社会開発調査部報告書

JAPAN INTERNATIONAL COOPERATION AGENCY

HANOI PEOPLE'S COMMITTEE
SOCIALIST REPUBLIC OF VIET NAM

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

FINAL REPORT

EXECUTIVE SUMMARY

FEBRUARY 1995

NIPPON KOEI CO., LTD.
CTI ENGINEERING CO., LTD.

ESTIMATE OF PROJECT COST

Estimate of Base Cost : At 1994 Price Level

Currency Exchange Rate : US$ 1 = Dong 10,800 = Yen 100

PREFACE

In response to a request from the Government of Socialist Republic of Viet Nam, the Government of Japan decided to conduct a master plan and feasibility study on Urban Drainage and Wastewater Disposal System in Hanoi City and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Viet Nam a study team headed by Mr. Michito Kato, Nippon Koei Co., Ltd. and composed of staff members of Nippon Koei Co., Ltd. and CTI Engineering Co., Ltd., three times between November 1993 and December 1994.

The team held discussions with the officials concerned of the Government of Viet Nam, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Socialist Republic of Viet Nam for their close cooperation extended to the team.

February 1995

Kimio Fujita
President
Japan International Cooperation Agency

February 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir,

We are pleased to submit herewith the Final Report of the Study on Urban Drainage and Wastewater Disposal System in Hanoi City, Viet Nam. This Final Report compiles the results of the Study conducted by the Study Team, jointly organized by Nippon Koei Co., Ltd. and CTI Engineering Co., Ltd., for one year and four months since November, 1993 under the contract with the Japan International Cooperation Agency.

The Report presents the study results on (i) the master plan for the urban drainage and wastewater disposal system in Hanoi City with a target year of 2010 (Main Report, Part I), and (ii) the feasibility study for the To Lich River Basin Drainage Project selected as the priority project in the master plan (Main Report, Part II). In the course of the Study, we particularly paid attention to reaching mutual understanding for issues related to the Study through intensive and frequent discussions with the Vietnamese side. Many of the Study results therefore largely depend on the cooperation and suggestions given by the Vietnamese agencies concerned.

We wish to gratefully acknowledge the Japan International Cooperation Agency, the Advisory Committee, the Ministry of Foreign Affairs, the Ministry of Construction, and the officials concerned of the Government of Viet Nam, especially the Hanoi People's Committee, the Hanoi Transport and Urban Public Works Service, the Hanoi Sewerage and Drainage Company, the State Planning Committee, the Ministry of Construction, the Ministry of Water Resources, the Ministry of Science, Technology and Environment, and other concerned ministries and agencies, for their kind cooperation and assistance to the Study.

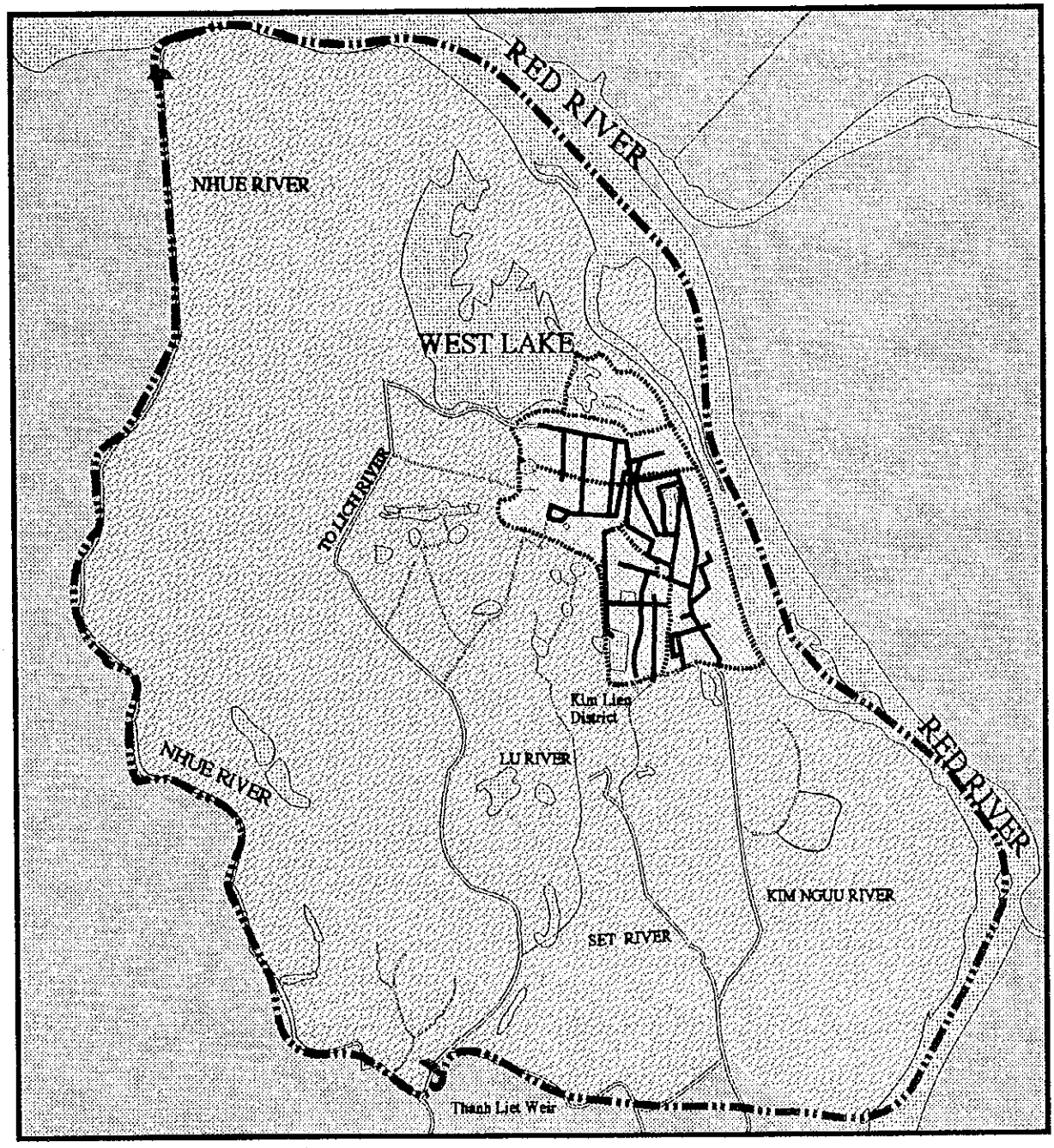
Moreover, we would like to express our sincere appreciation to the counterpart personnel who rendered a lot of efforts to the Study Team throughout the Study period.

We hope that this Report will contribute to the development of Hanoi City.

Very truly yours,

M. Kato

Michito Kato
Team Leader
Study Team for the Study on
Urban Drainage and Wastewater
Disposal System in Hanoi City



LEGEND

- Lake, River, Canal
- Sewage
- Existing Sewered Area
- Old Town Area

LOCATION MAP OF STUDY AREA

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

Study Period : October 29, 1993 – February 28, 1995
Counterpart Agency : Hanoi People's Committee
Socialist Republic of Viet Nam

OUTLINE OF THE STUDY

1. BACKGROUND

Hanoi City is the capital city of Viet Nam and is the political, economic, and cultural centre of the country. The Government of Viet Nam (GOV) has long since been keen to improve the drainage and wastewater disposal systems as quickly as possible in order to sustain Hanoi's economic growth and hygienic improvement.

Existing drainage and wastewater disposal systems are falling into a state of disrepair and their conveyance capacities are being reduced. This results in frequent flooding of the urban area and deterioration of water quality in rivers and lakes of the surrounding areas. These have been creating serious problems for the environment and have hampered economic development activities. In recent years, several peripheral areas have been subject to rapid population increase and development without provision of adequate drainage and wastewater disposal systems. This further aggravates the problems.

2. OBJECTIVE

The Study's objectives are: (1) to formulate a master plan (target year: 2010) on urban drainage and wastewater disposal systems in the central part of Hanoi City (almost 135 km^2, see the Location Map of Study Area), and (2) to conduct a feasibility study (F/S) on urban drainage systems and/or wastewater systems for the prioritized projects selected in the master plan.

3. STUDY AREA

The Study Area comprises the central part of Hanoi City (the existing urbanized area and its adjacent areas), which is surrounded by the Red River (in the north and east), the Nhue River (in the West), and the Old To Lich River (in the south). The area occupies about 135 km^2 (including the West Lake) while the total area of Hanoi City is 925 km^2.

4. OUTLINE OF THE PROPOSED PLANS

4.1 Basic Policy

In the formulation of this drainage/sewerage master plan (Master Plan), primary attention shall be paid to coordinating with the City Master Development Plan. A phased implementation plan of the drainage/sewerage projects shall be proposed considering the suitable scale of each project in ensuring viability of the projects proposed in the Master Plan.

From these viewpoints, the Master Plan mainly consists of two projects;. the Drainage Project and the Wastewater Disposal Project. Both projects are scheduled to be implemented in stages until the year 2020.

Of the plans examined in the Master Plan, a priority project for the feasibility study was selected in consideration of the specific aspects such as needs and technical requirements for each district.

4.2 Outline of the Master Plan

The outline of the Master Plan is shown in Table-1.

Table-1 Outline of the Master Plan

Projects	Outline
Drainage Plan	
A. To Lich River Basin Drainage Plan	– Development of the drainage area of 77.5 km^2 , by 2004.
B. Nhue River Basin Drainage Plan	– Development of the drainage area of 57.9 km^2 , by 2015.
C. Sewer/Channel Dredging Works	– Execution of dredging works for the existing combined sewers (120 km) and channels (31 km), initiated by procurement of machinery.
D. West Lake Conservation	– Execution of the West Lake Comprehensive Environment Study proposed separately.
E. City Lake Conservation	– Implementation of shoreline revetment works for 50 lakes and environmental conservation works for 20 lakes in the long term.
Wastewater Disposal Plan	
H. Centralized Treatment System	– Development of 5 zones with a public sewerage system, by 2020.
I. On-site Treatment System	– Installation of community plants and/or septic tanks in 2 zones
J. Pilot Wastewater Treatment Projects	– Formulation of some pilot projects for advance implementation, prior to the implementation of the centralized treatment systems which would be commenced after 2000.
K. Flushing Water Diversion Plan	– Presentation of a preliminary plan to convey the Red River water
Non-structural Measures	– Recommendation of institutional/ financial measures for supporting the drainage/sewerage development plan

4.3 Outline of the Priority Project

The To Lich River Basin Drainage Project (the Project) has been selected as the priority project for implementation because this project has the highest economic viability among the plans examined in the master plan study and proves to be beneficial in improving people's livelihood and hygienic conditions. The outline of the Project is shown in Table-2.

