BANGKOK METROPOLITAN
ADMINISTRATION (BMA)

# PREPARATORY SURVEY
# FOR
# BANGKOK WASTEWATER
# TREATMENT PROJECT
# IN
# THAILAND

# FINAL REPORT (I)
# CONCEPTUAL MASTER PLAN
# VOL. 2 MAIN REPORT

**JULY 2011**


**JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)**

**TOKYO ENGINEERING CONSULTANTS CO., LTD. (TEC)**
**NIPPON KOEI CO., LTD. (NK)**


| SAP |
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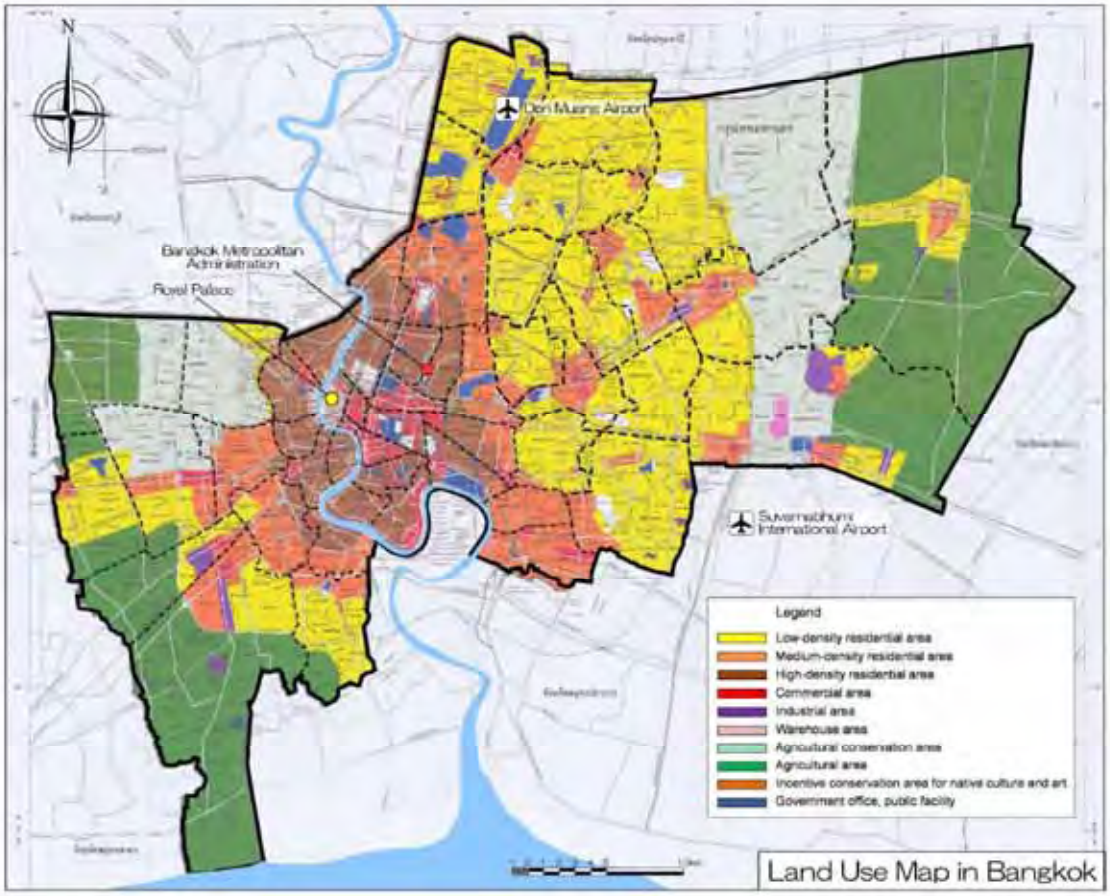
| JR |
| 11-016 |

as of October 1, 2010

1 Baht = 0.0330 US dollar
1 Baht = 2.76 yen

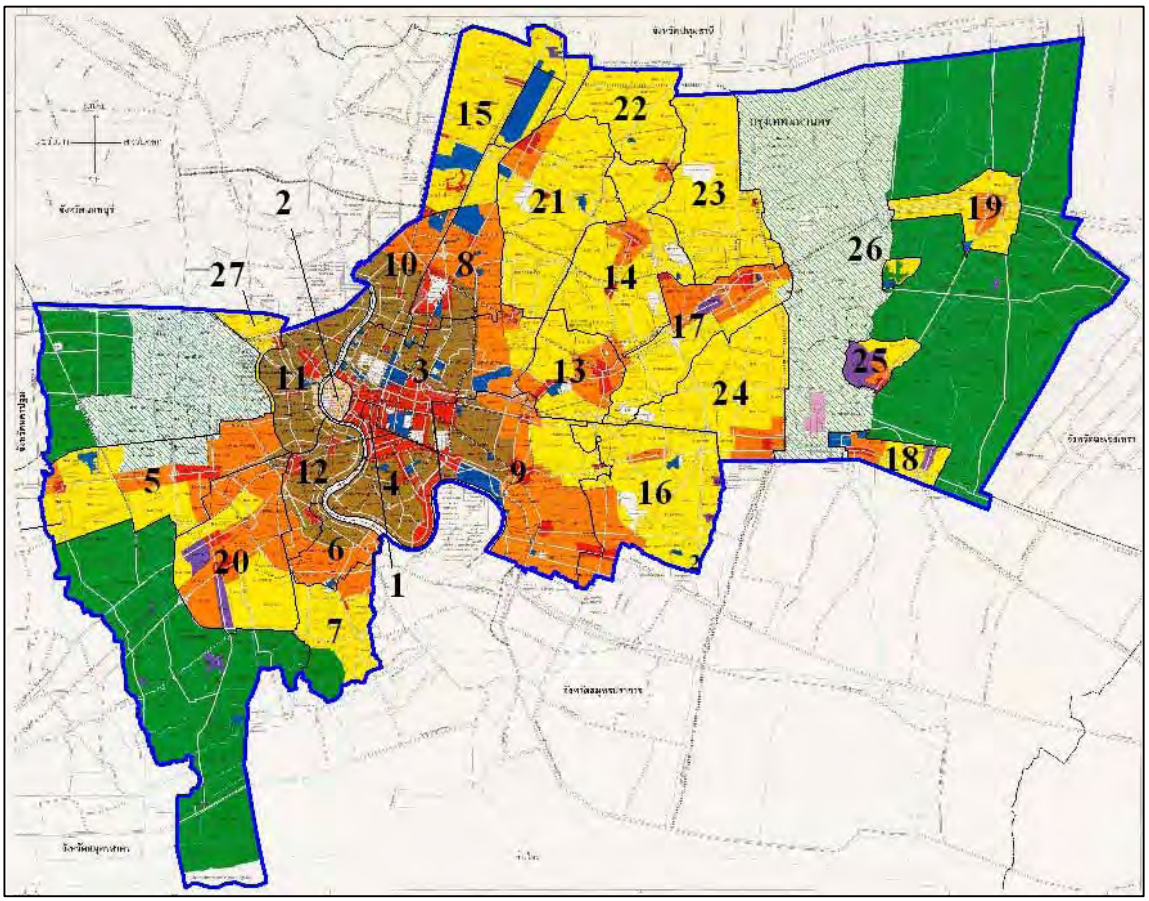





**Location Map**

## Area, Served Population and Design Wastewater Flow in 2040

| No. | Treatment Area | Area | Served Population | Design Wastewater Flow | No. | Treatment Area | Area | Served Population | Design Wastewater Flow |
|---|---|---|---|---|---|---|---|---|---|
| | | (ha) | (person) | ($m^3$/day) | | | (ha) | (person) | ($m^3$/day) |
| 1 | Si Praya | 226 | 57,495 | 30,107 | 15 | Don Mueang | 4,941 | 383,983 | 154,822 |
| 2 | Rattanakosin | 367 | 49,480 | 28,608 | 16 | Nong Bon | 6,385 | 264,883 | 133,501 |
| 3 | Din Daeng | 5,931 | 689,699 | 357,260 | 17 | Min Buri | 4,165 | 274,182 | 138,188 |
| 4 | Chong Nonsi | 2,872 | 372,960 | 202,332 | 18 | Lat Krabang-1 | 1,258 | 59,502 | 29,989 |
| 5 | Nong Khaem | 6,239 | 590,483 | 232,450 | 19 | Nong Chok-1 | 2,109 | 208,634 | 96,199 |
| 6 | Thung Khru North | 1,513 | 128,637 | 53,875 | 20 | Jomthong | 5,816 | 453,938 | 221,578 |
| 7 | Thung Khru South | 2,934 | 127,396 | 60,532 | 21 | Lat Phrao | 6,206 | 475,384 | 191,675 |
| 8 | Chatuchak | 3,645 | 239,653 | 139,980 | 22 | Sai Mai | 2,958 | 158,188 | 63,781 |
| 9 | KhlongToei | 7,309 | 579,670 | 323,508 | 23 | KhlongSam Wa | 5,015 | 310,738 | 156,612 |
| 10 | Bang Sue | 2,095 | 229,063 | 103,413 | 24 | Lat Krabang-2 | 4,959 | 211,457 | 106,575 |
| 11 | Thon Buri North | 2,922 | 359,542 | 158,655 | 25 | Lat Krabang-3 | 988 | 28,129 | 14,178 |
| 12 | Thon Buri South | 2,087 | 333,707 | 141,005 | 26 | Nong Chok-2 | 309 | 20,908 | 10,538 |
| 13 | Wangthonlang | 2,872 | 246,098 | 117,315 | 27 | Taling Chan | 759 | 149,866 | 50,751 |
| 14 | Bunkhum | 5,639 | 340,430 | 137,262 | Total Treatment Area | | 92,519 | 7,344,105 | 3,454,689 |
| | | | | | Outside | | 62,939 | 281,895 | 113,660 |
| | | | | | Total BMA | | 155,458 | 7,626,000 | 3,568,349 |




**Treatment Areas of Updated M/P and Nong Bon Treatment Area (No. 16)**

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**Final Report (I) Conceptual Master Plan**

**Volume 1 Summary**
**Volume 2 Main Report**
**CD-R**

**Final Report (II) Feasibility Study**

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**Volume 2 Main Report**
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# Abbreviations

| | |
|---|---|
| ADB | Asian Development Bank |
| AFD | French Development Agency |
| BMA | Bangkok Metropolitan Administration |
| BMR | Bangkok Metropolitan Region |
| BMTA | Bangkok Mass Transit Authority |
| BOD | Biochemical Oxygen Demand |
| BOO | Build, Operate, and Own |
| BOT | Build, Operate, and Transfer |
| BRT | Bus Rapid Transit |
| CI | Context Information |
| COD | Chemical Oxygen Demand |
| CSO | Combined Sewage Overflow |
| DDS | Department of Drainage and Sewerage, BMA |
| DIW | Department of Industrial Works, MOIn |
| DO | Dissolved Oxygen |
| DOE | Department of Environment, BMA |
| DOLA | Department of Local Administration, MOI |
| DWF | Dry Weather Flow |
| EIA | Environmental Impact Assessment |
| F/S | Feasibility Study |
| IC | Interceptor Chamber |
| JICA | Japan International Cooperation Agency |
| JST | JICA Survey Team |
| MOI | Ministry of Interior |
| MOIn | Ministry of Industry |
| MONRE | Ministry of Natural Resources and Environment |
| MOSTE | Ministry of Science, Technology and Environment (present MONRE) |
| M/P | Master Plan |
| MWA | Metropolitan Water Works Authority |
| NEB | National Environment Board, MONRE |
| NEQA | National Environmental Quality Act, 1992 |
| NHA | National Housing Authority |
| ODA | Official Development Aid |
| OECD | Organization for Economic Cooperation and Development |
| ONEP | Office of Natural Resources and Environmental Policy and Planning |
| O&M | Operation and Maintenance |
| PCD | Pollution Control Department, MONRE |
| PFI | Private Finance Initiative |

| | |
|---|---|
| PI | Performance Indicator |
| PPP | Public Private Partnership |
| PWD | Public Works Department, BMA |
| RID | Royal Irrigation Department |
| SS | Suspended Solids |
| TDA | Trade and Development Agency, USA |
| TDS | Total Dry Solids |
| T-N | Total Nitrogen |
| T-P | Total Phosphrus |
| WG | Working Groupe |
| WMA | Wastewater Management Authority |
| WQMO | Water Quality Management Office |
| WWTP | Wastewater Treatment Plant |

# 1. INTRODUCTION

## 1.1 Background of the Survey

With rapid economic growth and urbanization of the Bangkok metropolis in recent years, pollution of rivers and klongs (canals) has become a serious problem. The development of the public sewerage system is being promoted as a measure for domestic wastewater collection and treatment in the city; thereby targeting the main source of pollution. The Bangkok Metropolitan Administration (BMA) has been working on improvements of the sewerage system based on the JICA development study "Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok (1999)". In that M/P, 20 treatment plants are planned. As of 2010, large wastewater treatment plants (WWTPs) have been constructed at 7 locations, and together with 12 other small-scale community treatment plants, the total treatment capacity has reached approximately 1,000,000 $m^3$/d, which is about 40% of the generated wastewater. However, improvements to water quality of public water bodies in the Bangkok metropolis, such as canals (klongs), are yet to reach satisfactory level. Further enhancement in the percentage of sewered population has become an urgent issue for ensuring the health and hygiene of residents of the Bangkok metropolis.

In view of this background, BMA is formulating a new sewerage system development plan, and has requested Japan International Cooperation Agency (JICA) to review the existing Master Plan (M/P) based on the current circumstances and implement a feasibility study (F/S) related to matters with high priority project that is expected to utilize JICA ODA loan in future. JICA dispatched an evaluation mission in November 2009 and signed the Scope of Works (S/W) with the BMA on 11 December 2009 for this Survey.

## 1.2 Objectives and Scope of the Survey

The Survey was implemented based on the S/W agreed between JICA and BMA. The objectives of the Survey are listed below.

(1) To confirm plans in the sewerage sector; to review the existing Master Plan; to study the status of sewerage system development and strategies; and to grasp the status of the organization system, etc.; in order to suggest strategy for developing the sewerage system and to select priority project.
(2) To conduct F/S for the project considered to be urgent based on the findings coming from the studies mentioned above.

## 1.3 Area under the Survey

The Survey area covers the entire BMA jurisdiction.

## 1.4 Implementing Organizations in Thailand

The counterpart organization for the Survey is the Bangkok Metropolitan Administration (BMA).

The direct counterpart of this Survey is the BMA Drainage and Sewerage Department (DDS), and the division in charge within the DDS is the "Water Quality Management Office (WQMO)".

# 2. WORK SCHEDULE AND IMPLEMENTATION OF PHASE 1 WORK

## 2.1 Work Schedule for the Entire Survey

The Survey period (approx. 15 months) is divided into two phases as given below. The Survey flow chart is as shown in Figure 2.1.1.

Phase 1: Confirm plans in the sewerage sector; review the existing Master Plan; study the status of sewerage system development and strategies, grasp the status of the organization system, etc., in order to suggest strategy for developing the sewerage system. Also, select the priority project and confirm the essence of the plans. (About 6 months)

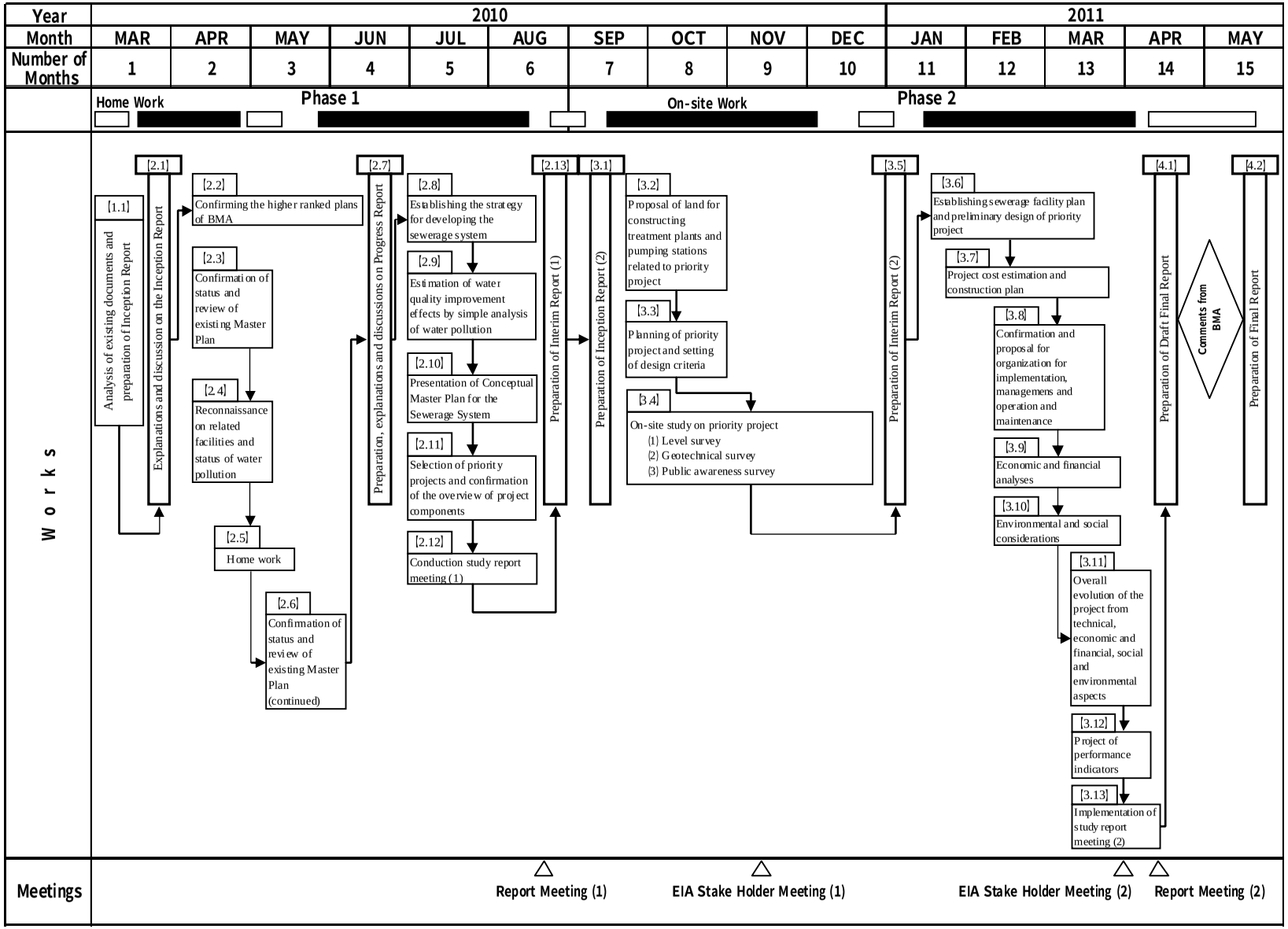
Phase 2: Implement the feasibility study (F/S) of the priority project. (About 9 months)

“Interim Report (I)” in Figure 2.1.1 was changed to “Final Report (I)”, “Final Report” was changed to “Final Report (II)”. Date of EIA Stakeholder Meeting (I) was changed from November 2010 to February 2011, and Report Meeting (2) was cancelled.

## 2.2 Basic Policies for the Survey

The Survey is implemented based on the basic policies described in the Inception Report. During the implemention of the Survey, the importance of the following points mentioned in JICA’s TOR is taken into account.

(1) The current M/P for sewerage system of BMA at this point of time is the "The Study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Re-use in Bangkok," which is a JICA development study conducted in 1999. This M/P is reviewed.
(2) Since sewerage development for Klong Toei, Bang Sue, and Thon Buri treatment areas are either under construction or design, the priority projects are selected from the remaining 10 treatment areas not yet considered. Main selection criteria are urgency, improvements to the water environment, and social and economic conditions of the treatment areas.
(3) Proposals are made for sites of treatment plants and pumping stations for the priority projects. Some alternative sites are examined including land proposed by the BMA in the selection process. From these, the optimum proposal is submitted after adequate discussions with BMA and JICA based on economic, social and environmental aspects.
(4) For environmental and social considerations, the Thai national regulations are followed. Further, the "JBIC Guidelines for Confirmation of Environmental and Social Considerations (April 2004)" or the "Revised JICA Guidelines for Environmental and Social Considerations (April 2010)" are also referred to, and confirmed.




Source: JST

**Figure 2.1.1 Flowchart of the Survey**

## 2.3 Survey Organization

BMA established a Steering Committee chaired by Deputy Permanent Secretary to monitor the progress and to give suggestions for the implementation of the Survey (refer to Appendix 1-6, Order for Establishment of Steering Committee).

A group of twelve (12) persons were designated as counterparts from members of Water Quality Management Office of DDS to support JICA Survey Team (refer to Appendix 1-3, Member List of DDS Working Group).

Consultant Survey Team is composed of 4 persons from Tokyo Engineering Consultants Co Ltd. and 3 persons from Nippon Koei Co., Ltd. (refer to Appendix 1-1, Manning Schedule).

## 2.4 Implementation of Phase 1 Work and Final Report (I) Volume 2

### (1) Confirmation of Fundamental Items (Explanation and Discussion of IC/R)

During preparatory home work, analysis of collected data was carried out, and policies and methodologies for the Survey were established. In order to implement the Survey efficiently, work schedule, list of places to visit, data to be collected and reconnaissance survey plan were prepared. In the Inception Report, basic policies and methodology for the Survey proposed in the proposal including JICA's consultant TOR are described together with questionnaire for BMA.

