CHAPTER 8 PRELIMINARY COST ESTIMATION AND FINANCIAL/ ECONOMIC EVALUATION

8.1 Preliminary Cost Estimate

8.1.1 Basic Conditions for the Cost Estimation

The following basic conditions and assumptions are incorporated in the cost estimation:

- The price level of the estimation was set at October 1998. The exchange rates of foreign currencies between Thai Baht and US Dollars and Japanese Yen used in this report are:
  1.00 US$ = 36.00 Thai Baht = 120.00 JPYen
  Price escalation is not considered in this cost estimation.
- The unit prices of wastewater treatment works are estimated on the basis of the information obtained from the existing and ongoing wastewater treatment projects in Bangkok, latest similar projects in the Southeast Asian countries, and experiences of similar projects in Japan.
- Quantities of wastewater flow (DWF), sludge amount that will be generated from the existing, ongoing, and proposed treatment plants, night soil amounts that will be generated from the existing and proposed septic tanks, on-site treatment plants and reclaimed wastewater amounts estimated in this report are based on the facilities described in the previous sections.
- Tax and custom duty are assumed to be exempted in view of the nature of the project, and thus excluded from the cost estimation in the report.
- Construction, supply, and installation works were envisaged to be carried out by competent contractors selected through International Competitive Bidding (ICB).
- Land acquisition and compensation costs are not included in this cost estimation. It was envisaged that land acquisition, compensation, and resettlement cost will be the responsibility of BMA.
- The construction costs of transmission line to outdoor switchyard to be installed in the respective treatment plant and access road to them are not included.
- Operation and maintenance cost, i.e. salaries including benefits and overtime, process energy, process chemicals, maintenance of various plants such as wastewater treatment, digesting and compost, and training cost for BMA's staff are all estimated on the basis of the information obtained from the existing and ongoing projects in Bangkok as well as Southeast Asian countries and Japan.

The cost estimate was made for all the project works including construction, commissioning, training of BMA's staff, first year operation and maintenance by

contractors and engineering services for detailed design and supervision. However, physical and price contingency are not included in this cost estimate.

8.1.2 Unit Cost Estimation

The following unit values were used for the financial analysis, which is summarized in Table 8.1.2.1.:

- Charging rate of wastewater treatment is 5 Bahts/m^3.
- Non-digested sludge is mixed with bulking materials for composting at the rate of 1:0.5 in weight, as shown in Table 8.1.2.4.
- 5 t of compost is produced from 1 t of ds.
- Depreciation of all machines and plants is 20 years.
- Distances from the Central WWTPs to STC, from STC to landfill site, from the Central WWTPs to the composting plants, and from the composting plants to the agricultural land are assumed to be 25, 15, 100, and 10 km respectively.
- Weight reduction rate by incineration from cake to ash is 12.5.
- Density of bulking materials such as straw and husk is 0.2.
- Sales price of compost is 1,500 Bahts/t and bulking material cost is 75 Bahts/t.
- Power generated from digestion plant is sold at the rate of 2.25 Bahts/kWh to recover the cost, as calculated in Table 8.1.2.2.
- Transportation cost (2 ways) is calculated by the following equation: Transportation cost in Baht = 3.28 x Distance in km + 38.4 (See Figure H1, DATABOOK)
- Rehabilitation cost for NSTP is one third of its construction cost.
- Charging rate to collect night soil is 50 Bahts/t.
- Distance of night soil transportation to NSTP is 20 km.

Unit costs of construction and O&M for plants are estimated based on cost data supplied from manufacturers with appropriate modification considering local conditions. Estimations for Digestion plant, Generation plant and composting plants are presented in Table 8.1.2.2 and 8.1.2.3. The attached tables of Part H, Unit Cost in DATA BOOK show the detailed estimation of other unit costs..

8.1.3 Local Cost Based Estimation of Representative Options

As discussed in the earlier section, Options A2, L1, L2, and L4 were selected as the most appropriate sludge treatment/disposal ways. The unit treatment/disposal cost of each Option is estimated in more detail in this section for further financial analysis by using the above unit values.

The results of the preliminary cost comparison among these options are presented in Table 8.1.3.1 and are summarized as follows:

- Among Landfill disposal options, Option L1 or incineration is most expensive due to the high cost of incineration process. Disposal costs of Option L2 is a little bit large, compared to L4. Since this is a very preliminary cost estimation, however, both options should be considered to be indifferent in terms of treatment unit cost. Option L2 needs digestion process, which cost is partially recovered by selling generated electricity.
- Option A2 is the most economical way. In this option, sludge is dewatered at the Central WWTP and transported to a centralized compost plant in an agricultural area. This is the most economical way because 1) no digestion process is needed and 2) bulking materials is easily available near there. However, comparing composting after digestion, this composting plant become expensive since 1) sludge has to be composted in the vessel in order to carefully keep temperature high and 2) odor removal facility is needed for composting non-digested sludge.
- Assuming that dewater process is done by the public sector and the sludge is given to compost manufacturers free of charge at treatment plants, this preliminary cost estimation shows that a composting business could be feasible. (See "Balance after composting" in Table 8.1.3.1)

All cost estimations were made based on experiences in developed countries. Composting process heavily depends on various local conditions such as sludge quality, natural temperature, available microorganism, acceptable working conditions, market taste, and so on, which, in turn, affects design requirement of plants. Therefore, cost of plant construction and O&M will certainly vary depending on these local required conditions.

Nevertheless, above study is an attempt to compare sludge treatment cost of each option in order to make a preliminary evaluation of each option in this Master Plan Study, although the detailed cost estimation obviously has to be done at the implementation stage.

8.2 Financial and Economic Evaluation

8.2.1 Financial Evaluation of Relevant Existing Plants

(1) Si Phraya Central WWTP

The Si Phraya Wastewater Treatment Plant (WWTP) is the only WWTP currently in operation, collecting wastewater and discharging treated wastewater to the nearby canal. The operating data, as shown in Table 8.2.1.1, provides the following findings:

i) The average unit cost to treat wastewater including utility, chemicals, maintenance, and labor is 1.84 Bahts/m^3, which shows a clear learning curve, starting 2.94, 1.63, and 1.43 Bahts/m^3 for the 96, 97, and 98 Thai Fiscal Year, respectively. The major contribution factors to reduce the unit cost are a)

increase of treated wastewater volume, b) decrease of maintenance and operation cost, and c) decrease of labor cost.

ii) There are no cost recovery activities, since no charging system on wastewater treatment is available and both sludge and reclaimed wastewater are to be transferred free of charge.

iii) Since sludge production is relatively small, ranging from 27 to 54 t/month, it is transferred by small size pick-up truck to be used for tree gardening in public parks. In case of large Central WWTPs, these costs to treat sludge will certainly significantly increase the unit cost. The average sludge content in wastewater is 66.06 g/m^3, which is quite low.

iv) The number of permanent staff suddenly decreased from 12 to 5 in April 1998. This is because 7 staff shifted to 17 other small scale treatment plants, which implies that Si Phraya WWTP has an On-the-Job Training function as a pilot project.

v) Their constraint is maintenance, largely due to financial decisions required in BMA to draw an emergency budget. Since the plant has to be operated for 24 hours a day, mechanical and electrical breakdowns cause serious damage in operation. Privatization to contract out maintenance services would be one practical solution.

(2) Nong Khaem NSTP

There are two night soil treatment plants in BMA, namely, On-Nut and Nong Khaem, both of which have design capacity of 600 m^3/d. On-Nut NSTP is operated by BMA, while Nong Khaem by a private operation company.

Nong Khaem NSTP was constructed and operated by a Japanese engineering company for 5 years and has been operating by a local company since 1996. For the period of operation by the Japanese company, the average treatment amount ranged from 244 to 270 m^3/d, which is only 40 to 45 % of the design capacity, because of the limited night soil collection capacity.

After operation by Japanese company, the local company made a contract with DPC, BMA two years ago in terms of operation and maintenance of the Nong Khaem NSTP. The target operation capacity is 480, 500, 530, 600 and 600 m^3/d for 1996 to 2000 and the actual treated volume was 412, 368 and 542 m^3/d for the first three years.

DPC provides all investment, maintenance cost, utilities, collection of night soil, while the local company operates the plant properly for which 215 Bahts is paid for each ton of night soil. Collection of night soil is made by request from individual households, in which the average collection cost is 50 Bahts per ton. The catchment area for the Nong Khaem plant is 33 districts out of the 50 districts in BMA, while

the On-Nut plant covers the rest. The plant is currently in operation for 24 hours by 50 workers (10 office workers and 40 operation workers) plus 17 BMA staff.

The following findings are identified from the operation data of Nong Khaem NSTP, as shown in Table 8.2.1.2:

i) The average O&M cost is 343 Bahts/m^3, which consists of salary of administrative staff, engineer and technician (56.06 %), labor (17.86 %), chemical (12.01 %), maintenance and repair (8.99 %), electricity (4.58 %) and water (0.50 %).

ii) Since variable cost items such as chemical and electricity has relatively small cost portion, the O&M unit cost could be sharply decreased in case of full operation, say around 240 Bahts/m^3.

8.2.2 Financial Analysis of Each Treatment System

This section provides a preliminary financial analysis up to the year 2020, which could be used to start discussion on how to recover the total investment and O&M cost, how much the charging fee could be and what kind of managerial mechanism should be most appropriate. The scope of the financial analysis includes (1) wastewater treatment systems to be build up to the year 2020, (2) sludge treatment systems produced from these WWTPs and NSTPs, (3) reclaimed wastewater reuse systems from WWTPs and (4) night soil treatment systems up to the year 2020 and its sludge treatment.

The costs in the analysis are (1) construction cost of wastewater treatment plant, wastewater collector system, digestion plants with power generation, compost plant, sand filter and activated carbon filter, (2) land acquisition cost for wastewater treatment plant, (3) O&M and production cost of these plants, (4) bill charging cost, (5) transportation cost for collection and dumping, (6) dumping site construction cost. The revenues are (1) treatment charge of wastewater and night soil, (2) sales revenue of compost and reclaimed wastewater and (3) sales revenue of power generated by digestion plant.

The fundamental assumptions are:

- Capital cost is zero, assuming all project costs are covered by the BMA's own budget.
- A depreciation period for plant construction cost is assumed to be 20 years, a expected plant life.
- All figures are based on the present value as of 1999.
- The charging unit cost of bill is adopted from "A Feasibility Study of BMA Wastewater User Charge (E2-2 page), that is, 2.8 Bahts/bill/month and the

average number of people per house is assumed to be 5 from the same report (B1-1 page).

(1) Wastewater Treatment System (WWTS)

i) Basic Assumptions

- Besides the existing, ongoing and planned WWTS, 9 proposed new WWTS will be constructed under a schedule of the estimated completion date, as shown in Table 8.2.2.1.
- The past investment for construction of existing and ongoing WWTSs is ignored as a sunk cost in this financial analysis.
- Since WWTSs are constructed in a different schedule and the overall financial evaluation has to be done up to the year 2020, the construction cost was calculated by unit cost so that the analysis is not affected by depreciation period .
- The revenue in this part is only from treatment charge and the costs consist of plant construction, plant O&M, and charging cost.

ii) Unit Cost

- Unit costs for construction and O&M are based on the SAPROF report for the newly proposed WWTSs in the Study. Operation data of Si Phraya WWTS is not used, since plant capacity is so different from others and quality of influent wastewater is much better than expected at future Central WWTPs. The O&M cost of Si Phraya is 1.84 Bahts/m^3, while 1.48 Bahts/m^3 (15 x 36 / 365) is used in this Study, which includes a replacement cost. Construction costs for ongoing projects are based on their contract amount.
- Land cost is 12,000 Bahts/m^3, which is calculated from "A Feasibility Study of BMA Wastewater User Charge" (4-28 page), for a case of no data and information available. Land cost for others are based on interviews during the Study.
- In order to make a preliminary cash flow, wastewater treatment charge is assumed to be 5 Bahts/m^3 without any connecting charges.

iii) Findings

- Assuming the past investment is a sunk cost and therefore excluded in a cost-benefit analysis, the total balance up to 2020 is 11,881 Million Bahts.
- The breakeven point in terms of wastewater treatment charge is 4.06 Bahts/m^3 as shown in Table 8.2.2.10. This is a rather reasonable charge compared to that for water supply, of which current charging rate is around 14 Bahts/ m^3.

(2) Wastewater Sludge

i) Basic Assumption

- The sources of sludge are (1) Central WWTPs in existing and current BMA schemes, (2) Community WWTPs and (3) Central WWTPs in planned and proposed schemes, all of which produces capacity of 258 t DS/d in 2020, as shown in Table 8.2.2.2.
- Scenario 1 is applied for this analysis.
- This sludge is divided into two groups, i.e., the high risk sludge which is treated and disposed by Option L2 and the low risk sludge which is used for agriculture by Option A2, as earlier discussed in this report.
- The cost includes processes only after sludge cake produced by WWTPs and NSTPs.

ii) Unit Cost

- The sales prices of compost is assumed to be sold at 1,500 Bahts/t.
- All unit costs used in this section were discussed in Section 8.1.2.

iii) Findings

- The overall sludge treatment system can be feasible and the total accumulated balance up to 2020 is 1,069 Million Bahts under these assumptions, as shown in Table 8.2.2.2.

(3) Reclaimed Water Reuse for Road Sprinkling and Tree Watering

i) Basic Assumption

- The effluent water from Central WWTPs is re-treated by sand filter to meet with a requirement to be used for road sprinkling and tree watering in parks and roads. The costs include additional treatment processes and additional transportation after WWTPs.
- Tree is watered everyday, but it becomes half in rainy season.
- Road washing is done only once a week.
- Reclaimed water is competitive, if the selling price is sufficiently lower than public supply water, which price is 14.31 Bahts/m^3
- Water is transported by 6 m^3 tanker.

ii) Unit Cost

- The demand of watering trees is 30 m^3/100ha and the demand of road sprinkling is 10 m^3/100ha.
- The sales price of reclaimed water is 5 Bahts/m^3.

iii) Findings

- The reclaimed water reuse for road sprinkling and tree watering is feasible, if the additional transportation distance is shorter than 6 km per trip, since the cost is lower than the public supply water, as shown in Table 8.2.2.3.
- The unit cost to produce reclaimed water by sand filter is 2.40 Bahts/m^3, as shown in Table 8.2.2.4 and 8.2.2.5.
- If it is charged at the rate of 5 Bahts/m^3, the total balance from this activities reaches at 179.5 Million Bahts and the public supply water of 69 Mil. m^3 will be saved up to the year 2020, which is approximately 4.2 % of the annual water production by MWA. This is not a significant amount of water compared to the overall water consumption of BMA, but it is certainly important to start water reuse from possible options.

