumping Station. The general conditions and specifications of both the pump and pump pit were inspected as the part of preparation for sampling. The recording paper of both the water level gauge and rain gauge had been changed daily hereafter.
8. Discussing on the distribution of questionnaires, it was decided that the letter from the survey team asking necessary

data for sewerage planning would be attached. The distribution would be started from Oct. 10.

Oct. 9. The preparation for questionnaires' distribution was made. The schedule of distribution was set.

10. On this day following agencies were visited by Mr. Nakatake and Miss Injira and questionnaires were handed over directly to persons mentioned below.

- 1) Bureau of Public Health, BMA and met Dr. Prasongporn Jarunitintorn, Deputy Director-General.
- 2) Environmental Health Division, Bureau of Public Health, BMA and met Dr. Voravit Leknark, Chief of the Occupational Health Section.
- 3) Construction Control Division, Bureau of Public Works, BMA and met Mr. Nikom Pradnakorn, Deputy Director of The Division.
- 4) City Planning Division, Office of the Under Secretary of State for BMA and left the questionnaires to the director secretary.
- 5) Water Operation and Maintenance Division, Department of Royal Irrigation, Ministry of Agriculture and met Mr. Lek Jindasangan.
- 6) Planning Department, Electricity Generating Authority of Thailand (EGAT) and met Mr. Sride Aphaiphuminart, Director of the department and also visited Water Resources Planning and Development Division, Planning Department, EGAT and met Mr. Payak Ratnarathorn.
- 7) Planning and Control Division, MWWA and left the questionnaire.

Messrs. Takayanagi, Mizutani and Chaiwat visited to Makkassan Pond to observe proposable treatment plant site.

Oct. 11. Messrs. Takayanagi, Mizutani and Chaiwat visited following agencies:

- 1) Technical Division, Bureau of Sanitation, BMA and met Mr. Somchitt Trewichian, Head of the Division.
- 2) Office of National Environmental Board, Ministry of Scientific Technology and Energy and met Dr. Pakit Kiravanich, Deputy Secretary General.
- 3) Community Estate Section, Estate Management Division, National Housing Authority and met Mr. Vivad Premprasert, Engineer.

Mr. Nakatake and Miss Injira visited agencies including:

- 1) Permit Section, Building Control Division, Bureau of Public Works, BMA and met Mr. Tanoosuk, Engineer.
- 2) Route Division, Port Authority of Thailand and met Mr. Chit Swangsook, Director of the Division.
- 3) Environmental Health Division, Ministry of Health and met Mrs. Nittaya Mahaplon.
- 4) Ground Water Division, Department of Mineral Resources, Ministry of Industry and met Dr. Vagee Rumananong.
- 5) Chao Phya Project Section, Industrial Environmental Division, Department of Industry, Ministry of Industry and left questionnaire.
- 6) Physics and Engineering Division, Department of Science, Ministry of Industry and met the director.

12. The survey team accompanied by counterparts Mr. Teeradej and Miss Injira visited Chulalongkorn University and met Dr. Surin Setamanit, Faculty of Engineering and Dr. Suthirak Sujarittanonta, Institute of Environmental Research.

The team also met Prof. Sudchai Champa, Dr. Thongchai Panswad, Department of Sanitary Engineering.

Mr. Nakatake and Miss Injira visited Communicable Disease Division, Department of Health, Ministry of Health for seeking data.

