No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

STATE WATER DIRECTORATE
CROATIAN WATERS
THE REPUBLIC OF CROATIA

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN IN THE REPUBLIC OF CROATIA

FINAL REPORT

Vol. 1 : EXECUTIVE SUMMARY

AUGUST 2001

CTI ENGINEERING INTERNATIONAL CO., LTD.

IN ASSOCIATION WITH

NIHON SUIDO CONSULTANTS CO., LTD.

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EXCHANGE RATE

The currency exchange rates used in this Study are:

US Dollar (US$) 1.00 = Japanese Yen (¥) 116

= Croatian Kuna (Kn.) 8.3

As of February 2001

PREFACE

In response to a request from the Government of the Republic of Croatia, the Government of Japan decided to conduct the Study for Water Pollution Reduction on the Sava River Basin and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Naohito Murata of CTI Engineering International Co., Ltd., and consisting of members from CTI Engineering International Co., Ltd. and Nihon Suido Consultants Co., Ltd., to the Republic of Croatia three times between October 2000 to July 2001. In addition, JICA set up an advisory committee headed by Mr. Shigeharu Iinoue, Senior Researcher, Urban Development Corporation, between September 2000 and August 2001, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of the Republic of Croatia and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Croatia for their close cooperation extended to the team.

August, 2001

Kunihiko Saito
President
Japan International Cooperation Agency

August, 2001

Mr. Kunihiko Saito
President
Japan International Cooperation Agency
Tokyo, Japan

Sir:

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report on the Study for Water Pollution Reduction on the Sava River Basin in the Republic of Croatia.

The study was conducted by CTI Engineering International Co., Ltd. in association with Nihon Suido Consultants Co., Ltd., under contracts with JICA during the period from September 2000 to August 2001. In conducting the study, particular attention was paid to the formulation of a master plan, complying with the required conditions for the country to join the European Union in the future. A feasibility study was also conducted on the urgent sewerage development projects of the priority five (5) towns.

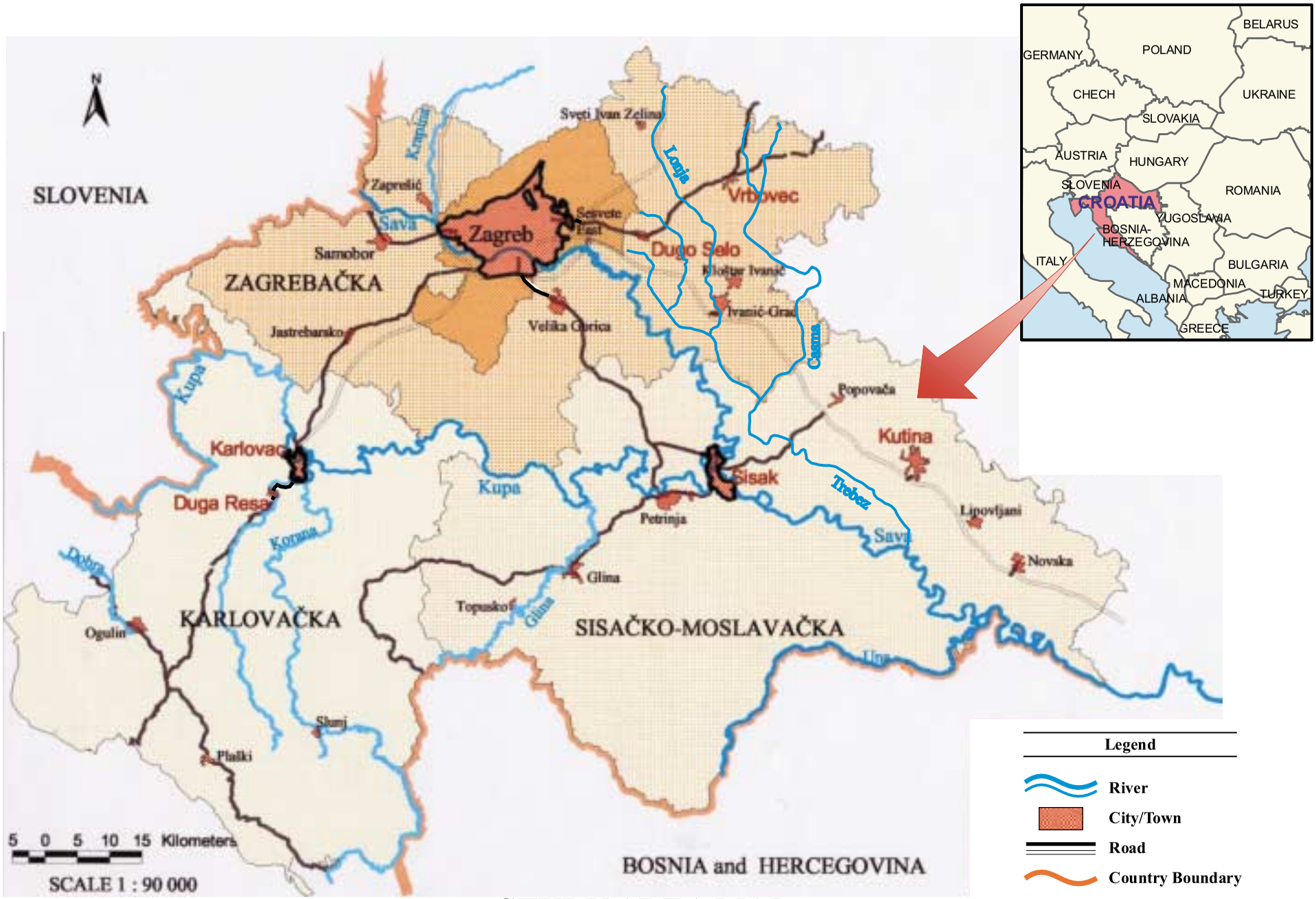
We wish to take this opportunity to express our sincere gratitude to the Government of Japan, particularly, JICA, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, and other offices concerned. We also wish to express our deep appreciation to the State Water Directorate and the Croatian Waters, the Ministry of Environment, and other authorities concerned of the Government of Croatia for their close cooperation and assistance extended to the JICA study team during the study.

Finally, we hope that this report will contribute to the further promotion of the project.

Very truly yours,

Naohito Murata
Leader, JICA Study Team
CTI Engineering International Co., Ltd.

Encl. : a/s



STUDY AREA MAP

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APPENDIX	B	Water Quality and Pollution Mechanism
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APPENDIX	D	Sewerage Development (Master Plan Study)
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ABSTRACT

PART I MASTER PLAN STUDY

1. INTRODUCTION

The Study Area in the basin of the Sava River, a tributary of the Donau, covers the whole administrative area (11,794 km^2) of Zagreb City, the capital of Croatia, and the three (3) surrounding counties of Zagrebacka, Sisacko-Moslavacka and Karlovacka. Approximately 1,590,000 people live in the Study Area at present. For location of the Study Area, see the Study Area Map.

The Sava River within the territory of Croatia is much polluted due to the untreated domestic, commercial, public and industrial wastewaters of Zagreb City and the neighboring towns/municipalities. The Government of Croatia undertakes water pollution control of the river by constructing and operating wastewater treatment plants in Zagreb City and these towns/municipalities.

In response to the request of the Government of Croatia, the Japan International Cooperation Agency decided to conduct "The Study for Water Pollution Reduction on the Sava River Basin in the Republic of Croatia" from September 2000 to August 2001. The Study has the following objectives:

(1) To formulate a master plan for water environmental management of the Sava River Basin including pollution loading reduction up to the target year 2015;

(2) To conduct the feasibility study on the wastewater treatment of the selected five (5) towns neighboring Zagreb City (Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac); and

(3) To pursue technology transfer on planning methods and skills to counterpart personnel in the course of the Study.

2. INDUSTRIAL WASTEWATER TREATMENT

In this Study, to meet the government regulations, the optimum treatment processes and discharge systems (to sewerage system or directly to river) for the 51 large industries identified as significant pollution sources are proposed. The industries in Zagreb City are excluded since they will be treated under the ongoing Zagreb Sewerage Project. Wastewater of the other small industries is dealt as part of municipal wastewater.

The treated wastewater quantity and pollution load effluent from the industries and their recipients in the future (2015) are shown in the table below compared with the existing ones (1999). Since many large industries will change recipient from river to public sewerage, the industrial pollution load into the sewerage systems will increase and the pollution load into the rivers will decrease. As a result, the total pollution load effluent from the industries will remain at almost the present level even in 2015.

Recipient	Number of Industry		Wastewater Quantity (m^3/d)		BOD Load (kg/d)	
	1999	2015	1999	2015	1999	2015
Sewerage	26	37	9,132	31,560	1,896	4,797
River	25	14	36,339	43,330	3,240	769
Total	51	51	45,471	74,890	5,135	5,565

The total construction cost for the improvement of industrial wastewater treatment systems is roughly estimated to be Kn. 128 million at 2001 prices.

3. SEWERAGE DEVELOPMENT

3.1 Objective Urban Centers for Sewerage Master Plan Study

Twenty-four (24) urban centers in 22 sewerage systems were selected for the master plan study on sewerage development, based on the policy of the National Water Protection Plan. The selected urban centers are given below. For the locations, see Outline of the Proposed Project.

Zagreb, Sesvete East, Dugo Selo, Sveti Ivan Zelina, Vrbovec, Ivanić Grad–Kloštar Ivanić, Samobor, Zaprešić, Velika Gorica, Jastrebarsko, Sisak, Petrinja, Glina, Topusko, Popovača, Kutina, Lipovljani, Novska, Karlovac–Duga Resa, Ogulin, Plaški, Slunj

3.2 Proposed Sewerage Development Plan

The proposed sewerage system will serve almost all the population of Zagreb City (95% of the future total population). In the other 23 towns/municipalities, it will cover 19,186 ha (174% of the existing urban area) and serve the total population 381,800 people (122% of the future urban population or 70% of the future total town/municipality population).

All the sewerage systems are provided with necessary treatment plants to treat the wastewater to the permissible limits of the regulations. However, the treatment of nutrients is limited to T-P only and that of T-N is deferred to the later stage after 2015.

The main features of the proposed sewerage development are summarized below.

Urban Center	Service Area (ha)		Served Population		Design Wastewater (m^3/d) (2015)			BOD Load (kg/d)
	1999	2015	1999	2015	Municipal	Industry	Total	
Zagreb	25,600	25,600	800,000	935,000	274,860	167,510	442,370	90,000
Others	10,549	19,186	210,500	381,800	149,726	32,643	182,369	34,376
Total	36,149	44,786	1,010,500	1,316,800	424,586	200,153	624,739	124,376 (2,073,000 PE)

The total construction cost of the 22 sewerage development projects is estimated to be Kn. 2,739 million, broken down into Kn. 1,365 million for the Zagreb Sewerage Development Project and Kn. 1,374 million for the other 21 sewerage development projects. The total construction cost of the 21 sewerage development projects is further broken down into Kn. 531 million for collectors and Kn. 843 million for treatment plants.

4. EVALUATION OF RIVER WATER QUALITY IMPROVEMENT

The river water quality under existing, future without project, and future with project situations was simulated for the river flow rate of 95% probability according to the government standard. The results of simulation of river water quality at the principal river locations are shown below.

(Unit: BOD, mg/l)

River	Location	Existing	Future		Standard (Category)
			Without Project (2015)	With Project (2015)	
Sava Main	Oborovo	8.8	11.6	4.6	≤8.0 (III)
	Utok Kupe Nizvodno	5.6	7.4	3.1	≤4.0 (II)
Kupa	Recica	4.3	6.2	3.1	≤4.0 (II)
	Brest	3.5	4.7	2.6	≤4.0 (II)
Lonja	K. Lonja Strug (Crnec River)	27.1	49.1	7.2	≤8.0 (III)
	Struzec (Lonjsko Polje)	8.5	14.6	3.4	≤4.0 (II)
Kutina	Kutina	70.0	70.0	16.0	≤4.0 (II)

The proposed master plan will improve the river water quality to a large extent. The improved river water quality will satisfy the national standards in the Sava Main, Kupa and Lonja rivers. However, improvement of the Kutina River is limited due to the small dilution effect of natural river flow.

PART II FEASIBILITY STUDY

1. INTRODUCTION

Five (5) sewerage development projects; namely, Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac-Duga Resa, were selected for the feasibility study from among the 22 projects proposed in the master plan. The target year of F/S projects is set at the year 2007, since these projects are the first stage projects of the master plan.

2. PLANNING BASIS

(1) The proposed sewerage system aims to serve almost all the population living within the existing service area in 2007, in principle. No significant extension of the service area is proposed.

(2) Necessary transport collectors, main sewers and secondary/tertiary sewers are proposed to attain the objective services. The collector/sewer size is designed to meet the design wastewater flow of the master plan.

(3) The treatment plant is proposed as the first stage of the master plan. The capacity is designed to treat the wastewater flow in 2007 and the process is applied to meet the requirement of river water quality improvement in 2007.

3. WASTEWATER TREATMENT LEVEL

The water quality of the Sava Main River in 2007 is expected to greatly improve due to the ongoing Zagreb Project. The water quality of the Kupa River will not exceed the standard quality to a serious level even in the case of without-project. Hence, the treatment level of primary sedimentation is applicable for the Sisak and Karlovac-Duga Resa F/S projects.

The Lonja and Kutina rivers are much polluted even at present. Biological treatment is definitely necessary for the Dugo Selo, Vrbovec and Kutina sewerage improvement projects to mitigate the water pollution of the respective rivers to the possible extent.

Hence, the Dugo Selo, Vrbovec and Kutina projects will treat the wastewater to BOD 25 mg/l; whereas, the Sisak and Karlovac-Duga Resa projects will treat the influent BOD by 40%. However, the treatment of T-P will be deferred to the second stage in all the projects in due consideration of priority sequence.

4. PROPOSED SEWERAGE DEVELOPMENT

4.1 Design Bases for Sewerage System and Treatment Plant

The design bases of the sewerage systems and treatment plants for the five (5) projects are summarized below.

Item	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Service Area (ha)	516	422	944	734	1,142
Served Population	10,300	5,900	45,400	19,600	43,800
Served Large Industry (No.)	-	2	3	1	10
Wastewater Quantity (m^3/d)	3,605	4,539	16,973	7,678	23,285
Municipal Wastewater (m^3/d)	3,605	1,770	15,890	6,860	15,430
Industrial Wastewater (m^3/d)	-	2,769	1,083	818	7,855
Influent BOD Concentration (mg/l)	211	198	211	190	193
Pollution Load (PE)	12,700	14,600	59,900	24,500	74,800
Effluent BOD Concentration (mg/l)	25	25	127	25	116

4.2 Proposed Sewer

The main features of the proposed collectors for the five (5) projects are summarized below.

Urban Center	Transport /Main Collector		Secondary/Tertiary Sewer		Total	
	∅ (mm)	L (m)	∅ (mm)	L (m)	∅ (mm)	L (m)
Dugo Selo	800-1,200	5,490	400	2,100	400-1,200	7,590
Vrbovec	350-400	1,880	100	750	100-400	2,630
Sisak	450-1,000	6,340	-	-	450-1,000	6,340
Kutina	400	180	100-200	9,000	100-400	9,180
Karlovac-Duga Resa	300-1,700	11,670	400	1,000	300-1,700	12,670
Total		25,560		12,850		38,410

4.3 Proposed Treatment Plant

The main features of the proposed treatment plants of the five (5) projects are summarized below.

Main Features	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Treatment Process	Activated Sludge	Activated Sludge	Primary Sedimentation	Activated Sludge	Primary Sedimentation
Preliminary Treatment (unit)	1	1	1	1	1
Primary Sedimentation Tank (unit)	3	3	6	3	5
Aeration Tank (unit)	3	3	-	3	-
Secondary Sedimentation Tank (unit)	2	2	-	2	-
Belt Press Filter (unit)	2	2	2	2	2

4.4 Construction and Annual O&M Costs

The construction and annual O&M costs of each of the five (5) projects are estimated as follows at 2001 prices.

Item	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa	Total
Construction Cost (million Kn)	50.94	39.51	68.95	41.16	129.76	330.31
Collector	15.34	3.56	20.88	8.95	61.43	110.15
Treatment Plant	35.60	35.95	48.08	32.21	68.33	220.16
Annual O&M Cost (million Kn)	1.59	1.53	1.98	2.52	2.33	9.95

5. ENVIRONMENTAL IMPACT ASSESSMENT

The environmental impacts of the proposed projects were assessed on the following items: (i) land acquisition, (ii) noise during construction/operation, (iii) foundation geology of treatment plant, (iv) flora/fauna, (v) dust/odor, (vi) water pollution/water use, and (vii) sludge disposal/groundwater. No significant adverse effects were predicted for all the projects.

6. FINANCIAL ANALYSIS

6.1 Implementation Schedule

The proposed projects are assumed to start in 2003 with completion in 2007. The proposed implementation schedules of the five (5) projects are shown below.

Item	Construction Works	Dugo Selo, Vrbovec, Kutina	Sisak, Karlovac-Duga Resa
Detailed Design and Land Acquisition		2003	2003
Stage I Construction	Collector, Primary Treatment, Sludge Treatment, etc.	2004 - Mid 2005	2004 - 2006
Monitoring		Mid 2005 - Mid 2006	-
Stage II Construction	Biological Treatment	Mid 2006 - 2007	-

6.2 Financial Evaluation

6.2.1 General

Each municipal service company should perform a sound sewerage business by collecting sewerage charges set within the users' affordability. For this purpose, a considerable amount of financial assistance from the Central Government (including Croatian Waters) is considered necessary for the construction of the proposed projects. The possible financial sources of construction cost are the Central Government (Grant and Water Management Fund Loan) and external loan (ODA).

The required sewerage charge and financial assistance from the Central Government were estimated by analyzing the financial statement of each municipal service company. To ensure financial feasibility of the municipal service companies,

(1) Annual net income should be mostly positive through the entire period of 25 years;

(2) Loan liability of the company should be zero in 25 years; and

(3) Necessary cash should be reserved before the replacement of mechanical/electrical equipment.

