Besides wastewater treatment and drainage, lakes are used for fish farming and recreation. The importance of recreation is growing all the time and more attention has to be paid to the water quality. All waterbodies are also important in creating an aesthetic, comfortable living environment.

4.3 The Project's Impact on the Environment

The exact numbers and work, which includes the first stage of Hanoi City Drainage and Environment Improvement Project, are presented in Table F4.1.

4.3.1 Yen So Pumping Station and Connecting Channels

The capacity of the pumping station during the first stage will be 45 m^3/s, and it will be doubled during the second stage. The total length of the channels will be 4,700 m (Inlet channel 1,200 m, Ordinary drainage channel 1,900 m and Outlet channel 1,600 m). There will be maintenance roads on the both sides of the channel and at least two bridges crossing the channel (see Figure F4.1).

The pumping station will create small environmental impact, and the area required is relatively small. At least, according to the present information, the buildings will not disturb and alter the landscape greatly.

Instead, the channel connecting the reservoir to the pumping station (Inlet channel), and the pumping station to the Red River (Outlet channel) are totally new structures, cutting the natural connection from area to area. Also, the outlet channel will be constructed outside the Red River levee, and should be provided with embankments on both sides. The construction work will also have an impact on the environment.

4.3.2 Yen So Regulating Reservoir

(1) Area and Construction

The total area of the Yen So regulation reservoir is 203 ha, of which the lake area is 130 ha consisting of three different reservoirs. Reservoirs are partly located in the same area as the present fish ponds. The reservoirs, besides being used for drainage will also be used for fish farming and recreation. The surrounding areas will be parks and/or green areas. For recreation purpose there will be aesthetic arrangements and islands.

The construction work will last about three years and during that time about 3,500,000 m^3 soil will be excavated. The difference between the maximum and the minimum water level in the reservoir is 3.0 meters, which creates a large impact on vegetation and fauna, and causes erosion on the banks, if the changes of water level happen very quickly and often.

(2) Water Quality

The degree and duration of disturbances by storm water discharge depends on the type of receiving water. In isolated, small and stagnant waters, such as ponds, the effects are the most severe, due to their long exposure to pollution.

It is very probable that in the reservoirs the amount of suspended solids, nutrients and bacteria will increase after the discharge of storm water. It has been noticed that a large part of the suspended solid load will settle near the outlet, at least the heaviest particles. The reservoir is quite far from the inundation areas, and the quality of storm water discharged to the reservoir depends very much on the condition of the drainage channels.

Water pumped from the reservoir to the Red River may also further decrease the water quality in the Red River. The impact will probably be quite small, because during the wet season the volume of water and dilution condition in the Red River are high.

(3) Fish farming

In the Yen So area, the present lakes are used for fish farming, and are emptied and dredged every year. The needs of fish farming and flood controlling, especially concerning water levels, can conflict. The water level will be higher than present, and of different parts of reservoir will be enlarged. This will cause some changes for fish farming methods, and the maintenance of the reservoir. Water level demand for flood regulation and fish farming are different, but a combination of these two modes of reservoir use has to be devised.

(4) Groundwater

The groundwater level and the quality of the Phap Van well field adjacent to the regulation reservoir has to be considered to avoid groundwater pollution and soil subsidence.

Area around the proposed Yen So regulating reservoir is also one of wellfield areas for water supply of Hanoi. There are also proposals to investigate new groundwater areas, and groundwater exploitation may be feasible if the water quality fulfills the standards.

Already now there has been noticed mitigation of groundwater quality also in lower aquifer, and amount of ammonia and phosphate has increased. Therefore in this area all possible further contamination of groundwater should be prevented.

Because the groundwater sources are limited, serious attention should be paid to protect the aquifer from deterioration. Protection zones should be established for the wellfields and wells. Activities which can be a risk for water quality should be controlled or prohibited.

The planning of the depth and construction of regulating reservoir has to be done without any disturbance to upper or lower aquifers. It is possible to discharge the most polluted storm water along channels straight to pumping station. The retention time in reservoir has to be so short that there will no accumulation of wastewater. This is also recommended for recreational and fish farming reasons.

The quality and level of groundwater has to be monitored continuous during the construction and use of regulating reservoir in co-operation with Hanoi Water Business Company and Hydrogeological Division K2.

(5) Site-clearing and Resettlement

There are only a few houses in the proposed new reservoir area, and site-clearing and resettlement will not be a problem.

4.3.3 Linh Dam and Dinh Cong Lakes and Channels

Linh Dam (Hoang Liet) and Dinh Cong lakes are proposed to be excavated to complete the regulation function of the Yen So reservoir. The capacity of the lakes is small compared with the capacity of Yen So. Linh Dam and Dinh Cong will be used to distribute the storm water. In the first stage there will not be any impact on the lakes as the excavation will be done during the second stage.

According to the City Master Plan, Linh Dam lake will be used for recreation in the future and demand of water quality will be high. There are also many pagodas around the lake.

Linh Dam channel is proposed to be constructed during the first stage and Dinh Cong channel during the second stage. The impact of the channels depends on how wide they are and where they are situated. Also the channels will be newly constructed, there will be temporary impact during the construction work.

4.3.4 Floodgates and Control Gates

With gates it is possible to control the amount of flow, and keep the water level stable. It is good to have several gates to regulate the amount of water in different places to avoid large and rapid changes in water level, which disturbs the water ecosystem.

4.3.5 River Improvement

Planned improvements consist of small dredging upstream and downstream, and some bridge re-construction. Resettlement will not be a problem, as there are no houses on the river banks.

4.3.6 Drainage Channel Improvement

Planned improvements concern mostly the re-construction of bridges to increase the flow in the channels. Insufficient culverts collect floating garbage and clogged culverts prevent the flow. Improvement of the flow is especially obvious if the channels are cleaned. The water quality doesn't improve if waste waters are discharged untreated into channels.

Resettlement will be the biggest problem along the channels, because the number of houses, which have to be moved is great, especially, if the three meter wide maintenance road is constructed along the channels.

4.3.7 Lake Improvement and Aeration

A total of 18 lakes are planned to be dredged to regulate storm waters and improve the environment around the lakes. Four lakes will be dredged during the first stage.

There will be an aeration pilot project in two lakes. This will attempt to prevent the lack of oxygen caused by eutrophication, to reduce the internal phosphorus load from sediment, and to improve the whole condition of lake.

There is no reliable data about water quality and sediment from most of the lakes, but even with some measurements and visual analyzing it is obvious that these lakes need restoration. There are several methods to conserve and restore lakes including aeration, increasing of depth, and controlling of nuisance algae and macrophytes.

Many lake bottoms seem to be lifeless, so dredging will not cause harm to the lake ecosystem. One of the biggest environmental problems is the storage of the sludge without harming any other lake or river or the living environment of the people.

At the same time as lake dredging, attention should also be paid to the banks and surrounding areas to improve the whole area and use of the lakes. The lakes which are used for recreation should be conserved for that reason. Well-maintained lake parks increase the value of the living environment and welfare.

There is also a proposal for the conservation of 11 environmentally valuable lakes. Proposed conservation methods are, the excavation of sludge from the bottoms, the construction of revetment on the slopes, and aeration of selected lakes. Implementation will be during the second stage.

4.3.8 Sewer Rehabilitation and Construction

The main target of the proposed work is to increase the existing sewer capacity in the most serious inundation areas in the inner city area, where the need is the greatest and the need for improvement is evident.

The work consists mainly of construction of new pipes. The replacement of old pipes will be determinated only after the inspection of the condition of the existing pipes made during the cleaning. The work will start in the trunk sewer lines during the first stage.

Sewer rehabilitation and construction is also highly recommended for environmental reasons. Especially if it is possible to change from open channels to pipes, as there will be less odor, and the health situation will be improved.

A problem is the small amount of sewer construction, especially during the first stage, and it will be mostly for the needs of drainage. To obtain environmental and socio-economic improvement, the sewer and wastewater treatment construction should be implemented earlier than proposed.

4.3.9 Equipment Supply for Cleanup of Drainage Channels and Sewers

Cleaning of the sewers has a very positive environmental impact and is highly recommended, because clogged sewers cause serious environmental problems, especially during the wet season.

4.4 Mitigation of Adverse Impacts

4.4.1 Yen So Pumping Station and Connecting Channels

Channels should be constructed and paved to ensure there is no erosion during use. If there are great and frequent changes in the water level, or the intensity of the flow changes rapidly, erosion is possible. Erosion increases the amount of suspended solids.

Erosion in the channel can be checked by visual controlling and with turbidity and/or suspended solid measurements. Water level and flow should be measured from all channels, not only for the needs of operation, but also for controlling water quality and assessing the impact on the possible ecosystem.

4.4.2 Yen So Regulating Reservoir

To minimize transportation and other extra work during the construction work, excavated soil should be used near the construction area, as material for dikes, etc..

The location, area and depth of the reservoir has to be designed with care to eliminate groundwater contamination, lowering of the groundwater level and soil subsidence in Phap Van well field, which is located just next to the reservoir.

The present situation in the Yen So area has to be studied with care, and possibility for fish farming guaranteed in the future. The most important thing is that the use and maintenance of reservoirs is arranged effectively, and there will not be any eutrophicated, foul-smelling water bodies. This can be prevented if the retardation in the reservoir is not long enough to cause sedimentation. Bottom sediment has to be dredged frequently to keep the water level in its planned elevation. To prevent erosion, banks have to be covered with grass or other material.

Because the reservoir is also planned for recreation, the shape and surroundings are designed in naturally. If maintenance is arranged in properly in the future it will become a convenient, recreational area. To keep the water quality in the reservoir as clean as possible, there will be an ordinary drainage channel provided to connect the river system directly to the pumping station.

The operation and maintenance of the reservoir should also cover water quality and sediment measurements, especially during the rainy season. Turbidity and/or suspended solids should be measured as frequently as the water level. The thickness of the sediment should be observed from selected points to follow the sedimentation. If possible studies should be done concerning the sedimentation rate, to help with the maintenance.

4.4.3 Linh Dam and Dinh Cong Lakes and Channels

The surroundings and shape of the present lakes have to be considered during planning and construction of the reservoir capacity.

After construction and during the operation, special attention has to be paid to the prevention of erosion, especially in the channels. The impact and rate of erosion can be controlled from the critical points, by visual checking and measurements. Breakdowns have to be detected and repaired.

4.4.4 Floodgates and Control Gates

Operation and maintenance have to be arranged properly, including water level and flow measurements. Gates and surroundings of gates have to be kept clean and garbage collected.

4.4.5 River Improvement

Impacts of the Project can be controlled and measured at selected points downstream. Presently, there are already some water quality sampling points, which include the Wastewater Monitoring Programme carried out by HSDC. If necessary more sampling points can be added to the program.

Impacts may mostly occur during the construction, and can be limited in small areas, if the work is done properly.

4.4.6 Drainage Channel Improvement

The drainage channel improvement will be a long lasting project, and its impact can extend to a large area, if consideration is not given.

Construction work has to done to prevent the water quality from changing downstream. Special attention has to be paid to the prevention of erosion during and after the construction. At the same time there should also be an improvement in garbage collection. Revetment of the banks prevents erosion and helps to keep the banks clean.

It is very possible that the soil in the channel banks and bottom sediment is polluted, and has to be re-moved. Channels and banks are used as illegal dumping sites, so it would be important to conduct heavy metal analyses from the soil. The increase of erosion and amount of suspended solids have to be measured and prevented during the construction work.

4.4.7 Lake Improvement and Aeration

Water quality, the amount and type of sediment, especially the amount of phosphorus, and possible bottom fauna and vegetation have to be studied before and after dredging to discover the real impact of the dredging. Mitigation of the waste water load, especially the phosphorus load, to the lakes has to occur before dredging, otherwise the dredging will not have any long lasting influence.

The impact of dredging can be mitigated through good planning. The treatment and location of the sediment has to be arranged so the problem is not only moved from place to place.

The amount of sediment will so great, that the timing of the work has to be done carefully. The implementation has to be done during the dry season to mitigate the impacts. There has to be control also during the construction work to prevent any surprising and unforeseen changes.

Aeration is a long lasting process and in serious cases it can take years to reach the satisfactory oxygen level. Initially, water quality can even decrease before the system settles down. Aeration doesn't limit or prevent any other use of the lakes.

4.4.8 Sewer Rehabilitation and Construction

During the first stage, the work will be done in limited areas in the most densely populated inner city. Special attention has to be paid to safely and protection during the work, because of the health risks caused by wastewater and contaminated soil. Excavated soil and sludge has to be stored without causing harm to the environment and people.

4.4.9 Equipment Supply and Cleanup of the Drainage Channels

Sludge and garbage removed from the channels and sewers have to be handled with care because it can consist of a lot of bacteria and other harmful matter. Special attention has to be paid to the safe use of equipment and protection during the work.

The treatment and the final location of the sludge have to be arranged without causing any health or environmental problem. Transportation of sludge has to be done carefully. If vacuum tanks are not used, the load must be covered.

4.5 Proposed Studies and Conclusions

4.5.1 Proposed Studies

(1) Wastewater Monitoring Program

Wastewater Monitoring Program carried out by HSDC and supported by FINNIDA started in 1993. There are sampling points in the main rivers, channels and factories. For the needs of planning a sewer network and waste water treatment plants, it is essential to continue and support this monitoring program in order to get long-term background information about waste water quality, quantity and polluters.

(2) Environmental Monitoring Program

There is very little reliable data and studies available concerning the environment in general, water quality and bottom fauna. Long-term series of sampling and analyzing have not been done. Therefore it is necessary to start an environmental monitoring program, which also includes visual checking of the condition of different water bodies and surrounding areas.

