3.4 Routing of Interceptors

Options of possible routes of interceptors have been developed and assessed in this Section. All of the outlets are to be intercepted and collected wastewater is to be conveyed to Nong Bon WWTP which will be constructed at the site adjacent to Rama IX Park in all options.

3.4.1 Comparison of Routes

The following prerequisite conditions are established for selecting interceptor routes.

1) All of the existing outlets are intercepted.
2) Interceptors are laid under klongs or roads.
3) Outlets are connected to WWTP by shortest possible routes since the topography of the treatment area is almost flat.

Among the above conditions, (1) is thought to be natural because all wastewater is to be collected. The reasons for condition (2) are described in the former Section 3.3.3. The reasons for condition (3) are to minimize construction cost by making interceptors as shallow as possible. Taking into account the above conditions, the following 2 options are developed as trial options.

Option 1: Almost all interceptors are laid under klongs
Option 2: Almost all interceptors are laid under roads

Routes of these two options are shown in Figure 3.4.1 and 3.4.2 respectively. Features of these options are as follows.

1) A total length of interceptors of Option 1 is approximately 66 km which is shorter than that of Option 2 (78 km) by approximately 12 km, since klongs run in all directions in the treatment area.
2) Wastewater can be received directly from the existing outlets in Option 1. However, connecting pipe lines from outlets which are currently discharging to klongs, to the interceptor are necessary in Option 2, and this is the main reason for longer total length of interceptors.

Option 3 was worked out based on the Option 1 which has shorter length of interceptors and easiness of receiving wastewater, and a part of interceptors are laid under roads. Interceptors are laid under roads, where the roads run in parallel with klongs or klongs run zigzag. Because of easiness of construction and maintenance, interceptors are laid under roads at these points. Further, Option 4 was worked out by changing downstream end of interceptor near WWTP from

one line to two lines. After discussion with DDS, Option 4 was selected because lower construction cost due to smaller diameter of downstream end of interceptor. Options 3 and 4 are shown in Figure 3.4.3 and 3.4.4 respectively. Comparison of Options 3 and 4 is described in Table 3.4.1

Table 3.4.1 Comparison of Options 3 and 4

	Option 3	Option 4
Total length of interceptor	63.70 km	64.27 km
Average depth of interceptor	10.9 m	10.3 m
Depth at inlet of WWTP	GL -21 to 22 m	GL -20 to 21 m
Estimate of construction cost	3,701 million Baht	3,642 million Baht
Influence on surrounding roads (Neighborhood of WWTP)	Diameter of pipe near WWTP is larger than that of Option 4. Sizes of vertical shaft and working yard are larger than those of Option 4. Longer time is required for construction..	Less influence on surrounding roads than Option 3.
Evaluation	△	○

Source: JST

Total length of the interceptor of Option 3 is shorter than that of Option 4. However, since diameters of pipes are smaller and depth of pipes is shallower, construction cost for Option 4 is lower than that of Option 3. Also, more influence on surrounding roads is envisaged for Option 3.

Taking into consideration the above, Option 4 is selected for the project.

Construction cost in the above table was estimated by the following formula developed for pipe jacking method under F/S for Klong Toie Project.

$$C = \{3305.9H - 7738.1 + D\,(987.72H + 19580)\}\,L$$

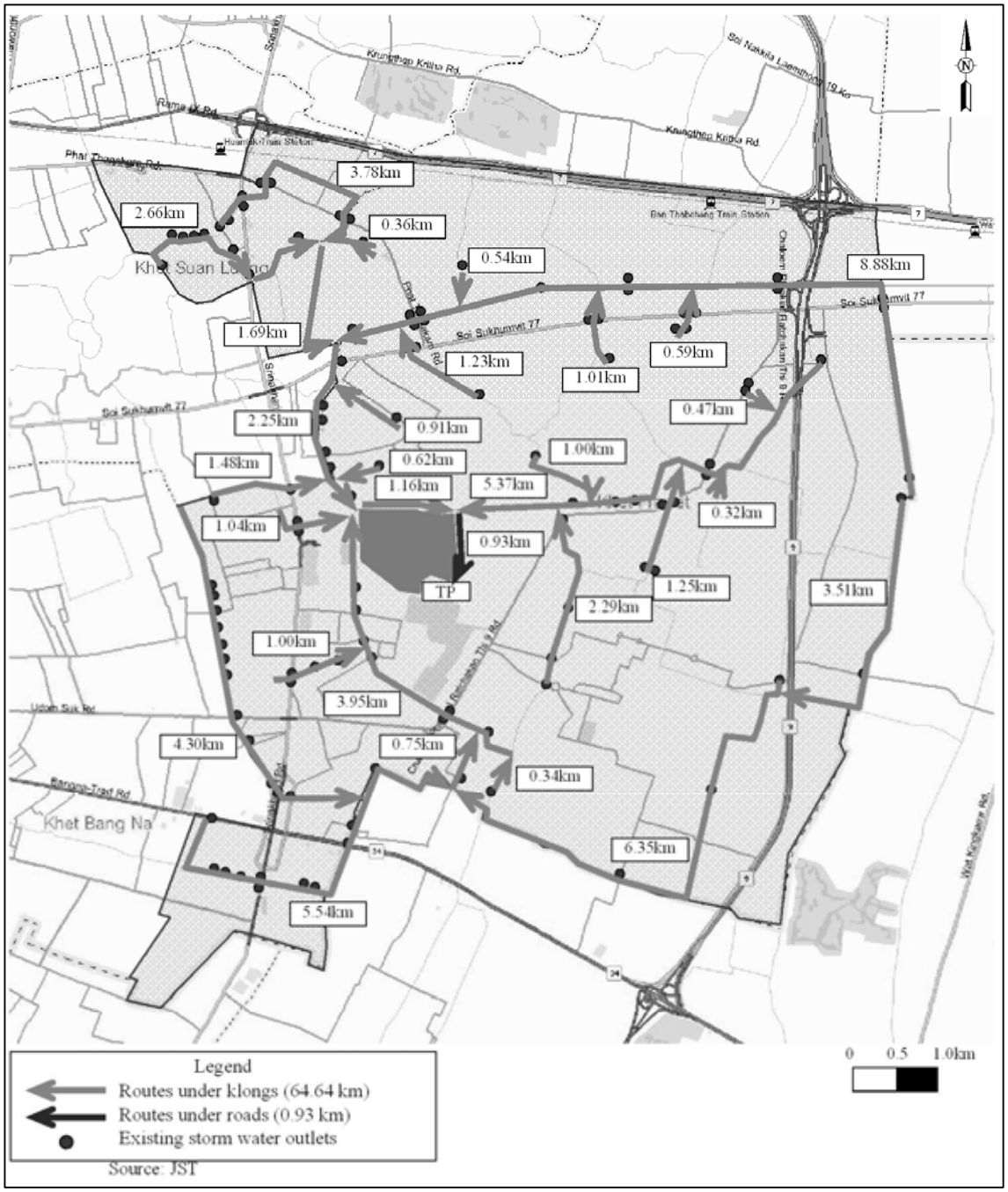
Where

C: Construction Cost (1,000 BAHT)

H: Average Depth of Interceptor (m)

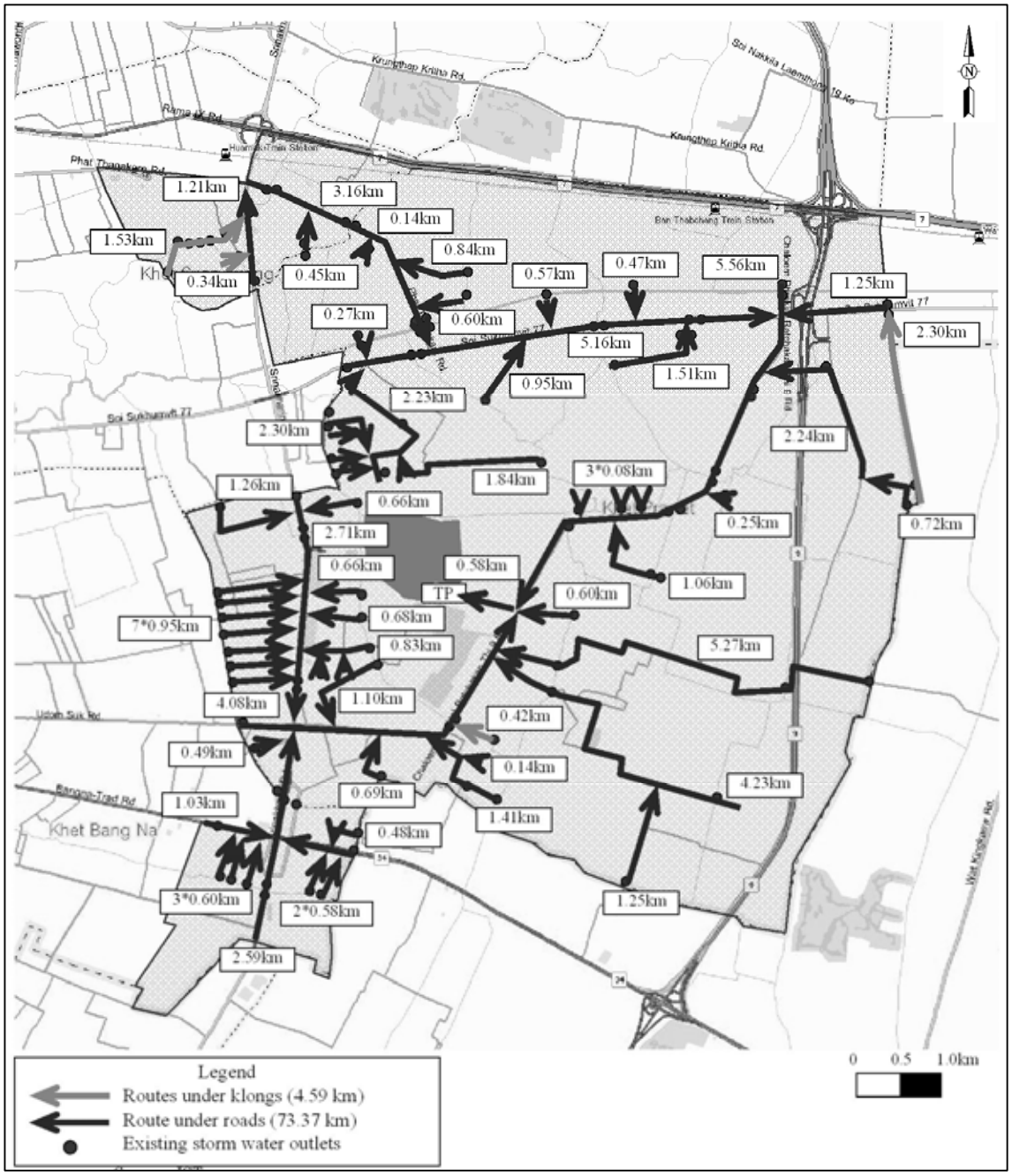
D: Diameter of Interceptor (m)

L: Length of Interceptor (m)



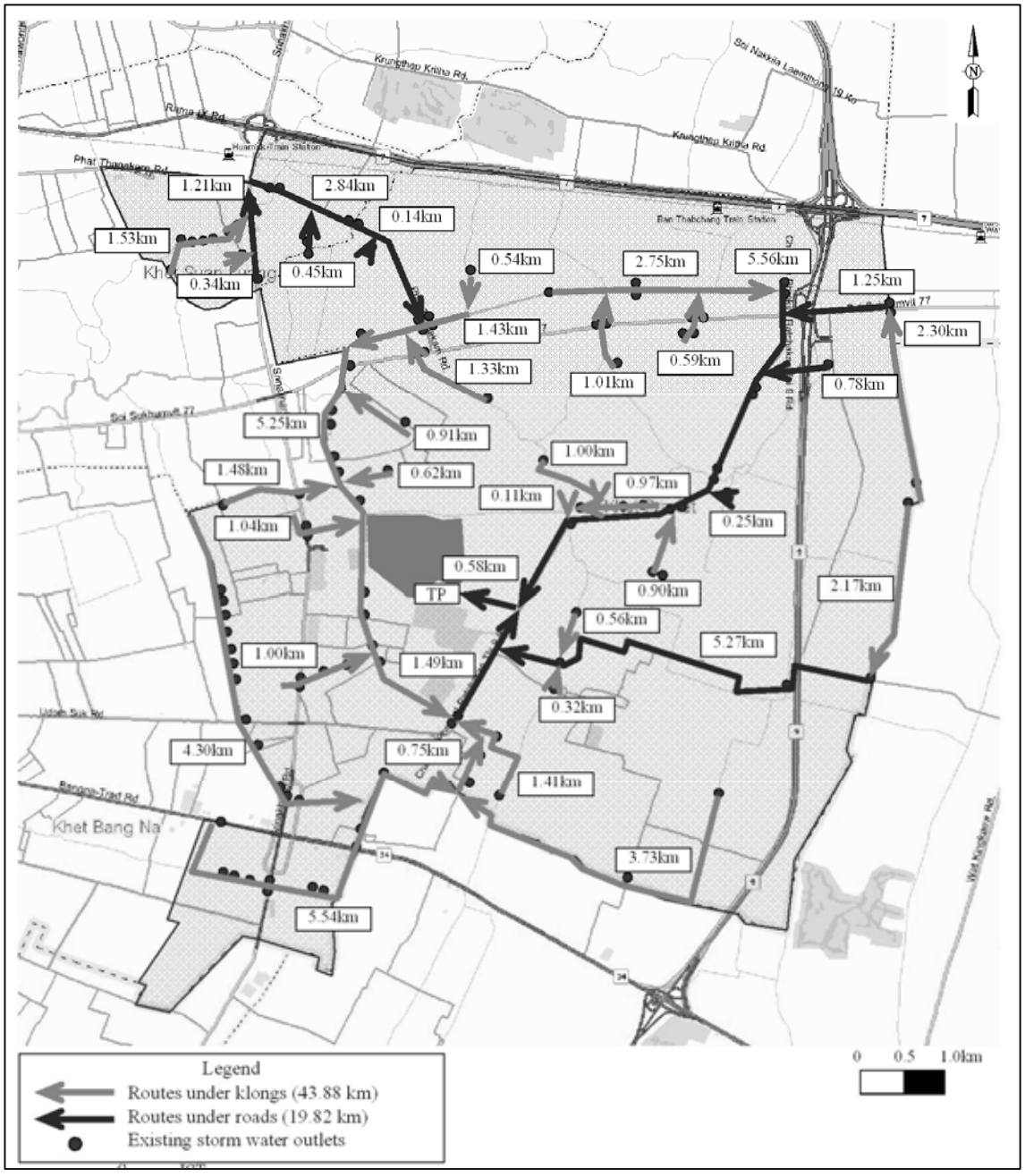
Source: JST

Figure 3.4.1 Routes of Interceptors, Option 1



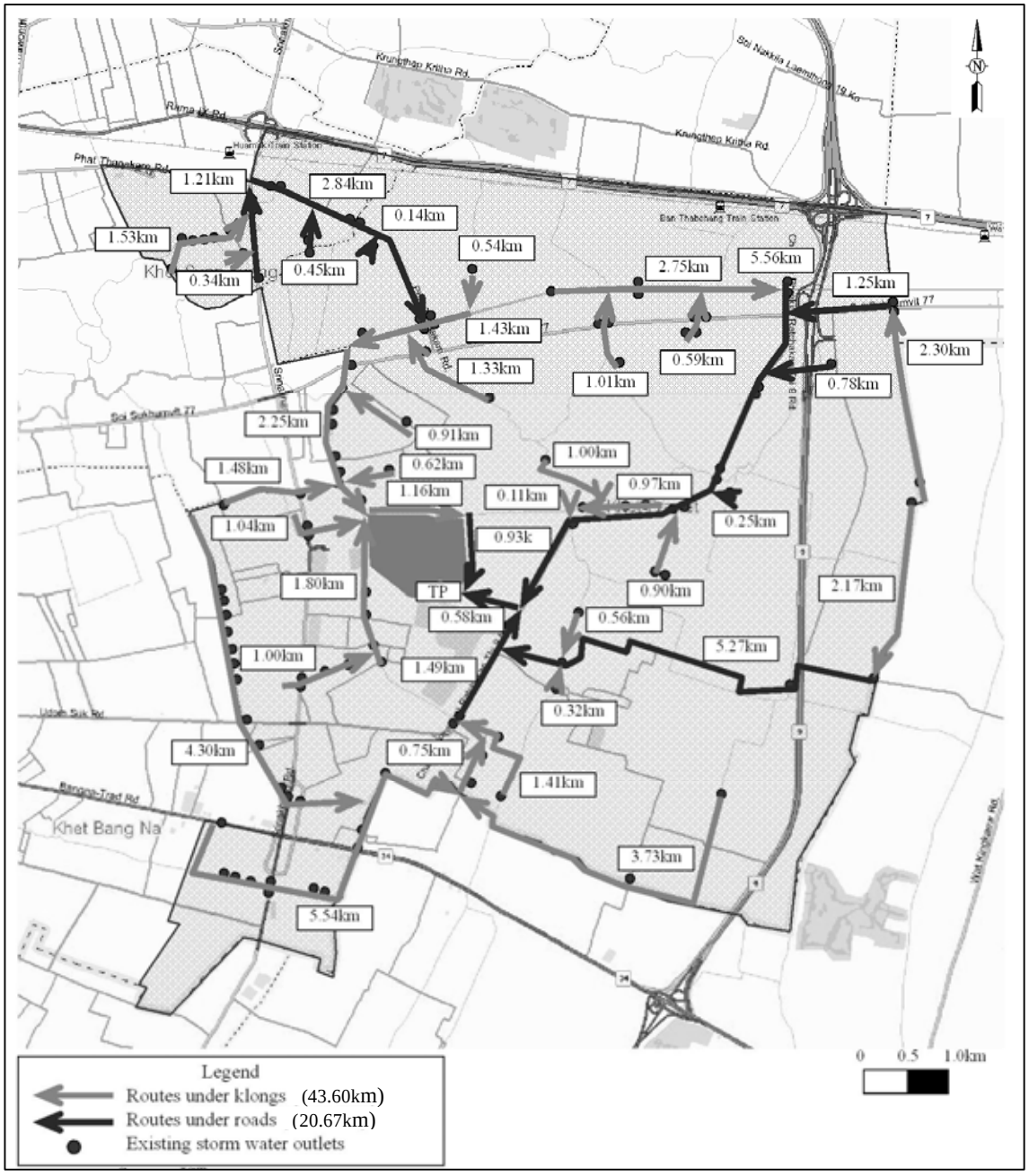
Source: JST

Figure 3.4.2 Routes of Interceptors, Option 2



Source: JST

Figure 3.4.3 Routes of Interceptors, Option 3



Source: JST

Figure 3.4.4 Routes of Interceptors, Option 4

3.4.2 Runoff Analysis and Flow Calculation

Diameters, gradients and depths of interceptor pipes were determined based on the runoff analysis for Option 4. In wet weather, downstream portion of interceptor is pressurized, but spilling over is prevented. For this reason, diameter of a part of interceptor can be made smaller. Results of runoff analysis is presented in Appendix 4 Software "MOUSE" developed by DHI Company was used for runoff analysis.

3.4.3 Longitudinal Sections of Interceptor

Longitudinal section of interceptor was determined based on the runoff analysis and flow calculation mentioned above.
Longitudinal section of interceptor is presented in Drawings.

3.5 Summary of Interceptor and Pumping Station

Interceptors and pumping station preliminary designed in this Chapter are summarized in this Section.

1) Interceptors

Sizes, lengths and other conditions of interceptors and vertical shafts for construction are summarized in Table 3.5.1 below.

Table 3.5.1 Summary of Interceptors

Interceptor			Vertical Shaft			
Diameter (mm)	Length (m)		Number		Average depth (m)	
	Under road	Under klong	Under road	Under klong	Under road	Under klong
300	480	0	4	0	6.9	-
450	0	1,455	0	11	-	7.8
600	4,970	24,900	36	172	7.5	8.1
800	4,025	9,720	27	50	14.9	10.0
1,000	4,270	755	22	5	11.7	13.3
1,200	1,595	4,125	11	23	16.7	14.8
1,500	4,970	2,645	21	19	19.0	15.6
2,000	385	0	3	0	20.6	-
Total	20,665	43,600	124	280	-	-

Source: JST

All interceptors will be constructed by pipe jacking method.

2) Interceptor Chambers

136 points (can be reduced to 121 points by integration of chambers)

3) Pumping Station

None

3.6 Phased Construction of Interceptors

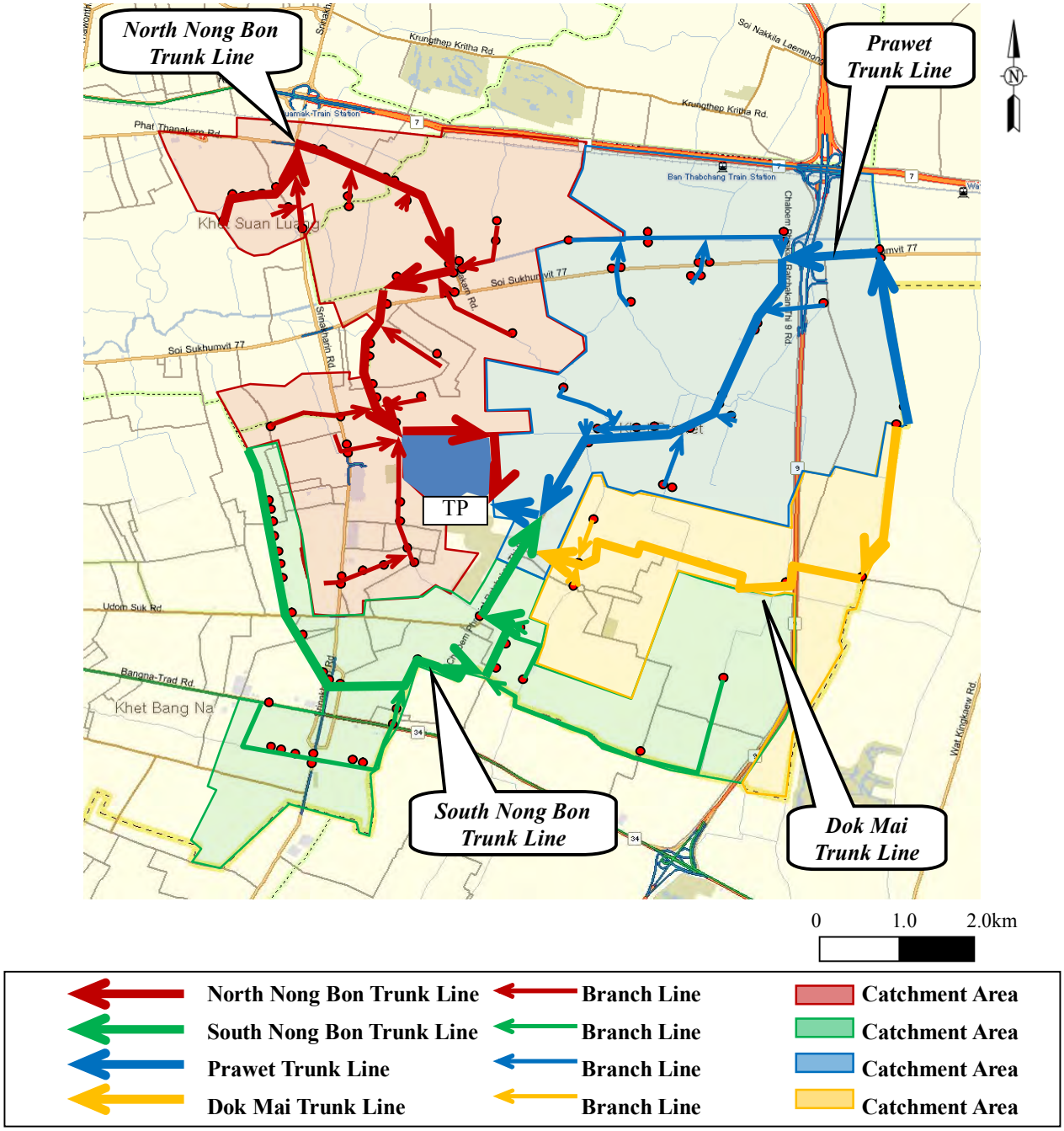
(1) Division of Interceptor Construction

Total length of interceptors in Nong Bon treatment area is approximately 64 km. It is expected to take long time to construct interceptors. Therefore, construction work is to be divided into a few lots and to be implemented in parallel. Construction of interceptors of which total length is approximately 30 km is divided into two lots in case of Bang Sue project which is currently under construction. Taking Bang Sue project into account, construction of interceptors in Nong Bon treatment area is divided into four lots. Interceptors are classified into four groups as shown in Table 3.6.1 and Figure 3.6.1 for smooth implementation.

Table 3.6.1 Four Groups of Interceptors in Nong Bon Treatment Area

Group No.	Name of trunk	Length (km)	Construction cost (million Baht)	Area (ha)	Served population (persons)	Pop. density (person/ ha)	Features of the service area
1	North Nong Bon	20.2 (Trunk 9.8 , Branch 10.4)	811	1,910	81,000	42	Urbanization advanced mostly in the treatment area
2	South Nong Bon	18.2 (Trunk 8.6 , Branch 9.6)	707	1,768	79,000	45	Commercial area and congested residential area are mixed
3	Prawet	17.6km (Trunk 9.0, Branch 8.6)	684	1,913	75,000	39	Congested residential area with a new railway station
4	Dokmai	8.3 (Trunk 7.3, Branch 1.0)	266	794	30,000	38	Rural area with scattered residents
Total		64.3 (Trunk 34.7, Branch 29.6)	2,468	6,385	265,000		

Source: JST



Source: JST

Figure 3.6.1 Division of Interceptors into Four Groups In Nong Bon Treatment Area

(2) Priority of Interceptor Groups

DDS has the intention to implement all interceptors at once. However, phased construction might be required according to circumstances, e.g. restriction of budget. In this case, implementation should be commenced from the priority group.

The following two groups are considered to be priority groups for the reasons mentioned in

Table 3.6.2.

Table 3.6.2 Priority Interceptor Groups

Name of Trunk（Group）	Reasons
North Nong Bon	Urbanization has been progressed most
South Nong Bon	Catchment of significantly polluted Klong Bang Na

Source: JST

In case phased construction is implemented, two groups, i.e. North Nong Bon and South Nong Bon should be constructed first followed by the remaining two groups, i.e. Prawet and Dokmai. Construction schedules for both cases are presented later in Chapter 4 of this report.

3.7 Issues and Technical Countermeasures in Future

Interceptor sewerage system has been adopted in Nong Bon treatment area as well as in other treatment areas in BMA, for which interceptor chambers are constructed in neighborhood of existing outlet to collect wastewater and convey it to WWTP. However, as described in Conceptual Master Plan Report, there are many issues regarding the interceptor sewerage system. These issues should be resolved on medium- and long-term basis after implementation of the proposed project including construction of WWTP, interceptors and interceptor chambers under this F/S.

Three issues to be resolved and countermeasures on mid- and long-term basis are described below.

3.7.1 Prevention of Back Flow from Klong

Topography of the Nong Bon treatment area is flat and low lying, and existing drain pipes are often constructed below water level in klong as can be seen in existing treatment areas in BMA. Many submerged outlets are observed even in dry weather (Photo 3.7.1).

Source: JST

Photo 3.7.1 Submerged Existing Outlets in Nong Bon Treatment Area

An interceptor chamber is constructed at the location where the existing outlet is submerged, klong water flows back into the chamber resulting in low concentrations of wastewater and low efficiency of treatment. Provision of a flap gate is planned in an interceptor chamber to prevent back flow as can be seen in other treatment areas. When flap gate is not completely closed by clogging of garbage, it can not prevent back flow from klong. Therefore the following short-term and medium- and long-term countermeasures are required.

- Periodical cleaning of interceptor chamber is to be carried out as short-term countermeasures.

- Convert the treatment area to pump drainage area and close all outlets of interceptor chamber as medium- and long-term countermeasure.

In order to convert the area to pump drainage area, the following considerations should be applied.

- Basically outlets and interceptor chambers are to be closed.
- No modification is necessary for interceptors because 2 to 5 DWF is conveyed to WWTP.
- Storm water runoff which is currently discharged from an interceptor chamber will over flow to roads and low lying areas because of closing of outlets.
- DDS is implementing deep drainage tunnel as a countermeasure against flooding. Prawet District office plans to provide temporary pumping unit to flood prone areas. Storm water runoff flooding to roads and low lying areas should immediately be removed by countermeasures in cooperation with these programs. It is also necessary to consider provision of pumping stations to flood prone areas for which flood mitigation program is yet to be planned.

Countermeasures to prevent back flow from klong should be provided by DDS which is responsible for operation and maintenance of interceptors, WWTPs and for flood control. However, outlets of existing drain pipes are under responsibility of PWD, DDS should closely cooperates with PWD when it closes outlets to convert the area to pump drainage area.

3.7.2 Enhancement of Connection of Uncollected Wastewater to Interceptor

Direct wastewater discharge to klongs in the existing treatment areas are observed at many places in BMA as shown in Photo 3.7.2. In interceptor sewerage system, usually wastewater discharged from households is collected through the existing drain pipes, intercepted at interceptor chambers and finally conveyed to WWTP. Water quality improvement in public water bodies is not realized unless wastewater is properly discharged to drain pipes. It is, therefore, very important to collect uncollected wastewater to realize water quality improvement in public water bodies. To realize complete (100 %) collection of wastewater in future, compulsory connection to sewerage system in a treatment area by regulations and subsidy from district office or BMA for the cost of house connection should be considered. In Japan there is a certain amount of cases that local governments subsidize a half of the connection cost or a one-third to a sewer user after start to use the sewerage system for one or two years.

Source: JST

Photo 3.7.2 Direct Discharge of Wastewater from Households to Klong

The above enhancement of connection should be conducted by PWD with cooperation with DDS, the former department is currently responsible for connection between houses and drain pipes.

3.7.3 Strengthening of Operation and Maintenance of the Existing Drainage Pipes

The existing drainage pipes become a part of sewerage system once facilities proposed under this F/S are completed which include interceptor chambers, interceptors and a WWTP. Improvement of water quality of the receiving water bodies, which is the main purpose of the wastewater project can not be realized unless all of the sewerage system including the existing drainage pipes functions properly.

The existing drainage pipes are under responsibility of PWD or district office, and DDS is responsible for construction and operation and maintenance of interceptor chambers and interceptors. Issues about operation and maintenance of the existing drainage pipes became clear through data collection and site visits for this F/S, which are shown in Table 3.7.1.

Table 3.7.1 Issues and Countermeasures about the Existing Drainage Pipes

Category	Issues	Countermeasures	Responsible agency
Management of information about pipes	Data about the drainage pipes are required for this F/S, but necessary data are not available because construction was very old. District office was forced to prepare these data. Sewerage inventory which is common in many countries including Japan is not prepared. Management of information is dependent on certain engineers' memory.	Sewerage inventory is to be prepared as quickly as possible, although time and cost are necessary. Electronic inventory which links to map information was introduced in large cities in Japan. This is useful tool for efficient management of information about sewerage system in Bangkok.	PWD
Grasp of internal conditions of pipes	Cleaning of drainage pipes is conducted. However current status of deterioration of pipes is yet to be grasped.	There is a possibility of accident caused by road subsidence because of damage of aged or deteriorated pipes. These accidents can be avoided by countermeasures in advance if the status of the pipes is grasped. Investigation by eyes utilizing mirrors should be carried out to monitor conditions pipes. Further monitoring by TV camera should be carried out according to plan if more detail monitoring is necessary.	PWD
Flow capacity of pipes	Flow capacities of the existing pipes are not known, although interceptors are designed to flow 5 DWF to WWTP. There is a possibility of spilling of storm water runoff before interceptor chamber even if interceptors are installed correctly.	Investigate all existing drainage pipes of its catchment, calculate storm water runoff and evaluate their capacities. If capacity is not enough, replacement or construction of new pipes should be carried out.	PWD

Source: JST

These issues will certainly surface as development of sewerage system proceeds. DDS should cope with these issues with cooperation with PWD as soon as possible.

4. Preliminary Design of Nong Bon WWTP

4.1 Basis for Planning

4.1.1 Outline of Nong Bon WWTP

Outline of Nong Bon WWTP which have been selected for the Priority Project are summarized in Table 4.1.1.

Table 4.1.1 Outlines of Nong Bon WWTP

Item	Value / Remark
Serviced area	6,385 ha
Type of collection system	Combined
Total population	265,000 for MP targeting 2040
Treatment capacity	135,000 m^3/day for MP targeting 2040
WWTP proposed site	Beside storm water reservoir under Monkey Cheek Project next to Rama IX Park (Area 3.5ha, for above ground facilities 1.1 ha)

Source: JST

4.1.2 Design Wastewater Characteristics

Design influent wastewater characteristics and effluent standards which are applied for Nong Bon WWTP are summarized in Table 4.1.2.

The pollution loading of influent in the beginning of operation is expected to be considerably lower comparing to that expected for Master Plan of which target year is 2040 since the current pollution loading of the existing WWTPs in BMA is quite low due to infiltration of groundwater, back flow of klong water from interceptor chambers and provision of septic tanks.

It takes some time for pollution loading to increase to design influent characteristics by tackling those problems. However, it is rather difficult to improve facilities later so as to treat wastewater, of which pollution lording is higher than planned design characteristics, once facilities are constructed. Therefore, gradual change of influent wastewater characteristics shown below are applied for design of Nong Bon WWTP so as to reduce excessive initial investment and at the same time make it possible that facilities can treat higher pollution lording in the future.

Table 4.1.2 Design Water Quality

Parameters	Influent characteristic		Effluent Standards
	2040(M/P)	2020(F/S)	
pH			5.5 – 9
Biochemical oxygen demand (BOD)	150 mg/l	100 mg/l	20 mg/l
Suspended solids (SS)	150 mg/l	100 mg/l	30 mg/l
Total nitrogen (T-N)	30 mg/l	20 mg/l	10 mg/l
Nitrogen (Ammonia)	-	-	5 mg/l
Total phosphorus (T-P)	8 mg/l	6 mg/l	2 mg/l
Dissolved oxygen (DO)	-	-	5 mg/l
Fat, oil and grease	-	-	5 mg/l

Source: JST

4.1.3 Projected Dry Weather Flow and Design Capacity of WWTP

Projected dry weather flows (DWF) from 2020 until 2040 i.e. target year of the Master Plan to Nong Bon WWTP are shown in Table 4.1.3.

Table 4.1.3 Projected Dry Weather Flow

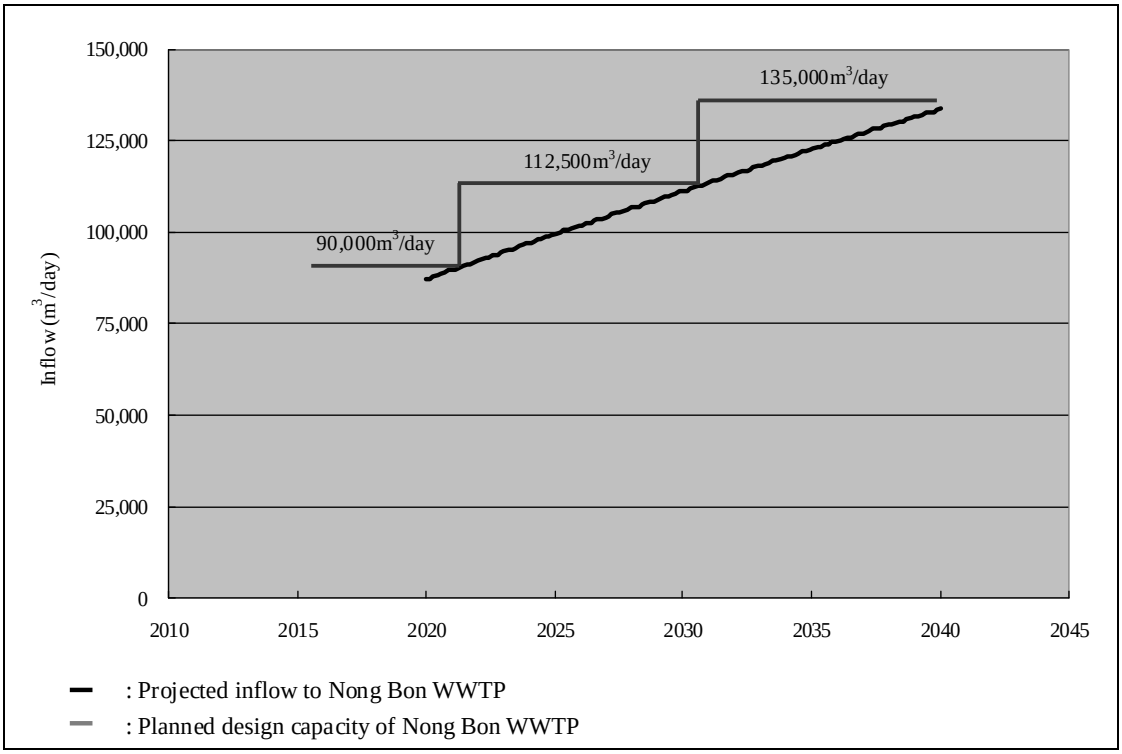
Year	2020	2030	2040
Daily average flow	87,100 m^3/day	111,100 m^3/day	133,600 m^3/day
Hourly maximum flow	174,200 m^3/day	222,200 m^3/day	267,200 m^3/day

Source: JST

Wastewater treatment facilities of the ultimate stage are planned to be composed of three trains of wastewater treatment facilities each having treatment capacity of 45,000 m^3/day considering projected flows and adequate design capacity.

Civil and architecture works of all three trains will be implemented under the Priority Project since staged development is rather uneconomical. On the other hand, mechanical and electrical works of two trains will be implemented under the Priority Project to meet required capacity for target year of the Priority Project to reduce initial investment since phased installation of equipment is possible.

The staged development plan and design capacity of Nong Bon WWTP together with projected inflow is presented in Figure 4.1.1 and Table 4.1.4.



Source: JST

Figure 4.1.1 Staged Development Plan of WWTP

Table 4.1.4 Design Capacity of WWTP

Year	Civil and Architecture	Mechanical and Electrical	Design capacity of WWTP
Start – 2021	3 trains	2 trains	90,000 m^3/day
2022 – 2031	3 trains	2 + (1/2) trains	112,500 m^3/day
2032 – 2040	3 trains	3 trains	135,000 m^3/day

Source: JST

4.1.4 Design Concepts and Requirements

Design concepts and requirements applied for designing of Nong Bon WWTP are summarized below.

1) The capacity of treatment facilities is designed on the basis of daily average flow and at the same time hydraulic capacity of treatment facilities is designed to accommodate hourly maximum flow.
2) Nong Bon WWTP receives five times design flow in rainy day. Daily average dry weather flow (DWF) i.e. design flow is purified by the secondary treatment consisting of biological processes while two times design flow is discharged after the primary treatment consisting of removal of garbage and grit which are included in

wastewater. Inflow exceeding three times design flow is directly discharged without any treatment.

3) Treatment processes which ensure removal of nitrogen and phosphorus are required to satisfy effluent standard.
4) Treatment processes are required to be flexible with fluctuation of pollution loading since expected pollution loading in the beginning of operation is considerably lower comparing to the design pollution loading.
5) Sludge generated from wastewater treatment facilities is dewatered at the site and transferred to Nongkaem WWTP, which is the centralized sludge treatment plant for sludge generated in BMA.
6) Consideration of landscape and pollution control against adverse impacts such as odor, noise and vibration is required taking into account the neighboring environment and designated land use of surrounding area.

4.2 Selection of Wastewater Treatment Process

4.2.1 Nutrient Removal Process

Treatment processes which ensure to remove nutrient to satisfy effluent standard are required to be adopted for Nong Bon WWTP. Treatment processes which enable to remove nitrogen and phosphorus to satisfy the level of effluent standards are shown in Table 4.2.1.

Table 4.2.1 Treatment Process of Nutrient Removal

Process	Explanation
Biological Nitrogen Removal	Nitrogen is removed by combined processes of nitrification and denitrification. Ammonia nitrogen is oxidized to nitrate nitrogen and nitrite nitrogen by nitrifying bacteria such as Nitrosomonas and Nitrobacter in aerobic tanks. Nitrate nitrogen and nitrite nitrogen is deoxidized to nitrogen gas by denitrifying bacteria such as Pseudomonas, Micrococcus, Achromobacter and Bacilius in anoxic tanks.
Biological Phosphorus Removal	Phosphorus is removed by luxury phosphorus uptake phenomenon of activated sludge microbes. Microbes discharge phosphorus in anaerobic tanks and uptakes more phosphorus than discharged amount in the following aerobic tanks. Phosphorus concentration of wastewater is reduced by uptake of activated sludge microbes and activated sludge which contains phosphorus is removed by settling tanks.
Physical-chemical Phosphorus Removal	Phosphorus is removed by adding coagulant such as alum and ferric sulfate. Phosphorus turns into insoluble substance by the reaction with coagulant. Mixing coagulant with wastewater and flocculation is done by turbulence of aeration tanks and removal of insoluble substance is done by solid-liquid separation in settling tanks.

Source: JST

Biological process, which is composed of anoxic tanks, aerobic tanks and pumps which circulates nitrified wastewater from aerobic tanks to anoxic tanks for denitrification, is adopted for removal of nitrogen.

Physical-chemical process is adopted for the removal of phosphorus by the following merits and reasons.

1) Removal efficiency of physical-chemical process is more stable than biological process especially on rainy day when anaerobic condition is difficult to maintain.
2) Physical-chemical process requires space only for dosing equipment of coagulant while biological process requires additional volume which is equal to approximately one hour of hydraulic retention time of anaerobic tanks.
3) Even if biological process is adopted, dosing equipment of coagulant is usually installed for backup of biological process since biological process becomes

frequently unstable.

4) Physical-chemical process is already practiced in the existing WWTPs of BWA (Chatuchak WWTP, Din Daeng WWTP, Nong Khaem WWTP, and Thung Khru WWTP).

4.2.2 Alternatives of Wastewater Treatment Process

There are several wastewater treatment processes which can purify wastewater to satisfy the level of effluent standards. Wastewater treatment processes, which can be potential alternatives for Nong Bon WWTP, are listed below together with newly developed technology of membrane bioreactor (MBR) and carrier added activated sludge process (CAASP). Other biological treatment processes, such as oxidation pond and aerated lagoon, are excluded from assessment of alternatives because these processes require huge areas for construction, which prevent them from being adopted for Nong Bon WWTP. Brief explanations of newly developed technologies are shown in Table 4.2.2. The other treatment processes are conventional and practiced worldwide including Thailand.

- Recycled nitrification denitrification process (RNDP)
- Oxygen activated sludge process (OASP)
- Oxidation ditch process (OD)
- Extended aeration process (EAP)
- Sequencing batch reactor (SBR)
- Membrane bioreactor (MBR)
- Carrier added activated sludge process (CAASP)

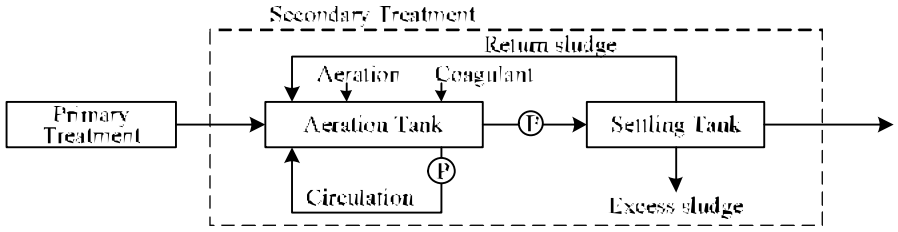
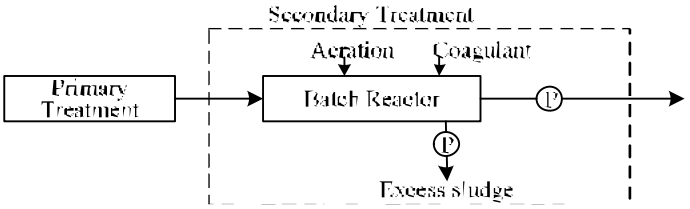
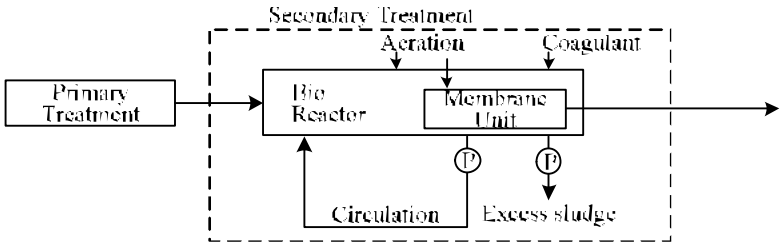
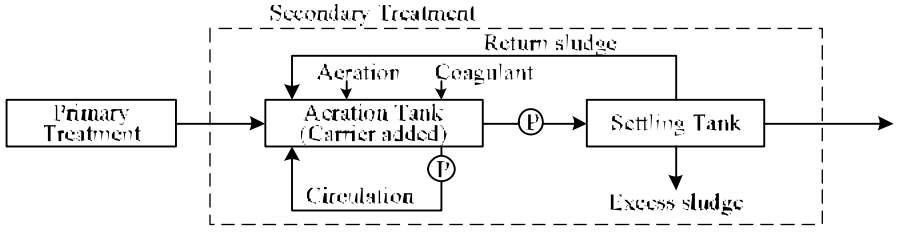
Table 4.2.2 Explanation of Newly Developed Technology

Process	Explanation
Membrane bioreactor (MBR)	MBR directly separates effluent from activated sludge liquid by membranes which are installed inside of aeration tanks. Hydraulic retention time can be reduced since MLSS is retained much higher from 8,000 mg/l to 15,000 mg/l owing to the way of solid-liquid separation. Effluent is expected to be better quality than those of conventional processes since effluent does not include suspended solid.
Carrier added activated sludge process (CAASP)	CAASP enables to increase concentration of nitrification bacteria in aeration tanks by adding carriers which contains nitrification bacteria. Hydraulic retention time can be reduced owing to increase of microbe. CAASP is usually adopted for biological nitrogen removal process since it requires longer hydraulic retention time and sludge retention time. Stable nitrification is achieved owing to nitrifying bacteria contained in carriers since carriers are retained in aeration tanks.

Source: JST

Oxygen activated sludge process (OASP) is not suitable since OASP is usually adopted for wastewater of high organic concentration. Besides, oxidation ditch process (OD) and extended aeration process (EAP) are not appropriate because of its suitability for smaller scale plants and required area is considerably larger because of longer hydraulic retention time. Hence, oxidation ditch process (OD) and extended aeration process (EAP) are not suitable for Nong Bon WWTP, which has severe limitation for available area.

Therefore, the following four alternatives of wastewater treatment process shown in Figure 4.2.1 are compared.

Process	Systematic flow of wastewater treatment process
Recycled Nitrification Denitrification Process (RNDP)	
Sequencing Batch Reactor (SBR)	
Membrane Bioreactor (MBR)	
Carrier added Activated Sludge Process (CAASP)	

Source: JST

Figure 4.2.1 Systematic Flow of Alternatives

4.2.3 Basic Planning of Alternatives

Basic planning of wastewater treatment facilities is prepared for each alternative to compare

financial aspects including the initial investment, O&M cost and major replacement cost. Basic planning is conducted based on the following site conditions and assumptions.

1) There is limitation of space at the proposed site for the construction of facilities above the ground level.
2) Height of main facilities of WWTP is planned not to exceed fifteen meter above the ground level considering the restriction of designated land use.
3) Inflow level of raw wastewater to WWTP is assumed to be fifteen meter below the ground level.
4) Receiving water body of treated effluent and storm water is Klong Nong Bon. Effluent water level inside the WWTP is assumed to be five meter above the ground level considering the length of effluent pipeline.
5) Construction of the facilities under the ground level is avoided as much as possible from the view point of economical aspect.
6) The site for facilities which require buildings above the ground level such as lift pump station is reserved before placing wastewater treatment facilities.

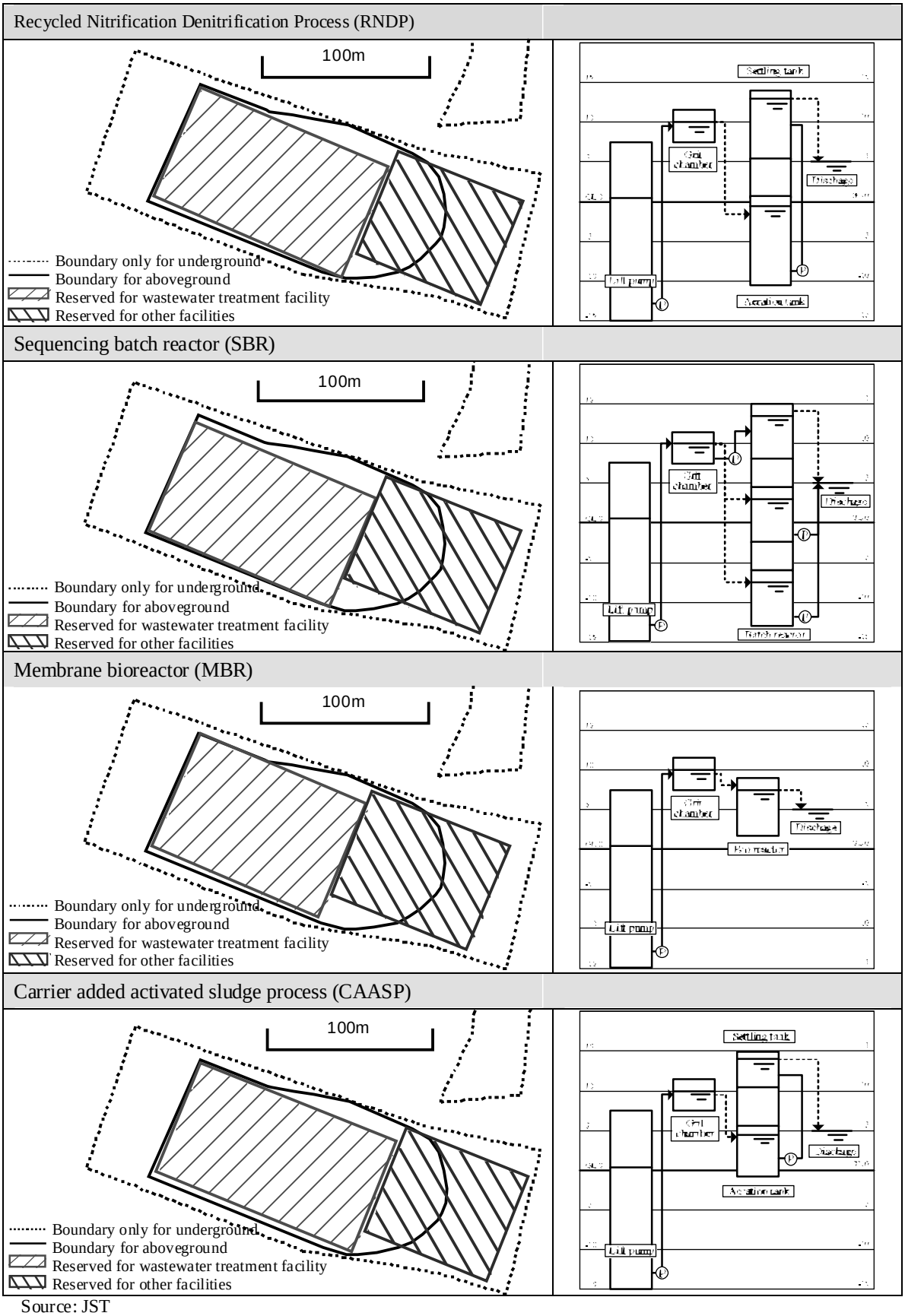
Basic planning of general layout and hydraulic profile is presented in Figure 4.2.2 for each alternative. As the results of layout planning, plane areas of wastewater treatment facilities for all alternatives are similar since those facilities are arranged to utilize available land for aboveground structures as efficient as possible. On the contrary, cross sections of wastewater treatment facilities are quite different.

For RNDP, settling tanks are to be vertically placed on the aeration tanks due to the land restriction for aboveground facilities. And also RNDP requires deep aeration tanks, of which depth is 10 meter, and two-story settling tanks for space saving considering all facilities are to be arranged within available land. As the results, RNDP has underground structures with approximately 12 meter depth, which required extensive temporary works for the construction.

SBR requires batch reactors to be arranged vertically in three stories. As the results, SBR has underground structures with approximately 14 meter depth.

MBR does not require any underground structures and relatively lower aboveground structure, which is the major advantage compared with other alternatives for construction costs.

CAASP requires settling tanks to be vertically placed on the aeration tanks as well as RNDP. However, CAASP can be planned with normal aeration tanks, of which depth is 5.5 meter, and single story settling tanks owing to the less hydraulic retention time and the lower MLSS concentration than those of RNDP. As the results, CAASP does not require major underground structure, which is the major advantage of this process.



Source: JST

Figure 4.2.2 Basic Planning of Alternatives

4.2.4 Comparison of Alternatives

Comparisons of alternatives are summarized in Table 4.2.3. As the result of comparison, carrier added activated sludge process (CAASP) is recommended due to the following advantages.

1) Stable performance of purification of organic substances and nitrification is expected owing to nitrifying bacteria and microbe contained in carriers
2) Basically O&M technology is the same as those of RNDP and BMA is well accustomed to process technology.
3) CAASP has high flexibility on rainy day since carriers are retained in aeration tanks and keep microbe for purification.
4) Amount of carrier is adjusted according to pollution loading of influent at the start of operation and can be added in the future to increase to design capacity.
5) CAASP is the most economical in terms of Net Present Value since it requires the lowest investment cost and O&M cost.

Table 4.2.3 (1) Comparison of Wastewater Treatment Processes (1/2)

	Recycled Nitrification Denitrification process (RNDP)	Sequencing Batch Reactor (SBR)
Performance	Performance of RNDP is well proven for its prevailing adoption. However, RNDP requires proper management of control items such as MLSS, SRT, circulation, return sludge ratio, SVI, DO and sludge withdrawing to keep adequate performance.	Liquid-solid separation is supposed to be stable since sedimentation is done by complete static condition. It is difficult to keep sufficient effluent quality stable while inflow of raw wastewater is largely fluctuated.
Operation and maintenance	O&M technology of RNDP is well established for its prevailing adoption including the existing WWTPs of BMA. Liquid solid separation in settling tanks requires careful attention because of relatively high MLSS concentration.	O&M technology of SBR is well established for its prevailing adoption including the existing WWTPs of BMA. Control items of operation are fewer since SBR does not require circulation and return sludge.
Flexibility to fluctuation of inflow (rainy day)	RNDP has risk of carry over of activated sludge on rainy day because of high MLSS comparing to CAASP. Decline of MLSS in aeration tanks causes deterioration of purification performance.	SBR has less flexibility since performance of SBR is easily affected by fluctuation of inflow. Extra capacity of batch reactors is required to accommodate fluctuation of inflow.
Flexibility to fluctuation of pollution loading	RNDP is required to operate with lower MLSS in case of low pollution loading since considerable long ASRT causes deflocculation and deterioration of activated sludge and makes liquid-solid separation in settling tanks difficult	Cycle time and withdrawing rate is flexibly adjusted according to pollution loading of inflow. Duration of aeration, mixing, settling and decant can also be optimized to adjust pollution loading from operating experiences, but not easy to realize.
Aeration requirement	Aeration tanks of 10m depth require for formulating spiral flow to supply aeration equally. Spiral flow is formulated by air current from diffusers installed in one side of aeration tanks. Total requirement of aeration is approximately 9 times wastewater inflow.	Oxygen requirement is the lowest owing to low MLSS and no circulation flow. However, capacity of blowers is relatively larger since supply of air is intermittent. Total requirement of aeration is approximately 7 times wastewater inflow.
Outline of design criteria	MLSS: 4,000 mg/l BOD-SS loading: 0.11 kgBOD/kgMLSS/day HRT of aeration tank: 8.6 hours Hydraulic surface loading: 15 m^3/m^2/day	MLSS: 2,000 mg/l BOD-SS loading: 0.40 kgBOD/kgMLSS/day Cycle: 6 times/day Withdrawing rate: 1/3
Outline of facilities	Anoxic tank: 15mW×8mL×10mD×12tanks Aerobic tank: 15mW×19mL×10mD×12tanks ST :7.5mW×25mL×3.5mD×2story×24tanks	Batch reactor: 25mW×44mL×5.5mD×12tanks
Experience in BMA	Din Daeng WWTP / Bang Sue WWTP	Chongnonsi WWTP / Chatuchak WWTP
Initial investment	2,473 Million Baht (109 %)	2,999 Million Baht (132 %)
O&M cost	77.1 Million Baht/ year (102 %)	81.7 Million Baht/ year (108 %)
Net present value	3,670 Million Baht (105 %)	4,362 Million Baht (125 %)
Evaluation	2/4	3/4

Net preset value: Discount rate = 4% / period = 30year,
Source: JST

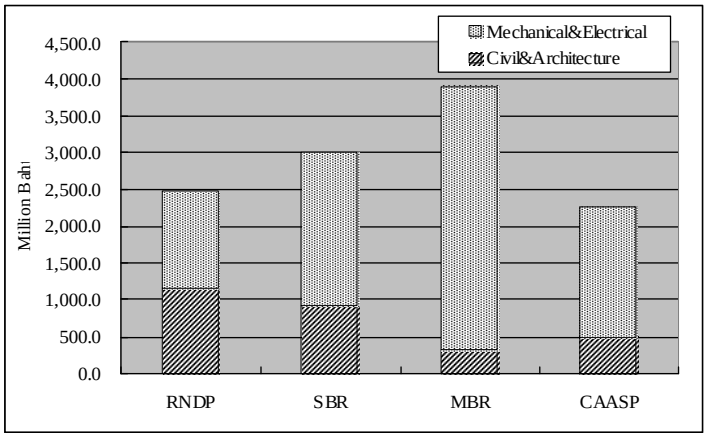
Table 4.2.3 (2) Comparison of Wastewater Treatment Processes (2/2)

	Membrane Bioreactor (MBR)	Carrier Added Activated Sludge Process (CAASP)
Performance	Effluent quality is stable and better than the other treatment processes since effluent does not include suspended solids. Effluent can be directly reused owing to quality and safety that majority of coliform bacteria are removed by membrane.	More stable performance of purification of organic substances and nitrification than RNDP is expected under the adverse condition such as rainy day owing to nitrifying bacteria and microbe contained in carriers.
Operation and maintenance	Operation of liquid-solid separation is easy and stable since it is done physically by membrane. However, periodical washing of membrane and replacement of membrane modules are required to keep adequate performance of membrane.	O&M technology of CAASP is the same as those of RNDP except for management of carrier. Operation of liquid solid separation in settling tanks is easier than RNDP owing to relatively low MLSS concentration.
Flexibility to fluctuation of inflow (rainy day)	Influence of flux rate fluctuation on effluent quality is almost none as long as flux rate remains within design value since liquid-solid separation is done physically. MBR can not treat more than flux rate and flux rate of membrane has physical limit.	CAASP has high flexibility since carriers are retained in aeration tanks and microbe can be kept always for purification. Carry over of activated sludge on rainy day is less owing to low MLSS comparing to RNDP.
Flexibility to fluctuation of pollution loading	MBR is required to operate with lower MLSS in case of low pollution loading since considerable long ASRT causes deflocculation and deterioration of activated sludge and consume more energy for aeration.	CAASP has high flexibility since amount of carrier can be adjusted according to pollution loading of inflow. In case of low loading, CAASP starts to operate with less or non carrier and carriers can be added later as loading increases.
Aeration requirement	Membrane requires washing of surface by air to prevent from clogging. Oxygen requirement is relatively high due to demand for endogenous respiration of high MLSS. Total requirement of aeration is approximately 20 times wastewater inflow.	Carriers need to float in order to efficiently contact with pollution load. Additional aeration is required for floating and diffusing carrier equally. Total requirement of aeration is approximately 10 times wastewater inflow.
Outline of design criteria	MLSS: 10,000 mg/l BOD-SS loading: 0.08 kgBOD/kgMLSS/day HRT of aeration tank: 4.9 hours	MLSS: 2,000 mg/l BOD-SS loading: 0.37 kgBOD/kgMLSS/day HRT of aeration tank: 5.3 hours Hydraulic surface loading: 25 m^3/m^2/day
Outline of facilities	Bioreactor: 7.3mW×57mL×5.5mD×12tanks (Anoxic zone: 15mL / Aerobic zone: 42mL)	Anoxic tank: 15mW×13mL×5.5mD×12tanks Aerobic tank: 15mW×17mL×5.5mD×12tanks ST :7.5mW×30mL×3.5mD×24tanks
Experience in BMA	None	None
Initial investment	3,898 Million Baht (172 %)	2,267 Million Baht (100 %)
O&M cost	268.4 Million Baht/ year (355 %)	75.5 Million Baht/ year (100 %)
Net present value	8,145 Million Baht (234 %)	3,478 Million Baht (100 %)
Evaluation	4/4	1/4

Net preset value: Discount rate = 4% / period = 30year,
Source: JST

4.2.5 Cost Analysis of Alternatives

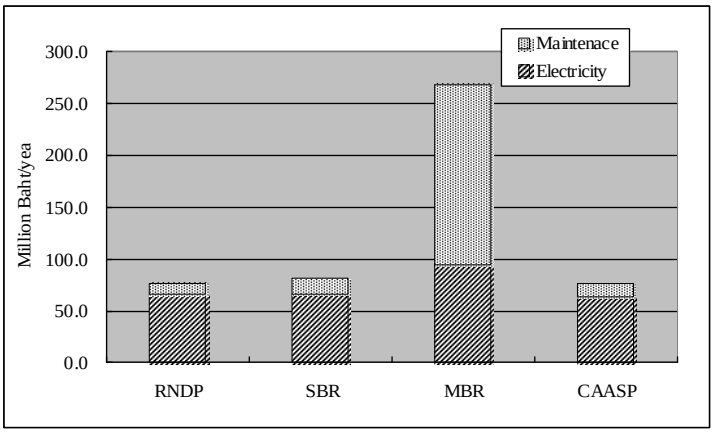
Initial investment of alternatives is analyzed as shown in Figure 4.2.3. Initial cost of CAASP is the lowest among alternatives. Civil and architecture costs of MBR and CAASP are lower since volume of structures is smaller and both of them do not require underground structure because of less hydraulic retention time for biological treatment. Initial cost of MBR is the highest since cost of membrane unit is rather expensive even though unit cost of membrane is currently getting cheaper.