6.2.2 Proposed Sewerage Charge and Financial Assistance

The required sewerage charge for each municipal service company to perform a sound sewerage business was estimated under the following assumptions.

(1) The proposed projects mainly benefit the populations downstream and enhance the environment nationwide, so that they are of national importance. Therefore, the financial assistance of the Central Government is set higher than has been usually extended.

(2) Sixty percent (60%) of the construction cost is provided by the Central Government as Grant. The remaining 40% is financed by an external ODA loan through the Central Government. The loan conditions are assumed as: 2.0% interest and 25-year repayment with a 7-year grace period.

(3) The loan repayment, and the O&M and depreciation costs of the sewerage systems are to be covered by sewerage charges.

(4) At present, two (2) kinds of sewerage charges are individually set for each town. One is for domestic user and the other is for other users (institution and small/large industries). The domestic unit sewerage charge will increase in proportion to the growth of per capita GDP. However, the existing ratio between the two (2) unit sewerage charges will be maintained.

(5) In the Karlovac-Duga Resa sewerage system, the replacement cost of damaged sewers in Karlovac Town is considered apart from the proposed sewerage development cost. The replacement cost is to be covered by both grant from the Local Government and sewerage charges.

The proposed sewerage charges of the five (5) municipal service companies in 2001 are shown below at 2001 prices, along with the existing ones and the internal rate of return (FIRR) of the proposed projects.

Item	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Existing Unit Sewerage Charge (Kn/m^3)					
Domestic User	0.36	0.59	1.34	4.12	1.45 (0.54)*
Other Users	0.74	0.81	4.00	4.12	2.67 (0.54)*
Proposed Unit Sewerage Charge (Kn/m^3)					
Domestic User	2.55	2.25	1.41	4.12	1.86
Other Users	5.24	3.09	4.21	4.12	2.87
Domestic Charge Rate to Household Income (%)					
Existing	0.12	0.20	0.45	1.37	0.48 (0.18)*
Proposed	0.85	0.75	0.47	1.37	0.62
FIRR of Proposed Project (%)	6.58	5.98	5.48	Large	5.91

* Values not in parentheses are charges of Karlovac, while values in parentheses are those of Duga Resa

In order to set the sewerage charges within the user's affordability, 60% of the construction cost need to be provided by the Central Government as a Grant and the remaining 40% shall be financed by an external loan through the Central Government as assumed above.

However, it should be noted that the above external loan does not mean the actual amount of loan to be obtained by the Central Government but only the loan amount to be repaid from sewerage charges. In case the financial resources of the Central Government are limited, it may need to obtain more external loan to be able to extend the necessary grant (60% of construction cost) to the municipal service companies.

7. RECOMMENDATIONS

(1) The proposed five (5) sewerage development projects consisting of Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac-Duga Resa are technically feasible and financially viable. The early implementation of these projects is necessary to cope with the existing water pollution in the Sava River Basin.

(2) For this purpose, the Central Government/State Water Directorate/Croatian Waters and the local governments concerned should immediately proceed with the necessary legal procedures and financial arrangements.

(3) Water pollution of the Lonja River is the worst in the entire Sava River Basin. Early implementation of the Sesvete East and Ivanić Grad-Kloštar Ivanić sewerage development projects is also awaited to attain a satisfactory water pollution control of the Lonja River.

(4) Since the available data on river water quantity and quality in the Lonja River are limited, necessary monitoring of the river water quantity and quality should be commenced immediately.

Study Area

	MP	Treatment Process
1	Zagrb	AS
2	Sesvete East	AO
3	Dugo Selo	AO
4	Vrbovec	AO
5	Sisak	AO
6	Kutina	AO
7	Karlovac and Duga Resa	AO
8	Sv.Ivan Zelina	OD
9	Ivanic Grad and Klostar Ivanic	AO
10	Samobor	AO
11	Zapresic	AO
12	Velika Gorica	AS
13	Jastrebarsko	OD
14	Petrinja	AO
15	Glina	OD
16	Topusko	AL
17	Popovaca	OD
18	Lipovljani	OD
19	Novska	OD
20	Ogulin	AO
21	Plaski	OD
22	Slunj	OD

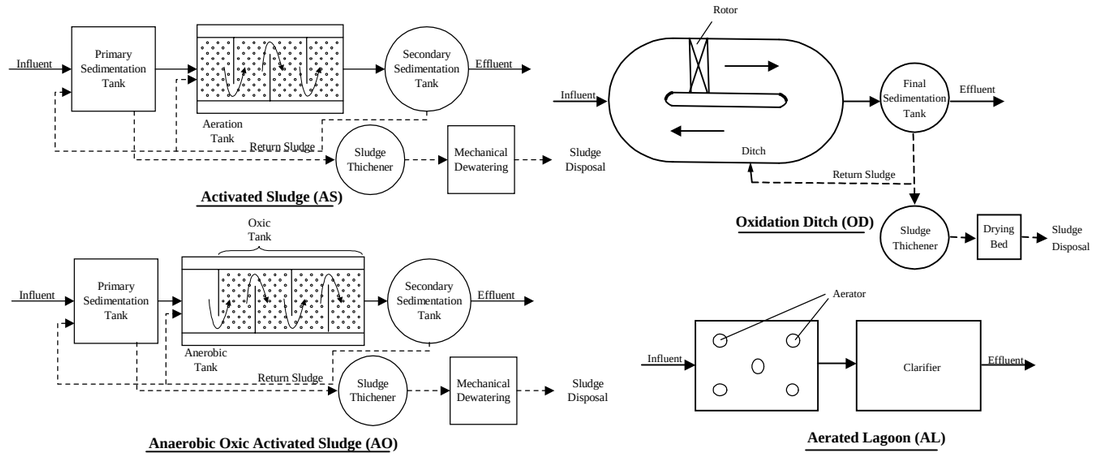
	FS Project	Treatment Process
1	Dugo Selo	AS
2	Vrbovec	AS
3	Sisak	PS*
4	Kutina	AS
5	Karlovac and Duga Resa	PS*

*Primary Sedimentation

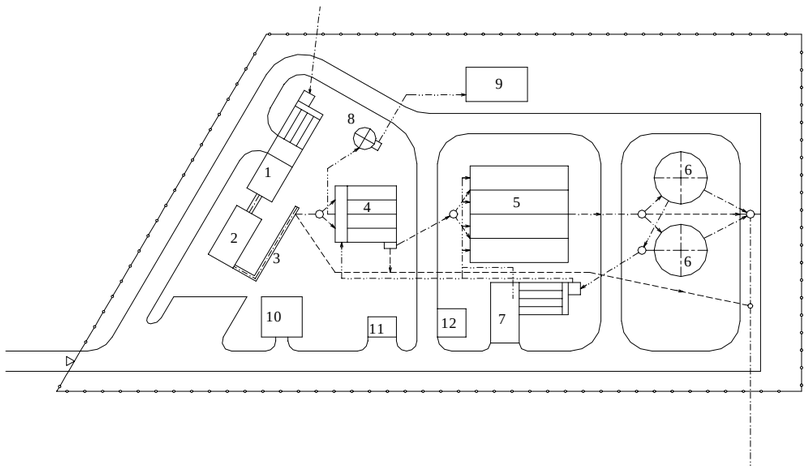
Water Quality Evaluation Point

① Sava River at Oborovo
② Sava River at Utok Kupe Nizvodno
③ Kupa River at Recica
④ Kupa River at Brest
⑤ Lonja River at K.Lonja Strug
⑥ Lonja River at Struzec

Flow Sheet of Wastewater Treatment Process



Typical Layout of Wastewater Treatment Plant (F/S Project)

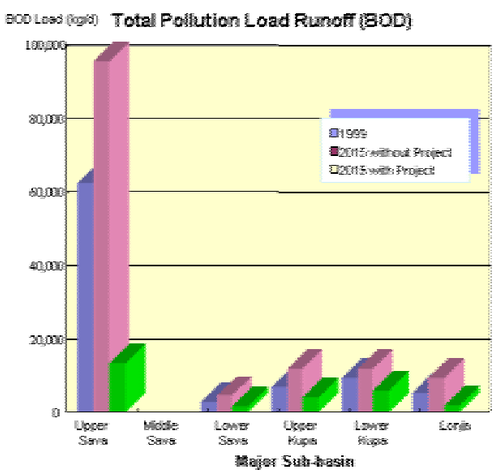


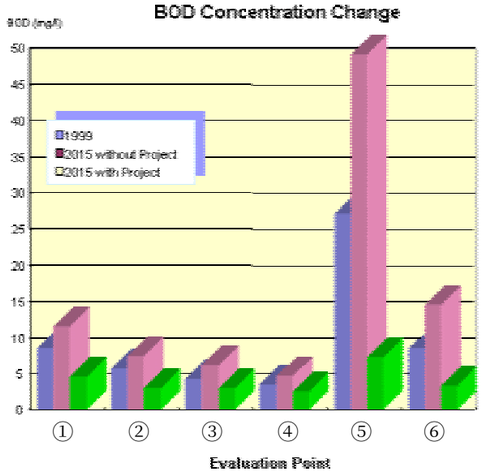
Legend

1 Influent pumping station
2 Grit oil/sand removal equipment
3 Parshall flume
4 Primary sedimentation tank
5 Aeration tank
6 Secondary sedimentation tank
7 Return sludge pumping station (Blower building)
8 Sludge thickener
9 Dewatering equipment
10 Administration building
11 Generator
12 Electricity reception, Transformer station

Boundary
Wastewater line
Sludge line
By Pass line

Pollution Load Runoff and River Water Quality





Proposed Projects

Proposed Projects		*Outline of Project Components*	*Construction Cost and Beneficiaries*
Master Plan *	1 Industry	Development of wastewater treatment system of 51 large industries	• 128 million Kuna
	2 Sewerage	Development of wastewater treatment plants and collectors of 21 Sewerage Systems for 23 urban centers	• 1,374 million Kuna • Served population: 381,800
Feasibility Study	1 Dugo-Selo	A wastewater treatment plant with Activated Sludge process and collectors	• 50.94 million Kuna • Served population: 10,300
	2 Vrbovec	A wastewater treatment plant with Activated Sludge process and collectors	• 39.51 million Kuna • Served population: 5,900
	3 Sisak	A wastewater treatment plant with primary sedimentation and collectors	• 68.95 million Kuna • Served population: 45,400
	4 Kutina	A wastewater treatment plant with Activated Sludge process and collectors	• 41.16 million Kuna • Served population: 19,600
	5 Karlovac-Duga Resa	A wastewater treatment plant with primary sedimentation and collectors	• 129.76 million Kuna • Served population: 43,800

* Descriptions in this table are for the urban centers other than Zagreb.

OUTLINE OF THE PROPOSED PROJECT

THE STUDY FOR
WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN
IN THE REPUBLIC OF CROATIA

FINAL REPORT

VOL. 1: EXECUTIVE SUMMARY

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ABBREVIATIONS AND ACRONYMS

AGENCIES/ORGANIZATIONS

EU	European Union
JICA	Japan International Cooperation Agency

OTHER ACRONYMS/ABBREVIATIONS

A_2O	Anaerobic-Anoxic-Oxic Activated Sludge
AA	Aeroaccelerator
AL	Aerated Lagoon
AO	Anaerobic-Oxic Activated Sludge
AS	Activated Sludge
BOD	Biochemical Oxygen Demand
CAST	Cyclic Activated Sludge Technology
CODCr	Chemical Oxygen Demand (Chromium)
CODMn	Chemical Oxygen Demand (Manganese)
DO	Dissolved Oxygen
FIRR	Financial Internal Rate of Return
F/S, FS	Feasibility Study
GDP	Gross Domestic Product
M/P, MP	Master Plan
N	Nitrogen
No.	Number
O&M, O/M	Operation and Maintenance
OD	Oxidation Ditch
ODA	Official Development Assistance
P	Phosphorus
PE	Person Equivalent
PS	Primary Settlement
TF	Trickling Filter
T-N	Total Nitrogen
T-P	Total Phosphorous
TSS	Total Suspended Solids
VAT	Value Added Tax = PDV

MEASUREMENTS/SYMBOLS

ha	Hectare
km	Kilometer
km^2	Square kilometer
L	Length
m^3	Cubic Meter
mg	Milligram
mg/l	Milligram per Liter
mm	Millimeter
%	Percent
°C	Degree Centigrade
∅	Diameter

Kn, HRK	Croatian Kuna
¥, JP¥	Japanese Yen
DM	German Mark, Deutsche Mark
US$	United States Dollar

PART I MASTER PLAN STUDY

1. INTRODUCTION

The Sava River runs a 945 km distance draining a total area of 95,551 km^2 in the countries of Slovenia, Croatia, Bosnia-Herzegovina and Yugoslavia before it joins the Donau as a tributary. The river length and drainage area within the territory of Croatia are 518 km and 25,100 km^2, respectively.

The population of the Sava River Basin in Croatia is 2,340,000, including the 1,590,000 inhabitants of Zagreb City, the capital of Croatia, and the three (3) surrounding counties of Zagrebacka, Sisacko-Moslavacka and Karlovacka. The Study Area covers the whole administrative area (11,794 km^2) of Zagreb City and the above three (3) counties.

The water of Sava River is much polluted due to the untreated domestic, commercial, public and industrial wastewaters of Zagreb City and the neighboring towns/municipalities and cities. The Government of Croatia undertakes water pollution control of the river by constructing wastewater treatment plants in the urban center of Zagreb City and these towns/municipalities.

In response to the request of the Government of Croatia, the Japan International Cooperation Agency conducted "The Study for Water Pollution Reduction on the Sava River Basin in the Republic of Croatia" from September 2000 to August 2001. The objectives of the Study are:

(1) To formulate a master plan for water environmental management of the Sava River Basin including pollution load reduction up to the target year 2015;

(2) To conduct a feasibility study on the wastewater treatment of the selected five (5) towns in the suburban area of Zagreb City (Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac); and

(3) To pursue technology transfer on planning methods and skills to counterpart personnel in the course of the Study.

2. STUDY AREA

2.1 Natural Conditions

(1) Climate and Hydrology

The climate of the Study Area is affected by both the Continental and Mediterranean climates. The monthly average temperature at Zagreb City varies from 1.6°C in December to 22.3°C in July, with a yearly average of 12.2°C. The average monthly rainfall at Zagreb City ranges from 33 mm in February to 125 mm in August, with the yearly average of 921 mm.

However, the water of the Sava River lowers in summer (July-September) and rises in spring (March-April) independently of the rainfall distribution in the Study Area.

(2) River Basin and River System

The Study Area, covering approximately 11,800 km^2, is drained by the river system consisting of the Sava Main, Kupa and Lonja rivers, as well as their tributaries. The river system and drainage basins are shown in Fig. I-1.

The latest land use map of the Study Area was prepared by using the satellite digital data taken in August 2000. The existing land use distribution is summarized below.

Land Use Category	Area (km^2)	(%)
1. Forest	5,430	46.1
2. Shrub/Grass Land	4,640	39.3
3. Pasture/Agricultural Land	1,154	9.8
4. Built up Area	286	2.4
5. Water Body/Bare Land	283	2.4
Total	11,794	100.0

The nature park "Lonjsko Polje" is located in the downstream reaches of the Lonja River (a flood plain of the Sava River). The park, covering 56,000 ha, is designated as a valuable reserved area of the country. It is characterized as having one of the largest white stork concentrations in Europe.

2.2 Socio-economy

(1) Population

The existing (1999) and future (2015) populations of the Study Area are estimated based on the latest studies of the departments concerned of the local and central governments, as follows:

Administrative Unit	1999			2015			Ratio
	Total (1)	Urban	Rural	Total (2)	Urban	Rural	(2)/(1)
Zagreb City	935,000	935,000	-	998,000	998,000	-	1.07
Zagreb County	313,812	123,713	190,099	352,000	140,710	211,290	1.12
Sisak-Moslavina County	194,320	97,604	96,716	227,138	113,679	113,459	1.17
Karlovac County	148,892	81,122	67,770	148,892	82,682	66,210	1.00
Total	1,592,024	1,237,439	354,585	1,726,030	1,335,071	390,959	1.08

(2) Economic Growth of the Country

The growth rate of GDP is assumed based on the latest studies of the Ministry of Finance and the Zagreb Economy Institute as follows: 3.6% for 2000-2005, 5.5% for 2006-2010 and 4.5% for 2011-2015. These growth rates are based on the presumption that the country will join the European Union (EU) by 2010.

No data is available for the future growth rate of the manufacturing industry. However, the Ministry of Finance estimated the current growth rate of manufacturing industry as 2.7% based on the data during January to September 2000. Hence, it is assumed in this Study that the future growth rate is the same as that of GDP.

2.3 River Water Use and Water Classification

(1) Existing River Water Use

Water use in the Study Area mostly depends on the groundwater. The consumptive river water use is limited to the municipal and industrial purposes at seven (7) locations. No irrigation water is taken from the river. There are 49 species of fish in the River Basin. However, the number of fish species in the Sava Main, Lonja and Crnec rivers are definitely less than the number in the other tributaries due to water pollution. The Kupa and Korana rivers are the most abundant in fish species.

(2) Water Classification and Standard Water Quality

The watercourses are classified into five (5) categories; namely, Category I to V. The standard river water quality for each category is designated in the Decree as below.

Parameter/Category	I	II	III	IV	V
DO (mg/l)	>7	7 - 6	6 - 4	4 - 3	<3
BOD (mg/l)	<2	2 - 4	4 - 8	8 - 15	>15
COD-Mn (mg/l)	<4	4 - 8	8 - 15	15 - 30	>30
T-P	<0.1	0.10 - 0.25	0.25 - 0.60	0.60 - 1.50	>1.5
T-N	<1	1 - 3	3 - 10	10 - 20	>20

The major rivers in the Study Area are categorized as follows.