Table-2 Outline of the Project

Work Components	1st Stage Construction (1995 – 2000)	2nd Stage Construction (2000 – 2004)
(a) Yen So Pumping Station (Total Pumping Capacity : 90 m^3/s)	45 m^3/s	45 m^3/s
(b) Regulating Reservoir (Reservoir Capacity: 5.19 million m^3)	3.87 million m^3	1.32 million m^3
(c) River Improvement (Improvement Length: 33 km)	33 km	–
(d) Drainage Channels (Total Length: 30.8 km)		
- Removal of sediments (as an urgent project)	30.8 km	–
- Establishment of channel sections	–	30.8 km
(e) Floodgates and Control Gates (7 places)	7 places	–
(f) Bridges and Culverts : 125 places	96 places	29 places
(g) Lake Drainage/Conservation		
Dredging Works: 18 lakes	4 lakes	14 lakes
Conservation Works: 11 lakes	–	11 lakes
(h) Sewer Network		
- Removal of sediments: Total Length 120km (as an urgent project)	120 km	–
- Addition/new installation of pipes: 225 km	35 km	190 km
- Addition/new installation of culverts : 116 x 10^3 m^3 (spatial volume)	22 x 10^3 m^3	94 x 10^3 m^3

5. PROJECT COST

This Study aimed to prepare a master plan up until the year 2010, following the original scope of works. However, the result of a preliminary review showed that all the plans cannot be completed within 15 years due mainly to financial constraints. Accordingly, the implementation period will be extended up to the year 2020.

The implementation costs of major projects (structural measures) proposed in the Master Plan were estimated at about US$ 1,162 million equivalent (Dong 12,550

billion, 1994 base price). The fund requirement for the implementation is shown in Table-3.

Table-3 Fund Required for the Implementation of Plans

(Unit: US$ million equiv.)

Plans	1995-2000	2001-2005	2006-2010	2010-2015	2016-2020	Grand Total
	(Yearly Average)					
Drainage Plan	28.6	36.1	26.1	7.1	–	524.1
Wastewater Disposal Plan	4.7	25.8	32.1	32.3	31.9	637.9
Total	35.3	61.9	58.2	39.4	31.9	1,162.0

The To Lich River Basin Drainage Project proposed as the priority project is a relatively large project costing as much as US$ 377 million equiv. (Dong 4,069 billion), as shown in Table-4. Hence, it is appropriate to implement the Project in stages, mainly to distribute the financial burden over a period of years. In this Study, a two-phase implementation is proposed.

Table-4 Implementation Cost by Phase

(Unit: US$ million equiv.)

Description	1st Stage Construction (1995 ~ 2000)			2nd Stage Construction (2000 ~ 2004)			Grand Total
	FC	LC	Total	FC	LC	Total	
Construction Cost	80.0	23.7	103.7	69.9	31.7	101.6	205.3
Procurement of Dredging Equipment	8.8	0.9	9.7	0	0	0	9.7
Sub-total	88.8	24.6	113.4	69.9	31.7	101.6	215.0
Government Administration Cost	0	3.4	3.4	0	3.0	3.0	6.4
Land Acquisition and Resettlement	0	15.2	15.2	0	20.0	20.0	35.2
Sub-total	0	18.6	18.6	0	23.0	23.0	41.6
Engineering Services	10.7	4.7	15.4	12.2	6.5	18.7	34.1
Physical Contingency	9.3	5.5	14.8	9.3	7.9	17.2	32.0
Total	108.8	53.4	162.2	91.4	69.1	160.5	322.7
Import Tax	0	4.0	4.0	0	3.3	3.3	7.3
Price Contingency	9.1	4.4	13.5	19.0	14.3	33.3	46.8
Grand Total	117.9	61.8	179.7	110.4	86.7	197.1	376.8

6. EVALUATION

The proposed drainage and wastewater disposal plans were proved to be economically, financially, technically, and environmentally viable. The To Lich River Basin Drainage Project, selected as the priority project, aims to improve flood control and drainage, and is also evaluated as improving residential environment, living standards, and urban transportation systems.

6.1 Economic Evaluation

The benefits of a drainage project and a wastewater disposal project relate to each other. However, the Study assumes that the reduction in flood damage is the benefit of the drainage project, and the improvement of hygienic conditions, including the increase of land value, is the benefit of the wastewater disposal project. The economic evaluation indexes were assessed in comparison of the benefits and the costs of projects as shown in Table-5.

Table-5 Result of Economic Evaluation

Project	Cost (US$ x 10^6 equiv.)		Annual Benefit (US$ x 10^6 equiv.)	EIRR (%)
	Financial Cost	Economic Cost		
Drainage Plan				
A) To Lich River Basin Drainage Plan	317.4	285.7	12.6	11.6
– 1st Stage	160.4	146.8	7.6	11.7
– 2nd Stage	157.0	138.9	5.0	11.4
B) Nhue River Basin Drainage Plan	206.7	174.8	2.7	9.3
Total	524.1	460.5	15.2	10.9
Wastewater Disposal Plan				
A) Centralized Treatment System	567.1	523.4	63.4	5.2
B) On site Treatment System	70.8	66.1	6.1	–
Total	637.9	589.5	69.5	5.2

In general, the drainage plan is economically viable, taking into account its Economic Internal Rate of Return (EIRR) of more than 10%. For the on-site treatment system in the wastewater disposal plan, a negative EIRR value was obtained. However, the plan should be assessed overall in view of the necessity of improving the hygienic environment of Hanoi City as a whole. The overall EIRR of 5.2% is fairly adequate to justify the plan as viable for a sewerage project.

6.2 Financial Analysis

The projection of financial resources was attempted on a premise that national budget would increase almost in proportion to the Gross Domestic Product (GDP) growth rate (10 - 12 %/year) and accordingly the Hanoi's development expenditures would also increase. The projected figures are shown in Table 6 below.

Table-6 Projection of Hanoi's Development Expenditures

(Unit: US$ million equiv.)

Item	2000	2005	2010
Hanoi Total Development Expenditures	343	635	1,081
Allocation to Drainage/Sewerage Sector	34	64	130

The required fund for the implementation of the plans proposed in the Master Plan, estimated in Table-3, is generally within the range of the budgetary resources projected in the above table, though there may be some surplus or shortage each year. Hence, the proposed implementation plan is deemed to be practical.

6.3 Environmental Impact Assessment

Drainage and sewerage development, in particular the latter, aims at improving living standards and water quality, and hence is regarded to be the development which would improve the city's environment. The plans formulated in the Master Plan are in general in line with this concept and will not cause any particular environmental problems.

Overall, the To Lich River Basin Drainage Project will contribute to the improvement of the City's environmental conditions. Flood inundation results in economic loss for the people, and is also one of the main factors aggravating hygienic conditions, which would be mitigated by the Project. The improvement of river and lake facilities will result in the improvement of people's living environment.

Nevertheless, several environmental impacts may arise, particularly during construction. The supposed environmental problems and required measures are shown in Table-7.

Table-7 Environmental Items Requiring Attention

Environmental Items	Assessment	Problems and Measures
People's resettlement	Negative	– To materialize the plan in order to minimize people's resettlement. – To reinforce the organization for the implementation of resettlement and compensation.
Lakes/river basins	Unknown	– To carry out an Environmental Monitoring Program because dredging works might cause a negative impact on the ecosystem.
Landscape	Positive	– Landscape at the pumping station/ reservoir will change the natural scenery. However, it will be a positive impact if it is well coordinated with the development plan of the surrounding areas.
Groundwater	Unknown	– Positive impact in general – At the reservoir area, attention should be paid to the conservation of groundwater. – Monitoring is necessary.
Sedimentation in the reservoir	Negative	– Requiring periodical dredging and securing a final disposal site.
Sludge in the sewers and channels	Negative	– ditto –

7. RECOMMENDATIONS

1) The Sewerage and Drainage Company (SDC) is the most important agency responsible for the implementation and operation and maintenance of the drainage and sewerage projects. Its functions shall be strenghened by providing of sufficient O&M budget, reinforcing middle to senior class engineers, and training technicians.

2) A new organization for the implementation of the To Lich River Basin Drainage Project shall be established in order to discuss and determine all collaborations required to lead the Project to a successful completion, both for management and technical guidance.

3) Comprehensive environmental survey data have not been accumulated at present. It is recommended that an "Environmental Monitoring Program" be implemented separately from the projects.

4) It is presumed that more than half of the Study Area has been subject to ground subsidence of 5-10 mm/year. It is necessary to continue the observation of ground subsidences following a well established program.

5) Lakes and ponds in the City area play a very important role in drainage and sewerage. They should be conserved for the future.

6) Any works relevant to the West Lake should be preceded by a comprehensive environmental study on the Lake, which should be commenced as early as possible.

7) It is recommended that unused lands adjacent to the Yen So pumping station and reservoir be reserved for the future expansion of the pumping stations and regulating reservoirs.

8) Substantial improvement of rivers/lakes' water quality cannot be attained unless wastewater treatment systems are introduced. A feasibility study shall be conducted in order to accelerate the program's implementation.

9) The role of the Urban Environment Company (URENCO), which is responsible for the collection and disposal of solid waste and excreta, is particularly important. The reinforcement of this institution, together with the provision of the necessary equipment and facilities, should be carried out under a separate aid program.

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1. Executive Summary (This Volume)

2. Main Report
   - Part I : Master Plan for Urban Drainage and Wastewater Disposal System in Hanoi City
   - Part II : Feasibility Study on the To Lich River Basin Drainage Project

3. Appendix Vol. I
   - A. Socio-economy
   - B. City Development Plan
   - C. Hydrology
   - D. Drainage Plan

4. Appendix Vol. II
   - E. Wastewater Disposal Plan
   - F. Environment and Water Quality
   - G. Construction Plan and Cost Estimate
   - H. Economic Evaluation
   - J. Geotechnical Investigation
   - K. Topographic Survey
   - L. Urgent Project - Basic Design Report

5. Data Book

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

FINAL REPORT
EXECUTIVE SUMMARY

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1. INTRODUCTION

1.1 Background of the Study

Hanoi City, which is located in the Song Hong (the Red River) delta, is the capital city of Viet Nam and is the political, economic, and cultural centre of the country. It has a total population of about two million, of which about one million live in the central urban area.