Explanation of and consultation on the Inception Report was conducted with the counterpart organization, i.e. DDS, on 17$^{th}$ March. At the meeting, agreement was obtained regarding basic policies, Survey plan, Survey organization, Survey Area, undertakings of DDS, arrangement of counterpart personnel, meetings and seminars, and so on. (refer to Appendix 1-2, 1$^{st}$ WG Record)

At the meeting held on 25$^{th}$ May, information exchange and discussion on issues about sewerage system in Bangkok were held between the counterparts and the Survey Team. (refer to Appendix 1- 4, Comment & Discussion with DDS). In addition, responsible counterpart persons were designated for each category of the data to be collected.

Opinions were exchanged regarding dates of Steering Committee meetings, fundamental items for the Survey on 8$^{th}$ April (refer to Appendix 1-5, Discussion with DDS).

### (2) Implementation of Survey Work (Explanation and Discussion of Progress Report and Interim Report)

Based on the results of the first on-site work, Progress Report was prepared. The second Working Group meeting was held on 15th June, and Progress Report was explained to counterpart organization, i.e. DDS. Views and opinions about population projection, design capacities of the existing WWTPs, issues of combined sewerage system in Bangkok, planned treatment area of the Master Plan and so on were exchanged. After the meeting, detailed comments were expressed by DDS Working Group to the Survey Team. (refer to Appendices 1-7 and 1-8, 2nd Working Group Record and Comments)

The first Steering Committee meeting was held on 21st June. At the beginning of the meeting, outline of the JICA Preparatory Survey, role of the Steering Committee, and so on were explained, followed by explanation by the Survey Team about Inception Report and Progress Report. Various topics were raised and discussed by the committee members, and suggestions would be reflected in the Survey. (refer to minutes of meeting of the first Steering Committee in Appendix 1-9 Steering Committee Meeting Report)

A meeting was held on 5th July with DDS to confirm matters found during on-site work and to exchange views (refer to minutes in Appendix 1-10). Since data enquired to MWA about water supply are important for planning of sewerage development, therefore enquiry was submitted again to MWA by DDS.

Policy for rearrangement of existing treatment areas and setting of new treatment areas was reconfirmed on 16th July.

At the Working Group meeting held on 25th August, the consultant explained the framework of ITR, i.e. strategies for development of sewerage system in BMA and conceptual master plan. Various opinions from chairman and working group members were expressed on various subjects such as cooperation with flood control measures (refer to Appendix 1-11, Minutes of the 3rd Working Group Meeting).

A meeting to explain the contents of ITR to authorities concerned with the project was held on 31st August. The outlines of the ITR was explained by the consultant. Various opinions and views were expressed from chairman and authorities concerned and intensive discussions was held (refer to Appendix 1-12, ITR Meeting for Related Organizations).

The second Steering Committee meeting was held on 30th September. Contents of ITR was explained by the consultant. Opinions and views were exchanged, and it was agreed that these would be reflected in the report (refer to Appendix 1-14, minutes of the second Steering

Committee).

### (3) Dates of Field Survey

A list of places to visit was prepared and presented by the Survey Team for observation of facilities related to sewerage system and water pollution situation. Field survey was carried out as described below with cooperation from counterparts.

| | |
|---|---|
| 18th Mar. (Thu.) | Din Daeng WWTP and Chatuchak WWTP |
| 19th Mar. (Fri.) | Si Praya WWTP |
| 23rd Mar. (Tue.) | Rattanakosin WWTP |
| 24th Mar. (Wed.) | Chong Nonsi WWTP |
| 29th Mar. (Mon.) | Water Quality Laboratory and Flood Control Center of DDS |
| 31st Mar. (Wed.) | Nong Khaem WWTP and Tung Khru WWTP |
| 1st Apr. (Thu.) | Bong Kai, Klong Toei and Bang Na community plants transferred from NHA |
| 5th Apr. (Mon.) | Bang Sue WWTP construction site, Bang Khen PS and Bang Sue PS |
| 7th Apr. (Wed.): | Nong Bon and Min Buri treatment areas and their WWTP sites |
| 12th Apr. (Mon.) | Thon Buri WWTP site and Klongs |
| 20th Apr. (Tue.) | Klongs on the east bank and Phra Khanong PS |
| 9th June (Wed.) | Interceptor chambers in Din Daeng treatment area |
| 10th June (Thu.) | On Nuch Septage Treatment Plant |
| 11th June (Fri.) | Din Daeng WWTP |
| 14th June (Mon.) | Aqua Nishihara factory for septic tanks |

### (4) Data Collection

Data to be collected mentioned in the Questionnaire of the Inception Report were collected by counterparts. Almost all of the data were collected by the end of the first on-site work. Additional data collection was continued as required in the second on-site work. The final list of data collected is attached in Appendix-1.

In parallel with data collection, the following authorities were interviewed to obtain information about basic data, monitoring/control system and regulations. Dates of interviews are as follows.

| | |
|---|---|
| 7th Apr. (Wed.) | Public Works Department of BMA (regulations about buildings) |
| 8th Apr. (Thu.) | City Planning Department of BMA (city planning of Bangkok) |
| 19th Apr. (Mon.) | Pollution Control Department (PCD) of Ministry of Natural Resources and Environment (MONRE) (national policies for water pollution abatement and sewerage system development) |

| | |
|---|---|
| 22nd Apr. (Thu.) | Metropolitan Water Works Authority (MWA) (water works development plan in BMA) |
| 18th June (Fri.) | Cleaning and Park Department of Din Daeng District Office (treatment of septage) |
| 22nd June (Tue.) | Metropolitan Water Works Authority (MWA) (water supply records by branch office) |
| 10th Aug. (Tue.) | Royal Irrigation Department (RID) for flow of klongs from outside of BMA |
| 29th Oct. (Fri.) | Department of Groundwater Resources, MONRE for groundwater use in BMA |
| 29th Oct. (Fri.) | Department of Industrial Works (DIW), MOIn, for industrial wastewater and its treatment. |
| 4th Nov. (Thu.) | Department of Groundwater Resources, MONRE for groundwater use in BMA |

**(5) Final Report (I) Volume 2**

This Final Report (I) Volume 2 has been prepared to put together the results of the first phase work, including review of the relevant plans for sewerage project and the current Sewerage Master Plan, and proposals of strategies and Conceptual Master Plan.

# 3. ISSUES OF SEWERAGE WORKS IN BMA

## 3.1 Sewerage System in Thailand

### 3.1.1 Administration of Sewerage System

#### (1) National Agencies

Ministry of Natural Resources and Environment (MONRE) is responsible for environmental administration in general which includes sewerage system.

Office of the Natural Resources and Environmental Policy and Planning (ONEP) establishes environmental policy and program, and checks priority of sewerage projects from environmental view point for which Department of Local Administration (DOLA), Ministry of Interior allocated its budget.

Pollution Control Department (PCD) establishes environmental standards including water quality standards, and controls and monitors environmental items. However, control and monitoring of industrial wastewater are under responsibility of Ministry of Industry (MOIn).

Wastewater Management Authority (WMA) is a national enterprise under MONRE which assists local governments to implement sewerage projects.

#### (2) Local Government

Local government has a duty to observe regulations for water pollution. Local government is empowered to manage and operate sewerage projects as an implementing agency according to Decentralization Act, 1999.

Local government can apply for a sewerage project to ONEP on condition that it is included in the provincial development plan, and budget is allocated through DOLA. Once ONEP receives an application, it assesses feasibility of the project from various aspects, financial aspect in particular.

### 3.1.2 National Sewerage System Development Plan

#### (1) National Economic and Social Development Plan

Since 1961, the Government of Thailand (GOT) has developed five-year National Economic and Social Development plans that establish the overall priorities and policy framework for the country's development.

The 7th Plan (1992-1996) declared the government's commitment on promoting sustainable economic development that protects the environment. One key objective of the 7th plan was to rehabilitate water quality in the lower reaches of the Chao Phraya and Tha Chin rivers.

The 8th Plan (1997-2001) continues to emphasize the rehabilitation of natural resources and the environment by strengthening environmental management, and increasing local and community participation. Key principles emphasize good governance through decentralization, public participation in decision-making, increased transparency and accountability, and empowerment of communities.

The 9th Plan (2002-2006) is focused on management of natural resource and environment by enhancing participation of all sectors in the society, employing effective, transparent as well as trustworthy regulations, and conducting practical research. In issues related to water quality strategies, the Plan states that the inland water quality of main rivers in terms of Dissolved Oxygen (DO) should not be less than 2 mg/l and the coastal water quality should be restored according to determined national standards.

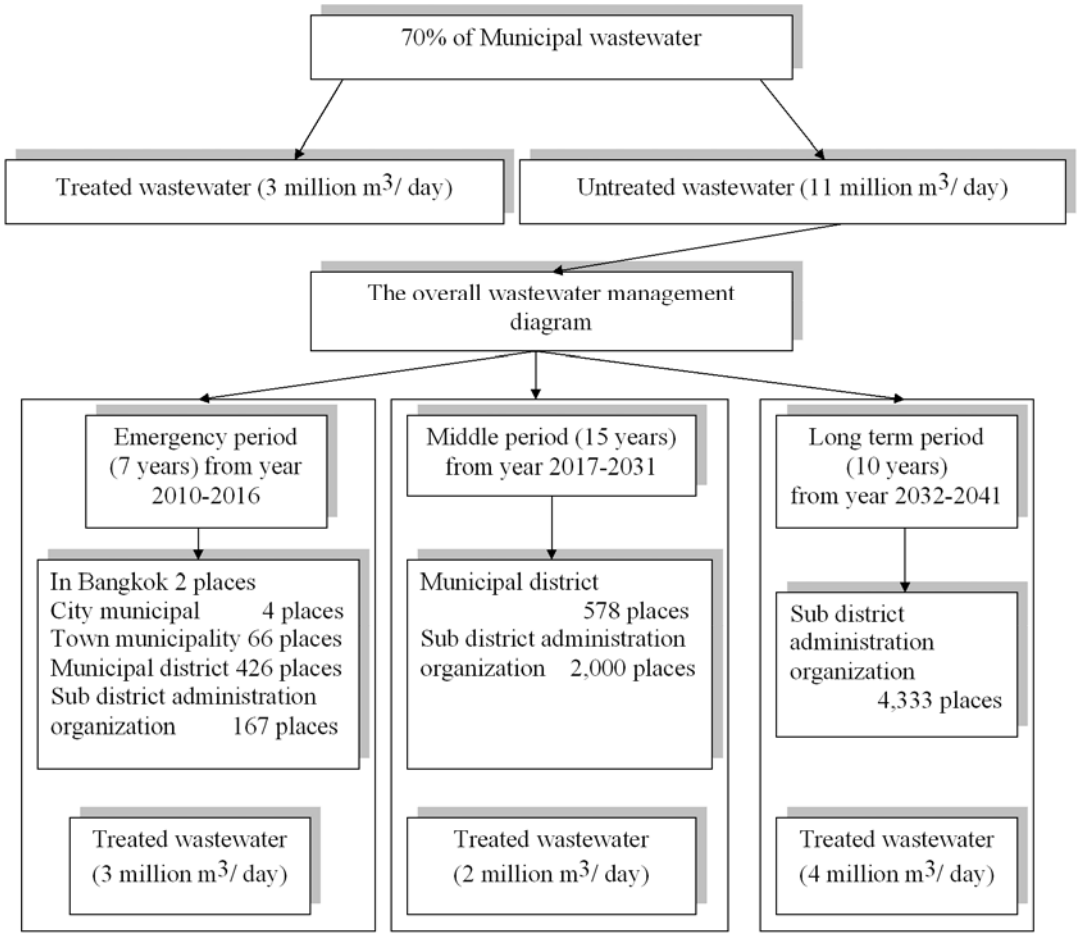
The $10^{th}$ Plan (2007-2011) aims to realize "Happy and Coexistence Society which is Friendly to the Earth" under an idea of "Economic Idea Having Awareness of Satisfaction". One of its missions is to maintain diversity of ecosystem and conservation of quality of environment. It is mentioned that one of the objectives of the Plan is to secure fairly good water quality for more than 85 % of rivers and water resources.

#### (2) National Sewerage Development 32 Year Plan (2010 – 2041)

Regarding sewerage plan at national level, "National Sewerage Development 32 Year Plan (2010 – 2041)" which aims to improve water environment in the whole country was approved by National Environmental Board held in October, 2009.

Currently out of 14 million $m^3/d$ wastewater generated, 3.2 million $m^3/d$ is treated at 101 WWTPs. In this long term plan, planning period is divided into three periods, viz. urgent (7 years), middle (next 15 years) and long (next 10 years), and for each period names of local

governments of which sewerage system development will be implemented are listed (Figure 3.1.1). With completion of the Plan, 9 million $m^3$/d wastewater will be treated. Two projects in BMA under urgent period are Klong Toei and Tong Buri Projects




Source: PCD

**Figure 3.1.1 Outline of National Sewerage Development 32 Year Plan (2010 – 2041)**

## 3.2 Confirmation of Related Legal Framework and BMA Higher Ranked Plans

### 3.2.1 Related Legal Framework

Legal framework of the nation and BMA related to sewerage project was sorted out and explained briefly as below.

#### (1) Related Laws

There is no direct law regarding sewerage system operation for BMA. However, there are some relevant laws. These laws and regulations give the BMA the powers to carry out certain functions, enable it to raise funds, impose targets against which its success is measured and coordinates with other authorities whose actions may interfere with the BMA. Some of the important laws are briefed in the following.

*Enhancement and Conservation of National Environmental Quality Act, 1992*

This law is the key environmental legislation and basis of environmental impact assessment (EIA). The part 5 of this act elaborates about water pollution. It says, "the owner or possessor of the point source of pollution has the duty to construct, install, or bring into operation an on-site facility for wastewater treatment or waste disposal". This law also states that in case of an area served by central wastewater treatment facilities, point source polluters should connect to the service and pay appropriate fees. This law also gives authority to some agencies to set effluent standard. Based on this, Pollution Control Department (PCD) under MONRE sets effluent standards.

*Environmental Quality Promotion and Prevention Act, 1992*

In the part covering the wastewater issues, this act specifies that wastewater must be treated either by the generator or at a central treatment plant; and in the later case, generator must pay for the service.

*BMA Service Administration Regulations Act, 1985, and its amendment, 1996*

Since wastewater treatment is one of the designated activities of BMA (as stipulated in its foundation act of 1977), this law prescribed that BMA must provide this service to ensure the environmental wellbeing and public health.

*Building Control Act, 1979, and its amendment, 1992*

This act, as an environmental protection measure, requires property owners to construct some

kind of wastewater preventive measures like septic tanks. PCD followed this act to prepare Effluent Quality Standard Code of Law (1994) where treatment requirements are described based on building types.

*The Land Development Act, 2000*

This act is related to control of land development and requires developer to provide buildings and households with sewerage system (wastewater treatment and storm water drainage).

*Other related acts:*

- Public Health Act, 1992
- Factory Act, 1992
- Royal Decree on Wastewater Management Authority, 1995
- Industrial Works Act, 1992
- Hazardous Substances Act, 1992
- Industrial Estate Authority of Thailand Act, 1979
- Public Works Department Decree, 1994
- Private Sector Participation Act, 1992

### (2) Control of Water Quality Stipulated by Enhancement and Conservation of National Environment Quality Act

Standards for water environment and for wastewater discharges are stipulated in "Enhancement and Conservation of National Environment Quality Act 1992", and standards for industrial wastewater are stipulated in "Factory Act of 1992" under Ministry of Industry.

Water quality standards for public water bodies were stipulated in 1994 according to Enhancement and Conservation of National Environmental Quality Act taking into account the beneficial use of each water body. For Chao Phraya River, water quality standards are stipulated dividing the river into three sections, i.e. up-, middle- and down-stream as shown in Table 3.2.1. The sections are categorized as Class 4 for down-stream (7 km from river mouth to 62 km), Class 3 for middle-stream (62 to 142 km) and Class 2 for up-stream (142 to379 km). For sections in BMR, conservation area for water supply resource is also determined. Water quality standards for groundwater are stipulated as well.

As for discharge standards, Industrial Effluent Standards, Building Effluent Standards, Housing Estate Effluent Standards, Effluent Standard for Pig Farm, Gas Station and Oil Terminal Effluent Standard, Effluent Standard for Coastal Aquaculture, and Effluent Standard for Brackish Aquaculture are enforced.

**Table 3.2.1 Water Quality Standards for Chao Phraya River**

| Section | Class | Color, Odor, Taste | DO (mg/l) | BOD (mg/l) |
|---|---|---|---|---|
| Down-stream (from river mouth 7 – 62 km) | Class 4 | Not abnormal | 2 | 4 |
| Middle-stream (62 – 142 km) | Class 3 | Not abnormal | 4 | 2 |
| Up-stream (142 – 379 km) | Class 2 | Not abnormal | 6 | 1.5 |

Classification

Class 1 Extra clean fresh surface water resources used for:
(1) conservation not necessary pass through water treatment process require only ordinary process for pathogenic destruction
(2) ecosystem conservation where basic organism can breed natually

Class 2 Very clean fresh surface water resources used for:
(1) consumption which requires ordinary water treatment process before use
(2) aquatic organism of conservation
(3) fisheries
(4) recreation

Class 3 Medium clean fresh surface water resources used for:
(1) consumption, but passing through an ordinary treatment process before using
(2) agriculture

Class 4 Fairly clean fresh surface water resources used for:
(1) consumption, but requires special water treatment process before using
(2) industry

Class 5 The source which are not classification in class 1-4 and used navigation.

Source: Law and Standard on Pollution Control in Thailand, 3rd Edition, 1994

### (3) Effluent Standard for WWTP

BMA decided standards for WWTP effluent as ”BMA Requirements”, and parameters such as nitrogen (Ammonia and T-N), phosphorus, DO are stipulated in conformity to Building Effluent Standard (Type A) under Public Health Act(1992). BOD/T-N ratio is stipulated to be 4 or higher and this is decided for biological wastewater treatment (Table 3.2.2).

**Table 3.2.2 Effluent Standards (BMA)**

| Parameter | Unit | Building Effluent Standards | BMA Requirements |
|---|---|---|---|
| 1. pH | - | 5-9 | 5-9 |
| 2. BOD | mg/l | < 20 | < 20 |
| 3. SS | mg/l | < 30 | < 30 |
| 4. Total Nitrogen* | mg/l | | < 10 |
| 5. Nitrogen (Kjeldahl ) | mg/l | < 35 | |
| 6. Nitrogen (Ammonia) | mg/l | | < 5 |
| 7. Total Phosphorus | mg/l | | < 2 |
| 8. Dissolved Oxygen | mg/l | | > 5 |

Note: * Only applicable when BOD/N ratio in the incoming wastewater is 4 or higher

Source: DDS

Effluent standards for WWTP have not been enforced at national level. Draft standard as shown in Table 3.2.3 was submitted and approved at National Environmental Board meeting held in October, 2009 and published and the standards came into effect on 2nd June 2010.

**Table 3.2.3 Standard for Centralized Wastewater Treatment Plant**

(Published on 2nd June 2010)

| Water Quality Index | Unit | Criteria |
|---|---|---|
| 1. pH | - | 5.5-9.0 |
| 2. BOD *(Biochemical Oxygen Demand) | mg/l | = 20 |
| 3. Suspended Solids ** | mg/l | = 30 |
| 4. Fat ,Oil and Grease | mg/l | = 5 |
| 5. Total Phosphorus | mg. P/l | = 2 |
| 6. Total Nitrogen | mg. N/ l | = 20 |

Remarks:

* In case the last treatment unit is Stabilization Pond or Oxidation Pond, use the Filtrate BOD through the Glass Fiber Filter Disk to collect the Suspended Solids.

** In case the last treatment unit is the Stabilization Pond or the Oxidation Pond, not greater than 50 mg/liter

Source: DDS

### (4) Control Measures for Discharge by BMA

Provision of on-site wastewater treatment facilities are compulsory for construction permission of condominium, hotel, dormitory, hospital, educational institution, government agency, state or private sector enterprise, department store, market, restaurant, and residential (Table 3.2.4).

## Table 3.2.4 Building Effluent Standards

| Effluent Quality Standards | Types of Buildings | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| 1. pH | 5-9 | 5-9 | 5-9 | 5-9 | 5-9 |
| 2. BOD (mg/l) | = 20 | = 30 | = 40 | = 50 | = 200 |
| 3. Suspended Solids (mg/l) | = 30 | = 40 | = 50 | = 50 | = 60 |
| 4. TDS (mg/l) | = 500 | = 500 | = 500 | = 500 | — |
| 5. Settable Solid (mg/l) | = 0.5 | = 0.5 | = 0.5 | = 0.5 | — |
| 6. TKN (mg/l) | = 35 | = 35 | = 40 | = 40 | — |
| 7. Org.-N (mg/l) | = 10 | = 10 | = 15 | = 15 | — |
| 8. $NH_3$-N (mg/l) | — | — | = 25 | = 25 | — |
| 9. Fat, Oil & Grease (mg/l) | = 20 | = 20 | = 20 | = 20 | = 100 |
| 10. $H_2S$ (mg/l) | = 1.0 | = 1.0 | = 3.0 | = 4.0 | — |

| Buildings | Types of Buildings | | | | |
|---|---|---|---|---|---|
| | A | B | C | D | E |
| Condominiums (No. of units) | = 500 | 100 = B < 500 | < 100 | - | - |
| Hotels (No. of rooms) | = 200 | 60 = B < 200 | < 60 | - | - |
| Dormitories (No. of rooms) | - | = 250 | 50 = C < 250 | 10 = D < 50 | - |
| Massage Parlors (or equivalent) - ($m^2$) | - | = 5,000 | 1,000 = C < 5,000 | < 1,000 [1] | - |
| Hospitals (No. of beds) | = 30 | 10 = B < 30 | - | < 10 [1] | - |
| Educational Institutes ($m^2$) | = 25,000 | 5,000 = B < 25,000 | - | < 5,000 [1] | - |
| Buildings on lands of the housing estate (No. of units) [1] | > 500 [2] | 100 = B = 500 [2] | 10 = C < 100 [1] | | |
| Government offices, State enterprises, International agencies, Banks and Office buildings ($m^2$) | = 55,000 | 10,000 = B < 55,000 | 5,000 = C < 10,000 | < 5,000 | - |
| Department Stores ($m^2$) | = 25,000 | 5,000 = B < 25,000 | 1,000 = C < 5,000 [1] | < 1,000 [1] | - |
| Fresh Food Markets ($m^2$) | = 2,500 | 2,500 = B < 1,500 | 1,000 = C < 1,500 | 500 = D < 1,000 | - |
| Restaurants, Food shops or Food centers ($m^2$) | = 2,500 | 500 = B < 2,500 | 250 = C < 500 | 100 = D < 250 | < 100 |
| Residential Building($m^2$) | | = 10,000 | 2,000 = C < 10,000 | < 2,000 | |
| Single House ($m^2$) [3] | | | | = 1,000 [3] | |

Remarks

1 - Ministerial Regulation Copy 51 B.E. 2541 (1998) – Building Control – The Ministry of Interior Affairs

2 - Notification of the Ministry of Natural Resources and Environment : Housing Estate Standards dated November 7, B.E. 2548 (2005) published in the Royal Government Gazette, Vol. 122 Part 125 D, dated December 29, B.E. 2548 (2005)

3 - Bangkok Metropolitan Administration Ordinance on Building Control 2001

*For individual house, provision of septic tank, grease trap and filter trap (to remove impurities) is mandated, which is written on the BMA same regulation above.