Source: JST

Figure 4.2.3 Cost Analysis of Initial Investment

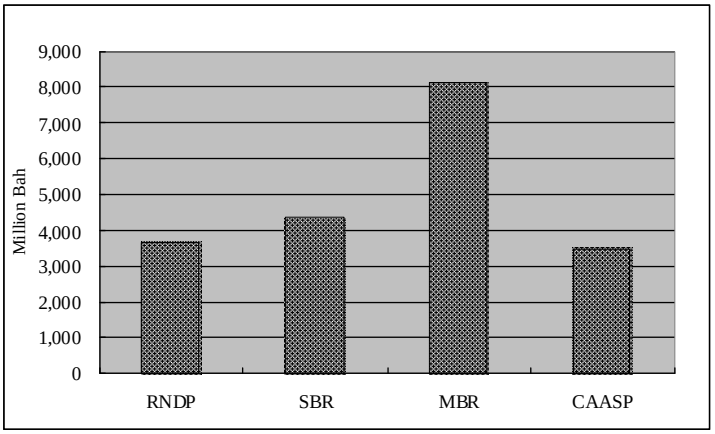
O&M cost of alternatives is analyzed as shown in Figure 4.2.4. Electricity consumption and maintenance cost of alternatives except for MBR are similar even though CAASP has a slight advantage. Electricity consumption of MBR is higher due to larger aeration demand for washing membranes. Maintenance cost is also higher due to periodical replacement of membrane modules.



Source: JST

Figure 4.2.4 Cost Analysis of O&M Cost

Net present value of alternatives is calculated to compare financial advantage for long time of period considering the initial investment, O&M cost and major replacement cost. Net present value of alternatives is analyzed as shown in Figure 4.2.5. CAASP gains an advantage over other alternatives.



Source: JST

Figure 4.2.5 Cost Analysis of Net Present Valve

4.3 Aboveground WWTP and Underground WWTP

4.3.1 Basic Planning of Alternatives

DDS requested the Survey Team to conduct economical comparison of above-ground WWTP and underground WWTP. The reasons for the request are as follows. Currently, Bang Sue WWTP is under construction in BMA. Bang Sue WWTP is located in the park, and all of the treatment facilities are designed under ground, and an environment education center is designed above the treatment facility taking into account beautiful scenery of the surrounding environment. People living in the neighborhood of Nong Bon WWTP might desire the same underground WWTP. BMA can not neglect residents' desire. Thus DDS's intention is as such that economical comparison between above-ground WWTP proposed by the Survey Team and underground WWTP is to be done.

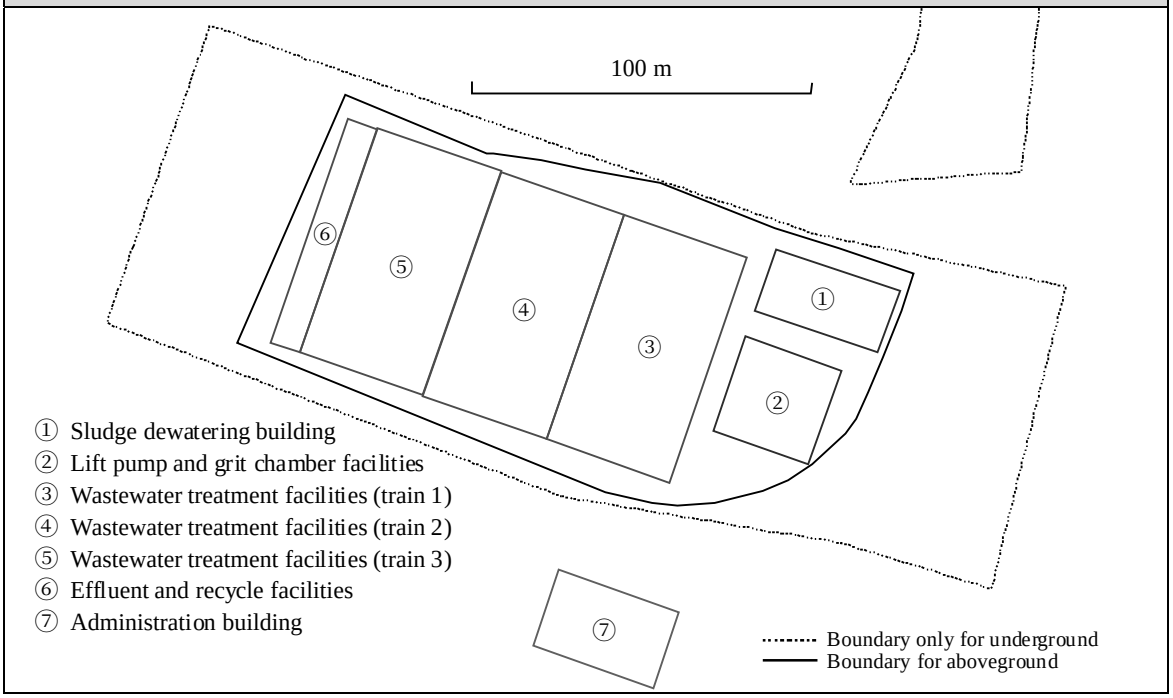
Construction site for Nong Bon WWTP is located in the site of storm water reservoir constructed for flood control and it is DDS's property. In addition, an administration building and three workshops, all of them are DDS own property, are currently under construction in the neighborhood of the construction site. Therefore, surrounding environment is quite different from that of Bang Sue WWTP. However, a part of storm water reservoir is opened to the public for recreational activities, and people are enjoying water support and taking rest at the site.

Thus the Survey Team conducted cost comparison of underground WWTP and above-ground WWTP in accordance with request from DDS. Basic planning of facilities is prepared for each alternative to compare project cost including the initial investment, O&M cost and major replacement cost. Basic planning is prepared based on the following conditions.

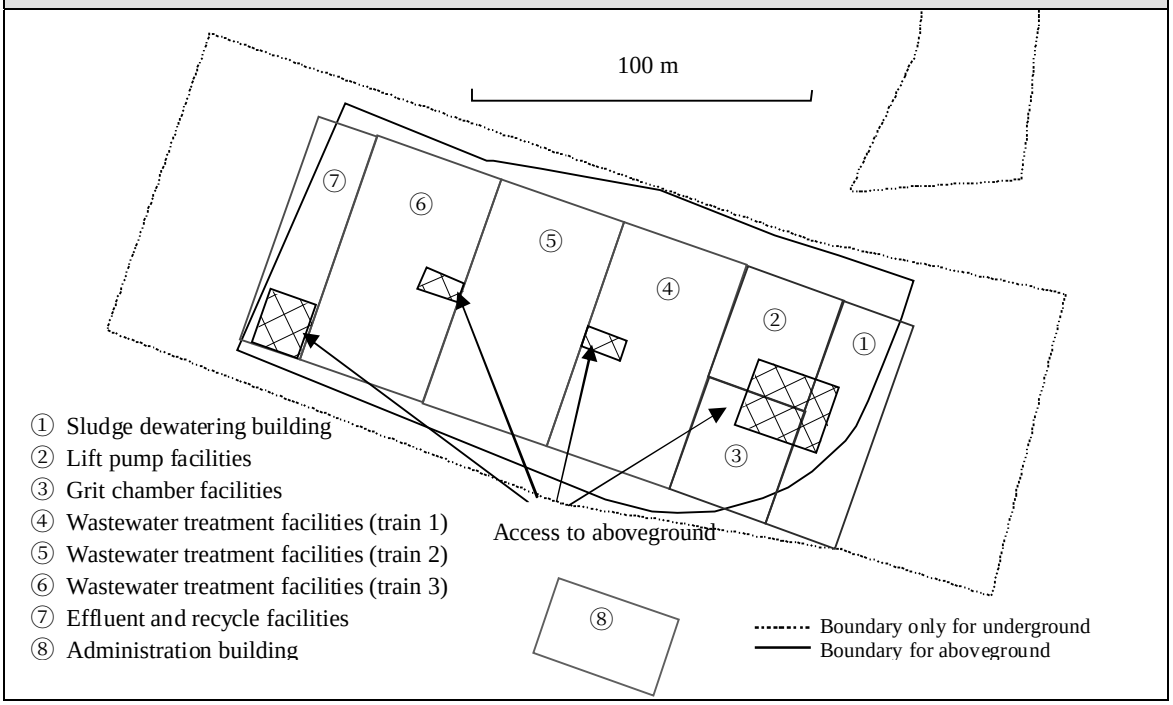
1) Administration building is planned above the parking lots of DDS administration building, which is currently under construction and located close to the site for both alternatives.
2) All facilities of underground WWTP are planned to be integrated together to encase all facilities in one structure considering construction method of the consecutive underground wall.
3) For underground WWTP, it is also inevitable that aeration tanks and settling tanks are placed vertically because available area for underground structureis also not enough to place those facilities sidewise.
4) For underground WWTP, it is inevitable that there is room above maintenance space for aeration tanks since the water level of aeration tanks is determined from the water level of grit chambers. That room is utilized as space for equipment such as electrical equipment, ventilation equipment and so on.

Basic planning of the general layout and cross section is presented in Figure 4.3.1 and Figure 4.3.2 for each alternative.

Application of above-ground WWTP

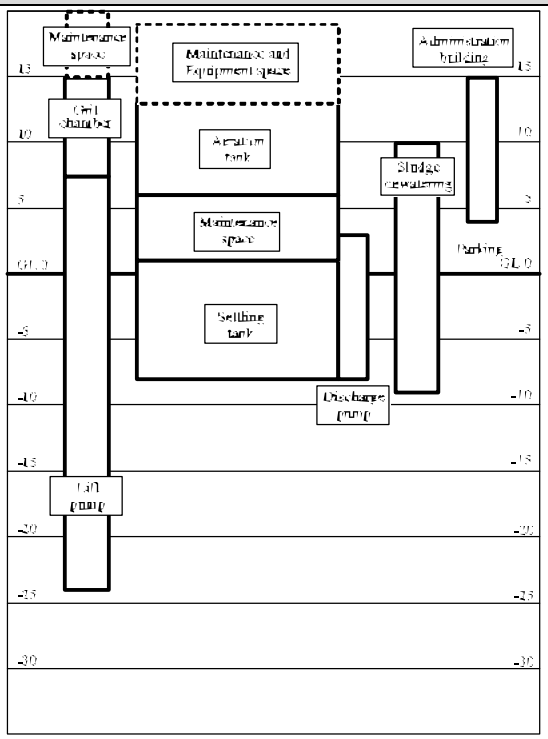
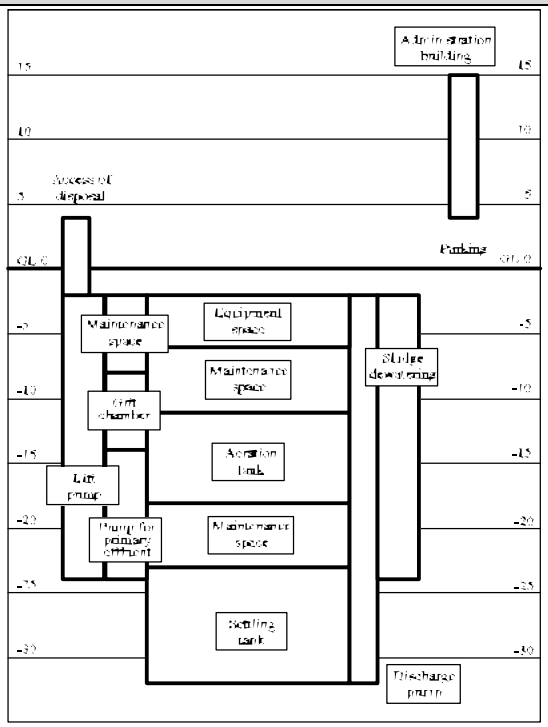


Application of underground WWTP



Source: JST

Figure 4.3.1 General Layout of Alternatives

Application of Aboveground WWTP	Application of Underground WWTP
	

Source: JST

Figure 4.3.2 Cross Section of Alternatives

4.3.2 Economic Comparison of Alternatives

Economic comparison of alternatives are summarized in Table 4.3.1.

Table 4.3.1 Economic Comparison of Alternatives

	Above-ground WWTP	Underground WWTP
Initial investment	Construction cost: 3,316 Million Baht Indirect cost: 1,989 Million Baht 5,305 Million Baht (100 %)	Construction cost: 4,369 Million Baht Indirect cost: 2,621 Million Bah 6,990Million Baht (132 %)
O&M cost	107.7 Million Baht/ year (100 %)	117.5 Million Baht/ year (109 %)
Net present value	7,259 Million Baht (100 %)	9,109 Million Baht (125 %)

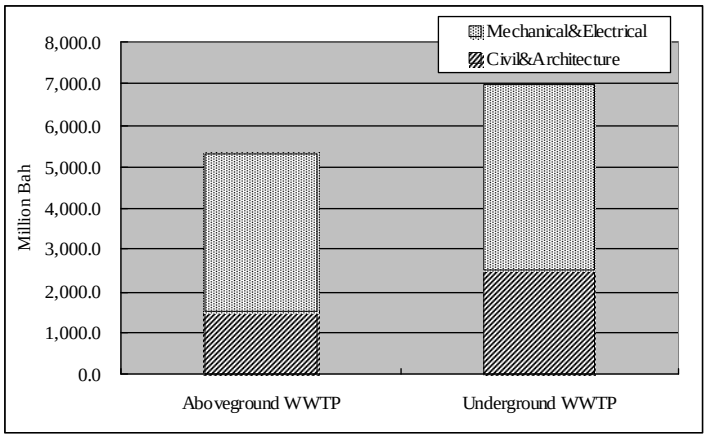
Net preset value: Discount rate = 4% / period = 30year

Source: JST

Initial investment of alternatives is analyzed as shown in Figure 4.3,3. Initial investment of underground WWTP is totally 32 % i.e. 1,685 million Baht higher than that of above-ground WWTP.

The costs of civil and architectural works for underground WWTP are 170 % of above-ground WWTP. This difference of initial investment mainly results from the construction cost of deep underground structures such as consecutive underground wall, temporary works and additional structures required for installing facilities under the ground.

The costs of mechanical and electrical works for underground WWTP are 117 % of above-ground WWTP. Comparing to civil and architecture works, the cost difference of mechanical and electrical works is less. The differences of initial investment mainly results from equipment of main pump system i.e. lift/discharge pumps and the conveyance system of disposal i.e. sludge cake, screening and grit.



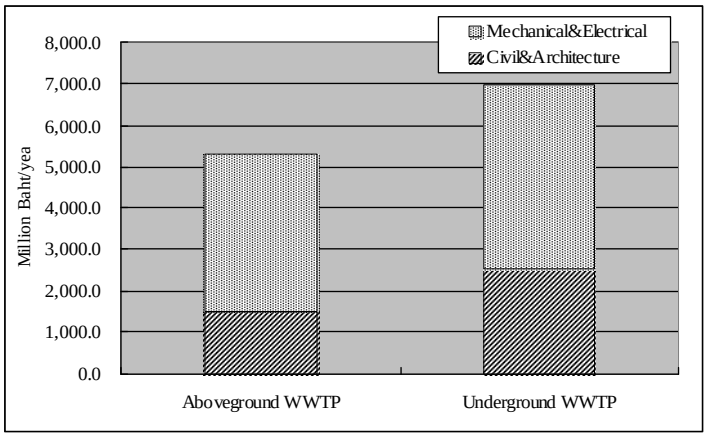
Source: JST

Figure 4.3.3 Cost Analysis of Initial Investment

O&M cost of alternatives is analyzed as shown in Figure 4.3.4. O&M cost of underground WWTP is totally 9 % i.e. 9.8 million Baht/year higher than that of above-ground WWTP.

Electricity consumption of two alternatives is similar due to the following reasons. The majority of electricity for wastewater treatment is consumed by pumps and aeration. Influent level of wastewater and discharge level of receiving water bodies are the same. Therefore, required total heads of lift and discharge pumps for both alternatives basically are the same, those results in similar electricity consumption for pumps. And also, electricity consumption required for aeration is the same for both alternatives because of the same conditions. The minor difference of electricity consumption mainly results from building equipment such as ventilation and lighting system.

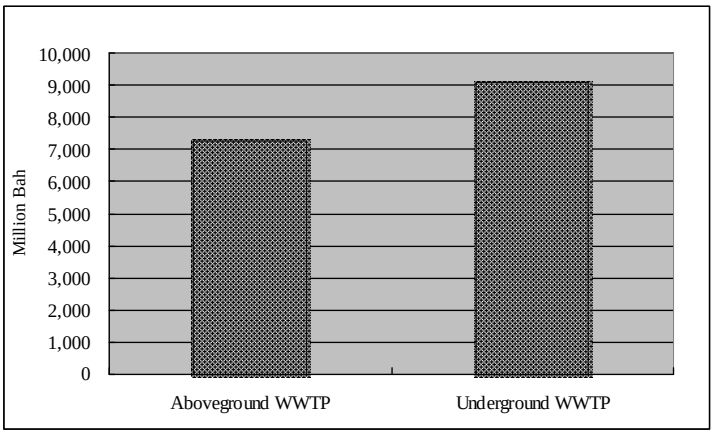
Maintenance cost of underground WWTP is slightly higher than above-ground WWTP since underground WWTP has additional equipment for conveyance system of disposal i.e. sludge cake, screening and grit.



Source: JST

Figure 4.3.4 Cost Analysis of O&M Cost

Net present value of alternatives is calculated to compare financial advantage for long time of period considering the initial investment, O&M cost and major replacement cost. Net present value of alternatives is analyzed as shown in Figure 4.3.5. Above-ground WWTP gains economic advantage of 25 % i.e. 1,850 million Baht over underground WWTP.



Source: JST

Figure 4.3.5 Cost Analysis of Net Present Value

4.4 Facilities Planning

4.4.1 Concepts for Facilities Planning

DDS expects to introduce reliable technologies in order to enable steady and secured treatment for a large scale WWTP. At the same time, DDS expects to introduce technologies that would result in resource saving and energy saving from the view point of sustainability. Concepts adopted for facility planning are summarized below.

1) Consideration of life cycle cost including initial investment, costs for operation & maintenance and replacement
2) Stable and easy operation by introducing necessary backup and automation by SCADA system and instrument
3) Total energy saving by introducing highly efficient technology, optimizing operation and minimizing hydraulic loss
4) Reduction of initial investment by applying phased installation according to increase of influent flow and pollution loading
5) Consideration of environmental and social impacts

4.4.2 Design Flow

Design flows, which flow to each treatment process, are summarized in Table 4.4.1.

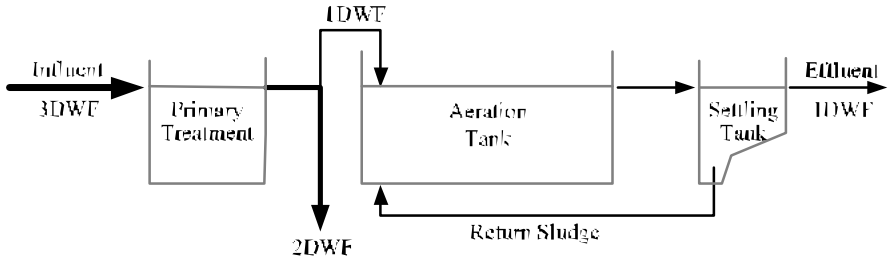
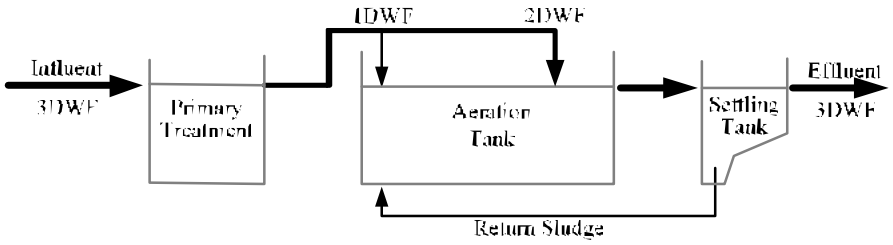
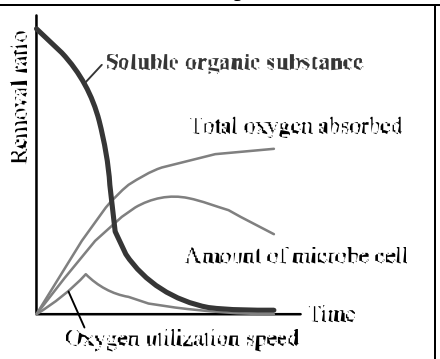
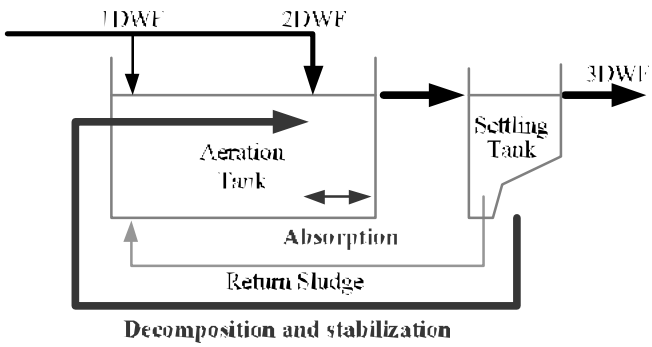
Table 4.4.1 Design Flow

Design flow	Explanation
Influent to WWTP	The maximum influent, which flows to WWTP on the peak, is five times design flow.
Primary treatment	Three times design flow flows to the primary treatment facilities which are comprised of grit chambers and fine screens.
Secondary treatment	Design flow flows to secondary treatment facilities which are comprised of biological treatment i.e. aeration tanks and settling tanks.
Wet weather activated sludge process	Two times design flow i.e. the remainder of primary effluent has two options i.e. discharging to receiving water body after the primary treatment and treating by wet weather activated sludge process. In case of wet weather activated sludge process, two times design flow flows into the later stage of aeration tanks.
Direct discharge	Two times design flow i.e. exceeding three times design flow for the primary treatment is directly discharged to the receiving water body after pumping up by lift pumps.

Source: JST

Brief explanation of wet weather activated sludge process is presented in Table 4.4.2.

Table 4.4.2 Explanation of Wet Weather Activated Sludge Process

Process
The conventional practice in rainy day is that only DFW is treated by secondary treatment and two times DWF is discharged after primary treatment. Wet weather activated sludge process is that DFW flows to the beginning of aeration tanks as the regular operation and two times DFW flows to the later stage of aeration tanks.
Conventional practice 
Wet weather activated sludge process 
Principle
The majority of organic substances of wastewater are removed in relatively short time i.e. approximately thirty minutes after contacting with activated sludge. This phenomenon is known as initial absorption. Wet weather activated sludge process reduces total pollution lording of effluent, which flows to receiving water body in rainy day, by utilizing this phenomenon. Organic substances, which are absorbed by activated sludge in the later stage of aeration tanks, are settled down in the settling tanks and retuned to the beginning of aeration tanks. Organic substances are decomposed and stabilized by activated sludge during the time that activated sludge flows through settling tanks and aeration tanks. Absorbability of activated sludge is restored again by the time these reach the later stage of aeration tanks and that make it possible to continue stable treatment.
 Removal of organic substances  Restoration of absorbability of activated sludge

Source: JST

Wet weather activated sludge process requires appropriate operation according to duration of treatment, return sludge ratio, MLSS concentration and sludge volume index. At the same time, it require careful attention in order not to carry over activated sludge from settling tanks by monitoring sludge-liquid interface. As above mentioned conditions of each WWTP are different, the characteristics of each WWTP are required to be comprehended throughout operation experiences. Wet weather activated sludge process is regarded as option of operation in rainy day for planning of Nong Bon WWTP. Hence, hydraulic profile planning, which allows DWF to flow into the beginning of aeration tanks and two times DWF to flow into the later stage of aeration tanks, is considered to enable wet weather activated sludge process to be operated.

4.4.3 Receiving Water Body

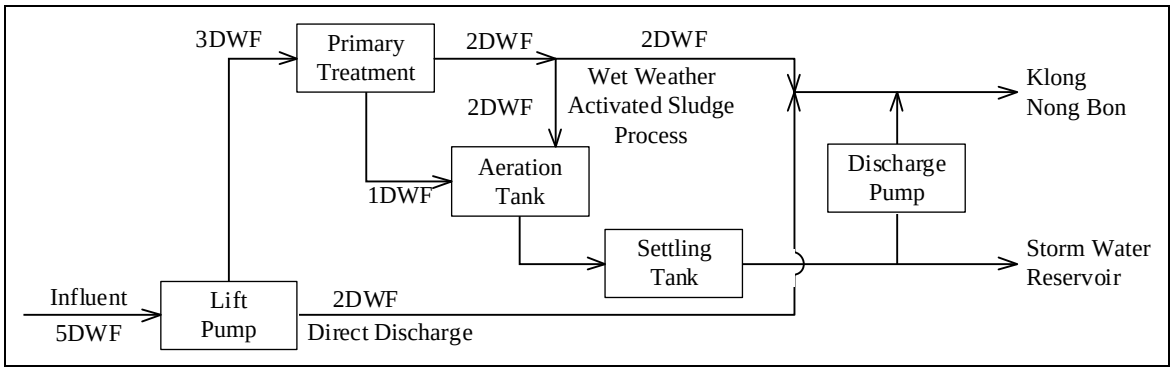
More than one receiving water bodies are to be secured to select suitable one in operating WWTP. Klong Nong Bon, Nong Bon storm water reservoir and Nong Bon drainage tunnel can be a receiving water body. Outlines of these are described in the previous Section 2.1.

In principal, treated wastewater is to be discharged to Klong Nong Bon for the purpose of improvement of water quality in the klong in dry weather. In case treated wastewater is discharged to the Nong Bon storm water reservoir, reduction of O&M cost can be expected because of reduction of electricity consumption for pumping. However, deterioration of water quality in the reservoir by eutrophication should be monitored.

In principal, treated wastewater is to be discharged to Klong Nong Bon in wet weather. However, in case of intensive rainfall and high water level in Klong Nong Bon, and flow capacity of Klong Nong Bon is determined not to be enough to accommodate outflow from WWTP, outflow is to be discharged to the reservoir. After completion of drainage tunnel, discharge to the tunnel should also be considered.

A part of treated wastewater is planned to be reused for beautification purpose in adjacent Rama IX Park.

Schematic flow showing design flows of treatment facilities and receiving water bodies depending on of effluent characteristics is shown in Figure 4.4.1.



Source: JST

Figure 4.4.1 Design Flow and Receiving Water Body

Five times DWF is intercepted in rainy day and intercepted wastewater sequentially flows into the WWTP. By the time that the WWTP receives wastewater which exceeds three times DWF, most of wastewater which is relatively high pollution lording in the begiging of rain has already reached to the WWTP. Hence, wastewater of low pollution loading flows into the WWTP after exceeding three times DWF. Therefore, design flow of prinmary treatment facilities is to be three times DFW considering the financial efficiency. However, maximum five times DWF flows into the WWTP even though frequency of occurance and pollution lording is considerably low. Pumps which discharge two times DWF directly to the receiving water bodies are installed so as to prevent the WWTP from flooding.

4.4.4 Design Parameters of Wastewater Characteristics

Influent, which flows to wastewater treatment facilities, contains supernatant from the sludge treatment facilities. Therefore, design wastewater characteristics, which are used for design of wastewater treatment facilities, are calculated based on mass balance calculations of pollution loading in Nong Bon WWTP. Design wastewater characteristics are summarized in Table 4.4.3.

Table 4.4.3 Design Wastewater Characteristics

	Parameters	2040(M/P)	2020(F/S)
Influent wastewater characteristics	BOD	150 mg/1	100 mg/1
	SS	150 mg/1	100 mg/1
Wastewater characteristics flowing to treatment facilities	BOD	164 mg/1	109 mg/1
	SS	164 mg/1	109 mg/1

Source: JST

Amount of sludge generated from wastewater treatment facilities is calculated based on mass balance calculations and shown in Table 4.4.4. Those figures of sludge generation are used for the basis of design of sludge treatment facilities.

Table 4.4.4 Generation of Sludge

	Dry solid	Volume	Solid concentration
2040 (M/P)	23,014 kg-DS/day	2,877 m^3/day	0.8 %
2020 (F/S)	9,107 kg-DS/day	1,138 m^3/day	0.8 %

Source: JST

4.4.5 Design Criteria

Design criteria which are applied for design of wastewater treatment facilities and sludge treatment facilities of Nong Bon WWTP are summarized in Table 4.4.5.

Table 4.4.5 Design Criteria

No	Item	Design Criteria	
1.	Grit chamber		
1-1	Hydraulic overflow rate (dry weather)	1,800	m^3/m^2/day
1-2	Hydraulic overflow rate (wet weather)	3,600	m^3/m^2/day
1-3	Average velocity	0.3	m/second
1-4	HRT (hydraulic retention time)	30-60	second
2.	Aeration tank		
2-1	MLSS concentration	2,000	mg/l
2-2	Dissolved oxygen	3.0	mg/l
2-3	HRT (hydraulic retention time)	5.3	hour
2-4	Solid concentration of return sludge	0.8	%
2-5	Return sludge ratio	33	%
2-6	Circulation ratio	147	%
2-7	SRT (sludge return time)	2.2	day
3.	Settling tank		
3-1	Hydraulic surface loading	25	m^3/m^2/day
3-2	Effective depth	4.0	m
3-3	Weir overflow rate	150	m^3/m/day
4.	Recycle facilities		
4-1	Filtration speed	400	m/day
5.	Sludge dewatering		
5-1	Sludge concentration of excess sludge	0.8	%
5-2	Moisture content of sludge cake	80	%
5-3	Filtration ratio	80	kg Dry Solid /m h
5-4	Recovery rate	90	%
5-5	Dosing rate of coagulant	1.4	%

Source: JST

4.4.6 Hydraulic Profile Planning

Hydraulic profile has been planned based on the hydraulic conditions of influent and receiving

water bodies as shown in Table 4.4.6.

Table 4.4.6 Conditions of Hydraulic Planning

Item		Water level	
Influent	1 DWF	North Nong Bon Trunk Line: Prawet Trunk Line:	- 15.280 m - 18.392 m
	3 DWF	North Nong Bon Trunk Line: Prawet Trunk Line:	- 14.790 m - 17.202 m
	5 DWF	North Nong Bon Trunk Line: Prawet Trunk Line: - 4.275 m	- 5.081 m - 4.275 m
Receiving water body	Klong Nong Bon	H.W.L L.W.L	+ 1.000 m - 0.500 m
	Storm water reservoir	H.W.L L.W.L	0.000 m - 7.000 m

Note: 5 DWF water levels are those of surcharged condition
Source: JST

It is inevitable that aeration tanks and settling tanks are placed vertically because of the restriction of available land. Plane area required for the structures of aeration tanks and settling tanks is similar. Therefore, the following two alternatives are compared from the view points of hydraulic profile planning.

Alternative-1: Lower story/ Aeration tank, Higher story/ Settling tank
Alternative-2: Lower story/ Settling tank, Higher story/ Aeration tank

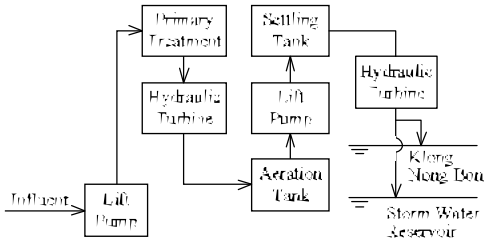
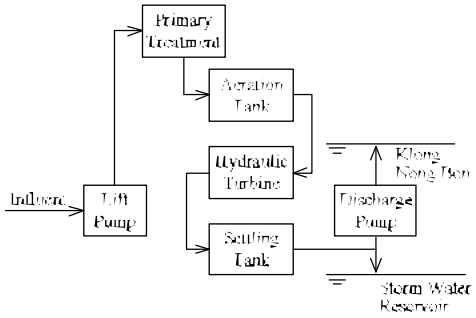
Comparison of hydraulic profile planning is conducted based on the following site conditions and assumptions.

1) Primary treatment facilities are placed on the structure of lift pump facilities because of the restriction of available land for above-ground facilities.
2) If significant head loss can not be avoided, small scale hydraulic turbine is introduced for electricity generation as energy saving measure.
3) Electricity energy of equipment relating to hydraulic profile i.e. pumps and hydraulic turbines is estimated to compare those alternatives.
4) Electricity consumption is estimated base on assumption that secondary effluent is discharged to Klong Nong Bon in dry season and to the storm water reservoir in rainy season.

Comparisons of alternatives are summarized in Table 4.4.7. As the result of comparisons, Altenative-2 is recommended due to the following advantages.

1) Electricity consumption is less and that leads to less operation cost and less emission of greenhouse gas.
2) Operation is less complex and risk of flooding inside of WWTP by operating errors and troubles is avoided.

Table 4.4.7 Comparison of Hydraulic Profile Planning

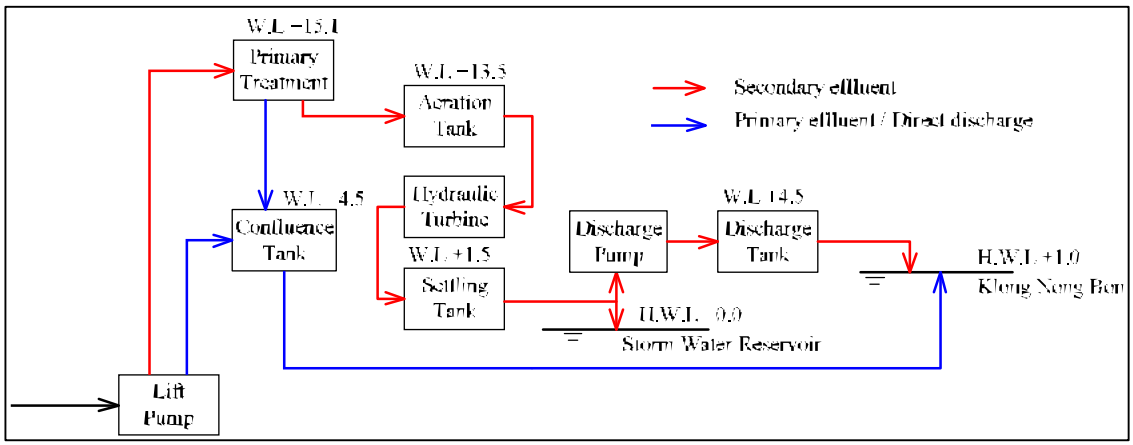
	Alternative-1	Alternative-2
Hydraulic profile planning		
Main pump station	Four main pump stations consisting of an influent lift pump station and three series of interim lift pump stations.	Two main pump stations consisting of an influent lift pump station and a discharge pump station.
Operation	Operation is more complex since main pump stations are four and three series of interim lift pumps should be controlled separately for each train. There is risk of flooding inside of WWTP by operating errors and failure of interim lift pumps.	Operation is less complex since main pump stations consists of influent and discharge pump stations. There is no risk of flooding inside of WWTP since effluent can be discharged to the storm water reservoir by gravity.
Electricity consumption	9,590,000 kWh/year (134)	7,183,000 kWh/year (100)
Electricity cost	27.3 million Baht/year (134)	20.5 million Baht/year (100)
Evaluation	2	1

Source: JST

Hydraulic profile has been planned considering the following concepts and hydraulic profiles for both dry weather and wet weather are shown in Figure 4.4.2. Red line shows hydraulic profile of secondary effluent in dry weather and blue line shows hydraulic profile of primary effluent and untreated effluent.

1) Hydraulic profile of wastewater treatment is planned to flow wastewater from primary treatment facilities to settling tanks by gravity in order to make operation simple.
2) Level of wastewater treatment facilities is planned considering water level in storm water reservoir so that effluent can be discharged by gravity in case of discharging to the reservoir in order to save energy consumption. Effluent is pumped up in case of discharging secondary effluent to Klong Nong Bon.

3) Primary treated effluent is planned to flow to the receiving water body by gravity
4) Lift pumps for direct discharge are separated into different series due to the difference of required head in order to reduce energy consumption.
5) Hydraulic profile is planned so as not to be affected by downstream condition.



Source: JST

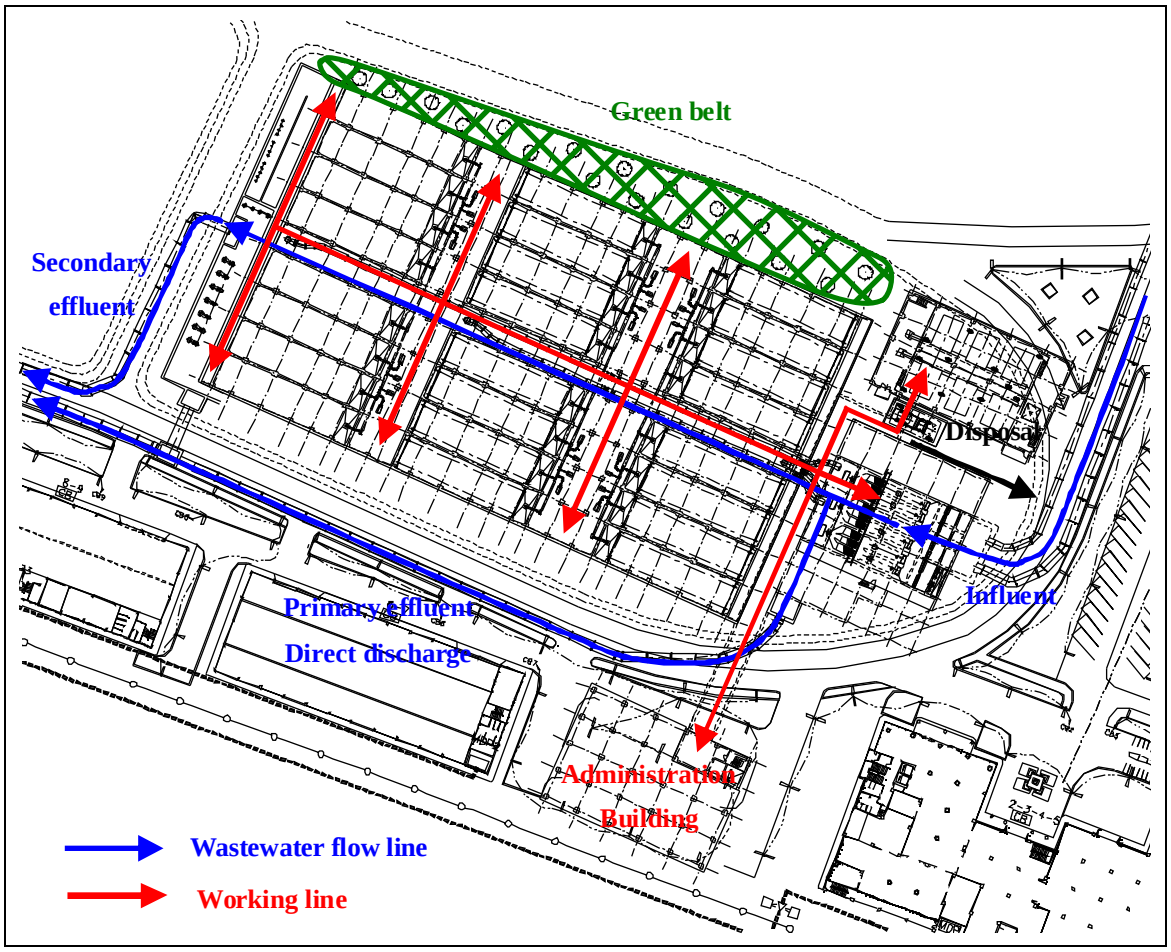
Figure 4.4.2 Hydraulic Profile Planning

4.4.7 General Layout Planning

General layout plan of the facilities in the proposed site has been worked out considering the following concepts.

1) The proposed facilities are placed so that wastewater flow line during treatment processes is optimized and shortened.
2) The proposed facilities are placed so that the efficient working line is secured for the workability of daily operation and maintenance of facilities.
3) Lift pumps and sludge dewatering facilities, which require frequent operation and maintenance, are placed close to the administration building in order to reduce the length of working line of operators.
4) The facilities for storing and loading of wastes i.e. sludge cakes, screenings and girt are gathered so as to share passageway of trucks for carrying out and mitigate undesirable effect to the surrounding environment.
5) Marginal green belt along the boundary with the storm water reservoir and sports center are secured to accord with the landscape and to mitigate undesirable effect to the surrounding environment.

General layout planning of Nong Bon WWTP is shown in Figure 4.4.3.



Source: JST

Figure 4.4.3 General Layout Planning

4.4.8 Selection of Sludge Treatment Process

One of the key elements of wastewater treatment is to treat sludge produced from wastewater treatment stably and efficiently. At present, sludge generated from the existing WWTPs in BMA is transferred to Nong Khaem WWTP i.e. the centralized sludge treatment plant. In Nong Khaem WWTP, sludge is digested and composted after diluting sludge cake transferred form existing WWTPs in order to improve stability and safety of sludge considering its final disposal for agricultural usage. Organic substances present in sludge is disintegrated and stabilized owing to the function of anaerobic biodegradation and composting.

Sludge generated from Nong Bon WWTP is also planned to be transferred to Nong Khaem WWTP. Therefore, sludge treatment required at the site is to dewater sludge for the transportation. There are a few alternatives of mechanical dewatering machines shown in below and the optimal method should be selected considering efficiency of dewatering sludge, economical aspect, and ease of operation and maintenance.

- Belt press dewatering machine
- Centrifugal dewatering machine
- Screw press dewatering machine

Comparisons of alternatives are summarized in Table 4.4.8. As the result of comparison, belt press dewatering machine is recommended due to the following advantages.

1) Characteristics of dewatered sludge generated in BMA are proved to be stable and DDS staff is well accustomed to operation and maintenance due to wide adaption in existing BMA WWTPs.
2) It is the most economical in terms of net present value.

Table 4.4.8 (1) Comparison of Mechanical Dewatering Machine (1/3)

	Belt Press Dewatering Machine
Dewatering mechanism	Belt press dewatering machines dewater sludge by squeezing and shearing flocculated sludge with two belts, which are pressurized by rollers. Belt press dewatering machines are composed of filtration devices, flocculation devices and control panels.
Efficiency	Moisture content of sludge cake: 80 % Filtration ratio: 80 kg DS/m h Recovery rate of sludge: 90 % Dosing rate of coagulant: 1.4 %
Size and number of dewatering machine	Width of belt 3.0 m Number: 6 nos. (1 standby)
Required space	562 m^2 (Dewatering machine only)
Operation	Belt press dewatering machines can adjust speed of belts, dosing rate of coagulant, feeding amount of sludge against fluctuation of sludge characteristics.
Maintenance	Belt press dewatering machines require replacement of belts every 8,000 operation hours. The replacement of belts can be carried out at the site by the maintenance staff.
Washing water	Belt press dewatering machines require washing of belts continuously during the operation. Therefore, belt press dewatering machines consume much more water comparing to the other machines.
Noise and vibration	Belt press dewatering machines do not cause noise and vibration owing to slow speed movement.
Emission of GHG	Emission of greenhouse gas is less since energy consumption is relatively low.
Experience in BMA	Chatuchak WWTP / Chong Nonsi WWTP / Din Daeng WWTP Nong Khaem WWTP / Rattanakosin WWTP Si Praya WWTP / Thung Khru WWTP
Initial investment	Equipment: 50.8 Million Baht Building: 28.1 Million Baht Total: 78.9 Million Baht (100 %)
O&M cost	Electricity: 1.0 Million Baht/ year Coagulant: 20.0 Million Baht/ year Maintenance: 3.7 Million Baht/ year Total: 24.7 Million Baht/ year (100 %)
Net present value	844.9 Million Baht (100 %)
Evaluation	A

Net preset value: Discount rate = 4% , Period = 30year
Source: JST

Table 4.4.8 (2) Comparison of Mechanical Dewatering Machine (2/3)

	Centrifugal Dewatering Machine
Dewatering mechanism	Centrifugal dewatering machines dewater sludge by centrifugal force which is generated by rotating external cylinders at a high speed. Centrifugal dewatering machines are composed of external cylinders, screws, differential driving devices and control panels.
Efficiency	Moisture content of sludge cake: 80 % Dewatering capacity: 30 m^3/hour Recovery rate of sludge: 95 % Dosing rate of coagulant: 1.4 %
Size and number of dewatering machine	Dewatering capacity: 30 m^3/h Number: 6 nos. (1 standby)
Required space	546 m^2 (Dewatering machine only)
Operation	Centrifugal dewatering machines can adjust rotating speed of cylinders, dosing rate of coagulant, pressure of presser, feeding amount of sludge against fluctuation of sludge characteristics.
Maintenance	Centrifugal dewatering machines require replacement of edges every 20,000 operation hours. The machines need to be taken to workshops or factories for replacement of edges.
Washing water	Centrifugal dewatering machines require washing inside of cylinders once a day. Washing time is around ten minutes. Therefore, centrifugal dewatering machines consume less water.
Noise and vibration	Centrifugal dewatering machines required preventive measures for noise and vibration because of high speed rotation of cylinders.
Emission of GHG	Emission of greenhouse gas is more since energy consumption is relatively high comparing to the other machines.
Experience in BMA	None
Initial investment	Equipment: 45.0 Million Baht Building: 27.3 Million Baht Total: 72.3 Million Baht (92 %)
O&M cost	Electricity: 6.6 Million Baht/ year Coagulant: 20.0 Million Baht/ year Maintenance: 5.1 Million Baht/ year Total: 31.7 Million Baht/ year (127 %)
Net present value	1,036.4 Million Baht (123 %)
Evaluation	B

Net preset value: Discount rate = 4% , Period = 30year
Source: JST

Table 4.4.8 (3) Comparison of Mechanical Dewatering Machine (3/3)

	Screw press Dewatering Machine
Dewatering mechanism	Screw press dewatering machines dewater sludge by squeezing flocculated sludge with screws and perforated metal screens. Screw press dewatering machines are composed of screws, outer screens, presser, driving devices, flocculation devices and control panels.
Efficiency	Moisture content of sludge cake: 80 % Filtration ratio: 2.6 kg DS/h Diameter Recovery rate of sludge: 90 % Dosing rate of coagulant: 1.9 %
Size and number of dewatering machine	Diameter of screw: 800 mm Number: 6 nos. (1 standby)
Required space	370 m^2 (Dewatering machine only)
Operation	Screw press dewatering machines can adjust rotating speed of screws, dosing rate of coagulant, mixing speed of flocculation devices, feeding pressure, pressure of presser, feeding amount of sludge against fluctuation of sludge characteristics.
Maintenance	Screw press dewatering machines require replacement of screens every 14,000 operation hours. The replacement of screens can be carried out at the site but require supervision of manufacturer.
Washing water	Screw press dewatering machines require washing of screens every 6-8 hours. Washing time is around thirty minutes. Therefore, screw press dewatering machines consume less water.
Noise and vibration	Screw press dewatering machines do not cause noise and vibration owing to slow speed movement.
Emission of GHG	Emission of greenhouse gas is less since energy consumption is relatively low.
Experience in BMA	None
Initial investment O&M cost	Equipment: 69.8 Million Baht Building: 18.5 Million Baht Total: 88.3 Million Baht (112 %) Electricity: 0.5 Million Baht/ year Coagulant: 27.1 Million Baht/ year Maintenance: 2.6 Million Baht/ year Total: 30.2 Million Baht/ year (123 %)
Net present value	1,034.6 Million Baht (122 %)
Evaluation	B

Net preset value: Discount rate = 4% , Period = 30year
Source: JST

4.4.9 Monitoring and Control System

Monitoring and control system is equipped to monitor and control operation of a plant and to process the operation information effectively. It consists of digital control device, operation control device, monitoring device, and data processing device. Therefore, monitoring and control device is key part of equipment to operate and manage wastewater treatment plant totally. The application of monitoring and control system should be decided considering factors such as the scale of WWTP, administrative structure, technical level of staff and economic aspect.

Nong Bon WWTP is regarded as a large scale WWTP since its design capacity at the ultimate stage is 135,000 m^3/day. Therefore, introduction of SCADA (Supervisory Control and Data Acquisition) System is recommended in order to realize central control from the administration building for effective and rational operation, monitoring, control, collection and analysis of data. As a result of introduction of SCADA, following advantages are expected.

1) To improve quality and efficiency of wastewater treatment and reduce workload
2) To reduce operation cost by labor saving and energy saving
3) To improve and stabilize process through appropriate operation
4) To understand characteristics of process better by collecting and analyzing data and optimize operation management

PLC (Programmable Logic Controller) monitoring system in local areas and optical cable network is installed in order to cope efficiently and promptly with a great deal of data from SCADA system. It enables controlling operation of equipment both from local areas by PC and from administration building by operation device of SCADA system. By using this, it is possible to adjust control parameters such as PID and timer setting from operation device of SCADA system in administration building in order for operation to be flexible toward fluctuation of characteristics and quantity of influent wastewater. Furthermore, trend of water quality on each process and operation hour of equipment are displayed on PC. It enables to improve safety and smooth operation by alarming in case if monitored parameters exceed the set levels.

Better visibility than graphic panel can be expected if pictures produced by PC are displayed on 100 inch high resolution screen. Also, easy operation and better applicability can be expected, because real time response on PC display can be carried out.

Monitored and controlled items for better understanding of process status at each stage and operation status of facilities and equipment are listed in Table 4.4.9.

Table 4.4.9 Monitored and Controlled Items of SCADA System

Classification	Detailed classification	Individual item
Display of operation status	On / Off of machinery	On / Off, Open / Close
	Operation place	Center / Local, Remote / Field
	Mode of operation	Auto / Manual, Interlock / Single
	Failure of machinery	Failure and breakdown of machinery Abnormal process status
Display of instrumental value	Instrumental value of power receiving and transferring, and treatment process	Voltage, Current, Electricity, Phase factor, Level, Pressure, Flow, Quantity of chemicals, Density, DO, MLSS, etc.
Control and operation	Operation items	On / Off of main machinery, Emergency stop, Selection of operation mode
	Setting items	Setting and adjustment of operation parameters on each process (target value, operation hour, operating sequence, controlled parameter, alarm setting and etc)
Report and record	Instrumental value of power receiving and transferring, and treatment process	Trend (daily, monthly and yearly), Record of Instruments
	Failure and operation status	Record of failure and operation by printer

Source: JST

4.4.10 Countermeasure for Climate Change

BMA enhances the reduction of CO_2 emission in order to prevent global warming. Hence, countermeasures for grovel warming have been considered for planning of Nong Bon WWTP. The countermeasures for global warming which are commonly practiced at WWTPs and planning of Nong Bon WWTP are summarized in Table 4.4.10.

Table 4.4.10 Countermeasures for Global Warming

Category	Common countermeasures	Countermeasures for Nong Bon WWTP
Emission relating to energy consumption such as electricity and fuel	Reduce energy consumption by introducing equipment which consumes less energy	Lift pumps of dry pit type which are more efficient than lift pumps of submersible type commonly used in Thai are introduced. The measures to reduce energy consumption of lift pump facilities are shown below.
	Introduce ultrafine air diffuser which excels at efficiency for supplying air to aeration tank	Adaptable types of air diffuser are restricted by kind of carrier for CAASP. Hence, it is not possible to specify the type of air diffuser at this stage.
	Consider general layout of facilities so as to minimize total head of lift pumps	The proposed facilities are placed so that wastewater flow line during treatment processes is shortened to minimize head loss.
	Reduce energy consumption by optimizing operation of treatment process	Optimization of aeration according to air requirement of each train is possible by decentralizing blowers to each train of sewage treatment facilities.

Category	Common countermeasures	Countermeasures for Nong Bon WWTP
Emission relating to operation of treatment process	Introduction of digestion process which can collect methane gas for sludge treatment process	Nongkaem WWTP, centralized sludge treatment WWTP, has digestion process. Hence, Nong Bon WWTP is not required to have digestion process to avoid dual investment.
	Reduce emission of N_2O by burning sewage sludge at high temperature	Sludge generated in Nong Bon WWTP is transferred to Nongkaem WWTP, centralized sludge treatment WWTP, as mentioned above.
Emission relating to consumption of water supply and chemicals	Reduce emission of green house effect gas by reducing consumption of water supply by utilizing effluent	Consumption of water supply is reduced by utilizing filtrate produced by filtrating secondary effluent for inside and outside usage including Rama IX part.
Reduction of emission by utilizing the resource of sewerage system	Introduction of power generation by utilizing methane gas produced in digestion process	Sludge generated in Nong Bon WWTP is transferred to Nongkaem WWTP, centralized sludge treatment WWTP, as mentioned above.
	Introduction of hydraulic turbines to recover excess pressure and/or excess head	It is inevitable that aeration tanks and settling tanks are placed vertically because of the restriction of available land. Hence, introduction of hydraulic turbines is investigated.

Source: JST

1) Measures to reduce enrgy consumption of lift pump facilities

The meassues to reduce energy consumption of lift pump facilities by applying energy saving thechnolugy and operation are shonw in Table 4.4.11.

Table 4.4.11 Messures to Reduce Energy Consumtion of Lift Pump Facilities

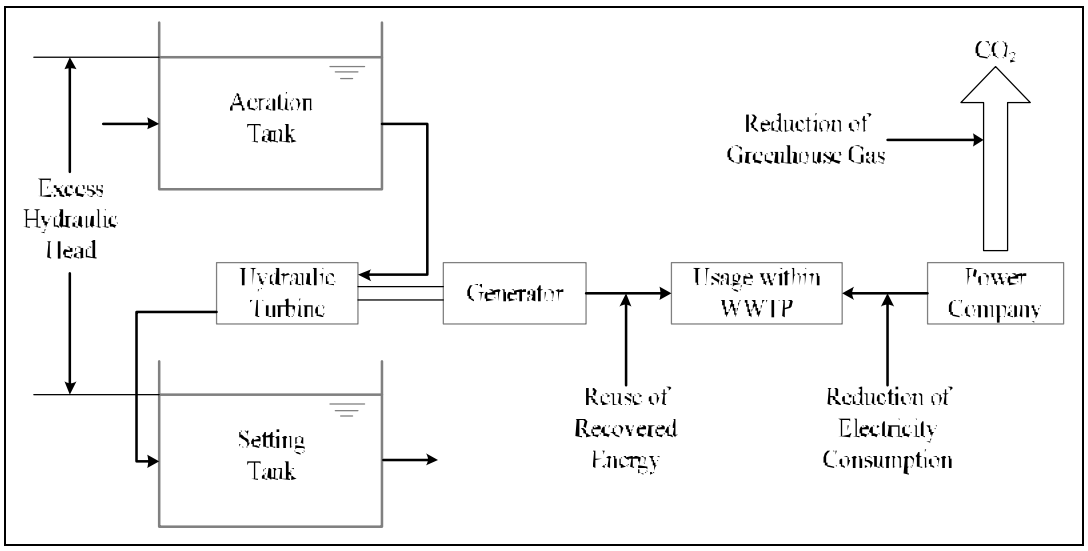
Meassure	Brief explanation
Energy saving thechnology	The number of operated lift pumps change time to time according to fluctuation of influent to WWTP in dry weather day. Application of frequency control by VVVF to three small lift pumps makes continuous flow control possible and results in reduction of energy consumption of lift pump facilities. And also constant inflow to wastewater treatment facilities by continiouse flow control is expected to result in improvement of efficiency and stability of treatment.
Energy saving operation	Setting operating level of pumps higher reduce the acutual head of pump operatioin and results in reduction of energy consumption of lift pump facilities in dry weather day. Setting operating level of pumps higher makes flow velocity slower and might cause sedimentation in sewer lines. Hence, preventative measures such as flushing by lowering water level of sewer lines on regular basis is required in order to prevent sedimentation. And alos careful attension is required so that wastewater do not overflow from intercepter chambers by rising water level of sewer lines.

2) Introduction of energy recovery thechnology

It is inevitable that aeration tanks and settling tanks are placed vertically because of the restriction of available land. Therefore, there is excess hydraulic head between aeration tanks and settling tanks. Inflow of wastewater to WWTPs is continuous and stable event though that

has yearly and daily fluctuation. These are preferable conditions for applying hydraulic turbines to recover excess hydraulic head. The application of energy recovery technology to Nong Bon WWTP has been investigated.

The systematic flow of energy recovery and reduction of greenhouse gas with hydraulic turbines is shown in Figure 4.4.4. The generators convert excess hydraulic energy recovered by the hydraulic turbines to electricity. Generated electricity is planned to be used by equipment installed in WWTP. At the same time, energy recovery results in reduction of emission of carbon dioxide i.e. greenhouse gas by reducing total electricity consumption supplied from the power company to WWTP.