Existing drainage and wastewater disposal systems are falling into a state of disrepair and their conveyance capacities are being reduced. This results in frequent flooding of the urban area and deterioration of water quality in rivers and lakes of the surrounding areas. These have been creating serious problems for the environment and have hampered economic development activities. In recent years, several peripheral areas have been subject to rapid population increase and development without provision of adequate drainage and wastewater disposal systems. This further aggravates problems such as increase of flood damage. The Government of Viet Nam (GOV) has long since been keen to improve the drainage and wastewater disposal systems as quickly as possible in order to sustain Hanoi's economic growth and hygienic improvement.

GOV believed that the primary action to be taken would be the formulation of a comprehensive plan, therefore, it requested the Government of Japan (GOV) to undertake this Study, in December 1992. In June 1993, the Japan International Cooperation Agency (JICA) despatched a pre-survey mission to discuss with GOV the Scope of Works for the Study, which was signed on June 10, 1993 (see Annex 1 of the Main Report Part I for the Scope of Works).

1.2 Objective of the Study

Based on the Scope of Works agreed upon in June 1993, the Study's objectives have been set forth as follows:

(1) To formulate a master plan (M/P) on urban drainage and wastewater disposal systems, including its phased implementation program; and

(2) To conduct a feasibility study (F/S) on urban drainage systems and/or wastewater systems for the prioritized projects selected in the master plan

1.3 Study Area

The Study Area comprises the central part of Hanoi City (existing urbanized area and its adjacent areas), which is surrounded by the Red River (in the north and east), the Nhue River (in the west), and the Old To Lich River (in the south). The area occupies about 135 km^2 (including the West Lake), while the total area of Hanoi City is 925 km^2.

1.4 Implementation Organization for the Study

The Study has been carried out by a Study Team organized by JICA. The Study Team consisted of 12 experts. JICA also organized an Advisory Committee to provide technical guidance to the Study Team.

On the Vietnamese side, the Hanoi People's Committee (HPC) was the counterpart agency for the JICA Study. HPC established a Steering Board to assist the Study and discuss various issues related to the Study's output. The Steering Board consisted of representatives from various departments of HPC and other related ministries (see Annex 2 of the Main Report Part I for the list of Steering Board Members)

1.5 Progress of the Study

The Study commenced in November 1993 with the arrival of the Study Team in Hanoi, and all the activities were completed with the submittal of this Final Report in February 1995. The progress of the Study was as follows:

Month/Year	Reports Submitted	Description
Nov. 1993	Inception Report	Presentation of study plans
Feb. 1994	Progress Report (1)	Submittal of the results of the 1st field investigation (for M/P)
July 1994	Interim Report	Submittal of the draft master plan studies
Sept. 1994	Progress Report (2)	Submittal of the results of the 2nd field investigation (for F/S)
Dec. 1994	Draft Final Report	Submittal of the M/P and F/S reports
Feb. 1995	Final Report	Submittal of the final outputs incorporating comments from the Vietnamese side

In Hanoi, the Study Team was stationed at the Hanoi Sewerage and Drainage Company (SDC) and was engaged in the field activities.

1.6 Acknowledgments

The Study Team wishes to express its heartfelt thanks to the members of the Steering Board, staff of HPC, Transport and Urban Public Works Service (TUPWS), Hanoi Sewerage and Drainage Company (HSDC) in particular, and the personnel of other agencies concerned for their kind collaboration and assistance during the Study Team's stay in Hanoi.

Many thanks are also expressed to the Embassy of Japan in Hanoi, Advisory Committee, and JICA's headquarters for providing assistance to the Study. The Study

Many thanks are also expressed to the Embassy of Japan in Hanoi, Advisory Committee, and JICA's headquarters for providing assistance to the Study. The Study is supported by the Ministry of Construction and Ministry of Foreign Affairs, Japan, for which due appreciation is also expressed.

2. STUDY AREA - PRESENT CONDITIONS

2.1 Main Socio-economic Indices

The Study reviewed various socio-economic indices (population, GDP, national budget, currency exchange rate, inflation rate, etc.) on both a national and regional bases. The main regional indices of Hanoi City are summarized below:

Socio-economic Indices of Hanoi City

Description		Unit	Hanoi City Total	Study Area (M/P)	Data used for estimating the following
(a) Area		km^2	925	135	
(b) Population:	1992	million	2.1	1.20	- Flood damage
	2000	"	2.3	1.38	- Pollution load
	2010	"	2.7	1.60	
(c) RGDP	1990	US10^6	920	-	- Property value
	2000	"	3,216	-	
	2010	"	12,850	-	
Growth Rate	1989-1993	%/yr	11.8*1	-	- Growth of flood damage potential
	1991-2000	"	13.3	-	
	2001-2010	"	14.9	-	
Per-capita RGDP:	1990	US$	447	-	- Increase of property value
	2000	"	1,382	-	
	2010	"	4,715	-	
(d) No. of Tourists	1993	million	0.45	-	- Sewerage benefit
	2000	"	1.5	-	
	2010	"	3.5	-	
(e) No. of Patients *2	(Average)				
- Diarrhea		person	48,000	-	- Sewerage benefit
- Dysentery		"	4,800	-	
(f) Household Income					
- Urban	US$/yr	-	960	-	- Capacity to pay
- Suburban	"	-	890	-	

*1: GDP growth rate for the whole country: 6.8% per year approximately

*2: Estimated by the Study (Estimation of likely actual number, including the number unaccounted for in official statistics)

The above indices were taken into account in various aspects of the Study, such as the determination of the framework of planning, and estimation of economic benefits.

2.2 Socio-economic Interview Survey

For obtaining basic information and data on the socio-economic conditions of the residents in the Study Area, an interview survey was carried out by the Study Team in collaboration with SDC, in December 1993 (sampling survey on some 160 households). The following are the noteworthy results:

(a) All the households interviewed recognize the importance of drainage/sewerage improvements. The main reasons for the improvements are as follows: (i) mitigate odor, (ii) mitigate mosquitoes/germs, and (iii) obtain safe drinking water (fear of groundwater contamination).

(b) About 93% of the households believe that they should not pay more than 20,000 Dong (US$ 2 equivalent) for sewerage per month.

(c) More than 80% of the households are affected by floods which occur more than once a year, and 50% by frequent floods which occur more than 5 times a year.

2.3 Integration with City Master Development Plan

The "Hanoi City Master Development Plan" (Planning horizon: year 2010) was approved by the Government in March 1993. Figure 2.1 shows the present land use (prepared by the Study Team) and Figure 2.2 the future land use (envisaged by the City Master Plan). As indicated by the two figures, future development will chiefly progress towards the northwest, southwest, and south along the main highways.

In the formulation of this drainage/sewerage master plan, primary attention was paid to coodinating with the City Master Development Plan. Aspects particularly taken into account include the following:

(a) Even in the future, the present urbanized area will remain the core area of Hanoi's economic activities. This urbanized area would be the priority area for drainage/sewerage development.

(b) In the future, many lakes will be preserved. These lakes shall function as drainage facilities.

(c) Special attention shall be paid to coodination with future road and district development plans (e.g., development plans around the West Lake, Linh Dam, etc.).

(d) Part of the southwestern and southern areas will be left undeveloped and remain as agricultural land and fishponds. These areas shall be used effectively in planning the drainage facilities.

Under the City Master Development Plan, the drainage and sewerage sector is accorded high priority together with the transportation sector. In fact, the Government has already approved the implementation of (i) the Yen So pumping station and (ii) the Yen So regulating reservoir, which are both key facilities in the proposed drainage master plan.

2.4 Physical Conditions (Topography and Meteo-hydrology)

2.4.1 Topography/Drainage Basins

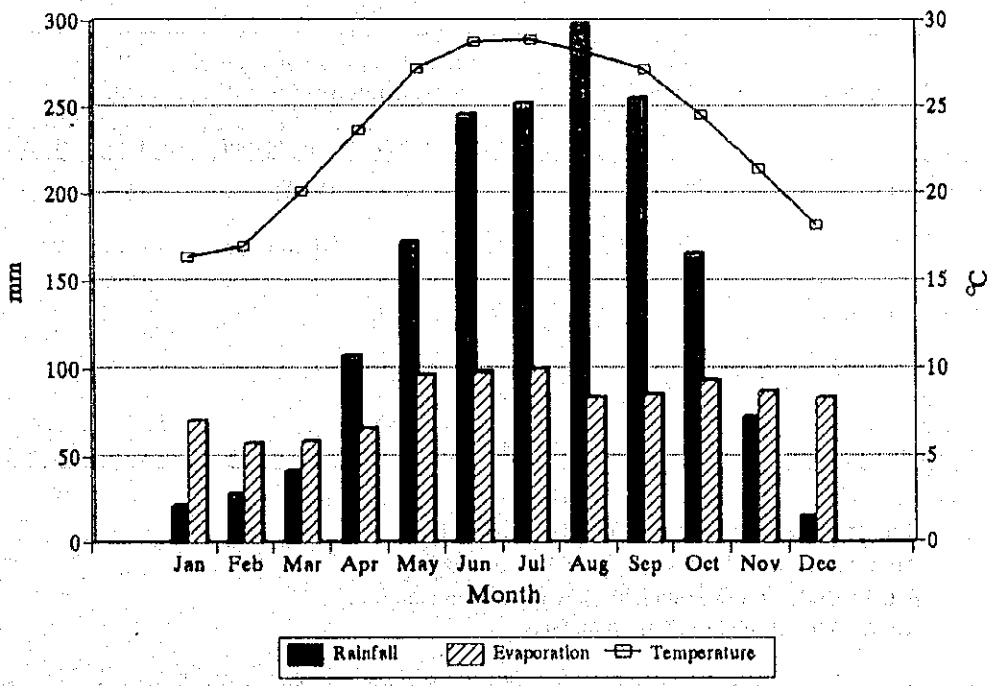
The Study Area possesses a very flat topography. The highest area is in the urbanized area in the northeast and has an elevation of 6 - 9m, while the lower area in the south (Yen So area) has an elevation of 4 - 4.5m. Geologically, the area is in the alluvial plain of the Red River delta, and consists of clayey and silt layers to a depth of 20 m and a sandy layer in the deeper soils.

The Study Area can be divided broadly into two river basins: the To Lich River basin (77.5 km^2) and the Nhue River basin (57.9 km^2) (see Figure 2.3). The To Lich River basin is drained by four rivers (from west to east: To Lich, Lu, Set and Kim Nguu) which flow into the Nhue River via the existing Thanh Liet weir. The Nhue River contains no major rivers, but is divided by main drainage channels into four sub-basins (from north to south: Co Nhue, My Dinh, Me Tri, and Ba Xa). The catchment area of each basin/sub-basin is shown in the table in Subsection 2.4.3 below.