(4) Reclaimed Water Reuse for Incidental Water Use

i) Basic Assumption

- The large-scale new town or condominium with double water piping systems is constructed at a distance of 3 km from the Central WWTP. Reclaimed water is supplied by pipe from WWTP for toilet flushing, floor cleaning, gardening and so on.
- Reclaimed water after WWTP is additionally re-treated by sand filter and activated carbon filter.
- Water amount replaced by reclaimed water is 76.8 l/c/d, which is 30 % of 256 l/c/d, the total daily water consumption, as shown in Table 8.2.2.6.
- The user population is 1 %, 2 %, 3 %, and 4 % of the population in catchment area of WWTP in 2001, 2006, 2011, and 2016, respectively.

ii) Unit Cost

- The reclaimed water production cost is 5.0 Bahts/m^3 for a demand capacity of 1,800 m^3/d at a distance of 3km. The production cost includes additional treatment cost, pumping cost and its O&M cost.
- The sales charge is 8.0 Bahts/m^3, which is sufficiently competitive, compared to 14.31 Bahts/m^3 of public supply water.

iii) Findings

- Although the idea is financially feasible, some policy guideline with financial incentives is needed in order to encourage people to adopt the reclaimed wastewater reuse system, since financial benefit of individual people is very limited, 3,538 Bahts/capita for 20 years. As BMA certainly faces a water shortage in the future, however, this option should be strongly encouraged.

- Under this assumption, the annual water consumption of reclaimed water is 8 Million m^3 in 2016, which is 0.5 % of the total annual water consumption supplied by MWA.

By both ways to reuse reclaimed water, accumulated surplus reaches 488 Million Bahts up to 2020, as shown in Table 8.2.2.7.

(5) Night Soil Treatment Plant

i) Basic Assumption

- There will be 4 NSTPs under operation in 2020, which treat wastewater of 1,100 m^3/d and produce sludge of 44.0 t DS/d, as shown in Table 8.2.2.8.
- The construction costs of 2 new plants, that is, Yannawa and Ratburana Central WWTPs, are not considered in this analysis, since both are joint operation with wastewater and these costs are included within wastewater treatment system.
- 2 existing plants, that is, On-Nut and Nong Khaem, will be used until 2020 with rehabilitation, which is assumed to be included in the O&M cost.
- The sludge to be treated by Ratburana WWTP is considered a high risk sludge and therefore treated by Option L2, while the rest is used for compost, treated by Option A2.
- Collection charge is 50 Bahts/m^3.

ii) Findings

- The night soil treatment scheme can not be feasible by itself, because the charging rate is only 50 Bahts/m^3 in this analysis. The accumulated loss up to 2020 will be 1,256 Million Bahts. The cost recovery by compost contributes, but only to some extent, as shown in Table 8.2.2.8.
- Under the present assumption and unit costs, the break-even point of the charging rate is 353 Bahts/m^3 and the break-even point of the compost price is 2,780 Bahts/t, as shown in Table 8.2.2.10.

(6) Preliminary Aggregate Financial Estimation

Table 8.2.2.9 shows the overall cash flow under this scheme. Introducing the proper charging system for wastewater treatment and night soil and developing the cost recovering mechanism by compost production, the scheme could be financially feasible under the assumption used in the Study.

Only nightsoil treatment system can not be self-financed. Wastewater treatment system is the major role with 97.5 % share of the overall treatment system in terms of surplus, while wastewater sludge treatment system and reclaimed water reuse system have only 8.8 % and 4.0 %, respectively.

Table 8.2.2.10 shows the breakeven costs of selected key parameters. The wastewater treatment system has a breakeven point at the Wastewater charge rate of 4.06 Bahts/m^3. The nightsoil treatment system can breakeven at the charge rate of 353 Bahts/m^3, which is 7 times higher than the present rate. If compost can be sold at 2,780 Bahts/ton, which is 85 % higher than the original target price, the system can reach the breakeven point.

The overall treatment system is largely affected by Wastewater charge rate, but not much by other factors. The overall system has a breakeven point at the Wastewater charge rate of 4.04 Bahts/m^3, while all other assumed variables are the same.

(7) Total Initial Investment Cost

The total initial investment cost up to the year 2020 was estimated to be 2,029 Mil. US$, 2,034 Mil. US$, and 2,023 Mil. US$ for Scenario 1, 2, and 3, respectively, as shown in Table 8.2.2.11.

Table 8.2.2.11 Total Initial Investment Cost for 3 Scenarios

(Unit: Mil. US$)

Item	Scenario 1	Scenario 2	Scenario 3
WWTP	1,928.3	1,928.3	1,928.3
WW Sludge			
Digestion	33.9	25.4	33.9
Compost Factory	43.6	43.6	21.8
Incineration	0.0	17.1	0.0
Dumping site	16.3	13.2	32.2
Reclaimed WW Reuse	4.7	4.7	4.7
NSTP	1.8	1.8	1.8
Total	2,028.6	2,034.2	2,022.7

8.2.3 Pre-Feasibility Study of the Overall Sludge Treatment System for the proposed 3 Scenarios

Financial viability of the overall sludge treatment system was carried out by assessing the Financial Internal Rate of Return (FIRR) on the basis of estimated project cost for digestion plant, compost plant and landfill site and estimated revenue generated by selling compost and power from digestion process.

As discussed in Section 7.2.5, the three representative scenarios were financially evaluated in order to make a comparative analysis. These three scenarios will give

the BMA some flexibility in making decision with different circumstances in the future.

Assuming the maximum utilization of the private sector, the sludge treatment processes up to digestion at Nong Khaem STC for high risk sludge and up to thickening and dewatering at WWTPs for low risk sludge are excluded in this feasibility study. In other words, the BMA should have the responsibility for these processes.

(1) Scenario 1 (See Table 8.2.3.1 and Table 8.2.3.2)

- As all WWTPs under operation and construction by BMA were or have been covered by its own capital, it is assumed that the overall sludge treatment system is also covered by its own budget, not by borrowed capital from international lending agencies. Therefore, the FIRR in this evaluation is on investment.
- The financial evaluation includes all sludge produced from WWTPs and NSTPs constructed until 2020, out of which 38 % is dumped at a landfill site after digestion at the Nong Khaem STC, based on Option L2 and the rest is transported to one of the centralized composting factories located in the north, east and west areas and is composted without digestion by Option A2. The estimation of annual sludge production is presented in Table 8.2.3.1.
- For high risk sludge, the financial calculation includes all sludge treatment processes after Nong Khaem STC, while for low risk sludge all sludge treatment process after dewatering at Central WWTPs are included in the Study.
- Since the depreciation period is 20 years, it is assumed some plants have residual value in 2020.

As shown in Table 8.2.3.2, the FIRR on investment is calculated at 10.92 % and the present value in cases of 5 % and 10 % discount rate is 17.54 and 1.83 Million US$, respectively. Since this project is to prevent environmental deterioration by recovering environmental protection cost by means of sludge utilization for agricultural purpose, this FIRR is sufficiently high and therefore it can be concluded that the project is financially viable, even by the private sector.

The key financial factors have a high level of uncertainty, so a sensitivity analysis was made on two of them, i.e., the compost sales price and the compost factory construction cost. The results are shown in Table 8.2.3.5, which indicates that the project is quite sensitive on both compost sales price and compost plant construction cost. A 10 % change of the compost price causes around 3.4 % change in FIRR and 10 % change of the compost plant construction cost affects approximately 1.6 % change in FIRR.

(2) Scenario 2 (See Table 8.2.3.3)

Assumption of Scenario 2 is that 25 % of the high risk sludge is treated by Option L1, incineration and ash disposed after 2010.

As shown in Table 8.2.3.3, FIRR of Scenario 2 is 7.22 %, which is lower than Scenario 1, 10.92 %. Although the sludge treatment by incineration is expensive, the results of Option 2 did not show a sharp decrease of FIRR, since only 25 % of high risk sludge is incinerated after 2010.

(3) Scenario 3

The condition of Scenario 3 was considered, assuming that half of the low risk sludge is disposed by Option L4, considering the possibility that half of low risk sludge can not be sold in the compost market and therefore have to be dumped in the controlled landfill site. The detailed calculation results are shown in Table 8.2.3.4.

FIRR of Scenario 3 is 1.94 %, indicating that this model is significantly sensitive to revenue from compost selling.

Lastly, Table 8.2.3.6 shows the summarized results of the feasibility study on the three representative scenarios.

(4) Recommendation

These financial analysis was made from a viewpoint of private compost manufactures, assuming that the market development of the sludge compost is a very challenging business and therefore it is more appropriate to be done by the private sector in cooperation with the public sector. In this connection, it was assumed in this financial analysis that the roles of the public sector are from collecting wastewater and nightsoil to dewatering sludge including digestion plant construction, while the roles of the private sector are from transportation of dewatered sludge and to the sludge compost selling or dumping including O&M of digestion plant.

In order to introduce the sludge composting scheme successfully, the following activities need to be carried out by BMA and other public sector organisations before private sector implementation: 1) monitoring of sludge quality for safety, 2) educating people not to discharge toxic staff into sewerage system, 3) research on how much and how to apply the sludge compost to what kinds of agricultural products, 4) research on appropriate and efficient manufacturing process of the sludge compost, 5) promotion of the sludge compost to farmers and 6) training of farmers for use of the sludge compost. However, the private sector must contribute to these tasks and should be willing to do so in the interests of their business development.

Since these costs, as well as capital interest charges, are not included in this financial analysis, the sludge compost business can not be viable without sufficient level of cooperation from the private sector, even in case of Scenario 1.

8.2.4 Economic Evaluation of Overall Wastewater and Night Soil Treatment System

The proposed overall WW and NS treatment system is economically viable and acceptable since the proposed system would have major intangible economic benefits stemming from various aspects of social, economic and agricultural viewpoints.

(1) Social Aspect

The project will contribute to reduce health hazards to the local population through better sewerage infrastructure and treatment of wastewater. These include improvement of infant mortality and incidence of water-related disease such as acute, diarrhea, bacillary dysentery, enteric fever, typhoid and conjunctivitis, which will significantly reduce medical expenditures.

The development of wastewater services and sludge treatment and disposal will redress the environmental degradation resulting from urbanisation, and in particular the quality of the khlongs which should be an important amenity in Bangkok.

The activities to use reclaimed water from Central WWTPs will reduce water shortages in Bangkok and reduce the need for additional water development investment in water supplies. Furthermore, the project could be a trigger for Thais to think more about environmental conservation and the social benefits of recycling.

(2) Economic Aspect

During the construction and operation of the project, the project will promote local resource mobilization and cost recovery by creating jobs to absorb skilled and unskilled labor and by stimulating local industries by utilizing their manufactured products, which, in turn, create other jobs in manufacturing, commerce and service sectors.

In addition, the project will contribute to the Bangkok Metropolitan to become an environmentally healthy modern city by promoting the city as the regional center, by which business and tourism industries will be stimulated, affecting land values and increasing the overall productivity in the society by developing an environmentally friendly society.

(3) Agricultural Aspect

The project encourages the use of organic fertilizer by replacing chemical fertilizer which is largely imported and much more expensive. The project will encourage

agricultural recycling skills and know-how, by which the agriculture sector will become more internationally competitive in the long term in terms of cost and quality.

The project also provide benefit by improving the soil condition of farm land, where some farmers are currently seriously suffering from soil erosion.

CHAPTER 9 ORGANIZATION AND INSTITUTIONAL PLAN

9.1 Legislation

9.1.1 Amendments to Legislation

The legislative framework is considered adequate for the main sectoral purposes, which include: to empower state agencies to treat wastewater and establish central wastewater treatment systems, to require the private sector to treat wastewater, to empower state agencies to regulate effluent, to monitor environmental quality, to empower organizations to collect a wastewater treatment charge, and to allow private participation in State business activities. However, there are too many laws dealing with similar subject areas.

The chief problem at present appears to be the lack of effective enforcement (see 9.1.2 below) not helped by the multiplicity of laws involved.

As a short term measure, it is recommended that the Bangkok Metropolitan Administration Service Administration Regulations Act should have a section added dealing specifically with wastewater and night soil treatment and disposal, in view of the importance of these responsibilities.

In the longer term, it is recommended that the number of laws dealing with environmental protection should be reduced, preferably to one, in a process of progressive consolidation. Consolidation should also include the merging of water and sanitation laws and agencies and should be consistent with GOT's policy of decentralization and local empowerment. The Enhancement and Conservation of National Environmental Quality Act (NEQA) 1992 could provide the framework for a single enforcement agency and the further consolidation of water and environmental legislation. One successful instance of this arrangement can be found in the UK where the Environment Agency has comprehensive responsibilities for water resource management and environmental protection under one all encompassing environmental law, the 1995 Environment Act.

9.1.2 Enforcement of Legislation

Environmental law should be enforced wherever feasible at the district level, coordinated by a District Environmental Board or Committee. Officials responsible for enforcement should be thoroughly trained in the law and its application, and be committed to enforcement. Such commitment must come from, and be seen to come from, NEB and BMA top management, otherwise little will be accomplished. The lack of police action must be remedied and the delegation of specific enforcement powers to environmental personnel as well as the police

should be seriously considered. Responsibility for law enforcement should appear on all relevant managers' job descriptions as well as those of the responsible lower level staff.

Finally, a major PR campaign should be launched to inform the public about the environmental laws, the need for them, and why enforcement is necessary to benefit both individual and community.

9.2 Organization

9.2.1 Overall Organization of the Water and Sewage Sectors

It is suggested that the objectives for the organization of the water and sewage sector in Thailand generally and for BMR in particular should include the following:

i) to promote effective and efficient regulation of the water and sewage sector, and clearly segregate regulation from the operation of water and sewage schemes;
ii) to rationalize and clarify the roles and boundaries of responsibility between the main sectoral institutions while increasing the role of local authorities (including BMA) as water and sewerage service providers;
iii) the management of sewerage should be closely linked with drainage and flood control;
iv) to establish a lean, unified body at national level responsible for ensuring: water and sewage sectoral planning; monitoring of design, supervision of construction, and O&M; and advisory services for the water and sewage subsector;
v) to support longer term public sector reforms by:
   - enabling water and sewerage schemes to be operated on a commercial basis with a greater degree of autonomy, with the aim of funding future capital investment from scheme revenue, and by
   - encouraging and promoting investment from the private sector at the appropriate time;
vi) to improve and monitor against targets the delivery of services to the customer.

During data collection, certain issues emerged regarding the overall organization of the sewerage and water supply sectors and the relationship between them. These can be summarized briefly as follows:

i) A virtually total separation between sewerage and water supply in BMA, BMR and probably the provinces. This is against the trend in many modern municipalities and tends to result in underfunding and lack of attention for sewerage development, as well as increased O&M costs in aggregate. It also cuts across the constitutional requirement for devolution to local government of

the management of their own services. The past lack of attention to sewerage in Bangkok is self-evident;

ii) An apparent lack of an overall policy framework to help ensure the orderly development of water and sewerage in Thailand.

The following action is suggested to address these issues.

A National Water Policy should be created to help achieve sustainable development and management of the water and sanitation sector by providing a framework in which the desired goals and targets are set, outlining the necessary measures to guide all water and sanitation related activities and actors.

The National Water Policy would address the areas of water resources management, water supply and sewerage development, institutional arrangements, and sector financing. For each area, objectives would be first stated followed by an outline of the main issues, strategies to resolve these, and the related policy statements. The institutional arrangements could include policy on devolution of water supply and sewerage development and management to municipalities and communities.