Source: JST

Figure 4.4.4 Schematic Flow of Energy Recovery and Reduction of GHG

Estimation of production of electricity and reduction of emission of carbon dioxide is summarized in Table 4.4.12.

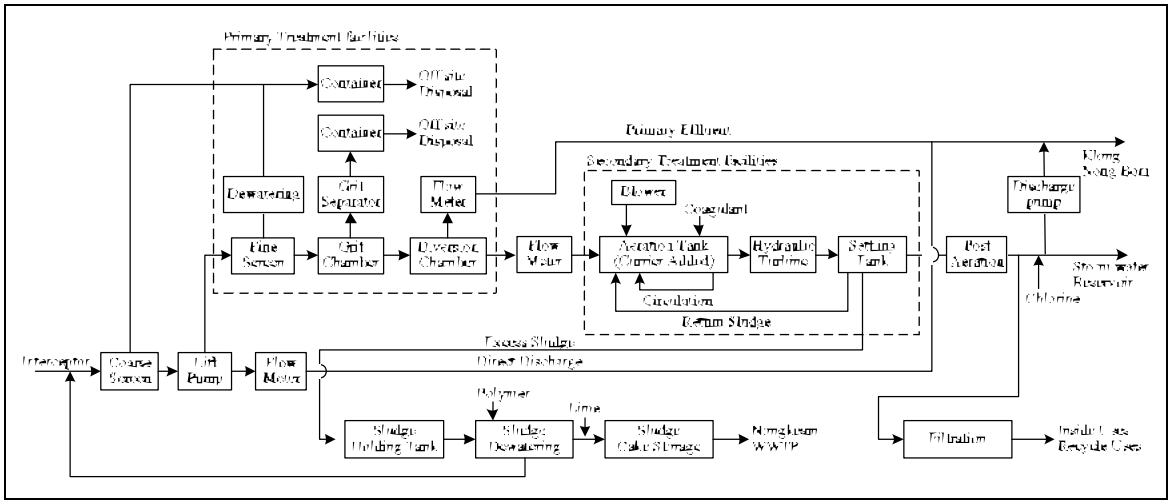
Table 4.4.12 Estimation of Energy Recovery and Reduction of CO_2

Item	Value	Remarks
Design flow	135,000 m^3/day	Average DWF
Excess hydraulic head	11.0 m	Level difference
Number of equipment	6 set	2 set per train
Capacity of generators	20 kW	Efficiency = 72 %
Production of electricity	788,000 kWh/year	
Reduction of electricity cost	2,246,000 Baht/year	
Reduction of greenhouse gas	407,000 kg-CO_2/year	0.517 kg-CO_2/kWh

Source: JST

4.4.11 Process of Nong Bon WWTP

The schematic flow of treatment process recommended for Nong Bon WWTP considering the results of facilities planning is shown in Figure 4.4.5 and brief explanation of treatment process is summarized in Table 4.4.13.



Source: JST

Figure 4.4.5 Schematic Flow of Process

Table 4.4.13 Outlines of Treatment Processes

Treatment process	Brief explanation
Lift pump facilities	Coarse screens are installed in order to protect lift pumps. Lift pumps are operated by unit control according to the level of pump suction well. Flow is controlled by the combination of number of operated pumps.
Grit chamber facilities	Fine screens and grit collectors are installed in grit chambers. Screenings removed by fine screens are dewatered, stored in containers and carried out. Grit removed by grit chambers is separated from sewage, stored in containers and carried out.
Aeration tank facilities	Carriers are added to aeration tanks. Air required for aeration is supplied by blowers. Circulation from aerobic tank to anoxic tank is conducted for denitrification. Coagulant is added at later stage of aeration tank to remove phosphorous.
Settling tank facilities	Sludge collectors are installed in settling tanks. Sludge is returned to the head of aeration tanks and excess sludge is transferred to sludge holding tanks. Hydraulic turbines are installed to recover excess head between aeration tanks and settling tanks.
Effluent and recycle facilities	Post aeration is conducted in order to keep dissolved oxygen of effluent. Filtrate produced by filtrating secondary effluent is used inside of WWTP and Rama IX park. Rama IX park is supplied with filtrate by pipe and the other users are supplied by water tankers.
Sludge dewatering facilities	Sludge generated in wastewater treatment facilities is stored in sludge holding tanks. Polymer is added to sludge and sludge is dewatered by mechanical dewatering machines. Lime is added for adjustment of solid contents and deodorization. Sludge cake is stored in storage tanks and transferred to Nong Khaem WWTP.

Source: JST

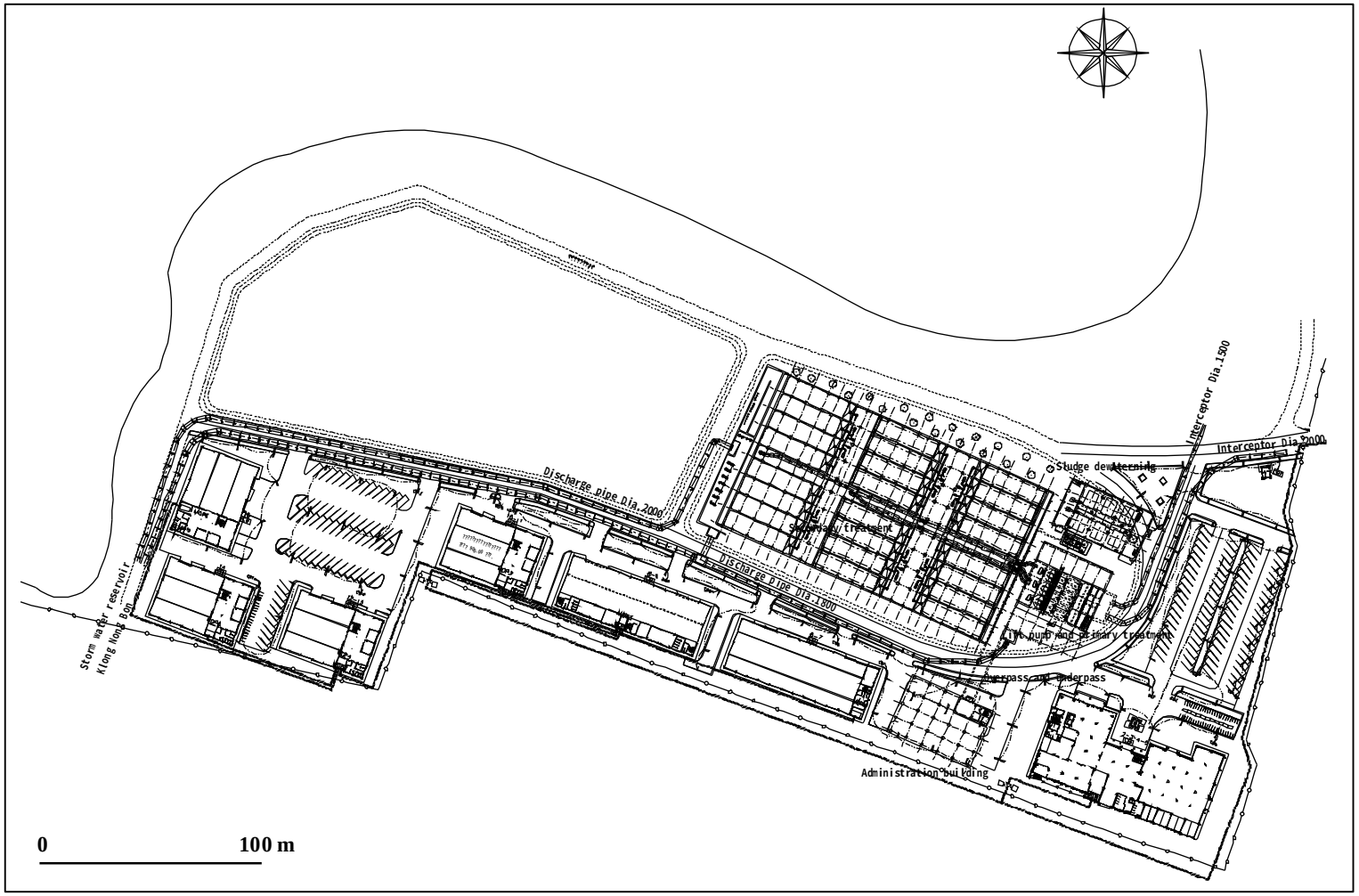
4.4.12 Outlines of Facilities Planning

Dimensions of main facilities and specifications of equipment are calculated according to design criteria shown in Table 4.4.6 and summarized in Table 4.4.14. Facility and process calculation of planned facilities is show in Appendix 6-2. The general layout of proposed facilities, the hydraulics profile and the flow diagram are shown in Figures 4.4.6, 4.4.7 and 4.4.8, respectively. The drawings of proposed facilities are presented in Volume 4 Drawings.

Table 4.4.14 Outline of Facilities Planning

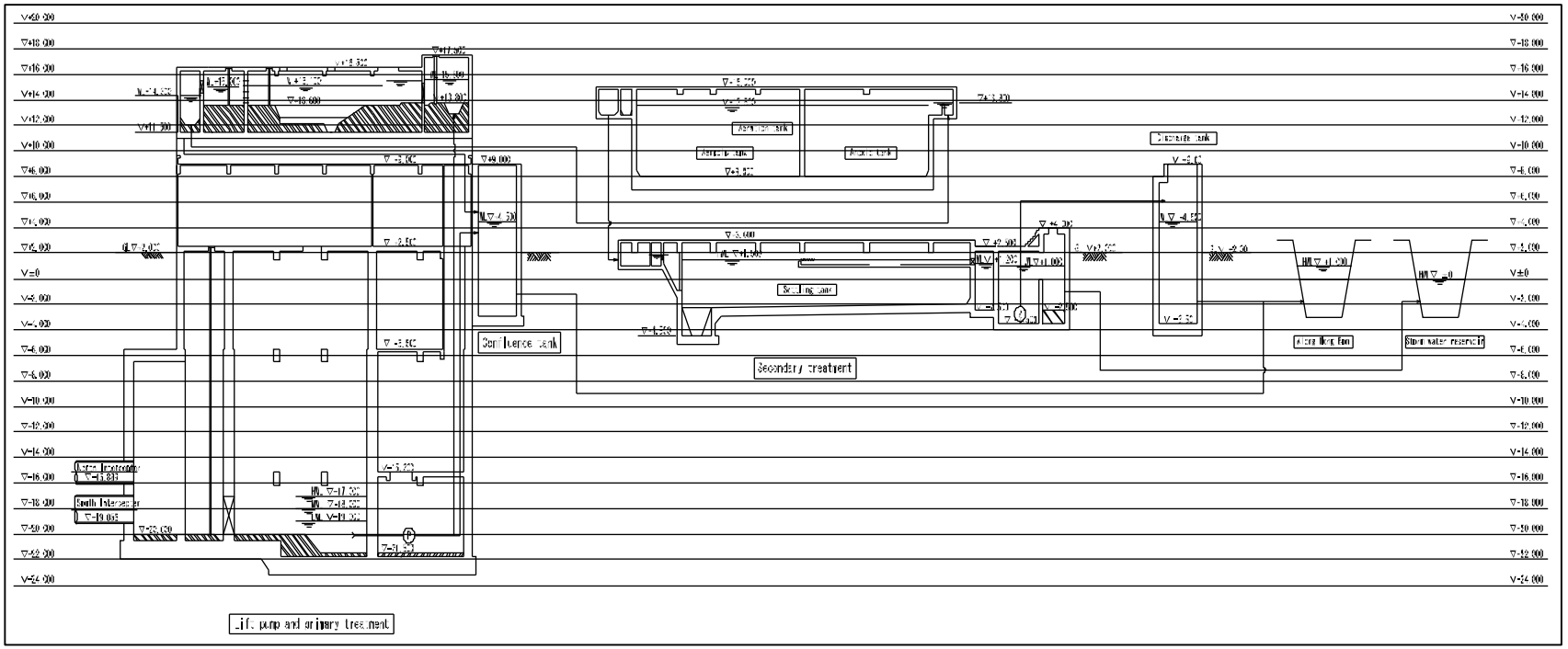
No	Facilities / Dimension / Specification	Number for M/P	Number for F/S
1.	Lift pump facilities		
1-1	Coarse screen (Channel width: 2.5m)	3 nos.	2 nos.
1-2	Large lift pump ($94m^3$/min × 38m × 800kW)	3 nos. (1 standby)	2 nos. (1 standby)
1-3	Small lift pump ($32m^3$/min × 38m × 280kW)	3 nos.	3 nos.
1-4	Direct discharge pump ($94m^3$/min × 25m × 540kW)	3 nos. (1 standby)	3 nos. (1 standby)
2.	Grit chamber facilities		
2-1	Grit chamber (2.0mW × 9.5mL)	6 channels	4 channels
2-2	Fine screen (Channel width: 1.4m)	9 nos.	6 nos.
2-3	Grit dewatering ($7.5m^3$/hour)	2 nos	2 nos
2-4	Screening dewatering ($3.0m^3$/hour)	2 nos	2 nos
3.	Aeration tank facilities		
3-1	Anoxic tank (15.0mW × 13.0mL × 5.5mD)	12 tanks	8 tanks
3-2	Aerobic tank (15.0mW × 17.0mL × 5.5mD)	12 tanks	8 tanks
3-3	Air blower ($160m^3$/min × 6500mmAq × 260kW)	9 nos. (3 standby)	6 nos. (2 standby)
3-4	Circulation pump (air lift pump)	12 nos.	8 nos.
3-5	Return sludge pump ($8m^3$/min × 17m × 45kW)	12 nos.	8 nos.
4.	Settling tank facilities		
4-1	Settling tank (5.0mW × 30.0mL × 4.0mD)	24 tanks	16 tanks
4-2	Sludge collector (two tanks driven type)	12 nos.	8 nos.
5.	Effluent and recycle facilities		
5-1	Discharge pump ($47m^3$/min × 8m × 110kW)	7 nos. (1 standby)	5 nos. (1 standby)
5-2	Disc filter (filtration area: $12m^2$)	3 nos.	2 nos.
6.	Sludge dewatering facilities		
6-1	Belt press dewatering machine (Width:3.0m)	6 nos. (1 standby)	3 nos. (1 standby)
6-2	Sludge cake storage ($40m^3$)	2 nos.	1 nos.
7.	Power facilities		
7-1	Emergency generator (2,500kVA)	3 nos.	2 nos.
7-2	Hydraulic turbine generator (20kW)	6 nos.	4 nos.
8.	Deodorization facilities		
8-1	Biological deodorization equipment ($240m^3$/min)	1 no.	1 no.
8-2	Biological deodorization equipment ($760m^3$/min)	1 no.	1 no.
8-3	Biological deodorization equipment ($380m^3$/min)	1 no.	0 no.

Source: JST



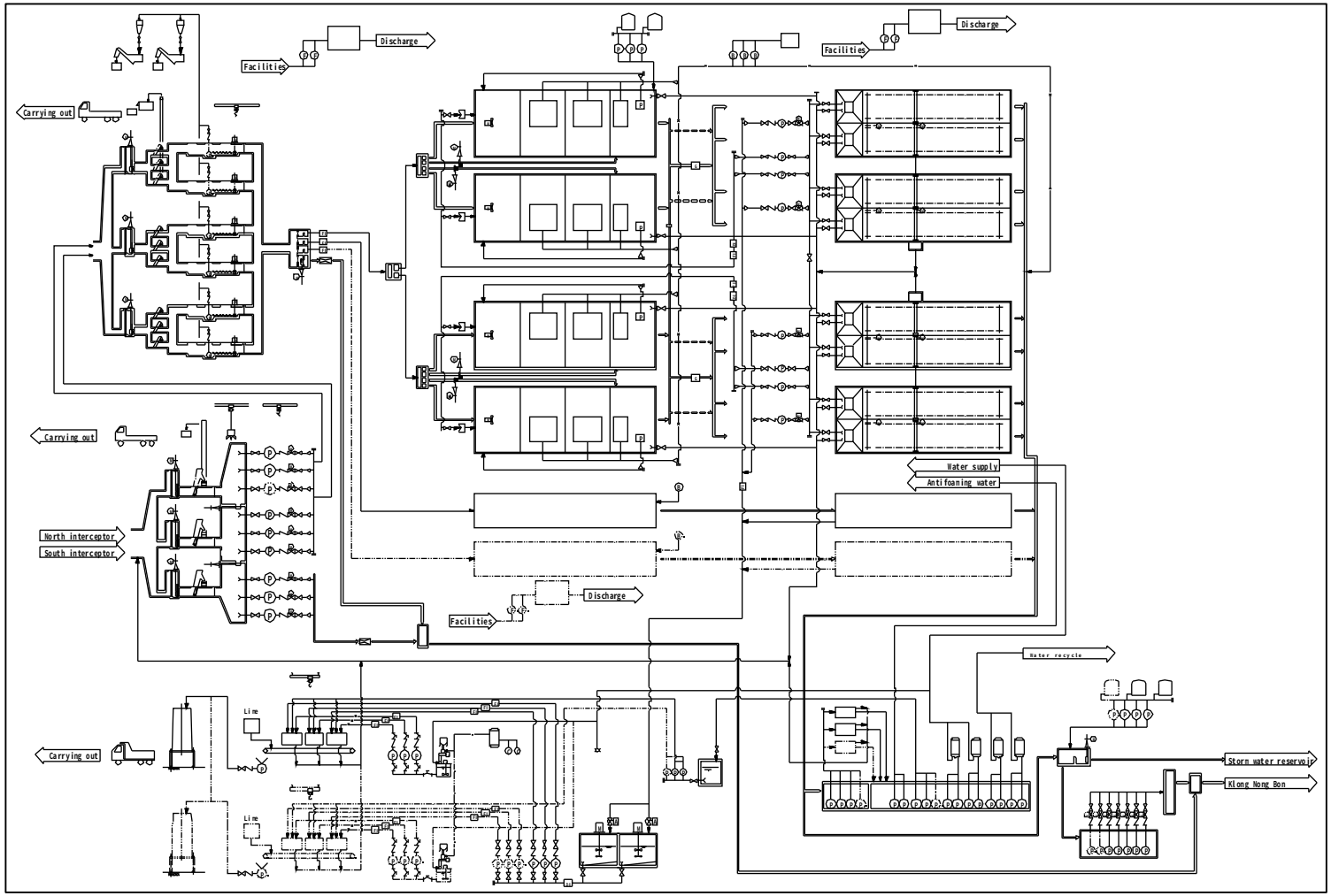
Source: JST

Figure 4.4.6 General Layout of Nong Bon WWTP



Source: JST

Figure 4.4.7 Hydraulic Profile of Nong Bon WWTP



Source: JST

Figure 4.4.8 Flow Diagram of Nong Bon WWTP

5. Cost Estimation and Implementation Schedule

5.1 Project Cost

5.1.1 Condition of Cost Estimation

The project cost is estimated based on the conditions stated below.

1) The project cost comprises construction cost, administration cost, engineering cost, contingency (physical and price escalation), interest during construction, commitment charge and relevant tax.
2) The project cost is composed of the local currency potion (L.C.) and foreign currency portion (F.C.).
3) Administration cost is assumed to be 2.0 % of the construction cost.
4) Engineering cost is assumed to be 10.0 % of the construction cost.
5) Physical contingency is considered as 10.0 % of total of construction cost, administration cost, and engineering cost.
6) Price escalation of 3.3 % per annum for the local currency portion and 2.4 % per annum for the foreign currency portion are applied and price contingency is estimated based on implementation schedule shown in Table 5.2.1.
7) The base period of cost estimation is October in 2010 and the exchange rate considered is 1 Baht = 2.76 Yen, 1 USD=83.63 Yen.
8) The cost for land acquisition is not considered since the land required for this Project belongs to DDS i.e. the responsible agency.
9) Interest during construction is estimated taking into consideration that Project cost is financed by JICA ODA loan. (Loan condition: Preferential terms / Standard, Interest rate=0.65%, Repayment period=40year, Grace period=10year)
10) Commitment charge, which is 0.1 % of loan outstanding from signing of Loan Agreement, is estimated in order to enhance the implementation of project.
11) Custom rate is 5 % for imported goods procured for environmental project taking custom tariff of Thailand into account. Tax rate is 7 % including sales taxes and other relevant taxes.

5.1.2 Conditions of Estimating the Construction Cost

The construction cost is estimated based on the conditions listed as follows.

1) The materials for civil and building works, labor and construction machineries are basically procured from the local market.
2) Mechanical and electrical equipment are basically procured from abroad including

Japan and the third counties such as EU. Procurement is decided considering factors such as quality, economical aspect and maintenance.

3) Utilization of local contractors is considered for planning of execution since they have enough experiences and abilities.
4) The construction cost of interceptors is estimated based on unit prices obtained from the analysis of past experiences of projects in BMA.
5) Local physical conditions such as geographical, geological and meteorological conditions and local regulations and customs are taken into consideration to prepare implementation schedule.

5.1.3 Estimated Project Cost

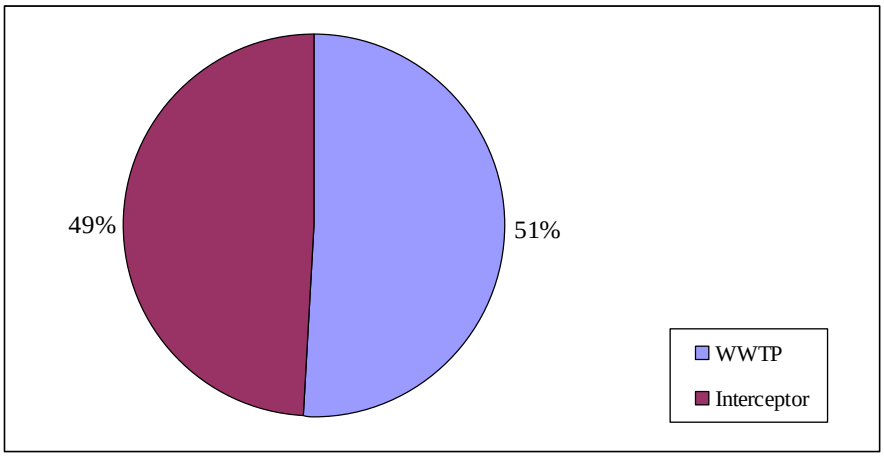
Cost estimation has been carried out considering factors mentioned above and is shown in Table 5.1.1. The estimated project cost for Priority Project is 7,835 million Baht (JPY 21.6 billion) including taxes and 7,198 million Baht (JPY 19.9 billion) excluding taxes. The breakdown of the estimates is presented in Appendix 7. The estimated project cost of Nong Bon treatment area for Master Plan is also presented in Appendix 7 for reference. The difference of the project cost is for the expansion of mechanical and electrical facilities, which will be installed by phases.

Table 5.1.1 Estimated Project Cost

No	Items	L.C. (1,000 Baht)	F.C. (1,000 Baht)	Total (1,000 Baht)
1.	Construction Cost			
A	Wastewater treatment plant			
A-1	Lift pump facilities	155,811	294,995	450,806
A-2	Grit chamber facilities	52,109	123,513	175,622
A-3	Aeration tank facilities	215,634	480,650	696,284
A-4	Settling tank facilities	287,992	167,506	455,498
A-5	Effluent and recycle facilities	113,862	73,907	187,769
A-6	Sludge dewatering facilities	96,858	111,363	208,221
A-7	Administration building	177,909	11,697	189,606
A-8	Power facilities	20,257	173,179	193,436
	Sub-total of A	1,120,432	1,436,810	2,557,242
B	Interceptor			
B-1	Pipe jacking	1,609,424	0	1,609,424
B-2	Pipe jacking shaft	721,165	0	721,165
B-3	Interceptor chamber	137,000	0	137,000
	Sub-total of B	2,467,589	0	2,467,589
	Sub-total of 1	**3,588,021**	**1,436,810**	**5,024,831**
2.	Administration Cost	100,497	0	100,497
3.	Engineering Cost	358,802	143,681	502,483
4.	Physical Contingency	404,732	158,049	562,781
5.	Price Contingency	696,347	195,584	891,931
6.	Interest during construction	63,587	23,393	86,980
7.	Commitment charge	20,320	7,683	28,003
8.	Tax and Duty	366,261	270,787	637,048
	Sub-total of (2-8)	**2,010,546**	**799,177**	**2,809,723**
	Total including Tax and Duty	**5,598,567**	**2,235,987**	**7,834,554**
	Total excluding Tax and Duty	**5,232,306**	**1,965,200**	**7,197,506**

Source: JST

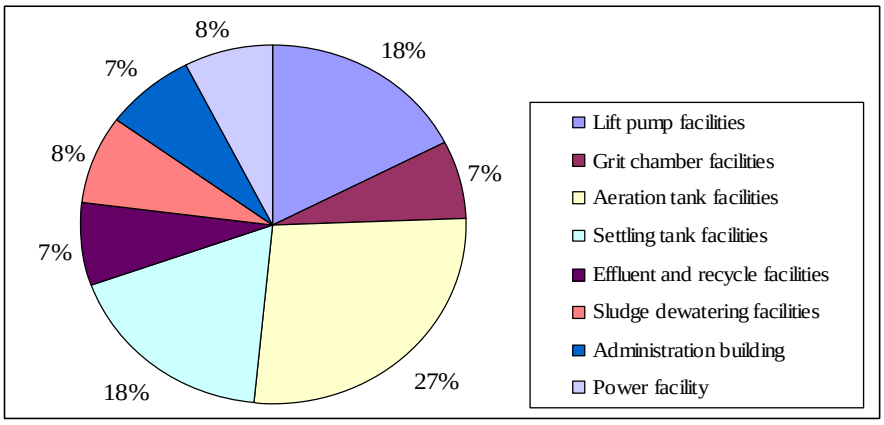
The percentage of the estimated construction cost of Nong Bon WWTP and interceptors is shown in Figure 5.1.1. The construction costs of Nong Bon WWTP account for 51 % while interceptors account for 49 % of the total construction costs.



Source: JST

Figure 5.1.1 Composition of the Construction Cost

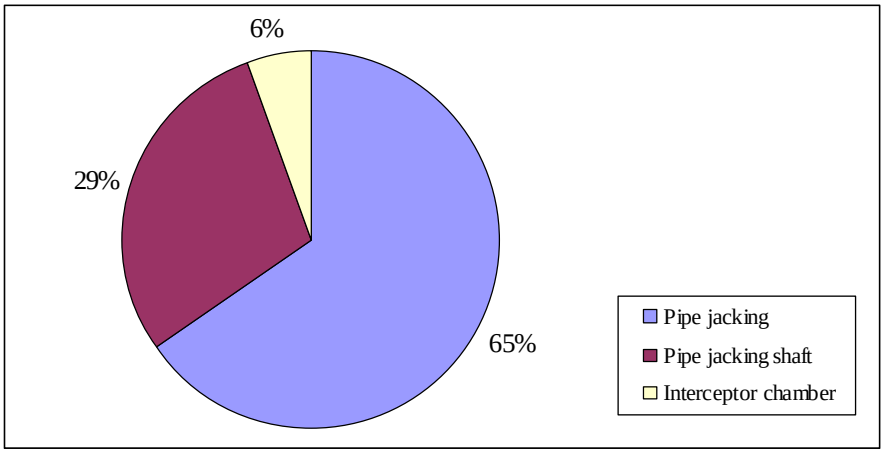
The composition of the estimated construction cost by facilities of Nong Bon WWTP is analyzed as shown in Figure 5.1.2. The construction costs of primary treatment facilities including lift pump and grit chamber facilities account for 25 % of the construction cost. Secondary treatment facilities including aeration tank, final setting tank, effluent and recycle facilities account for 52 %. Sludge treatment facilities account for 8 %. The communal facilities including administration facilities and power facilities account for 15 %.



Source: JST

Figure 5.1.2 Composition of the Construction Cost of WWTP Facilities

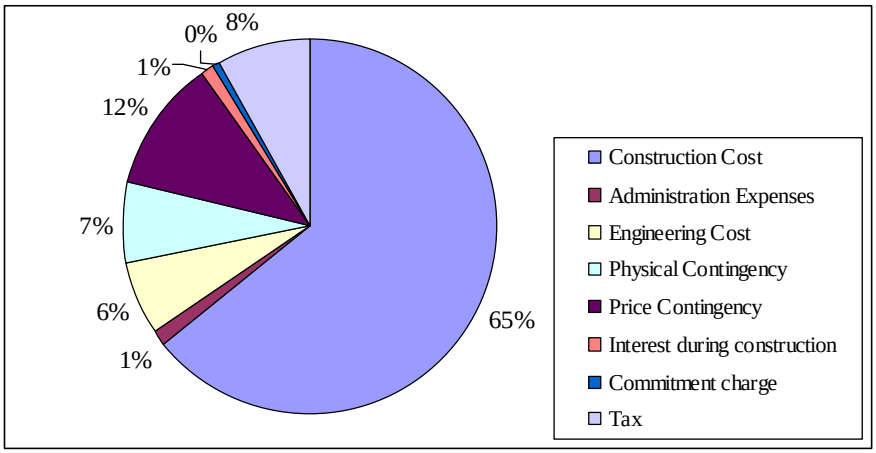
The composition of the estimated construction cost by facilities of interceptors is analyzed as shown in Figure 5.1.3. The construction cost of pipe jacking accounts for 65 % of the construction cost. The vertical shafts of pipe jacking account for 29 % while interceptor chambers account for 6 %.



Source: JST

Figure 5.1.3 Composition of the Construction Cost of Interceptor Facilities

The composition of the estimated project cost by cost items is analyzed as shown in Figure 5.1.4. The direct construction cost accounts for 65 % of the total project cost and indirect construction cost including remaining costs accounts for 35 %.



Source: JST

Figure 5.1.4 Composition of Components of Project Cost

5.1.4 Estimated Operation and Maintenance Cost

The operation and maintenance cost required for operating facilities after implementation of the Project is estimated and summarized in Table 5.1.2. The operation and maintenance cost comprises expenses on salary, electricity, maintenance, transport cost of sludge cake, consumable, and others. Annual operation and maintenance cost is estimated to be 112.1 million Baht/year (309 million Yen/year).

Table 5.1.2 Estimated Operation and Maintenance Cost

No	Items	Total (Million Baht/year)
1.	Salary	14.8
2.	Electricity	51.5
3.	Maintenance	20.0
4.	Transport cost of sludge cake	4.8
5.	Consumable	13.8
6.	Interceptor	4.0
7.	Others	3.1
Total		112.1

Source: JST

Unit O&M cost of Nong Bon WWTP is estimated to be 3.41 Baht/m^3. The unit cost of Nong Bon WWTP is higher comparing to 2.11 Baht/m^3, which is the average unit O&M cost among the existing WWTPs. The primary reason is higher energy consumption for lifting wastewater due to the vertical arrangement of treatment process. Unit O&M cost of Ding Den WWTP, which is operated under the same situation, is 2.91 Baht/m^3 and also relatively high. O&M cost of Nong Bon WWTP is estimated based on 100 mg/l of planned pollution lording for F/S. In case that pollution lording is lower than planned one under the same conditions as the existing WWTPs, O&M cost is expected to become lower owing to the reduction of consumption of consumable such as chemical.

5.1.5 Reduction of Initial Investment

The concept of staged development has not been well considered so far for the existing WWTPs in BMA. Therefore, there are several WWTPs of which current inflow is considerably less than design capacities. The design capacity of WWTPs is required to have marginal capacity to accommodate future inflow, which will increase year by year. However, the excessive marginal capacity results in uneconomical implementation.

The excessive marginal capacity has possibility to cause demolition of activated sludge and deterioration of activation by self-oxidation of activated sludge and also result in increase of energy consumption for aeration. Hence, it is common practice to reduce the number of operated trains of wastewater treatment facilities in case that actual influent is considerably less than the design capacity.

Therefore, staged development according to the projected flow is planned for Nong Bon WWTP considering reduction of the initial investment and treatment efficiency. At the same time, change of influent characteristics is also considered taking the current condition of low pollution lording into account.

As mentioned before, all civil and architecture structures will be implemented under the Priority Project because of economical aspect while mechanical and electrical equipment will be installed by phase. Major equipment which can be omitted for the first phase of the Project because of phased development and influent characteristics are as follows.

- Lift pump facilities (one large lift pump)
- Grit chamber facilities (one girt chamber and three fine screens)
- Aeration tank facilities (one train of aeration tank i.e. four tanks)
- Settling tank facilities (one train of settling tank i.e. eight tanks)
- Discharge pump facilities (two discharge pump)
- Amount of carrier (amount of carrier added per aeration tanks)
- Sludge dewatering facilities (three dewatering unit and one sludge cake storage)

The reduced construction cost by omitting the above mentioned equipment is estimated. Both of construction costs for Master Plan and Priority Project are shown in Table 5.1.3 together with reduced cost. As the result of the application of staged development for Nong Bon WWTP, 23 % of the initial investment i.e. 1,193.2 million Baht can be reduced.

Table 5.1.3 Reduction of Construction Cost of WWTP

	Construction cost (Million Baht)	Project cost (Million Baht)	%
Construction of WWTP (Master Plan)	3,316.2	5,203.9	100 %
Reduction of construction cost of WWTP	759.0	1,193.2	23 %
Construction of WWTP (Priority Project)	2,557.2	4,010.7	77 %

Source: JST

5.2 Implementation Schedule and Disbursement Schedule

5.2.1 Implementation Schedule

In case this Project is financed through JICA ODA Loan, the Government of Thailand must follow JICA Procurement Guidelines for the selection of the consultants and contractors to implement the Project. Therefore, implementation schedule is prepared based on the requirements of JICA Procurement Guidelines.

Implementation schedule starting from signing of Loan Agreement has been developed as shown in Table 5.2.1 taking into account necessary steps. Implementation of the project has been estimated to extend over 72 months (6 years) in total.

Table 5.2.1 Implementation Schedule

	Period	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Signing of LA	-	▼							
Selection of Consultant	12month	■							
Detailed Design	12month		■						
Tender Evaluation	12month			■					
Consultant Supervision	36month				■	■	■		
Selection of Contractor	12month			■					
Construction Works	36month				■	■	■		
Commissioning	24month							■	■

Source: JST

Duration necessary for selection of the consultant and the contractor has been decided considering the JICA's standard procedures and shown in Table 5.2.2 and Table 5.2.3, respectively.

Table 5.2.2 Detailed Implementation Schedule of Selection of Consultant

Month	1	2	3	4	5	6	7	8	9	10	11	12
Preparation of shortlist and RFP												
Approval of RFP by GOT												
Concurrence to RFP by JICA												
Issuing RFP to consultant												
Evaluation of proposals												
Approval of evaluation by GOT												
Concurrence to evaluation by JICA												
Contact negotiation with candidate												
Approval of contract by GOT												
Concurrence to contract by JICA												
Contract award												

Source: JST

Table 5.2.3 Detailed Implementation Schedule of Selection of Contractor

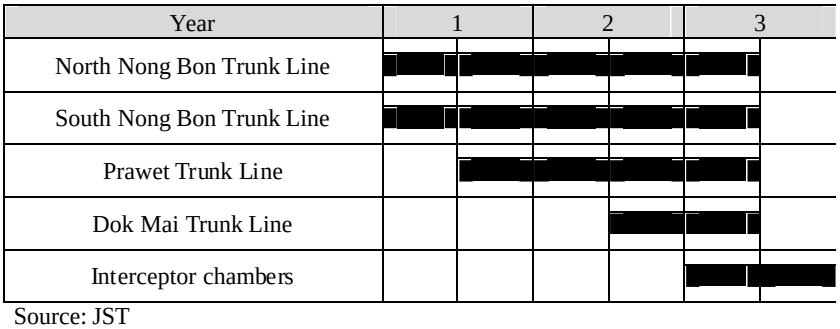
Month	1	2	3	4	5	6	7	8	9	10	11	12
Preparation of tender document												
Concurrence to TD by JICA												
Prequalification of tenderers												
Concurrence to PQ by JICA												
Tender period												
Evaluation of tender												
Concurrence to evaluation by JICA												
Contract negotiation with candidate												
Concurrence to contract by JICA												
Contract award												

Source: JST

Duration necessary for construction works has been planned to ensure the proper execution of the work considering conditions including ability of contractors, procurement of materials and labor force, manner of construction in Thailand and construction scale. The construction schedule is mainly estimated based on length of pipe line in case of interceptors and according to procedure and working volume of construction such as excavation and concrete casting in case of WWTP since there is rarely restriction regarding procurement. Implementation schedule of the construction has been estimated to extend over 36 months (3 years) in total and shown in Table 5.2.4 and Table 5.2.5. As for construction of interceptors, DDS's intention is that four

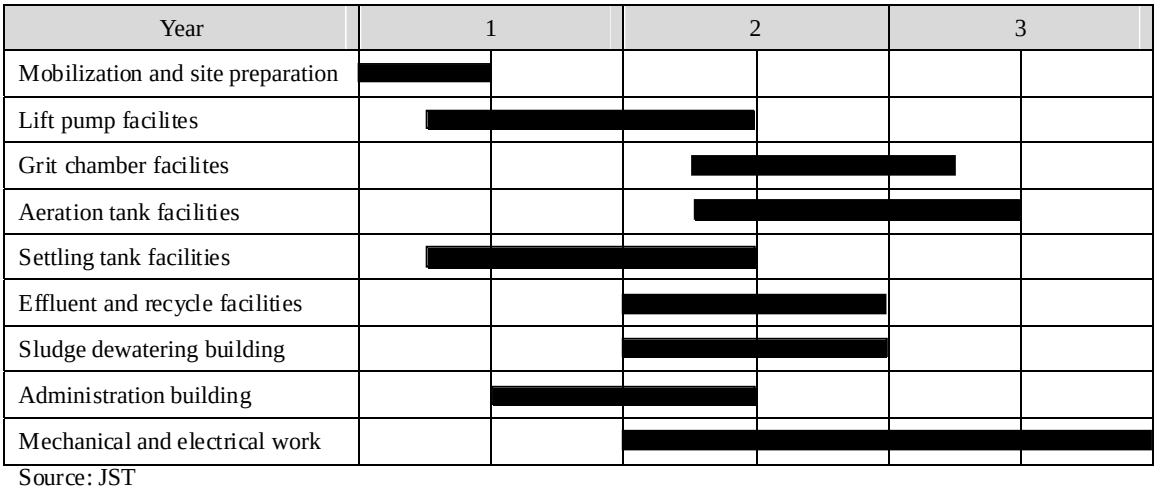
trunk lines are to be completed before operation of WWTP. However, phased construction might be required according to circumstances. Therefore, two options are considered, one for construction of four trunk lines at once and another for priority two trunk lines are constructed first followed by other two trunk lines (refer to Section 3.6). Construction schedule of the latter case is shown in Table 5.2.6.

Table 5.2.4 Detailed Implementation Schedule of Construction Works for Interceptors (4 Trunk Lines at once)



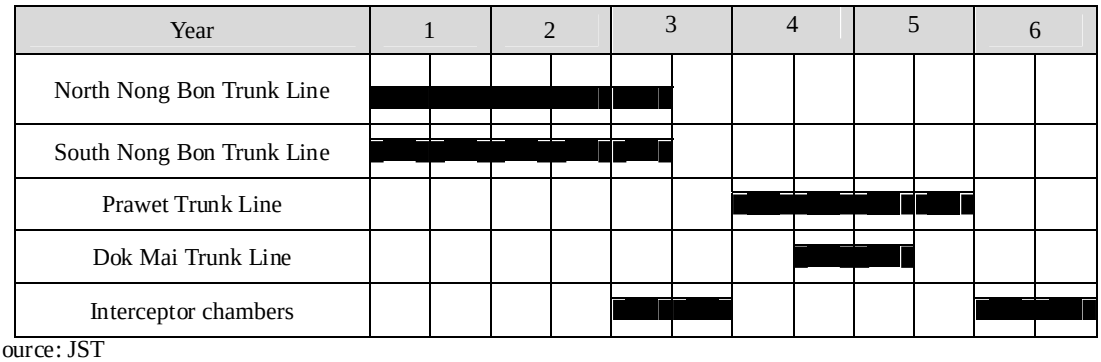
Source: JST

Table 5.2.5 Detailed Implementation Schedule of Construction Works for WWTP



Source: JST

Table 5.2.6 Detailed Implementation Schedule of Construction Works for Interceptors (Phased Construction)



Source: JST

Two years of commissioning period including on-the-job training is planned after the completion of construction of WWTP so that DDS, which is responsible for operation and maintenance, takes over operation of the constructed facilities smoothly.

5.2.2 Disbursement Schedule

The disbursement schedule based on the implementation schedule has been prepared as shown in Table 5.2.7.

Table 5.2.7 Disbursement Schedule

(Million Baht)

			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
Direct construction cost	WWTP	L.C.	0	0	0	373.5	373.5	373.5	1,120.4
		F.C.	0	0	0	478.9	478.9	478.9	1,436.8
		Total	0	0	0	852.4	852.4	852.4	2,557.2
	Interceptor	L.C.	0	0	0	822.5	822.5	822.5	2,467.6
		F.C.	0	0	0	0	0	0	0
		Total	0	0	0	822.5	822.5	822.5	2,467.6
	Total	L.C.	0	0	0	1,196.0	1,196.0	1,196.0	3,588.0
		F.C.	0	0	0	478.9	478.9	478.9	1,436.8
		Total	0	0	0	1,674.9	1,674.9	1,674.9	5,024.8
Indirect construction cost	Engineering cost	L.C.	0	71.8	71.8	71.8	71.8	71.8	358.8
		F.C.	0	28.7	28.7	28.7	28.7	28.7	143.7
		Total	0	100.5	100.5	100.5	100.5	100.5	502.5
	Contingency	L.C.	2.2	14.8	17.9	306.6	354.9	404.7	1,101.1
		F.C.	0	4.3	5.0	101.3	114.7	128.4	353.6
		Total	2.2	19.1	22.9	407.9	469.5	533.1	1,454.7
	Other indirect cost	L.C.	24.4	30.6	30.5	163.7	155.2	146.3	550.7
		F.C.	2.1	4.5	4.5	100.6	96.9	93.2	301.9
		Total	26.5	35.1	35.1	264.2	252.2	239.4	852.5
	Total	L.C.	26.7	117.1	120.2	542.0	581.8	622.7	2,010.5
		F.C.	2.1	37.5	38.3	230.6	240.4	250.3	799.2
		Total	28.8	154.7	158.5	772.6	822.2	873.0	2,809.7
Total		L.C.	26.7	117.1	120.2	1,738.0	1,777.8	1,818.7	5,598.6
		F.C.	2.1	37.5	38.3	709.5	719.3	729.2	2,236.0
		Total	28.8	154.7	158.5	2,447.6	2,497.1	2,548.0	7,834.6
		%	0.4	2.0	2.0	31.2	31.9	32.5	100.0

Source: JST

5.2.3 Disbursement Schedule in Case Interceptors are Constructed by Two Phases

Disbursement schedule in case interceptors are constructed by two phases is worked out. Construction of interceptors is divided into two phases, North Nong Bon and Sout Nong Bon trunk lines in the first phase and Prawet and Dok mai trunk lines in the second phase. Project cost, implementation schedule and disbursement schedule for phased construction of interceptors are shown in Tables 5.2.8 and Table 5.2.9 respectively.

Table 5.2.8 Estimated Project Cost
(in Case Interceptors are Constructed by Two Phases)

No.	Item	L.C (1,000 Baht)	F.C. (1,000 Baht)	Total (1,000 Baht)
1.	Construction Cost			
A	Wastewater treatment plant			
A-1	Lift pump facilities	155,811	294,995	450,806
A-2	Grit chamber facilities	52,109	123,513	175,622
A-3	Aeration tank facilities	215,634	480,650	696,284
A-4	Settling tank facilities	287,992	167,506	455,498
A-5	Effluent and recycle facilities	113,862	73,907	187,769
A-6	Sludge dewatering facilities	96,858	111,363	208,221
A-7	Administration building	177,909	11,697	189,606
A-8	Power facilities	20,257	173,179	193,436
	Sub-total of A	1,120,432	1,436,810	2,557,242
B	Interceptor			
B-1	Interceptor (Phase 1)	981,052	0	981,052
B-2	Shaft (Phase 1)	444,825	0	444,825
B-3	Interceptor Chamber (Phase 1)	91,000	0	91,000
B-4	Interceptor (Phase 2)	628,373	0	628,373
B-5	Shaft (Phase 2)	276,340	0	276,340
B-6	Interceptor Chamber (Phase 2)	46,000	0	46,000
	Sub-total of B	2,467,590	0	2,467,590
	Sub-total of 1	3,588,022	1,436,810	5,024,832
2.	Administration Cost	100,497	0	100,497
3.	Engineering Cost	358,802	143,681	502,483
4.	Physical Contingency	404,732	158,049	562,781
5.	Price Contingency	810,791	195,584	1,006,375
6.	Interest during construction	123,881	59,035	182,916
7.	Commitment charge	25,020	7,825	32,845
8.	Tax and Duty	378,822	273,292	652,114
	Sub-total of (2-8)	2,202,545	837,466	3,040,011
	Total including Tax and Duty	5,790,567	2,274,276	8,064,843
	Total excluding Tax and Duty	5,411,745	2,000,984	7,412,729

Source: JST

Table 5.2.9 Disbursement Schedule
(in Case Interceptors are Constructed by Two Phases)

（Million Baht）

			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Total
Direct constructiuon cost	WWTP	L.C.	0	0	0	373.5	373.5	373.5	0	0	0	1,120.4
		F.C.	0	0	0	478.9	478.9	478.9	0	0	0	1,436.8
		Total	0	0	0	852.4	852.4	852.4	0	0	0	2,557.2
	Interceptor	L.C.	0	0	0	505.6	505.6	505.6	316.9	316.9	316.9	2,467.6
		F.C.	0	0	0	0	0	0	0	0	0	0
		Total	0	0	0	505.6	505.6	505.6	316.9	316.9	316.9	2,467.6
	Total	L.C.	0	0	0	879.1	879.1	879.1	316.9	316.9	316.9	3,588.0
		F.C.	0	0	0	478.9	478.9	478.9	0	0	0	1,436.8
		Total	0	0	0	1,358.0	1,358.0	1,358.0	316.9	316.9	316.9	5,024.8
Indirect constructiuon cost	Engineering cost	L.C.	0	71.8	71.8	71.8	71.8	71.8	71.8	0	0	358.8
		F.C.	0	28.7	28.7	28.7	28.7	28.7	28.7	0	0	143.7
		Total	0	100.5	100.5	100.5	100.5	100.5	100.5	0	0	502.5
	Contingency	L.C.	2.2	14.8	17.9	230.9	267.3	304.9	112.6	125.7	139.2	1,215.5
		F.C.	0	4.3	5.0	101.3	114.7	128.4	0	0	0	353.6
		Total	2.2	19.1	22.9	332.2	382.0	432.3	112.6	125.7	139.2	1,569.2
	Other indirect cost	L.C.	25.0	31.5	31.5	152.7	147.0	141.0	33.4	33.2	32.9	628.2
		F.C.	2.1	4.7	4.7	113.0	109.6	106.0	0	0	0	340.2
		Total	27.2	36.1	36.2	265.7	256.6	247.0	33.4	33.2	32.9	968.4
	Total	L.C.	27.3	118.0	121.2	455.4	486.1	517.6	145.9	158.9	172.1	2,202.5
		F.C.	2.1	37.7	38.4	243.1	253.0	263.1	0	0	0	837.5
		Total	29.4	155.7	159.6	698.5	739.1	780.8	145.9	158.9	172.1	3,040.0
Total		L.C.	27.3	118.0	121.2	1,334.5	1,365.2	1,396.7	462.8	475.8	489.0	5,790.6
		F.C.	2.1	37.7	38.4	722.0	732.0	742.1	0	0	0	2,274.3
		Total	29.4	155.7	159.6	2,056.5	2,097.2	2,138.8	462.8	475.8	489.0	8,064.8
		%	0.4	1.9	2.0	25.5	26.0	26.5	5.7	5.9	6.1	100.0

Source: JST

5.3 Consulting Service

If the Project is financed through JICA ODA Loan, the procurement procedure of Design-Bid-Build contract is a common practice for the construction project. In the procurement of Design-Bid-Build contract, detailed design and supervision of the construction works is done by the consultants. Consulting services including the followings will be required for smooth implementation of the Project by assisting DDS, the executing agency.

- Preparation of detailed design
- Preparation of tender documents for the contract
- Assistance in tender/qualification evaluation and contract negotiation
- Supervision of the construction works
- Technical assistance of management, operation and maintenance

The consultants are composed of international and local experts. The local experts should support international experts in all the activities of the Project. The proposed work schedule of the consultants should accord with the implementation schedule as shown in Table 5.2.1. Required international and local experts along with man-months for consulting services for the implementation of the Project are presented in Table 5.3.1. Based on the estimation of required man-months, 136 man-months of international experts and 213 man-months of local experts would be required for assisting the executing agency for the Project.

Consultant office should be set up in Bangkok for carrying out the consulting services for the Project and executing agency office is proposed to be stationed full time at the consultant Bangkok office for smooth implementation of the Project. It is proposed that consultants retained for detailed design and construction supervision should provide DDS staff with suitable training program. Components of the training program will be explained in the latter sections of Chapter 5 of this report.

Table 5.3.1 M/M for Consulting Services

	International			Local		
	No.	Month	MM	No.	Month	MM
Project manager	1	45	45	0	0	0
Deputy project manager	0	0	0	1	60	60
Process engineer	1	12	12	1	18	18
Structural engineer	1	6	6	1	9	9
Architect	1	6	6	1	9	9
Mechanical engineer	1	12	12	1	18	18
Electrical engineer	1	12	12	1	18	18
Pipeline engineer	2	12	24	2	18	36
Site survey supervisor	1	3	3	1	6	6
Cost estimator	1	4	4	4	6	24
Contact specialist	1	3	3	0	0	0
Environmental expert	1	3	3	1	6	6
Technical assistance expert	1	6	6	1	9	9
Total	13		136	15		213

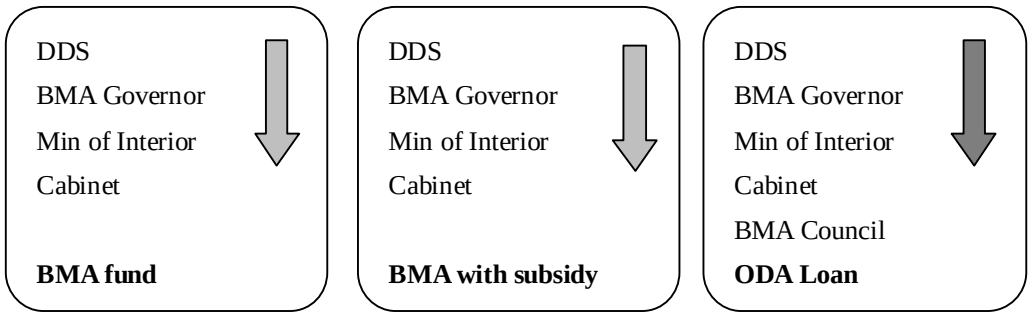
Source: JST

5.4 Management and Institutional Issues

5.4.1 Implementation Management

(1) Project Approval Process

After the approval of this JICA F/S for the proposed Nong Bon sewerage system, first by DDS / BMA and later by National Economic and Social Development Board (NESDB) under the Office of the Prime Minister, funding needs to be arranged for the implementation. Depending on the funding source, the Project approval process differs slightly. Three alternative funding sources can be considered, full BMA financing, BMA financing with central government subsidy and ODA loan financing. The approval processes for each of the alternatives are shown below.



Source: JST, based on discussion with Finance Dept of BMA

Figure 5.4.1 Project Approval Flow

Current regulation says that for any project with a total cost of more than THB 1,000 million must need approval from the Cabinet, so approval from Cabinet is required even in case of sole BMA funding. For the ODA loan financing, an extra step is required, which is the approval from the BMA Council.

(2) Implementation Organization and Flow

As explained in Section 3.6.2 and shown in the Figure 3.6.10 of the Conceptual Master Plan Report, implementation of new treatment plant and ancillary facilities including related interceptor pipes, pumping station and overflow chambers are the responsibility of 'Project and Sludge Management Section (PSMS)' of "Water Quality Management Office (WQMO)" under the Department of Drainage and Sewerage (DDS) of BMA. Until now, PSMS implemented 7 central WWTPs and related structures. Also, PSMS is now carrying out the implementation of 4 other systems; one of them is under construction stage while the others are in design stage. As a result, it can be concluded that PSMS has enough capability and competence to implement the proposed Nong Bon Wastewater Treatment Project.

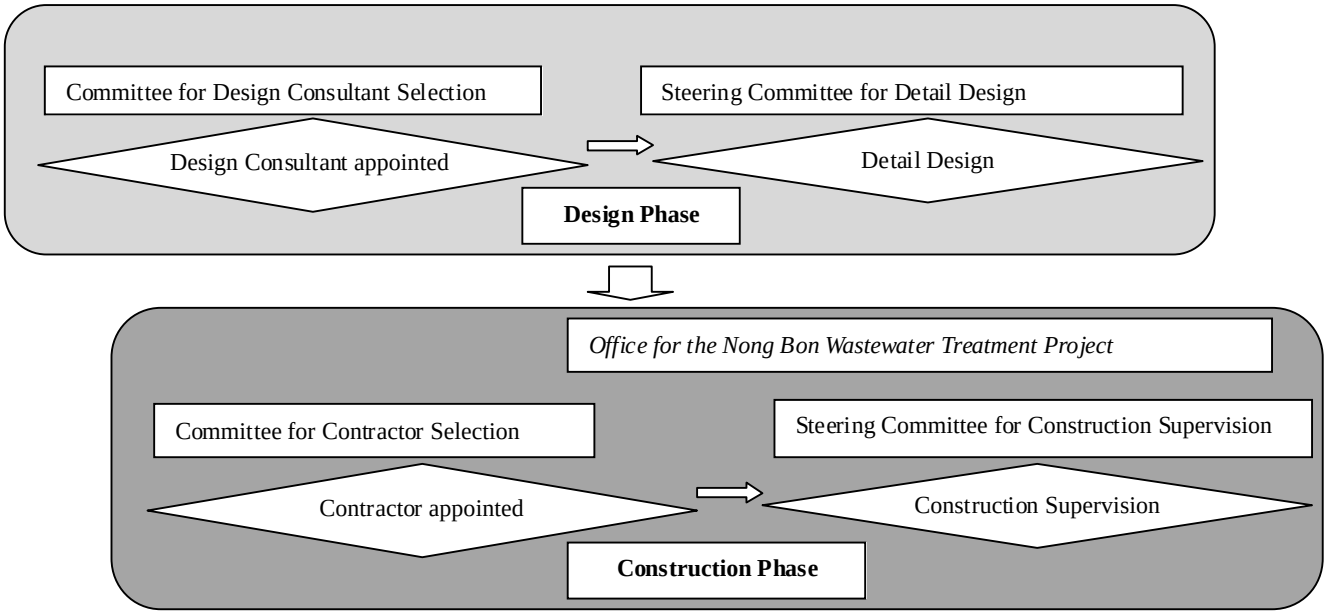
It is expected that the organizational procedure to be followed for the implementation of proposed Nong Bon Wastewater Treatment Project will be similar to current PSMS/ DDS practice. Thus the current practice is explained below.

For the selection of design consultants, usually DDS set up temporary selection committees. For example, currently there are two such committees working to select the design consultants for Thon Buri and Min Buri sewerage projects, respectively. Between 3 and 5 members are drawn from the different divisions of DDS to constitute these committees. It is reported that selection process takes between 3 and 6 months. A Steering Committee usually supervises the work of the consultant. For Steering Committee, the members are drawn not only from DDS but also from other departments of BMA or even sometimes from outside of BMA. The number of Steering Committee members is around 5.

For the selection of contractors, usually DDS set up temporary committees named 'e-Auction Committee'. For example, 3 such committees recently selected 3 contractors for the Bang Sue sewerage system construction. For each of those committees, 5 members were drawn from different divisions of DDS. It is reported that selection process takes around 6 months. A Steering Committee usually supervises the work progress. In this case, committee members are drawn not only from DDS but also from other departments of BMA. The number of Steering Committee members is around 5.

For the day-to-day administrative and management purpose for Bang Sue sewerage system construction Project, a specific unit has been established under DDS called "Office for the Implementation of Bang Sue Sewerage System". This 8 member unit is chaired by DG of DDS and the deputy chairman of the unit is the deputy DG of DDS in charge of WQMO. Three (3) members are drawn from 'Project and Sludge Management Section' including the section chief and two members are selected from 'Operations 1 Section'. One member is co-opted by the Chairman from any section of DDS as and when required basis. This unit works as the working group for the project dealing with the supervision consultants and contractors for 3 packages.

Based on the above discussion, it is expected that the implementation of the proposed Nong Bon sewerage system would follow the following flow. The Office for the Nong Bon Wastewater Treatment Project is expected to be formed just before the selection of Contractor and will execute the implementation.



Source: JST, based on discussion with DDS, BMA.

Figure 5.4.2 Process Flow of Project Implementation

(3) Implementation Capacity and its Improvement

As explained before, DDS has enough capability and competence to execute sewerage projects. Although the funding source has not been decided yet, it is expected that BMA will request for JICA ODA loan through Government of Thailand. However, it is to be noted that DDS has no previous experience of handling any external bilateral or multilateral ODA loans for construction. They only have some experience of handling US export loan (F/S of Klong Toei WWTP). It is thus recommended that capacity building is required regarding external finance management.

The current organization of the "Office for the Implementation of Bang Sue Sewerage System" comprises of only 8 members including DG and DDG of the DDS. Thus, it can be said that it is rather difficult to manage the project with this limited manpower. Obviously, such limited staffing cannot cover all required expertise; and thus there are no experts for economic/financial, environmental/social or institutional issues in the "Office for the Implementation of Bang Sue Sewerage System". It is recommended that the Implementation Office for the proposed Nong Bon Project should include more staff covering all required expertise.

The following steps are recommended for the implementation capacity building.

Table 5.4.1 Requirement for Implementation Capacity Development

Needs	Required Action
ODA loan management	- Study JICA guideline of borrowing, - Discuss with JICA official, and - Request for short term JICA expert to explain and train DDS on ODA loan Management
Execution management	- Increase the man power of the "Office for the Implementation" - Include experts in the fields of financial/economic, environmental, institutional, and social issues

Source: JST

5.4.2 Operation Management

(1) Operation Organization

The operations of the treatment plants and sewerage systems are the responsibility of the 'Operations Sections' of WQMO under DDS. There are 3 Operations Sections namely, 1, 2 and 3 based on geographic location of the sewerage areas. It is most likely that the proposed Nong Bon sewerage system will come under the section of 'Operations 2'.

Out of current 7 WWTPs, operations of 5 plants are outsourced to private entities through management contract. The first 2 plants are operated directly by DDS. Apart from these, it is now a general policy of DDS to outsource the operation of all WWTPs. As a result, it is expected that similar approach will be followed for the proposed Nong Bon Wastewater Treatment Project.

(2) Operation Capacity and its Improvement

As a private company is expected to operate the Project, the main responsibility of the Operations Section of WQMO is contract management, including preparing the most optimum contract, closely follow the execution of the concluded contract, and take required measures in case execution is not complying with the contract. Since DDS is managing the operation contractors for many years for 5 plants, it is expected that they developed required competence on this issue.

However, to maintain this competence and to improve further, there is no alternative of continuing education and capacity building. An outline for capacity development through training program is given later in this Section.

(3) Operation Contract

Though different companies are operating different WWTPs, the content of the contracts

documents are essentially similar. The contract document of Chatuchak WWTP has been reviewed and salient features are described below. The capacity of proposed Nong Bon WWTP is close to that of Chatuchak WWTP.