A monitoring program should be started as soon as possible for lakes which are proposed to be dredged or where there will be some other restoration or conservation. There will be a separate project for the restoration of West Lake.

The monitoring program should consist of studies concerning physical and chemical water quality, algae, bottom fauna, vegetation, amount and quality of sediment, and the general condition of surroundings. It should be continuous so that it is possible to control the impact of dredging and other restoration methods.

The Environmental Monitoring Program has been planned separately for different sub-projects, which have the biggest environmental impact and need long-term monitoring.

(a) Yen So Pumping Station, Connecting Channels and Linh Dam Channel

The Yen So pumping station and connecting channels are totally new structures, and will have impact on the environment during the construction work. Monitoring is needed during the construction work. Water quality and erosion monitoring is needed after the construction.

(b) Yen So Regulation Reservoir

Water quality of the present fish ponds has to be studied before excavation, to find out the present situation. This data is needed to evaluate the impact of the construction work, and especially the impact of storm water on the water quality in the reservoir, after construction.

There should be sampling points in every inlet near the reservoir to establish the quality of water discharged into the reservoir, and sampling points in every part of the reservoir. Water samples should be taken about once per month during the dry season, and especially during the wet season. pH, conductivity, dissolved oxygen, nutrients, turbidity, suspended solids, BOD and COD should be analyzed.

Fish ponds are already now emptied and dredged every year, resulting in no original bottom fauna or vegetation. Development of the bottom fauna, after construction, should be studied.

Data from the groundwater level and quality of the Phap Van well field has to be collected to ensure the construction and operation of the regulating reservoir doesn't cause any lowering of the groundwater level, pollution of groundwater or soil subsidence.

(c) Linh Dam and Dinh Cong Lakes

During the first stage, there will be no dredging of these lakes, but the water quality, sediment and bottom fauna has to be studied to establish the present situation. Data is needed to compare the impact of storm water on the water quality of the lakes.

There should be sampling points in every inlet near the lakes to evaluate the quality of water discharged into the lakes, and also sampling points in different parts of the lakes. Samples should be taken about once per month during the dry season, and especially during the wet season. pH, conductivity, dissolved oxygen, nutrients, turbidity, suspended solids, BOD and COD should be analyzed.

Parts of these two lakes are presently used as fish ponds, and emptied and dredged yearly. Sediment and bottom fauna should be studied from the ponds which are not dredged frequently, to find out if there is any life on the bottoms.

(d) River Improvement and Drainage Channels Improvement

River and channel improvement during the first stage consists mainly of bridge re-construction. Monitoring during the construction is necessary. Checking and controlling of erosion is needed after construction.

The water quality of the rivers and channels is studied in the Wastewater Monitoring Program carried out by HSDC. More sampling points can be added if necessary.

(f) Lake Improvement

During the first stage, four lakes are proposed to be dredged, and two lakes will have an aeration pilot project. Fourteen lakes are proposed to be dredged during the second stage, but the monitoring of the all the lakes must be started during the first stage.

The details of the lake monitoring program depend on what kind of restoration and conservation methods have been selected. There should be sampling points near the main inlets and outlets, and if possible also in the middle of the lake, to find out the potential self-purification process of the lake. Samples should be taken during the dry and rainy season about once per month.

The following physical-chemical water analyses should be done: pH, conductivity, dissolved oxygen in different layers (on-site analyzing), nutrients, turbidity, suspended solids, color, BOD and COD.

Sediment quality and bottom fauna should be studied at least twice per year, and more frequently just before dredging. Nutrients, and some heavy metals should be analyzed from the sediment.

Visual checking of the general condition of lakes and surroundings has to be done during the sampling, including odor and color of the water, and the amount of garbage in the water and banks.

4.5.2 Conclusions

The two main objectives of the Hanoi City Drainage and Environment Improvement Project are to improve the drainage system in the city and to reduce the disadvantages and damages caused by floods, and to improve the living environment in the city, particularly concerning health and hygiene.

The first stage of Project will compose of construction of drainage facilities in the To Lich River Basin, the urgent supply of dredging equipment to clean sewers and channels, and engineering services to cover the detailed design and construction supervision.

The implementing of this project will especially improve socio-economic aspects. Only resettlement from the channels will have a negative impact. Most of the construction work relating to the drainage and flood controlling system will have a positive impact in the long run, on the environment (See Table F4.2). During the construction work there may be temporary problems, which can be minimized by using proper working methods.

The discharge of storm waters to the reservoirs can decrease the water quality temporarily. Planned river and channel improvements will only have a small effect on the water quality.

The dredging of lakes eventually, will increase water quality, if the wastewater load is decreased at the same time. Dredging can have a negative impact on fauna, which must be studied before starting the work. The living environment and health will improve and there will be more possibilities for recreation.

Unfortunately, especially during the first stage, there is not a lot of sewer construction, so, the water quality, especially in the inner city area, will not improve.

The environmental situation in Hanoi is so serious that any kind of improvement will increase the level of the living environment. During the first stage, the proposed improvements concern mainly drainage and the mitigation of the inundation areas. To really improve the environment, emphasis should be placed on the development of the wastewater treatment system, and the collection and re-cycling of solid waste.

F5. LAKE IMPROVEMENT

The study on water quality has been made for twenty lakes in Hanoi city. Of these twenty, three lakes have been excluded from examinations because their conditions do not meet the criteria for the examination. Two pilot lakes for improving water quality, were selected after the examination.

5.1 Present State of Lakes in Hanoi

The quality of water in the lakes is constantly changing due to the inflow of untreated sewage water and drainage. Inflow materials physically change (sedimentation and adsorption), chemically change (decomposition and degeneration), and biologically change (assimilation) in the lake, and result in the overtrophication of the lake water.

The lakes in Hanoi city play the following six roles.

a. Flood control
b. Dilution and spontaneous oxidation of waste water
c. Fish culture
d. Aqua plant culture
e. Washing places
f. Recreation

Because of the heavy pollution load, the lakes are not able to sufficiently achieve their expected roles.

5.2 Improvement of Lakes

The fundamental principle in controlling the eutrophication and organic contamination of the lake, is to reduce the inflow of nutrients and organic materials that are the sources of contamination. In order to achieve the above results, the reduction of point pollution sources by regulating industrial waste water, extension of sewerage systems, and the establishment of countermeasures to control domestic waste water are necessary. Further, countermeasures have to be established to reduce the non-point pollution sources such as flood and drainage by rainfalls.

In addition to the above preventive countermeasures to reduce the pollution load at water catchment areas, some of the direct countermeasures to remove nutrients that have flowed into the lakes may be necessary.

Typical measures to reduce eutrophication and organic pollution of the lakes are as follows:

a. Dredging of mud at the lake bed

b. Collection and removal of nutrients produced by water hyacinths and water spinach

c. Collection and removal of phyto-plankton (microcytes and other microbes) and suspended solids.

d. Prevention of the dissolution of nutrients from the bottom layer of mud by covering the mud with sand, gravel, etc., and prevention of nutrients solution from the mud by ensuring sufficient dissolved oxygen in the lake.

e. Dilution of polluted lake water by introducing fresh water

f. Control method of algal production by managing the quantity and quality of chemical, biological circulation and change (Biomanipulation).

Using the two pilot lakes, purification facilities that are considered the most effective, and economical countermeasures selected from the above measures, will be planned.

5.3 Examination and Selection of Target Lakes

(1) Lakes for examination

The seventeen lakes are selected and examined. These are supposed to be considerably contaminated with sewage inflows. Nevertheless, they serve as pleasure resorts with beautiful views.(refer to Table F5.1)

The ○ and □ marks in the above mentioned table indicate the preference given by authorities concerned.

The ○ marks indicate the preference given by the Department of Civil Engineer, □ marks indicate the preference given by the HSDC. Simple "x"s show the utilization of the lakes confirmed by the Study Team.

(2) Lakes excluded from the examination

For the reasons described below the following eight lakes have been excluded from the examination.

Dong Da:	Used only for fish culture
Thanh Nham:	Used only for fish culture
Truc Bach:	The lake is too large
Ngoc Khanh:	Used for drainage and fish culture
Trung Tu:	Used for drainage and fishing
Hoan Kiem:	Many monuments are around the lake, and any changes in the area are prohibited by national guidelines.
Van Chung:	Used for water plant culture and fish culture
Kim Lien:	Used for sewage acception and water plant culture

The selection of the pilot lakes from the remaining nine lakes has been made based on the six criterion shown in Table F5.2.

Figure F5.2 is prepared to evaluate the eligibility of the nine lakes as the pilot lakes. The higher the total points, the higher the priority as a pilot lake. The lakes that are given higher priorities are: Thien Quang, Bay Mau, Thanh Cong, Ba Mau, and Thanh Nhan-1, in that ranking.

From the above five lakes, lake Bay Mau shall be excluded because the lake is too large for a pilot lake. Accordingly, the first choice will be Thien Quang, the second Thanh Cong, and the third Ba Mau and Thanh Nhan-1.

Thien Quang and Thanh Cong have been selected as pilot lakes.

5.4 Improvement of the Selected Two Lakes

As mentioned in the previous section, there are several technics to improve the quality of lake water, but the most effective and economical improvement methods should be adopted for the pilot lakes.

One method is to remove suspended solids, including phyto-plankton, from the lake water by coagulation and sedimentation. Another is to prevent the excessive increase in phyto-plankton and to stop the dissolution of nutrients from the lake bottom mud.

5.4.1 Improvement of Thien Quang Lake

One of the above two methods will be applied for lake Thien Quang to improve its condition.

However, a conceptual design and cost estimate will be prepared for both methods.

(1) Description of the Lake

Area:	5.0 Ha
Water Depth:	3.5 m
Volume:	175,000m^3

(2) Coagulation and Sedimentation Facilities

(Ref. Fig. F5.1)

(a) Facilities

Sewage and lake water are taken into a tank as shown in the figure, then neutralizer, coagulant and organic flocculent are added by a pump to flocculate the suspended solid in the water. The sludge settles by sedimentation in a settlement pond. The clean supernatant will be returned to the lake.

(b) Purification effect

Removal of phyto-plankton produced in the lake. Because phyto-plankton absorbs nitrogen and phosphate that flow into lakes, the removal of the plankton indirectly cleans the water. The organic pollutants in the inflowing sewage generally adhere to the suspended solid. Therefore, the removal of the suspended solids will eventually remove the organic pollutants from the sewage.

(3) Aeration facility (Ref. Figure F5.2)

(a) Facilities

As shown in the figure, three floating aerators will be constructed in the pond, aerating the surface water.

(b) Purification effect

- Neutralization of lake water
- Reduce BOD and COD (oxidation of organic matters by O_2 of aeration)
- Homogenization of DO content
- Destruction of plankton cells
- Prevention of the growth of plankton by stirring the lake water
- Prevention from dissolution of nutrients from the lake bed helped by DO supply
- Improvement of fish habitat
- Prevention of odors
- Improvement of outlook

5.4.2 Purification of Thanh Cong Lake

This lake is also located in Hanoi city. The description of the lake is as follows.

Area: 6.8 ha.

Depth: 2.0 m

Volume: 136,000m^3

The aeration method that is explained in the previous section will be applied for this lake.

5.4.3 Specification of Purification Plants

To purify Thien Quang Lake, floating aerators and a suspended solid removal plant will be adopted as shown in Figure F5.3. This is able to be used in individual plants and both plants. For Thanh Cong Lake, only aerators are recommended.

Specifications of plants are shown as follows.

(1) Specifications of Floating Aerator

(a) Floating Aerator for Thien Quang Lake

Quantity	:	3
Type	:	Standard type/submersible motor
Motor	:	200 V x 3 Phase x 50 Hz x 3.7 kW
Materials	:	Casing : SS304
		Impeller : Synthetic Resin
		Shaft : SS420
Dimensions	:	Ø 930 x 1,100H
O2 Transfer Efficiency	:	5.2 kg 02/hr (20°C, dissolved oxygen level = 02 mg/l)
Water Traveling Distance (radius)	:	7 m
Discharge Water Volume	:	15 m3/min.
Accessories	:	Standard accessories

(b) Floating Aerator for Thanh Cong Lake

Quantity	:	3
Type	:	Shallow lake type/submersible motor
Motor	:	200 V x 3 Phase x 50 Hz x 3.7 kW
Materials	:	Casing : SS304
		Impeller : Synthetic Resin
		Shaft : SS420
Dimensions	:	Ø 930 x 1,100H
O2 Transfer Efficiency	:	5.2 kg 0_2/hr (20°C, dissolved oxygen level = 0_2 mg/l)
Water Traveling Distance (radius)	:	7 m
Discharge Water Volume	:	15 m^3/min.
Accessories	:	Standard accessories

(2) Specifications of Water Treatment Facility for Thien Quang Lake (Suspended Solids Removal)

(a) Intake Pump

Quantity	:	2
Type	:	Centrifugal/submersible
Capacity	:	4.7 m^3/min. x 7m
Motor	:	200 V x3 Phase x 50 Hz x 11 kW
Materials	:	Casing : FC20
		Impeller : FC20
		Shaft : SS403

(b) Measuring Tank

Quantity	:	1
Structure	:	RC
Dimensions	:	200 W x 3,800 L x 2,500 H
Fittings	:	Weir plate

(c) Coagulation Tank

Quantity	:	1
Structure	:	RC
Effective Volume	:	16 m3
Retention Time	:	3.4 min.
Dimensions	:	2,000 W x2,300 L x4,500 H
Fittings	:	Rapid Mixer Quantity : 1 Rotation : 295 rpm Motor : 3.7 kW pH meter