- Oct. 15. The arrangement of collected data was initiated.
16. The team together with Mr. Teeradej visited AIT and met Dr. Watanabe and Assist. Prof. Samorn. The research lists of environmental technology were collected. After visiting AIT, the team called at National Research Council.
17. The arrangement of collected data was continued. Mr. Nakatake and Miss Injira visited MWWA and met Mr. Bengapon, Engineer.
18. Collected data had been arranged.
19. The team visited JICA office to report the survey progress.
22. The data arrangement
23. -----do-----
24. Mr. Nakatake, Mizutani and Miss Injira visited NHA and met Mr. Vivad, Engineer. At around 10:00 p.m. the rainfall started. The team rushed to Klong Tan Pumping Station and carried out sampling of wet weather wastewaters in terms of quantity and quality until around one o'clock in the midnight.
25. Messrs. Takayanagi and Mizutani visited AIT and met Dr. Watanabe from whom various study reports were borrowed for copying.
26. The team accompanied by Mr. Chaiwat and Miss Injira visited Bureau of Sanitation and met Mr. Somchit Trevichian, Head of Technical Division. He had prepared data in response to the questionnaires previously distributed and gave supplemental explanations for the team.
29. Arrangement of data was continued.
30. Mr. Nakatake and Miss Injira visited Meteorological

Department and investigated the system for recording and arranging of rainfall, temperature and other weather items.

Messrs. Takayanagi and Mizutani together with Miss Injira made field survey on the existing sewage treatment facilities. They visited On Nooch in which the treatment plant for night soil and leachate from garbage dumps, were constructed.

- Oct. 31. Messrs. Takayanagi and Mizutani visited Huay Kwang and Klong Jan Wastewater Treatment Plant.
- Nov. 1. Messrs. Takayanagi and Mizutani visited the fringe of the Master Plan Area proposed by CDM for the purpose of surveying the general situations in terms of development.
2. Messrs. Takayanagi and Mizutani visited AIT and met Dr. Watanabe and Dr. Chongrak Polprasert and asked additional study reports. They observed the sewage treatment pond system in AIT.
5. Collected data were arranged.
6. -----do-----
7. -----do-----
8. Mr. Mizutani visited NEB and met Dr. Pakit Kiravanich, Deputy Secretary General, and received some additional data.
- Messrs. Takayanagi and Chaiwat surveyed Nong Khaem night-soil dumping site.
9. Mr. Takayanagi and Miss Injira went AIT for returning back borrowed study reports.
- Messrs. Nakatake and Chaiwat visited City Planning Division, Office of the Under Secretary of State for BMA and met Mr. Charitparkorn Veraphalin, Director. The data on population was collected and it was promised by the director to show existing land use map on some later day.
12. The preparation of the Progress Report was started.

- Nov. 13. Mr. Mizutani and Miss Injira visited Department of Industry, Ministry of Industry and met Mr. Samarn Thungthongtavee, Chief of the Chao Phya Project Section.
14. Messrs. Nakatake and Chaiwat visited City Planning Division and made a copy of the existing land use.
- Mr. Takayanagi visited JICA and Japan Embassy to discuss schedule for mission of Japan.
15. Messrs. Nakatake and Chaiwat continued to make copy of the existing land use.
16. The schedule for field survey to be carried out by the mission team from Japan was discussed and developed by Japanese Survey Team in Bangkok and counterparts.
17. Preparation for briefing the progress of the survey work was made.
19. The progress of the survey work was reported to the mission team, Japan Embassy and JICA. The mission team accompanied by Mr. Takayanagi visited DTEC. The mission came to BDS and met Mr. Anuchit and counterparts, in the afternoon.
20. A further report of the progress in the survey work carried out.
21. A meeting was held between the Japanese Survey Team and BDS.
22. A field survey was carried out by a team consisted of the Japanese Survey Team and Thai counterparts.
23. The field survey was continued.
24. A meeting was held between the mission team and Bangkok resident members.
25. Dr. Kashiwaya left Bangkok.
26. Finding of the mission team was reported to Japan Embassy and JICA office.