Source: Bangkok Metropolitan Administration Code of Law (Minister of Interior), Effluent Quality Standard (Amended Act)

### (5) Wastewater Service Tariff

BMA Ordinance "Collected Wastewater Tariff, 2004" enabling BMA to collect service charge was enacted but yet to be implemented.

## 3.2.2 Higher Ranked Plans of BMA

Information about latest national and BMA plans which are related to the sewerage system was collected to harmonize policies of these plans with those for sewerage development.

### (1) Sewerage System Development Plan of BMA

Bangkok Metropolitan Administration Action Plan on Global Warming Mitigation (2009 – 2012) was established in 2008 on which the sewerage system development plan should be based. In the Plan, BMA published five strategies to lead the world and to make Bangkok regional center by maintaining high quality of city environment and citizens' life. One of the five strategies is "Enhancement of Efficiencies of Water Quality Improvement Projects". To realize the strategy, three goals are mentioned, i.e. i) wastewater treatment service ratio, ii) water quality target for klongs and iii) treated wastewater reuse ratio and sludge reuse. Targets for these items in 2020 and those in 2009 and 2012 are also mentioned as shown in Table 3.2.5.

**Table 3.2.5 Enhancement of Efficiencies of Water Quality Improvement Projects**

| Indicators for Strategic Issue | Unit | Current (2008) | 2009 | 2012 | 2020 |
|---|---|---|---|---|---|
| 1. Percentage of domestic wastewater treated | % | 40 | 40 | 42 | 60 |
| 2. Recovered water quality in the target canals. | | | | | |
| 2.1 Enhancing the quality of effluent from the BMA's wastewater treatment plants (BOD) | mg/l | ≦15 | ≦15 | ≦10 | ≦10 |
| 2.2 Recovered water quality (DO) | mg/l | ≧1 | ≧1 | ≧1.5 | ≧2.0 |
| 2.3 Maintained water quality (DO) | mg/l | ≧2 | ≧2 | ≧2 | ≧2.5 |
| 3. Reused by-products from wastewater treatment plants. | | | | | |
| 3.1Percentage of treated wastewater volume | % | 3 | 4 | 5 | 7 |
| 3.2 Quality of compost produced by sludge | $m^3$/year | 5,000 | 5,000 | 10,000 | 12,000 |

Source: BMA

In order to realize the goals, the following strategies are proposed.

i) Increase the volume of wastewater treated in northern part of Bangkok.
ii) Enhance the effluent quality of BMA's wastewater treatment plants in terms of BOD and increase the efficiency of the circulatory water system in the target canals of service area in Bangkok.

iii) Support the utilization of by-products of wastewater treatment plants.

### (2) City Planning/Land Use Plan

City Development Plan and Land Use Plan were established by City Planning Department of BMA. Contents of the Plans are described in the following Chapter 5 Conceptual Master Plan.

### (3) Water Supply Project by MWA

MWA prepared a water supply master plan of which target year is 2057. Wastewater flows can be estimated based on the past records and future projections of water supply and its usage. MWA service area covers BMR area including neighboring Nonthabri and Samut Prakarn Provinces. Therefore, it is difficult to separate data for BMA.

Volumes of water sale by user category in 2009 were obtained from MWA and are shown in Table 3.2.6. Total residential uses was 654 million $m^3$/year (595 million $m^3$/year + 59 million $m^3$/year), and accounts for 53 % of total volume. Industrial use accounts for only 4 % at present. MWA has a policy to appeal to factories in the suburbs to convert their industrial water source from groundwater to water supply.

**Table 3.2.6 MWA Sale Water Volume in FY 2009**

| Type of Users | Sale Water Volume (million $m^3$/year) |
|---|---|
| Residences | 595 |
| Commercial Business | 403 |
| Governmental office | 46 |
| Industrial sector | 50 |
| Temporary use (In occasion case) | 46 |
| Bulk Sale (Residence) | 59 |
| Bulk Sale (Commercial) | 31 |
| Public Water Supply and Other | 20 |
| Total | 1,250 |

Source: MWA

### (4) BMA Countermeasures against Climate Change and Global Warming

In Action Plan on Global Warming Mitigation 2007–2012 of BMA, construction of wastewater treatment plants to control emission of methane gas, and campaign for citizens not to dump wastes to klongs are planned (Table 3.2.7). Brief description is as follows.

Objective: The action plans and activities under this initiative aim to increase efficiencies in

solid waste management and waste water treatment

Action plan under consideration: Waste-to-Energy Project

Action Plan 2: Increase efficiency in wastewater treatment

- Activity 2.1: Increase wastewater treatment capacity

  The Bangkok Metropolitan Administration is planning to construct additional wastewater treatment plants which will increase treatment capacity from 1 million $m^3$ to 1.8 million $m^3$/d, which will help to reduce methane gas emissions by 0.05 million tons $CO_2$ equivalent.

- Activity 2.2: Reduce household wastewater

  Campaign for Bangkokians not to dump organic matter, e.g. cooking oil, food, etc. into drainage systems. This activity aims to reduce wastewater in Bangkok by 10%.

  (Source: Bangkok Metropolitan Administration Action Plan on Global Warming Mitigation 2007 – 2012, Executive Summary)

**Table 3.2.7 Action Plans for Reduction of GHG**

| Activity | Target GHG Reduction (million tons $CO_2$ equivalent) |
|---|---|
| Action Plan 1 | |
| Activity 1.1: Improve efficiency in organic waste management | 0.10 |
| Activity 1.2: Support solid wastes reuse and recycling | 0.28 |
| Action Plan 2 | |
| Activity 2.1: Increase treatment capacity | 0.05 |
| Activity 2.2: Reduce household wastewater | 0.03 |
| Total | 0.46 |

Source: Bangkok Metropolitan Administration Action Plan on Global Warming Mitigation 2007 – 2012, Executive Summary)

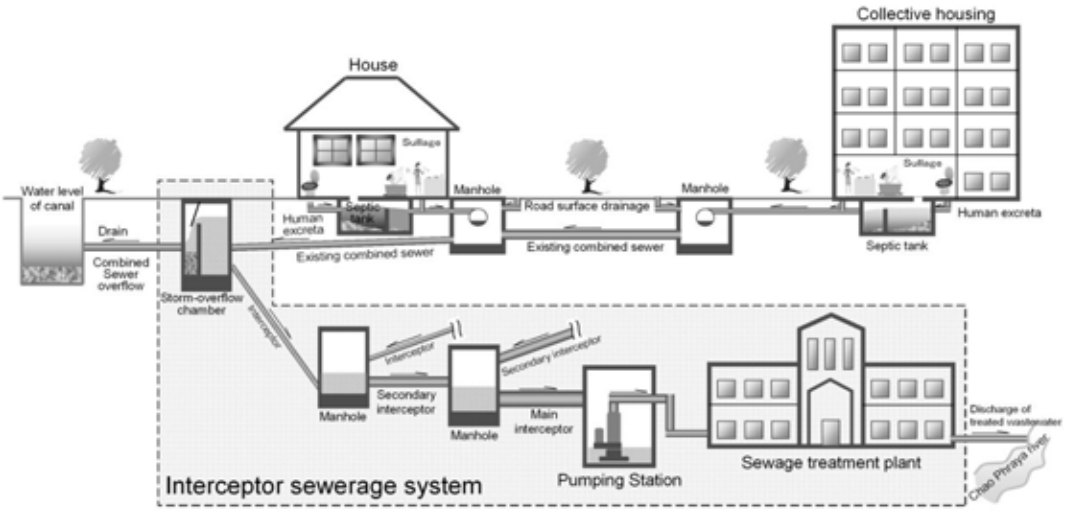
## 3.3 Confirmation of Current Sewerage System and Review of Existing Plan

### 3.3.1 Current Situation of Sewerage System

#### (1) Sewerage System in BMA (Interceptor Sewerage System, Thai Combined System)

Historically, sewerage system in BMA has been developed to aim at providing storm water drainage, and combined sewerage system collecting both wastewater and storm water has been adopted generally. In dry weather all of wastewater is collected by interceptors and treated at WWTPs. In wet weather, wastewater and storm water flow in combined sewers and up to a certain volume of combined sewage (usually 5 times Dry Weather Flow, DWF) is collected by interceptors and treated at WWTPs, and excess sewage is discharged at interceptor chambers which were constructed near klongs. Combined sewage up to design capacity of the WWTP is treated and excess sewage is again discharged to klong or river after removing grits by screen. There are more than 1,000 interceptor chambers in BMA area. In the areas where interceptor sewerage system is not provided, wastewater and storm water are discharged to klongs or rivers without treatment. Interceptor sewerage system utilizes the existing sewer pipes and reduction of pollution load in public water body can be expected. Therefore, interceptor sewerage system can be said as low-cost sewerage system.

Pollution load in wastewater is low because provision of septic tank to treat toilet wastewater is compulsory. Also unknown water to sewers such as backflow of klong water and groundwater infiltration is significant. Therefore, BOD concentration is as low as 1/2 to 1/3 that in Japan




Source: JST

**Figure 3.3.1 Concept of Interceptor Sewerage**

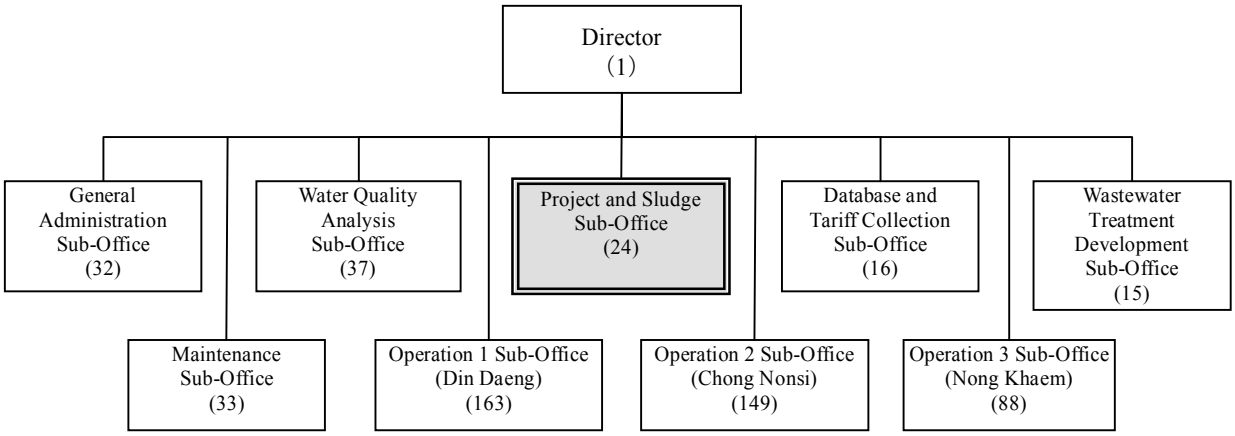
### (2) Current Situation about Sewerage Project

Thai government published its cabinet resolution in 1998, according to stipulations of Environmental Conservation Act of 1992, to enable BMA implement sewerage projects in the central core district of 100 $km^2$ area with subsidy. Thai government agreed that it would give subsidy at 75:25 ratio to BMA. Since then five (5) WWTPs and more than 220 km interceptors have been constructed.

Currently, DDS operates seven (7) WWTPs (total design capacity 992,000 $m^3/d$ ). A total of 675,000 $m^3/d$ of wastewater which is generated from the treatment areas of 192 $km^2$ is treated. Also DDS operates 12 small scale wastewater treatment plants transferred from NHA, and three small treatment facilities including purification plants of Makkason Pond and Rama IX Pond.

### (3) Organization and Operation and Maintenance

Water Quality Management Office's (former Wastewater Treatment Division) responsibility includes planning, construction and management of WWTPs. Total number of DDS regular staff is 156 in 2008. In addition to the regular staff there are 289 non-regular technicians, and 113 temporary staff totaling 558 persons all together. Organization chart of DDS is shown in Figure 3.3.2 below.




Source: DDS

**Figure 3.3.2 Organization Chart of Water Quality Management Office**

Operation and maintenance of two oldest WWTPs (Rattanakosin and Si Praya) is carried out by DDS itself and those of remaining five WWTPs (Chong Nonsi, Nong Khaem, Thung Khru, Chatuchak and Din Daeng) are entrusted to private companies on management contract.

### (4) Funds for Construction, Operation and Maintenance Cost and Sewerage Tariff

Although the Thai government agreed to give subsidy on 75:25 ratio base for implementation of sewerage project in 1998, the ratio of the subsidy has since been gradually decreased as shown in Table 3.3.1.

**Table 3.3.1 Funds for Construction of Sewerage Systems in BMA**

| Treatment Area | Area ($km^2$) | Population | Capacity ($m^3/d$) | Start Operation | Source of Fund (BMA. : GOV) | Cost (Million Baht) |
|---|---|---|---|---|---|---|
| 1. Si Phraya | 2.7 | 120,000 | 30,000 | 1994 | BMA 100 % | 464 |
| 2. Rattanakosin | 4.1 | 70,000 | 40,000 | 2000 | GOV. 100% | 883 |
| 3. Din Daeng | 37.0 | 1,080,000 | 350,000 | 2004 | 25 : 75 | 6,382 |
| 4. Chong Nonsi | 28.5 | 580,000 | 200,000 | 2000 | 40 : 60 | 4,552 |
| 5. Nong Khaem | 44.0 | 520,000 | 157,000 | 2002 | 40 : 60 | 2,348 |
| 6. Thung Khru | 42.0 | 177,000 | 65,000 | 2002 | 40 : 60 | 1,760 |
| 7. Chatuchak | 33.4 | 432,000 | 150,000 | 2005 | 60 : 40 | 3,482 |
| 8. 12-Community Plant | | | 25,700 | | | |
| Total | 191.7 | 2,979,000 | 1,017,700 | | | 19,871 |
| Future BMA. Wastewater Treatment Project (F/S basis) | | | | | | |
| 1. Bang Sue | 21.0 | 250,000 | 120,000 | 2012 | BMA 100 % | 4,732 |
| 2. Klong Toei | 56.0 | 485,000 | 360,000 | | 60 : 40 | 11,046 |
| 3. Thon Buri | 59.0 | 704,000 | 305,000 | | | 11,561 |
| Total | 136.0 | 1,439,000 | 785,000 | | | 27,339 |

Note: Cost includes construction cost of WWTP and interceptors

Source: JST

On the other hand, entire operation and maintenance cost has been borne by BMA as shown below.

O&M cost in 2008 without depreciation

- O&M cost for large scale WWTPs: 587 million Baht
- O&M for small scale WWTPs: 40 million Baht
- O&M for klong purification plants: 17 million Baht
- Total 644 million Baht

From above cost figures, unit O&M cost for each category was calculated as follows.

- Unit O&M cost for large scale WWTPs: 2.38 Baht/$m^3$
- Unit O&M cost for small scale WWTPs: 7.44 Baht/$m^3$

BMA Ordinance for wastewater tariff was enacted in 2004, but tariff has yet to be collected. In

Thailand, cities where wastewater tariff is collected are limited to a few tourism cities such as Pattaya. BMA has been conducting various preparatory works to collect wastewater tariff for several years. Discussions with MWA were held for collection of wastewater tariff together with water tariff. A report was submitted in 2008 for approval of the governor, which describes tariff system, appropriateness of collection of tariff, procedures for introduction of the system, and method of collection. Proposed tariff system is basically based on volume and rates are 2 Baht/$m^3$ for residential and public facility use, 4 Baht/$m^3$ for large scale commercial use and 4–8 Baht/$m^3$ for industrial use.

### (5) Revenues and Expenditures of DDS and BMA

Revenues and expenditures of BMA for the latest five years (2007 – 2011) are shown in Table 3.3.2. Fiscal year in Thailand starts from October and ends in September next year.

**Table 3.3.2 Revenues and Expenditures of BMA (2007 -2011)**

**Revenue of BMA** **unit: Baht**

| Fiscal Year | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| 1. Tax | 37,372,400,000 | 42,832,700,000 | 43,783,000,000 | 39,133,000,000 | 44,133,000,000 |
| 2. Fees, Permission Charge, Fines and Services | 815,000,000 | 897,300,000 | 950,000,000 | 950,000,000 | 1,150,000,000 |
| 3. Property Management | 500,000,000 | 802,000,000 | 723,000,000 | 373,000,000 | 323,000,000 |
| 4. Commercial Infrastructure and etc. | 30,000,000 | 44,000,000 | 44,000,000 | 44,000,000 | 34,000,000 |
| 5. Miscellaneous | 282,600,000 | 424,000,000 | 500,000,000 | 500,000,000 | 360,000,000 |
| **Total Revenue** | **39,000,000,000** | **45,000,000,000** | **46,000,000,000** | **41,000,000,000** | **46,000,000,000** |

**Expenditure of BMA** **2550** **unit: Baht**

| Fiscal Year | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| 1. General Administration | 8,359,262,200 | 9,738,893,800 | 9,140,100,500 | 8,695,308,000 | 10,343,264,100 |
| 2. Cleansing and Tidiness Management | 6,945,997,700 | 7,063,651,400 | 7,694,338,800 | 6,781,565,400 | 6,528,033,500 |
| 3. Civil Engineering and Transportation | 6,310,388,600 | 7,824,462,700 | 9,502,949,300 | 6,839,042,500 | 9,247,871,600 |
| 4. Drainage and Wastewater Management | 4,327,169,300 | 3,403,212,200 | 4,392,755,400 | 4,162,919,900 | 3,863,689,700 |
| 5. Social Services and development | 4,268,172,600 | 7,568,494,200 | 4,900,007,800 | 5,005,342,300 | 5,536,988,100 |
| 6. Public Health | 4,560,127,100 | 4,877,101,300 | 5,440,200,900 | 5,331,121,400 | 5,710,355,500 |
| 7. Education | 4,228,882,500 | 4,524,184,400 | 4,929,647,300 | 4,184,700,500 | 4,769,797,500 |
| **Total Expenditure** | **39,000,000,000** | **45,000,000,000** | **46,000,000,000** | **41,000,000,000** | **46,000,000,000** |

Source: BMA

DDS's budgets for purposes and expenditures for type of expenses are shown in Table 3.3.3.

**Table 3.3.3 Budgets and Expenditures of DDS (2007 – 2011)**

**DDS Budget for Purposes** unit: Baht

| Fiscal Year | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| 1. General Administration | 27,714,400 | 41,286,200 | 41,241,600 | 71,209,300 | 62,731,200 |
| 2. Drainage System Development | 1,351,714,200 | 517,832,800 | 675,557,400 | 374,933,100 | 416,328,500 |
| 3. Drainage Management and Flood Protection | 1,495,572,700 | 1,684,136,300 | 1,919,903,600 | 1,920,235,900 | 2,037,003,700 |
| 4. Water Quality Management | 706,220,300 | 354,428,300 | 977,039,300 | 1,214,282,700 | 673,887,600 |
| **Total Budget** | **3,581,221,600** | **2,597,683,600** | **3,613,741,900** | **3,580,661,000** | **3,189,951,000** |

**DDS Expenditure for Type of Expenses** unit: Baht

| Fiscal Year | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| 1. Salaries | 464,421,300 | 502,133,300 | 530,948,400 | 532,284,500 | 446,714,700 |
| 2. Wages | 69,022,700 | 63,131,400 | 62,232,900 | 88,306,000 | 46,253,800 |
| 3. Office supplies and materials | 292,363,800 | 546,557,900 | 560,184,400 | 518,065,800 | 604,200,200 |
| 4. Utilities | 182,112,500 | 182,166,600 | 187,226,200 | 264,552,700 | 198,257,500 |
| 5. Land and Property | 1,982,196,900 | 954,059,200 | 1,361,213,800 | 1,171,004,000 | 870,834,600 |
| 6. Subsidy | 8,720,500 | 8,841,500 | 9,185,500 | 9,533,000 | 10,016,000 |
| 7. Other expenses | 582,383,900 | 340,793,700 | 902,750,700 | 996,915,000 | 1,013,674,200 |
| **Total Expenditures** | **3,581,221,600** | **2,597,683,600** | **3,613,741,900** | **3,580,661,000** | **3,189,951,000** |

Source: BMA

### 3.3.2 Development Plan of Sewerage System

#### (1) Outline of Previous Sewerage Plans

Previous Master Plans for sewerage development were mentioned below.