The contract reviewed by JST was concluded on May 26, 2006 for a period of 54 months between BMA and IBC Construction and Development Co. Ltd. From 28 November, 2010, BMA entered into similar contract with GUSCO-GEM consortium for a 5 year period. The maximum capacity of the plant is 150,000 m^3/d and the plant employs Cyclic Activated Sludge System as the secondary treatment process, which is basically a sequential batch reactor. Maximum capacity of the primary treatment is 5Q, i.e., 750,000 m^3/d. The Contract covered not only the operation of the plant but also extended to collection system including 181 interceptor chambers, 13 pumping stations, 199 manholes and 37.5 km of interceptors. However, the contract did not include any pipes discharging into the interceptor chambers.

The monthly payment was computed as the following:

$$\text{Monthly payment} = \text{Fixed amount} + A * Q_1 + B * Q_2 + C * Q_3$$

where, A, B, and C are multiplier factors and Q is volume. (Q_1: bypass flow, Q_2:treated wastewater, Q_3: sludge). In addition, a CPI inflation index was also used to count the price escalation.

There was a maximum ceiling prize of the contract and total fixed amount could not exceed 40% of the maximum ceiling. With these clauses, safeguard had been ensured against extraordinary high flow or abnormal low flow. The variable payment linked with the volume also encouraged the private company to consume less energy and chemical and reduce the administrative cost.

The contract stipulated total number of staff, thus cost cutting by reduced manpower was not possible, thereby ensuring operation quality. The contract requires employing 46 staff including 4 engineers. There exists no generally recognized indicator to represent the appropriate number of staff in a sewerage company. In case of water companies, low-to-mid single digit numbers per 1,000 connections are generally considered ideal. Although such a rule of thumb does not apply to sewerage, experiences say that the number of staff of a sewerage/drainage sector tends to be similar to or slightly smaller than that of the water sector in the same place. Considering that indicator as 6 (calculated by JST based on Chatuchak contract), it can be said that required number of staff for the proposed Nong Bon Project is 49 in 2020, 52 in 2020 and 55 in 2040. However, in 2009, MWA has only 2.13 staff per 1,000 connections. Thus, it is proposed that total staff number for sewerage service should also be reduced gradually.

The private company had to take all liabilities against property and life loss. However, calculation of fixed cost includes payment to the insurance company. Various monitoring parameters were also set and BMA was to analyze the samples twice monthly. There were also penalty clauses for non compliance. From the above discussion, it can be concluded that the contract document was well written and conveniently protects the interest of BMA.

(4) Up-gradation of Operation Contract

As explained in Conceptual Master Plan Report: Section 4.2- Strategy 4.3, most of the higher level PPP form may not function well for an independent sewerage system. To overcome this, in many cases, sewerage service is ring fenced with the water supply service. However, it is not applicable in Bangkok as water supply is out of the scope of BMA.

Lease Contract, which requires higher level of public sector involvement compared to currently employed management contract, can only work if there is a tariff collection. As a result, this cannot be started until there is a tariff collection. However, it is recommended to explore its' application after the introduction of tariff collection. In this type of arrangement, the operator or the lease holder is responsible for operation and maintenance of the facilities and services by taking some of the commercial risks. If the tariff is set below the O&M cost recovery level, BMA have to pay a fixed amount to the lease holder. Meanwhile, current management contract model could be upgraded to tap extra efficiency. Some of the issues are described below:

- The payment is based on dewatered sludge volume. So there is no incentive to reduce the volume.
- Contract says that all equipment should be same as contract start. However, with the rapid technological advances, new equipment is coming up. The present contract does not allow for introduction of newer and more advance technology.
- Currently there are penalty clauses in the contract but no award clause. Compliance with the contract or improvement of service should be rewarded.
- Performance indictors should be introduced as regular monitoring parameters.

(5) Performance Indicator

As explained in Conceptual Master Plan Report: Section 4.2, Strategy 4.1 (6), Performance Indicators (PI) are used in many developed countries like Japan and Australia as a management tool to evaluate the efficiency and effectiveness of a sewerage service and also for comparative assessment between utilities. International Water Association (IWA) first published PIs for the wastewater sector in 2003, and later it was standardized by ISO in 2007. Details of PIs are shown in Table 4.2.12 of the Conceptual Master Plan Report.

As sewerage service in BMA is expanding and improving, it is recommended that designated PIs should be introduced. This should cover not only the services undertaken by DDS itself but also the management contractors for the operation of WWTPs. The following PIs are recommended to be introduced; however, DDS can modify this list based on field requirements.

DDS is required to collect and accumulate continuously necessary data to calculate these PIs. Among the necessary data, data related to operation and maintenance of sewerage facilities such as O&M cost of interceptors and WWTPs, electricity consumption and water quality can be obtained easily from operation companies based on the contracts. On the other hand, data related to sewerage services and asset management such as number of collapse of pipe, sewer blockages, complains, wastewater reuse, ration of repaired sewer, ratio of age of main equipment area to be collected purposely. Also, data which are difficult to be obtained by DDS should be collected in cooperation with other agencies.

Table 5.4.2 Performance Indicators (PIs) recommended to be Introduced

PI	Calculation Formula	Purpose and Use
Ratio of inspected sewer	Total length of inspected sewers / Total length of sewers maintained x 100	Operation efficiency
Ratio of repaired sewer	Total length of repaired sewers / Total length of sewers maintained x 100	Asset condition Service quality
Number of collapse per 1 km of sewer	Number of collapse / Total length of sewers maintained	Asset condition
Maintenance cost per 1 m of sewer	Maintenance cost for sewers / Total length of sewers	Historical comparison Operation efficiency
Ratio of age of main equipment	Total age of main equipment / Total average life time of main equipment x 100	Asset condition
Compliance with discharge standard (BOD)	Number of tests complied with standard (BOD) / Total number of tests (BOD) x.100	Operation efficiency
Compliance with standard (SS)	Number of tests complied with standard (SS) / Total number of tests (SS) x.100	Operation efficiency
Compliance with standard (T-N)	Number of tests complied with standard (T-N) / Total number of tests (T-N) x.100	Operation efficiency
Compliance with standard (T-P)	Number of tests complied with standard (T-P) / Total number of tests (T-P) x.100	Operation efficiency
Compliance with standard of odor	Number of tests complied with standard of ordor / Total number of tests of odor x.100	Operation efficiency
Unit power consumption (wastewater treatment) Unit disinfection chemical usage	Power consumed (wastewater treatment) / Total wastewater treated Annual consumption of chemical / Total wastewater treated	Operation efficiency Cost control measure Operation efficiency Cost control measure
Compliance with legal water quality standard for water body (BOD)	Number of samples complied with legal standard (BOD) / Total number of legal tests (BOD) x 100	Pollution control Operation effectiveness
Compliance with legal water quality standard for water body (T-N)	Number of samples complied with legal standard (T-N) / Total number of legal tests (T-N) x 100	Pollution control Operation effectiveness

PI	Calculation Formula	Purpose and Use
Compliance with legal water quality standard for water body (T-P)	Number of samples complied with legal standard (T-P) / Total number of legal tests (T-P) x 100	Pollution control Operation effectiveness
Compliance with legal water quality standard for water body (E-coli)	Number of samples complied with legal standard (E-coli) / Total number of legal tests (E-coli) x 100	Pollution control Operation effectiveness
Sewer Blockages (per 100,000 persons)	Number of sewer blockages / Served population x 100,000	Asset condition
Complaints (per 100,000 persons)	Number of complaints / Served population x 100,000	Service quality
Unit operating cost per person (O&M)	Operating cost (O&M) / Served population	Operation efficiency Cost control measure
Working accidents (per 1 million m^3 treated wastewater)	Number of accidents which caused 4 days of absence or more / Total wastewater treated x 1,000,000	Working condition
Pollutant reduction ratio in dry weather (BOD)	(1 - Effluent BOD / Inflow BOD) x 100	Pollution control Operation effectiveness
Wastewater reuse	Wastewater reused / Total wastewater treated by advanced treatment x 100	Reuse efficiency
Sludge recycle ratio	Sludge recycled / Total sludge generated x 100	Reuse efficiency
GHG emission per person	GHG emission by sewerage service in terms of CO_2 / Served population	Global Environment

Source: JST

(6) Capacity Development through Training Program

The O&M works are quite important for the proper functioning of the treatment equipments and machinery. Though it is expected that the operation of the proposed WWTP will be outsourced, WQMO of DDS needs competent staffs to understand the detail task regime so that they can easily detect any non compliance of the contract. This is important for project sustainability. Although WQMO of DDS already acquired high qualification by managing 5 operators over the years, proper training is also equally important to ensure maintaining and improving the skill level. In fact, two types of human resources should be developed, officials at the managerial level in charge of policy, management information system, contract management and asset management; and officials at the operation level.

The human resources development program for both management officials and core operating staff should follow the following steps:

- to determine the required necessity of the human resources development through the analysis of the problems affecting the organization;
- to decide the goal of the human resources development from the perspective of the entire organization;
- to select the suitable method or a combination, form training course, lecture series, field investigation, on the job training, workshop, etc.;

- to develop the method of communication depending on requirements;
- to prepare short and long term human resources development program;
- to implement the program; and
- to make appraisal to evaluate the effectiveness of the program.

5.5 Technical Assistance

Technical assistance which is required when Japanese ODA Loan is realized is described in this section.

5.5.1 Training

(1) Necessary Training

Staff training and capacity development systems need improvement in order to enable the staffs to perform effectively during both implementation and operation phases. Two types of human resources should be developed; namely, for officials at the managerial level and for core members of operating staffs.

Managerial level development should be targeted to the staffs of different sections of WQMO. The focus should be on:

- long term policy and planning,
- contract management,
- construction management,
- management information system (MIS);
- asset management,
- tariff collection, and
- customer relations.

Operational level development should be targeted to the staffs of Operations sections of WQMO, so that they are to be able to understand the new process of the plant comprehensively.
The focus should be on:

- effluent water quality control,
- adjustments of the treatment process to suit different influent water quality,
- operation and maintenance of the equipment,
- daily routine work,
- water quality monitoring.

For human resources development program, particular attention should be paid for the following new technologies proposed in this F/S.

- Improvement of interceptor sewerage system (pump drainage area)
- New treatment technologies applied to narrow site area (carrier added activated sludge, membrane bioreactor etc.)
- Pollutant load reduction technologies in wet weather (wet weather activated sludge process)
- Energy recovering technologies (hydro power generation, biogas power generation)

(2) Method of the Proposed Training

Training program for WQMO staffs should be provided in the early stage of detail design. It is recommended that scope of training including subject, timing, duration and participants will be prepared by the DD consultant in the early stage of detail design stage in consultation with DDS.

Three types of training provider are proposed. They are (i) consultant – preparation for and providing training during detail design, (ii) contractor - providing training during and after construction, and (iii) external agency (like JICA) - providing training over the entire period. The most effective training method is a series of lectures followed by On-the-Job Training (OJT). Field visit, training course, and workshop will also be used.

Preparation of the Training Component in the DD Stage

It is proposed that a separate training component be included in the DD consultancy service. In addition to providing training, the scope will cover a long term training planning.
The following steps are suggested to be implemented under the service:

- Training Policy: Prepare/update training policy, the redeployment plan and skill mix requirement program of WQMO staff.
- Training Needs Assessment: Prepare the training needs assessment in the light of implementation and operation of advanced treatment plants.
- Training Plan: Develop a Training Plan which contains annual plan and refresher training plan.
- Training Centers/ Venues: Prepare plan for venues considering cost, ease of participation, access to expertise and development of future trainers.
- Resource Persons/ Trainers: Propose a pool of resource persons as trainers drawn from consultants, contractors, suppliers, universities, research institutions and government agencies.

- Topics and duration of Training: The consultant will decide training topics and duration in consultation with DDS.

Trainings Proposed in the DD Stage

As explained above, managerial level training for WQMO staffs should be arranged by DD consultant at an early stage of detailed design.

On the Job Training (OJT) is the most effective training method. WQMO should assign counterpart staff to each of the international/national experts. By working together with the experts, such counterpart staffs will not only get deep understanding of the related topic, but also learn how to handle unexpected situation and how to deliver an output on time, within budget and with required quality.

In addition, it is proposed that the training include a series of interactive workshop on core topics. Resource persons can be drawn from both locally or internationally. Topics might include fundamental subjects such as planning procedure, combined sewer system, overflow chamber, pipe construction methods, wastewater treatment unit processes for small foot print, cost estimation, financial planning, capacity development, sewage tariff, environmental management plan, and project evaluation. Advantage of workshop method is that a large number of trainees can take part with low cost per trainee. Each topic can be covered in half day and should be arranged in regular interval.

Trainings Proposed in the Construction Stage

Operation level training for WQMO Operations Section staffs should be arranged by the Contractor under supervision consultant's guidance. In addition, the contractor will provide technical guidance to WQMO for one year after completion of the construction. The topics should cover operation and maintenance of the equipment, daily routine work, chemical dose control, process control, measurement of performance indicator, and water quality measurement.

Training by External Agency

DDS can request external agencies like JICA to provide such trainings. Basically JICA trainings are technical assistance base. In some cases, the trainees are taken to Japan for a period between 2 weeks and 6 months. In other cases, JICA dispatch short or long term experts to provide on the job trainings. It may be noted that a number of WQMO staffs previously received such trainings in Japan.

Each year, JICA arranges Group Training Course (GTC) on various topics in general. DDS can check the contents and apply to JICA for a placement. For more pertinent to this Project, DDS can request JICA to arrange a tailor-made specific training on relevant fields, for example,

- Improvement technologies of interceptor sewerage system
- Advanced treatment processes with small foot print
- Pollutant load reduction technologies in wet weather
- Energy recovery technologies applied for sewerage facilities
- Construction management
- Management information system (MIS)
- Asset management

5.5.2 Program for Improvement of Management of Sewerage Works

Interceptor sewerage system in BMA is considered to be provisional system to conventional sewerage system. In order to improve service level of the sewerage system, various measures which are proposed in the M/P should be taken on a long term basis. In this regard, improvement projects mentioned elsewhere in this Main Report and M/P Report are summarized as shown below.

i) Improvement of interceptor sewerage system (Sections 3.7.1 and 3.7.2)
ii) Inventory investigation of existing drain pipes (Section 3.7.3)
iii) Institutionalize exceptional service area where installation of septic tank is exempted (Appendix 11)
iv) Introduction of PIs (Section 5.4.2)
v) Stipulation of sewerage ordinance (M/P)

6. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

6.1 Environmental and Social Considerations Study

6.1.1 Objectives of Environmental and Social Considerations Study

The purpose of the environmental and social considerations study is to ensure that proposed project components are environmentally and socially sound and sustainable and that the environmental consequences of the project are recognized at early stage and taken into account in the project design.

The major objectives of the study are to establish baseline data on environmental and social conditions of the project area, to predict the impacts on relevant environmental and social attribute due to the construction and operation of proposed wastewater collection and treatment facilities and ancillary works, to suggest appropriate and adequate mitigation measures to minimize/reduce adverse impacts, to prepare environmental mitigation and monitoring plan, to assist DDS to hold public consultation.

The works to be carried out under environmental and social considerations study includes following activities.

1) Conduct of environmental and social considerations
2) Assistance in holding public consultation
3) Assistance in preparation of land acquisition and resettlement plan, if required.
4) Preparation of environmental check list.

6.1.2 Components of This Chapter

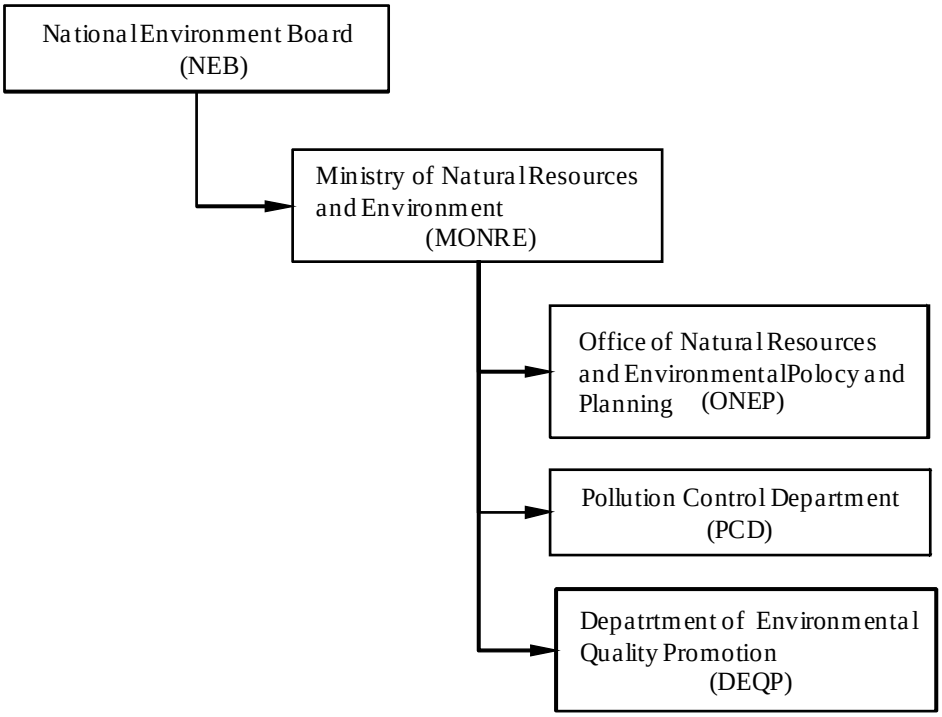
This Chapter includes the followings.

1) Legal and administrative framework for environmental and social considerations
2) Description of proposed project and consideration of alternatives
3) Baseline data on natural environment, pollution and contamination, Socio-economic environment
4) Identification of adverse impacts due to implementation of the project, consideration of mitigation measures, and monitoring plan
5) Result of public awareness survey
6) Record of public consultation

6.2 Environmental Impact Assessment

6.2.1 Administrative Framework for Environmental and Social Considerations

Administrative framework for environmental issues in Thailand was reformed in accordance with provisions of the Enhancement and Conservation of National Environmental Quality Act which was established in 1992. Responsibilities of National Environment Board (NBA) based on the Act were clearly prescribed, Office of the National Environmental Board, which had been responsible for preparation of environmental plans, was integrated to the Ministry of Natural Resources and Environment (MONRE). Three departments established under MONRE took charge of such important environmental administrative functions, as preparation of national environmental policy, establishment of environmental standards, preparation of environmental management plan, and approval of discharge standards as shown in Figure 6.2.1.



Source: JST

Figure 6.2.1 Preparation and Establishment of Environmental Policy

Office of Natural Resources and Environmental Policy and Planning (ONEP):

ONEP is responsible for coordinating environmental policies and prepares environmental master plan based on the Five Year National Economic and Social Development Plan. ONEP is also in charge of procedures regarding environmental impact assessment.

Pollution Control Department (PCD):

PCD solely manages pollution control in Thailand through divisions which are responsible for water pollution, air and noise, solid wastes, hazardous wastes and claims of pollution.

Department of Environmental Quality Promotion (DEQP):
There are office of administration, public relations division, environmental information division, and environmental study and training center under DEQP which takes charge of public relations to the public, and collection and management of environmental information.

6.2.2 Legal Framework for Environmental and Social Considerations

Enhancement and Conservation of National Environmental Quality Act, 1992 is a comprehensive environmental act in Thailand, and its major aims are establishment of fundamental policy for conservation of environmental quality relating to natural resources and pollution control. This Act consists of the following seven chapters and 115 clauses. The competent authority of the Act is MONRE.

Chapter 1 National Environmental Board
Chapter 2 Environmental Fund
Chapter 3 Environmental Protection
Chapter 4 Pollution Control
Chapter 5 Promotional Measures
Chapter 6 Civil Liability
Chapter 7 Penal Provisions and Interim Provisions

Part 4 of Chapter 3 stipulates issues regarding environmental impact assessment. Important provisions are summarized below.

(1) Projects for Which Submission and Approval of Environmental Impact Assessment Report is Required

Section 46 of Part 4 mentions that "For the purpose of environmental quality promotion and conservation, the Minister shall, with the approval of the National Environmental Board, have the power to specify, by notification published in the Government Gazette types and sizes of projects or activities, likely to have environmental impact, of any government agency, state enterprise or private person, which are required to prepare reports on environmental assessment for submission to seek approval in accordance with Section 47, Section 48 and Section 49." Based on the provision, a list of projects for which submission and approval of environmental impact assessment reports is required was published. The list is shown in Table 6.2.1.

Table 6.2.1 Projects for Which Submission and Approval of Environmental Impact Assessment Report is Required

Item	Type of Projects or Activities	Size
1	Dam or reservoir	With storage volume of 100,000,000 m^3 or more, or storage surface area of 15 km^2 or more
2	Irrigation	Irrigation area of 80,000 rails (12,800 ha) or more
3	Highway or road as defined by the Highway Act, passing through following area; 1) Wildlife sanctuaries and wildlife non-hunting areas as defined by the Wildlife Conservation and Protection Act 2) National park as defined by the National Park Act 3) Watershed area classified as class 2 * by the Cabinet resolution 4) Mangrove forests designated as the National Forest Reserve 5) Coastal area within 50 m of high tide level	All projects with equivalents to or above the minimum standard of rural highway, including road expansion on existing route
4	Commercial port	With capacity for vessel of 500 gross tons or more
5	Commercial airport	All sizes
6	Mass transit system under the Mass Transit System and Expressway Act or project as the same characteristic or mass transit which use rail	All size
7	Coastal land reclamation	All size
8	All type of project located in the areas approved by the Cabinet as class 1 B ** watershed area	All size
9	Industries 1) Petrochemical industry 2) Oil refinery 3) Natural gas separation or processing 4) Chlor-alkaline industry requiring sodium chloride (NaCl) as raw material for production of sodium carbonate (Na_2CO_3), sodium hydroxide (NaOH), hydro chloric acid, chlorine (Cl_2), sodium hypo-chloride (NaOCl) and bleaching powder 5) Iron and /or steel industry 6) Cement industry 7) Smelting industry other than iron and steel 8) Pulp industry	 Using raw materials which are produced from oil refining and or natural gas separation, with production capacity of 100 tons/day or more All sizes All sizes Production capacity of each or combined products of 100 tons/day or more Production capacity of 100 tons/day or more (production capacity shall be calculated by multiply by 24 hours) All sizes Production capacity 50 tons/day or more Production capacity 50 tons/day or more
10	Pesticide Industry Producing active ingredient by chemical process	All sizes
11	Chemical fertilizer industry using chemical process	All sizes
12	Central waste treatment plant as defined by the	All sizes

Item	Type of Projects or Activities	Size
	Industry Act	
13	Sugar Industry 1) producing raw sugar, white sugar, refined sugar 2) producing glucose, dextrose, fructose or the like	 All sizes Production capacity of 20 tons/day or more
14	Industrial estate as defined by the Industrial estate Authority of Thailand Act or projects with similar feature	All sizes
15	Thermal power plant	Capacity 10 MW or more
16	Petroleum development 1) Geophysical drilling, exploration and /or production 2) Oil and gas pipeline system	 All sizes All sizes
17 18	Mining as defined by the Mineral Act Hotel or resort facility	All sizes 80 rooms or more
19	Residential building as defined by the Building Control Act	80 rooms or more
20	Building in areas adjacent to rivers, coastal areas, lakes or beaches or in the vicinity of National Parks or Historical Park which are the area its environmental quality may be effected	With Height of 23 m or more, or total floor area or individual floor area in the building is 10,000 m^2 or more
21	Land allocation of residential or commercial purpose	500 land plots or more or total developed area exceed 100 rails (16 ha)
22	Hospital which located 1) in area adjacent to river, coastal area, lake or beach 2) in area other than 1.	 1) With 30 in – patient's beds or more 2) With 60 in – patient's bed or more

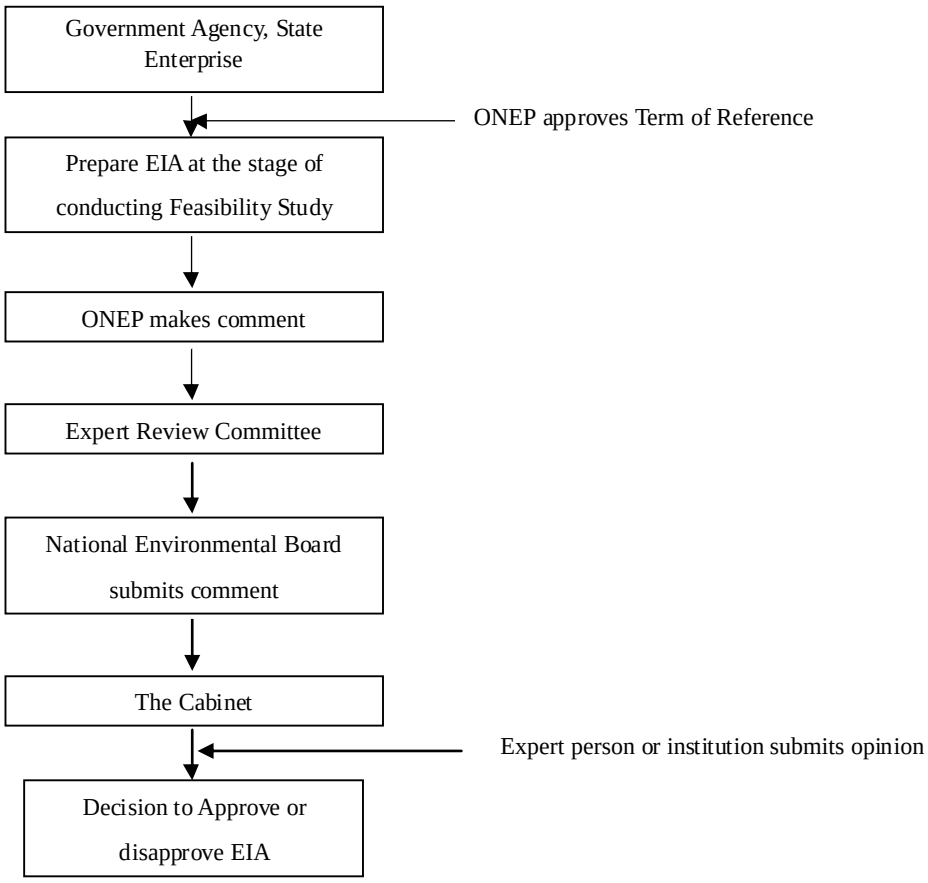
Note: * Watershed area where mining and cutting are allowed
** Watershed conservation area. A part of it is developed for agricultural purpose. Conservation of soil is required.

Source: Environmental Impact Assessment in Thailand (2007), ONEP, MONRE

(2) Procedures for Examination and Approval of Environmental Impact Assessment Report

Sections 47, 48 and 49 stipulate procedures relating to examination and approval of environmental assessment report.

Procedures for examination and approval of environmental impact assessment are different depending on either developer is public or private. In case of public project, environmental impact assessment report is to be submitted to NEB. NEB will then examine with consultation with ONEP and the special committee, and report the result to the cabinet. Cabinet will decide after examination of the project based on the result of examination by NEB and opinion of the special committee. Procedures for public project are shown in Figure 6.2.2.



Source: Environmental Impact Assessment in Thailand (2007), ONEP, MONRE

Figure 6.2.2 Procedures for Examination and Approval of Environmental Impact Assessment Report

Environmental impact assessment report to be submitted should include the following.

- Components of the project and project plan
- Environmental baseline data of the project site
- Environmental impacts due to project implementation
- Components of measures for minimizing or mitigating environmental impacts and its cost.
- Environmental monitoring plan

(3) Environmental Standards and Effluent Standards

Environmental standards are stipulated in Section 32 of Chapter 3 as follows.

"Section 32: For the purpose of environmental quality enhancement and conservation, the National Environment Board shall have the power to prescribe by notifications published in the

Government Gazette the following environmental quality standards:

1) Water quality standards for river, canal, swamp, marsh, lake, reservoir and other public inland water sources according to their use classifications in each river basin or water catchment.
2) Water quality standards for coastal and estuarine water areas
3) Groundwater quality standards.
4) Atmospheric ambient air standards.
5) Ambient standards for noise and vibration.
6) Environmental quality standards for other matters

The prescription of environmental quality standards pursuant to the foregoing paragraph shall be based upon scientific knowledge, principles, criteria and evidence related thereto and shall also take into account the practicability of such standards from the viewpoint of economic, social and technological considerations."

Effluent standards are stipulated in Section 55 as follows.

"Section 55: The Minister shall, with the advice of the Pollution Control Committee and the approval of National Environmental Board, have the power to publish notification in the Government Gazette prescribing emission or effluent standards for the control of wastewater discharge, polluted air emissions, of discharge of other wastes or pollutants from point sources into the environment, in order to meet the environmental quality standards set by virtue of this Act for the conservation on national environmental quality."

There is no standards about odor among regulating items for environmental impact assessment for WWTP. Effluent standards for WWTP and building effluent standards have been stipulated by BMA (refer to Table 3.2.2 in Volume 1 Conceptual Master Plan).

(4) Other Major Environmental Laws

Many authorities are concerned in environmental issues in Thailand. In fact, each authority established its laws and regulations for its jurisdiction in vertically divided administration system. They are carrying out controls in their areas relating to environmental issues based on these regulations. Table 6.2.2 shows major laws and regulations relating to environmental issues in Thailand.

Table 6.2.2 Major Laws and Regulations Relating to Environmental Issues

Title	Outline
Environmental Quality Promotion and Prevention Act, 1992	In the part relating to wastewater, it is prescribed that wastewater shall be treated by producer or treatment facility. In the latter case, producer shall pay service charge.
Factory Act, 1992	This Act controls factories under jurisdiction of Ministry of Industry (MOIn). This Act gives authority to the Minister to publish supplementary provisions. Factories are classified into three categories, and regulations and duties are stipulated according to these categories.
Public Health Act, 1992	This Act is implemented by local governments. This Act is directly related to citizen's health, sound life and quality of life. There is no regulations relating to foul smell. A part of this Act relating to hazards to life can be applied to control factories which emits foul smell disturbing sound life of neighboring residents.
Navigation in Thai Water Act, 1913 (Amended in 1992)	Main purpose of this Act is to control activities and to prevent disturbances which influence navigation by controlling transportation and use of water courses. A part of this Act is related to water pollution and to control of water pollution.
Hazardous Substance Act, 1992	The purpose of this Act is to determine proper management rules and procedures, and to put all hazardous materials under proper control by establishing relevant management systems between ministries which are concerned with control and management of hazardous materials. This Act gives authority, in case prevention of danger is required, to the Minster to designate an area where possession, distribution and use of hazardous materials are prohibited.
BMA Service Administration Regulations Act, 1985 (Amended in 1996)	Since wastewater treatment is one of the designated activities of BMA (as stipulated in its foundation act of 1977), this Act prescribed that BMA must provide this service to ensure the environmental wellbeing and public health.
Building Control Act, 1979 (Amended in 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 developers to provide buildings and households with sewerage system (wastewater treatment and storm water drainage).

Source: JST

(5) Necessity of Environmental and Social Considerations and EIA Report for This Project

Basic policy for environmental and social considerations for this project is described below.

i) Projects for which environmental and social impact assessment is required to be implemented and approved are determined by Environmental Quality Promotion and Prevention Act, 1992. According to provisions of this Act, environmental and social impact assessment is not required for wastewater project.

ii) The following serious impacts are not envisaged at planning, construction and operation stages.

- Significant impacts such as involuntary resettlement of residents and adverse impacts on employment, household economy, or regional economy, are not

caused for land acquisition of WWTP and interceptors construction under roads/klongs..

- WWTP and its ancillary works do not become sources of adverse impacts on health and safety.
- This project does not adversely impact on natural environment which is difficult to restore.
- This project does not influence any cultural heritage and natural reserves.

iii) Consequently, Survey Team will assist DDS to carry out investigation of initial environmental assessment based on JICA Guidelines (JICA Guidelines for Environmental and Social Considerations) to minimize and mitigate potential impacts.

iv) Environmental and social considerations in this Survey includes examination of project alternatives, estimation and evaluation of impacts, recommendation of mitigation measures and preparation of monitoring plan based on data collection, site visits and stakeholder meetings (held twice in January and March, 2011).

6.2.3 Base Line Data

In this section, base line data relating to natural environment, pollution/contamination, and social environment are described.

(1) Natural Environment

Outline of the Project Site and Its Natural Environment:

Area of the project site is approximately 64 km^2, and 80 % of the area belong to Prawet District and the remaining area belong to Suang Luang and Bang Na Districts. Project area is very flat and is located on the alluvial plain on the east bank of Chao Phraya River. Klong Phrakanong flows through the project area from east to west, and tributaries of Klong Prakanong flow in north-south direction. In northern part of the area (two thirds of the total area) tributary klongs flow into Klong Phrakanong, and in southern part of the area (one third of the total area) tributary klongs flow into Klong Bang Na or to outside of BMA (Samut Prakarn Province).

Topography and Geology:

Bangkok is located on the flat and low lying plain along the Chao Phraya River. Geological formation in this area is composed of soils transferred by the Chao Phraya River. Depth of top soil is 1 to 2 m, soft and comparatively solid clay layer exists at 2 to 16 m depth and solid clay and sand layer exists below them.

Climate and Meteorology:

Temperature

Average monthly maximum temperatures are as high as 35 ºC to 39 ºC throughout a year, and highest in March and April. Lowest average monthly minimum temperatures are less than 20 ºC which occur in December and January (refer to Table 6.2.3).

Rainfall

Annual rainfall fluctuates significantly, 1,160 mm to 2,272 mm in the latest 6 years from 2004 to 2009. Monthly rainfalls are influenced by monsoon and clearly classified into rainy and dry seasons. Most of rain falls in rainy season, from May to November, rainy days account for 50 % to 70 %, and average monthly rain fall exceeds 200 mm/month (refer to Table 6.2.3).

Relative Humidity

Relative humidity does not fall below 60 % throughout a year (as monthly average), and climate is humid (refer to Table 6.2.3).

Wind Direction

Wind direction is influenced by monsoon, and dominant directions are north and northeast from October to January and south and southwest from February to September (refer to Table 6.2.4).

Table 6.2.3 Climate in Bangkok (Average from 2004 to 2009)

Month	Temp. (Max)	Temp. (Min.)	Temp. (daily average)	Rainfall (mm/month)	Rainy day (days)	Rainfall (Max. mm/24hr.)	Relative Humidity (%)
Jan.	35.5	18.5	27.4	27.9	2	26.7	63.2
Feb.	36.3	19.3	28.5	36.2	3	21.1	68.8
Mar.	37.4	22.9	30.1	24.9	4	17.7	69.6
Apr.	38.5	23.6	30.8	162.4	9	85.8	69.8
May	36.8	23.8	29.6	275.2	18	63.1	74.4
Jun.	36.2	22.8	29.5	219.9	19	58.1	74.2
Jul.	35.5	24.1	29.1	199.6	18	44.1	73.6
Aug.	35.9	23.9	29.2	194.8	18	45.7	73.4
Sep	36.1	23.3	28.8	296.1	22	75.7	76.6
Oct.	36.2	23.4	29.0	255.3	15	70.9	74.0
Nov.	36.7	21.0	28.5	29.7	4	19.5	64.4
Dec.	35.3	19.9	27.6	1.6	1	1.9	60.6
Total	-	-	-	1,723.5	133	-	-

Source: Thai Meteorological Dept.

Table 6.2.4 Frequency of Wind Directions (1943 to 1953)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
N	22.4	6.6	3.0	6.3	4.1	0.5	1.4	2.0	6.5	33.1	51.4	48.7
NE	23.9	11.7	5.4	5.2	3.6	1.3	1.0	1.0	4.2	24.3	30.7	31.3
E	23.5	19.4	10.7	11.4	7.8	2.1	2.1	2.8	4.7	14.2	13.3	16.6
SE	6.3	12.3	14.9	13.3	10.4	7.5	7.0	6.4	7.9	7.6	1.6	1.9
S	12.1	34.4	57.0	46.6	40.7	33.7	27.6	21.8	20.3	8.9	2.5	1.0
SW	9.9	25.7	38.3	31.5	31.7	50.0	52.4	48.5	35.9	8.2	2.5	1.6
W	4.0	3.6	4.4	7.8	15.7	26.7	30.0	37.5	25.0	11.5	3.5	3.8
NW	8.6	3.7	2.1	4.0	3.7	1.4	4.5	4.3	7.8	11.9	13.7	21.1
Calm	55.8	42.2	37.3	40.9	55.8	44.5	44.3	46.7	55.5	51.9	50.5	49.5
NE direction	69.8	37.7	19.1	22.9	15.5	3.9	4.5	5.8	15.4	71.6	95.4	96.6
SW direction	26.0	63.7	99.7	85.9	88.1	110.4	110.0	107.8	81.2	28.6	8.5	6.4

Source: Kazukiko Hagini, 1967

Biological Environment, National Parks and Natural Reserves:

There are approximately 150 national parks (including plans) in Thailand to conserve natural resources, wild lives and aesthetic beauties. However, there is no national park in the project area and surrounding areas of BMR (refer to Figure 6.2.3).

Source： National Parks in Thailand (2006) , National Park, Wildlife and Plant Conservation Department, MONRE

Figure 6.2.3 National Parks in Thailand (Central and Eastern Districts)

There is no designated “Important Bird Area” in the project area and surrounding areas of BMR. The nearest “Important Bird Area IBA” is Don Hoi Lot (Samuthsong Kram Province, refer to Figure 6.2.3) which is located at approximately 30 km southeast to Bangkok.

Site for construction of WWTP has been developed as a park near storm water reservoirs. Characteristics of the site are described below.

1) Nong Bon storm water reservoir is not natural water body. Water level is controlled artificially according to seasons or rainfall. Therefore, there is little shallow marsh area where vegetation is suitable for breeding and feeding of birds.
2) There are many water bodies in addition to Nong Bon storm water reservoir in Prawet district between Bangkok International Airport located in Samut Prakan Province (distance approximately 7 km) and the site. Birds can scatter among these water bodies even if Nong Bon storm water reservoir can not be used.
3) The size of Nong Bon storm water reservoir is approximately 1 km in east-west direction and approximately 0.8 km in north-south direction. The site for WWTP is located at southeastern part of the reservoir. Influence of noise can not reach beyond 500 m radius (approximately 3/4 total area of the reservoir). If noise at 90 dB level occur during construction, this will reduce to 50 dB at 500 m distance.
4) Noise at operation stage of WWTP (largest one is from blowers) can be reduced sufficiently at boundary of the site because main equipment is confined in buildings. Noise will actually not influence birds.

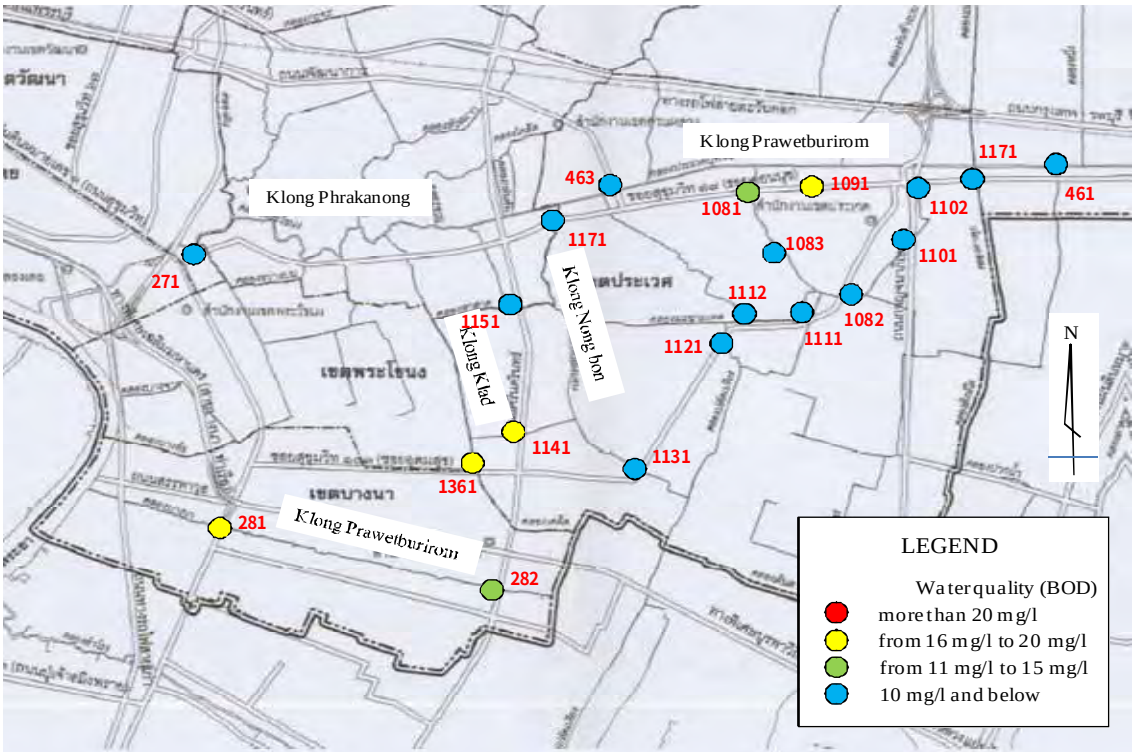
Thus implementation or operation of the project is not expected to have any negative impact on important birds.

(2) Pollution and Contamination

Water Pollution:

Largest klong in the project area is Klong Phra Khanong which flows from east to west. Tributary klongs flow in north-south directions at right angle to Klong Phra Khanong. There are natural and artificial watersheds which divide the project area. In the northern part of the area (approximately two thirds of the total area) tributary klongs flow into Klong Phra Khanon, and in the southern part of the area (approximately one third of the total area) tributary klongs flow into Klong Bang Na or to Samut Prakarn Province.

There are 20 monitoring points monitored by DDs in Klong Phra Khanon, Klong Bang Na and tributary klongs. Distribution of monitoring points and their BOD concentrations are described below.



Source: DDS

Figure 6.2.4 Distribution of BOD Concentrations (Average in 2009)

Air Pollution:

Situation of air pollution in BMA is shown in Table 6.2.5. Yearly changes of air pollution for the last 5 years are as follows. All parameters except for total particulate matters and PM10 have been improved, however these two parameters are still high at some sampling points. It is reported that air pollution in areas which are facing roads is severe, and influence of emission gases from vehicles is thought to be significant. Situation of air pollution in districts related to the project area is shown in Table 6.2.6. Maximum values exceeding the permissible level have been observed.

Table 6.2.5 Situation of Air Pollution in BMA

Year	Total Particulate Matters (Average for 24 hrs. mg/m^3)	PM10 (Average for 24 hrs. µg/m^3)	NO (Average for 8 hrs. ppm)	Ozone (Average for 1 hr. ppb)	SO_2 (Average for 24 hrs. ppb)	NO_2 (Average for 1hr. ppb)
2003	0.04-0.48	12.7-208.9	0-13.0	0-145.0	0.7-22.0	0-166.0
2004	0.01-0.77	21.5-224.8	0-10.6	0-143.0	0.4-23.6	0-172.0
2005	0.01-0.72	12.2-216.0	0-8.2	0-110.0	0-37.3	0-170.0
2006	0.03-0.80	10.4-206.2	0-8.6	0-137	1-18.6	0-182
2007	0.03-0.76	9.8-242.7	0-9.4	0-102	0.4-19.0	0-150
Limit	0.33	120	9	100	120	170

Source: Bangkok State of The Environment 2006-2007, Department of Environment, BMA

Table 6.2.6 Situation of Air Pollution in the Districts Related to the Project Area

District	Monitoring point	Year	Measurement period (days)	TSP (mg/m^3)		PM_{10} (mg/m^3)	
				Min.	Max.	Min.	Max.
Bang Na	Bang Na-Trad in front of Bang Na 1 Hospital	2007	14	0.332	0.973	0.113	0.261
		2008	10	0.218	0.486	0.082	0.255
		2009	11	0.161	0.411	0.077	0.197
		2010	36	0.138	0.542	0.052	0.192
		2011	14	0.127	0.421	0.068	0.166
	Sukhumvit Rd. Police box, Udomsuk intersection	2008	3	0.201	0.334	0.075	0.130
		2009	14	0.280	0.433	0.119	0.216
		2010	39	0.093	0.623	0.036	0.297
		2011	14	0.140	0.499	0.071	0.371
	Bang Na-Trad Bang Na intersection	2008	6	0.218	0.390	0.067	0.154
		2009	8	0.213	0.430	0.081	0.409
		2010	39	0.142	0.494	0.058	0.183
		2011	14	0.153	0.285	0.088	0.230
	Soi Bang Na-Trad 21	2009	5	0.184	0.341	0.098	0.172
		2010	39	0.073	0.355	0.043	0.184
		2011	14	0.131	0.411	0.054	0.137
Prawet	On-nut Rd.-Police Box Prawet Police station	2007	14	0.132	0.409	0.063	0.132
		2008	7	0.206	0.308	0.103	0.199
	Srinakarin Rd. Police box - Seri center	2007	14	0.089	0.243	0.042	0.132
		2008	7	0.248	0.305	0.140	0.194
	Srinakarin Rd. Land office-Prakanong branch	2008	2	0.123	0.159	0.067	0.089
		2009	6	0.172	0.219	0.090	0.123
	Chalerm Prakiat Rama 9, Soi 73 Shell gas station	2010	30	0.060	0.248	0.031	0.150
	Chalerm prakiat Rama 9 Park Rachawadi gate Shell station	2010	44	0.090	0.370	0.050	0.199
		2011	14	0.141	0.281	0.073	0.159
Suan Luang	Onnut Rd. - Police box Suan Luang intersection	2008	3	0.117	0.290	0.057	0.094
		2009	6	0.149	0.281	0.077	0.145
		2010	30	0.058	0.155	0.031	0.091

Source: Department of Environment, BMA

Noise:

Situation of noise in BMA is shown in Table 6.2.7. Sources of noise are reported to be the following.

- Vehicles for transportation
- Factories
- Construction work
- Events, amusements, demonstrations etc.
- Roars of domestic animals

Table 6.2.7 Situation of Noise in BMA

Year	Equivalent Sound Level (dB)
2002	62.7 – 83.7
2003	66.2 – 86.3
2004	63.8 – 80.6
2005	60.8 – 90.3
2006	58.4 – 88.1
2007	54.5 – 83.3
Limit	70

Source: Bangkok State of The Environment 2006-2007, Department of Environment, BMA

Results of observation at some monitoring points in BMA are shown in Table 6.2.8. Most of the monitoring points of which noise level exceeds the limit are facing to roads. These results indicate that main sources of noise are vehicles for transportation.

Table 6.2.8 Results of Observation of Noise (2009)

Ambient

District	Name of Station	Equivalent Sound Level (dB)		Ratio of Exceeding Standard (%)
		Min.	Max.	
Wong Thong Lang	Bodindecha School	51.2	73.0	2
Bang Kapi	Khlong Chan- National Housing Authority	53.4	63.4	0
Yan Nawa	Nonsi Witthaya School	51.3	83.9	25
Bang Kun Thien	Sing-racha Pitthaya School	53.2	68.8	0

Roadside

District	Name of Station	Equivalent Sound Level (dB)		Ratio of Exceeding Standard (%)
		Min.	Min.	
Huai Khwang	Huai Khwang-NHA Stadium	63.5	70.6	0
Pom Prap Sattru Phai	Wongwien 22	66.0	81.9	98
Thon Buri	Thonburi Power Substation	65.8	74.6	58
Bang Kapi	Chokchai Police Box	70.2	73.9	100
Din Daeng	Din Daeng-National Housing Authority	66.7	84.8	99
Phra Nakon	Pha-hu-rat	74.4	78.9	100

Note: Environmental standard is 70 dB (equivalent sound level)
Source: PCD, MONRE

Results of observation of noise in the districts related to the project area are shown in Tables 6.2.9 and 6.2.10. Results monitored at the district office satisfied the standards, however, maximum values obtained at all monitoring points along roads exceeded the permissible level of the standards.

Table 6.2.9 Situation of Noise in the Districts Related to the Project Area (Monitoring Points along Roads)

District	Monitoring point	Year	Measurement period (days)	Equivalent Sound Level (dB)		Maximum Sound Level (dB)	
				Min.	Max.	Min.	Max.
Bang Na	Bang Na-Trad in front of Bang Na 1 Hospital	2007	14	79.5	81.7	87.3	125.7
		2008	10	76.1	77.1	86.4	117.7
		2009	11	72.7	79.7	83.6	113.1
		2010	36	76.1	78.0	83.1	111.0
		2011	14	76.6	78.0	85.6	113.2
	Sukhumvit Rd. Police box, Udomsuk intersection	2008	3	75.3	82.0	90.4	105.2
		2009	14	78.9	80.2	92.2	111.2
		2010	39	76.4	80.4	86.3	114.3
		2011	14	77.5	80.9	90.5	113.2
	Bang Na-Trad Bang Na intersection	2008	6	76.8	78.9	84.5	109.5
		2009	8	75.4	78.8	88.8	110.9
		2010	39	72.4	80.3	78.8	116.1
		2011	14	76.4	78.6	88.2	114.9
	Soi Bang Na-Trad 21	2009	5	77.1	78.6	85.2	110.5
		2010	39	75.0	81.5	83.0	112.6
		2011	14	76.8	78.1	86.2	112.9
Prawet	On-nut Rd.-Police Box Prawet Police station	2007	14	71.6	72.9	81.1	111.8
		2008	7	71.4	72.3	83.6	107.6
	Srinakarin Rd. Police box - Seri center	2007	14	73.6	75.9	85.7	111.1
		2008	7	73.4	74.0	86.6	108.4
	Srinakarin Rd. Land office- Prakanong branch	2008	2	77.4	77.5	85.8	108.3
		2009	6	77.1	77.9	87.9	122.7
	Chalerm Prakiat Rama 9, Soi 73 Shell gas station	2010	30	73.0	76.2	83.9	110.5
	Chalerm prakiat Rama 9 Park Rachawadi gate Shell station	2010	44	70.2	76.0	81.3	110.4
		2011	14	74.0	76.8	86.2	110.0
Suan Luang	Onnut Rd. - Police box Suan Luang intersection	2008	3	71.6	71.8	82.7	105.2
		2009	6	72.0	78.1	82.7	103.1
		2010	30	70.3	77.4	79.0	112.4

Source: Department of Environment, BMA

Table 6.2.10 Situation of Noise at Prawet District Office

Observation period	Equivalent Sound Level (dB)		Number of times of observation
	Min.	Max.	
From 31 May to 4 June 2010	56.3	59.7	n=75
From 17 Aug. to 20 Aug. 2010	55.7	57.5	n=49
From 14 Mar. to 18 Mar. 2011	57.1	61.5	n=71

Source: Department of Environment, BMA

Odor:

Permissible limits of odor for environmental standards or at sources are not established in Thailand. Therefore, there is no data of odor nor observation station.

(3) Socio-economic Environment

The project area includes almost all of Prawet District and parts of Suang Luang and Bang Na Districts which are located west of Prawet District. BMA is the capital of Thailand, and political, cultural and commercial center of the country. Project area lies in the middle between the central part of BMA and newly developed airport. Many housing developments are progressing resulting in rapid urbanization and population growth. Transportation networks have been developed as construction of airport has been implemented. East-west highway and main roads, rapid railway connecting the city center and the airport and north-south highway have been provided. The project area is convenient to the city center and to the airport.

Most of the project area is designated as low density residential area except for small portions which are designated as medium density residential area and commercial area. One of medium density residential areas and a commercial area are continuity of those in Bang Na District which is located west to Prawet District. Main features of the project area can be, therefore, said to be low density residential area and newly developed housing area (refer to Figure 2.1.1).

Population:

Recently population growth in BMA became slow after rapid growth since 1960's until 1990. This trend is considered to continue for some time in the future, and population projection was made based on this assumption. Population projections for BMA, related Districts and the project area are shown in Table 6.2.11.

Table 6.2.11 Population Projections for BMA, Related Districts and the Project Area

District	Area(km^2)	Population Projection		
		2008	2030	2040
BMA	1,569.9	6,586,947	7,322,390	7,626,000
Prawet District	52.49	176,089	203,770	216,470
Suan Luang District	23.68	133,872	145,170	149,510
Bang Na District	18.17	115,887	115,950	115,950
Nong Bon Project Area	63.85	222,293	251,574	264,883
Prawet District	52.49	176,089	203,770	216,470
Suan Luang District	6.69	18,787	20,372	20,981
Bang Na District	4.67	27,417	27,432	27,432

Source: JST

Household Socio-economics:

Data regarding household socio-economics in Thailand and BMA are shown in Table 6.2.12 below.

Table 6.2.12 Household Socio-economics in Thailand and BMA

Item	Thailand	BMA
Average household size (person in 2004)	3.4	3.2
Gross Provincial Product（Baht/year/person）	101,304	283,780
Population with no education (2005)	5.4	3.3
Educational attainment of population aged 15+ (2005) Less than primary (%)	34.6	19.4
Primary (%)	19.7	15.6
Lower secondary (%)	16.4	15.6
Upper secondary (%)	12.1	18.4
Diploma (%)	3.3	4.4
University (%)	8.0	22.5
Unemployment rate (% in 2005)	1.3	1.9
Household income (2004, Baht/month)	14,778	29,696
Household expenditure (2004, Baht/month)	10,885	19,841
Household with debt (2004, % of household)	66.4	45.8
Average household debt (2004, Baht)	157,439	351,000
Living condition 2004 Safe sanitation (% of household)	99.8	100
Clean drinking water (% of household)	99.2	99.9
Electricity in dwelling (% of household)	98.9	99.7
Telephone in structure (5 of household)	23.9	51.2
Population with mobile phone 2005 (%)	36.7	59.3
Population with internet access 2005 (%)	12.0	25.9

Source: Thailand Human Development Report 2007, UNDP

Cultural Heritage:

There are many cultural heritages preserved in BMA and tourist industry is very prosperous. These cultural heritages are concentrated in the city center (old Bangkok). On the other hand, the project area is located in the eastern part of BMA, and far from old city. There is no cultural heritages confirmed in and around the project area.

Public Health:

Occurrence of infectious diseases in BMA and Prawet District is shown in Table 6.2.13. Comparing figures of occurrence in the project area (Prawet District) and BMA, those in the project area is equal to or less than those of BMA. Thus, public health condition in the Project area is judged to be not bad from view point of occurrence of infectious diseases.

Table 6.2.13 Number of Patients of Infectious Diseases (2008)

(Unit: Number of patients per 1,000 persons)

Disease	Average in BMA	Prawet District	Maximum (per District)
Acute Diarrhea	7.134	4.112	17.123
Food Poisoning	0.666	0.312	2.212
Dysentery	0.036	0.045	0.245
Enteric Fever	0.022	0.028	0.092
Hepatitis A	0.004	-	0.031
Hepatitis B	0.048	0.062	0.238
Hepatitis (non-A & non-B)	0.009	-	0.044
Hepatitis (unspecified)	0.072	0.028	0.248
Hemorrhagic Conjunctivitis	0.374	0.261	1.315
Influenza	0.713	0.466	2.431
Rubella	0.021	0.011	0.113
Chickenpox	0.676	0.505	1.791
Measles	0.140	0.136	0.431
D.H.F	1.587	1.459	2.605
Encephalitis	0.001	-	0.018
Malaria	0.018	-	0.055
Pneumonia	1.109	1.159	2.188
Tuberculosis	0.360	0.352	1.270
Sexually Transmitted Diseases	0.452	0.216	1.453

Source：Annual Epidemiological Surveillance Report 2008

6.2.4 Identification of Negative Impacts due to Implementation of the Project, Consideration of Mitigation Measures and Monitoring Plan

(1) Consideration of Alternatives

Aim of the project is enhancement of water quality improvement in Chao Phraya River and klongs by reducing pollutant load. Alternatives to be considered here should be measures or projects which are effectively reduce pollutant load. The following measures are considered as alternatives at various stages of generation to discharge of pollutant.

Generation stage: Measures to reduce pollutant load at generation points such as household and commercial establishments

Discharging stage: Measures to reduce pollutant load along drain route (from generating point to klong)

Arrival stage: Measures to reduce pollutant load in water bodies where pollutant load finally arrive at, such as klong and Chao Phraya River.

Each alternative is required to realize 10 mg/l BOD concentration in klongs which is goal of sewerage project. Possible measures at each stage and their problems and evaluation are described below.

Generation stage

Installation of onsite treatment system which has enough capacity to treat wastewater at 20 mg/l BOD concentration is considered to be an alternative. Small scale onsite system for household and large scale onsite system for commercial establishment are applicable. Treatment processes of these systems are activated sludge process or other biological processes. There are many applications of the system and this alternative is technically feasible. These onsite systems should be installed in all households and commercial establishments. Moreover, these systems should be operated and maintained properly. Currently installation of septic tank and oil separator is compulsory, but proper treatment by septic tank can not be expected and oil separator is scarcely installed. Taking the current situation into account, it can be said that it is extremely difficult to install onsite system to each household and to maintain properly.

Discharge stage

There is no application of the treatment system which can treat wastewater at 20 mg/l BOD concentration level. Development of technology has not been progressed. It is therefore difficult to adopt any technology.

Arrival stage

Objective water bodies at this stage are klongs and Chao Phraya River which finally receive pollutant load. There are applications of treatment facilities in klongs in BMA. However, these are supplemental treatment facilities to the sewerage system and are not designed to treat all of the pollutant loads generated in the catchment area. These systems are not suitable to treat all of the pollutant loads which are received in klongs.

From the above, it is judged that no alternative is available to treat pollutant load to the same level as sewerage system can achieve. Thus, there are only two cases, viz. “with project” and “without project”. In case “without project”, water quality in klongs will be deteriorated by population growth and commercial activities as analyzed in M/P.

Alternatives of treatment processes and facilities structure, above ground or underground are considered in depth in Sections 4.2. and 4.3 of this report.

(2) Identification of Negative Impacts due to Implementation of the Project

Impacts caused by the implementation of the Nong Bon wastewater project have been identified and are shown in Table 6.2.14 as Scoping Matrix. Outlines, evaluation and their durations are described in Table 6.2 15.