River	Existing Water Use	Category
Sava Main (Upper Reaches)	Recreation, Scenic View, Aquatic Life	II
Sava Main (Middle Reaches)	Recreation, Scenic View, Aquatic Life	III
Sava Main (Lower Reaches)	Industrial, Recreation, Scenic View, Aquatic Life	II
Kupa (Upper Reaches)	Recreation, Scenic View, Aquatic Life	I
Kupa (Middle Reaches)	Municipal, Recreation, Scenic View, Aquatic Life	II
Kupa (Lower Reaches)	Municipal, Industrial, Recreation, Scenic View, Aquatic Life	II
Lonja (Entire Reaches)	Recreation, Scenic View, Aquatic Life	II

3. INDUSTRIAL WASTEWATER TREATMENT

3.1 Objectives and Scope of the Study

The major objectives and scope of the industrial wastewater treatment study are:

(1) To establish the existing discharge system of the industrial wastewater.

(2) To estimate the existing and future wastewater quantity and quality and to evaluate the pollution load to the sewerage systems and rivers.

(3) To propose the optimum discharge system, i.e., whether to discharge into the sewerage system with necessary pre-treatment or directly into river with necessary treatment.

(4) To propose the necessary improvements to the existing treatment systems. Required construction cost is roughly estimated to provide necessary basic data for the preparation of financial policies on the promotion of industrial wastewater treatment.

3.2 Selection of the Objective Large Industries for the Study

Out of a number of industries in the Study Area, 51 large industries discharging more than 100 m^3/d were selected for the study on wastewater treatment. The wastewaters of small industries were dealt as part of the municipal wastewater. The industries in Zagreb City (except the Sesvete East Area) were excluded in the Study because they are already included under the ongoing Zagreb Sewerage Project.

Further, 18 large pollutant industries from among the 51 large industries were selected for detailed study. These 18 large pollutant industries share most of the industrial wastewater quantity (approx. 80%) and pollution load (approx. 90% in BOD) in the Study Area. The 18 large pollutant industries are given in Table I-1.

3.3 Planning Basis

(1) Permissible Limits of Industrial Effluent

The permissible limits of major parameters of industrial wastewater discharged into natural receiving waters and public sewerage systems are specified in the Decree, as shown below.

Parameter/Category	II	III	IV	V	Sewerage
TSS	35	35 - 60	60 - 150	150	-
BOD (mg/l)	25	25	40	80	250
COD-Cr (mg/l)	125	125	200	400	700
T-P	1	2	4	8	10
T-N	21	31	42	42	-
Oil and Grease ((mg/l)	25	30	40	50	100

(2) Projection of Future Industrial Wastewater Quantity

The future wastewater quantity of the 51 objective large industries in the year 2015 was estimated based on the following assumptions:

(a) Industrial production will increase in proportion to the growth of GDP.

(b) However, unit wastewater quantity per production will decrease in the future due to the technological improvement of production processes. The reduction rate is assumed for each industry in due consideration of: (i) existing level of water use quantity, (ii) existing ratio of cooling water use to total use, and (iii) age of existing production equipment.

(3) Selection of Wastewater Recipient

The industrial wastewater is discharged into public sewerage in principle, except the cases given below, to execute the pollution control of industrial wastewater at the minimum cost. On the other hand, the public sewerage can allocate the necessary cost for industry and as a result, the integral treatment of municipal and industrial wastewater will attain the target at the minimum cost. The exceptions are:

(a) The industry is already provided with a high-tech treatment system and can easily discharge wastewater into the river with a small improvement as required.

(b) The wastewater is not much polluted in quality and industry can easily discharge it into the river with a small improvement as required.

(c) The wastewater quality is not proper for the treatment of public sewage.

(d) The industry is located far from the sewerage system, requiring a large additional cost.

The wastewater recipient (public sewerage or natural watercourse) of the objective 51 large industries was determined individually in consideration of the above criteria.

(4) Wastewater Treatment Process

The optimum treatment process varies, depending on the wastewater quality and kind of recipient of the effluent. However, the following four (4) typical treatment processes are applied in this master plan study. The adequate process is to be selected by each industry according to its required treatment conditions.

Treatment Process	Applicable Industry
Conventional Activated Sludge	Industry which treats BOD and COD with a normal concentration for discharge into public sewerage or natural water
Two Stage Activated Sludge	Industry which treats BOD and COD with a high concentration for discharge into natural water
Chemical Coagulation	Industry which treats TSS, heavy metals, color and insoluble BOD/COD for discharge into public sewerage or natural water
Conventional Activated Sludge + Chemical Coagulation	Industry which treats BOD, COD, TSS, heavy metals, color and oil for discharge into natural water

3.4 Proposed Industrial Wastewater Treatment

(1) Treated Wastewater Quantity and Pollution Load

The treated wastewater quantity and pollution load effluent (BOD) from the industries and their recipients in the future (2015) are summarized below, compared with the existing ones (1999). The 18 large pollutant industries will share 81% in quantity and 87% in BOD load in 2015. The wastewater quantity, pollution load and recipient of the 18 large pollutant industries are individually shown in Table I-1.

Many large pollutant industries will change their recipients from river to public sewerage. Hence, the industrial pollution load into the sewerage system will increase, while the pollution load into the rivers will decrease. As a result, the total pollution load of effluent from the industries will remain at almost the present level even in 2015.

Industry	Recipient	Number of Industries		Wastewater Quantity (m^3/d)		BOD Load (kg/d)	
		1999	2015	1999	2015	1999	2015
Large Pollutant Industries (18)	Sewerage	4	14	3,855	22,496	1,494	4,175
	River	14	4	33,143	38,390	3,041	644
	Sub-total	18	18	36,998	60,886	4,534	4,818
Other Large Industries (33)	Sewerage	22	23	5,277	9,064	402	622
	River	11	10	3,196	4,940	199	125
	Sub-total	33	33	8,473	14,004	601	747
Total Large Industries (51)	Sewerage	26	37	9,132	31,560	1,896	4,797
	River	25	14	36,339	43,330	3,240	769
	Total	51	51	45,471	74,890	5,135	5,565

(2) Cost Estimate

The total construction cost for the improvement of treatment systems is roughly estimated to be Kn. 128 million at 2001 prices. It is broken down into Kn. 90 million for the 18 large pollutant industries and Kn. 38 million for the 33 other large industries. The construction cost of each of the 18 large pollutant industries is also shown in Table I-1.

The above construction costs include direct construction cost, engineering and administration costs, VAT, Customs Duties and contingency. In this estimate, the currency exchange rate at the end of February 2001 is employed as follows: US$1.00 = Kn. 8.3 = JP¥ 116.

4. SEWERAGE DEVELOPMENT

4.1 Objective Urban Centers for Sewerage Master Plan Study

Twenty-four (24) urban centers comprising 22 sewerage systems were selected for the master plan study on sewerage development based on the National Water Protection Plan. The selected urban centers meet either of the following criteria:

(1) Urban center is expected to discharge wastewater of over 2,000 PE in 2015.

(2) Urban center is located in an area where drinking water sources may be affected.

The selected urban centers are given below. For the location of selected urban centers, see Fig. I-1

Zagreb, Sesvete East, Dugo Selo, Sveti Ivan Zelina, Vrbovec, Ivanić Grad - Kloštar Ivanić, Samobor, Zaprešić, Velika Gorica, Jastrebarsko, Sisak, Petrinja, Glina, Topusko, Popovača, Kutina, Lipovljani, Novska, Karlovac - Duga Resa, Ogulin, Plaški, Slunj

4.2 Existing Sewerage System

The 22 existing sewerage systems cover a total area of 36,149 ha, serving a total population of 1,010,500 inhabitants, which are mostly served by the Zagreb City sewerage system. The service area and served population in 21 of the sewerage systems (excluding Zagreb City) are 10,549 ha (96% of the existing urban area: 11,006 ha) and 210,500 inhabitants (74% of the existing urban population: 284,700 or 42% of total town/municipal population: 499,500), respectively.

However, only three (3) sewerage systems are provided with treatment plants, treating the wastewater of approximately 60,000 inhabitants. Even Zagreb City has only recently started the construction of a treatment plant. The existing treatment plants are Velika Gorica (biological treatment), Kutina (preliminary treatment) and Ivanić Grad (preliminary treatment).

4.3 Planning Basis

4.3.1 Permissible Quality of Treatment Plant Effluent

The permissible limits of effluent (TSS, BOD, COD-Cr, T-N, T-P) discharged from the sewage treatment plant into the receiving water vary according to the size of the treatment plant and the category of the receiving water, as follows.

Category	Plant Size	TSS (mg/l)	BOD (mg/l)	COD-Cr (mg/l)	T-P (mg/l)	T-N (mg/l)
Watercourse II	<10,000 PE	60	40	150	-	-
	10,000 PE - 100,000 PE	35	25	125	2	15
	>100,000 PE	35	25	125	1	10
Watercourse III	<10,000 PE	120 – 150	-	-	-	-
	>10,000 PE	35	25	125	-	-

4.3.2 Wastewater Flow

The wastewaters in sewerage systems include domestic, institutional and industrial wastewater, and groundwater infiltration. As mentioned before, the wastewaters of 51 large industries in the

Study Area are estimated individually; whereas, wastewaters of the other smaller industries are dealt as part of the municipal wastewater, as well as domestic and institutional wastewater.

(1) Design Unit Municipal Wastewater Quantity

The existing average unit municipal wastewater quantity (domestic, institutional and small industries: l/capita/day) is estimated from the water consumption data. It varies depending on the population size of town. In this Study, it is classified into two (2) categories: less than 10,000 people and larger than 10,000 people, based on the existing water consumption data in the Study Area. The return rate of consumed water to the sewerage is assumed at 80%.

The groundwater infiltration is also an important factor for the determination of design sewage quantity. The groundwater infiltration ratio to the municipal wastewater quantity (domestic, institutional and small industries) is estimated to be 30%, based on the actual inflow to the Kutina Treatment Plant in the driest period.

On the other hand, the municipal wastewater varies throughout the year. Hence, the treatment plant is designed to meet the daily maximum wastewater. The ratio of daily maximum to daily average is estimated to be 1.30 based on the actual variation data in the Study Area.

The unit municipal wastewater quantity will increase according to the improvement of living standards in the future. The design unit municipal wastewater quantity for the master plan study (target year: 2015) is summarized below.

Population Size		<10,000 (l/capita/day)	≧10,000 (l/capita/day)
Daily Average	Domestic	190	190
	Institutional/Small Industry	30	70
	Groundwater Infiltration	70	70
	Total	290	330
Daily Maximum	Domestic	240	240
	Institutional/Small Industry	30	90
	Groundwater Infiltration	70	70
	Total	340	400

(2) Design Unit Pollution Load of Municipal Wastewater

The design unit pollution load of domestic wastewater is set at BOD: 60 g/capita/day by employing the widely used one in Croatia. The design unit BOD load of institutional and small industrial wastewater is determined by assuming the BOD concentration of 200 mg/l.

(3) Design Total Sewerage Wastewater

The wastewater quantity and quality in the large industries are estimated individually. The total wastewater quantity and pollution loads into public sewerage are estimated by adding those of large industries to the municipal ones.

4.3.3 Wastewater Treatment

(1) Treatment of Nutrients (P, N)

According to the government regulations, the treatment plant with a size of more than 10,000 PE shall treat both T-P and T-N when the effluent is to be discharged into a Category II river. The normal biological treatment process (Activated Sludge: AS) can

coincidentally treat nutrients to some extent; however, some advanced treatment processes must be introduced to meet the regulation level. Usually, Anaerobic-Oxic Activated Sludge (AO) is applied for the treatment of T-P and Anaerobic-Anoxic-Oxic Activated Sludge (A_2O) is applied for the treatment of both T-P and T-N. The required costs of the three (3) processes are compared in index as follows.

Treatment Process	AS	AO	A_2O
Required Land Space	100	111	199
Construction Cost	100	108	172
O&M Cost	100	104	218

As shown in the above table, the treatment of T-N requires a large cost. Hence, the treatment of T-N is deferred as a future target after 2015. The proposed master plan will treat only T-P by the Anaerobic-Oxic Activated Sludge (AO).

(2) Selection of Optimum Treatment Process

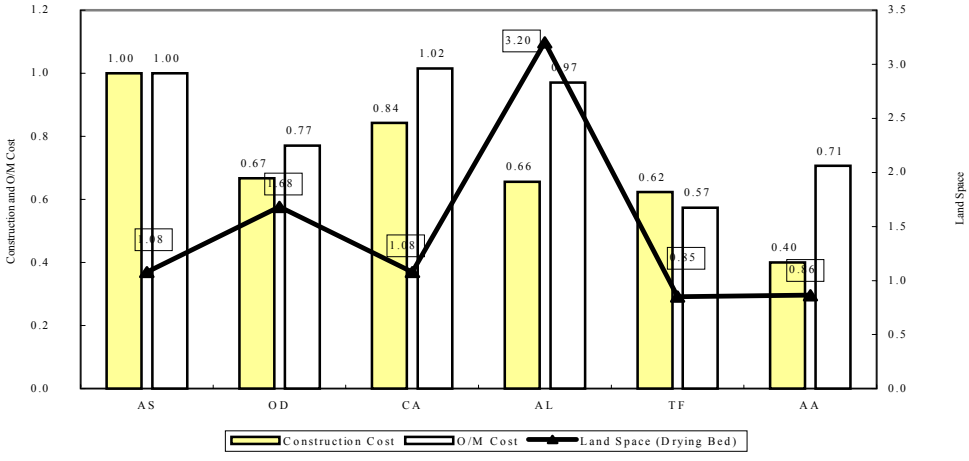
(a) Applicable Processes

The permissible limits of effluent quality vary according to the plant size for a Category II river, as shown below together with the applicable processes.

Plant Size	Permissible Limit (mg/l)		Applicable Treatment Process
	BOD	T-P	
<10,000 PE	40	-	Activated Sludge (AS) Oxidation Ditch (OD) Aerated Lagoon (AL) Trickling Filter (TF) Aeroaccelerator (AA)
>10,000 PE	25	2	Anaerobic Oxic Process (AO) Activated Sludge Coagulation (AS + CO) Cyclic Activated Sludge Technology (CAST)

(b) Optimum Process for Plant Size <10,000 PE

The construction cost, O&M cost and required land space are compared in index below. In this figure, the required land space includes a drying bed space.



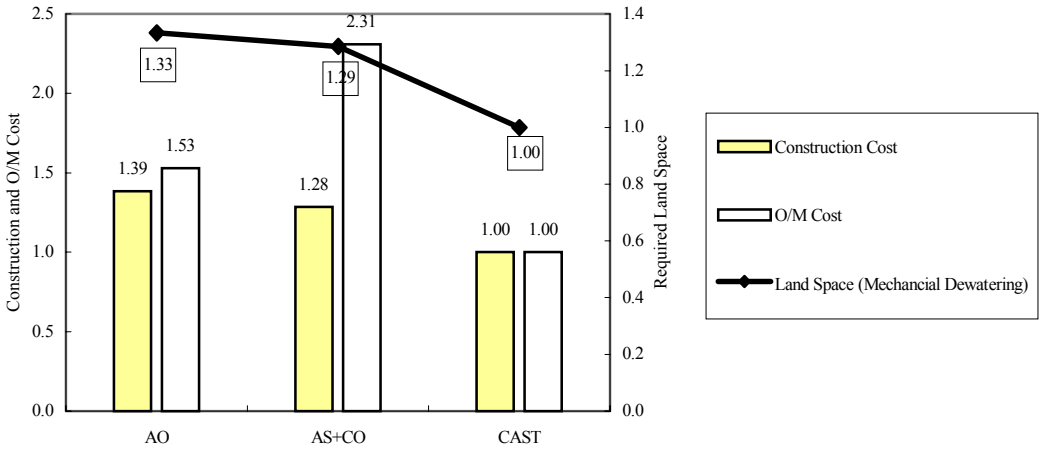
TF and AA are comparatively economical. However, their treatment efficiency is 80% at most and they are not reliable enough. The treatment efficiency of TF and

AL lowers in the winter season, and AL requires a large land space. AS requires a large cost although it can save in required land space.

OD is widely used in small towns or villages due to its simple operation. Hence, OD is proposed in this Study.

(c) Optimum Process for Plant Size >10,000 PE

The construction cost, O&M cost and required land space are compared in index below. In this figure, the required land space includes a mechanical dewatering space.



CAST is the most economical. In this case, however, the operation rule must be changed according to the fluctuation of influent and an automatic control system must be installed for a satisfactory operation. Hence, this system is not recommended. AS + CO requires a high O&M cost and to make matters worse, it will increase sludge volume. Hence, AO is applied in this Study.

(3) Sludge Treatment System

Drying bed is applied for small plants (<10,000 PE) from economical aspects. However, mechanical dewatering system is proposed for large plants (>10,000 PE) to minimize the adverse effects on the surrounding environments.

4.4 Proposed Sewerage Development Plan

(1) Future Service Area and Treatment Plant Site

The future service area is delineated in accordance with the detailed discussions with each local government (town/municipality) along with Croatian Waters. The service area covers not only the existing urban center but also the surrounding rural areas to the possible extent. The location of treatment plant is determined following the existing physical plan of each local government as far as it is not technically difficult.

(2) Sewerage Development Plan

In principle, the central urban areas are served by the combined system, while the surrounding areas are by the separate system.

The proposed sewerage system will serve almost all the population of Zagreb City (95% of the future total population). In the 23 towns/municipalities other than Zagreb City, it will cover 19,186 ha (174% of the existing urban area: 11,006 ha) and serve a total population of 381,800 inhabitants (122% of the future urban population: 313,300 or 70% of the future total town/municipality population: 549,000).

The main features of the proposed sewerage development are summarized below. Those of each sewerage development plan are shown in Table I-2.