2.4.2 Meteo-hydrology

The climate of Hanoi City is observed at the Lang Meteorological Observation Station which is nearly located at the center of the Study Area. The average temperature is 28°C and average yearly rainfall is 1,670mm. About 90% of rainfall occurs in the rainy season which starts in April-May and ends in November. The seasonal variations of temperature, rainfall, and evaporation are shown below:

Average Monthly Temperature, Rainfall, and Evaporation



The water level of the Nhue River tends to rise relatively quickly when the basin is subjected to heavy rains caused by storms. In this case, drainage by pumping water into the Red River becomes necessary (see detailed description in the subsequent section). The water levels of the Red River are as follows:

Seasonal Variations of the Red River's Water Levels

(Unit: EL.m)

	Rainy Season (August)	Dry Season (March)	Average
Maximum	11.44	4.18	6.67
Minimum	6.04	2.01	3.57
Average	8.55	2.68	5.01

Note: Based on the 1956-1990 records at Hanoi Station.

The ground level of Hanoi City ranges mostly from an elevation of 5 to 7 m (mean EL.6 m). However, the water level of Red River is higher for about 4 months of the year. Hanoi City is protected from flooding of the Red River by the existing Red River dyke. The dyke is a very important structure for Hanoi City.

2.4.3 Design Storm and Flood Runoff

In this Study, the design storm was determined to be a 5-year recurrence storm for urban drainage (sewer design) and 10-year recurrence storm for flood control/river channel design, which corresponds to the current Vietnamese planning criteria. Design storm and flood discharges analyzed for the respective basins are shown in the table below, where the flood analysis was based on the storage function method:

Design Storm/Flood Discharge

Description	Urban Drainage (Sewer)	Flood Control Plan According to Basins (River Improvement/Pump Scheme)				
		To Lich	Co Nhue	My Dinh	Me Tri	Ba Xa
Return Period	5-year	10 - year				
Design Rainfall	70 mm/hr	310 mm/2 days				
Drainage Area (km^2)	-	77.5	19.7	13.6	14.7	9.9
Design Discharge (m^3/s)						
- Alt. 0	-	256	-	-	-	-
- Alt. 1	-	203	55	26	31	14
- Alt. 6	-	174	-	-	-	-

Note: Runoff analysis assumes the future land use (2010):
Alt. 0 : In case no lakes exist (hypothetical case)
Alt. 1 : Under the existing lake flow regulation condition
Alt. 6 : After dredging of 18 main lakes

As represented by the figures estimated for the To Lich River basin, flow retardation by lakes is relatively large. In a hypothetical case of "no lake" (256 m^3/s),

the peak flood discharge is 203 m^3/s under the present lakes' natural flow retarding condition, and in the case 18 lakes are dredged for providing extra regulation capacity, the peak flood discharge is reduced to 174 m^3/s.

2.4.4 Flow Capacity of Existing Rivers/Channels

The flow capacity of the four rivers in the To Lich River basin (Figure 2.3) varies by location/stretch, but in general can discharge only 1 to 1.2-year recurrence floods. This implies the necessity for river improvement works if the flood protection level is to be raised to cope with 10-year recurrence floods. The present bankful capacity is assessed as follows:

- To Lich River : 10 m^3/s (upper reaches) - 50 m^3/s (middle to lower reaches)
- Lu River : About 10 m^3/s
- Set River : Less than 10 m^3/s
- Kim Nguu River : 20 m^3/s (upper reaches) - 40 m^3/s (lower reaches)

The above 4 rivers receive inflow from many drainage channels. The overall discharge capacity of the channels is barely enough to accommodate runoff of floods with less than 1-year recurrence probability, though it varies to some extent according to channels and locations. About 80 bridges/culverts, which have very small flow sections and constitute bottlenecks for the smooth flow of floodwater, exist on the channels.

2.4.5 Flood Inundation Analysis

Flood area mapping was carried out through verbal information collection and an in-situ spot elevation survey. Figures 2.4 to 2.6 show the inundation areas of the 1984 flood, 1989 flood, and habitual flood areas for an average year, respectively.

Using this information as cross-check material, a flood inundation analysis was carried out to simulate the cases of flooding of various return periods: 1.2- to 50-year floods. Information obtained from the analysis, such as duration and depth of inundation, was used to estimate flood damage.

2.4.6 Low Flow Condition

No discharge measurement records have been accumulated for rivers/channels in the City. The Study carried out spot measurements of low flow at six places in December 1993. Through the interpretation of these measurement data, water supply quantities, and by referring to empiric data of low flow in Japan, the low flow of the To Lich River basin (at Thanh Liet weir) has been estimated as follows:

(a) Low flow at Thanh Liet weir : 5.0 m^3/s

(b) Discharge due to water supply : 4.5 m^3/s

(c) Natural runoff (low flow) : 0.5 m^3/s

Of the above, (c) is regarded as the runoff contributing to the dilution of wastewater discharged into the river.

