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. 3 : SUPPORTING REPORT (1/3)
(Master Plan : Appendix A to D)

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:

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As of February 2001

COMPOSITION OF REPORT

Vol. 1 EXECUTIVE SUMMARY

Vol. 2 MAIN REPORT

Vol. 3 SUPPORTING REPORT (APPENDIX A TO K)

APPENDIX	A	Socio-economy
APPENDIX	B	Water Quality and Pollution Mechanism
APPENDIX	C	Industrial Wastewater Treatment
APPENDIX	D	Sewerage Development (Master Plan Study)
APPENDIX	E	Sewerage Development (Feasibility Study)
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APPENDIX A

SOCIOECONOMIC CONDITIONS

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CHAPTER I EXISTING SOCIOECONOMIC CONDITIONS

1.1 Introduction

Croatia had been confronted by war which lasted for five years from 1991 to 1995. Its economy has been very much affected, resulting in the drastic decline of GDP and the high negative impact on industrial production. Loss of life and property and the displacement of thousands of people have been cited as the consequences, and the number of displaced persons and refugees in Croatia had been greater than 8% of the total population.

Two counties of the Study Area, Karlovac and Sisak-Moslavina, were directly affected by the war. Under the circumstances, the survey on the existing socioeconomic conditions was made, utilizing the existing available data such as the Counties' Physical Development Plans, the Zagreb City Office data, the Central Bureau of Statistics data, the electricity companies data, the water supply and sewerage service companies, municipalities and towns data, and so on.

With regard to the projection of future socio-economy, the population for the target year was projected considering data on population provided by the Zagreb City Institute for Planning of the Development and Environmental Protection, Zagreb County Institute for Physical Planning and Environmental Protection, the Institute of Physical Planning of the Ministry of Environmental Protection and Physical Planning, Karlovac County Department for Physical Planning, and by some municipalities in the study area. As for industrial production, agricultural production, livestock production and fish production in ponds, existing available data published in the Statistical Year Book of Croatia and data from the Ministry of Agriculture were considered.

As for the Gross Domestic Product, in view of the absence of information from the counties and municipalities on the subject, data on the Country level was analyzed.

1.2 Socioeconomic Conditions of the Study Area

1.2.1 Population and Administrative Units

The Study Area covers the City of Zagreb and the three (3) counties named respectively as Zagrebacka, Sisacko-Moslavacka and Karlovacka. It includes nineteen (19) large towns and fifty-five (55) other municipalities. Presented below is the total population for the year 1999 of each municipality involved in the study area, whose urban and rural population for the year 1999 were calculated adopting the same proportion of the last census year 1991. However, in the case of Sisak, Dugo Selo and Kutina, their urban populations were estimated by the water and sewerage service company of the town, the police station of the town, and the JICA Study Team, respectively.

(1) Zagreb City

Zagreb City is composed by seventy (70) settlements. The population of Zagreb City for the year 1999 was estimated to be 935,000 persons by the Zagreb City Institute for Planning of the Development and Environmental Protection.

(2) Zagreb County

Zagreb County is composed of eight (8) large towns and twenty-six (26) smaller municipalities. The population for the year 1999, except for Dugo Selo, was estimated based on data provided by the Zagreb County Institute for Physical Planning and Environmental Protection, as shown in the table below. As for Dugo Selo, its population for the year 1999 was provided by the police station of this town.

Towns		Municipalities		Municipalities		Municipalities	
1. Dugo Selo	15,326	1. Bistra	6,063	10. Farkasevac	2,203	19. Marija Gorica	1,886
2. Ivanic Grad	14,844	2. Brckovljani	5,304	11. Gradec	3,826	20. Orle	2,236
3. Samobor	39,920	3. Brdovec	10,406	12. Jakovlje	3,857	21. Pisarovina	4,249
4. Velika Gorica	65,680	4. Rugvica	6,035	13. Klinca Sela	4,582	22. Pokupsko	2,730
5. Zapresic	23,883	5. Stupnik	3,120	14. Kloštar Ivanić	4,818	23. Preseka	1,873
6. Jastrebarsko	18,073	6. Sveta Nedjelja	14,780	15. Krasic	3,893	24. Pusca	2,296
7. S. Ivan Zelina	15,707	7. Bedenica	1,616	16. Kravarsko	1,860	25. Rakovec	1,450
8. Vrbovec	13,435	8. Dubrava	5,566	17. Kriz	7,400	26. Zumberak	1,918
		9. Dubravica	1,591	18. Luka	1,387		
		County Total:		313,812			

The towns of Dugo Selo and Vrbovec were selected for the feasibility study for sewerage development system. For details refer to Table A.1.1.

(3) Sisak-Moslavina County

This county is composed of six (6) large towns and thirteen (13) smaller municipalities. The population of this county for the year 1999 was estimated in the Physical Planning Report of the County which was provided by the Institute of Physical Planning of the Ministry of Environmental Protection and Physical Planning, as shown below. However, in the case of Topusko, the municipality's data on 1999 population was considered.

Towns		**Municipalities**		**Municipalities**	
1. Glina	13,617	1. Donji Kukuruzari	826	7. Lipovljani	3,571
2. Hrvatska Kostajnica	1,328	2. Dvor	1,841	8. Majur	468
3. Kutina	23,052	3. Gvozd	1,947	9. Martinska Ves	4,588
4. Novska	12,296	4. Hrvatska Dubica	981	10. Popovaca	11,383
5. Petrinja	23,573	5. Jasenovac	1,516	11. Sunja	8,449
6. Sisak	69,283	6. Lekenik	7,924	12. Topusko	4,800
				13. Velika Ludina	2,877
		County Total:		194,320	

The towns of Kutina and Sisak were selected for the feasibility study for the sewerage development system. For details refer to Table A.1.2.

(4) Karlovac county

This county is composed of five (5) large towns and sixteen (16) smaller municipalities. The population of Karlovac for the year 1998 was estimated to be 60,000 persons by the Karlovac County Department for Physical Planning. For projection purposes, it was assumed that population of year 1998 is equal to that of year 1999.

As for the other municipalities, some of them had estimated their populations for the year 1999 and others for the year 2000, except the municipalities of Ogulin, Ozalj, Generalski Stol, Netretic and Saborsko. In order to know the respective populations of these municipalities for the year 1999, the number of households with electricity supply connections and family sizes were considered.

For projection purposes, it is assumed in this study that the population of year 2000 estimated by some municipalities is equal to that of year 1999. Besides, according to the Karolovac County Department for Physical Planning, the average family size in the county is about of 3 persons per households.

The table below shows the estimated population of each municipality of the county for the year 1999.

Towns		Municipalities		Municipalities	
1. Karlovac	60,000	1. Barilovic	3,020	9. Plaski	3,270
2. Dugaresa	15,500	2. Bosiljevo	1,700	10. Rakovica	2,870
3. Ogulin	13,800	3. Draganici	3,700	11. Ribnik	800
4. Ozalj	10,144	4. Generalski Stol	2,966	12. Saborsko	1,082
5. Slunj	6,500	5. Josipdol	4,000	13. Tounj	1,500
		6. Krnjak	2,300	14. Vojnic	2,500
		7. Lasinja	2,000	15. Zakanje	2,000
		8. Netretic	2,540	16. Centigrad	4,700
		Total in the County		148,892	

The town of Karlovac was selected for the feasibility study for the sewerage development system. For details refer to Table A.1.3.

1.2.2 Gross Domestic Product

The average composition of the country GDP during the period 1995-1998 indicates that services is more than twice higher than production. The basic services constitute around of 11% and other services are approximately 57%. As for production, it is composed of around 8% for the primary sector and approximately 24% for the secondary sector. For details, see Tables A.1.4 and A.1.5.

The industry, commerce, business and agriculture sectors are the main generators of GDP in the country since they occupy all together around 45% of the total. The industrial participation into the GDP structure in current prices had fallen to 2.9% in the period 1995-1998. However, according to the Croatian National Bank, in August of the year 2000, industrial production grew by 7.6% compared with the same month the previous year and it was attributable to the production increase in the processing industry (manufacture of domestic goods, chemicals and wood) and mining/extraction.

(1) Population, GDP and GDP per Capita in Current Prices

The nominal growth of the GDP per capita was unstable in the period 1991-1994, then it stabilized with a reduced projection. The mid-year population, GDP of the country and the GDP per capita in current prices is shown below:

Year	Population	GDP	GDP	GDP	GDP	Average Annual Exchange Rate
	Mills.	Mills. Kuna	Mills. US$	Per capita Kuna	Per capita: US$	Kuna: 1US$
1991	4.513	441.2	18,156.4	97.762	4023.1	0.0243
1992	4.470	2,706.6	10,240.6	605.50	2,291	0.2643
1993	4.641	39,004.3	10,902.7	8,404.28	2,349	3.5774
1994	4.649	87,441.4	14,585	18,808.64	3,137	5.9953
1995	4.669	98,381.5	18,811.1	21,071.21	4,029	5.23
1996	4.494	107,980.6	19,872	24,027.72	4,422	5.4338
1997	4.572	123,811.0	20,108.6	27,080.27	4,398	6.1571
1998	4.501*	138,392*	21,751.8	30,746.94*	4,833*	6.3623
1999	4.60**	143,500.0**	20,176**	31,180.54**	4,383.97**	7.1124
2000	4.56**	157,000.0**	19,430.6**	34,378.29**	4,254.74**	8.08***

* preliminary data; ** estimated; *** as of June, 2000
Source: Central Bureau of Statistics, Croatian National Bank, Ministry of Finance

(2) GDP, Rate of Growth in Constant Prices 1997 (%)

The table below gives the summary of the growth rate of GDP for the period 1991-1999:

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999
GDP(%)	-21.1	-11.7	-8	5.9	6.8	5.9	6.8	2.5*	-0.3**

* preliminary data; ** obtained from a three-month calculation of GDP
Source: Central Bureau of Statistics, Croatian National Bank

From the table above it can be concluded that the economic sector had declined in the period 1991-1993. From 1994 the recovery process had begun, however, by year 1999 it had declined to minus 0.3%. Table A.1.6 shows the rate of growth of GDP by sector for the period 1996-1998.

1.2.3 Industry

(1) Industrial Production in the Study Area

At present there are 8,737 registered industries in the study area. From this amount, 5,364 are in operation as shown in the table below.

County	1998	1999			2000		
	Registered	Registered	Active	%*	Registered	Active	%*
Zagreb	1,516	1,527	951	62	1,569	999	64
Sisak-Moslavina	422	422	249	59	431	261	61
Karlovac	464	469	293	62	502	323	64
Zagreb City	6,102	6,135	3,665	60	6,235	3,781	61
Total in the Study Area	8,504	8,553	5,158	60	8,737	5,364	61
Total in Croatia	18,011	18,133	10,807	60	18,579	11,346	61

* Percentage of factories working at present

Historical production of these factories is only available for those located in Zagreb City for the period 1986-1996, which is presented in the next table:

	1986	1990	1991	1995	1996
Indices of Production in Zagreb City	100	90.2	66.3	54.0	54.1

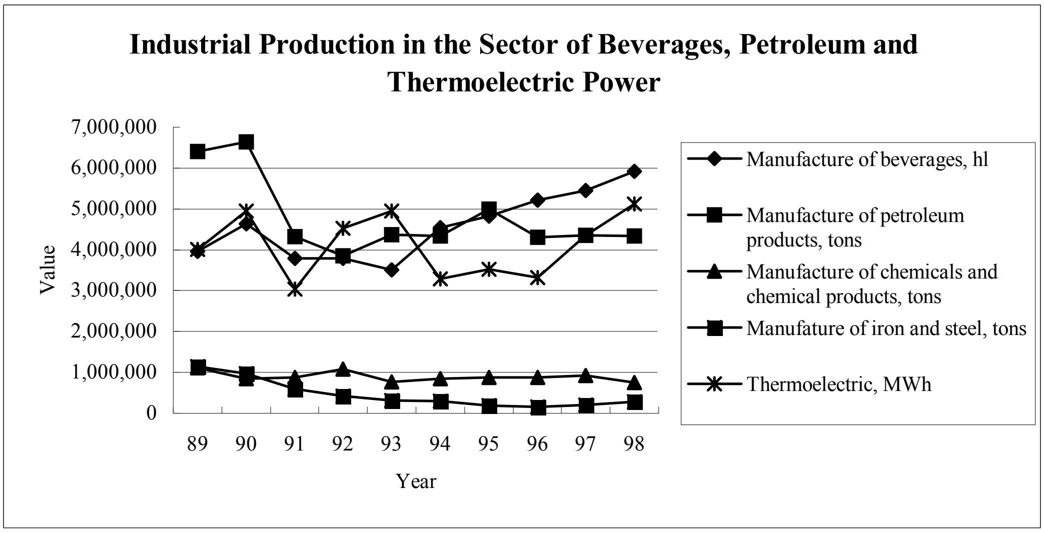
From the above tables it can be concluded that the number of factories and its production had decreased in the Study Area. In case of Zagreb City the reduction on production was almost half for the period 1986-1996. Considering that the other counties of the Study Area were more directly influenced by the consequences of the war, it is assumed that in these counties the production was much more hampered.

(2) Industrial Production in all Croatia

Officials of the Ministry of Finance had mentioned that industrial production in Croatia had fallen by around 55% compared with the production before the war. In this Study the production of some industries at national level was analyzed. The selection of industries for the analysis was made in due consideration to their types of production similar to those existing in the Study Area. The summary of industrial production by selected sectors is presented in Table A.1.7. On the other hand, for analysis purposes, these sectors were divided into two categories according to their production values as follows.

(a) Sectors of Beverages, Petroleum, Chemical, Iron & Steel and Thermoelectric Power

The volume of industrial production recorded in the period 1989-1998 was analyzed. From the analysis it is concluded that the sectors of beverages and thermoelectric power had experienced a rate of growth of 50% and 27%, respectively. However, the production growth rates of other sectors in the same period had decreased; namely, iron & steel sector (-76 %), petroleum sector (-32 %), and chemical sector (-32 %). The summary is graphically presented as follows. For more details, refer to Tables A.1.8, A.1.9, A.1.10 and A.1.11.



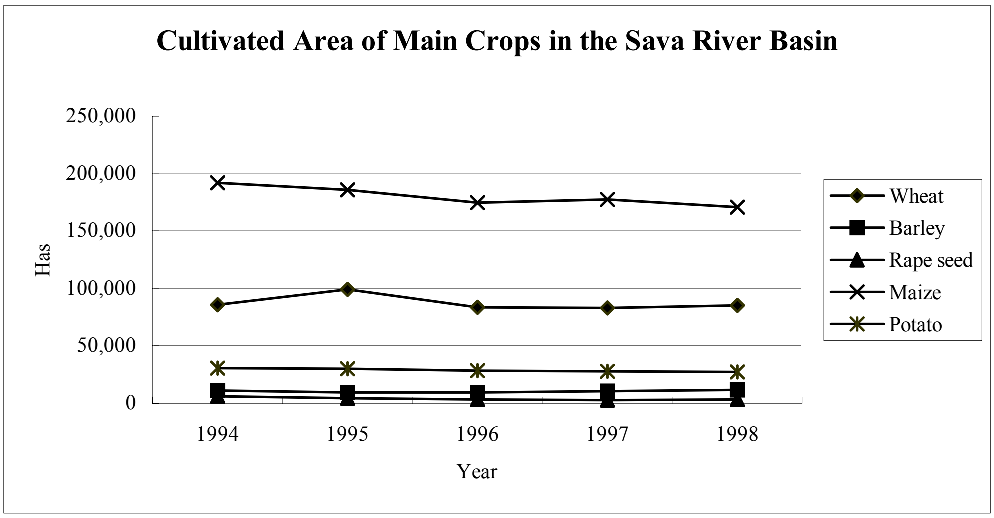
(b) Sectors of Food, Textile, Metal Products and Machinery/Equipment

During the period 1989-1998 a high rate of decrease was given in all the sectors considered. Their rates are as follows: food sector (-33%), textile sector (-85 %), metal products sector (-63 %) and machinery sector (-76 %). For details refer to Tables A.1.12, A.1.13, A.1.14 and A1.15.

1.2.4 Agriculture, Livestock and Fish Cultivation

Agriculture is less important in terms of economy in the region and the main crops cultivated are wheat, barley, rape seed, maize and potato.

The historical yearly cultivated area of main crops in the counties of the drainage basin of the Sava River is graphically shown below:.



From the graph it is concluded that, in the basin, maize occupies the first place in terms of agriculture economy. On the other hand, the total cultivated area of the main crops had not experienced remarkable change in the analyzed period 1994-1998. The agricultural production for the year 1998 is presented in the Table A.1.16.

As for livestock, its production is not so largely developed and rests on farmers with small parcels of land. The production in the study area for the year 1999 is presented below.

Counties	Bovine (heads)	Pigs (heads)	Horse (heads)	Sheep (heads)
Zagreb	56,963	132,114	321	1,969
Sisak-Moslavina	23,850	109,144	3,534	7,346
Karlovac	21,645	16,089	815	5,119
Zagreb City	6,212	46,816	149	651
Total	108,670	304,163	4,819	15,085

As for fish cultivation, Table A.1.17 shows the production of fish in ponds in the study area. The JICA Study Team had visited a fishpond named "Ribarski Centar Draganici" which is located in Karlovac County. The company is owned by both the government and the private sector. The total area of the fishpond is about 400 has. This pond allows sport fishing activities and most of the customers are Serbian people.

The main species of fishes existing in the pond are: (a) Cyprinus carpio (Saran Ribnjacki); (b) Ctenopharyngodon Idealla Val (Amur); (c) Silurus glanis (Som); and (d) others.

1.2.5 Tourism

The table below shows the number of tourists in the period 1990-2000.

Counties	1990	1995	1996	1997	1998	1999	2000
Zagreb	19,344	310,152	17,169	18,609	16,326	10,723	11,429
Sisak-Moslavina	43,031	12,271	13,013	17,420	17,425	10,277	11,328
Karlovac	165,879	3,063	6,863	17,257	39,803	36,140	78,357
Zagreb City	789,775	295,862	393,276	384,989	376,442	253,210	270,445
Other counties	6,625,129	1,816,625	3,468,532	4,767,423	4,999,480	4,054,483	5,809,114
Total	7,643,158	2,437,973	3,898,853	5,205,698	5,449,476	4,364,833	6,180,673

* Counted in the period January-September, 2000

From the table above it can be concluded that most of the tourists visit other counties than the counties in the study area. According to the interview with the manager of the fishpond in Karlovac County, the number of fishermen tourists who visited the pond was 10,000 persons for the year 1999. As for Zagreb City, it is assumed that most of the tourists visiting the city are persons involved in the business sector.

1.2.6 Employment

The number of employed people is recorded by the Central Bureau of Statistics. On the other hand, since health insurance is mandatory for all employees, the Croatian Health Insurance Institute also has a record on the number of employed or unemployed persons. The table below presents the employment situation in Croatia.

	1994	1995	1996	1997	1998	1999
Employed						
- Central Bureau of Statistics	1,437,059	1,417,427	1,329,547	1,310,918	1,384,841	1,304,540
- Health Insurance Institute	1,654,494	1,588,344	1,599,226	1,604,895	1,430,649	1,416,617
Unemployed						
- Employment Institute	243,324	240,601	261,022	277,691	287,762	341,730
- Health Insurance Institute	161,660	158,164	174,123	189,844	192,148	251,833
Rate of Unemployment						
- Central Bureau of Statistics	14.5	14.5	16.4	17.5	17.2	20.8
- Health Insurance Institute	9.4	9.1	9.8	10.6	11.8	15.1

Source: Central Bureau of Statistics, Health Insurance Fund, Employment Fund

1.2.7 Other Socioeconomic Indicators

The levels of export and import for the period 1996-1999 are given below.

Year	Export in Mil. US$	Import in Mil. US$
1996	4,512.0	7,788.0
1997	4,171.0	9,104.0
1998	4,541.0	8,383.0
1999	4,279.70	7,777.4

CHAPTER II PROJECTION OF FUTURE SOCIOECONOMY

2.1 Existing Plans

2.1.1 Spatial Planning Strategy of the Republic of Croatia

The Spatial Planning Strategy of the Republic of Croatia is the basic document for land use planning at national level. To put this Strategy into practice, the Land Use Programme of the Republic of Croatia, which contains the measures and activities, was prepared. Both documents, the Strategy and the Programme together, determine the long term objectives of land use development and planning in line with the total economic, social and cultural development. They are mandatory, applied to all ministerial and section development programmes and for the preparation of land use plans in accordance with the Land Use Law.

(1) General Objectives

The major spatial development objectives are:

(a) To implement an accelerated but sustainable development according to international standards relating to economic efficiency and environmental protection, and in accordance with national interests.

(b) To strengthen Croatia's spatial development structure through a balanced and realistically polycentric development such as the establishment of a strong development structure and points of emphasis based on defined and potential transport routes, a network of towns (particularly of smaller and medium-sized), and improvement of the equipment with infrastructure as a precondition for quality development.

(2) Special Objectives and Interest

The following are mentioned as special objectives and interest:

(a) To reconstruct and to develop war-torn and endangered areas

Primarily through the reconstruction of settlements that have suffered during the war and into which returnees are either coming back or should soon be coming back, through the creation of jobs (by the reconstruction and development of the economy), through reconstruction of the infrastructure and, by introducing things and facilities related to welfare and the standard of living, so as to provide returnees and the whole population a high quality, secure life and work.

(b) To preserve the land and the environment

Land and the environment are the most important global and strategic resource of Croatia. These resources, on which the national spatial and developmental identity rests, gives Croatia a comparative advantage in Europe particularly in those resources that Europe is increasingly short of.

(c) International Cooperation

It is related to the internationalization of development programmes in order to speed up development, protect the environment, ensure expert, scientific, technological and material support from international figures, harmonization with the world qualitative development trends, integration into the European development system, and the protection of natural assets (especially those that are valuable in the world and in Europe).

(d) Advancement of the Effectiveness of Systems for Managing Space

This will permit the introduction of new views of development, new initiatives and figures, all the while ensuring protection and rational use of all national assets.

(3) Orientations for Development of Goals

For the development of goals, the Spatial Planning Strategy give some orientations where particular interests of Croatia are:

(a) To use the State's favorable transport-related geographical and strategic position and its belonging to Central European, Danubian and Mediterranean spatial development units, along with the use of European integration elements for internal consolidation.

(b) Not to accept development models and out-dated technologies being abandoned by developed countries, but to foster development programs with technologies which promote space and do not pollute the environment (low water and energy consumption), while reconstruction of destroyed areas is to be carried out in a way to allow future development along with the correction of previous mistakes.

(c) To preserve physical and ecological integrity of resources areas by applying development models adequate to the features of space.

(d) To develop major infrastructure systems so as to enable the full functional integration of Croatian territory into the European networks.

(4) Goals

Finally, the Spatial Planning Strategy give some goals to be reached by each development sector. The following gives the referred goals for those sectors related to this study:

(a) Settlement Development Sector

(i) Growth reduction of large cities.

(ii) Functional restoration of smaller and medium-sized towns and local centers.

(iii) Prevention of unnecessary expansion, mainly, along the state road network and in areas of valuable natural resources.

(b) Energy Development Sector

(i) By year 2010, Croatia has to make up for the predicted lack of energy and ensure new 1,500 MW of power.

(ii) Provision of transport and distribution to ensure security of supply.

(c) Water Management Sector

(i) An increase of Croatia's coverage with water supply from 63% to 81-90% is forecasted.

(ii) Significant investments in the construction of sewerage networks and treatment plants.

(d) Economic Development Sector

(i) Transformation and rehabilitation of existing, partially used or under-utilized industrial zones with shut down production.

(ii) Improvement on tourism development making use of the existence of preserved and attractive natural environment as an advantage of Croatian space.

2.1.2 Short Term Economic Revitalization Program

The Ministry of Finance had prepared a revitalization program for the period 2000-2004. Currently this program is under consideration of the Parliament. The main policies of this program are as follows:

(1) Privatization of public enterprises

(2) Improvement of the productivity of the industrial sector

(3) Promotion of investment domestically and internationally

(4) Pension system reform

(5) Promotion of tourism and business activities

2.2 Population

2.2.1 Zagreb City

The Zagreb County Institute for Physical Planning and Environmental Protection had estimated preliminarily the total population of Zagreb County and Zagreb City for the target year 2015 as 1,350,000 persons. The breakdown is as follows:

Zagreb County	352,000
Zagreb City	998,000
Total	1,350,000

On the other hand, the Zagreb City Institute for Planning of the Development and Environmental Protection had estimated the population of the city for the year 1999 as 935,000 persons.

Taking these data into account, the yearly increase of population was calculated for Zagreb City as shown in Table A.2.1. (Rate of annual average growth = 0.4 %, for the period 1999-2015).

2.2.2 Zagreb County

The yearly population increase of the county is presented in the Table A.2.1. The Zagreb County Institute for Physical Planning and Environmental Protection had estimated the population of the Zagreb County for the target year 2015 as 352,000 persons, which will be distributed in the following manner:

(1) Towns and Municipalities with remarkable rate of growth of population

Dugo Selo, Ivanic Grad, Samobor, Velika Gorica, Zapresic, Bistra, Brckovljani, Brdovec, Rugvica, Stupnik and Sveta Nedjelja had a dynamic growth in its population in the last years and it is expected that they will grow in the future with an annual average rate of 0.95% for the period 1999-2015 (population in 2015 = 239,000 persons).

(2) Towns and Municipalities with lower rate of growth of population

Jastrebarsko, Sveti Ivan Zelina, Vrbovec, Bedenica, Dubrava, Dubravica, Farkasevac, Gradec, Jakovlje, Klinca Sela, Kloštar Ivanić, Krasic, Kravarsko, Kriz, Luka, Marija Gorica, Orle, Pisanoriva, Pokupsko, Preseka, Pusca, Rakovec and Zumberack have to grow with an annual average rate of 0.25% for the period 1999-2015 to reach the estimated population of 113,000 persons (352,000-239,000).

Among these towns and municipalities, Dugo Selo and Vrbovec were selected for feasibility study for the sewerage development system. The estimated population of these towns for the year 2015 are 13,632 and 13,999, respectively.

2.2.3 Sisak-Moslavina County

Sisak-Moslavina County also had suffered from the war in the period 1991-1995.

The population for the year 1999 and 2010 were estimated in the Physical Planning Report of the County which was provided by the Institute of Physical Planning of the Ministry of Environmental Protection and Physical Planning.

Taking into account these estimations, the projection for the target year 2015 was made. See Table A.2.2.

2.2.3 Karlovac County

The population of Karlovac Town for the year 2005 and 2015 were estimated by the Karlovac County Department of Physical Planning as 58,000 and 60,000 persons, respectively.

As for the other towns and municipalities, the projection of their population were made using the same estimated annual rate of growth as Karlovac Town. Refer to Table A.2.3.

2.3 GDP Projection at National Level

The Ministry of Finance had estimated in its short term economic revitalization program, which is under consideration of the Parliament, the following rates of growth of GDP for the period 2000-2004:

Year	2000	2001	2002	2003	2004	Average for the period
GDP(%)	2.8	3	3.5	4	5	3.6

On the other hand, the Zagreb Economy Institute is preparing some strategies to be recommended to the government to make up for the continuous deficit in the balance of payment of the country recorded in the recent years. The table below presents the major strategies and the expected rate of growth of the GDP if they are applied by the government in the period 2000-2015.

Period	Strategies	Expected Annual Rate of Growth of GDP
2000-2005	-Government expenditure reduction by 10% for the period in terms of GDP -Reforms on pension and health system -Social agreement between employees, government and employers, to maintain a low increase of wages for the period -Preparing the legal framework for industrial promotion -Promotion of tourism -Preparing the grounds to enter into the European Union	3-4%
2006-2010	-Promotion of tourism -Foreign and domestic investment in the industrial sector -Application of new technologies to increase industrial production -Increase of exports taking advantages of the lower prices reached with the above strategies. -Negotiation to enter to the European Union	5-6%
2011-2015	-Once inside of the European Union, the country will follow the policies of the European Union. This means that the growth of the economy of the country will depend mainly on the growth of the economy of the European Union.	4-5%

For projection purposes, the average GDP value estimated by the Ministry of Finance will be used for the period 2000-2005, while for the next periods the average values of GDP forecasted by the Zagreb Economy Institute will be used. Then, it is assumed that the rate of growth of GDP at national level, in constant prices of 1997, will be 3.6% per annum during 2000-2005, 5.5% per annum during 2006-2010 and 4.5% per annum during 2011-2015. The table below shows the projection, which shall be used for the Study Area:

Year	GDP (Mil. Kuna)	GrowthRate (%)
2000	107,417	3.6
2001	111,284	3.6
2002	115,290	3.6
2003	119,440	3.6
2004	123,740	3.6
2005	128,195	3.6
2006	135,245	5.5
2007	142,684	5.5
2008	150,532	5.5
2009	158,811	5.5
2010	167,545	5.5
2011	175,085	4.5
2012	182,964	4.5
2013	191,197	4.5
2014	199,801	4.5
2015	208,792	4.5

2.4 Industry

The Ministry of Finance had estimated the current rate of growth of the manufacture sector as 2.7%. The estimation was made based on the observation of values during the months of January-September of year 2000.

Since no projection on industrial growth was available at the national/local level, it was assumed that the industrial sector will grow at the same values of the estimated GDP until the target year, as indicated below:

Period	2000-2005	2006-2010	2011-2015
Rate of Growth of Industry Sector (%)	3.6	5.5	4.5

2.5 Agriculture and Livestock

One of the non-point pollution sources are the farmlands. An analysis of the statistical data on agricultural production of main crops in the study area for the period 1990-1998 show that the tendency is the reduction of cultivated areas in the recent years.

For projection purposes, in the Study Area, it is assumed that the cultivated area until the target year will be constant as the maximum value registered in the period considered, which corresponds to the year 1997 with 301,553, as shown below:

	1994	1995	1996	1997	1998
Wheat	85,683	99,231	83,939	83,326	85,418
Barley	11,056	9,685	9,562	10,631	11,690
Rape seed	6,315	4,479	3,172	2,722	3,194
Maize	191,907	185,717	174,934	177,201	170,630
Potato	30,612	30,109	28,733	27,673	27,599
Total has	325,573	329,221	300,340	301,553	298,531

As for livestock, for projection purposes, it is assumed that the number of livestock in the Study Area until the target year will be constant as the maximum value registered in the period 1994-1999, which corresponds to the year 1994, as shown below:

	1994	1995	1996	1997	1998	1999
Bovine (heads)	155,430	148,087	116,887	120,129	112,258	108,670
Pigs (heads)	317,402	265,394	266,018	285,422	290,129	304,163
Horse (heads)	6,029	5,473	5,309	5,668	5,228	4,819
Sheep (heads)	15,793	15,437	12,837	10,936	14,066	15,085
Total	494,654	434,391	401,051	422,155	421,681	432,737

2.6 Tourism

The number of tourists in the future has not been forecasted. Tourists, in fact, are potential wastewater generators and for this reason the projection of its number is crucial. On the other hand, tourists also will benefit from the implementation of this project, because the project aims to improve the environmental condition of the river and its surroundings. For projection purposes, it is assumed that the number of tourists in the target year 2015 will reach again its value in the year 1990 (year previous to the war). Then, the number of tourist should increase from 6,180,673 to 7,643,158 between the period 2000-2015.

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4) Data provided by Karlovac County Department for Physical Planning
5) Spatial Planning Strategy of the Republic of Croatia. Ministry of Environmental Protection and Physical Planning.
6) Revitalization Program. Ministry of Finance
7) Estimation on GDP by Zagreb Economy Institute
8) Data provided by the Ministry of Tourism
9) Data on Agriculture and fish production provided by Ministry of Agriculture and Forestry
10) Electricity Company for Croatia
11) Electricity Company of Karlovac County
12) Data on population by some Municipalities and Towns of Karlovac and Sisak-Moslavina Counties
13) Data on population given by the Water & Sewerage Company of Sisak town
14) Data on population given by Police Station of Dugo Selo town
15) Croatian National Bank
16) Central Bureau of Statistics
17) Chamber of Economy of Zagreb City
18) Chamber of Economy of Zagreb County
19) Chamber of Economy of Sisak-Moslavina County
20) Chamber of Economy of Karlovac County

TABLES

Table A.1.1 Zagreb County Population as of 1991/1999

A. First Group	1991			1999		
A.1 Towns	Total	Urban	Rural	Total	Urban	Rural
1. Dugo Selo	9,969	6,508	3,461	15,326	10,570	4,756
2. Ivanic Grad	13,494	7,104	6,390	14,844	7,815	7,029
3. Samobor	35,017	14,170	20,847	39,920	16,154	23,766
4.Velika Gorica	56,884	31,614	25,270	65,680	36,502	29,178
5.Zapresic	20,720	15,678	5,042	23,883	18,071	5,812
A.2 Mun icipalities						
1. Bistra	5,512	1,569	3,943	6,063	1,726	4,337
2. Brckovljani	4,802	696	4,106	5,304	769	4,535
3. Brdovec	8,762	1,901	6,861	10,406	2,258	8,148
4. Rugvica	4,922	600	4,322	6,035	736	5,299
5. Stupnik	2,536	948	1,588	3,120	1,166	1,954
6. Sveta Nedjelja	12,988	981	12,007	14,780	1,116	13,664
Subtotal	175,606	81,769	93,837	205,361	96,883	108,478
B. Second Group						
B.1 Towns						
1. Jastrebarsko	17,895	5,380	12,515	18,073	5,434	12,639
2. Sveti Ivan Zelina	15,552	2,535	13,017	15,707	2,560	13,146
3.Vrbovec	13,303	4,149	9,154	13,435	4,190	9,245
B.2 Mun icipalities						
1. Bedenica	1,600	515	1,085	1,616	520	1,096
2. Dubrava	5,511	1,309	4,202	5,566	1,322	4,244
3. Dubravica	1,575	148	1,427	1,591	149	1,441
4. Farkasevac	2,181	332	1,849	2,203	335	1,867
5. Gradec	3,788	442	3,346	3,826	446	3,379
6. Jakovlje	3,819	2,586	1,233	3,857	2,612	1,245
7. Klinca Sela	4,537	1,057	3,480	4,582	1,068	3,515
8. Klostar Ivani	4,771	2,568	2,203	4,818	2,594	2,225
9. Krasic	3,855	768	3,087	3,893	776	3,118
10. Kravarsko	1,842	480	1,362	1,860	485	1,376
11. Kriz	7,327	1,770	5,557	7,400	1,788	5,612
12. Luka	1,373	362	1,011	1,387	366	1,021
13. Marija Gorica	1,867	138	1,729	1,886	139	1,746
14. Orle	2,214	77	2,137	2,236	78	2,158
15. Pisarovina	4,207	451	3,756	4,249	455	3,793
16. Pokupsko	2,703	289	2,414	2,730	292	2,438
17. Preseka	1,855	140	1,715	1,873	141	1,732
18. Pusca	2,273	707	1,566	2,296	714	1,582
19. Rakovec	1,436	227	1,209	1,450	229	1,221
20. Zumberak	1,899	136	1,763	1,918	137	1,781
Subtotal	107,383	26,566	80,817	108,451	26,830	81,621
Total County	282,989	108,335	174,654	313,812	123,713	190,099

Zagreb City*	777,826	777,826	-	935,000	935,000	-

*: also recognized as a county

Table A.1.2 Sisak-Moslavina County Population as of 1991/1999

	1991			1999		
	Total	Urban	Rural	Total	Urban	Rural
Towns						
1. Glina	23,040	6,933	16,107	13,617	4,098	9,519
2. Hrvatska Kostajnica	4,996	3,480	1,516	1,328	925	403
3. Kutina	24,829	14,992	9,837	23,052	16,800	6,252
4. Novska	17,231	8,053	9,178	12,296	5,747	6,549
5. Petrinja	35,151	18,706	16,445	23,573	12,545	11,028
6. Sisak	61,413	45,792	15,621	69,283	44,175	25,108
Subtotal	166,660	97,956	68,704	143,149	84,289	58,860
Municipalities						
1. Donji Kukuruzari	3,063	301	2,762	826	81	745
2. Dvor	14,555	2,351	12,204	1,841	297	1,544
3. Gvozd	8,082	1,570	6,512	1,947	378	1,569
4. Hrvatska Dubica	4,237	2,062	2,175	981	477	504
5. Jasenovac	3,599	1,154	2,445	1,516	486	1,030
6. Lekenik	6,248	1,652	4,596	7,924	2,095	5,829
7. Lipovljani	3,866	2,430	1,436	3,571	2,245	1,326
8. Majur	2,555	532	2,023	468	97	371
9. Martinska Ves	4,643	443	4,200	4,588	438	4,150
10. Popovaca	11,822	3,596	8,226	11,383	3,462	7,921
11. Sunja	12,309	2,113	10,196	8,449	1,450	6,999
12. Topusko*	6,824	1,587	5,237	4,800	1,116	3,684
13. Velika Ludina	2,869	689	2,180	2,877	691	2,186
Subtotal	84,672	20,480	64,192	51,171	13,315	37,856
Total county	251,332	118,436	132,896	194,320	97,604	96,716

*population of 1999 year was estimated by the municipality

Table A.1.3 Karlovac County Population as of 1991/1999

	1991			1999		
	Total	Urban	Rural	Total	Urban	Rural
Towns						
1. Karlovac	73,426	59,999	13,427	60,000	52,000	8,000
2. Dugaresa	14,088	7,513	6,575	15,500	8,266	7,234
3. Ogulin*	16,732	10,857	5,875	15,800	10,252	5,548
4. Ozalj*	9,988	1,184	8,804	10,144	1,202	8,942
5. Slunj	10,096	2,026	8,070	6,500	1,304	5,196
Municipalities						
1. Barilovic	4,529	391	4,138	3,020	261	2,759
2. Bosiljevo	2,598	114	2,484	1,700	75	1,625
3. Draganici	3,561	400	3,161	3,700	416	3,284
4. Generalski Stol*	3,833	712	3,121	2,966	551	2,415
5. Josipdol	4,850	1,116	3,734	4,000	920	3,080
6. Krnjak	3,204	441	2,763	2,300	317	1,983
7. Lasinja	2,821	550	2,271	2,000	390	1,610
8. Netretic*	5,437	547	4,890	2,540	256	2,284
9. Plaski	4,317	2,271	2,046	3,270	1,720	1,550
10. Rakovica	4,108	1,012	3,096	2,870	707	2,163
11. Ribnik	878	154	724	800	140	660
12. Saborsko*	1,501	852	649	1,082	614	468
13. Tounj	1,695	414	1,281	1,500	366	1,134
14. Vojnic	8,236	1,204	7,032	2,500	365	2,135
15. Zakanje	3,921	197	3,724	2,000	100	1,900
16. Cetingrad	4,758	910	3,848	4,700	899	3,801
Total	184,577	92,864	91,713	148,892	81,122	67,770

* population by 1999 is estimated from the number of households connected to the electricity service

Table A.1.4 Gross Domestic Product at Current Prices by Sector

Unit: '000 Kunas

	1995	1996	1997	1998
Agriculture, hunting and Forestry	8,193,855	8,887,439	9,471,183	9,673,626
Fishing	219,032	171,382	216,478	167,217
Sub-total	8,412,887	9,058,821	9,687,661	9,840,843
Mining and quarrying	238,032	234,854	645,864	616,298
Manufacturing	19,177,646	19,660,216	22,791,428	22,980,794
Construction	4,625,174	5,965,132	7,436,954	7,807,224
Subtotal	24,040,852	25,860,202	30,874,246	31,404,316
Total Production	32,453,739	34,919,023	40,561,907	41,245,159
Electricity, gas and water supply	3,023,292	3,411,326	3,675,532	4,438,700
Transport, storage and communication	7,805,431	8,022,310	9,091,672	10,608,043
Subtotal	10,828,723	11,433,636	12,767,204	15,046,743
Commerce	9,502,415	11,121,567	13,050,889	13,250,713
Restaurants & hotels	2,049,758	2,731,847	3,266,304	3,420,977
Financial intermediation	3,312,342	3,952,318	4,043,747	5,428,084
Renting & business activities	8,452,349	9,362,540	10,649,883	12,211,136
Public administration and defense, social security	7,055,385	8,241,931	9,548,691	11,877,690
Education	2,862,954	3,433,819	3,864,591	4,870,239
Health and social work	2,609,692	3,522,167	4,441,356	5,398,807
Other community, social and personal activities	1,980,305	2,140,804	2,487,924	2,802,190
Private households with employed persons	15,751	20,745	24,657	37,194
Financial intermediation services indirectly measured	-2,240,920	-2,793,738	-3,788,231	-5,056,196
Taxes on products less subsidies on products	19,499,491	19,893,900	22,891,815	27,859,000
Subtotal	55,099,522	61,627,900	70,481,626	82,099,834
Total services	65,928,245	73,061,536	83,248,830	97,146,577
Gross Domestic Product	98,381,984	107,980,559	123,810,737	138,391,736