- Nov. 27. The mission team left for Tokyo.
28. The minutes of the meeting held on 21st Dec. was prepared. Preparation of the Progress Report was resumed.
29. -----do-----
30. -----do-----
- Dec. 3. -----do-----
4. -----do-----
6. While the preparation of the report was continued. Mr. Takayknkgi and Mizutain visited Klong Tan pumping station for checking the situation of instruments which were in stand by for wet weather wastewater sampling. The discussion was held between survey team and counterparts on the minutes held on 20 Nov.
7. The survey team visited JICA office and submitted monthly report.
The typewriting of the Progress Repor was started.
9. The preparation of the report was continued.
11. -----do-----
12. A proofreading of the typewritten report and finalizing it
13. The Progress Report in draft version was submitted to BDS. The survey team asked them to have discussion on the submitted draft report.
14. The arrangement and analysis of data already collected were carried out.
17. The preparation of additional questionnaires for collecting insufficient part of data were started.
18. The draft Progress Report was partly improved by the survey team after discussion within the team.
19. -----do-----
20. A discussion on the Draft Progress Report was held between BDS staffs and the survey team.
21. The finalization of the Progress Report was started and additional discussions were held between counterparts and the team.

- 24. -----do-----
- 25. -----do-----
- 26. The final check of the Progress Report was carried out.
- 27. The Progress Report was prepared and 20 copies were submitted to BDS. The additional questionnaires for asking inadequate part of data which had been collected by the time, were prepared.

Jan. 4 1980

- The contents of questionnaires which had already been submitted, were explained by the team to BDS counterparts. The schedule of the sampling for dry weather wastewater and Klong's water were developed.
- 7. The work schedule thereafter was discussed and adjusted within the survey team.
The prepared schedule for dry weather wastewater was discussed again within the team.
 - 8. The prepared work schedule for the period from the beginning of Jan. to the end of Feb. was submitted and explained to BDS.
The standby for the wet weather wastewater sampling was gave up and the instruments set for the sampling were withdrawn.
 - 9. Mr. Takayanagi and Mizutani visited NEB and returned borrowed data. Additional informations were collected there.
Mr. Takayanagi and Mizutani visited two treatment plants in NHA's estates and investigated them.
 - 10. Mr. Takayanagi and Mizutani visited two treatment plant of NHA and surveyed the situation of sludge treatment and disposal.
 - 11. The arrangement of collected data.
 - 14. The survey team visited JICA office and discussed about general affaires related to the survey work.
Bureau of Public Works, BMA was visited and data was collected.
 - 15. The preparation of the Preliminary Enginerring survey Report was started.

16. The schedule for dry weather wastewater and sampling of klong water was discussed between BDS counterparts and the team.
- The scope of work for Master Plan was partly discussed by the team.
17. The procedure of sampling works were discussed in Huay Kwang estate.
- The additional questionnaires were prepared and submitted to BDS.
- The questionnaires were distributed by the name of BDS to the following government agencies;
- 1). Meteorological Department, Ministry of Communications
 - 2). Department of Lands, Ministry of Interior
 - 3). Chulalongkorn University
 - 4). Bureau of Public Work
 - 5). Office of Town and Country Planning, Ministry of Interior
 - 6). Department of Highways, Ministry of Communications
 - 7). Telephone Organization of Thailand, Ministry of Communications
 - 8). Metropolitan Electricity Authority, Ministry of Interior
 - 9). Metropolitan Water Works Authority, Ministry of Interior
 - 10). Budget Division, Office of the Under Secretary of State for BMA
 - 11). Legislative Division, Office of the Under Secretary of State for BMA.
18. Messrs. Nakatake and Chaiwat visited Meteorological Department and borrowed the rain recording papers in these ten years.
- The Northeast part of urbanized city area were visited and proposable treatment plant sites were observed.
22. The discussion was held between BDS officials and Mr. Akiguchi, a first secretary of the Japan Embassy, together with the survey team, on the demonstration project in terms of the technical assistance by Japan.