The development of a National Water Policy in Thailand might be somewhat hindered by the current absence of a ministry with sole responsibility for the water sector, although the Ministry of Interior and MOSTE could jointly act as developers and promoters of such a policy.

9.2.2 Bangkok Metropolitan Administration

Three components of the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Reuse need to be addressed when considering specific institutional and organizational requirements for BMA. The components are:

i) Current Central WWTPs and Community WWTPs, and a major expansion of Central WWTP facilities in BMA;

ii) The treatment of sludge produced from the above WWTP facilities and the disposal of treated sludge and night soil sludge cake produced from the existing night soil processing plants and those attached to new Central WWTPs,

iii) The reuse of reclaimed wastewater from Central WWTPs.

Components (i) and (ii) will give rise to organizational changes at two levels: those within the BMA hierarchy and those at plant or field level. The changes will be affected by the degree to which the private sector participates.

9.2.3 Central Wastewater Treatment Plants

Current and future Central WWTPs already under construction or planned are described in Chapter 3. The additional schemes proposed in the Master Plan are described in Chapter 6.

(1) Organization Structure

The current structure and reporting arrangements outlined in Chapter 5 seem adequate for the time being. It is therefore recommended that the Community WWTPs should continue to report to a designated engineer in the appropriate WQMC.

The plant managers of the larger Central WWTPs should report to the WQMD Director until his span of control becomes excessive at which point, say after two or three Central WWTPs are operational, a deputy director could be appointed with specific responsibility for all Central WWTPs. This is because the head of a Central WWTPs should be at least equivalent in status to the head of a subdivision. An alternative, but for later implementation, would be to establish a separate division under Deputy Director General (Technical) with responsibility for the wastewater treatment systems, Central WWTPs and, if so decided, the associated sewerage systems. This would be analogous to the MWA structure whereby all production and transmission operation and maintenance are subordinate to a Deputy Governor dedicated to these functions.

The Technical Subdivision and the three Water Quality Management Centers would continue to provide services to the new Central WWTPs. For example, Technical SD would be the technical resource in treatment technology and staff training for all WWTPs. The WQMCs would monitor wastewater treatment processes and the effluent to the environment. However, most routine quality tests, and the maintenance of facilities and equipment would be done by Central WWTP staff.

The organization structure of the typical Central WWTP is proposed in Figure 9.2.3.1.

There are several options for managing the operation and maintenance of the collection system, illustrated in Figure 9.2.3.2, associated with each Central WWTP. For example, the collection system could be managed by the Central WWTP or by the Drainage System Division in DDS. The Study Team favors the first alternative but recommends that all options should be identified and fully reviewed by the agencies concerned before a final decision is made.

(2) Private Sector Participation

It is proposed (see 9.9 below) that the private sector should be invited to participate in either non-core activities such as maintenance, or as management contractors in operating and maintaining Central WWTPs. If either of these options is pursued, then DDS's responsibility for providing Central WWTP staff would reduce accordingly. The last option, in particular, would require an adequate service fee to be collected. There is a further option. That is to invite WMA to operate, manage, maintain and collect revenue for one or more Central WWTPs according to its laid down responsibilities, either independently or as a joint venture partner with an experienced operator. Where a private firm or WMA is involved, BMA would need to monitor their activities.

9.2.4 Sludge and Night Soil Collection, Treatment and Disposal

Wastewater sludge and treated night soil will be produced in increasing quantities from both Central and Community WWTPs and night soil treatment plants, respectively, over the Master Plan period. There are a number of options for disposing of wastewater sludge and treated night soil depending, for example, on its toxicity, the locations of digestor plant, the need to compost and locations of composting facilities. Additional facilities for sludge digestion and composting will be needed which, together with forecasts of total sludge quantities and descriptions and assessments of the options for managing sludge, are set out in Chapter 6 above. The development of the new facilities should be managed by DDS or DPC, according to the decision on where NSCD and the proposed Sludge Management Agency (see below) should reside.

After treatment, which may include digestion (on site or centrally located) and composting, processed sludge and night soil will be transported to various outlets including land treatment (used as fertilizer), landfill at a designated site, or incineration (least favored). At present, the precise uses and destinations cannot be specified. However, it seems likely that most will continue to be used as fertilizer.

On this basis, the successful disposal of processed sludge and night soil will require the following key activities:

i) General promotion of and research into its use for agricultural and horticultural application;
ii) Specific marketing of the service, to include farmer training;
iii) Receiving at treatment plants and transporting the processed sludge, as required, for digestion, composting, and to its destination, whether fields, parks, landfill or incinerators;
iv) Management of the whole process from treatment plant output to final destination;

v) Routine monitoring of sludge quality and quantity.

All three methods of disposal will be needed depending partly on the results of sludge monitoring and analysis and partly on the balance between demand and supply. This aspect is dealt with in Chapter 6 above.

To execute these functions and the sludge management plan set out in Chapter 6, a sludge management agency is needed. The agency could be a division in the Department of Drainage and Sewerage reporting to the Deputy Director General (Technical) or a division in the Department of Public Cleansing reporting to the Director General of DPC. The same organizational options apply to the Night Soil Control Division (NSCD) discussed later in this section.

The advantages of being part of DDS are: broadly similar technology to wastewater treatment; and probable (partial) funding through the sewerage fee when this is implemented. The advantages of being part of DPC are: DPC's familiarity with transporting large quantities of waste products of various kinds and dumping or landfilling them; and managing a fleet of vehicles to undertake this work. The advantage of the DDS option would be enhanced if Night Soil Control Division was also part of it, since NSCD and SMD are closely linked, both from a process sequencing viewpoint and related technology. This point is discussed later in this section of the report. A possible organization structure[1] for the Sludge Management Division is shown in Figure 9.2.4.1 below:

[1] After an organization suggested by A.I.T. in their Feasibility Study on Agricultural Use and Land Application of Sewage and Night Soil Sludge for Bangkok Metropolitan [Area], March 1998

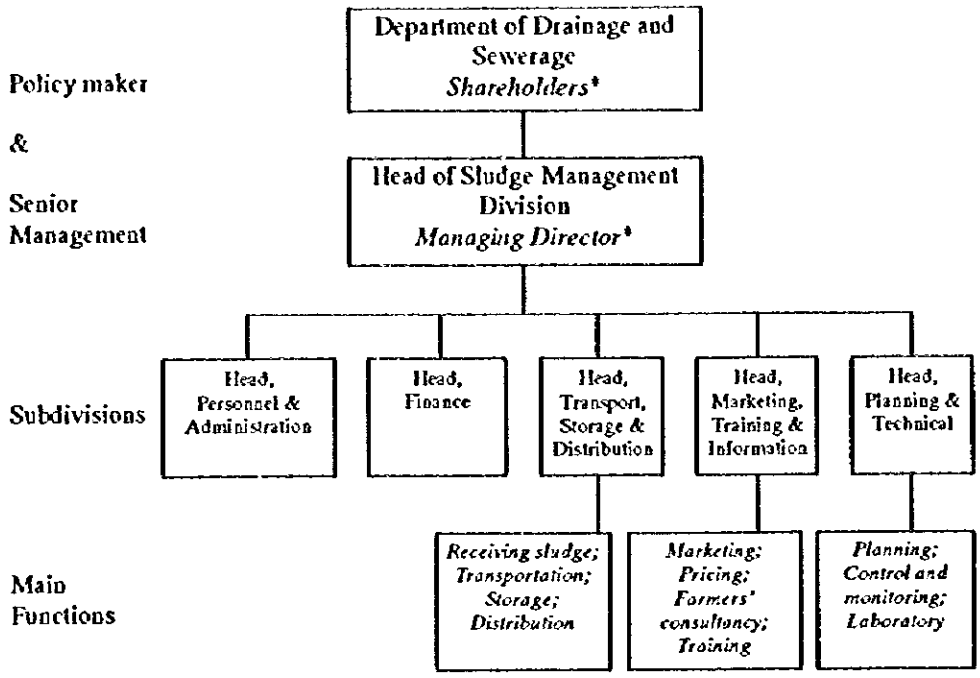

Figure 9.2.4.1 Proposed Organization of Sludge Management Division

The proposed Sludge Management Division (SMD) would contain five subdivisions including two providing finance and administrative support services. Three subdivisions would undertake the main tasks of the division. These are: Transportation, Storage and Distribution; Marketing, Training and Information; and Planning and Technical. The last named subdivision would also liaise and coordinate with associated entities outside DDS, such as the Ministry of Agriculture and relevant subsidiary bodies such as the Department of Agricultural Extension, and organizations representing farmers.

The funding of this division would need to be considered, whether or not the private sector is to be involved (see later in this section of the report). Ideally, the total cost of all infrastructure providing benefit for the city's inhabitants should be recovered from the beneficiaries. On this principle, which has been accepted by GOT (the "polluter pays" principle) but not yet applied widely to the provision of sewerage services, a proportion of the revenue collected should go to defraying the cost of sludge disposal. This cost would include the cost of operating and maintaining the sludge and night soil processing plants at On-Nut and Nong Khaem. In Germany about one third of revenue collected through the sewerage tariff goes towards sludge disposal. Additional sources of funding will be needed and every attempt should be made, through the marketing function of the SMD, to explore potential customers and processes for adding value to the treated sludge

Concerning possible private sector involvement, it is unlikely that SMD's work could be performed economically at an early stage by the private sector because: (1) there is no cost recovery of wastewater treatment (except on industrial estates); (2) standards, regulations and legislation concerning sludge reuse and disposal are not complete; (3) large scale agricultural reuse of processed sludge will be a new practice in Thailand so that only foreign companies will have the necessary expertise; and (4) awareness of SMD's potential customers is low or nonexistent.

Therefore, BMA should establish and start up SMD, and create the necessary conditions for a successful operation.

Finally in this section, the responsibility for night soil collection and treatment is considered. At present the entire operation is under the Night Soil Control Division (NSCD) in the Department of Public Cleansing (DPC), a large proportion of the collection work being performed by the 50 Districts employing their own vehicles and staff.

There are two options for the future. The first is to continue with the existing arrangement for which the advantages are: no costs involved in changing the organization; DPC's familiarity with transporting large quantities of waste products of various kinds and dumping or landfilling them; and DPC's familiarity with managing a fleet of vehicles to undertake this work. The second option is for the entire Night Soil Control Division to be transferred to DDS. The advantages of night soil collection and control being part of DDS are: broadly similar technology to wastewater treatment; and probable funding through the anticipated sewerage fee when this is implemented.

The Study Team's preference is, narrowly, for the DDS option although this would make the DDS a much larger organization than DPC.

9.2.5 Reclaimed Wastewater Reuse

Four principal uses have been identified for reclaimed wastewater from public plants. These are: (1) watering roads and public gardens by District offices, the DO to collect reclaimed wastewater from the Central WWTP; (2) use for services in large public or private buildings, the WWTP to supply via pipeline for a charge per cubic meter one third of the charge for treated water; (3) supplying water to public green areas in the dry season, the WWTP to supply free via transport or pipeline at its cost; and (4) for purification of khlongs, by the WWTP at its expense. All these uses can be supplied by existing entities at a cost, which in the case of (2) can be partially recovered.

9.3 Wastewater User Charge

The preparation of this Master Plan has emphasized the importance of implementing the wastewater user charge needed to help finance the construction, operation and maintenance of Central WWTPs, and the treatment and disposal of sludge and night soil. The recent Feasibility Study of the BMA Wastewater User Charge issued in May 1998 made detailed recommendations for the collection of revenue from beneficiaries of Central WWTP systems but no decisions have yet been made.

A decision should be reached on the proposals of this study without further delay.

9.4 Privatization

The progressive devolution away from the public sector as direct operator and owner of utilities is accepted in principle in Thailand, but is some way from being adequately realized. The considerable PSP experience accumulated in the water and wastewater sector should be consolidated and extended. This would be in line with resolutions from BMA, MWA and IEAT to extend privatization, although key decisions have not yet been taken in BMA or MWA.

The types of participation shown in Table 9.4.1.1 below are in order of complexity, contract period and delegation:

Table 9.4.1.1 Types of Private Sector Participation in Public Service Provision

Type of Participation	Scope of Private Participation	Comment
1) Service Contract (1-2 years)	Specific tasks: eg installing / reading meters; repair and maintenance; billing and collection; monitoring losses; system operation	Simple arrangement but with limited benefits.
2) Management Contract (3-5 years)	Responsibility for operation and maintenance, eg of water supply or wastewater treatment system.	Can include performance targets and incentives. Good for improving O&M without private investment.
3) Lease Contract (8-15 years)	Leases assets and assumes responsibility for operation and maintenance, and funding working capital. Assumes commercial risk.	Public capital investment. Administratively complex.
4) Concession Arrangement (20-30 years)	Responsibility for capital investment, operation and maintenance. Assets publicly owned. Assumes all risk.	Adequate regulation essential.
5) Joint Venture Contract (8-30 years)	Government/private company to operate leases and concessions	Limited private sector autonomy but considerable corporate autonomy. Reassures stakeholders
6) Build-operate-transfer (BOT) Contract (20-30 years)	Construction of green field projects or major rehabilitations. Major asset creation.	Assets returned to government after completion.
7) Build-operate-own (BOO) Contract	Construction of green field projects or major rehabilitations. Major asset creation.	Assets retained by private entity.
8) Divestiture	Full or partial sale of assets to private sector. Full responsibility for operating and maintaining assets profitably.	Adequate regulation essential, of operations and asset base

Some major targets for, and types of, privatization in the area under this Master Plan are suggested in Table 9.4.1.2 below:

Table 9.4.1.2 Potential Private Sector Participation in Wastewater and Sludge Treatment/Disposal

Entity	Privatization Type	Timing	Priority
Central Wastewater Treatment Plants	Management contract for O&M OR, if more limited application required initially: Service contract for maintenance	When contractor O&M period completed When contractor O&M period completed	High High
Night Soil Treatment Plants	Management contract for O&M	When NSTPs adequately equipped and throughput assured	High
Sludge Management Agency	Management contract	After initial running-in period under DDS (or DPC)	Low initially, higher later
Composting plant •construction •operation and maintenance	Joint venture? BOO? BOO?	Soonest, after BMA pilot project and financial analysis to indicate profit potential	High* High* High*
District Offices •sewer cleaning •night soil collection	Service contract(s) Service contract(s)	Test pilot scheme(s) and review results Test pilot scheme(s) and review results	Medium Medium

Notes: (1) * Financial position to be clarified. BOO and JV feasible only if operation profitable or subsidies guaranteed.

9.5 Training Facilities and Needs

At the level of this Study's investigation, existing education and training facilities seem adequate for officer grades. From interviews with division managers there appear to be no major outstanding requirements for training in DDS and DPC apart from the exceptions below.

The training of unskilled staff should be the job of line management unless the effort required is unreasonable. In this case, management should request assistance from the BMA division responsible for training.