Urban Center	Service Area (ha)		Served Population		Design Wastewater (m^3/d) (2015)			BOD Load (kg/d)
	1999	2015	1999	2015	Municipal	Industrial	Total	
Zagreb	25,600	25,600	800,000	935,000	274,860	167,510	442,370	90,000 (1,500,000 PE)
Others	10,549	19,186	210,500	381,800	149,726	32,643	182,369	34,376 (573,000 PE)
Total	36,149	44,786	1,010,500	1,316,800	424,586	200,153	624,739	124,376 (2,073,000 PE)

4.5 Cost Estimate

The total construction cost for the 22 sewerage development projects is estimated to be Kn. 2,739 million, broken down into Kn. 1,365 million for the Zagreb sewerage development project and Kn. 1,374 million for the other 21 sewerage development projects. The total construction cost of Kn. 1,374 million for the 21 sewerage development projects is further broken down into Kn. 531 million for collector and Kn. 843 million for treatment plant as shown below. The construction cost of each sewerage development project is also shown in Table I-2.

Item	Cost (million Kn)
Direct Construction Cost	853.5
Collector	337.7
Transport/Main Collector	153.4
Secondary/Tertiary Sewer	184.3
Treatment Plant	515.8
Land Acquisition Cost	3.6
Indirect Construction Cost*	345.9
Contingency	170.7
Total	1,373.8

* Include engineering, administration, Customs Duties and VAT.
Ex. Rate: US$1.00 = Kn 8.3 = JP¥ 116 at February 2001 prices

5. EVALUATION OF RIVER WATER QUALITY IMPROVEMENT

5.1 Objective Location for Water Quality Simulation

The existing and future river water quality was simulated at the following locations of the Sava Main River, Kupa River, Lonja River and Kutina River for both cases of without and with project situations. For the objective locations of the simulation, see Fig. I-1.

River	Location of Simulation
Sava Main River	Oborovo (downstream of Zagreb); Utok Kupe Nizvodno (downstream of Sisak)
Kupa River	Recica (downstream of Karlovac); Brest (immediately upstream of Petrinja)
Lonja River	K. Lonja Strug (before confluence with Cesma River); Struzec (after confluence with Cesma River)
Kutina River	Kutina (downstream of treatment plant)

5.2 Simulation Methodology

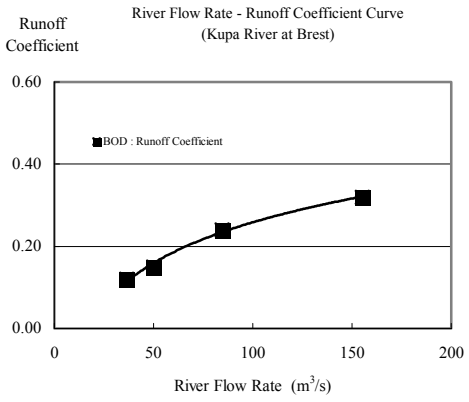
(1) General

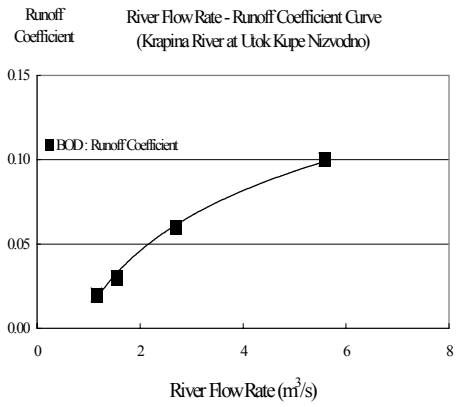
The point pollution load includes municipal wastewater and industrial wastewater; whereas, non-point pollution load includes the wastewater from households (not served by sewerage), livestock and lands. Moreover, point pollution loads run off 100% into the rivers, while non-point pollution loads lose a large portion before entering the rivers, especially in dry period. Both point and non-point loads decrease while they flow down the rivers (tributary and main river) due to self-purification effects.

The pollution load generation in the Study Area is estimated for 20 subdivided basins aggregated into six (6) major sub-basins.

(2) Runoff Coefficient

Non-point load runoff is largely affected by rainfall. The runoff coefficients of non-point loads vary depending on the river flow rate and basin topography/geology. The runoff coefficients of non-point loads are estimated, based on the observed river water quantity and quality data. Runoff coefficients of the Krapina and Kupa river basins are graphically shown below.





(3) Self-purification Rate

The self-purification rates of rivers vary depending on the river flow velocity. The rate is estimated based on the analysis of the pollution load reduction between Zagreb and Sisak. The self-purification rates of the tributaries in the left and right bank basins of the Sava Main River are assumed at 0.5% per km and 2% per km, respectively. However, the self-purification rates of the main rivers (Sava Main, Kupa and Lonja rivers) are calculated in more detail by using the Streeter-Phelps Formula.

5.3 Simulation of River Water Quality

5.3.1 Pollution Load Runoff to Main River Without Project

The future pollution load runoff of the six (6) major sub-basins to the main rivers (Sava Main, Lower Kupa and Lonja) without project are summarized below compared with the existing ones.

(Unit: BOD, kg/d)

Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	
Existing (1999)								
Municipal	50,594	0	1,734	2,208	3,878	2,862	61,308	(70%)
Industrial	10,942	0	159	1,639	906	1,540	15,196	(17%)
Non-point	848	22	963	3,199	4,550	1,066	10,649	(12%)
Total	62,384	22	2,857	7,046	9,334	5,468	87,153	(100%)
Without (2015)								
Municipal	78,141	0	3,396	8,637	6,705	7,768	104,648	(77%)
Industrial	16,535	0	216	8	507	485	23,752	(13%)
Non-point	848	22	963	3,199	4,550	1,066	10,649	(8%)
Total	95,524	22	4,575	11,845	11,762	9,319	133,047	(100%)

5.3.2 Simulated River Water Quality

The river water quality of the existing, future without project, and future with project were simulated for the river flow rate of 95% probability according to the government standard. The simulated river water quality at the principal locations is shown below.

(Unit: BOD, mg/l)

River	Location	Existing	Future Without Project (2015)	Future With Project (2015)	Standard (Category)
Sava Main	Oborovo	8.8 (8.6)	11.6	4.6	≤8.0 (III)
	Utok Kupe Nizvodno	5.6 (5.7)	7.4	3.1	≤4.0 (II)
Kupa	Recica	4.3 (4.3)	6.2	3.1	≤4.0 (II)
	Brest	3.5 (3.5)	4.7	2.6	≤4.0 (II)
Lonja	K. Lonja Strug (Crnec River)	27.1	49.1	7.2	≤8.0 (III)
	Struzec (Lonjsko Polje)	8.5	14.6	3.4	≤4.0 (II)
Kutina	Kutina	70.0	70.0	16.0	≤4.0 (II)

Note: Values in parentheses are the observed quality.

The proposed master plan will improve the river water quality to a large extent. The improved river water quality will satisfy the national standards in the Sava Main, Kupa and Lonja rivers. For the Kutina River, the improvement to BOD 16 mg/l is the maximum due to the limitation of natural river flow.

6. RECOMMENDATIONS FOR FINANCING POLICY

(1) Greater Government Contribution

The proposed master plan project will require a large amount of investment cost: (i) Kn. 530 million for collectors, and (ii) Kn. 840 million for treatment plants (excluding Zagreb City).

Recent financing mechanisms for municipal company sewerage projects have been: equity (20%), water management fund (40%), and local funding (40%).

Since the Water Management Fund is an interest free loan, the municipal service companies have to shoulder 80% of the investment cost. Furthermore, although the sewerage network is of benefit to the local population, wastewater treatment plants benefit the populations downstream and enhance the environment nationwide; therefore, they are of national importance.

It is therefore recommended that consideration be given to a higher level of government subsidy than has been granted in the recent past.

(2) Utilization of the Water Management Fund

The Water Management Financing Act practically limits the financial source for water pollution control to the payments collected through the water protection charge.

Besides, water supply systems are more developed than sewerage systems. Hence, more funds will be required in the sewerage sector in the immediate future.

It is suggested that the water use charge and the water protection charge be combined and made available for water supply and/or sewerage projects. This will make it possible to have a larger source of funds on a priority basis for the particular needs of the sewerage sector.

(3) Financial Arrangements for Sewerage Development

It is important to the success of the project in the Sava River Basin that a policy is developed to enhance the financial capability of the municipal service companies. Of major importance are the collection efficiency of these companies, and the level of tariff for sewerage services.

Source of funds for Croatian Waters is the water protection charge, which could be increased by improved collection efficiency. In addition, the level of the water pollution charge should not be lower than the cost of wastewater treatment in accordance with the Water Management Financing Act. This charge should be determined annually and enforced within the limitations of affordability.

Source of funds for the municipal service companies is the tariff, which should be set to cover the cost of operation, maintenance and development. Realistic tariffs should be set, within the limitations of affordability. The sources of funds to the companies could be increased by improved collection efficiencies.

In addition, loan agreements between Croatian Waters and the municipal companies should include provisions for the attainment of collection efficiency targets, for the setting of tariff levels necessary to meet financial obligations, and others.

(4) Financial Assistance for Industrial Wastewater Treatment

A substantial sum is billed annually by Croatian Waters to industries that pollute. The amount contributed by industry to the water protection charge is allocated for the protection of water resources in general and not specifically returned to industry for investment in prevention of pollution.

Approximately Kn. 130 million (excluding Zagreb) will be required to upgrade the pre-treatment facilities of large industries in the Study Area. It is therefore recommended that soft loans be made available to these industries, through the Water Management Fund, to upgrade their pre-treatment facilities.

PART II FEASIBILITY STUDY

1. INTRODUCTION

Among the 22 projects proposed in the master plan, five (5) sewerage development projects were selected as priority ones for the feasibility study through detailed discussions with the State Water Directorate and the Croatian Waters. These five (5) projects are: (i) the Dugo Selo Sewerage Development Project, (ii) the Vrbovec Sewerage Development Project, (iii) the Sisak Sewerage Development Project, (iv) the Kutina Sewerage Development Project, and (v) the Karlovac-Duga Resa Sewerage Development Project.

The proposed projects will treat a large quantity of industrial wastewater. Since setting a farther target year may cause a significant error in the estimation of industrial wastewater flow because the future economic growth of the country is still uncertain, the target year of the F/S projects, which are the first stage of the master plan, is set at the year 2007.

2. PLANNING BASIS

2.1 Design Wastewater Flow

(1) Design Unit Municipal Wastewater Quantity

The design unit municipal wastewater quantity for the F/S projects is summarized below.

Population Size		<10,000 (l/capita/day)	≥10,000 (l/capita/day)
Daily Average	Domestic	160	160
	Institutional/Small Industry	20	60
	Groundwater Infiltration	60	60
	Total	240	280
Daily Maximum	Domestic	210	210
	Institutional/Small Industry	30	80
	Groundwater Infiltration	60	60
	Total	300	350

(2) Design Unit Pollution Load of Municipal Wastewater

In the same way as the master plan study, the design unit pollution load of domestic wastewater is set at BOD: 60 g/capita/day and the design unit BOD pollution load of institutional and small industrial wastewater is set by assuming the BOD concentration at 200 mg/l.

(3) Design Total Sewerage Wastewater

In the same way as the master plan study, the wastewater quantity and quality of large industry is estimated individually. The total wastewater quantity and pollution loads into public sewerage are estimated by adding those of large industries to the municipal ones.

2.2 Wastewater Treatment Level

(1) General

The proposed master plan of all the five (5) sewage treatment plants will treat the wastewater to the level: BOD = 25 mg/l, COD-Cr = 125 mg/l, TSS = 35 mg/l and T-P = 2 mg/l by Anaerobic-Oxic Activated Sludge (AO) treatment system. The AO system consists of: (i) preliminary treatment; (ii) primary sedimentation; (iii) anaerobic process; (iv) aeration process; and (v) secondary sedimentation.

This feasibility study proposes the first stage treatment process of the master plan in due consideration of: (i) required improvement of river water quality; and (ii) required treatment cost.

(2) River Water Quality Simulation

For the above-mentioned purposes, the river water quality at the principal stations in the year 2007 was simulated for the cases of without and with project situations. The simulation was made for the river flow rate of 95% probability according to the government standard.

The point and non-point pollution load runoffs of the six (6) major sub-basins to the main rivers without project in 2007 are estimated as follows in terms of BOD, compared with the existing ones.

(Unit: BOD, kg/d)

Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	
Existing (1999)								
Municipal	50,594	0	1,734	2,208	3,878	2,862	61,308	(70%)
Industrial	10,942	0	159	1,639	906	1,540	15,196	(17%)
Non-point	848	22	963	3,199	4,550	1,066	10,649	(12%)
Total	62,384	22	2,857	7,046	9,334	5,468	87,153	(100%)
Without (2007)								
Municipal	53,829	0	2,703	5,516	5,371	4,361	71,780	(66%)
Industrial	23,947	0	160	115	538	1,656	26,411	(24%)
Non-point	848	22	963	3,199	4,550	1,066	10,649	(10%)
Total	78,621	22	3,826	8,829	10,459	7,084	108,840	(100%)

The river water quality with F/S projects was simulated under the following basic assumptions:

(a) In the above F/S towns, the industries that directly discharge into the rivers will also treat the wastewater in compliance with the government regulations. However, all the industries in the other towns/municipalities are assumed to maintain their existing conditions of wastewater treatment.

(b) The ongoing Zagreb sewerage project will treat the wastewater to the permissible limits of effluent (BOD = 25 mg/l, COD-Cr = 125 mg/l, TSS = 35 mg/l).

(3) Simulated Water Quality of Sava Main and Kupa River

The water quality of the Sava Main and Kupa rivers in 2007 without project was simulated and the results are shown in the table below compared with the existing ones.

(Unit: BOD mg/l)

River	Location	Existing (1999)	Without (2007)	With F/S (2007)	Remarks
Sava Main	Oborovo	8.8 (8.6)	10.2	4.8*	After Zagreb
	Utok Kupe Nizvodno	5.6 (5.7)	6.5	3.1*	After Sisak
Kupa	Recica	4.3 (4.3)	5.0	4.0	After Karlovac
	Brest	3.5 (3.5)	3.9	3.5	Before Petrinja

Note: Values in parentheses are the observed quality; * including effects of Zagreb Project

The water quality of the Sava Main River in 2007 is expected to greatly improve due to the ongoing Zagreb Project. Besides, the water quality of the Kupa River will not exceed the standard quality to a serious level even in the case of without project as shown in the above table. Hence, the treatment level of primary sedimentation is considered applicable for the Sisak and Karlovac-Duga Resa F/S projects.

The river water quality in 2007 with primary sedimentation (treatment efficiency: 40%) of the Sisak and Karlovac-Duga Resa F/S projects was simulated and the results are shown in the above table as well.

(4) Simulated Water Quality of Lonja River

The water quality of the Lonja River with Dugo Selo and Vrbovec F/S projects in 2007 was simulated for the principal river locations: Crnec River at K. Lonja Strug and Lonja River (Lonjsko Polje) at Struzec. In this simulation, two (2) alternatives of treatment level: (i) primary sedimentation (treatment efficiency: 40%) and (ii) biological treatment (effluent BOD: 25 mg/l) were also compared. The results are summarized below.

(Unit: BOD mg/l)

Treatment Level	K. Lonja Strug	Struzec
Existing (1999)	27.1	8.5
Without Project (2007)	36.3	11.1
Primary Sedimentation (2007)	33.5	10.6
Biological Process (2007)	31.0	10.1

As shown in the above table, the improvement effects are small. Additional projects may be necessary to attain a significant water quality improvement of the Lonja River.

On the other hand, the implementation of the Sesvete East project has already been approved and the Ivanić Grad-Kloštar Ivanić project will be implemented in the near future. The river water quality of the Lonja River will improve as shown below in relation to the above two (2) projects. The improved river water quality would satisfy the Category III standards for the Crnec River and nearly meets the Category II standards for the Lonjsko Polje.

(Unit: BOD mg/l)

Treatment Level	K. Lonja Strug	Struzec
Existing (1999)	27.1	8.5
Without Project (2007)	36.3	11.1
Primary Sedimentation (2007)	19.4	7.9
Biological Process (2007)	7.6	5.2
Standard (category)	≤8.0 (III)	≤4.0 (II)

(5) Simulated Water Quality of Kutina River

The natural flow of the Kutina River is negligible in dry season. All the river water is recharged by the wastewater of the sewerage and factories. Besides, the Petrokemija factory discharges a large quantity of wastewater into the Kutina River with a low BOD concentration, but a high T-N content.

The river water quality with the Kutina F/S project is estimated as follows, compared with the case without project.

(Unit: BOD, mg/l)

Treatment	1999	2007
Without	70	70
Primary Sedimentation	-	50
Biological Treatment	-	16

(6) Proposed Wastewater Treatment Level

The Dugo Selo, Vrbovec and Kutina F/S projects will treat the wastewater to BOD 25 mg/l; while, the Sisak and Karlovac-Duga Resa F/S projects will treat the influent BOD by 40%. However, the treatment of T-P will be deferred to the second stage in all the projects in due consideration of priority sequence.

2.3 Structural Design Principle

(1) In principle, the proposed sewerage system aims to serve almost all the population within the existing service area in 2007. No significant extension of the service area is proposed.

(2) Necessary transport collectors, main sewers and secondary/tertiary sewers to attain the above objectives are proposed. The collector/sewer size is designed to meet the design wastewater flow of the master plan.

(3) The treatment plant is proposed since it is the first stage of the master plan. The capacity is designed to treat the wastewater flow in 2007 and the process is applied to meet the requirement of river water quality improvement in 2007.

3. PROPOSED SEWERAGE DEVELOPMENT

3.1 Design Criteria for Sewerage System and Treatment Plant

The design criteria of the sewerage systems and treatment plants of the five (5) F/S projects are summarized below. The proposed sewerage service areas are shown in Fig. II-1 (1) to Fig. II-5 (1).