- The main records were arranged for making a copy of them.
23. Bureau of Public Works, BMA, was visited and asked the data related to the planning.
The rain recording papers were returned back to Meteorological Department.
24. The final arrangement and adjustment of sampling works of dry weather wastewater were carried out at Huay Kwang Treatment site.
Department of Land, MIN, was visited and the land price data was asked for. It was refused to release data covering whole areas by the department.
The price in sport area was said to be able to be disclosed.
Office of Town and Country Planning, MIN, was visited and the data of the future land use was asked.
MEA, MIN, and legislation division, OUSS, BMA, were also visited and the necessary data were asked.
25. The survey team together with counterparts visited Mahidol University and met Mr. Suvit, assistant professor in Faculty of Sanitary Engineering.
27. Dry weather wastewater sampling was started at Huay Kwang.
28. The sampling was continued.
The preparation of scope of work for Master Plan was continued.
29. The sampling of dry weather wastewater was completed. The analysis of collected samples was asked for Chulalongkorn University.
The discussion of scope of work for Master Plan was held within the team.
30. Data of high way plan was collected from HWD, MOC.
The Northern part of urbanized city area and tonburi area were visited and reconnaissances were carried.
31. The survey team accompanied by counterparts visited Chulalongkorn University and met Dr. Charuay Boonyubol, Dean of Faculty of Engineering and Professor Sudchai Champa,

Department of Sanitary Engineering, Faculty of Engineering.
Data on the routes of under ground main cable were collected from TOT.

- Feb. 1. The preparation of the Preliminary Engineering Survey Report was continued.
The arrangement of collection data was continuously carried out in these days as the final stage of survey works.
4. -----do-----
5. -----do-----
6. The survey team visited AIT and met Mrs. Samorn Muttamara, Assistant Professor, Environmental Engineering Division, AIT.
7. The preparation of the Preliminary Engineering Survey Report.
8. -----do-----
11. -----do-----
12. The survey team worked with the Japanese Mission which arrived on 11 Feb., for discussing the scope of work for Master Plan Study. The draft of the Preliminary Engineering Survey Report together with the scope of work were submitted to BDS.
13. The achievements of the survey works were briefed to the mission.
14. The meeting between BDS and the Japanese Survey Team, the mission member and Bangkok resident survey members, was held, and the achievements of the Preliminary Engineering Survey as well as the scope of work for the study of Master plan were discussed.
15. The Japanese Survey Team started the finalization of the Preliminary Engineering Survey Report in association with the agreement reached at the meeting held on 14th.

16. -----do-----
17. -----do-----
18. -----do-----
19. The meeting was held between BDS and the Japanese Survey Team.
A tentative schedule of the coming studies and other related matters were discussed.
20. The Japanese Mission left for Tokyo.
The finalization of the Preliminary Engineering Report was continued.
21. The finalization and submission of the Report and winding up of the office.
- 29.

ANNEX 2. LIST OF COLLECTED DATA

I. CONTENTS OF THE LIST

1. General

- 1.1 General Discription of Thailand & Bangkok
- 1.2 Administrative Organization
- 1.3 Legal Data
- 1.4 Maps
- 1.5 Meteorological Data

2. City Planning

- 2.1 Population
- 2.2 Land Use
- 2.3 Water Supply (Municipal Water, Ground Water Use)
- 2.4 Infra Structures (Roads, Electric, Telephone ect.)

3. Sewerage System

- 3.1 Data on Existing System (Drainage and Sewerage)
- 3.2 Stormwater Data
- 3.3 Hydraulic Data
- 3.4 Geological Plan & Studies On Drainage & Sewerage System

4. Wastewater

- 4.1 Domestic Wastewater
- 4.2 Industrial Wastewater

5. Wastewater Treatment

6. Water Pollution

- 6.1 Field Survey Data
- 6.2 Water System Analysis (Quality, Flow)
- 6.3 Water Pollution Control

7. Sanitation & Hygienic Condition

- 7.1 Land Cost
- 7.2 Water Borne Disease
- 7.3 Solid Wastes Disposal

8. Price Data

8.1 Land Cost

8.2 Material, Energy & Construction

8.3 Labour

9. Financial Data

10. Others