Table 6.2.14 Scoping Matrix for the Project

Environmental Elements		Preparatory stage			Construction stage			Operation stage		
		Wastewater treatment	Sludge treatment	Interceptors	Wastewater treatment	Sludge treatment	Interceptors	Wastewater treatment	Sludge treatment	Interceptors
Social Environment	Land acquisition, resettlement									
	Local economy									
	Utilization of land and local resources									
	Social institutions									
	Exiting social infrastructures and services				○	○	○			
	Poor and indigenous peoples									
	Equality of benefits and losses									
	Local conflicts of interest									
	Cultural heritage									
	Water right and so on									
	Health and sanitation				○	○	○			
	Infectious diseases such as HIV/AIDS				○	○	○			
	Hazard and security risks				○	○	○			
	Accidents				○	○	○			
Natural Environment	Topography and geology									
	Soil erosion									
	Groundwater									
	Flow and hydrological features							○		
	Situation of estuary									
	Biota and ecosystems									
	Landscape									
	Local climate									
	Global warming									
Pollution	Air pollution				○	○	○			
	Water pollution							○		
	Soil pollution								○	
	Pollution of bottom layer Waste									
	Noise and vibration				○	○	○			
	Ground subsidence									
	Offensive odor								○	

Source: JST

Table 6.2.15 Foreseeable Adverse Impacts

Environmental Elements			Grade	Reason
Social Environment	1	Land acquisition and involuntary resettlement	D	Construction site for WWTP belongs DDS and it is not necessary to acquire any new land. No pumping station is planned. Land acquisition is no t necessary for construction of interceptors. Interceptors are planned to be constructed under roads or klongs. Permission to use property of road may be required.
	2	Local economy (Livelihood and employment)	D	Land acquisition for interceptors and pumping stations is not necessary.
	3	Utilization of land and local resources	D	Land acquisition for interceptors and pumping stations is not necessary.
	4	Social institutions (Social capital and local decision-making institutions)	D	Public participation and information disclosure will be actively promoted about the project, so that understanding and cooperation of residents will be sought. (Stakeholder meetings were held twice in February and March, 2011.) WWTP site is bordered by a park to the south and by storm water reservoirs to the north and west (refer to Figures 6.2.5 and 6.2.6).
	5	Existing social infrastructures and services	B	Construction Stage 1) During construction of interceptors, closing of roads (one side traffic), or use of detour may be necessary resulting in traffic congestion and inconvenience of access to public facilities 2) Traffic congestion may occur due to carrying in and out of construction materials and wastes (refer to Photo 6.2.1).
	6	Vulnerable social groups such ad poor and indigenous peoples	D	Little possibility of benefit or negative influence to specific communities or residents.
	7	Equality of benefits and losses and equality in the development process	D	Implementation of the project does not harm equality of benefits as the same as the above. Most important effect of the project is improvement of water quality in klongs. This will bring benefits to all the residents whose living environment includes the klong.
	8	Local conflicts of interest	D	None
	9	Cultural heritage	D	None
	10	Water right, fishery right and right of common	D	This project does not affect water right such as water intake, fishery right and right of common. Discharge of treated effluent improves water quality in klong, never worsen it.
	11	Health and sanitation	B D	Construction Stage Negative impacts due to generation of the particulates and noise by vehicles at construction stage are envisaged, which will affect health and sanitation of residents living near access road. Operation Stage Improvement of water quality in klongs by intercepting wastewater discharge is expected. There is no elements to worsen health and sanitation.

Environmental Elements			Grade	Reason
	12	Infectious diseases such as HIV/AIDS	C	Construction Stage Possibility of occurrence of infectious diseases such as HIV/AIDS due to lodging of construction workers and contact to women is envisaged. However, it is difficult to assess the impacts at present. (At present employment of foreign workers is not considered.)
	13	Hazards and security risks	C	Construction Stage Possibility of deterioration of security due to occurrence of crimes caused by lodging of construction workers is envisaged. However, the actual impacts are not clear as the above.
	14	Accidents (Traffic accidents etc.)	B	Construction Stage Possibility of traffic accidents will increase as traffic of vehicles will increase due to construction. Special attention should be paid if schools and hospitals are located along interceptor routes. However, it is not clear at present.
Natural Environment	15	Topography and geology	D	The project is not a large scale development which changes topography and geology.
	16	Soil erosion	D	The project is not a development which accompanies with large scale land reclamation and earth and sand mining.
	17	Groundwater	D	No impacts are envisaged since groundwater extraction or injection to the groundwater is not planned.
	18	Flow and hydrological features	D C	Water intake from river or klong is not planned. Operation Stage Flood should be prevented considering flow capacity of the since treated effluent is discharged to the klong. Receiving water body is Klong Nong Bon. In addition to this klong Nong Bon storm water reservoir and deep tunnel are considered to be alternative receiving water bodies. Therefore, enough consideration was taken. (refer to Sections 2.1.3 and 4.4.3)
	19	Situation of estuary	D	The project area is inland area and there is no estuary.
	20	Biota and ecosystems	D	The project area is located next to a park, and is controlled area. There is no biota to be conserved. Noise caused by construction work will temporally influence birds coming to reservoir. None of water plants nor marsh plants exist in the reservoir. There is no feeding area of birds in the large reservoir (refer to Photo 6.2.2). There are unused areas and klongs with vegetation in surrounding areas of the WWTP. Impacts to ecosystems at both construction and operation stages are considered to be negligible.
	21	Landscape	D	Configuration and scale of WWTP do not cause adverse impact to landscape. There are several buildings nearby, and height of the WWTP is almost same as those of these buildings. Structure of WWTP does not exceed the height of surrounding buildings.
	22	Local climate	D	The project is not a large scale development which affects local climate. WWTP will be designed not to affect the capacity of storm water reservoir.
	23	Global warming	D	Generation of green house gases such as CO_2 due to electricity consumption at WWTP is considered to be negligible. Reduction of methane gas which is emitted from klongs can be expected because of wastewater treatment.

Environmental Elements			Grade	Reason
Pollution	24	Air pollution	B D	<u>Construction Stage</u> Emission of particulates is envisaged from construction machines and vehicles during construction although its duration is short. <u>Operation Stage</u> Emission of exhausted gas is envisaged during power failure, but duration is very limited.
	25	Water pollution	C	<u>Operation Stage</u> Significant positive impact, i.e. improvement of water quality in klongs is expected by reducing pollutant loads by wastewater treatment. There is no negative impact on water environment. However, in some small klongs flow will be reduced to almost zero because wastewater is intercepted. Effect of intercepting wastewater does not result in improvement of water quality. In dry season, original flow in the klong become minimal, and water pollution and emission of offensive odor may occur due to small portion of wastewater which can not be intercepted. Water pollution due to CSO in rainy weather is considered not to be sever because of dilution by storm water
	26	Soil pollution	C	<u>Operation Stage</u> Sludge generated at WWTP is planned to be utilize after composting as manure or soil conditioner. Monitoring of wastewater should be conducted properly since wastewater may contain heavy metals. Selection of reuse purpose, e.g. reuse for agricultural purposes as compost and reuse for greenery should be determined based on the results of the monitoring.
	27	Pollution of bottom layer	D	Possibility of pollution of bottom layer by treated effluent is considered to be very low. (Items related to the bottom layer will be added to monitoring plan for klongs, if necessary.)
	28	Waste	D	Primary sludge from primary sedimentation tank and excess sludge from activated sludge are generated at wastewater treatment processes. All sludge is planned to be composted for this project. Therefore, waste is not generated from sludge. Monitoring of heavy metals and hazardous materials in wastewater and sludge should be conducted as mentioned in “soil pollution”.
	29	Noise and vibration	B D	<u>Construction Stage</u> Generation of noise and vibration from construction machinery and vehicles is envisaged. <u>Operation Stage</u> All of the sources of noise and vibration at operation stage is designed to be housed in buildings, and there is no effect outside of WWTP.
	30	Ground subsidence	D	Pumping of groundwater is not planned for this project. Thus, there is no possibility of ground subsidence
	31	Offensive odor	B	<u>Operation Stage</u> Sources of offensive odor are sludge treatment facility and aeration tank although odor level from it is low. Countermeasures for odor are necessary.

Note: Grade is classified as follows

A: Significant effect is envisaged.

B: Some impact is envisaged.

C: Impact is not quite sure (examination is necessary).

D: No impact is envisaged.

Source: JST

Results of scoping are described below.

There is no “A” (significant impact) impact.
There are several “B” (some impact) impacts, 5 at construction stage and 1 at operation stage. There are 5 “C” impacts which are not quite sure at present, viz. infectious diseases due to lodging of construction workers, security risks, water pollution in small klongs, and soil pollution due to reuse of sludge.

Source: JST

Figure 6.2.5 Site for Construction of WWTP and Surroundings (1)

Source: JST

Figure 6.2.6 Site for Construction of WWTP and Surroundings (2)

Photo 6.2.1 Access Road to Nong Bon WWTP

Photo 6.2.2 Storm Water Reservoir

(3) Consideration of Mitigation Measures

Mitigation measures against adverse effects of the project during construction stage and operation stage are shown in Table 6.2.16 and Table 6.2.17 respectively.

Table 6.2.16 Mitigation Measures during Construction Stage of the Project Facilities

Item	Effects	Measures
<Existing social infrastructures and social services>	・Obstruction to traffic during construction of interceptors and obstruction to access to public institutions ・Possible adverse effects such as air pollution (particulates), noise and vibration due to transportation of construction materials and wastes	• Publication of construction contents and its schedule • Agreement and observation regarding construction contents, operation and working hours of vehicles for transportation of materials • Arrangement of staff for traffic control • Attentive operation and speed restrictions of construction vehicles • Instructions to drivers operators and workers about traffic manners by contractor • Water sprinkling at roads to prevent dust

Item	Effects	Measures
		• Provision of cover on the bed of lorry to prevent scattering • Arrangement of information desk and deployment of a responsible person to receive complaints from residents living in the neighborhood of construction site (quick response to complaints)
＜Health and hygiene＞	Same as above, air pollution and noise to the residents living in the neighborhood of the construction site	Same as above
<Accidents (traffic accidents)>	・Risks of occurrence of traffic accident increase due to increase of traffic of vehicles related to construction ・Reduction of road width due to construction of interceptors, particular attention should be paid for vulnerable institutions such as schools and hospitals	Same as above
＜Air pollution ＞	・Generation of particulates due to transportation of materials and construction activities ・Exhausted gases from construction vehicles and machines	• Attentive operation of construction vehicles and machined, and speed restrictions • Preventive maintenance of construction vehicles and machines • Positive use of construction machines with countermeasures against exhausted gases • Arrangement of an information desk and deployment of a responsible person to receive complaints from residents, and monitoring of number and contents of complaints
<Noise and vibration>	Noise and vibration due to construction vehicles and machines	• Attentive operation of construction vehicles and machined, and speed restrictions • Preventive maintenance of construction vehicles and machines • Positive use of low noise and low vibration construction machines • Arrangement of an information desk and deployment of a responsible person to receive complaints from residents, and monitoring of number and contents of complaints • Monitoring of noise and vibration based on information given by the residents
＜Infectious diseases , such as HIV/AIDS＞	Possibility of occurrence of infectious diseases by persons relating to construction	• Education and enhancement of awareness to persons relating to construction (employee) by construction management company

Item	Effects	Measures
＜Hazard (Risk)＞	Industrial accidents due to construction work Possibility of deterioration in terms of safety such as climes caused by persons relating to construction	• Safety education to persons relating to construction, and provision of safety measures • Observation of laws relating to labor environment • Education to persons relating to construction (employee) by construction management company

Source: JST

Table 6.2.17 Mitigation Measures during Operation Stage

Item	Effects	Measures
<Flow status, hydrological characteristics>	Effect on flow capacity of receiving klong	• Monitoring of water level in klong
<Water pollution>	Deterioration of water quality due to decrease of flow in dry season	• Improvement of water quality by introduction of purification water or treated effluent from WWTP.* • Monitoring of water quality in nearby klong
<Soil contamination>	Soil contamination by reuse of sewage sludge	• Monitoring of hazardous components of sludge Results of investigation indicated that some parameters exceeded permissible limits (Japanese standards).* *Monitoring of sludge should be carried out and careful attention should be paid to the site of reuse (limit to green and park).
<Noise and vibration.>	Effect due to operation of WWTP (source of noise)	• Blowers and pumps should be installed in buildings. Monitoring of noise • Proper countermeasures should be provided at detailed design to protect operators. As a result, noise can be reduced at boundary of the site.
<Offensive odor>	Effect due to operation of WWTP (source of offensive odor)	• Sludge treatment and transfer facilities should be confined in buildings, and deodorization should be provided. • Monitoring of odor • Countermeasures for odor to be considered at detailed design include those in the area for transporting vehicles. Tightly close up vehicles should be selected.

Note: * Introduction of purification waster of treated effluent should be carried out by utilizing the existing gates at Klong Phra Kanong and existing pumping station on Klongs Ta Cham and Kwang to enhance improvement of water quality. In particular, introduction of purification water or treated effluent through pumping station on Klong Kwang is necessary for Klong Klet of which flow is wastewater in dry season.

** Master Plan on Sewage Sludge Treatment and Reclaimed Wastewater, 1999, JICA

Source: JST

(4) Environmental Management Plan

The following risks should be noticed at operation stage.

Table 6.2.18 Risks at Operation Stage

Risk items	Remarks and mitigation measures
Power failure	Provision of emergency generator
Failure of mechanical and electrical equipment	Provision of stand-by spare parts and preparation of a manual for emergency. Training of staff for operation and maintenance
Leakage of calcium hypochlorite	Preparation of a manual for emergency Provision of protective cloths, grabs, masks and glasses Technical training of staff
Inflow of hazardous materials	Monitoring of hazardous material in wastewater

Source: JST

(5) Monitoring Program

Monitoring program is categorized under construction stage and operation stage. For preparing the monitoring program, it is considered that during construction stage influence will be short duration and therefore it is important to have measurement result immediately rather than caring for the level of accuracy and accordingly measurement methods should be selected. However, in the operation stage it is required to evaluate the level of influence and make any judgment based on environmental standards. Therefore, measuring method is selected considering sufficiency in terms of accuracy and its simplicity in use. In case when new influence is expected in future, the measuring method should be improved based on the need of new impacts and desired accuracy or measured parameters. Monitoring programs for construction and operation stages are described below.

Table 6.2.19 Monitoring Program at Construction Stage

Subject	Monitoring place	Item	Frequency	Responsible agency	Evaluation standards
Complaints and demands from residents	− Access road and neighborhood of construction site	Contents of demands and complaints and their numbers	Arrangement of an information desk and response at any time during construction	DDS	Correspond to individual demand or complaint
Noise	− Access road − WWTP − Interceptors	Noise (monitoring by simple monitoring device)	At any times during construction More frequent monitoring when complaints and demands are many	DDS	Maximum noise level = 115dB *1 Equivalent sound level =70dB *1

Subject	Monitoring place	Item	Frequency	Responsible agency	Evaluation standards
Particulates	– Access road and neighborhood of construction site	Total Suspended Particulates (TSP)	Monitoring of particulates at any time in addition to providing countermeasures such as water sprinkling	DDS	TPS 0.33 mg/m^3 (Environmental standards)*2
Air quality	– Access road – WWTP	CO, Ozone, SO_2, NO_2, , TSP, PM10、PM2.5	Monitoring of air quality in addition to countermeasures such as speed restriction and preventive maintenance when many complaints and demands are received or air pollution is thought to exceed environmental standards	DDS	Environmental standards*2

*1: Notification of Environmental Board No. 15 B.E.2540 (1997) under the Conservation and Enhancement of National Environmental Quality Act B.E.2535(1992)

*2: Notification of Environmental Board No. 10 B.E.2538 (1995) under the Conservation and Enhancement of National Environmental Quality Act B.E.2535(1992)

Source: JST

Table 6.2.20 Monitoring Program at Operation Stage

Subject	Monitoring place	Monitoring parameters	Monitoring frequency	Responsible agency	Evaluation standards
Water pollution	Surrounding klongs	Water temperature, pH, Color, BOD(COD), DO, SS, Nitrogen, Phosphorus, E-coli Water level in klong	Monthly At any time (wet weather)	DDS	BMA Plans (refer to Table 3.2.5 in Volume 1 Conceptual Master Plan)
Water pollution	Wastewater inflow Wastewater inflow (by interceptor routes)	pH, BOD, SS, Oil and grease, T-P, T-N, NH_4-N As, Cd, Hg, Ni, Cr, Pb	Monthly (daily if required for operation and maintenance) 4 times a year	DDS	None
Water pollution	Treated effluent	pH, BOD, SS, Oil and grease, T-P, T-N, NH_4-N, DO	Monthly (daily if required for operation and maintenance)	DDS	BMA Discharge Standards (refer to Table 3.2.2 in Volume 1 Conceptual Master Plan)
Noise	Boundary of WWTP site	Level of noise	4 times a year (night time)	DDS	Maximum noise level = 115dB Equivalent sound level = 70dB *1

Subject	Monitoring place	Monitoring parameters	Monitoring frequency	Responsible agency	Evaluation standards
Odor	Boundary of WWTP site	Concentration of odor	4 times a year	DDS	Concentration of odor less than 15 (Boundary of factory site located in non-industrial area)*2
Sewage sludge	Sludge treatment facilities	As, Cd, Hg, Ni, Cr, Pb, and other health parameters	4 times a year	DDS	As: 0.005 Cd: 0.0005 Hg: 0.0002 Ni: 0.03 Cr: 0.05 Pb: 0.01 unit: mg/dry-g *3

*1: Notification of Environmental Board No. 15 B.E.2540 (1997) under the Conservation and Enhancement of National Environmental Quality Act B.E.2535(1992)

*2: Ministerial Regulation, Prescribing the Industrial Air Odor Test Standard and Process B.E. 2548, Ministry of Industry

*3: Permissible contents for fertilizer made from sewage sludge, Ministry of Agriculture and Fishery, Japan, October 2000

Source: JST

(6) Conclusions

Environmental items which require particular attention, in other words items which may cause significant impacts or which can not be recovered easily are following five items. It is judged that there is no adverse effects on these items due to the implementation of the project.

Table 6.2.21 Environmental Items Which Require Particular Attention

Environmental items	Adverse effects
Involuntary resettlement of residents	Construction site of WWTP is DDS's property, acquisition of new land is unnecessary. Involuntary resettlement of residents does not occur.
Local economy such as employment and livelihood etc.	There is no loss of livelihood nor loss of property due to construction and operation of the project.
Occurrence of secondary contamination (environmental contamination caused by heavy metals and hazardous materials contained in wastewater)	Contamination by heavy metals or hazardous materials is not recognized in klongs in the project area. However, monitoring of wastewater and sludge should be carried out to ascertain these heavy metals and hazardous materials are not discharged.
Disappearance of and damage to cultural properties and heritage	There is no structures relating to cultural properties and heritage at the construction site for WWTP
Effect of natural reservation areas	There is no natural reservation areas in the project area. Nearest internationally designated area is located at a distance of 30 km.

Source: JST

In conclusion, it is judged that there is no significant adverse effect due to the implementation of the project. However, some environmental items (minor adverse effects) require attention at both construction stage and operation stage. Mitigation measures and monitoring of these

environmental items are required. On the other hand, it is expected that implementation of the project will contribute to improvement of water environment and prevention of water pollution in klongs by collecting and treating of wastewater in Nong Bon treatment area.

Results of confirmation of environmental and social considerations with environmental check list are shown in 6.2.22.

Table 6.2.22 Results of Confirmation of Environmental and Social Considerations according to Check List

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) N (c) N (d) N	(a, b, c) According to environment act of Thailand, this project is out of list of projects which require EIA report. Therefore, EIA report for the project will not be prepared. However initial environmental impact assessment will be done based on JICA Guidelines for Environmental and Social Considerations (d) None
	(2) Explanation to the Public	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design	(a) Y (b) Y	(a) Stakeholder meetings were held twice to explain outlines of the project and mitigation measures and stakeholders' understanding was obtained. (b) All of the comments from the stakeholders are reflected.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) Alternatives regarding treatment efficiency, ease of O&M, flexibility to inflow rate and pollution load, limitation of land, restriction of height of structures, and economic aspect were studied.
2 Pollution Control	(1) Water Quality	(a) Do pollutants, such as SS, BOD, COD, pH contained in treated effluent from a sewage treatment plant comply with the country's effluent standards? (b) Does untreated water contain heavy metals?	(a) Y (b) N	(a) BMA stipulated discharge standards for treated effluent. WWTP under the project has been designed to satisfy the standards (refer to Table 3.2.2 in Volume 1 Conceptual Master Plan) (b) Basically, heavy metals are not contained. However, monitoring of heavy metals is planned as a preventive measure for the project.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations
	(2) Wastes	(a) Are sludge generated by the facility operations properly treated and disposed of in accordance with the country's standards?	(a) Y	(a) Sludge generated from the WWTP will be transferred to the existing composting plant adjacent to Nong Khaem WWTP, and composed and reused for greenery.
	(3) Soil Contamination	(a) If wastes, such as sludge are suspected to contain heavy metals, are adequate measures taken to prevent contamination of soil and groundwater by leachates from the wastes?	(a) Y	(a) Composted sludge is used for greenery (not for crops). Monitoring of heavy metals is planned as a preventive measure for the project.
	(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as sludge treatment facilities and pumping stations comply with the country's standards?	(a) Y	(a) Sources of noise such as blowers and pumps are installed in buildings to reduce noise level sufficiently at boundary of the site.
	(5) Odor	(a) Are adequate control measures taken for odor sources, such as sludge treatment facilities?	(a) Y	(a) Sludge treatment facilities are confined in a building, and air from the building are released after deodorization.
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	(a) Site for construction of WWTP and effluent discharging point are not located in protected area. Also there is no protected area in the project area and no effect is envisaged.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	(a) N (b) N (c) N (d) N	(a) There is no primeval forests, tropical rain forests, ecologically valuable habitats in the construction site for WWTP and near effluent discharging point. No effect is envisaged. (b) The nearest protected site by laws or international treaties is located at a distance of 30 km from the project area. (c) No significant ecological impacts are anticipated. (d) No effect on aquatic environments, such as rivers. Current conditions such as water environment, in particular reduced flow, decrease of DO, emission of offensive odor in dry season will be improved by the implementation of the project.
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs,	(a) N (b) N (c) N (d) N (e) N (f) N (g) N (h) N (i) N (j) N	(a, b, c, d, e, f, g, h, i) Involuntary resettlement is not caused by implementation of the project.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations
		restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensations going to be paid prior to the resettlement? (e) Is the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?		
	(2) Living and Livelihood	(a) Is there a possibility that changes in land uses and water uses due to the project will adversely affect the living conditions of inhabitants? (b) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	(a) N (b) N	(a) Effects on land uses and water uses due to the project are minimal. Reduction of water surface by construction of interceptors along walls of klongs are limited and effect on main stream of klong which is used for boats for public transportation and cargo. Also interceptors are installed under roads, possibility of light impacts on traffic is anticipated in this case. After construction, there is no impact on road traffic. (b) No effect is anticipated on living conditions of inhabitants.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) There is no possibility that the project will damage the archeological, historical, cultural, and religious heritage.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) Construction site for WWTP is located in the site of storm water reservoir, and consideration for landscape is unnecessary. Two buildings exist next to the site and DDS's administration building is currently under construction. The same restriction about height of the structure is applied for

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations
				WWTP under the project, and its height does not exceed the limit.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to lands and resources respected?	(a) N (b) N	(a, b) The project area lies between the central part of Bangkok and Bangkok international airport and is dominantly residential area with some commercial areas along the main roads. Urbanization has been progressed and no areas for ethnic minorities and indigenous peoples.
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) Y (b) Y (c) Y (d) Y	(a, b, c, d) DDS has constructed seven (7) WWTPs in BMA, and there were no problems associated with working conditions, safety and health in relation with construction. It is judged that sufficient attentions were paid. From these facts, it is judged that selection of an excellent contractor(s) is not difficult and proper instructions by DDS to the contractor(s) is quite possible.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) Y (b) N (c) Y (d) Y	(a) Impacts expected during construction are noise and vibration, and dust. Mitigation measures for these impacts are to be considered. Small amount of turbid water will be generated. Treatment of turbid water by chemicals is to be done and treated water is to be discharged to the reservoir. Excessive amount of excavated earth will be generated. This earth can be used in the surrounding areas. (b) There is no effect to the ecosystem by construction activities. Construction site is in the site of reservoir which is managed artificially. Storm water reservoirs have enough space to avoid influence from construction. (c) Impacts such as noise and vibration and dust on the access road from the main road to site are anticipated. Mitigation measures for these

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations
		(d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?		impacts are to be considered. (d) Impacts on traffic is anticipated during construction of interceptors. Mitigation measures for these impacts are to be considered.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) Y (c) Y (d) Y	(a) Monitoring plans on both construction stage and operation stage have been prepared. Monitoring is to be conducted based on these plans. (b) Essential monitoring parameters for items and their frequencies of monitoring are to be determined. (c) Monitoring framework is to be established by DDS. DDS who is the proponent has already established monitoring framework for the seven existing WWTPs and is expected to be able do the same for Nong Bon WWTP. (d) Periodical water quality monitoring currently undertaken and its results are reported to PCD.
6 Note	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) Improvement effects regarding global warming are considered. There is no impacts to transboundary waste treatment, acid rain, and destruction of the ozone layer. i) Reuse of waste (sewage sludge) is planned and no transboundary treatment is anticipated. ii) There is no facilities which emit NO_2 gas causing acid rain. iii) Any chemical compounds which cause destruction of ozone layer will not be handled.

1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience)
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which the project is located.

Source: JST

6.3 Public Awareness Survey

6.3.1 Outline of the Survey

Public awareness survey was conducted to grasp awareness of residents living in the priority project area regarding sewerage system, water environment of klongs and health facilities. The survey was conducted as interview survey (interview to individual residents with questionnaire prepared beforehand). Local consultants were assigned to carry out interviews which were conducted during November and December, 2010. Main contents of the questionnaire are as follows.

i) Status of water supply and electricity supply in household
ii) Status of wastewater facilities in household
iii) Peoples awareness of sewerage system and water environment of klong
iv) Willingness to pay for sewerage services

The main interviewees are residents (350 samples), and additional interviews were conducted for non-residential entities (hotels, hospitals, fruits and vegetable markets, schools and factories, total 50 samples) with similar questionnaire.

6.3.2 Results of Survey

Results of the survey for residents and non-resident entities are as follows.

(1) Residents

Awareness of sewerage system

Approximately half of the interviewees answered that they know sewerage system at the beginning of the interview. This means that a half of the residents do not have good chance to access to the information on sewerage system.

Background of households

An average number of a household is 4.9 persons/household, average income per household is 34,300 Baht/household/month, and an average income per person is 8,700 Baht/person /month. Question about occupation of the residents revealed that persons engaged in agriculture accounts for as low as 1 %. All households have water and electricity supply services. Average tariff rates for water supply and electricity supply are 489 Baht/household and 1,965 Baht/household. An average rates for solid wastes is 29 Baht/household. Ratios of these rates to income are 1.4 % for water supply, 5.7 % for electricity, and 0.1 % for solid wastes.

Wastewater treatment facilities

Most of the households (94 % of all households) are equipped with human excreta treatment facilities, such as septic tanks with seepage (59 %), septic tanks with discharge to klong (32 %), and septic tanks with aeration tank (9 %). Households which answered that they have no treatment facility may have seepage tanks (cesspools).

Removal of sludge from septic tanks is carried out more than once a year (32 %), or once in 2 to 3 years (20 %). However, households which have never removed sludge for more than 3 years accounts for 48 %. Removal of sludge is carried out by specialized company. Charge for removal is approximately 350 Baht/time.

Oil separator is the only one treatment method of sullage water (wastewater from kitchen, laundry, shower etc.), and households which have oil separator accounts for only 3 %. Almost all sullage water is discharged without any treatment to klongs.

Water environment of klongs

Answers to the question about water environment of klongs are as follows.

- "No problem" answers to question about odor from klongs account for 54 %. "Smell occasionally" accounts for 32 %, "Offensive odor" accounts for 14 %.
- Evaluation of color of water widely varied depending on individual standards. "Black or dark gray" answers account for more than half. "Green" accounts for 20 %, and "Greenish" accounts for 22 %, both of the colors may be influenced by algae bloom.
- Answers that mentioned about floating garbage account for approximately 20 %.

To the question about source of pollution, most of them answered that main source of pollution is domestic wastewater, followed by industrial wastewater and commercial wastewater. Dominant source of pollution is actually domestic wastewater. This fact indicates that residents are understanding the source of pollution correctly.

It is expected in the project area that treated effluent is reused. To the question about purposes of reuse, the largest number selected sprinkling to roads and greenery (37 %), followed by individual use of sprinkling to garden and car washing (33 %). Although these answers were made based on the assumption that enough safety and good water quality are secured, this indicated that residents do not have strong distaste for treated wastewater. However, it should be noted that refusal accounts for 5 %. Careful attention should be paid for subconsciousness and emotion of residents to enhance reuse of treated effluent.

Willingness to pay

A question was prepared to know residents' willingness to pay for sewerage services. Sewerage tariff is indispensable for sustainability of sewerage system to improve water quality in klongs. As a result, 78 % of the residents answered their willingness to pay. An average of tariff rate is 73 Baht/household/month was obtained.

(2) Non-resident Entities

Additional survey was conducted for limited number of non-resident entities. Category and number of samples of the survey is shown in Table 6.3.1.

Table 6.3.1 Category and Number of Samples

Category	Number of Samples
Hotel	3
Hospital	2
Department store	2
Fruit and vegetable market	3
Temple, mosque	12
School	25
Factory	3
Total	50

Source: JST

All of the above mentioned entities are provided with human excreta treatment facilities. In particular, hotels and hospitals have treatment facilities with activated sludge process, two factories have aerated lagoons, and another factory has treatment facility with coagulation and settling process.

Positive answers were obtained from the above entities except for department store. The answers for their willingness to pay is summarized as shown in Table 6.3.2.

Table 6.3.2 Willingness to Pay for Sewerage Services by Non-Resident Entities

Category	Willingness to pay for sewerage services	
	Monthly Rate (Baht/month)	Per volume of water (Baht/month)
Hotel	1,000	0.25
Hospital (national)	10,000	
Hospital (private)	600	
Department store	5,000	2.0
Fruit and vegetable market	1,650	
Temple, mosque	320	
School	227	
Factory	10,000	1.5

Source: JST

6.3.3 Summary of the Survey

The facts revealed from the residents awareness survey are summarized below.

- Role of the sewerage system is not sufficiently understood by residents in the Nong Bon project area. Opportunities to access to information about sewerage system (its role and effects) should be provided through mass media and schools.
- Water environment in klongs (odor, color of water, and garbage) is sufficiently recognized by the residents. Demand for improvement of water environment is thought to be strong.
- It is highly evaluated that residents recognize that main source of pollution is domestic wastewater. However, it should be noticed that pollutant load generated from sullage is larger than that generated from human excreta. Thus the fact that sewerage system is required to reduce pollutant load generated from sullage should be understood by residents.
- Residents' distaste for reuse of treated wastewater is thought not to be strong. However information about actual cases of reuse is not provided to the residents. Information about methods of reuse and effects due to effluent reuse should be provided as soon as possible to obtain their consent.
- Information on willingness to pay for sewerage service was obtained although its rate is not so high (73 Baht/household/month). This figure is approximately 1/7 water charge. It is necessary to enhance residents' awareness, and to increase willingness to pay by providing information on sewerage system (role and effects).

6.4 Stakeholder Meeting

Stakeholder meetings regarding Nong Bon Wastewater Treatment Project were held on 17th February, and 29th March, 2011. Aims of the meetings are to explain to the stakeholders including representatives of the communities about outlines of the project, environmental adverse impacts due to the implementation of the project, and mitigation measures for these impacts, and to hear comments from them to reflect these comments in implementation of the project. Simultaneously, it is also important to enhance residents' understanding about the project and to seek cooperation from them. Contents of the meeting are summarized below.

6.4.1 First Stakeholder Meeting

The first stakeholder meeting was held at conference room of the district office with a total of 113 participants including 56 community representatives, 12 proprietors, and other stakeholders. DDS which is the sponsor of the meeting explained Nong Bon Wastewater Treatment Project followed by questions and answers session. Opinions and comments from stakeholders are summarized below.

Questions

- Benefits for residents from the project
- Impacts due to construction of interceptors in klongs
- Implementation schedule
- Introduction of wastewater tariff
- Reuse of treated wastewater
- Activities by residents to conserve water environment in klongs
-

Requests and suggestions

- Wastewater is discharged directly or illegally to klong in some of new residential areas, and appropriate measures should be taken
- Pay attention to utilize information possessed residents
- Proposal to select two representatives from each community for committee for conservation of water environment in klongs

Site visit to Din Daeng WWTP was held by the request from residents. Participants were reported to deepen their understandings for role and effects of WWTP and environmental measures.

6.4.2 Second Stakeholder Meeting

The second stakeholder meeting was held at conference room of the Dusit Princess Hotel in Prawet District with a total of 118 participants. DDS explained Nong Bon Wastewater Treatment Project, including facilities planning, environmental and social considerations (adverse impacts due to implementation of the projects and mitigation measures). Questions and answers session followed. Opinions and comments from stakeholders are summarized below.

Questions

- Possibility of treatment of storm water by sewerage system
- Project implementation schedule
- Rate of wastewater tariff

Requests and suggestions

- Enhancement of public awareness regarding water saving and illegal discharge
- Past experience of improvement of water quality in klong by residents. Welcome to involvement of public sector in improvement of water quality. Necessity of residents participation
- Avoidance of traffic jam and provision of mitigation measures in construction of interceptors in Srinakarin road
- Different rates of wastewater tariff for domestic and business users
- Improvement of flooding in flood prone areas
- Sewerage system development in entire BMA, improvement of water quality in klongs (Klong Saen Saep in particular), and strengthening of countermeasures against flooding

6.4.3 Conclusion

No opposition opinion against wastewater project was presented at both meetings. Residents' understanding about role and effects of sewerage system was obtained through site visit to Din Daeng WWTP. It became clear that every participant wishes early implementation of wastewater project.

However, DDS made promises at the meetings to pay sufficient attention for traffic disturbances and transportation and fishery in klongs in construction of interceptors at detailed design stage. In detailed design of interceptors, location of vertical shafts should be determined with close consultation with residents and authorities concerned.

Questions regarding wastewater tariff were expressed. DDS should provide information about role and effects of sewerage system and strive to enhance understanding of residents for "appropriate cost for wastewater services".

7. ECONOMIC AND FINANCIAL ANALYSIS

7.1 Present Financial Condition of BMA

In this Section, the financial and budgetary conditions of whole BMA and the DDS which manages the wastewater treatment service, are evaluated.

7.1.1 Financial Condition of BMA

The Balance Sheet (B/S) and Profit and Loss Statement (P/L) of BMA in the year 2006 – 2008 is shown below. The accounting is managed based on the fiscal period of Thailand which starts in October and terminates in September (fiscal year of 2010 means from the beginning of October, 2009 to the end of September, 2010).

Basically, the cooperate accounting system is not applied for the accounting of BMA, and the budgetary control of each fiscal year is only conducted. The indicated financial statements is created as the public information disclosure. The latest financial statements after the year 2009 is not available as they have not been approved by Office of the Auditor General of Thailand at this moment.

Table 7.1.1 Trend of Balance Sheet and Financial Indicators of BMA (2006-2008)

(Baht)

	2006	2007	2008
Assets			
Current Assets			
Cash and cash equivalents	39,874,864,585	45,181,212,030	42,542,457,253
Current debts and Account Receivable from net Foreign Exchange	473,521,901	78,689,166	40,524,747
Account Receivable - from net non-foreign exchange	262,515,368	225,325,630	330,781,144
Other Current Assets	9,748,705	1,579,706,018	40,498,860
Total Current Assets	**40,620,650,559**	**47,064,932,843**	**42,954,262,003**
Fixed Assets			
Long Term Investment	545,237,000	545,237,000	545,237,000
Property, plant and equipment - net	30,827,183,376	32,334,507,281	34,643,724,827
Other Infrastructure - net	15,289,783,570	18,107,640,406	22,178,018,401
Intangible assets - net	59,776,541	100,039,880	110,234,029
Work under process	13,082,584,334	15,534,122,003	19,731,995,354
Total Non-Current Assets	**59,804,564,821**	**66,621,546,570**	**77,209,209,611**
Total Assets	**100,425,215,379**	**113,686,479,413**	**120,163,471,614**
Liabilities			
Current liabilities			
Account Payable	669,162,545	254,757,513	370,590,182
Accurued Liabilities	141,688,596	215,550,739	58,573,576
Advanced Revenue	18,940,701	12,511,948	14,128,701
Suspend Revenue	-	1,967,865,507	626,283,066
Accrual remittance to the Ministry of Finance	751,028	2,509,978	5,221,348
Deposits - Short term	2,486,366,072	1,346,539,201	995,646,141
Total Current Liabilities	**3,316,908,941**	**3,799,734,887**	**2,070,443,015**
Fixed Liabilities			
Loans - Long term			599,306,149
Deposits - Long term	368,516,520	521,711,055	547,929,954
Receivable Revenue	3,734,991,092	4,473,041,570	6,039,388,611
Total Non-Current Liabilities	4,103,507,612	4,994,752,625	7,186,624,714
Total Liabilities	**7,420,416,552**	**8,794,487,512**	**9,257,067,729**
Equity			
Capital	38,948,031,472	38,948,676,075	38,979,690,615
Revenues gain/loss than accomulated expenses	18,185,010,601	25,249,623,140	31,675,848,412
Money Retained of BMA	35,871,756,754	40,693,692,686	40,250,864,859
Total Capital	**93,004,798,827**	**104,891,991,901**	**110,906,403,886**
Total Liability + Equity	**100,425,215,379**	**113,686,479,413**	**120,163,471,614**

	2006	2007	2008	Average
Financial Indicators of Stability				
Current Liquidity Ratio	1225%	1239%	2075%	1513%
Capital Adequacy Ratio	93%	92%	92%	92.4%
Fixed Ratio	64%	64%	70%	65.8%
Indebtedness	8.0%	8.4%	8.3%	8.2%

Source: BMA

As evaluating the several financial indicators, such as current liquidity ratio and capital adequacy ratio, these indicators show the eminent figures of financial stability. Its main reason is the amount of total liability (9.3 billion Baht) is quite smaller compared with the total fixed asset (77.2 billion Baht). It indicates that the past infrastructure projects are executed not by borrowing loan, but mainly by the sufficient budget procured from government subsidy or several kinds of tax.

Table 7.1.2 Trend of Profit and Loss Statement and Financial Indicators of BMA (2006-2008)

(Baht)

	2006	2007	2008	Average	
Operating revenues					
BMA Revenues	43,682,516,282	43,659,933,561	45,483,599,386	44,275,349,743	72.94%
BMA Revenues - Extra (accomulated earning)	7,114,700,000	0	4,621,247,890	3,911,982,630	6.44%
Non-Budgetary Fund revenues	971,931,997	1,110,395,217	569,363,885	883,897,033	1.46%
Government subsidy	10,827,790,540	11,843,664,717	12,202,752,079	11,624,735,779	19.15%
Other revenues	0	1,863,382	4,552,142	2,138,508	0.00%
Total operating revenues	62,596,938,819	56,615,856,877	62,881,515,382	60,698,103,693	100.00%
Operating expenses					
Employee expenses	10,665,471,984	11,570,106,577	12,880,759,362	11,705,445,974	25.34%
Operating expenses	15,797,252,011	16,894,115,114	19,831,309,833	17,507,558,986	37.90%
Subsidy expenses	937,172,752	905,391,919	814,107,958	885,557,543	1.92%
Depreciation and amortization expenses	2,586,047,737	3,097,248,171	3,746,922,590	3,143,406,166	6.81%
Other expenses	5,283,712	0	0	1,761,237	0.00%
Gross Loan expenses	1,176,359,236	1,668,941,178	2,555,084,881	1,800,128,432	3.90%
Non-Budgetary Fund expenses	861,906,916	1,047,241,843	484,028,302	797,725,687	1.73%
Government subsidy expenses	8,876,968,868	11,044,139,001	11,119,371,652	10,346,826,507	22.40%
Total operating expenses	40,906,463,216	46,227,183,804	51,431,584,576	46,188,410,532	100.00%
Revenue gain/(Loss) Operating expenses	21,690,475,604	10,388,673,072	11,449,930,805	14,509,693,160	
Difference from Property distribution	-1,173,814	-5,268,092	-4,705,646	-3,715,851	
Revenue gain/(Loss) Activity expenses	21,689,301,789	10,383,404,980	11,445,225,160	14,505,977,310	

	2006	2007	2008	Average
Financial Indicators of Profitability				
Reccuring Net Margin	34.6%	18.3%	18.2%	23.7%
Ordinary balance ratio	153%	122%	122%	133%
ROA (Return on Asset)	21.6%	9.1%	9.5%	13.4%
ROE (Return on Equity)	23.3%	9.9%	10.3%	14.5%

Source: BMA

Total revenue amount of BMA is approximately 60.7 billion Baht, and around 19 % is provided from the government subsidy. The average expenditure becomes 46.2 billion Baht. About the financial indicators of profitability, recurring net margin shows 23.7 %, and both ROA and ROE became more than 10 %. It implies the quite high profitability of BMA.

At present, the accounting of BMA is conducted by balancing income of subsidy and tax, and the expenditure of fixed cost and infrastructure investment cost. During the past period of the metropolitan Bangkok expansion, small amount of loan was borrowed and any kind of revenue has been used to cover the substantial infrastructure (transportation, medicals, education, sewerage service and etc.) investment cost. It is thought that the favorable net margin is obtained mainly because the depreciation cost (6.8 % of all expenditure) is smaller compared with the annual infrastructure investment cost.

From the above evaluation, the financial condition of BMA is high in terms of stability and profitability. Hence, there is less possibility that the financial condition interrupts the project execution.

Government Subsidy for Wastewater Service

There are two types of government subsidies such as specific purpose subsidy and general

purpose subsidy, and the subsidy for wastewater service is categorized to the specific purpose subsidy and is not transferred to spend for other purpose. For wastewater service, the government subsidy is granted to the certain composition of initial investment cost of WWTP and interceptors. As shown in the Table 7.1.8, the subsidy composition rate of each WWTP construction varies from 0% - 100% depending on the project contents and political situation.

7.1.2 Revenue and Expenditure of BMA

Trend of revenue and expenditure of BMA for the latest five years (2007-2011) are shown in the Table 7.1.3. This data is made for BMA'S budget control purpose, and the revenue from subsidy is excluded from the total amount.

The main revenue of BMA is the tax (approximately 94 %), and the other revenues such as fees and service charges account for less than 6 %. The total revenue in the year 2009 decreased significantly affected by the global depression after Lehman's fall, and it recovered in 2010 to achieve the same level of the year 2008. Afterward, BMA predicted the gradual revenue increase in the future.

By present accounting system, the saved money of planned budget and actual expenditure amount is transferred to the revenue of next year, as reported by budget department of BMA and approved by the government. The budget amount by sector is shown in the Table 7.1.4 below.

Table 7.1.3 Trend of Revenue of BMA (by Revenue Category)

(Baht)

Source: BMA

Thai Fiscal Year	2550	2551	2552	2553	2554	Average	Composition
Year	2007	2008	2009	2010	2011		
Item	Closed	Closed	Closed	Closed	Budget		
Annual Revenue of BMA							
1. Tax	40,258,080,841	42,639,532,397	36,032,286,541	42,283,310,000	44,133,000,000	41,069,241,956	93.6%
2. Fees, Permission Charge, Fines and Services	968,463,438	988,537,793	960,549,224	950,480,000	1,150,000,000	1,003,606,091	2.3%
3. Property Management	1,495,457,361	1,304,242,503	681,426,191	302,280,000	323,000,000	821,281,211	1.9%
4. Commercial Infrastructure and etc.	35,202,866	41,805,544	34,870,470	30,650,000	34,000,000	35,305,776	0.1%
5. Miscellenous	643,629,846	496,515,115	793,131,696	2,483,220,000	360,000,000	955,299,331	2.2%
合計	43,400,834,353	45,470,633,352	38,502,264,123	46,049,940,000	46,000,000,000	43,884,734,365	

Table 7.1.4 Trend of Expenditure of BMA (by Sector)

(Baht)

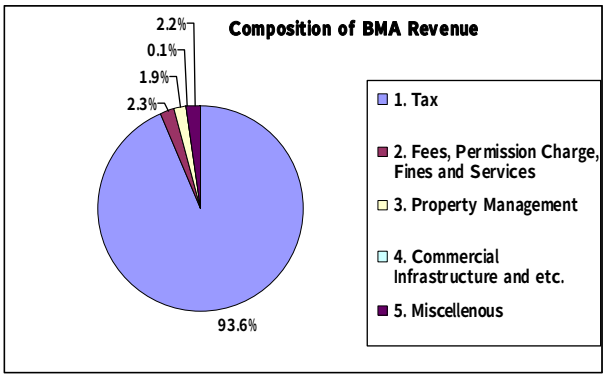
Thai Fiscal Year	2550	2551	2552	2553	2554	Average	Composition
Year	2007	2008	2009	2010	2011		
Item	Budget	Budget	Budget	Budget	Budget		
Annual Expenditure of BMA							
1. General Administration	8,359,262,200	9,738,893,800	9,140,100,500	8,695,308,000	10,343,264,100	9,255,365,720	21.3%
2. Cleansing and Tidiness Management	6,945,997,700	7,063,651,400	7,694,338,800	6,781,565,400	6,528,033,500	7,002,717,360	16.1%
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	7,944,942,940	18.3%
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	4,029,949,300	9.3%
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	5,455,801,000	12.6%
6. Public Health	4,560,127,100	4,877,101,300	5,440,200,900	5,331,121,400	5,710,355,500	5,183,781,240	11.9%
7. Education	4,228,882,500	4,524,184,400	4,929,647,300	4,184,700,500	4,769,797,500	4,527,442,440	10.4%
合計	39,000,000,000	45,000,000,000	46,000,000,000	41,000,000,000	46,000,000,000	43,400,000,000	

Note: The column of “Drainage and Wastewater Management” includes the budget of DDS and the other drainage and wastewater management cost in local government offices

Planned budget amount is used for all year.

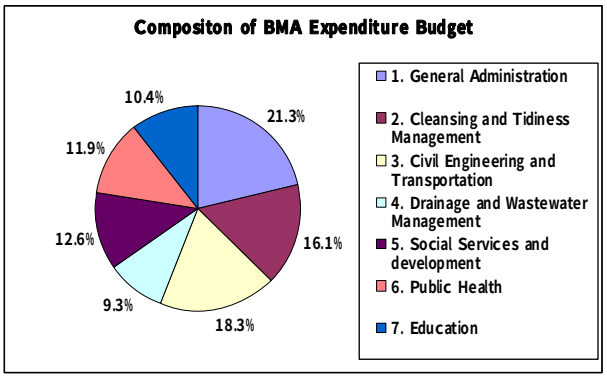
Source: BMA

The wastewater sector expenditure accounts for about 9% of whole BMA budget in the last five years. In descending order, the BMA budget is composed of categories of general administration, transportation, cleaning, social service, public health, education and wastewater service. As a whole, the wastewater service budget composes the smallest part of the BMA budget.



Source : BMA

Figure 7.1.1 Composition of BMA Revenue



Source: BMA

Figure 7.1.2 Composition of BMA Budget

7.1.3 Budget and Operating Condition of Wastewater Service (DDS)

(1) Trend of Revenue and Budget of DDS

Trend of revenue and budget of DDS, which manages the wastewater service, for the last five years (2007-2011) are shown in the Tables 7.1.5 and 7.1.6.

Table 7.1.5 Trend of DDS Budget (by sector, 2007-2011)

(Baht)

Thai Fiscal Year	2550	2551	2552	2553	2554	Average	Composition
Year	2007	2008	2009	2010	2011		
Annual Budget of DDS							
1. General Administration	27,714,400	41,286,200	41,241,600	71,209,300	62,731,200	48,836,540	1.5%
2. Drainage System Development	1,351,714,200	517,832,800	675,557,400	374,933,100	416,328,500	667,273,200	20.1%
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	1,811,370,440	54.7%
4. Water Quality Management	706,220,300	354,428,300	977,039,300	1,214,282,700	673,887,600	785,171,640	23.7%
Total	3,581,221,600	2,597,683,600	3,613,741,900	3,580,661,000	3,189,951,000	3,312,651,820	100.0%

Note: Planned budget amount is used for all year
Source: BMA

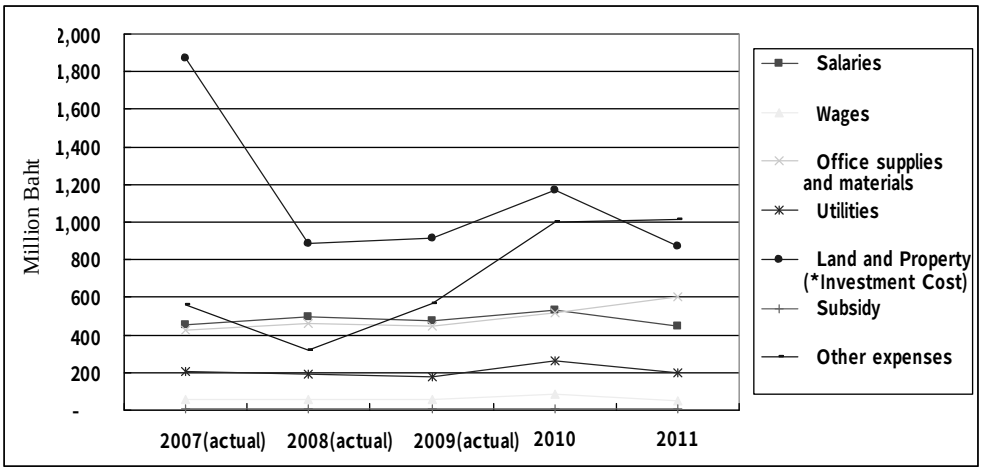
Table 7.1.6 Trend of DDS Budget (by expense items, 2007-2011)

(Baht)

Thai Fiscal Year	2550	2551	2552	2553	2554	Average	Composition
Year	2007 (Closed)	2008 (Closed)	2009 (Closed)	2010 (Budget)	2011 (Budget)		
Annual Budgete of DDS							
Salaries	457,078,471	497,174,462	473,531,942	532,284,500	446,714,700	481,356,815	15.6%
Wages	57,790,566	58,042,668	59203773.52	88,306,000	46,253,800	61,919,361	2.0%
Office supplies and materials	423,764,630	461,946,772	444,839,125	518,065,800	604,200,200	490,563,305	15.9%
Utilities	207,250,283	192,203,349	178,116,713	264,552,700	198,257,500	208,076,109	6.8%
Land and Property (*Investment Cost)	1,875,374,343	884,139,632	913,356,698	1,171,004,000	870,834,600	1,142,941,855	37.1%
Subsidy	7,886,500	8,144,500	8,263,000	9,533,000	10,016,000	8,768,600	0.3%
Other expenses	557,863,724	316,505,394	568,881,538	996,915,000	1,013,674,200	690,767,971	22.4%
Total	3,587,008,516	2,418,156,778	2,646,192,789	3,580,661,000	3,189,951,000	3,084,394,016	100.0%

Note: The actual expenditure amount is used in 2007-2009. Planned budget amount is used in 2010- 2011.

Source: BMA



Source: JST

Figure 7.1.3 Trend of DDS Budget by Expense Item

Evaluating the budget composition by expense items, the average total expenditure is stable around 3.1 billion Baht, and the fixed costs such as salaries and office supplies basically stay constant. In contrast, the annual expenditure amount varies significantly each year. The average investment cost for procuring land and facility construction accounts for approximately 37% of annual budget. About the WWTP construction cost, the constructing cost of 1.297 billion Baht for Bang Sue WWTP is included in the figures during 2008-2010.

The outsourced operation contract cost is categorized in the "other expenses" of the above data. As mentioned in the Section 5.4.2, the operation contract was made based on the five consecutive operation years, and the remuneration amount is defined by the treated wastewater amount and the generated sludge amount.

(2) Support from International Donors

The accepted loan and granted support for wastewater service from the international donors to BMA is summarized below.

1) Acceptance of Loan

In the past, BMA has accepted the loan from international donor agency of DANIDA only once. The detail of the said loan is as follows.

"DANIDA (Danish International Development Agency) Project"

The procurement project loan of medical equipments was signed in November, 2005. The total project cost is approximately 1.86 million US dollars, and 4.3% of it was the grant fund, and the rest of the amount is borrowed without interest and repaid for 10 years. The loan borrowing was conducted as the following procedure. The procedure took around three years from the planning phase to the decision of procurement company by bidding.

- Evaluation of the project (F/S)
- Submission/Approval of the Bangkok parliament
- Submission to the Ministry of Interior Affairs
- Approval from the Cabinet (Comment from NESDB, MOF and others)
- Contract drafting by BMA, Approval from DANIDA
- Reintroduction/Approval from the Bangkok Parliament
- Signing of loan
- Publication/Bidding of procurement project

2) Support for Wastewater Service

The support from international donor agencies to BMA's wastewater service is limited to the execution of feasibility studies in the past for Klong Toei project and Thon Buri project.

Table 7.1.7 Support from International Donor Agencies for Wastewater Service

	Support Contents	Present Progress
1) Klong Toei WWTP 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 for construction was abandoned because implementation policy of BMA was changed with change of governor. Financial source for construction was agreed to be provided by BMA and the government (60:40 ratio). Site for WWTP was acquired five years ago.
2) Thon Buri WWTP project	Feasibility study on the project of 305,000 m^3/d WWTP capacity was completed in 2005 with an aid from French government.	DDS found it difficult to procure the land for whole capacity facility at the site, and the project area is divided into North area and South area. The F/S of north area is completed as modifying the existing report, and the financial source for construction is not yet prepared. Acquisition of land for WWTP in South area is necessary. The detail plan is not yet created.

Source: JST

7.1.4 Future Prediction of Financial Condition (Construction cost and O&M cost)

(1) Facility Construction Cost

The subsidy composition rate for the whole WWTP construction cost is decided by the discussion at the cabinet proposed through the MOI affairs, after evaluation of budget

committee of MOF.

The construction cost, capacity, and subsidy composition of the past constructed WWTP and future plans are indicated in the Table 7.1.8. For the latest Klong Toei project, the government admitted the 40 % burden of whole cost; however, the composition varied from 0% to 100% in the past experiences, and there is no constant criteria of the said composition rate for the future planned projects including the Nong Bon Project.

For the expenditure of BMA fund source, the construction remuneration is paid based on the monthly construction progress system. In general, the construction period continues for 2 – 3 years until the completion and the investment expenditure tends to increase during this period.

Table 7.1.8 Fund Source of WWTPs Construction Works (WWTP and Interceptors) of BMA

Water Environment Control Plant	Population (person)	Capacity (m^3/d)	Start Operation	Fund Source (BMA : GOV.)	Construction Cost (Million Baht)	**Note** (Million Baht)
1. Si Praya	120,000	30,000	1994	BMA 100 %	464	
2. Rattanakosin	70,000	40,000	2000	Government 100%	883	
3. Din Daeng	1,080,000	350,000	2004	25 : 75	6,382	
4. Chong Nonsi	580,000	200,000	2000	40 : 60	4,552	
5. Nong Khaem	520,000	157,000	2002	40 : 60	2,348	
6. Thung Khru	177,000	65,000	2002	40 : 60	1,760	
7. Chatuchak	432,000	150,000	2005	60 : 40	3,482	
8. 12-Community Plant		25,700				
Total	2,979,000	1,017,700			19,871	
Planned WWTP Projects						
1. Bang Sue	250,000	120,000	2012	BMA 100 %	3,287 (After 2011)	Contracted Amount: 4,584, Paid Amount during 2008-10: 1,297
2. Klong Toei	485,000	360,000	-	60 : 40	11,046 (F/S)	BMA's own budget: 6,628
3. Thon Buri North	400,000	148,000	-	To be discussed	5,871 (F/S)	
4. Nong Bon	265,000	135,000		To be discussed	7,834 (F/S)	
5. Min Buri	275,000	140,000		To be discussed	5,760 (M/P)	
Total	1,675,000	903,000			33,798 (After 2011)	

Source: JST

Summing up the construction cost of future five WWTP projects during next 10 years (after 2011), the total cost becomes 33.8 billion Baht. In case that the subsidy rate of 40 %, the same

rate of Klong Toei project (6,628 million Baht), is applied to the Thon Buri North, Nong Bon, and Min Buri projects (BMA's responsible amount is 3,523, 4,700 and 3,456 million Baht), total amount of 21.6 billion Baht is needed for the investment cost by BMA's own fund source for next 10 years. By average, 2.16 billion baht should be paid, and comparing this amount with the 5 years average cost of 1.14 billion Baht shown in the Table 7.1.6, the additional 1.02 billion Baht (around 89 %) is necessary to be prepared every year. Whereas, in case of no subsidy is granted for the Thon Buri North, Nong Bon and Min Buri projects, as same condition as the past Bang Sue project, the average investment cost of BMA becomes 2.94 billion Baht per year. Comparing it with the 5 years average of 1.14 billion Baht, the cost will be more than 2.5 times.

(2) Operation and Maintenance (O&M) Cost

Currently, DDS operates seven (7) WWTPs, to treat the wastewater generated in 192 km^2 area. Also DDS operates 12 small scale wastewater treatment plants transferred from NHA, and three small treatment facilities including klong purification plants of Makkason Pond and Rama IX Pond. Operation and maintenance of two oldest WWTPs (Rattanakosin and Si Praya) is carried out by DDS itself and those of remaining five WWTPs (Din Daeng, Chong Nonsi, Nong Khaem, Thung Khru, and Chatuchak) are entrusted to private companies by 5 years operating contract. The operating contract includes the O&M of interceptors as well as WWTP as mentioned in the previous chapter.

The treated water amount, O&M cost, and average unit O&M cost of existing seven WWTP during 2008-2010 are indicated in the Table 7.1.9. The total treatment amount in 2010 is 238 million m^3 (653,000 m^3/day), and annual O&M cost is 445 million Baht. Regarding the information, the average unit O&M cost in 2010 becomes 1.87 Baht/m^3. The average cost during the last three years (2008-2010) becomes 2.11 Baht/m^3. In case of the year 2010, the said O&M cost accounts for the 12.4% of whole DDS budget (refer to Table 7.1.5).

Comparing the average unit O&M cost of each WWTP of Figure 7.1.4, the cost of Si Phraya WWTP with smaller treatment capacity, and the one of Din Dang WWTP of high electricity consumption system shows the higher cost around 3Baht/m^3. Considering the average cost of seven WWTPs, the trend of the last three years shows the slight decreasing tendency; however the same cost level is anticipated in the future O&M activities.