1968 Sewerage Master Plan by CDM (USA consultants), Planned area 370 $km^2$
1981 Sewerage Master Plan by JICA, Planned area 370 $km^2$, 10 zones
1992 Master Plan of Wastewater Management by PCD and Macro Consult
1998 Cabinet Resolution to Construct WWTPs, Planned area 100 $km^2$, inner cities
1999 Master Plan on Sewage Sludge Treatment and Reclaimed Wastewater Reuse by JICA

In addition to the Master Plans mentioned above, the following two studies were conducted by JICA.

Master Plan on Flood Protection/Drainage Project in Eastern Suburban Bangkok (1983–86)
Feasibility Study on Water Quality Improvement of Klongs in Bangkok (1987–89)

BMA prepared “Sewerage Master Plan” in 1981 with assistance from JICA. In the Master Plan, it is mentioned that water quality in the river will be deteriorated further without sewerage project and DO level of the river in sections at 40 – 20 km upstream of the river mouth will reach to almost zero. It also mentioned that management and control of domestic and industrial wastewater was necessary. The Master Plan recommended adoption of combined system with treatment plant for which existing sewers could be utilized until such time when investment for separate system become available although sewerage system should be provided as separate system. Entire master plan area was divided into 10 treatment areas each of which would have

wastewater treatment plant.

This Master Plan was at least revised twice, firstly in 1992 by PCD, MOST, and secondly in 1999 by JICA. Revised Master Plan in 1999 is the basis for current implementation of sewerage project by BMA. BMA has been constructing interceptors and wastewater treatment plants based on this revised Master Plan.

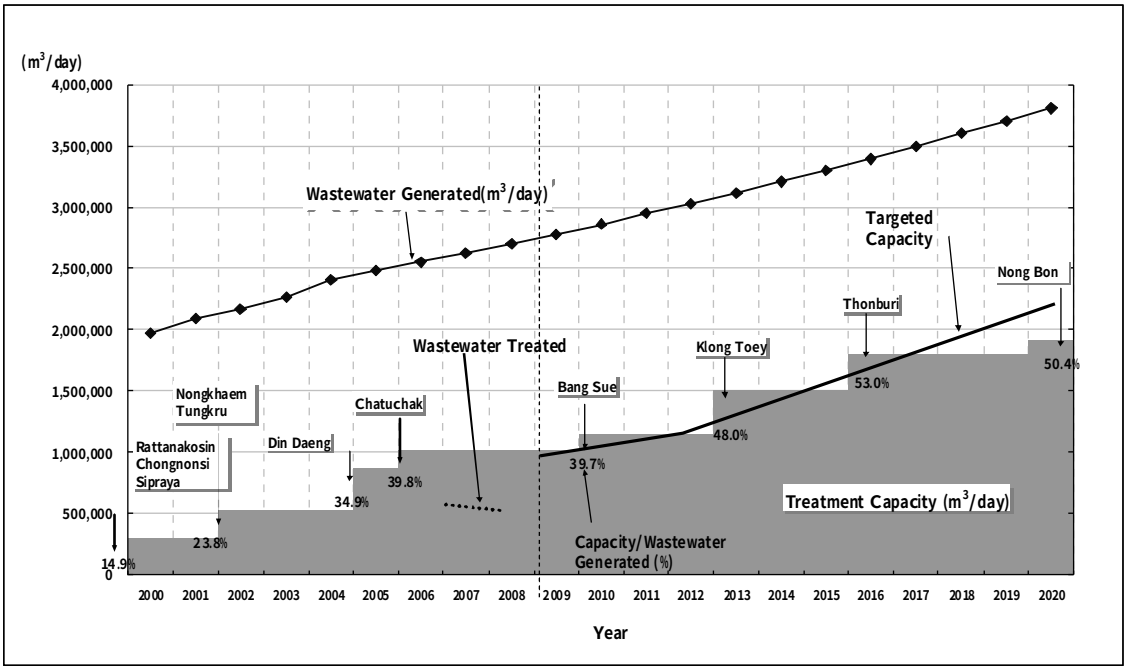
**(2) Current Sewerage Implementation Plan**

In "Master Plan on Sewage Sludge Treatment and Reclaimed Wastewater Reuse" prepared by JICA in 1999, 13 new treatment areas are proposed together with reuse of sludge and reclaimed wastewater. BMA established sewerage implementation plan up to 2020 based on the Master Plan in which 20 treatment areas are planed (refer to Figure 3.3.3).

BMA has been implementing sewerage projects based on the 1999 master plan, and seven (7) WWTPs are now in operation, Bang Sue WWTP is under construction, Klong Toei WWTP and Thon Buri WWTP are in process of planning. Total design capacity of the existing WWTPs together with 12 small scale treatment plants is approximately 1 million $m^3$/d which accounts for 40 % of wastewater generated.

On the other hand, there is BMA Action Plan prepared in 2008 as higher ranked plan in which service ratio in 2012 is targeted to be 42 % and that of long term in 2020 is targeted to be 60 %. DDS is considering implementation program as shown in Figure 3.3.3 to realize these targets. According to the program, after completion of construction of Bang Sue WWTP, construction of Klong Toei WWTP and Thong Buri WWTP is planned and further construction of Nong Bon WWTP is expected. In addition, DDS secured next year budget to carry out F/S for Min Buri treatment area.

For the remaining 8 treatment areas among 20 treatment areas in the existing M/P, there is no concrete implementation plan due to non-availability of site. DDS should consider ways to materialize these projects. In addition, improvement and strengthening of function to intercept more wastewater for treatment, and expansion and modification of the existing WWTPs are required.




Source: DDS

**Figure 3.3.3 Wastewater Generated and Treatment Capacity**

### 3.3.3 Reuse of Reclaimed Wastewater and Sludge

#### (1) Plan for Reclaimed Wastewater

BMA has a policy to utilize reclaimed wastewater efficiently and established a committee to study on guidelines for reuse and to monitor the situation of reuse. In 2008, about 20,000 $m^3$/d of the treated wastewater, which is approximately 3% of the total 620,000 $m^3$/d, had been reused. Main purposes of reuse are washing water in the plants, sprinkling water to trees, and street cleaning water.

Activities proposed in reuse plan in 2008 are as follows.

- Construction of water channel from Chong Nonsi WWTP to Lum Pini Park
- Detailed design of dripping tubes for trees along Silom Road
- Investigation of route of water channel from Rama IX treatment plant to Somdet Saranraj Maneerom Park, Klong Chuat Ta Chiang and Plub Pla pumping station
- Consultation with managers of the 7 large-scale wastewater treatment plants to seek for additional benefit for more recycle of treated wastewater

**(2) Reuse of Sewerage Sludge**

Dehydrated sludge from all WWTPs are transferred to Nong Khaem WWTP and treated at the plant. Sludge is mixed with natural rice straw at ratio of 7:3 and compost is produced. A total of 9,430 $m^3$ compost is produced from 15,100 $m^3$ sludge in 2008 and delivered to nearby district offices and park administration offices. Main purpose of reuse is manure for trees along streets and in parks. DDS is planning to increase production capacity of compost plant because annual demand is estimated to be 12,000 $m^3$. DDS is carrying out investigation with Mahidol University to use compost manure for agriculture.

A total of 9,430 $m^3$ compost was delivered to the following places.

- Cleansing and Park Division: Nong Khaem District, Chatuchak District, Bang Plad District, Bang Kae District
- Park Office: Thonburirom Park, Somdet Pra Sirikit Park, Bangkok Mass Transport Authority

### 3.3.4 Other Water Quality Improvement Plan (Klong Water Purification Project etc.)

**(1) Introduction and Circulation of Purification Water Project**

DDS has been implementing Introduction and Circulation of Purification Water Project under name of "Clean 95 Klongs Plan" to improve water quality in klongs (DO level at 1 mg/l). This Project, which was proposed in Feasibility Study on Water Quality Improvement of Klongs in Bangkok (1987 – 89) by JICA, aims to improve water quality in klongs by introducing purification water from Chao Phraya River in dry season and circulating the water in klongs, and pumping out contaminated klong water to downstream of Chao Phraya River. Implementation of the project resulted in improvement of water quality, and average DO level in 41 klongs in Bangkok side reached to 1.8 mg/l and that in 16 klongs in Thon Buri side reached to 2.8 mg/l in 2008.

Eighteen (18) pumping stations were constructed under this Project, and these pumping stations are used for pumping out storm water from klongs to Chao Phraya River in wet weather.

**Photo 3.3.1 Dilution of Klong Water System (No.8 Pak K. Talad Gate)**

**Photo 3.3.2 Dilution of Klong Water System (No.13 Chong Nonsi Pumping Station)**

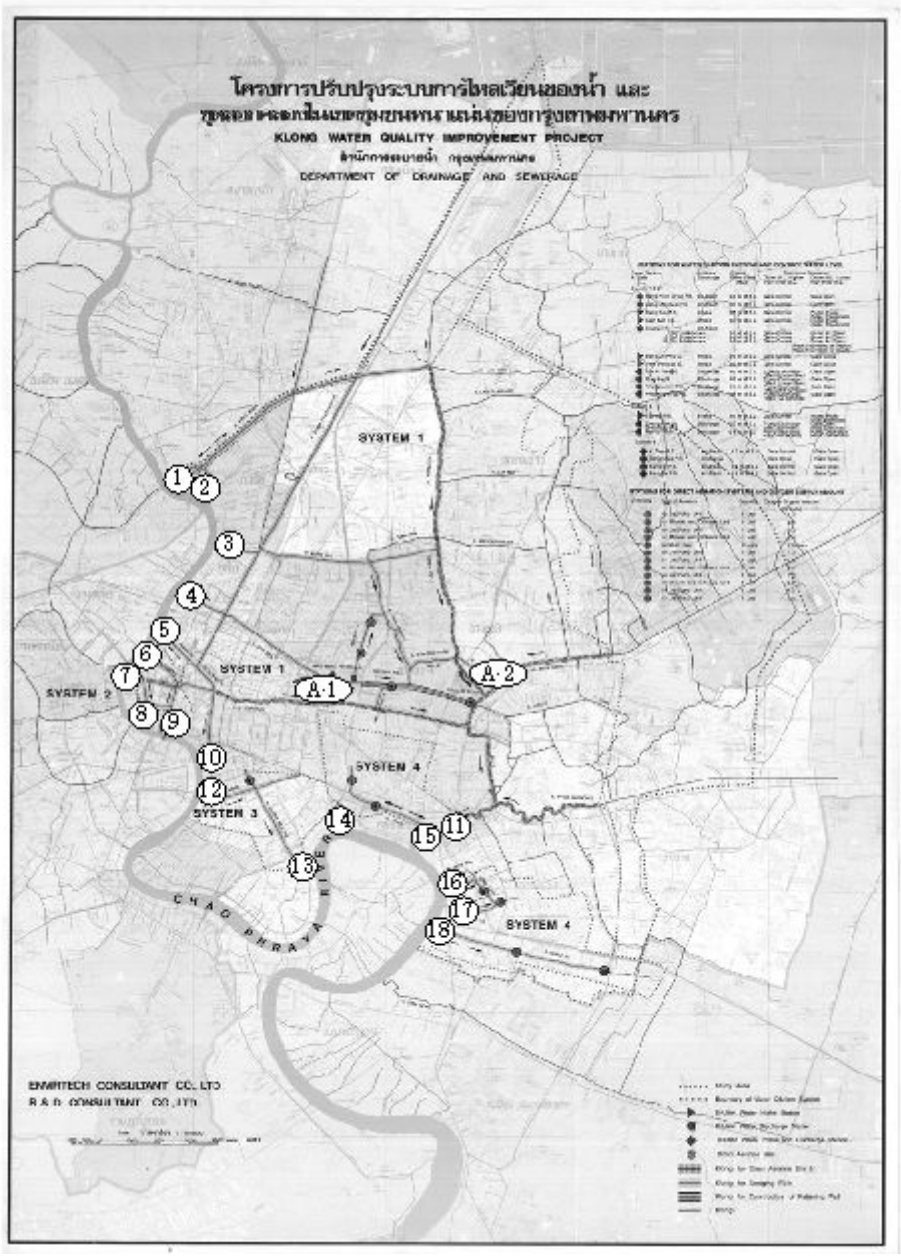
### (2) Purification of Klong Project (Aerated Lagoon System)

In addition to Klong Water Purification Project mentioned above, water purification by direct aeration is operated in two ponds to improve water quality in neighboring klongs. These are as follows.

- Makkason Pond：Improvement of Klong Sam Sen
- Rama IX Pond：Improvement of Klong Lat Phrao

**Photo 3.3.3 Rama IX Pond (1)**

**Photo 3.3.4 Rama IX Pond (2)**




**Station for Water Dilution Systems**

| | Name of P.S. and Gate |
|---|---|
| System 1 & 2 | |
| 1 | Bang Khen Ghao P.S. |
| 2 | Bang Khen Mai P.S. |
| 3 | Bang Sue P.S. |
| 4 | Sam Sen P.S. |
| 5 | Tavale P.S. |
| 6 | Ban Lum Phu Gate |
| 7 | Phra Phinhlao Gate |
| 8 | Pak K Talad Gate |
| 9 | Oug Ang Gate |
| 10 | Krung Kasem P.S. |
| 11 | Phra Khanong P.S. |
| System 3 | |
| 12 | Sathong P.S. |
| 13 | Chong Nonsi Temporary P.S. |
| 14 | Rama IV P.S. |
| System 4 | |
| 15 | Khlong Toey P.S. |
| 16 | Bang Chak P.S. |
| 17 | Bang Or P.S. |
| 18 | Bang Na P.S. |

**Aerated Lagoon Systems**

| | Name of Aerated Lagoon Systems |
|---|---|
| A-1 | Makkasan Pond |
| A-2 | Rama IX Pond |

Source: DDS

**Figure 3.3.4 Location of Klong Purification Plant**

### 3.3.5 Status of Aid to Sewerage Sector in Bangkok by International Aid Organization

Aid from international aid organization to sewerage sector in Bangkok has been materialized to Klong Toei and Thon Buri Projects both of which are under planning.

#### (1) Klong Toei Project

Feasibility study was completed by CDM (Camp Dresser & Mckee International Inc.) under aid program of the US TDA (Trade and Development Agency) in August, 2001. At the same time, WB (World Bank) approached and economic analysis and social analysis were conducted.

Aid from international aid organization was abandoned because implementation policy was changed with change of governor. Financial source for construction was agreed to be provided by BMA and the government (at 60:40 ratio). Implementation of the project is currently consulted among government agencies. Site for WWTP was acquired five years ago.

#### (2) Thon Buri Project

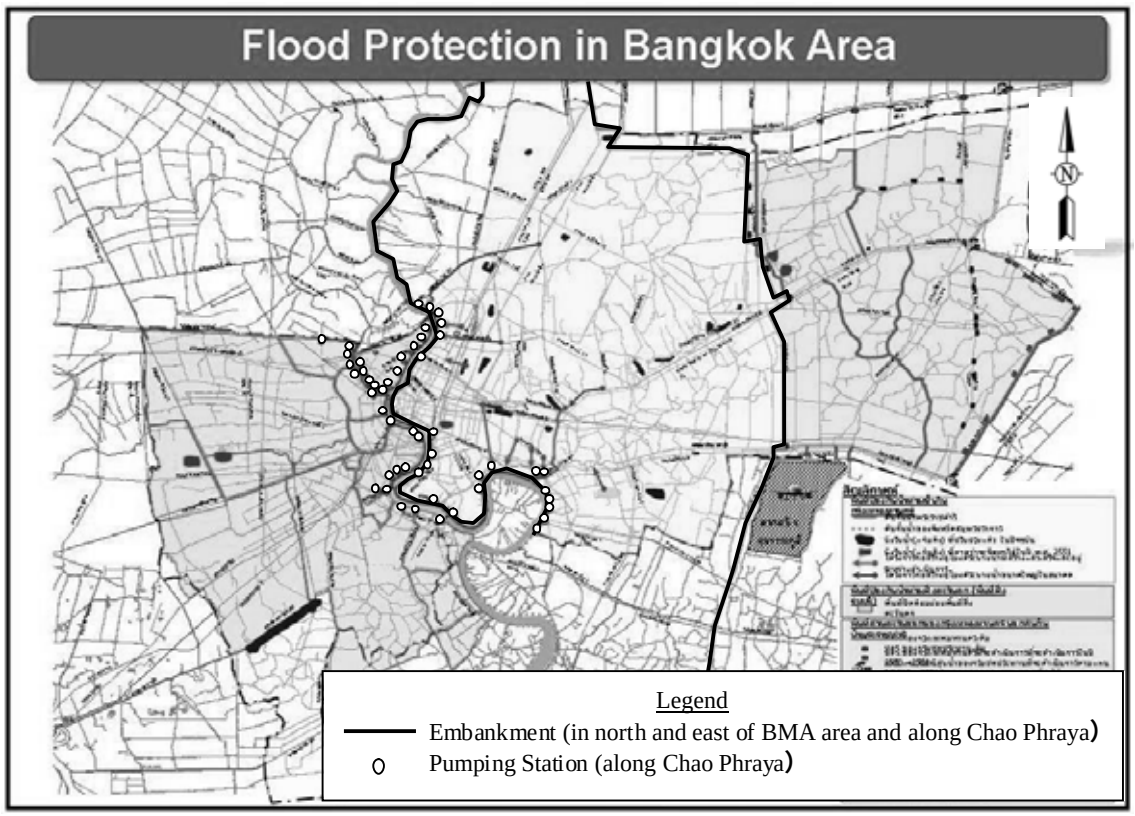
Feasibility study on the project was completed in 2005 with an aid from French government. Division of treatment area is under consideration because it is difficult to secure necessary land for construction of WWTP of which design capacity is 300,000 $m^3$/d. DDS is planning to complete review of the feasibility study within 2012, to secure budget in 2013, and to construct facilities in 2014/16. ADB and AFD (French Development Agency) are interested in financing the project.

## 3.4 Current Situation of Sewerage Facilities

### 3.4.1 Storm Water Drainage and Relevant Facilities

Topography of BMA is very flat and low-lying, and Chao Phraya River in BMA is a tidal river. Thus, BMA has often been suffered from flooding. Countermeasures against flooding have usually been implemented in advance of wastewater countermeasures.

In BMA, storm water run-off was discharged by gravity to Chao Phraya River through U-shaped drains and drain pipes constructed under roads. However, discharge by gravity became difficult because of the topography and thus, damages caused by flood became more serious due to rapid urbanization. Full-scale countermeasures for urban drainage and flood protection have been first taken after severe flood in 1983 which caused damages for not only Bangkok but Thai society and economy amounting 6,600 million Baths.




Source: DDS

**Figure 3.4.1 Flood Protection in Bangkok**

Several countermeasures have been implemented by the Department of Drainage and Sewerage (DDS, BMA), based on "JICA Master Plan on Urban Drainage and Flood Protection in Bangkok" (1983-86). The concept is polder system to protect urbanized area in Bangkok by the following countermeasures (Figure 3.4.1).

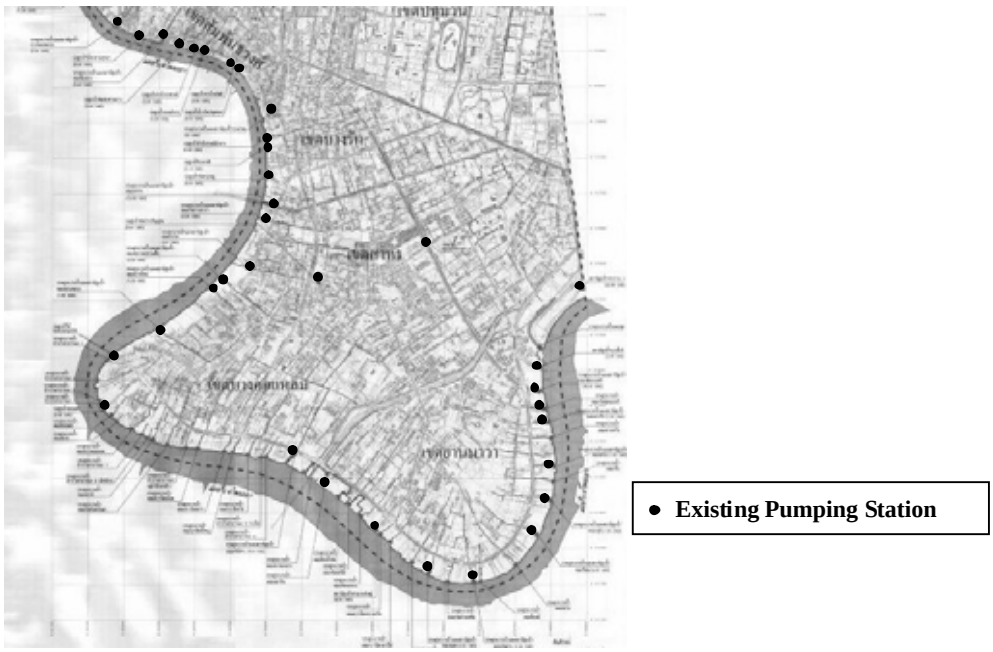
A) Inside the polder area the submersible pumps have been installed at several main pumping stations at the klong mouths along the Chao Phraya River. The pumping stations have been designed and built to increase the drainage capacity, which is 1,531 $m^3/s$ at present; of which 1,057 $m^3/s$ is for the east bank and 474 $m^3/s$ is for the west bank.