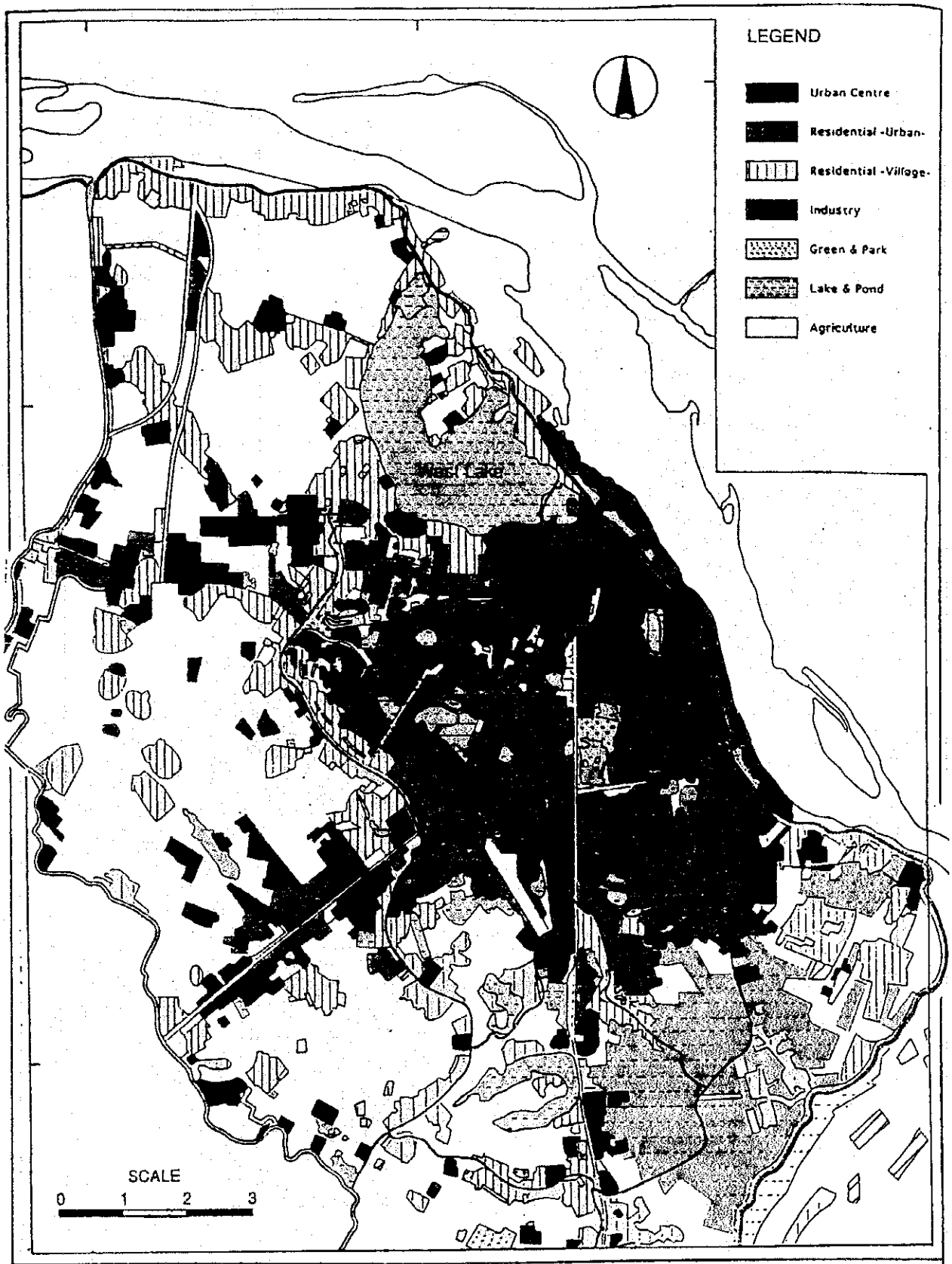


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Fig. 2.1

Present Land Use, 1993

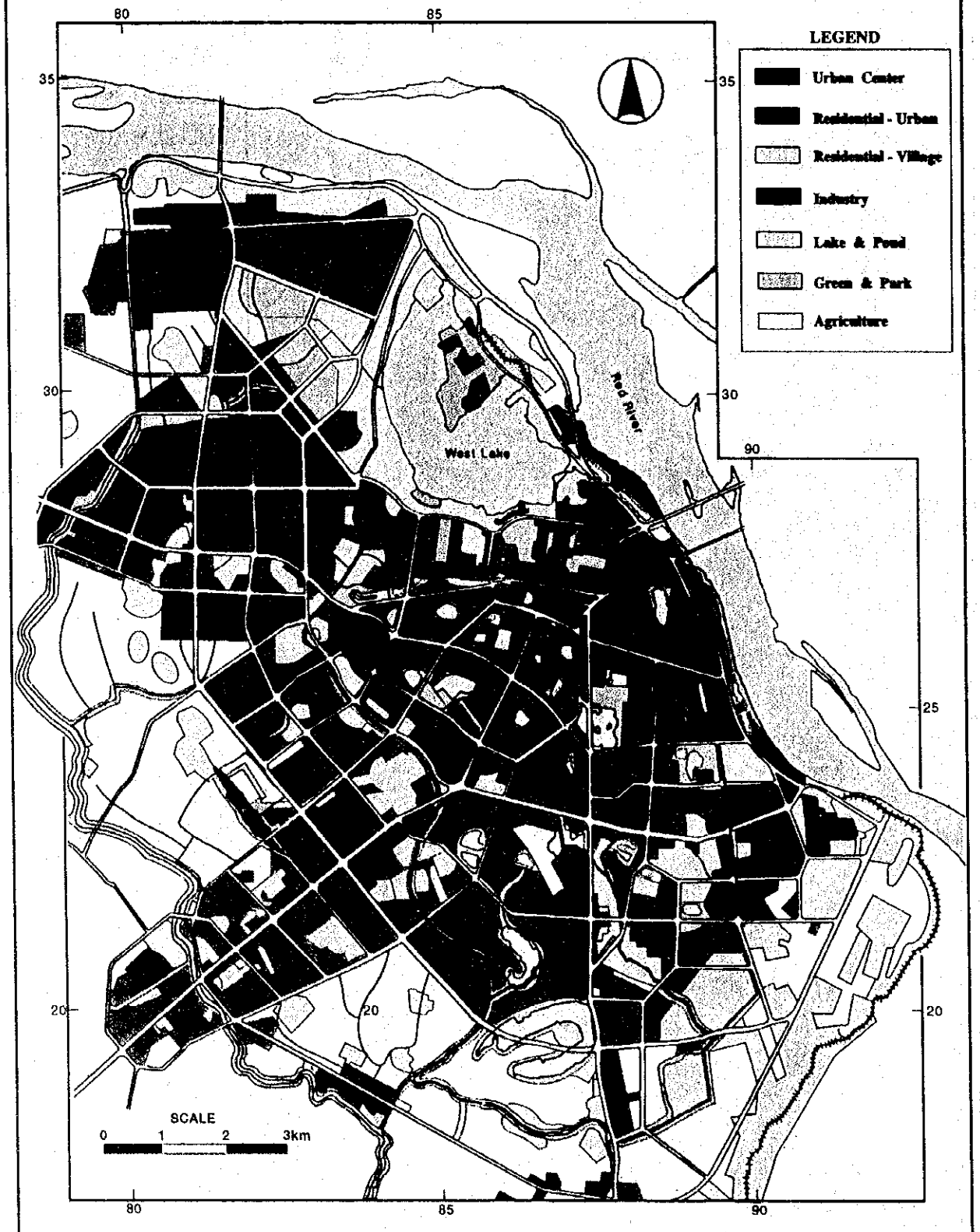

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Fig. 2.2

FUTURE LAND USE, 2010

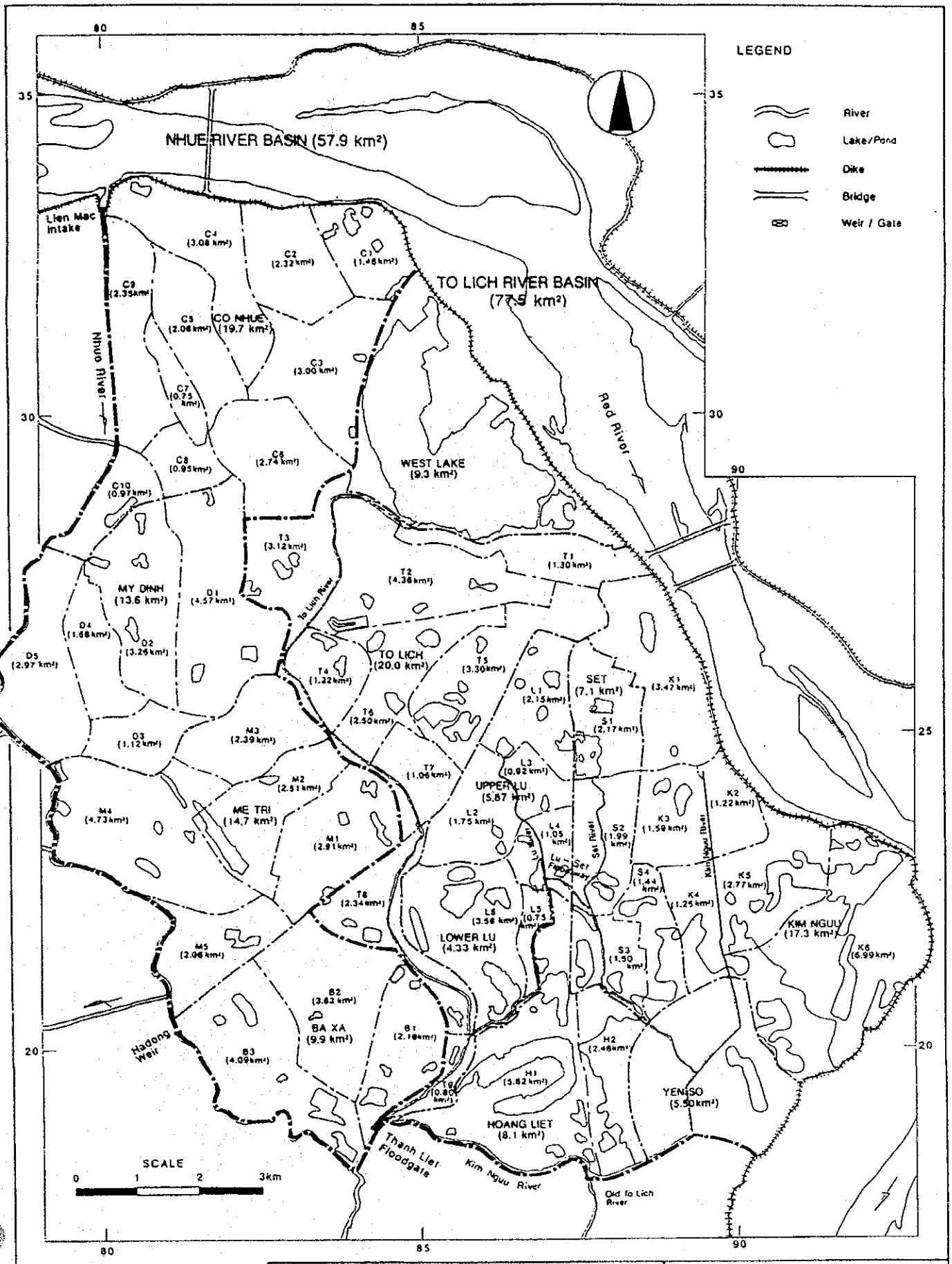

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Fig. 2.3 WATERSHEDS

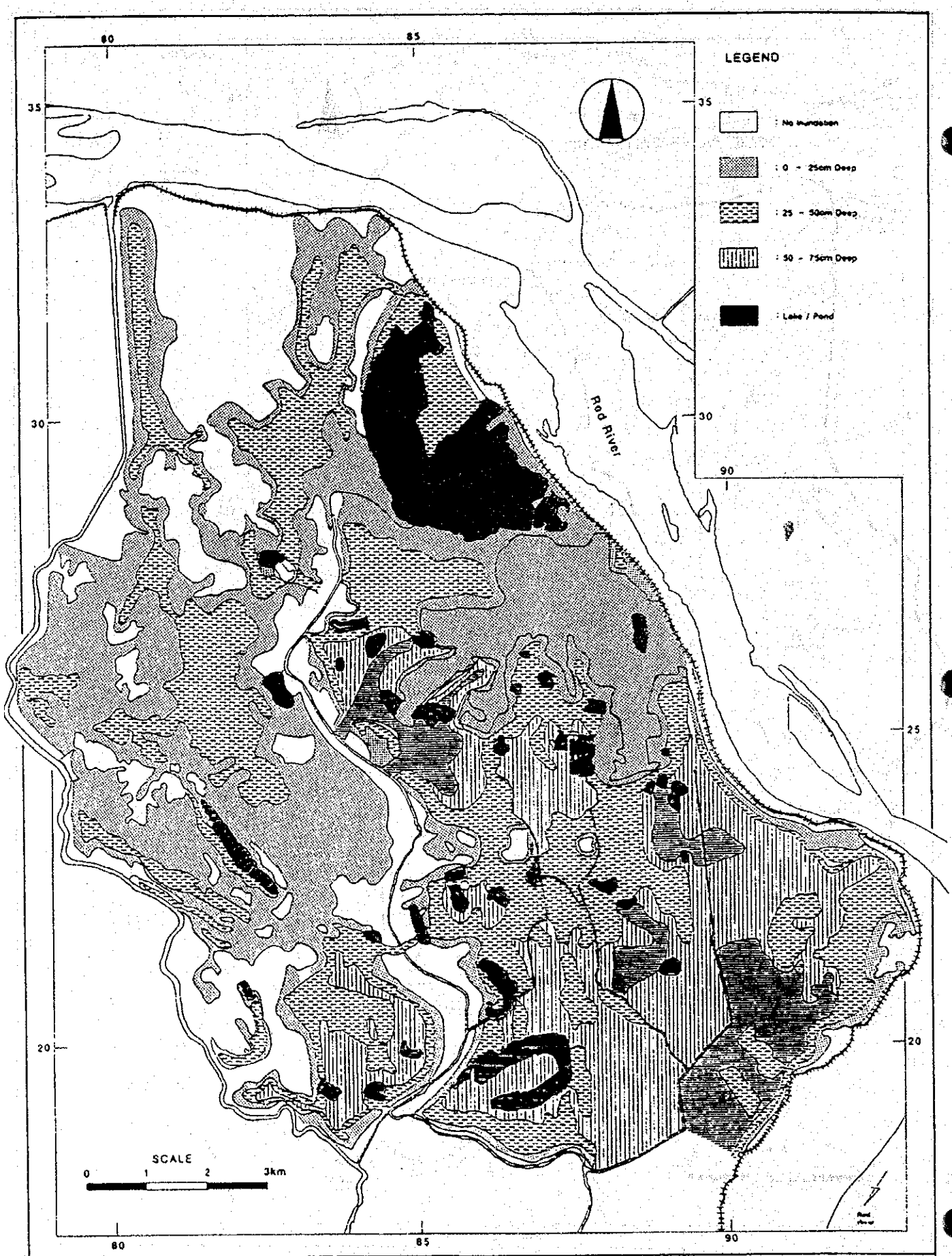

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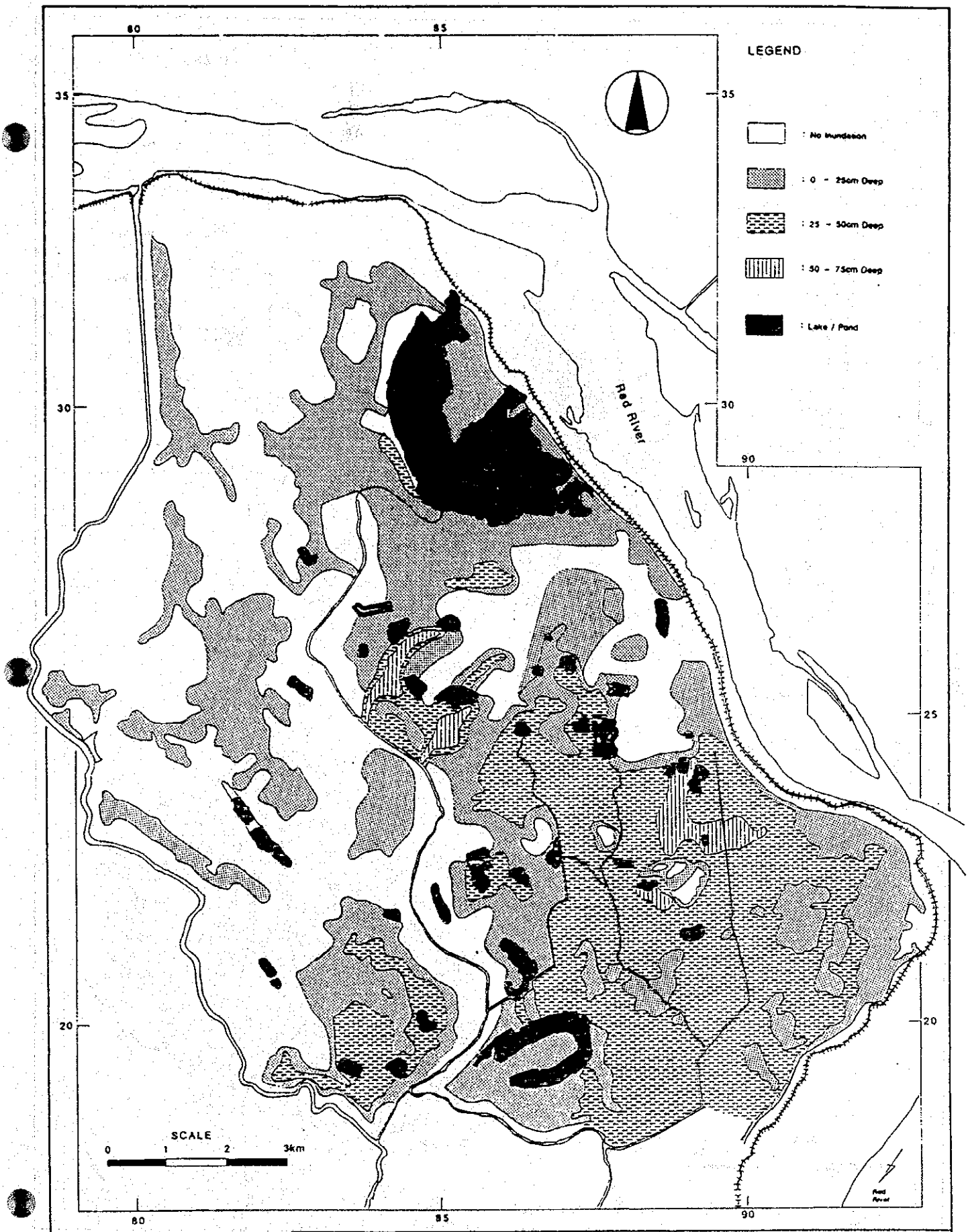
Fig. 2.4
YEAR 1984 FLOOD MAP



SOCIALIST REPUBLIC OF VIET NAM THE STUDY ON URBAN DRAINAGE AND WASTEWATER DISPOSAL SYSTEM IN HANOI CITY JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2.5 YEAR 1989 FLOOD MAP

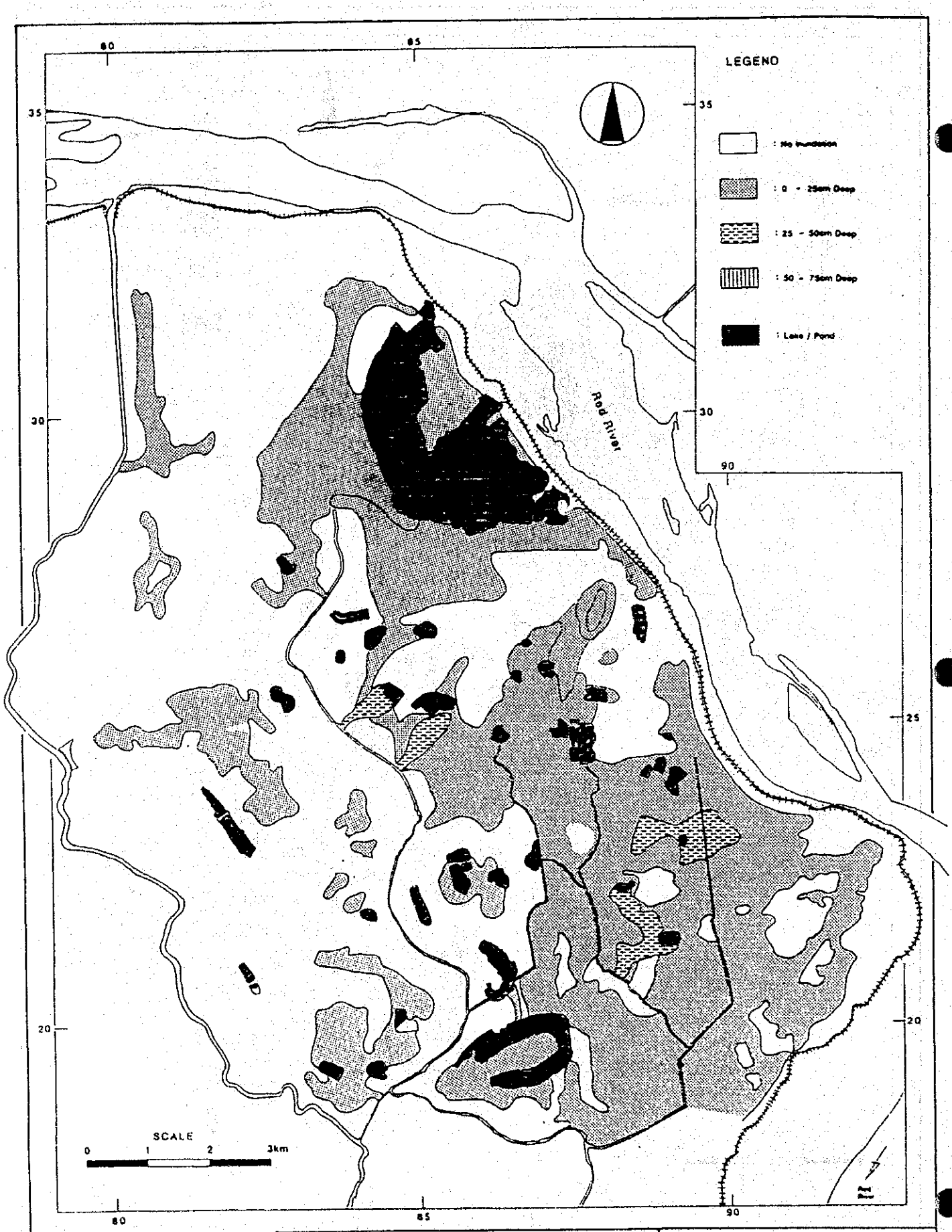


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Fig. 2.6
ANNUAL FLOOD MAP

3. FORMULATION OF THE MASTER PLAN

The master plan presented herein covers both the drainage plan and the wastewater disposal plan. The plans were formulated through examination of alternative plans and also paying attention to the interrelation between the drainage and wastewater disposal functions. The drainage plan was formulated in principle for each basin/sub-basin, while the wastewater disposal plan was prepared by zone which was determined taking into account drainage basins, the population distribution, and other factors for future city development.

3.1 Drainage Plan

3.1.1 To Lich River Basin Drainage Plan

The overall To Lich River basin drainage plan has been proposed with the following concepts:

(a) Runoff from the West Lake sub-basin (basin area: 9.3 km^2) is temporarily stored in the West Lake (water area: 5.67 km^2).

(b) Of the city lakes which are regarded as having drainage functions (flow retardation), 18 lakes which have not been dredged before will be dredged in order to augment their flow retardation capacity.

(c) Runoff from the Upper Lu sub-basin will be diverted to the Set River through the Lu-Set floodway, and runoff from the Hoang Liet sub-basin will be conveyed to the Kim Nguu River through the Linh Dam channel. This is to reduce flow at a bridge section on the National Highway No.1 (Kim Nguu River 3.9 km point - 1 km north of Van Dien); otherwise reconstruction of the bridge may become necessary.