(d) Flocculation Tank

Quantity	:	1
Structure	:	RC
Effective Volume	:	70 m^3
Retention Time	:	15 min.
Dimensions	:	2,300 W x 10,100 L x 4,500 H
Fittings	:	Slow Mixer Quantity : 4 Rotation : 50 rpm Motor : 2.2 kW

(e) Sedimentation Tank

Quantity	:	1
Type	:	Clarifier
Structure	:	RC
Effective Volume	:	484 m^3
Retention Time	:	104 min.
Dimensions	:	12,700 W x 12,700 L x 5,200 H
Fittings	:	Scraper (0.75 kW) Weir plates

(f) Treated Water Pit

Quantity	:	1
Structure	:	RC
Effective Volume	:	27 m^3
Retention Time	:	5 min.
Dimensions	:	3,000 W x 3,600 L x4,500 H

(g) Sludge Pit

Quantity	:	1
Structure	:	RC
Effective Volume	:	98 m^3
Dimensions	:	3,600 W x 9,100 Lx 4,500 H
Fittings	:	Sludge measuring tank Quantity : 1 Material : FRP Dimensions : 450 W x 800 L x 400 H

Sludge suction pump
Quantity : 2
Type : Air-lift

(h) Sludge Transfer Pump

Quantity	:	1
Type	:	Centrifugal/submersible
Capacity	:	0.5 m^3/min. x10 m
Motor	:	200 V x 3 Phase x 50 Hz x 3.7 kW
Materials of Casing	:	FC20
Materials of Impeller	:	FC20
Materials of Shaft	:	SS403

(i) Blower

Quantity	:	1
Capacity	:	1.0 m^3/min. x 3.5 m
Motor	:	200 V x 3 Phase x 50 Hz x 1.5 kWÅ
Materials	:	Casing : FC20 Housing : FC20

(j) Sludge Thickener

Quantity	:	1
Type	:	Clarifier
Structure	:	RC
Effective Volume	:	50 m^3
Retention Time	:	3 days
Dimensions	:	4,000 W x 4,000 L x 3,500 H
Fittings	:	Scraper (0.4 kW) Weir plates

(k) Sludge Storage Tank

Quantity	:	1
Structure	:	RC
Effective Volume	:	17 m3
Dimensions	:	1,500 W x 4,000 L x 3,500 H
Fittings	:	Sludge measuring tank Quantity : 1 Material : FRP Dimensions : 450 W x 800 L x 400 H Sludge suction pump Quantity : 2 Type : Air-lift

(l) H_2SO_4 Dosing Unit

- H_2SO_4 Storage Tank

Quantity	:	1
Material	:	Polyethylene
Effective Volume	:	1 m^3
Dimensions	:	Ø 1,065 x 1,255 H

Fittings	:	SS supporting frame

- H_2SO_4 Feeding Pump

Quantity	:	1
Type	:	Oil pressure/diaphragm
Capacity	:	2.1 l/h x 100 m
Motor	:	200 V x 3 Phase x 50 Hz x 0.2 kW
Materials	:	PVC

(m) Aluminum Sulfate Dosing Unit

- Aluminum Sulfate(10%) Storage Tank

Quantity	:	1
Material	:	Polyethylene
Effective Volume	:	2 m^3
Dimensions	:	Ø 1,425 x 1,570 H
Fittings	:	Steel supporting frame

- Aluminum Sulfate Feeding Pump

Quantity	:	1
Type	:	Oil pressure/diaphragm
Capacity	:	8.7 l/h x 100 m
Motor	:	200 V x 3 Phase x 50 Hz x 0.2 kW
Materials	:	PVC

(n) NaOH Dosing Unit

- NaOH(20%) Storage Tank

Quantity	:	1
Material	:	Polyethylene
Effective Volume	:	1 m^3
Dimensions	:	Ø 1,065 x 1,255 H
Fittings	:	Steel supporting frame

- NaOH Feeding Pump

Quantity	:	1
Type	:	Oil pressure/diaphragm
Capacity	:	4.2 l/h x 100 m
Motor	:	200 V x 3 Phase x 50 Hz x 0.2 kW
Materials	:	PVC

(o) Polymer Dosing Unit

- Polymer Dissolving Tank

Quantity	:	1
Type	:	Automatic powder dosing
Dissolving Rate	:	1.5 kg/h
Tank Volume	:	3 m^3
Tank Material	:	Carbon steel
Dimensions	:	Ø 1,700 x 1,500 H

Fittings : Hopper

- Polymer Solution Feeding Pump
  Quantity : 1
  Type : Oil pressure/diaphragm
  Capacity : 3.0 l/min. x 100 m
  Motor : 200 Vx 3 Phase x 50 Hz x 0.4 kW
  Materials : PVC

(p) Piping

- Raw Water Pipe
  250A flexible pressure tube : Total length = 50 m
  250A PVC pressure pipes : Total length = 200 m

- Treated Water Pipe
  250A flexible pressure tube : Total length = 200 m
  250A PVC pressure pipes : Total length = 800 m

5.5 Project Cost Estimate (Unit: US$)

(1) Floating Aeration Facilities for Thien Quang Lake

a) Floating Aerators	3 units	90,000
b) Electrical Equipment	1 set	70,000
c) Installation Cost	1 set	50,000
Total		US$ 210,000

(2) Floating Aeration Facilities for Thanh Cong Lake

a) Floating Aerators	3 units	85,000
b) Electrical Equipment	1 set	70,000
c) Installation Cost	1 set	50,000
Total		US$ 205,000

(3) Water Treatment Facility for Thien Quang Lake
(Suspended Solids Removal: Capacity=6,500)

a) Floating Aerators	3 units	650,000
b) Electrical Equipment	1 set	350,000
c) Installation Cost	1 set	50,000
Total		US$ 1,050,000

(4) Running Cost of Floating Aerators per One Lake

a) Electrical Consumption

Total Power 3.7kw x 3 set = 11.1kw
10 hrs / day run : 11.1kw x 10 hrs /day
365 days run / year : 111kwh x 365 days = 40,515kwh / year

b) Personal Expenditure

1 man / month = 12 men / year
(check and greasing the machine)

c) Annual O&M cost : US$ 2,400 / year / lake

- Electric Charge	:	40,515kwh x $0.04	=	1,620
- Personnel expenses	:	12 M/M x $40/MM	=	480
- Miscellaneous	:	15% of the above	=	300
Total				US$ 2,400/year/lake

5.6 Impacts of Lake Aeration

The targets of aeration are to prevent the lack of oxygen caused by eutrophication and to improve the whole condition of the lake. Oxidation influences the water and sediment and causes changes in the chemical water quality. The living conditions of fish and their food will improve. In the long-run the level of eutrophication will reduce, and the surface of the sediment will be oxidized gradually.

It is most important to increase the amount of oxygen in the water, realizing many other targets. It is also important to reduce the phosphorus concentration in the bottom layer and the internal phosphorus load from the sediment, and thus reduce eutrophication. With aeration, it is also possible to reduce anaerobic productions including, ammonium, hydrogen sulphide, methane, and the concentration of dissolved iron and manganese. The maintenance of a toxic environment overlying lake sediments with sufficiently available iron, can reduce phosphorus cycling, which will have an impact on the reduction of algae biomass.

With aeration, it is possible, to prevent the death, increase the growth and production of, fishes, zooplankton and bottom fauna. Aeration also has an impact on the prevention of odor, slime and fungus.

Aeration is usually a long lasting process, in serious cases it can take years to reach satisfactory oxygen levels. In the beginning, water quality can even decrease and the amount of algae increase, before the system settles down. To evaluate the success of aeration, dissolved oxygen, temperature, algal biomass, phosphorus and ammonium concentrations should be monitored.

Table F2.1 RESULTS OF WATER QUALITY IN LAKES, RIVERS AND CHANNELS DURING DRY SEASON 1993 – 94 (1/3)
FOR STUDY URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM

IN HANOI CITY

SAMPLING POINTS:

TO LICH SYSTEM
02.4.01 Phan Dinh Phung Outlet
04.4.01 Trinh Hoai Duc
00.2.05 Cau Moi Bridge

LU RIVER SYSTEM
06.1.02 Van Chuong Lake
00.2.06 Tan Bay Bridge
00.2.02 Cau Dau Bridge

SET RIVER SYSTEM
05.1.02 Bay Mau Lake
05.4.01 Ba Trieu Outlet

KIM NGUU RIVER SYSTEM
03.1.02 Hoan Kiem Lake
03.4.01 Lac Trung Bridge
00.2.04 Hoang Van Thu
00.2.03 Phap Van

THANH LIET SYSTEM
00.2.01 Cau Son Bridge
00.2.07 Nhue River
00.2.08 Cau To Bridge

	TOLICH SYSTEM			LU RIVER SYSTEM			SET RIVER SYSTEM		KIM NGUU RIVER SYSTEM				THANH LIET SYSTEM		
	02.4.01	04.4.01	00.2.05	06.1.02	00.2.06	00.2.02	05.1.02	05.4.01	03.1.02	03.4.01	00.2.04	00.2.03	00.2.01	00.2.07	00.2.08
TEMPERATURE oC DEC. 93 JAN. 94 SDCo.	18,5 25,3	20,5 23,8	17,0 22,5	21,0 22,7	18,0 23,3	16,0 23,1	20,0 22,0	21,0 23,0	17,0 22,0	22,0 24,0	16,0 22,8	17,0 22,4	16,0 23,1	18,0 22,1	18,0 21,8
AVERAGE	21,9	22,1	19,7	21,8	20,7	19,6	21,0	22,0	19,5	23,0	19,4	19,7	19,5	20,0	19,9
DISSOLVED OXYGEN mg/l DEC. 93 JAN. 94 SDCo.	2,2 0,8	0,9 0	0,3 0	0 0	0,9 0	0 0	1,2 1,4	0,8 0	3,9 11,3	0 0	2,6 0	1,4 0	1,6 0	7,1 7,1	6,6 7,3
AVERAGE	1,5	0,4	0,1	0	0,5	0	1,3	0,4	7,6	0	1,3	0,7	0,8	7,1	6,9
pH DEC. 93 JAN. 94 SDCo.	7,8 7,8	7,7 7,6	7,5 7,5	7,3 7,3	7,6 7,5	7,5 7,4	7,7 7,7	7,9 7,8	9,5 9,6	7,2 7,0	7,6 7,3	7,6 7,5	7,5 7,4	8,0 7,8	8,0 7,9
AVERAGE	7,8	7,7	7,5	7,3	7,6	7,5	7,7	7,9	9,6	7,1	7,4	7,5	7,5	7,9	8,0
CONDUCTIVITY µ∫/cm DEC. 93 JAN. 94 SDCo.	877 907	895 904	741 710	700 710	900 796	767 730	690 730	960 1.040	210 200	840 680	666 759	733 710	690 737	222 213	220 207
AVERAGE	892	900	726	705	848	749	710	1.000	205	760	713	722	714	218	214

Table F2.1 RESULTS OF WATER QUALITY IN LAKES, RIVERS AND CHANNELS DURING DRY SEASON 1993 – 94 (2/3)

	TOLICH SYSTEM			LU RIVER SYSTEM			SET RIVER SYSTEM		KIM NGUU RIVER SYSTEM				THANH LIET SYSTEM		
	02.4.01	04.4.01	00.2.05	06.1.02	00.2.06	00.2.02	05.1.02	05.4.01	03.1.02	03.4.01	00.2.04	00.2.03	00.2.01	00.2.07	00.2.08
NO2 - N mg/l															
DEC. 93	0,327	0,012	0,030	0,012	0,010	0,206	2,508	0,017	0,383	0,008	0,533	0,353	0,761	0,025	0,831
JAN. 94	0,031	0,022	0,026	0,009	0,006	0,094	0,928	0,021	0	0,002	0,032	0,022	0,013	0,033	0,916
AVERAGE	0,179	0,017	0,028	0,011	0,008	0,108	1,718	0,019	0,192	0,005	0,283	0,189	0,387	0,029	0,874
NO3 - N mg/l															
DEC. 93	0,46	0,85	1,18	0,44	0,24	0,48	4,60	0,70	3,20	0,71	2,61	2,51	0,89	0,73	1,81
JAN. 94	3,39	2,63	3,40	0,49	4,47	1,37	8,86	0,73	3,24	0,73	1,79	4,46	1,47	0,98	2,74
AVERAGE	1,93	1,74	2,29	0,47	2,36	0,93	6,73	0,71	3,22	0,72	2,20	3,49	1,18	0,86	2,28
NH4 - N mg/l															
DEC. 93	3,56	3,73	3,35	4,58	4,23	4,38	1,98	5,85	0,98	3,48	2,77	1,32	2,78	0,92	2,21
JAN. 94	6,15	4,79	4,74	6,79	5,18	5,30	3,59	7,94	0,99	5,85	4,61	2,75	3,14	0,57	3,26
AVERAGE	4,85	4,26	3,91	5,68	4,73	4,84	2,78	6,89	0,99	4,66	3,69	2,03	2,96	0,75	2,74
T - N mg/l															
DEC. 93	19,2	14,8	10,9	10,7	17,6	13,1	9,3	11,5	6,8	21,1	8,5	8,1	7,7	1,0	4,8
JAN. 94	17,9	17,4	14,5	13,9	15,8	10,5	12,0	15,2	4,1	16,5	10,3	10,0	7,1	0,6	9,9
AVERAGE	18,6	16,1	12,7	12,3	16,7	11,8	10,7	13,4	5,5	18,8	9,4	9,0	7,4	0,8	7,4
T - P mg/l															
DEC. 93	3,2	2,2	1,8	3,4	3,6	2,5	1,8	2,8	0,7	3,9	2,6	1,6	1,8	0,2	1,6
JAN. 94	4,3	2,4	2,4	3,6	2,5	1,1	1,2	3,9	0,7	2,8	3,9	3,9	2,2	0,2	2,1
AVERAGE	3,8	2,3	2,1	3,5	3,1	1,8	1,5	3,4	0,7	3,4	3,3	2,8	2,0	0,2	1,9
BOD5 mg/l															
DEC. 93	60	51	40	81	64	42	13	79	52	64	47	37	33	5	31
JAN. 94	69	73	59	70	60	50	34	86	28	74	57	45	43	6	30
AVERAGE	64	62	50	76	62	46	24	83	40	69	52	41	38	6	31
COD mg/l															
DEC. 93	95	121	82	151	155	91	82	145	144	179	116	131	78	15	62
JAN. 94	121	151	107	131	170	105	96	121	137	150	107	172	98	19	90
AVERAGE	108	136	95	141	163	98	89	133	141	165	112	152	88	17	76
TURBIDITY FTU															
DEC. 93	40	17	40	34	75	38	24	43	105	112	134	104	30	68	75
JAN. 94 SDCo.	46	41	39	51	46	36	35	61	125	63	85	101	50	35	32
AVERAGE	43	29	40	43	61	37	30	52	115	88	110	103	40	52	54