Source: Central Bureau of Statistics; Year 1998: preliminary results

Table A.1.5 Structure of Gross Domestic Product at Current Prices

Unit: %

	1995	1996	1997	1998
Agriculture, hunting and Forestry	8.3	8.2	7.6	7.0
Fishing	0.2	0.2	0.2	0.1
Sub-total	8.6	8.4	7.8	7.1
Mining and quarrying	0.2	0.2	0.5	0.4
Manufacturing	19.5	18.2	18.4	16.6
Construction	4.7	5.5	6.0	5.6
Subtotal	24.4	23.9	24.9	22.7
Total Production	33.0	32.3	32.8	29.8
Electricity, gas and water supply	3.1	3.2	3.0	3.2
Transport, storage and communication	7.9	7.4	7.3	7.7
Subtotal	11.0	10.6	10.3	10.9
Commerce	9.7	10.3	10.5	9.6
Restaurants & hotels	2.1	2.5	2.6	2.5
Financial intermediation	3.4	3.7	3.3	3.9
Renting & business activities	8.6	8.7	8.6	8.8
Public administration and defense, social security	7.2	7.6	7.7	8.6
Education	2.9	3.2	3.1	3.5
Health and social work	2.7	3.3	3.6	3.9
Other community, social and personal activities	2.0	2.0	2.0	2.0
Private households with employed persons	0.0	0.0	0.0	0.0
Financial intermediation services indirectly measured	-2.3	-2.6	-3.1	-3.7
Taxes on products less subsidies on products	19.8	18.4	18.5	20.1
Subtotal	56.0	57.1	56.9	59.3
Total services	67.0	67.7	67.2	70.2
Gross Domestic Product	100.0	100.0	100.0	100.0

Source: Central Bureau of Statistics; Year 1998: preliminary results

Table A.1.6 Rate of Growth of Gross Domestic Product by Sector (constant prices 1997)

Unit: %

	1996	1997	1998
Agriculture, hunting and Forestry	1.8	2.4	3.8
Fishing	-20.4	-3.4	-2.6
Sub-total	-18.6	-1.0	1.2
Mining and quarrying	-3.0	0.1	-2.4
Manufacturing	1.7	4.3	2.7
Construction	18.8	13.0	3.2
Electricity, gas and water supply	20.8	24.4	8.7
Transport, storage and communication	7.0	3.5	3.7
Commerce	15.6	13.2	-0.6
Restaurants & hotels	21.8	18.1	3.4
Financial intermediation	1.3	6.3	8.4
Renting & business activities	2.5	5.2	4.2
Public administration and defense, social security	2.3	2.0	2.3
Education	0.7	3.7	3.5
Health and social work	1.7	3.0	1.1
Other community, social and personal activities	2.5	5.9	5.1
Private households with employed persons	27.2	14.7	42.7
Financial intermediation services indirectly measured	5.1	9.5	7.2
Taxes on products less subsidies on products	5.4	5.6	5.8
Gross Domestic Product	5.9	6.8	2.5

Source: Central Bureau of Statistics; Year 1998: preliminary results

Table A.1.7 Summary of Production Volume by Selected Industrial Sectors in Croatia

Type of Industry	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	*Rate %
Manufacture of food products, tons	2,437,829	2,421,232	1,937,759	1,757,654	1,626,995	1,512,924	1,555,473	1,507,838	1,435,030	1,643,531	-33
Manufacture of beverages, hl	3,958,270	4,642,808	3,786,877	3,790,121	3,504,181	4,533,817	4,828,208	5,220,520	5,447,952	5,919,703	50
Manufacture of textiles, tons	47,891	37,359	22,586	20,437	16,805	16,785	14,275	9,365	7,572	7,018	-85
Manufacture of petroleum products, tons	6,412,302	6,646,783	4,325,840	3,858,798	4,376,062	4,342,372	4,999,495	4,313,618	4,356,539	4,340,805	-32
Manufacture of chemicals and chemical products	1,109,678	852,537	870,952	1,082,601	763,639	841,114	869,972	878,682	920,971	743,918	-33
Manufature of iron and steel, tons	1,145,912	964,474	598,367	421,559	318,527	298,882	195,624	157,561	205,809	278,939	-76
Manufacture of metals products, tons	260,426	212,056	126,949	92,820	84,008	71,200	72,184	80,456	94,375	96,542	-63
Manufacture of machinery and equipment, tons	83,950	64,606	31,445	17,807	15,210	14,252	17,137	16,087	17,785	20,092	-76
Thermoelectric, MWh	4,014,789	4,942,876	3,043,454	4,521,753	4,953,063	3,290,733	3,531,206	3,326,602	4,353,103	5,113,150	27

*Rate of increase/decrease in the period 1988/1999

Table A.1.8 Production Volume by Category in the Sector of Manufacture of Beverages

Unit: hl

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	*Rate %
1) Beer	2,292,329	2,800,703	2,248,784	2,720,037	2,481,344	3,121,755	3,165,645	3,291,593	3,606,546	3,759,435	64
2) Distilled alcoholic beverages	784,800	789,343	757,233	317,036	292,931	287,988	265,478	262,000	260,366	240,778	-69
3) Soft drinks	881,141	1,052,762	780,860	753,048	729,906	1,124,074	1,397,085	1,666,927	1,581,040	1,919,490	118
Total	3,958,270	4,642,808	3,786,877	3,790,121	3,504,181	4,533,817	4,828,208	5,220,520	5,447,952	5,919,703	50

*Rate of increase/decrease in the period 1988/1999

Table A.1.9 Production Volume by Category in the Sector of Manufacture of Petroleum Products

Unit: tons

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	*Rate %
1) Motor petrol	1,733,841	1,713,106	1,160,843	862,182	963,521	1,124,064	1,353,526	1,057,784	1,096,635	1,116,880	-36
2) Crude petrol for petrochemical industry	329,220	217,809	171,079	117,791	164,131	230,941	352,936	215,002	210,648	193,574	-41
3) White spirit	5,529	5,470	3,507	3,020	3,159	2,809	2,868	2,178	3,130	3,394	-39
4) Motor fuel	180,849	176,282	53,894	29,008	88,007	101,601	101,007	84,705	92,909	87,807	-51
5) Kerosene	4,753	5,207	4,102	4,974	7,445	7,763	7,523	10,331	3,506	562	-88
6) Oil gas	1,488,079	1,398,428	902,512	696,804	772,375	951,937	1,140,548	832,450	811,424	906,293	-39
7) Fuel oil	2,217,361	2,747,748	1,764,324	1,915,655	2,146,536	1,657,317	1,817,445	1,841,047	1,850,222	1,827,646	-18
8) Lubricants, oil and grease	213,191	163,823	89,120	69,717	89,276	84,709	78,176	75,321	95,757	61,038	-71
9) Bitumen	239,479	218,910	176,459	159,647	141,612	181,231	145,466	194,800	192,308	143,611	-40
Total	6,412,302	6,646,783	4,325,840	3,858,798	4,376,062	4,342,372	4,999,495	4,313,618	4,356,539	4,340,805	-32

*Rate of increase/decrease in the period 1988/1999

Table A.1.10 Production Volume by Category in the Sector of Manufacture of Chemicals and Chemical Products

Unit: tons

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	*Rate %
1) Plant pesticides and herbicides	15,599	15,661	10,841	9,069	7,568	7,663	7,431	8,700	8,813	7,250	-54
2) Urea	415,960	280,354	328,029	356,995	273,226	278,981	314,136	353,822	375,426	279,111	-33
3) Compound fertilizers	678,119	556,522	532,082	716,537	482,845	554,470	548,405	516,160	536,732	457,557	-33
Total	1,109,678	852,537	870,952	1,082,601	763,639	841,114	869,972	878,682	920,971	743,918	-33

*Rate of increase/decrease in the period 1988/1999

Table A.1.11 Production Volume by Category in the Sector of Manufacture of Iron and Steel

Unit: tons

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	*Rate %
1) Crude steel, Electric Arc Furnace	189,852	170,328	119,759	101,942	73,815	63,352	45,373	45,752	70,660	104,114	-45
2) Semi-fishished rolled products	42,078	31,881	23,816	5,666	6,591	2,430	3,893	2,842	281	0	-100
3) Concrete reinforcers and rolled wire	107,580	109,124	81,592	55,275	35,543	42,608	26,742	21,797	29,408	42,537	-60
4) Strip steel	242,471	183,774	56,968	61,861	51,712	45,048	35,144	22,283	7,764	0	-100
5) Seamless pipes	166,622	126,819	96,131	47,569	37,550	26,116	12,966	16,923	31,904	56,673	-66
6) Welded pipes	247,016	212,593	95,838	67,616	76,711	64,991	45,425	37,405	41,561	63,844	-74
7) Ferro alloys	150,293	129,955	124,263	81,630	36,605	54,337	26,081	10,559	24,231	11,771	-92
Total	1,145,912	964,474	598,367	421,559	318,527	298,882	195,624	157,561	205,809	278,939	-76

*Rate of increase/decrease in the period 1988/1999

Table A.1.12 Production Volume by Category in the Sector of Manufacture of Food Products

Unit: tons

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	*Rate %
1) Wheat flour	489,174	468,844	428,663	418,142	346,467	324,114	323,644	314,896	305,263	297,643	-39
2) Bread	255,807	227,488	184,348	188,759	177,796	164,216	156,914	139,457	155,141	139,722	-45
3) Pasta	17,134	15,893	16,301	13,829	9,849	9,267	8,884	9,214	7,145	7,290	-57
4) Fruit juices	14,644	18,327	15,332	12,309	18,121	16,321	22,695	17,783	8,784	11,894	-19
5) Canned vegetables	24,566	23,266	23,043	25,574	21,763	23,843	22,709	19,216	16,508	22,735	-7
6) Condiments	20,488	21,292	20,110	17,203	20,146	25,731	27,795	30,112	26,414	24,824	21
7) Fresh meat	190,905	188,520	160,614	141,441	130,817	124,538	106,891	105,421	102,473	91,464	-52
8) Sausage products	40,289	39,839	32,748	28,810	30,614	31,073	30,687	33,414	36,553	33,938	-16
9) Canned meat	26,731	26,820	21,262	17,898	16,511	17,054	17,896	15,678	16,328	16,256	-39
10) Concentrated soups	4,433	4,742	3,286	1,674	2,616	3,452	4,133	4,737	4,771	4,606	4
11) Canned fish	28,529	26,437	18,228	17,969	13,482	11,354	12,477	14,778	13,512	11,931	-58
12) Powdered milk	7,419	7,133	3,674	3,827	3,860	3,439	3,623	3,215	2,737	3,963	-47
13) Baby food	6,991	8,631	6,961	6,523	5,998	6,774	6,146	4,932	4,611	4,438	-37
14) Butter	3,078	2,851	1,982	1,722	2,250	2,400	2,243	2,587	2,569	2,414	-22
15) Cheese	25,109	21,350	18,507	15,644	15,524	16,701	17,441	19,003	18,698	18,540	-26
16) Sugar	208,690	200,645	100,162	94,666	78,847	115,440	175,340	195,316	141,380	139,207	-33
17) Candy, sweets and cocoa products	45,978	44,377	32,488	22,473	20,641	20,160	20,154	19,562	19,905	197,727	330
18) Biscuits and related products	44,022	40,848	32,337	23,637	21,528	22,608	23,752	24,479	23,375	23,368	-47
19) Cooking oil	48,465	44,501	42,669	35,770	24,626	29,301	35,575	35,397	36,481	40,951	-16
20) Margarine	15,556	14,730	12,762	11,519	9,779	9,488	10,320	12,374	14,676	15,370	-1
21) Fresh and dried yeast	13,273	14,254	12,586	8,987	8,521	8,453	9,568	11,694	12,109	12,098	-9
22) Coffee substitutes	1,623	1,360	1,091	1,151	834	886	764	792	907	834	-49
23) Livestock feed	904,925	959,084	748,605	648,127	646,405	526,311	515,822	473,781	464,690	522,318	-42
Total	2,437,829	2,421,232	1,937,759	1,757,654	1,626,995	1,512,924	1,555,473	1,507,838	1,435,030	1,643,531	-33

*Rate of increase/decrease in the period 1988/1999

Table A.1.13 Production Volume by Category in the Sector of Manufacture of Textiles

Unit: tons

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	*Rate %
1) Hemp fibre	1,734	1,521	1,161	1,478	698	556	361	127	0	0	-100
2) Cotton textile fibre	25,980	20,372	12,448	12,132	10,301	10,587	8,867	5,276	5,415	5,088	-80
3) Wool textile fibre	13,046	9,650	5,553	4,159	4,079	3,704	3,333	2,490	676	468	-96
4) Hemp textile fibre	2,019	1,772	1,075	811	171	116	99	68	0	0	-100
5) Rope, cord and straps	1,001	1,119	570	393	345	306	272	316	364	406	-59
6) Thread	4,111	2,925	1,779	1,464	1,211	1,516	1,343	1,088	1,117	1,056	-74
Total	47,891	37,359	22,586	20,437	16,805	16,785	14,275	9,365	7,572	7,018	-85

*Rate of increase/decrease in the period 1988/1999

Table A.1.14 Production Volume by Category in the Sector of Manufacture of Metal Products

Unit: tons

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	*Rate %
1) Cast iron and steel semi/finished products and formed	95,327	81,054	40,651	31,492	33,390	29,677	26,035	27,832	30,552	33,397	-65
2) Casting of light metals	5,707	4,627	3,367	2,515	1,425	1,682	1,707	1,323	3,875	4,763	-17
3) Casting of heavy metals	2,312	1,448	825	842	656	725	550	626	515	550	-76
4) Packaging of light metals	17,420	14,195	10,149	8,191	7,421	6,800	7,396	6,940	963	699	-96
5) Drums and similar containers of steel and other metals	11,719	11,054	8,852	7,415	5,739	5,885	6,025	6,168	14,044	14,794	26
6) Nails, rivets and screw products	27,181	18,904	12,684	2,712	1,777	1,263	1,448	1,763	2,153	2,225	-92
7) Electrodes for welding	8,003	4,980	3,111	2,608	1,759	2,190	2,750	3,233	3,319	3,164	-60
8) Metal structure	46,111	35,808	26,188	23,331	15,820	10,986	15,610	18,958	22,749	20,526	-55
9) Metal products for construction	6,126	3,876	1,912	1,756	1,425	1,496	1,317	1,053	1,917	2,619	-57
10) Metal products for safe-keeping, metal household articles and equipment for roads and railways	9,609	8,564	5,103	2,587	2,789	2,134	1,921	2,256	532	440	-95
11) Tanks and cisterns	6,994	7,737	3,714	1,047	2,860	1,452	987	965	3,146	2,189	-69
12) Metal equipment for offices, shops and work shops	7,429	6,648	3,508	1,424	1,963	1,423	1,626	1,381	955	1,102	-85
13) Metal equipment for hospitals	60	42	22	170	127	94	120	71	56	51	-15
14) Stoves, ranges and parts	16,428	13,119	6,863	6,730	6,857	5,393	4,692	7,887	9,599	10,023	-39
Total	260,426	212,056	126,949	92,820	84,008	71,200	72,184	80,456	94,375	96,542	-63

*Rate of increase/decrease in the period 1988/1999

Table A.1.15 Production Volume by Category in the Sector of Manufacture of Machinery and Equipment

Unit: tons

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Rate %
1) Steam boilers (excluding central heating hot water boi	3,580	3,124	1,510	1,713	2,157	2,524	2,955	3,243	3,263	3,877	8
2) Marine engines	7,940	4,747	5,325	3,467	2,856	1,886	2,912	3,386	3,257	2,799	-65
3) Other internal combustion engines	163	103	76	47	32	16	12	23	9	13	-92
4) Machinery for mining, quarrying and construction	3,194	3,980	3,799	1,652	1,116	1,150	789	686	1,622	1,952	-39
5) Machinery for metal and wood processing	10,184	10,027	4,259	3,036	2,320	1,899	1,997	1,648	2,525	2,201	-78
6) Machinery for food, beverage and tobacco processing	7,138	7,166	2,091	1,035	971	866	1,488	994	760	1,030	-86
7) Special purpose machinery	6,064	5,423	2,163	1,105	1,172	504	575	633	358	540	-91
8) Mechanical and electromechanical transmitters	1,195	1,228	715	313	231	312	670	252	643	1,379	15
9) Lifting and handling equipment	11,538	8,134	4,387	2,797	2,289	3,034	3,188	2,980	2,386	2,443	-79
10) Agricultural machinery	32,954	20,674	7,120	2,642	2,066	2,061	2,551	2,242	2,962	3,858	-88
Total	83,950	64,606	31,445	17,807	15,210	14,252	17,137	16,087	17,785	20,092	-76

*Rate of increase/decrease in the period 1988/1999

Table A1.16. Agriculture Production in the Drainage Basin of the Sava River as of 1998

Counties	Main Crops										
	Wheat		Barley		Rape seed		Maize		Potato		Total Has
	Tons	Has	Tons	Has	Tons	Has	Tons	Has	Tons	Has	
Zagreb	55,704	16,202	7,959	2,984	440	313	161,706	38,684	50,612	5,533	63,716
Karlovac	14,803	5,130	3,413	1,223	-	-	32,757	8,865	31,907	3,207	18,425
Sisak-Moslavina	36,151	9,229	6,111	1,854	2,207	832	119,877	23,453	19,231	2,565	37,933
Krapina-Zagorge	15,532	4,995	1,636	620	-	-	64,795	19,322	14,350	2,922	27,859
Koprivnica-Krizevci	52,601	14,805	3,571	1,195	877	456	133,891	31,380	16,588	2,365	50,201
Bjelovar-Bilogora	68,441	20,822	6,606	2,205	1,574	684	148,994	29,169	47,234	5,462	58,342
Primorje-Gorski Kotar	101	34	40	13	-	-	303	142	13,453	1,584	1,773
Pozega-Slavonia	56,595	12,027	4,938	1,439	3,067	904	82,338	14,730	27,509	2,154	31,254
Zagreb City	5,932	2,174	366	157	1	5	21,532	4,885	11,065	1,807	9,028
Total	305,860	85,418	34,640	11,690	8,166	3,194	766,193	170,630	231,949	27,599	298,531

Table A. 1.17 Production of Fish in Ponds of the Study Area as of 1999 year

Name of Fish	Karlovack	Sisak	Zagrebacka County	Total (kg)	Unit Price (Kn/kg)	Total Kuna
Cyprinus Carpio	71,107	171,832	205,000	447,939	14	6,271,146
Aristichthys Novilis	4,545	0	2,500	7,045	10	70,450
Hypophthalmichthys Molitri	2,500	0	500	3,000	10	30,000
Ctenepharyngodon Idella	74,610	2,488	8,000	85,098	11	936,078
Silurus Glanis	1,528	103	6,500	8,131	36	292,716
Exos Lucius	1,030	500	200	1,730	26	44,980
Tinca Tinca	630	0	4,000	4,630	35	162,050
Stizostedion Lucioperca	0	606	2,000	2,606	41	106,846

Average Exchange Rate in 1999: 1US$= 7.11Kuna

Table A.2.1 Projection of the Population in Towns/Municipalities of Zagreb County

A. First Group	1991			1999			2005			2010			2015		
A.1 Towns	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
1. Dugo Selo	9,969	6,508	3,461	15,326	10,570	4,756	16,223	11,189	5,034	17,011	11,732	5,279	17,836	12,301	5,535
2. Ivanic Grad	13,494	7,104	6,390	14,844	7,815	7,029	15,713	8,272	7,441	16,476	8,674	7,802	17,276	9,095	8,181
3. Samobor	35,017	14,170	20,847	39,920	16,154	23,766	42,257	17,100	25,157	44,308	17,930	26,378	46,459	18,800	27,659
4.Velika Gorica	56,884	31,614	25,270	65,680	36,502	29,178	69,525	38,639	30,885	72,900	40,515	32,385	76,439	42,482	33,957
5.Zapresic	20,720	15,678	5,042	23,883	18,071	5,812	25,281	19,129	6,152	26,508	20,058	6,451	27,795	21,031	6,764
A.2 Mun icipalities															
1. Bistra	5,512	1,569	3,943	6,063	1,726	4,337	6,418	1,827	4,591	6,729	1,916	4,814	7,056	2,009	5,048
2. Brckovljani	4,802	696	4,106	5,304	769	4,535	5,614	814	4,801	5,887	854	5,033	6,173	895	5,278
3. Brdovec	8,762	1,901	6,861	10,406	2,258	8,148	11,015	2,390	8,625	11,550	2,506	9,044	12,111	2,627	9,483
4. Rugvica	4,922	600	4,322	6,035	736	5,299	6,388	779	5,610	6,698	817	5,881	7,024	857	6,167
5. Stupnik	2,536	948	1,588	3,120	1,166	1,954	3,303	1,235	2,068	3,463	1,295	2,168	3,631	1,357	2,274
6. Sveta Nedjelja	12,988	981	12,007	14,780	1,116	13,664	15,645	1,182	14,463	16,405	1,239	15,166	17,201	1,299	15,902
Subtotal	175,606	81,769	93,837	205,361	96,883	108,478	217,382	102,554	114,827	227,935	107,534	120,401	239,000	112,754	126,246
B. Second Group															
B.1 Towns															
1. Jastrebarsko	17,895	5,380	12,515	18,073	5,434	12,639	18,354	5,518	12,836	18,591	5,589	13,002	18,831	5,661	13,170
2. Sveti Ivan Zelina	15,552	2,535	13,017	15,707	2,560	13,146	15,951	2,600	13,351	16,157	2,634	13,523	16,365	2,668	13,698
3.Vrbovec	13,303	4,149	9,154	13,435	4,190	9,245	13,644	4,255	9,389	13,726	4,281	9,445	13,999	4,366	9,633
B.2 Mun icipalities															
1. Bedenica	1,600	515	1,085	1,616	520	1,096	1,641	528	1,113	1,662	535	1,127	1,684	542	1,142
2. Dubrava	5,511	1,309	4,202	5,566	1,322	4,244	5,652	1,343	4,310	5,725	1,360	4,365	5,799	1,377	4,422
3. Dubravica	1,575	148	1,427	1,591	149	1,441	1,615	152	1,464	1,636	154	1,482	1,657	156	1,502
4. Farkasevac	2,181	332	1,849	2,203	335	1,867	2,237	341	1,896	2,266	345	1,921	2,295	349	1,946
5. Gradec	3,788	442	3,346	3,826	446	3,379	3,885	453	3,432	3,935	459	3,476	3,986	465	3,521
6. Jakovlje	3,819	2,586	1,233	3,857	2,612	1,245	3,917	2,652	1,265	3,967	2,687	1,281	4,019	2,721	1,297
7. Klinca Sela	4,537	1,057	3,480	4,582	1,068	3,515	4,653	1,084	3,569	4,713	1,098	3,615	4,774	1,112	3,662
8. Klostar Ivani	4,771	2,568	2,203	4,818	2,594	2,225	4,893	2,634	2,259	4,957	2,668	2,289	5,021	2,702	2,318
9. Krasic	3,855	768	3,087	3,893	776	3,118	3,954	788	3,166	4,005	798	3,207	4,057	808	3,248
10. Kravarsko	1,842	480	1,362	1,860	485	1,376	1,889	492	1,397	1,914	499	1,415	1,938	505	1,433
11. Kriz	7,327	1,770	5,557	7,400	1,788	5,612	7,515	1,815	5,699	7,612	1,839	5,773	7,710	1,863	5,848
12. Luka	1,373	362	1,011	1,387	366	1,021	1,408	371	1,037	1,426	376	1,050	1,445	381	1,064
13. Marija Gorica	1,867	138	1,729	1,886	139	1,746	1,915	142	1,773	1,940	143	1,796	1,965	145	1,819
14. Orle	2,214	77	2,137	2,236	78	2,158	2,271	79	2,192	2,300	80	2,220	2,330	81	2,249
15. Pisarovina	4,207	451	3,756	4,249	455	3,793	4,315	463	3,852	4,371	469	3,902	4,427	475	3,952
16. Pokupsko	2,703	289	2,414	2,730	292	2,438	2,772	296	2,476	2,808	300	2,508	2,844	304	2,540
17. Preseka	1,855	140	1,715	1,873	141	1,732	1,903	144	1,759	1,927	145	1,782	1,952	147	1,805
18. Pusca	2,273	707	1,566	2,296	714	1,582	2,331	725	1,606	2,361	734	1,627	2,392	744	1,648
19. Rakovec	1,436	227	1,209	1,450	229	1,221	1,473	233	1,240	1,492	236	1,256	1,511	239	1,272
20. Zumberak	1,899	136	1,763	1,918	137	1,781	1,948	139	1,808	1,973	141	1,832	1,998	143	1,855
Subtotal	107,383	26,566	80,817	108,451	26,830	81,621	110,135	27,247	82,888	111,464	27,570	83,895	113,000	27,956	85,044
Total County	282,989	108,335	174,654	313,812	123,713	190,099	327,517	129,801	197,716	339,399	135,103	204,296	352,000	140,710	211,290
Zagreb City*	777,826	777,826	-	935,000	935,000	-	958,145	958,145	-	977,869	977,869	-	998,000	998,000	-

*: also recognized as a county

Table A.2.2 Projection of the Population in Towns/Municipalities of Sisak-Moslavina County

	1991			1999			2005			2010			2015		
	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Towns															
1. Glina	23,040	6,933	16,107	13,617	4,098	9,519	14,092	4,240	9,851	14,500	4,363	10,137	14,920	4,490	10,430
2. Hrvatska Kostajnica	4,996	3,480	1,516	1,328	925	403	2,423	1,688	735	4,000	2,786	1,214	6,603	4,599	2,004
3. Kutina	24,829	14,992	9,837	23,052	16,800	6,252	24,461	17,827	6,634	25,700	18,730	6,970	27,002	19,679	7,323
4. Novska	17,231	8,053	9,178	12,296	5,747	6,549	14,098	6,589	7,509	15,800	7,384	8,416	17,707	8,276	9,432
5. Petrinja	35,151	18,706	16,445	23,573	12,545	11,028	24,867	13,233	11,634	26,000	13,836	12,164	27,184	14,466	12,718
6. Sisak	61,413	45,792	15,621	69,283	44,175	25,108	69,673	44,424	25,249	70,000	44,632	25,368	70,328	44,842	25,487
Subtotal	166,660	97,956	68,704	143,149	84,289	58,860	149,614	88,001	61,613	156,000	91,732	64,268	163,745	96,351	67,394
Municipalities															
1. Donji Kukuruzari	3,063	301	2,762	826	81	745	917	90	827	1,000	98	902	1,091	695	395
2. Dvor	14,555	2,351	12,204	1,841	297	1,544	2,573	416	2,157	3,400	549	2,851	4,493	726	3,768
3. Gvozd	8,082	1,570	6,512	1,947	378	1,569	2,639	513	2,126	3,400	660	2,740	4,381	851	3,530
4. Hrvatska Dubica	4,237	2,062	2,175	981	477	504	1,598	778	820	2,400	1,168	1,232	3,604	1,754	1,850
5. Jasenovac	3,599	1,154	2,445	1,516	486	1,030	1,948	625	1,323	2,400	770	1,630	2,957	948	2,009
6. Lekenik	6,248	1,652	4,596	7,924	2,095	5,829	7,965	2,106	5,859	8,000	2,115	5,885	8,035	2,124	5,910
7. Lipovljani	3,866	2,430	1,436	3,571	2,245	1,326	3,694	2,322	1,372	3,800	2,389	1,411	3,909	2,457	1,452
8. Majur	2,555	532	2,023	468	97	371	627	131	496	800	167	633	1,021	213	808
9. Martinska Ves	4,643	443	4,200	4,588	438	4,150	4,595	438	4,156	4,600	439	4,161	4,605	439	4,166
10. Popovaca	11,822	3,596	8,226	11,383	3,462	7,921	11,555	3,515	8,040	11,700	3,559	8,141	11,847	3,604	8,243
11. Sunja	12,309	2,113	10,196	8,449	1,450	6,999	8,745	1,501	7,244	9,000	1,545	7,455	9,262	1,590	7,672
12. Topusko*	6,824	1,587	5,237	4,800	1,116	3,684	4,974	1,157	3,817	5,123	1,191	3,932	5,277	1,227	4,050
13. Velika Ludina	2,869	689	2,180	2,877	691	2,186	2,890	694	2,196	2,900	696	2,204	2,911	699	2,212
Subtotal	84,672	20,480	64,192	51,171	13,315	37,856	54,718	14,284	40,434	58,523	15,346	43,177	63,393	17,328	46,065
Total county	251,332	118,436	132,896	194,320	97,604	96,716	204,332	102,285	102,048	214,523	107,078	107,445	227,138	113,679	113,459

*population of 1999 year was estimated by the municipality and the projection was calculated on base of data provided by the Ministry of Physical Planning and Environmental Protection

Table A.2.3 Projection of the Population in Towns/Municipalities of Karlovac County

	1991			1999			2005			2010			2015		
	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
Towns															
1. Karlovac	73,426	59,999	13,427	60,000	52,000	8,000	58,000	50,500	7,500	58,992	51,735	7,257	60,000	53,000	7,000
2. Dugaresa	14,088	7,513	6,575	15,500	8,266	7,234	14,983	8,028	6,956	15,239	8,224	7,016	15,500	8,425	7,075
3. Ogulin*	16,732	10,857	5,875	15,800	10,252	5,548	15,273	9,957	5,317	15,534	10,200	5,334	15,800	10,449	5,351
4. Ozalj*	9,988	1,184	8,804	10,144	1,202	8,942	9,806	1,168	8,638	9,974	1,196	8,777	10,144	1,226	8,918
5. Slunj	10,096	2,026	8,070	6,500	1,304	5,196	6,283	1,267	5,017	6,391	1,298	5,093	6,500	1,329	5,171
Municipalities															
1. Barilovic	4,529	391	4,138	3,020	261	2,759	2,919	253	2,666	2,969	259	2,710	3,020	266	2,754
2. Bosiljevo	2,598	114	2,484	1,700	75	1,625	1,643	72	1,571	1,671	74	1,597	1,700	76	1,624
3. Draganici	3,561	400	3,161	3,700	416	3,284	3,577	404	3,173	3,638	413	3,224	3,700	424	3,276
4. Generalski Stol*	3,833	712	3,121	2,966	551	2,415	2,867	535	2,332	2,916	548	2,368	2,966	562	2,404
5. Josipdol	4,850	1,116	3,734	4,000	920	3,080	3,867	894	2,973	3,933	916	3,017	4,000	938	3,062
6. Krnjak	3,204	441	2,763	2,300	317	1,983	2,223	307	1,916	2,261	315	1,946	2,300	323	1,977
7. Lasinja	2,821	550	2,271	2,000	390	1,610	1,933	379	1,555	1,966	388	1,578	2,000	397	1,603
8. Netretic*	5,437	547	4,890	2,540	256	2,284	2,455	248	2,207	2,497	254	2,243	2,540	260	2,280
9. Plaski	4,317	2,271	2,046	3,270	1,720	1,550	3,161	1,671	1,490	3,215	1,711	1,504	3,270	1,753	1,517
10. Rakovica	4,108	1,012	3,096	2,870	707	2,163	2,774	687	2,088	2,822	703	2,118	2,870	721	2,149
11. Ribnik	878	154	724	800	140	660	773	136	637	787	140	647	800	143	657
12. Saborsko*	1,501	852	649	1,082	614	468	1,046	596	449	1,064	611	453	1,082	626	456
13. Tounj	1,695	414	1,281	1,500	366	1,134	1,450	356	1,094	1,475	365	1,110	1,500	373	1,127
14. Vojnic	8,236	1,204	7,032	2,500	365	2,135	2,417	355	2,062	2,458	364	2,094	2,500	372	2,128
15. Zakanje	3,921	197	3,724	2,000	100	1,900	1,933	98	1,836	1,966	100	1,866	2,000	102	1,898
16. Cetingrad	4,758	910	3,848	4,700	899	3,801	4,543	873	3,670	4,621	894	3,727	4,700	916	3,784
Total	184,577	92,864	91,713	148,892	81,122	67,770	143,929	78,782	65,147	146,389	80,709	65,681	148,892	82,682	66,210

* population by 1999 is estimated from the number of households connected to the electricity service

APPENDIX B

WATER QUALITY AND POLLUTION MECHANISM

APPENDIX B

WATER QUALITY AND POLLUTION MECHANISM

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APPENDIX B WATER QUALITY AND POLLUTION MECHANISM

CHAPTER I INTRODUCTION

1.1 General

The water quality of Sava Main River worsens at drought time due to the decrease of dilution and self-purification effects of the river water. It already exceeds the criteria at the border to Slovenia, and the river water is much more polluted immediately downstream of Zagreb City and the town of Sisak due to the large quantity of untreated industrial and domestic wastewater effluent. The water of Kupa River is also much affected by the untreated industrial and domestic wastewater of the town of Karlovac.

On the other hand, the Lonja river system is more polluted than the Sava Main and Kupa rivers because the river flow rate is inadequate. In addition, this river system receives pollution load from not only the eastern part (eastern part of Zagreb and Sisak-Moslavina counties) but also the areas outside of the Study Area. Lonjsko Polje, a nature park, is located in the lower reaches of the Lonja river system, where water pollution protection is also necessary to preserve the existing ecology.

The major point pollution sources of rivers in the Study Area are the sewerage and industrial wastewaters from the urban centers shown in the table below.

Receiving Water	Urban Centers (Point Pollution Sources)
Sava Main River	Samobor, Zapresic, Zagreb, Velika Golica, Sisak
Kupa River	Plaski, Ogulin, Slunj, Duga Resa, Karlovac, Jastrebarsko, Topusko, Glina, Petrinja
Lonja River	Sesvete East*, Sv. Ivan Zelina, Dugo Selo, Vrbovec, Klostar Ivanic, Ivanic Grad, Popovaca, Kutina, Lipovljani, Novska

* Part of Zagreb City

The pollution mechanism of rivers is complicated. Not all of the pollution loads generated from the basins run off to the rivers; especially, most part of the non-point pollution loads infiltrate into the ground or are treated in the lands/ditches/channels before they enter the rivers. Even the pollution loads that enter the rivers gradually decrease toward downstream due to the self-purification effects of river water. Hence, an elaborate analysis of the pollution mechanism in the river basins is essential to assess the river water quality at the objective river sections.

1.2 Scope of the Study

This Appendix B covers the following major scopes of the Study:

(1) The identification of existing river systems in the Study Area and the analysis of river flow rates at the principal stations in order to obtain the bases for the analysis of pollution mechanism of the river water and for the evaluation of the river water quality;

(2) The analysis of existing river water quality based on data collected as well as those actually observed in the course of the Study in order to evaluate the level of river water quality;

(3) The analysis of existing industrial and sewerage wastewater qualities based on the data collected and actually observed in the course of the Study in order to evaluate the point pollution load generation in the basin;

(4) The estimation of existing and future pollution loads generated in the basin, including point (industrial and sewerage wastewater) and non-point (wastewater of rural households, livestock and lands) sources;

(5) The construction of an integrated simulation model covering pollution load runoffs from the basins to the rivers and the dilution/self-purification effects of the river water in order to analyze the existing pollution mechanism of the river water and to predict the future water quality at the principal river sections; and

(6) The estimation of the pollution reduction effects of the proposed industrial and sewerage wastewater treatment schemes.

CHAPTER II RIVER FLOW AND WATER USE

2.1 Climate

2.1.1 Available Data

The meteorological conditions in the Study Area are observed by the Meteorological and Hydrological Service of Croatia. The observation data of three (3) stations (Zagreb Center, Karlovac Center and Sisak Center) during the recent five (5) years (1994-1998) are employed in the Study to establish the existing climatic conditions of the Study Area, since these stations represent the northern, southwestern and southeastern parts, respectively [1)].

2.1.2 Climatic Characteristics of the Study Area

(1) Temperature

The temperature of the Study Area widely changes throughout the year, recording the highest in July and lowest in December. The monthly mean temperature is in the range of 1.6°C to 22.3°C at the Zagreb Center, 0.0°C to 21.4°C at the Karlovac Center, and 0.5°C to 21.7°C at the Sisak Center. As for the seasonal variation of monthly average temperature, see Fig. B.2.1.

(2) Humidity

The annual average humidity of the Study Area is 69% at the Zagreb Center, 77% at the Karlovac Center and 77% at the Sisak Center.

(3) Rainfall

The average annual rainfall is 921 mm at the Zagreb Center, 1,135 mm at the Karlovac Center and 984 mm at the Sisak Center. Rainfall in the Study Area concentrates in the summer season (June-September); however, severe drought spells also usually occur in this season. The lowest monthly rainfall is recorded in February and March. The monthly average rainfall in the Study Area ranges from approximately 40 mm in February and March to about 120 mm in August and September. As for the seasonal variation of monthly rainfall, see Fig. B.2.1.

(4) Number of Clear/Cloudy/Rainy Days

The average annual number of clear/cloudy/rainy days at the Zagreb, Karlovac and Sisak centers are given below.

Item	Zagreb Center	Karlovac Center	Sisak Center
Clear Days	47	57	39
Cloudy Days	131	130	119
Rainy Days	104	89	123

2.2 River System

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 joining the Donau as a tributary. The river originates in the mountains located in the country boundary between Slovenia and Austria, and flows down for 259 km through Slovenia before crossing the boundary into Croatia. The river length and drainage area within the territory of Croatia are 518 km and 25,100 km^2, respectively.

The Sava drainage area within Croatia (from Slovenian border to confluence with Una River) is divided into three (3) main basins; namely, Upper Sava River Basin, Middle Sava River Basin and Lower Sava River Basin, which are further divided into 34 sub-basins. The subdivided drainage basins in the Study Area are shown in Fig. B.2.2. As for the area of each sub-basin (whole and within the Study Area), see Appendix F, Table F.1.2.

On the other hand, considering also the main tributaries of the Sava River in Croatia, the Sava drainage area can be divided into the following six (6) river systems. As for the area of each sub-basin of these river systems, see Appendix F, Table F.2.3.

(1) Upper Sava Main River System

The upper part of the Study Area is drained by the Upper Sava Main River and its tributaries, namely, Sutla River and Krapina River. Starting from the country boundary between Slovenia and Croatia, the Upper Sava Main River flows through Zagreb City and down to the principal river station named Oborovo for a distance of 63 km. This river system has six (6) sub-basins: Sutla, Bregana, Luznica, Gradna-Rakovica, Krapina and Zagreb City.

The Sutla River drains an area of 593 km^2 into the Sava River at the country boundary between Slovenia and Croatia. To the west of the Sutla river basin is Slovenia, which has an area of 423 km^2. The Krapina River, with a basin area of 1,234 km^2, joins the Sava River at the upstream of Zagreb from the north. The sewerage channel in Zagreb joins the Sava River at the downstream of the city.

After the confluence of these rivers and channel, the water flows down the middle stretch of the Sava Main River. Hence, the Upper Sava Main River drains a total area of 2,527 km^2 along with its tributaries (Basin upstream of Zagreb: Upper Sava Main River Basin).

(2) Middle Sava Main River System

The Middle Sava Main River is defined as the stretch from the confluence of the channel downstream of Zagreb to the confluence point of the Kupa River at Sisak. No additional tributary discharges into this 58 km stretch until Sisak; the flood plains directly drain into this Middle Sava Main River, which has a total drainage area of 77 km^2 (Basin upstream of Sisak: Middle Sava Main River Basin).

(3) Lower Sava Main River System

In the lower part of the Study Area (downstream of Sisak), the Sava River is joined by the Lonja and Veliki-Strug rivers from northeast of the drainage basin. The Lower Sava Main River drains four (4) sub-basins: Sunja-Jastrebica, Lower Una, Ilova-Pakra and Veliki-Strug. A total of 3,807 km^2 is drained by this lower 124 km stretch of the river (Basin downstream of Sisak: Lower Sava Main River Basin).

(4) Upper Kupa River System

The Upper Kupa River drains four (4) sub-basins: Upper Kupa (2,203 km^2), Dobra (1,397 km^2), Mreznica (459 km^2) and Korana (1,358 km^2). The upper part of Kupa River (upstream of Karlovac) is joined by the Dobra, Mreznica and Korana rivers before Karlovac. For a distance of 76 km, this upper part of Kupa River drains a total of 5,417 km^2 (Basin upstream of Karlovac: Upper Kupa River Basin).

(5) Lower Kupa River System

The Lower Kupa River drains five (5) sub-basins: Lower Kupa (1,710 km^2), Glina (1,453 km^2), Utinja-Petrinjcica (261 km^2), Moatanica (66 km^2) and Odra (763 km^2).

The lower part of Kupa River (downstream of Karlovac) is joined by the Glina and Odra rivers before Sisak. For a distance of 146 km, the lower part of Kupa River drains a total of 4,253 km^2 (Basin downstream of Karlovac: Lower Kupa River Basin).

(6) Lonja River System

Lonja River can be divided into 12 sub-basins: Upper Lonja, Middle Lonja, Lower Lonja, Upper N. Zelina, Lower N. Zelina, Upper Cesma, Middle Cesma, Lower Cesma, Crnec, Crnec (Lonja), Lonja-Trebez and Glogovnica. Lonja River drains an area of 4,320 km^2 in the northern part of the Study Area.

The Lonja River system presents a very complicated structure because of the entangled channels constructed for flood control. The upper part of Lonja River (after Vrbovec) is joined by Zelina River from the northwest, then the Lonja River bifurcates into two (2) rivers, the Lonja and Glogovnica. The Lonja River further flows down southward through Ivanic Grad and then joined by Zelina River after the confluence of Crnec River. On the other hand, Glogovnica Channel and Cesma River flow into each other at Cazma.

The lower part of Lonja River (downstream of Kriz) is met by Cesma River (C.A.: 1,951 km^2) from the north after Kriz, drains the lower part of the Lonja River River Basin, and then meets the Lower Sava Main River.

2.3 River Flow Rate

2.3.1 Available Data

The Meteorological and Hydrological Service of Croatia is the principal agency responsible for water level and flow rate measurements in the rivers of the Study Area. As given in Table B.2.1, there are 183 water level and flow rate measurement stations operated by the Service in the Study Area.