Item	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Service Area (ha)	516	422	944	734	1,142
Served Population	10,300	5,900	45,400	19,600	43,800
Served Large Industry (No.)	-	2	3	1	10
Daily Maximum Wastewater Quantity (m^3/d)	3,605	4,539	16,973	7,678	23,285
Municipal Wastewater (m^3/d)	3,605	1,770	15,890	6,860	15,430
Industrial Wastewater (m^3/d)	-	2,769	1,083	818	7,855
Influent BOD Concentration (mg/l)	211	198	211	190	193
Pollution Load (PE)	12,700	14,600	59,900	24,500	74,800
Effluent BOD Concentration (mg/l)	25	25	127	25	116

3.2 Proposed Sewer

The main features of the proposed collectors in the five (5) F/S projects are summarized below. Location of the proposed collectors is shown in Fig. II-1 (1) to Fig. II-5 (1).

Urban Center	Transport Collector		Main Sewer		Secondary/Tertiary		Total	
	∅ (mm)	L (m)	∅ (mm)	L (m)	∅ (mm)	L (m)	∅ (mm)	L (m)
Dugo Selo	800-1,200	5,490	-	-	400	2,100	400-1,200	7,590
Vrbovec	350-400	1,880	-	-	100	750	100-400	2,630
Sisak	450-1,000	6,340	-	-	-	-	450-1,000	6,340
Kutina	-	-	400	180	100-200	9,000	100-400	9,180
Karlovac - Duga Resa	300-1,700	11,670	-	-	400	1,000	300-1,700	12,670
Total		25,380		180		12,850		38,410

3.3 Proposed Treatment Plant

The mechanical dewatering system is proposed for the sludge treatment of all the five (5) F/S projects. The following treatment processes are proposed:

(1) Biological Treatment (AS) is proposed for the Dugo Selo, Vrbovec and Kutina F/S projects as the first stage. AS is part of the AO process. The remaining part of the AO process will be deferred to the second stage to remove T-P.

(2) Primary Sedimentation is proposed for the Sisak and Karlovac-Duga Resa F/S projects as the first stage.

The main features of the proposed treatment plants in the five (5) F/S projects are summarized in the following table. Layouts of the proposed treatment plants are shown in Fig. II-1 (2) to Fig. II-5 (2).

Main Features	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Treatment Process	Activated Sludge	Activated Sludge	Primary Sedimentation	Activated Sludge	Primary Sedimentation
Preliminary Treatment (unit)	1	1	1	1	1
Primary Sedimentation Tank					
Unit	3	3	6	3	5
Width (m)	3.0	3.0	4.0	4.0	6.5
Length (m)	12.0	14.0	18.0	18.0	19.0
Depth (m)	3.0	3.0	3.0	3.0	3.0
Aeration Tank					
Unit	3	3	-	3	-
Width (m)	5.0	5.0	-	5.0	-
Length (m)	20.0	22.0	-	35.0	-
Depth (m)	5.0	5.0	-	5.0	-
Secondary Sedimentation Tank					
Unit	2	2	-	2	-
Diameter (m)	12.0	13.0	-	17.0	-
Depth (m)	3.5	3.5	-	3.5	-
Belt Press Filter					
Unit	2	2	2	2	2
Width (m)	1.5	1.5	2.0	1.5	2.0

Note: Preliminary Treatment includes inlet pump, screen, oil/sand trap.

4. PROJECT COST

4.1 Construction Cost

The construction cost of collectors and treatment plants is estimated with the following cost components. In this estimate, the following exchange rates at the end of February 2001 is employed: US$1.00 = Kn. 8.3 = JP¥ 116.

Item	Remarks
(1) Direct Construction Cost	
(2) Land Acquisition Cost	
(3) Indirect Construction Cost	
(a) Engineering Cost	10% × (1)
(b) Administration Cost	3% × (1)
(c) Customs Duties	10% of Mechanical/Electrical Works
(d) VAT	22% × {(1) + (a)}
(4) Contingency	10% × (1)

The construction cost of each of the five (5) F/S projects is as estimated below at 2001 prices.

(Unit: million Kn)

Item	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa	Total
Direct Construction Cost	33.51	25.69	45.52	27.12	85.39	217.22
Collector	10.42	2.42	14.18	6.08	41.73	74.83
Transport/Main Collector	8.77	2.10	14.18	0.18	40.86	66.09
Secondary/Tertiary Sewer	1.65	0.32	-	5.91	0.87	8.74
Treatment Plant	23.08	23.27	31.33	21.04	43.66	142.38
Land Acquisition Cost	0.19	0.20	-	-	1.45	1.84
Indirect Construction Cost	13.90	11.05	18.89	11.33	34.38	89.53
Contingency	3.35	2.57	4.55	2.71	8.54	21.72
Total	50.94	39.51	68.95	41.16	129.76	330.31

4.2 Operation and Maintenance Cost

The annual operation and maintenance (O&M) costs of the five (5) F/S projects (excluding O&M costs for the existing sewerage systems) are as estimated below at 2001prices.

(Unit: 10^3 Kn)

Facilities	Item	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa	Total
Collector	Maintenance	79	19	46	107	317	568
WWTP		1,508	1,508	1,937	2,417	2,013	9,383
	Electric Charge	350	350	499	666	526	2,391
	Personnel Expense	499	499	499	499	499	2,495
	Mechanical Maintenance	168	168	240	320	252	1,148
	Laboratory	154	154	220	293	231	1,052
	Others	336	336	479	639	505	2,295
Total		1,588	1,527	1,983	2,524	2,330	9,952

Note: WWTP means wastewater treatment plant.

5. ENVIRONMENTAL IMPACT ASSESSMENT

The environmental impacts of the proposed projects were assessed as to the following items: (i) land acquisition, (ii) noise during construction/operation, (iii) foundation geology of treatment plant, (iv) flora/fauna, (v) dust/odor, (vi) water pollution/water use, and (vii) sludge disposal/groundwater. The assessment results are summarized below.

Item	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Land Acquisition	O	O	O	O	O
Noise	O	O	Δ	O	O
Geology	O	O	O	O	O
Flora/Fauna	O	O	O	O	O
Dust/Odor	Δ	Δ	Δ	Δ	Δ
Water Pollution/Water Use	O	O	O	O	O
Sludge Disposal/Groundwater	Δ	Δ	Δ	Δ	Δ

Note: O: none or negligible Δ: slight impact but acceptable

(1) Noise may be caused by the installation of the transport collectors in the Sisak project. However, the impact is slight, temporary and acceptable in the daytime.

(2) The operation of construction equipment and earth works may produce dust. Although the impacts are temporary, some control measures (such as covering) should be taken. However, the operation of the sewage treatment plant will cause no significant odor since the generated sludge is treated by the mechanical dewatering system and the treatment plants are located more than 250 to 300 m away from the nearest residences.

(3) Heavy metals were either not detected or negligible in the wastewater effluent of the large industries in the F/S towns. Hence, the quality of sludge generated from the projects is considered normal. On the other hand, the concentration of heavy metals in the sludge of the existing biological treatment plants in the country is lower than the permissible limits of the Croatian Government for sludge disposal.

Accordingly, the dewatered sludge of projects can be disposed on the solid waste disposal sites of the respective towns. The groundwater around the existing solid waste disposal sites in the F/S towns has only been slightly polluted by organic matter. Further, the F/S towns have plans to install a leachate treatment system in the near future. Hence, the sludge disposal on the existing solid waste disposal sites will cause no significant impacts on the surrounding environments.

6. FINANCIAL ANALYSIS

6.1 Introduction

The sewerage systems of Dugo Selo, Vrbovec, Sisak, Kutina, Karlovac and Duga Resa are independently operated and maintained by their respective municipal service companies at present. However, the sewerage systems of Karlovac and Duga Resa will be jointly operated and maintained by their service companies in the future.

The financial feasibility of the proposed five (5) sewerage development projects was confirmed through evaluation of the financial statement of each municipal company. Further, it was checked through the calculation of financial internal rate of return (FIRR). The financial analysis was made for both the existing and the proposed integrated sewerage system.

The financial feasibility of the projects much depends on the future growth of GDP. It is because the affordable sewerage charges and the personnel expenses for operation/maintenance will increase in proportion to the growth of per capita GDP and further, the industrial wastewater quantity will also increase according to the growth of GDP.

The industrial activities in the Study Area have not recovered yet and the future economic growth of the country is still uncertain. Hence, in this financial analysis, a lower growth of GDP (half of the assumed growth for the engineering studies) is applied to ensure the reliability of financial evaluation; namely, 1.8% for 2001-2005, 2.75% for 2006-2010 and 2.25% for 2011-2015.

6.2 Implementation Schedule

The proposed projects are assumed to start in 2003 with completion in 2007. The treatment plants of Dugo Selo, Vrbovec and Kutina will be constructed in two (2) stages: Stage I for primary treatment system and Stage II for biological treatment system. The influent/effluent wastewater to/from the primary sedimentation tank will be monitored for one (1) year before the commencement of Stage II works. On the other hand, the treatment plant of Sisak and Karlovac-Duga Resa will be constructed simultaneously since the wastewater is to be treated only by the primary sedimentation process.

The proposed implementation schedule of the five (5) F/S projects is given below.

Item	Construction Works	Dugo Selo, Vrbovec, Kutina	Sisak, Karlovac-Duga Resa
Detailed Design and Land Acquisition		2003	2003
Stage I Construction	Collector, Primary Treatment, Sludge Treatment, etc.	2004 - Mid 2005	2004 - 2006
Monitoring	---	Mid 2005 - Mid 2006	-
Stage II Construction	Biological Treatment	Mid 2006 - 2007	-

6.3 Disbursement Schedule of Construction and O&M Costs

The disbursement schedules of construction costs are summarized below.

(Unit: 10^3 Kn, 2001 Price)

Project	2003	2004	2005	2006	2007	Total
Dugo Selo	1,058	26,414	13,643	3,566	6,261	50,941
Vrbovec	867	18,616	9,642	3,683	6,698	39,506
Sisak	1,479	8,027	29,724	29,724	-	68,954
Kutina	705	18,753	9,729	4,225	7,744	41,157
Karlovac-Duga Resa	4,228	21,867	51,830	51,830	-	129,755
Total	8,337	93,677	114,567	93,028	20,703	330,312

The disbursement schedules of the total O&M cost of existing and proposed sewerage systems are summarized below.

(Unit: 10^3 Kn, 2001 Price)

Year	2003	2004	2005	2006	2007	2008	2010	2015 -
Dugo Selo	120	122	696	1,280	1,291	2,387	2,428	2,520
Vrbovec	768	776	1,326	1,889	1,911	3,019	3,082	3,222
Sisak	7,308	7,388	7,469	7,596	10,307	10,458	10,771	11,470
Kutina	2,252	2,276	3,167	4,082	4,133	5,826	5,950	6,226
Karlovac-Duga Resa	8,091	8,180	8,270	8,410	12,077	12,248	12,606	13,403

6.4 Revenue of Sewerage Charge

(1) Existing Unit Sewerage Charge

At present, two (2) kinds of unit charges are set in each town: one is for domestic users and another is for the other users (institutional and small/large industries). The sewerage charges are imposed on the users based on their water consumption. The unit sewerage charges including VAT (22%) of the six (6) towns in 2001 are as estimated below on the basis of wastewater quantity by assuming the sewerage return rate at 80%.

(Unit: Kn/m^3, 2001 Price)

Town	Domestic User	Other Users
Dugo Selo	0.36	0.74
Vrbovec	0.59	0.81
Sisak	1.34	4.00
Kutina	4.12	4.12
Karlovac	1.45	2.67
Duga Resa	0.54	0.54
Average	1.40	2.15

(2) Affordable Unit Domestic Sewerage Charge

The average household income in the six (6) towns is estimated at 3,600 Kn/month. According to the questionnaire survey, the inhabitants' willingness to pay domestic sewerage charges ranges from 18.0 Kn/household/month to 34.0 Kn/household/month, or 24.5 Kn/household/month on the average.

On the other hand, the average domestic wastewater quantity of households is estimated to be 12.0 m^3/household/month when the family size is assumed at 3 persons.

From the above data and discussions, the rates of existing and affordable domestic sewerage charges to household income are calculated as follows.

Town	Household Domestic Charge (Kn/household/month)		Domestic Charge Rate to Household Income (%)	
	Existing	Willingness to Pay	Existing	Willingness to Pay
Dugo Selo	4.32	28.0	0.12	0.78
Vrbovec	7.08	20.0	0.20	0.56
Sisak	16.08	18.0	0.45	0.50
Kutina	49.44	34.0	1.37	0.94
Karlovac	17.40	20.0	0.48	0.56
Duga Resa	6.48	27.0	0.18	0.75
Average	16.80	24.5	0.47	0.68
Note: Estimated at 2001 prices				

As shown in the above table, the affordable ratio of domestic sewerage charge to household income is in the range of 0.5% and 0.9%, or 0.7% on the average.

(3) Wastewater Quantity

The sewerage wastewater quantity is classified into domestic wastewater and other wastewater (institutional, small industries and large industries) corresponding to the classification of sewerage charge collection. The wastewater quantity is assumed to increase at a certain rate until 2007 and thereafter, become constant.

The projects are the first stage of the master plan and the treatment of excess wastewater generated after 2007 is regarded as the second stage project. The annual wastewater quantity of the five (5) sewerage systems is as estimated below. In this estimation, the connection rate is assumed at 90% for domestic users and 100% for other users.

(Unit: 10^3 m^3/year)

Year	2003	2004	2005	2006	2007 -
Dugo Selo	742	798	853	908	974
Domestic	520	558	596	634	682
Others	221	239	257	274	292
Vrbovec	348	376	835	1,298	1,333
Domestic	304	327	350	373	396
Others	45	49	485	925	937
Sisak	3,662	3,915	4,168	4,421	4,674
Domestic	2,360	2,532	2,703	2,875	3,046
Others	1,301	1,383	1,465	1,546	1,628
Kutina	1,663	1,783	1,903	2,022	2,143
Domestic	996	1,075	1,154	1,233	1,313
Others	667	708	749	789	830
Karlovac-Duga Resa	4,260	4,559	4,859	5,745	6,637
Domestic	2,126	2,325	2,524	2,723	2,922
Others	2,133	2,234	2,335	3,023	3,715

(4) Revenue of Sewerage Charge

The annual revenue of sewerage charge is estimated as the product of the annual wastewater quantity and the proposed sewerage charge. In this estimation, the existing collection rate of sewerage charge is assumed to gradually improve to 90% by 2007.

6.5 Financial Evaluation

6.5.1 General

Each municipal service company should be able to perform a sound sewerage business by collecting sewerage charges set within the users' affordability. For this purpose, a certain

amount of financial assistance from the Central Government (including Croatian Waters) is considered necessary for the construction of the proposed projects. The possible financial sources of construction cost are the Central Government (Grant and Water Management Fund Loan) and the external ODA loan to be extended through the Central Government.

In this financial evaluation, the required sewerage charge and financial assistance from the Central Government are estimated by analyzing the financial status of each municipal service company. The financial limitation of the Central Government is not considered.

6.5.2 Existing Financing System

The financing system usually applied for sewerage projects in Croatia is as follows:

(1) Twenty percent (20%) of the construction cost is provided by the Central Government as Grant.

(2) Forty percent (40%) of the construction cost is financed from the proceeds of an interest free loan with 50-year repayment from the Water Management Fund through Croatian Waters.

(3) The remaining 40% of the construction cost is financed with funds from the Local Government/municipal service company.

(4) The O/M and depreciation costs are fully covered by sewerage charges, in principle.

6.5.3 Calculation of Required Sewerage Charge

(1) General

In the determination of the required sewerage charges, financial statements consisting of income and cash flow statements of the municipal service companies were prepared on the assumption that they satisfy the following conditions under the assumed financial assistance of the Central Government and the external loan.

(a) Annual net income should be almost positive throughout the entire period of 25 years (2003–2027).

(b) External loan liability should be zero in 25 years.

(c) Necessary cash should be reserved before the replacement of mechanical and electrical equipment.

(2) Preparation of Alternatives

The required sewerage charges vary depending on the conditions of the financial assistance of the Central Government and the external loan. Hence, the following typical four (4) alternatives were prepared for the financial evaluation.

Case	Financing for Construction Cost		
	Central Government Grant	Water Management Fund	External Loan
Alternative-1	20%	40% (no interest)	40% (interest: 2%)
Alternative-2	20%	40% (no interest)	40% (interest: 6%)
Alternative-3	40%	-	60% (interest: 2%)
Alternative-4	60%	-	40% (interest: 2%)

In the above alternatives, repayment of the Water Management Fund loan is assumed to be 50 years including a 7-year grace period, and that of the external loan is 25 years also including a 7-year grace period.

(3) Calculated Sewerage Charge

The required sewerage charges of the five (5) municipal service companies under the four (4) alternatives were calculated under the following assumptions:

(a) The Water Management Fund loan and the external loan are repaid from sewerage charges. Besides, the O/M and depreciation costs are also covered by sewerage charges.

(b) The unit sewerage charges vary at present and are set by each town individually. The ratio between unit domestic charge and unit other charges also vary town at present and the existing ratio is assumed to be maintained in the future.

(c) The unit sewerage charge will increase in proportion to the growth of per capita GDP.

(d) Profit tax is assumed at 20%.

(e) In Karlovac Town, the replacement of damaged sewers will be implemented during five (5) years (2003-2007), separately from the proposed sewerage development project of Karlovac-Duga Resa. The replacement cost is estimated to be Kn. 58.88 million at the price of 2001. It is assumed that 60% of the cost is to be provided by the Local Government in the sort of grant and 40% is to be covered by sewerage charges.

The calculated sewerage charges in 2001 are shown in the following table at the price of 2001 compared with the existing ones. The values of calculated internal rate of return (FIRR) are also shown in the same table.