B) The 72 km King's Dike on the eastern Bangkok was constructed from the north through the east and south to prevent overland flow from the eastern flood plain into the city. Several control gates along King's Dike were also constructed. Further, DDS also constructed 77 km barriers along the Chao Phraya River.

Storm water drainage systems existing in BMA and those planned for future are described briefly below.

### (1) Existing Storm Water Pumping Station

Pumping stations to pump klong water to Chao Phraya River are provided at connecting points of klongs to the river and fitted with flow regulating gates. There exist several pumping stations at connecting points of klongs and drain pipes which were installed under roads. Locations of existing pumping stations from Pra Nakon to Yannawa districts are shown in Figure 3.4.2 below.




Source: DDS Drainage System Development Division

**Figure 3.4.2 Location of Existing Pumping Stations（Pra Nakon to Yannawa）**

**Photo 3.4.1 Phra Khanong Pumping Station**

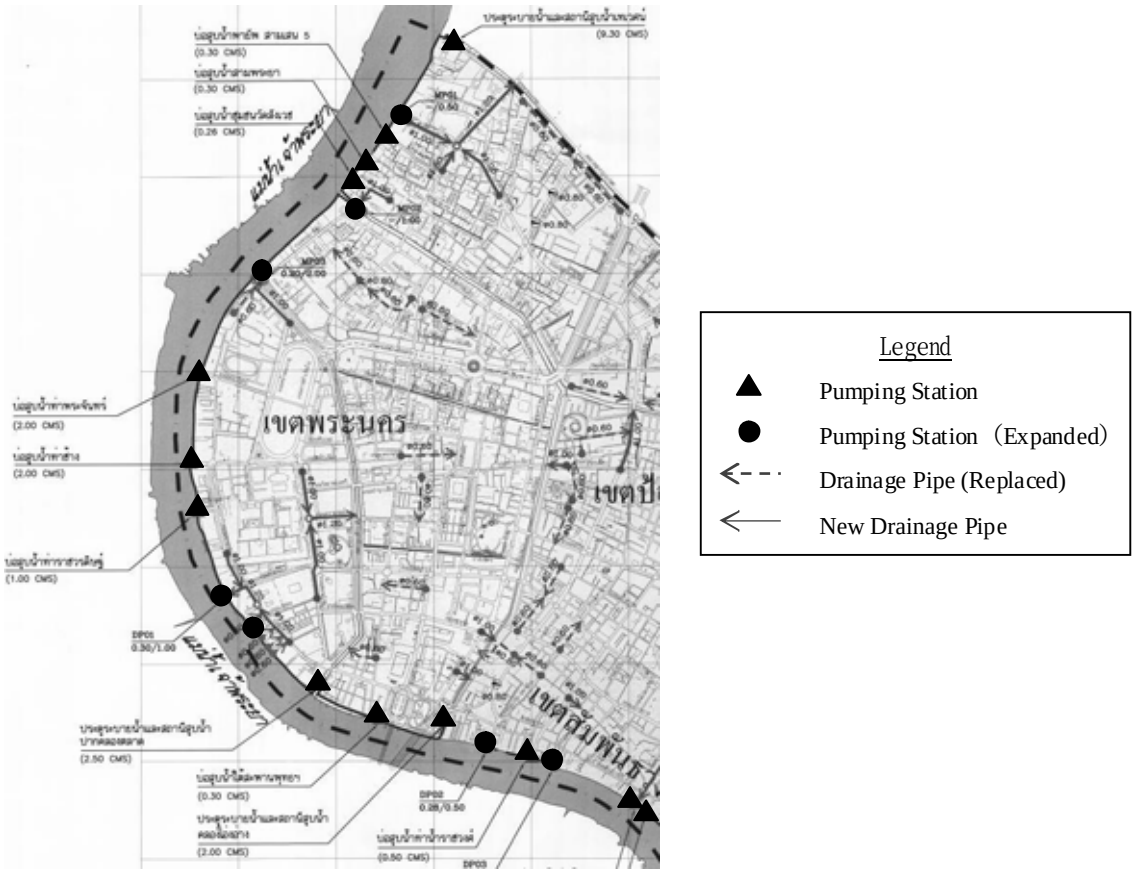
**Photo 3.4.2 Chong Nonsi Pumping Station**

**Photo 3.4.3 Existing Storm Water Pumping Station（along Nara Thiwat Rajanagarindra Street）**

**Photo 3.4.4 Existing Storm Water Pumping Station（along Phetchaburi Street）**

### (2) Construction of Additional Drain Pipes and Pumping Stations

Projects for construction of additional drain pipes and pumping stations are planned to increase flow capacity of existing drain pipes and to pump out storm water immediately to klongs or to Chao Phraya River. Figure 3.4.3 shows sample of these projecs in Pra Nakon district.

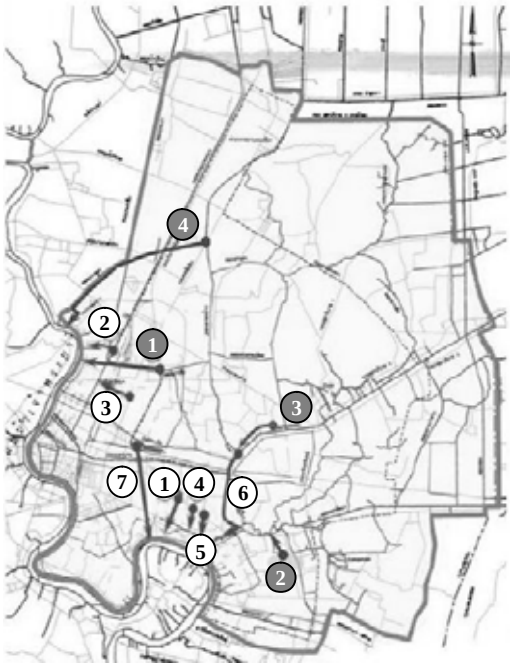



Source: DDS

**Figure 3.4.3 Sample of Projects for Additional Deep Tunnels and Pumping Stations**

### (3) Drainage Tunnel Project

Large scale projects for construction of tunnels have been implemented in BMA. In order to supplement flow capacity of klongs having insufficient capacity, deep tunnels with diameter 1 m to 5 m are laid in depth of 15 m to 22 m. Storm water is pumped to Chao Phraya River at pumping stations provided at the downstream end of tunnels. Seven (7) tunnels have been constructed with a total capacity of 155.5 $m^3/s$. Four (4) other tunnels are now under construction with an additional total capacity of 130 $m^3/s$.




7 Existing Drainage Tunnels ①②③④⑤⑥⑦

| No. | Tunnel Description | Capacity ($m^3/s$) | Diameter (m) | Length (km) | Budget (Mil. Baht) |
|---|---|---|---|---|---|
| 1 | Sukmvid Soi 26 | 4.0 | φ1.00 | 1.10 | 30 |
| 2 | Klong Permprachakorn | 30.0 | φ3.40 | 1.88 | 495 |
| 3 | Phaya Thai District | 4.5 | φ1.50<br>φ2.40 | 1.90<br>0.68 | 339 |
| 4 | Sukmvid Soi 42 | 6.0 | φ1.50<br>φ1.80 | 0.03<br>1.32 | 129 |
| 5 | Sukmvid Soi 49 | 6.0 | φ1.50<br>φ1.80 | 0.03<br>1.10 | 109 |
| 6 | Klong Saeng Saeb & Klong Lab Prao to Chao Phraya River | 60.0 | φ5.00 | 5.16 | 2,336 |
| 7 | Makkasan Pond to Chao Phraya River | 45.0 | φ4.60 | 5.98 | 2,166 |
| | Total | 155.5 | | 19.18 | 5,604 |

4 Tunnels under constructions ①②③④

| No. | Tunnel Description | Capacity ($m^3/s$) | Diameter (m) | Length (km) | Budget (Mil. Baht) |
|---|---|---|---|---|---|
| 1 | Klong Bansue | 60.0 | φ5.00 | 6.40 | 2,500 |
| 2 | Nongbon to Khlong Prawet Burirom | 20.0 | φ3.00 | 3.30 | 995 |
| 3 | Klong Samg Saob to Chao Phraya River | 10.0 | φ4.00 | 3.80 | 615 |
| 4 | Klong Bang Khem | 40.0 | φ3.80 | 10.70 | 2,400 |
| | Total | 130.0 | | 24.20 | 6,510 |

Source: Action Plan For Flooding Preventation (2010)

**Figure 3.4.4 Drainage Tunnel Project**

**Photo 3.4.5 Manhole Pumping Station at the Beginning of Tunnel, No.1 Sukmvid Soi 26**

**Photo 3.4.6 Manhole at the Beginning of Tunnel, No.6 Klong Saen Saep**


**Photo 3.4.7 Entrance to No.7 Makkasan Tunnel Pumping Station**

**Photo 3.4.8 Pump Pit of No.7 Makkasan Tunnel Pumping Station**

### (4) Priority Countermeasures for Flood Prone Areas

Increasing capacities of existing storm water pumping stations and provision of additional drain pipes as local countermeasures has been implemented in 15 areas in BMA. Flood prone areas and countermeasures are shown in Figures 3.4.5 and 3.4.6 and Table 3.4.1.

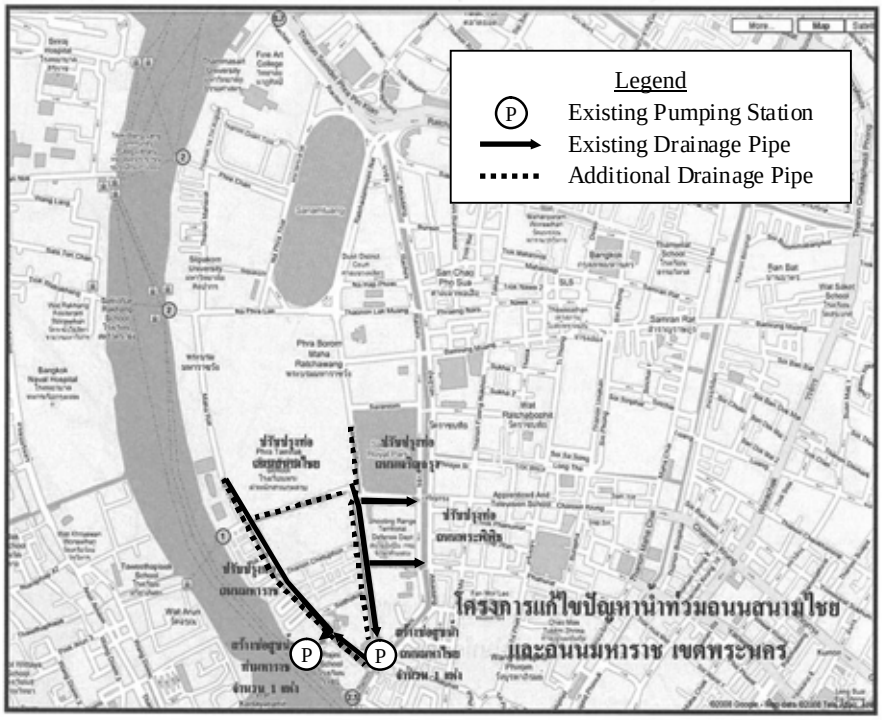

Source: Action Plan for Flooding Prevention (2010)

**Figure 3.4.5 Fifteen Flood Prone Areas**

**Table 3.4.1 Fifteen Flood Prone Areas**

| No. | Flood Vilunerability | District |
|---|---|---|
| 1 | Chan Road, St. Louis and Sarhupradit | Sathorn |
| 2 | Phahonyothin Road between Klong Samsen and Klong Bang Sue | Prayathai |
| 3 | Sukhumvit Road from Klong Prakanong to Soi La salle | Pra-ka-nong |
| 4 | Sukhumvit Road (Soi Sukhumvit 39 and 49) | Wtthana |
| 5 | Lad Prao Road from Klong Lad Prao to The Mall Department | Wangthonglang, Bang Kapi |
| 6 | Nawamin Road from Klong don-e-ka to Prasert Monookij | Bieng Koom |
| 7 | Ratchadapisek Road (in front of Robinson Department Store) | Dingdaeng |
| 8 | Ratchadapisek Road (Lap Prao intersection area) | Chatuchak |
| 9 | Phechaburi Road from Bunthutthong to Ratthawee inter section | Ratchathawee |
| 10 | Nikom Makkasun Road | Ratchathawee |
| 11 | Rama VI Road (in front of Pra-jae-jeen Market) | Ratchathawee |
| 12 | Phetkasem Road, Soi Phetkasem 63 (Wat Muang) | Bang kae |
| 13 | Yen-R-Kad Road from Nanglinjee Road to Soi Sri Bumpen | Yannawa |
| 14 | Srinakarin between klong Ta-sat to Klong Ta-chang | Prawet |
| 15 | Sanam-Chai Road and Maharaj Road | Pra-nakon |

Source: Action Plan For Flooding Prevention (2010)




Source: Action Plan for Flooding Prevention (2010)

**Figure 3.4.6 Example of Countermeasures in No.15 Pra Nakon District**

In this Pra Nakhon case, although pumping stations and drain pipes are provided, capacity of drain pipes is not enough to prevent flooding. Thus, additional drain pipes are to be provided.

### 3.4.2 Exiting Sewerage Facilities

DDS operates the following sewerage facilities;

i) Wastewater treatment plants and interceptors (seven treatment areas)
ii) Community wastewater treatment plants transferred from NHA (12 small scale plants)
iii) Other wastewater treatment plants (two klong water treatment plants and one waste leachate treatment plant)

#### (1) Wastewater Treatment Plants (Seven Large Scale Plants)

#### (A) Outline of Seven WWTPs

Seven existing wastewater treatment plants are in operation, of which two plants (Si Praya and Rattanakosin) are operated and maintained by DDS own staff and the other five plants are by O&M companies entrusted by DDS. Outline of seven wastewater treatment plants and interceptors are shown in Table 3.4.2.

## Table 3.4.2 Outlines of Existing Seven WWTP and Interceptors

| | Si Praya | Rattanakosin | Din Daeng | Chong Nonsi | Nong Khaem | Tung Khru | Chatuchak |
|---|---|---|---|---|---|---|---|
| 1. Start of Operation | 1994 | 2000 | 2004 | 2000 | 2002 | 2002 | 2006 |
| 2. Treatment Area | 2.7 $km^2$ | 4.142 $km^2$ | 37 $km^2$ | 28.5 $km^2$ | 44 $km^2$ | 42 $km^2$ | 33.4 $km^2$ |
| 3. Served Population | 120,000 | 70,000 | 1,080,000 | 580,000 | 520,000 | 177,000 | 432,500 |
| 4. Treatment Process | Contact Stabilization Activated Sludge | Two stage activated sludge N&P Removal | Activated Sludge with Nutrient N&P Removal | Cyclic Activated Sludge System N&P Removal | Vertical Loop Reactor Activated Sludge N&P Removal | Vertical Loop Reactor Activated Sludge (VLR-AS) N&P Removal | Cyclic Activated Sludge System (CASS) N&P Removal |
| 5. Site | 0.28 ha | 0.6683 ha | 2.72 ha | 3.2 ha | 8.64 ha | 0.48 ha | 1.12 ha |
| 6. Construction Cost | 464 M Baht | 883 M Baht | 6,382 M Baht | 4,552 M Baht | 2,348 M Baht | 1,760 M Baht | 3,482 M Baht |
| 7. Length of Sewer Pipe | 2.3 km | 16.25 km | 66 km | 55 km | 46 km | 26 km | 37.5 km |
| 8. Treatment Capacity | 30,000 $m^3/d$ | 40,000 $m^3/d$ | 350,000 $m^3/d$ | 200,000 $m^3/d$ | 157,000 $m^3/d$ | 65,000 $m^3/d$ | 150,000 $m^3/d$ |
| 9. Flow (Avearge in 2009) | 18,213 $m^3/d$ | 28,791 $m^3/d$ | 204,931 $m^3/d$ | 124,282 $m^3/d$ | 132,605 $m^3/d$ | 63,980 $m^3/d$ | 120,470 $m^3/d$ |
| 10. O&M by | DDS | DDS | Private Company | Private Company | Private Company | Private Company | Private Company |
| 11. Design Criteria for Influent Wastewater | | | | | | | |
| (1) BOD | 150 mg/l | 200 mg/l | 150 mg/l | 150 mg/l | 150 mg/l | 150 mg/l | 150 mg/l |
| (2) COD | - | 500 mg/l | - | - | - | - | - |
| (3) T-N | 30 mg/l | 40 mg/l | 30 mg/l | 30 mg/l | 30 mg/l | 30 mg/l | 30 mg/l |
| (4) T-P | 8 mg/l | 10 mg/l | 8 mg/l | 8 mg/l | 8 mg/l | 8 mg/l | 8 mg/l |
| (5) SS | 150 mg/l | 200 mg/l | 150 mg/l | 150 mg/l | 150 mg/l | 150 mg/l | 150 mg/l |
| 12. Design Criteria for Effluent | | | | | | | |
| (1) SS | $\leq$ 30 mg/l | $\leq$ 30 mg/l | $\leq$ 30 mg/l | $\leq$ 30 mg/l | $\leq$ 30 mg/l | $\leq$ 30 mg/l | $\leq$ 30 mg/l |
| (2) BOD | $\leq$ 20 mg/l | $\leq$ 20 mg/l | $\leq$ 20 mg/l | $\leq$ 20 mg/l | $\leq$ 20 mg/l | $\leq$ 20 mg/l | $\leq$ 20 mg/l |
| (3) T-N | $\leq$ 10 mg/l | $\leq$ 10 mg/l | $\leq$ 10 mg/l | $\leq$ 10 mg/l | $\leq$ 10 mg/l | $\leq$ 10 mg/l | $\leq$ 10 mg/l |
| (4) $NH_3$-N | $\leq$ 5 mg/l | $\leq$ 5 mg/l | $\leq$ 5 mg/l | $\leq$ 5 mg/l | $\leq$ 5 mg/l | $\leq$ 5 mg/l | $\leq$ 5 mg/l |
| (5) T-P | $\leq$ 2 mg/l | $\leq$ 2 mg/l | $\leq$ 2 mg/l | $\leq$ 2 mg/l | $\leq$ 2 mg/l | $\leq$ 2 mg/l | $\leq$ 2 mg/l |
| (6) DO | $\geq$ 5 mg/l | $\geq$ 5 mg/l | $\geq$ 5 mg/l | $\geq$ 5 mg/l | $\geq$ 5 mg/l | $\geq$ 5 mg/l | $\geq$ 5 mg/l |

Remarks: Flow data of 2007 is shown for Chong Nonsi WWTP. Because some data of 2008 and 2009 are missing

Source: DDS

**(B) Treatment Performance**

Treatment performances of the seven WWTPs in 2009 are shown in Table 3.4.3. Total inflow to the seven plants was 693,300 $m^3$/d which accounted for 70 % of the total design capacities of 992,000 $m^3$/d. Inflow to Thung Khru WWTP was close to its capacity. On the other hand, inflows to the five WWTPs which are located on the east bank accounted 60 to 80 %, and thus there is room for receiving more wastewater.

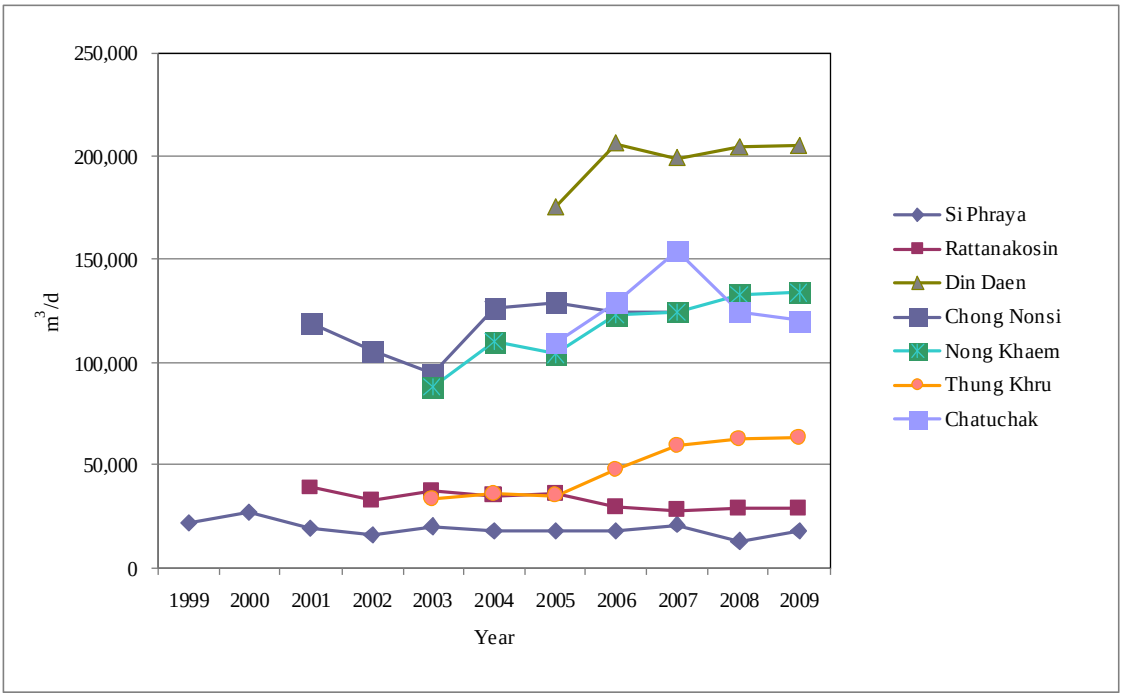
BOD and SS concentrations of raw wastewater were 24~56mg/l, (average 38 mg/l) and 24~121 mg/l, (average 58 mg/l) respectively. These concentrations were very low for raw wastewater causing an obstacle to proper treatment. BOD and SS concentrations of effluent were 3.3~10.5mg/l, (average 6.2mg/l) and 5.6~11.7 mg/l (average 8.6mg/l) respectively. These concentrations well satisfy the discharge standards. Removal ratios are 82 % for BOD and 78 % for SS on average. Removal ratios are relatively low because of low concentrations of inflow, however, it indicates that treatment was performed satisfactorily.