The director of one district office considered that all his staff, including management, urgently needed training and support (particularly in environmental matters). If this office is typical, districts require a comprehensive assessment of training needs by the BMA Institute of Officer Training followed by an appropriate program of training. Because of their responsibilities for service delivery, public contact and law enforcement, district staff should be at least as well trained and developed as those in BMA 1 and BMA 2.

CHAPTER 10 IMPLEMENTATION PLAN

10.1 Project Procurement

(1) Contract and Funding Options

It is assumed in this Master Plan that BMA will wish to contract out the majority of construction works and will require international aid to fund many of the components of the Master Plan. However, some privately financed schemes may be arranged where the contractor funds procurement and is paid through operational charges.

(2) Contract Responsibilities

The main options for construction contracts concern the scope of the contractor's tasks.

Traditional contract arrangements include only the construction of the plant and supply and installation of equipment to an appointed Engineer's design and specification.

Design and Construct or "Turnkey" contracts require the contractor to design the plant and these contracts may also include a period of operation and staff training.

The advantages of traditional contract arrangements are that the Engineer can undertake necessary investigations and design precisely what the client requires. The design specification for a Turnkey contract cannot be complete and the bidder takes risks in estimating costs of matters which have not been developed or investigated at the bid stage. However, detailed design needs to be agreed and there are often difficulties in pricing variations which are found necessary during construction, and whether or not they should be included in the bid price.

The Turnkey contract arrangement is usually more quickly implemented as construction can start before the design is finalized.

The need for proper prior investigation is desirable in any form of contract to limit contractual disputes.

BMA have adopted a Turnkey form of contract for the major wastewater schemes complete with a one year period of operation. This period of operation is particularly desirable to prove the satisfactory operation of the WWTP which may take some months to commission.

(3) Bidding Procedures

The major International Funding Institutions (IFIs) have specific requirements for bidding. Generally they require international competitive bidding for major schemes, pre-qualification of bidders and specific tendering procedures concerning currencies, tax exemptions and guarantees. Certain items such a land acquisition are not usually permitted under loan agreements. Some items of standard equipment, such as trucks for conveying sludge cake may be bought with loan funds and IFIs have requirements for such purchases.

10.2 Implementation Schedule

A proposed implementation schedule for the Master Plan is shown in Figure 10.2.1.1. This indicates the development of wastewater collection and treatment schemes, the sludge treatment center at Nong Khaem, three new composting plants, facilities for reclaimed wastewater use, and the development of a new sanitary landfill for sludge cake disposal. The schedule takes account of the current commitments and plans of BMA.

Many of the components of the Master Plan are proposed to be developed in phases to allow for increasing demands for these services over the Master Plan period and for incremental investment. Phased development will facilitate adjustment of the schedule should service demands differ from those forecast and allow for limitations on investment funds. The timing proposed for the implementation of future wastewater schemes is discussed in Section 6.1.2.

Figure 10.2.1.1 indicates the various stages of project implementation: investigations and surveys, detail design and contractual arrangements, construction and equipment supply and implementation, and the first year of operation in which the operation of the new works will be properly established.

CHAPTER 11 INITIAL ENVIRONMENTAL EXAMINATION

11.1 General

11.1.1 Objectives of IEE

An Initial Environmental Examination (IEE) was conducted as a part of the Study. The objectives of the IEE for the Project are as follows:

i) To identify potential impacts of the proposed Project
ii) To evaluate potential impacts of the proposed project through JICA Environmental Guideline
iii) To indicate the scope of EIA to be conducted in due course

11.1.2 Environmental Impact Assessment in Thailand

The basic policy and concepts of Environmental Impact Assessment in Thailand are described in the Enhancement and Conservation of "National Environmental Quality Act". According to the act, the proponent, who proposes the types of project specified in Table 11.1.1.1 are required to prepare reports on environmental assessment and submit them for approval to the Ministry of Science Technology and Environment (MOSTE).

Wastewater collection, WWTP projects, STC projects and sludge disposal are not included in Table 11.1.1.1, therefore an environmental report is not required for submission to MOSTE. In fact the BMA has started five wastewater projects in Bangkok, and did not have to submit an environmental report for any of them to MOSTE. The first projects were initiated prior to the creation of MOSTE in its present form under the Environment Act 1992.

11.1.3 JICA Guidelines on Environmental Assessments

Whilst appraising a project, JICA confirms that the necessary mitigation measures will be taken during the project planning with regard to environmental issues in accordance with either the local environmental law or JICA Environmental Guidelines. The confirmation is carried out on the basis of materials provided by the recipient country. According to the guidelines, responsibility with regard to the environmental consideration of a project rests ultimately with the recipient country.

The JICA Environmental Guidelines give instructions related to environmental consideration by JICA in its development study. It also gives the environmental matters to be considered and environmental measures to be prepared by the recipient country in the planning and preparation stages of a project.

Since, Thailand does not have any regulation of IEE and EIA for wastewater and sludge management, JICA guidelines will be followed in order to conduct environmental assessment of this project.

11.1.4 IEE Methodology

In order to attain the objectives shown in Section 11.1.1, the IEE proceeds as follows:

(1) Identify potential impacts of the proposed project by using the Screening Checklist with 23 environmental items to be considered.
(2) Evaluate potential impacts of the proposed project in accordance with the checklist from the JICA Environmental Guidelines.
(3) Indicate the necessary procedure for environmental study, if any during the feasibility study of the selected alternatives.

The Initial Environmental Examination (IEE) was carried out on various alternatives proposed in the Study.

11.2 Scope of IEE

11.2.1 Project Description

(1) Project Background

The water environment of the metropolitan area of Bangkok has deteriorated over the years. In response to this, the improvement in wastewater management has become a key national issue.

The BMA, in compliance with the national and regional development plans and revised edition of the Feasibility Study of Bangkok Sewage System Project, 1982, carried out by JICA, commenced the planning for establishment of wastewater disposal facilities. Since the commissioning of the first scheme, the Si Phraya interceptor sewer and wastewater treatment plant, 1994, nine further wastewater schemes are now under construction and planned. However, with the completion of these schemes and their subsequent operation, large amount of sewage sludge will be generated and plans are now required for its disposal.

In these circumstances, arrangements for the efficient disposal of sewage sludge and reuse of reclaimed wastewater are urgently required to meet the needs of wastewater disposal and improvement of urban environment, and as a countermeasure to the water shortage. In order to achieve these targets, the Study for the Master Plan on Sewage Sludge Treatment/Disposal and Reclaimed Wastewater Re-use was started.

(2) Objectives

The objective of this Study is to formulate Master Plan for the year 2020 for effective sewage sludge treatment/disposal for BMA area, and to conduct the Study for viable reclaimed wastewater re-use plan for BMA area.

(3) Location

The Study area covers the entire BMA area together with its surrounding area.

(4) Project Components

i) Recommendation of future wastewater disposal system
ii) To establish options for sewage and night soil sludge treatment and disposal systems and select the best option
iii) To plan facilities necessary for establishment of sludge disposal systems, and execute cost estimate and financial assessment

11.2.2 Site Description

(1) Social Environment

With the development and economical growth in the Bangkok Metropolitan area in recent years, socioeconomic condition has been greatly improved in the city core area, and most of them have been already developed for residential, commercial and institutional areas having a large population density. However, large difference in living standard between the city center and the country side area is still remarkable. In the country side, infrastructure has not reached an appropriately high level, and the life of residents are mainly supported by agricultural activities.

(2) Natural Environment

The city of Bangkok is situated on flat alluvial deposited areas. The ground level is 1.0 to 2.0 m above MSL. The city area is surrounded by khlong networks which have been used for residential lives, tourism and transportation purpose. The khlongs are currently highly polluted due to direct wastewater discharge throughout the city area. Green areas cannot be seen in the central area due to construction of residential and commercial buildings except in the green park areas.

(3) Pollution Condition

The prominent pollution in the Bangkok area is water quality contamination of rivers and khlongs. This is brought from the lack of wastewater disposal facilities. Air pollution is also remarkable on emission due to traffic jam and

noise is also a serious problem. In the future, when wastewater and night soil sludge have been largely generated, the sludge from the treatment sites should be transported by track, so that current condition of traffic may be worsen.

11.2.3 Project Alternatives

A number of alternative options are proposed. The wastewater sludge disposal is principally branched in the line of existence of high level toxic heavy metals. From the final disposal point of view, it is possible to categorize into two main streams, that is, landfill and agricultural use.

For IEE, it would be sufficient to examine the environmental evaluation considering the final disposal options for sludge disposal. This can be justified because, in different options for similar final disposal option, the differences are the unit processes involved and degree of treatment. These internal processes have less significant impact on the final products. However, detail EIA is highly recommended in the feasibility study stage.

The two stream-lined options to be subjected to IEE are as follows:

Option A : High-risk sludge ---------- Landfill

B : Low-risk sludge ---------- Agricultural Use

It may be mentioned here that in case of construction of STC, they will not create any major environmental hazard as these will be constructed within existing NSTP yard. However, they will experience same environmental hazard as associated with any new construction. Hence, for the present study, construction of STC can be kept out of the IEE scope.

For the cases of land filling option, the Study is promoting "co-landfilling" along with solid waste. This will make the management of landfill site more economical and easily operable. As a result, site selection and construction of landfill site will also be kept out of the scope of IEE of the Study.

Summarizing, the IEE will concentrate on "end use" options proposed in the Study, which constitutes major outcome of the Study.

11.3 Screening

In order to identify the potential impacts, a checklist method was applied for screening for the IEE. The checklist includes 23 environmental items defined by JICA (Japan International Cooperation Agency) Environmental Guideline.

The result of the screening is shown in Table 11.3.1.1 and 11.3.1.2.

11.4 Evaluation of Potential Impacts

11.4.1 Scoping

The potential impacts caused by the project are evaluated on ten environmental items, which are raised after screening in Section 11.3. The results of the evaluation are summarized in the environmental checklist shown in Table 11.4.1.1, with a brief explanation as described below.

(1) Traffic and public facilities: In both options, sludge will be transported by truck to end disposal sites (either landfill or agricultural use). This will generate a large number of truck trips in and around Bangkok city, increasing the traffic volume of the city and may lead to increased traffic jams and accidents. This can be minimized by properly planning route and time of transport.

(2) Public health condition: Health site is associated with the land application of sludge. Many water related contiguous disease can easily spread if the sludge is not properly digested. In case the wastewater sludge, exposure of heavy metal can lead to chronic disease like cancer, loss of sight, less of fertility and so on. A proper reuse plan is necessary to reduce exposure of human with the sludge. Also, type of crops will be selected properly in order to minimize risk of exposure during the cultivation and consumption. Further, a proper treatment of sludge has to be ensured. A regular moralizing is required to check the contamination concentration in the sludge.

(3) Waste: Both the options will generate sludge to be disposed. If sludge is disposed of regularly and property, this will not create any problem. As a result, a fail-proof operational set up is essential for the disposal of wastes.

(4) Ground water: For both the cases of landfilling and agricultural use, there is a chance of seepage and percolation of leachate into the ground water. The consequence can be grave in case of wastewater sludge, as it contains heavy metal pollution. It is recommended to construct sanitary landfill with leachate treatment. A proper ground water monitoring system has to be set up near the landfill site and agricultural use site. For the agricultural use, crop type and site location have to be selected very carefully. Ground water use has to be monitored even in the case of agricultural use.

(5) Fauna & Flora: In case of agriculture use of sludge, the residual toxic substances may change the ecological balance and destroy or degrade some flora and fauna. To overcome this, controlled land application has to be practised in order to reduce the risk of destruction of endangered species.

(6) Landscape: The use of compost for agriculture can change the prevailing crop pattern. This may change landscape of the area. Distribution of compost should be done keeping this impact in consideration.

(7) Water Pollution: General water pollution can happen mainly as a result of

ground water contamination. It can also happen by surface wash of agricultural land, where compost will be applied. Sanitary landfill with leachate treatment is highly recommended to reduce this effect. Flow of surface runoff must be monitored before entering into water bodies. Also land application should be controlled properly to reduce the damage of important surface water resources caused by surface wash out.

(8) Soil Contamination: Trace heavy metal included in the WW sludge may cause permanent soil contamination. This can also happen for agricultural use case. Sanitary landfill with leachate treatment and controlled land application for agricultural use can eliminate this adverse effect.

(9) Noise and Vibration: Since all the option have to use trucks to transport end products, it will increase the noise level in the road ways. However, this impact is insignificant and can be easily overcome with proper planning of route and time of transport.

(10) Offensive Odor: All sludge is associated with odor. However, since most of the treatment will take place within the treatment plants, major odor nuisance will be confined within the plants. A covered truck can reduce the odor pollution during transport. Proper selection of landfill site and agricultural plot will minimize the impact on common people.

11.4.2 Positive Impacts

The project will have a number of possible impacts. These are briefly outlined in the following:

(1) Economic Achieves: In case of sludge reuse in agricultural land, availability of cheap compost will make the agricultural activity more active and more profitable. This will increase the income level and also reduce the unemployment. This will, as a whole, contribute to the regional economy. Further, a number of people will be working in the process itself including transportation of the end product. This will directly benefit the employment market.

(2) Public Health: After the proper sludge treatment, there will be no dumping of untreated sludge. This will improve the hygiene condition of water bodies and dump sites. As an indirect measure, this will reduce the risk of water borne diseases and improve public health considerably.

(3) Waste: Proper treatment will reduce the volume of untreated sludge. This decreased volume will benefit the environment.

(4) Water Pollution: Untreated sludge, especially WW sludge is a hazard to ground water and surface water. The proper sludge management will reduce this risk considerably.

(5) Fauna & Flora: Disposal of untreated sludge haphazardly is a matter of

concern for the flora and fauna. This even lead to extinction of endangered species. Proper sludge management will reduce the risk.

(6) Landscape: Sludge management will improve the landscape compared to untreated sludge disposal in an unplanned way. Moreover, compost will increase the agricultural activity.

(7) Offensive Odor: Untreated sludge produces much more odor than treated sludge. Hence, sludge management will improve overall odor condition.

11.4.3 Other Aspects

(1) Impact during Construction Period: Construction work may cause various kinds of impacts in and around the construction sites. However, such impacts during construction stage are temporary and can be mitigated with careful design, planning and public information.

(2) Environmental Monitoring: BMA already has sufficient monitoring points in the Study area. However, some supplemental monitoring point should be established in the landfill site and agricultural plots to monitor the quality of incoming sludge, ground water, surface wash and surrounding water bodies.

11.5 Scope of EIA

The conclusion of the IEE is that a further environmental study at the level of Environmental Impact Assessment (EIA) is required for feasibility study (F/S). The following points are to be included in the TOR of the EIA study, as these are sensitive issues to be taken care of:

i) Public Health Condition
ii) Ground Water Pollution
iii) Flora and Fauna
iv) Landscape
v) Water Pollution
vi) Soil Contamination

However, EIA should be carried out in a conventional pattern covering all other relevant aspects. If STC construction differ from the anticipated program of the Study, IEE and EIA have to be carried out. If "well-prepared landfill site" is to be constructed far from the existing solid waste landfill site, IEE and EIA have to be carried out properly.