(d) Small floods which occur several times a year can be drained by gravity into the Nhue River. However, in the case of relatively large floods (say, larger than the flood with a 1.2-year recurrence probability), gravity flow becomes impossible due to the rise of water level of the Nhue River (reverse flow occurs in case the Nhue water level rises sharply). This necessitates the construction of a pumping station. The Yen So site is suitable for this purpose.

(e) Based on the result of a cost comparison study, the optimum combination of pumping capacity and regulating reservoir capacity would be the following:

- Pumping capacity : 90 m^3/s
- Regulating reservoir capacity : 5.19 million m^3

The required reservoir capacity will be secured by a combination of three lakes: (i) a new reservoir in the Yen So area, (ii) the existing Linh Dam Lake, and (iii) the existing Dinh Cong Lake.

(f) In order to preserve rivers/lakes and improve the living environment in areas surrounding them, the plan envisages the provision of waterside parks and other scenery improving measures around the city lakes, at the Yen So reservoir, and along the rivers/channels.

On the basis of the above planning concepts, the To Lich River basin drainage works were proposed as summarized below. An overall layout plan is shown in Figure 3.1.

Principal Components of the To Lich River Basin Drainage Plan
(Major Works Only)

(a)	Yen So Pumping Station:	90 m^3/s (incl. two inlet channels of 3,100 m long in total and an outlet channel of 1,600m long)	
(b)	Regulating Reservoir:		
	- Yen So Reservoir (new):	Regulating capacity	3.87 million m^3
		Total lot area	203 ha
	- Linh Dam Lake (existing):	Regulating capacity	1.07 million m^3
	- Dinh Cong Lake (existing):	Regulating capacity	0.25 million m^3
(c)	River Improvement	Total length	33.0 km
	(4 rivers)	Floodgate	6 places
		Bridge/culvert	29 places
(d)	Drainage Channel Improvement (in urbanized area)	Total length	30.8 km
		Floodgate	1 place
		Bridge/culvert	81 places
(e)	Lake Dredging/Conservation		
	- Lake dredging and conservation works	18 lakes	
	- Lake conservation works	11 lakes	
(f)	Sewers Installation	Whole urban area	6,200 ha

3.1.2 Nhue River Basin Drainage Plan

The plan has been formulated with the following concepts:

(a) In conformity with the Nhue River improvement plan formulated by the Ministry of Water Resources (MOWR), disposal of flood flow into the Nhue River will be restricted to a specific discharge rate of 0.6 $m^3/s/km^2$ and the rest of flood runoff will be retarded by regulating reservoir(s). The rate of 0.6 $m^3/s/km^2$ shall be subject to agreement with MOWR when the plan is put into the next stage of studies.