Table F2.1 RESULTS OF WATER QUALITY IN LAKES, RIVERS AND CHANNELS DURING DRY SEASON 1993 – 94 (3/3)

	TOLICH SYSTEM			LU RIVER SYSTEM			SET RIVER SYSTEM		KIM NGUU RIVER SYSTEM				THANH LIET SYSTEM		
	02.4.01	04.4.01	00.2.05	06.1.02	00.2.06	00.2.02	05.1.02	05.4.01	03.1.02	03.4.01	00.2.04	00.2.03	00.2.01	00.2.07	00.2.08
SUSPENDED SOLIDS mg/l															
DEC. 93	108	81	105	103	131	50	32	116	87	79	147	132	73	58	62
JAN. 94	115	102	114	31	123	64	18	136	15	132	98	108	68	40	80
AVERAGE	112	92	110	67	127	57	25	126	51	105	123	120	71	49	71
TOTAL DISSOLVED SOLIDS mg/l															
DEC. 93	449	148	370	350	454	384	350	490	110	430	334	368	345	113	111
JAN. 94 SDCo.	454	453	360	360	398	370	370	530	100	350	380	356	369	107	104
AVERAGE	452	300	365	355	426	377	360	510	105	390	357	362	357	110	108
TOTAL COLIFORM PCS/100ml															
DEC. 93	700	3 600	1 500	10 100	900	400	900	5 900	420	4 200	1 500	2 800	1 100	130	600
JAN. 94	11 000	6 000	8 500	9 200	4 900	3 100	8 700	10 200	1 100	11 000	9 000	7 000	9 500	400	4 200
AVERAGE	5 850	4 800	5 000	9 650	2 900	1 750	4 800	8 050	710	7 100	5 250	4 900	5 300	265	2 400
HETEROTROPHIC PLATE COUNT/100ml															
DEC. 93	1 300	5 000	1 900	9 800	2000	2000	1 400	7 000	700	4 100	2 400	3 100	1 900	600	2 200
JAN. 94	9 000	4 600	7 900	8 800	4 300	4000	7 000	11 000	1 000	9 000	9 400	6 100	8 000	390	4 700
AVERAGE	5 150	4 800	4 800	9 300	3 150	3000	4 200	9 000	850	6 550	5 900	4 600	4 950	485	3 450

Analyzed in the "Environmental laboratory of Center for Management and Control of Asmospheric and Water Environment Vietnam".

Table F2.2 **RESULTS OF HEAVY METALS IN RIVER WATER DURING DRY SEASON 1993 – 94 (1/2)**

SAMPLING POINTS :

00 . 2 . 05	Cau Moi Bridge
00 . 2 . 06	Tau Bay Bridge
05 . 1 . 02	Bay Mau Lake
03 . 4 . 01	Lac Trung Bridge
00 . 2 . 01	Cau Son Bridge

	To Lich System 00 - 2 - 05	Lu river System 00 - 2 - 06	Set river System 05 - 1 - 02	Kim Ngưu river system 03 - 4 - 01	Thanh Liet System 00 - 2 - 01
Temperature °C					
DEC. 93	17,0	17,0	20,0	22,0	16,0
JAN. 94	22,5	23,3	22,0	24,0	23,1
AVERAGE	19,8	20,1	21,0	23,0	19,5
Cyanide mg/l					
DEC. 93	0,20	0,42	0,45	0,60	0,20
JAN. 94	0,40	0,37	0,45	0,42	0,25
AVERAGE	0,30	0.40	0,45	0,51	0,22
Cadmium mg/l					
DEC. 93	0,019	0	0	0	0
JAN. 94	0,003	0	0,008	0,005	0,005
AVERAGE	0,011	0	0,004	0,002	0,002
Lead (Pb) mg/l					
DEC. 93	0,06	0,07	0,08	0,10	0,08
JAN. 94	0,08	0,05	0,08	0,12	0,06
AVERAGE	0,07	0,06	0,08	0,11	0,07
Zinc (Zn) mg/l					
DEC. 93	0,40	0,52	0,22	0,62	0,24
JAN. 94	1,22	1,35	0,33	0,64	0,52
AVERAGE	0,81	0,93	0,28	0,63	0,38
Total Chromium (Cr) mg/l					
DEC. 93	0	0	0	0	0
JAN. 94	0	0.02	0	0	0
AVERAGE	0	0.01	0	0	0
Hexavalent chromium (Cr+6)mg/l					
DEC. 93	0	0	0	0	0
JAN. 94	0	0	0	0	0
AVERAGE	0	0	0	0	0
Arsenic (As) mg/l					
DEC. 93	0,05	0,05	0,05	0,28	0,05
JAN. 94	0,03	0,11	0,02	0,07	0,10
AVERAGE	0,04	0,08	0,04	0,18	0,08

Table F2.2 RESULTS OF HEAVY METALS IN RIVER WATER DURING DRY SEASON 1993 – 94 (2/2)

	To Lich System 00 - 2 - 05	Lu river System 00 - 2 - 06	Set river System 05 - 1 - 02	Kim Nguu river System 03 - 4 - 01	Thanh Liet System 00 - 2 - 01
Total Mercury (Hg) mg/l					
DEC. 93	0	0	0	0	0
JAN. 94	0	0	0	0	0
AVERAGE	0	0	0	0	0
Copper (Cu) mg/l					
DEC. 93	0,10	0,01	0,05	0,05	0,04
JAN. 94	0,03	0,02	0,05	0,05	0,08
AVERAGE	0,07	0,01	0,05	0,05	0,06
Oil (N - Hexane Extract) mg/l					
DEC. 93	30	50	80	110	30
JAN. 94	50	43	49	81	41
AVERAGE	40	47	65	96	36

ANALYSED IN THE LABORATORY OF INSTITUTE OF MINING AND METALLUGRY

Table F2.3 **RESULTS OF HEAVY METALS IN RIVER SLUDGE DURING DRY SEASON 1993 - 94 (1/2)**

SAMPLING POINTS :

00.2.05 Cau Moi Bridge
00.2.06 Tau Bay Bridge
05.1.02 Bay Mau Lake
03.4.01 Lac Trung Bridge
00.2.01 Cau Son Bridge

	To Lich System 00-2-05	Lu river System 00-2-06	Set river System 05-1-02	Kim Nguu river System 03-4-01	Thanh Liet System 00-2-01
Depth of sludge cm					
DEC. 93	30	80	30	50	15
JAN. 94	40	50	30	50	—
AVERAGE	35	65	30	50	8
Moisture content %					
DEC. 93	43	47	34	58	32
JAN. 94	29	52	47	57	49
AVERAGE	36	50	40	58	41
Volatill solids g/kg					
DEC. 93	70	160	280	168	50
JAN. 94	120	140	150	100	140
AVERAGE	95	150	215	134	95
Total solids g/kg					
DEC. 93	538	678	700	810	412
JAN. 94	457	723	705	750	665
AVERAGE	498	701	703	780	539
Apparent Density kg/m3					
DEC. 93	1590	1400	1370	1170	1640
JAN. 94	1610	1615	1435	1510	1485
AVERAGE	1600	1508	1403	1340	1563
T-N mg/kg					
DEC. 93	1100	1220	1400	1960	1610
JAN. 94	1145	1108	1450	2150	1080
AVERAGE	1123	1164	1425	2055	1340
T-P mg/kg					
DEC. 93	300	1200	1400	1400	600
JAN. 94	400	1500	1200	1900	600
AVERAGE	350	1350	1300	1650	600
Cadmium (Cd) mg/kg					
DEC. 93	0,45	0,50	0,88	2,90	1,42
JAN. 94	0,48	0,83	0,92	2,23	0,56
AVERAGE	0,47	0,67	0,90	2,57	0,99

Table F2.3 RESULTS OF HEAVY METALS IN RIVER SLUDGE DURING DRY SEASON 1993 - 94 (2/2)

	To Lich System 00 - 2 - 05	Lu river System 00 - 2 - 06	Set river System 05 - 1 - 02	Kim Nguu river System 03 - 4 - 01	Thanh Liet System 00 - 2 - 01
Cyanide (Cn) mg/kg					
DEC. 93	30	45	52	65	28
JAN. 94	32	33	57	51	25
AVERAGE	31	39	55	58	27
Lead (Pb) mg/kg					
DEC. 93	36	77	142	83	52
JAN. 94	52	65	133	110	38
AVERAGE	44	71	138	97	45
Zinc (Zn) mg/kg					
DEC. 93	61	149	243	212	88
JAN. 94	98	214	287	392	77
AVERAGE	80	182	265	302	83
Total Chromium (Cr) mg/kg					
DEC. 93	33	32	16	33	27
JAN. 94	38	51	33	86	48
AVERAGE	36	42	25	60	38
Hexavalent chromium (Cr+6)mg/kg					
DEC. 93	0	0	0	0	0
JAN. 94	0	0	0	0	0
AVERAGE	0	0	0	0	0
Arsenic (As) mg/kg					
DEC. 93	11	18	15	50	13
JAN. 94	7	9	11	26	4
AVERAGE	9	14	13	38	9
Total Mercury (Hg) mg/kg					
DEC . 93	0	0	0	0	0
JAN. 94	0	0	0	0	0
AVERAGE	0	0	0	0	0
Copper (Cu) mg/kg					
DEC. 93	28	71	89	57	39
JAN. 94	30	49	136	101	48
AVERAGE	29	60	113	79	44

ANALYSED IN THE LABORATORY OF INSTITUTE OF MINING AND METALLURGY

Table F2.4 RESULTS OF WATER QUALITY IN LAKES DURING RAINY SEASON 1994

Name of Lake	Results on-site				Results in Laboratory of HSDC						Results in Environmental Laboratorio		
	Temp. (oC)	pH	Conductivity (μS/cm)	DO (mg/l)	NH3-N (mg/l)	NO3-N (mg/l)	TBD (FTU)	SS (mg/l)	Colour (no filt) (Pt Co)	Colour (filt) (PtCo)	PO4-P (mg/l)	COD (mg/l)	BOD (mg/l)
T7 Giang Vo Inlet	30.8	8.21	351	6.14	4.90	1.10	40	26	213	111	–	–	–
T13 Dong Da	30.2	8.05	342	4.20	2.40	0.00	43	35	85	137	0.30	51	17
K3 Thanh Nhan 1	28.0	7.67	345	1.09	0.49	1.60	42	31	154	123	0.60	77	28
K4 Thanh Nhan 2	27.0	7.64	314	1.69	0.34	1.60	59	49	298	147	0.42	65	29
W1 Truc Bach Inlet	29.0	7.56	395	6.45	0.30	2.60	20	23	148	48	–	–	–
W1 Truc Bach Outlet	29.5	7.61	340	8.90	0.80	2.30	43	20	–	–	–	–	–
T4 Thu Le	31.2	8.82	282	7.33	0.00	1.70	15	12	161	189	0.04	37	10
T8 Ngoc Khanh	31.0	8.64	334	7.48	0.55	0.90	43	32	226	153	0.70	66	18
T9 Thanh Cong	31.5	8.75	324	10.31	0.90	4.50	47	33	250	86	0.32	48	12
T16 Nghia Do	30.8	8.93	235	6.67	0.65	0.70	29	22	142	198	0.06	32	11
L5 Ba Mau	28.1	7.57	391	1.13	0.93	0.60	32	22	169	90	0.71	73	24
L6 Trung Tu	27.1	7.48	460	0.21	9.20	1.00	24	19	140	94	1.07	95	21
S1 Thuyen Quang	28.4	7.72	258	1.48	3.91	1.50	23	18	94	40	0.57	62	19
S2 Bay Mau Inlet	28.2	7.62	539	0.61	4.40	1.40	68	11	189	150	–	–	–
S2 Bay Mau Outlet	30.3	8.97	349	11.57	4.40	1.20	30	16	175	122	–	–	–
K1 Hoan Kiem	28.4	10.02	121	8.10	0.76	0.00	47	50	229	79	0.33	86	18
L3 Van Chuong	27.8	7.61	398	1.22	0.52	0.00	32	27	159	90	0.48	120	33
L7 Kim Lien	27.9	7.95	285	3.10	8.80	0.50	21	15	125	91	0.58	74	19
K2 Hai Ba Trung	28.9	7.77	218	1.45	0.74	1.70	14	8	67	38	0.48	55	24
Y1 Yen So	29.4	8.00	285	3.85	4.40	0.00	66	42	350	134	1.00	65	16
H3 Linh Dam	28.0	7.53	198	0.91	1.60	0.00	21	14	120	81	0.27	50	18
L17 Dinh Cong	28.7	8.12	220	1.97	1.25	0.30	20	13	124	91	0.12	40	12