	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Existing					
Rate to Household Income (%)	0.12	0.20	0.45	1.37	0.48 (0.18)
Domestic Charge (Kn/m^3)	0.36	0.59	1.34	4.12	1.45 (0.54)
Other Charge (Kn/m^3)	0.74	0.81	4.00	4.12	2.67 (0.54)
FIRR (%)					
Alternative 1					
Rate to Household Income (%)	0.95	0.80	0.48	1.37	0.63
Domestic Charge (Kn/m^3)	2.85	2.40	1.44	4.12	1.89
Other Charge (Kn/m^3)	5.86	3.29	4.30	4.12	2.92
FIRR (%)	4.81	4.69	3.67	24.23	4.87
Alternative 2					
Rate to Household Income (%)	1.02	0.85	0.51	1.37	0.66
Domestic Charge (Kn/m^3)	3.06	2.55	1.53	4.12	1.98
Other Charge (Kn/m^3)	6.29	3.50	4.57	4.12	3.06
FIRR (%)	6.54	6.51	6.75	24.23	6.20
Alternative 3					
Rate to Household Income (%)	0.98	0.84	0.50	1.37	0.67
Domestic Charge (Kn/m^3)	2.94	2.52	1.50	4.12	2.01
Other Charge (Kn/m^3)	6.04	3.46	4.48	4.12	3.11
FIRR (%)	5.54	5.70	5.35	40.67	5.55
Alternative 4					
Rate to Household Income (%)	0.85	0.75	0.47	1.37	0.62
Domestic Charge (Kn/m^3)	2.55	2.25	1.41	4.12	1.86
Other Charge (Kn/m^3)	5.24	3.09	4.21	4.12	2.87
FIRR (%)	6.58	5.98	5.48	Large	5.91

Note: Values are estimated at 2001 prices. Values not in parentheses are the existing charges in Karlovac, while those in parentheses are for Duga Resa.

6.5.4 Proposed Sewerage Charge and Financial Assistance

According to the questionnaire survey, the inhabitants' willingness to pay domestic sewerage charges is in the range of 0.5% to 0.9% of household income, or 0.7% on the average. Hence, the proposed domestic sewerage charge should not exceed 0.9% of household income.

Further, the proposed projects mainly benefit the population downstream, enhance the environment nationwide and are therefore of national importance. Hence, the financial assistance of the Central Government for each of the five (5) projects should be set higher than has been usually extended.

From the above considerations, the sewerage charges in Alternative 4 are proposed; namely, sixty percent (60%) of the construction cost shall be provided by the Central Government as a Grant and the remaining forty percent (40%) is to be financed with funds from an external loan through the Central Government. The external loan conditions are to be 2.0% interest and 25-year repayment including a 7-year grace period.

It should be noted that the above external loan (40% of construction cost) does not mean the actual amount of loan to be obtained by the Central Government but only the loan amount to be repaid from sewerage charges. In case the financial resources of the Central Government are limited, it may need to obtain more external loan to be able to extend the necessary grant (60% of construction cost) to the municipal service companies.

The proposed sewerage charges will increase according to the assumed growth of GDP in the future, as shown below.

(Unit: Kn/m^3, 2001 Price)

Project	Existing (2001)	Proposed				
		2001	2003	2005	2010	2015 -
Dugo Selo						
Domestic	0.36	2.55	2.64	2.74	3.14	3.51
Others	0.74	5.24	5.43	5.63	6.45	7.20
Vrbovec						
Domestic	0.59	2.25	2.33	2.42	2.77	3.09
Others	0.81	3.09	3.20	3.32	3.80	4.25
Sisak						
Domestic	1.34	1.41	1.46	1.51	1.73	1.94
Others	4.00	4.21	4.36	4.52	5.18	5.79
Kutina						
Domestic	4.12	4.12	4.27	4.42	5.07	5.66
Others	4.12	4.12	4.27	4.42	5.07	5.66
Karlovac-Duga Resa						
Domestic	1.45 (0.54) *	1.86	1.93	2.00	2.29	2.56
Others	2.67 (0.54) *	2.87	2.98	3.09	3.54	3.95

*: Values not in parentheses are existing charges in Karlovac, while those in parentheses are for Duga Resa

7. RECOMMENDATIONS

(1) The proposed five (5) sewerage development projects; namely, Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac-Duga Resa are technically feasible and financially viable. Early implementation of the projects is necessary to cope with the existing water pollution in the Sava River Basin.

(2) For this purpose, the Central Government/State Water Directorate/Croatian Waters and the local governments concerned should immediately proceed with the necessary legal procedures and financial arrangements.

(3) Water pollution of the Lonja River is the worst in the entire Sava River Basin. Early implementation of the Sesvete East and the Ivanić Grad-Kloštar Ivanić sewerage development projects is also awaited to attain a satisfactory water pollution control of the Lonja River.

(4) Since the available data on river water quantity and quality in the Lonja River are at present limited, necessary monitoring of the river water quantity and quality should be commenced immediately.

TABLES

Table I-1 Proposed Wastewater Treatment of Large Pollutant Industries

Town	Industry Name	Wastewater Quantity (m^3/d)		Wastewater Quality BOD (mg/l)		Pollution Load BOD (kg/d)		Effluent Recipient (Category)		Construction Cost (Million Kuna)
		1999	2015	1999	2015	1999	2015	1999	2015	
Sesvete-East	Agroproteinka d.d.	228	377	2,230	250	508	94	Lonja R. (II)	Sewerage	9.91
	Duma Kože d.o.o.	509	1,222	686	250	349	306	Lonja R. (II)	Sewerage	2.00
Vrbovec	PIK Vrbovec Mesna Ind.	2,132	3,523	186	186	397	655	Lonja R. (II)	Sewerage	-
Sisak	Industrija Nafte d.d. Rafinerija	9,399	15,531	27	25	251	388	Kupa R. (II)	Kupa R. (II)	10.30
	Herbos d.d.	604	939	205	205	124	192	Sewerage	Sewerage	1.50
	Termoelektrana Sisak	451	745	5	5	2	3	Sava R. (II)	Sava R. (II)	1.00
	Tvornica Segestica	204	337	866	250	177	84	Sewerage	Sewerage	7.16
	Zeljezara Poduzece Metaval	3,182	4,949	12	12	39	61	Sava R. (II)	Sava R. (II)	2.00
	Ljudevit Posavski Mlin i Pekare	83	137	1,584	250	131	34	Sewerage	Sewerage	5.91
Kutina	Petrokemija (Industry)	10,388	17,165	11	11	115	191	Kutina R. (II)	Kutina R. (II)	10.00
	Petrokemija (Sanitary)	663	1,063	19	19	12	20	Sewerage	Sewerage	-
Karlovac	Karlovaeka Pipovara d.d.	2,301	3,802	456	250	1,049	951	Sewerage	Sewerage	16.28
	PPK-karlovacka Industrija Mesna	348	609	484	250	168	152	Kupa R. (II)	Sewerage	7.46
	Velebit	248	410	150	150	37	62	Kupa R. (II)	Sewerage	-
	Lola Ribar	307	507	116	116	36	59	Mrežnica R. (II)	Sewerage	-
	Karlovacka Industrija Mlijeka	250	413	147	147	37	61	Kupa R. (II)	Sewerage	0.50
Duga Resa	Pamućna Industrija Duga Resa	2,416	3,992	120	120	290	479	Mrzenica R. (II)	Sewerage	0.10
Zabrešić	PLIVA	1,928	3,186	339	250	654	797	Sava R. (II)	Sewerage	15.30
Petrinja	Gavrilovic d.d.	1,357	1,979	116	116	157	230	Kupa R. (II)	Sewerage	1.00
Sub-total (Sewerage)		3,855	22,496			1,494	4,175			
Sub-total (River)		33,143	38,390			3,041	644			
Total		36,998	60,886			4,534	4,818			90.42

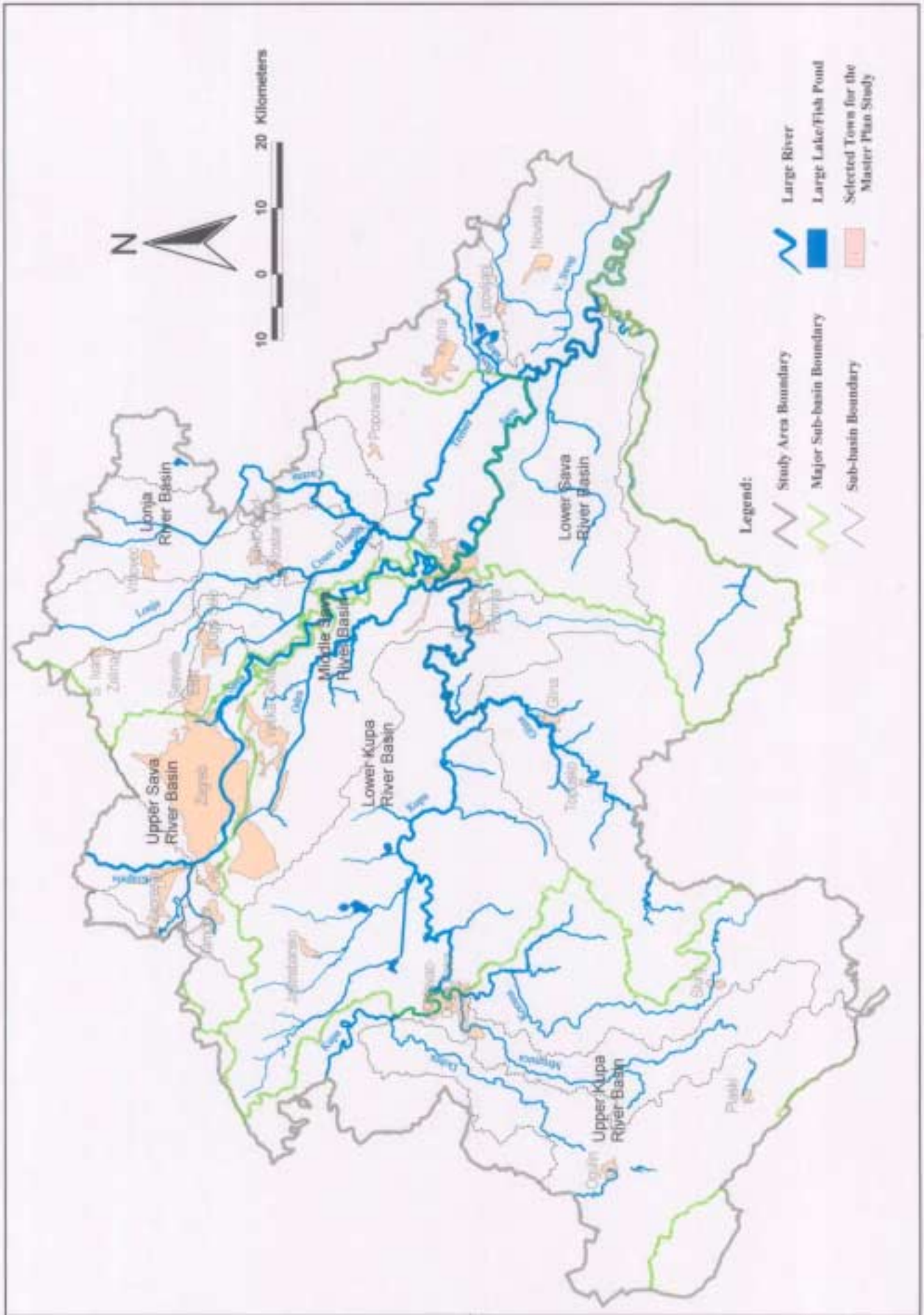
Table I-2 Proposed Sewerage Development Plan

Name	Served Population		Served Area (ha)		Design Quantity (m^3/day)			Person Equivalent (PE)	Treatment Process *	Construction Cost (Million Kuna)		
	1999	2015	1999	2015	Domestic	Industry	Total			Collector	WWTP	Total
1 Zagreb	800,000	935,000	25,600	25,600	274,860	167,510	442,370	1,500,000	AS			1,365.0
2 Sesvete-East	11,900	17,600	555	837	7,040	1,599	8,639	29,600	AO	17.2	49.3	66.5
3 Dugo Selo	9,100	14,200	516	1,072	5,680	0	5,680	18,500	AO	49.7	41.3	91.0
4 Vrbovec	5,000	8,400	393	791	2,856	3,710	6,566	20,400	AO	36.5	41.7	78.2
5 Sisak	39,400	52,400	944	2,380	20,960	1,413	22,373	73,400	AO	67.8	92.0	159.8
6 Kutina	16,100	24,800	549	1,303	9,920	1,063	10,983	32,900	AO	43.7	40.2	84.0
7 Karlovac -	28,200	55,800	966	1,978	22,320	7,603	29,923	94,800	AO	133.2	126.7	259.9
Duga Resa	3,800	10,900	133	205	4,360	3,992	8,352	22,200				
8 Sv. Ivan Zelina	3,200	7,000	251	569	2,380	0	2,380	7,700	OD	18.1	25.5	43.6
9 Ivanić Grad -	5,700	10,600	524	863	4,240	1,283	5,523	14,300	AO	10.9	32.4	43.4
Kloštar Ivanić	600	800	138	150	272	0	272	900				
10 Samobor	15,400	29,200	1,518	1,914	11,680	1,528	13,208	39,500	AO	14.4	44.0	58.4
11 Zaprešić	13,300	30,500	949	1,491	12,200	6,544	18,744	61,300	AO	29.4	76.8	106.3
12 Velika Gorica	33,500	62,400	1,453	2,011	24,960	662	25,622	82,200	AS	30.0	47.5	77.5
13 Jastrebarsko	5,300	8,100	409	623	2,754	180	2,934	9,600	OD	8.4	27.7	36.0
14 Petrinja	10,300	13,100	419	650	5,240	1,979	7,219	20,900	AO	10.4	45.2	55.6
15 Glina	2,000	5,200	175	480	1,768	0	1,768	5,800	OD	14.3	22.3	36.6
16 Topusko	500	1,600	34	84	544	0	544	1,800	AL	3.5	3.0	6.5
17 Popovaća	1,800	3,600	123	179	1,224	747	1,971	7,200	OD	3.7	23.1	26.7
18 Lipovljani	800	3,000	60	328	1,020	0	1,020	3,300	OD	11.2	17.1	28.3
19 Novska	4,000	9,000	380	541	3,060	0	3,060	9,900	OD	9.0	28.2	37.2
20 Ogulin	0	10,400	0	468	4,160	340	4,500	13,800	AO	8.5	34.0	42.5
21 Plaški	0	800	0	52	272	0	272	900	OD	3.0	9.3	12.4
22 Slunj	600	2,400	62	219	816	0	816	2,700	OD	7.8	15.7	23.4
Sub-total (except Zagreb)	210,500	381,800	10,549	19,186	149,726	32,643	182,369	573,600				2,738.8
Total	1,010,500	1,316,800	36,149	44,786	424,586	200,153	624,739	2,073,600		530.8	843.0	1,373.8

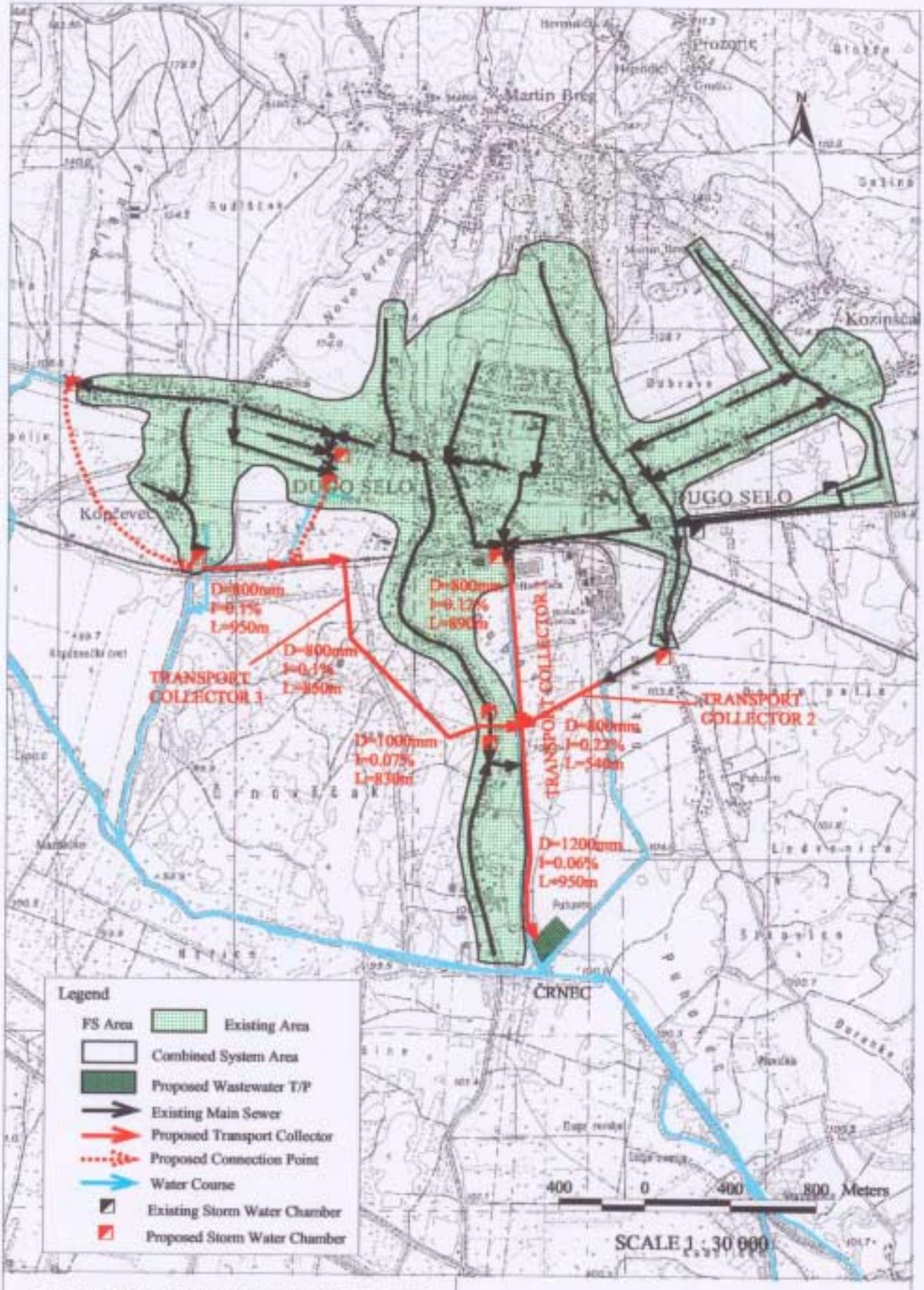
1): * AS:Activated Sludge, AO: Anaerobic Oxic Activated Sludge, OD: Oxidation Ditch, AL: Aerated Lagoon