Summary of IEE is given in Table 11.4.1.2. Out of the options shown by the symbols, M and X which show "major issues" and "not clear" respectively should be considered as Environmental Impact Assessment (EIA) items to be implemented in the later stage.

CHAPTER 12 RECOMMEDATIONS

This Master Plan Study differs from many in forecasting future sludge quantities and treatment and disposal needs in that it included extensive surveys to determine wastewater quality and quantity and sludge characteristics, and used these to develop proposals for sludge treatment and disposal systems for the target year. However the Study period and resources restricted the extent of the survey and the extent to which the plans and programs could be developed. Further, only the Si Phraya wastewater treatment plant is operational and from which plant performance records are available, although another fifteen treatment plants are now being developed and proposed in the Master Plan. As a result, extensive assumptions were necessary to estimate future sludge quantities and it is recommended that sludge production forecasts be re-assessed when these new sewage treatment plants become operational and can provide new data. In particular, the BOD Reduction Factor accounting for the loss of BOD in the drainage system described in Chapter 6 should be re-evaluated.

In the course of the Study many problems and constraints were identified which will need to be resolved for the Plan to be successfully implemented, and BMA will need to give the execution of the Plan high priority maintaining a high degree of flexibility and enthusiasm.

The following are recommendations which address many of these problems and constraints.

12.1 Improvements to the Wastewater Collection System

Current wastewater projects in BMA will provide interceptors on the existing combined sewer pipes to convey wastewater to treatment plants downstream. However, these networks are primarily provided to remove storm water to the khlongs for flood control and in many respects are unsuitable for wastewater transfer. In the city of Bangkok, the flat and low-lying terrain and small topographic gradient hinders natural drainage, and this, together with poor catchment definition and the general condition of the pipe network gives concern as to whether the new interceptor sewers will be effective. The heavy congestion and high density development in much of the city would make it very difficult and expensive to install new separate sewers. There is therefore no choice other than the continued use of the combined drainage system and this must predominate in future plans. Further, due to the topography, the pipe network frequently becomes surcharged constraining the free flow of wastewater and this is likely to remain a problem even after the new interceptor sewers are connected. The following are major problems concerning the present pipe reticulation system.

1) Catchment boundaries are not clearly established and the arrangement is often inappropriate for wastewater transfer. In particular the catchment area of each branch pipe is not specific, flow directions in the sewers are variable and uncertain, and there is no basis for establishing wastewater flows.
2) The sewer pipes do not generally have hydraulically appropriate gradients. The direction of flow is sometimes variable and much of the network contains stagnant wastewater and backflows from the khlongs often occur.
3) Due to their age and condition, the pipes allow groundwater intrusion sometimes resulting in unexpectedly large flows. This, together with backflows from the khlongs downstream results in weak wastewaters in the pipe network.
4) The drainage system includes U-shaped side drains, closed conduits and open channels, many of which are unsuitable for conveying wastewater.
5) Many properties discharge wastewaters directly to the khlongs which will limit the proportion of wastewater collected in the new interceptor sewers.

Taking these matters into account, the following improvements are required to ensure that the combined drainage interceptor sewer systems will be properly effective.

1) A comprehensive survey of the existing pipe reticulation system is needed.
2) A register of each pipeline is required recording its structural and operating condition.
3) A full review of the catchment arrangements is needed.
4) Hydraulic analysis of the existing pipe networks is needed.
5) Damaged pipelines and other works need to be repaired or replaced.
6) Sewer maintenance needs to be improved to ensure that the pipes are free of blockages.
7) A program to ensure that all properties are connected to the pipe network must be established.
8) Hydraulic modeling should be undertaken for the design of drainage improvements taking into account both storm water and wastewater requirements.
9) The new interceptor sewer designs should be re-evaluated taking these matters into account. This should include a re-assessment of the necessary Peak Flow capacity requirements.

It is recommended that a pilot project be undertaken in the Si Phraya wastewater service area to address these matters which may serve as a demonstration project.

12.2 Sludge Treatment and Disposal

Three alternatives for sludge treatment and disposal are proposed in this Master Plan described in Chapter 7. In the implementation of the Plan, BMA will need to introduce a number of control measures in which careful judgement will be necessary to balance the practicalities of implementation and operation, environmental needs and financial constraints. The following recommendations and activities should be taken into consideration.

1) Heavy metal contamination in the sludge could only be predicted as a risk assessment in this Master Plan. This should be re-evaluated for each wastewater treatment plant sludge when the new plants are commissioned and following adequate monitoring of the sludge properties. Monitoring sludge properties should continue on a regular basis and the method of treatment and disposal route for each sludge kept continuously under review. Management arrangements must be sufficiently flexible to provide for these changes in requirements.
2) Heavy metal contamination may also occur in solid wastes and these should be similarly monitored and controlled. New regulations to limit hazardous materials in each disposal option need to be developed. The regulations concerning the discharge of heavy metals to the sewers need to be better enforced in future which should reduce the proportion of heavy metal contaminated sludge and consequently the constraints on disposal.
3) Comprehensive monitoring of sludge quality is essential before sludges are used for agriculture. BMA should seek the cooperation and assistance of universities and other research institutions to develop the necessary monitoring programs. Monitoring programs must continue during implementation and be developed as new requirements are identified.
4) Sludges uncontaminated with heavy metals are recommended for agricultural use in this Master Plan. Two options are proposed, using either 100% or 50% of the uncontaminated sludge depending on the market demand. In developing agricultural use of sludge, BMA must produce attractive sludge products at a price to compete with already available organic fertilizers, find and develop new markets, and enlighten and educate farmers and traders in the agricultural sector.

12.3 Reclaimed Wastewater Reuse

Treated wastewater reuse is practised to a limited extent in the private sector in the central part of Bangkok for miscellaneous use in buildings and garden watering in hotels, hospitals and offices, and by District offices in the vicinity of Si Phraya Wastewater Treatment Plant. By the target year of 2020, this Master Plan proposes that sixteen wastewater treatment plants will be in operation in the

central part of BMA making available huge quantities of treated wastewater. However, it will not be possible to utilize this to a large extent since it will generally be more expensive than readily available potable water after taking additional treatment needs and transport into account.

For extensive reuse of treated wastewater, a large new pipe network would need to be established, but this is not a realistic option in the midst of the congested city center. Treated wastewater reuse will therefore remain limited to miscellaneous building and garden purposes in the private sector. Nevertheless BMA should consider developing this market opportunity selling treated wastewater to the private sector organisations.

In view of the large volumes of treated wastewater soon to be available, it use for khlong water improvement is an attractive option which should be developed. However, this should be considered together with BMA current projects for khlong water improvement and for flood control management. Further study is necessary in this area taking all aspects of khlong management into account.

12.4 Organizations and Institutions

Cooperation and coordination between DDS and DPC is essential for the development and implementation of the proposals for sludge treatment and disposal in this Master Plan. The new sewerage, wastewater and sludge treatment, and sludge disposal systems are currently controlled by DDS, whereas night soil treatment and disposal is to be controlled by DPC as at present. In Chapter 9, two options are proposed, unifying the organizations and maintaining the independent activities of each. The establishment of new organization arrangements should be further studied by BMA to address the new activities identified in this Master Plan.

The Master Plan proposes that the management for the agricultural use of composted sludge be undertaken by the private sector in due course. However the establishment of this new market, the operation of compost factories, and the distribution and sale of compost requires further study in conjunction with both BMA and the agriculture sector organizations.

Tables

Table 2.1.5.1 Khlong Water Re-circulation Systems

No.	Pump Station & Gate	Intake or Discharge	Control Water Level (Max.)	Method of Operation		Quantity from Chao Phraya River (m^3/year, m^3/min)	Operation Hours (hr/year, hr/day)	Operation Period
				Outer W.L. Higher than Inner W.L.	Outer W.L. Lower than Inner W.L.			
	System 1 & 2							
1	Bang Khen Ghao P.S.	Int/Disch	0.7mM.S.L	Gate Control	Gate Open	Quantity from Chao Phraya River to be circulated drainage wastewater depends on the amount of the water flow by controlling water gate. The water gate are closed or opened depending on the Chao Phraya River water level. Pump operation hours will be function with water level in khlong.		December-April
2	Bang Khen Mai P.S.	Int/Disch	0.7mM.S.L	Gate Control	Gate Open			December-April
3	Bang Sue P.S.	Intake	0.5mM.S.L	Gate Control	Pump Intake Max. 51 cum/sec			December-April
4	Sam Sen P.S.	Intake	0.5mM.S.L	Gate Control	Pump Intake Max. 45 cum/sec			December-April
5	Tavate P.S. 0:00-5:00 hours 5:00-20:00 hours 20:00-24:00 hours	Int/Disch	 0.3mM.S.L 0.1mM.S.L 0.3mM.S.L	 Gate Control Gate Control Gate Control	 Pump Int./Disch. Pump Int./Disch. Pump Int./Disch. Max. 6cum/sec for Intake Max. 9cum/sec for Disch	21,135,600 m^3/year (ave. 40 m^3/min)	1,957 hr/year (ave. 5.4 hr/day)	All year
6	Ban Lum Phu G.	Intake	0.3mM.S.L	Gate Control	Gate Close	The water gates are opened and sometimes closed depending on the Chao Phraya River's water level. Drainage Pumps are not operated.		All year
7	Phra Phinklao G.	Intake	0.3mM.S.L	Gate Control	Gate Close			All year
8	Pak K. Talad G.	Discharge	0.3mM.S.L	Pump Discharge Max. 0.4cum/sec	Gate Open			All year
9	Ong Ang G.	Discharge	0.3mM.S.L	Pump Discharge Max. 1.5cum/sec	Gate Open			All year
10	Krung Kasem P.S.	Discharge	-0.2mM.S.L	Pump Discharge Max. 25.5cum/sec	Gate Open	77,940,000 m^3/year (ave. 361 m^3/min)	2,165 hr/year (ave. 14 hr/day)	December-April
11	Phra Khanong P.S.	Discharge	0.5mM.S.L	Pump Discharge Max. 105cum/sec	Gate Open	450,000,000 m^3/year (ave. 2,083 m^3/min)	3,000 hr/year (ave. 20 hr/day)	December-April
	System 3							
12	Sathorn P.S.	Intake	0.7mM.S.L	Gate Control	Pump Intake Max. 6cum/sec	The water gates are closed or opened depending on the Chao Phraya River's water level.		December-April
13	Chong Non Sri Tempora	Discharge	0.5mM.S.L	Pump Discharge Max. 3cum/sec	Gate Open Max. 3cum/sec	–	–	–
14	Rama IV P.S.	Discharge	-2.3mM.S.L	Pump Discharge Max. 22cum/sec	Pump Discharge Max. 22cum/sec	36,939,000 m^3/year (ave. 171 m^3/min)	1,800 hr/year (ave. 12 hr/day)	December-April
	System 4							
15	K.Toey P.S.	Discharge	0.7mM.S.L	Gate Control	Gate Open	25,000,000 m^3/year	1,500 hr/year	December-April
16	Bang Chak P.S.	Intake	0.7mM.S.L	Gate Control	Gate Open	6,500,000 m^3/year	1,500 hr/year	December-April
17	Bang Or P.S.	Discharge	0.7mM.S.L	Gate Control	Gate Open	15,000,000 m^3/year	1,500 hr/year	December-April
18	Bang Na P.S.	Discharge	0.7mM.S.L	Gate Control	Gate Open	15,000,000 m^3/year	1,500 hr/year	December-April

Source : Khlong Water Quality Improvement Project (completed in 1996) by Department of Drainage and Sewerage, BMA

Table 2.1.5.2 Aeration Systems for Khlong Water Improvement

Stations for Direct Aeration Systems

No.	Type of Aerators	Quantity	Oxygen Supply Amount O_2 kg/hr
1	Air Jet Pump Unit	1 unit	1.3
2	Air Blower and Diffusers Unit	1 unit	2.0
3	Air Jet Pump Unit	1 unit	1.3
4	Air Blower and Diffusers Unit	1 unit	2.0
5	Aeration Boat	4 units	2.0 each
6	Air Jet Pump Unit	1 unit	1.3
7	Air Jet Pump Unit	1 unit	1.3
8	Air Blower and Diffusers Unit	1 unit	2.0
9	Air Jet Pump Unit	1 unit	1.3
10	Air Blower and Diffusers Unit	1 unit	2.0
11	Air Jet Pump Unit	1 unit	1.3
12	Air Jet Pump Unit	1 unit	1.3

Aerated Lagoon Systems

No.	Name of Aerated Lagoon Systemns	Detention Period	day	Capacity m^3/d	Removal Rate of	Equipment
1	Makkasan Pond	dry season	7-12	30,000 -140,000	19-85	aerator 11 kW x 10
		rainy season	3-5			
2	Rama IX Pond		1	30,000 -60,000	65	aerator 11 kW x 3 aerator 18.5 kW x 4
3	Buddamonthon Sai 2		4	3,500	85	aerator 2 kW x 26

Source : Khlong Water Quality Improvement Project (completed in 1996) by DDS, BMA

Table 2.1.5.3 Improvements in Khlongs Water Quality

No.	Name of Khlong	Sampling Point No.	Average BOD (mg/l)			
			1993	1994	1996	1997
System 1 of Khlong Water Quality Improvement Project						
1	Bang Khaen	511	24	22	13	10
		512	18	15	14	12
		513	25	19	23	12
		514	26	20	14	13
2	Prem Prachakorn	113	43	22	29	19
		114	30	18	22	13
3	Bang Sue	121	23	30	26	16
		122	31	35	33	22
		123	39	30	33	24
4	Sam Sen	081	34	29	41	36
		082	28	22	29	16
		083	-	-	-	21
		085	40	25	29	40
5	Padung Krung Kasem	072	31	24	14	13
		073	-	-	-	11
		074	-	14	15	10
		075	38	22	14	19
		076	-	-	-	16
6	Mahanak	061	33	19	20	15
		062	22	21	18	18
		063	25	17	17	18
7	San Saep	091	43	23	24	16
		092	-	-	-	13
		093	30	23	16	11
8	Pra Kanong	271	32	22	24	13
		272	-	-	-	8
		273	28	19	15	17
9	Tan	101	26	25	27	20
10	Lad Phrao	181	-	-	-	11
		182	27	22	19	13
		183	-	-	-	11
11	Huay Kwuang	171	57	33	42	47
System 2 of Khlong Water Quality Improvement Project						
12	Bang Lam Poo	041	26	19	19	13
		042	17	-	17	12
		043	14	17	11	10
13	Lord	012	17	18	14	15
		013	22	18	13	13
		015	22	17	12	12
14	Ong Ang	051	22	14	15	16
		052	17	18	16	20
		053	24	20	16	17
System 3 of Khlong Water Quality Improvement Project						
15	Sathon	131	80	27	31	29
		132	-	-	-	21
16	Chong Nons	141	26	14	32	18
System 4 of Khlong Water Quality Improvement Project						
17	Toey	611	-	-	-	-
		612	-	-	-	-
18	Bang-chark	481	-	-	-	20
19	Bang Na	281	44	42	30	21
		282	-	-	-	16