Among the above 183 stations, the following eight (8) stations were selected for this Study, taking into account their location and observation periods. As to their location, see Fig. B.2.3.

River/Station	Catchment Area (km^2)	Observation Period	Remarks
Sava River Main			
Jesenice	10,750	1964 - 1995	Slovenian border
Zagreb	12,450	1926 - 1995	
Crnac	22,852	1955 - 1990	After confluence with Kupa
Kupa River			
Dobra-Upper Kupa	3,405	1957 - 1995	After confluence with Dobra River
Mreznica	975	1947 - 1995	Lowest
Korana	1,297	1946 - 1990	Lowest
Farkasic	8,902	1965 - 1990	Upstream of Sisak
Lonja River (Cesma River)			
Cazma	2,877	1963 - 1995	Cesma River (after confluence with Glogovnica)

All of the flow rate data available at the eight (8) measurement stations are shown in Table B.2.2. Among the available data, those of the latest 20 years were used for the hydrological analysis in this Study [2-9].

2.3.2 Seasonal Variation of River Flow Rate

The river flow seasonally varies independently of the seasonal change of rainfall. The monthly average river flow lowers during July to September and rises during March to May. The variation of monthly average flow rate at the major five (5) principal stations is shown in Fig. B.2.4.

2.3.3 Flow Regime

The river flow regimes at the eight (8) principal stations were analyzed, based on the flow data during the latest 20 years. River flow regime is presented in a manner of monthly average flow rate - frequency curve in Fig. B.2.5. The flow regime at each station is summarized below.

River/Station	C.A. (km^2)	Ave. (m^3/s)	75% (m^3/s)	85% (m^3/s)	95% (m^3/s)
Sava River Main					
Jesenice	10,750	292	186	152	109
Zagreb	12,450	309	199	157	120
Crnac	22,852	527	273	212	149
Kupa River					
Dobra-Upper Kupa	3,405	57.5	46.2	31.2	19.6
Mreznica	975	24.4	9.2	7.0	4.6
Korana	1,297	27.3	9.9	6.1	4.0
Upper Kupa Total	5,677	109	65.3	44.3	28.2
Recica*	5,806	109	66.8	45.3	28.8
Farkasic	8,902	194	84.9	59.8	36.5
Lonja River (Cesma River)					
Cazma	2,877	17.4	3.39	1.96	1.16

Note: C.A. means catchment area; Ave. is yearly average flow rate; * estimated from Upper Kupa Total

2.4 Existing River Water Use

Water use in the Study Area mostly depends on the groundwater. River water use is limited to the domestic/industrial purposes of the Sisak, Petrinja, Duga Resa and Kutina towns. No irrigation water is taken from the river.

Based on the data file of Croatian Waters, the existing river water uses of the Study Area are as summarized below.

Town	Factory Name/Municipal	Intake Quantity (m^3/year)	River	Treatment	Remarks (Year)
Sisak	Termoelektrana Sisak	178,910	Sava	-	Permission (1999)
	Segestica Sisak	214,396	Kupa	-	Permission (1999)
Kutina	Petrokemija Kutina	40,400,000	Pakra	-	Records (1999)
Petrinja	Petrinja/Sisak Municipal	8,760,000	Kupa	Conventional	Records (1999)
Duga Resa	Pamucna Ind.	1,015,555	Mreznica	-	Records (1998)
Duga Resa	Duga Resa Municipal	1,095,000	Dobra	Chlorination	Records (1999)
	Total	51,663,861	-	-	-

Further, the municipal water (6,210,707 m^3/year) of Karlovac is taken from the riverine groundwater of the Korana River. The groundwater is directly recharged by the Korana River although it is not defined as river water.

2.5 Existing Aquatic Life and Water Recreation

2.5.1 Existing Aquatic Life

(1) General

Generally, the existing conditions of aquatic life especially ichthylogical fauna give important information on water pollution. For this purpose, the JICA Study Team conducted a fish survey in cooperation with the Department of Zoology, Zagreb University. This Section presents the existing conditions of ichthylogical fauna in the Sava River Basin based on the survey results [10)].

(2) General Structure of Fish Communities in the Sava River Basin

About 49 species of fish live in the Sava Main River and its tributaries, according to the present information (Habeković, Mrakovčić, Lajner Povž). This is about 16 species less than those in the Drava River, which is another large Danubian watershed river in Croatia.

The observed fishing area belongs to the European-Mediterranean ichthyological region, which is characterized by a small number of sub-families. The identified species of fish in the Sava River belong to 8 families, as shown below.

Family	Species
Petromyzoniade	Danubian lamprey (*Eudontomyzon danfordi* Regan 1911)
Salmonidae	Brown trout (*Salmo trutta f.fario* L. 1758)
	Rainbow trout (*Oncorhynchus mykiss* Richardson 1836)
Cyprinidae	roach (*Rutilus rutilus* L. Vladykov 1930)
	chub (*Leuciscus cephalus* L. 1758)
	nase (*Chondrostoma nasus* L. 1758)
	barbel (*Barbus barbus* L. 1758)
	Southern barbel (*Barbus meridionalis* Risso 1828)
	carp (*Cyprinus caprio* L. 1758)
	bleak (*Alburnus alburnus* L. 1758)
	bream (*Abramis brama* L.1758)
	Schneider (*Alburnoides bipuctatus* L. Bloch, 1782)
	soufie (*Leuciscus souffia* Risso 1826)
	false rasbora (*Pseudorazbora parva* Schlegel 1842)
	vimba (*Vimba vimba* L. Carinatta Pallas 1811)
	rudd (*Scardinius erithropthalmus* L. 1758)
	asp (*Aspius aspius* L. 1758)
	tench (*Tinca tinca* L. 1758)
	Prussian carp (*Carassius auratus gibelio* Bloch 1783)
	Bitterling (*Rhodeus sericeus amarus* Bloch 1782)
	Gudgeon (*Gobio gobio* L. Valenciennes 1844)
	Danubian gudgeon (*Gobio uranoscopus* Agassiz 1828)
Cottidae	Bullhead (*Cottus gobio* L. 1758)
Cobitidae	Balcan loach (*Cobitis elongata* Heckel &Kner 1858)
	Spined loach (*Cobitis taenia* L. 1758)
Percidae	perch (*Perca fluviatilis* L. 1758)
	streber (*Zingel streber* L. S. Pebold 1863)
Centrarchidae	Pumpkinseed (*Lepomis gibbosus* L. 1758)
Siluridae	Wels (*Silurus glanis* L. 1758)

(3) Distribution of Existing Ichthyological Fauna

Based on the fish survey in this Study, the distribution of existing ichthylogical fauna is as tabulated below. Profiles of the existing ichthylogical fauna are illustrated in Fig. B.2.6.

River	Location	Number of Species	Dominant Fish Fauna
Sava	Podsused	6	Albumoides bipuctatus
	Savski Most	12	Leuciscus cephalus
	Toplana (near Zagreb)	15	Leuciscus cephalus
	Confluence point with Una	13	Albumoides bipuctatus
Odra	Selce bridge, Donji gaz and Pescenka-Vratovo Channel	23	Rutius rutilus
Kupa	Source	4	
	Upper area	23	
	Middle area	27	
	Lower area	24	
Dobra	Source	7	Phoxinus phoxinus-minow
	Upper area	19	Alburnodes bipuntatus-shneider
	Middle area	18	Alburnodes bipuntatus-shneider
	Lower area	13	Alburnodes bipuntatus-shneider
Mreznica	Existing Data	15	Cyprinidae
Korana	Upper area	15	Phoxinus phoxinus-minow
	Lower area	26	Leuciscus cephalus-chab
Krapina	Existing Data	23	Schneider
Lonja	Upstream of Ivan Zelina	10	Pseudirasbora parva
	Near Ivanic Grad	10	Carassius auratus
	Near Lonijsko polje	9	Leuciscus cephalus
Crnec	Existing Data	7	Carassius auratus
Zelina	Existing Data	10	Albumus albumus

As shown in the above table, the Krapina, Odra, Kupa, Dobra, Mreznica and Korana rivers are abundant in ichthylogical fauna. However, the number of fish species in the Sava Main, Lonja and Crnec rivers is less, compared to the above-mentioned rivers, due to water pollution.

2.5.2 Existing Water Recreation

Fishing and swimming were identified as the dominant water recreation activities in the Study Area. The existing condition of these activities are governed by not only access time to the shore and fish condition, but also river water quality. This Section presents the existing distribution of water recreation related to fishing and swimming.

(1) Fishing

Based on the information provided by the Department of Zoology, Zagreb University, approximately 40-60 thousand people like fishing in the Sava River Basin. It was also reported that about 30 sport-fishing associations are active in the fishing area.

(2) Swimming

Swimming is not common in the Sava River Basin. However, in rivers with satisfactory water quality for this purpose, for instance, Korana River, Dobra River, Mreznica River and Kupa River, this activity is popular. Based on the information from the municipalities concerned, the swimming spots located in the Study Area are as shown below [11, 12].

River	Municipality	Location Name
Mreznica	Slunj	K.O. Donnje Primisje
		K.O. Gornje Primisje
Korana	Slunj	Nazivlja
Kupa	Petrinja	Kupelizje
		Zibel

The water quality of the above swimming spots is determined to be suitable for swimming.

CHAPTER III EXISTING RIVER WATER QUALITY

3.1 Available Water Quality Data

3.1.1 Sampling Location and Frequency

Croatian Waters has periodically analyzed river water quality in the Study Area since 1973. Four (4) laboratories of other organizations under the control of the central laboratory of Croatian Waters have been entrusted with the analysis.

The sampling locations and frequency are given below. These sampling locations are also shown in Fig. B.3.1.

No.	River	Location	Code No. (GIS Code)	Yearly Frequency	Remarks
	Sava River				
1	Main	Jsenice	10017 (289)	48	Boundary of Slovenia
2		Jankomir	10016 (280)	48	Upper Zagreb
3		Petrujevac	10015 (291)	48	
4		Oborovo	10014 (242)	48	
5		Martinska Ves	10013 (241)	48	
6		Galdovo	10012 (238)	48	
7		Utok Kupe Nizvodno	10011 (237)	48	
8		Utok Une Uzovodno	10010 (230)	48	
9		Utok Une Nizvodno	10009 (229)	48	Lowest end of the Study Area
10	Krapina River	Zapresic	17001 (281)	5	
11	Lonja River	Ivanic Grad	15481 (245)	5	
	Kupa River				
12	Main	Sisak	16001 (248)	48	
13		Brest	16002 (249)	48	
14		Sisinec	16003 (250)	48	
15		Jamnicka Kiselica	16004 (252)	48	
16		Recica	16005 (254)	48	
17		Gornje Pokupje	16006 (267)	48	
18		Kamanje	16007 (268)	48	Boundary of Slovenia
19	Korana River	Velemeric	16331 (255)	5	
20		Veljun	16333 (256)	5	
21		Slunj	16334 (257)	5	
22		Bogovolja	16335 (258)	12	
23	Mreznica River	Mostanje	16451 (260)	12	
24		Juzbasici	16453 (261)	12	
25	Dobra River	Donje Stative	16571 (262)	5	
26		Lesce	16572 (263)	5	
27	Odra	Sisak	16220 (240)	12	

3.1.2 Water Quality in the Past

The periodically analyzed water quality parameters are as follows:

Water Temperature, EC, pH, DO (Dissolved O_2), BOD, COD, TOC, SS, T-S, Fe, Mn, Ca, Mg, K, Na. Oil, NH_4, NO_3, NO_2, Org-N, PO_4, T-P, Anionic Detergent, Mineral Oils, Hardness ($CaCO_3$), Fecal Coliform Bacteria Number, etc.

The analyzed water quality at the above 27 sampling locations during the recent six (6) years (1994-1999) are shown in Table B.3.1 [13, 14)].

Four (4) of the 27 locations, namely, Sava River (after Grad Zagreb and after Sisak), Kupa River (after Karlovac) and Lonja River (after Ivanic Grad), are essential for the evaluation of water quality in the Study Area. The average and 95% values of water quality in major parameters are summarized in the table below. Further, the longitudinal variation of river water quality in the Sava Main River and Kupa River were analyzed for the parameters of BOD, T-N and PO_4-P, as shown in Fig. B.3.2.

Parameter		Sava River (after Zagreb)	Sava River (after Sisak)	Kupa River (after Karlovac)	Lonja River (after Ivanic Grad)
Average	Water Temp. (°C)	13.2	12.6	16.2	14.2
	pH	7.7	7.8	8.1	7.5
	DO (O_2) (mg/l)	7.8	7.5	9.8	6.1
	BOD (mg/l)	4.8	3.7	2.5	10.0
	COD (mg/l)	5.3	4.8	2.2	14.1
	SS (mg/l)	28	23	19	24
	Fecal coli (MPN/100ml)	71×10^4	20×10^3	15×10^4	93×10^2
	NH_4–N (mg/l)	0.76	0.76	0.17	0.78
	NO_2-N (mg/l)	0.057	0.76	0.050	0.159
	NO_3-N (mg/l)	2.41	0.76	0.64	2.20
	T-N (mg/l)	4.29	5.64	-	6.46
	PO_4-P (mg/l)	0.18	0.51	0.21	0.43
	Phenol (mg/l)	0.004	0.006	0.010	0.005
95% Value	pH	8.1	8.2	8.4	7.9
	DO (O_2) (mg/l)	4.2	4.5	6.6	1.6
	BOD (mg/l)	8.6	6.3	4.3	21.2
	COD (mg/l)	9.52	8.0	3.0	23.5
	SS (mg/l)	102	93	34	57
	Fecal coli (MPN/100ml)	39×10^5	32×10^3	78×10^4	24×10^4
	NH_4–N (mg/l)	0.91	0.87	0.23	0.78
	NO_2–N (mg/l)	0.134	0.407	0.103	0.159
	NO_3-N (mg/l)	3.81	6.71	0.98	2.20
	T-N (mg/l)	7.37	8.84	-	6.46
	PO_4-P (mg/l)	0.40	0.89	0.34	0.43
	Phenol (mg/l)	0.008	0.013	0.012	0.005

As reflected in the table above, water quality has the following characteristics:

(1) The river water temperature varies between 3°C and 25°C throughout the year. The yearly average river water temperature is 13°C to 16°C.

(2) pH value is in a normal range with reference to the standards of river water quality.

(3) BOD and COD show high values on the Sava Main River after Zagreb and on the Kupa River after Karlovac.

(4) T-N and T-P (PO_4-P) are also considerably high because of the untreated sewerage/industrial wastewater effluent. This phenomenon is also shown in Fig. B.3.2

(5) Fecal coliform and NH_4 are high on the Sava Main River after Zagreb and Kupa River after Karlovac. This is considered mainly due to the large domestic wastewater effluents of the city and the town.

(6) The 95% value of DO in Lonja River at Ivanic Grad is very low. This is considered due to the oxygen consumption by excessive organic pollution loads.

(7) Lonja River at Ivanic Grad is highly polluted. Most of the water quality parameters much exceed the criteria for the river.

3.2 Supplementary Water Quality Observation

Supplementary water quality observation was executed twice; namely, in December 2000 and in May 2001. Sampling of water from the major rivers was done during fine weather to evaluate the existing water quality. Sampling of sediment deposit on major rivers was made only in December 2000 at the same time with the water quality sampling to evaluate the existing deposit quality.

3.2.1 Sampling Time and Location

(1) Water Quality

(a) Major Rivers

Samples of river water were taken at 16 points on the major rivers. The sampling locations are as follows (see Fig. B 3.1):

River	Sampling Location	Code No. (GIS Code)
Sava River	Jesenice (Boundary of Slovenia)	10017 (289)
	Jankomir	10016 (280)
	Petrujevac	10015 (291)
	Oborovo	10014 (242)
	Martinska Ves	10013 (241)
	Galdovo	10012 (238)
	Topolovac	(296)
	Utok Kupe Nizvodono (Lukavec)	10011 (237)
Kupa River	Recica	16003 (254)
	Brest (Before Petrinja)	16006 (249)
	Sisak	16007 (248)
Lonja River	After Vrbovec City (Poljanski Lug)	(291)
	After Ivanic Grad	15481 (245)
	After Confluence of R. Crnec (K.Lonja Strug)	(292)
	After Confluence of R. Cesma (Struzec)	(294)
	Lowest	(298)

(b) Tributary/Canal

Samples of river water were taken at four (4) points on the tributary/canal. The sampling locations are as follows (see, Fig. B.3.1):

River/Channel	Sampling Location	Code No. (GIS Code)
Crnec	Lowest	(297)
Cesma River	Casma	(244)
Kutina River	After Kutina	(295)
V.Strug	Bridge	-

(2) Deposit Quality

Samples of sediment deposit were taken at 12 points on the major rivers. The sampling locations are as follows (see, Fig. B.3.1):

River	Sampling Location	Code No. (GIS Code)
Sava River	Oborovo	10014 (242)
	Martinska Ves	10013 (241)
	Galdovo	10012 (238)
	Topolovac	(296)
	Utoc Kupe Nizvodno (Lukavec)	10011 (237)
Kupa River	Recica	16003 (254)
	Brest	16006 (249)
Lonja River	After Ivanic Grad	15481 (245)
	After confluence of Cesma (Struzec)	(294)
	Lowest (Trebez)	(298)
Other Tributries	Crnec	(297)
	Kutina River	(298)

3.2.2 Observed Parameters

(1) Water Quality

The observation of river water quality of the major rivers involving 36 parameters was done in fine weather; namely, one (1) time at the Sava Main River and the Kupa River, and three (3) times at the Lonja River and other tributaries.

The observed parameters are given below.

Classification	Parameter
General Items	Discharge, Color, Odor, EC, Turbidity, pH, DO (O_2), Temperature
Organic Substances	BOD, COD
Eutrophication	T-N, NH_4, NO_3, NO_2, T-P, PO_4
Suspended Solids	SS, Particle Size Distribution, V-SS
Toxic Substances	Phenol, As, Cd, CN, Cr, Cu, Hg, Ni, Pb, Zn, Pesticides (3 kinds)
General Metal	Fe, Mn
Coliform Bacillus	Total, Fecal

(2) Deposit Quality

The quality of deposits in the river was also observed in fine weather at the principal stations of water quality observation. The observed parameters were 14, as shown below.

Classification	Parameter
General Items	Color, Odor
Heavy Metals	As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, Se, F
Peticides and Others	Organo-chlorine, PCB

3.2.3 Results of Analysis

(1) Water Quality

The results of water quality analysis are shown in Table B.3.2.

(2) Deposit Quality

The results of deposit quality analysis are shown in Table B.3.3.

3.3 Evaluation of Observation Results

3.3.1 River Water Quality

(1) River Water Quality in December 2000

The average water quality at the major river stations in December 2000 are summarized below (Sava River: Jesenice, Oborovo, Galdovo, and Utok Kupe Nizvodono; Kupa River: Recica, Brest and Sisak).

Item	Unit	Sava River				Kupa River		
		Jesenice	Oborovo	Galdovo	Utok Kupe Nizvodono	Recica	Brest	Sisak
Flow Rate	m^3/s	310	-	-	-	240	-	-
pH	-	7.3	8.1	7.8	7.8	7.0	7.8	7.9
DO	mg/l	8.8	8.7	9.3	9.1	9.9	10.0	9.5
BOD_5	mg/l	2.1	2.1	2.1	2.5	6.9	4.1	2.4
COD	mg/l	3.1	4.3	3.5	3.4	8.6	5.1	3.7
T-N	mg/l	1.50	1.50	1.60	1.60	3.50	1.60	1.60
T-P	mg/l	0.07	0.09	0.03	0.07	0.03	0.33	0.07
NH_4-N	mg/l	0.05	0.06	0.13	0.13	0.12	0.08	0.09
NO_3-N	mg/l	1.14	1.13	1.16	1.09	2.36	0.78	0.73
NO_2-N^-	mg/l	0.043	0.127	0.080	0.081	0.019	0.006	0.008
SS	mg/l	12	6	4	24	20	4	6
Phenol	mg/l	0.000	0.000	0.000	0.000	0.001	0.002	0.001
Oil	mg/l	0.14	0.09	0.12	0.10	0.04	0.05	0.08
Total coli.	MPN	54×10^3	61×10^3	87×10^3	90×10^3	15×10^3	42×10^3	31×10^3
Fecal coli.	MPN	46×10^2	54×10^3	27×10^3	14×10^3	20×10^2	34×10^2	30×10^2

The average water quality at the tributaries and canals in December 2000 are summarized below (Lonja River: After Vrbovec, Ivanic Grad, After Crnec, and After Cesma; Crnec River: Lowest; Cesma River: Cazma; Kutina River: Kutina).

Item	Unit	Lonja River				Crnec River	Cesma River	Kutina River
		After Vrbovec	Ivanic Grad	After Crnec	After Cesma	Lowest	Casma	Kutina
Flow Rate	m^3/s	4.66	2.53	6.08	20.65	28.70	12.68	1.91
pH	-	7.5	7.5	7.4	7.4	7.5	7.7	7.4
DO	mg/l	8.3	7.8	5.4	7.1	6.2	8.5	6.6
BOD_5	mg/l	4.2	6.6	6.8	7.3	5.6	5.0	9.9
COD	mg/l	12.1	13.3	14.8	16.5	17.8	14.0	20.7
T-N	mg/l	3.37	5.80	10.65	4.10	5.20	4.67	26.85
T-P	mg/l	0.55	0.33	0.71	0.57	0.28	0.34	5.95
NH_4-N^+	mg/l	0.88	1.14	4.13	0.87	1.51	1.77	13.37
NO_3-N	mg/l	1.66	3.05	2.08	2.01	2.51	2.08	9.13
NO_2-N	mg/l	0.056	0.083	0.054	0.043	0.071	0.050	0.255
SS	mg/l	31	14	11	157	8	34	73
Phenol	mg/l	0.005	0.002	0.007	0.009	0.003	0.003	0.017
Oil	mg/l	0.03	0.03	0.11	0.07	0.09	0.07	0.08
Total coli.	MPN	10×10^3	58×10^3	61×10^3	20×10^2	14×10^2	65×10^2	12×10^5
Fecal coli.	MPN	36×10^2	62×10^2	20×10^3	23×10	64×10	46×10^2	74×10^3

(2) River Water Quality in May 2001

The average water quality at the major river stations in May 2001 are summarized below (Sava River: Jesenice, Oborovo, Galdovo, and Utok Kupe Nizvodono; Kupa River: Recica, Brest and Sisak).

Item	Unit	Sava River				Kupa River		
		Jesenice	Oborovo	Galdovo	Utok Kupe Nizvodono	Recica	Brest	Sisak
Flow Rate	m^3/s	130	-	-	-	-	48	-
pH	-	7.6	7.6	7.7	8.1	7.9	6.7	7.7
DO	mg/l	9.6	6.5	5.2	6.8	8.8	10.0	9.4
BOD_5	mg/l	2.3	2.4	2.0	1.8	2.6	1.5	1.2
COD	mg/l	3.6	3.3	3.1	2.9	3.1	2.5	2.0
T-N	mg/l	1.80	2.14	2.44	1.90	1.02	1.04	1.02
T-P	mg/l	0.07	0.09	0.14	0.06	0.03	0.05	0.16
NH_4-N	mg/l	0.03	0.29	0.27	0.19	0.04	0.04	0.04
NO_3-N	mg/l	1.07	1.09	1.11	0.94	0.45	0.37	0.32
NO_2-N^-	mg/l	0.031	0.030	0.024	0.025	0.009	0.009	0.010
SS	mg/l	4	38	34	4	91	8	10
Phenol	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Oil	mg/l	0.10	0.05	0.04	0.04	0.03	0.04	0.03
Total coli.	MPN	42×10	31×10^2	27×10^2	21×10^2	36×10^2	30×10	50×10
Fecal coli.	MPN	80	14×10^2	40×10	18×10^2	24×10^2	11×10	20×10

The average water quality at the tributaries and canals in May 2001 are summarized below (Lonja River: After Vrbovec, Ivanic Grad, After Crnec, and After Cesma; Crnec River: Lowest; Cesma River: Cazma; Kutina River: Kutina).

Item	Unit	Lonja River				Crnec River	Cesma River	Kutina River
		After Vrbovec	Ivanic Grad	After Crnec	After Cesma	Lowest	Casma	Kutina
Flow Rate	m^3/s	0.66	0.52	1.32	10.84	0.72	4.09	0.28
pH	-	7.3	7.7	7.7	7.2	7.8	7.8	7.5
DO	mg/l	5.6	6.4	6.1	2.5	4.8	6.0	4.8
BOD_5	mg/l	6.5	12.8	11.3	10.5	10.5	6.3	7.3
COD	mg/l	13.6	27.4	18.9	18.2	18.6	14.3	17.9
T-N	mg/l	2.31	2.21	4.42	3.33	5.17	2.16	30.70
T-P	mg/l	0.30	0.28	0.28	0.23	0.49	0.31	31.70
NH_4-N^+	mg/l	0.71	0.34	2.56	0.71	3.06	0.43	13.98
NO_3-N	mg/l	0.64	0.97	0.27	0.98	0.15	1.13	7.41
NO_2-N	mg/l	0.110	0.110	0.050	0.124	0.060	0.120	0.393
SS	mg/l	38	14	24	23	44	34	93
Phenol	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Oil	mg/l	0.02	0.05	0.07	0.03	0.04	0.05	0.05
Total coli.	MPN	17×10^2	21×10^2	27×10^2	24×10	54×10	86×10	22×10^2
Fecal coli.	MPN	11×10^2	16×10^2	15×10^2	93	29×10	52×10	14×10^2

(3) Evaluation of River Water Quality Observation Results

The river water quality observed in December 2000 and May 2001 is characterized as below, compared to the river water quality standards mentioned in Section 3.4.

(a) River flow rate in December 2000 is three to five times larger than the rate in May 2001. Hence, the dilution effect on pollutants in December 2000 is much larger than the one in May 2001.

(b) pH at all the sampling points is normal in both seasons.

(c) In both seasons, SS value in both the Sava Main and Kupa rivers indicate that these rivers are not turbid; however, Lonja River is turbid, especially after the confluence of Cesma River. A change in SS value has no significant effect.

(d) DO values in both seasons are summarized below.

(i) December 2000

DO in the Sava Main, Kupa and Lonja rivers is almost saturated, but the DO values satisfy the national standard water quality of Category II (7-6 mg/l). However, DO in the Crnec River is lower than the standard for Category II.

(ii) May 2001

DO in the Sava Main and Kupa is almost in the same condition as December 2000. On the other hand, DO in Lonja River is much lower than in December 2000, especially after the confluence of Cesma River (Struzec).

(e) BOD and COD concentration are summarized below.

(i) December 2000

BOD and COD concentrations in the Sava Main River satisfy the river water quality standard for Category II (2-4 mg/l) because of the sufficient river flow rate. On the other hand, Kupa River (except at Sisak), Lonja River, Crnec River, Cesma River and Kutina River are polluted by organic substances, and BOD at the sampling points is higher than the standard for Category II (2-4 mg/l).

(ii) May 2001

The longitudinal change of BOD and COD concentrations in the Sava Main and Kupa rivers are similar to the values in December 2000. As for Lonja River, Crnec River, Cesma River and Kutina River, there is an indication that these rivers are polluted by organic substances, i.e., the BOD values at the sampling points are higher than those in December 2000 due to the small river flow rate.

(f) Regardless of season, high contents of NH_4-N were observed in both the Crnec River and the Kutina River. This is considered mainly due to the large sewerage wastewater of the upper area.

(g) Regardless of the sampling season, T-N and T-P concentrations in the Lonja River become higher as the river flow lowers due to a large quantity of untreated wastewater inflow from the basin. Further, T-N and T-P in the Lonja River after the confluence of the Crenec and Cesma rivers far exceed the ordinary criteria of lake eutrophication (T-N>0.2 mg/l, T-P>0.02 mg/l). Since Lonjsko Polje, one of the nature parks in the country, is located in the downstream reaches of the Lonja river system (a flood plain of Sava River), the inflow of river water polluted with T-N and T-P may cause severe eutrophication of Lonjsko Polje.

(h) All of the nine (9) major heavy metals (As, Cd, CN, Cr^{6+}, Cu, Hg, Ni, Pb, Zn) were either not detected or negligible in both sampling seasons.

(i) Oil concentrations at all points were quite low in both sampling seasons.

(j) In both seasons, pesticides were detected at many sampling points. However, the concentration is negligible.

3.3.2 Deposit Quality

The average quality of deposits in the riverbed of the Sava, Kupa, Lonja, Crnec and Kutina rivers are summarized below.

(Unit: mg/dry-kg)

Item	Sava River	Kupa River	Lonja River	Crnec River	Kutina River
Hg	N.D.	N.D.	N.D.	N.D.	N.D.
As	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	0.26	1.25	0.37	0.90	7.10
Pb	5.3	0.2	1.6	N.D.	N.D.
Se	N.D.	N.D.	N.D.	N.D.	N.D.
Cr	27.4	26.3	21.7	8.8	35.9
Cu	24.3	16.7	31.1	6.0	23.1
Zn	124	60.5	115	37.0	179
Ni	22.3	34.3	35.7	16.0	25.3
F	6.2	5.4	15.5	25.2	229
PCB	0.01	0.01	N.D.	N.D.	0.53
Pesticides	0.036	0.003	0.023	0.005	0.001

Note: N.D. means Not Detected

(1) Hg, As and Se were not detected at any sampling location. On the other hand, certain levels of Pb, Cr, Cu, and Ni concentrations were identified, although the concentration level was as low as that of ordinary soils, causing no problem concerning deposits and water environments.

(2) Cd, F and PCB of relatively high concentrations were detected in the deposits of the Kutina River. This is attributable to the factory effluent. However, those in the other sampling locations are in the same level as ordinary soils.

(3) Pesticides were detected at all sampling points. However, the concentration was negligible.

3.4 River Water Quality Standards

River water is classified into five (5) categories in the Decree on Water Classification [Official Gazette: Narodne Novine (NN) No. 77/98] according to quality corresponding to the established conditions of general ecological function and to the condition under which water is used for a particular purpose. The five categories correspond to the following water uses.

Category	Water Use
I	(1) Drinking and food processing industry in its natural condition or after disinfection (2) Breeding of high quality fish species (trout)
II	(1) Drinking and other industrial purposes after proper treatment (2) Bathing, recreation, water sports (3) Breeding of other fish species (cyprinid)
III	(1) Industrial purposes requiring no specific water quality and agricultural purposes
IV	(1) Water uses with treatment in great water shortage areas
V	(1) Unsuitable for any water use

The Decree prescribes the standard water quality of each category. The major water quality parameters are shown below. For details, see Table B.3.4.

Parameter	I	II	III	IV	V
pH (mg/l)	8.5-6.5	6.5-6.3, 8.5-9.0	6.3-6.0, 9.0-9.3	6.0-5.3, 9.3-9.5	< 5.3, > 9.5
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
NH_4-N (mg/l)	< 0.10	0.1-0.25	0.25-0.60	0.60-1.50	> 1.50
NO_2-N (mg/l)	<0.01	0.01-0.03	0.03-0.100	0.10-0.20	> 0.20
NO_3-N (mg/l)	<0.5	0.5-1.5	1.5-4.0	4.0-10.0	10.0<
T-N (mg/l)	< 1.0	1.0-3.0	3.0-10.0	10.0-20.0	> 20
T-P (mg/l)	< 0.1	0.10-0.25	0.25-0.60	0.60-1.50	> 1.50

On the other hand, the National Water Protection Plan sets the standard river flow rate to evaluate the river water quality as follows: "Water categorization relates to rivers with unregulated flow, for all flows equal to or greater than the monthly low water of 95% probability and to rivers with a regulated flow, with a greater than the guaranteed low water." The major rivers in the Study Area are currently categorized as follows.

River	Existing Water Use	Category
Trans-National River		
Sava Main (Upstream of Zagreb)	Recreation, Scenic View, Aquatic Life	II
Sava Main (Zagreb - Sisak)	Industrial, Recreation, Scenic View, Aquatic Life	III
Sava Main (Downstream of Sisak)	Recreation, Scenic View, Aquatic Life	II
Kupa (Upstream of Metlika)	Recreation, Scenic View, Aquatic Life	I
Kupa (Metlika - Confluence with Korana)	Recreation, Scenic View, Aquatic Life	II
Kupa (Karlovac - Sisak)	Drinking, Industrial, Recreation, Scenic View, Aquatic Life	II
Glina (Source to Topusko)	Recreation, Scenic View, Aquatic Life	II
Glina (Topusko to Confluence with Kupa)	Recreation, Scenic View, Aquatic Life	II
Korana (Plitvice Lake - Slunj)	Recreation, Scenic View, Aquatic Life	I
Korana (Slunj - Confluence with Kupa)	Drinking, Recreation, Scenic View, Aquatic Life	II
Other National Rivers		
Odra River		II
Dobra River	Drinking, Recreation, Scenic View, Aquatic Life	II
Mreznica River	Industrial, Recreation, Scenic View, Aquatic Life	II
Kupcina River	Recreation, Scenic View, Aquatic Life	II
Linking/Relief/Rim Channel		
Lonja - Strug Channel	Recreation, Scenic View, Aquatic Life	II
Kupa - Kupa Channel		II
Sava - Odra Channel		II
Zelina - Lonja - Glogovnica - Cesma Channel		II

CHAPTER IV EXISTING WASTEWATER QUALITY

4.1 Industrial Wastewater Quality

4.1.1 Existing Available Data

Factories concerned are required under the existing regulations to undertake industrial wastewater quality analysis by entrusting it to licensed laboratories. The industrial wastewater quality at 234 effluent points in the Study Area has been analyzed and data since 1996 are available at the Croatian Waters.

The sampling locations of the industrial wastewater quality are shown in Table B.4.1, while the average industrial wastewater quality at the major factories during 1996-1999 are shown in Table B.4.2. The analyzed water quality parameters are as follows.

> Water Temperature, EC, pH, DO (Dissolved O_2), BOD, COD, TOC, SS, Heavy Metals (Cd, Pb, Cr, Zn, Hg, etc.), Toxic Substance (CN, F, Pesticides), Oil, NH_4, NO_3, NO_2, T-N, PO_4, T-P, T-Fe, Mg, Hardness ($CaCO_3$), Fecal Coli.

4.1.2 Supplementary Observation

To evaluate the current wastewater quality, the JICA Study Team observed the quality of wastewater of the 12 major factories in the Study Area in November to December, 2000. The quality of sediment deposits on the effluent points was also observed.

(1) Sampling Frequency and Location

Sampling of industrial wastewater was made three (3) times on the same day at each outlet point. The wastewater quantity was also observed three (3) times along with the wastewater quality sampling. The sampling locations are shown in Fig. B.4.1.

On the other hand, three (3) deposits were sampled once on the same day at the wastewater effluent points along with the wastewater sampling. The sampling locations are also shown in Fig. B.4.1.

The factory name, location, activities and wastewater recipients are as follows.

Factory Name	Location	Activities	Receiving Body
Pamucna Ind. DR	Duga Resa	Textile	Mreznica River
Pivovara - Brewery	Karlovac	Brewery	Sewerage
PPK - Meat	Karlovac	Meat/Food Products	Kupa River
Herbos	Sisak	Chemicals	Sewerage
Segestica - Alchol	Sisak	Beverage	Sewerage
INA Rafinerija nafte	Sisak	Oil Refinery	Sava River
Termoelektrana	Sisak	Electric Power Supply	Sava River
Gavrilovic	Petrinja	Meat Products	Kupa River
Petrokemija	Kutina	Fertilizer	Kutia River
PIK - Meat	Vrbovec	Meat Products	Luka Canal
Agroproteinka	Sesvete	Animal Food Products	Crnec River
Pliva	Savski Moruf	Drug/Chemicals	Gorjak Stream

(2) Observed Parameters

The observed parameters are shown below.

Classification	Parameter
General Items	Discharge, Color, Odor, EC, Turbidity, pH, Temperature, DO
Organic Substances	BOD, COD (Mn)
Eutrophication	T-N, NH_4, NO_3, NO_2, T-P, PO_4
Suspended Solids	SS
Toxic Item	Phenol, Hg, Cd, Pb, CN, Se, Cr, Zn, Ni^{2+}, F, PCB, Org-Chloride (Pesticides)
Coliform Bacillus	Total, Fecal
Other Items	Detergent, Oil (n-hexane Extract), Cl (Chloride)
Deposits	Hg, As, Cd, Pb, Se, Cr, Zn, Ni^{2+}, F, PCB, Org-Chloride (Pesticides)

(3) Results of Analysis

The observed wastewater and deposit quality are shown in Table B.4.3 and Table B.4.4, respectively.

(4) Evaluation of Observation Results

The average water quality of industrial effluent is summarized below.

Parameter	Pamucna Ind. D.R.	Pivovara Brewery	PPK	Herbos	Segestica	INA
	Duga Resa	Karlovac	Karlovac	Sisak	Sisak	Sisak
Discharge (m^3/s)	0.035	0.077	0.011	0.002	0.002	0.046
pH	10.2	8.8	7.7	9.8	5.3	7.3
BOD (mg/l)	141	373	277	15	4170	12
COD (mg/l)	197	281	154	17	5430	23
SS (mg/l)	159	202	52	172	2330	24
T-N (mg/l)	4.48	7.59	9.91	19.44	700	72.2
T-P (mg/l)	0.75	12.6	8.12	1.73	23.7	2.19
Phenol (mg/l)	0.000	0.019	0.069	0.015	0.203	0.018
Oil (mg/l)	0.04	0.14	0.11	10.08	7.77	7.60
Parameter	Termo-elektrana	Gavrilovic	Petrokemija	PIK	Agropro-teinka	Pliva
	Sisak	Petrija	Kutina	Vrbovec	Sesvete	Svaski Moruf
Discharge (m^3/s)	6.94	0.024	0.067	0.024	0.003	0.082
pH	6.9	7.4	7.5	7.3	5.5	8.7
BOD (mg/l)	2	25	4.3	201	4950	480
COD (mg/l)	3.9	27	7.0	89.5	1980	560
SS (mg/l)	43	80	32	293	3100	180
T-N (mg/l)	3.25	10.17	37.40	30.50	570	166
T-P (mg/l)	0.15	2.73	4.85	4.58	45.71	3.22
Phenol (mg/l)	0.050	0.068	0.004	0.117	1.085	0.024
Oil (mg/l)	4.10	13.97	2.53	4.07	25.98	0.28

As reflected in the above table and in Table B.4.2 (Average Industrial Wastewater Quality in 1996-1999), the industrial wastewater quality is characterized as follows:

(a) Wastewater quality of organic pollutants are very high at Segestica in Sisak and Agroproteinka in Sesvete.

(b) Wastewater from Segestica, INA, Petrokemija, PIK, Agroproteinka and Pliva contain a large quantity of T-N and T-P.

(c) Oil concentration in all the factories is not so high and lower than the permissible limits of industrial wastewater except Agroproteinka.

(d) Among the 11 major heavy metals and toxic substances (Cd, CN, Se, Cr, Hg, Ni, Pb, Cu, Zn, PCB and Pesticides), low concentrations of Cr, CN, Pb, Cu, and Zn were detected in the industrial wastewater.

Further, the deposit quality at the industrial effluent is summarized below.

Parameter	Herbos	Agroproteinka	Priva
	Sisak	Sesvete	Svaski Moruf
Hg (mg/dry kg)	102	0.04	0.07
Cd (mg/dry kg)	<1.0	<1.0	<1.0
Pb (mg/dry kg)	64.3	<10	<10
Se (mg/dry kg)	0.13	0.02	<0.01
Cr (mg/dry kg)	65.0	7.3	1130
Ni (mg/dry kg)	28.2	102	<5
Cu (mg/dry kg)	361	49.8	9.2
Zn (mg/dry kg)	639	98.3	35.2
F (mg/dry kg)	9.9	6.3	5.1
PCB (mg/dry kg)	20.0	1.96	0.37
Pesticides (mg/dry kg)	10.6	ND	ND

As shown in the above table, toxic substances of high concentration were detected in the deposits of Herbos in Sisak and Pliva in Svaski Moruf, compared to ordinary soils. Especially, Hg, PCB and pesticides of Herbos were very high. This may be due to the fact that Herbos produces agricultural chemicals containing mercury (Hg).

4.2 Sewerage Wastewater Quality

4.2.1 Existing Available Data

Municipalities concerned are required under the existing regulations to undertake wastewater quality analysis by entrusting it to licensed laboratories. The sewerage wastewater quality at 24 effluent points in the Study Area has been analyzed and data since 1996 are available at the Croatian Waters.

The analyzed wastewater quality parameters are as follows.

Water Temperature, EC, pH, DO (Dissolved O_2), BOD, COD, TOC, SS, Heavy Metals (Cd, Pb, Cr, Zn, Hg, etc), Toxic Substance (CN, F, Pesticides), Oil, NH_4, NO_3, NO_2, T-N, PO_4, T-P, T-Fe, Mg, Hardness ($CaCO_3$), Fecal Coli

The municipalities, sampling locations and receiving bodies are shown below.