(b) A cost comparison between the gravity disposal scheme and the pumping scheme indicated that the latter would be more advantageous in terms of cost (land upgrading will be required for a 31 km^2 area in the case of gravity disposal). The pumping station will be provided with a gated-sluice structure in order to enable gravity outflow during the period when the Nhue River water level is low.

(c) The plan includes the environmental enhancement measures as same as in item (f) of Subsection 3.1.1 above.

On the basis of the above concepts, the Nhue River Basin Drainage Plan was formulated as outlined below. A layout plan is shown in Figure 3.1.

Principal Components of the Proposed Nhue River Basin Drainage Plan

Description	Sub-basin				Total
	Co Nhue	My Dinh	Me Tri	Ba Xa	
(a) Pumping Station *	12	8	9	6	35
(b) Regulating Reservoir					
- Regulating capacity (m3)	3,020,000	1,590,000	1,600,000	1,070,000	7,280,000
- Water area (ha)	76	40	40	27	183
- Total lot area (ha)	84	44	44	30	202
(c) Drainage Channel Improvement (m)**	19,200	13,400	13,500	8,700	54,800
(d) Sewers Installation (ha)	1,970	670	870	440	3,950

Note: * With the installation of a gated sluiceway for gravity drainage

** Including reconstruction of about 90 bridges/culverts

In this Master Plan, it is proposed to construct a low levee/riverside road on the left bank of the Nhue River in order to protect the Nhue River left bank (east side) area from being flooded by the Nhue River. However, this plan will carefully be reviewed in the feasibility study stage, including studies of other possible alternative measures. The levee, if justified, should preferably be implemented by MOWR as a part of the Nhue River improvement works (see Subsection 3.1.4 below). The specific discharge rate of 0.6 $m^3/s/km^2$ mentioned in (a) above shall also be subject to further review by MOWR in connection with the study of the Nhue River improvement works.

3.1.3 Dredging of Existing Sewers/Channels (Urgent Project)

At present, there exist about 120 km of sewers (of combined type) and 31.3 km of drainage channels covering the central urban areas, mainly in 4 urban districts. As a result of the accumulation of sediments/sludges over a long time, the present deposited sediment volume is about 26,000 m^3 in sewers (32% of sewer inner volume) and about 90,000 m^3 in channels (24% of flow area). This significantly reduces the flow capacity. The accumulation of sediments causes frequent flooding in urban areas and worsens the riverine environments (odor, scenery, hygienic condition, etc.).

The dredging of existing sewers/channels is very necessary and can be started within a relatively short period. Hence, the work is proposed to be carried out under an urgent project. The project will consist of "Supply of Equipment to SDC" since (i) technically, SDC can carry out the dredging work on force account if it has equipment, and (ii) this method would enable the earliest commencement of the work.

The procurement will cover equipment, spare parts and materials required for the proposed dredging operation. The equipment will mainly include water jet cleaners, vacuum trucks, grab-bucket excavators, and others. A detailed list is given in Annex 3.1. The number of equipment was assessed on an assumption that the initial dredging work should be completed within a period of 3.5 - 4 years.

3.1.4 Red River and Nhue River Improvement Works

In parallel with the implementation of the To Lich and Nhue River Basin Drainage Plans, the following works should be carried out in future for the Red River and Nhue River. Although these works are to be undertaken by MOWR outside the Study Area, a description is given below since they are interrelated with the works proposed in this Study. Annex 3.2 shows the relative location of the Study Area and the Red River and Nhue River main stems.

(1) Upstream Nhue River Improvement Works
(Upstream of the To Lich confluence, 20 km long)

If flood control measures are provided in the left bank area (Hanoi City side) according to the Nhue Basin Drainage Plan (Ref. Sub-section 3.1.2 above), the flood inundation condition in the right bank area (Ha Tay Province side) will be worsened. Hence, flood protection measures should also be provided in the right bank area in parallel with the left bank drainage works.

Principal components of the right bank flood protection works will be (i) construction of a right bank dyke along the Nhue River, and (ii) drainage of inner lands (by pumping stations + regulating reservoirs). Diversion of flood flow to the Day River may be an alternative solution, which should also be examined.

(2) Downstream Nhue River Flood Control Works
(Downstream of the To Lich confluence to Day confluence, 50 km long)

At present, the drainage capacity of the Nhue River channel in the lower reaches is very small and flooding occurs almost every year. It is necessary to undertake flood control work for the downstream area in the future. River improvement work is foreseen to require a long time and a great cost, so it would be practical to use a cost-minimum approach, such as a reduced protection level in the initial stage, polder dyke protection for selected areas, use of low lying areas as temporary retarding basins (including paddy fields as necessary), etc.

Owing to the current limited capacity of the Nhue River lower reaches, discharge from the To Lich River is restricted to 30 m^3/s, which constitutes a great constraint to the planning of Hanoi City drainage. In the long term, flood protection levels for Hanoi City may have to be upgraded from the current planning level (10-year flood) to a 25-year flood level and further to a 50-year flood level as the City's development expands. In that case, an important measure may be to increase the pump drainage capacity at the Yen So pumping station, but it would be most advantageous if gravity drainage (natural drainage) into the Nhue River could also be practiced.

Incorporating these aspects, it is necessary to formulate a comprehensive flood control plan covering the whole Nhue River basin. An initial activity would be to carry out a basinwide flood

control study by MOWR. This study is herein referred to as the Overall Nhue River Flood Control Study.

(3) Red River Dyke Rehabilitation Work

As discussed in Sub-section 2.4.2 above, the existing Red River dyke is the lifeline for Hanoi City because it protects the City from flooding. The dyke, which was built in 11th century, has been reinforced and is presently in a relatively stable condition. However, there are encroachments of buildings onto the dike section, collapses of dike slopes and water leakages during high water periods at some places. These should be remedied.

MOWR is implementing a dyke rehabilitation/reinforcement project under financial assistance of ADB. It is scheduled that a major part of the construction works will start at the end of 1994. In terms of flood control and drainage, the conservation of the Red River dyke will continue to be the most important undertaking for Hanoi City in the future.

3.1.5 Non-structural Measures

In addition to structural measures described in foregoing Sub-sections 3.1.1 to 3.1.3, the following non-structural measures shall also be implemented:

(1) Flood Plain Management

Basically, flood plain management aims at preventing further increase of flood damage potential in the area and is applied particularly to the areas where structural measures are not undertaken in the near future. Issues to be noted specifically include:

(a) According to the City Master Development Plan (2010), no positive development is foreseen in the northwestern suburbs (a part of My Dinh-Me Tri), southern suburbs (a part of Ba Xa-Hoang Liet), and southeastern suburbs (a part of Yen So-Kim Nguu) in the future (Figure 2.2). These areas are subject to heavy flooding (Figure 2.4). Construction of new houses and factories shall be restricted in these areas. The areas shall be used for temporary floodwater impounding in the case of unforeseeable occurrence of floods larger than the design flood.

(b) Part of the high water channel of the Red River (outside the dyke) is extensively used as residential land. Although relocation of the present residents is impractical, building permits shall be restricted in order not to increase the population beyond the present level. Installation of "risk warning boards" (showing probable flood water levels) will caution the people against building the houses in such flood risk areas. It is proposed to organize a separate study to examine these issues jointly by MOWR and HPC.

(2) Obligation to Provide Stormwater Regulation Facilities in Estate Development

Developers of residential and industrial estates shall have obligation to provide adequate stormwater regulation facilities in each estate. This shall be clearly stated in Government regulations along with design criteria and shall be strictly enforced.

(3) Flood Forecasting and Warning System

In the case of the To Lich River basin, since floods reach the Thanh Liet - Yen So area within 4 to 5 hours after a storm occurs in the City area, there is no sufficient time for dissemination of flood warning after forecasting the flood runoff. This makes it difficult to establish a practically working flood forecasting/warning system for the To Lich River basin as far as the forecasting is based on actual rainfall observation. The Nhue River basin also has a similar characteristic. Nevertheless, a different approach may be possible by introducing rainfall forecasting by using a rainfall radar system, the necessity of which would be examined in future.

The To Lich Basin Drainage Plan proposed in foregoing Sub-section 3.1.1 includes the installation of flood forecasting equipment. However, the equipment will serve chiefly as a supporting facility which provides forecasting information required for operation of the Yen So pumping station and Thanh Liet floodgates.

On the other hand, though this subject is outside the scope of the Study, it is necessary to establish a flood warning system for the people who live in the high water area of the Red River. An adequate forecasting/warning system shall be worked out through a study which should cover an analysis of flood runoff in the upper Red River basin and the preparation of forecasting models and proposed warning methods by MOWR. The establishment of this system needs to be studied separately from this Master Plan.

(4) Public Information and Education

The Government has already issued a set of regulations/guidelines concerning the care and management of rivers and drainage/sewerage facilities (e.g. Government Regulation No.6032). It is important to provide relevant public information and education so that the people are conscious of and abide by the regulations. In particular, their attention should be drawn to the following:

(a) Prohibition of illegal encroachment on and/or occupation of rivers, channels, and lakes;

(b) Prohibition of disposal of solid wastes/sludges into rivers, channels, and sewers.

It would be fairly effective to use visual mass-media (e.g. TV) for general information/education and warning boards installed at the sites

for information on specific issues. More positive measures would be to organize "campaigns for cleaning rivers, channels and lakes" through the district people's committees or cooperatives and call for people's direct participation in the cleaning operations.

3.2 Lake Conservation Plan

3.2.1 West Lake Conservation Plan

The West Lake is a very important natural resource for Hanoi City in terms of amenity, inland fishery, and tourism. For the conservation of the natural environment of the Lake, the following works will be required in the future:

West Lake Conservation Plan

(a) Lake Shore Road/Parks/ Shoreline Revetment Work	:	Prevention of encroachment (land filling) and waste disposal by the people
(b) Lake Bottom Dredging	:	Water quality improvement by removal of bottom sludges, increase of fishery production and increase of flood regulating capacity
(c) Reduction of Wastewater Inflow	:	Treatment and/or diversion of wastewaters

Of the above, (a) will be implementated in parallel with the West Lake Surrounding Area Development Plan which is under formulation by the Public Work Design Company under the umbrella of the Transportation and Urban Public Works Service (TUPWS). With regard to (b) and (c), it is recommended to proceed with further steps on the basis of findings from the "West Lake Comprehensive Environment Study" proposed separately.