Table F2.5 RESULTS OF OXYGEN STRATIFICATION IN LAKES IN SEPTEMBER 1994

		Temp. °C	DO mg/l	COND µn/cm	NH3 - N mg/l	SS mg/l	TURB. NTU	COLOUR NOT FILT. Pt Co	COLOUR FILTERED Pt Co
	S	28.7	1.6	240	1.7	10	16	74	23
HAI BA TRUNG	M	28.8	1.8	240	0.3	8	14	88	13
	B		1.3	230	1,0	8	13	68	13
	S	28.4	7.8	310	3.5	26	37	186	54
TRUC BACH	M	27.9	4.9	340	2.2	26	37	198	20
	B	27.9	3.6	340	4.3	22	31	172	35
	S	28.3	2.8	410	8.9	23	30	139	61
GIANG VO	M	28.3	2.5	410	9.2	22	29	142	70
	B		-	420	15.2	39	51	147	91
	S	29,0	3.2	290	0.9	30	35	176	6
THU LE	M	28.7	2.2	300	1.2	25	29	171	36
	B		1.6	290	1.1	71	16	308	55
	S	28.3	3.2	340	4.7	25	32	157	57
THANH LONG	M	28.1	1.7	350	4,0	23	29	160	61
	B		0.5	350	4.3	45	51	236	61
	S	29.4	6.3	370	8.2	24	32	168	107
THUYEN QUANG	M	29.1	6.3	370	8.7	26	32	185	105
	B	28,6	1.1	370	8.3	17	25	134	72

TABLE F3.1 CHARACTERISTICS OF WASTEWATER DISPOSAL ZONES

Item	ZONE 1		ZONE 2		ZONE 3	ZONE 4	ZONE 5	ZONE 6		ZONE7	Total/Average
	ZONE 1-1	ZONE 1-2	ZONE 2-1	ZONE 2-2				ZONE 6-1	ZONE 6-2		
Area (ha)	930	1,060	990	1,010	1,350	500	2,800	870	2,290	1,740	13,540
Future Population	40,300	46,500	303,800	129,200	299,400	190,300	243,900	114,200	180,100	49,100	1,596,800
Future Population Dencity (person /ha)	43.3 (111.0)	43.9	306.9	127.9	221.8	380.6	87.1	131.3	78.6	28.2	117.9
Future Wastewater Yield (m3/d)	8,260	7,910	73,370	36,000	70,360	44,720	56,450	29,830	43,220	8,290	378,410
- Domestic	6,539	5,585	54,660	23,026	53,892	34,254	42,063	20,480	31,151	6,330	277,980
- Commercial	1,722	642	16,689	6,951	16,467	10,467	12,147	6,230	9,035	977	81,327
- Industrial	0	1,680	2,016	6,020	0	0	2,240	3,121	3,035	984	19,096
Future Pollutant Load (kg/d)	2,765	3,591	22,455	11,507	21,257	13,511	17,962	9,378	13,827	3,463	119,716
Specific Yield (m3/d/ha)	8.88 (22.75)	7.46	74.11	35.64	52.12	89.44	20.16	34.29	18.87	4.76	27.95
Specific Load (kg/d/ha)	2.97 (7.62)	3.39	22.68	11.39	15.75	27.02	6.42	10.78	6.04	1.99	8.84
Raw wastewater Quality (BOD & SS :mg/l)	335 301	454 409	306 275	320 288	302 272	302 272	318 286	314 283	320 288	418 376	316 285
Name of Receiving Water	West Lake	Nhue	Kim Nguu	Kim Nguu	To Lich	Lu	Nhue	To Lich	Nhue	To Lich	
Proposed Removal Efficiency of BOD & SS(%)	80 80		85 80	85 80	85 80	85 80	75 80	75 80	75 80	75 80	
Treated Wastewater Quality (BOD:mg/l)			50	50	50	50	80	80	80		
- Domestic	60	50								90	
-Commercial/Industrial	50	50								50	
Proposed Wastewater Disposal System	On-site/ Community	Community	Large Scale Centralized		Mediun Scale Centralized	Mediun Scale Centralized	Mediun Scale Centralized	Mediun Scale Centralized		None-Treatment	
Alternative Wastewater Disposal System	Small Scale Centralized		Mediun Scale Centralized		Large Scale Centralized					On-site/ Community	
Priority of Developed Zone	4	9	1	5	3	2	7	6	8	10	

Table F4.1 PRINCIPAL FEATURES OF HANOI CITY DRAINAGE AND ENVIRONMENT IMPROVEMENT PROJECT (1/2)

Item	First Stage Project	Second Stage Project
1- Yen So Pumping Station		
(1) Pumping Station	Q = 45 m3/s	Q = 45 m3/s
(2) Inlet Structure	B = 200 m	--
(3) Inlet Channel	L = 1,200 m	--
(4) Ordinary Drainage Channel	L = 1,900 m	--
(5) Outlet Sluiceway	A = 30 m2	A = 30 m2
(6) Outlet Channel	L = 1,600 m	--
2- Yen So Regulating Reservoir		
(1) Regulating Reservoir	A = 203ha (130ha)	--
(2) Yen So Channel	L = 3,400 m	--
(3) Spoil Bank	A = 40 ha	--
3- Linh Dam and Dinh Cong Lakes		
(1) Linh Dam Channel	L = 1,000 m	--
(2) Linh Dam Lake	--	A = 107 ha
(3) Dinh Cong Channel	--	L = 400 m
(4) Dinh Cong Lake	--	A = 25 ha
4- Floodgates and Control Gates	7 places	--
5- River Improvement		
(1) To Lich and Lower Lu River System	L = 22.1 km (Lower Lu = 3.2km)	--
(2) Set and Upper Lu River System	L = 7.5 km (Upper Lu = 3.1km)	--
(3) Kim Nguu River System	L = 3.4 km	--
6- Drainage Channel Improvement		
(1) To Lich and Lower Lu River Basin	Bridges/Box Culverts (21 places)	Channel Works (L = 16.4 km) and Bridge/Box Culverts (24 places)
(2) Set and Upper Lu River Basin	Bridges/Box Culverts (13 places)	Channel Works (L = 3.7 km) and Bridge/Box Culverts (2 places)
(3) Kim Nguu River Basin	Bridges/Box Culverts (20 places)	Channel Works (L = 10.7 km) and Bridge/Box Culverts (1 places)

Table F4.1 PRINCIPAL FEATURES OF HANOI CITY DRAINAGE AND ENVIRONMENT IMPROVEMENT PROJECT (2/2)

Item	First Stage Project	Second Stage Project
7- Lake Improvement		
(1) Lake Dredging	4 lakes	14 lakes
(2) Lake Conservation	Aeration in 2 lakes as a pilot project	Overall environmental measures for 11 lakes
8- Sewer Rehabilitation and Construction		
(1) West Lake Basin	Rehabilitation	New construction
(2) To Lich River Basin	Rehabilitation	Rehabilitation/ New construction
(3) Lower Lu River Basin	—	New construction
(4) Hoang Liet Drainage Basin	—	New construction
(5) Set River Basin	Rehabilitation	New construction
(6) Upper Lu River Basin	Rehabilitation/ New construction	New construction
(7) Kim Nguu River Basin	Rehabilitation/ New construction	New construction
(8) Yen So Drainage Basin	—	New construction
9- Equipment Supply for Cleanup of Drainage Channels and Sewers	Grab bucket excavator, water jet cleaner, etc.	--

Table F4.2 ENVIRONMENTAL IMPACTS OF HANOI CITY DRAINAGE AND ENVIRONMENT IMPROVEMENT PROJECT

Subject	Water Quality		Flora and Fauna		Health and Hygiene		Living Conditions		Landscape		Resettlement	
	During Construction	In the Future	During Construction	In the Future	During Construction	In the Future	During Construction	In the Future	During Construction	In the Future	During Construction	In the Future
1) Yen So pumping station and channel	No	Medium	High	Small	No	Small	Small	Small	High	Medium	No	No
2) Yen So regulation reservoir	High	High	High	Medium	Small	Medium	Medium	Medium	High	High	Small	No
3) Linh Dam and Dinh Cong channel	Small	Medium	High	Small	No	Small	Medium	Medium	High	High	Small	No
4) Linh Dam and Dinh Con lakes	High	Medium	High	Medium	Small	Medium	Medium	Medium	Medium	Small	No	No
5) River improvement	High	Small	High	Small	Small	Small	Medium	Small	Small	Small	Medium	Small
6) Drainage channel improvement	Medium	Small	Small	Small	Medium	Medium	Medium	Medium	High	High	High	Medium
7) Lake dredging	High	Medium	High	Medium	High	Medium	Medium	High	Small	No	No	No
8) Sewer construction	Medium	High	No	No	High	High	Medium	High	Medium	Small	Small	No
9) Equipment supply	High	High	No	No	High	High	High	High	No	No	No	No

Table F5.1 CHARACTERISTICS OF MAIN LAKES

Name of Lake	Water Area (ha)	Depth (m)	Volume (m)	Present Status of Surrounding Area	Level of Pollution	Flood Control	Sewage Treatment	Fishery	Plant Culture	Washing	Recreation	Managed by	Classification	Remarks	Recent, Dredging by HPC
1 T-7 Giang Vo	4.5	2	90000	Hotel,Residence,Park	Moderate	⊗	×	⊠	—	—	×	HSDC,Fishing Co.	A	Dredging(1st Stage)	—
2 T-13 Dong Da	18.6	4.7	874200	Residence,Building	Heavy	⊗	×	⊠	—	—	—	Fishing Co.	B	Dredging(1st Stage)	—
3 K-3 Thanh Nham 1	8.5	2	170000	Residence,Park,Hospital	Moderate	×	×	×	—	—	[⊗]	HSDC,Fishing Co.	A	Dredging(1st Stage)	—
4 K-4 Thanh Nham 2	4.0	2	80000	Residence,Waste,land	Moderate	×	×	⊠	—	—	×	HSDC,Fishing Co.	A	Dredging(1st Stage)	—
5 W-1 Truc Bach	26.0	4	1040000	Residence,Park	Moderate	[⊗]	×	×	—	×	×	HSDC	A	Conservation(2nd Stage)	—
6 T-4 Thu Le	12.0	3.5	420000	Office,Park,Zoo	Light	×	—	—	—	—	[⊗]	HSDC	C	Conservation(2nd Stage)	—
7 T-8 Ngoc Khanh	3.8	2	76000	Residence, Park	Moderate	[⊗]	×	×	—	—	×	HSDC,Fishing Co.	A	Dredging(2nd Stage)	×
8 T-9 Thang Cong	6.8	2	136000	Residence,Hotel,Park	Moderate	⊠	×	×	—	—	⊗	HSDC,Fishing Co.	A	Dredging(2nd Stage)	×
9 T-16 Naghia Do	5.2	5	260000	Park	Moderate	×	—	×	—	—	[⊗]	-	A	Dredging(2nd Stage)	×
10 L-5 Ba Mau	3.0	4	120000	Residence,Park,Street,Railway	Moderate	×	×	⊠	—	—	⊗	HSDC,Fishing Co.	A	Conservation(2nd Stage)	—
11 L-6 Trung Tu	5.0	2	100000	Residence,Diplomatic Area	Heavy	[⊗]	×	×	×	—	—	HSDC,Fishing Co.	B	Dredging(2nd Stage)	—
12 S-1 Thien Quang	5.0	4	200000	Residence,Hotel,Park,Business	Moderate	⊠	×	×	—	—	⊗	HSDC,Fishing Co.	A	Conservation(2nd Stage)	—
13 S-2 Bay Mau	18.0	4	720000	Park	Heavy	⊠	×	×	—	—	⊗	HSDC,Fishing Co.	A	Dredging(2nd Stage)	×
14 K-1 Hoan Kiem	16.0	5.5	880000	Park,Monument,Residence,Shopping	Moderate	×	—	×	—	—	[⊗]	HSDC,Fishing Co.	A	Conservation(2nd Stage)	—
15 L-3 Van Chuong	6.0	3	180000	Residence,Building	Moderate	[⊗]	×	—	×	—	—	HSDC,Fishing Co.	B	Conservation(2nd Stage)	—
16 L-7 Kim Lien	3.5	3	615000	Residence	Heavy	[⊗]	×	×	×	—	—	HSDC,Fishing Co.	B	Conservation(2nd Stage)	—
17 K-2 Hai Ba Trung	1.3	3	39000	Park,Residence,Pagoda	Light	[⊗]	×	×	×	—	×	HSDC,Fishing Co.	A	Conservation(2nd Stage)	—