Municipality	Sampling Location	Receiving Body
Duga Resa	VINICE	Mreznica River
	DOM SPORTOVA	Mreznica River
	MLIN	Mreznica River
Karlovac	Collector DREŽNIK	Kupa River
	Collector BANIJA I	Kupa River
	Collector BANIJA II	Kupa River
	Collector GRAD	Kupa River
Trska Cesta	No. 1 (the old one)	Kupa River
Ivanic Grad	Inlet	Ivancic Grad Treatment System
	Outlet	Lonja River
Sisak	Pump Station - Galdovo Outlet 1	Sava River
	Žitna Outlet 2	Kupa River
	MAŽURANIĆEVA Outlet 3	Kupa River
	Ladjaska Outlet 4	Kupa River
	Školska Outlet 5	Kupa River
Kutina	Inlet	Kutina Sewerage Treatment System
	Outlet to Canal Kutina-Ilova	Kutina Canal
Novska, Brocice	Outlet 1	Outlet in Novljancica
Novska, Grad	Outlet 2	Outlet in Novljancica
Vrbovec	Livadarska Street Outlet 1	Outlet in Novljancica
	Kolodvorska Street Outlet 2	Outlet in Luku
	Zagrebacka Street Zagrebacka Outlet 3	Outlet in Luku
Ivan Zelina	ZAGREBAČKA Street Outlet 1	Outlet in ZELINU

The average sewerage wastewater quality at the above 24 sampling locations in 1996-1999 are shown in Table B.4.5.

4.2.2 Supplementary Observation

The JICA Study Team observed the sewerage wastewater effluent at 14 towns to evaluate the current wastewater quality based on the following sampling specifications:

(1) Sampling Time and Location

(a) Sewerage-1 (Standard Sampling: 11 points)

One (1) sample was taken at each of the 11 sewerage effluent points.

(b) Sewerage-2 (Continuous Sampling: 3 points)

One (1) sample was taken in every three (3) hours, i.e., eight (8) samples a day at each of the three (3) sewerage effluent points (Kutina, Sisak and Vrbovec).

The sampling type, location and receiving body are tabulated below. As for the sampling locations, see also Fig. B.4.1.

Type	Sampling Location	Receiving Body
Sewerage-1	Zagreb	Sava River
	Sesvete	Crnec River
	Karlovac	Kupa River
	Samobor	Sava River
	Velika Golica	Sava River
	Zapresic	Krapina River
	Dugo Selo	Crnec River
	Jastrebarsko	Bresnica Stream
	Petrija	Kupa River
	Duga Resa	Mreznica River
	Ivanic Grad	Lonja River
Sewerage-2	Kutina	Kutina Channel
	Sisak	Sava River
	Vrbovec	Luka Channel

(2) Observed Parameters

The observed parameters are given below.

Classification	Parameter
General Items	Discharge, Color, Odor, EC, Turbidity, pH, Temperature, DO
Organic Substances	BOD, COD (Mn)
Eutrophication	T-N, NH_4, NO_3, NO_2, T-P, PO_4
Suspended Solid	SS
Toxic Item	Phenol, Hg, As, Cd, Pb, CN, Se, Cr, Zn, Ni^{2+}, F, PCB, Org-Chloride (Pesticides)
Coliform Bacillus	Total, Fecal
Other Items	Detergent, Oil (n-hexane Extract), Cl (Chloride)

(3) Results of Analysis

The observed wastewater quality is shown in Table B.4.6.

(4) Evaluation of Observation Results

The average wastewater quality of sewerage effluent is summarized in the following table.

Parameter	Zagreb	Sesvete	Karlovac	Samobor	Velika Golica	Zapresic	Dugo Selo
Discharge (m^3/s)	4.22	0.017	0.126	0.270	0.139	0.093	0.046
pH	8.0	7.2	7.1	7.5	7.7	7.5	7.5
BOD (mg/l)	190	63.0	460	32.0	15.0	96.0	70.0
COD (mg/l)	68.0	31.0	138	20.0	17.0	50.0	33.0
SS (mg/l)	370	103	111	110	66	126	120
T-N (mg/l)	21.5	27.4	37.7	11.1	35.0	15.6	28.0
T-P (mg/l)	5.60	5.13	8.60	1.73	4.15	4.96	3.91
Phenol (mg/l)	0.033	0.042	0.051	0.013	0.018	0.022	0.024
Oil (mg/l)	3.37	0.33	0.18	0.48	0.14	3.63	0.11
Parameter	Jastre-bersko	Petrinja	Duga Resa	Ivanic Grad	Kutina	Sisak	Vrbovec
Discharge (m^3/s)	0.025	0.052	0.004	0.082	0.027	0.096	0.029
pH	7.5	7.5	7.1	7.4	7.8	8.3	7.8
BOD (mg/l)	60.0	25.0	31.0	43.0	29.4	30.5	78.5
COD (mg/l)	42.0	28.0	28.0	30.0	37.9	44.6	39.5
SS (mg/l)	73	106	119	102	41	134	82
T-N (mg/l)	25.3	20.0	8.77	19.5	35.1	44.6	25.9
T-P (mg/l)	4.16	4.24	1.19	3.54	6.21	6.14	5.54
Phenol (mg/l)	0.007	0.011	0.004	0.030	0.031	0.053	0.025
Oil (mg/l)	0.217	7.40	0.17	0.47	4.4	30.2	0.23

As shown in the above table and in Table B.4.5 (Average Wastewater Quality in 1996-1999), sewerage wastewater quality is characterized as follows:

(a) Concentrations of organic pollutants vary much among wastewater effluents.

(b) Concentrations of T-N and T-P are moderate, compared with ordinary sewerage wastewater.

(c) Oil concentrations are lower than the permissible limits.

(d) Among the 11 major heavy metals and toxic substances (Cd, CN, Se, Cr, Hg, Ni, Pb, Cu, Zn, PCB and Pesticides), only Cr, CN, Pb, Cu, and Zn were detected, but their concentrations were very small.

4.3 Standard of Wastewater Quality

4.3.1 Regulation of Industrial Wastewater Effluent

The permissible limits of industrial wastewater discharged into rivers and public sewerage systems are prescribed in the Decree (NN No. 40/99, as amended by NN No. 6/01). The values of major parameters are as tabulated below. As for the permissible limits of other parameters, see Table B.4.7. Industrial wastewater discharge into rivers of Category I (Very Sensitive Area) is not allowed.

Parameter	II	III	IV	V	Sewerage
pH	6.5 - 8.0	6.0 - 8.5	5.5 - 9.0	5.0 - 9.5	5.0 - 9.5
SS (mg/l)	35	35 - 60	60-150	150	*
BOD (mg/l)	25	25	40	80	250 [1)]
COD-Cr (mg/l)	125	125	200	400	700 [1)]
T-N (mg/l)	21	31	42	42	-
T-P (mg/l)	1	2	4	8	10
Oil and Grease ((mg/l)	25	30	40	50	100

Note: * To be determined at sewerage company's option.
[1)] Sewerage company can change the values depending on its treatment capacity.

4.3.2 Regulation of Effluent from Sewage Treatment Plant

The permissible limits of effluent (SS, BOD, COD-Cr, T-N, T-P) discharged into rivers from sewage treatment plants are also prescribed in the Decree (NN No. 40/99). The limitations vary according to the size of treatment plant and the category of receiving river, as follows.

River Category	Plant Size	SS (mg/l)	BOD (mg/l)	COD-Cr (mg/l)	T-N (mg/l)	T-P (mg/l)
II (Sensitive Area)	< 10,000 PE	60	40	150	-	-
	10,000 PE - 100,000 PE	35	25	125	15	2
	> 100,000 PE	35	25	125	10	1
III (Less Sensitive Area)	< 10,000 PE	120 - 150	-	-	-	-
	> 10,000 PE	35	25	125	-	-
IV (Less Sensitive Area)	< 10,000 PE	Appropriate	-	-	-	-
	10,000 PE - 50,000 PE	120 - 150	-	-	-	-
	> 50,000 PE	35	25	125	-	-

The effluent of toxic substances shall comply with the regulation on industrial wastewater discharge. Wastewater discharge into the river of Category I (Very Sensitive Area) is not allowed irrespective of the treatment level of sewage treatment plant.

CHAPTER V EXISTING AND FUTURE POLLUTION LOAD GENERATION

5.1 General

For the river water quality simulation, the pollution load generation needs to be calculated not only for the Study Area (Zagreb City and the Zagreb, Sisak-Moslavina and Karlovac counties with a total area of 11,794 km^2), but also for the outer areas (Kurapina, Upper Glogovnica, Upper Cesma, Upper Ilova and other river basins with a total area of 6,487 km^2). The objective outer areas include the whole or part of the five (5) counties (Krapina-Zagorje, Koprivnica-Krizevci, Bjelovar-Bilogora, Pozego-Slavonia and Slavonski Brod-Posavina).

The objective Sava River Basin covering the Study Area and outer areas (simulation objective area: 18,280 km^2) was divided into six (6) major sub-basins which were further subdivided into 20 sub-basins, as tabulated below, for the estimation of existing and future pollution load generation. As for the location of the six (6) major sub-basins and the 20 sub-basins, see Fig. B.5.1. The main features of the 20 sub-basins are shown in Table B.5.1.

Major Sub-basins	20 Sub-basins
Upper Sava River	(1) Sutla River, (2) Krapina River, (3) Zagreb Area
Middle Sava River	(11) Middle Sava River
Lower Sava River	(18) Una-Sunja River, (19) Ilova-Pakra River, (20) Veliki-Strug River
Upper Kupa River	(4) Upper Kupa River, (5) Dobra River, (6) Mreznica River, (7) Korana River
Lower Kupa River	(8) Lower Kupa - Glina River, (9) Moatanica Area, (10) Odra River
Lonja River	(12) Zelina-Crnec River, (13) Upper Lonja River, (14) Middle Lonja River, (15) Upper Cesma - Glogovnica River, (16) Moslavina Area, (17) Lower Lonja River

Note: Number in parenthesis is the sub-basin number in Fig. B.5.1

In this Study, pollution load is classified into the point and non-point load. The point load includes (i) municipal wastewater discharged into rivers from sewerage system, (ii) industrial wastewater discharged into rivers from sewerage system, and (iii) industrial wastewater discharged directly into rivers. However, domestic wastewater not covered by sewerage system is dealt as non-point load. Hence, the non-point load includes the wastewater from households (not covered by sewerage system), livestock and lands (agricultural land, pasture and shrub/forest). The wastewater from urban lands is disregarded since urban areas are small.

5.2 Existing Pollution Load Generation

5.2.1 Point Pollution Load Generation

The point pollution load in the Study Area is assumed to be generated from the 24 urban centers tabulated below. The municipal and industrial wastewaters in the other urban centers in the Study Area are dealt as non-point pollution load since they are small in quantity.

County/City	Urban Center	County	Urban Center
Zagreb City	Zagreb	Sisak-Moslavina	Kutina
	Sesvete East		Petrinja
Zagreb County	Dugo Selo		Glina
	Vrbovec		Topusko
	Sv. Ivan Zelina		Popovaca
	Ivanic Grad		Lipovljani
	Klostar Ivanic		Novska
	Samobor	Karlovac	Karlovac
	Zapresic		Duga Resa
	Velika Gorica		Ogulin
	Jastrebarsko		Plaski
Sisak-Moslavina	Sisak		Slunj

The pollution load consists of sewerage effluent including municipal and industrial wastewaters, and industrial wastewater directly discharged into the river. They are separately estimated for each urban center.

The wastewater of the sewerage system in the above urban centers is discharged with no treatment except Velika Gorica (biological treatment), Kutina (preliminary treatment) and Ivanic Grad (preliminary treatment). The industrial wastewater is discharged into sewerage systems or directly into rivers with either no treatment or insufficient treatment. The existing generated pollution loads of sewerage and industrial wastewater from the 24 urban centers are as estimated in Appendix D, Table D.10.1.

On the other hand, the following 18 urban centers (18 towns) are located outside of the Study Area but the pollution load generation from these urban centers are also counted as point pollution load.

County	Urban Center	County	Urban Center
Krapina-Zagorje	Krapina	Bjelovar-Bilogora	Cazma
	Zabok		Daruvar
	Zlatar		Grubisno Polje
	Pregrada		Garensnica
	Donja Stubica	Pozego-Slavonia	Lipik
	Kanjec		Pakrac
	Oroslavje	Slavonski Brod-Posavina	Cernik
Koprivnica-Krizevci	Krizevci		Okucani
Bjelovar-Bilogora	Bjelovar		Goruji Bogcevci

Among the sewerage systems of the above 18 urban centers, three (3) urban centers, namely Bjelovar, Daruvar and Garensnica, are provided with the biological treatment system. The point pollution load generation from these 18 urban centers are roughly estimated by multiplying the existing population with the per capita pollution load generation.

5.2.2 Non-point Pollution Load Generation

In this Study, non-point pollution load is assumed to be generated from livestock, lands (agricultural land, pastureland, shrub/forest) and households in rural area. The number of livestock, rural population and land use area in each sub-basin are estimated, as shown in Table B.5.1.

Unit pollution load generation (BOD, COD, T-N and T-P) of each non-point source category are assumed, as shown in Table B.5.2, based on previous studies and reports. In the above table, unit population load generation of household is the load generated after septic tank treatment.

The non-point pollution load generation of BOD, COD, T-N and T-P in each sub-basin are calculated as products of values in Table B.5.1 and Table B.5.2.

5.2.3 Total Existing Pollution Load Generation

The existing total pollution load generation of BOD, COD, T-N and T-P in the objective Sava River Basin (simulation objective area: 18,280 km^2) are summarized below.

(Unit: kg/d)

Pollution Load Parameter	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total
BOD	113,200	1,208	60,541	37,011	56,345	112,063	380,367
COD	76,931	1,107	54,019	23,502	60,170	95,999	311,638
T-N	39,812	855	25,566	10,973	26,307	53,914	158,428
T-P	6,136	105	4,529	1,550	5,167	5,987	23,474

The above pollution load generation of BOD, COD, T-N and T-P are broken down by pollution source, as shown below.

(1) BOD

(Unit: kg/day)

Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
Point (sewerage)	52,854	0	3,428	2,241	3,952	3,505	65,979	17.4
Point (industry)	11,465	0	364	1,654	916	1,712	16,111	4.2
Sub-total	64,319	0	3,792	3,895	4,868	5,217	82,090	21.6
Non-point (household)	796	21	263	221	791	1,162	3,254	0.9
Non-point (livestock)	42,623	931	52,195	30,259	45,770	96,756	268,534	70.6
Non-point (land)	5,462	256	4,291	2,635	4,916	8,928	26,488	7.0
Sub-total	48,881	1,208	56,749	33,116	51,477	106,846	298,277	78.4
Total	113,200	1,208	60,541	37,011	56,345	112,063	380,367	100.0

(2) COD

(Unit: kg/day)

Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
Point (sewerage)	25,629	0	720	1,618	2,823	3,532	34,322	11.0
Point (industry)	9,506	0	144	1,176	686	1,712	13,274	4.2
Sub-total	34,360	0	581	2,146	2,399	3,927	43,414	15.3
Non-point (household)	494	12	152	99	455	667	1,879	0.6
Non-point (livestock)	32,312	688	38,622	10,884	42,184	72,854	197,544	63.3
Non-point (land)	8,900	317	14,381	9,725	14,022	17,235	64,670	20.8
Sub-total	41,796	1,017	53,155	20,708	56,661	90,756	264,093	84.7
Total	76,931	1,017	54,019	23,502	60,170	95,999	311,638	100.0

(3) T-N

(Unit: kg/day)

Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
Point (sewerage)	10,508	0	653	411	725	938	13,234	8.4
Point (industry)	2,715	0	583	86	732	762	4,880	3.1
Sub-total	13,222	0	1,238	496	1,457	1,700	18,114	11.4
Non-point (household)	134	3	44	29	133	194	537	0.3
Non-point (livestock)	15,071	305	17,376	5,716	15,310	33,776	87,554	55.3
Non-point (land)	11,385	547	7,908	4,732	9,407	18,244	52,223	33.0
Sub-total	26,590	855	25,328	10,477	24,850	52,214	140,314	88.9
Total	39,812	855	26,566	10,973	26,307	53,914	158,428	100.0

(4) T-P

(Unit: kg/day)

Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
Point (sewerage)	1,220	0	142	94	165	173	1,795	7.7
Point (industry)	553	0	60	30	29	39	710	3.0
Sub-total	1,773	0	202	124	194	212	2,505	10.7
Non-point (household)	21	1	7	4	21	31	85	0.4
Non-point (livestock)	4,118	95	3,973	1,194	4,593	5,282	19,255	82.0
Non-point (land)	224	9	347	228	359	462	1,629	6.9
Sub-total	4,363	105	4,327	1,426	4,973	5,775	20,969	89.3
Total	6,136	105	4,529	1,550	5,167	5,987	23,474	100.0

The existing pollution load generation of BOD, COD, T-N and T-P by source and by major sub-basin is illustrated in Fig. B.5.2. Further, it is broken down by source and by sub-basin, as shown in Table B.5.3.

The ratio of existing pollution load generation of each source in the objective Sava River Basin is shown in Fig. B.5.3. Of the total pollution load generation, non-point pollution load generation of BOD shares 78%, COD is 84%, T-N is 89% and T-P is 89%.

Further, the distribution of existing pollution load generation (BOD) in the Study Area is shown in Fig. B.5.4.

5.3 Future Pollution Load Generation Without Project

5.3.1 Point Pollution Load Generation

Municipal wastewater will increase according to the growth of sewerage served population and per capita wastewater quantity, while industrial wastewater will increase according to the growth of industrial production. The future point pollution load generation without project in the objective Sava River Basin in the target years of the Master Plan (2015) and F/S (2007) are estimated, as shown in the tables in Appendix D and Appendix E. Table D.10.2 in Appendix D shows the sewerage and industrial pollution load generated from 24 urban centers of the Study Area in 2015, while Table E-I.2.1 in Appendix E shows the sewerage and industrial pollution load generated from the 24 urban centers in 2007.

On the other hand, the future pollution load generation of the 18 urban centers in the outer area is assumed to increase in proportion to the growth of pollution load generation in Ivanic Grad whose population size is nearly equal to the average size in the 18 urban centers. The estimated growth rate of pollution load generation in Ivanic Grad is 152% in 2007 and 219% in 2015.

5.3.2 Non-point Pollution Load Generation

The future non-point pollution load generation is assumed to be the same as the existing one since no significant development/increase of land, livestock and rural population is expected in the future.

5.3.3 Total Future Pollution Load Generation

The total future pollution load generation of BOD, COD, T-N and T-P in the objective Sava River Basin (simulation objective area: 18,280 km^2) are summarized in the table below.

(Unit: kg/d)

Target Year	Pollution Load Parameter	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total
2007	BOD	130,444	1,208	62,503	38,939	57,500	114,066	404,660
	COD	93,979	1,107	57,159	24,862	61,018	96,423	334,459
	T-N	44,658	855	26,678	11,304	26,030	54,349	163,875
	T-P	8,403	105	4,566	1,621	5,217	6,023	25,935
2015	BOD	148,442	1,208	64,491	42,103	58,837	116,792	431,873
	COD	95,062	1,017	58,797	27,115	61,981	98,104	342,077
	T-N	47,232	855	27,181	11,775	27,288	55,123	169,454
	T-P	7,214	105	4,663	1,738	5,280	6,114	25,115

The future pollution load generation of BOD, COD, T-N and T-P are broken down into point and non-point sources, as shown in the table below. It is further broken down by sub-basin and by source, as shown in Table B.5.4 (2007) and Table B.5.5 (2015).

(Unit: kg/day)

Parameter	Target Year	Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
BOD	2007	Point	81,563	0	5,754	5,823	6,023	7,220	106,383	26.3
		Non-Point	48,881	1,208	56,749	33,116	51,477	106,846	298,277	73.7
		Total	130,444	1,208	62,503	38,939	57,500	114,066	404,660	100.0
	2015	Point	99,561	0	7,742	8,988	7,360	9,946	133,596	30.9
		Non-Point	48,881	1,208	56,749	33,116	51,477	106,846	298,277	69.1
		Total	148,442	1,208	64,491	42,103	58,837	116,792	431,873	100.0
COD	2007	Point	52,183	0	4,004	4,154	4,357	5,667	70,366	21.0
		Non-Point	41,796	1,017	53,155	20,708	56,661	90,756	264,093	79.0
		Total	93,979	1,017	57,159	24,862	61,018	96,423	334,459	100.0
	2015	Point	53,266	0	5,642	6,407	5,320	7,348	77,984	22.8
		Non-Point	41,796	1,017	53,155	20,708	56,661	90,756	264,093	77.2
		Total	95,062	1,017	58,797	27,115	61,981	98,104	342,077	100.0
T-N	2007	Point	18,068	0	1,350	827	1,180	2,135	23,561	14.4
		Non-Point	26,590	855	25,328	10,477	24,850	52,214	140,314	85.6
		Total	44,658	855	26,678	11,304	26,030	54,349	163,875	100.0
	2015	Point	20,642	0	1,853	1,298	2,438	2,909	29,140	17.2
		Non-Point	26,590	855	25,328	10,477	24,850	52,214	140,314	82.8
		Total	47,232	855	27,181	11,775	27,2886	55,123	169,454	100.0
T-P	2007	Point	4,040	0	239	195	244	248	4,966	19.1
		Non-Point	4,363	105	4,327	1,426	4,973	5,775	20,969	80.9
		Total	8,403	105	4,566	1,621	5,217	6,023	25,935	100.0
	2015	Point	2,851	0	336	312	307	339	4,146	16.5
		Non-Point	4,363	105	4,327	1,426	4,973	5,775	20,969	83.5
		Total	7,214	105	4,663	1,738	5,280	6,114	25,115	100.0

The above table shows that non-point pollution load generation without project is much larger than point pollution load generation, as summarized below.

Without Project	Pollution Load Parameter	Ratio of Non-point Source (%)
2007	BOD	74
	COD	81
	T-N	86
	T-P	81
2015	BOD	69
	COD	77
	T-N	83
	T-P	83

CHAPTER VI SIMULATION OF RIVER WATER QUALITY

6.1 Construction of Simulation Model

6.1.1 General

Non-point pollution loads run off on lands or through small channels/ditches to a tributary. On the other hand, point pollution load is discharged directly into a tributary or a main river either with treatment or without treatment. In case of discharge into a tributary, both point and non-point pollution loads finally flow into the main river.

In the first runoff stage, the non-point pollution load is decreased to a large extent by the natural purification effect of lands and small channels. In the second runoff stage, the point and non-point pollution loads are reduced by the self-purification effect of tributaries until they enter the main river, and are further reduced by the self-purification effect of the main river while flowing down to the objective station of river water quality simulation.

The river water quality at the objective station of the main river is then simulated by combining (i) the basin runoff model and (ii) the self-purification model of main river. In this Study, the term “pollution load runoff” is defined as the pollution load that enters the main river through the above-mentioned first and second runoff stages.

The objective drainage basin for simulation (18,280 km^2) is subdivided into 20 sub-basins, each with a representative tributary, and the pollution load runoff is simulated at the downstream end of each representative tributary. The main rivers are the following river courses: Sava Main River (Jesenice – Utok Kupe Nizvodno), Kupa River (Karlovac – Confluence with Sava Main), and Lonja River (Sveti Ivan Zelina – Cazma – Struzec – Trebez and Sesvete East – K. Lonja Strug – Confluence with Cesma River).

The schematic diagram of the simulation of pollution load runoff and river water quality is shown in Fig. B.6.1. In this Study, pollution load runoff is estimated in parameters of BOD, COD, T-N and T-P.

6.1.2 Basin Runoff Model

The pollution load runoff from basin to the main river is estimated for each of the 20 sub-basins by multiplying the generated pollution load by runoff coefficients R_1 and R_2 as follows:

$$\textit{Pollution Load Runoff} = \textit{Generated Pollution Load} \times R_1 \times R_2$$

Here, R_1 is the runoff coefficient of pollution load generated from a sub-basin to its representative tributary, while R_2 is the self-purification rate of pollution load in the representative tributary.

(1) Estimation of Runoff Coefficient (R_1)

Generally, a large portion of the non-point pollution load runs off from the basin in a rainy time while the amount of runoff decreases in drought time. The runoff coefficient of non-point load then varies according to the variation of river flow rate. On the other hand, the runoff coefficient of pollution load also varies depending on the topographical, geological and other environmental conditions of the objective sub-basin.

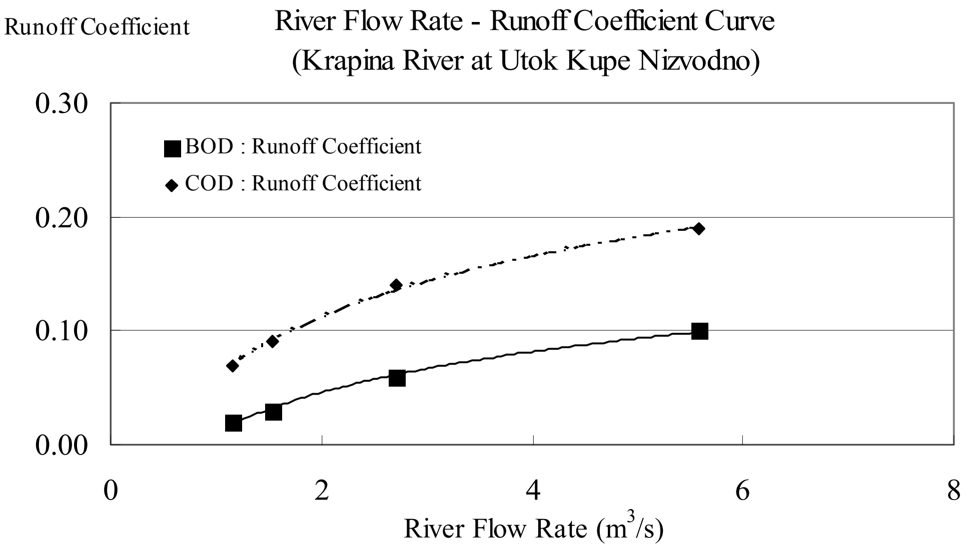
In this Study, the runoff coefficient (R_1) of a sub-basin is obtained through the comparison of calculated pollution load runoff with the observed one at the representative water quality observation point. In this comparison, the pollution load reduction by the self-purification effect in the tributary is duly considered.

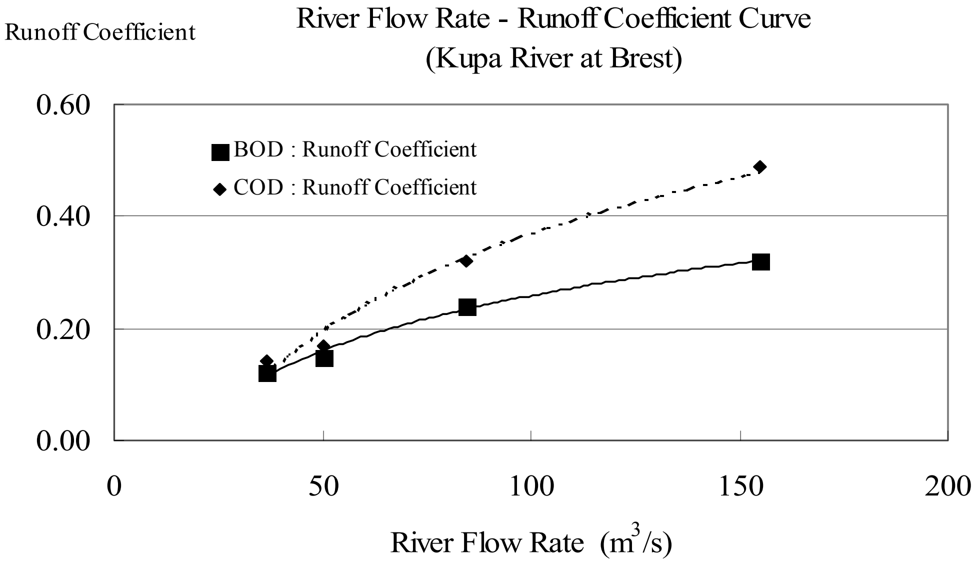
However, the self purification effect of river water on T-N and T-P is generally negligible, namely, R_2 = 1.0. Hence, the self purification effect of the tributary is considered only for BOD and COD.

As mentioned before, there is a certain relationship between runoff coefficient (R_1) of non-point pollution load (BOD, COD, T-N and T-P) and river flow rate. Such a relationship at the monitoring stations was analyzed; i.e., at Utok Krapinice Nizvodno of the Krapina River and at Brest of the Kupa River, where necessary data for the analysis were available.

The relationships between river flow rate and BOD/COD runoff coefficients at Utok Krapinice Nizvodno of the Krapina River and Brest of the Kupa River are determined, as shown in the table below, based on the existing available data (water quality data: past six (6) years and river flow rate data: past 20 years). The relationships are further graphically illustrated below.

River	Probability (%)	Flow Rate (m^3/s)	BOD			COD		
			Runoff Coeff.	Calculated (mg/l)	Actual (mg/l)	Runoff Coeff.	Calculated (mg/l)	Actual (mg/l)
Krapina	95	1.15	0.02	13.3	13.3	0.07	19.1	19.3
	90	1.54	0.03	11.2	11.6	0.09	16.5	16.8
	75	2.70	0.06	8.6	8.9	0.14	12.6	12.5
	50	5.58	0.10	5.6	5.8	0.19	7.7	7.8
Kupa	95	36.50	0.12	4.3	4.3	0.14	4.1	4.3
	90	50.10	0.15	3.9	3.9	0.17	3.9	4.0
	75	84.60	0.24	3.0	3.2	0.32	3.3	3.4
	50	155.00	0.32	2.2	2.5	0.49	2.5	2.8





Considering the topographic features of the Sava River Basin, the runoff coefficients of the Krapina River are applied for the left side sub-basins while those of the Kupa River are applied for the right side sub-basins of the Sava Main River.

Further, the runoff coefficients of T-P and T-N are roughly assumed by using the limited available data to the maximum extent. In this Study, the runoff coefficients for 95% river flow rate are employed in line with the government standards.

From the above discussions, the runoff coefficient of non-point load (BOD, COD, T-P and T-N) for 95% river flow rate are assumed, as follows.

Parameter	Left Side Area of Sava Main River	Right Side Area of Sava Main River
BOD	0.02	0.12
COD	0.07	0.14
T-P	0.01	0.06
T-N	0.03	0.18

(2) Estimation of Self-purification Rate of Tributary (R_2)

The variation of pollution load reduction rate at a certain river length mainly depends on the flow velocity of river water. The unit pollution load reduction rate (reduction rate per river length) of a slowly flowing river is thus larger than that of the fast flowing river.

In this Study, the self-purification rate of the tributary in each sub-basin is estimated by assuming the unit self-purification rate (pollution load reduction rate per river length). The unit self-purification rate of the Sava Main River is thus estimated based on the water quality data at Oborovo (downstream of Zagreb) and Galdovo (upstream of Sisak). There is no lateral pollution load inflow between these two (2) locations, which is approximately 57 km apart. The river water quality for 95% river flow rate at the two (2) stations are estimated and based on these river water quality, the unit self-purification rate is calculated, as also shown in the table below.

Parameter	Sava River at Oborovo	Sava River at Galdovo	Unit Self-purification Rate (1/km)
BOD	8.6 mg/l	6.3 mg/l	0.0047
COD	9.0 mg/l	8.0 mg/l	0.0027

The unit self-purification rate of tributaries is estimated from that of the Sava Main River considering the difference of river flow velocity since the available water quality and hydrological data are limited in the tributaries. In this estimation, the unit self-purification rate is assumed to be in inverse proportion to the river flow velocity.

The average flow velocity in the tributaries of the Kupa River Basin is considered almost the same as that of the Sava Main River. However, the flow velocity in the tributaries of the Lonja River Basin is very slow compared to that of the Sava Main River.

The average flow velocity at the gauging station (Cazma) of the representative tributary (Cesma River) of the Lonja River Basin for 95% flow rate is compared to that of the Sava Main River, as tabulated below. As shown in the table, the average flow velocity of the Cesma River is estimated to be approximately 1/4 of that of the Sava Main River.

River	Station	95% River Flow Rate (m^3/s)	Flow Area (m^2)	Average Flow Velocity (m/s)
Sava Main River	Ruguvica	120	246	0.5
	Crnac	149	453	0.3
	Average	-	-	0.4
Cesma River	Cazma	1.16	18	0.1

From the above discussions, the unit self-purification rates on BOD and COD of the tributaries of the Kupa River are estimated to be approximately 0.5% per km and 0.3% per km, respectively. Similarly, the unit self-purification rates on BOD and COD of the Cesma River are estimated to be approximately 2% per km and 1.2% per km, respectively.

Therefore, the unit self–purification rates of 0.5% per km (BOD) and 0.3% per km (COD) are applied for the tributaries in all the right side sub-basins of the Sava Main River. On the other hand, 2% per km (BOD) and 1.2% per km (COD) are applied for the tributaries in all the left side sub-basins of the same river.

(3) Adopted Runoff Coefficient (R_1) and Tributary Self-purification Rate (R_2)

The following runoff coefficient of sub-basin (R_1) and self-purification rate of tributary (R_2) for point and non-point pollution loads are adopted for the pollution load runoff simulation of the 20 sub-basins.

Pollution Load (Sub-basin Area)	BOD	COD	T-N	T-P
Point Load (right side of Sava River)				
R_1	1.0	1.0	1.0	1.0
R_2	0.5% reduction/km	0.3% reduction/km	1.0	1.0
Point Load (left side of Sava River)				
R_1	1.0	1.0	1.0	1.0
R_2	2.0% reduction/km	1.2% reduction/km	1.0	1.0
Non-Point Load (right side of Sava River)				
R_1	0.12	0.14	0.18	0.06
R_2	0.5% reduction/km	0.3% reduction/km	1.0	1.0
Non-Point Load (left side of Sava River)				
R_1	0.02	0.07	0.03	0.01
R_2	2.0% reduction/km	1.2% reduction/km	1.0	1.0

6.1.3 Self-purification Model of Main River Water

The Streeter-Phelps Model is widely applied to estimate the self-purification effect of river water on BOD. In this Study, this model was used to estimate the self-purification effect of the main rivers not only on BOD but also COD. The objective main river courses are: Sava Main River (Jesenice - Utok Kupe Nizvodno), Kupa River (Karlovac - Confluence with Sava Main), and Lonja River (Sveti Ivan Zelina - Cazma - Struzec - Trebez and Sesvete East - K. Lonja Strug - Confluence with Cesma River).

BOD and COD concentrations at the objective points were simulated based on the following equations:

Variation speed of BOD and COD concentration: $dC/dt = -K \bullet C$

BOD/COD concentration at objective point (i): $Ci = Li/Qi$

Where,

C: BOD/COD concentration (mg/l)
Ci: BOD/COD concentration at objective point (i) (mg/l)
K: Variation speed coefficient (1/day)
Li: Pollution load at objective point (i) (kg/day)
Qi: River flow rate at objective point (i) (m^3/s)

The self-purification constant K for BOD and COD in the Sava Main River are estimated to be 0.188 (1/day) and 0.071 (1/day), respectively, based on the water quality data at the Oborovo and Galdovo monitoring stations. These constants are also applied for the Kupa River and the Lonja River.

On the other hand, T-N and T-P concentrations at the objective point (i) were simply simulated by the following equation since no significant self-purification effect is expected.

T-N/T-P concentration at objective point (i): $Ci = Li/Qi$

Where,

Ci: T-N/T-P concentration at objective point (i) (mg/l)
Li: Pollution load at objective point (i) (kg/day)
Qi: River flow rate at objective point (i) (m^3/s)

6.2 Existing Pollution Load Runoff

The existing point and non-point pollution load runoffs (BOD, COD, T-N, T-P) were calculated for the 20 sub-basins of the objective Sava River Basin (simulation objective area: 18,280 km^2), respectively, aggregated into six (6) major sub-basins as shown below.

(Unit: kg/d)

Pollution Load Parameter	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total
BOD	62,384	22	2,857	7,046	9,334	5,468	87,112
COD	36,023	29	7,437	6,068	10,170	8,701	68,428
T-N	14,020	26	2,797	2,382	5,930	5,438	30,593
T-P	1,817	1	307	210	492	269	3,097

The above existing pollution load runoff of BOD, COD, T-N and T-P are broken down by pollution source, as shown in the tables below and as illustrated in Fig. B.6.2. They are also broken down by source as shown in Table B.6.1.

(1) BOD

(Unit: kg/day)

Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
Point (sewerage)	50,594	0	1,734	2,208	3,878	2,862	61,308	70.4
Point (industry)	10,942	0	159	1,639	906	1,540	15,196	17.4
Sub-total	61,536	0	1,894	3,847	4,783	4,402	76,504	87.8
Non-point (household)	14	0	7	21	69	13	125	0.1
Non-point (livestock)	741	16	867	2,967	4,048	962	9,601	11.0
Non-point (land)	93	5	88	211	433	91	923	1.1
Sub-total	848	22	963	3,199	4,550	1,066	10,649	12.2
Total	62,384	22	2,857	7,046	9,334	5,468	87,153	100.0

(2) COD

(Unit: kg/day)

Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
Point (sewerage)	25,129	0	3,444	1,605	2,793	2,940	35,910	52.5
Point (industry)	8,193	0	293	1,170	680	1,227	11,563	16.9
Sub-total	33,322	0	3,737	2,774	3,473	4,166	47,473	69.4
Non-point (household)	32	1	12	12	40	35	132	0.2
Non-point (livestock)	2,091	7	2,638	2,091	4,996	3,631	15,454	22.6
Non-point (land)	579	20	1,050	1,191	1,660	869	5,369	7.8
Sub-total	2,701	29	3,700	3,294	6,696	4,534	20,955	30.6
Total	36,023	29	7,437	6,068	10,170	8,701	68.428	100.0

(3) T-N

(Unit: kg/day)

Source	Upper Sava	Middl Sava	Lowe Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
Point (sewerage)	10,508	0	653	411	725	938	13,234	43.3
Point (industry)	2,715	0	585	86	732	762	4,880	16.0
Sub-total	13,222	0	1,238	496	1,457	1,700	18,114	59.2
Non-point (household)	4	0	4	5	24	6	43	0.1
Non-point (livestock)	452	9	1,013	1,029	2,756	1,013	6,273	20.5
Non-point (land)	342	16	541	852	1,693	2,719	6,163	20.1
Sub-total	798	26	1,559	1,886	4,473	3,738	12,479	40.8
Total	14,020	26	2,797	2,382	5,930	5,438	30,593	100.0

(4) T-P

(Unit: kg/day)

Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
Point (sewerage)	1,220	0	142	94	165	173	1,795	58.0
Point (industry)	553	0	60	30	29	39	710	22.9
Sub-total	1,773	0	202	124	194	212	2,505	80.9
Non-point (household)	0	0	0	0	1	0	2	0.1
Non-point (livestock)	41	0	96	72	276	53	538	17.4
Non-point (land)	2	1	9	14	22	5	51	1.7
Sub-total	44	0	105	86	298	58	592	19.1
Total	1,817	1	307	210	492	269	3,097	100.0

The ratio of pollution load runoff at each source in the objective Sava River Basin is shown in Fig. B.6.3. On the runoff basis, point pollution load shares a large portion different from the generation basis, as follows: BOD: 88%, COD: 69%, T-N: 59% and T-P: 81%. As for the distribution of existing pollution load runoff (BOD) in the Study Area, refer to Fig. B.6.4.

6.3 Future Pollution Load Runoff Without Project

The future pollution load runoff of BOD, COD, T-N and T-P without project in the objective Sava River Basin (simulation objective area: 18,280 km^2) in 2007 and 2015 were simulated, as summarized in the table below. In this simulation, the runoff coefficients were assumed to be the same as the existing ones.

(Unit: kg/d)

Target Year	Pollution Load Parameter	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total
2007	BOD	78,621	22	3,826	8,829	10,459	7,084	108,840
	COD	53,536	29	9,142	7,369	11,005	9,129	90,209
	T-N	18,866	26	2,909	2,713	5,653	6,309	36,475
	T-P	4,084	1	344	281	542	305	5,558
2015	BOD	95,524	22	4,575	11,845	11,762	9,319	133,047
	COD	54,352	29	11,347	9,562	11,955	10,894	98,138
	T-N	21,440	26	3,4611	3,184	6,911	7,855	42,828
	T-P	2,784	1	309	325	534	304	4,275

The above future pollution load runoff of BOD, COD, T-N and T-P are broken down by pollution source (point and non-point) as shown in the table below. They are further broken down by source and by sub-basin in Table B.6.2 (2007) and Table B.6.3 (2015). The distribution of future pollution load runoff (BOD in 2015) without project in the Study Area is shown in Fig. B.6.5.

(Unit: kg/day)

Parameter	Year	Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
BOD	2007	Point	77,773	0	2,862	5,630	5,909	6,017	98,191	90.2
		Non-point	848	22	963	3,199	4,550	1,066	10,649	9.8
		Total	78,621	22	3,826	8,829	10,459	7,084	108,840	100.0
	2015	Point	94,676	0	3,612	8,646	7,212	8,253	122,398	92.0
		Non-point	848	22	963	3,199	4,550	1,066	10,649	8.0
		Total	95,524	22	4,575	11,845	11,762	9,319	133,047	100.0
COD	2007	Point	50,834	0	5,442	4,075	4,309	4,594	69,254	76.8
		Non-point	2,701	29	3,700	3,294	6,696	4,534	20,955	23.2
		Total	53,536	29	9,142	7,369	11,005	9,129	90,209	100.0
	2015	Point	51,651	0	7,646	6,268	5,258	6,360	77,183	78.6
		Non-point	2,701	29	3,700	3,294	6,696	4,534	20,955	21.4
		Total	54,352	29	11.347	9,562	11,955	10,894	98,138	100.0
T-N	2007	Point	18,068	0	1,350	827	1,180	2,135	23,561	64.6
		Non-point	798	26	1,559	1,886	4,473	4,173	12,914	35.4
		Total	18,866	26	2,909	2,713	5,653	6,309	36,475	100.0
	2015	Point	20,642	0	1,853	1,298	2,438	2,909	29,140	68.0
		Non-point	798	26	1,559	1,886	4,473	4,947	13,688	32.0
		Total	21,440	26	3,411	3,184	6,911	7,855	42,828	100.0
T-P	2007	Point	4,040	0	239	195	244	248	4,966	89.4
		Non-point	44	1	105	86	298	58	592	10.6
		Total	4,084	1	344	281	542	305	5,558	100.0
	2015	Point	2,851	0	336	312	307	339	4,146	87.5
		Non-point	44	1	105	86	298	58	592	12.5
		Total	2,895	1	441	397	606	397	4,738	100.0

Point pollution load runoff shares a large portion of the total runoff in 2007 and 2015, as shown below.