2): Zaprešić includes Brdovec

FIGURES



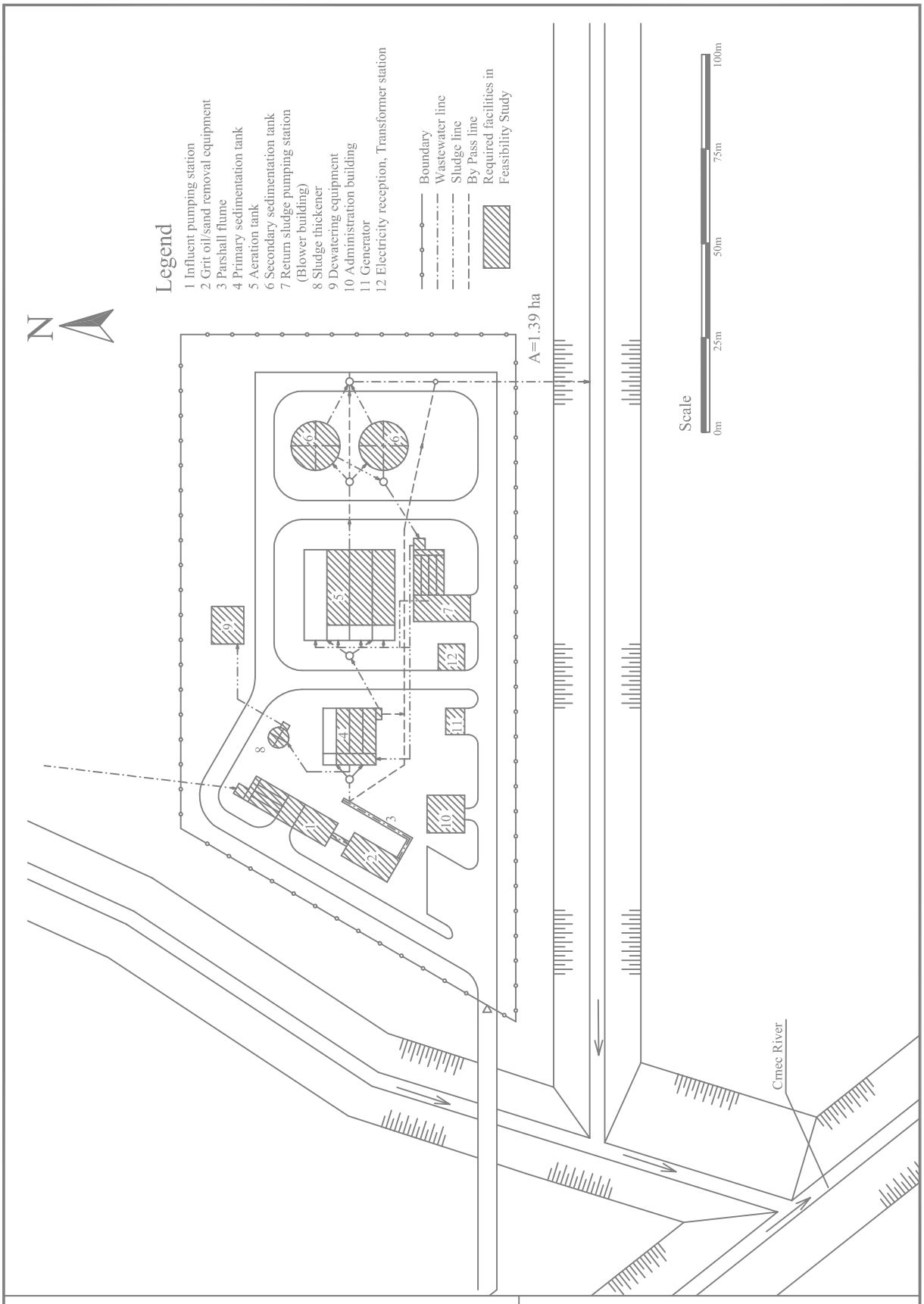
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. 1-4 River Systems and Objective Urban Centers in the Study Area
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

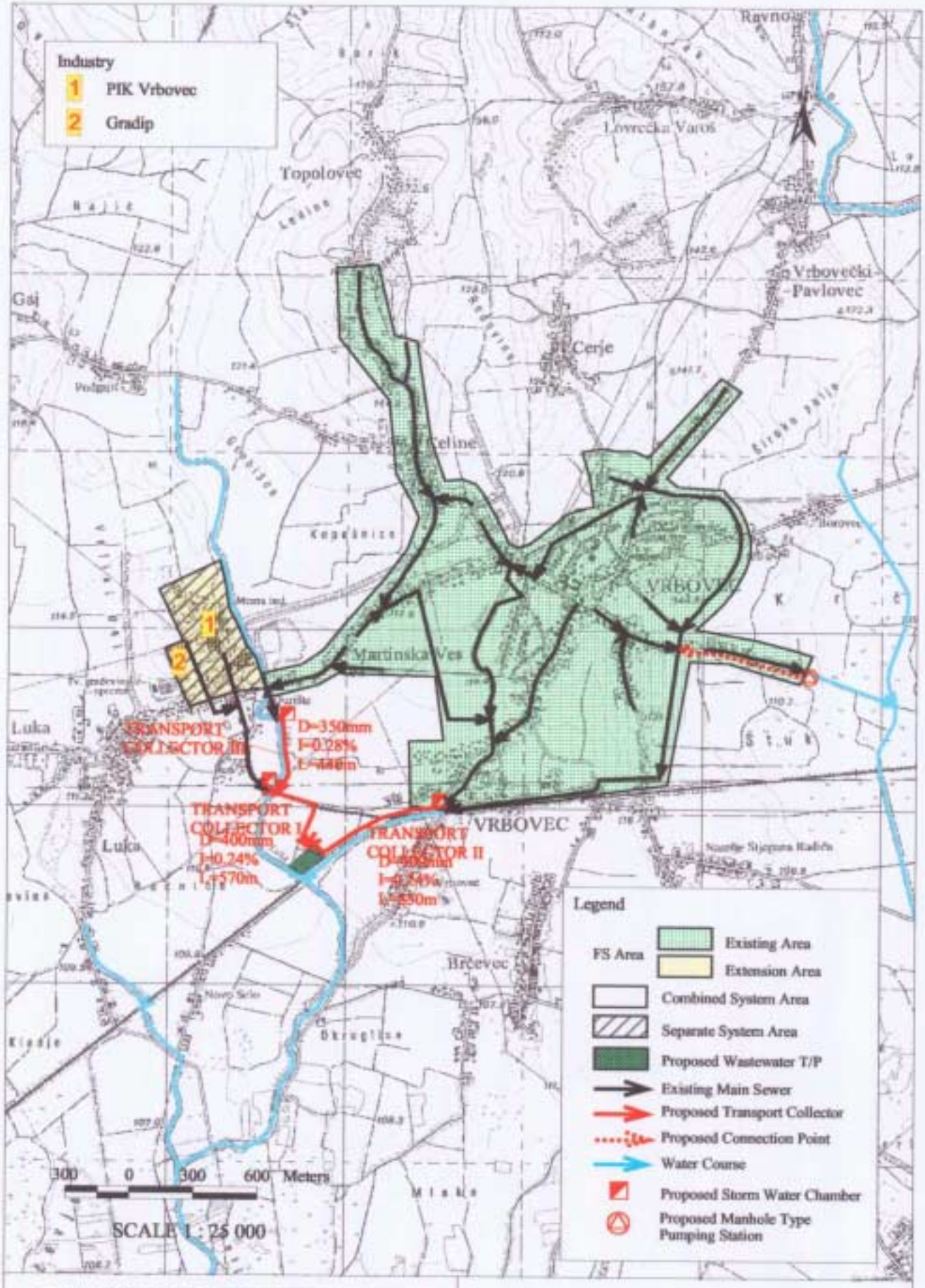
Fig. II-1(1) Sewerage Development System in Dugo Selo



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

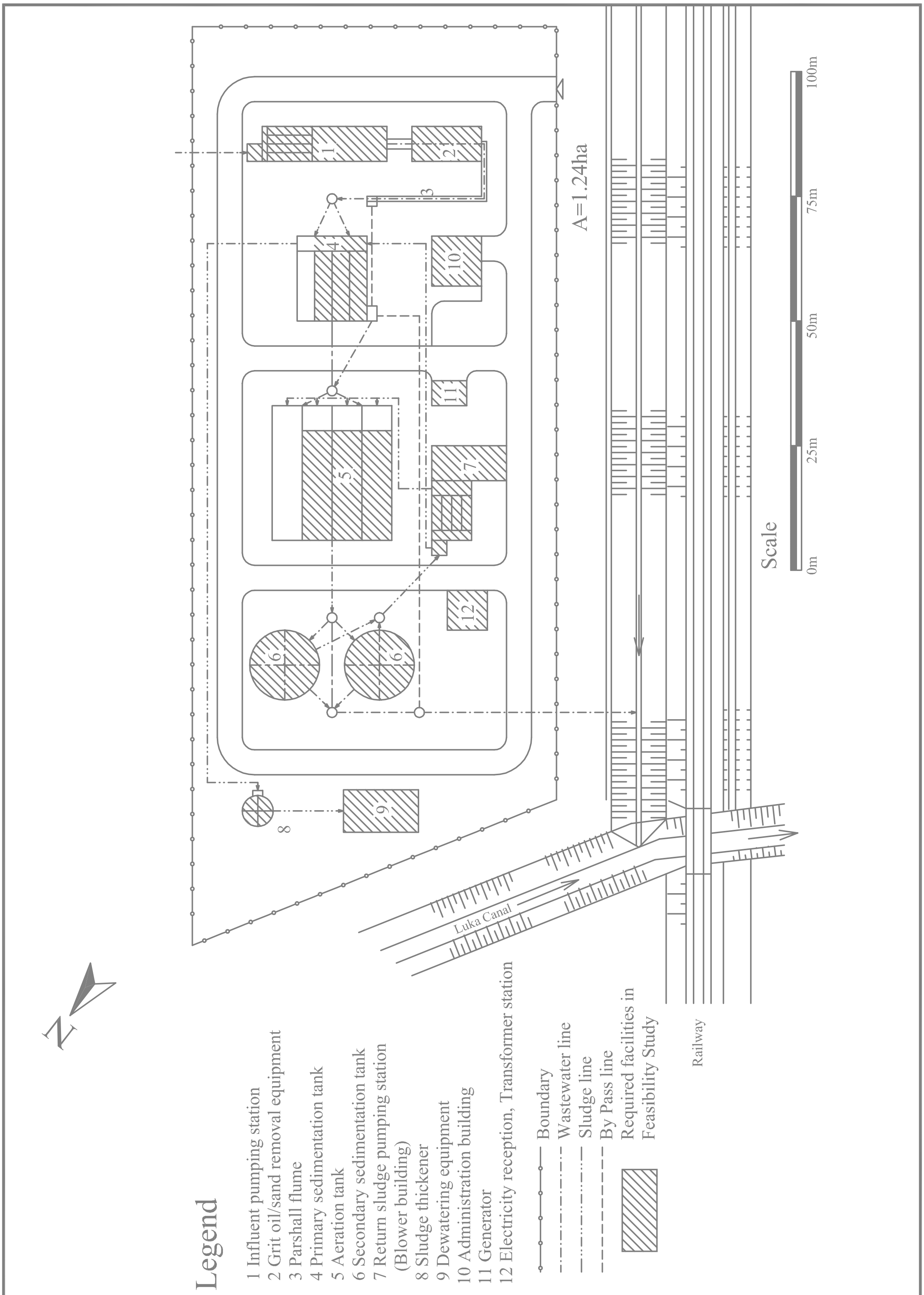
Fig.II-1 (2)
Layout of Wastewater Treatment Plant in Dugo Selo



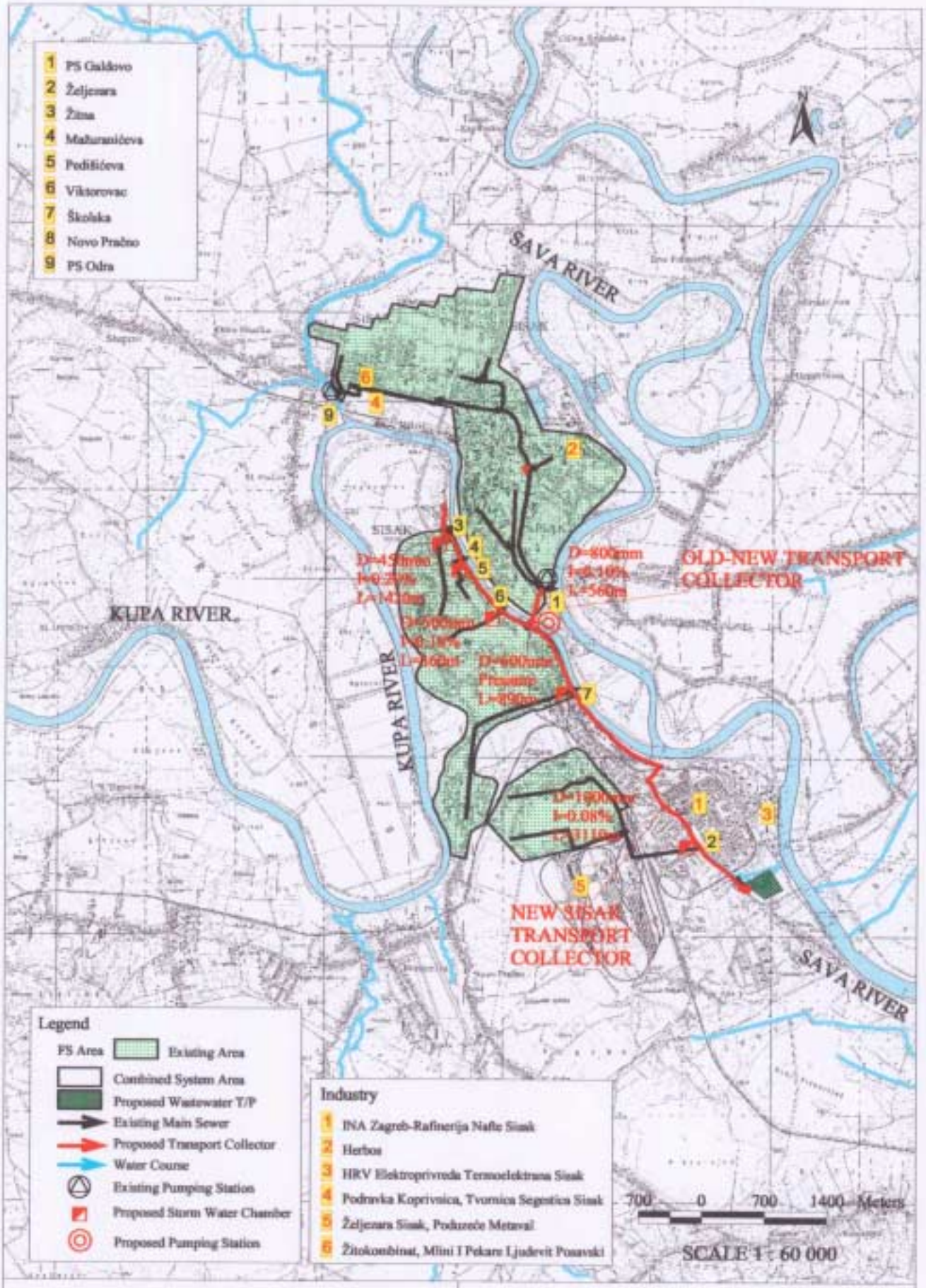
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. II-2(1) Sewerage Development System in Vrbovec