3.2.2 City Lakes Conservation Plan

Hanoi City has a very unique atmosphere and appearance owing to its numerous lakes and ponds. At present, these lakes and ponds are not in good condition mainly due to the deterioration of water quality, and constitute one of the factors aggravating the city's living environment. Nevertheless, the lakes and ponds have a potential to be of great value for people in the surrounding area, and hence are regarded as valuable natural resources to be conserved carefully.

Lakes and ponds play very important roles in the city's drainage. The lakes and ponds proposed to remain in the City Master Plan as well as in this Study shall be preserved in the future (86 lakes), and any significant landfill should not be allowed. The To Lich Basin Drainage Plan described in foregoing Sub-section 3.1.1 envisages to carry out dredging and conservation works for 18 lakes, environmental conservation works for another 11 lakes, and also lake water aeration works for 2 lakes under a pilot project (observation of the aeration effect on the improvement of water quality).

In addition to the above, it is proposed to implement over a long term, similar environmental conservation works for other small lakes (tentatively assumed to be 50) and also aeration works (for about 20 lakes) after observing the aeration effect in the pilot projects.

3.3 Wastewater Disposal Plan

3.3.1 Formulation of the Master Plan

(1) Current Issues

A serious problem of Hanoi City is the contamination of lakes and rivers and the deterioration of the people's living environment, which are being worsened day by day as wastewater yield increases in parallel with urbanization. The city has no wastewater treatment facilities (except 3 small facilities for local use) and most of the existing sewers were built during the French colonial period.

(2) Basic Planning Framework

The basic framework assumed in the planning is as follows:

(a) Target year : 2010

(b) Objective area : 135 km^2

(c) Planned population : 1,597,000 (2010)

(d) Unit pollution load generation : see table below (2010)

Description	Wastewater Yield	Pollution Load
Domestic Wastewater:		60 g/c/d
- Public water supply area	180 l/c/d	
- Individual water supply area	100 l/c/d	
Commercial Wastewater:		200 mg/l
- Small industries	15 l/c/d	
- Offices and public facilities	40 l/c/d	
Industrial Wastewater:	28 m3/ha/d	400 mg/l

l/c/d litre/capita/day
g/c/d gram/capita/day

(e) Present and Projected Pollutant Load

Description	Present (1992)	Projected (2010)
Wastewater yield (10^3m^3/day)	173.9	378.4
Pollutant load (ton/day)	64.2	119.7
Average BOD (mg/l)	369	316
Average SS (mg/l)	332	285

(3) Projection of River Water Quality

No.	River/Point	Drainage Area (ha)	Estimated BOD (mg/l) 1992	Projected BOD (mg/l) Without Treatment 2010	Projected BOD (mg/l) With Treatment 2010
(1)	Upper To Lich	1,690	50	91	14
(2)	To Lich-Lu Confluence	2,960	46	89	13
(3)	To Lich at Thanh Liet	6,820	31	54	8
(4)	Lu	460	62	130	19
(5)	Kim Nguu	1,960	52	79	12
(6)	Set	2,850	41	54	8

Note: According to Vietnamese standards, allowable BOD of river water is 25 mg/l

(4) Water Treatment Level

Population Density (person/ha)	Required Removal Efficiency (%)	Target Treated Water Quality (BOD, mg/l) Domestic Wastewater	Target Treated Water Quality (BOD, mg/l) Industrial Wastewater	Relevant River
Less than 50 *1	75	90	50	Lower To Lich, Lower Kim Nguu
50-350 *2	80	60	50	Set, Upper To Lich Lower Lu
More than 350 *3	85	50	50	Upper Lu, Upper Kim Nguu

Note: *1 Low population density area
*2 Medium population density area
*3 High population density area

(5) Overall Plan of Wastewater Disposal Systems

The objective area is divided into seven zones, taking into account the characteristics of the respective districts (e.g. land use, population distribution/projected pollutant loads as shown in Annex 3.3) and also the configuration of drainage basins. Based on the results of studies including a comparison of alternative plans for the respective zones, the following plans were considered as most recommendable. The proposed plans are shown in Figure 3.2.

Wastewater Disposal - Proposed Master Plan

Zone	Area (ha)	Population (2010)	Wastewater Yield (m3/day)	Proposed Wastewater Disposal System (Master Plan)
Zone1				
- Zone 1-1	930	40,000	8,300	Medium-scale Community Plant
- Zone 1-2	1,060	47,000	7,900	Large-scale Community Plant
Zone 2				
- Zone 2-1	990	304,000	73,400	Large-scale Centralized Treatment (as 1st stage plan)
- Zone 2-2	1,010	129,000	36,000	Large-scale Centralized Treatment (as 2nd stage plan)
Zone 3	1,350	299,000	70,400	Medium-scale Centralized Treatment
Zone 4	500	190,000	44,700	Medium-scale Centralized Treatment
Zone 5	2,500	244,000	56,500	Medium-scale Centralized Treatment
Zone 6				
- Zone 6-1	870	114,000	29,800	Medium-scale Centralized Treatment (as 1st stage plan)
- Zone 6-2	2,290	180,000	43,200	Medium-scale Centralized Treatment (as 2nd stage plan)
Zone 7	1,740	49,000	8,300	On-site Treatment/Community Plant

(6) Wastewater Disposal Facilities

The types of wastewater disposal facilities associated with the above plans are as follows:

Type	Zone Applied
(a) Separate Sewer	Zone 2-2, Zone 5 and Zone 6 (Areas to be newly developed)
(b) Partially Separate Sewer - Partially Combined Sewer	Zone 2-1, Zone 3 and Zone 4 (Areas where combined sewers exist)
(c) Disposal along Drainage Channels	Zone 1 and Zone 7 (Areas where on-site treatment/ community plants are proposed)

3.3.2 Centralized Wastewater Treatment System

About 72% of the objective area will be covered by five centralized wastewater treatment systems of various sizes. This Master Plan proposes to apply the "oxidation ditch process" for water treatment and the "dry bed process" for sludge treatment. These are considered to be the most practical methods, but should be

subject to further refinement according to each zone, in the subsequent feasibility study and detailed design stages. The location of treatment plants will also be subject to further review according to the actual social condition. The main facilities contemplated for the proposed centralized treatment systems are summarized below:

Main Facilities of Centralized Wastewater Treatment Systems

Zone	Disposal Facilities			Treatment Plant - Lot Area (ha)	Sludge Drying Bed-Lot Area (ha)
	Sewer (km)	Interceptor/ Diversion Chamber (Place)	Pump Station (Place)		
Zone 2	392	4	5	9	5
Zone 3	275	7	3	8	*
Zone 4	87	8	3	5	*
Zone 5	505	-	2	6	4
Zone 6	589	-	3	7	*

3.3.3 On-site Treatment Plan

Judging mainly from the topography and population scale, provision of a centralized treatment system would not be economical for Zone 1 and Zone 7. The introduction of community-based treatment facilities and/or household septic tanks seems most appropriate for these zones.

Wastewater Treatment by Community Plant and Septic Tank

Land Use	Zone 1		Zone 7
	Zone 1-1 (West Lake)	Zone 1-2 (Co Nhue)	(Thanh Tri South)
Industrial Area	14 plants	1 plant	10 plants
Commercial Area	*	-	9 plants
Residential Area	32 plants	1 plant	900 septic tanks

Note: Plant = Community plant installed for each community and/or estate (residential, industrial)
Septic Tank = Household septic tank for treatment of both toilet water and gray water
* Included in Industrial Area
- No facility

Developers of residential/industrial estates will have obligation to install adequate wastewater treatment facilities in each area. For the installation of community plants for existing villages and septic tanks for households, it is proposed to establish a Revolving Fund System which would provide low-interest loans to communities and people so that they could build their own facilities (see also Subsection 3.3.7 below). Nevertheless, there may arise the necessity of installing facilities under public projects, and also other types of needs (e.g. installation of a community plant instead of household septic tanks), according to the actual progress of urbanization in that area. These should be examined in further studies.

3.3.4 Pilot Wastewater Treatment Project

The implementation of the Centralized Treatment Systems is envisaged to commence after the year 2000. Prior to this, some pilot projects may be formulated for advance implementation. The following projects are worth taking up as pilot projects:

(a) Kim Lien Sewerage Rehabilitation Project	:	The rehabilitation works will be carried out to use the existing facilities effectively. The project will contribute to acquiring O&M technology for the Oxidation Ditch Process
(b) Truc Bach Treatment Works	:	Treatment of wastewaters discharged from existing sewers is proposed as a model community plant. The necessity of advance implementation and time schedule will depend on how fast the deterioration of the West Lake water quality will progress henceforwards
(c) Measures against Wastewater Inflow into City Lakes	:	A temporary measure may have to be taken in case the deterioration of the lake water quality becomes an acute problem. Conceivable measures are (i) low level treatment of inflow wastewaters by sedimentation tanks or (ii) diversion of wastewaters by diversion chambers/ interceptors

For the above, some tentative plans have been prepared in this Study (see Appendix E). It is suggested that the final formulation of the plans should follow the recommendations from the two separately proposed studies: the "Sewerage Feasibility Study for Zones 2 - 3 - 4" (for (a) and (c) above) and the "West Lake Environmental Study" (for (b) above).

3.3.5 Flushing Water Diversion Plan

This plan was examined on a very preliminary basis as a potential plan which may be incorporated into a future program depending on the demand. After centralized wastewater treatment systems are installed, most of the wastewaters are delivered directly to the treatment plants and the discharge into rivers will decrease. In Zones 2, 3 and 4, there may be a shortage of river maintenance discharges (supply of irrigation water, minimum discharge for river course conservation).

The West Lake and other city lakes do not have enough water resources to meet this requirement. The only possible solution may be to convey the Red River water by pumping at Lien Mac. However, the use of the Red River water may cause different environmental problems, such as inflow of sediments and changes in the ecosystem, which will need careful surveys and studies. Moreover, there are other measures to be tackled in advance, such as (i) the release of treated water as for upstream as possible (i.e. installation of a treatment plant in the upper reaches), (ii) prevention of inflow of other pollutant loads into the river, and (iii) periodical cleaning of the river channels.