Target Year	Pollution Load Parameter	Ratio of Point Load (%)
2007	BOD	90
	COD	77
	T-N	65
	T-P	89
2015	BOD	92
	COD	79
	T-N	68
	T-P	87

6.4 Objective River Station and Standard River Flow Rate for Simulation

6.4.1 Objective River Station

River water quality at six (6) objective river stations was simulated; namely, at Oborovo (A) and Utok Kupe Nizvodno (B) on the Sava Main River; at Recica (C) and Brest (D) on the Kupa River; and at K. Lonja Strug (E) and Struzec (F) on the Lonja River, covering catchment areas as shown in the following table.

River	Code	Objective Station	Catchment Area (km^2)	Remarks
Sava	A	Oborovo	2,036	Excluding Slovenian territory (10,700 km^2)
	B	Utok Kupe Nizvodno	8,664	Excluding Slovenian territory (10,700 km^2)
Kupa	C	Recica	2,768	
	D	Brest	5,722	
Lonja	E	K. Lonja Strug	511	
	F	Struzec	3,802	

In the water quality simulation of the Sava Main River, the pollution load inflow from Slovenia was assumed to be constant (river water quality at Jesenice was assumed as constant: 5.6 mg/l in BOD, 8.4 mg/l in COD-Mn, 5.97 mg/l in T-N and 0.18 mg/l in T-P for 95% flow rate).

6.4.2 Standard River Flow Rate

In this Study, 95% river flow rate is applied for the evaluation of river water quality and 75% river flow rate is also used for the supplementary simulation studies of the Lonja River, as shown below.

River/Objective Station	Catchment Area (km^2)	95% Flow Rate (m^3/s)	75% Flow Rate (m^3/s)	Remarks
Sava Main River				
Oborovo	12,450	120	-	River flow rate at Zagreb is used
Utok Kupe Nizvodno	22,852	149	-	River flow rate at Crnac is used
Kupa River				
Recica	2,768	28.8 [1)]	-	
Brest	5,722	36.5	-	River flow rate at Farkasic is used
Lonja River				
K. Lonja Strug	511	0.68 [2)]	1.07 [3)]	Incl. 0.4 m^3/s diverted from Glogovnica
Struzec	3,802	2.06 [4)]	5.01 [5)]	

Note that in the above Table, figures with notation marks in close parenthesis were estimated or obtained as follows:

1) Estimated by summing up the 95% river flow rates of Dobra-Upper Kupa, Mreznica and Korana rivers (see, the table in Chapter II, Subsection 2.3.3).

2) Obtained by adding a diversion flow rate from the Glogovnica River to the river flow rate calculated from the 95% specific river flow rate at Cazma of the Cesma River [= (1.16 m^3/s + 0.4 m^3/s) × 511 km^2 / 2,877 km^2 + 0.4 m^3/s, where 1.16 m^3/s: recorded 95% flow rate at Cazma, 511 km^2: catchment area at K. Lonja Strug, 2,877 km^2: catchment area at Cazma and 0.4 m^3/s: diverted flow rate from the Glogovnica River].

3) Similarly, obtained by adding the diversion flow rate from the Glogovnica River to the river flow rate calculated from the 75% specific river flow rate at Cazma of the Cesma River [= (3.39 m^3/s + 0.4 m^3/s) × 511 km^2 / 2,877 km^2 + 0.4 m^3/s, where 3.39 m^3/s: recorded 75% flow rate at Cazma, 511 km^2: catchment area at K. Lonja Strug, 2,877 km^2: catchment area at Cazma and 0.4 m^3/s: diverted flow rate from the Glogovnica River].

4) Estimated from the 95% specific river flow rate at Cazma of the Cesma River [= (1.16 m^3/s + 0.4 m^3/s) × 3,802 km^2 / 2,877 km^2, where 1.16 m^3/s: recorded 95% flow rate at Cazma, 3,802 km^2: catchment area at Struzec, 2,877 km^2: catchment area at Cazma and 0.4 m^3/s: diverted flow rate from the Glogovnica River].

5) Similarly, estimated from the 75% specific river flow rate at Cazma of the Cesma River [= (3.39 m^3/s + 0.4 m^3/s) × 3,802 km^2 / 2,877 km^2, where 3.39 m^3/s: recorded 75% flow rate at Cazma, 3,802 km^2: catchment area at Struzec, 2,877 km^2: catchment area at Cazma and 0.4 m^3/s: diverted flow rate from the Glogovnica River].

6.5 Simulated River Water Quality

6.5.1 Simulated Existing River Water Quality

The existing water quality of the Sava Main River and the Kupa River at the time of 95% river flow rate was simulated, as given below.

Item	Unit	Sava Main River		Kupa River	
		Oborovo	Utok Kupe Nizvodno	Recica	Brest
BOD	mg/l	8.8 (8.6)	5.6 (5.7)	4.3 (4.3)	3.5 (3.5)
COD	mg/l	9.8 (9.5)	8.2 (5.2)	3.7 (3.0)	4.4 (4.3)
T-N	mg/l	6.61 (7.38)	6.19 (4.34)	1.41 (1.85)	2.20 (2.67)
T-P	mg/l	0.46 (0.48)	0.47 (0.78)	0.18 (0.41)	0.23 (0.24)

Note: Figures in parentheses indicate observed water quality

As shown in the above table, the simulated river water quality is well in agreement with the observed one. Hence, the established simulation model in this Chapter is considered applicable for the prediction of future river water quality.

The existing water quality of the Lonja River at the time of 95% river flow rate was also simulated, as given below.

Item	Unit	Lonja River	
		K. Lonja Strug	Struzec
BOD	mg/l	27.1	8.5
COD	mg/l	33.9	28.0
T-N	mg/l	19.2	16.0
T-P	mg/l	1.72	1.25

6.5.2 Simulated Future River Water Quality Without Project

The future water quality of the Sava Main River and the Kupa River without project in 2007 and 2015 at the time of 95% river flow rate was simulated, as given below.

Year	Item	Unit	Sava Main River		Kupa River	
			Oborovo	Utok Kupe Nizvodno	Recica	Brest
2007	BOD	mg/l	10.2	6.5	5.0	3.9
	COD	mg/l	11.4	9.3	4.2	4.8
	T-N	mg/l	7.07	6.57	1.55	2.34
	T-P	mg/l	0.67	0.66	0.21	0.25
2015	BOD	mg/l	11.6	7.4	6.2	4.7
	COD	mg/l	11.4	9.5	5.1	5.5
	T-N	mg/l	7.31	6.91	1.74	2.51
	T-P	mg/l	0.56	0.58	0.26	0.30

Similarly, the future water quality of the Lonja River without project in 2007 and 2015 at the time of 95% river flow rate was simulated, as given below.

Year	Item	Unit	Lonja River	
			K. Lonja Strug	Struzec
2007	BOD	mg/l	36.3	11.1
	COD	mg/l	59.1	38.3
	T-N	mg/l	39.1	24.4
	T-P	mg/l	3.13	1.85
2015	BOD	mg/l	49.1	14.6
	COD	mg/l	57.1	33.5
	T-N	mg/l	38.3	21.9
	T-P	mg/l	3.07	1.78

6.5.3 Simulated Future River Water Quality With Master Plan Project

(1) Basic Assumptions of Simulation

The river water quality with Master Plan (M/P) project in 2015 was simulated under the following assumptions:

(a) By the year of 2015, all of the municipal wastewater (domestic, institutional and small industries) covered by the proposed 22 sewerage development projects of 24 urban centers will be treated by the biological process to meet the government regulations on plant effluent except the treatment of Nitrogen (N). Treatment of Nitrogen (N) is not considered in this master plan and will be implemented after 2015. As for the government regulations related to the effluent of 22 sewerage treatment plants, see Appendix D, Table D.1.2.

(b) There are 51 large industries in the Study Area (excluding Zagreb) at present. Among them, wastewater of 40 industries will be discharged into the sewerage systems with necessary pre-treatment and finally treated by the proposed sewage treatment plants. Wastewater of the remaining 11 industries will be discharged directly into the neighboring rivers with necessary treatment to satisfy the government regulations.

(c) Non-point loads are not controlled.

(d) The point loads of the 18 urban centers in the outer area (wastewater of Bjelovar, Krizevci, Cazma, Krapina and other towns) are assumed to be reduced to the same level as those in the Study Area.

(2) Pollution Load Generation and Runoff

The total future pollution load generation and runoff of BOD, COD, T-N and T-P with M/P project in the objective Sava River Basin (simulation objective area: 18,280 km^2) in 2015 are summarized below.

(Unit: kg/d)

Item	Pollution Load Parameter	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total
Generation	BOD	61,579	1,208	57,611	34,229	52,910	107,987	315,524
	COD	64,347	1,017	54,268	22,691	58,705	92,408	293,436
	T-N	36,562	855	26,122	11,151	26,114	53,015	153,818
	T-P	5,854	105	4,411	1,518	5,095	5,877	22,859
Runoff	BOD	13,430	22	1,594	4,271	5,951	1,961	27,227
	COD	22,551	37	6,211	5,997	9,669	7,322	55,075
	T-N	10,770	26	2,352	2,560	5,737	3,639	25,084
	T-P	1,535	1	189	178	420	159	2,482

The above future pollution load generation and runoff of BOD, COD, T-N and T-P are broken down into point and non-point, as shown below.

(Unit: kg/d)

Item	Para-meter	Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
Generation	BOD	Point	12,698	0	862	1,113	1,433	1,141	17,247	5.5
		Non-Point	48,881	1,208	56,749	33,116	51,477	106,846	298,277	94.5
		Total	61,579	1,208	57,611	34,229	52,910	107,987	315,524	100.0
	COD	Point	22,551	0	1,113	1,983	2,044	1,652	29,343	10.0
		Non-Point	41,796	1,017	53,155	20,708	56,661	90,756	264,093	90.0
		Total	64,347	1,017	54,268	22,691	58,705	92,408	293,436	100.0
	T-N	Point	9,972	0	794	674	1,264	801	13,504	8.8
		Non-Point	26,590	855	25,328	10,477	24,850	52,214	140,314	91.2
		Total	36,562	855	26,122	11,151	26,114	53,015	153,818	100.0
	T-P	Point	1,491	0	84	92	122	102	1,890	8.3
		Non-Point	4,363	105	4,327	1,426	4,973	5,775	20,969	91.7
		Total	5,854	105	4,411	1,518	5,095	5,877	22,859	100.0
Runoff	BOD	Point	12,582	0	631	1,072	1,400	894	16,578	60.9
		Non-Point	848	22	963	3,199	4,550	1,066	10,649	39.1
		Total	13,430	22	1,594	4,271	5,951	1,961	27,227	100.0
	COD	Point	22,447	0	1,550	1,934	2,019	1,492	29,442	58.4
		Non-Point	2,701	29	3,700	3,294	6,696	4,534	22,633	41.6
		Total	25,149	29	5,251	5,228	8,715	6,026	50,397	100.0
	T-N	Point	9,972	0	794	674	1,264	801	13,504	53.8
		Non-Point	798	26	1,559	1,886	4,473	2,876	11,617	46.2
		Total	10,770	26	2,352	2,560	5,737	3,639	25,084	100.0
	T-P	Point	1,491	0	84	92	122	102	1,890	76.2
		Non-Point	44	1	105	86	298	58	592	23.8
		Total	1,535	1	189	178	420	159	2,4782	100.0

The above table is further presented according to sub-basin and source as shown in Table B.5.7 for pollution load generation and in Table B.6.5 for pollution load runoff. As for the pollution load generation of sewerage and industrial wastewater in the 24 urban centers, see Appendix D, Table D.10.3.

Further, the distribution of future pollution load runoff (BOD in 2015) with M/P project in the Study Area is shown in Fig. B.6.6.

(3) Simulated River Water Quality

The future water quality of the Sava Main River and the Kupa River with M/P project in 2015 at the time of 95% river flow rate was simulated, as shown below compared with the water quality without project.

Project	Item	Unit	Sava Main River		Kupa River	
			Oborovo	Utok Kupe Nizvodno	Recica	Brest
Without Project	BOD	mg/l	11.6	7.4	6.2	4.7
	COD	mg/l	11.4	9.5	5.1	5.5
	T-N	mg/l	7.31	6.91	1.74	2.51
	T-P	mg/l	0.56	0.58	0.26	0.30
With Project	BOD	mg/l	4.6	3.1	3.1	2.6
	COD	mg/l	8.8	7.4	3.4	4.0
	T-N	mg/l	6.30	5.94	1.48	2.26
	T-P	mg/l	0.43	0.44	0.17	0.21

Similarly, the future water quality of the Lonja River with M/P project in 2015 at the time of 95% river flow rate was simulated, as shown below, compared with the water quality without project.

Poject	Item	Unit	Lonja River	
			K. Lonja Strug	Struzec
Without Project	BOD	mg/l	49.1	14.6
	COD	mg/l	57.1	33.5
	T-N	mg/l	38.3	21.9
	T-P	mg/l	3.07	1.78
With Project	BOD	mg/l	7.2	3.4
	COD	mg/l	20.8	19.3
	T-N	mg/l	9.3	10.9
	T-P	mg/l	0.82	0.70

The improved river water quality will satisfy the standard river water quality in BOD; namely, Category II (BOD <4.0 mg/l) at Utok Kupe Nizvodno and Category III (BOD <8.0 mg/l) at Oborovo in the Sava Main River; and Category II (BOD <4.0 mg/l) at Recica and Brest in the Kupa River.

In the Lonja River, the improved river water quality will meet the standard river water quality on BOD; namely, Category II (BOD <4.0 mg/l) at Struzec and Category III (BOD <8.0 mg/l) at K. Lonja Strug.

6.5.4 Simulated Future River Water Quality With F/S Project

(1) Basic Assumptions of Simulation

The river water quality with F/S project in 2007 was simulated under the following assumptions:

(a) The objective projects are the sewerage development projects in the towns of Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac-Duga Resa.

(b) In the above five (5) F/S towns, industries that discharge wastewater directly into rivers will also treat their wastewater in order to comply with the government regulations. However, all of the industries in the other municipalities are assumed not to improve their existing treatment systems.

(c) Non-point pollution loads are not controlled.

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

(e) As shown in the table in Section 6.6, the water quality of the Kupa River in 2007 is not much polluted even under the without project situation. On the other hand, the water quality of the Sava Main River is expected to be greatly improved by the ongoing Zagreb project. Hence, the treatment level of primary sedimentation is considered applicable for the sewage treatment of the Karlovac-Duga Resa and Sisak F/S projects. The treatment efficiency of primary sedimentation is assumed as 40% in BOD and COD.

On the other hand, the sewage of Dugo Selo, Vrbovec and Kutina is treated by the biological process in order to meet the permissible limits of plant effluent (BOD: 25 mg/l, COD-Cr: 125 mg/l).

However, Phosphorus (P) and Nitrogen (N) are not treated by the sewage treatment plants.

(2) Pollution Load Generation and Runoff

The total future pollution load generation and runoff of BOD, COD, T-N and T-P with F/S project in the objective Sava River Basin (simulation objective area: 18,280 km^2) in 2007 is summarized below.

(Unit: kg/d)

Item	Pollution Load Parameter	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total
Generation	BOD	64,245	1,208	61,113	36,553	56,670	112,368	331,157
	COD	63,692	1,017	56,522	22,837	59,484	95,317	298,869
	T-N	35,447	855	26,496	11,177	25,854	54,239	154,068
	T-P	5,710	105	4,512	1,545	5,143	5,981	22,997
Runoff	BOD	15,215	22	2,487	6,466	8,645	5,462	38,297
	COD	23,976	29	8,170	5,354	9,479	8,157	55,165
	T-N	9.655	26	2,727	2,585	5,477	6.088	26,558
	T-P	1,391	1	291	205	468	263	2,619

The above future pollution load generation and runoff of BOD, COD, T-N and T-P are broken down into point and non-point, as shown in the table below.

(Unit: kg/d)

Item	Para-meter	Source	Upper Sava	Middle Sava	Lower Sava	Upper Kupa	Lower Kupa	Lonja	Total	(%)
Genera-tion		Point	15,364	0	4,364	3,437	4,193	5,522	32,880	9.9
	BOD	Non-Point	48,881	0	56,749	33,116	51,477	106,846	298,277	90.1
		Total	64,245	1,208	61,113	36,553	56,670	112,368	331,157	100.0
		Point	21,896	0	3,367	2,129	2,823	4,561	34,776	11.6
	COD	Non-Point	41,796	1,017	53,155	20,708	56,661	90,756	264,093	88.4
		Total	63,692	1,017	56,522	22,837	59,484	95,317	298,869	100.0
		Point	8,857	0	1,168	700	1,004	2,025	13,754	8.9
	T-N	Non-Point	26,590	855	25,328	10,477	24,850	52,214	140,314	85.6
		Total	35,447	855	26,496	11,177	25,854	54,259	154,068	100.0
		Point	1,347	0	185	119	170	206	2,028	8.8
	T-P	Non-Point	4,363	95	4,327	1,426	4,973	5,775	20,969	91.8
		Total	5,710	105	4,512	1,545	5,143	5,981	22,997	100.0
Runoff		Point	14,367	0	1,524	3,267	4,094	4,396	27,648	72.2
	BOD	Non-Point	848	22	963	3,199	4,550	1,066	10,649	27.8
		Total	15,215	22	2,487	6,466	8,645	5,462	38,297	100.0
		Point	21,275	0	4,470	2,060	2,783	3,623	34,211	62.0
	COD	Non-Point	2,701	29	3,700	3,294	6,696	4,534	20,955	38.0
		Total	23.976	29	8,170	5,354	9,479	8,157	55,165	100.0
		Point	8,857	0	1,168	700	1,004	2,025	13,754	51.8
	T-N	Non-Point	798	26	1,559	1,886	4,473	4,063	12,804	48.2
		Total	9.655	26	2,727	2,585	5,477	6,088	26,558	100.0
		Point	1,347	0	185	115	170	206	2,028	77.4
	T-P	Non-Point	44	1	105	86	298	58	592	22.6
		Total	1,391	1	291	205	468	263	2,619	100.0

The above table is further presented according to sub-basin and source as shown in Table B.5.6 for pollution load generation and in Table B.6.4 for pollution load runoff. As for the pollution load generation of sewerage and industrial wastewater in the 24 urban centers, see Appendix E, Table E-I.2.2.

(3) Simulated River Water Quality

The future water quality of the Sava Main River and the Kupa River with F/S projects in 2007 at the time of 95% river flow rate was simulated, as shown below compared with the water quality without project.

Project	Item	Unit	Sava Main River		Kupa River	
			Oborovo	Utok Kupe Nizvodno	Recica	Brest
Without Project	BOD	mg/l	10.2	6.5	5.0	3.9
	COD	mg/l	11.4	9.3	4.2	4.8
	T-N	mg/l	7.07	6.57	1.55	2.34
	T-P	mg/l	0.67	0.66	0.21	0.25
With Project	BOD	mg/l	4.8	3.1	4.0	3.5
	COD	mg/l	8.7	7.2	3.4	4.3
	T-N	mg/l	6.20	5.83	1.50	2.29
	T-P	mg/l	0.42	0.44	0.18	0.23

The improved river water quality will satisfy the standard river water quality in BOD; namely, Category II (BOD <4.0 mg/l) at Utok Kupe Nizvodno and Category III (BOD <8.0 mg/l) at Oborovo in the Sava Main River; and Category II (BOD <4.0 mg/l) at Recica and Brest in the Kupa River.

Similarly, the future water quality of the Lonja River with F/S project in 2007 at the time of 95% river flow rate was simulated, as shown below compared with the water quality without project.

Project	Item	Unit	Lonja River	
			K. Lonja Strug	Struzec
Without Project	BOD	mg/l	36.3	11.1
	COD	mg/l	59.1	38.3
	T-N	mg/l	39.1	24.4
	T-P	mg/l	3.13	1.85
With Project	BOD	mg/l	31.0	10.1
	COD	mg/l	39.5	27.1
	T-N	mg/l	28.3	17.8
	T-P	mg/l	1.93	1.24

As reflected in the above table, the improvement effects of the Dugo Selo and Vrbovec F/S projects are small. Additional projects are considered necessary to attain a significant water quality improvement of the Lonja River.

6.6 Supplementary Simulation Studies for the Lonja River

(1) Diversion of Treated Wastewater of Sesvete East, Dugo Selo and Ivanic Grad-Klostar Ivanic

In the proposed master plan, the sewerage wastewaters of Sesvete East, Dugo Selo and Ivanic Grad-Klostar Ivanic are treated before discharge into the Crnec River. As the alternative, diversion of the above treated sewerage wastewater through a force main into the Sava Main River was studied to further reduce the pollution load of the Lonja River.

The river water quality (BOD) with the proposed M/P and the Alternative Plan in 2015 at K. Lonja Strug and Struzec are compared as follows.

(Unit: BOD mg/l)

River	Location	Existing (1999)	Future W/O (2015)	Proposed M/P (2015)	Alternative (2015)
Lonja	K. Lonja Strug	27.1	49.1	7.2	2.2
	Struzec	8.5	14.6	3.4	2.4
Sava	Oborovo	8.8 (8.6)	11.6	4.6	4.7
	Utok Kupe Nizvodno	5.6 (5.7)	7.4	3.1	3.1

Note: Figures in parentheses indicate the observed quality.

The alternative plan will much improve the water quality of the Lonja River with no significant adverse effect on the water quality of the Sava Main River. However, it requires additional construction and O&M costs for the diversion as summarized in the table below.

	Sesvete East	Dugo Selo	Ivanic Grad	Total
Pipe Length (m)	4,000	5,500	7,500	17,000
Pipe Size (mm)	400	300	300	-
Construction Cost (million Kn)	5.17	4.26	5.70	15.13
Direct Construction Cost	3.85	3.17	4.25	11.27
Indirect Cost	0.39	0.32	0.42	1.13
VAT	0.93	0.77	1.03	2.73
Annual O&M Cost (million Kn)*	0.22	0.18	0.20	0.60

* Including depreciation cost

On the other hand, the above three (3) plants must remove also T-P when they discharge the wastewater into the Crnec River instead of diverting it into the Sava Main River. The required additional construction and annual O&M costs for the removal are 1.3 million Kn and 0.40 million Kn, respectively.

Therefore, the net additional required construction and annual O&M costs would come to 13.83 million Kn and 0.20 million Kn, respectively. Furthermore, the diversion will decrease the river flow of the Crnec River and almost dry up the river section between Sesvete East and Ivanic Grad at drought time, causing damage to the biological environment. In view of the foregoing discussions, therefore, the diversion of wastewater is not recommended.

(2) Effects of Sesvete East and Ivanic Grad-Klostar Ivanic Sewage Treatment Project on River Water Quality

As mentioned in Subsection 6.8.3, the improvement effects of the Dugo Selo and Vrbovec F/S projects are small. Additional projects are considered necessary to attain a significant water quality improvement of the Crnec/Lonja River.

On the other hand, the implementation of the Sesvete East project was already approved by the authorities concerned and the implementation of the Ivanic Grad-Klostar Ivanic project is further expected in the near future. To verify the effect of sewerage improvement projects, therefore, a comparative study by simulation was made between the water quality of the Crnec/Lonja River in 2007 with four (4) projects (Dugo Selo, Vrbovec, Sesvete East and Ivanic Grad-Klostar Ivanic) and the water quality with the F/S projects only (Dugo Selo and Vrbovec) in two (2) cases of standard river flow rates (95% and 75% probability) and two (2) cases of treatment level (primary sedimentation and biological process).

The simulated water quality (BOD) at K. Lonja Strug of the Crnec River and at Struzec of the Lonja River is shown in the tables below. In this simulation, it is assumed that the treatment efficiency of primary sedimentation is 40% and biological process treats wastewater to BOD 25 mg/l.

(a) Simulated River Water Quality with F/S Projects Only

(Unit: BOD mg/l)

River Flow Rate	Treatment Level	K. Lonja Strug	Struzec
95% Probability	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
75% Probability	Existing (1999)	21.7	6.2
	Without Project (2007)	28.2	7.6
	Primary Sedimentation (2007)	26.2	7.3
	Biological Process (2007)	24.3	7.0

(b) Simulated River Water Quality with Four (4) Projects

(Unit: BOD mg/l)

River Flow Rate	Treatment Level	K. Lonja Strug	Struzec
95% Probability	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
75% Probability	Existing (1999)	21.7	6.2
	Without Project (2007)	28.2	7.6
	Primary Sedimentation (2007)	16.0	5.9
	Biological Process (2007)	6.4	4.6

The river water quality at K. Lonja Strug will be controlled by the three (3) projects: Dugo Selo, Sesvete East and Ivanic Grad-Klostar Ivanic. On the other hand, the river water quality at Struzec will be improved by the four (4) projects: Dugo Selo, Sesvete East, Ivanic Grad-Klostar Ivanic and Vrbovec.

The river water quality will be much improved with the implementation of the four (4) projects compared to the case of implementation of only the F/S projects as shown above. Therefore, the water quality improvement of the Crnec/Lonja River in 2007 should be evaluated, considering the successive implementation of the Sesvete East and Ivanic Grad-Klostar Ivanic projects.

The improvement by the primary sedimentation process is limited and hence, biological treatment is necessary to improve the river water quality to a satisfactory level. On the other hand, no large difference was recognized between the simulated river water quality under 95% and 75% river flow rate probabilities. Therefore, the river water quality improvement of the Crnec/Lonja River in 2007 was evaluated for the 95% river flow rate probability with biological treatment.

The river water quality with four (4) projects in 2007 will satisfy the requirements of Category III (BOD <8.0 mg/l) at K. Lonja Strug of the Crnec River, and almost meet Category II (BOD <4.0 mg/l) at Struzec of the Lonja River.

(3) Simulated River Water Quality with Kutina M/P and F/S Projects

The natural flow of the Kutina River is negligible in drought time. All of the river water is recharged by the wastewater of the sewerage system and factories. Especially, the Petrokemija Factory discharges a large quantity of wastewater into the Kutina River with a low BOD concentration, although the T-N content is high.

The river water quality (BOD) with sewage treatment project (both M/P and F/S) was roughly estimated as shown in the table below, compared to the without project situation. In the simulation, it was assumed that the treatment efficiency of primary sedimentation is 40% and biological process treats wastewater to BOD 25 mg/l.

(Unit: BOD, mg/l)

	1999	2007	2015
Without Treatment	70	70	70
With Primary Sedimentation	-	50	-
With Biological Treatment	-	16	16

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TABLES

Table-B.2.1 Existing Monitoring Stations of River Flow Rate

River Name	Code Number	Montoring Point Name	River Name	Code Number	Montoring Point Name	River Name	Code Number	Montoring Point Name
SAVA	3045	JESENICE	GLOGOVICA	3071	MOSTARI	KUPA	4031	LADESIĆ DRAGA
SAVA	3273	BREGANA RIVER MOUTH	LONJA	3268	KOMIN	KUPA	4024	KAMANJE
SAVA	3272	OTOK	LONJA	3062	LONJICA BRIDGE	KUPA	4140	ZORKOVAC
SAVA	3066	MEDSAVE	ZELINA	3367	BOŽJAKOVINA	KUPA	4139	LEVKUSJE
SAVA	3087	PODSUSED	BJELOVATSKA	3188	BJELOVAR	KUPA	4138	GORNJE POKUPLJE
SAVA	3121	ZAGREB	BJELOVATSKA	3301	VELIKO TROJSTVO	KUPA	4003	BRODARCI
SAVA	3016	BUNDEK	ČESMA	3299	PAVLOVAC	KUPA	4111	KARLOVAC
SAVA	3223	KOSNICA	ČESMA	3072	NARTA	KUPA	4056	REČICA 2
SAVA	3211	ŽUPANJA	ČESMA	3022	ČAZMA	KUPA	4107	JAMNIČKA KISELICA
SAVA	3096	RUGVICA	ČESMA	3289	SISČANI	KUPA	4065	ŠIŠINEC
SAVA	3373	DUBROVČAK LIJEVI	VELIKA HORVATSKA	3297	MARKOVAC	KUPA	4010	FARKASIĆ
SAVA	3020	CRNAC	VLAHINIČKA	3305	VLAHINIČKA	KUPA-KUPA		CANAL
SAVA	3036	GUŠĆE	GRAČENICA	3303	GRAČENICA	GORNJA DOBRA	4115	MORAVICE
SAVA	3219	JASENOVAC	KUTINA	3168	KUTINSKE ĆAIRE	GORNJA DOBRA	4038	LUKE
SAVA	3104	STARA GRADIŠKA	KUTINA	3158	KUTINA	GORNJA DOBRA	4088	TURKOVIĆI
SAVA	3207	MAČKOVAC GATE	KUTINICA	3156	KUTINA	GORNJA DOBRA	4068	TROŠMARIJA
SAVA	3179	DAVOR DOWNSTREAM	POLOJAC	3155	KUTINA	GORNJA DOBRA	4113	LEŠĆE TOPLICE
SAVA	3177	SLAVONSKI KOBAS	SUBOCKA	3381	SUBOCKA	GORNJA DOBRA	4061	STATIVE DONJE
SAVA	3098	SLAVONSKI BROD	NOVSKA	3151	NOVSKA GORNJA	GORNJA DOBRA	4141	TREŠĆENJE
SAVA	3101	SLAVONSKI ŠAMAC	NOVSKA	3153	NOVSKA DONJA	GORNJA DOBRA	4142	PRISELCI
CANAL		PREVLAKA	JEZERO	3233	NOVSKA	GRAVEL PIT	4143	ZORKOVAC POTOK
SAVA-ODRA-SAVA		CANAL	RIJEKA	3324	RAJIĆ DAM	FISHPOUNT	4101	GOMIRJE
UNA RIVER SOURCE	3215	DONJA SUVAJA	SLOBOŠTINA	3257	OKUČANI	VITUNJČICA	4096	BRESTOVAC
UNA	3217	KOSTAJNICA	ŠUMETLICA	3238	CERNIK	MREŽNICA	4022	JUZBAŠIĆI
SUNJA	3108	SUNJA	GLOGOVNICA	3209	PODCRKAVLJE	MREŽNICA	4042	MRZLO POLJE
VRAPČAK	3032	GORNJE VRAPČE	PAKRA	3399	ACUMULATION PAKRA	ZAGORSKA MREŽNICA	4181	IZVOR
VRAPČAK	3125	ZAGREB	ILOVA	3185	MUNIJE	SUŠIK	4157	TOMIĆI
KUSTOŠAK	3371	KUSTOŠIJA 2	ILOVA	3148	RAŠENICA	BISTRAC	4164	IZVOR
ČRNOMEREC	3138	FRATERŠĆICA 1	ILOVA	3115	VELIKO VUKOVJE	PEĆINA	4165	IZVOR
BLIZNEC	3383	MARKUŠEVEC	TOPLICA	3293	DARUVAR	DONJA DOBRA	4196	JARČE POLJE
MEDVEŠČAK	3389	MIHALJEVAC	RIJEKA	3181	BASTAJI	MREŽNICA	4198	ERDELJ
TRNAVA	3280	TRNAVA	BIJELA	3171	BADLJEVINA	KUPČINA	4063	STRMAC
TRNAVA	3281	SLANOVEC 1	SUMETLICA	3140	GORNJA SUMETLICA	KUPČINA	4166	LAZINA BRANA
TRNAVA	3310	GRANEŠINA 1	BRZAJA	3266	ZVEČEVO	KUPICA	4161	IZVOR
VIDOVEC	3326	SLANOVEC 1	ORLJAVA	3162	POŽEGA	KUPICA	4005	BROD NA KUPI
RIJEKA	3385	SESVETE	ORLJAVA	3173	PLETERNICA	STARČA	4117	OBREŽ
ŠTEFANOVEC	3312	DUBRAVA	LONJA	3083	PLETERNICA	LOMNICA	4202	OBREŽ STEPENICA
VUGROV POTOK	3234	SESVETE	PAKRA	3295	MANASTIR	ODRA	4009	DONJA POLJANA
ČRNOMEREC	3354	MIKULIĆI	PAKRA	3393	JANJA LIPA	KOSNICA	4133	JAGODNO II
KRAPINA	3387	BRAČAK	ORLJAVA	3397	FRKLJEVCI	JEZERO	4135	NOVO ČIČE
KRAPINČICA	3369	KRAPINA	PAKRA	3000	KUSONJE	BUNA	4144	BUŠEVEC II
KRAPINČICA	3175	ZABOK	BIĐ	3018	CERNA	ODRA	4159	LEKENIK
KRAPINA	3330	ZLATAR BISTRICA	BIĐ	3352	VRPOLJE	CHANNEL	4160	VELEŠEVAC
KRAPINA	3054	KUPLJENOVO	LATERAL CANAL	3342	TOPOLJE	KORANA	4059	SLUNJ UPSTREAMS
VELIKA HORVATSKA	3240	GUBAŠEVO 1	LATERAL CANAL	3344	GARČIN	SLUNJČICA	4172	RASTOKE
SUTLA	3391	BRATKOVEC	BOSUT	3345	STARA BRANA	KORANA	4103	VELJUN
SUTLA	3127	ZELENJAK	BOSUT	3346	VINKOVCI	KORANA	4073	VELEMERIĆ
VUČELNICA	3274	HRUŠEVEC	BREZNICA	3350	DRAGOTIN	KORANA	4026	KARLOVAC
PUŠĆA	3276	PUŠĆA DONJA	KALUĐER	3356	PRKOVCI	RADONJA	4092	TUŠILOVIĆ
BISTRA	3221	DONJA BISTRA	BIĐ	3357	KLADAVAC	GLINA	4174	ŠIROKA RIJEKA
DEDINA	3279	JAKOVLJE	KAZNICA	3358	ĐAKOVAČKA SELNICA	GLINA	4094	VRANOVINA
POLJANICA	3278	POLJANICA	JOŠAVA	3362	SOLJAK	GLINA	4013	GLINA
RAVNINŠĆICA	3365	ĐURMANEC	SPAČVA	3363	OTOK	TREPČA	4079	GVOZD
TOPLICA	3375	STUBIČKE TOPLICE	SAVA	3332	HE PODSUSED	TREPČA	4155	TREPČA TRAVERZA
REKA	3377	LOBOR	SUTLA	3336	KLJUČ	BIJELA RIJEKA	415	PLITVIČKI LJESKOVAC
LIPOVAČKA GRADNA	3037	HAMOR	KRAPINA	3337	ZAPREŠIĆ	CRNA RIJEKA	4151	PLITVIČKI LJESKOVAC
RUDARSKA GRADNA	3225	RUDARSKA DRAGA	SAVA	3334	TIŠINA	MATICA	4131	PROŠĆE
GRADNA	3194	SAMOBOR	SAVA	3335	STRELEČKO	PROŠĆE JEZERO	4149	PLITVICE
BREGANA	3254	KORETIĆI	SAVA	3333	HE DRENJE	PLITVICA	4125	LUKETIĆI
BREGANA	3012	BRAGANA REMONT	KUPA	4029	KUPARI	KORANA	4105	
BREGANICA	3252	SVINJARIĆI	KUPA	4016	HRVATSKO			
KAŠINA	3201	GORNJA KAŠINA	GEROVČICA	4179	SMREČJE STEPENICA			
KAŠINA	3205	POPOVEC	ČABRANKA	4082	ZAMOST II			

Table B.2.2 River Flow Rate at the Principal River Stations 1/8

River: SAVA
Station Name: JESENICE
Basin Area: 10750 km^2
Available Period: 1964-1995

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1964	124	146	350	429	248	210	276	157	156	808	382	412	309
1965	373	344	422	494	454	477	350	219	568	246	403	660	417
1966	215	353	235	314	237	162	220	250	171	254	506	502	284
1967	217	222	296	503	264	211	116	91.8	169	191	348	224	237
1968	163	484	232	184	189	399	146	175	322	186	377	267	259
1969	242	400	496	396	386	330	185	393	289	119	397	257	323
1970	453	282	464	697	432	245	277	190	147	121	280	170	313
1971	379	357	327	371	285	179	116	93.8	80.0	74.7	142	156	212
1972	132	431	419	595	624	399	371	239	257	117	493	406	373
1973	122	300	167	339	206	227	174	101	354	512	328	256	256
1974	224	232	294	150	294	346	254	183	362	783	375	239	312
1975	133	108	356	609	353	368	460	187	159	199	215	298	288
1976	110	99.9	239	399	297	218	123	181	276	230	497	641	276
1977	526	583	290	468	249	158	190	311	207	130	270	193	296
1978	223	274	413	445	411	414	314	155	154	354	94.7	255	293
1979	490	545	452	397	335	220	219	160	199	204	599	341	345
1980	248	338	205	261	308	280	356	149	204	716	581	380	336
1981	186	175	433	191	307	313	171	116	199	306	152	283	237
1982	414	111	180	230	331	306	158	152	158	478	382	544	289
1983	267	189	437	339	237	185	122	105	150	189	101	285	218
1984	292	277	407	542	396	295	295	185	280	436	263	289	330
1985	368	331	516	542	543	490	254	183	133	68.5	307	400	345
1986	361	234	466	545	335	526	198	202	254	202	240	222	315
1987	168	423	347	449	391	320	200	294	182	393	569	383	342
1988	281	389	338	378	311	366	184	183	322	266	138	198	279
1989	96.8	110	339	382	367	284	403	344	308	205	293	250	283
1990	183	196	163	402	191	361	229	135	178	384	724	412	296
1991	318	228	291	284	556	357	244	170	116	301	654	279	317
1992	154	218	260	380	261	238	145	89.8	106	550	632	502	295
1993	192	109	103	206	114	99.0	90.1	79.1	234	704	436	481	238
1994	448	190	168	383	208	286	142	133	217	279	302	144	242
1995	328	322	466	221	231	279	146	150	465	137	133	300	264

1964-1995

Average	263	281	330	391	323	298	223	180	231	317	363	332	294
STD	120	129	113	134	113	102	92.5	74.2	105	208	171	134	45.4
CV	0.457	0.457	0.341	0.343	0.351	0.341	0.415	0.413	0.457	0.656	0.472	0.404	0.154
CS	0.562	0.516	-0.2	0.143	0.827	0.321	0.822	1.17	1.37	1.11	0.289	0.877	0.386
Max	526	583	516	697	624	526	460	393	568	808	724	660	417
Min	96.8	99.9	103	150	114	99.0	90.1	79.1	80.0	68.5	94.7	144	212

Average	
STD	
CV	
CS	
Min	
Max	

Table B.2.2 River Water Flow Rate at the Principal River Stations 2/8

River: SAVA
Station Name: ZAGREB
Basin Area: 12,450 km2
Available Period: 1926-1995