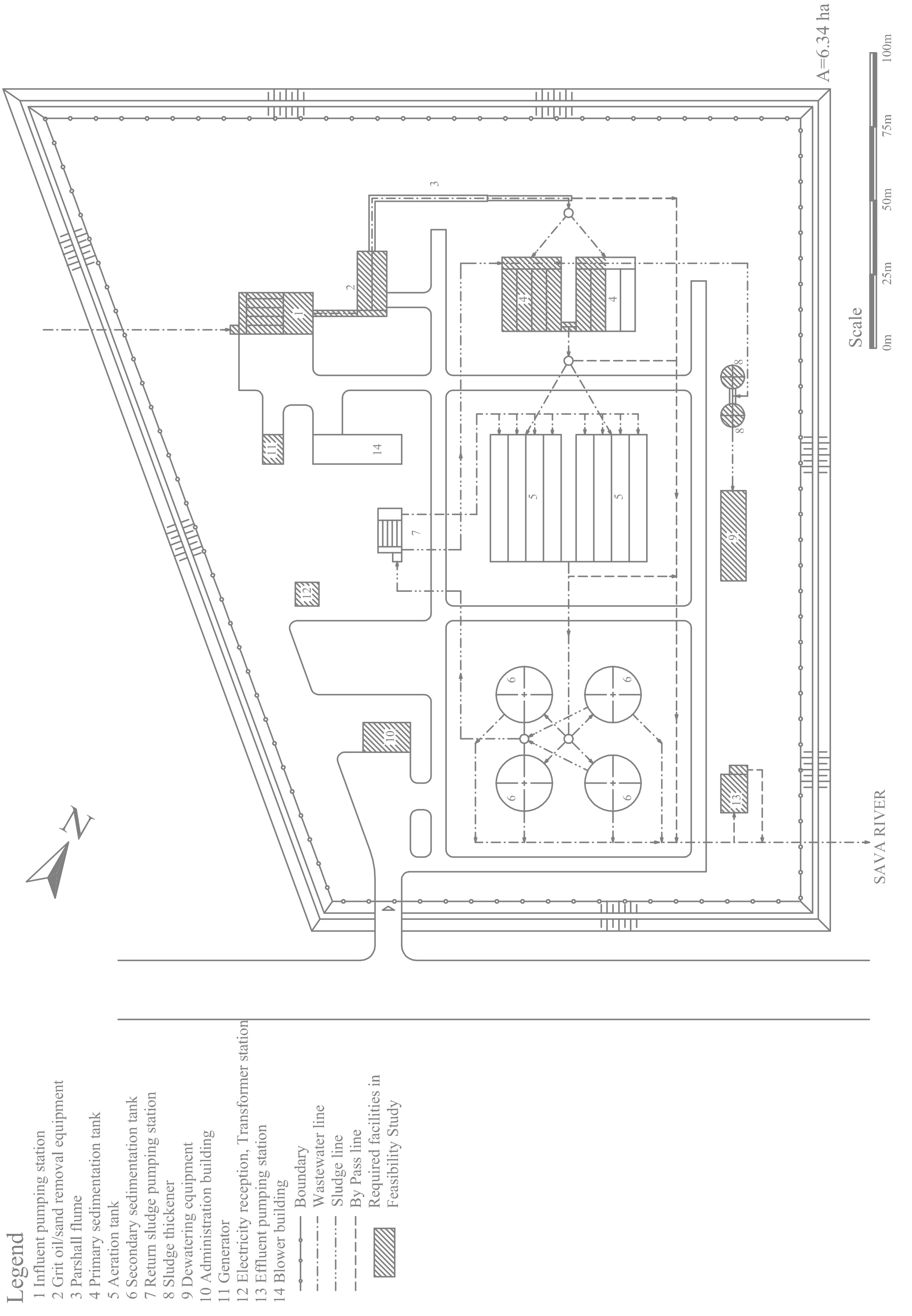
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.II-2 (2) Layout of Wastewater Treatment Plant in Vrbovec
JAPAN INTERNATIONAL COOPERATION AGENCY	



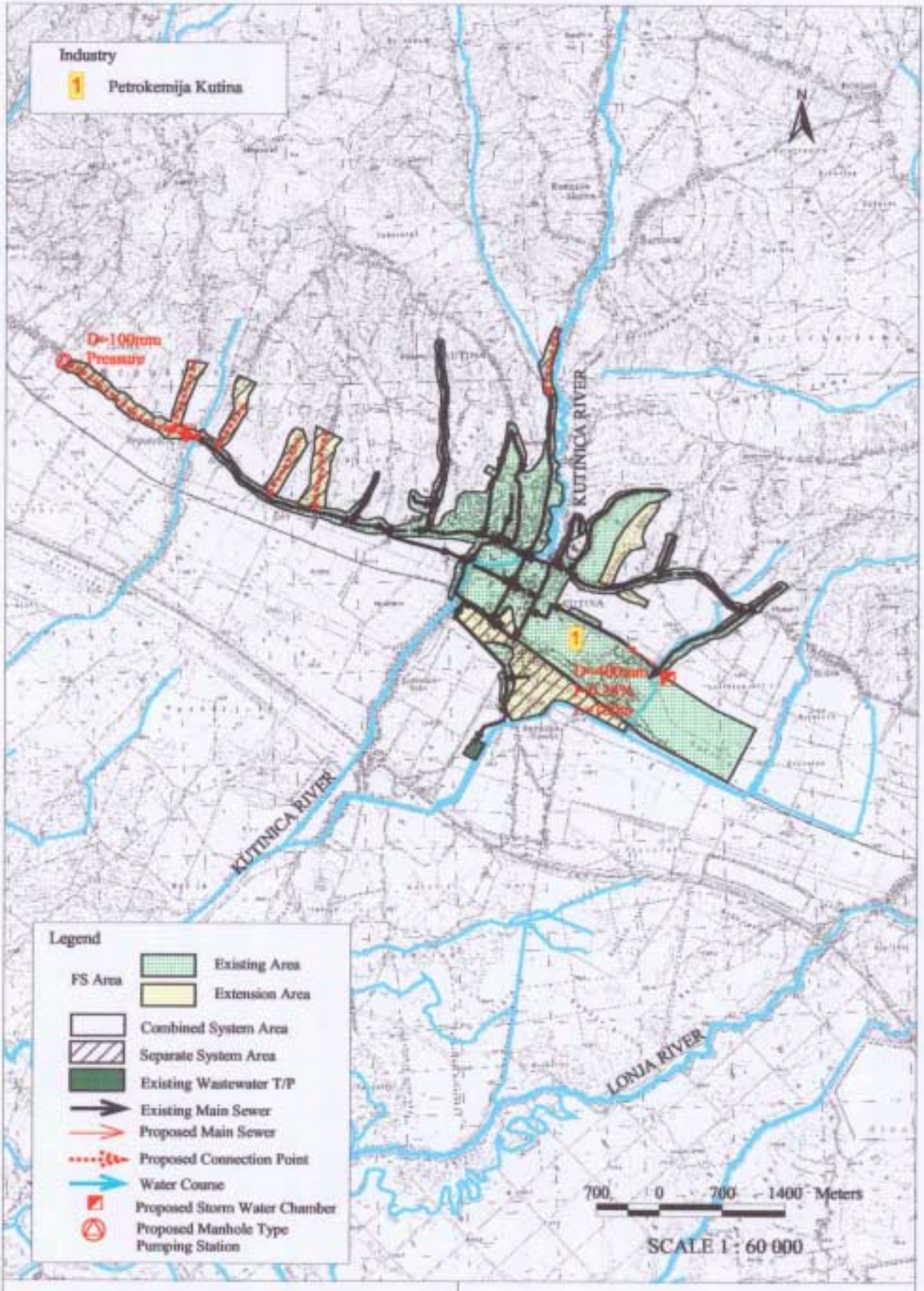
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. II-3(1) Sewerage Development System in Sisak



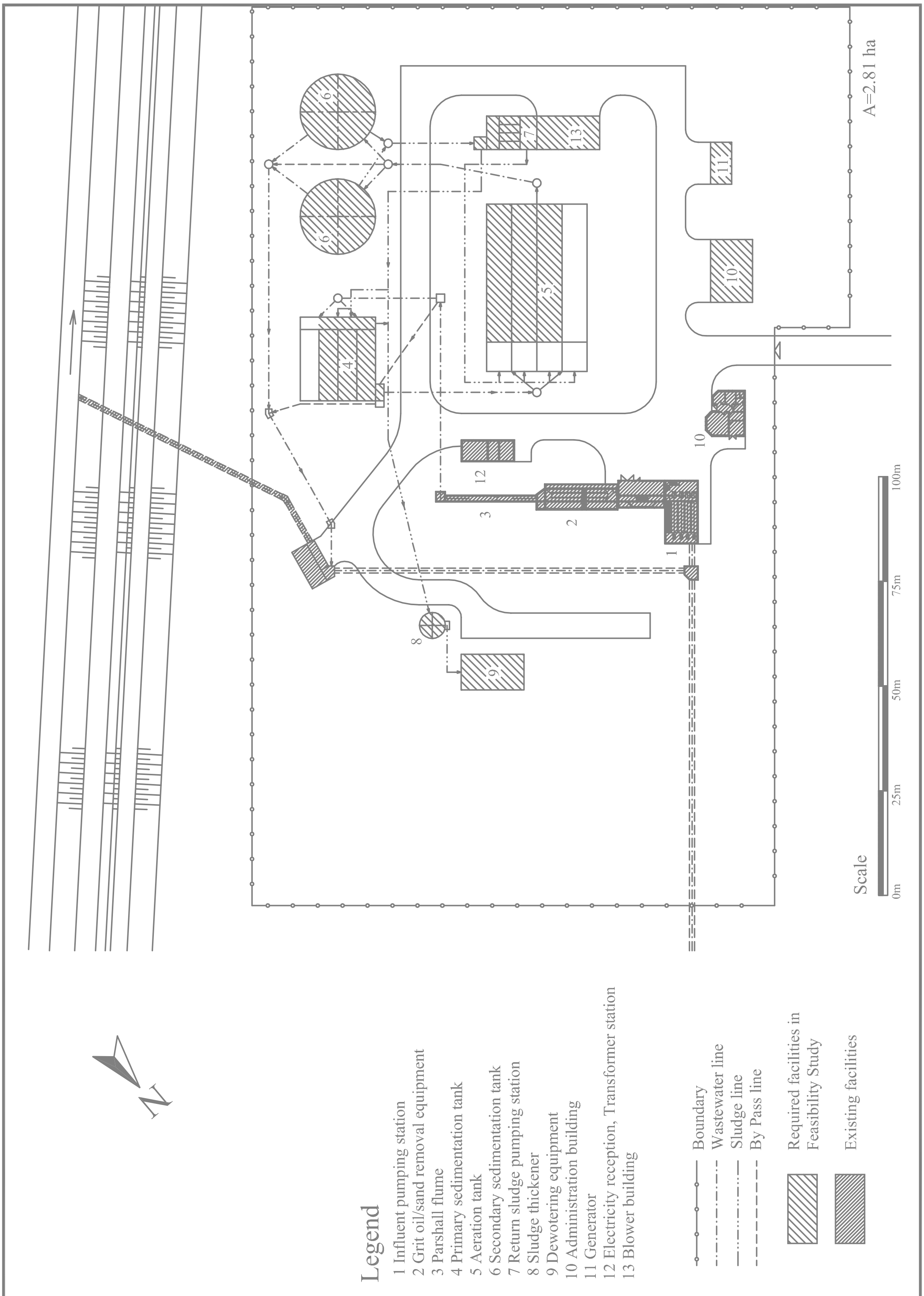
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.II-3 (2) Layout of Wastewater Treatment Plant in Sisak
JAPAN INTERNATIONAL COOPERATION AGENCY	



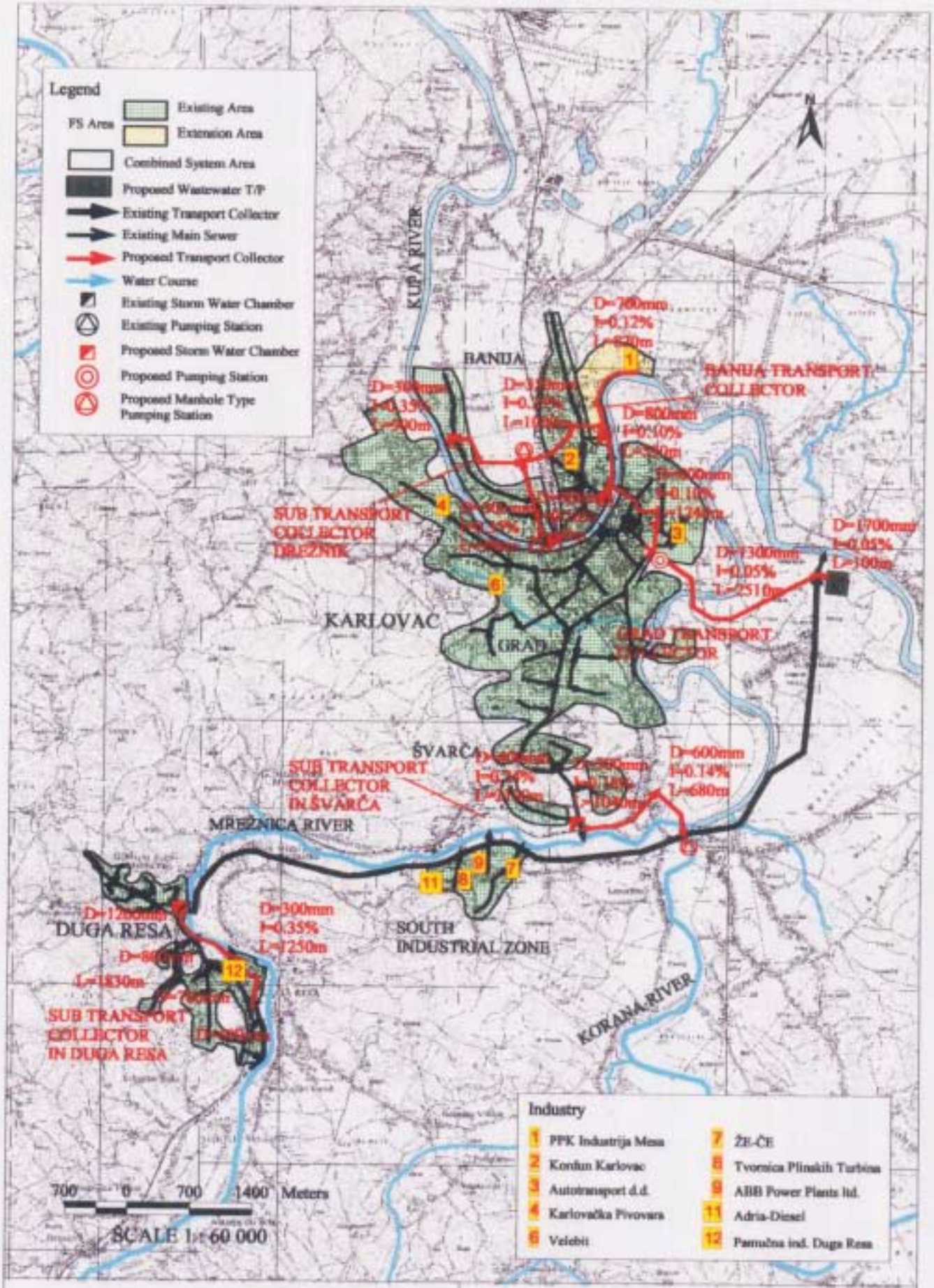
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. II-4(1) Sewerage Development System in Kutina



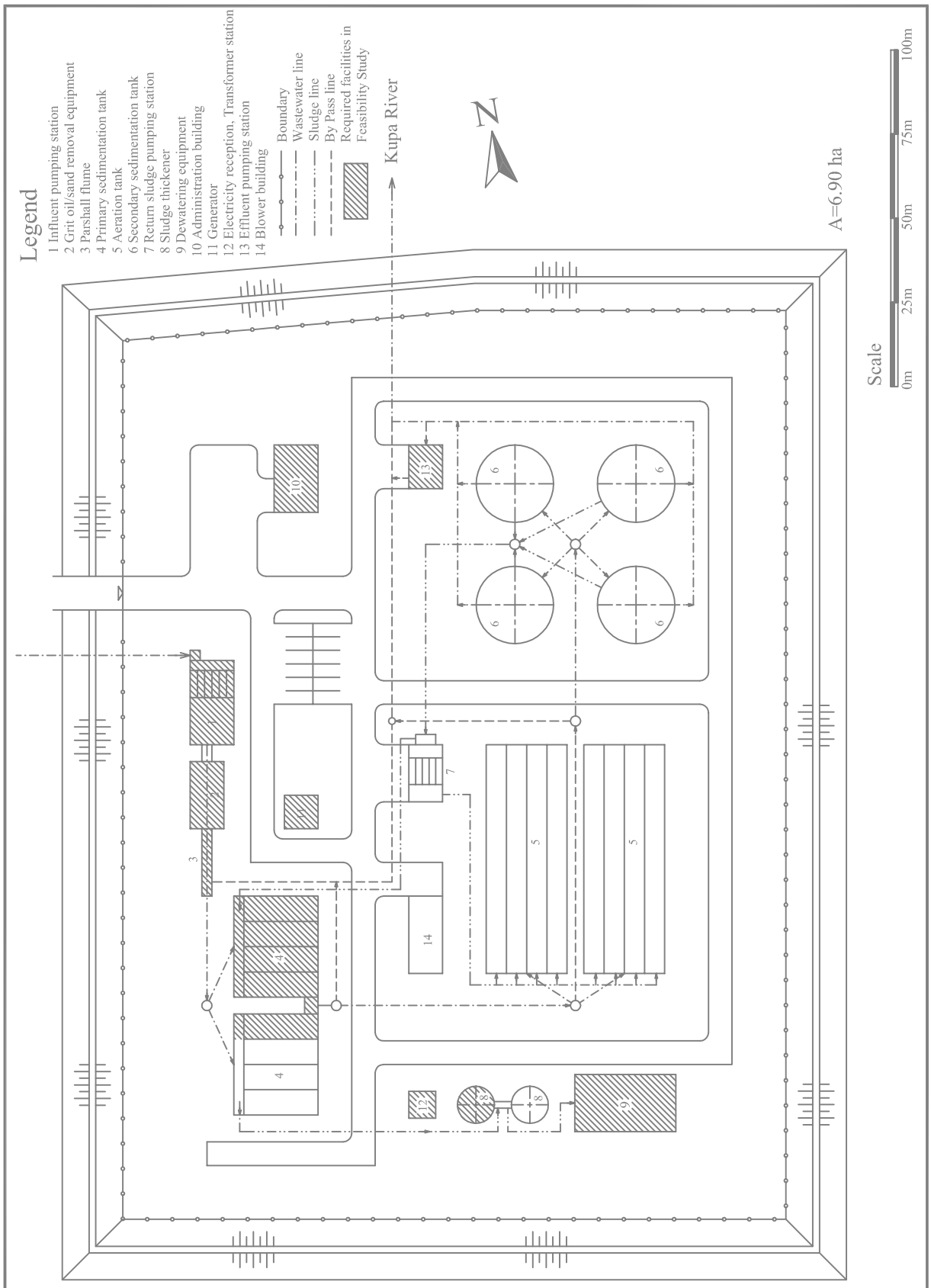
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.II-4 (2) Layout of Wastewater Treatment Plant in Kutina
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.II-5 (1) Sewerage Development System in Karlovac and Duga Resa



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.II-5 (2)
Layout of Wastewater Treatment Plant in Karlovac - Duga Resa