Source : Wastewater Analysis Section Khlong Survey Annual Data, Water Quality Control Division, DDS, BMA

Note: [ ] is larger then effluent standard

Table 2.2.1.2 Population Projection by NESDB (1995) (1/2)

(in thousands)

Age Group	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0-4	249	247	243	237	230	224	223	222	223	227	231
5-9	254	252	250	249	248	246	240	235	229	225	220
10-14	278	280	281	281	280	279	281	282	280	277	272
15-19	349	353	354	351	349	346	348	350	351	352	352
20-24	378	389	400	409	417	423	425	425	425	425	425
25-29	350	361	374	389	404	418	428	439	449	458	463
30-34	313	323	333	341	351	362	374	388	402	416	429
35-39	254	268	282	294	307	316	328	337	346	355	367
40-44	185	198	212	227	242	256	270	283	296	308	319
45-49	141	147	154	163	173	185	198	212	226	241	255
50-54	125	129	131	133	135	140	145	153	161	172	183
55-59	91	97	104	111	118	122	126	128	130	132	136
60-64	69	72	75	78	83	88	93	100	107	114	118
65-69	48	51	54	57	61	65	67	69	72	77	83
70-74	40	38	38	38	40	43	48	52	55	56	58
75+	50	52	54	56	58	60	60	62	64	66	67
Female	3,174	3,258	3,338	3,415	3,496	3,574	3,654	3,737	3,817	3,901	3,980
0-4	258	256	252	245	238	232	230	230	231	235	240
5-9	265	262	258	256	255	252	245	239	233	229	224
10-14	278	280	281	280	279	277	278	276	273	270	265
15-19	313	317	319	322	323	323	327	328	328	326	325
20-24	353	358	361	364	366	368	371	374	377	380	382
25-29	340	348	357	368	377	384	389	393	395	398	402
30-34	308	318	326	333	340	348	356	365	375	384	391
35-39	240	254	269	283	296	308	317	323	330	336	344
40-44	178	189	201	213	225	239	252	266	279	290	300
45-49	131	137	145	154	164	175	186	197	209	221	234
50-54	117	120	121	122	123	127	133	140	149	159	169
55-59	83	89	95	102	107	111	114	115	116	118	121
60-64	59	61	64	68	73	77	81	87	94	100	104
65-69	40	42	44	46	49	53	54	56	59	63	69
70-74	30	29	29	30	31	33	37	39	42	43	44
75+	30	31	33	34	35	37	38	39	40	42	44
Male	3,024	3,091	3,156	3,220	3,282	3,345	3,406	3,467	3,531	3,595	3,657
Total	**6,198**	**6,349**	**6,495**	**6,635**	**6,778**	**6,919**	**7,061**	**7,204**	**7,348**	**7,496**	**7,637**

Table 2.2.1.2 Population Projection by NESDB (1995) (2/2)

(in thousands)

Age Group	2,001	2,002	2,003	2,004	2,005	2,006	2,007	2,008	2,009	2,010
0-4	234	236	239	242	244	246	249	228	237	249
5-9	218	218	221	224	228	229	231	232	237	240
10-14	271	267	261	253	249	250	253	253	254	257
15-19	354	355	355	353	349	348	344	337	332	330
20-24	425	426	429	433	434	434	435	435	436	436
25-29	466	467	466	467	468	469	470	473	476	480
30-34	441	452	463	470	476	479	481	479	480	482
35-39	379	392	406	420	433	444	455	464	472	480
40-44	329	338	347	356	367	378	391	404	419	432
45-49	269	282	295	307	318	327	337	344	354	365
50-54	195	209	224	238	252	266	278	290	302	314
55-59	142	149	158	168	179	191	204	217	231	248
60-64	121	122	125	128	132	137	144	151	161	173
65-69	89	96	101	107	111	112	113	114	118	124
70-74	56	57	60	66	74	82	89	94	98	100
75+	70	74	77	80	84	88	92	96	102	107
Female	4,059	4,140	4,225	4,312	4,399	4,479	4,565	4,612	4,709	4,814
0-4	242	244	247	250	252	252	250	254	257	258
5-9	222	223	224	228	231	232	235	237	241	244
10-14	261	256	249	242	238	238	239	240	242	245
15-19	326	326	324	320	316	312	307	299	294	291
20-24	383	385	387	387	388	386	386	383	382	380
25-29	404	407	411	414	418	419	420	420	422	424
30-34	397	401	404	407	410	414	417	419	423	427
35-39	352	361	372	381	388	394	398	401	405	409
40-44	309	316	322	328	336	344	354	363	373	381
45-49	248	259	271	283	293	298	304	310	317	326
50-54	180	191	202	214	226	261	268	271	276	282
55-59	127	134	142	152	161	175	192	209	225	239
60-64	104	105	106	109	113	116	121	128	138	150
65-69	75	80	85	89	93	93	92	93	96	102
70-74	42	42	45	51	59	64	69	73	76	78
75+	45	47	49	52	55	58	61	64	67	72
Male	3,716	3,777	3,840	3,906	3,976	4,054	4,112	4,164	4,234	4,308
Total	**7,775**	**7,917**	**8,065**	**8,218**	**8,375**	**8,533**	**8,677**	**8,776**	**8,943**	**9,122**

Table 2.2.1.3 Wastewater User Charge and Study Team Population Foercasts and Densities in BMA Districts (1/2)

No.	District	Area	1998		2000		2005		2010		2015		2020	
		(km^2)	Pop.	Density (Pers/km^2)	Pop.	Density (Pers/km^2)	Pop.	Density (Pers/km^2)	Pop.	Density (Pers/km^2)	Pop.	Density (Pers/km^2)	Pop.	Density (Pers/km^2)
	BMA	1,568.99	7,725,200	4,924	8,006,700	5,103	8,777,800	5,595	9,663,500	6,159	10,681,100	6,808	11,856,000	7,556
1	PHRA NAKHON	5.54	119,200	21,516	119,800	21,625	121,300	21,895	122,800	22,166	124,300	22,437	125,800	22,708
2	DUSIT	10.67	215,900	20,238	216,300	20,272	217,200	20,356	218,200	20,450	219,100	20,534	220,100	20,628
3	NONG JOK	236.26	83,600	354	88,500	375	102,000	432	117,500	497	135,400	573	156,000	660
4	BANG RAK	5.54	110,500	19,946	112,300	20,271	116,900	21,101	121,700	21,968	126,600	22,852	131,800	23,791
5	BANG KHEN	37.29	207,700	5,570	220,600	5,916	256,600	6,881	298,500	8,005	347,200	9,311	403,800	10,829
6	BANG KAPI	29.70	207,400	6,983	218,700	7,364	249,700	8,407	285,100	9,599	325,500	10,960	371,600	12,512
7	PATHUMWAN	8.37	166,100	19,845	169,000	20,191	176,300	21,063	184,000	21,983	192,000	22,939	200,400	23,943
8	POM PRAP SATTRU PHAI	1.93	118,300	61,295	119,700	62,021	123,500	63,990	127,400	66,010	131,400	68,083	135,500	70,207
9	PHRA KHANONG	13.60	139,300	10,243	146,300	10,757	165,300	12,154	186,800	13,735	211,200	15,529	238,700	17,551
10	MIN BURI	58.24	97,000	1,666	105,600	1,813	130,500	2,241	161,200	2,768	199,300	3,422	246,300	4,229
11	LAT KRABANG	123.86	112,900	912	125,000	1,009	160,800	1,298	207,000	1,671	266,500	2,152	343,000	2,769
12	YAN NAWA	16.66	131,900	7,917	133,700	8,025	138,100	8,289	142,800	8,571	147,500	8,854	152,500	9,154
13	SAMPHANTHAWONG	1.46	67,600	46,301	67,900	46,507	68,800	47,123	69,700	47,740	70,600	48,356	71,600	49,041
14	PHAYA THAI	9.60	153,600	16,000	155,900	16,240	161,900	16,865	168,200	17,521	174,600	18,188	181,400	18,896
15	THON BURI	8.63	288,900	33,476	289,600	33,557	291,400	33,766	293,200	33,975	295,000	34,183	296,800	34,392
16	BANGKOK YAI	6.18	149,100	24,126	152,000	24,595	159,400	25,793	167,200	27,055	175,400	28,382	184,000	29,773
17	HUAY KWUANG	15.03	150,100	9,987	160,400	10,672	189,400	12,601	223,600	14,877	263,900	17,558	311,500	20,725
18	KHLONG SAN	6.05	178,300	29,471	179,300	29,636	181,700	30,033	184,200	30,446	186,800	30,876	189,300	31,289
19	TALING CHAN	32.85	105,100	3,199	108,400	3,300	116,900	3,559	126,100	3,839	136,000	4,140	146,700	4,466
20	BANGKOK NOI	11.94	212,800	17,822	214,000	17,923	217,100	18,183	220,200	18,442	223,300	18,702	226,500	18,970
21	BANG KHUN THIAN	123.26	105,700	858	112,500	913	131,200	1,064	153,100	1,242	178,600	1,449	208,400	1,691
22	PHASI CHAROEN	18.20	191,000	10,495	198,800	10,923	219,500	12,060	242,400	13,319	267,700	14,709	295,600	16,242
23	NONG KHAEM	40.53	110,800	2,734	117,900	2,909	137,600	3,395	160,700	3,965	187,500	4,626	218,900	5,401
24	RAT BURANA	15.70	136,300	8,682	145,100	9,242	169,500	10,796	198,100	12,618	231,400	14,739	270,400	17,223
25	BANG PHLAT	11.36	170,800	15,035	174,400	15,352	183,700	16,171	193,600	17,042	203,900	17,949	214,800	18,908

Table 2.2.1.3 Wastewater User Charge and Study Team Population Foercasts and Densities in BMA Districts (2/2)

No.	District	Area	1998		2000		2005		2010		2015		2020	
		(km^2)	Pop.	Density (Pers/km^2)	Pop.	Density (Pers/km^2)	Pop.	Density (Pers/km^2)	Pop.	Density (Pers/km^2)	Pop.	Density (Pers/km^2)	Pop.	Density (Pers/km^2)
	BMA	1,568.99	7,725,200	4,924	8,006,700	5,103	8,777,800	5,595	9,663,500	6,159	10,681,100	6,808	11,856,000	7,556
26	DIN DAENG	8.35	271,800	32,551	278,800	33,389	297,200	35,593	316,800	37,940	337,700	40,443	359,900	43,102
27	BUNG KUM	25.00	177,900	7,116	191,300	7,652	229,300	9,172	274,900	10,996	329,500	13,180	395,000	15,800
28	SATHON	9.33	148,100	15,874	149,800	16,056	154,200	16,527	158,700	17,010	163,300	17,503	168,100	18,017
29	BANG SUE	11.55	256,700	22,225	262,200	22,701	276,500	23,939	291,700	25,255	307,600	26,632	324,400	28,087
30	CHATUCHAK	32.91	238,100	7,235	241,700	7,344	250,900	7,624	260,400	7,912	270,300	8,213	280,600	8,526
31	BANG KHO LAEM	10.92	159,300	14,588	161,400	14,780	167,000	15,293	172,800	15,824	178,800	16,374	185,000	16,941
32	PRAWET	45.88	139,500	3,041	141,600	3,086	146,800	3,200	152,300	3,320	158,000	3,444	163,900	3,572
33	KHLONG TOEY	12.27	203,500	16,585	206,100	16,797	212,600	17,327	219,400	17,881	226,400	18,452	233,500	19,030
34	SUAN LUANG	23.68	155,500	6,567	165,300	6,981	192,300	8,121	223,700	9,447	260,300	10,992	302,900	12,791
35	CHOM THONG	26.25	183,700	6,998	187,100	7,128	195,900	7,463	205,100	7,813	214,700	8,179	224,800	8,564
36	DON MUANG	34.56	191,400	5,538	200,600	5,804	225,700	6,531	254,000	7,350	285,700	8,267	321,400	9,300
37	RATCHATHEWI	7.13	184,400	25,863	188,800	26,480	200,000	28,050	212,000	29,734	224,600	31,501	238,000	33,380
38	LAT PHRAO	30.48	190,100	6,237	199,000	6,529	223,300	7,326	250,600	8,222	281,200	9,226	315,600	10,354
39	BANG NA	20.28	140,000	6,903	145,700	7,184	160,800	7,929	177,500	8,752	195,900	9,660	216,200	10,661
40	VADHANA	13.28	123,600	9,307	127,400	9,593	137,400	10,346	148,200	11,160	159,800	12,033	172,300	12,974
41	SAI MAI	36.70	203,100	5,534	214,700	5,850	246,600	6,719	283,200	7,717	325,300	8,864	373,600	10,180
42	LAK SI	25.06	156,600	6,249	166,100	6,628	192,600	7,686	223,300	8,911	258,800	10,327	300,000	11,971
43	WANG THONG LANG	19.21	142,400	7,413	150,900	7,855	174,300	9,073	201,400	10,484	232,700	12,113	268,800	13,993
44	KHANNA YAO	28.72	94,300	3,283	101,800	3,545	123,100	4,286	148,800	5,181	180,000	6,267	217,700	7,580
45	SAPHAN SUNG	30.14	96,400	3,198	104,000	3,451	125,800	4,174	152,100	5,046	184,000	6,105	222,600	7,386
46	SAM WA	116.09	77,000	663	84,100	724	105,000	904	131,000	1,128	163,400	1,408	203,800	1,756
47	BANG KAE	43.48	222,700	5,122	231,000	5,313	252,900	5,816	276,900	6,368	303,200	6,973	332,000	7,636
48	BANG BON	34.62	74,500	2,152	79,300	2,291	92,600	2,675	108,100	3,122	126,300	3,648	147,500	4,261
49	THAWI WATTANA	46.83	53,100	1,134	56,900	1,215	67,400	1,439	80,000	1,708	94,900	2,026	112,600	2,404
50	THUNG KRUE	27.84	111,600	4,009	119,400	4,289	141,300	5,075	167,300	6,009	198,000	7,112	234,400	8,420

Source: A Feasibility Study of BMA Wastewater User Charge (1998)
Water Quality Management Division. Department of Drainage and Sewerage.
Bangkok Metropolitan Administration.