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1926	253	441	198	318	320	442	845	567	298	887	1067	436	506
1927	407	208	567	496	325	232	117	133	395	207	567	269	327
1928	210	162	367	353	657	207	99,4	108	303	377	594	269	309
1929	128	245	329	385	280	249	169	129	83,0	208	659	310	264
1930	272	283	499	354	409	202	155	399	254	818	496	273	369
1931	348	280	725	418	362	228	135	162	282	300	620	243	342
1932	359	97,6	223	742	341	302	194	116	127	497	349	320	306
1933	152	236	394	238	630	575	209	139	491	678	903	319	413
1934	378	251	832	424	362	576	306	305	382	385	794	513	460
1935	207	318	346	364	318	261	123	127	135	520	467	603	316
1936	815	510	433	414	404	465	247	145	129	364	308	170	367
1937	106	440	829	911	484	324	233	318	724	555	591	820	527
1938	237	176	188	156	418	170	108	194	150	171	247	236	205
1939	588	234	181	146	629	810	167	93,1	138	442	471	255	347
1940	118	150	508	287	427	237	238	322	402	702	954	205	379
1941	328	556	414	447	486	336	203	250	167	155	569	288	348
1942	176	179	584	345	379	156	156	107	122	115	152	156	220
1943	125	348	117	114	260	279	262	110	207	231	318	443	234
1944	149	123	243	229	216	343	210	115	137	477	801	670	310
1945	145	295	212	194	234	120	146	131	102	108	153	244	173
1946	157	253	222	150	131	179	197	106	85,1	81,3	433	295	190
1947	138	414	1032	451	225	162	155	77,3	64,7	56,9	80,6	400	271
1948	586	309	190	295	188	393	727	242	202	337	649	170	357
1949	396	111	124	132	183	149	119	136	98,4	82,1	425	407	198
1950	161	460	246	360	242	159	115	124	124	163	641	804	298
1951	532	724	678	620	555	362	272	171	188	230	579	327	434
1952	386	343	550	585	229	161	127	179	380	687	517	569	393
1953	461	207	221	227	259	340	179	216	267	215	296	113	250
1954	116	95,9	452	207	589	457	291	155	170	230	347	391	293
1955	210	362	602	342	399	293	191	179	230	376	434	231	320
1956	329	230	239	420	461	518	269	202	139	213	407	185	301
1957	167	486	194	421	376	241	288	200	227	236	259	239	276
1958	235	383	377	406	240	190	180	131	120	257	424	486	285
1959	301	126	158	383	387	371	350	237	133	181	440	790	323
1960	408	509	474	330	274	156	241	184	464	712	731	844	444
1961	455	289	215	263	421	369	316	223	147	318	580	350	329
1962	672	259	503	718	536	342	467	148	230	101	686	417	424
1963	431	230	600	426	371	315	170	243	401	327	545	294	363
1964	110	146	352	490	279	235	311	165	150	878	386	444	330
1965	369	364	405	475	464	489	363	236	534	281	422	689	424
1966	251	399	288	358	273	200	269	276	209	277	557	550	325
1967	249	244	309	546	287	237	130	98,5	178	197	367	252	257
1968	194	493	267	208	203	414	140	163	312	188	385	308	271
1969	281	450	556	423	414	370	216	410	332	137	407	283	355
1970	495	328	515	754	474	254	292	191	156	135	308	186	340
1971	430	400	360	406	314	192	120	99,5	83,7	76,2	146	174	232
1972	130	451	425	650	671	391	402	256	280	138	544	427	396
1973	150	345	194	367	214	239	188	121	369	522	320	257	273
1974	231	233	300	154	314	338	269	197	381	882	366	246	327
1975	137	114	360	619	339	366	471	198	161	212	229	300	293
1976	116	111	243	424	317	225	128	184	283	230	519	687	289
1977	560	612	301	489	255	167	198	313	217	145	297	218	312
1978	245	306	451	464	423	427	330	167	156	366	97.9	261	308
1979	491	613	471	415	346	214	209	184	228	222	689	364	368
1980	263	368	207	273	341	294	375	157	218	735	638	420	357
1981	207	191	494	199	329	356	199	127	219	337	150	309	261
1982	448	101	187	259	340	324	167	157	172	513	404	594	307
1983	277	203	464	350	242	197	140	125	163	199	109	293	231
1984	324	320	451	578	424	313	319	202	305	450	281	304	356
1985	387	355	560	559	565	499	265	189	143	69.8	329	424	362
1986	410	274	528	571	361	574	216	207	261	204	246	227	340
1987	195	481	377	487	423	342	205	296	178	410	595	405	365
1988	306	421	373	385	324	378	180	180	325	275	133	204	289
1989	130	120	353	383	389	293	446	368	313	217	285	252	297
1990	199	212	185	410	210	366	235	144	186	374	716	437	306
1991	336	225	290	290	611	367	234	165	120	318	734	266	330
1992	152	224	281	398	255	237	135	89.4	133	591	703	559	313
1993	204	126	121	215	118	104	99.2	82.1	227	711	455	538	251
1994	494	212	183	426	219	292	145	135	218	289	305	142	255
1995	358	358	500	216	227	269	142	154	517	158	148	334	281

Average	297	302	380	390	357	309	236	188	235	339	455	367	321
STD	153	141	184	161	128	128	130	87,1	126	219	215	175	69,5
CV	,517	,468	,485	,412	,360	,415	,553	,463	,536	,645	,473	,476	,217
CS	,945	,638	1,02	,689	,639	1,15	2,45	1,81	1,39	1,02	,429	1,11	,504
Max	815	724	1032	911	671	810	845	567	724	887	1067	844	527
Min	106	95,9	117	114	118	104	99,2	77,3	64,7	56,9	80,6	113	173

Table B.2.2 River Flow Rate at the Principal River Stations 3/8

River: SAVA
Station Name: CRNAC
Basin Area: 22852 km^2
Available Period: 1955-1990

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1955	395	735	1064	855	572	453	313	353	416	888	911	382	610
1956	634	338	492	605	747	651	321	201	137	221	546	397	441
1957	299	883	305	752	593	430	321	291	384	491	461	404	464
1958	568	742	771	886	416	288	247	153	158	337	725	844	509
1959	756	280	333	707	604	639	516	452	197	200	794	1321	569
1960	887	973	836	651	566	219	341	244	584	1157	1162	1356	748
1961	722	492	319	406	595	510	385	324	177	409	944	532	484
1962	1173	546	906	1340	772	450	653	178	264	136	1082	864	697
1963	790	436	1006	710	586	461	207	274	682	568	737	539	584
1964	276	335	719	878	414	352	461	266	247	1196	855	847	572
1965	842	735	756	908	770	795	500	302	643	426	787	1439	741
1966	516	820	490	602	507	259	407	457	347	419	1136	1216	596
1967	539	496	568	1016	485	488	228	142	279	317	524	582	471
1968	487	792	429	273	257	700	211	303	545	332	688	559	462
1969	481	813	1120	809	620	580	273	596	513	191	588	555	593
1970	1091	936	1062	1410	799	316	372	234	196	162	380	206	595
1971	789	753	620	726	414	249	155	118	107	109	199	295	375
1972	244	858	743	1180	1238	546	598	557	592	211	975	795	709
1973	218	679	308	742	372	291	221	135	348	686	458	464	407
1974	450	378	578	247	625	471	389	273	569	1795	933	597	611
1975	240	208	550	1025	525	504	744	304	329	475	436	514	489
1976	172	212	489	757	535	498	178	326	489	335	1065	1311	530
1977	1042	1116	568	1040	327	186	241	345	267	267	653	463	538
1978	415	587	1058	848	705	569	379	178	199	538	133	449	505
1979	805	1318	860	698	463	236	264	201	309	277	1161	771	608
1980	537	725	378	586	878	441	475	148	225	1044	1282	1002	643
1981	463	439	1150	421	572	671	281	161	322	609	269	853	519
1982	934	189	365	700	539	462	196	207	256	880	617	1224	551
1983	705	484	955	824	293	203	142	120	175	251	121	412	390
1984	493	590	851	1231	761	370	369	218	495	823	581	481	605
1985	612	625	1037	991	1018	619	306	189	138	86.5	436	623	556
1986	692	401	995	1075	478	935	300	224	314	323	448	373	546
1987	257	991	566	985	814	364	213	313	195	490	989	771	575
1988	445	812	931	670	409	465	189	198	416	333	186	368	450
1989	149	152	552	487	983	369	608	499	486	490	393	370	464
1990	243	307	255	729	249	433	240	149	193	549	1116	959	451

1955-1990

Average	566	616	694	799	597	458	340	268	339	501	688	698	546
STD	271	282	274	269	219	171	148	122	161	363	326	339	93.1
CV	0.479	0.458	0.395	0.336	0.367	0.374	0.435	0.454	0.476	0.726	0.474	0.486	0.170
CS	0.411	0.282	0.066	0.156	0.808	0.597	1.01	1.12	0.547	1.71	0.0	0.802	0.328
Max	1173	1318	1150	1410	1238	935	744	596	682	1795	1282	1439	748
Min	149	152	255	247	249	186	142	118	107	86.5	121	206	375

1970-1990

Average	524	608	708	827	619	438	327	243	315	511	611	633	530
STD	289	323	278	282	263	176	162	116	143	390	370	304	86.2
CV	0.552	0.532	0.392	0.341	0.425	0.402	0.497	0.479	0.454	0.763	0.606	0.480	0.163
CS	0.528	0.428	0.011	0.052	0.702	0.965	1.23	1.47	0.555	1.94	0.404	0.823	0.0
Min	1091	1318	1150	1410	1238	935	744	557	592	1795	1282	1311	709
Max	149	152	255	247	249	186	142	118	107	86.5	121	206	375

Table B.2.2 River Water Flow Rate at the Principal River Stations 4/8

River: KUPA
Station Name: BRODARCI
Basin Area: 3405 km2
Available Period: 1957-1995

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1957	60,1	205	44,3	187	170	54,5	39,9	47,5	65,5	134	94,1	101	99,4
1958	133	201	121	216	58,5	47,6	29,2	18,7	20,9	54,5	177	214	107
1959	184	46,9	76,8	138	123	112	78,5	73,5	32,4	54,2	154	357	120
1960	181	231	186	147	112	28,7	52,3	27,7	134	273	262	255	157
1961	141	88,6	56,1	99,4	98,0	75,5	81,9	37,6	19,4	94,5	255	113	96,5
1962	238	107	214	289	139	56,3	107	22,5	31,3	18,2	255	168	137
1963	157	72,3	214	162	120	82,2	26,2	52,9	168	128	197	88,8	122
1964	44,7	88,5	177	151	83,0	49,2	69,5	56,9	56,4	356	168	187	124
1965	185	138	168	197	143	114	58,0	28,7	101	40,0	258	331	147
1966	100	200	103	126	112	44,8	64,7	89,1	52,5	138	200	289	126
1967	127	118	148	238	85,0	99,6	30,7	19,7	60,9	71,6	99,5	166	105
1968	112	238	91,6	48,8	48,5	137	27,2	76,1	163	67,3	175	145	110
1969	112	202	224	216	129	116	38,5	142	80,1	27,1	165	109	129
1970	222	180	237	300	129	44,9	55,3	39,0	39,0	30,3	86,2	63,3	118
1971	192	131	130	148	57,6	60,3	35,6	17,9	16,1	22,0	65,7	74,3	78,9
1972	65,9	223	158	280	242	51,7	81,8	77,5	131	71,7	235	130	145
1973	42,9	134	68,9	162	53,7	33,1	39,6	19,8	56,8	97,9	93,1	125	76,6
1974	73,9	99,5	132	74,3	168	96,4	56,0	102	133	407	162	120	136
1975	51,0	47,7	154	183	102	79,7	97,4	56,6	90,6	133	99,0	97,1	99,6
1976	31,2	46,2	113	193	70,3	89,4	27,8	69,8	139	74,9	240	320	118
1977	239	223	106	208	50,0	27,7	49,2	47,6	50,2	88,0	209	108	116
1978	111	130	248	175	118	82,4	45,3	27,4	49,6	104	20,6	134	104
1979	230	230	183	132	72,5	29,1	40,5	49,2	109	73,0	273	162	131
1980	115	157	102	165	153	90,2	81,5	27,6	43,7	213	272	167	132
1981	80,9	87,7	257	91,4	147	163	42,2	28,9	91,6	181	51,8	276	125
1982	220	39,9	90,6	143	98,6	93,0	22,0	53,7	55,8	221	120	309	123
1983	114	72,7	284	131	46,3	23,7	17,0	17,0	31,6	54,9	27,1	118	78,6
1984													
1985	150	104	183	173	141	55,0	24,9	19,7	15,1	11,2	96,0	143	92,9
1986	153	67,2	197	219	72,0	159	42,7	30,2	29,5	69,9	94,4	81,5	101
1987	48,9	171	115	190	161	46,0	27,7	25,3	43,0	104	242	105	106
1988	104	143	171	115	69,0	74,3	15,7	26,4	79,3	61,5	34,1	89,1	81,7
1989	18,0	38,8	103	94,7	173	70,6	87,6	110	74,2	66,5	89,3	93,3	85,3
1990	53,3	62,1	56,9	161	36,8	43,2	19,0	14,7	27,4	142	215	168	83,1
1991	161	87,7	83,1	111	209	66,9	24,2	19,6	17,6	95,9	266	58,8	100
1992	40,4	81,1	104	143	43,5	44,4	37,9	11,4	14,6	193	259	174	95,5
1993	67,9	21,3	36,1	138	32,4	43,6	20,0	13,7	114	261	151	255	96,6
1994	209	106	69,0	169	56,1	108	26,6	19,8	40,3	77,4	103	70,9	87,6
1995	208	184	180	80,9	106	116	40,0	55,2	157	32,0	88,5	184	119

1957-1995													
Average	126	126	142	163	106	74,0	46,3	44,0	69,3	114	159	162	111
STD	66,3	64,5	64,2	57,3	50,3	36,0	24,2	30,4	45,7	91,5	79,0	82,0	20,7
CV	,527	,510	,453	,351	,475	,487	,522	,691	,660	,801	,496	,507	,187
CS	,179	,267	,340	,484	,598	,762	,889	1,40	,749	1,59	-0,1	,947	,177
Min	239	238	284	300	242	163	107	142	168	407	273	357	157
Max	18,0	21,3	36,1	48,8	32,4	23,7	15,7	11,4	14,6	11,2	20,6	58,8	76,6

1970-1990													
Average	116	119	154	167	108	70,7	45,4	43,0	65,3	111	136	144	107
STD	72,2	63,1	64,7	57,2	54,8	38,7	24,6	28,0	39,0	90,3	86,0	74,2	21,6
CV	,623	,529	,419	,343	,507	,548	,541	,651	,598	,811	,631	,515	,203
CS	,501	,410	,516	,692	,690	1,17	,830	1,24	,674	2,03	,351	1,51	,090
Min	239	230	284	300	242	163	97,4	110	139	407	273	320	145
Max	18,0	38,8	56,9	74,3	36,8	23,7	15,7	14,7	15,1	11,2	20,6	63,3	76,6

Table B.2.2 River Water Flow Rate at the Principal River Stations 5/8

River: MREŽNICA
Station Name: MRZLO POLJE
Basin Area: 975 km2
Available Period: 1959-1995

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1959	80,2	30,6	30,3	55,3	26,7	35,1	21,7	59,2	17,5	11,1	34,5	81,8	40,5
1960	40,4	55,0	34,6	41,8	38,0	13,6	15,1	10,3	16,0	48,2	64,1	58,2	36,2
1961	37,7	20,7	16,8	30,4	31,5	19,0	12,1	7,80	4,70	8,76	44,3	23,8	21,4
1962	52,4	31,8	54,6	89,2	32,0	20,1	25,7	6,86	5,60	5,32	66,8	43,6	36,1
1963	33,4	24,2	52,9	30,1	23,3	25,0	12,4	8,35	29,9	37,2	15,6	19,6	26,0
1964	14,5	23,5	50,3	36,3	27,8	18,4	27,2	19,1	12,3	92,5	54,2	41,8	34,9
1965	42,4	34,6	39,4	54,1	32,3	21,6	12,3	6,99	13,7	10,5	70,4	71,7	34,1
1966	23,9	40,3	29,4	31,8	44,0	15,1	15,3	20,3	17,1	23,5	55,9	84,7	33,4
1967	34,7	25,9	28,6	51,2	25,1	39,3	12,8	6,39	7,77	5,60	11,7	47,9	24,7
1968	30,5	46,3	16,3	9,78	8,42	53,2	9,18	19,5	29,7	12,2	39,7	36,0	25,7
1969	28,7	47,8	63,3	55,0	23,4	27,7	14,8	21,5	14,8	7,10	26,2	27,6	29,6
1970	69,7	60,2	67,7	89,5	30,5	14,9	15,2	7,78	6,07	6,51	7,13	9,38	31,8
1971	53,3	27,5	32,2	39,4	12,9	11,3	6,77	4,32	4,42	6,15	7,35	18,1	18,6
1972	16,4	68,5	36,2	95,9	72,3	18,4	26,2	47,0	45,0	18,1	54,7	31,6	44,0
1973	10,8	31,3	16,6	43,4	16,4	15,9	7,88	5,09	7,64	9,78	12,3	21,5	16,4
1974	18,6	13,6	37,3	18,8	31,2	18,5	11,5	15,3	25,1	145	55,7	29,3	35,2
1975	14,8	13,6	23,6	31,5	21,9	13,8	30,2	33,8	17,7	31,8	24,1	22,1	23,3
1976	9,59	11,7	28,1	49,0	20,7	37,3	12,2	28,8	22,9	16,6	60,6	74,2	31,0
1977	49,9	50,3	23,6	56,4	11,7	6,96	8,55	5,39	6,66	22,1	38,0	28,5	25,4
1978	26,1	32,8	75,0	40,0	20,0	13,1	8,79	4,59	7,61	14,7	4,58	23,9	22,6
1979	42,0	53,0	35,5	24,5	10,1	5,04	5,47	8,49	15,8	10,7	69,5	33,9	25,9
1980	33,2	39,9	25,3	49,2	61,7	17,5	16,6	4,50	6,74	54,1	86,3	42,0	36,4
1981	23,4	22,4	90,0	22,5	25,1	56,2	13,0	7,58	38,4	25,7	10,2	79,4	34,6
1982	37,6	8,73	21,3	43,3	17,0	10,0	4,00	4,19	6,64	39,9	12,6	59,2	22,2
1983	36,0	25,7	62,5	32,4	11,2	7,84	5,69	4,56	5,20	7,28	3,98	8,77	17,6
1984	14,3	24,4	54,5	91,4	46,8	13,7	8,92	6,49	32,8	37,7	31,4	14,0	31,3
1985	35,6	19,0	51,9	38,3	43,3	12,0	7,76	4,62	4,10	3,59	11,0	26,7	21,6
1986	24,2	14,3	45,4	46,1	16,6	26,1	12,2	6,10	5,71	27,5	21,6	14,5	21,7
1987	11,2	38,0	22,2	42,6	39,2	12,6	9,57	5,32	9,04	6,95	45,5	26,6	22,2
1988	15,3	28,7	59,7	26,6	15,8	17,3	6,21	5,08	11,3	7,96	8,97	18,1	18,4
1989	5,89	5,46	17,0	13,1	70,5	12,9	13,3	14,6	20,2	27,1	9,76	9,08	18,4
1990	6,42	9,21	9,80	21,7	8,52	6,56	4,42	2,99	3,60	22,2	46,1	36,0	14,8
1991	50,9	18,2	15,9	26,4	77,5	17,7	11,5	8,13	4,78	19,3	55,3	16,0	26,9
1992	10,2	16,8	19,7	31,4	10,2	10,3	8,19	4,34	4,02	24,4	71,4	36,0	20,5
1993	20,8	11,0	14,3	40,1	13,0	11,7	6,49	4,84	14,3	36,4	32,7	80,8	24,0
1994	59,6	31,4	22,3	37,1	14,5	30,7	8,90	8,92	7,25	13,9	22,7	16,0	22,7
1995	52,5	38,5	44,2	26,6	20,3	38,2	11,8	14,3	25,3	9,01	11,5	59,3	29,2

1959-1995													
Average	31.5	29,6	37,0	42,2	28,4	20,1	12,4	12,3	14,3	24,5	35,1	37,1	27,0
STD	18,3	15,5	19,4	20,9	18,2	12,2	6,46	12,3	10,6	26,9	23,7	22,9	7,25
CV	,579	,523	,525	,495	,639	,607	,520	1,01	,743	1,10	,676	,616	,268
CS	,674	,623	,813	1,22	1,34	1,45	1,28	2,43	1,23	3,05	,341	,835	,391
Max	80,2	68,5	90,0	95,9	77,5	56,2	30,2	59,2	45,0	145	86,3	84,7	44,0
Min	5,89	5,46	9,80	9,78	8,42	5,04	4,00	2,99	3,60	3,59	3,98	8,77	14,8

1970-1990													
Average	26,4	28,5	39,8	43,6	28,7	16,6	11,2	10,8	14,4	25,8	29,6	29,8	25,4
STD	17,2	17,8	21,7	23,3	19,7	11,5	6,67	11,6	12,1	30,3	24,7	19,7	7,79
CV	,650	,623	,545	,533	,687	,695	,598	1,07	,842	1,18	,834	,659	,307
CS	,938	,802	,758	1,20	1,17	2,43	1,71	2,22	1,34	3,29	,817	1,43	,759
Min	69,7	68,5	90,0	95,9	72,3	56,2	30,2	47,0	45,0	145	86,3	79,4	44,0
Max	5,89	5,46	9,80	13,1	8,52	5,04	4,00	2,99	3,60	3,59	3,98	8,77	14,8

Table B.2.2 River Water Flow Rate at the Principal River Stations 6/8

River: KORANA
Station Name: VELEMERIĆ
Basin Area: 1297km2
Available Period: 1946-1990

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1946	26,5	44,6	22,4	8,84	5,46	4,15	3,04	2,15	2,50	3,84	91,4	39,0	20,9
1947	16,1	106	81,0	17,1	14,1	10,1	11,9	3,84	2,53	2,17	11,8	20,0	24,2
1948	63,8	30,0	25,3	39,6	12,6	14,8	36,9	7,95	7,17	17,8	64,7	8,76	27,4
1949	14,2	6,46	25,9	15,5	20,6	12,0	7,24	4,42	3,41	2,75	42,7	33,5	15,8
1950	10,6	82,4	42,8	28,6	12,7	5,54	4,39	3,41	3,92	11,5	45,9	85,8	27,8
1951	55,6	66,0	56,0	56,4	29,9	12,2	28,0	8,86	23,5	41,7	63,1	30,5	39,1
1952	45,9	46,8	24,6	24,0	9,05	5,56	3,29	2,94	3,72	8,71	30,8	91,0	24,7
1953	47,7	49,5	32,4	29,2	39,3	40,4	16,5	6,99	6,11	4,55	16,1	4,40	24,2
1954	26,3	14,0	72,1	37,0	86,7	23,3	9,23	5,00	4,20	10,6	22,8	38,5	29,4
1955	21,3	62,0	101	52,6	20,3	19,9	26,6	41,7	25,2	110	52,1	23,5	46,3
1956	29,6	11,7	51,3	40,4	42,6	28,8	12,4	5,22	3,27	3,65	30,0	35,2	24,6
1957	19,7	65,1	14,3	50,2	45,5	19,4	6,42	10,5	34,0	37,7	22,6	18,9	28,4
1958	28,7	52,8	51,0	65,6	17,9	10,7	5,10	3,74	3,40	7,59	31,4	34,1	25,8
1959	51,9	17,4	24,5	41,6	21,1	48,9	17,6	40,2	12,9	9,73	42,2	100	35,9
1960	47,2	48,9	34,0	46,0	48,0	9,35	13,2	8,18	9,85	38,8	71,1	50,8	35,4
1961	34,9	21,9	15,9	24,7	41,9	14,6	11,6	7,07	3,58	8,15	51,1	30,3	22,1
1962	67,6	44,9	74,5	82,7	27,7	21,7	28,9	5,60	4,48	3,73	74,7	54,1	40,8
1963	34,2	38,9	52,8	33,5	21,7	23,6	8,81	5,49	21,4	34,0	12,4	19,8	25,5
1964	16,0	35,3	63,7	44,7	27,5	17,8	26,9	17,3	12,0	77,5	54,8	61,7	38,0
1965	54,6	35,0	39,3	61,5	36,4	24,9	10,7	6,81	15,1	8,75	61,8	60,0	34,5
1966	24,5	56,9	38,6	35,4	54,9	13,4	23,1	15,0	18,7	28,5	93,1	87,4	40,7
1967	43,1	28,7	26,6	55,9	30,0	47,4	11,7	5,02	8,20	4,74	13,4	64,7	28,2
1968	42,9	35,0	13,2	7,67	6,47	50,0	6,38	14,3	22,8	9,03	47,5	31,3	23,7
1969	36,8	62,5	63,0	52,3	19,1	30,0	13,4	20,6	17,2	6,12	14,3	34,0	30,5
1970	90,3	65,5	78,0	61,3	30,3	22,3	22,7	9,84	5,43	6,22	6,03	8,08	33,7
1971	61,8	24,9	37,2	32,5	12,6	9,68	4,58	3,31	3,71	5,72	6,92	22,9	18,8
1972	22,3	74,5	29,5	90,8	72,2	16,0	29,1	56,2	54,2	17,6	59,8	26,2	45,4
1973	11,0	44,1	20,4	58,5	15,6	22,8	7,69	3,93	10,2	9,37	15,2	34,9	20,9
1974	22,3	13,9	42,1	18,5	28,6	25,2	11,1	11,0	22,3	164	49,1	32,3	37,0
1975	16,5	16,1	25,2	33,6	25,0	15,5	34,7	26,0	18,9	29,1	31,5	28,4	25,1
1976	9,10	17,8	46,0	47,7	28,6	47,6	14,2	41,7	31,8	24,1	69,6	52,6	35,8
1977	42,9	46,7	26,2	75,5	12,2	6,87	17,2	6,17	7,94	22,4	41,6	38,2	28,5
1978	35,3	44,5	69,4	41,7	27,9	12,8	9,08	5,01	8,11	18,5	5,11	29,4	25,5
1979	36,8	47,4	34,1	27,0	11,3	4,93	5,07	4,04	5,81	10,1	72,2	46,0	25,2
1980	45,1	37,6	33,4	59,5	67,8	22,6	13,0	5,07	5,87	31,5	85,1	60,6	38,9
1981	30,9	34,5	93,0	23,0	22,2	55,9	11,9	6,97	28,1	26,1	14,7	83,9	36,0
1982	33,2	9,79	31,6	58,1	19,8	11,2	5,67	5,61	7,26	31,1	15,8	65,5	24,7
1983	50,0	39,0	74,7	33,7	9,72	6,51	4,94	3,56	4,36	6,97	3,73	6,14	20,2
1984	21,2	37,6	66,3	63,8	41,3	10,8	5,95	5,57	29,8	34,6	41,5	15,6	31,1
1985	36,5	16,3	57,2	46,1	39,0	8,06	6,27	3,36	3,53	2,62	9,92	29,9	21,7
1986	26,2	21,9	63,2	32,4	14,1	33,0	21,0	5,53	4,68	24,6	26,6	16,9	24,2
1987	16,4	68,7	25,1	49,4	50,1	11,2	9,87	3,95	3,90	5,03	40,6	29,0	25,8
1988	23,6	37,5	76,6	27,3	14,1	13,4	5,47	5,79	10,6	11,6	10,0	23,4	21,6
1989	5,29	6,80	22,9	18,9	87,9	11,8	12,1	12,7	33,0	39,7	9,07	10,5	22,7
1990	7,24	10,9	12,7	35,0	7,44	5,40	3,84	3,23	3,99	19,3	45,6	47,8	16,9

1946-1990													
Average	34,0	40,2	45,4	42,1	30,0	19,9	13,5	10,9	12,9	23,0	38,1	39,0	29,0
STD	17,9	21,9	22,8	19,0	20,1	13,5	8,91	12,1	11,5	30,0	25,6	24,2	7,39
CV	,525	,545	,502	,452	,669	,679	,659	1,12	,889	1,30	,671	,620	,255
CS	,833	,629	,603	,393	1,34	1,23	1,06	2,41	1,51	3,21	,466	,905	,607
Min	90,3	106	101	90,8	87,9	55,9	36,9	56,2	54,2	164	93,1	100	46,3
Max	5,29	6,46	13,2	7,67	5,46	4,15	3,04	2,15	2,50	2,17	3,73	4,40	15,8

1970-1990													
Average	31,8	35,3	47,6	45,0	31,5	18,4	12,6	11,3	15,0	26,1	30,7	33,0	28,1
STD	19,9	19,6	22,5	19,6	22,3	13,5	8,48	14,1	13,9	34,4	25,5	20,1	7,35
CV	,626	,555	,473	,437	,707	,735	,674	1,25	,927	1,32	,830	,610	,261
CS	1,38	,458	,528	,606	1,34	1,69	1,37	2,48	1,46	3,72	,785	,993	,832
Min	90,3	74,5	93,0	90,8	87,9	55,9	34,7	56,2	54,2	164	85,1	83,9	45,4
Max	5,29	6,80	20,4	18,5	9,72	4,93	4,58	3,31	3,53	2,62	3,73	6,14	18,8

Table B.2.2 River Flow Rate at the Principal River Stations 7/8

River: KUPA
Station Name: FARKAŠIĆ
Basin Area: 8902 km^2
Available Period: 1965-1990

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1965	358	323	275	367	250	224	101	50.3	139	79.5	391	658	267
1966	191	386	200	229	239	74.0	122	143	111	173	510	608	248
1967	263	214	229	398	165	219	65.3	38.1	83.4	83.9	134	334	185
1968	237	326	132	68.9	57.3	253	45.6	103	197	98.0	302	245	171
1969	209	380	444	370	186	193	73.0	201	134	48.7	195	225	220
1970	547	434	494	553	243	92.2	107	73.0	63.8	59.1	113	70.2	236
1971	394	234	243	250	96.8	84.9	50.9	32.8	31.7	41.5	77.2	123	138
1972	116	416	260	616	529	111	179	235	272	94.5	478	239	294
1973	82.6	277	112	319	104	78.6	63.4	39.1	81.8	132	128	199	133
1974	145	134	244	109	263	143	99.2	114	200	1118	338	235	264
1975	101	91.9	201	309	160	116	215	117	139	221	183	176	170
1976	57.9	98.6	232	314	152	210	59.8	144	203	123	477	520	216
1977	386	390	185	455	82.4	50.2	81.8	66.5	70.8	132	347	220	204
1978	187	257	481	316	202	116	67.8	40.1	69.2	153	37.5	195	177
1979	332	498	296	214	99.0	37.9	50.8	55.6	115	82.1	554	293	216
1980	243	292	204	302	382	168	129	34.7	61.0	343	563	420	262
1981	181	208	589	173	207	304	89.3	47.6	163	255	100	454	232
1982	393	74.9	166	333	166	129	34.9	70.0	86.7	307	175	537	207
1983	277	227	470	295	77.8	50.5	36.5	28.4	47.4	78.9	39.4	138	147
1984	193	246	349	473	282	107	68.6	66.7	252	299	261	174	230
1985	278	186	372	315	296	100	57.0	36.0	25.9	20.8	138	221	171
1986	243	146	373	334	126	252	94.2	50.1	52.9	137	177	137	177
1987	121	417	176	330	323	95.0	63.9	49.4	53.1	122	363	228	193
1988	165	300	401	206	130	126	34.8	34.7	108	92.1	56.4	155	150
1989	38.4	53.8	188	144	456	107	150	147	141	184	124	131	156
1990	76.7	104	88.6	252	61.4	76.2	33.7	24.4	42.5	170	318	316	130

1964-1990

Average	224	258	285	309	205	135	83.6	78.6	113	179	253	279	200
STD	124	125	132	126	120	70.9	45.4	56.0	67.7	209	166	159	45.7
CV	0.553	0.484	0.463	0.407	0.587	0.524	0.543	0.713	0.598	1.17	0.657	0.568	0.229
CS	0.690	0.065	0.664	0.437	1.08	0.828	1.36	1.42	0.848	3.88	0.513	1.11	0.255
Max	547	498	589	616	529	304	215	235	272	1118	563	658	294
Mın	38.4	53.8	88.6	68.9	57.3	37.9	33.7	24.4	25.9	20.8	37.5	70.2	130

1960-1990

Average	217	242	292	315	211	122	84.1	71.7	109	198	240	247	196
STD	134	131	137	126	129	65.5	48.9	52.5	72.5	229	171	132	46.6
CV	0.619	0.541	0.470	0.399	0.612	0.539	0.582	0.732	0.668	1.15	0.711	0.534	0.238
CS	0.795	0.373	0.597	0.787	1.04	1.47	1.36	1.86	1.01	3.53	0.654	1.11	0.401
Min	547	498	589	616	529	304	215	235	272	1118	563	537	294
Max	38.4	53.8	88.6	109	61.4	37.9	33.7	24.4	25.9	20.8	37.5	70.2	130

Table B.2.2 River Flow Rate at the Principal River Stations 8/8

River: ČESMA
Station Name: ČAZMA
Basin Area: 2877 km^2
Available Period: 1963.-1995.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1963	20.6	27.4	43.5	3.98	1.48	1.95	0.306	0.364	1.51	2.87	3.19	3.28	9.12
1964	4.68	21.7	25.6	20.5	13.9	9.29	3.69	0.787	1.50	11.7	7.79	27.4	12.4
1965	56.8	12.6	42.3	37.6	32.1	29.7	20.5	3.56	4.50	2.52	46.1	102	32.7
1966	26.9	75.4	21.5	38.7	15.3	12.9	25.7	11.1	10.3	3.31	65.2	68.3	30.9
1967	53.0	47.6	23.9	33.0	9.34	17.7	4.65	0.752	20.6	3.36	4.15	27.5	20.3
1968	13.7	26.5	4.81	2.29	0.696	1.82	0.313	1.07	2.31	1.37	24.5	15.3	7.80
1969	29.3	69.3	56.7	17.1	4.30	5.14	2.42	12.7	4.25	1.82	4.78	22.1	18.9
1970	78.4	132	84.2	56.4	30.6	3.12	3.60	51.6	3.03	4.77	5.45	4.36	37.6
1971	47.8	20.5	43.6	12.3	14.7	2.47	1.25	1.21	1.06	1.31	1.56	3.45	12.6
1972	3.46	19.0	8.10	38.3	60.3	7.01	67.0	57.0	21.4	9.27	65.8	27.2	32.0
1973	15.9	82.4	11.4	61.4	26.9	3.70	2.53	1.43	1.54	2.06	3.29	15.6	18.5
1974	21.5	19.6	9.75	2.51	35.9	9.21	15.6	3.40	3.41	103	35.8	41.0	25.3
1975	10.8	8.42	11.9	27.2	6.22	15.5	41.4	5.24	4.04	25.1	12.7	17.3	15.5
1976	8.33	18.3	30.3	19.1	32.5	9.80	1.99	1.37	1.69	5.93	9.25	64.0	17.0
1977	59.5	74.1	19.3	48.0	3.14	2.02	2.11	1.57	1.11	1.30	39.2	33.5	23.3
1978	12.7	22.9	43.1	24.4	24.1	7.61	3.89	2.14	2.09	3.50	1.96	8.08	13.0
1979	27.2	115	20.2	10.4	3.34	1.63	2.67	1.24	1.20	1.80	10.7	25.9	17.8
1980	15.8	32.0	6.69	30.0	36.3	9.62	5.12	1.64	1.88	5.78	61.2	77.8	23.6
1981	24.3	53.0	66.4	5.32	7.72	19.1	4.26	1.78	2.02	4.58	5.22	63.2	21.3
1982	31.1	2.40	9.45	28.3	3.00	2.07	3.93	4.98	2.83	6.46	7.73	54.0	13.1
1983	29.5	41.6	56.4	37.5	3.58	2.46	1.19	0.844	1.16	1.86	1.67	1.47	14.8
1984	12.3	25.7	27.3	18.3	9.74	4.10	4.80	2.61	3.39	7.47	18.3	10.6	12.0
1985	21.1	25.2	63.9	11.7	17.7	6.92	3.32	1.56	0.841	1.13	11.2	14.3	14.9
1986	31.2	16.2	80.1	24.8	7.14	47.0	6.02	2.03	1.65	7.36	4.35	7.71	19.7
1987	12.3	61.3	17.0	36.3	27.8	4.42	4.11	1.76	1.09	4.83	42.9	21.9	19.3
1988	16.8	44.1	69.1	20.2	5.86	3.79	1.82	1.52	4.32	11.3	3.92	9.29	15.9
1989	3.52	6.06	17.3	3.87	41.0	8.19	5.60	12.5	24.2	11.0	7.24	9.49	12.6
1990	8.22	11.9	12.1	13.8	2.61	3.89	0.914	0.487	0.874	2.03	10.7	18.7	7.14
1991	23.4	9.50	15.0	8.10	35.6	3.80	4.00	5.33	3.36	27.1	56.9	18.3	17.6
1992	9.53	22.1	26.4	20.1	3.46	7.68	1.87	0.954	1.16	5.22	59.3	38.2	16.2
1993	7.44	3.70	9.25	15.3	2.26	1.28	1.01	0.814	1.01	10.8	34.4	119	17.3
1994	76.6	24.8	24.8	43.9	5.84	10.3	2.61	5.83	4.79	9.73	10.2	11.0	19.2
1995	55.6	28.2	46.0	8.78	11.2	33.2	7.62	2.99	38.1	5.38	7.95	35.6	23.4

1963-1995

Average	26.3	36.4	31.7	23.6	16.2	9.35	7.81	6.19	5.40	9.31	20.7	30.8	18.6
STD	20.6	31.2	22.8	15.7	15.0	10.2	13.6	12.8	8.38	17.9	21.6	28.8	7.13
CV	0.781	0.858	0.717	0.664	0.922	1.09	1.73	2.08	1.55	1.92	1.04	0.934	0.384
CS	1.19	1.54	0.852	0.621	1.07	2.3	3.33	3.50	2.71	4.82	1.05	1.55	0.884
Max	78.4	132	84.2	61.4	60.3	47.0	67.0	57.0	38.1	103	65.8	119	37.6
Mın	3.46	2.4	4.81	2.29	0.696	1.28	0.306	0.364	0.841	1.13	1.56	1.47	7.14

1970-1990

Average	23.4	39.6	33.7	25.2	19.1	8.27	8.72	7.52	4.04	10.6	17.1	25.2	18.4
STD	18.7	35.4	26.1	16.5	16.2	9.96	15.9	15.8	6.34	21.9	19.6	22.3	7.06
CV	0.801	0.894	0.775	0.655	0.848	1.20	1.83	2.10	1.57	2.07	1.15	0.887	0.383
CS	1.67	1.43	0.741	0.677	0.88	3.24	3.13	2.86	2.86	4.17	1.53	1.14	1.19
Min	78.4	132	84.2	61.4	60.3	47.0	67.0	57.0	24.2	103	65.8	77.8	37.6
Max	3.46	2.40	6.69	2.51	2.61	1.63	0.914	0.487	0.841	1.13	1.56	1.47	7.14

Table B.3.1 Existing Average River Water Quality (1994-1999)-1/4

River Basin	Sava									Krapina					Lonja
River Name	Main									Krapinica		Krapina			Lonja
Sampling Site	JESENICE	JANKOMIR	PETRUŠEVAC	OBOROVO	MARTINSKA VES	GALDOVO	UTOK KUPE NIZVODNO	UTOK UNE UZVODNO	UTOK UNE NIZVODNO	KRAPINA	ZABOK	BEDEKOVČINA	UTOK KRAPINICE NIZVODNO	ZAPREŠIĆ	IVANIĆ GRAD
Point Code Namber	10017	10016	10015	10014	10013	10012	10011	10010	10009	17552	17551	17004	17003	17001	15481
Temperature (℃)	12.7	12.7	13.1	13.2	12.6	12.6	12.6	12.3	11.8	10.9	11.6	11.3	11.9	12.1	14.2
pH (-)	7.6	7.7	7.7	7.7	7.8	7.8	7.8	7.7	7.5						7.5
Conductivity(μ S/cm)	350	357	359	371	511	508	483	450	437	378	436	414	412	427	493
DO (mg/l)	9.3	9.0	9.5	7.8	7.8	7.5	8.5	8.3	8.8						6.1
Oxygen Saturation (%)	86.1	83.5	89.5	72.3	70.7	69.3	78.8	76.0	79.9	67.1	61.5	61.1	60.7	65.6	57.4
BOD (mg/l)	2.7	2.9	2.8	4.8	3.3	3.7	3.1	2.5	2.5	8.5	7.5	6.0	6.0	4.2	10.0
COD (Mn) (mg/l)	4.4	4.8	4.6	5.3	4.4	4.8	3.7	4.1	3.9	10.8	14.4	11.3	10.7	9.6	14.1
Suspended Solids (mg/l)	25	29	30	28	20	23	10	16	12	151	198	122	147	107	25
T-Dry Residue (mg/l)	286	298	298	302	287	290	256	266	271	448	517	415	433	402	392
F-Dry Residue	185	194	194	194	-	-	-	-	-	15300	8420	6050	10800	9710	254
Faecal Coli (MPN/100ml)	26×10^3	41×10^3	91×10^3	71×10^4	21×10^3	20×10^3	16×10^3	12×10^3	12×10^3	64×10^4	26×10^4	13×10^4	14×10^4	14×10^4	68×10^3
No. Bacteria (MPN/ml)	21×10^3	27×10^3	36×10^3	24×10^4	14×10^3	17×10^3	10×10^3	62×10^2	47×10^2	39×10^4	19×10^4	10×10^4	87×10^3	11×10^4	37×10^3
Saprobic Index (mg/l)	2.6	2.6	2.6	3.0	2.7	3.8	2.0	2.8	2.5	3.2	2.9	2.4	2.2	3.3	2.9
Phenol (mg/l)	0.003	0.003	0.003	0.004	0.009	0.006	0.006	0.006	0.005	0.005	0.003	0.002	0.003	0.002	0.005
Iron (Fe-mg/l)	0.19	0.25	0.26	0.30	0.47	0.34	0.68	0.56	0.61	0.69	0.78	0.53	0.71	0.43	0.33
Manganese (Mn-mg/l)	0.03	0.05	0.04	0.04	0.04	10.93	0.04	0.04	0.05	13.11	13.92	13.81	13.8	14.0	0.02
Calcium (Ca-mg/l)	58.6	60.6	60.2	61.6	57.8	47.1	57.8	48.7	53.5	55.2	53.8	72.2	61.8	66.1	84.7
Potassium (K-mg/l)	1.3	1.5	1.5	1.7	-	-	-	-	-	7.1	7.7	7.12	7.48	8.18	5.38
Magnesium (Mg-mg/l)	15.6	15.9	16.5	16.4	12.8	11.7	11.3	8.9	10.2	18.6	18.4	21.9	19.45	20.35	27.33
Sodium (Na-mg/l)	5.72	6.09	5.97	7.26	-	-	-	-	-	10.35	7.04	9.59	8.57	10.90	30.47
Ammounium (mg/l)	0.23	0.26	0.29	0.57	0.52	0.46	0.37	0.31	0.28	0.95	0.47	0.80	0.55	0.43	0.78
Nitrite (mg/l)	0.034	0.036	0.046	0.057	0.042	0.245	0.034	0.035	0.029	0.314	0.861	0.244	0.374	0.381	0.159
Nitrate (mg/l)	2.30	2.23	2.30	2.41	1.62	4.53	1.45	1.27	1.24	5.63	9.23	4.15	5.13	3.95	2.20
T-N (mg/l)	3.39	3.42	3.62	4.29	2.68	5.64	2.36	2.21	2.18	9.61	12.17	7.76	7.49	6.33	6.46
Sulphate (mg/l)	19.1	20.6	20.7	21.2	27.3	22.8	24.9	20.6	23.4	18.6	15.0	15.3	17.6	18.5	21.0
Phosphate (mg/l)	0.13	0.13	0.14	0.18	0.46	0.51	0.38	0.40	0.38	2.16	5.34	1.55	1.82	4.70	0.43
Chloride (mg/l)	8.4	9.0	9.2	10.1	10.6	9.3	9.4	8.3	8.0	10.3	10.6	18.6	11.7	16.7	37.63
Oils (mg/l)	0.23	0.23	0.23	0.31	1.24	1.42	1.23	1.24	1.06	2.7	14.0	1.95	1.80	2.6	0.3
COD (Cr) (mg/l)	13.5	14.1	13.7	17.7	-	-	-	-	-	37.6	14.8	22.6	22.1	16.7	42.0
Organic Nitrogen (mg/l)	0.82	0.90	0.98	1.25	0.50	0.41	0.51	0.59	0.64	2.72	1.61	2.56	1.43	1.57	3.32
TOC (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anionic Detergents (mg/l)	0.02	0.02	0.02	0.05	0.09	0.11	0.09	0.08	0.07	0.08	0.11	0.03	0.04	0.04	0.08
T-P (mg/l)	-	-	-	-	0.26	64.1	0.23	0.20	0.18	-	-	-	-	-	-
Mineral oils (mg/l)	0.13	0.13	0.13	0.18	0.20	0.07	0.05	0.06	0.03	47.4	107.3	51.0	50.2	50.9	0.1
DOC (mg/l)	2.49	-	0.000	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonates (mg/l)	191	197	198	202	351	295	366	350	370	242	242	309	294	289	276
Carbonates (mg/l)	-	0.21	0.00	0.21	17.2	48.3	16.8	11.6	12.8	0.00	53.8	5.0	62.0	88.3	50.8
Total Hardness (mg/l)	-	-	-	-	201.4	191.8	190.2	157.8	174.5	-	-	-	-	-	-