**Table 3.4.3 Treatment Performance of Existing Seven WWTPs（2009）**

| | Design Capacity ($m^3$/d) | Inflow ($m^3$/d) | Effective Ratio (%) | BOD (mg/l) | | Removal Ratio (%) | SS (mg/l) | | Removal Ratio (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | In | Out | | In | Out | |
| Si Praya | 30,000 | 18,213 | 60.7 | 56 | 5 | 90.5 | 109 | 7 | 94.0 |
| Rattanakosin | 40,000 | 28,791 | 72.0 | 44 | 11 | 76.4 | 26 | 11 | 55.5 |
| Din Daeng | 350,000 | 204,931 | 58.6 | 27 | 5 | 80.6 | 31 | 8 | 73.4 |
| Chong Nonsi | 200,000 | 124,282 | 62.1 | 24 | 5 | 79.3 | 24 | 7 | 72.7 |
| Nong Kaem | 157,000 | 132,605 | 84.5 | 51 | 4 | 93.2 | 121 | 10 | 91.4 |
| Thung Khru | 65,000 | 63,980 | 98.4 | 28 | 3 | 88.5 | 59 | 6 | 90.6 |
| Chatuchak | 150,000 | 120,470 | 80.3 | 33 | 11 | 67.8 | 37 | 12 | 68.4 |

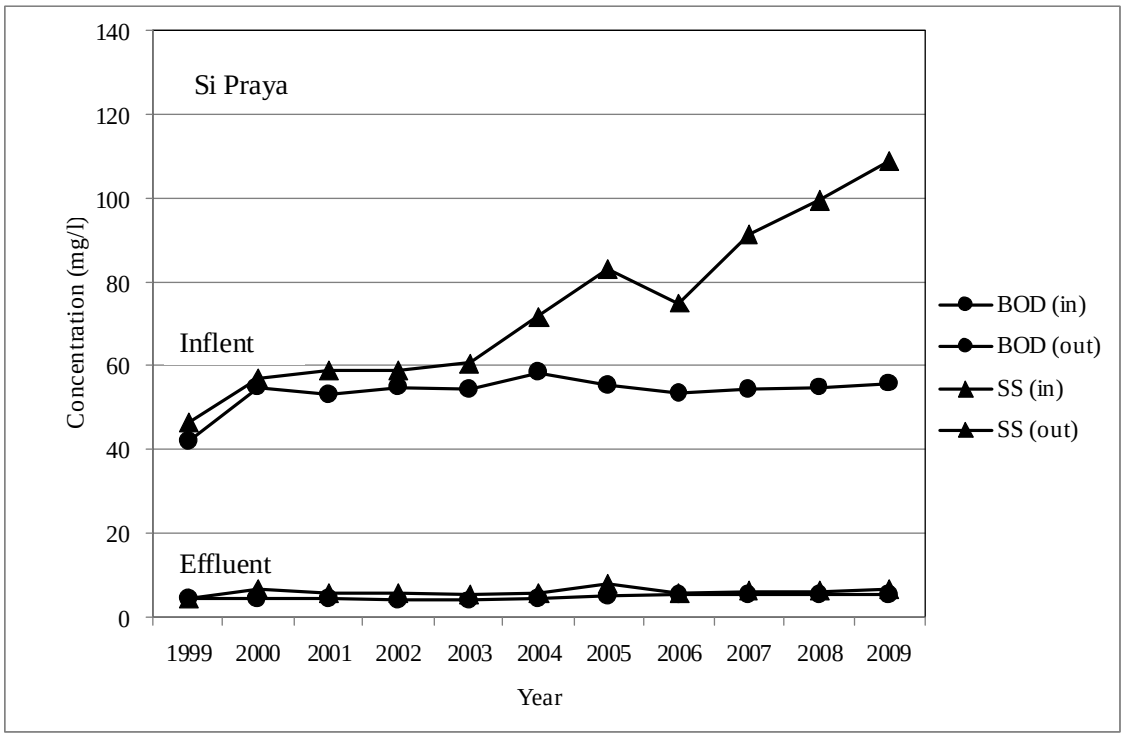
Source: JST

Treatment performance of the seven WWTPs since the beginning of operation up to 2009 is shown in from Figure 3.4.7 to 3.4.14. Inflows to Nong Khaem and Thung Khru WWTPs have been increasing since the beginning of operation, but those to five other WWTPs on the east bank have been stable or even in some cases, have been decreasing. BOD and SS concentrations of inflows have been fluctuating, but those of effluent have been stable.



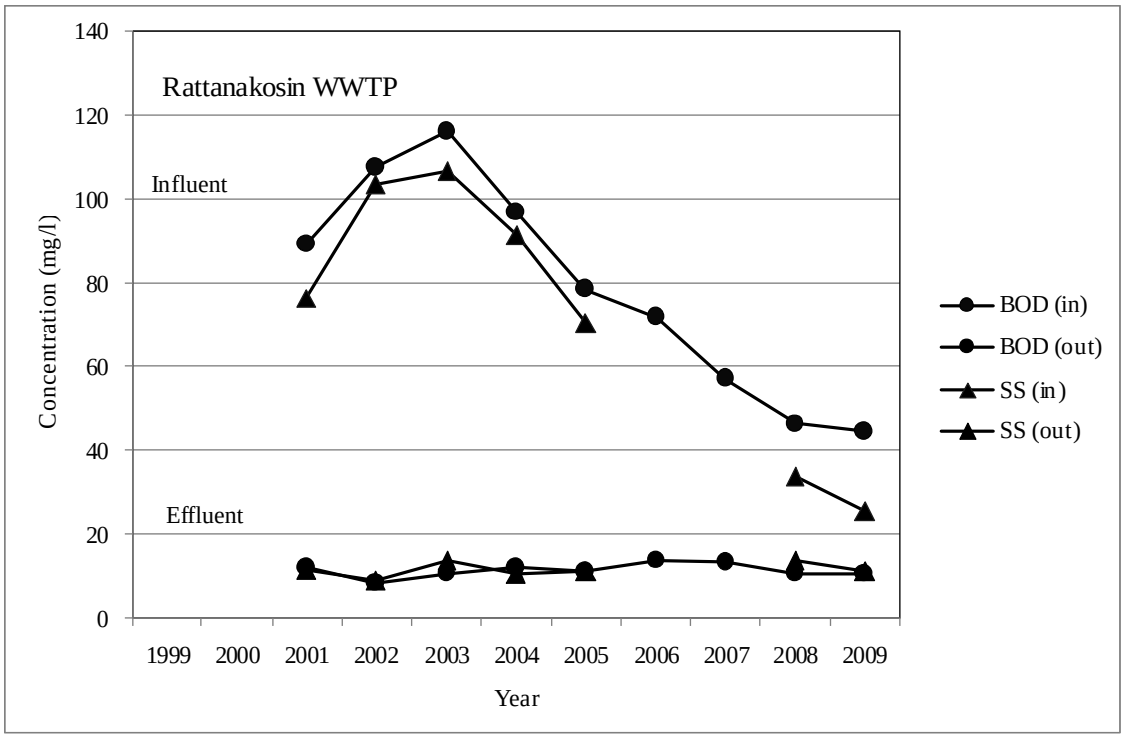

Source: JST

**Figure 3.4.7 Inflow of Existing Seven WWTPs**



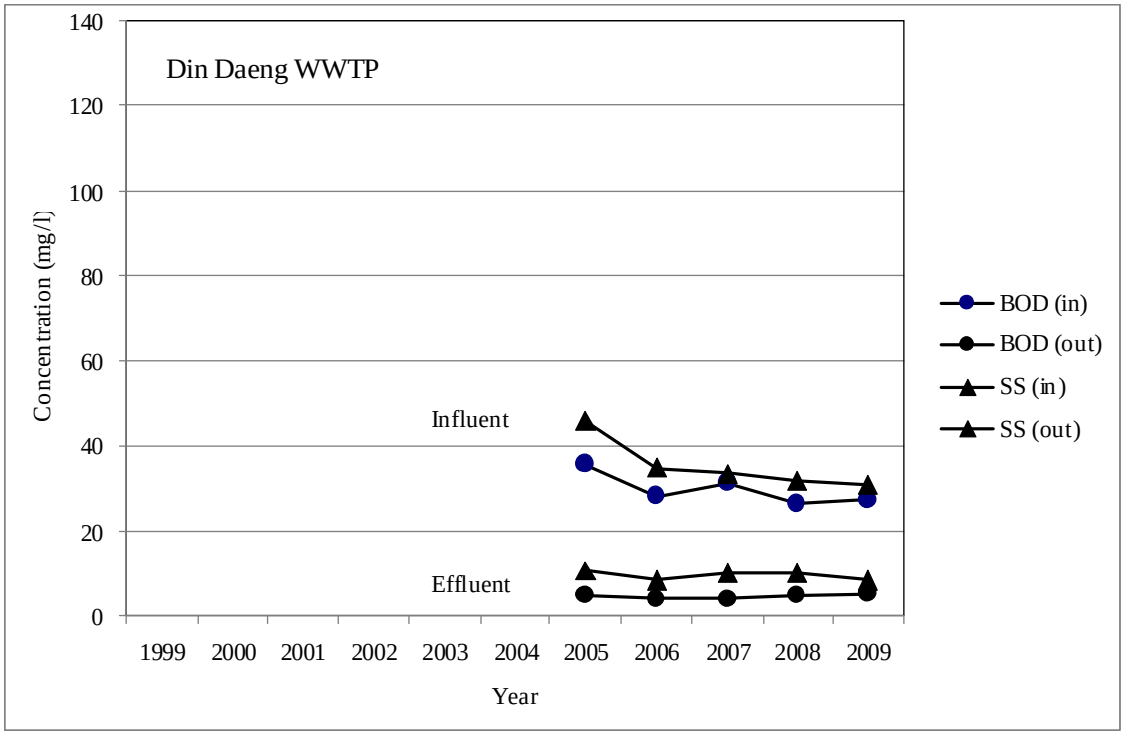

Source: JST

**Figure 3.4.8 BOD and SS Concentration of Si Praya WWTP**



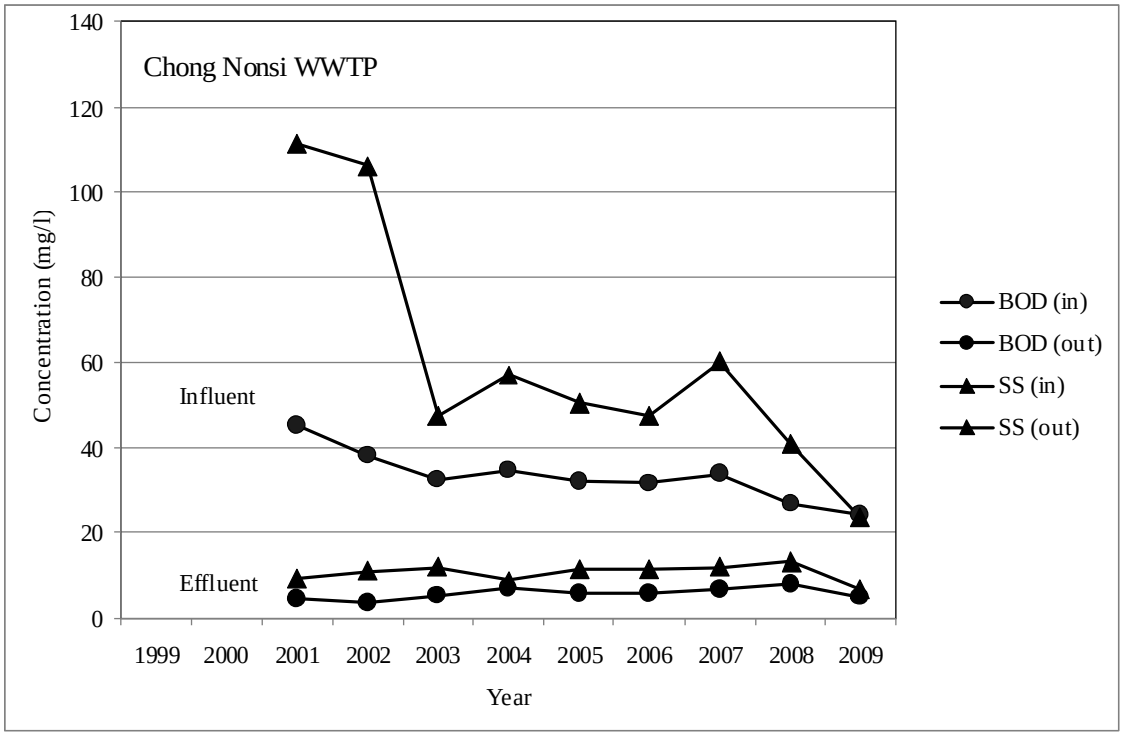

Source: JST

**Figure 3.4.9 BOD and SS Concentration of Rattanakosin WWTP**



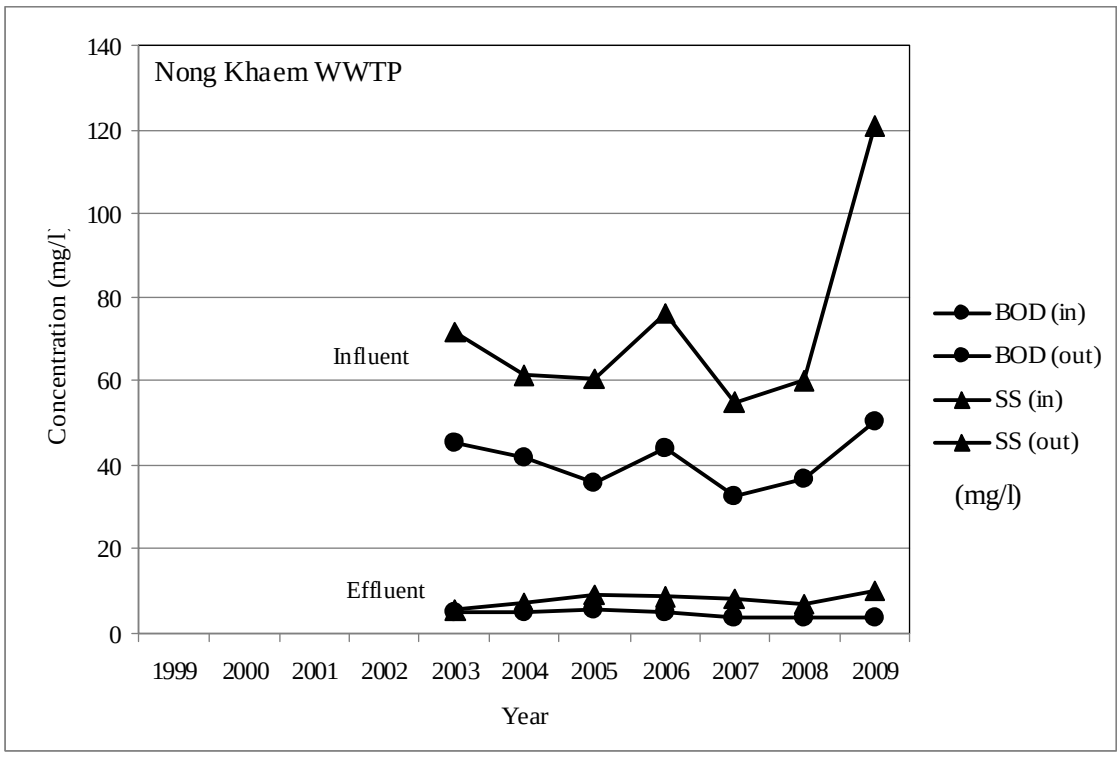

Source: JST

**Figure 3.4.10 BOD and SS Concentration of Din Daeng WWTP**



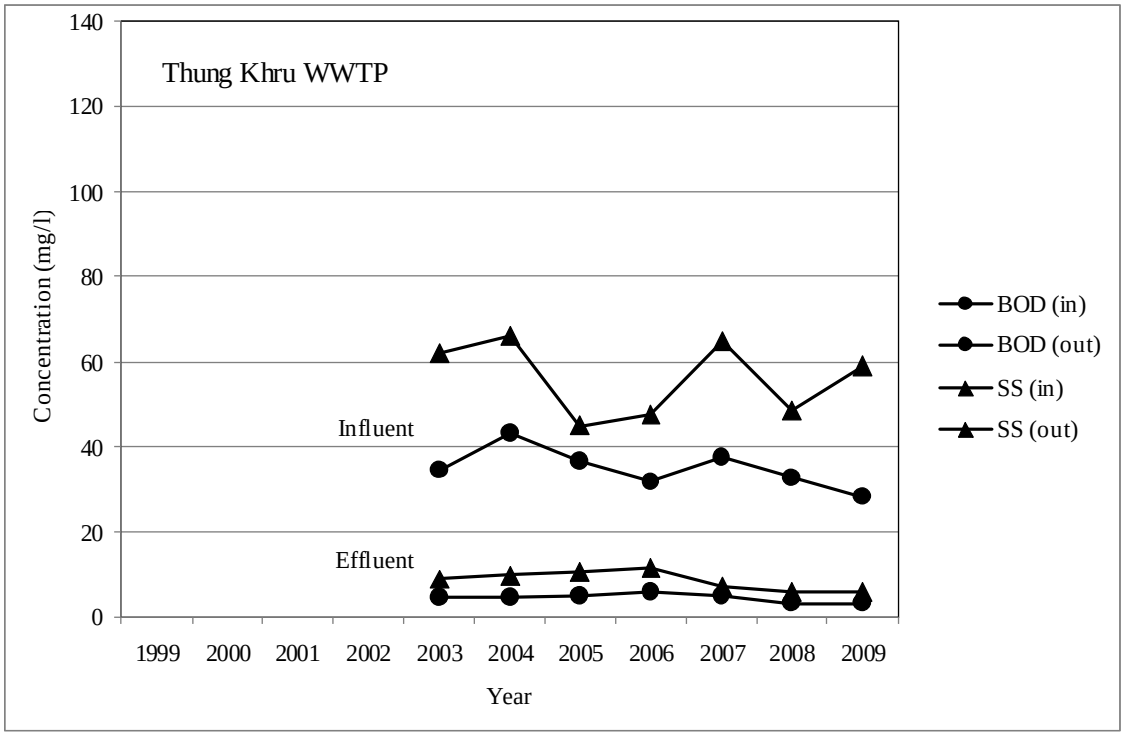

Source: JST

**Figure 3.4.11 BOD and SS Concentration of Chong Nonsi WWTP**



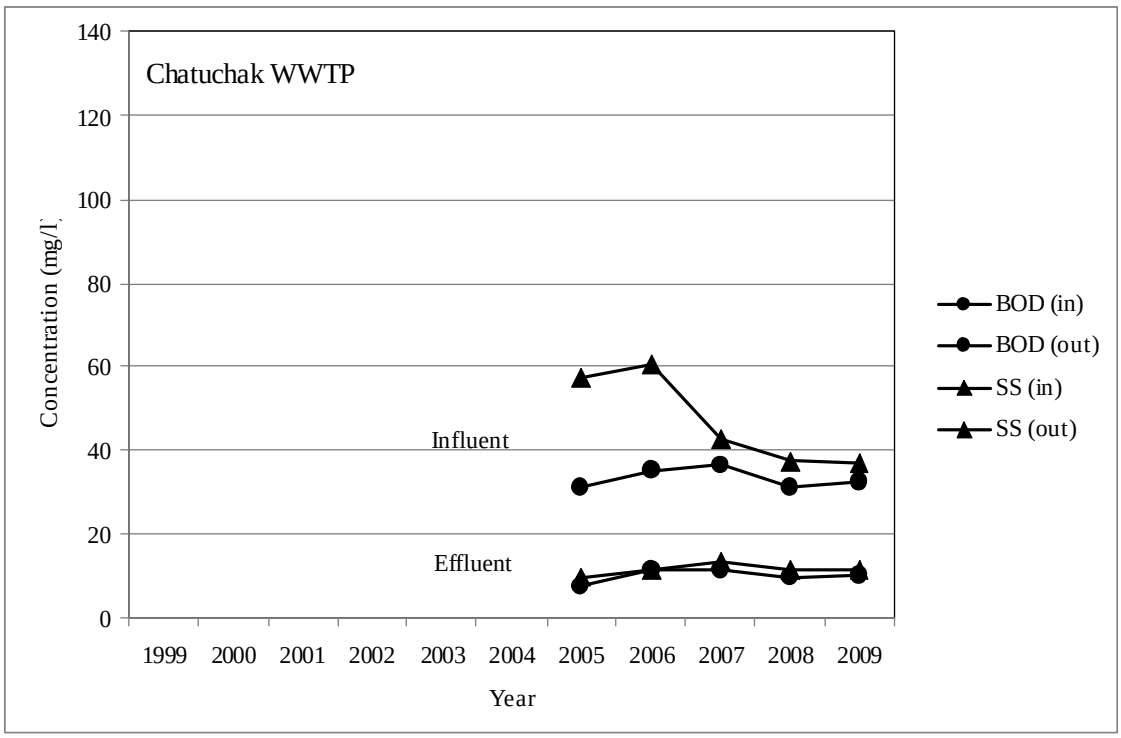

Source: JST

**Figure 3.4.12 BOD and SS Concentration of Nong Khaem WWTP**




Source: JST

**Figure 3.4.13 BOD and SS of Concentration Thong Khru WWTP**




Source: JST

**Figure 3.4.14 BOD and SS Concentration of Chatuchak WWTP**

## (C) Operation and Maintenance Cost

Operation and maintenance cost and inflow volume of seven WWTPs during 2006-2008 are shown in Table 3.4.4. This table shows that total annual inflow to seven WWTPs was 247 million $m^3$/year (674,881 $m^3$/d) in 2008, and total O&M cost was 587.2 million Baht/year (1.6 million Baht/d). This means the operation and maintenance cost was 2.38 Baht/$m^3$.