Table 2.2.3.1 MWA Water Treatment Plant Capacities

Treatment Plants	Present Capacity m^3/d	Planned Future Capacity m^3/d	Water Source
Bangkhen	3,200,000	4,000,000	Chao Phraya River
Maha Sawat	400,000	3,200,000	Tha Chin River (present), Mae Khlong River (future)
Sam Sen	700,000	700,000	Chao Phraya River
Thonburi	170,000	170,000	Chao Phraya River
Deep Wells	140,000	140,000	Groundwater
Others	58,000	58,000	Chao Phraya River
Total	4,668,000	8,268,000	

Source: MWA Annual Report 1997

Table 2.2.7.1 Trend of the National Budget Allocation in Terms of Environment Related Budget

Budget Item	Unit	1992		1993		1994		1995		1996		1997		1998		Average growth rate 92 to 97 (%)
		Budget	Growth (%)	Budget	Growth (%)	Budget	Growth (%)	Budget (Mil. B)	Growth (%)	Budget (Mil. B)	Growth (%)	Budget (Mil. B)	Growth (%)	Budget (Mil. B)	Growth (%)	
Overall national budget	(Mil. B)	560,000	--	625,000	11.6	715,000	14.4	843,200	17.9	984,000	16.7	984,000	0.0	825,000	-16.2	11.9
Environment development budget	(Mil. B)	5,175	--	6,716	29.8	7,113	5.9	10,052	41.3	12,819	27.5	12,819	0.0	6,366	-50.3	19.9
Share in overall national budget	(%)	0.92		1.07		0.99		1.19		1.30		1.30		0.77		
BMA budget	(Mil. B)	929	--	1,297	39.6	1,625	25.3	2,651	63.1	3,135	18.3	3,374	7.6	1,030	-69.5	29.4
Share in env. develop. budget	(%)	17.95		19.31		22.84		26.37		24.46		26.32		16.17		

Source: Budget reports in 1992 to 1998, Budget Bureau

Table 2.2.7.2 Detailed National Budget Allocation Related to Environmental Development (1/3)

Overall National Budget for the 1997 Thai Fiscal Year 984,000,000,000 (Baht)
Share of Environmental Development Related Budget 1.30 (%)

Environmental Development Total 12,819,027,100 (Baht) 100.00 (%)
Objectives - Maintain quality and condition balance of environment, pollution, spreading population and settling, including to damaging of natural resources problem.

1. Environmental developing administrator plan 885,878,900 6.91
Objectives - Administer environmental development effectively.
1.1 Administrator environmental development plan (sub-plan) 885,878,900 6.91
Objectives - Administer environmental development effectively.

Work / Project will operated in the fiscal year 1997

Work / Project	Official / Enterprises responsibility	Ministry BMA	The fiscal year 1997	Share
1.1.1 To 1.1.4 General Administer	- Pollution Control Department	MOSTE	76,384,000	0.60
	- Office of Environmental Policy and Planning	MOSTE	42,210,900	0.33
	- Department of Environmental Quality Promotion	MOSTE	11,184,100	0.09
	- Wastewater Management Organization	MOSTE	29,308,400	0.23
1.1.5 Making pollution data base project	- Pollution Control Department	MOSTE	82,478,100	0.64
1.1.6 Building construction Project of Pollution Control Department Organization office	- Pollution Control Department	MOSTE	223,184,000	1.74
1.1.7 Efficiency adding project of Thailand environmental maintenance organization	- Pollution Control Department	MOSTE	10,558,500	0.08
1.1.8 Work of preservation nature environment and art environment	- Office of Environmental Policy and Planning	MOSTE	41,895,000	0.33
1.1.9 Work of following and evaluating environment	- Office of Environmental Policy and Planning	MOSTE	33,977,100	0.27
1.1.10 Rattanakosin project (stage 2)	- Office of Environmental Policy and Planning	MOSTE	4,269,200	0.03
1.1.11 Work of Provincial environment administration	- Office of Environmental Policy and Planning	MOSTE	20,355,200	0.16
1.1.12 Management for protect the variety of biological	- Office of Environmental Policy and Planning	MOSTE	8,477,900	0.07
1.1.13 Information system development project to manage environment	- Office of Environmental Policy and Planning	MOSTE	5,433,500	0.04
1.1.14 Work of promotion and publishing	- Department of Environment Quality Promotion	MOSTE	134,780,400	1.05
1.1.15 Work of environmental information	- Department of Environment Quality Promotion	MOSTE	31,912,000	0.25
1.1.16 Support private organization	- Department of Environment Quality Promotion	MOSTE	13,145,000	0.10
1.1.17 Support environmental reviving in protecting area and pollution control area	- Department of Environment Quality Promotion	MOSTE	6,328,000	0.05
1.1.18 Organization building construction project	- Department of Environment Quality Promotion	MOSTE	97,134,000	0.76
1.1.19 Environmental information project for youth	- Department of Environment Quality Promotion	MOSTE	4,800,000	0.04
1.1.20 Environmental data network sub-provincial project (Kong river)	- Department of Environment Quality Promotion	MOSTE	1,400,000	0.01
1.1.21 Management project for allowing to the 21 plan	- Office of Environmental Policy and Planning	MOSTE	6,663,600	0.05

Table 2.2.7.2 Detailed National Budget Allocation Related to Environmental Development (2/3)

2. Environment controlling plan — 10,516,251,900 — 81.04

Objectives - Plan for maintaining and solving the quality of environment

2.1 Environmental controlling plan — 6,395,463,600 — 49.89

Objectives - To study and plan for controlling the qualification of environment and protecting wastewater. To control using natural sources that making an effect to environment

Work / Project	Official / Enterprises responsibility	Ministry BMA	The fiscal year 1997	Share
2.1.1 Environmental studying project (in the main river)	Department of Fisheries	M. of Agri.	2,951,000	0.02
2.1.2 Wastewater treatment and drainage system (high density area)	The public works Department	M. of Interior	1,926,422,000	15.03
2.1.3 Construction drainage system and waste-water treatment project of Hua-Hin district municipality (Pradheobkirikhan province)	The public works Department	M. of Interior	104,625,000	0.82
2.1.4 Wastewater problems solving project (San-Suk sub-district community)	The public works Department	M. of Interior	79,686,000	0.62
2.1.5 Wastewater drainage system construction project (municipality of Sakonnakorn)	The public works Department	M. of Interior	81,000,000	0.63
2.1.6 Construction drainage system and wastewater treatment project of Muang Puket municipality	The public works Department	M. of Interior	124,844,500	0.97
2.1.7 Garbage disposal system construction project (community area)	The public works Department	M. of Interior	589,078,000	4.60
2.1.8 Wastewater treatment project (Krung Rattanakosin)	BMA	BMA	218,238,100	1.70
2.1.9 Wastewater treatment project (stage 1)	BMA	BMA	1,066,407,600	8.32
2.1.10 Improving flow water and dredging canal in the area of BMA	BMA	BMA	83,884,000	0.63
2.1.11 Wastewater treatment project (Yannawa)	BMA	BMA	824,361,600	6.43
2.1.12 Garbage disposal project (Nongkhaem)	BMA	BMA	102,240,000	0.80
2.1.13 Wastewater treatment system construction project (Nongkheam - Pasicharoen - Ratburana)	BMA	BMA	842,767,200	6.57
2.1.14 Land subsidence and ground water crisis protecting and solving project in the Bangkok area	Department of Mineral Resources	M. of Ind.	6,068,700	0.05
2.1.15 Making geographic information system of industrial factory project	Department of Industrial Works	M. of Ind.	10,000,000	0.08
2.1.16 Environmental quality development planning project in specific and community area	Office of Environmental Policy and Planning	MOSTE	16,868,000	0.13
2.1.17 Natural resources management project in basin area project	Office of Environmental Policy and Planning	MOSTE	21,799,600	0.17
2.1.18 Management seacoast resource work	Office of Environmental Policy and Planning	MOSTE	4,016,400	0.03
2.1.19 Environmental training and researching center work	Department of Environment quality promotion	MOSTE	53,805,900	0.42
2.1.20 Wastewater treatment project (stage 4)	BMA	BMA	239,400,000	1.87

2.2 Improve environmental quality plan — 45,779,500 — 0.36

Objectives - Treat the damage environment that damage from using natural resources

Work / Project	Official / Enterprises responsibility	Ministry BMA	The fiscal year 1997	Share
2.2.1 Controlling fishery environmental quality work	Department of Fisheries	M. of Agri.	22,661,900	0.18
2.2.2 Reviving seacoast project for fishery	Department of Fisheries	M. of Agri.	7,000,000	0.05
2.2.3 Management coral resource project	Department of Fisheries	M. of Agri.	16,117,600	0.13

2.3 Support and control environmental quality plan (sub-plan) — 4,075,068,800 — 31.79

Objectives - Manage and support the management to develop environmental quality caused by industrial development and living of community

Work / Project	Official / Enterprises responsibility	Ministry BMA	The fiscal year 1997	Share
2.3.1 Environmental pollution protecting project	Office of the Permanent Secretary for transport and Communications	Others	58,402,400	0.46
2.3.2 The project under the plan for manage sample seacoast area (Tang , Chem seacoast and Klong Yan)	Department of Local Administration	M. of Interior	408,400	0.00
2.3.3 Solving environmental problems in city and circumference project	Department of Local Administration	M. of Interior	489,810,000	3.82
2.3.4 Mineral resources environmental quality support and control work	Department of Mineral Resources	M. of Ind.	18,342,300	0.14
2.3.5 Wastewater drainage controlling and environmental pollution work	Department of Industrial Works	M. of Ind.	82,757,700	0.65
2.3.6 Settling administrative center for manage material from industry project	Department of Industrial Works	M. of Ind.	463,119,400	3.61
2.3.7 Protecting the accident from chemical materiel work	Department of Industrial Works	M. of Ind.	29,908,000	0.23
2.3.8 Settling the analytical center for analyze toxic substance from industry project (provincial)	Department of Industrial Works	M. of Ind.	46,218,200	0.36
2.3.9 Controlling pollution substance from industry factory by long distance system project	Department of Industrial Works	M. of Ind.	20,000,000	0.16
2.3.10 The Suan Klang Mahanakorn project	Office of Environmental Policy and Planning	MOSTE	653,091,000	5.09
2.3.11 Management for revive environmental quality project (province)	Office of Environmental Policy and Planning	MOSTE	2,212,951,400	17.26

Table 2.2.7.2 Detailed National Budget Allocation Related to Environmental Development (3/3)

3. Pollution controlling work — 1,119,814,400 — 8.74

Objective - Find suitable measuring in protecting and solving pollution by private cooperation

3.1 Researching and controlling general pollution plan (sub plan) — 1,119,814,400 — 8.74

Objective - Find measuring in protecting and solving pollution

Work / Project	Official / Enterprises responsibility		The fiscal year 1997	Share
3.1.1 Controlling pollution from vehicle project	The Thai Industrial Standards Institute	M. of Ind.	23,750,600	0.19
3.1.2 Protecting and solving air and noise pollution project	Pollution Control department	MOSTE	324,023,700	2.53
3.1.3 Protecting and solving water pollution stage 2 project	Pollution Control department	MOSTE	101,857,200	0.79
3.1.4 Protecting and solving toxic substance and waste project	Pollution Control department	MOSTE	34,938,300	0.27
3.1.5 Checking the effect of air pollution from electrical factory and Mae-Moh lignite mine	Pollution Control department	MOSTE	5,183,800	0.04
3.1.6 Cooperation with foreign country and solving pollution problem project	Pollution Control department	MOSTE	15,500,000	0.12
3.1.7 Management wastewater in pollution controlling area project (Samutprakarn)	Pollution Control department	MOSTE	485,300,300	3.79
3.1.8 Settling garbage disposal center in pollution controlling area project	Pollution Control department	MOSTE	129,260,500	1.01

4. Researching plan — 17,957,700 — 0.14

Objective - Research and develop technology about natural resources and environment to progress and apply to solve the country problems

4.1 Sub-plan for research (Botany) — 17,957,700 — 0.14

Objective - Studying research in botany field and cooperate in education with researcher. Apply knowledge to use in conservation and extend plants.

Work / Project	Official / Enterprises responsibility	Ministry/BMA	The fiscal year 1997	Share
4.1.1 Study and Research in botany field	Botany Organization	Others	17,957,700	0.14

5. Natural resources management plan — 279,124,200 — 2.18

Objective - Effectively administer on development and conservation natural resources

5.1 Sub-plan for natural resources management plan (botany) — 279,124,200 — 2.18

Objective - Effectively manage about botany

Work / Project	Official / Enterprises responsibility	Ministry/BMA	The fiscal year 1997	Share
5.1.1 General administer	Botany Organization	Others	18,469,400	0.14
5.1.2 Botany garden work and improve condition	Botany Organization	Others	13,465,800	0.11
5.1.3 Support natural studying and travelling work	Botany Organization	Others	3,770,800	0.03
5.1.4 Development Queen Sirikit botany garden project	Botany Organization	Others	233,759,000	1.82
5.1.5 Finding heavy durable goods for building 1997 project	Botany Organization	Others	9,659,200	0.08

Source: Budget report in 1997, Budget Bureau

National Budget Allocation by Ministries

MOSTE	4,944,475,000	38.57
M. of Interior (Exclude BMA)	3,395,873,900	26.49
BMA	3,374,298,500	26.32
M. of Ind.	700,164,900	5.46
M. of Agri.	48,730,500	0.38
Others	355,484,300	2.77
Total	12,819,027,100	100.00

Table 2.2.7.3 Overall Financial Structure and Trend of BMA

Unit: Mil. Baht

Revenue and Expenditure	Thai Fiscal Year					Annual Growth rate
	1994	1995	1996	1997	1998	
						(%)
Revenue						
Regular revenue	14,170	17,000	20,400	24,200	26,400	16.8
Local taxes	12,819	15,348	18,286	21,923	24,107	17.1
Rental from BMA assets	822	1,020	1,443	1,537	1,544	17.1
Fee, fine, permits, service charge	364	444	432	428	428	4.2
Income from miscellaneous activities	141	155	195	252	316	22.3
Income from public utilities and enterprises	24	33	44	60	5	-32.4
Special revenue	4,819	766	1,838	3,636	n.a.	-9.0
Grand total revenues	18,989	17,766	22,238	27,836	26,400	8.6
Expenditure						
Public works and traffic	3,529	4,597	6,689	7,745	5,741	12.9
Drainage and wastewater treatment	2,103	2,332	3,712	4,162	4,264	19.3
General administration	2,671	3,947	3,350	3,730	4,950	16.7
Cleansing services and city orderliness operation	2,117	2,261	2,530	3,171	3,753	15.4
Public health	2,114	2,174	2,195	2,574	3,587	14.1
Social service and development	903	888	1,114	1,574	1,621	15.8
Education	732	802	811	1,244	2,484	35.7
Commercial of BMA	157	139	189	270	361	23.2
Grand total expenditure	14,327	17,139	20,590	24,470	26,761	16.9
Balance	4,662	627	1,649	3,366	-361	

Source: Statistical Profile of BMA, 1998, Department of Policy and Planning, BMA

Table 2.2.7.4 Budget Structure of DDS Financial Reports

Budget

Unit: 1000 baht

Budget Item	1.994	1.995	1.996	1.997	Share in 1996 (%)	Share in 1997 (%)
Budget						
1 General admi.	11.764	39.808	14.184	19.137	0.49	0.62
2 Dev. Of drainage system	257.050	279.992	205.562	737.052	7.15	23.79
3 Ope. Of drainage for flooding	841.931	1.188.334	866.998	1.126.099	30.15	36.34
4 Control of wastewater quality	Included in Item 3	Included in Item 3	1.788.523	1.216.420	62.20	39.26
5 Extra expenditure	607.130	203.387	0	0	0.00	0.00
Total	1.717.875	1.711.521	2.875.267	3.098.708	100.00	100.00