Table B.3.1 Existing Average River Water Quality (1994-1999)-2/4

River Basin	Kupa																	
River Name	Main							Dobra				MREŽNICA		Korana				Odra
Sampling Site	KAMANJE	G. POKUPJE	REČICA	JAMNIČKA KISELICA	SISINEC	BREST	SISAK	MORAVICE	LUKE	LEŠĆE	DONJE STATIV E	JUZBAŠIĆI	MOSTANJ E	BOGOVOLJA	SLUNJ	VELJUN	VELEMERIĆ	SISAK
Point Code Nanber	16007	16006	16005	16004	16003	16002	16001	16582	16581	16572	16571	16453	16451	16335	16334	16333	16331	16220
Temperature (℃)	14.8	16.0	16.2	16.1	12.4	12.1	12.5	11.5	12.2	13.5	15.4	13.5	16.0	15.2	15.5	15.7	15.5	15.0
pH (-)		8.0	8.1	8.1	7.8	7.7	7.9	8.0	8.1	8.1	8.0	8.1	8.2	8.2	8.2	8.0	8.2	7.8
Conductivity(μ S/cm)	262	303	310	322	393	362	426	295	321	317	320	346	331	401	340	327	326	586
DO (mg/l)		10.2	9.8	10.1	10.3	10.0	9.7	11.4	11.3	11.3	10.6	10.5	9.7	10.0	10.3	10.0	9.7	8.4
Oxygen Saturation (%)	85.2	101.9	98.4	101.4	95.0	91.2	89.3	104.4	104.8	108.4	105.1	100.0	97.2	98.7	102.4	99.0	95.3	82.2
BOD (mg/l)	2.0	2.1	2.5	2.8	2.1	1.4	2.6	2.0	2.0	1.7	2.5	1.9	2.5	2.0	1.8	1.5	1.8	2.5
COD (Mn) (mg/l)	3.5	1.9	2.2	2.3	2.3	2.8	3.2	1.8	2.2	1.9	2.2	1.8	1.9	2.8	2.6	2.0	2.0	4.6
Suspended Solids (mg/l)	47	18	19	21	11	9	13	19	17	19	17	18	18	18	17	16	15	9
T-Dry Residue (mg/l)	197	229	208	218	219	226	230	229	226	228	234	223	220	286	231	213	218	316
F-Dry Residue	438	122	125	132	-	-	-	141	148	142	140	138	138	159	137	122	128	-
Faecal Coli (MPN/100ml)	27×10^3	23×10^3	15×10^4	19×10^3	43×10^2	76×10^2	83×10^2	46×10^2	95×10^2	87×10^2	67×10^2	27×10^3	13×10^3	18×10^2	95×10^3	10×10^3	55×10^2	93×10^2
No. Bacteria (MPN/ml)	24×10^2	12×10^2	70×10^2	55×10^2	52×10^2	20×10^2	56×10^2	25×10^2	16×10^2	11×10^2	36×10^2	25×10^2	63×10^2	25×10^2	20×10^2	42×10^2	75×10^2	23×10^2
Saprobic Index (mg/l)	1.8	2.0	2.2	2.1	2.5	-	2.4	1.6	1.7	1.8	2.2	-	2.1	1.9	2.1	2.1	-	-
Phenol (mg/l)	0.004	-	0.010	0.020	0.004	0.002	0.006	0.031	0.002	0.003	0.002	0.006	0.024	0.000	0.001	0.001	0.001	0.003
Iron (Fe-mg/l)	-	-	-	-	0.32	0.45	0.43	-	-	-	-	-	-	-	-	-	-	1.76
Manganese (Mn-mg/l)	-	-	-	-	0.05	0.04	0.06	-	-	-	-	-	-	-	-	-	-	0.14
Calcium (Ca-mg/l)	-	-	-	-	48.9	59.6	53.3	-	-	-	-	-	-	-	-	-	-	43.9
Potassium (K-mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg-mg/l)	-	-	-	-	7.25	9.52	10.29	-	-	-	-	-	-	-	-	-	-	35.24
Sodium (Na-mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammounium (mg/l)	0.10	0.11	0.17	0.12	0.09	0.14	0.23	0.05	0.04	0.02	0.09	0.09	0.09	0.23	0.22	0.056	1.52	4.55
Nitrite (mg/l)	0.021	0.021	0.050	0.069	0.009	0.016	0.011	0.023	0.010	0.023	0.015	0.012	0.061	0.103	0.033	0.007	0.037	0.074
Nitrate (mg/l)	0.65	0.50	0.64	0.44	0.93	0.81	1.02	1.01	1.36	1.25	0.62	0.67	0.68	0.39	0.44	0.37	0.17	0.89
T-N (mg/l)	-	-	-	-	1.48	1.48	1.70	-	-	-	-	-	-	-	-	-	-	6.27
Sulphate (mg/l)	-	-	-	-	17.0	13.1	18.3	-	-	-	-	-	-	-	-	-	-	-
Phosphate (mg/l)	0.04	0.04	0.21	0.19	0.10	0.09	0.11	0.02	0.01	0.01	0.02	0.04	0.14	0.59	0.25	0.10	0.04	0.45
Chloride (mg/l)	-	-	-	-	4.1	3.7	6.2	-	-	-	-	-	-	-	-	-	-	15.5
Oils (mg/l)	-	-	-	-	1.2	1.0	1.1	-	-	-	-	-	-	-	-	-	-	2.7
COD (Cr) (mg/l)	4.5	4.9	5.6	6.3	-	-	-	4.7	4.9	5.1	6.4	4.5	4.7	8.3	7.2	4.9	5.3	-
Organic Nitrogen (mg/l)	-	-	-	-	0.45	0.53	0.44	-	-	-	-	-	-	-	-	-	-	0.75
TOC (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anionic Detergents (mg/l)	-	-	-	-	0.05	0.04	0.09	-	-	-	-	-	-	-	-	-	-	0.08
T-P (mg/l)	-	-	-	-	0.11	0.09	0.08	-	-	-	-	-	-	-	-	-	-	0.23
Mineral oils (mg/l)	0.01	0.01	0.03	0.01	-	-	-	0.00	0.04	0.07	0.01	0.02	0.01	0.07	0.03	0.03	0.02	-
DOC (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonates (mg/l)	81	79	108	109	335	342	336	-	88	81	81	129	114	157	131	134	144	296
Carbonates (mg/l)	0.0	0.0	0.0	0.2	16.3	-	13.2	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.0	2.5	0.0	99.2
Total Hardness (mg/l)	-	-	-	-	151.0	186.8	173.5	-	-	-	-	-	-	-	-	-	-	210.9

Table B.3.1 Existing River Water Quality of 95% Value (1994-1999) -3/4

River Basin	Sava									Krapina					Lonja
River Name	Main									Krapinica		Krapina			Lonja
Sampling Site	JESENICE	JANKOMIR	PETRUŠEVAC	OBOROVO	MARTINSKA VES	GALDOVO	UTOK KUPE NIZVODNO	UTOK UNE UZVODNO	UTOK UNE NIZVODNO	KRAPINA	ZABOK	BEDEKOV ČINA	UTOK KRAPINICE NIZVODNO	ZAPREŠIĆ	IVANIĆ GRAD
Point Code Namber	10017	10016	10015	10014	10013	10012	10011	10010	10009	17552	17551	17004	17003	17001	15481
pH (-)	8.1	8.1	8.1	8.1	8.2	8.2	8.3	8.2	8.0	-	-	-	-	-	7.9
Conductivity(μ S/cm)	420	431	435	454	613	610	573	533	516	499	543	498	517	516	676
DO (mg/l)	6.7	6.3	7.3	4.2	4.3	4.5	5.5	5.3	5.7	-	-	-	-	-	1.6
Oxygen Saturation (%)	73.1	69.5	81.9	49.4	47.4	46.2	53.5	54.7	56.6	52.3	44.4	40.6	44.4	54.6	20.2
BOD (mg/l)	5.6	6.7	5.7	8.6	5.9	6.3	5.7	4.6	4.5	20.5	20.2	12.8	13.3	8.4	21.2
COD (Mn) (mg/l)	8.4	10.1	9.4	9.5	6.5	8.0	5.2	6.3	5.3	26.7	28.3	27.1	19.3	23.7	23.5
Suspended Solids (mg/l)	103	151	134	102	55	93	22	52	26	400	588	247	378	185	57
T-Dry Residue (mg/l)	391	459	431	401	348	370	317	331	313	800	1014	596	680	507	538
F-Dry Residue	273	328	308	278	-	-	-	-	-	40400	18700	16200	21000	38000	360
Faecal Coli (MPN/100ml)	12×10^4	26×10^4	65×10^4	39×10^5	31×10^3	32×10^3	33×10^3	30×10^3	30×10^3	20×10^5	11×10^5	40×10^4	45×10^4	55×10^4	24×10^4
No. Bacteria (MPN/ml)	64×10^3	90×10^3	12×10^4	90×10^4	37×10^3	83×10^3	31×10^3	34×10^3	16×10^3	15×10^5	19×10^4	31×10^4	23×10^4	36×10^4	11×10^4
Saprobic Index (mg/l)	2.8	2.7	2.8	3.3	2.7	5.0	2.1	2.9	2.5	3.2	2.9	2.4	2.2	3.3	2.9
Phenol (mg/l)	0.008	0.007	0.008	0.008	0.020	0.013	0.013	0.013	0.010	0.005	0.003	0.002	0.003	0.002	0.005
Iron (Fe-mg/l)	0.57	1.03	0.97	0.90	1.13	0.73	2.49	1.45	1.06	0.69	1.23	0.78	1.16	0.43	0.33
Manganese (Mn-mg/l)	0.16	0.28	0.16	0.16	0.12	14.1	0.12	0.11	0.10	13.11	13.95	13.81	13.9	14.0	0.018
Calcium (Ca-mg/l)	69.6	72.1	73.8	73.1	70.5	72.3	68.3	74.6	57.7	55.2	53.8	72.2	61.8	66.1	84.7
Potassium (K-mg/l)	1.97	2.14	2.08	2.35	-	-	-	-	-	7.11	7.74	7.12	7.48	8.18	5.38
Magnesium (Mg-mg/l)	19.8	19.8	22.1	21.3	24.1	22.5	21.2	16.2	15.5	18.6	18.4	21.9	19.5	20.4	27.3
Sodium (Na-mg/l)	9.0	9.3	9.0	10.7	-	-	-	-	-	10.35	7.12	9.59	8.57	10.90	30.47
Ammounium (mg/l)	0.43	0.49	0.51	0.91	0.94	0.87	0.73	0.69	0.61	0.95	0.55	0.82	0.55	0.43	0.78
Nitrite (mg/l)	0.057	0.070	0.140	0.134	0.068	0.41	0.057	0.061	0.051	0.314	0.939	0.247	0.398	0.381	0.159
Nitrate (mg/l)	3.59	3.64	3.60	3.81	2.60	6.71	2.37	1.90	2.02	5.63	9.23	4.34	5.33	3.95	2.20
T-N (mg/l)	5.97	6.48	6.51	7.38	4.67	8.84	4.34	3.98	3.85	9.61	12.33	8.04	7.71	6.33	6.46
Sulphate (mg/l)	27.0	30.0	29.7	29.5	39.0	34.0	34.9	29.6	34.5	18.6	15.1	15.3	17.6	18.5	21.0
Phosphate (mg/l)	0.33	0.32	0.33	0.40	0.79	0.89	0.65	0.70	0.71	0.14	0.37	0.14	0.19	0.20	0.43
Chloride (mg/l)	13.3	14.1	14.6	16.6	16.2	14.2	13.2	12.9	12.2	10.4	10.6	18.6	11.8	16.8	37.6
Oils (mg/l)	0.46	0.45	0.45	0.67	2.60	4.03	2.54	2.52	1.75	4.31	49.96	2.44	2.30	3.67	0.50
COD (Cr) (mg/l)	25.0	31.8	28.2	30.9	-	-	-	-	-	109.0	25.2	49.7	48.3	32.6	65.3
Organic Nitrogen (mg/l)	1.90	2.28	2.27	2.52	1.07	0.85	1.18	1.33	1.17	2.72	1.61	2.63	1.44	1.57	3.32
TOC (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anionic Detergents (mg/l)	0.08	0.09	0.06	0.15	0.15	0.24	0.16	0.17	0.13	0.17	0.15	0.05	0.06	0.06	0.08
T-P (mg/l)	-	-	-	-	0.49	74.4	0.53	0.35	0.32	-	-	-	-	-	-
Mineral oils (mg/l)	0.30	0.29	0.29	0.44	0.07	0.19	0.19	0.31	0.11	0.80	0.32	0.37	0.51	0.23	0.25
DOC (mg/l)	3.89	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonates (mg/l)	213	222	221	229	432	361	441	412	435	242	242	309	294	290	276
Carbonates (mg/l)	-	1.4	0.0	1.4	34.7	67.6	34.8	21.7	22.3	0.0	53.8	5.0	0.0	88.3	50.8
Total Hardness (mg/l)	-	-	-	-	259.7	290.9	241.4	234.4	203.5	-	-	-	-	-	-

Table B.3.1 Existing River Water Quality of 95% Value (1994-1999) -4/4

River Basin	Kupa																
River Name	Main							Dobra				MREŽNICA		Korana			Odra
Sampling Site	KAMANJE	G. POKUPJE	REČICA	JAMNIČKA KISELICA	SISINEC	BREST	SISAK	MORAVICE	LUKE	LEŠĆE	DONJE STATIVE	JUZBAŠIĆI	MOSTANJE	BOGOVOLJA	SLUNJ	VELJUN	VELEMERIĆ	SISAK
Point Code Namber	16007	16006	16005	16004	16003	16002	16001	16582	16581	16572	16571	16453	16451	16335	16334	16333	16331	16220
pH (-)	-	8.2	8.4	8.4	8.5	8.3	8.4	8.2	8.5	8.5	8.3	8.3	8.4	8.4	8.5	9.1	8.6	8.3
Conductivity(μ S/cm)	296	337	346	389	446	414	496	383	361	364	391	396	370	532	402	365	366	762
DO (mg/l)	-	7.2	6.6	7.7	7.4	7.4	6.6	9.5	9.1	9.0	8.0	8.0	6.4	7.8	7.7	6.7	6.6	6.0
Oxygen Saturation (%)	68.3	81.7	76.9	77.6	75.5	82.3	70.3	85.0	83.0	81.3	77.7	76.2	70.8	83.8	83.8	74.8	75.9	59.4
BOD (mg/l)	3.5	3.7	4.3	5.1	4.0	3.5	5.0	2.8	3.6	2.7	5.1	3.6	4.2	3.1	3.3	2.7	3.7	4.8
COD (Mn) (mg/l)	6.5	2.7	3.0	3.9	4.1	4.3	5.8	2.9	3.8	2.8	4.4	2.9	3.0	4.5	4.6	3.6	3.2	9.0
Suspended Solids (mg/l)	71	31	34	38	40	21	42	31	33	38	31	37	39	34	35	31	27	19
T-Dry Residue (mg/l)	273	298	251	276	271	252	281	306	305	292	315	276	275	398	290	263	261	405
F-Dry Residue	1110	175	176	195	-	-	-	203	225	205	194	194	214	243	210	166	186	-
Faecal Coli (MPN/100ml)	11×10^{4}	92×10^{3}	78×10^{4}	96×10^{3}	15×10^{3}	25×10^{3}	24×10^{3}	16×10^{3}	42×10^{3}	39×10^{3}	23×10^{3}	11×10^{4}	45×10^{3}	60×10^{2}	36×10^{4}	39×10^{3}	16×10^{3}	25×10^{3}
No. Bacteria (MPN/ml)	63×10^{2}	47×10^{2}	37×10^{3}	30×10^{3}	27×10^{3}	63×10^{2}	40×10^{3}	90×10^{2}	58×10^{2}	39×10^{2}	12×10^{3}	11×10^{3}	30×10^{3}	87×10^{2}	55×10^{2}	12×10^{3}	27×10^{3}	61×10^{2}
Saprobic Index (mg/l)	1.8	2.0	2.3	2.2	2.5	-	2.5	1.6	1.7	1.8	2.0	-	2.1	1.9	2.1	2.1	-	-
Phenol (mg/l)	0.004	0.056	0.012	0.063	0.010	0.004	0.013	0.031	0.002	0.003	0.002	0.020	0.025	0.000	0.001	0.002	0.002	0.007
Iron (Fe-mg/l)	-	-	-	-	0.96	1.20	1.34	-	-	-	-	-	-	-	-	-	-	1.97
Manganese (Mn-mg/l)	-	-	-	-	0.15	0.11	0.30	-	-	-	-	-	-	-	-	-	-	0.20
Calcium (Ca-mg/l)	-	-	-	-	68.1	73.5	79.7	-	-	-	-	-	-	-	-	-	-	54.4
Potassium (K-mg/l)	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-
Magnesium (Mg-mg/l)	-	-	-	-	12.80	14.10	20.34	-	-	-	-	-	-	-	-	-	-	37.64
Sodium (Na-mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ammounium (mg/l)	0.10	0.11	0.23	0.18	0.25	0.32	0.75	0.05	0.04	0.02	0.09	0.25	0.13	0.33	0.22	0.09	1.52	4.8
Nitrite (mg/l)	0.021	0.021	0.103	0.108	0.019	0.049	0.022	0.023	0.010	0.023	0.015	0.034	0.090	0.111	0.033	0.007	0.037	0.140
Nitrate (mg/l)	0.65	0.50	0.98	0.53	1.49	1.18	1.78	1.01	1.36	1.25	0.62	1.18	0.75	0.41	0.44	0.37	0.17	1.5
T-N (mg/l)	-	-	-	-	2.97	2.65	3.48	-	-	-	-	-	-	-	-	-	-	8.32
Sulphate (mg/l)	-	-	-	-	25.0	21.1	29.6	-	-	-	-	-	-	-	-	-	-	-
Phosphate (mg/l)	0.04	0.04	0.34	0.26	0.21	0.19	0.24	0.02	0.01	0.01	0.02	0.16	0.21	0.79	0.25	0.20	0.04	0.81
Chloride (mg/l)	-	-	-	-	5.7	5.5	9.1	-	-	-	-	-	-	-	-	-	-	17.2
Oils (mg/l)	-	-	-	-	2.35	1.45	0.93	-	-	-	-	-	-	-	-	-	-	3.45
COD (Cr) (mg/l)	8.1	8.6	8.3	11.8	-	-	-	7.3	8.4	7.9	12.4	7.5	7.30	12.4	14.4	8.1	9.0	-
Organic Nitrogen (mg/l)	-	-	-	-	1.20	1.09	0.93	-	-	-	-	-	-	-	-	-	-	1.91
TOC (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anionic Detergents (mg/l)	0.01	0.01	0.04	0.03	0.14	0.08	0.23	-	-	-	-	-	-	-	-	-	-	-
T-P (mg/l)	-	-	-	-	0.32	0.21	0.17	-	-	-	-	-	-	-	-	-	-	0.56
Mineral oils (mg/l)	-	-	-	-	-	-	-	0.00	0.04	0.08	0.01	0.06	0.02	0.08	0.03	0.04	0.02	-
DOC (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonates (mg/l)	81	79	112	112	380	382	398	87	88	81	81	153	116.0	158	131	135	144	330
Carbonates (mg/l)	0.0	0.0	0.0	0.6	30.6	11.4	24.7	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2	25	0.0	109
Total Hardness (mg/l)	-	-	-	-	184.7	186.8	261.3	-	-	-	-	-	-	-	-	-	-	245.2

Table B.3.2 Results of Water Quality Observation of River/Tributary/Canal - 1/10

Sample No.	1	2	3	4	5	6	7	8
Location	Recica	Brest	Before Sisak	Jesenice	Jankomir	Petruševac	Oborovo	Martinska Ves
River Name	Kupa	Kupa	Kupa	Sava	Sava	Sava	Sava	Sava
Sampling Site	bank	bridge	bank	bank	bank	bank	ferry	ferry
Remarks								
Code No.	254	249	248	289	280	291	242	241
Sampling Date	18 Dec. 2000	18. Dec. 2000	18 Dec. 2000	20 Dec. 2000	20 Dec. 2000	20 Dec. 2000	20 Dec. 2000	21 Dec. 2000
Sampling Time	11,20 a.m.	14,15 p.m.	15,40 p.m.	9,10 a.m.	10,05 a.m.	10,50 a.m.	12,00 p.m.	9,55 a.m.
Climate	cloud	cloud	cloud	cloud	cloud	cloud	cloud	cloud
Discharge(m^3/s)	240	-	-	310	315	350	-	-
Color	yellowish	greyish	greyish	greyish	greyish	greyish	greyish	colourless
Odor	no	no	no	no	no	no	no	no
EC (μ S/cm)	253	296	299	354	356	357	357	371
Turbidity (mg/l)	25.0	18.0	15.0	4.5	4.0	5.5	6.0	3.5
pH	6.95	7.82	7.92	7.26	7.94	8.16	8.13	7.73
BOD (mg/l)	6.9	4.1	2.4	2.1	1.3	2.4	2.1	1.8
COD(Mn) (mg/l)	8.63	5.12	3.68	3.08	3.60	3.78	4.28	4.20
T-N (mg/l)	3.5	1.6	1.6	1.5	1.5	1.5	1.5	1.50
NH_4^+-N (mg/l)	0.12	0.08	0.09	0.05	0.05	0.03	0.06	0.25
NO_3^- -N (mg/l)	2.36	0.78	0.73	1.14	1.16	1.17	1.13	1.16
NO_2^- -N (mg/l)	0.02	0.01	0.01	0.04	0.04	0.05	0.13	0.09
T-P (mg/l)	0.03	0.33	0.07	0.07	0.02	0.06	0.09	0.07
PO_4-P (mg/l)	<0,01	<0,01	0.03	<0,01	<0,01	<0,01	<0,01	0.000
DO (mg/l)	9.8	10.0	9.5	8.8	9.0	9.1	8.7	8.70
SS (mg/l)	20.2	4.4	6.0	11.6	6.2	3.6	5.6	5.2
Phenol (mg/l)	0.001	0.002	0.001	<0,001	<0,001	<0,001	<0,001	<0,001
Cadmium (ug/l)	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005
Aresenic (ug/l)	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006
Cyanide (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Selenium (ug/l)	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001
Cr (ug/l)	0.004	0.005	<0,003	<0,003	<0,003	<0,003	<0,003	0.0035
Hg (ug/l)	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003
Ni^{2+} (ug/l)	0.0048	0.0028	0.0076	0.0045	0.0031	0.0041	0.0038	0.0075
Lead (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Copper (ug/l)	0.0128	0.0120	0.0129	0.0224	0.0185	0.0311	0.01	0.0235
Zinc (ug/l)	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002
Fe (ug/l)	1.0629	0.4781	0.3171	0.0530	0.0388	0.0608	0.0398	0.0428
F (mg/l)	0.072	0.051	0.056	0.057	0.046	0.052	0.051	0.097
PCB (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Organo-chlorine(Pesticides) (ug/l)	0.002	0.015	0.001	0.001	0.011	0.007	0.002000	0.002000
Detergent (mg/l)	0.041	0.048	0.077	0.047	0.019	0.030	0.029	0.039
Total oil (n-hexane Extract) (mg/l)	0.036	0.054	0.083	0.143	0.162	0.084	0.090	0.080
Cl (Cloride) (mg/l)	10.4	2.6	2.8	4.1	4.1	4.2	4.4	5.57
Total coliform (MPN/100ml)	1500	4200	3100	5400	4400	6800	6100	11200
Fecal oliform (MPN/100ml)	200	340	1300	460	640	730	5400	2800

Table B.3.2 Results of Water Quality Observation of River/Tributary/Canal - 2/10

Sample No.	9	10	11					
Location	Galdovo	Topolovac	Lukavec					
River Name	Sava	Sava	Sava					
Sampling Site	ship	ship	boat					
Remarks								
Code No.	238	296	237					
Sampling Date	21 Dec. 2000	21 Dec. 2000	21 Dec. 2000					
Sampling Time	10,25 a.m.	11,05 a.m.	11,35 a.m.					
Climate	cloud	cloud	cloud					
Discharge(m^3/s)	-	720	-					
Color	colourless	colourless	colourless					
Odor	no	no	no					
EC (μ S/cm)	357	346	355					
Turbidity (mg/l)	3.0	4.5	4.5					
pH	7.84	7.85	7.81					
BOD (mg/l)	2.1	2.2	2.5					
COD(Mn) (mg/l)	3.45	3.37	3.37					
T-N (mg/l)	1.6	1.5	1.6					
NH_4^+-N (mg/l)	0.13	0.12	0.13					
NO_3^- -N (mg/l)	1.16	1.02	1.09					
NO_2^- -N (mg/l)	0.08	0.06	0.08					
T-P (mg/l)	0.06	0.08	0.07					
PO_4-P (mg/l)	0	0.02	0.06					
DO (mg/l)	9.3	9.1	9.1					
SS (mg/l)	4.0	22.4	24.4					
Phenol (mg/l)	<0,001	<0,001	<0,001					
Cadmium (ug/l)	<0,0005	<0,0005	<0,0005					
Aresenic (ug/l)	<0,00006	<0,00006	<0,00006					
Cyanide (mg/l)	<0,001	<0,001	<0,001					
Selenium (ug/l)	<0,00001	<0,00001	<0,00001					
Cr (ug/l)	0.0064	<0,003	<0,003					
Hg (ug/l)	<0,0003	<0,0003	<0,0003					
Ni^{2+} (ug/l)	0.0044	0.0042	0.0042					
Lead (ug/l)	<0,001	0.0155	<0,001					
Copper (ug/l)	0.0228	0.0153	0.0115					
Zinc (ug/l)	<0,002	<0,002	<0,002					
Fe (ug/l)	0.0474	0.0702	0.0666					
F (mg/l)	0.06	0.06	0.05					
PCB (ug/l)	<0,001	<0,001	<0,001					
Organo-chlorine(Pesticides) (ug/l)	0.004	0.001	0.007					
Detergent (mg/l)	0.041	0.048	0.054					
Oil (n-hexane Extract) (mg/l)	0.117	0.113	0.097					
Cl (Cloride) (mg/l)	4.2	3.7	4.0					
Total coliform (MPN/100ml)	8700	9100	9000					
Fecal oliform (MPN/100ml)	2700	1300	1400					

Table B.3.2 Results of Water Quality Observation of River/Tributary/Canal - 3/10

Sample No.	12	13	14	15	16	17	18	19
Location	Poljanski Lug	Ivanic Grad	After Confluence of R. Crnec	Struzec	Trebez	Crnec	Cazma	Kutina
River Name	Lonja	Lonja	Lonja	Lonja	Lonja	Crnec	Cesma	Kutina
Sampling Site	bridge	bridge	bank	bridge	retention	bridge	bridge	bridge
Remarks								
Code No.	291	245	292	294	298	297	244	295
Sampling Date	14 Dec. 2000	14 Dec. 2000	14 Dec. 2000	13 Dec. 2000	13 Dec. 2000	8 Jan. 2001	13 Dec. 2000	13 Dec. 2000
Sampling Time	11,25 a.m.	13,30 p.m.	14,30 p.m.	9,15 a.m.	11,20 a.m.	12,35 p.m.	13,45 p.m.	12,15 p.m.
Climate	cloud	cloud	cloud	cloud	cloud	cloud	cloud	cloud
Discharge(m^3/s)	0.38	0.34	0.42	9.09	31.07	2.99	1.31	0.84
Color	colourless	greyish	greyish-brown	greenish	yellowish	yellowish	greenish	greyish
Odor	no	no	no	no	no	no	no	no
EC (μ S/cm)	652	645	799	529	305	588	638	634
Turbidity (mg/l)	6.0	25.0	15.0	9.5	8.0	16.0	7.5	20.0
pH	7.49	7.54	7.42	7.40	7.36	7.55	7.91	7.44
BOD (mg/l)	3.4	5.3	8.3	5.5	6.0	5.2	4.1	7.1
COD(Mn) (mg/l)	5.25	6.60	10.35	7.95	8.63	16.80	6.23	9.58
T-N (mg/l)	3.7	4.2	14.0	3.8	1.4	5.2	5.8	20.7
NH_4^+-N (mg/l)	1.92	1.21	10.32	1.57	0.07	1.96	2.23	11.76
NO_3^- -N (mg/l)	1.20	1.79	0.05	1.13	0.12	2.17	2.02	4.06
NO_2^- -N (mg/l)	0.07	0.099	0.026	0.026	0.008	0.049	0.058	0.370
T-P (mg/l)	1.29	0.37	1.20	0.82	0.26	0.33	0.52	6.50
PO_4-P (mg/l)	1.280	0.366	1.018	0.025	0.001	0.223	0.473	6.003
DO (mg/l)	6.4	6.3	3.1	3.7	5.2	6.4	9.6	3.0
SS (mg/l)	40.4	20.2	20.0	24.4	36.0	14.0	54.6	54.0
Phenol (mg/l)	0.003	0.003	0.009	0.025	0.008	<0,001	0.003	0.004
Cadmium (ug/l)	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005
Aresenic (ug/l)	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006
Cyanide (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Selenium (ug/l)	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001
Cr (ug/l)	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003
Hg (ug/l)	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003
Ni^{2+} (ug/l)	0.0087	0.0123	0.0100	0.0098	0.0066	0.0213	0.0112	0.0106
Lead (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Copper (ug/l)	0.0177	0.0144	0.0133	0.0149	0.0128	0.0105	0.0166	0.0128
Zinc (ug/l)	<0,002	<0,002	<0,002	0.0475	<0,002	0.0395	<0,002	0.0362
Fe (ug/l)	0.1483	0.5413	0.3075	0.3166	0.1601	0.6480	0.3051	0.1152
F (mg/l)	0.215	0.219	0.181	0.161	0.101	0.249	0.230	2.411
PCB (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Organo-chlorine(Pesticides)	0.008	0.002	0.017	0.012	0.003	0.006	0.013	0.023
Detergent (mg/l)	0.095	0.081	0.109	0.105	0.094	0.088	0.107	0.279
Tot.oil (n-hexane Extract) (mg/l)	0.022	0.045	0.185	0.054	0.014	0.092	0.056	0.077
Cl (Cloride) (mg/l)	27.0	25.7	72.7	24.0	5.1	32.2	24.0	25.7
Total coliform (MPN/100n	2400	11200	18000	52	34	2100	1600	21400
Fecal coliform (MPN/100n	740	1080	5900	12	19	1000	1200	13800

Table B.3.2 Results of Water Quality Observation of River/Tributary/Canal - 4/10

Sample No.	20	21	22	23	24	25	26	27
Location	Poljanski Lug	Ivanic Grad	After Confluence of R. Crnec	Struzec	Trebez	Crnec	Cazma	Kutina
River Name	Lonja	Lonja	Lonja	Lonja	Lonja	Crnec	Cesma	Kutina
Sampling Site	bridge	bridge	bank	bridge	retention	bridge	bridge	bridge
Remarks								
Code No.	291	245	292	294	298	297	244	295
Sampling Date	8 Jan. 2001	8 Jan. 2001	8 Jan. 2001	9 Jan. 2001	9 Jan. 2001	11 Jan. 2001	8 Jan. 2001	9 Jan. 2001
Sampling Time	9,40 a.m.	11,05 a.m.	14,00 p.m.	9,15 a.m.	10,15 a.m.	10,40 a.m.	10,30 a.m.	11,55 a.m.
Climate	cloud	cloud	cloud	cloud	cloud	cloud	cloud	cloud
Discharge(m^3/s)	5.59	1.25	4.67	37.40	42.35	8.52	10.35	2.98
Color	yellowish	yellowish	yellowish	yellowish	yellowish	yellowish	yellowish	yellow
Odor	no	no	no	no	no	no	no	no
EC (μ S/cm)	478	387	511	402	296	486	479	574
Turbidity (mg/l)	17.0	27.0	20.0	25.0	10.0	40.0	12.0	140.0
pH	7.33	7.45	7.44	7.51	7.53	7.49	7.83	7.31
BOD (mg/l)	4.0	7.9	6.5	10.8	8.5	6.0	5.7	12.7
COD(Mn) (mg/l)	15.21	20.00	16.80	22.00	16.30	18.70	16.00	31.90
T-N (mg/l)	3.2	7.4	7.3	4.5	2.0	5.1	3.7	33.0
NH_4^+-N (mg/l)	0.47	1.06	1.49	0.43	0.007	1.06	0.67	14.97
NO_3^- -N (mg/l)	1.81	4.32	2.98	2.70	0.95	2.85	1.80	14.2
NO_2^- -N (mg/l)	0.05	0.07	0.06	0.04	0.02	0.09	0.05	0.14
T-P (mg/l)	0.18	0.28	0.21	0.24	0.08	0.22	0.29	5.40
PO_4-P (mg/l)	0.098	0.221	0.207	0.150	<0,001	0.137	0.140	4.416
DO (mg/l)	8.9	9.2	6.4	9.1	8.6	5.9	9.1	10.3
SS (mg/l)	4.0	7.4	5.0	44.0	20.4	2.0	12.4	91.2
Phenol (mg/l)	<0,001	<0,001	0.003	0.017	<0,001	0.006	<0,001	0.03
Cadmium (ug/l)	<0,0005	<0,0005	<0,0005	<0,0005	<0,0005	0.0192	<0,0005	<0,0005
Aresenic (ug/l)	<0,0006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006
Cyanide (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Selenium (ug/l)	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001
Cr (ug/l)	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003
Hg (ug/l)	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003
Ni^{2+} (ug/l)	0.0149	0.0157	0.0190	0.0158	0.0123	0.0172	0.0197	0.0281
Lead (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Copper (ug/l)	0.0115	0.0145	0.0130	0.0150	0.0090	0.0080	0.0140	0.0275
Zinc (ug/l)	0.0283	0.0375	0.0424	0.0327	0.0224	0.0446	0.0378	0.0921
Fe (ug/l)	0.9055	2.1494	0.9105	1.8627	0.4225	3.2735	0.6878	8.6308
F (mg/l)	0.162	0.205	0.239	0.230	0.116	0.235	0.205	0.875
PCB (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Organo-chlorine(Pesticides)	0.023	0.379	0.040	0.005	0.004	<0,001	<0,001	0.103
Detergent (mg/l)	0.076	0.116	0.104	0.080	0.050	0.071	0.079	0.057
Oil (n-hexane Extract) (mg/l)	0.034	0.017	0.117	0.041	0.022	0.081	0.075	0.085
Cl (Cloride) (mg/l)	14.419	17.828	31.196	17.252	3.875	29.297	13.248	27.228
Total coliform (MPN/100n	4900	3400	3500	210	34	660	2700	18000
Fecal coliform (MPN/100n	3100	1600	600	164	4	280	400	10200

Table B.3.2 Results of Water Quality Observation of River/Tributary/Canal - 5/10

Sample No.	28	29	30	31	32			
Location	Poljanski Lug	After Confluence of R. Crnec	Struzec	Cazma	Strug			
River Name	Lonja	Lonja	Lonja	Cesma				
Sampling Site	bridge	bank	bridge	bridge	bridge			
Remarks								
Code No.	291	292	294	244	-			
Sampling Date	11 Jan. 2001	11 Jan. 2001	11 Jan. 2001	11 Jan. 2001	9 Jan. 2001			
Sampling Time	13,25 p.m.	11,50 a.m.	8,50 a.m.	10,00 a.m.	10,55 a.m.			
Climate	cloud	cloud	cloud	cloud	rain			
Discharge(m^3/s)	9.82	2.37	42.77	17.36	37.4			
Color	yellowish	yellowish	yellow	yellowish	yellowish			
Odor	no	no	no	no	no			
EC (μ S/cm)	393	479	362	363	308			
Turbidity (mg/l)	23.0	38.0	40.0	28.0	10.0			
pH	7.74	7.46	7.29	7.64	7.58			
BOD (mg/l)	5.2	5.7	5.6	5.2	6.8			
COD(Mn) (mg/l)	15.70	17.20	19.50	18.70	17.20			
T-N (mg/l)	3.2	6.2	4.0	4.5	2.5			
NH_4^+-N (mg/l)	0.26	0.58	0.60	1.13	0.11			
NO_3^- -N (mg/l)	1.98	3.28	2.02	2.05	1.08			
NO_2^- -N (mg/l)	0.05	0.08	0.06	0.04	0.03			
T-P (mg/l)	0.18	0.27	0.64	0.42	0.14			
PO_4-P (mg/l)	0.077	0.126	0.563	0.224	<0,001			
DO (mg/l)	9.6	6.8	8.6	9.5	9.3			
SS (mg/l)	48.0	36.4	81.8	34.0	13.6			
Phenol (mg/l)	0.012	0.010	0.007	0.007	0.002			
Cadmium (ug/l)	0.0168	0.0196	0.0192	0.0228	<0,0005			
Aresenic (ug/l)	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006			
Cyanide (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001			
Selenium (ug/l)	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001			
Cr (ug/l)	<0,003	<0,003	<0,003	<0,003	<0,003			
Hg (ug/l)	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003			
Ni^{2+} (ug/l)	0.0154	0.0141	0.0177	0.0123	0.0119			
Lead (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001			
Copper (ug/l)	0.009	0.009	0.0155	0.0135	0.009			
Zinc (ug/l)	0.0344	0.025	0.0387	0.0789	0.0308			
Fe (ug/l)	2.248	3.068	3.171	2.9575	0.3341			
F (mg/l)	0.163	0.224	0.170	0.165	0.147			
PCB (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001			
Organo-chlorine(Pesticides)	<0,001	<0,001	0.010	0.044	0.007			
Detergent (mg/l)	0.091	0.077	0.031	0.043	0.036			
Tot. oil (n-hexane Extract) (mg/l)	0.026	0.026	0.113	0.051	0.019			
Cl (Cloride) (mg/l)	10.8	22.9	11.7	10.0	4.6			
Total coliform (MPN/100n	1040	740	5400	1480	32			
Fecal oliform (MPN/100m	380	370	420	700	6			