**Table 3.4.4 Operation and Maintenance Cost of Seven WWTPs**

| WWTP | 2006 | | | 2007 | | |
|---|---|---|---|---|---|---|
| | O&M Cost (Baht/year) | Inflow ($m^3$/year) | Unit Cost (Baht/$m^3$) | O&M Cost (Baht/year) | Inflow ($m^3$/year) | Unit Cost (Baht/$m^3$) |
| Si Praya | 16,924,600 | 6,707,970 | 2.52 | 14,527,323 | 7,650,765 | 1.90 |
| Rattanakosin | 21,733,797 | 10,858,020 | 2.00 | 20,531,156 | 10,259,055 | 2.00 |
| Din Daeng | 211,671,464 | 75,310,876 | 2.81 | 211,731,322 | 72,562,479 | 2.92 |
| Chong Nonsi | 102,543,095 | 45,470,240 | 2.26 | 101,382,983 | 45,362,930 | 2.23 |
| Nong Khaem | 102,707,502 | 44,882,225 | 2.29 | 103,967,998 | 45,414,395 | 2.29 |
| Tung Khru | 37,032,813 | 17,565,260 | 2.11 | 48,149,850 | 21,856,930 | 2.20 |
| Chatuchak | 62,236,862 | 47,114,200 | 1.32 | 77,109,548 | 56,378,995 | 1.37 |
| 計 | 554,850,133 | 247,908,791 | 2.24 | 577,400,180 | 259,485,549 | 2.23 |

| WWTP | 2008 | | |
|---|---|---|---|
| | O&M Cost (Baht/year) | Inflow ($m^3$/year) | Unit Cost (Baht/$m^3$) |
| Si Praya | 15,816,624 | 4,870,102 | 3.25 |
| Rattanakosin | 20,396,005 | 10,511,637 | 1.94 |
| Din Daeng | 226,426,946 | 74,845,646 | 3.03 |
| Chong Nonsi | 102,651,954 | 39,761,658 | 2.58 |
| Nong Khaem | 105,338,029 | 48,533,481 | 2.17 |
| Tung Khru | 51,074,817 | 22,981,418 | 2.22 |
| Chatuchak | 65,492,251 | 45,502,829 | 1.44 |
| Total | 587,196,626 | 247,006,771 | 2.38 |

Note: O&M cost does not include depreciation
Source: JST

## (2) Community Wastewater Treatment Plants Transferred from NHA (12 Small Scale Plants)

DDS operates 12 small scale wastewater treatment plants (so-called community plant) transferred from NHA through its direct management. Table 3.4.5 and 3.4.6 show inflow and characteristics of influent/effluent in 2007 and 2008. Management of these treatment plants was transferred from NHA to DDS. However, pipe networks are still under responsibility of NHA. Wastewater flows fluctuated because of troubles in pipe networks such as clogging by garbage and failures of aged equipment of treatment plants.

**Table 3.4.5 Inflow and Design Capacity of Small Scale WWTPs**

| WWTP | Yearly Inflow ($m^3$/y) | | Daily Average ($m^3$/d) | | Treatment Capacity ($m^3$/d) |
|---|---|---|---|---|---|
| | 2007 | 2008 | 2007 | 2008 | |
| Ting Song Hong 1 | 578,160 | 387,960 | 1,584 | 1,060 | 3,000 |
| Ting Song Hong 2 | 189,800 | 214,110 | 520 | 585 | 1,100 |
| Bang Bua | 360,255 | 259,860 | 987 | 710 | 1,200 |
| Ram Indra | 219,000 | 219,600 | 600 | 600 | 800 |
| Huay Kwang | 958,125 | 1,104,222 | 2,625 | 3,017 | 2,400 |
| Tha Sai | 505,525 | 538,752 | 1,385 | 1,472 | 1,400 |
| Bang Na | 419,385 | 432,612 | 1,149 | 1,182 | 1,500 |
| Bon Kai | 127,750 | 128,100 | 350 | 350 | 400 |
| Klong Toey | 438,000 | 356,850 | 1,200 | 975 | 1,200 |
| Klong Chan | 532,535 | 430,416 | 1,459 | 1,176 | 6,500 |
| Hua Mark | 433,620 | 530,334 | 1,188 | 1,449 | 1,500 |
| Rom Kloa | 856,290 | 733,098 | 2,346 | 2,003 | 3,800 |
| Total | 5,618,445 | 5,335,914 | 15,393 | 14,579 | 24,800 |

Source: DDS

**Table 3.4.6 Characteristics of Influent/Effluent of Small Scale WWTPs**

| WWTP | Influent BOD(mg/l) | | Effluent BOD(mg/l) | | Removal Ratio (%) | |
|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 |
| Ting Song Hong 1 | 75 | 56 | 12 | 14 | 84 | 70 |
| Ting Song Hong 2 | 165 | 168 | 13 | 10 | 92 | 94 |
| Bang Bua | 225 | 188 | | | | |
| Ram Indra | 123 | 146 | 5 | 4 | 96 | 97 |
| Huay Kwang | 177 | 155 | | | | |
| Tha Sai | 62 | 52 | 5 | 4 | 91 | 93 |
| Bang Na | 165 | 168 | 6 | 6 | 96 | 97 |
| Bon Kai | 97 | 218 | 6 | 6 | 97 | 97 |
| Klong Toey | 179 | 150 | 9 | 6 | 95 | 96 |
| Klong Chan | 108 | 115 | 8 | 10 | 93 | 01 |
| Hua Mark | 70 | 72 | 11 | 7 | 85 | 90 |
| Rom Kloa | 63 | 67 | 10 | 11 | 85 | 84 |

| WWTP | Influent BOD(mg/l) | | Effluent BOD(mg/l) | | Removal Ratio (%) | |
|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2007 | 2007 | 2008 | 2007 |
| Ting Song Hong 1 | 30 | 32 | 13 | 13 | 57 | 59 |
| Ting Song Hong 2 | 86 | 123 | 8 | 10 | 91 | 92 |
| Bang Bua | 154 | 124 | | | | |
| Ram Indra | 192 | 292 | 15 | 14 | 92 | 95 |
| Huay Kwang | 58 | 52 | | | | |
| Tha Sai | 19 | 28 | 5 | 9 | 72 | 67 |
| Bang Na | 142 | 172 | 6 | 7 | 96 | 96 |
| Bon Kai | 219 | 136 | 6 | 4 | 97 | 97 |
| Klong Toey | 161 | 111 | 12 | 5 | 93 | 95 |
| Klong Chan | 103 | 106 | 35 | 34 | 66 | 68 |

| WWTP | Influent BOD(mg/l) | | Effluent BOD(mg/l) | | Removal Ratio (%) | |
|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2007 | 2007 | 2008 | 2007 |
| Hua Mark | 96 | 98 | 34 | 34 | 69 | 65 |
| Rom Kloa | 83 | 89 | 35 | 36 | 57 | 60 |

Source: DDS

### (3) Other Wastewater Treatment Plants

DDS operates some other wastewater treatment facilities, such as two klong water treatment plants and waste leachate treatment plant. Klong waters are purified by direct aeration at the following ponds, as mentioned in 3.2.4 above;

- Makkasan Pond：Improvement of Klong Sam Sen
- Rama IX Pond：Improvement of Klong Lat Phrao

A waste leach treatment plant is located at On Nuch garbage disposal facility and treats the leach. Table 3.4.7 and 3.4.8 show their inflow data and influent/effluent water quality in 2007 and 2008.

**Table 3.4.7 Inflow and Design Capacity of Other WWTPs**

| WWTP | Yearly Inflow ($m^3$/y) | | Daily Average Flow ($m^3$/d) | | Treatment Capacity ($m^3$/d) |
|---|---|---|---|---|---|
| | 2007 | 2008 | 2007 | 2008 | |
| Makkasarn | 94,900,000 | 95,160,000 | 260,000 | 260,000 | 260,000 |
| Rama IX | 31,536,000 | 31,622,400 | 86,400 | 86,400 | 86,400 |
| On Nuch | 257,325 | 191,784 | 705 | 524 | 960 |

Source: DDS

**Table 3.4.8 Influent/Effluent Water Quality of Other WWTPs**

| WWTP | Influent BOD(mg/l) | | Effluent BOD(mg/l) | | Removal Ratio (%) | |
|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 |
| Makkasan | 27 | 17 | 21 | 15 | 22 | 10 |
| Rama IX | 21 | 19 | 14 | 10 | 35 | 45 |
| On Nuch | 358 | 352 | 35 | 36 | 90 | 90 |

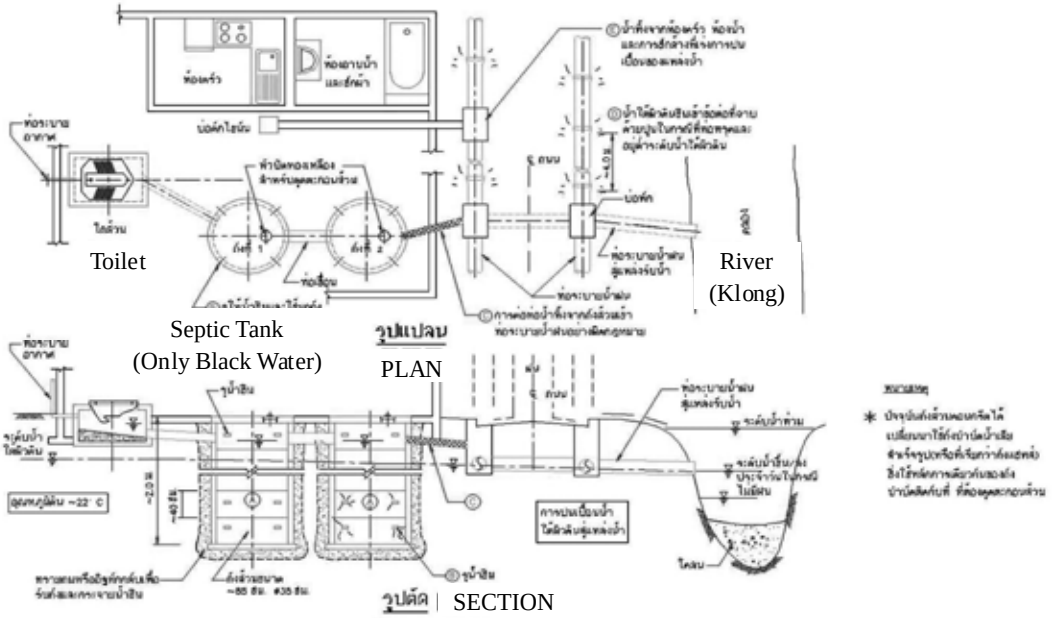
| WWTP | Influent SS (mg/l) | | Effluent SS (mg/l) | | Removal Ratio (%) | |
|---|---|---|---|---|---|---|
| | 2007 | 2008 | 2007 | 2008 | 2007 | 2008 |
| Makkasan | 23 | 94 | 14 | 58 | 40 | 38 |
| Rama IX | 38 | 26 | 13 | 7 | 66 | 74 |
| On Nuch | 150 | 174 | 52 | 54 | 65 | 69 |

Source: DDS

### 3.4.3 Existing On-site Wastewater Treatment Facility

#### (1) Human Excreta Treatment Facility of Ordinary Household

Human excreta receive anaerobic treatment in septic tank and effluent is discharged into the existing drain or klong. Sullage water (grey water) is discharged to klong without any treatment. Two stage or one vessel septic tank is commonly used. Figure 3.4.15 shows typical domestic sanitary facilities including toilet and septic tank.




รูปที่ 1 ลักษณะถังส้วมซึมชนิดและการปนเปื้อนของแหล่งรับน้ำทิ้งใบพื้นที่มีน้ำใต้ผิวดินสูง

Thai domestic sanitary facilities (Toilet, Septic Tank) (Before connecting to sewer lines)

Source: Project of Improvement of Sewerage Treatment Plant Management in Thailand, JICA

**Figure 3.4.15 Thai Domestic Sanitary Facilities**


**Photo 3.4.9 Ready-made Septic Tank**

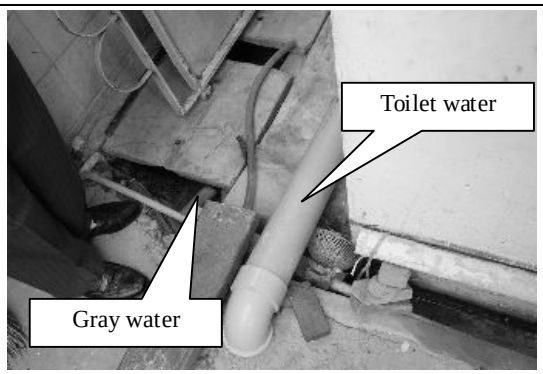



**Photo 3.4.10 Drain Pipe**

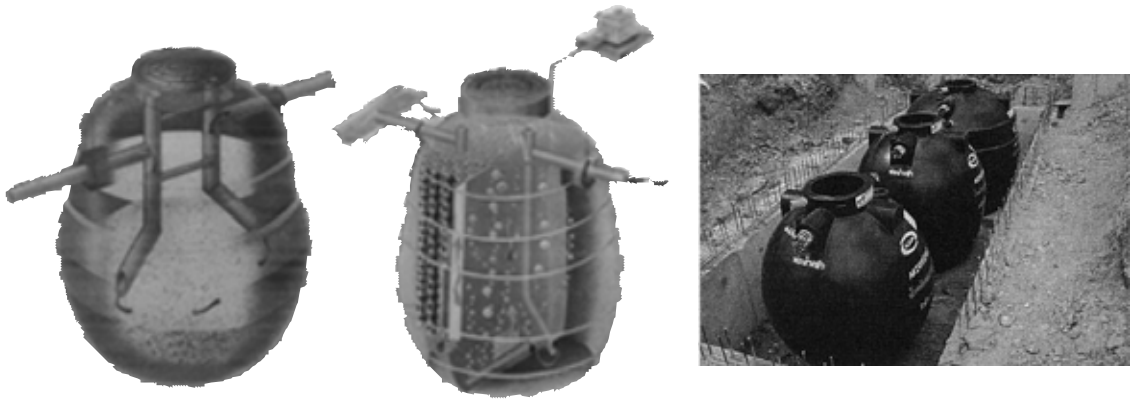
### (2) Latest On-site Wastewater Treatment Facility

Septic tanks or small scale wastewater treatment facilities up to 200 $m^3$/d are manufactured in factories. Combination of an anaerobic tank, an anaerobic contact tank, an activated sludge tank and grease trap is selected according to required effluent standard and number of residents, and assembled on site. Examples of ready-made wastewater treatment facility are shown in Figure 3.4.16.

### (3) Wastewater Treatment Facility for New Housing Development

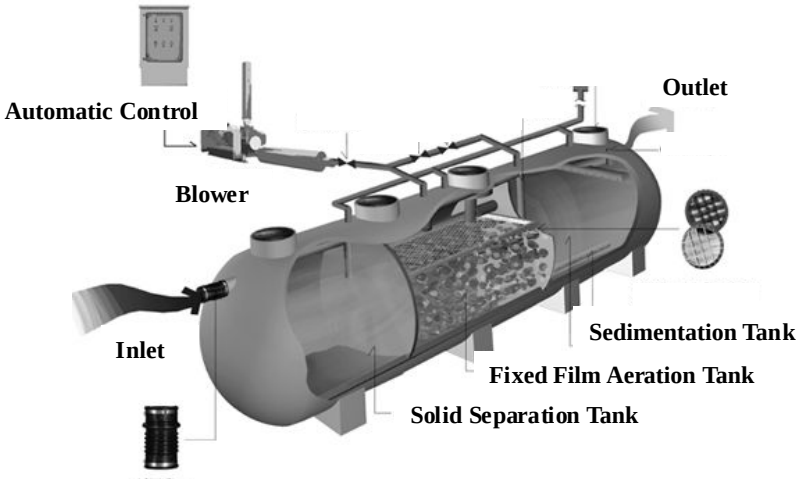
Provision of wastewater treatment facility is compulsory for new housing development with more than ten (10) detached houses. Since effluent standard is stricter for housing development with more than 500 units, small scale sewerage system which collects effluent from septic tanks and gray water through drain pipes (combined system) and treats it by anaerobic process is constructed. Combination of an anaerobic tank and an anaerobic contact tank is most commonly used for wastewater treatment. If BOD concentration less than 20 mg/l is required, activated sludge process is applied.

Figure3.4.17 shows typical wastewater treatment system in new housing development. Figure 3.4.18 shows central wastewater treatment facility for new housing development.

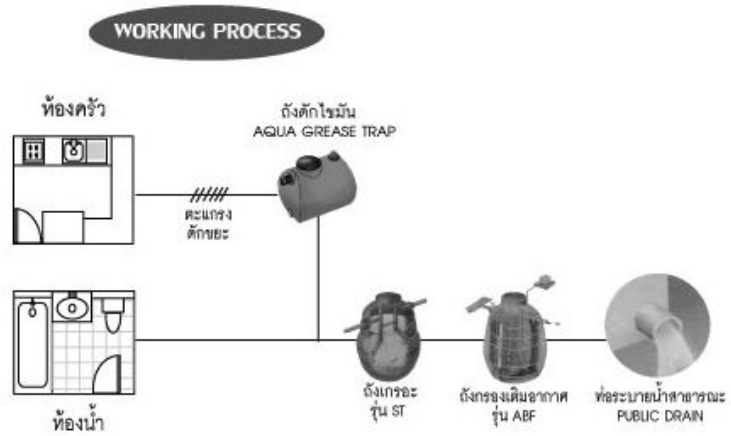


Unit Process(Septic tank, Aerobic, Grease trap)