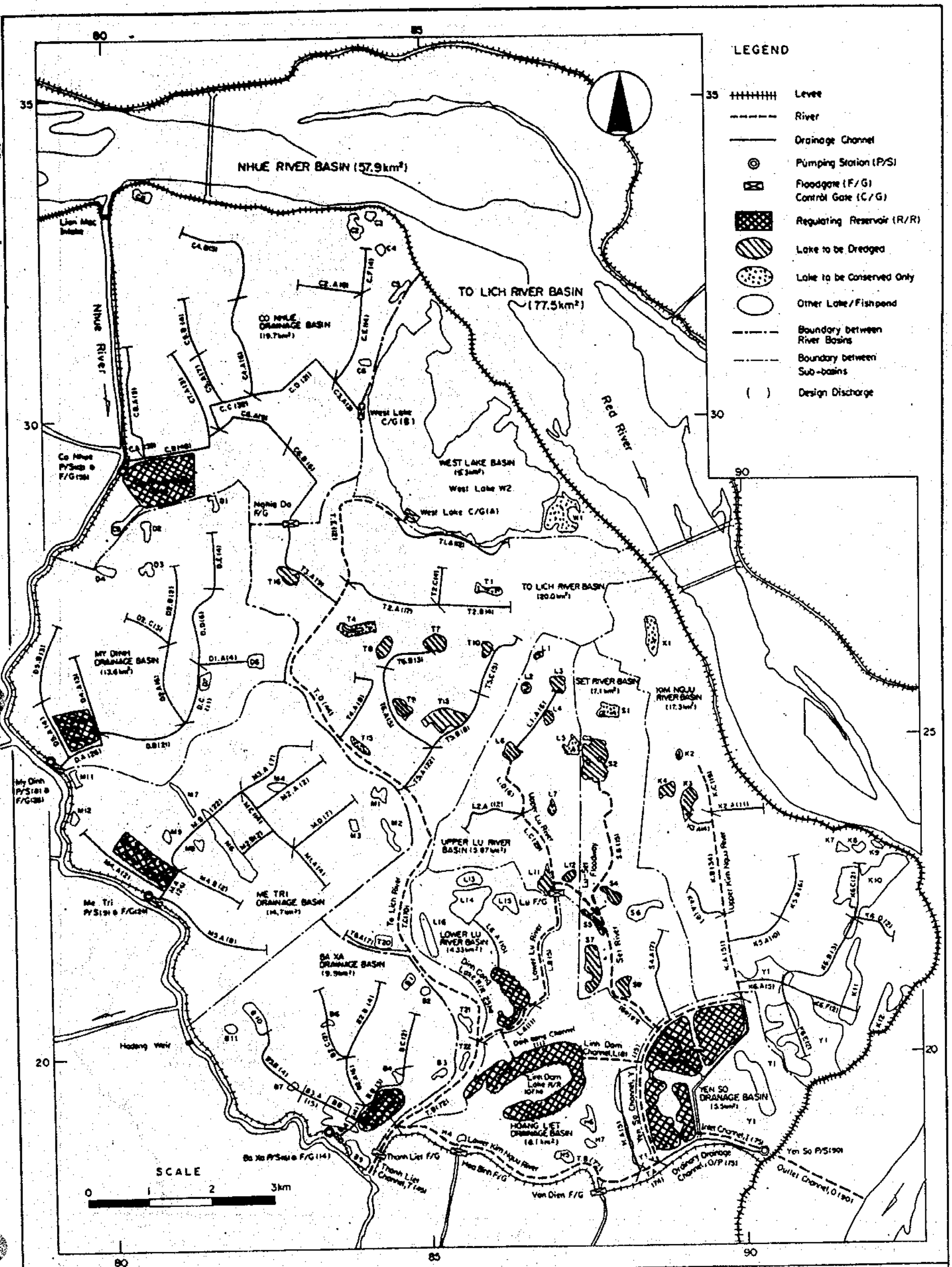
Classification
A: Drainage+Sewage Treatment+Fishery+Recreation
B: Drainage+Sewage Treatment+Fishing
C: Drainage+Recreation

Priorities given by concern authority
○: By the Depertment of Civil Engineer
□: By HSDC
×: By Study Team

Table F5.2 COMPARISON OF LAKES

Lake Name	①	②	③	④	⑤	⑥	Total
S-1 Thien Quang	3	2	3	3	1	2	14
T-4 Thu Le	1	1	1	3	1	3	10
S-2 Bay Mau	1	3	3	3	2	2	14
L-5 Ba Mau	3	2	3	1	1	2	12
T-9 Thanh Cong	2	2	2	3	2	2	13
T-16 Nahia Do	2	2	1	1	2	3	11
K-3 Thanh Nhan-1	2	2	2	2	1	3	12
K-2 Hy Ba Trung	3	2	2	2	1	1	11
T-7 Gian Vo	3	2	2	2	1	1	11

① Area 3(≦5ha), 2(5～10ha), 1(≧10ha)
② Level of Contamination 3(Heavy), 2(Moderate), 1(Light)
③ Distance from Center of City
3(Near Center), 2(Middle Distance)
1(Long Distance)
④ Utilization Level for Recreation
3(High), 2(Middle), 1(Low)
⑤ Dredging 2(Finished), 1(Not Finished)
⑥ Recommended by Department of Civil Engineer and HSDC
3(⊠), 2(☒ or ⊗), 1(×)



Note:
Study results in the Feasibility Study are also reflected on this plan.

SOCIALIST REPUBLIC OF VIET NAM

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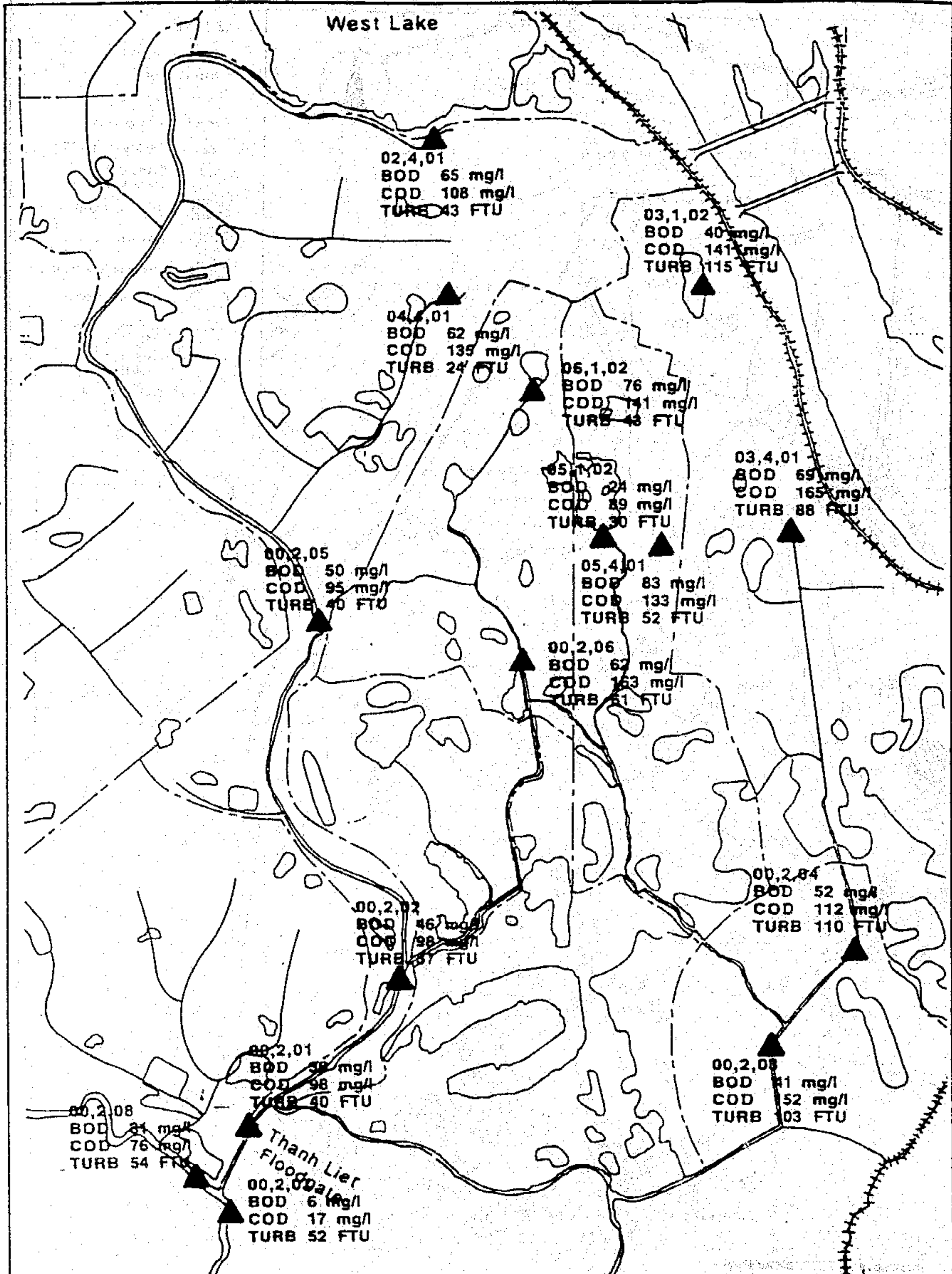
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. F2.1

REVISED LAYOUT OF DRAINAGE MASTER PLAN



SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY	Fig. F2.2 SAMPLING POINTS AND RESULTS OF BOD AND COD DURING DRY SEASON 1993 – 94
JAPAN INTERNATIONAL COOPERATION AGENCY	

Fig. F3.1 MASTER PLAN – IMPLEMENTATION SCHEDULE (1/2)

No.	Proposed Project	Cost US$ mil	YEAR (94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20)	Remark
	STORMWATER DRAINAGE PROJECTS			
A.	TO LICH RIVER BASIN DRAINAGE PROJECT	317	1st Stage; 2nd Stage; (Additional installation in parallel with the construction of new city road)	1st Stage Project proposed for OECF loan program
	A1. Yen So Pump Station (90m3/s)		(45m3/s) (45m3/s)	
	A2. Regulating Reservoir (130ha)		(Yen So Reserv.) (Linh Dam/Dinh Cong Lakes)	
	A3. River Improvement W/Gates (33km)			
	A4. Drainage Channel Improvement (31km)			
	A5. Lake Dredging (18 main lakes)			
	A6. Lakeshore Protection Works (11 lakes)			
	A7. Stormwater Sewers			
	(1) Rehabilitation of existing sewers		(Additional installation in parallel	
	(2) Installation of new sewers		with the construction of new city road)	
B.	NHUE RIVER BASIN DRAINAGE PROJECT	207		
	B1. Co Nhue Sub-basin Drainage Project	86		1st priority area in Nhue basin
	(1) Pump Station/Reservoir/Channels		(Additional installation in parallel	
	(2) Stormwater sewers		with the construction of new road)	
	B2. My Dinh and Me Tri Sub-basins Drainage Project	95		2 sub-basin projects in parallel
	(1) Pump Station/Reservoir/Channels		(Additional installation in parallel	
	(2) Stormwater sewers		with the construction of new road)	
	B3. Ba Xa Sub-basin Drainage Project	26		
	(1) Pump Station/Reservoir/Channels		(Additional installation in parallel	
	(2) Stormwater sewers		with the construction of new road)	
C.	EXISTING SEWER/CHANNEL DREDGING PROJECT	20		
	C1. Supply of dredging/cleaning equipment	10		
	C2. Dredging/cleaning work	10	Initial Dredging; Continous Dredging	By SDC
D.	ASSOCIATED PROJECTS (By Other Agencies)			
	D1. Nhue River Improvement Project	MOWR		
	(1) Right Bank Dyke with Inland Drainage (u/s from To Lich confluence, L=20km)		(Construction)	
	(2) Nhue River Overall Improvement (d/s from To Lich confluence, L=50km)		(Study) (Design) (Construction)	Improvement from downstream to upstream
	D2. Red River Dyke Reinstatement Project	MOWR	(Construction)	
E.	NON-STRUCTURAL MEASURES	10		
	E1. Flood Plain Management	5		Land use control
	E2. Provision of On-site Storage for New Estate Development	Private		Strengthening of regulations
	E3. Flood Forecasting and Warning System	MOWR		For Red River
	E4. Public Information and Education Programme	5		
	LAKE CONSERVATION PROJECTS			
F.	WEST LAKE CONSERVATION PROJECTS	110		
	F1. Comprehensive Environmental Study	3		
	F2. Lake Shore Road/Park Project	(50)		
	F3. Lake Sediments Dredging Project	50		Dredging area by area for protection of bottom fauna
G.	CITY LAKE CONSERVATION PROJECT	10		
	G1. Lake side Road / Park Projects (say 50 lakes)	(10)		
	G2. Lake water Aeration Projects (say 20 lakes)	0.5		

Fig. F3.1 MASTER PLAN – IMPLEMENTATION SCHEDULE (2/2)

No.	Proposed Project	Cost US$ mil	Year (94–20)	Remark
	WASTEWATER DISPOSAL PROJECT			
H.	CENTRALIZED WASTEWATER DISPOSAL PROJECT	567		
	H1. Zone-2 Wastewater Disposal Project	138	(Zone 2, 3 & 4) (Zone 2-1)	
	(1) Wastewater Treatment Plant			
	(2) Wastewater Sewers			
	H2. Zone-3 Wastewater Disposal Project	110		
	(1) Wastewater Treatment Plant			
	(2) Wastewater Sewers			
	H3. Zone-4 Wastewater Disposal Project	69		
	(1) Wastewater Treatment Plant			
	(2) Wastewater Sewers			
	H4. Zone-5 Wastewater Disposal Project	115		
	(1) Wastewater Treatment Plant			
	(2) Wastewater Sewers			
	H5. Zone-6 Wastewater Disposal Project	135	(Zone 6-1) (Zone 6-1)	
	(1) Wastewater Treatment Plant			
	(2) Wastewater Sewers			
J.	ON-SITE WASTEWATER TREATMENT PROJECT	71		
	J1. Zone-1 Community-based Treatment Project	51	(Zone 1-1) (Zone 1-2)	For selected areas
	J2. Zone-7 Community-based Treatment Project	20		For selected areas
K.	PILOT WASTEWATER TREATMENT PROJECT	22		
	K1. Kim Lien Rehabilitation Project	6		
	K2. Truc Bach Wastewater Treatment	6		Low level treatment at existing sewer outlets
	K3. Lake Inlet Pollutant Load Reduction	10	(Zone 3 & 2-2)	Either sedimentation basin or interceptor basin
L.	FLUSHING WATER DIVERSION PROJECT	60	(Monitoring in Zones 2 & 4)	To be implemented only if the necessity is observed
	L1. Nhue Pumping Station/Diversion Channel			Increase in capacities of pump, settling basin and channels
	L2. To Lich Diversion Weir			Rubber dam
	L3. Canals and Pipes in City Areas			Extension of canals/pipes area by area
M.	ASSOCIATED PROJECT (by Other Agencies)			
	M1. Upgrading/Increase of Public Latrines	URENCO		
	M2. Reinforcement of Domestic Wastes Collection System	URENCO		
	(1) Solid waste collection/disposal			
	(2) Nightsoil and septic tank sludge collection			
N.	NON-STRUCTURAL MEASURES	20		
	N1. Household's Obligation of Installing Septic Tanks	--		Strict enforcement of regulations
	N2. Effluent Pre-treatment by Industries	--		Strict enforcement of regulations
	N3. Provision of Soft Loan for Installing Septic Tanks	10		Set-up of fund system
	N4. Public Awareness Campaign	5		
	N5. Wastewater Quality Monitoring Program	5		