Expenditure

Unit: 1000 baht

Expenditure Item	1.994	1.995	1.996	1.997	Share in 1996 (%)	Share in 1997 (%)
Regular expenditure						
1 Salary of full time worker	180.577	189.501	223.855	235.136	7.79	7.59
2 Salary of part time worker	29.429	33.043	48.744	57.347	1.70	1.85
3 Over time, Small equipment	150.666	156.948	170.531	192.209	5.93	6.20
4 Public Utility Fare	51.288	53.421	59.820	72.574	2.08	2.34
5 Construction, Big equipment	610.031	1.000.879	2.273.147	2.456.639	79.06	79.28
6 Supported Money	0	0	0	0	0.00	0.00
7 Other Expenditure	88.755	74.341	99.167	84.803	3.45	2.74
Sub-total	1.110.746	1.508.133	2.875.264	3.098.708	100.00	100.00
Extra expenditure	607.130	203.387	0	0	0.00	0.00
Total	1.717.876	1.711.520	2.875.264	3.098.708	100.00	100.00

Source: BMA Enactment on Budget Expenditure of DDS in 1994, 1995, 1996, and 1997 (in Thai)

Table 2.2.7.5 Detailed Expenditure of DDS by Activities in 1997

	(B 1,000) 1997 report	(%) Share
1 General admi.	19,137	0.62
2 Dev. Of drainage system	737,052	23.79
2.1 Develop of drainage system	29,552	0.95
2.2 Construction drainage system in Payathai district project	180,000	5.81
2.3 Construction flood protection system project	90,000	2.90
2.4 Construction flood protection system project at the bank of Chaophraya river (from King Rama 4 bridge to Klongsan)	90,000	2.90
2.5 Survey the details of flood protection system at the bank of Chaophraya river, Klong Mahasawat and Klong Bangkoknoi in Bangkok area	30,000	0.97
2.6 Construction flood protection system project at the bank of Chaophraya river and Klong Bangkoknoi(from King Rama 9 bridge to Jaransanitwong Road)	100,000	3.23
2.7 Construction flood protection system project at the bank of Chaophraya river (from krungthonburi bridge to Phrapinklao bridge)	110,000	3.55
2.8 Construction flood protection system project in Bangplad and Bangkoknoi district	26,000	0.84
2.9 Dam (concrete with metal) construction project (Klong Samsen) around Kind Rama 9 Road (from the last dam : water flow system improving project to the last dam near Klong Sansab)	30,500	0.98
2.10 Dam and drainage gate (Klong Bangpokwang Pracharat Soi 1) construction project	13,000	0.42
2.11 Surveying and designing drainage system in Sukhumvit district area project	6,000	0.19
2.12 Surveying and designing drainage system in Dusit and Rajtevee district area project	3,000	0.10
2.13 Surveying and designing drainage system in Talingchan and Pasijaroean district area project	15,000	0.48
2.14 Surveying and designing drainage system in Donmuang district area project	14,000	0.45
3 Ope. Of drainage for flooding	1,126,099	36.34
3.1 Controlling drainage system	383,765	12.38
3.2 Construction the office building of the Thonburi bank flood protection department project	30,000	0.97
3.3 Machine	72,637	2.34
3.4 Klong protecting	436,716	14.09
3.5 Dam (concrete with metal) and tube under road construction project (the canal beside Ratchadapisek Road) from Klong Huaykwang to Klong Bangnumkaew	20,000	0.65
3.6 Dam (concrete with metal) construction (Klong Sansab) project from Klongton drainage gate to Mitrmahartthai bridge	41,980	1.35
3.7 Dam (concrete with metal) construction (Klong Sansab) project from the canal beside Indonesia embassy to the Klongton drainage gate	25,000	0.81
3.8 Dam (concrete with metal) construction project (Klong Bangjak) from Pakininat temple to Sirionthorn Road	27,000	0.87
3.9 Dam (concrete with metal) construction project (Klong Lumpangpuay) from National Housing Authority Pond (the way to Sukapiban 2 Road) to the target point	29,000	0.94
3.10 Dam (concrete with metal) construction project (Klong Radsamakkee) from Klong Prayarajchamontri to around Klong Yaithieb	17,000	0.55
3.11 Dam (concrete with metal) construction project (Klong Bangoohnoi) from the express way (the way to Bangoohnoi) to the target point	25,000	0.81
3.11 Dam (concrete with metal) construction project (Klong Lao) from Klong Kaja (the way to Praramklao Road) to the target point	18,000	0.58
4 Control of wastewater quality	1,216,420	39.26
4.1 Controlling the quality of water	88,429	2.85
4.2 Project of construction waste water treatment system (step 1)	143,262	4.62
4.3 Yannawa waste water treatment project	439,659	14.19
4.4 Project of construction waste water treatment system (Nongkheam, Pasijaroan, Ratburana)	365,470	11.79
4.5 Project of construction waste water treatment system (included step 4)	179,600	5.80
5 Extra expenditure	0	0.00
Total	3,098,708	100.00

Source: BMA Enactment on Budget Expenditure of DDS in 1994, 1995, 1996, and 1997 (in Thai)

Table 2.2.7.6 Budget Structure of DPC Financial Reports

Unit: 1000 Baht

Budget

Budget Item	1.994	1.995	1.996	1.997	Share in 1996 (%)	Share in 1997 (%)
Budget						
1 General admi.	50,795		19,281	49,024	2.25	3.76
2 Develop.Support	7,597		9,567	51,467	1.11	3.94
3 Cleansing	722,703	(missing)	829,436	1,205,022	96.64	92.30
4 Extra expenditure	42,000		0	0	0.00	0.00
Total	823,095		858,284	1,305,513	100.00	100.00

Unit: 1000 Baht

Expenditure

Expenditure Item	1.994	1.995	1.996	1.997	Share in 1996 (%)	Share in 1997 (%)
Regular expenditure						
1 Salary of full time worker	128,176		157,104	162,772	18.30	12.47
2 Salary of part time worker	10,241		13,569	29,470	1.58	2.26
3 Over time, Small equipment	98,112		107,242	117,834	12.49	9.03
4 Public Utility Fare	7,749		7,903	8,288	0.92	0.63
5 Construction.Big equipment	435,385	(missing)	232,520	590,306	27.09	45.22
6 Supported Money	0		0	0	0.00	0.00
7 Other Expenditure	101,433		339,944	396,842	39.61	30.40
Sub-total	781,096		858,282	1,305,512	100.00	100.00
Extra expenditure	42,000		0	0	0.00	0.00
Total	823,096		858,282	1,305,512	100.00	100.00

Source: BMA Enactment on Budget Expenditure of DPC in 1994, 1996, and 1997 (in Thai)

Table 2.2.7.7 Detailed Expenditure of DPC by Activities in 1997

	(B 1,000) 1997 report	(%) Share
1 General admi.	49,024	3.76
1.1 General administrative in public cleansing	14,175	1.09
1.2 Flat construction project at On-Nut garbage disposal plant	34,850	2.67
2 Develop, Support	51,467	3.94
3 Cleansing	1,205,022	92.30
3.1 Public cleansing	467,798	35.83
3.2 Night soil disposal	75,407	5.78
3.3 (Private Type) Bring the garbage from the area of BMA (Ta-rang sub district, Bangkhen district) and dumping by sanitary landfill	29,017	2.22
3.4 Construction sludge disposal plant from waste water and fat treatment system project at Tarang Bangkhen district	159,500	12.22
3.5 Garbage disposal	236,300	18.10
3.6 (Private Type) Bring the garbage from the area of BMA (Ta-rang sub district, Bangkhen district) and dumping by sanitary landfill	50,000	3.83
3.7 (Private Type) Bring the garbage from Nong-Kheam garbage disposal plant and dumping by sanitary landfill	75,000	5.74
3.8 (Private Type) Bring the garbage from On-Nut garbage disposal plant and dumping by sanitary landfill	82,000	6.28
3.9 Nong-Khaem garbage disposal project	0	0.00
3.10 (Private Type) Operation the garbage disposal factory machine project (1,000 ton/day) at On-Nut garbage disposal plant	20,000	1.53
3.11 Construction incinerator (1,000 ton/day) project at On-Nut garbage disposal plant	10,000	0.77
4 Extra expenditure	0	0.00
Total	1,305,513	100.00

Source: BMA Enactment on Budget Expenditure of DPC in 1994, 1995, 1996, and 1997 (in Thai)

Table 2.2.7.8 Detailed BMA Revenue Structure (1/2)

	1997 Fiscal Year (Baht)	(%)	1998 Fiscal Year (Baht)	(%)
BMA Revenue				
A. Permanent revenue				
1 BMA collected				
1 Local maintenance tax	125,000,000	0.44	125,000,000	0.47
2 Property and land tax	4,220,000,000	14.96	5,275,000,000	19.64
3 Signboard tax	385,000,000	1.36	443,000,000	1.65
4 Animal slaughtering duty	1,400,000	0.00	1,200,000	0.00
Other government organization collected				
5 Value Added and Special Tax	11,282,000,000	40.00	11,800,000,000	43.93
6 Car and vehicles Tax and Fee	4,375,000,000	15.51	4,843,000,000	18.03
7 Liquor tax	370,000,000	1.31	415,000,000	1.55
8 Gambling tax	135,000,000	0.48	135,000,000	0.50
9 Excise tax	1,030,000,000	3.65	1,070,000,000	3.98
Total	**21,923,400,000**	**77.72**	**24,107,200,000**	**89.75**
2 Fee, Service, Fine, License				
Fee				
1 Garbage collection fee	60,000,000	0.21	62,000,000	0.23
2 Waste collection fee	23,800,000	0.08	23,800,000	0.09
3 Construction approval fee	102,000,000	0.36	71,000,000	0.26
4 Parking fee	27,000,000	0.10	30,000,000	0.11
5 Gambling allowance fee	1,100,000	0.00	1,200,000	0.00
6 Slaughterhouse fee	2,000,000	0.01	1,700,000	0.01
7 Livestock station fee	400,000	0.00	350,000	0.00
8 Install advertising signboard fee	700,000	0.00	145,000	0.00
9 I.D.card fee	9,150,000	0.03	10,655,000	0.04
License				
10 Commercial fee	45,600,000	0.16	47,778,000	0.18
11 Catering and food stocking fee	11,420,000	0.04	12,720,000	0.05
12 Liquor and selling fee	1,100,000	0.00	1,155,000	0.00
13 Barber fee	403,000	0.00	405,000	0.00
14 Advertisement fee	200,000	0.00	189,000	0.00
15 Ice making fee	300,000	0.00	367,500	0.00
16 Hairdresser fee	110,000	0.00	115,000	0.00
17 Private fresh market license	80,000	0.00	84,600	0.00
18 Cemetery and cremation	2,000	0.00	900	0.00
Fine				
19 Break the law fee	124,000,000	0.44	145,000,000	0.54
Service				
20 Designing	50,000	0.00	50,000	0.00
21 Copy	1,000,000	0.00	1,200,000	0.00
22 Mosquito	50,000	0.00	100,000	0.00
23 Daycare for children	900,000	0.00	900,000	0.00
24 Public place activities	1,800,000	0.01	1,800,000	0.01
25 Use of public place	1,000,000	0.00	1,000,000	0.00
26 Use of public materials	50,000	0.00	50,000	0.00
27 Cleansing	2,400,000	0.01	2,400,000	0.01
28 Dog	5,000	0.00	5,000	0.00
29 Testing the quality of material	10,000,000	0.04	11,000,000	0.04
30 Checking water quality	50,000	0.00	70,000	0.00
31 Tree arrangement	650,000	0.00	650,000	0.00
32 Medical	410,000	0.00	410,000	0.00
Total	**427,730,000**	**1.52**	**428,300,000**	**1.59**
3 Revenue from property				
1 Building rental	34,000,000	0.12	40,790,000	0.15
2 Port rental	1,900,000	0.01	1,900,000	0.01
3 Land rental	500,000	0.00	692,000	0.00
4 Public vendor rental	350,000	0.00	380,000	0.00
5 Bank interest	1,500,000,000	5.32	1,500,000,000	5.58

Table 2.2.7.8 Detailed BMA Revenue Structure (2/2)

	1997 Fiscal Year (Baht)	(%)	1998 Fiscal Year (Baht)	(%)
6 Dividends from local printing press	20,000	0.00	28,000	0.00
Total	1,536,770,000	5.45	1,543,790,000	5.75
4 Revenue from public utility and commerce				
1 Pawn shop	50,000,000	0.18	0	0.00
2 Market office	10,000,000	0.04	5,000,000	0.02
Total	60,000,000	0.21	5,000,000	0.02
5 Miscellaneous				
1 Money left from last year	10,000,000	0.04	12,000,000	0.04
2 Bidding blueprint selling	60,000,000	0.21	65,000,000	0.24
3 Selling printed form	100,000	0.00	100,000	0.00
4 Miscellaneous	182,000,000	0.65	238,610,000	0.89
Total	252,100,000	0.89	315,710,000	1.18
Total BMA collected	7,008,000,000	24.84	8,137,000,000	30.29
Other government agency collected	17,192,000,000	60.95	18,263,000,000	67.99
Total permanent revenue	24,200,000,000	85.79	26,400,000,000	98.29
B Special revenue				
	3,636,078,000	12.89	0	0.00
Total special revenue	3,636,078,000	12.89	0	0.00
Total BMA revenue	27,836,078,000	98.69	26,400,000,000	98.29
Commercial Revenue				
1 Pawnshop				
A Permanent revenue				
1 Revenue from	1,866,000	0.01	2,455,000	0.01
Total	1,866,000	0.01	2,455,000	0.01
2 Revenue from				
2 Interest from pawning	96,000,000	0.34	112,100,000	0.42
Total	96,000,000	0.34	112,100,000	0.42
2 Profit from	28,750,000	0.10	32,000,000	0.12
Total	28,750,000	0.10	32,000,000	0.12
Total revenue from	124,750,000	0.44	144,100,000	0.54
Total permanent revenue	126,616,000	0.45	146,555,000	0.55
B Special revenue				
Collecting profits	181,354,000	0.64	259,000,000	0.96
Total special revenue	181,354,000	0.64	259,000,000	0.96
Total revenue	307,970,000	1.09	405,555,000	1.51
2 Market office				
A Permanent revenue				
1 Revenue from property	27,804,561	0.10	30,548,680	0.11
Total	27,804,561	0.10	30,548,680	0.11
2 Miscellaneous	12,742,769	0.05	3,781,920	0.01
Total	12,742,769	0.05	3,781,920	0.01
Total permanent revenue	40,547,330	0.14	34,330,600	0.13
B Special revenue				
Collecting profits	22,348,600	0.08	19,446,000	0.07
Total special revenue	22,348,600	0.08	19,446,000	0.07
Total revenue	62,895,930	0.22	53,776,600	0.20
Total commercial permanent revenue	167,163,330	0.59	180,885,600	0.67
Total commercial special revenue	203,702,600	0.72	278,446,000	1.04
Total commercial revenue	370,865,930	1.31	459,331,600	1.71
Total BMA and commercial revenue	28,206,943,930	100.00	26,859,331,600	100.00

Source: The BMA Revenue Report in 1998 (Thai)