**Community Type STP**
**(Capacity 200 $m^3$/d)**

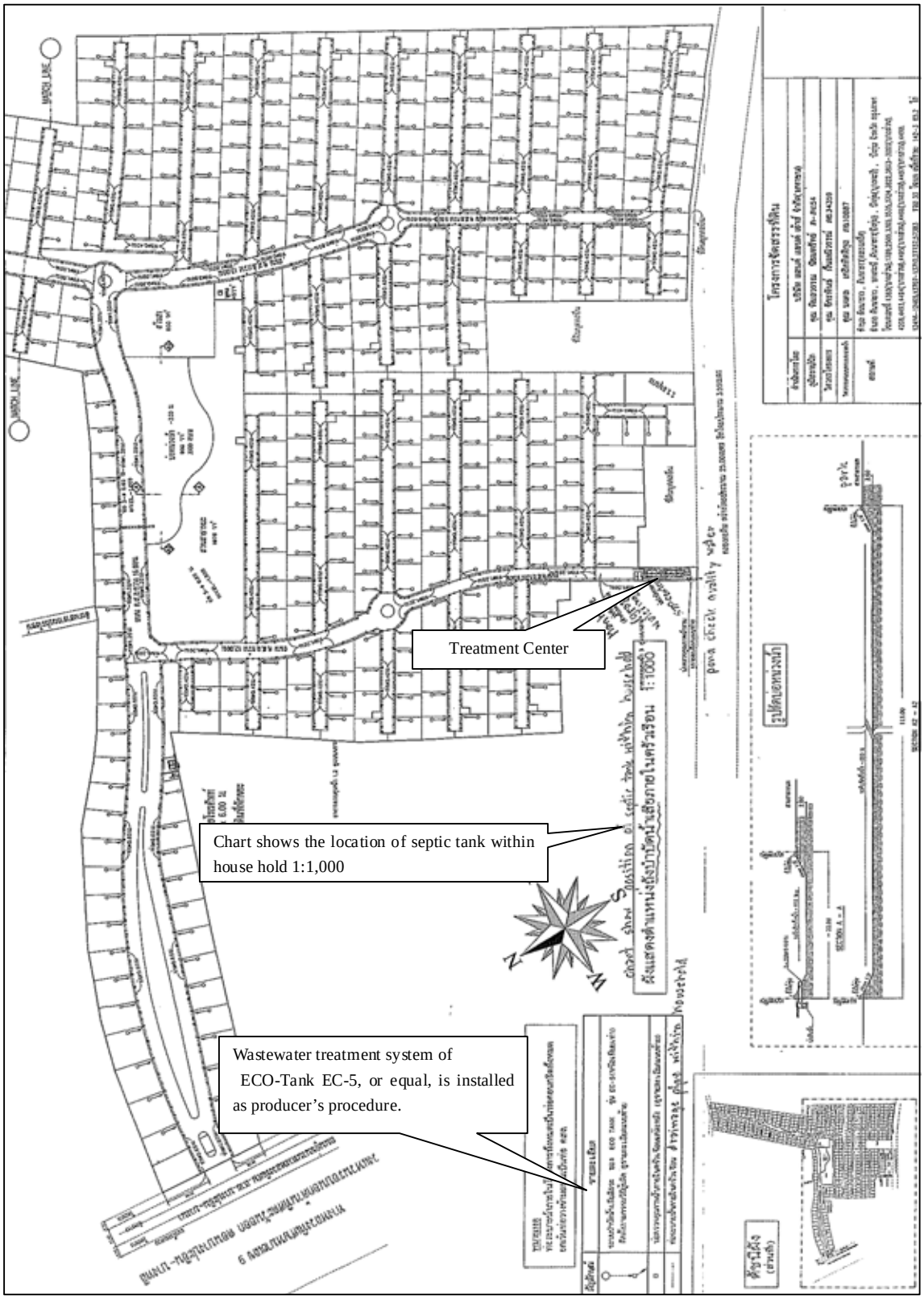



**Lay-out Plan**
**2-stage treatment**
**with grease trap**



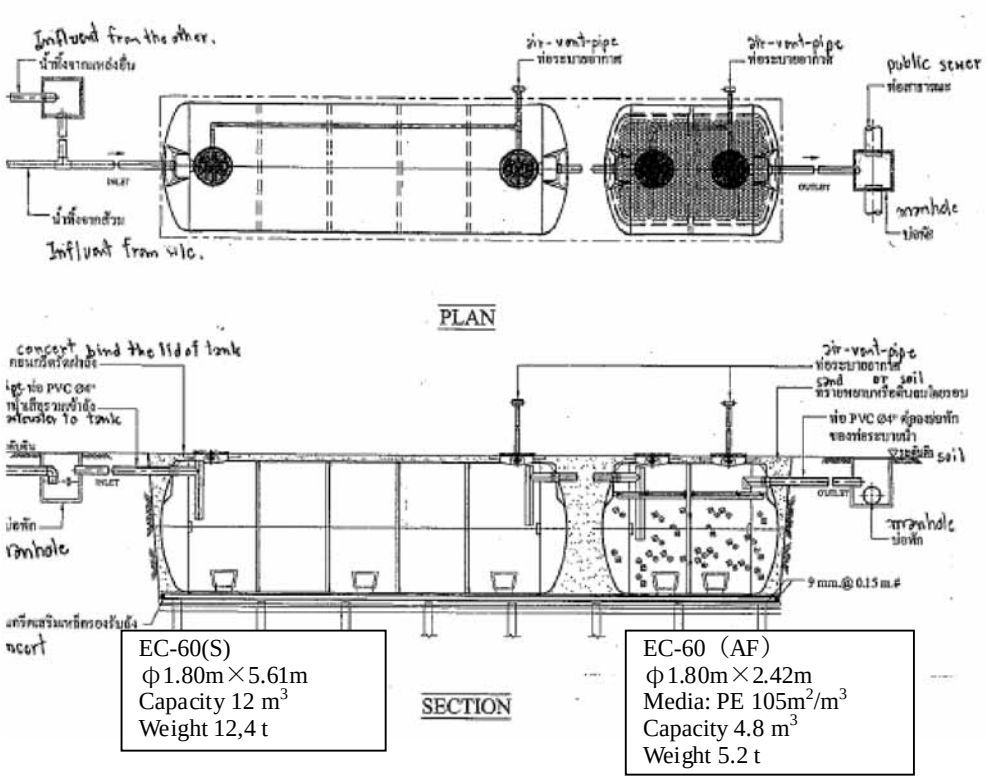

Source: Some engineering companies

**Figure 3.4.16 Septic Tank, Community Type Wastewater Treatment Facility and Layout Plan of Tanks**




Source: DDS

**Figure 3.4.17 Wastewater Treatment System in New Housing Development (Detached Houses)**




Source: DDS

**Figure 3.4.18 Central Wastewater Treatment Facility for New Housing Development (Detached Houses)**

### (4) Septic Tank Sludge Treatment

### (A) Septic Tank Sludge Service

Septic tank sludge removal service to households and commercial buildings is provided by Department of Environmental of BMA. Removal of sludge is carried out by owner's request. Current service charge is 250 Baht/$m^3$ which only compensates costs for fuel and maintenance of vehicles. Personnel cost is appropriated by general budget of BMA. A pilot project for which private sector provided septic tank sludge removal service had been tested, but it was not popular because of high service charge. Collected sludge is transported to two treatment plants by lorries and treated by composting for final disposal or reuse.

Frequency of sludge removal was reported in a feasibility study (Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study, 1996) as shown in Table 3.4.9. Houses which remove sludge every year or more frequently account for approximately 25 %. Houses which remove sludge every 2 – 3 years or less frequently account for 25% or less. Houses which replied that they have never removed sludge account for 40 % or more.

**Table 3.4.9 Frequency of Removal of Septic Tank Sludge**

| Frequency of disposal | BMA/Nonthaburi/Pathum Thani | | | |
|---|---|---|---|---|
| | Residential Houses | Commercial/ Residential | Klong Houses | Informal Settlement |
| Every year or more frequency | 22 % | 27 % | 26 % | 26% |
| Every 2 - 3 years | 18 % | 16 % | 17 % | 10 % |
| More than every 3 years | 4 % | 9 % | 6 % | 4 % |
| Never emptied | 43 % | 39 % | 43 % | 41 % |
| No answer | 13 % | 9 % | 8 % | 19 % |
| Sample size | 198 | 198 | 35 | 70 |

Source: Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study, 1996

Results of public awareness survy conducted in November and December, 2010 by the Survey Team indicate that households which remove sludge more than once a year account for 32 %, once every 2 or 3 years account for 20 %, and which do not remove for more than 3 years account for 48 %. Results of the survey show similar tendency.

**(B) Septic Tank Sludge Treatment Plant**

There are two septage treatment plants in BMA which are under management of PCD.

- On Nuch Treatment Plant: design capacity 600 $m^3$/day, actual 200 $m^3$/day
- Nong Khaem Treatment Plant: design capacity 600 $m^3$/day, actual 420 $m^3$/day

Outline of On Nuch treatment plant are described below (refer to Figure 3.4.19).

*Treatment Process*

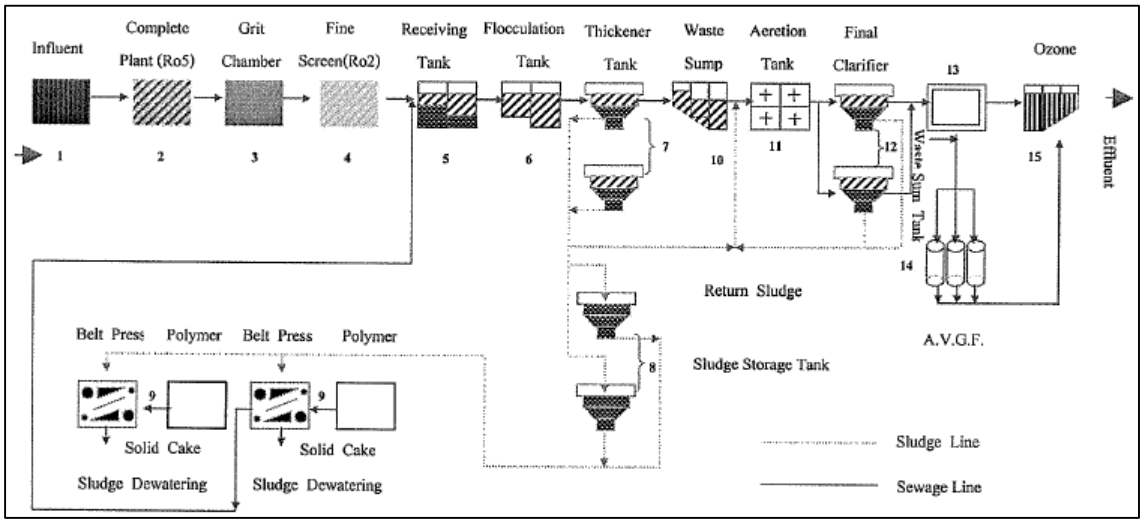
- Screen
  Receiving pit with punching screens, two stage rotor mat (dehydrate function)
- Wastewater treatment
  Activated sludge process
  Reactor and Final Clarifier (HRT 3 to 6 hrs.), quicklime is added to effluent (4 kg/$m^3$), Automatic Valve less Gravity Filter, Ozone treatment (suspended)
- Sludge treatment
  Thickening, Dehydration by belt press, Composting

*Characteristics of inflow*

BOD: 6,000 mg/l, $COD_{Mn}$ 8,000～12,000 mg/l, SS unknown

*Effluent characteristics*

Transparency: almost zero,




Source: DOE

**Figure 3.4.19 Process Flow, On Nuch Treatment Plant**

**Photo 3.4.11 Dumping of Sludge, Screening**

**Photo 3.4.12 Reactor (Quicklime Addition)**

**Photo 3.4.13 Quicklime**

**Photo 3.4.14 Final Clarifier**

**Photo 3.4.15 Effluent Discharge**

**Photo 3.4.16 Beltpress Dehydrator**

### 3.4.4 Industrial Wastewater Treatment Facilities

#### (1) Industrial Wastewater Treatment Facilities

Factories are classified into three categories by law (Factory Act of 1992), viz. Group 1, Group 2 and Group 3 according to their scale. All factories shall satisfy the effluent standards (Table 3.4.10). Control and monitoring of industrial wastewater are under responsibility of MOIn. The authority which control, monitor, recommend and assist industrial wastewater treatment facilities of Group 3 factories is Department of Industrial Works (DIW) of MOIn. Monitoring of industrial wastewater from Group 2 and Group 3 factories is carried out BMA district offices with cooperation with DIW.

A factory is defined by the Factory Act as a building that produce or fabricate with machine with 5 horse power or more or with 7 laborers or more. Group 1 factory does not need to obtain permission nor registration for operation (less than 20 horse power or less than 20 laborers). Group 2 factory needs to register (less than 50 horse power or less the 50 laborers). Group 3 factory needs to obtain permissions (equal to or more than 50 horse power or equal to or more than 50 laborers).

Effluent standards for industrial wastewater were established by Factory Act, 1992. Effluent standards were established assuming that treated effluent is discharged directly or through roadside drain into public water body. Warning is issued in case of violation. Effluent standards to discharge to sewerage system have yet to be established.

## Table 3.4.10 Discharge Standards for Industrial Wastewater

| Items | Unit | Standard Values |
|---|---|---|
| 1) pH | - | 5.0 - 9.0 |
| 2) Total Dissolved Solids (TDS) | mg/l | 2.1) not more than 3,000 mg/l depending in receiving water or type of industry under consideration of PCC* but not exceed 500 mg/l<br>2.2) not more than 5,000 mg/l exceed TDS of receiving water having salinity of more than 2,000 mg/l or TDS of sea if discharge to sea |
| 3) Suspended Solids (SS) | mg/l | not more than 50 mg/l depending on receiving water or type of industry or type of wastewater treatment system under consideration of PCC but notexceed mg/l |
| 4) Temperature | C | not more than 40 |
| 5) Color and Odor | - | not objectionable |
| 6) Sulfide (as $H_2S$) | mg/l | not more than 1 |
| 7) Cyanide (as HCN) | mg/l | not more than 0.2 |
| 8) Heavy Metals | | |
| 8.1) Zinc | mg/l | not more than 5 |
| 8.2) Chromium (hexavalent) | mg/l | not more than 0.25 |
| 8.3) Chromium (Trivalent) | mg/l | not more than 0.75 |
| 8.4) Arsenic | mg/l | not more than 0.25 |
| 8.5) Copper | mg/l | not more than 2 |
| 8.6) Mercury | mg/l | not more than 0.005 |
| 8.7) Cadmium | mg/l | not more than 0.03 |
| 8.8) Barium | mg/l | not more than 1 |
| 8.9) Selenium | mg/l | not more than 0.02 |
| 8.10) Lead | mg/l | not more than 0.2 |
| 8.11) Nickle | mg/l | not more than 1 |
| 8.12) Manganese | mg/l | not more than 5 |
| 9) Fats, Oil and Grease (FOG) | mg/l | not more than 5 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 15mg/l |
| 10) Formaldehyde | mg/l | not more than 1 |
| 11) Phenols | mg/l | not more than 1 |
| 12) Free Chlorine | mg/l | not more than 1 |
| 13) Pesticides | mg/l | none |
| 14) Biochemical Oxygen Demand (BOD) | mg/l | not more than 20 mg/l unless the specific type of industry or different level of capacity of receiving water can be permitted more than 20 mg/l by PCC consideration but maximum allowance figure should not more than 60 mg/l |
| 15) Total Kjedahl Nitrogen (TKN) | mg/l | not more than 100 mg/l unless the specific type of industry or different level of capacity of receiving water can be permitted more than 100 mg/l by PCC consideration but maximum allowance figure should not more than 200 mg/l |
| 16) Chemical Oxygen Demand (COD) | mg/l | not more than 120 mg/l depending on receiving water or type of industry under consideration of PCC but not exceed 400 mg/l |

Effluent standards of Industrial estates follow the above criteria + BOD not over 20 mg/l (ammended in 1996)
PCC: Pollution Control Committee
PCD: Pollution Control Department
note:
Type of industries which has been considered and accepted by PCC to discharge the Effluent BOD up to 60 mg/l are:

1) animal food industries
2) Stratch industries
3) food from stratch industries
4) pulp and paper industries
5) tanning industries
6) cold storage industries
7) chemical industries
8) textile industries
9) pharmaceutical industries

Source：MOIn

There are more than 17,000 factories registered in BMA. Most of them are small scale factories. Industrial wastewater and pollutant load (in terms of BOD) in BMA estimated by MOIn are shown in Table 3.4.11. Factories from which wastewater flows exceed 50 $m^3$/day are 60 (refer to Table 3.4.12). Total wastewater flow from these factories is 56,700 $m^3$/day. Wastewater and pollutant load from these 60 factories total 39,295 $m^3$/day and 364 kg/day respectively, and which account for 97 % and 93% of the total. These 60 registered factories have their own treatment facilities, and discharge effluent directly or through roadside drain to public water body.

**Table 3.4.11 Industrial Wastewater and BOD Load (October, 2010)**

| | All of wastewater | More than 50 $m^3$/day |
|---|---|---|
| Inflow BOD | 4,790 kg/day | 4,153 kg/day |
| Effluent BOD | 393 kg/day | 364 kg/day |
| Wastewater discharged | 40,432 $m^3$/day | 39,295 $m^3$/day |

Source：MOIn

Water supply to industrial use is 50 million $m^3$/year (137,000 $m^3$/day) and accounts for 4 % of the total water supply based on the data obtained from MWA (refer to Table 3.2.6). Groundwater for industrial use in BMA is estimated by Department of Groundwater Resources, MONRE to be 47,470 $m^3$/day (license base).

BMA completed a customer list which includes information about all individual households, hotels, commercial establishments, markets and so on located in the existing seven treatment areas. A total of 2,408 business establishments are listed up in Industrial Factory Group, of which wastewater discharges are less than 200 $m^3$/month. There is no business establishment of which wastewater discharge exceeds 200 $m^3$/month (6.7 $m^3$/day) in the existing treatment areas.

### (2) Business Wastewater Treatment Facilities

At present, PCD is responsible for establishment of effluent standards for business wastewater, and control and monitoring of business wastewater have also been transferred to PCD. However, it is said that organization has yet to be sufficiently established and it is not functioning properly.

## Table 3.4.12 Factories in BMA of Which Wastewater Flow 50m $^3$/day or More

| No. | NAME of the Factory | Production | Location | Water Supply Used (m3/day) | Wastewater Discharge (m3/day) |
|---|---|---|---|---|---|
| 1 | Wittaya Yanyont Co Ltd | Garage - Body works and Paint | Suanluang | | 100 |
| 2 | Union Button Corporation Co Ltd | Button Industry | Wangthonglang | | 100 |
| 3 | The Royal Chitralada Projects | UHT and pasturized milk products | Dusit | | 900 |
| 4 | Post Publishing Co Ltd | Printing: Newspaper, books | Klongtoey | | 80 |
| 5 | Daily Foods Co Ltd | Butter, fruit juice, vegie, canned fruits | Kannayao | | 200 |
| 6 | Kiat Service Garage | Garage - Body works and Paint | Ladprao | | 100 |
| 7 | Vikrom's Garage Co Ltd | Garage - Body works and Paint | Wattana | | 200 |
| 8 | Bangkoknoi Water Works, MWA | WaterSupply Production | Bangkok-Noi | | 3,000 |
| 9 | Narongwit Pattanakarn LP | Garage - Body works and Paint | Pravate | | 200 |
| 10 | CPF Food Products Co Ltd | Chicken products, ready meals | Bang-na | | 500 |
| 11 | Foremost Milk Foods Co Ltd | Food from milk, yoghurt products | Laksi | 625 | 410 |
| 12 | Sinchaihua Industry Co Ltd | Laundry Industry | Ladkrabang | | 1,300 |
| 13 | Yakult (Thailand) Co Ltd | Fermented milk drink | Laksi | 600 | 360 |
| 14 | Bangkok Park Dealer | Meat - Wholesale | Klongtoey | | 150 |
| 15 | Pack Food PCL. | Frozen foods - Wholesale - Freezer | Sathorn | | 200 |
| 16 | United Foods PCL. | Bakers-Wholesale & Manufacturers - Wafer, cracker, candies | Bangkhunthian | | 50 |
| 17 | Asian Seafoods Coldstorage PCL. | Frozen ready seafood | Klongtoey | | 300 |
| 18 | CPF Food Products Co Ltd | Ready food; meat and vegetables | Minburi | | 250 |
| 19 | CPF Food Products Co Ltd | Frozen ready seafood, meat, vegetable and fruits | Minburi | | 1,200 |
| 20 | K. Vichian Cloth Printing Factory LP | Textile Printer | Jomthong | | 200 |
| 21 | Muramoto Electron (Thailand) PCL. | Electronic Equipment & Supplies | Kannayao | | 100 |
| 22 | Jong Stit Co.,Ltd | Weaving and cloth printing | Bangkhunthian | | 7,000 |
| 23 | Chokchai Industrial LP | Textile Printing | Pravate | 100 | 70 |
| 24 | Siam Paper J N K Industrial Co Ltd | White Page, brown paper | Ratburana | 400 | 200 |
| 25 | Industrial Waste Management Center | Total industrial waste | Bangkhunthian | | 100 |
| 26 | General Environmetnal Conservation PCL | Waste Reduction & Recycling | Bangkhunthian | | 96 |
| 27 | Saiviwat Industrial Co Ltd | Dyers-Industrial | Bangkhunthian | | 400 |
| 28 | Venus Threat Co Ltd | Weaving Looms | Wangthonglang | 1,500 | 800 |
| 29 | Venus Threat Co Ltd | Embroidery thread and knitting yarn | Wangthonglang | 1,200 | 1,200 |
| 30 | TTL Industrial PCL | Textiles-Wholesale & Manufacturers | Donmeung | | 2,000 |
| 31 | Bangkok Nylon Co Ltd | Nylon socks and underwear | Bangkhen | 246 | 200 |
| 32 | Hana Semi Conductor (Bangkok) Co.,Ltd. | Electronic parts, electronic circuits | Laksi | | 200 |
| 33 | NXP Manufacturing (Thailand) Co Ltd | Electronic circuits | Laksi | | 729 |
| 34 | Bangchak Petroleum PCL | Petroleum Refinery | Prakanong | 6,000 | 1,990 |
| 35 | Sahafarm Co Ltd | Abattoir and storage; chicken and eel | Kannayao | | 200 |
| 36 | Thai Toray Stnthetics Co Ltd | Polyester/ Ployester chip/ Nylon | Bangkhen | | 200 |
| 37 | Mahajak Autopart Co Ltd | - | Nongjok | | 400 |
| 38 | Siam Knitwear and Garment Co Ltd | Dying | Bangkapi | | 80 |
| 39 | Golden Sun Sport | Dying | Ladkrabang | 300 | 200 |
| 40 | Little Home Bakery Co Ltd | Bakers-Wholesale & Manufacturers - biscuit, cracker, cakes, chocolate, etc. | Pomprabsattrupai | | 80 |
| 41 | ISA Value Co Ltd | Canned seafood | Bangkunthian | | 500 |
| 42 | Useful Food Co Ltd | Snack manufacturer | Minburi | 80 | 80 |
| 43 | CPF Food Products Co Ltd | sausage, bacon, ready meal | Minburi | 1,200 | 1,200 |
| 44 | CPF Food Products Co Ltd | Waste quality improvement plant | Minburi | 250 | 250 |
| 45 | CPF Food Products Co Ltd | Abattoir and storage; chicken, meal | Bang-na | 3,000 | 3,000 |
| 46 | United Dairy Foods Co Ltd | Fruit juice, jellt, pudding and jam | Bangna | | 120 |
| 47 | Eng Thai Botting LP | Sparkling water | Suanluang | | 50 |
| 48 | Osotspa Co Ltd | Daily products | Bangkapi | | 2,000 |
| 49 | Thai Namthip Co Ltd | Syrup, sparkling water, drinking water | Bangkapi | | 1,800 |
| 50 | A Foods 1991 Co Ltd | Frozen seafood | Bangkhunthian | 400 | 400 |
| 51 | S&P Syndicate PCL | Bakery, cake and cookies | Prakanong | 140 | 140 |
| 52 | Bangkok TM Drinks Co Ltd | Fruit juice, mineral drinks | Bangkae | | 1,500 |
| 53 | Mae-Ruay Snack Food Factory Co Ltd | Snacks, crispy peanut | Bangkhunthian | 300 | 300 |
| 54 | Thai Rung Union Car PCL | Car Manufacturer | Nongkam | | 50 |
| 55 | CPF Food Products Co Ltd | Abattoir and storage; frozen chicken | Minburi | 100 | 100 |
| 56 | T C Pharmaceutical Industries Co Ltd | Drinks and Beverage | Bangbon | | 150 |
| 57 | Thai Airways International PCL | Aircraft, machines and parts Repair | Donmeung | | 100 |
| 58 | U Tac Thai Co Ltd | IC - electronic parts and chips | Bangna | | 360 |
| 59 | Thailand Tobacco Monopoly | Cigarettes and tobacco | Klongtoey | | 1,000 |
| 60 | Thai Toray Stnthetics Co Ltd | Polyester, Nylon | Bangkhen | | 150 |
| | **Total Discharge** | | | **16,441** | **39,295** |

Source：MOIn