Legend: Study; Design; Financing/Tender-Contract; Construction; Intermittent Implementation; Implementation by Other Agencies

( ) Approx. Estimate

Cost : 1994 Base Price (excl. price contingency)

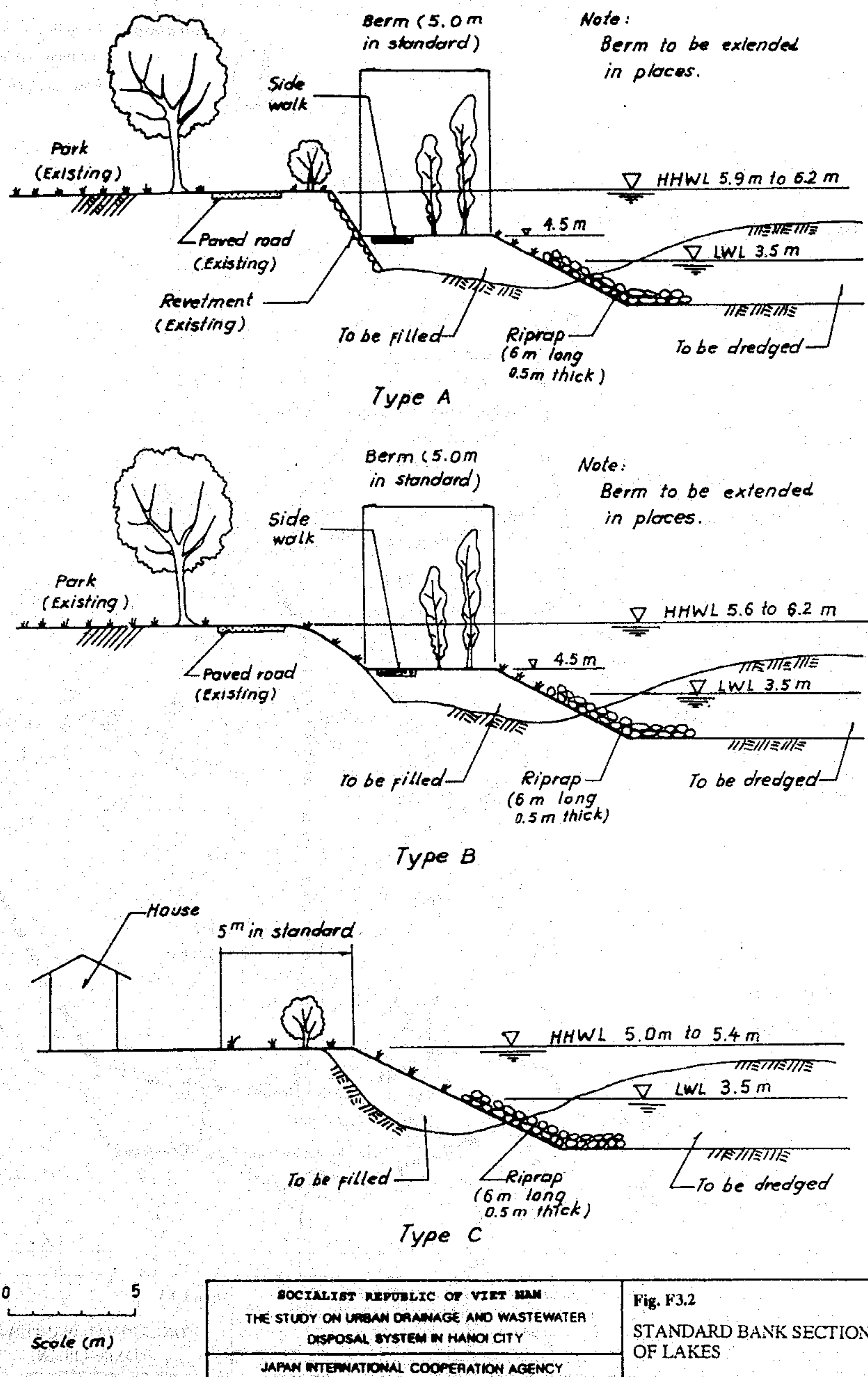


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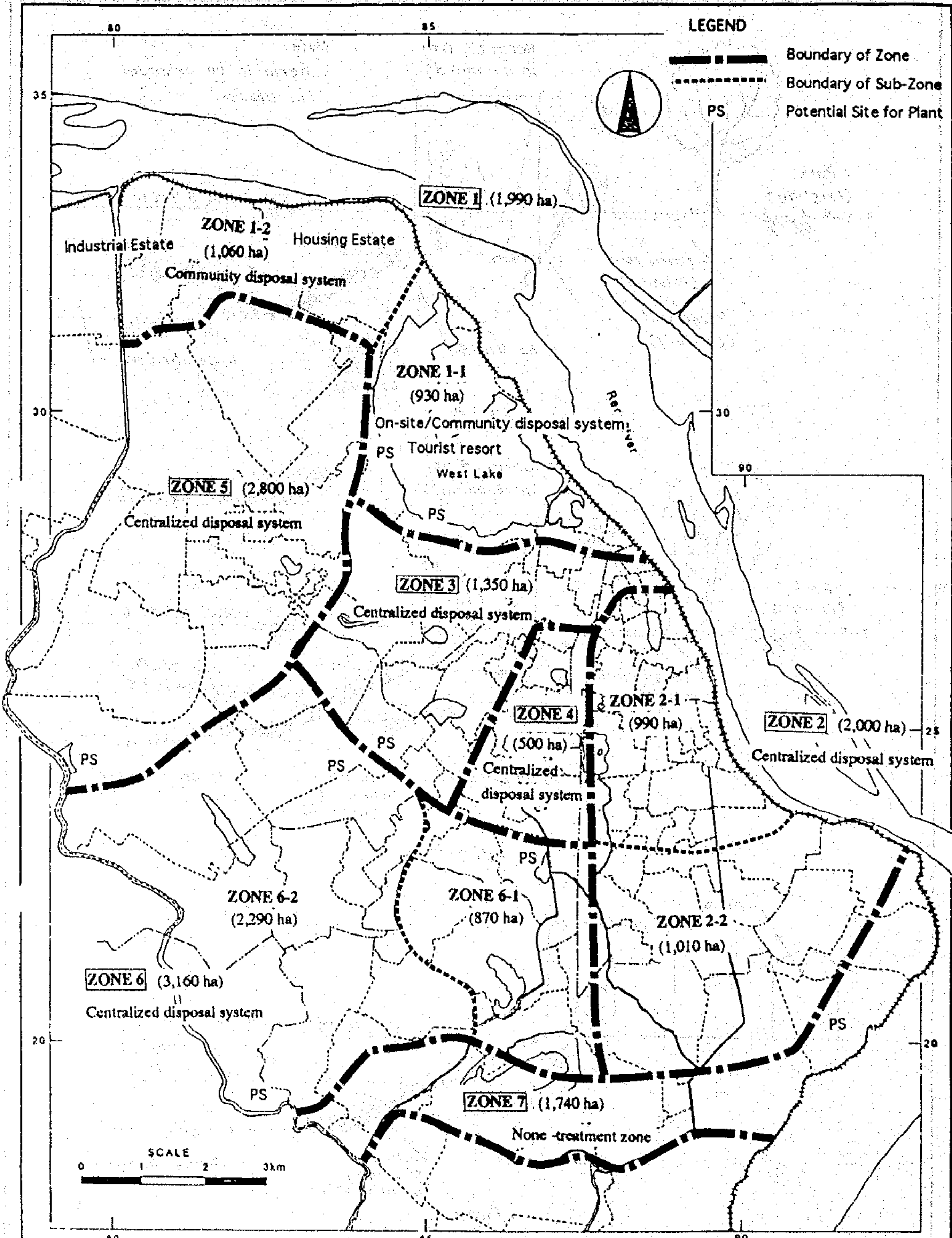
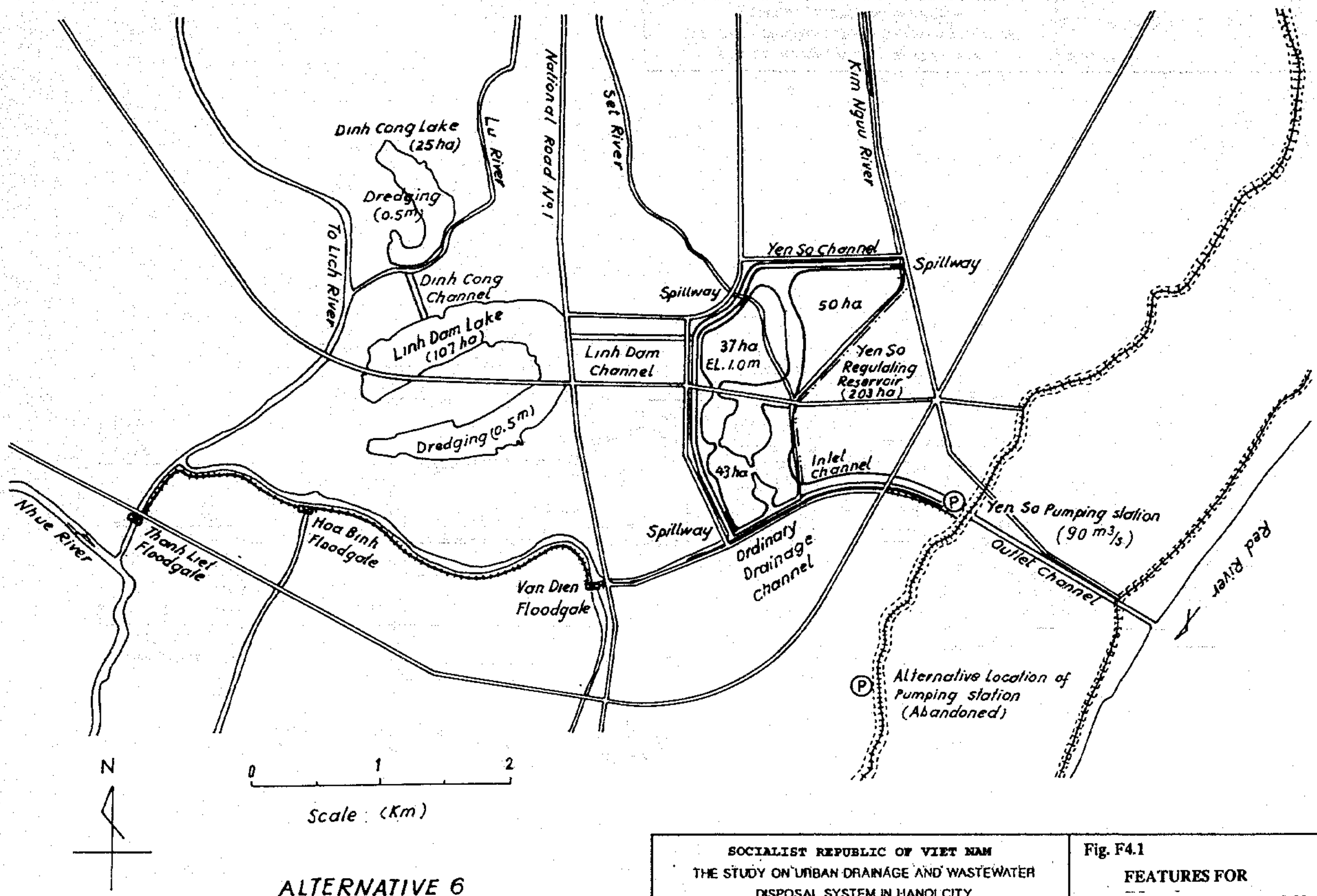
Fig. F3.2