Table 7.1.9 Treated Amount, O&M cost, Average Unit O&M cost of seven WWTPs (2008-2010)

Treated Waster Water Volume (m^3)

	Rattanakosin	Si Phraya	Chon Nonsi	Chatuchak	Din Daeng	Nong Khaem	Thung Khru	Total
2008	10,482,917	4,856,796	39,653,020	45,378,505	74,641,150	48,400,876	22,188,627	245,601,891
2009	10,508,806	6,647,563	27,451,318	43,971,579	74,799,819	48,696,632	23,352,601	235,428,318
2010	9,839,002	5,985,496	41,975,259	44,730,297	72,633,361	42,850,230	20,231,074	238,244,719

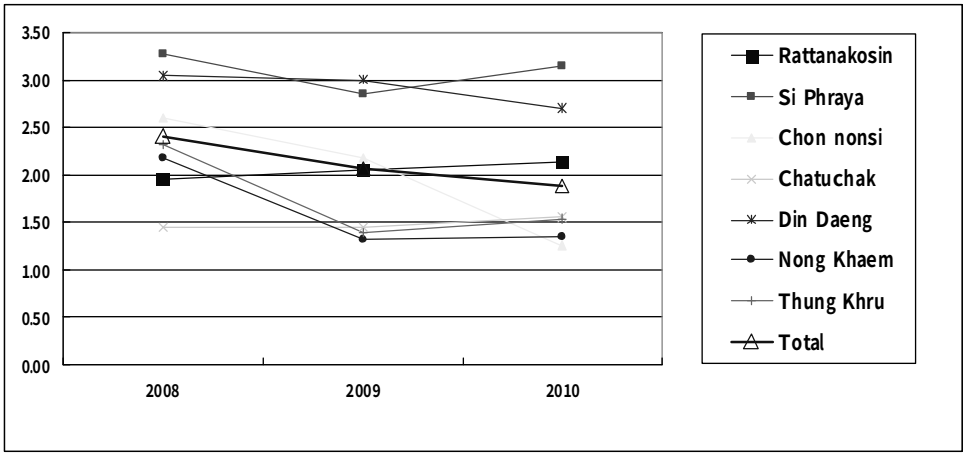
O&M Cost (Baht/year)

	Rattanakosin	Si Phraya	Chon Nonsi	Chatuchak	Din Daeng	Nong Khaem	Thung Khru	Total
2008	20,396,005	15,816,624	102,651,954	65,492,251	226,426,946	105,338,029	51,074,817	587,196,626
2009	21,499,635	18,958,369	59,798,424	63,595,725	224,059,193	63,802,596	32,209,401	483,923,341
2010	20,999,303	18,804,784	52,738,003	69,172,296	195,555,513	57,238,117	30,899,776	445,407,792

Average Treatment Cost (Baht/m^3)

	Rattanakosin	Si Phraya	Chon Nonsi	Chatuchak	Din Daeng	Nong Khaem	Thung Khru	Total
2008	1.95	3.26	2.59	1.44	3.03	2.18	2.30	2.39
2009	2.05	2.85	2.18	1.45	3.00	1.31	1.38	2.06
2010	2.13	3.14	1.26	1.55	2.69	1.34	1.53	1.87
						3 Yeas Average		2.11

Source: JST



Source: JST

Figure 7.1.4 Trend of Average Unit O&M cost

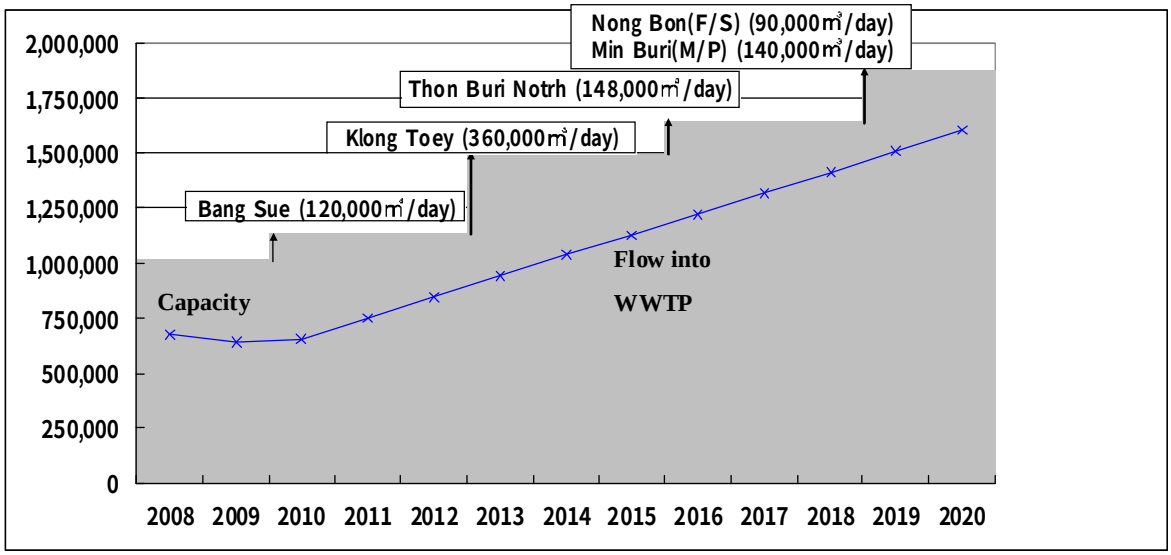
The past record of O&M cost until year 2011, and the predicted cost during 2012-2020 is shown in the Table 7.1.10. The future O&M cost is calculated as multiplying the predicted treatment amount and average unit O&M cost. The unit O&M cost is set at 2.11 baht/m^3 which is the same figure of the last three year's average in seven WWTPs. The treatment amount is obtained from the data mentioned in the Chapter 2.

Table 7.1.10 Treatment Amount, O&M Cost Prediction (until 2020)

Year	Treatment capacity	Wastewater inflow	O&M cost	
Unit	m^3/day	m^3/day	Million Baht	
2008	1,017,700	672,882	627	Average 545
2009	1,017,700	645,009	524	
2010	1,137,700	652,725	485	
2011	1,137,700	748,083	576	
2012	1,137,700	843,441	650	
2013	1,497,700	938,799	723	
2014	1,497,700	1,034,157	796	
2015	1,497,700	1,129,515	870	
2016	1,657,700	1,224,873	943	
2017	1,657,700	1,320,231	1,017	
2018	1,657,700	1,415,589	1,090	
2019	1,747,700	1,510,947	1,164	
2020	1,747,700	1,606,309	1,237	

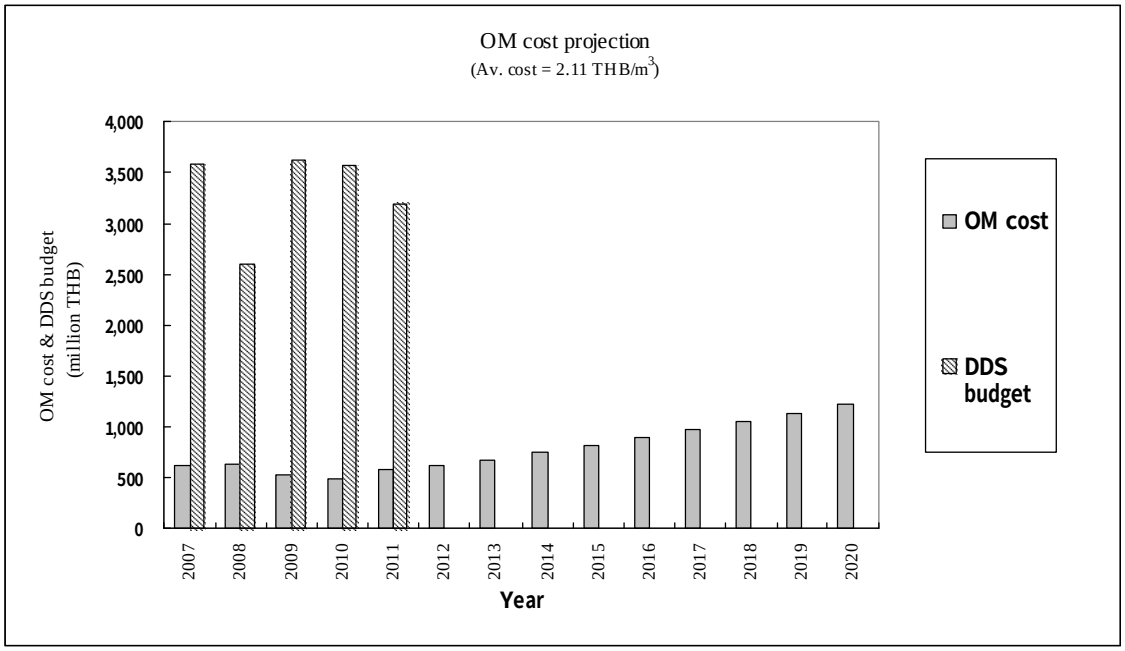
Source: JST

The total O&M cost increases 127 % up to 1,237 million Baht, compared with the average cost of 545 million Baht during 2008-2010. The future WWTP construction plan and the treatment capacity extension plan offered by Master Plan is shown in the Figure 7.1.5. The trend of DDS budget and the future O&M cost prediction is shown in the Figure 7.1.6.



Source: JST

Figure 7.1.5 Future Capacity and Predicted Treatment Amount (until 2020)



Source: JST

Figure 7.1.6 DDS Budget and O&M Cost Comparison (until 2020)

(3) Future Prediction of DDS Budget

Referring to the Table7.1.5, the average DDS budget in the last five years is 3,312 million Baht. From the previous prediction, the investment cost increases 670 – 1,220 million Baht additionally depending on the subsidy composition rate (40% - 0%). Moreover, the O&M cost is predicted to increase gradually as the treatment amount increase, and it becomes the additional 692 million baht annually in the year 2020. By the above assumptions, the total additional increase rate of whole DDS budget amount reached to 52% - 75% in 2020, as compared with the present budget level.

Table 7.1.11 Future Budget Prediction (until 2020)

(million Baht)

		Construction Cost		WWTP O&M Cost (in 2020)		Total	
Current Situation		1,140	-	545	-	3,312	-
Average 2012-2022	40% subsidized	2,160	+1,020	1,237	+692	5,024	+1,712 (+52%)
	0% subsidized	2,940	+1,800			5,804	+2,492 (+75%)

In the prediction, the price inflation and labor cost escalation is not considered, and the progress of four new WWTP is unknown. There are the said uncertain factors; however, it is obvious that the O&M cost increases as the treatment amount increases. Hence, for achieving the long-term financial stability, the wastewater charge collection should be started as soon as possible, and some cost reduction measures such as certain amount of subsidy reception, or JICA loan borrowing should be considered at the necessary period.

7.2 Evaluation of Wastewater Tariff

7.2.1 Plan of BMA's Wastewater Tariff Collection

BMA has been processing legal procedures to start the wastewater tariff collection for long time. In 2004, BMA obtained approval of "BMA Ordinance: Collection of Wastewater Tariff, 2004" from BMA Council and Minister of Interior.

This ordinance mentions that whenever BMA set up a sewerage treatment area, BMA can ask anybody living within the area to pay the wastewater tariff. It is decided that wastewater tariff collection is to be consigned to MWA, and even in case of not using water supply of MWA (such as using the private well), wastewater tariff is charged based on wastewater volume calculated by formula.

For starting the tariff collection, "(1) Approval of the governor of BMA", "(2) Agreement with MWA for outsourced collecting activity", and "(3) Preparation of data management in BMA" should be conducted. The progress of the each factor is explained below.

About the "(1) Approval of the governor of BMA", the report was submitted in 2008 officially to the governor for the approval. In the report, tariff system, appropriateness of collection of tariff, procedures for introduction of the system, and method of collection are described. The decision of the policy makers are postponed until now by the political reason.

Regarding to the "(2) Agreement with MWA for outsourced collecting activity", discussions between BMA and MWA are held for collecting wastewater tariff together with water tariff. The tariff collection is planned to be outsourced to MWA, as the tariff amount is decided based on the water consumption. The outsource cost is set at 10 Baht for the first time, and 3.5 Baht every month (42 Baht/year) for each user connections. In January 2011, negotiations about several conditions for tariff collection were continued to achieve the final agreement. Negotiated conditions are the unification of the water service invoice with the one of wastewater service, and the temporal termination condition of water service in case user neglects to pay for the wastewater charge.

The tariff is charged to the users in the area where the treatment is conducted, and the revenue amount is spent to cover the O&M cost of WWTP. The planned tariff structure is presented in the Table below. The tariff rate is set at 2.0 Baht/m^3 for residential and public buildings, 4.0 Baht/m^3 for large scale commercial facilities, and 4.0-8.0 Baht/m^3 for factories.

For the consideration of poor users, the tariff will not be collected from the residences which consume below 10 m^3 per month. Also the transition measures are considered to start the tariff

rate at 1.0 Baht/m^3, and gradually increase it up to 2.0 Baht/m^3 later. There is the draft plan of of the transaction period and increase rate (1.0Baht/m^3 for first three years, and increase 0.25Baht/m^3 every half year, to be 2.0Baht/m^3 in five years); however, the detail is not yet confirmed at present.

Table 7.2.1 Proposed Wastewater Tariff Rate

User Category		Waste Water Tariff Rate (Baht/m^3)
Residence (excluding water user below 10 m^3/month)		2.0 (increase gradually)
Govt. agency, state enterprises, office		2.0
Religious places, educational institute, foundations		2.0
Hospitals		4.0
Hotels		4.0
Shopping Malls, Department Stores		4.0
Fresh Markets		4.0
Restaurants	Space less than 100 m^2	2.0
	Space more than 100 m^2	4.0
Massage Parlous and spa		4.0
Commercial/ Business	Space less than 100 m^2	2.0
	Space more than 100 m^2	4.0
Multi function building		4.0
Industry	Wastewater less than 200 m^3	4.0
	Wastewater between 200 and 500 m^3	6.0
	Wastewater more than 500 m^3	8.0
Others		4.0

Source: Wastewater Tariff Code of Law, BMA, 2004

The rates were proposed in 2004, and it is supposed to be reviewed for reflecting price escalations; however no modification plan is made until now.

As shown in the latter Table 7.2.3, the user category of MWA's water service tariff are divided into only two categories of residential and non-residential users. This categorization does not match to the planned category of wastewater tariff, so the fixing work of the present water user data is necessary.

For this "(3) Preparation of data management in BMA", Database and Tariff Collection Section under WQMO made the work guidelines and prepared budget for buying necessary system. So, there will be no obstacle for executing the work in BMA itself.

The new tariff evaluation study was conducted by local consultant company in 2010 as ordered by BMA, and the report presents the prediction of revenue amount in the planned seven treatment area as indicated in the Table 7.2.2.

Table 7.2.2 Wastewater Tariff Prediction by Consultant in 2010

Category	Condition	Water Consumption (m^3/year)	Unit Cost (Baht/m^3)	Tariff Amount (Baht)	Composition (%)
1. Residential	More than 10m^3/month	48,232,776	2.00	96,465,552	19.48%
2. Government, State Building		18,190,655	2.00	36,381,310	7.35%
3. Religious, Public Building		6,768,662	2.00	13,537,324	2.73%
4. Hospital		3,856,063	4.00	15,424,252	3.12%
5. Hotel		7,223,524	4.00	28,894,096	5.84%
6. Commercial Store		4,184,597	4.00	16,738,388	3.38%
7. Market		181,654	4.00	726,616	0.15%
8-1. Restaurant 1	Less than 100m^2	3,080,498	2.00	6,160,996	1.24%
8-2 Restaurant 2	More than 100m^2	2,401,504	4.00	9,606,016	1.94%
9. Massage Parlor		367,127	4.00	1,468,508	0.30%
10-1. Commecial Building 1	Less than 100m^2	108,348,669	2.00	216,697,338	43.77%
10-2 Commecial Building 2	More than 100m^2	9,099,940	4.00	36,399,760	7.35%
11. Factory		4,147,620	4.00	16,590,480	3.35%
Total		216,083,289	2.29	495,090,636	

Source: The study of wastewater treatment tariff in Thailand and foreign countries, 2010

In conclusion, total charged water consumption becomes 216 million m^3, and the total revenue becomes 495 million Baht. Out of the total revenue, the revenue from residential category accounts for 19.5 %, and the one of the commercial building account for the majority of 51 %. (Tariff rate of 2.0 Baht/m^3 is applied for residential users of consuming more than 10 m^3/month)

This evaluation was conducted based on the consumption data in 2007, and the charged water amount is expected to be increased at present. Regarding to the data of MWA (annual report 2009), average increase rate of charged water amount is 2.0 % in the latest five years during 2005-2009. If this increase rate is applied for four years after the above data collecting time in 2007, total increase rate becomes 8.2 %, the charged water amount becomes 234 million m^3, and the revenue amount becomes 536 million Baht in 2011.

As shown in the Table 7.1.9, the actual O&M cost of 7 WWTPs (including O&M of interceptors) is 445.4 million Baht, and the above predicted revenue amount is more than this O&M cost. Hence, the principle of the treatment tariff to cover the O&M cost can be satisfied. In contrast, the average tariff rate for full cost recovery is calculated at 13.18 Baht/m^3 by referring average budget of DDS (3,084 million Baht) in 2007-2011, divided by the predicted charged water amount (234million m^3). Comparing the tariff of 13.18 Baht/m^3 for full cost recovery, and planned average tariff rate of 2.29 Baht/m^3, it covers only 17 %.

7.2.2 Water Tariff Structure of MWA

Water tariff system of MWA is progressive commodity charge system, and users are divided into two groups of Residential and Non-residential, as shown in Table 3.7.8. The users of lower

consumption amount such as normal residence and small scale company, the tariff burden is alleviated by this system. In 2009, the total revenue amount was 15,474 million Baht, and the revenue water amount was 1,250 million m^3, then the average tariff becomes 12.4 Baht/m^3. The financial condition of MWA remains sound recently, and the water tariff rate has not increased after the year 1999.

As mentioned previously, when the wastewater tariff collection begins, the collection work is outsourced to MWA by BMA, and both sides are negotiating about the detail conditions at present.

Table 7.2.3 Water Tariff Structure

Residential		Business, State Enterprise, Government Agency and Industrial	
Volume(m^3)	Baht/m^3	Volume(m^3)	Baht/m^3
0-30	8.50	0-10	9.50
Not less than 45.00 Baht		Not less than 90.00 Baht	
31-40	10.03	11-20	10.70
41-50	10.35	21-30	10.95
51-60	10.68	31-40	13.21
61-70	11.00	41-50	13.54
71-80	11.33	51-60	13.86
81-90	12.50	61-80	14.19
91-100	12.82	81-100	14.51
101-120	13.15	101-120	14.84
121-160	13.47	121-160	15.16
161-200	13.80	161-200	15.49
Over 200	14.45	Over 200	15.81

Source: MWA

7.2.3 Principle of Wastewater Tariff in Thailand

Pollution Control Department (PCD) of MONRE declares the Polluter Pays Principle (PPP) and defined that the people discharging wastewater need to pay the O&M cost by themselves. The "Handbook of wastewater treatment charge, 2010" published by PCD recommends the following wastewater tariff structure in Thailand.

- Tariff is collected monthly and used to cover the O&M cost of wastewater treatment.
- The connection fee to the service should be charged at constant amount every year, or at the connecting time.
- Tariff revenue is used for paying to the expenditure categories of (3), (4), and (7).
  (1) Land procurement, (2) Construction cost, (3) System operation cost, (4) System preparation cost, (5) Spare parts cost, (6) Administration cost, (7) Repayment for environment fund(*)

- There are two types of the tariff collection method.
  In case of the fixed cost type, tariff is charged once a year, and the amount is decided by the occupying area or type of the building.
  In case of the water consumption amount type, the long term marginal cost for around 20 years is adopted as the average tariff rate. The discount rate and inflation rate should be considered in the calculation, and the O&M cost is divided by the treatment amount for obtaining the long term marginal cost.
  Compared with the fixed cost system, the water consumption amount system imposes more fairly tariff amount to users. However, it is necessary to cooperate with water service agency for data arrangement, and collection work should be outsourced.
- Willingness to pay and affordability to pay should be surveyed, before the tariff collection starts. Taking the result into the consideration, higher tariff rate can be imposed on the industrial/commercial users, and lower tariff rate is granted to residential users.

*Environment Fund: Fund for environmental infrastructure construction including the wastewater service project, under the "Enhancement and Conservation of National Environmental Quality Act (NEQA, 1992)"

Purpose of Wastewater Tariff Collection

Most multi-lateral development donors recommend the full cost recovery for sewerage sector. However, the experience of tariff collection in Thailand is limited and none of them was introduced to achieve the full cost recovery. Similar situation is also prevailing in the neighboring countries like Vietnam. In addition, even in Japan, 48% of whole service revenue is procured by tariff based on the principle of "Public cost for rain water and user's cost for wastewater" (Ministry of Internal Affairs and Communications of Japan, 2009). Considering the above situation, at least the tariff rate should be set to cover the O&M cost, and partial capital cost recovery should be introduced in the future plan. Until now, BMA has not started the tariff collection, it should be started as soon as possible to cover the increasing O&M cost of WWTPs by fair responsibility of users.

7.2.4 Introduced Tariff Structure in Thailand

The concept of wastewater tariff collection is new to Thailand, and only few municipalities are currently utilizing this tool, such as municipalities of Patong and Pattaya charging with fixed cost system, and municipalities of Saensuk and Hatyai charging with water consumption amount system. The detail of tariff structure in four cities is described below. The approximate level of charge amount are set around 500 Baht/year for normal residential users by fixed cost system, and around 2.0 Baht/m^3 for residence and 3.0 Baht/m^3 for industrial are imposed by water consumption amount system. This charge level is similar to the planned one of BMA.

(1) Tariff Structure by Fixed Cost System

(A) Patong Municipality, Phuket Province

The tariff amount is decided based on the facility type in Patong Municipality as shown below.

Table 7.2.4 Annual Wastewater Tariff in Patong Municipality

Category		Annual Rate
1. Housing residence		500 Baht/household
2. Commercial Building	Up to 2 stories	500 Baht/Building
	3 stories or over	1,000 Baht/Building
3. Restaurants		100 Baht /m²
4. Hotels		600 Baht/Room

Source: The study of wastewater treatment tariff in Thailand and foreign countries, 2010

(B) Pattaya Municipality, Chonburi Province

The tariff amount is decided based on the facility type in Pattaya Municipality. In case the on-site treatment facility is equipped, the lower tariff rate is imposed. The effluent water quality is checked periodically for users of lower rate. The connection fee is also imposed.

Table 7.2.5 Annual Wastewater Tariff in Pattaya Municipality

Category	Annual Rate	
	Wastewater	Sufficiently Treated Water
1. Hotel, Bungalow	672.00 Baht/Room	67.20 Baht/Room
2. Condominium	360.00 Baht/Room	36.00 Baht/Room
3. Restaurants	36.00 Baht/ m²	3.60 Baht/ m²
4. Commercial Building	6.00 Baht/ m²	0.60 Baht/ m²
5. Low House Building	3.60 Baht/ m²	0.36 Baht/ m²
6. Government Office, State Enterprise	-	-
7. Workplaces	40 Baht/ Kilogram production/day	26 Baht/ Kilogram production/day

Source: The study of wastewater treatment tariff in Thailand and foreign countries, 2010

(2) Tariff Structure by Water Consumption Amount System

(A) Saen Suk Municipality, Chonburi Province

The tariff rate of Saen Suk Municipality is decided based on the user category, consumption amount and BOD values of effluent as indicated in the Table7.2.6.

Table 7.2.6 Wastewater Tariff Rate of Saen Suk Municipality

Building Category	Wastewater Tariffs Rate (Baht/ m^3)	
BOD values	Less than 200 mg / l	200 – 500 mg / l
1. Housing Residence	2.00	
2. Building Discharged wastewater		
(1) The condo	3.00-3.50 (depend on Room Number)	4.50
(2) Hotel		
(3) Public Hospitals, or Nursing home	3.00-3.50 (depend on Bed Number)	
(4) Building of private and governmental Schools, or institutions	3.25-3.50 (depend on area)	
(5) Governmental office, State Enterprise or International Organization or private	3.00-3.50 (depend on area)	
(6) Department store or complex		
(7) Market places		
(8) Restaurants or food shop		
3. Industrial Factories	3.00-3.50 (Depend on Wastewater Volume)	4.50
4. Other Pollution origins	3.50	4.50

Source: The study of wastewater treatment tariff in Thailand and foreign countries, 2010

(B) Hatyai Municipality, Songkhla Province

Tariff rate of Hatyai Municipality is quite similar to the structure of Saen Suk municipality. It is decided based on the user category, consumption amount and BOD values of effluent as indicated in the Table7.2.7.

Table 7.2.7 Wastewater Tariff Rate of Hatyai Municipality

No.	Pollution Sources Category	Tariffs Rate for Wastewater Treatment Baht/ m^3	
	BOD values	Less than 200 mg / l	200 – 500 mg / l
1	Housing Residences produced wastewater volume greater than 20 m^3	2.00	
2	(1) Condominium	3.00-3.50 (Depend on Area)	4.50
	(2) Hotel	3.00-3.50 (Depend on Room Number)	
	(3) Public Hospitals, or Nursing home		
	(4) Building of private and governmental Schools, or institutions	3.25-3.50 (Depend on Area)	
	(5) Governmental office, State Enterprise or International Organization or private	3.00-3.50 (Depend on Area)	
	(6) Department store or complex		
	(7) Market places		
	(8) Restaurants or food shop		
3	Industrial Factories	3.00-3.50 (Depend on Wastewater Volume)	4.50
4	Other Pollution origins sources	3.50	4.50

Source: The study of wastewater treatment tariff in Thailand and foreign countries, 2010

7.2.5 Willingness to Pay (WTP) and Affordability to Pay (ATP) for Wastewater Tariff

For evaluating the designed tariff amount with the user's opinion and affordability, willingness

to pay (WTP) and affordability to pay (ATP) is calculated.

(1) Willingness to Pay (WTP)

The result of past four survey of WTP in BMA area is summarized in the Table 7.2.8, and the survey detail is explained in the latter part. The sample number and methodology varies for each survey, and the WTP result indicated from 39.2 to 100.8 Baht/ month-household. The result of the social survey conducted under this JICA Survey became 73.3 Baht/month-household. This data matched to the past survey result, and is considered to be reliable.

Table 7.2.8 Past Survey Result of WTP

Survey Name (year)	Methodology	Question Method	Monthly WTP (Baht/month-household)
JICA Survey (2010)	Nong Bon area, 350 samples	CVM method	73.3
BMA Study (2010)	7 treatment areas, 2300 samples	Three answer choice	41.4
BMA Study (2006)	Bang Sue area, 326 samples	Free Answer	39.2
IDRC and others Study (1999)	6 treatment area, 1100 samples	CVM method	100.8

Source: JST

(A) Social Survey Result of the JICA Survey Team

In this study, the interview survey was conducted to 350 samples. The average of WTP becomes 73.3 Baht/month-household, and the medium value becomes 49.6 Baht/month-household. The monthly WTP for the benefit of water quality improvement by the project execution is asked, as showing two photos of conditions around klongs “with project” and “without project”. The CVM (Contingency Valuation Method), which is mainly applied to the environmental project evaluation, was used and the “double entry method of dichotomous election” (that is, asking the questions of two alternative answers for 2 times) is adopted for avoiding the biases.

“Double entry method of dichotomous election” is managed as follows;

- The first tariff amount, which should be paid additionally to the water tariff, is indicated to interviewee, and asked if they are willing to pay of not for achieving a better livelihood environment.
- If the interviewee answered “yes” to the first amount, the “higher” tariff amount is indicated, and asked their willing to pay for the amount.
- If the interviewee answered “no” to the first amount, the “lower” tariff amount is indicated, and asked their willing to pay for it.

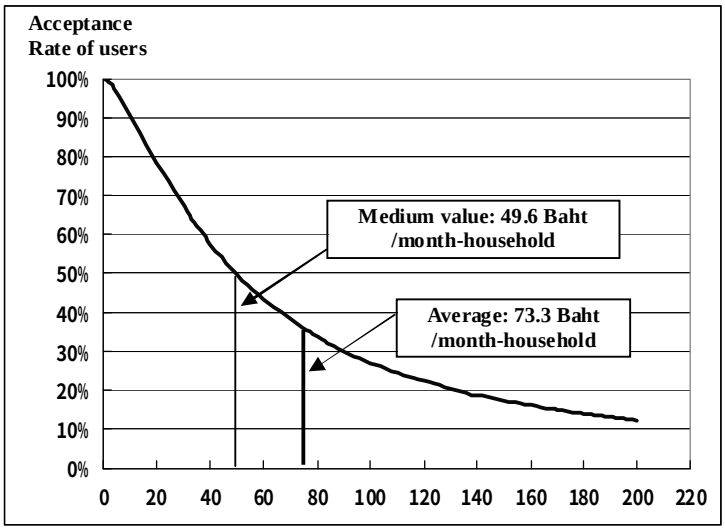
The indicated tariff amount is designed as shown in the Table 7.2.9. Five difference

questionnaire sheets are prepared for the survey, and the one of the five kinds is selected randomly for each interviewee, to avoid the bias of first indicated tariff amount. For calculating the WTP from survey result, approximated curve is calculated using logit linear method.

Table 7.2.9 WTP Survey Result in Nong Bon Treatment Area

Type	First Question	Second Question(*)	YY	YN	NY	NN	Total
1	10 Baht/month-household	20 or 5 Baht/month-household	32	22	3	13	70
2	20 Baht/month-household	40 or 10 Baht/month-household	32	28	3	7	70
3	40 Baht/month-household	70 or 20 Baht/month-household	16	34	10	10	70
4	70 Baht/month-household	120 or 40 Baht/month-household	15	24	16	15	70
5	120 Baht/month-household	200 or 70 Baht/month-household	14	9	19	28	70
Subtotal			109	117	51	73	350

Note: Second question amount is chosen depending on the answer of first question. If it was Yes, the higher amount, if No, the lower amount is selected.
YY: Sample number of answering Yes to first and second questions.
YN: Sample number of answering No to first question, and Yes to second question.
NY: Sample number of answering Yes to first question, and No to second question.
NN. Sample number of answering No to first and second questions.
Source: JST



※Approximated curb made by Logit Linear method
Source: Study Team

Figure 7.2.1 Average and Medium Value of WTP Survey (Baht/month-household)

(B) WTP Survey Result Executed by BMA in 2010

In the survey conducted by BMA during January to February 2010, the suitable tariff rate (Baht/m^3) is asked by choosing from three answers out of (1) 0.5 - 1.0 Baht/m^3, (2) 1.0 - 1.5 Baht/m^3, (3)1.5-2.0 Baht/m^3. Multiplying the composition of each category and average rate of the answer, the average tariff rate to be accepted becomes 0.88 Baht/m^3.

Table 7.2.10 Suitable Tariff Rate for Wastewater Treatment

Suitable Tariff Rate	Number	Percentage (%)	Weighted Average Rate
0.5 – 1.0 Baht/m^3	1,746	79.9	0.88
1.0 – 1.5 Baht/m^3	308	14.1	
1.5 – 2.0 Baht/m^3	132	6.0	
Total	2,186	100	

Source: DDS

Referring to the report of "The study of wastewater treatment tariff in Thailand and foreign countries, 2010", the planned charged water amount for residence is 4,527 thousand m^3/year, number of connection is 96,131 households, so the average consumption is calculated at 47.1 m^3/household. Using this figure, the WTP of users is calculated to be approximately 41.4 Baht/month-household.

(C) WTP Survey Result of Bang Sue Area Executed by BMA in 2006

Database and Tariff Collection Section of WQMO conducted the WTP study in 2006 called "Bang Sue Environmental Education and Conservation Project, Vol. 2, 2006". The survey area was 20 sub-ditrict in Bang Sue treatment area and sample number was 398. The result of 326 samples to "household and commercial users" is as follows. Calculating the WTP using the percentage and average WTP of each response category, it becomes 39.2 Baht/month-household.

Table 7.2.11 WTP for Wastewater Project (Household, Commercial Users)

Suitable Tariff Rate	Number of samples	Percentage (%)	Average WTP (Baht/month-household)
Not willing to pay	118	36.2%	0.0
Having as willingness to pay	198	62.7%	64.5
Not understanding	10	6.0%	0.0
Total	326	100.0%	39.2

Source: DDS

(D) WTP Survey Result in 6 Treatment Areas Conducted by IDRC and Others in 1999

The methodology of WTP survey "Water Quality Improvement: A Contingent Valuation Study of the Chao Phraya River (Dec. 1999)", which is conducted by IDRC and other agencies, is resembles to the survey of the Survey Team. Survey was executed for 1,100 samples in Bangkok in 6 treatment areas at that moment, CVM method of "double entry method of dichotomous election" is applied to know the WTP for the improvement of water quality in klongs. The result is shown in the Table 7.2.12.

Table 7.2.12 Result of WTP for Environmental Improvement

	Achieved Benefit Image	
	(1) Boatable (now) → Fishable	(2) Boatable (now) → Swimmable
Average WTP	100.81 Baht /month - household	115.03 Baht /month - household

Source: Survey Report

In the study, two kinds of the better environmental condition to be achieved from the project execution are assumed. The first one is the water quality in klong of fishable, and the other is the swimmable. The WTP is calculated for both cases, and the assumption of "fishable" seems more similar to the assumption of WTP survey of Survey Team in 2010; Hence the result of 100.81 Baht/month-household is used for the WTP data comparison.

From the survey conclusion, the researcher mentioned the existence of certain bias from the first indicated WTP amount (70, 85, 100, 120 Baht/month-household), even though the sample number is abundant and the result is considered to be reliable.

(2) Affordability to Pay (ATP)

Several international donor agencies recommend the affordability to pay (ATP) for wastewater tariff. As referring to the Guideline of JICA (JICA methodology of economic analysis for master plan survey -wastewater category), IBRD set it at 1.0 % of disposable income, and PAHO (Pan American Health Organization) set it at 1.5 % of total household income.

In this study, as the conservative view, the ATP is set at 1.0 % of total income of users. From the social survey result, the average household income is figured out to be 33,428 Baht/month. Hence, the ATP is calculated to be 334 Baht/month-household. In the said social survey, the average water tariff amount became 489 Baht/month-household. Comparing the calculated ATP amount (334 Baht/month-household) with this real expenditure amount, it consists 68%. The calculated ATP amount is considered as acceptable for the present users.

(3) Evaluation of User's Affordability

As mentioned before, the average water consumption of residence is 47.1 m^3/month-household refer to the report of tariff study in 2010. So, the average tariff amount becomes 94.2 Baht/month-household as applying the tariff rate of 2.0 Baht/m^3 for residential users. Comparing the WTP at 73.3 Baht/month-household taken from the social survey result, these amount stays at the similar level, so it is considered that users are willing to pay the tariff. Whereas, comparing the ATP at 334 Baht/month-household with average tariff amount (94.2 Baht/month-household), the average tariff amount becomes only 28 % of the ATP. Hence, it is concluded that users have the sufficient capacity to pay the planned tariff amount.

Table 7.2.13 Summary of WTP and ATP of Residential User

Item	Data Source	Monthly Tariff
Predicted average tariff amount	Calculated by average water consumption	94.2 Baht/month-household
Willingness to Pay (WTP)	Social Survey Result (WTP)	73.3 Baht/ month-household
Affordability to Pay (ATP)	Social Survey Result (Average income × 1.0%)	334 Baht/ month-household

Source: JST

7.3 Economic Analysis

In this Section, the economic analysis is conducted to evaluate the economic viability of the project. The normal cost benefit analysis method is applied for the analysis by assuming the conditions of "With Project" and "Without Project". The result of analysis is evaluated as using indicators of the Economic Internal Rate of Return (EIRR), Net Present Value (NPV), and Benefit/Cost Ratio (B/C).

7.3.1 Basic Assumptions

The analysis is conducted based on the assumptions below.

1) Assumption of "With Project" and "Without Project" :

"With Project"

The construction of Nong Bon WWTP and Interceptors are completed following to the planned schedule. The planned treatment amount is 90,000 m^3/day (FS phase) before 2017, and it is extended 22,500 m^3/day each time, in the year 2021 and 2031 respectively. Owing to the mentioned project execution, the water quality of klongs located in the project area will be improved, and the welfare of dwellers living in the area will be improved simultaneously.

"Without Project"

The present condition of wastewater drainage facility is maintained. The water quality of klongs in the Nong Bon treatment area will worsen as the wastewater discharging to the public water bodies increases.

2) Evaluation Period

The evaluation period is set for 36 years which includes 6 years of preparation/construction period during 2012 - 2017, and 30 years after starting the Nong Bon WWTP operation during 2018 - 2047.

3) Cost of Initial Construction and O&M

The cost of initial construction and O&M is estimated based on the price at October 2010 excluding any tax. Physical contingency is included in the estimated cost, and the price contingency is excluded from the estimate. The conversion factor is applied to the local cost obtained financial cost to convert to the economic cost.

4) Viability of the Project

In terms of domestic economics, the project is considered viable if the EIRR exceeds 10 %, which means the NPV becomes positive at Discount Rate of 10 %.

7.3.2 Economic Cost

The initial investment cost and O&M cost are indicated below.

(1) Initial Investment Cost

In case the Project is executed (With Project)

The disbursement schedule of initial investment cost is shown in the table below referring to theTable 5.2.7 in Chapter 5. In the previous chapter, two alternatives of different interceptor constructing phases are mentioned. Only the alternative case of single construction phase (base case) is used for the analysis as the result of economic analysis does not differ significantly between both cases.

Table 7.3.1 Disbursement Schedule of Initial Investment Cost (Financial Cost)

(Million Baht)

	2012	2013	2014	2015	2016	2017	Total
Local Currency	24.4	103.5	103.3	1,446.2	1,435.1	1,423.5	4,536.0
Foreign Currency	2.0	33.7	33.6	571.1	566.8	562.4	1,769.6
Total	26.4	137.2	136.9	2,017.3	2,001.9	1,985.9	6,305.6

Source: JST

Table 7.3.2 Disbursement Schedule of Initial Investment Cost (Economic Cost)

(Million Baht)

	CF	2012	2013	2014	2015	2016	2017	Total
Local Currency	0.92	22.4	95.2	95.0	1,330.5	1,320.3	1,309.6	4,536.0
Foreign Currency	1.00	2.0	33.7	33.6	571.1	566.8	562.4	1,769.6
Total		24.4	128.9	128.6	1,901.6	1,887.1	1,872.0	5,942.6

Note: CF: Conversion Factor

Source: JST

The Standard Conversion Factor of 0.92, which is presented by the report published by World Bank, is applied to obtain the economic cost. The reference report is “Sadiq Ahmed; Shadow Prices for Economics Appraisal of Project :An Application to Thailand, World Bank Staff Working Paper, Number 609.”

The extension cost, replacement cost and residual value are calculated based on the assumptions below;

- The replacement of equipment facility (1,249.9 million Baht) out of initial investment cost is executed in 15 years.
- The extension construction of WWTP of 22,500m^3/day which costs 539.8 million Baht is executed in 2021, and 2031 respectively to meet the inflow amount. The whole mentioned construction cost is considered as the equipment cost and the replacement (100% of cost) is executed in 15 years.

- The residual value of facilities is put at the final year as the benefit. The life time of concrete facility and building (which is considered as the whole facility except for equipment) is set at 50 years, and that of equipment is set at 15 years.

In case the Project is not executed (Without Project)
The initial investment cost is not charged.

(2) Operation and Maintenance (O&M) Cost

In case the Project is executed (With Project)
From Table 5.1.2 in Chapter 5, the O&M cost is calculated as 112.1 million Baht for 90,000 m^3/day (32,850,000 m^3/year) capacity. As using these figures, the average unit O&M cost (Baht/m^3) is set at 3.41 Baht/m^3, and multiplying this average cost with the annual treatment amount to have the annual O&M cost at Nong Bon WWTP. The planned treatment amount of each year is calculated referring to Table 4.1.3 in Chapter 4. The O&M cost after 2041 becomes constant as the treatment amount reaches to the maximum capacity of 135,000 m^3/day at that time.

In the project area, the residential and commercial building equips the septic tank at each site, and users pay the O&M cost for chemical consumption and cleaning activity. By the project execution, the reduction of this O&M cost is expected; however, this cost reduction is not considered in the calculation as the present law obliges the septic tank installation.

Table 7.3.3 Prediction of Treatment Amount in the Project Area (With Project)

Year	Capacity	Daily Treatment Capacity (Table 4.1.3)	Predicted Annual Treatment Amount	Daily Treatment Amount	Annual Treatment Amount	O&M Cost (3.41Baht/m^3)	O&M Economic Cost (3.41Baht/m^3 x 0.92)
	m^3/day	m^3/day	m^3/year	m^3/day	m^3/year	Million Baht/year	Million Baht/year
2018	90,000	82,270	30,028,550	82,270	30,028,550	102.40	94.21
2019	90,000	84,675	30,906,375	84,675	30,906,375	105.39	96.96
2020	90,000	87,080	31,784,200	87,080	31,784,200	108.38	99.71
2021	90,000	89,485	32,662,025	89,485	32,662,025	111.38	102.47
2022	112,500	91,890	33,539,850	91,890	33,539,850	114.37	105.22
2023	112,500	94,295	34,417,675	94,295	34,417,675	117.36	107.97
2024	112,500	96,700	35,295,500	96,700	35,295,500	120.36	110.73
2025	112,500	99,105	36,173,325	99,105	36,173,325	123.35	113.48
2026	112,500	101,510	37,051,150	101,510	37,051,150	126.34	116.23
2027	112,500	103,915	37,928,975	103,915	37,928,975	129.34	118.99
2028	112,500	106,320	38,806,800	106,320	38,806,800	132.33	121.74
2029	112,500	108,725	39,684,625	108,725	39,684,625	135.32	124.49
2030	112,500	111,128	40,561,720	111,128	40,561,720	138.32	127.25
2031	112,500	113,365	41,378,225	113,365	41,378,225	141.10	129.81
2032	135,000	115,602	42,194,730	115,602	42,194,730	143.88	132.37
2033	135,000	117,839	43,011,235	117,839	43,011,235	146.67	134.94
2034	135,000	120,076	43,827,740	120,076	43,827,740	149.45	137.49
2035	135,000	122,313	44,644,245	122,313	44,644,245	152.24	140.06
2036	135,000	124,550	45,460,750	124,550	45,460,750	155.02	142.62
2037	135,000	126,787	46,277,255	126,787	46,277,255	157.81	145.19
2038	135,000	129,024	47,093,760	129,024	47,093,760	160.59	147.74
2039	135,000	131,261	47,910,265	131,261	47,910,265	163.37	150.30
2040	135,000	133,501	48,727,865	133,501	48,727,865	166.16	152.87
2041	135,000	135,738	49,544,370	135,000	49,275,000	168.03	154.59
2042	135,000	137,975	50,360,875	135,000	49,275,000	168.03	154.59
2043	135,000	140,212	51,177,380	135,000	49,275,000	168.03	154.59
2044	135,000	142,449	51,993,885	135,000	49,275,000	168.03	154.59
2045	135,000	144,686	52,810,390	135,000	49,275,000	168.03	154.59
2046	135,000	146,923	53,626,895	135,000	49,275,000	168.03	154.59
2047	135,000	149,160	54,443,400	135,000	49,275,000	168.03	154.59

Source: JST

In case the Project is not executed (Without Project)

The O&M cost is not charged.

7.3.3 Economic Benefits

The potential economic benefits procured by the project execution are summarized below;

a) Improvement of living welfare
b) Land price escalation around klong
c) Cost reduction by reusing the treated water
d) Health expenditure reduction
e) Increase of tourism

f) Increase of klong boat transportation
g) Increase of fishery's revenue

The first three factors are quantified as the economic benefits, and the rest of the benefits are considered as the intangible benefits and excluded from the calculation.

a) Improvement of living welfare
The living welfare of users will be improved as the effluent water quality to klongs will be improved after completion of WWTP construction.

The benefit amount is calculated multiplying the number of household and Willingness to Pay (WTP, Baht/month-household) for the benefit. Moreover, the Affordability to Pay (ATP) is also applied for the calculation, as the WTP for sewerage project tends to be lower owing to the difficulty of user's imagination about the benefit.

The information are shown below about (a) WTP obtained by social survey (b) ATP calculated by certain percentage of revenue.

i) Benefit using Willingness to Pay (WTP) (Case1)
In the social survey, the future environmental conditions around klong are shown to the interviewee by using photos in both cases the project is executed (With Project) and not executed (Without Project). The acceptable charge amount for receiving the said benefit is asked in the survey, and the result amount is used as the Willingness to Pay (WTP) of benefit calculation (refer to Table 7.3.6).

The WTP for obtaining the better environment around klong by wastewater treatment project execution is calculated as 73.3Baht/month-household as shown in the Figure 7.2.1. The total benefit is calculated as using the below formula. The beneficial household number is obtained by dividing the beneficial population by average household persons (4.87 person/household) which is obtained in the social survey result.

Benefit = "Number of Beneficial Household" x "Willingness to Pay (WTP)"

ii) Benefit using Affordability to Pay (ATP) (Case2)
As mentioned in the previous section, international donors such as IBRD and PAHO recommends the ATP as 1.0% of disposable income or 1.5% of income and etc. As considering it in the conservative way, ATP for wastewater treatment charge is set at 1.0 % of average household income, which corresponds to 334 Baht/month-household.

Benefit = "Number of Beneficial Household" x "Affordability to Pay (ATP)"

b) Land price escalation around klong

The water quality in klong will be improved by project implementation. As the result, the land value increases in case the surrounding undeveloped area will be utilized as the residential/commercial area.

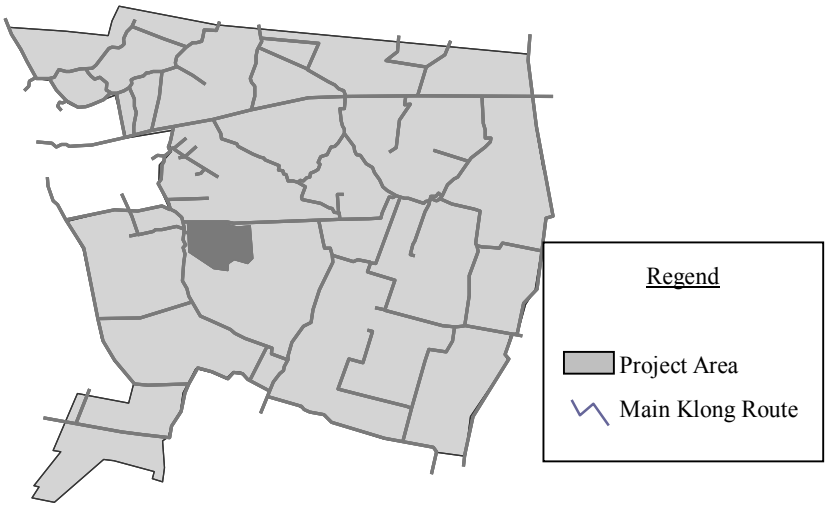
The expert of the study team evaluated the land value by local survey and interview with three local property agencies. By the local survey, the odd smell is felt at the site approximately 30 m from the klong, depending on the wind direction and environment. Hence, the area within 30 m from the klong side is considered as the beneficial area of land price escalation.

The main klong route in the Project site is shown in the Figure 7.3.1, and the total length of the klong is measured as shown in Table 7.3.4. There are some places where the klong forms the border of treatment area. In this case, only one side of klong area is included as the beneficial area.

Table 7.3.4 Klong Distance and Beneficial Area

Kind	Klong Length	Width of Beneficial Area	Beneficial Area
Both side	72.4 km	60 m	4,344,000 m^2
One side (treatment area border)	27.2 km	30 m	816,000 m^2
Total			5,160,000 m^2

Source: JST



Source: JST

Figure 7.3.1 Main Klongs in the Project Area

The land price information which Treasury Department published for the property tax collection is shown in the following table. The land price at project area varies from 2,500 Baht/m^2 to

10,500 Baht/m^2. In general, it is said that the mentioned land price is 20 or 30 % lower than the real commercial price. Considering these data and the information from the local property agencies, the average land price besides the klong is defined at 5,000 Baht/m^2.

Table 7.3.5 Land Price List for Property Tax

No.	Area Name	Baht/m^2	No.	Area Name	Baht/m^2
1	Flower Lee Garden Village	6,250	12	Kotchathanee Village	5,000
2	Sirin House Village	3,750	13	Country Villa Village	10,000
3	Suan Nakarin Village	10,500	14	KehaNakorn Village	8,750
4	Suan Suay Village	5,000	15	Sen Farm Garden Home	3,000 - 3,750
5	Suan Luang Village	5,000 - 6,250	16	Thung Sethi Village	3,750
6	Suan Luang Nivate Village	7,500 - 8,500	17	Prem-Ruthai Village 1, 2	3,000
7	Ake Pailan Village	7,500	18	Seri Village	8,750
8	Seri Villa	8,750 - 10,500	19	Charming Town Village	2,500
9	Soi Supapong	6,250 - 7,500	20	Prawet Place Village	3,750
10	Soi Wat Taglum	3,000 - 5,000	21	Chatra Nakorn Village	6,250
11	Kasemsan Village	5,500	22	Chomdeun Village	4,250

Source: Treasury Department, 2010

Influence of the project is predicted as follows. Firstly, the land price besides the klong will increase 15% more than the original price influenced by the better surrounding environment, as considering the experience of property agency and comment of BMA department. The project area is located between the city center and the airport, and both areas are connected by airport link transportation newly made available in 2010. Hence; the population density tends to increase, and the area has the sufficient potential to receive the benefit of the project. In the calculation, the land price increases 5% from 2020 (third year after WWTP operation) to 2022 for continuous three years.

Furthermore, after the year 2023, the annual revenue rate made from property value (land price) is set at 10 %, and the additional increase of 15 % of the said revenue is considered as the influence by the project execution. Thus, based on the original land price, the annual revenue rate at 1.5 % is considered as the incremental benefit from the project execution each year. (refer to Table 7.3.6)

Benefit = "Beneficial area (m^2)" × "Average land price (Baht/m^2)"
× "Escalation rate or annual revenue rate (%)"

c) Cost reduction by reusing the treated wastewater

At present, BMA intends to increase the reuse rate of treated wastewater, which is used mainly for planting and scenery use in park and public area. The average reuse rate during 2008 - 2010 is 3.69% from major 7 WWTPs in treatment amount. The value of treated wastewater reused is considered as the benefit, as considering the reduction of water consumption.

Benefit = “Treatment amount at Nong Bon WWTP (m^3/year)” × “Reuse rate (%)”
× “Water value (Baht/m^3)”

Regarding to the future prediction, BMA plans to increase the reuse rate up to 5 % until 2012, and 10 % in the long term future plan. Following to the BMA’s planning period of every 5 years, the reuse rate is predicted at 7 % during 2013 – 2017, and 10 % after 2018. The unit value of treated water is set at 6.2 Baht/m^3 which corresponds to the half price of average water tariff in 2009 (Annual report of MWA, 2009). (see Table 7.3.6 for more detail)

Table 7.3.6 Summary of Economic Benefits

(unit : Million Baht)

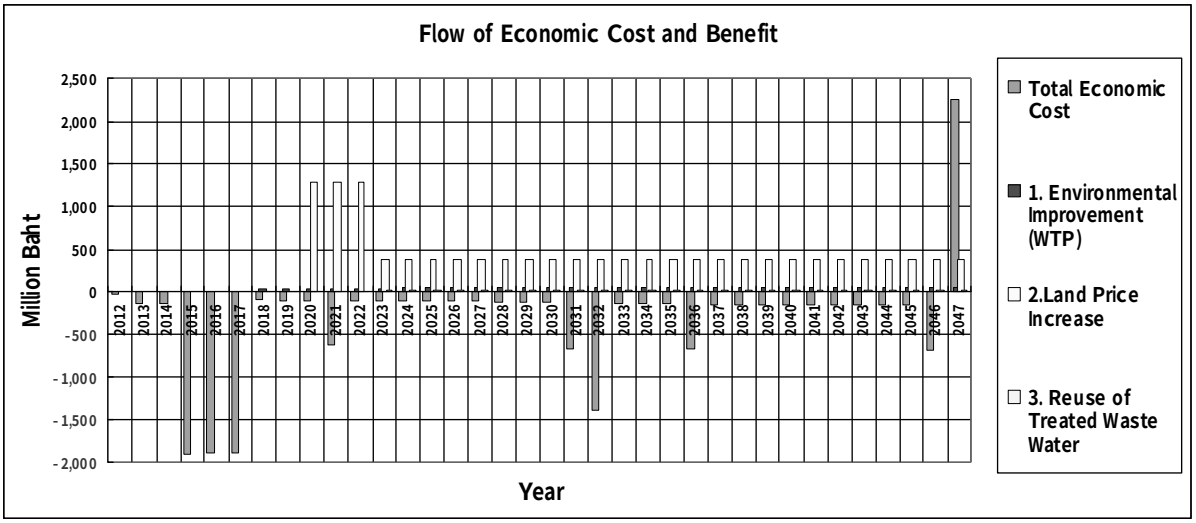
Year		1A. Willingness to Pay	1B. Affordability to Pay	2.Land Price Increase		3. Reuse of Treated Waste Water		Total	
Unit Cost	Number of Beneficial household	73.3Baht/month-household	334Baht/month-household	Increase/Revenue Rate	Average Land price 5,000Baht/m^2	Reuse Percent	Water Value 6.2Baht/m^3	WTP (1A+2+3)	ATP (1B+2+3)
2012	47,077	0.00	0.00	0.0%	0.0	5.0%	0.0	0.0	0.0
2013	47,323	0.00	0.00	0.0%	0.0	5.0%	0.0	0.0	0.0
2014	47,569	0.00	0.00	0.0%	0.0	7.0%	0.0	0.0	0.0
2015	47,816	0.00	0.00	0.0%	0.0	7.0%	0.0	0.0	0.0
2016	48,062	0.00	0.00	0.0%	0.0	7.0%	0.0	0.0	0.0
2017	48,309	0.00	0.00	0.0%	0.0	7.0%	0.0	0.0	0.0
2018	48,555	42.71	194.60	0.0%	0.0	7.0%	13.0	55.7	207.6
2019	48,801	42.93	195.60	0.0%	0.0	10.0%	19.2	62.1	214.8
2020	49,048	43.14	196.60	5.0%	1,290.0	10.0%	19.7	1,352.8	1,506.3
2021	49,309	43.37	197.60	5.0%	1,290.0	10.0%	20.3	1,353.7	1,507.9
2022	49,570	43.60	198.70	5.0%	1,290.0	10.0%	20.8	1,354.4	1,509.5
2023	49,831	43.83	199.70	1.5%	387.0	10.0%	21.3	452.1	608.0
2024	50,092	44.06	200.80	1.5%	387.0	10.0%	21.9	453.0	609.7
2025	50,353	44.29	201.80	1.5%	387.0	10.0%	22.4	453.7	611.2
2026	50,614	44.52	202.90	1.5%	387.0	10.0%	23.0	454.5	612.9
2027	50,875	44.75	203.90	1.5%	387.0	10.0%	23.5	455.3	614.4
2028	51,136	44.98	205.00	1.5%	387.0	10.0%	24.1	456.1	616.1
2029	51,397	45.21	206.00	1.5%	387.0	10.0%	24.6	456.8	617.6
2030	51,658	45.44	207.00	1.5%	387.0	10.0%	25.1	457.5	619.1
2031	51,931	45.68	208.10	1.5%	387.0	10.0%	25.7	458.4	620.8
2032	52,205	45.92	209.20	1.5%	387.0	10.0%	26.2	459.1	622.4
2033	52,478	46.16	210.30	1.5%	387.0	10.0%	26.7	459.9	624.0
2034	52,751	46.40	211.40	1.5%	387.0	10.0%	27.2	460.6	625.6
2035	53,024	46.64	212.50	1.5%	387.0	10.0%	27.7	461.3	627.2
2036	53,298	46.88	213.60	1.5%	387.0	10.0%	28.2	462.1	628.8
2037	53,571	47.12	214.70	1.5%	387.0	10.0%	28.7	462.8	630.4
2038	53,844	47.36	215.80	1.5%	387.0	10.0%	29.2	463.6	632.0
2039	54,118	47.60	216.90	1.5%	387.0	10.0%	29.7	464.3	633.6
2040	54,391	47.84	218.00	1.5%	387.0	10.0%	30.2	465.0	635.2
2041	54,664	48.08	219.10	1.5%	387.0	10.0%	30.6	465.7	636.7
2042	54,937	48.32	220.20	1.5%	387.0	10.0%	30.6	465.9	637.8
2043	55,210	48.56	221.30	1.5%	387.0	10.0%	30.6	466.2	638.9
2044	55,483	48.80	222.40	1.5%	387.0	10.0%	30.6	466.4	640.0
2045	55,756	49.04	223.50	1.5%	387.0	10.0%	30.6	466.6	641.1
2046	56,029	49.28	224.60	1.5%	387.0	10.0%	30.6	466.9	642.2
2047	56,302	49.52	225.70	1.5%	387.0	10.0%	30.6	467.1	643.3
Total	—	1382.03	6297.50	—	13,545.0	—	772.6	15,699.6	20,615.1
NPV(10%)	—	260.95	1189.07	—	3,000.6	—	131.0	3,392.6	4,320.7

Source: JST

7.3.4 Result of Economic Analysis and Sensibility Analysis

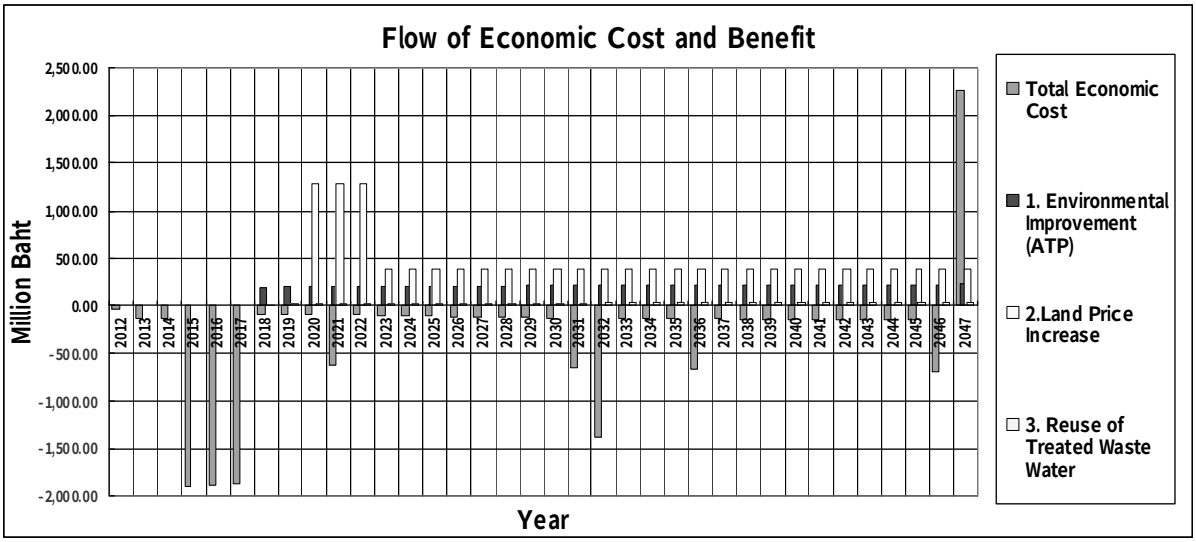
(1) Result of Economic Analysis

The result of economic analysis is indicated as below (refer to Appendix-8 for more detail) .



Source: JST

Figure 7.3.2 Flow of Economic Cost and Benefit (Case1:WTP)



Source: JST

Figure 7.3.3 Flow of Economic Cost and Benefit (Case2:ATP)

Table 7.3.7 Result of Economic Analysis

	EIRR	NPV (D.R.=10.0%)	B/C
Case1: using WTP	4.0%	-1,900 million Baht	0.64
Case2: using ATP	7.2%	-972 million Baht	0.82

Source: JST

The EIRR values become positive at 4.0 % and 7.2 % in each case of applying WTP (Case1) and ATP (Case2) for the environmental improvement. The NPV become –1,900 million Baht and -972 million Baht, and B/C become 0.64 and 0.82 respectively.

The EIRR became lower than 10.0 % in both cases of applying WTP and ATP for environmental improvement benefit. Hence, the project is considered to be not viable in economic view; however, considering the following factors, it is important to execute the project for the society.

- In general, EIRR value tends to be lower for sewerage project.
- Several social benefits are not included in the analysis as the difficulty of economic quantification.

Regarding to the result, EIRR of case1 (using WTP) shows the lower EIRR than case2 (using ATP). Theoretically, it is believed that the WTP value becomes close to the ATP amount as the user's understanding deepens. Hence, the education/enlightenment activity should be conducted to increase the social benefit.

(2) Result of Sensitivity Analysis

The sensitivity analysis is executed in case of the 10% benefit reduction, 10% cost increase, and both cases occurs at the same time. The result of every cases are summarized in the below table.

Table 7.3.8 Summary of Sensibility Analysis

	Condition	EIRR	NPV (D.R.=10.0%)	B/C
Case1 (using WTP)	A: Base case	4.0%	-1,900 million Baht	0.64
	B: Benefit－10%	2.8%	-2,240 million Baht	0.58
	C: Cost＋10%	2.9%	-2,430 million Baht	0.58
	D: Benefit－10%, Cost＋10%	1.7%	-2,769 million Baht	0.52
Case2 (using ATP)	A: Base case	7.2%	- 972 million Baht	0.82
	B: Benefit－10%	5.8%	- 1,404 million Baht	0.73
	C: Cost＋10%	5.9%	- 1,502 million Baht	0.74
	D: Benefit－10%, Cost＋10%	4.7%	- 1,934 million Baht	0.67

Source: JST

The 10% benefit reduction and 10% cost increase affect the similar impact on the EIRR and NPV. In conclusion, to maintain the benefit higher, the education activity should be done sufficiently as mentioned before. For avoiding the cost increase, prudent budget/schedule control and cost economization during operation period is expected.