STANDARD BANK SECTIONS OF LAKES

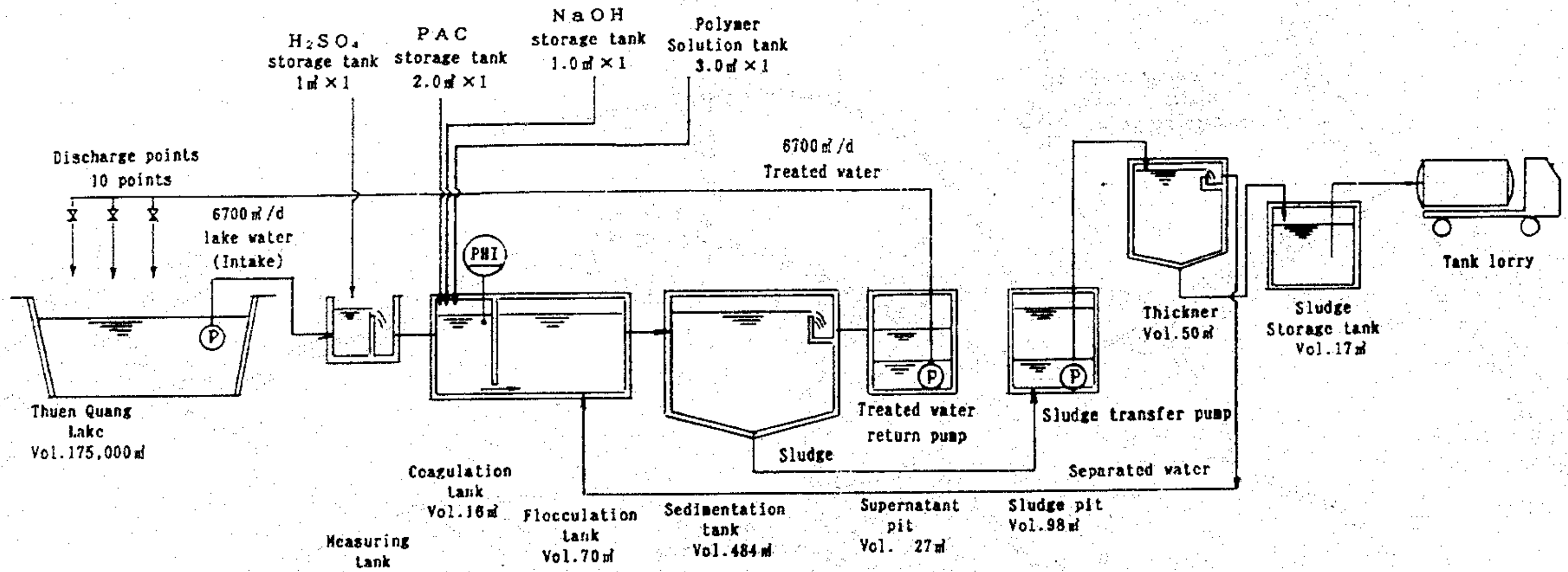


SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. F3.3 CONCEPTUAL WASTEWATER ZONING PLAN

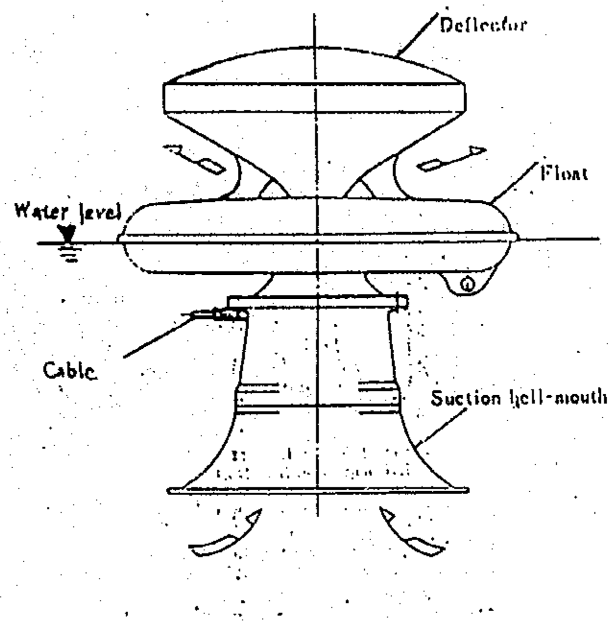


ALTERNATIVE 6

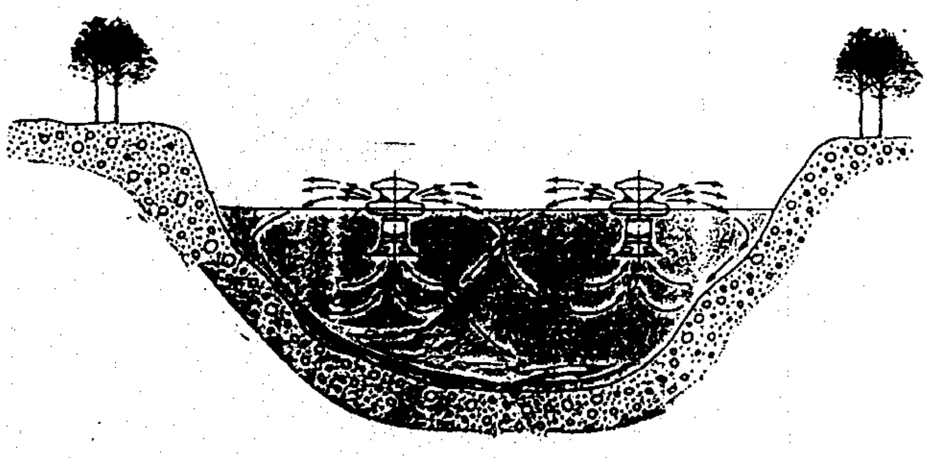
SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY	Fig. F4.1 FEATURES FOR TO LICH RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	



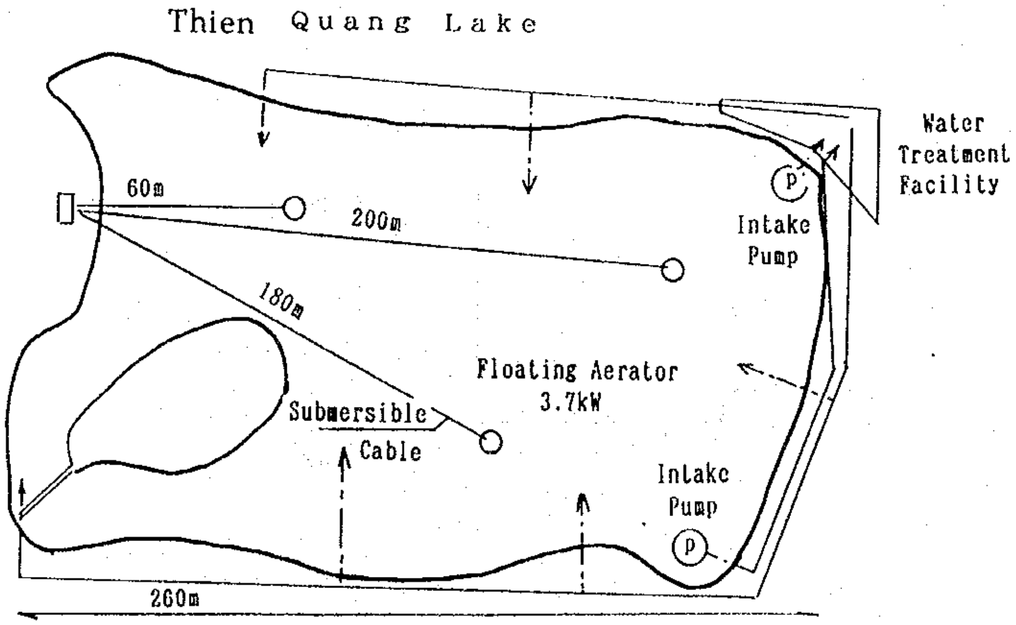
SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY	**Fig. F5.1** Flow Sheet of Treatment Plant
JAPAN INTERNATIONAL COOPERATION AGENCY	

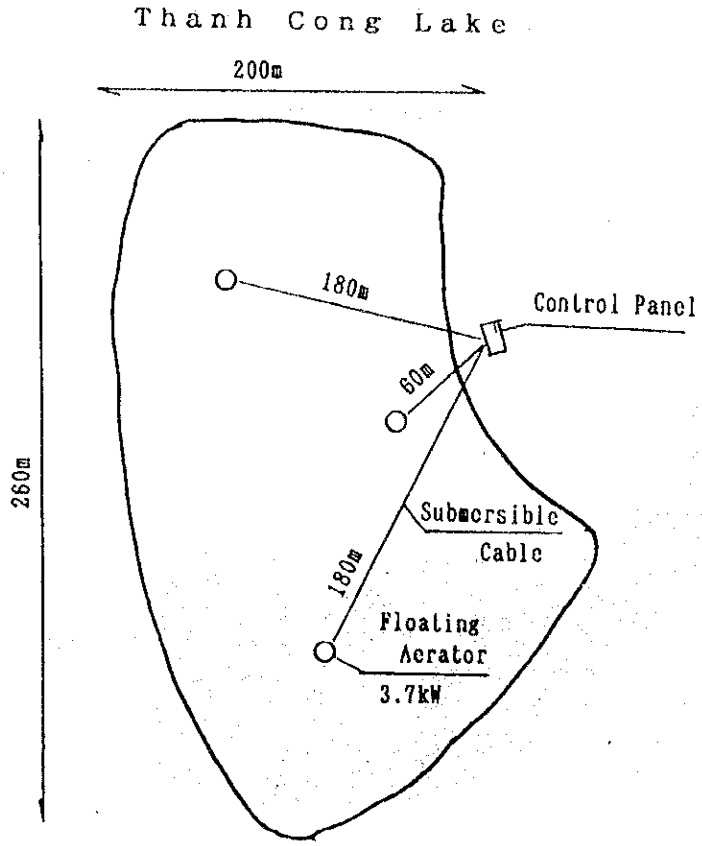


Floating aerator



SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY	Fig. F5.2
JAPAN INTERNATIONAL COOPERATION AGENCY	Floating Aerator





SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY	Fig. F5.3 Ground Plans of Facilities
JAPAN INTERNATIONAL COOPERATION AGENCY	

THE STUDY
ON
URBAN DRAINAGE AND WASTEWATER
DISPOSAL SYSTEM
IN
HANOI CITY

APPENDIX (G)

CONSTRUCTION PLAN AND COST ESTIMATE

FEBRUARY 1995

THE STUDY ON
URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM
IN
HANOI CITY

APPENDIX (G)
CONSTRUCTION PLAN AND COST ESTIMATE

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G1. Project Implementation Schedule

1.1 Implementation Schedule

The overall project implementation schedule of the To Rich Basin Drainage Project is shown on Figure G1.1.

In view of the amount of cost and limitation of time, the Project is recommended to be divided into two stages, comprised of respective work items listed in Table G1.1.

Upon approval of the project fund, selection of a consultants for the detailed design and construction supervision will be carried out.

Following the above detailed design, selection of contractors through pre-qualification and the international and local competitive bidding, and land acquisition and compensation will be commenced.

The Project will be divided into two stages: the First Stage Construction and the Second Stage Construction.

The works for each Stage are scheduled to be divided into the following packages.

The First Stage Construction:

A. Construction Works

A1: Site Preparatory Works (access road rehabilitation, land preparation for camp and spoil bank, etc.)

A2: Main Civil Works (construction of pumping station, regulating reservoir, floodgates and control gates, river improvement, hydro-mechanical equipment, flood forecasting system, etc.)

A3: Drainage Channel Improvement (To Rich, Lu, Set and Kim Nguu River Basin)

A4: Lake Improvement (lake dredging and lake conservation)

A5: Sewer Rehabilitation and Construction (West Lake, To Rich River, Set River, Upper Lu River and Kim Nguu River Basins)

B. Procurement of Equipment and Materials

B1: Dredging Equipment and Materials(for the Urgent Project)

Notes: Of the above works, package A1 and B1 will be completed within the construction period of the First Stage.

The Second Stage Construction:

A. Construction Works

A2: Main Civil Works (construction of remaining part of pumping station, hydro-mechanical equipment, etc.)

A3: Drainage Channel Improvement (To Rich, Lu, Set and Kim Nguu River Basin)

A4: Lake Improvement (lake dredging and lake conservation)

A5: Sewer Rehabilitation and Construction (West Lake, To Rich River, Set River, Upper Lu River and Kim Nguu River Basins)

The above mentioned works will be implemented during the period of 4 years and 5 months from 1995 to 2000 for the First Stage Construction and 2 years and 6 months from 2001 to 2004 for the Second Stage Construction.

G2. Construction Plan

2.1 Conditions for Construction Planning

The construction plans for the above mentioned works were prepared based on the following conditions:

(1) Workable Days

The annual workable days are estimated assuming that the works will be suspended on Sunday, national holidays and rainy days.

1) Rainy season : From May to October

2) Non-workable days

- Sunday	:	52 days
- National Holiday	:	8 days
- Suspended day due to rainfall,more than 3 mm	:	83 day
- more than 5 mm	:	76 days
- more than 10 mm	:	64 days

3) Average annual workable days

- For earth work = 365-52-8-86=222 = 220 days
- For dredging work = 365-52-8-76=229 = 230 days
- For structural work = 365-52-8-64=241 = 240 days

(2) Working Hours

Actual daily working hours are assumed to be 8 hours including 1.5 hours overtime. Two shifts of actual working hour of 6.5 hours each will be adopted for some works, earth excavation of reservoir and structural works in the dry season.

(3) Labor Force

Skilled and common laborers for the works will be recruited from the surrounding area of the project, in Hanoi City.

(4) Construction Materials

Major construction materials required are earth, sand, gravel, stone, lumber, cement, reinforcement bar, precast RC and PC pile, precast PC sewer pipe, structural steel, steel pipe/sheet piles, etc. and are available in Hanoi or surrounding areas except the structural steel, steel pipe/sheet piles, which will be imported.

(5) Construction Equipment

Major construction works include excavation/dredging of rivers, channels, lakes, and reservoirs, foundation for pumping station and related structures, piling and concreting for its foundation, concrete and steel works for structures, bridges, culverts, and sewer construction, and embankments.