7.4 Financial Analysis

In this Section, the financial analysis is conducted to evaluate the financial viability of the project. The future revenue and expenditure is predicted for both "With Project" and "Without Project", and the difference between these situations are analyzed as using Financial Rate of Return (FIRR) and Net Present Value (NPV).

7.4.1 Basic Assumptions

The analysis is conducted based on the assumptions below.

(1) Assumption of "With Project" and "Without Project"

"With Project"

The construction of Nong Bon WWTP and Interceptors are completed following to the planned period. The planned treatment amount is 90,000 m^3/day (FS phase) before 2017, and it is extended 22,500m^3/day each time, in the year 2021 and 2031 respectively. Owing to the mentioned project execution, the water quality of klongs located in the project area will be improved, and the welfare of dwellers living in the area will be improved simultaneously.

"Without Project"

The present condition of wastewater elimination facility is maintained. The water quality in klongs in the Nong Bon Area will worsen as the wastewater discharged to the public water bodies increases.

2) Evaluation Period

The evaluation period is set for 36 years which includes 6 years of preparation/construction period during 2012 - 2017, and 30 years after starting the WWTP operation during 2018 - 2047.

3) Cost of Initial Construction and O&M

The cost of initial construction and O&M is estimated based on the price as of October 2010 excluding any tax. Physical contingency is included in the estimated cost, and the price contingency is excluded from the estimate.

4) Financial Viability of the Project

The 3.13 % of FIRR is used as the criteria for judging the financial viability of the Project. The figure is obtained by excluding "CPI rate of 2.72 % in 2010" form the "average rate of minimum interest rate of commercial banks in 2010 at 5.94 %". (Source: Bank of Thailand)

7.4.2 Financial Cost

The initial investment cost and O&M cost are indicated.

(1) Initial Investment Cost

In case the Project is executed (With Project)

In the previous chapter 5, two alternatives of different interceptor constructing phases are mentioned. Only the alternative case of single construction phase (base case) is used for the analysis as the final results of both alternatives become almost the same. The disbursement schedule of initial investment cost for base case is shown in the Table 7.4.1. Depending on the governmental subsidy amount and the usage of Japanese ODA loan, five alternative cases are made as indicated in the Table 7.4.2.

Table 7.4.1 Disbursement Schedule of Initial Investment Cost (Financial Cost)

(Million Baht)

	2012	2013	2014	2015	2016	2017	Total
Local Currency	24.4	103.5	103.3	1,446.2	1,435.1	1,423.5	4,536.0
Foreign Currency	2.0	33.7	33.6	571.1	566.8	562.4	1,769.6
Total	26.4	137.2	136.9	2,017.3	2,001.9	1,985.9	6,305.6

Source: JST

Table 7.4.2 Alternative Cases of Initial Investment Cost

Cost Alternatives	Initial Investment Cost (2015-17)		
	BMA budget	Government Subsidy	JICA ODA loan repayment (*)
Alternative 1 : Full Cost Recovery	100%	0%	-
Alternative 2 : 40% Subsidy	60%	40%	-
Alternative 3 : 60% Subsidy	40%	60%	-
Alternative 4 : Only O&M Cost	0%	100%	-
Alternative 5 : Full Cost Recovery using ODA loan	15%	-	85%

Note: The condition of JICA ODA loan; Repayment period : 40 years, Grace period : 10 years, Interest rate : 0.65%, The repayment of the final year is set for 5years amount as the evaluation period is set at 36 years.
The above condition is only applied to the initial construction cost, and the costs of capacity extension, replacement, and residual value become the same as explained below for all alternatives.

Source: JST

The capacity extension cost, replacement cost and residual value are calculated following to the assumptions below;

- The replacement of equipment facility (1,249.9 million Baht) out of initial investment cost is executed in 15 years.
- The capacity extension construction of WWTP of 22,500 m^3/day which costs at 539.8 million Baht is executed in 2021, and 2031 respectively to meet the increase of

inflow. The whole mentioned construction cost is considered as the equipment cost, and the replacement (100 % of cost) is executed 15 years later.

- The residual value of facilities is put at the final year as the benefit. The life period of concrete facility and building (the whole facility cost except for equipment cost) is set at 50 years, and that of equipment is set at 15 years.

In case the Project is not executed (Without Project)
The initial investment cost is not charged.

(2) Operation and Maintenance (O&M) Cost

In case the Project is executed (With Project)
The same as the O&M cost prediction in economic analysis chapter, the average unit O&M cost of 3.41Baht/m^3 is used for the calculation. Refer the previous Table 7.3.3 for more detail.

In case the Project is not executed (Without Project)
The O&M cost is not charged as the treatment itself is not conducted at the area.

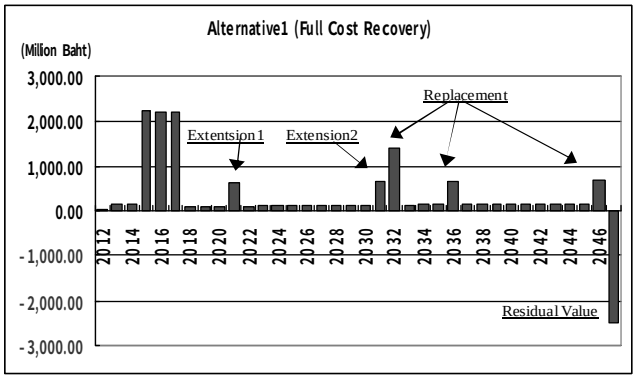
The whole costs including construction cost (initial investment cost, extension cost, replacement cost, and residual value) and O&M cost of every alternative is shown in the following Figures. (see the Appendix 8, Table 8.3 for more detail)

Introduction of PPP scheme

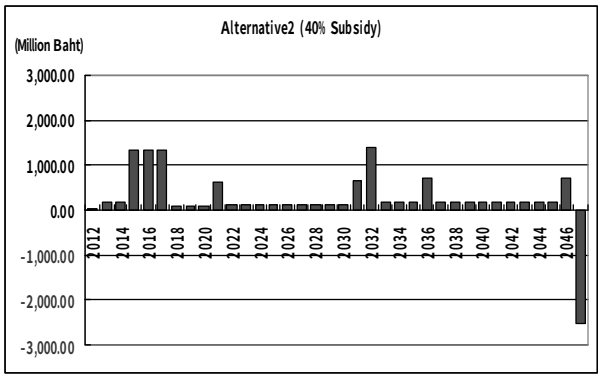
BMA is planning to apply the PPP (Public Private Partnership) scheme project in the future for improving the work efficiency. The Survey Team simulated the alternative case (Alternative-6) of applying BOT (Build Operate Own) scheme for Nong Bong Project as assuming BMA pays annual service charge for 30 years (2018 - 2037) contract period to cover the capital and O&M cost based on the mentioned cost condition. The calculation result is shown in the table of Appendix 8.

It is concluded that BMA needs to pay 710.5 million Baht every year to make the operator's cash flow positive after 30 years. The amount excesses the planned revenue amount, and the subsidy or scheme reduction is needed to make the project sustainable. Even the tariff collection has not been started at present in Bangkok, so the application of PPP scheme is considered as premature. Moreover, the above simulation does not include the expected work efficiency improvement and cost reduction derived from innovative design and etc., the more detail evaluation should be conducted in the future study.

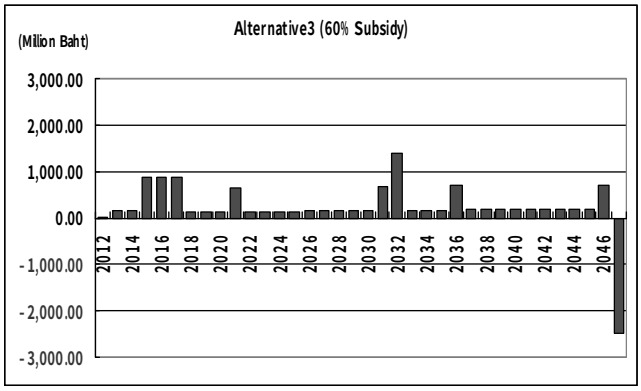
Alternative 1 : Full Cost Recovery



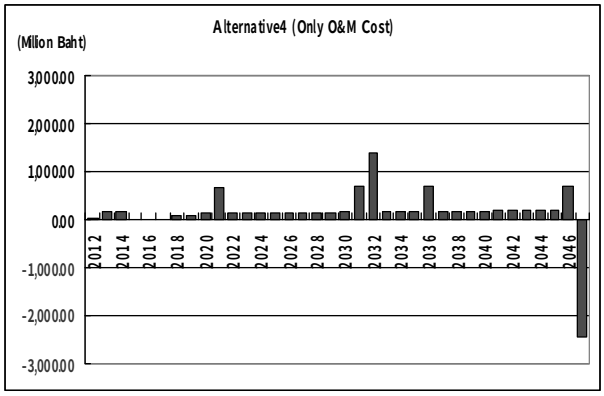
Alternative 2 : 40% Subsidy



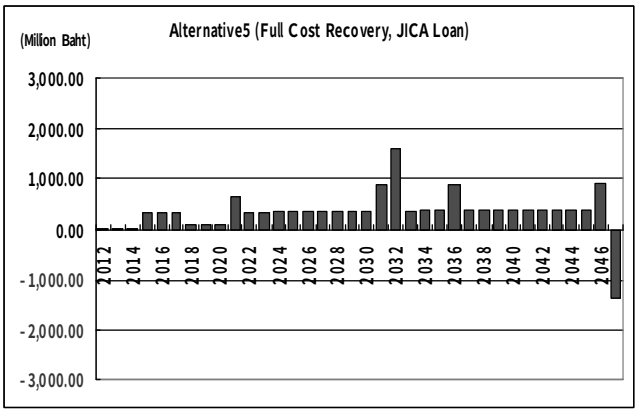
Alternative 3 : 60% Subsidy



Alternative 4 : Only O&M Cost



Alternative 5 : Full Cost Recovery using ODA loan



Source: JST

Figure 7.4.1 Cost Alternatives

7.4.3 Revenue Prediction

Regarding the revenue prediction, the revenue water amount is calculated based on data obtained from MWA (refer to Table 5.3.1 in M/P Report). The present planned wastewater tariff system indicated in the Table 7.2.1 is applied for the analysis. The average tariff is obtained by using the average tariff of both household category (2.00 Baht/m^3) and commercial category (2.37 Baht/m^3), referring to the consultant report in 2010. The average tariff of whole Nong Bon area becomes 2.22 Baht/m^3 as considering the category composition (household 16,216,409 m^3, commercial 24,324,614m^3).

In the Nong Bong project area, the wastewater tariff collection is assumed to be started from the year 2018 when the treatment starts. The annual revenue is calculated as multiplying the annual water consumption amount and the average tariff. The tariff collection rate (revenue amount / billed amount) of 99.2% is applied to the calculation, from the historical average data from October 2010 to April 2011.The revenue water amount is set at constant after the year 2041, as the treatment capacity is saturated in this year based on the demand and supply prediction.

Three alternatives are made for wastewater revenue prediction. The starting year of the tariff charge in the present treatment area is set at the year 2012 for all alternatives. As BMA decided to adjust the tariff rate every five years in the master plan, the simulation is made based on this condition. The tariff increase rates are set at 10, 20 and 30% every five years in alternatives 1 to 3 respectively. In the real monetary term, the tariff should be adjusted regarding to the inflation rate, additional to the mentioned prediction.

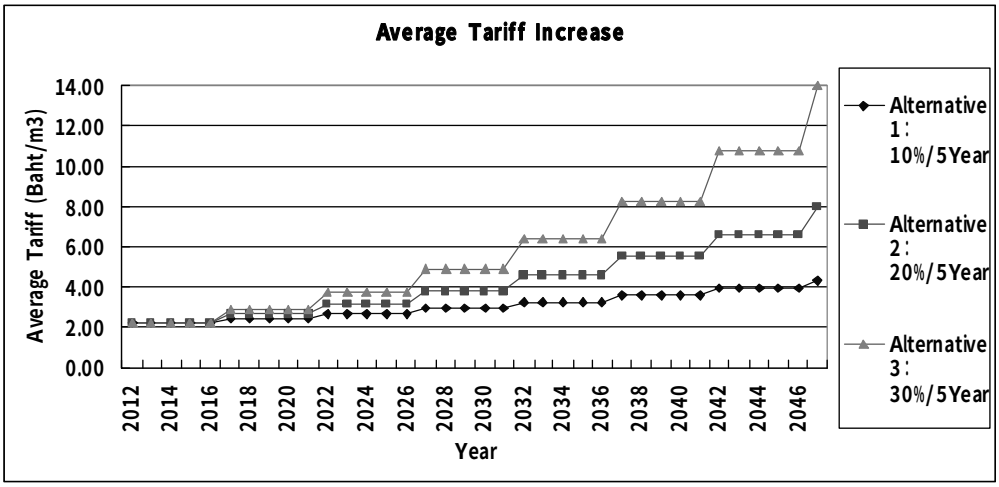
Even more, the tariff collection charge will be paid to MWA from BMA, and the rate of 3.5 Baht/month (42 Baht/year, 10 Baht only for the beginning month) for total connection number. The connection is forecasted to be approximately 70,000 in 2012 and, and assumed to be increasing 0.5% each year afterward corresponding to the water consumption amount.

Table 7.4.3 Revenue Prediction Alternatives

	Tariff Start Year	Tariff Increase Rate of Every 5 years
Alternative 1: 10% / 5 years	Year 2012	10%
Alternative 2: 20% / 5 years		20%
Alternative 3: 30% / 5 years		30%

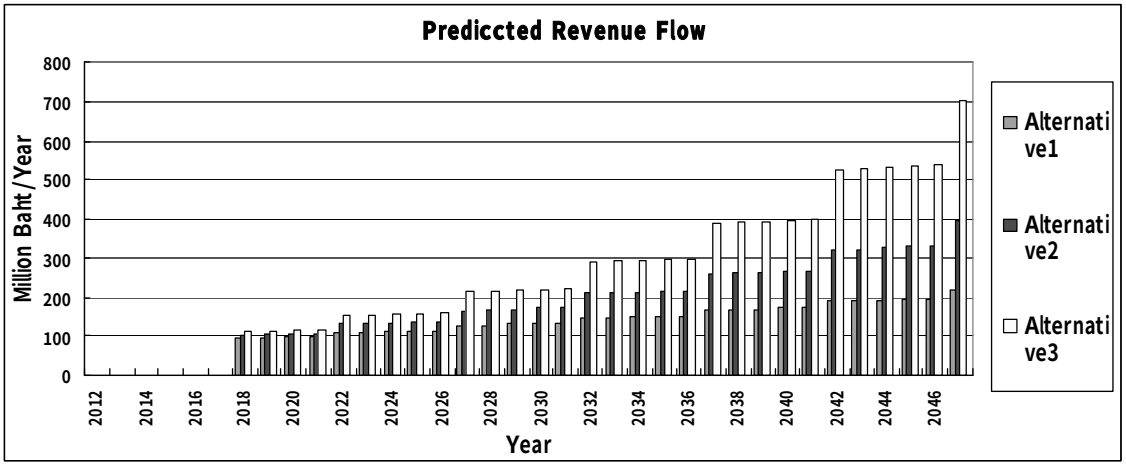
* Influence of price inflation is excluded form the analysis
Source: JST

The average tariff level and predicted revenue of whole alternatives are indicated in the following figures.



Source: JST

Figure 7.4.2 Predicted Average Tariff Rate of All Alternatives (Baht/m^3)



Source: JST

Figure 7.4.3 Predicted Revenue Amount of All Alternatives (Million Baht)

7.4.4 Result of Financial Analysis

As analyzing the "5 cost alternatives" x "3 revenue alternatives", the result of each alternative cases are shown below as using FIRR and NPV of discount rate of 0 % and 3.13 % (refer to Appendix 8, Table8.5 for the detail cash flow).

Table 7.4.4 Result of Financial Analysis

FIRR			Revenue		
			Alternative1	Alternative2	Alternative3
			10%/5years	20%/5years	30%/5years
Cost	Alternative1	BMA 100%, Subsidy 0%	-5.7%	-3.8%	-1.7%
	Alternative2	BMA 60%, Subsidy 40%	-4.8%	-2.6%	-0.3%
	Alternative3	BMA 40%, Subsidy 60%	-4.2%	-1.8%	0.8%
	Alternative4	BMA 0%, Subsidy 100%	-2.1%	1.6%	5.9%
	Alternative5	BMA15%, ODA Loan 85%	-17.7%	-11.7%	-5.5%

NPV (Discount Rate =0%)			Revenue		
			Alternative1	Alternative2	Alternative3
			10%/5years	20%/5years	30%/5years
Cost	Alternative1	BMA 100%, Subsidy 0%	-7,675.7	-5,743.5	-3,002.2
	Alternative2	BMA 60%, Subsidy 40%	-5,027.7	-3,095.5	-354.2
	Alternative3	BMA 40%, Subsidy 60%	-3,703.8	-1,771.6	969.7
	Alternative4	BMA 0%, Subsidy 100%	-1,055.8	876.4	3,617.7
	Alternative5	BMA15%, ODA Loan 85%	-8,494.5	-6,562.3	-3,821.0

NPV (D.R.=3.13%)			Revenue		
			Alternative1	Alternative2	Alternative3
			10%/5years	20%/5years	30%/5years
Cost	Alternative1	BMA 100%, Subsidy 0%	-7,125.3	-6,247.5	-5,033.4
	Alternative2	BMA 60%, Subsidy 40%	-4,783.4	-3,905.6	-2,691.5
	Alternative3	BMA 40%, Subsidy 60%	-3,612.6	-2,734.8	-1,520.7
	Alternative4	BMA 0%, Subsidy 100%	-1,270.7	-392.9	821.2
	Alternative5	BMA15%, ODA Loan 85%	-5,182.2	-4,304.4	-3,090.3

Source: JST

FIRR value becomes positive under the condition of receiving 60 % of government subsidy (cost alternative 3) if the tariff rate is increased 30 % every five years (revenue alternative 3). Also under the condition that 100 % of initial cost is covered by government subsidy (cost alternative 4), FIRR becomes positive by revenue alternative 2 (20 % increase / 5 years), and exceeds the criteria figure of 3.13 % by revenue alternative 3 (30 % increase / 5 years). Only in this best case, the financial viability is guaranteed as the FIRR exceeds the criteria of 3.13 %.

In contrast, for the full recovery cases (both cost alternative 1 and 5), the NPV does not become positive even the tariff increase rate is as high as 30 % per 5 years. It means the achievement of full cost recovery is quite difficult if the present planned tariff rate is applied at the beginning of the tariff collection.

By realistic way, the wastewater charge should be started as soon as possible, and the tariff should be increased 10–20 % every 5 years for achieving the stable wastewater service. In this

condition, the revenue becomes ideal, and it can cover approximately half of the whole operating expenditure (including O&M cost and investment cost).

As considering the previously mentioned situation about the charge collection in Thailand, starting the wastewater tariff collection itself is difficult. There will be a possibility of social opposition by users if BMA intends to increase the tariff rate drastically at the every tariff adjustment time. Hence, BMA needs to prepare the best mitigation way to alleviate their protest, such as executing the education/enlightenment activity about wastewater treatment, and increase the user's satisfaction by service improvement.

8. OVERALL EVALUATION AND RECOMMENDATIONS

Nong Bon treatment area has been selected as project area of the priority project under Preparatory Survey for Bangkok Wastewater Treatment Project, and feasibility study has been conducted. In this Chapter, the priority project is evaluated from various aspects such as technical, economic and financial, socio-environmental and institutional aspects.

8.1 Evaluation from Various Aspects

(1) Evaluation from Technical Aspect

Sewerage system proposed in the study is to intercept wastewater flowing in the existing drainage pipes which is currently discharged to klongs. This system is called as "Thai combined sewerage system". Approximately 80 % of the wastewater generated in the area can be collected based on the result of analysis of actual inflow to the existing WWTPs.

There is no particular problem about construction of interceptors and interceptor chambers since the same method and structure of the existing facilities (construction of interceptors under roads and klong by pipe jacking method) are adopted.

Compact type WWTP is proposed because of the limited land area for the construction of WWTP with large design capacity. Carrier added activated sludge process (CAAS) is proposed as most suitable process to satisfy the requirements. This process is quite popular in Japan, but quite new in Thailand. Therefore, a technical seminar was held to enhance knowledge of DDS staff. Various treatment technologies including those for nutrient removal (N and P) have been adopted in BMA. CAAS process is basically modification of conventional activated sludge process, and with provision of adequate information and training, it is possible for DDS to construct and operate WWTP.

On the other hand, there are various problems in Thai combined sewerage system (low concentrations of inflow, reduction of outlets of drainage system, introduction of pumping drainage area, collection of wastewater currently discharged to klongs). For the development of sewerage system in BMA, these problems should be resolved.

(2) Evaluation from Economic and Financial Aspect

As a result of economic analysis, EIRR figures become positive at 4.0 % and 7.2 % for two cases of benefit, i.e. benefits based on willingness to pay (WTP) and affordability to pay (ATP). These two figures are lower than 10 % which is the threshold to evaluate a project as

socio-economically viable. However, it is difficult to quantify benefits due to implementation of sewerage project. It is feasible to implement the project taking into account unquantified benefits and necessity as social infrastructure.

As a result of financial analysis, positive FIRR figures are obtained in cases government subsidy 60 to 100 % and wastewater tariff is increased by 20 to 30 % every 5 years, which assure financial feasibility of the project. However, in any cases to realize full cost recovery, no positive NPV was obtained. It means that if collection of wastewater charge is started with planned tariff structure, it is very difficult to realize full cost recovery.

In conclusion, it is considered realistic for stable and sustainable wastewater services by BMA that wastewater charge should be collected as soon as possible and should be increased by 10 to 20 % every 5 years to cover approximately half of the operation and maintenance cost including depreciation of initial cost.

However, currently in Thailand sewerage service charge is collected in a few areas. Therefore it is difficult to start collection in BMA. Also it might be difficult for BMA to continually increase the tariff even if collection of charges is started as project is implemented smoothly.

(3) Evaluation from Socio-Environmental Aspect

It is determined that any negative impacts for which particular attention should be paid, such as involuntary resettlement of residents, local economy such as employment and livelihood etc., occurrence of secondary contamination, disappearance of and damage to cultural properties and heritage and effect of natural reservation areas do not occur due to implementation of the project. In conclusion, although there is no significant impact due to the implementation of the project, some adverse impacts (slight negative impacts) are envisaged at construction and operation stages, for which mitigation measures and monitoring plan are necessary.

On the other hand, this project contributes to improve water environment and water quality in klongs by collecting and treating wastewater, resulting in enhancement of living conditions of residents and development of social infrastructures.

(4) Evaluation from Institutional Aspect

DDS has experience of implementing of large sewerage projects in the past, and manages 5 WWTPs through management contracts. Therefore DDS has enough capability to implement and manage the project.

However, if external loan is required for the implementation of the project, management

capability of DDS to handle external fund should be strengthened. Also, suitable training should be provided to staff of DDS to maintain and enhance their technical competence as operation and maintenance of the WWTP will be outsourced.

At present, responsibilities of sewerage services are fragmented into a few agencies in BMA, e.g. construction and operation and maintenance of interceptors and WWTPs by DDS, and existing drainage pipes and house connections by PWD or district office. These fragmented responsibilities should be brought into one agency, i.e. DDS for more efficient achievement of aims, enhancement of functions and proper management of the system. Sewerage ordinance should be stipulated in this regard.

With the measures mentioned above, DDS is strengthened, competence of its staff and DDS management capability are further enhanced.

8.2 Overall Evaluation and Recommendations

(1) Overall Evaluation

It is judged that the project is feasible from various aspects as mentioned above. Water environment and living conditions in Nong Bon treatment area will be improved and residents will receive benefits due to the implementation of the project.

However some issues should be dealt with for more efficient and effective implementation of the project, such as i) technical issues related to combined sewerage system, ii) economic and financial issues, e.g. collection of wastewater tariff, and iii) close cooperation between agencies concerned with sewerage system. These issues can be dealt with by adopting measures proposed in this report and with strategic and administrative efforts by BMA or DDS.

(2) Performance Indicators for Effects of the Project

In case loan is required for the project, lender usually evaluates effects of the project after completion. Appropriate performance indicators including those mentioned below should be utilized for this purpose. Performance indicators such as increase of served population or treatment area are not suitable since the project collects wastewater from areas where pipes are already provided.

Operation

- Ratio of marginal wastewater treatment capacity
- Ratio of actual characteristics against design characteristics (BOD)
- Compliance with discharge standard (BOD)

- Compliance with targeted water quality standard for water body (BOD)
- Ratio of treated wastewater reuse

Management

- Ratio of revenue water: Total revenue water/Total wastewater treated
- Unit wastewater unit O&M cost (O&M): Wastewater unit O&M cost(O&M)/Total accounted for water
- Cost covering ratio (O&M): Service charge revenue/Wastewater unit O&M cost x 100

(3) Recommendations

The following recommendations are made based on the evaluation mentioned above.

1) The project should be implemented as soon as possible since the project area will be developed as good residential areas and improvement of water environment and living conditions are required.
2) Issues related to Thai combined sewerage system should be dealt with for more efficient and effective implementation of the project.
3) Sewerage service charge should be collected to realize stable and sound management of the sewerage system. Activities to enhance public awareness for current water pollution and improvement measures should be undertaken to obtain residents' understanding.
4) Investigation of the existing drainage pipes should be conducted with cooperation with agencies concerned, with the aim to bring fragmented responsibilities of sewerage system into one agency. In addition sewerage ordinance should be stipulated.
5) Strengthening of project implementing agency and capacity building program for the staff of the agency should be conducted for smooth implementation of the project.

Finally, the following soft components which are necessary for implementation of the project are recommended.

Training

1) Training on improvement measures for combined sewerage system and on pollution load reduction technologies in wet weather
2) New treatment technology which can be applied to compact facilities and energy recovery technology at WWTP
3) Training and capacity building program for staff for construction management, management of external fund and management of sewerage system

Management Improvement Program

1) Improvement of interceptor sewerage system
2) Inventory investigation of existing drain pipes
3) Institutional set up for exceptional area where provision of septic tank is exempted
4) Introduction of PIs
5) Stipulation of sewerage ordinance

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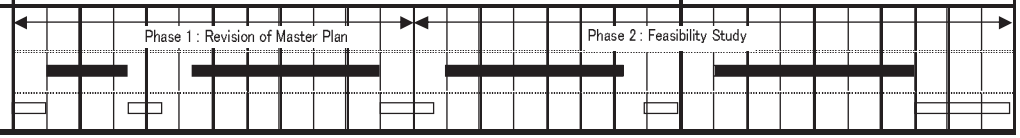
Appendix 1-2

1) Manning Schedule

Position	Name	Organization	2010 MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	2011 JAN	FEB	MAR	APR	MAY
Team Leader/Water Pollution Control	MIYAMOTO MASAFUMI	TOKYO ENGINEERING CONSULTANTS Co., Ltd.		(40)			(42)			(40)				(38)	(25)		
Sector Development Strategy/Legal System	INOUE YAKURO	NIPPON KOEI Co., Ltd.		(30)			(50)										
Sewerage Planning	TAKAHASHI HARUKI	TOKYO ENGINEERING CONSULTANTS Co., Ltd.		(40)			(22)		(30)		(21)	(20)			(72)		
Sewer and Pumping Station Design	KAJIURA TAKEKI	NIPPON KOEI Co., Ltd.					(60)				(49)				(56)		
WWTP Design/Water Quality Analysis	IZUMI KUNIMASA	TOKYO ENGINEERING CONSULTANTS Co., Ltd.		(30)					(46)		(35)					(39)	
Mechanical and Electrical Facilities Design	MISAWA YOSHINORI	TOKYO ENGINEERING CONSULTANTS Co., Ltd.									(28)				(39)		
Cost Estimation/Construction Planning	TANAKA NORIO	TOKYO ENGINEERING CONSULTANTS Co., Ltd.									(34)				(39)		
Organization and Business Management	NURUL ISLAM	NIPPON KOEI Co., Ltd.					(30)								(30)		
Economic and Financial Planning	MURAKAMI TAKESHI	NIPPON KOEI Co., Ltd. (KRI International Corp.)													(60)		
Environmental Assessment/Water Pollution Analysis	KAWACHI MASAHIRO	TOKYO ENGINEERING CONSULTANTS Co., Ltd.		(30)				(30)			(31)					(29)	
Report	Submission		△ IC/R			△ P/R		△ IT/R1	△ IC/R2				△ IT/R2			△ DF/R	△ F/R



Remarks: On-site Work

Home Work

2) DDS Working Group Member List

คณะทำงานสนับสนุนโครงการ Preparatory Survey for Bangkok Wastewater Treatment Project

ชื่อ-สกุล	Name	Position
1. นางสุทธิมล เกษสมบูรณ์	Mrs.Suthimol Kessomboon	Sanitary Engineer 8
2. นางจันทนา ริรัตนพงษ์	Mrs. Chantana Rirattanapong	Scientist 7
3. นางสาวเกศรัชฎา กลั่นกรอง	Ms.Katerachada Klankrong	Sanitary Engineer 7
4. นายกฤชภัทร ยินหิรัญ	Mr.Kitchapat Yinhirun	Civil Engineer 7
5. นายปธาน บรรจงปรู	Mr. Pathan Banjongproo	Sanitary Engineer 6
6. นางสาวโสภา บุราไกร	Ms. Sopa Burakrai	Sanitary Scientist 6
7. นายโอภาส แสงทองประกาย	Mr. Opas Seangtongprakay	Sanitary Scientist 6 Chonnonsi WWTP
8. นายประชา แก้วปรางค์	Mr. Pracha Kaewprang	Sanitary Scientist 6 Chatuchark WWTP
9. นายทรัพย์สิน นนสุราช	Mr. Supsin Nonsurach	Sanitary Scientist 6
10. นายศักดา ประยงค์หอม	Mr. Sakda Prayonghom	Civil Technician 6
11. นายฉมาพรรณ มาศจร	Mr. Chamaphan Masjorn	Sanitary Scientist 4
12. นายธีระสันต์ อมรสิน	Mr. Theerasan Amonsin	Sanitary Scientist 3

3) Discussion Record on F/S

Time and date: 14:00, September 27 (Mon.)

Place: 6F, DDS

Participants:	(DDS Working Group)	(JICA Survey Team)
	Ms. Suthimol Kessomboon	Mr. Masafumi Miyamoto
	Ms. Katerachada Klankrong	Mr. Haruki Takahashi
	Mr. Chamaphan Masjorn	Mr. Kunimasa Izumi

The following points were discussed on the Phase 2 Survey (F/S) from October.

1. Data collection on Nong Bon Treatment Area

Survey Team asked Working Group to cooperate in collecting data on Nong Bon Treatment Area, as follows;

(1) Conditions on WWTP site (Dr. Pathan is in charge)

- Building control/regulation (height, underground and so on)
- Approach road to WWTP
- Effluent discharge route and water body (klong, pond or drainage tunnel: wet & dry season)
- Existing topographical and geotechnical investigation data (level data, boring data and benchmark)

(2) Condition on WWTP design (Ms. Sripat in Information Center is in charge)

- Influent characteristics (Average BOD is 100 mg/l and Maximum BOD is 150 mg/l)
- Effluent characteristics (more stringent water quality in national and BMA standards are applied)
- Operation and maintenance of WWTP (refer to attached “Request relating to WWTP”)

(3) Conditions on main roads, klongs and drainage system in the Area (Mr. Chamaphan is in charge)

- Topographical and geotechnical data of existing road and klong (level, water depth and boring data)
- Existing drainage system (location on map, diameter, length, depth and so on)
- Large underground facilities data (electricity, water supply and so on)

(4) Cost and price data (Mr. Krichapat and Mr. Prada are in charge)

- Construction cost of interceptor and pipeline to make cost function, including jacking method and shield tunneling method
- Cost and price data related to cost estimation (refer to attached “Price inquiry list” and ”Cost

estimation"). This may be partly available via website of Ministry of Trade, Thailand.

2. Public awareness survey and stakeholder meeting (Ms. Sopa is in charge)

Survey Team explained the schedule of public awareness survey in October and 1st stakeholder meeting at the beginning of November.

Ms. Suthimol suggested that the timing of the 1st stakeholder meeting is not suitable, because it is necessary to explain the outline main facilities of Nong Bon Sewerage System at the first stakeholder meeting.

Survey Team agreed to her suggestion and proposed the 1st stakeholder meeting will be postponed in January 2011 with JICA's consent.

3. Additional data collection on ITR (Dr. Pathan is in charge)

Survey Team asked Working Group to cooperate in collecting the following data to finalize Interim Report.

(1) Budget and expenditure (settlement of accounts) of DDS/BMA in each field from 2001 to 2010
(2) Independent industrial water resource apart from water supply by MWA, which is own ground water use in urbanized area and the outskirt in BMA.

Working Group will nominate some members in each theme mentioned above to cooperate with Survey Team.

4) 2nd Steering Committee Meeting Report

Meeting Report 2/2553
The Preparatory Survey for Bangkok Wastewater Treatment Project
Date September 30nd B.E. 2553 10.00-12.00
Nopbhand Room, Drainage and Sewerage Department
3th Floor , Bangkok City Hall 2

Committees who has joined the meeting

1. Mr. Chanchai Vitoonpanyakit — Deputy Chair person
   Inspector General, Office of the Permanent Secretary for the BMA)
2. Mr. Thammanat Chunsano — Committee
   Deputy Director of Drainage and Sewerage Department
   (for Water Quality Management Office)
3. Assoc. Prof. Sutchai Champa — Committee
   Sanitary Engineer Expert
4. Assist. Prof. Boonyong Lowongwat — Committee
   Sanitary Engineer Expert
5. Ms. Darunee Supanai — Committee in charge
   On behalf of Director of Economic and Fiscal Office (Committee)
   Department of Finance
6. Ms. Suwannee Phusuwan — Committee in charge
   On behalf of Director of Legal and Litigation Office (Committee)
   Office of the Permanent Secretary for the BMA
7. Ms. Ammaraporn Jitpraphai — Committee in charge
   On behalf of Director of Drainage Information System Division (Committee)
   Drainage and Sewerage Department
8. Mr. Chainat Niyomtooon — Committee and Secretary
   Director of Water Quality Management Office
   Drainage and Sewerage Department
9. Ms.Suthimol Kessomboon — Committee and Assist. Secretary
   Water Quality Management Office
   Drainage and Sewerage Department
10. Ms.Kate-rachada Klankrong — Committee and Assist. Secretary
    Water Quality Management Office
    Drainage and Sewerage Department

Participants who has joined the meeting

1.	Mr. Miyamoto	Masafumi	JICA STUDY TEAM
2.	Mr. Takahashi	Haruki	JICA STUDY TEAM
3.	Mr. Izumi	Kunimasa	JICA STUDY TEAM
4.	Ms. Marisa	Kanchana	Economic and Fiscal Office (BMA)

Committees who was absent from the meeting

1. Mr. Chatinai Nauwaphut — Chair Person
   Deputy Permanent Secretary (For Department of Drainage and Sewerage)
2. Mr. Sunya Chinimit
   General Director Department of Drainage and Sewerage — Committee

Begin at 10.00

Period 1 : Introduction for meeting

Acting chair committee (Mr. Chanchai) has explained to the committee that Mr. Chatinai (Chair Person) has another official appointment, so Mr. Chanchai will be the acting chairman.

Result : The committee and participants noticed and accepted

Period 2 : Discussion of the Inception report

The JICA study team has proposed the progress task of the Interim Report "Preparatory Survey for Bangkok Wastewater Treatment Project." and the discussions are as follows.

1. The Steering committees suggest that the conventional (combined) Sewage System is not suitable for BMA because the wastewater has low BOD concentration which leads to high energy consumption and another question is how Japan can solve the problem of low BOD in wastewater and the definition of 3W wastewater (WWW).

The JICA study team declared that in Japan the wastewater treatment plant was designed in smaller size and smaller service area. BMA Wastewater is a 5 unique system with a lot of interceptors and very light capacity. The may leads to high rate of infiltration and lower BOD concentration. For about "3W-Wet Weather Wastewater" is Japanese terms to explain very low BOD concentration occurred after heavy rainfall. The wastewater can be treated by special AS system.

2. The special AS System is such as the "Step feed Aeration" and by design optimum size of aeration tank, the problems of law BOD can be avoided. Also the optional design for such low BOD and SS wastewater are design of WWTP without primary settling tank, using limiting area SBR or Modified Activated Sludge or Membrane System but for the Membrane designer must consider about the unstable of influent wastewater quality.

3. The steering committee suggested that the vicinity at outfall should be designed in harmonized with the public park and beautiful landscape.The outfall structure should be dual drainage options, in dry screen the effluent should be discharge to dilute canal water and to help improve water quality, in rainy season the effluent can be diverted in to Nong bon Reservoir to help reduce drainage capacity of the canal system

4. Chairman has given opinion that the water supply statistics BKK should be higher than 75% (of total MWA) as the JICA study team has presented. The JICA study team said the data was obtained from MWA as separated by branch office area respectively. It was clear for most of area, only Prakanong and Thonburi branch office have the common service area in Bangkok and Samutprakarn. Both of areas can be analyzed and the presented result is reasonable. Anyway Mr.Chairman said the information is critically important and should be rechecked for the certainty.

5. Ms.Supanai D. on behalf of department of finance, BMA has given advice that the study team should present the detail of financial analysis on the three options.

5.1 BMA and Central Government of Thailand invest together

5.2 Soft Loan from JICA, ADB, AFD or the others

5.3 Public Private Partnership (PPP)

Practically, JICA study team have to do the risk assessment on both the financial and technical issues especially in case that government join with private.

6. About the Wastewater Service Area Zoming in the year of 2040 and the Nongkhaem and Tung Kru WWTP which are propored to be expanded , the committee has question on the period of prediction if it is too long or not. Because too long prediction period can lead to higher deviation. The study team has the same opinion that this study is just a master plan that should be revised in every 5-10 years for better solution.

7. The committee offer to the chairman that in strategy 1.2 can not be practically applied.

Consent of Meeting : the study team should have to concern about all suggestion and let this to be implemented.

Period 4 : others

The JICA study team has submitted the plan to do the feasibility study on Non bon Wastewater Project which is as follows

- Area of Study
- Waste Water Treatment Technology (Process and Option)
- Social and Economy study
- Priority of Project
- Cost Estimation and Construction Plan
- Economical Analysis
- Social and Environmental Study

Consent of Meeting : Informed and Accepted

Meeting Closed at 12.00

Recorded by Chamaphan Masjorn
(Mr.Chamaphan Masjorn)

Translated by Pathan Banjongproo
(Mr.Pathan Banjongproo)

Approved by Suthimol Kessomboon
(Ms.Suthimol Kessomboon)

5) Discussion Record on Conditions of Feasibility Study

Time and date: 9:30, October 22, 2010 (Fri.)

Place: 4F, the Office of Prawet District

Participants:

(Prawet District)	(DDS Working Group)	(JICA Survey Team)
Mr. Supakit Patralarp	Dr. Pathan Banjongproo	Mr. Masafumi Miyamoto
(Chief of Public Work – Pravate)	Mr. Chamaphan Masjorn	Mr. Haruki Takahashi
		Mr. Takeki Kajiura
		Mr. Natjanapong Pimpin

The following points were discussed related to the condition of Feasibility Study.

1. Existing drainage network in Prawet District

   Mr. Supakit gave study team the existing drainage network map which the team asked to make.

2. Conditions of WWTP design

   a. The height of WWTP should not be higher than 15 meters as mentioned in the Ordinance of City Planning. The information can be reviewed from the reference at the end.

   (Note) A building of four divisions (Machinery, Canal System, Drainage Control Structure System and Sewer System Division) of DDS is under construction, which is 21 meters high. They got permission from the Foundation Suan Luang ROR9 together with Public Park Office, Department of Environment, BMA.

   b. The WWTP can be built underground and expanded to the area of Nong Bon Pond without any reduction of pond volume.
   Inlet pipe and effluent pipe can be laid down underground along the embankment.
   These conditions should be consulted with Drainage Control Structure System Division, DDS, who has responsibility for Nong Bon Pond.

3. Dr. Pathan showed some drawings of buildings of Machinery Division, DDS under construction and also the latest results of soil survey implemented by a surveying company, Ten Consulting Company Limited.

4. Public awareness survey and stakeholder meeting

Survey Team explained about the public awareness survey related to environmental and social consideration to the public in surrounding area of WWTP site.

Mr.Supakit informed that there are no legal measures related to the public hearings in the area. The stakeholder meeting can be held at the district office or at the building in the RAMA9 Park. For the neighborhood awareness, the survey team should pay attention to the users and joggers in the park and the luxurious real estate area 'Mai-Lom-Reoun' managed by a politician's family.

Reference

BMA Ordinance : The control areas to construct, renovate, use or modify the uses of the specific buildings around the RAMA9 Park in Nong Bon Sub-district, Prawat District, Bangkok 2532 (1989)

Article 3 - The controlling area comprised of 3 different areas.

The WWTP is located in Area 1. It covers from Klong Makamthed in the north, Klong Nong Bon in the west, Klong Paladprieng in the East. It exempted the area announced in the decree in the Year of 1988.

Article 4 - In the Area 1, any buildings cannot be built or modified except the followings;

- Single houses
- Government offices
- Commercial buildings excluding row buildings or the big buildings
- Sport arenas for 750 audiences or less or the big buildings
- Roads, dams, bridges, tunnels, waterways or sewers, piers, fences, walls, gates, power supplies, water supplies, governments billboards, billboards for elections and the name plate of the businesses which are smaller than 5 square meters.

Those buildings cannot be higher than 15 meters from the nearest road or pavement level to the highest point of the buildings.

Announced on November 10th, 1989

Major General Jamlong Srimeoung

BMA Governor

6) Discussion Record 2 on F/S

Time and date: 13:30, November 2 (Tue)

Place: 6F, DDS

Participants:	(DDS Working Group)	(JICA Survey Team)
	Ms. Suthimol Kessomboon	Mr. Masafumi Miyamoto
	Ms. Katerachada Klankrong	Mr. Haruki Takahashi
	Dr. Pathan Banjongproo	Mr. Takeki Kajiura
	Ms. Sopa Burakrai	Mr. Norio Tanaka
	Mr. Chamaphan Masjorn	Mr. Masahiro Kawachi

The following points were discussed on Feasibility Study

1. Major points of F/S

(1) Interceptor route

Study Team raised the following three types of route and recommended Plan 3;

Plan 1: Interceptors are laid down under klongs

Plan 2: Interceptors are laid down under roads

Plan 3: Interceptors are laid down under klongs and roads in a manner of most suitable

DDS will examine the Plan 3 and consider the most suitable route together with Study Team.

(2) Facilities planning of wastewater treatment plant

Study Team confirmed planning basis of WWTP, such as capacity, design water quality, projected dry weather flow and design concepts/requirements.

(3) Sewage treatment method

Study Team raised four sewage treatment methods, that is, Conventional Activated Sludge Process (CASP), Sequencing Batch Reactor (SBR), Membrane Bio-reactor (MBR) and Carrier Added Activated Sludge Process (CAASP).

(4) Comparison of four sewage treatment methods

Layout plan of sewage treatment facilities are shown by horizontal projection and profile view, and also Cost Analysis of initial investment and O&M cost are shown.

As the results, Study Team recommended Carrier Added ASP.

DDS requested more explanation on CAASP to examine the comparison because DDS have no experience for CAASP which is new technology.

2. A pilot project of separate sewerage system

DDS proposed some sewerage system in housing estate of National Housing Authority as a pilot project of separate sewerage system, which will be transferred to BMA in future, now under negotiation between BMA and NHA.

3. Surveys by sub-contractors

(1) Progress of contract with sub-contractors

Topographic Survey: PENCO,

Geo-technical Survey: STS Instruments

Public Awareness Survey: Ms. Pakwimol Phienlumlert

(2) The supervisory framework during absence of Study Team from November to January

Mr. Kitchapat, Dr. Pathan and Mr. Chamapan will be nominated as the supervisory team.

4. Consideration on Stakeholder Meeting held in January 2011

DDS will consider the followings.

- Date, place, target participants, program and speakers
- Contents of presentation, documents distributed and article on display
- Budget covered by JICA

7) Discussion Record 3 on F/S

Time and date: 15:30, November 12 (Fri)
Place: 3F, DDS

Participants:	(DDS Working Group)	(JICA Survey Team)
	Mr. Chainat Niyomtoon	Mr. Haruki Takahashi
	Ms. Suthimol Kessomboon	Mr. Takeki Kajiura
	Ms. Sopa Burakrai	
	Mr. Chamaphan Masjorn	

The following points were discussed on Feasibility Study

1. Interceptor Route (Final Plan)

Study team proposed Option 4 which has two influent pipes to WWTP.
Option 4 has the lowest construction cost and the shallowest inlet depth (-18.85m).
And there is no relay pumping station.

Mr. Chainat, Director of WQMD, agreed the Option 4 is adopted as interceptor route for F/S. DDS (Kitchapat team) will examine the route along road and klong.

2. Design flows were discussed, as follows;

(1) Design Wet Weather Inflow
Study team proposed 5 times of Average Dry Weather Flow as the Design Inflow.
That is; the intercepting rate at interceptor chamber is 5 ADWF, and interceptor pipes will be designed to flow 3-5 ADWF by gravity.

(2) Design Pretreatment Flow
Study team proposed 3 times of Average Dry Weather Flow as the Design Inflow.
This means that the design flow for screen and grit chamber of WWTP is 3 ADWF and excess of 3 ADWF will be discharged before pretreatment facilities.
And 2 times of Average Dry Weather Flow (Design pretreatment flow minus Design secondary treatment flow) will be discharged after pretreatment facilities.

(3) Design Secondary Treatment Flow

Study team proposed Average Dry Weather Flow as the Design Inflow.

DDS will review the design secondary treatment flow of Bang Sue WWTP if it is Average Dry Weather Flow or more.

3. Design influent quality in the final and initial stage

(1) Design Influent Quality in the Final Stage

Study team proposed BOD/SS 150 mg/l, T-N 30 mg/l and T-P 8 mg/l as the Design Quality in the final stage.

Mr. Chainat disagreed about BOD/SS 150 mg/l, because it will not increase in future even if we improve interceptor chamber. Then he gave instructions to his staff to review the actual daily maximum influent BOD/SS of non rain day in rainy season.

(2) Design Influent Quality in the Initial Stage

Study team proposed BOD/SS 100 mg/l as the Design Quality in the initial stage. Then T-N might be 15 or 20 mg/l and T-P 4 or 6 mg/l.

DDS will also review the actual daily maximum influent T-N/T-P of non rain day in rainy season.

4. Discharge point and level of each effluent from WWTP

Mr. Chainat agreed about direct discharge of secondary treated wastewater to the reservoir and also required to discharge the treated wastewater to Klong Nong Bon in order to dilute klong water, where is 1.2 km away from.

DDS said eutrophication would not occur because T-N/T-P of effluent is regulated.
Study Team expressed an idea to consider setting of discharge pump to save electricity.

Discharge points of pretreated wastewater and untreated wastewater should be considered more.

5. Wastewater Treatment Process

Mr. Chainat agreed the Carrier Added Activated Sludge Process (CAASP) is adopted as wastewater treatment process for F/S in order to avoid underground structure and reduce the construction cost.

DDS requests more information on CAASP such as possible suppliers, experiences, patents and so on.

8) Discussion Record (1) on F/S

Time and date: 14:00, January 20 (Thu)

Place: 6F, DDS

Participants:	(DDS Working Group)	(JICA Survey Team)
	Ms. Suthimol Kessomboon	Mr. Masafumi Miyamoto
	Ms. Katerachada Klankrong	Mr. Takeki Kajiura
	Ms. Sopa Burakrai	
	Mr. Chamaphan Masjorn	

The following points were discussed on Feasibility Study.

(1) Environmental and social considerations

- Study team should make an assessment using the specific facilities data of Nongbon area especially about air pollution, noise and so on.
- Study team should recommend the method to mitigate the impact of construction on the road traffic. This impact will be the biggest problem of the project from DDS experience.

(2) WWTP

- In DDS working group, they will discuss the 3 staged development plan of WWTP recommended by study team.

(3) Interceptor rout plan

- Regarding to major underground utilities, DDS will check the F/S data of the other flood control project.

(4) Sewerage planning

- Study team should write down the current wastewater generation of Nongbon area on the report chapter 1.

(5) Steering committee and stakeholder meeting

- Steering committee : the first week of February, stakeholder meeting : mid-February
- Study team should add the pictures of Rama IX park to the presentation document.
- DDS requests study team to translate the presentation document into Thai.

9) 4th Working Group Meeting

on JICA Preparatory Survey for Bangkok Wastewater Treatment

Date and time: 14:00 – 15:30 on January 26 (Wed)

Place: 6F, DDS

Participants;

[DDS] Mr. Chainat Niyomtoon: Director of WQMD, DDS (Chairman)

Ms. Sutimol Kessomboon: Chief of Project and Sludge Management Section, WQMD

Working Group Members（12）

[Study Team] Mr. Miyamoto Masafumi, TEC (Team Leader)

Mr. Takahashi Haruki, TEC

Mr. Kajiura Takeki, NK

Mr. Tanaka Norio, TEC

Mr. Misawa Yoshinori, TEC

Dr. Nurul Islam, NK

Documents distributed;

Draft of Interim Report (2)

Issues discussed at the meeting;

1. Opening

The chairman gave opening remarks.

2. Explanation of Interim Report (2)

Mr. Miyamoto explained the contents of Progress Report by power point presentation.

3. Discussion

(1) New wastewater treatment process and effluent standard

- A wastewater treatment process that removes nitrogen to less than 10 mg/l can comply with effluent standard of BOD 20 mg/l.
- Conventional Activate Sludge Process (CASP) in this alternative comparison should be Recirculating Nitrification/Denitrification Process.
- Study team was requested to give more information on new technologies such as CAASP and MBR including their investment/O&M costs, as Japan has considerable O&M experiences on these technologies .

(2) Influent quality

- Target influent quality in 2040 is questioned due to the big difference from present influent quality. Study team gave an appropriate explanation that the target influent quality is set expecting future increase in value until 2040. The provisional influent quality is set as a practical value in 2020. In this case the CAASP without carrier, that is Recirculating Nitrification/Denitrification Process, is adopted in the provisional stage in 2020 and the carrier will be added at an appropriate time.

(3) Environmental and social considerations

- Study team is requested to make an assessment using the specific data of Nong Bon area such as air pollution, noise and so on.
- Study team is requested to recommend the method to mitigate the impact of construction amid the road traffic. This impact is expected to be the biggest problem of the project from DDS experience.

4. Steering committee and stakeholder meeting

- Steering committee will be held on 31st January and stakeholder meeting in mid-February.
- Study team is requested to translate the presentation document into Thai.

10) 3rd Steering Committee Meeting Report

Meeting Report 1/2554
The Preparatory Survey for Bangkok Wastewater Treatment Project
Date 31st January B.E. 2554 14.00-16.00
Nopbhand Room, Drainage and Sewerage Department
3th Floor , Bangkok City Hall 2

Committees who has joined the meeting

1.	Mr. Thammanat Chunsano Deputy Director of Drainage and Sewerage Department (for Water Quality Management Office)	Committee
2.	Assoc. Prof. Sutchai Champa Sanitary Engineer Expert	Committee
3.	Assist. Prof. Boonyong Lowongwat Sanitary Engineer Expert	Committee
4.	Ms. Darunee Supanai On behalf of Director of Economic and Fiscal Office (Committee) Department of Finance	Committee in charge
5.	Ms. Suwannee Phusuwan On behalf of Director of Legal and Litigation Office (Committee) Office of the Permanent Secretary for the BMA	Committee in charge
6.	Mr. Narong Jirasubkunakran Director of Drainage Information System Division (Committee) Drainage and Sewerage Department	Committee in charge
7.	Mr. Chainat Niyomtooon Director of Water Quality Management Office Drainage and Sewerage Department	Committee and Secretary
8.	Ms.Suthimol Kessomboon Water Quality Management Office Drainage and Sewerage Department	Committee and Assist. Secretary
9.	Ms.Kate-rachada Klankrong Water Quality Management Office Drainage and Sewerage Department	Committee and Assist. Secretary

Participants who has joined the meeting

1.	Mr. Miyamoto	Masafumi	JICA STUDY TEAM
2.	Mr. Takahashi	Haruki	JICA STUDY TEAM
3.	Mr. Norio	Tanaka	JICA STUDY TEAM
4.	Mr. Nural	Islam	JICA STUDY TEAM
5.	Mr. Yoshinori	Misawa	JICA STUDY TEAM
6.	Mr. Takeki	Kajiura	JICA STUDY TEAM
7.	Mr. Takeshi	Murakami	JICA STUDY TEAM
8.	Ms. Yukiko	Tahira	JICA Thailand
9.	Ms. Wandee	Rojkarnwong	JICA Thailand
10.	Ms. Marisa	Kanchana	Economic and Fiscal Office (BMA)

Committees who was absent from the meeting

1.	Mr. Chatinai Nauwaphut Deputy Permanent Secretary (For Department of Drainage and Sewerage)	Chair Person
2.	Mr. Chanchai Vitoonpanyakit Inspector General, Office of the Permanent Secretary for the BMA)	Committee (Pensionist)
3.	Mr. Sunya Chinimit General Director Department of Drainage and Sewerage	Committee

Begin at 10.00

Period 1. Chairman announcement

Mr.Thammanat (Deputy Director of DDS) has informed the steering committee that the BMA Deputy Permanent Secretary (Mr.Chartinai) and the General Director of DDS (Mr.Sanya) were carrying official mission at the BMA house of representative and could not join this meeting. Mr.Thammanat has been assigned to be the chairman.

Result : The committee and participants noticed and accepted.

Period 2. Approval of Meeting Report 2/2553

Correction on Page 3, number 4 "chairman had has to concerned about data of demand on water supply" should be corrected to "chairman had concerned about data of demand on water supply."

Result : Approve the meeting report 2/2553

Period 3. Consideration of Interim Report (1) Conceptual Master Plan and Interim Report and (2) Feasibility Study, the steering committee has discussed as follow :

1) BOD values that presented by Water Quality Model in the Report seems to be unbelievable (page 3 , slide No.5)
   JICA expert : the BOD presented by Water Quality Model of Klongs in the report are the results from simplified mathematical model where the deviation can not be omitted .
2) Dissolved Oxygen in the effluent is controlled to be 5 mg/l, this value may be not so harmonized with other parameters , especially with the concentration BOD = 20 mg/l and SS = 30 mg/l
   JICA expert : the dissolved oxygen level in effluent referred to BMA standard only.
3) Comparison between Conventional Activated Sludge Process (CASP) and Carrier added Activated Sludge Process (CAASP)
   JICA expert : The Carrier added Activated Sludge Process (CAASP) can receive higher BOD load than the CASP at same size of reacter so this CAASP will help save construction area.
4) The Conceptual Master Plan has shown the rearranged service capacity of Dindang WWTP to be 263,171 m^3/d and which is less than the designed capacity 350,000 m^3/d .
   JICA expert : The number 263,171 just shows the estimation of wastewater generated in the rearranged service area of Dindang WWTP but in the practical situation, Dindang WWTP can be operated at the maximum capacity, depends on the operation.
5) The number of existing water outlet (136 points) in Nonbon Project should be rechecked because a lot of temporary pumps have been installed in such place and these are not the normal drainage points.
   JICA expert : The study team will check again about this matter.
6) The designer must concern about odor control, any structure of WWTP should have to be well protected and without future problem with odor.
   JICA expert : The study team will consider this comment again.
7) The committee has suggested the study team to do the risk assessment for this project investment. The financial analysis should be included with the comparison between case (1) BMA investment together with government subsidies (2) Pubic Private Partnership and (3) Soft loans from various sources

JICA expert : It is trued that the financial expert just have been arrived in Thailand and start his job only few days age. After the financial analysis result has its outcome, it will be reported to the committee.

8) The committee has suggested JICA expert to strongly concern about energy saving in the design of the project.
JICA expert : The study team accept this comment.

Result : The study team will concern about all suggestion and let this to be implemented.

Period 4. No matter for discussion.

Meeting Closed at 16.00

Recorded by Chamaphan Masjorn
(Mr.Chamaphan Masjorn)

Translated by Pathan Banjongproo.
(Mr.Pathan Banjongproo)

Approved by Suthimol Kessomboon.
(Ms.Suthimol Kessomboon)

11) Stakeholder Meeting Record

The 1st Stakeholder Meeting for Nongbon Wastewater Treatment Project

17th February B.E. 2554 09.00-12.00

7th Floor , Meeting Room at Prawet District Office

1. A number of stakeholders (participants)

Organization	A number of Stakeholders
1. Steering Committee	6
2. DDS officer	16
3. Prawet District officer	12
4. JICA Study Team and JICA (Thailand)	11
5. Representative from Communities	56
6. Business Representatives	12
Total	113

2. Suggestions from the Stakeholder

In the Nongbon Wastewater Project's Stakeholder meeting, stakeholders can spell their questions directly to the DDS administrator or write their questions and suggestions in the leaflets. All questions can be summarized as follows:

1) The wastewater treatment activities should be the co-operation between stakeholder and government bodies. People should have their self respect on water environmental protection while government bodies/ organizations should prepare/implementation of long term environmental project. As they know, the government bodies just work following their responsibilities as described in the legal framework only and many things are not practically applicable. Only when the governor joins the mission, then the canal water can be free from garbage. The suggestions are as follows

- How can the communities share parts in the integrate wastewater treatment activity
- People should take part in the work which makes the good cooperation aspect. feeling
- Government Officer should think on integration model.

Answer: The Project is now under the feasibility study in the construction stage, there will be some impacts but after the construction is finished, the WWTP will be under operation 24 hr, now the project requires comments

from stakeholder to apply to the project. It is possible to let people participate in some wastewater treatment activity.

2) Some real estate projects have directly discharge their wastewater to public canal and have no wastewater treatment

   Answer: wastewater should be drained into collection pipe (actually, it is the drainage pipe included with rain water) exceeding rain water will pass through to the public canal but wastewater will be separated to the wastewater collection system.

3) A Request from the stakeholder is all the sewers should be rechecked the illegal wastewater discharge into public canal.

   Answer: The survey will be carried on intensively during the detailed design.

4) Suggestion: real situation and information should be obtained from local resident, not only from the district office.

   Answer: Accepted to be considered

5) Wastewater is not solely originated from water consumption from water supply but also other sources and not has to flow through sewerage network.

   Answer: In principle, wastewater is originated from water supply but also some sources such as leachate etc., the organization who is the source of this should take care of the matter.

6) BMA Administrator or Officer should visit Tup Chang Canal Area because several new real estate projects have been developed, and they still discharge wastewater directly to the canal.

   Answer: there will be additional survey later.

7) What is the impact of Sewer Construction in canal?

   Answer: the impact may occur during rainy season. But we will apply better technology to minimize the impact to people who use canal for transportation or other proposes.

8) The community representative suggest that the DDS should select 2 representatives from each community along the canal to be the committee who is responsible for the canal protection in their community and all over the district area

   Answer: DDS may inform the others organization who is in charge to take care of this matter.

9) What can local people take part or benefit from the Nongbon's WWTP implementation.

Answer: As the result, Surface Water Quality will be improved, but the canal network is liked cross to other area outside the service area where without WWTP so in some area may have effect from wastewater originated from outside Nongbon Area. In the future after all areas have wastewater treatment service, there will be complete improvement of canal water quality.

10) How long does it take for the project implementation?

Answer: The feasibility study takes about one year period.

11) The community member should have right to be the committee who is responsible for canal protection.

Answer: To be Considered.

12) After the wastewater project finish, there will be also the collection of wastewater tariff or not?

Answer: the answer can not be confirmed now identified, the central government had policy to let MWA (Metropolitan Waterwork Authority) collect the wastewater bills. At the present time, BMA has to pay annually about 550 Million Baht to cover the wastewater treatment expense. The wastewater tariff will help subsidize these facilities.

13) What will be the application of the Effluent Water?

Answer: The Effluent will be partially reuse for road cleansing and plant watering (non-crop irrigation)

14) How about the effluent water quality and control of water qualities?

Answer: The BMA effluent water has higher quality than Effluent Water Quality Standard.

15) What should people adapt themselves to help water environment?

Answer: They should not litter in canal or public waterways.

12) Discussion Record (2) on F/S

Date and time: 15:00 – 16:00 on February 24 (Thu)
Place: 3F, DDS

Participants;
[DDS] Mr. Thammanat Chunsano: Deputy Director General, DDS
Mr. Chainat Niyomtoon: Director of WQMD, DDS
Ms. Sutimol Kessomboon: Chief of Project and Sludge Management Section, WQMD
[Study Team] Mr. Miyamoto Masafumi, TEC (Team Leader)
Mr. Takahashi Haruki, TEC
Mr. Tanaka Norio, TEC
Mr. Misawa Yoshinori, TEC

The following points were discussed on Feasibility Study.

1. Facility Planning of Nong Bon Wastewater Treatment Plant

Mr. Thammanat made a comment on the following points;

- Facility Planning of Nong Bon Wastewater Treatment Plant is planned based on only the economic point of view. Study team should consider some alternative Facility Planning from the view point of social impact.
- People in Prawet District may request the underground structure and it is difficult for DDS to reject such kind of request, because history of modernization, that is, underground structure has been adopted by DDS.

Study Team explained that the surrounding conditions are quite different from those of Bang Sue WWTP site, that there are office building/workshops and reservoir under DDS.

Also Study Team made a point that the idea of modernization history was risky in future development of WWTPs. DDS cannot select above-ground structure anymore in everywhere in future.

Then Mr. Thammanat requested Study Team to show an alternative of underground structure in the report in order to keep room for underground WWTP.

13) Discussion Record (3) on F/S

Date and time: 14:30 – 16:00 on March 10 (Thu)

Place: 2F, DDS

Participants;

[DDS] Mr. Thammanat Chinsano: Deputy Director General, DDS

Mr. Chainat Niyomtoon: Director of WQMD, DDS

Ms. Sutimol Kessomboon: Chief of Project and Sludge Management Section, WQMD

Working Group Members（3）

[Study Team] Mr. Takahashi Haruki, TEC

Mr. Izumi Kunimasa, TEC, Mr. Kawachi Masahiro, TEC

The following points were discussed on Feasibility Study.

1. Cost Estimation

Mr. Thammanat requested Study Team for the following cost comparison, since the estimated cost, 7,835 million Baht, is so high.

(1) To explain the reasons why Nong Bon WWTP is higher than Bang Sue WWTP which is underground structure and includes Environmental Education Building.

- Bang Sue WWTP: 2,475 MB/ 120,000m3/D=20,600 Baht/m3/D
- Nong Bon WWTP: 3,316 MB/ 135,000m3/D=24,563 Baht/m3/D

(2,700MB=135,000m3/D×20,600 Baht/m3/D)

(6) To show necessary indirect cost without foreign loan, since the estimated cost is too high.

- In case of DDS in budget request there is no administration cost, 3% of engineering cost and no contingencies.

(7) To explain the reasons why the cost of alternative plan, underground structure, is 32% higher than the above-ground structure.

2. Facility Planning

(1) Mr. Chainat requested Study Team to consider the alternative plan lowering the roof level to +8m above MSL. This idea comes from the slope setting to approach easily to the roof space which will be utilized for sports/recreation of staff members working at the WWTP.

Mr. Thammanat supported this idea because the 15 m height wall is overpowering for visitors.

(2) Mr. Chainat also requested Study Team to consider the simple structure to enclose the sludge hopper and truck..

14) Discussion Record (4) on F/S

Date and time: 15:00 – 16:30 on March 16 (Wed)

Place: 2F, DDS

Participants;

[DDS] Mr. Thammanat Chinsano: Deputy Director General, DDS

Mr. Chainat Niyomtoon: Director of WQMD, DDS

Ms. Sutimol Kessomboon: Chief of Project and Sludge Management Section, WQMD

Working Group Members（3）

[Study Team] Mr. Miyamoto Masafumi, TEC (Team Leader)

Mr. Takahashi Haruki, TEC

References; Breakdown Sheets of Cost Estimation

The following points were discussed on Feasibility Study.

1. Cost Estimation

(1) Study Team explained the reasons why Nong Bon WWTP is higher than Bang Sue WWTP, as follows;

- Additional cost of CAAS is 251 million Baht
- Additional cost of Emergency Generator and Energy Recovery is 258 million Baht
- Additional cost of Lift Pump for Direct Discharge (2DFW) is 128 million Baht

In addition to above;

- The structure and equipment cost for Dry Pit Pump System is higher than the Submergible Pump System.
- The cost of blower/aeration system and sludge treatment facilities will be higher, because the design influent quality BOD 150 mg/l is higher than the BOD100 mg/l of Bang Sue WWTP.

Furthermore,

- The inflation rate 3.3%/year (an average for the last three years) is considered in the cost estimation of Nong Bon WWTP.; that means 6.6% increase for two years

(Bang Sue WWTP: 2,475 MB/ 120,000m3/D=20,600 Baht/m3/D)

(Nong Bon WWTP: 3,316 MB/ 135,000m3/D=24,563 Baht/m3/D)

3,316 MB - (251 MB+258 MB+128 MB) =3,316MB – 637MB=2,679 MB

2,679 MB/ 1.066=2,513 MB; 2,513 MB/ 135,000m3/D=18,615 Baht/m3/D

(2) Study Team showed necessary indirect cost according to the request of DDS.

- The indirect cost of 2,810 million Baht will be lowered to 646 million Baht, under condition of only 3% of engineering cost and tax/duty.
- Mr. Thammanat requested the necessary indirect cost will be indicated in the report. Study Team answered that the team will consider it in manner of suitable way.

(3) Study Team explained the reasons why the cost of alternative plan, underground structure, is 32% higher than the above-ground structure.

- Civil & Architecture Work increase 650 MB
- Mechanical Work increase 241 MB
- Electrical Work increase 162 MB
- Total increase cost is 1,053 MB (32% of 3,316 MB)

2. Facility Planning

(1) Study Team explained that the proposed alternative plan lowering the roof level to +8m above MSL is almost the same as the underground structure. The reasons are as follows;

- D-wall will be adopted for earth retaining instead of sheet pile.
- Effluent Pumps will be operated anytime, even in case of effluent discharge to reservoir.

(2) Study Team agreed the construction of requested simple building to enclose the sludge hopper and truck.

15) 2nd Stakeholder Meeting Record

The result of
2nd Stakeholder Meeting for Nongbon Wastewater Treatment Project
Date 29th March B.E. 2554 09.00-12.00
Dusit Princess Hotel , Srinagarindra Road, Prawet District

1. Numbers of Stakeholder total 119 participants

From	Number of Participants
1. Member of Bangkok Metropolitan Council and District Council	5
2. The Steering Committee	21
3. Department of Drainage and Sewerage (DDS)	20
4. District officer (Prawet, Suanluang, Bangna)	14
5. JICA Study Team and JICA (Thailand)	9
6. Representative from Communities	47
7. Business Representatives	3
Total	119

2. Stakeholder Suggestions

In the stakeholder meeting for Nong bon wastewater project, it is allowed for the participant to ask directly to the DDS administrator and also to write out their questions and wait for the answer. The stakeholder suggestions can be summarized as follows:

1) A community representative has suggested: As he was informed during the first stakeholder meeting and to join the group of community members from Nongbon wastewater treatment area to visit the Dindang wastewater treatment plant and to see the operation and management of the wastewater treatment plant. He has found that the operation is going on in the good manner with high quality of services. After he asked the local residence near by Dindang WWTP, the answers from the local residents indicated no negative effect from both odor and noise but he want to give some suggestions:

- We should enhance public awareness to manage wastewater before dispose to water sources and also we should.
- Empower law enforcement in the topic of canal area resonation.
- Enhance people's self-discipline about water environment

2) Prawet Community Member has suggested: It is his great pleasure to know about the construction of Nongbon Wastewater Project which will lead to better water environment but he would like to propose possible method to help improve water quality as he has experienced, from Wan Community, that is dispose E.M. into canal twice a month each time 500 liters for 1 years continuously.

3) Ban Mar Community Member has asked: In case of heavy rain fall how can we protect rain water to flow into the wastewater collection system?
Answer: The wastewater sewer is typical a combined system (rain water mixed with wastewater) and is protected by weir and flap gate (for not to contaminate with canal water). During rainy season, the wastewater collection system will accept only 5 times Dry Weather Flow(DWF)only. The excess water runoff will overflow into the canal

4) What time this project will be completed?
Answer : In the next year will be 1 year of design and the next 3 years period will be the construction and testing operation.

5) How long is the sewer to be constructed under Srinagarindra Road?
Answer: It can not be confirmed in this step because this is just preliminary design, not detail design.

6) How much does it cost for the operation and maintenance and when will user being charged for the wastewater fee?
Answer : Bangkok Metropolitan Administration is responsible for the operational expense of the 7 Wastewater Treatment Plants, under the Pollute-Pay-Principle policy of the government, but practically the wastewater user charge still has not fix schedule.

7) How long is the project plan (at 135,000 cubic meters per day)
Answer: The beginning stage (2020) was designed to have capacity 90,000 cubic meter per day but the maximum capacity 135,000 was targeted in the year 2040.

8) How much does it cost for the project construction?
Answer: The construction cost around 7,000 Million Baht. The first stage design is for with the capacity close to 100,000 cubic meter per day but the next step will expand the capacity in accordance with wastewater inflow.

9) According to the information given during this meeting, the distance of sewer construction under road is 43.8 kilometers long. Which Street and road are under the construction plan? This will effect to people who pass on the street and other public utilities.
Answer : The sewer construction under main roads will not be done by open cut method but will be done by pipe jacking method and the opening of manhole/pit will be during late night time only with very small effect to traffic.

10) What is the impact during operation of wastewater treatment plant?
Is it possible to trap all of wastewater in to the treatment process?
Is the user charges are equal between the enterprise and normal local resident?
Answer: During dry season, all wastewater will be collected into the wastewater treatment plant but during rainy season some parts of run-off water will dilute with wastewater and overflow into the canal. The rate of wastewater use charge for business will be higher that the local residents due to higher pollution load and sharing of some investment cost.

11) The sewer construction under the canal will effect to people/local residents or not?
Answer: The sewer construction will be done under the canal not in the canal and at depth about 10 meters underground with the size of diameter around 2-3 meters so it will not effect the usage of Klong by local residents. Even it is the drainage tunnel, the tunnel line will lay more deeper than wastewater sewers at about 20-30 meters under mean sea or ground level with pipe diameter about 5-6 meters and also will not effect to usage of Klong by local residents.

12) When will this project finished?
Answer : The design will be during 2012-2013 and construction begin in 2014.

13) The canal bank in many areas have been occupied by illegal settlement. What will be the solution for this matter? And How?
Answer : Normally, under existing law and regulations this people should be move out but the operation can not be done practically and easily in many area. The gradually application of law should be done together with budget in hand and also the construction of wastewater collection system and treatment plant will help solve such problems by means of sustainable solution.

16) 5th Working Group Meeting on JICA Preparatory Survey

Date and time: 10:00 – 12:00 on March 30 (Wed)

Place: 3F, DDS

Participants;

[DDS] (Acting Chairman)

Ms. Sutimol Kessomboon: Chief of Project and Sludge Management Section, WQMD

Working Group Members（10）

[Study Team] Mr. Miyamoto Masafumi, TEC (Team Leader)

Mr. Takahashi Haruki, TEC, Mr. Izumi Kunimasa, TEC, Mr. Kawachi Masahiro, TEC

Documents distributed;

Power point handout of Draft Final Report on Feasibility Study

Issues discussed at the meeting;

1. Opening

The acting chairman gave opening remarks.

2. Explanation of Draft Final Report on Feasibility Study

Mr. Miyamoto explained the contents of the Draft Final Report by power point presentation.

3. Discussion

(1) Interceptor Route

- Length of interceptor indicated in the pamphlet is wrong. The following is correct.
  Length of interceptor under klong is 43.6 km.
  Length of interceptor under road is 20.6 km.
- Depth of interceptor under Klong Nong Bon is sallow as 5-10m below MSL, while on the other hand depth of Deep Drainage Tunnel is 20-30m below MSL.

(2) Designed wastewater treatment capacity

- The capacity of secondary treatment is designed by one Average Dry Weather Flow., but hydraulically hourly maximum DWF, that is, two times of DWF, can be received in secondary treatment process in dry season.

(3) Reuse of treated wastewater

- The treated wastewater of Nong Bon WWTP is planed to use for water resource of Rama IX Park.

17) 4th Steering Committee Meeting Report

Meeting Report 2/2554
The Preparatory Survey for Bangkok Wastewater Treatment Project
Date March 31st B.E. 2554 10.00-12.00
Nopbhand Room, Drainage and Sewerage Department
3th Floor, Bangkok City Hall 2

Committees who has joined the meeting

1.	Mr. Thammanat Chunsano Deputy Director General of Drainage and Sewerage Department (for Water Quality Management Office)	Committee
2.	Assoc. Prof. Sutchai Champa Sanitary Engineer Expert	Committee
3.	Ms. Darunee Supanai On behalf of Director of Economic and Fiscal Office (Committee) Department of Finance	Committee in charge
4.	Ms. Suwannee Phusuwan On behalf of Director of Legal and Litigation Office (Committee) Office of the Permanent Secretary for the BMA	Committee in charge
5.	Ms. Ammaraporn Jitpraphai On behalf of Director of Drainage Information System Division (Committee) Drainage and Sewerage Department	Committee in charge
6.	Mr. Chainat Niyomtooon Director of Water Quality Management Office Drainage and Sewerage Department	Committee and Secretary
7.	Ms.Suthimol Kessomboon Water Quality Management Office Drainage and Sewerage Department	Committee and Assist. Secretary
8.	Ms.Kate-rachada Klankrong Water Quality Management Office Drainage and Sewerage Department	Committee and Assist. Secretary

Participants who has joined the meeting

1.	Mr. Miyamoto Masafumi	JICA STUDY TEAM

2.	Mr. Takahashi Haruki	JICASTUDY TEAM
3.	Mr. Izumi Kunimasa	JICA STUDY TEAM
4.	Mr. Kawachi Masahiro	JICA STUDY TEAM
5.	Ms. Yukiko Tahira	JICA Thailand
6.	Ms. Wandee Rojkarnwong	JICA Thailand

Committees who was absent from the meeting

1. Mr. Chatinai Nauwaphut — Chair Person
   Deputy Permanent Secretary (For Department of Drainage and Sewerage)
2. Mr. Sunya Chinimit
   Director General Department of Drainage and Sewerage — Committee
3. Assist. Prof. Boonyong Lowongwat — Committee
   Sanitary Engineer Expert

Begin at 10.00 a.m.

Period 1 : Introduction for meeting

Acting Chair committee (Mr.Thammanat Chunsano) addressed to the Steering Committee that Mr.Chatinai Nauwaphut (Deputy Permanent Secretary to BMA) and Mr.Sunya Chinimit (Director General, DDS) are on other official appointment. Mr.Thammanat is assigned to be the acting chairman in this meeting and will be the last meeting to summarize the project contents within the Draft Final Report.

Result : The committee and participants noticed

Period 2 : Approval of the 1/2554 meeting report

1. The committee suggests to the secretary to correct line 2 page 3 from the last meeting report to be “such as the comparison between in the case that BMA invest together with central government and the case that BMA invest together with private sector and the case of soft loan (different sources of loans)

2. Correction of writing in page 3 line 5 the word in Thai mean “economic” is not in correct writing.

Result : The 1/2554 steering committee meeting report has been approved.

Period 3 : Consideration of the Final Report. “Feasibility Study : Nongbon Treatment Area” , the committee has suggestion on some topics as follows.

(1) Correction of Flow Diagram in the slide powerpoint presentation “Design Concept and Requirements” should be reconsider because it can lead to misunderstanding such as: the receiving water body should be “Klong Nong Bon” and “Storm Water Reservoir rather than “Primary Treatment and Secondary Treatment” and at the Sedimentation Basin, there should be the line of “Return Sludge” back to the aeration tank.

(2) The effluent outfall to Klong Nong bon, designers have to assess the adverse effect to the recipient (Klong Nong bon) particularly the problem of hydraulics overload, higher water level effect to people who lives on both sides of the canal. The detail should be written in the final report.

(3) The design of aeration upon the sedimentation tank, designer has to consider the effect of outfall aerosol, if necessary, there should be the cover structure to protect of wastewater aerosol. The JICA working group explains that the cover structure is already designed for the aeration basin to help solve the effect of aerosol.

(4) The project cost consideration, in the list of Foreign Cost (F.C.), there should be the detail of calculation (back up sheet) for the heavy equipments from abroad country and also shows the cost in Thai Baht currency.

(5) The committee suggests the working group to recheck the details of “Financial Status of BMA” in the topic of “Current Liquidity Ratio” data between years 2006-2007 because the printed out valve is higher than the aspect.

(6) The committee suggests the word “(Financial Analysis)” to change to be “(Economic Analysis)” and in the final report should identify which alternative is the best.

(7) The JICA study team should estimate the additional cost for the upgrade installation of equipment from the first phase WWTP around 100,000 cubic meter per second to be the second phase at capacity 135,000 cubic meter per second

Result : The JICA study team will complete the project report content as suggested by the steering committee.

Period 4 : Others

(1) The study team will submit “Draft Final Report” to JICA on 15 April 2554 and JICA will pass the document to BMA later.

(2) The secretary inform to the meeting that the representative from Department of Finance suggestion for Draft Final Report that the study team should add some more Financial Analysis which compare 5 alternatives. This is to add more private investment or PPP : Public Private Partnership to be the sixth alternative and to cover all existing possibilities.

Result : The study team will add this analysis into the Appendix.

Meeting closed at 12.00

Recorded by _____ (Mr.Chamaphan Masjorn**)**

Translated by _____ (Mr.Pathan Banjongproo)

Approved by _____ Ms.Suthimol Kessomboon)

Appendix-2
List of Documents and Data

1) **Summary of Documents and Data**
2) **List of Documents and Data**

Appendix 2-2

Summary of Documents and Data

Catogory / Name of Document and Organization		Number of Document					Administration/Policy			Technical				Economic	
		Document	Sheet	Map	CD	Brochure	General	Strategy	Policy /Regulations	Planning	Design	Survey	Environment	Organization	Finance
Department of Drainage and Sewerage : DDS															
1	Water Quality Management Office – Annual Report (2008)	1					O			/			/	/	/
2	Dindaeng Water Environment Control Plant - Annual Report (2009)	24					O						/	/	/
3	Chatujak Water Environment Control Plant - Annual Report (2009)	25					O						/	/	/
4	Bang Sue Feasibility Study Report - Vol.1/5 : For executive summary (Thai Ver.) (2006)	27					/			O	/		/		/
5	Bang Sue Feasibility Study Report - Vol.2/5 : For executive summary (2006)	28 *					/			O	/		/		/
6	Bang Sue Feasibility Study Report - Vol.3/5 : Main Report (Thai Ver.) (2006)	29*					/			O	/		/		/
7	Bang Sue Feasibility Study Report - Vol.4/5 : Appendices (Thai Ver.) (2006)	30					O				/		/		/
8	Bang Sue Feasibility Study Report - Vol.5/5 :Basic (2006)	31									O				
9	The Feasibility study of Wastewater Tariff (1998)(Thai)	32					/	/	/			O	/		
10	Feasibility Study of Klong Toey WTTP - Vol. 1 : Executive Summary (2001)	33 *					/			O			/		/
11	Feasibility Study of Klong Toey WTTP - Vol.2 : Main Report (2001)	34 *					/			O	/		/		/
12	Feasibility Study of Klong Toey WTTP - Vol.3 : Appendices (2001)	35					O			O					
13	Feasibility Study of Klong Toey WTTP - Vol.4 : Preliminary Design Drawings (2001)	36								/	O				
14	Water Quality Management Office - Annual Report (2007)	44								/				/	O
15	Action Plan for Flooding Prevention (2010) (Thai Ver.)	71							/	O			/		
16	Final Design Report of Chatuchak District	115									O				
17	The survey and design in Bangkapi district – Main road (# 1/10)	117									O				
18	The survey and design the drainage system project - Bangkapi district (#5/10)	118									O				
19	The survey and design the drainage system project - Wang Thong Lang District (#8/10)	119									O				
20	Regulation of the office of the PM in case of public consultation (2005)	120							O				/		

Appendix 2-3

Catogory / Name of Document and Organization		Number of Document					Administration/Policy			Technical				Economic	
		Document	Sheet	Map	CD	Brochure	General	Strategy	Policy /Regulations	Planning	Design	Survey	Environment	Organization	Finance
21	The meeting document of the Master Plan for drainage system project in Lad prao area, Bang khen area and the part of Chatuchak. (Document & Questionaire)	129										O			
22	The Revenue and Payment report of BMA budget in 1997-2008	130													O
23	The Operation & Maintenance and Management of WWTP – Chatuchak	139							/	O					
24	Klong Toey Wastewater Treatment Project ,Oct.2010	140								/		O	/		/
25	Location of pumping station installation at Prawet district	141							/	O	/				
26	The Revenue and Payment report of BMA budget in 2007-2009	156								/					O
27	BOD Loading in the Chaophraya River		23						/				O		
28	Questionnaire on Technical Survey		41									O	/		
29	Major public Park in Bangkok		46				/						O		
30	Operation and maintenance data in 2009		48												O
31	Map of Nongbon WWTP		60							O					
32	(Draft) Summary of waterworks improvement project and Demand for water and Capability to produce water		67				/			O					
33	Comparative study on Integrated Wastewater Management System Model for Developing Countries under Rapid Urbanization		72				/			/		O			
34	Critiria for obstaing the service of sewerage in BKK		74						O	/					
35	Geology of the lower central Plain. (Eng. Ver.)		75				/								
36	History and organization chart of DDS 1999		77 *						/	O			/	/	
37	(Content) Regulation of environment health in 1992		78						O						
38	Fiscal Year 2007-2008 of DDS		79												O
39	BKK : primate city (area & population)		80				O						/		
40	Data of Khlong in water environment control plant		81							O					

Appendix 2-4

	Catogory / Name of Document and Organization	Number of Document					Administration/Policy			Technical				Economic	
		Document	Sheet	Map	CD	Brochure	General	Strategy	Policy /Regulations	Planning	Design	Survey	Environment	Organization	Finance
41	Chart of Septic tank ,Chart of drainage pipe elevation plan		82 *								O				
42	(Drawing) Network Map of the existing Combined Drains in Din Daeng and Nongbon		84								O				
43	The Land development Act B.E.2543 (A.D.2000) (Eng. & Thai Ver.)		86 *						O						
44	(Copy) Plan of Minburi WWTP (June 18,2010)		89 *							O					
45	Database & Tariff Collection Section of WQMD		90						O				/		
46	Budget Fiscal year of DDS(2006–2009)(Eng&Thai Ver.)		96												O
47	Report of survey : WTP the tariff in wastewater treatment area		97									O			
48	The study on wastewater treatment charge in Thailand and foreign countries,2010 DDS, BMA (Eng&Thai Ver.)		98										/		O
49	Project drainage tunnel construction in BKK area		99						O	/					
50	Bangkok Four year Public Administration Plan,2005–2008		100				/						O		
51	Canal network (West & East Bangkok)		102 *									O	/		
52	Meeting report (Management about wastewater, garbage and tariff of wastewater treatment)		103						/				O		
53	Chart of Prawet district(Cleaning drainage and manhole)		105 *									O			
54	Profile of Bangkok City		109 *				O			/					
55	Water Quality Management		110 *						/	/			O		
56	Strategy to increase the efficiency of quality water management		111 *					/		O					
57	(Drawing)Bangkok Wastewater Project – YANNAWA (3 items - Interceptor Sewers Calculations : KCN catchment, Rama 4 catchment Final design submission		116								O				
58	Pipe Jacking Cost		121							/					O
59	Drawing of Buildings in Rama 9 Park		125								O				
60	Drawings of the existing WWTPs		126								O				

Appendix 2-5

	Catogory / Name of Document and Organization	Number of Document					Administration/Policy			Technical				Economic	
		Document	Sheet	Map	CD	Brochure	General	Strategy	Policy /Regulations	Planning	Design	Survey	Environment	Organization	Finance
61	(Copy) Documents of Price Assessment of Bang Sue Project		132							/					O
62	(Copy)Bangkok MRT of the dark yellow line,F/S Drawings		133								O				
63	Drainage Project at Suwannabhumi Airport, Dec.2010		142				/			O					
64	Map show the area of south-Thonburi WWTP Project		143 *							O					
65	Steps for Consultant Selection (Thai&English Version)		151						O						
66	Monthly Results of Water Quality Analysis in 2010		152										/		O
67	Expense for operating wastewater system of WWTP in 2010		153										/		O
68	Financial Assistance From the Danish International Development Agency		155												O
69	(Copy) AS-Built Drawings (Manhole in Klong Sam Sen and Sen Sep)		157								O				
70	(Copy)AS-Built Drawings (Manhole Type I & II)		158								O				
71	(Drawing) Profile of Klong Nongbon		159								O				
72	Land use Map 2006			53						O			/		
73	Chart of the position of manhole, pipe and septic tank in household			83							O				
74	AS Network Map of the existing Interceptor Pipes in Din Daeng			85							O				
75	WWTP 7			87 *							O				
76	DDS Sewerage Treatment Areas			91							O				
77	Maps of all administrative districts in Bangkok			107						O					
78	Watergate and Pump station Chart			112						O	/		/		
79	Network Map of the existing Combined Drains Phra Khanong District			113							O				
80	Network Map of the existing combined drains in “Prawet” District			122							O				

Appendix 2-6

	Catogory / Name of Document and Organization	Number of Document					Administration/Policy			Technical				Economic	
		Document	Sheet	Map	CD	Brochure	General	Strategy	Policy /Regulations	Planning	Design	Survey	Environment	Organization	Finance
81	Bangna District – City Planning Map			123							O				
82	Scope of the polder system for solving the flood problem			131						O					
83	Nongbon Area Topographic MAP			136							O				
84	Electricity Conduit Information Map of Nongbon Area			137							O				
85	Klong Water Quality Improvement Project			154						O	/		/		
86	Chatuchak WWTP : CD # 1				37					O	/				
87	Din Daeng WWTP CD#7				38					O	/				
88	Nong Khaem WWTP : CD #4 As-Built drawing				39					O	/				
89	Tungklu WWTP CD#6				40					O	/				
90	Water Quality Management Office Annual Report 2549-2551 (2006-2008)				45 *					/				/	O
91	BKK Comprehensive Plan (Regulation)				52				O						
92	Chaophraya River				58								O		
93	(a) SEA (Thai&Eng. Ver.) (b) Announcement–guideline of EIA (Eng Ver.)				70			O					/		
94	MWA Water Consumption (Dr.Pathan's Thesis)				104		/	/				O			
95	Khlong Data in BKK. (Water Transportation Plan)				108					O					
96	PC Improvement Drawing of Rattanakosin and PCD				114						O				
97	WWTP- Bangsue VDO Representation				135			/		O			/		
98	Map of WWTP site				144					O					
99	STP Brochures (WWTP: Chon nongsi, Si phraya, Dindaeng, ThungKhru)					94 *				O	/				
100	DDS E-magazine					95							O		

Appendix 2-7

Catogory / Name of Document and Organization		Number of Document					Administration/Policy			Technical				Economic	
		Document	Sheet	Map	CD	Brochure	General	Strategy	Policy /Regulations	Planning	Design	Survey	Environment	Organization	Finance
Bangkok Metropolitan Administrtion : BMA															
101	Performance Plan of BMA 2009-2012 (Eng Version)	2 *						O		/					
102	Performance Plan of BMA 2009-2012 (Thai Version)	3						O		/					
103	Statistical Profile of BMA (2008) (English Version)	4 *					/			O				/	/
104	Statistical Profile of BMA (2008) (Thai Version)	5					/			O				/	/
105	Bangkok State of Environment Report 2006-2007	43						/	/				O		/
106	City Planning BMA (Edit #2)	51			(51)		/		/	O					
107	Annual Performance Report for the Fiscal Year 2009	146												/	O
108	BMA ordinance : Collection of Wastewater Tariff B.E.2547(2004)		73						O				/		
109	Organization Chart of Finance Dept,BMA		147											O	
110	Balance Sheet of BMA as at Sep. 2005-2008		149												O
111	The Expenditure & Budgeting of BMA		150 *											/	O
112	Factory BMA Sep 2009 (Industrial area)				50								O		
113	Rainfall Data from BMA				59								O		
114	Credit News of BMA (Announcement No.742)					148 *								/	O
	Action Plan on Global Warming Mitigation 2007-2012	File from Share holder *								O					
Metropolitan Waterworks Authority : MWA															
115	Annual Report 2000	16												/	O
116	Annual Report 2001	17												/	O
117	Annual Report 2002	18												/	O
118	Annual Report 2003	19												/	O
119	Annual Report 2004	20								/				/	O
120	Annual Report 2006	21						/	/	/				/	O

Appendix 2-8

	Catogory / Name of Document and Organization	Number of Document					Administration/Policy			Technical				Economic	
		Document	Sheet	Map	CD	Brochure	General	Strategy	Policy /Regulations	Planning	Design	Survey	Environment	Organization	Finance
121	Annual Report 2007	22						/	/	/				/	O
122	Annual Report 2009 (Thai Version)	68							/	/				/	O
123	Annual Report 2008 (Thai Version)	69												/	O
124	Data of water consumption 2553 (2010)				47								O		
125	MWA (a)History (b) Water Treatment Plant-Bangkhen (c) Water Treatment Plant – Mahasawat					66	/			O					
	Ministry of Natural Resources and Environment														
126	EIA in Thailand (2007)	61							O				/		
127	Guidelines for participation of people and assessment the impact of social environment (EIA) (2006)	62							O				/		
128	Strategic Environment Assessment : SEA (2009)	63 *						O	/				/		
129	Guidelines for heath impact assessment (EIA) (2009)	64 *							O				/		
	Pollution Control Department :PCD														
130	Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study - Vol 1 : Executive Summary (1996)	10					/			O			/		
131	Vol 2 : Main Report (1996)	11					/		/	O	/		/		/
132	Vol 3 : Appendices (1996)	12					O								
133	Vol 4 : WMA Corporate Plan (1996)	13								O			/		
134	Bangkok Metropolitan Region Wastewater Management Plan - Main Report (1996)	14					/				/	O	/		/
135	Bangkok Metropolitan Region Wastewater Management Plan- Appendices : Part I	15					O						/		
136	Long Term Plan 32 years (2010 – 2041)		54						O	/			/		
137	(a) Wastewater Management in Thailand (Eng Ver.) (b) Wastewater Management of community (Thai Ver.)		55						/				O		
138	Building Effluent Standards from PCD		56						O						
139	(a) Water Quality in Chaophraya River(2009 : Jan.-July) (b) Water Quality of Khlong in BKK		57							O			/		
140	Human Development Report 2007		65 *		(65)		/	/					O		

	Catogory / Name of Document and Organization	Number of Document					Administration/Policy			Technical				Economic	
		Document	Sheet	Map	CD	Brochure	General	Strategy	Policy /Regulations	Planning	Design	Survey	Environment	Organization	Finance
141	Solid waste management		76 *		(76)			O	/						
142	(Book)Maps of all administrative districts and (CD#1) district & Bangkok map		106		(106)					O			/		
143	(a) Data of industrial activity, estimated wastewater volume, (b) Data of livestock and (c) Journal of infection diseases department				49 *					/		/	O		
144	CPD Brochure - Land use					128				O					
	The Other														
145	The study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse – Vol 1 : Executive Summary (1999)	6										O			
146	The study for the Master Plan and Reclaimed Wastewater Reuse in Bangkok – Vol 2 : Main Report (1999)	7										O			
147	Vol 3 : Supporting Report (1999)	8							/			O			
148	Vol 4 : Data Book (1999)	9										O			
149	Nongkhaem - Tungkru WWTP (Annual Report 2008)	26					/					O			
150	Hydraulic Design	88								/	O				
151	Wastewater Treatment Tank (AQUA Nishihara co., ltd.)	93								O					
152	Soil Boring Report – Project : DDS Building and Work Shop Nongbon swamp, Prawet (JUNE 2010)	124										O			
153	Draft Report of Public Awareness Survey (2 copies)	138										O	/		
154	Drawing of Telecom Information at Prawet, On Nuch and Suan Luang	145									O				
155	Presentation Sheet : Summary of Inception Report		42							/		O			
156	Water Supply Districts and Sewerage Treatment Areas			92							O				
157	Information of the housing areas in Prawet District					101				O					
158	Catalogs of Screw Press Dewatering					127				O					
159	Bangkok MRT Master Plan					134 *				O					

List of Documents and Data

1. Water Quality Management Office – Annual Report 2551 (2008)
2. Performance Plan of BMA 2009-2012 (English Version)
3. Performance Plan of BMA 2009-2012 (Thai Version)
4. Statistical Profile of BMA (2008) (English Version)
5. Statistical Profile of BMA (2008) (Thai Version)
6. The study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok – Vol 1 : Executive Summary (1999)
7. The study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok – Vol 2 : Main Report (1999)
8. The study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok – Vol 3 : Supporting Report (1999)
9. The study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse in Bangkok – Vol 4 : Data Book (1999)
10. Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study – Vol 1 : Executive Summary (1996)
11. Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study – Vol 2 : Main Report (1996)
12. Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study – Vol 3 : Appendices (1996)
13. Bangkok Metropolitan Region Wastewater Management Action Plan and Feasibility Study – Vol 4 : WMA Corporate Plan (1996)
14. Bangkok Metropolitan Region Wastewater Management Plan – Main Report (1996)
15. Bangkok Metropolitan Region Wastewater Management Plan – Appendices : Part I
16. Metropolitan Water Works Authority – Annual Report 2000
17. Metropolitan Water Works Authority – Annual Report 2001
18. Metropolitan Water Works Authority – Annual Report 2002
19. Metropolitan Water Works Authority – Annual Report 2003
20. Metropolitan Water Works Authority – Annual Report 2004
21. Metropolitan Water Works Authority – Annual Report 2006
22. Metropolitan Water Works Authority – Annual Report 2007
23. BOD Loading in the Chaophraya River
24. Dindaeng Water Environment Control Plant – Annual Report 2009
25. Chatujak Water Environment Control Plant – Annual Report 2009
26. Nongkhaem - Tungkru Water Environment Control Plant – Annual Report 2008

27. Bang Sue Feasibility Study Report Volume 1/5 - For executive summary (Thai Ver.) (2006)
28. Bang Sue Feasibility Study Report Volume 2/5 - For executive summary (Eng. Ver.) (2006)
29. Bang Sue Feasibility Study Report Volume 3/5 - Main Report (Thai Ver.) (2006)
30. Bang Sue Feasibility Study Report Volume 4/5 - Appendices (Thai Ver.) (2006)
31. Bang Sue Feasibility Study Report Volume 5/5 – Basic (2006)
32. Wastewater Tariff : Feasibility Study – Main Report (Thai Version) (1998)
33. Feasibility Study of Klong Toey Wastewater Treatment Project Vol.1 :Executive Summary (2001)
34. Feasibility Study of Klong Toey Wastewater Treatment Project Vol.2 : Main Report(2001)
35. Feasibility Study of Klong Toey Wastewater Treatment Project Vol.3 : Appendices (2001)
36. Feasibility Study of Klong Toey Wastewater Treatment Project Vol.4 : Preliminary Design Drawings (2001)
37. Chatuchak WWTP : CD #1
38. Din Daeng WWTP : CD #7
    Bangkok Wastewater project stage 1 (PART1) 1/2 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART2) 1/1 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART3) 1/4 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART3) 3/4 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART4) 1/1 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART5) 1/3 AS-Built drawing
    Bangkok Wastewater project stage 1 (PART5) 3/3 AS-Built drawing
39. Nong Khaem WWTP : CD #4 As-Built drawing
40. Tungklu WWTP : CD #6
41. Questionnaire on Technical Survey
42. Presentation Sheet : Summary of Inception Report
43. Bangkok State of Environment Report 2006-2007
44. Water Quality Management Office – Annual Report 2550 (2007)
45. (CD #1) Water Quality Management Office – Annual Report 2549-2551 (2006-2008)
46. Major Public Park in Bangkok
47. (CD #1) Data of water consumption 2553 (2010) -Transition of water supplied population and water consumption by use (domestic,commercial and industrial)
48. Operation and maintenance data in 2009

(a) O&M cost and utility consumption for personal, electrical power, chemicals, repair, replacement

and so on

(b) Wastewater flow of influent and effluent

(c) Treatment performance: Influent and effluent wastewater characteristic and target value

49. (CD #1) (a) Data of industrial activity, estimated wastewater volume
    (b) Data of livestock
    (c) Journal of infection diseases department
50. (CD #1) Factory BMA Sep 2009 (Industrial area)
51. City Planning BMA (Edit #2) and (CD #1) Map : landuse,transport and openspace.
52. (CD #1) BKK Comprehensive Plan (Regulation)
53. Map and (CD #1) (Land use 2006)
54. Long Term Plan 32 years (2010 – 2041) from PCD
55. (a) Wastewater Management in Thailand (Eng Ver.)
    (b) Wastewater Management of community (Thai Ver.)
56. Building Effluent Standards from PCD
57. (a) Water Quality in Chaophraya River (2009 : Jan.-July)
    (b) Water Quality of Khlong in BKK
58. Map and (CD #1) Chaophraya River
59. (CD #1) Rainfall Data from BMA
60. Map of Nongbon WWTP
61. EIA in Thailand (2007)
62. Guidelines for participation of people and assessment the impact of social environment (EIA)
    (2006)
63. Strategic Environment Assessment : SEA (2009)
64. Guidelines for heath impact assessment (EIA) (2009)
65. (CD #1) Human Development Report 2007
66. (Brochure #3) MWA (a) History
    (b) Water Treatment Plant-Bangkhen
    (c) Water Treatment Plant – Mahasawat
67. (Draft) Summary of waterworks improvement project
    And Demand for water and Capability to produce water
68. Metropolitan Water Works Authority – Annual Report 2009 (Thai Version)
69. Metropolitan Water Works Authority – Annual Report 2008 (Thai Version)
70. (CD #1) (a) Strategic Environmental Assessment : SEA (Thai & Eng. Version)
    (b) Announcement – guideline of EIA (Eng. Version)
71. Action Plan for Flooding Prevention (2010) (Thai Version)
72. Comparative study on Integrated Wastewater Management System Model for Developing Countries under Rapid Urbanization (Eng. Version)

73. BMA ordinance: Collection of Wastewater Tariff B.E.2547 (2004) (Thai & English Version)
74. Critiria for obstaing the service of sewerage in BKK.(Thai Version & Translation)
75. Geology of the lower central Plain. (Eng. Version)
76. (CD #1)(Power point) Solid waste management
77. History and organization chart of DDS 2542 (1999)
78. (Content) Regulation of environment health in 1992.
79. Fiscal Year 2007-2008 of DDS
80. BKK : primate city (area & population)
81. Data of Khlong in water environment control plant
82. Chart of Septic tank #5, Chart of drainage pipe elevation plan #1
83. Chart of the position of manhole, pipe and septic tank in household
84. (Drawing) Network Map of the existing Combined Drains in Din Daeng and Nongbon
85. AS Network Map of the existing Interceptor Pipes in Din Daeng
86. The Land development Act B.E.2543 (A.D.2000) (Eng. & Thai Version)
87. (Map) WWTP 7
88. Hydraulic Design
    88.1&2.for interceptor route&point chamber at Banthad Thong Rd., (Vol.2/1)
    And for throttle pipe at Rama 4 (Vol.2/2)
    88.3. for throttle pipe (Vol.3) Khlong Suan Luang
    88.4. for interceptor route & point chamber (Vol.4) Khlong Suan Oi
    88.6. for interceptor route (Vol.6) Samsen Rd.,
    88.7. for interceptor route (Vol.7) Si Ayutthaya Rd., - Ratchasima Rd.,
    88.8. Hydraulic Design (Vol.8) Pitsanuloh Rd.,
    88.9. for interceptor route & point chamber (Vol.9) Klong Bang Lamphu
    88.10. for interceptor route & point chamber (Vol.10) Krung Kasem Rd.,
    88.11. for interceptor route & point chamber (Vol.11) Krung Kasem Rd.,-Luk Luang Rd.,
    88.12. for throttle pipe (Vol.12) Krung Kasem Rd.,-Luk Luang Rd.,
    88.13. for throttle pipe (Vol.13) Rama 4 Rd., - Nakonpathom Rd.,
    88.14. for throttle pipe (Vol.14) Klong Phadung Krung Kasem
    88.15. for interceptor route (Vol.15) Klong Phadung Krung Kasem
    88.16. for interceptor point chamber (Vol.16) Klong Mahanak-Rama 6 Rd.,
    88.17. for throttle pipe (Vol.17) Klong Mahanak
    88.18. for interceptor point chamber (Vol.18) Klong Mahanak- Klong Bang Lumphu-
    Soi Bothitpimuk
89. (Map) Plan of Minburi WWTP (June 18,2010)
90. Database & Tariff Collection Section of WQMD

91. (Map) DDS Sewerage Treatment Areas

92. (Drawing) Water Supply Districts and Sewerage Treatment Areas

93. Wastewater Treatment Tank (by AQUA Nishihara co., ltd.)

94. STP Brochures (WWTP Chon nongsi, WWTP Si phraya, WWTP Dindaeng, WWTP Thung Khru #2, UNEP, BMA)

95. DDS E-magazine

96. Budget Fiscal year of DDS (2006 – 2009) (Eng. & Thai Version)

97. Report of survey : Willingness for paid the tariff in wastewater treatment area (from DDS)

98. The study on wastewater treatment charge in Thailand and foreign countries, 2010 DDS, BMA.
(Eng. & Thai Version)

99. Project drainage tunnel construction in BKK area. (DDS,BMA)

100. Bangkok Four year Public Administration Plan, 2005 – 2008.

101. Information of the housing areas in Prawet District.

102. Canal network (West & East Bangkok)

103. Meeting report (Management about wastewater , garbage and tariff of wastewater treatment)

104. MWA Water Consumption (Dr.Pathan's Thesis)

105. Chart of Prawet district (Cleaning drainage and manhole)

106. (Book) Maps of all administrative districts in Bangkok – separate district
(CD) district & Bangkok map

107. (Map #2) Maps of all administrative districts in Bangkok

108. Khlong Data in BKK. (Water Transportation Plan)

109. Profile of Bangkok City

110. Water Quality Management

111. Strategy to increase the efficiency of quality water management

112. Watergate and Pump station Chart

113. Network Map of the existing Combined Drains in Phra Khanong District

114. (CD) IPC Improvement Drawing of Rattanakosin and PCD (from DDS)

115. Final Design Report of Chatuchak District (from DDS)

116. Bangkok Wastewater Project – YANNAWA (3 items - Interceptor Sewers Calculations
: KCN catchment, Rama 3 catchment, Rama 4 catchment Final design submission)

117. The survey and design the drainage system project in Bangkapi district – Main road (# 1/10)

118. The survey and design the drainage system project in Bangkapi district – Bangkapi district (#5/10)

119. The survey and design the drainage system project in Bangkapi district
– Wang Thong Lang District (#8/10)

120. Regulation of the office of the Prime Minister in case of public consultation (2005) (From DDS)

121. Pipe Jacking Cost (From DDS)

122. Network Map of the existing combined drains in "Prawet" District

123. Bangna District – City Planning Map

124. Soil Boring Report – Project: DDS Building and Work Shop , Nongbon swamp, Prawet (JUNE 2010)

125. Drawing of Buildings in Rama 9 Park

126. Drawings of the existing WWTPs

127. Catalogs of Screw Press Dewatering

128. CPD Brochure - Land use

129. The meeting document of the Master Plan for drainage system project in Lad prao area, Bang khen area and the part of Chatuchak. (Document & Questionaire)

130. The Revenue and Payment report of BMA budget in 1997 - 2008

131. (MAP) Scope of the polder system for solving.

132. (Copy) Documents of Price Assessment of Bang Sue Project.

133. (Copy) Bangkok MRT of the dark yellow line, F/S Drawings

134. Bangkok MRT Master Plan

135. (DVD) WWTP- Bangsue VDO Representation

136. Nongbon Area Topographic MAP

137. Electricity Conduit Information Map of Nongbon Area

138. Draft Report of Public Awareness Survey (2 copies)

139. The Operation & Maintenance and management of WWTP – Chatuchak

140. Klong Toey Wastewater Treatment Project ,October 2010. (From DDS)

141. Location of pumping station installation at Prawet district

142. Drainage Project at Suwannabhumi Airport (Royal Irrigation Dept. ,Dec.2010)

143. Map show the area of south-Thonburi WWTP Project

144. (CD#1) Map of WWTP site (8 Feb. 2011 from DDS)

145. Drawing of Telecom Information at Prawet, On Nuch and Suan Luang

146. Annual Performance Report for the Fiscal Year 2009

147. (#1 sheet) Organization Chart of Finance Dept,BMA.

148. Credit News of BMA (Announcement No.742)

149. Balance Sheet of BMA as at Sep. 2008-2007 , Sep.2007-2006 and Sep.2006-2005

150. The Expenditure & Budgeting of BMA

151. (#1 sheet) Steps for Consultant Selection (Thai & Eng.Version)

152. Monthly Results of Water Quality Analysis in 2010 (From DDS)

153. Expense for operating wastewater system of WWTP in 2010 (From DDS)
154. (Map) Klong Water Quality Improvement Project (From DDS)
155. Financial Assistance From the Danish International Development Agency
156. The Revenue and Payment report of BMA budget in 2007 - 2009
157. (Copy) AS-Built Drawings Installation Details (Manhole 171A-3/4 in Klong Sam Sen and Manhole 1.60X in Klong Sen Sep)
158. (Copy) AS-Built Drawings Manhole and IPC Installation Details (Manhole Type I & II)
159. Profile of Klong Nongbon

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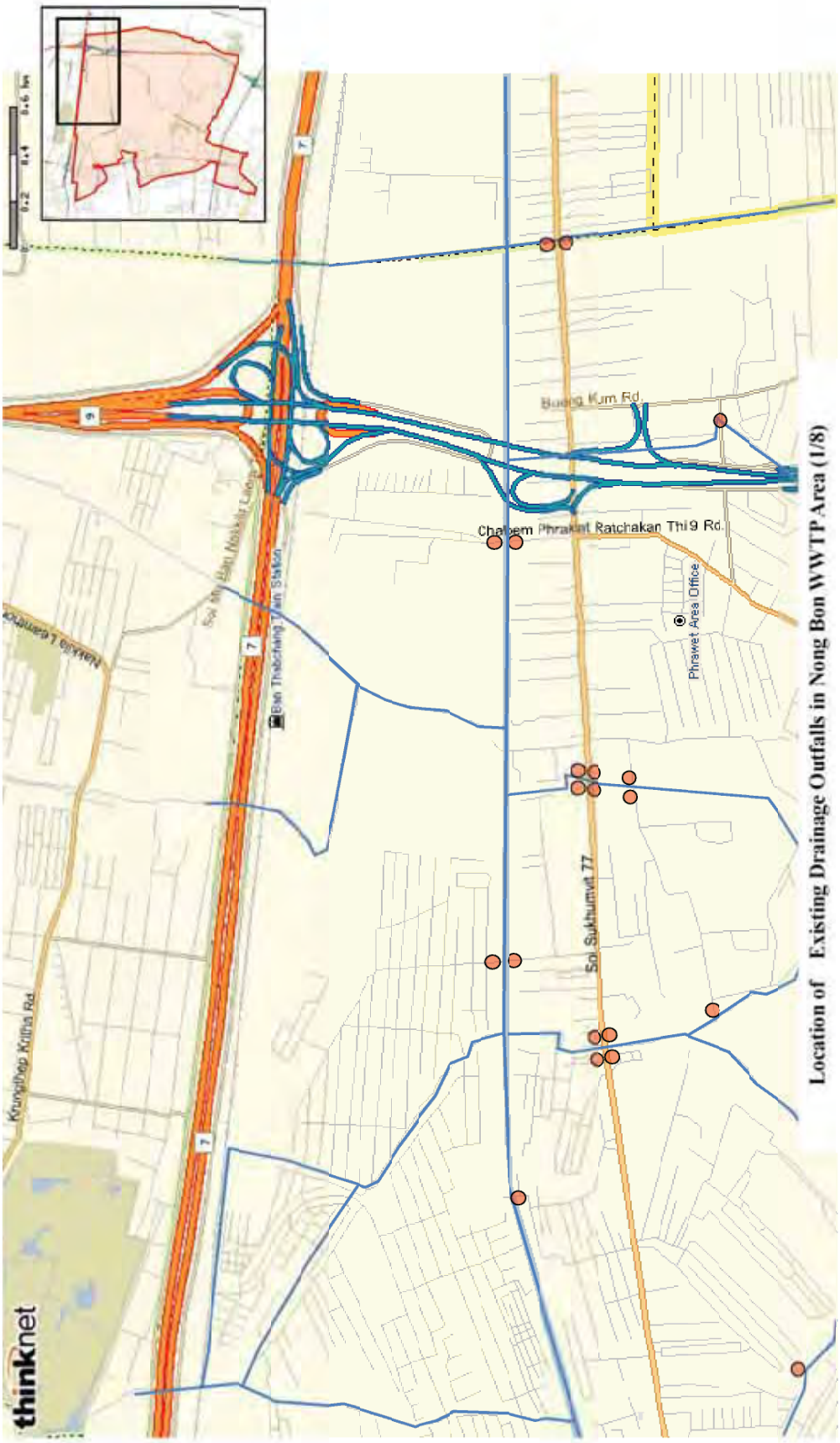
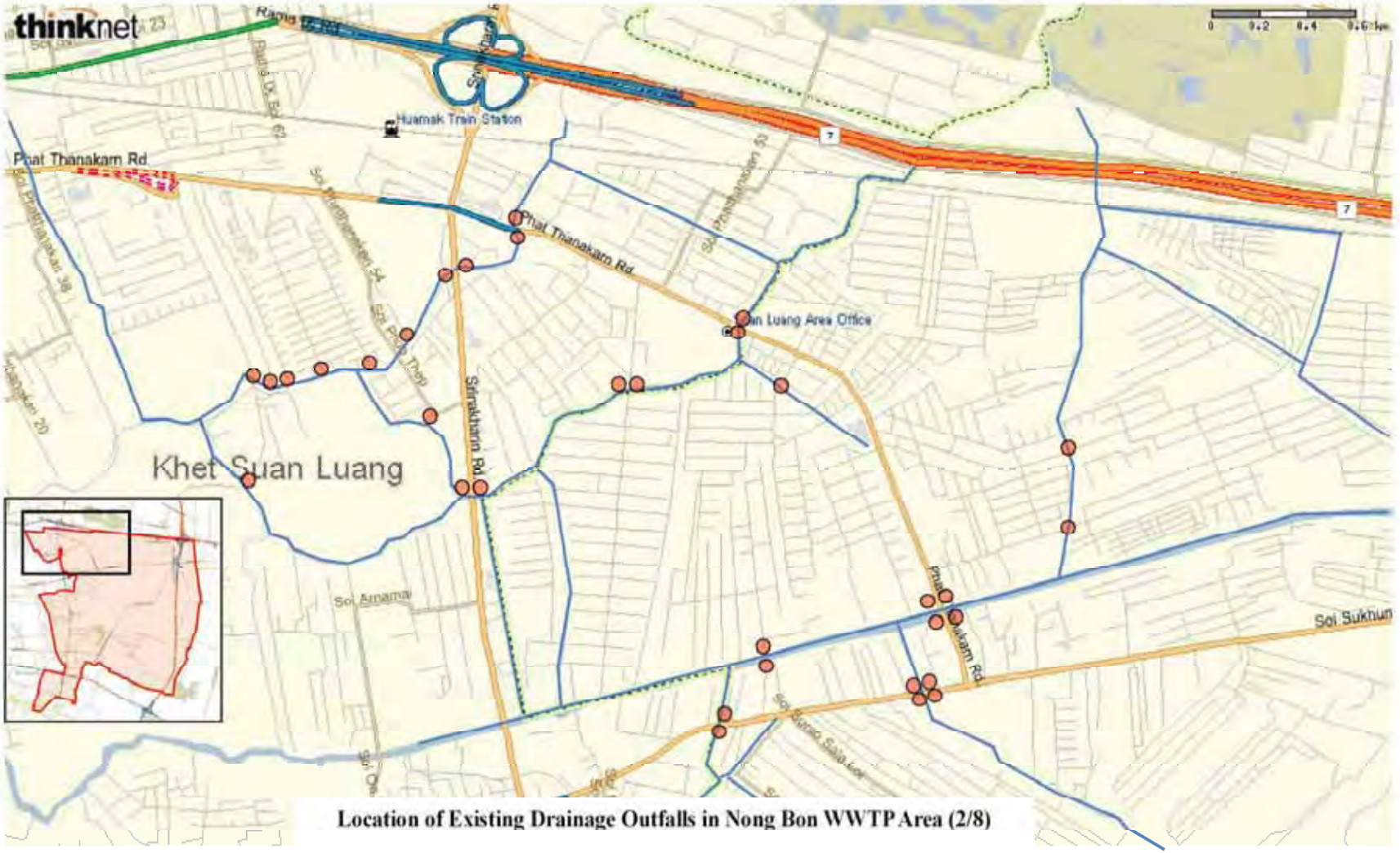
Appendix-3
Existing Drainage Outlets in Nong Bon Treatment Area


Location of Existing Drainage Outfalls in Nong Bon WWTP Area (1/8)
Chaloem Phrakiat Ratchakan Thi 9 Rd.
Bang Kum Rd.
Phrawet Area Office
Sukhumvit 77
Krungthep Kritha Rd.
thinknet

Appendix 3-2


thinknet
Huamak Train Station
Phat Thanakarn Rd.
Khet Suan Luang
Soi Arnamai
Soi Sukhun
Location of Existing Drainage Outfalls in Nong Bon WWTP Area (2/8)

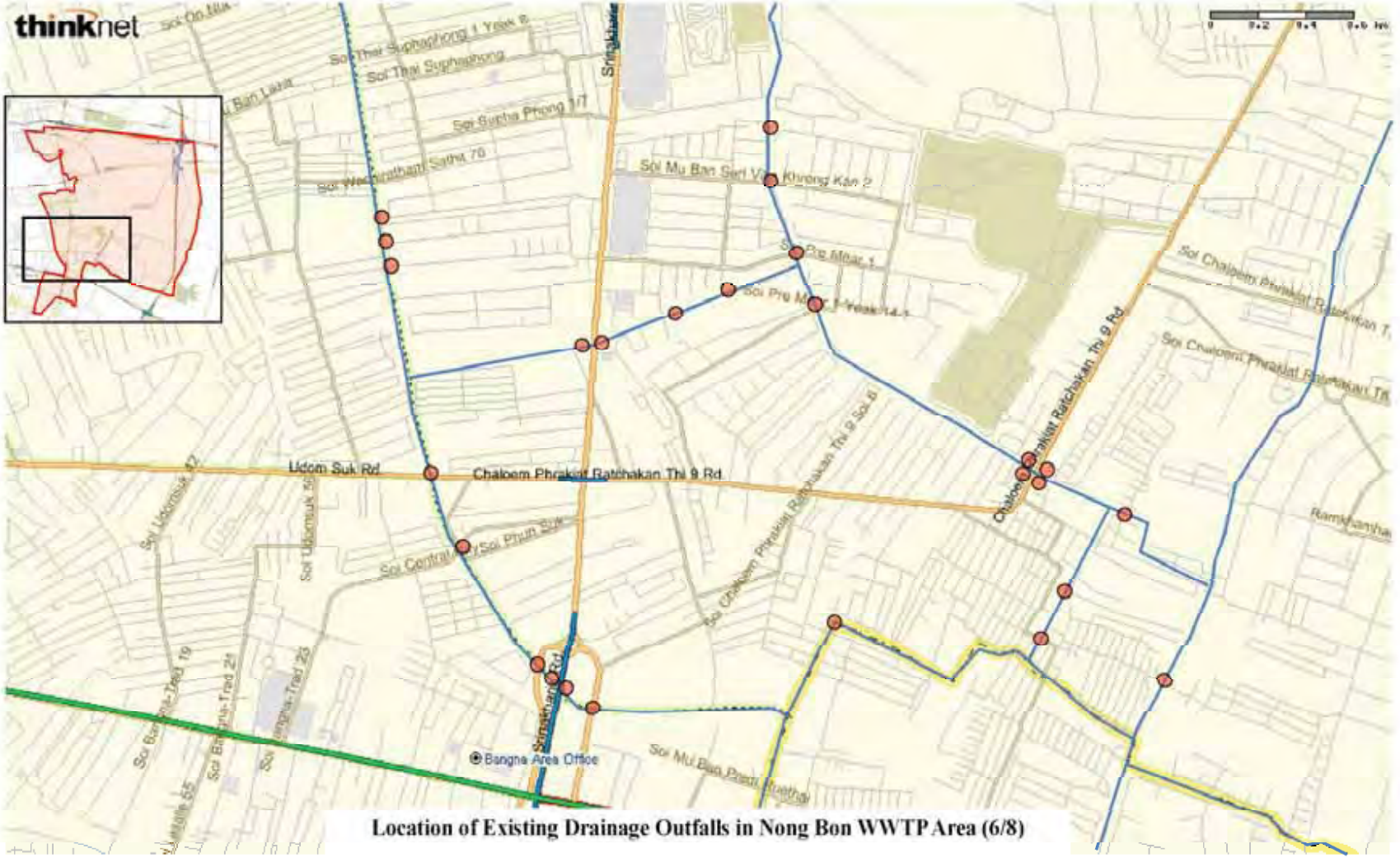

Location of Existing Drainage Outfalls in Nong Bon WWTP Area (3/8)
Khet Prawet
Prawet Area Office
thinknet

Appendix 3-4


Location of Existing Drainage Outfalls in Nong Bon WWTP Area (4/8)
Srinakharin Rd.
Thanakarn Rd.
Soi On Nut 86
Soi On Nut 64
Soi On Nut 44
Soi On Nut 40
thinknet

Appendix 3-5

Location of Existing Drainage Outfalls in Nong Bon WWTP Area (5/8)



Location of Existing Drainage Outfalls in Nong Bon WWTP Area (6/8)

Location of Existing Drainage Outfalls in Nong Bon WWTP Area (7/8)
thinknet

Appendix 3-8

Location of Existing Drainage Outfalls in Nong Bon WWTP Area (8/8)