Table B.3.2 Results of Water Quality Observation of River/Tributary/Canal - 6/10

Sample No.	33	34	35	36	37	38	39	40
Location	Recica	Brest	Before Sisak	Jesenice	Jankomir	Petrusevec	Oborovo	Martinska Ves
River Name	Kupa	Kupa	Kupa	Sava	Sava	Sava	Sava	Sava
Sampling Site	bank	bridge	bank	bank	bank	bank	ferry	ferry
Remarks								
Code No.	254	249	248	289	280	291	242	241
Sampling Date	16 May 2001	15 May 2001	15 May 2001	16 May 2001	16 May 2001	16 May 2001	16 May 2001	15 May 2001
Sampling Time	15,00 p.m.	14,30 p.m.	14,05 p.m.	9,40 a.m.	10,25 a.m.	11,10 a.m.	12,10 p.m.	11,00 a.m.
Climate	sunny	cloud	cloud	sunny	sunny	sunny	cloud	sunny
Discharge(m^3/s)		48		130		190		
Color	greenish	greyish	greyish	colourless	colourless	colourless	colourless	greyish
Odor	no	no	no	no	no	no	no	no
EC (μ S/cm)	396	393	395	397	417	423	448	425
Turbidity (mg/l)	4.2	0.5	10.0	2.5	3.2	2.5	3.0	18.0
pH	7.87	6.74	7.73	7.63	7.68	7.73	7.64	7.78
BOD (mg/l)	2.6	1.5	1.2	2.3	2.4	2.0	2.4	1.5
COD(Mn) (mg/l)	3.10	2.48	2.00	3.64	3.72	3.10	3.33	2.79
T-N (mg/l)	1.02	1.04	1.02	1.80	2.10	1.80	2.14	2.08
NH_4^+-N (mg/l)	0.038	0.044	0.043	0.028	0.029	0.035	0.294	0.340
NO_3^- -N (mg/l)	0.45	0.37	0.32	1.07	1.11	1.09	1.09	1.08
NO_2^- -N (mg/l)	0.009	0.009	0.010	0.031	0.030	0.022	0.030	0.021
T-P (mg/l)	0.03	0.05	0.16	0.07	0.05	0.06	0.09	0.10
PO_4-P (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	0.04
DO (mg/l)	8.8	10.0	9.4	9.6	8.3	9.7	6.5	6.9
SS (mg/l)	91.2	8.4	10.2	4.0	5.2	20.0	38.0	44.8
Phenol (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Cadmium (ug/l)	0.00023	0.00021	0.00023	0.00013	0.00021	0.00022	0.00024	0.00041
Aresenic (ug/l)	<0,0006	<0,0006	<0,0006	<0,0006	<0,0006	<0,0006	<0,0006	<0,0006
Cyanide (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Selenium (ug/l)	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001
Cr (ug/l)	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003
Hg (ug/l)	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003
Ni^{2+} (ug/l)	0.03360	0.01680	<0,01	0.01140	0.01890	0.02480	<0,01	<0,01
Lead (ug/l)	0.00180	0.00160	0.00270	0.00090	0.00100	0.00120	0.00130	0.00100
Copper (ug/l)	0.01260	0.01050	<0,001	<0,001	0.01030	0.01550	<0,001	<0,001
Zinc (ug/l)	0.01470	<0,002	0.61250	0.02040	0.01030	<0,002	0.01520	<0,002
Fe (ug/l)	0.19320	0.24990	0.57750	0.10070	0.10870	0.07590	0.60300	0.11730
F (mg/l)	0.0450	0.0560	0.0650	0.0520	0.0550	0.0800	0.0610	0.0570
PCB (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Organo-chlorine(Pesticides) (ug/l)	0.0010	0.0005	0.0009	0.0001	0.0064	0.0021	0.0005	0.0041
Detergent (mg/l)	0.03	0.016	0.046	0.009	0.038	0.012	0.055	0.057
Total oil (n-hexane Extract) (mg/l)	0.031	0.041	0.029	0.095	0.106	0.064	0.049	0.062
Cl (Cloride) (mg/l)	3.550	2.490	2.780	4.990	5.620	5.530	7.120	6.760
Total coliform (MPN/100ml)	3600	300	500	420	200	630	3100	4200
Fecal oliform (MPN/100ml)	2440	108	200	80	60	220	1380	3000

Table B.3.2 Results of Water Quality Observation of River/Tributary/Canal - 7/10

Sample No.	41	42	43					
Location	Galdovo	Topolovac	Lukavec					
River Name	Sava	Sava	Sava					
Sampling Site	ship	ship	boat					
Remarks								
Code No.	238	296	237					
Sampling Date	15 May 2001	15 May 2001	15 May 2001					
Sampling Time	11,30 p.m.	12,00 p.m.	12,30 p.m.					
Climate	sunny	sunny	sunny					
Discharge(m^3/s)		210						
Color	greyish	greyish	greyish					
Odor	no	no	no					
EC (μ S/cm)	438	434	438					
Turbidity (mg/l)	10.0	10.0	10.0					
pH	7.65	7.95	8.13					
BOD (mg/l)	2.0	2.0	1.8					
COD(Mn) (mg/l)	3.10	2.63	2.94					
T-N (mg/l)	2.44	1.70	1.90					
NH_4^+-N (mg/l)	0.268	0.190	0.193					
NO_3^- -N (mg/l)	1.11	0.88	0.94					
NO_2^- -N (mg/l)	0.024	0.022	0.025					
T-P (mg/l)	0.14	0.08	0.06					
PO_4-P (mg/l)	<0,001	<0,001	<0,001					
DO (mg/l)	5.2	7.2	6.8					
SS (mg/l)	34.0	11.6	4.0					
Phenol (mg/l)	<0,001	<0,001	<0,001					
Cadmium (ug/l)	0.00023	0.00022	0.00024					
Aresenic (ug/l)	<0,00006	<0,00006	<0,00006					
Cyanide (mg/l)	<0,001	<0,001	<0,001					
Selenium (ug/l)	<0,00001	<0,00001	<0,00001					
Cr (ug/l)	<0,003	<0,003	<0,003					
Hg (ug/l)	<0,0003	<0,0003	<0,0003					
Ni^{2+} (ug/l)	0.0188	0.0266	0.0203					
Lead (ug/l)	0.0013	0.0013	0.0013					
Copper (ug/l)	<0,001	<0,001	<0,001					
Zinc (ug/l)	0.0141	0.0144	0.0135					
Fe (ug/l)	0.1339	0.1619	0.1755					
F (mg/l)	0.064	0.059	0.069					
PCB (ug/l)	<0,001	<0,001	<0,001					
Organo-chlorine(Pesticides) (ug/l)	0.003	0.0003	0.0060					
Detergent (mg/l)	0.035	0.019	0.01					
Oil (n-hexane Extract) (mg/l)	0.0493	0.0403	0.0430					
Cl (Cloride) (mg/l)	6.770	5.490	5.540					
Total coliform (MPN/100ml)	2700	4600	2100					
Fecal oliform (MPN/100ml)	400	2100	1800					

Table B.3.2 Results of Water Quality Observation of River/Tributary/Canal - 8/10

Sample No.	44	45	46	47	48	49	50	51
Location	Poljanski Lug	Ivanic Grad	After confluents of R. Crnec	Struzec	Trebez	Posavski Bregi	Cazma	Kutina
River Name	Lonja	Lonja	Lonja	Lonja	Lonja	Crnec	Cesma	Kutina
Sampling Site	bridge	bridge	bank	bridge	retention	bridge	bridge	bridge
Remarks								
Code No.	291	245	292	294	298	297	244	295
Sampling Date	14 May 2001	11 May 2001	14 May 2001	11 May 2001	11 May 2001	14 May 2001	11 May 2001	11 May 2001
Sampling Time	10,10 a.m.	11,10 a.m.	12,30 p.m.	9,15 a.m.	10,20 a.m.	11,40 a.m.	14,00 p.m.	11,35 a.m.
Climate	sunny	sunny	sunny	sunny	sunny	sunny	cloud	cloud
Discharge(m^3/s)	1.12	0.57	1.30	13.72	21.03	0.67	6.50	0.31
Color	yellowish	yellowish	yellowish	yellowish	yellowish	yellowish	greyish	greyish
Odor	no	no	no	no	no	no	no	no
EC (μ S/cm)	657	533	723	490	453	784	557	1048
Turbidity (mg/l)	15.0	13.0	15.0	15.0	15.0	10.0	20.0	18.0
pH	7.74	7.55	7.64	6.70	7.49	7.79	7.72	7.28
BOD (mg/l)	4.5	11.5	13.5	10.5	13.8	12.0	5.5	6.5
COD(Mn) (mg/l)	15.00	31.70	23.30	19.20	21.70	20.0	15.8	15.9
T-N (mg/l)	2.00	2.80	4.17	2.81	2.40	4.7	2.10	43.20
NH_4^+-N (mg/l)	0.425	0.565	1.980	0.891	0.431	2.640	0.436	18.270
NO_3^- -N (mg/l)	0.71	1.27	0.30	1.02	0.4	0.190	0.930	11.197
NO_2^- -N (mg/l)	0.065	0.160	0.057	0.091	0.068	0.046	0.112	0.395
T-P (mg/l)	0.35	0.47	0.33	0.26	0.22	0.41	0.43	60.60
PO_4-P (mg/l)	0.096	0.333	0.324	0.143	0.105	0.371	0.153	43.600
DO (mg/l)	6.2	6.7	4.0	2.8	3.6	4.2	5.7	5.2
SS (mg/l)	33.6	8.8	20.2	34.4	49.4	13.6	51.6	87.6
Phenol (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Cadmium (ug/l)	0.00093	0.00081	0.00101	0.00080	0.00080	0.00085	0.00081	0.00104
Aresenic (ug/l)	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006
Cyanide (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Selenium (ug/l)	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001
Cr (ug/l)	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003	<0,003
Hg (ug/l)	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003
Ni^{2+} (ug/l)	0.0253	0.0156	0.0198	0.0483	0.0458	0.0117	<0,001	0.0432
Lead (ug/l)	0.0013	0.0013	0.0009	0.0013	0.0011	0.0019	0.0012	0.0010
Copper (ug/l)	0.0126	0.0104	<0,001	0.0141	<0,001	0.0141	0.0126	0.0168
Zinc (ug/l)	0.0108	0.0130	0.0108	0.0188	0.0135	0.0165	0.0147	0.0288
Fe (ug/l)	0.3060	0.6760	0.4500	0.3596	0.4275	0.3549	0.3255	0.2304
F (mg/l)	0.179	0.231	0.225	0.189	0.152	0.204	0.199	2.644
PCB (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Organo-chlorine(Pesticides)	0.0050	0.0013	0.0120	0.0062	0.0015	0.0015	<0,001	0.0490
Detergent (mg/l)	0.047	0.054	0.067	0.053	0.045	0.053	0.045	0.077
Tot.oil (n-hexane Extract) (mg/l)	0.0160	0.1280	0.1270	0.0380	0.0057	0.058	0.063	0.053
Cl (Cloride) (mg/l)	12.340	10.560	37.170	13.720	10.540	44.96	10.67	36.28
Total coliform (MPN/100n	1920	1600	520	210	70	700	760	2240
Fecal coliform (MPN/100n	1600	560	400	60	15	490	412	1860

Table B.3.2 Results of Water Quality Observation of River/Tributary/Canal - 9/10

Sample No.	52	53	54	55	56	57	58	59
Location	Poljanski Lug	Ivanic Grad	After Confluence of R. Crnec	Struzec	Trebez	Cazma	Kutina	Posavski Bregi
River Name	Lonja	Lonja	Lonja	Lonja	Lonja	Cesma	Kutina	Crnec
Sampling Site	bridge	bridge	bank	bridge	retention	bridge	bridge	bridge
Remarks								
Code No.	291	245	292	294	298	244	295	297
Sampling Date	17 May 2001	14 May 2001	17 May 2001	17 May 2001	18 May 2001	17 May 2001	18 May 2001	17 May 2001
Sampling Time	10,00 a.m.	11,10 a.m.	13,00 p.m.	14,15 p.m.	14,20 p.m.	11,00 a.m.	15,45 p.m.	12,10 p.m.
Climate	sunny	sunny	sunny	suuny	sunny	sunny	sunny	sunny
Discharge(m^3/s)	0.45	0.37	1.15	9.94	18.88	1.67	0.25	0.73
Color	greyish	yellowish	yellow	yellow	yellow	yellowish	grey	yellowish
Odor	no	no	no	no	no	no	no	no
EC (μ S/cm)	675	561	809	677	561	681	717	842
Turbidity (mg/l)	18.0	12.0	10.0	18.0	20.0	18.0	65.0	9.0
pH	6.86	7.74	7.78	7.35	7.49	7.82	7.68	7.76
BOD (mg/l)	7.0	15.0	11.5	10.0	20.0	7.0	8.0	9.5
COD(Mn) (mg/l)	10.0	30.0	18.1	16.6	36.8	12.8	19.9	15.8
T-N (mg/l)	2.80	1.90	4.72	4.48	2.93	2.21	18.20	5.71
NH_4^+-N (mg/l)	0.865	0.292	3.120	0.666	0.446	0.42	9.68	3.74
NO_3^- -N (mg/l)	0.620	0.950	0.220	0.940	0.158	1.32	3.63	0.12
NO_2^- -N (mg/l)	0.071	0.110	0.049	0.103	0.131	0.128	0.390	0.026
T-P (mg/l)	0.27	0.25	0.22	0.18	0.14	0.18	2.80	0.61
PO_4-P (mg/l)	0.227	0.082	<0,001	<0,001	0.012	0.149	1.614	0.529
DO (mg/l)	5.2	6.2	8.4	2.4	2.6	6.3	4.4	5.4
SS (mg/l)	33.2	22.2	28.4	20.4	42.0	16.0	98.2	46.0
Phenol (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Cadmium (ug/l)	0.00020	0.00087	0.00021	0.00017	0.00021	0.00020	0.00019	0.00018
Aresenic (ug/l)	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006
Cyanide (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Selenium (ug/l)	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001
Cr (ug/l)	<0,003	<0,003	<0,003	<0,003	<0,003	<0,0003	<0,003	<0,003
Hg (ug/l)	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003
Ni^{2+} (ug/l)	0.0293	0.0184	0.0252	0.0182	0.0315	0.0418	0.0150	0.0150
Lead (ug/l)	0.0006	0.0018	0.0047	0.0008	0.0012	0.0009	0.0014	0.0008
Copper (ug/l)	0.0113	0.0103	<0,001	<0,001	0.0132	<0,001	0.0135	0.0105
Zinc (ug/l)	0.0113	0.0123	0.8680	0.0185	0.0116	<0,002	0.0135	0.0150
Fe (ug/l)	0.2205	0.6462	0.6020	0.3922	0.2029	0.3340	0.1125	0.2314
F (mg/l)	0.192	0.232	0.213	0.219	0.207	0.250	1.805	0.219
PCB (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Organo-chlorine(Pesticides)	0.0160	0.0020	0.0012	0.0051	0.0021	0.006	0.019	<0,001
Detergent (mg/l)	0.072	0.051	0.172	0.017	0.013	0.006	0.107	0.068
Oil (n-hexane Extract) (mg/l)	0.024	0.029	0.018	0.027	0.019	0.029	0.043	0.037
Cl (Cloride) (mg/l)	19.25	12.65	44.17	19.48	13.37	13.07	29.59	39.49
Total coliform (MPN/100n	250	2600	5010	320	340	950	2200	780
Fecal coliform (MPN/100n	190	2420	2850	180	20	620	840	300

Table B.3.2 Results of Water Quality Observation of River/Tributary/Canal - 10/10

Sample No.	60	61	62	63	64			
Location	Poljanski Lug	Ivanic Grad	After Confluence of R. Crnec	Struzec	Posavski Bregi			
River Name	Lonja	Lonja	Lonja	Lonja	Crnec			
Sampling Site	bridge	bridge	bank	bridge	bridge			
Remarks								
Code No.	291	245	292	294	297			
Sampling Date	18 May 2001	17 May 2001	18 May 2001	18 May 2001	18 May 2001			
Sampling Time	10,10 a.m.	11,35 a.m.	12,10 p.m.	13,15 p.m.	11,30 a.m.			
Climate	sunny	sunny	sunny	sunny	sunny			
Discharge(m^3/s)	0.40	0.63	1.15	8.85	0.75			
Color	greyish	yellow	yellowish	yellow	greenish			
Odor	no	no	no	no	no			
EC (μ S/cm)	628	621	786	652	819			
Turbidity (mg/l)	18.0	10.0	12.0	18.0	12.0			
pH	7.39	7.72	7.57	7.59	7.73			
BOD (mg/l)	8.0	12.0	9.0	11.0	10.0			
COD(Mn) (mg/l)	15.9	20.4	15.4	18.9	19.9			
T-N (mg/l)	2.13	1.92	4.36	2.70	5.09			
NH_4^+-N (mg/l)	0.83	0.15	2.57	0.58	2.80			
NO_3^- -N (mg/l)	0.60	0.68	0.28	0.99	0.14			
NO_2^- -N (mg/l)	0.186	0.073	0.051	0.177	0.100			
T-P (mg/l)	0.27	0.11	0.29	0.24	0.46			
PO_4-P (mg/l)	0.246	0.106	<0,001	0.213	0.437			
DO (mg/l)	5.4	6.3	5.8	2.3	4.9			
SS (mg/l)	48.4	10.4	22.0	13.4	73.2			
Phenol (mg/l)	<0,001	<0,001	<0,001	<0,001	<0,001			
Cadmium (ug/l)	0.00016	0.00020	0.00020	0.00018	0.00019			
Aresenic (ug/l)	<0,00006	<0,00006	<0,00006	<0,00006	<0,00006			
Cyanide (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001			
Selenium (ug/l)	<0,00001	<0,00001	<0,00001	<0,00001	<0,00001			
Cr (ug/l)	<0,003	<0,003	<0,003	<0,003	<0,003			
Hg (ug/l)	<0,0003	<0,0003	<0,0003	<0,0003	<0,0003			
Ni^{2+} (ug/l)	0.0105	0.0383	0.0225	0.0108	0.0285			
Lead (ug/l)	0.0013	0.0009	0.0023	0.0015	0.0015			
Copper (ug/l)	0.0147	0.0102	<0,001	0.0126	0.0105			
Zinc (ug/l)	0.0147	<0,002	0.3412	0.0126	<0,002			
Fe (ug/l)	0.1635	0.3876	0.4520	0.0936	0.0875			
F (mg/l)	0.283	0.234	0.206	0.221	0.230			
PCB (ug/l)	<0,001	<0,001	<0,001	<0,001	<0,001			
Organo-chlorine(Pesticides)	<0,001	0.216	0.021	0.002	0.003			
Detergent (mg/l)	0.048	0.047	0.109	0.015	0.024			
Tot. oil (n-hexane Extract) (mg/l)	0.013	0.005	0.067	0.021	0.023			
Cl (Cloride) (mg/l)	14.02	12.11	39.76	18.38	36.95			
Total coliform (MPN/100n	2800	2200	2500	180	150			
Fecal oliform (MPN/100m	1500	1800	1200	40	84			

Table B.3.3 Results of River Deposit Quality Observation

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12
Location	Ivanic Grad	Struzec	Trebez	Posavski bregi	Kutina	Recica	Brest	Oborovo	Martinska Ves	Galdovo	Topolovac	Lukavec
Lake or River Name	Lonja	Lonja	Lonja	Crnec	Kutinica	Kupa	Kupa	Sava	Sava	Sava	Sava	Sava
Sampling Site	river	bridge	bank	bank	bridge	bank	bridge	bank	bank	bank	bank	bank
Remarks												
Code No.	245	297	298	300	298	254	249	242	241	238	296	237
Sampling Date	14 Dec. 2000	13 Dec. 2000	13 Dec. 2000	8 Jan. 2001	13 Dec. 2000	18 Dec. 2000	18 Dec. 2000	20 Dec. 2000	21 Dec. 2000	21 Dec. 2000	21 Dec. 2000	21 Dec. 2000
Point Depth (m)												
Color	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey	grey
Odor	no	no	no	no	no	no	no	no	no	no	no	no
Hg (mg/drykg)	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05
Arsenic (mg/drykg)	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006	<0,006
Cadmium (mg/drykg)	<0,05	0.80	0.30	0.90	7.10	1.30	1.20	0.10	<0,05	<0,05	1.10	0.10
Lead (mg/drykgl)	<0,03	<0,03	4.9	<0,03	<0,03	0.4	<0,03	<0,03	7.3	<0,03	11.7	7.5
Selenium (mg/drykg)	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001
Cr (mg/drykg)	24.6	14.0	26.5	8.8	35.9	29.7	22.9	34.8	35.3	17.8	24.8	24.3
Copper (mg/drykg)	50.40	11.70	31.10	6.00	23.10	14.10	19.20	29	32.2	14.6	23.40	22.30
Zinc (mg/drykg)	188	46	110	37	179	67	54	142	139	89	109	140
Ni2+ (mg/drykg)	47.4	24.8	34.9	16.0	25.3	22.2	22.4	36.8	36.4	25.0	31.6	41.7
F (mg/drykg)	20.02	16.89	9.64	25.24	229.49	6.53	4.28	5.16	9.21	5.49	6.24	5.15
PCB (mg/drykg)	<0,0001	<0,0001	<0,0001	<0,0001	0.5279	0.0194	<0,0001	<0,0001	0.0366	0.0140	0.0077	<0,0001
Organo-chlorine(Pesticides) (mg/drykg)	0.0129	0.0454	0.0111	0.0049	0.0012	0.0037	0.0031	0.0003	0.0033	0.0081	0.1663	0.0006

Table B.3.4 Croatian Standard of Surface Water Quality

Parameter	I	II	III	IV	V
PH (mg/l)	8.5-6.5	6.5-6.3, 8.5-9.0	6.3-6.0, 9.0-9.3	6.0-5.3, 9.3-9.5	< 5.3, > 9.5
Alkalinity ($CaCO_3$mg/l)	< 200	200-100	100-20	20-10	< 10
EC (μ S/cm) *	< 500	500-700	700-1000	1000−2000	> 2000
DO (mg/l)	< 7	7-6	6-4	4-3	< 3
Oxyge Satulation Value (%)					
Flowing Water (River)	80-110	70-80, 110-120	50-70, 120-140	20-50, 140-150	< 20, > 150
Stagnant Water (Lake)					
Surface water	90-110	70-90, 110-120	50-70, 120-130	30-50, 130-150	< 30, > 150
Deep Water	90-70	70-50	50-30	30-10	< 10
BOD (mg/l)	< 2	2-4	4-8	8-15	> 15
COD-Mn (mg/l)	< 4	4-8	8-15	15-30	> 30
NH_4-N (mg/l)	< 0.10	0.1−0.25	0.25−0.60	0.60−1.50	> 1.50
NO_2-N (mg/l)	<0.01	0.01−0.03	0.03−0.100	0.10−0.20	> 0.20
NO_3-N (mg/l)	<0.5	0.5−1.5	1.5−4.0	4.0−10.0	10.0<
T-N (mg/l)	< 1.0	1.0−3.0	3.0−10.0	10.0−20.0	> 20
T-P (mg/l)					
Flowing Water (River)	< 0.1	0.10−0.25	0.25−0.60	0.60−1.50	> 1.50
Stagnant Water (Lake)	< 0.01	0.01-0.025	0.025-0.06	0.06-0.15	> 0.15
Total Coli. (MPN/100ml)	$< 5\times10^2$	$5\times10^2-5\times10^3$	$5\times10^3-10^5$	10^5-10^6	$< 10^6$
Fecal Coli. (MPN/100ml)	$< 2\times10^2$	$2\times10^2-10^3$	10^3-10^4	10^4-10^5	$< 10^5$
Anaerobic Bacteria (MPN/100ml)	$< 10^3$	10^3-10^4	10^4-10^5	$10^5-7.5\times10^6$	$> 7.5\times10^6$
Copper (mg/l)	< 0.002	0.002-0.010	0.010-0.015	0.015-0.020	> 0.020
Zink (mg/l)	< 0.05	0.05-0,08	0.08-0.10	0.10-0.20	> 0.20
Cadmium (mg/l)	< 0.0001	0.0001-0.0005	0.0005-0.002	0.002-0.005	> 0.005
Cromium (mg/l)	< 0.001	0.001-0006	0.006-0.015	0.015-0.020	> 0.020
Nikel (mg/l)	< 0.015	0.015-0.030	0.030-0.050	0.050-0.20	> 0.20
Lead (mg/l)	< 0.0001	0.0001-0.002	0.002-0.010	0.05-0.08	> 0.08
Mercury (μ g/l)	< 0.005	0.005-0.02	0.02-0.10	0.10-1.00	> 1.00
Mineral Oil (mg/l)	< 0.02	0.02-0.05	0.05-0.10	0.10-0.25	> 0.25
Phenol (mg/l)	< 0.001	0.001-0,005	0.005-0.01	0.01-0.025	> 0.025
PCB (μ g/l)	< 0.010	0.01-0.02	0.02-0.04	0.04-0.20	> 0.20
Lindan (μ g/l)	< 0.010	0.01-0.02	0.02-0.04	0.04-0.20	> 0.20
DDT (μ g/l)	< 0.010	0.01-0.02	0.02-0.04	0.04-0.20	> 0.20
β rey Radio-active (mBq/l)	< 200	200-500	500-1000	1000-2500	> 2500

*EC:Electro-Conductivity

Table B.4.1 Existing Industrial Wastewater Sampling Locations -1/4

Code Number	Name of industry	Location	Activity	Recipient (R:River, S: Sewerage)	Code Number	Name of industry	Location	Activity	Recipient (R:River, S: Sewerage)
315260	Strojar	Bistra	Metal/Machinery	R	303017	Ireks Aroma	Zagreb Sesvete	Chemistry	S
309069	Imes	Sambor	Food/Beverage	S		Chromos Zia	Zagreb Sesvete	Chemistry	S
309021	Chromos Grafičke Boje	Sambor	Chemistry	S	313090	Katran	Zagreb Sesvete	Chemistry	S
309180	Chromos Grafičke Boje	Sambor	Chemistry	S	307122	Pliva	Zagreb Sesvete	Chemistry	R
309123	Pliva Kalinovica	Sambor	Chemistry	R	308070,71	Dioki d.d.	Zagreb Sesvete	Oil Refinary	S
309278	TOP	Sambor	Metal/Machinery	R	308072	INA Mayiva	Zagreb Sesvete	Oil Refinary	S
309149	Ege Goran	Sambor	Metal/Machinery	S	308074	INA Skladište Žitnjak	Zagreb Sesvete	Oil Refinary	S
309047	Fotokemika	Sambor	Others	S	308294	INA Naftaplin	Zagreb Sesvete	Oil Refinary	S
309285	Prerada Kože I Krazna Ban	Sambor	Others	R	302068	Ikom	Zagreb Sesvete	Metal/Machinery	S
309233	Imunološki Zavod Brezje	Sambor	Others	S	308039	Dalekovod	Zagreb Sesvete	Metal/Machinery	S
302048	Franck	Zagreb Sesvete	Food/Beverage	S	308044	Elektrokontakt	Zagreb Sesvete	Metal/Machinery	S
302164	Zagrebačka Pivovara	Zagreb Sesvete	Food/Beverage	S	308045	Elka	Zagreb Sesvete	Metal/Machinery	S
303112	Mlinar Križevci	Zagreb Sesvete	Food/Beverage	S	311210	Jedinstovo	Zagreb Sesvete	Metal/Machinery	S
305103	Kraš	Zagreb Sesvete	Food/Beverage	S	308098	Končar Energetika I Usluge	Zagreb Sesvete	Metal/Machinery	S
306102	Kraš	Zagreb Sesvete	Food/Beverage	S		Končar Transformatori	Zagreb Sesvete	Metal/Machinery	S
306170	Zvijezda	Zagreb Sesvete	Food/Beverage	S	308099	Končar Kućanski Aparati	Zagreb Sesvete	Metal/Machinery	S
	Klara	Zagreb Sesvete	Food/Beverage	S	308098	Končar Energetika I Usluge	Zagreb Sesvete	Metal/Machinery	S
308012	Badel Bap	Zagreb Sesvete	Food/Beverage	S	308120	Munja	Zagreb Sesvete	Metal/Machinery	S
308013	Badel 1862	Zagreb Sesvete	Food/Beverage	S		Tvornica Parnih Kotlova	Zagreb Sesvete	Metal/Machinery	S
308132	Coca-Cola Beverages	Zagreb Sesvete	Food/Beverage	S	313066	TŽV	Zagreb Sesvete	Metal/Machinery	S
308171	Zvijezda	Zagreb Sesvete	Food/Beverage	S	308067	TŽV	Zagreb Sesvete	Metal/Machinery	S
308184	Dukat	Zagreb Sesvete	Food/Beverage	S	311556	Utentilija	Zagreb Sesvete	Metal/Machinery	S
308195	Ledo	Zagreb Sesvete	Food/Beverage	S	308003	Siemens	Zagreb Sesvete	Metal/Machinery	S
310135	Sljeme Mesna Industrija	Zagreb Sesvete	Food/Beverage	S	308004	Siemens	Zagreb Sesvete	Metal/Machinery	S
310178	Badel	Zagreb Sesvete	Food/Beverage	S	311094	Končar Električne Lokomotive	Zagreb Sesvete	Metal/Machinery	S
308165	Zagrepčanka	Zagreb Sesvete	Food/Beverage	S	312086	Jadran Namještaj	Zagreb Sesvete	Metal/Machinery	S
308268	Cedevita	Zagreb Sesvete	Food/Beverage	S	312224	Hep, Pogon EL-TO	Zagreb Sesvete	Electricity	S
	Kamensko	Zagreb Sesvete	Textile	S	308056	HEP,Pogon TE-TO	Zagreb Sesvete	Electricity	R
313116	Nik	Zagreb Sesvete	Textile	S	312118	Ericsson	Zagreb Sesvete	Electricity	S
302142	Tekstilni Kombinat Zagreb	Zagreb Sesvete	Textile	S	311202	TEP	Zagreb Sesvete	Electricity	S
302262	Pliva d.d.	Zagreb Sesvete	Chemistry	S	313147	TEŽ	Zagreb Sesvete	Electricity	S
308028	Chromos Tvornica Smola	Zagreb Sesvete	Chemistry	S	305218	Riz Tvornica Odašiljača	Zagreb Sesvete	Electricity	S
308019	Chromos Boje I Lakovi	Zagreb Sesvete	Chemistry	S	308055	HEP Toplinske Mreže	Zagreb Sesvete	Electricity	R
308020	Komicro	Zagreb Sesvete	Chemistry	S	308034	Croatia bus	Zagreb Sesvete	Transportation	S
308023	Chromos Organske Boje	Zagreb Sesvete	Chemistry	S	301059	HŽ-glavni kolodvor	Zagreb Sesvete	Transportation	S
308025	Chromos Pigmeni	Zagreb Sesvete	Chemistry	S		HŽ	Zagreb Sesvete	Transportation	S
308030	Chromos Agro	Zagreb Sesvete	Chemistry	S		HŽ	Zagreb Sesvete	Transportation	S
308106	Labud	Zagreb Sesvete	Chemistry	S					

Table B.4.1 Existing Industrial Wastewater Sampling Locations -2/4

Code Number	Name of industry	Location	Activity	Recipient (R:River, S: Sewerage)	Code Number	Name of industry	Location	Activity	Recipient (R:River, S: Sewerage)
313174	Autobusni Kolodvor	Zagreb Sesvete	Transportation	S	315089	Karbon	Zaprešić	Chemistry	S
309161	ZET	Zagreb Sesvete	Transportation	S	315127	Pliva	Zaprešić	Chemistry	R
312166	ZET	Zagreb Sesvete	Transportation	S	315062	HŽ Infrastrucktura	Zaprešić	Transportation	S
308050	Ghetaldus	Zagreb Sesvete	Others	S	315080	Inker	Zaprešić	Other	R
208085	Lovinčić	Zagreb Sesvete	Others	S	315157	Viadukt	Zaprešić	Others	R
308110	Lotos	Zagreb Sesvete	Others	S	374001	INA Zagreb Rafinerija	Sisak	Oil Refinery	Kupa(2outfall),
307212	Mega	Zagreb Sesvete	Others	S	357009	Petrokemija	Kutina	Chemistry	River Trebež
308169	Pan	Zagreb Sesvete	Others	S	358005	HŽ Zagreb, lokacija	Novska	Transportation	River
	Ris	Zagreb Sesvete	Others	S	360004	PIK	Vrbovec	Food/Beverage	Canal Luka
311134	Robni Terminali Jankomir	Zagreb Sesvete	Others	S	373001	Gavrilović d.o.o.	Petrinja	Food/Beveragae	River Kupa
308254	Robni Terminali Jankomir	Zagreb Sesvete	Others	S	333006	Karlovačka Pivovara	Karlovac	Food/Beverage	Sewege & River Kupa
306081	Institut Ruder Bošković	Zagreb Sesvete	Others	S	374005	Željezara Poduzeće Metaval	Sisak	Metal/Machinery	River Sava
302153	TOZ	Zagreb Sesvete	Others	S	358006	Milka.Nova d.o.o.	Novska	Food/Beveragae	Sewage
302151	Tvornica Duhana Zagreb	Zagreb Sesvete	Others	S	331001	Pamućna Industrija	Duga Resa	Textile	River Mrežnica
302203	Unitas	Zagreb Sesvete	Others	S	357016	Petrokemija	Kutina	Chemistry	Sewage
305075	Riz Uslužne Djelatnosti	Zagreb Sesvete	Others	S	332002	Jamnica Zgb.Punionica	Jamnička Kislica	Food/Beverage	mel.canal
306265,66	NEVA	Zagreb Sesvete	Others	S	374002	Herbos d.d.	Sisak	Chemistry	Sewage
307213	P.E.S.	Zagreb Sesvete	Others	S	358007	Motoremont d.o.o.	Novska	Transportation	Sewage
308141	Tehnika	Zagreb Sesvete	Others	S	357003	Neuropsihijatrijska	Popovača	Hospital	Sewage
309233	Imunološki Zavod	Zagreb Sesvete	Others	S	355005	INA Naftaplin Pogon	Ivanić Grad	Oil Refinery	Sewage
310001	Agroproteinka	Sesvetski Kraljevec	Food/Beverage	R	374003	Termoelektrana	Sisak	Electricity	River Sava
310248	Duma Koža	Sesvetski Kraljevec	Others	R	374004	Podravka Koprivnica,	Sisak	Food/Beveragae	Sewage
314038	Dalekovod	Velika Gorica	Metal/Machinery	S	334001	Javna ustanova	Plitvička jezera	National Park	Underground
314205	Zračna Luka Zagreb	Velika Gorica	Transportation	S	333008	ŽE-ČE	Karlovac	Metal/Machinery	Sewage
314163	ZET Velica Gorica	Velika Gorica	Transportation	S	333012	Lola Ribar	Karlovac	Textile	River Mrežnica
314077	Industrogradnja	Velika Gorica	Others	S	333015	PPK-Karlovačka	Karlovac	Food/Beverage	River Kupa
314079	Industrogradnja	Velika Gorica	Others	R	355019	INA Naftaplin Radilište	Ivanečko Graberje	Oil Refinery	River
315043	Dubravica	Zaprešić	Food/Beverage	R	355010	Crosco Naftni servisi	Ivanić Grad	Oil Refinery	Sewage
315289	Bermes	Zaprešić	Food/Beverage	R	333005	Velebit	Karlovac	Textile	Sewege
315290	Šimun Milk	Zaprešić	Food-Beverage	S	335001	Opća Bolnica	Ogulin	Holpital	Underground

Table B.4.1 Existing Industrial Wastewater Sampling Locations -3/4

Code Number	Name of industry	Location	Activity	Recipient (R:River, S: Sewerage)	Code Number	Name of industry	Location	Activity	Recipient (R:River, S: Sewerage)
333016	Karlovačka Industrija Mlijeka	Karlovac	Food/Beverage	River Kupa	361003	Iskra d.d. Tvornica Kemijskih	Sv. Ivan Zelina	Chemistry	potok Zelina
333010	Tvornica Plinskih Turbina	Karlovac	Metal/Machinery	Sewage	360005	PIK	Vrbovec	Transportation	Canal Luka
335004	Bjelolasica	Ogulin,	Hotel	Jasenački potok	360017	Komunalac Vrbovec d.o.o.	Gradec		potok Stržen
355020	Di Novoselec d.o.o.	Ivanečko Graberje	Wood	mel. canal	360019	Komunalac d.o.o.	Vrbovec		Sewage
355015	Naftalan lječilište za kož.reum.	Ivanić Grad	Hospital	Sewage	355001	Croatia Baterije d.d.Zagreb	Ivanić Grad	Chemistry	Sewage
333003	Kordun	Karlovac	Metal/Machinery	Sewege	361007	Zelinka d.d. Modna	Sv. Ivan Zelina	Textile	potok Zelina
360002	Gradip d.d.	Vrbovec		Sewage	355003	Agroprerada d.d.	Ivanić Grad	Food/Beverage	mel.canal
332001	Mladina d.d.	Jastrebarsko	Food/Beverage	Sewage	360003	Gramip TPS	Dubrava		River
333011	Adria-Diesel	Karlovac	Metal/Machinery	Sewage	360021	Kalinski, klaonica i prerada	Gradec	Food/Beverage	mel. kanal
333029	Autotransport d.d.	Karlovac	Transportation	Sewage	357014	Naftaplin Skladište	Banova Jaruga	Oil Refinery	mel. kanal
360008	PIK Vorbovec farma	Poljanski Lug	Food/Beverage	River	357011	Čazmatrans Autokuća	Kutina	Transportation	Sewage
374006	Žitokombinat, Mlin i pekare	Sisak	Food/Beveragae	Sewage	361006	Drvna industrija Zelina d.d.	Sv. Ivan Zelina		Sewage
333019	Linde Plin d.o.o.	Karlovac	Chemistry	mel canal	360010	Galvanotehnika (Galtronik)	Vrbovec	Chemistry	Sewage
333004	Karlovačka Industrija Kože	Karlovac	Chemistry	River Kupa	360016	KOS d.o.o. benzinska postaja	Gradec		River
355006	Crosco Naftni servisi d.o.o.	Ivanić Grad	Oil Refinery	Sewage	360009	Galoks	Vrbovec	Chemistry	River
360006	PIK Vrbovec svinjogojska	Gradec	Food/Beverage	potok Črnec	333014	Boneja-prerada kože	Karlovac	Chemistry	Sewage
360007	Šavrić d.d.Tvornica masivnog	Vrbovec		River	355021	IVAKEM d.o.o.,proizvodnja,	Ivanić Grad	Chemistry	Sewage
360018	PIK Vrbovec mesna ind. d.d.	Vrbovec		Sewage	360014	Galvanotehnika	Vrbovec	Chemistry	Sewage
333001	Finvest-Corp d.d. Čabar-PC	Karlovac	Wood	V-mel. canal,	357007	INA Naftaplin Pogon	Popovača	Transportation	River
357006	Crosco naftni servisi d.o.o.	Moslavačka	Oil Refinery	River	360013	Jurval d.o.o.	Vrbovec	Metal/Machinery	River & Sewage
360011	Govedarska farma d.o.o. farma	Poljanski	Food/Beverage		332005	Maček-Tvornica Vijaka	Jastrebarsko	Metal/Machinery	Sewage
333027	Croatia Pumpe d.d.	Karlovac	Metal/Machinery	Sewage	360001	Trgovačko društvo VIND	lokacija pilane i		mel. kanal
332006	Klaonica i Prerada Mesa vl. M.	Jastrebarsko	Food/Beverage	V- Stiper	360012	Hrvatske šume, uprava šuma	Vrbovec		Sewage
336001	Kordun Karlovac, RJ Mali	Ozalj	Metal/Machinery	potok Slapno	335003	TAL	Ogulin	Car Wash	Underground
335005	Prehrambeni Kombinat	Ogulin	Food/Beverage	septic tank	355023	Ekofrom	Ivanić Grad		otvoreni canal
355024	Crosco d.o.o. Naftni servisi	Žutica	Oil Refinery	sabirni jarak	333007	KA-PLAST	Karlovac	Chemistry	Sewage
331002	Specijalna Bolnica i Gerijatrija	Duga Resa	Hospital	River Mrežnica	331004	Autopraona 2D-MAG	Duga Resa	Car Wash	Sewege
333020	Merkur-Lok Autopranice	Karlovac		Sewage	332004	Palma Zgb.	Jastrebarsko	Food/Beverage	V-potok Reka
357001	INA Naftaplin podzemna	Kutina,	Oil Refinery	mel. kanal	333024	Arka Obrt za Trgovinu i	Karlovac	Car Wash	mel. canal
333013	Kemijsko Građevinska	Karlovac	Chemistry	Sewage	333025	Beti Trikotaža Industrija	Žakanje	Textile	potok Žakanje
360020	Oprema d.o.o.	Vrbovec		mel. kanal	333026	Liga d.o.o.	Karlovac	Metal/Machinery	Sewage
333022	Automehanika d.d.	Karlovac	Transportation	mel.canal Ilovac	333028	TPK Strojevi Kamanje d.o.o.	Žakanje	Metal/Machinery	mel. canal
355014	Ivasim	Ivanić Grad	Chemistry	Sewage	357012	Autopraonica vl. Zoran	Kutina	Car Wash	River
361008	Tiskara Zelina d.d.	Sv. Ivan Zelina	Chemistry	River	357013	Autopraonica Spužvica, vl.	Kutina	Car Wash	Sewage

Table B.4.1 Existing Industrial Wastewater Sampling Locations -4/4

Code Number	Name of industry	Location	Activity	Recipient (R:River, S: Sewerage)	Code Number	Name of industry	Location	Activity	Recipient (R:River, S: Sewerage)
336002	Kemijsko Građevinska	Karlovac	Chemistry	River Kupa	355002	Agroposavina	Ivanić Grad	Food/Beverage	mel. canal
361009	Klaonica i prerada mesa	Sv. Ivan Zelina	Food/Beverage	potok Oreščak	355012	Ivakarton	Ivanić Grad		Sewage
361010	"Klaonica br. 25" vl. Drago	Sv. Ivan Zelina	Food/Beverage	potok Oreščak	355013	Ivanićplast	Ivanić Grad	Chemistry	Sewage
371001	Vivera d.o.o. Plliva Grupa	Glina	Food/Beveragae	Sewage	361001	Čazmatrans, PJ	Sveti Ivan Zelina	Transportation	potok Topličica
355022	INA Naftaplin pogon izgradnje	Ivanić Grad	Oil Refinery	Sewage	361002	Endi International	Sveti Ivan Zelina	Textile	River
332003	Iteks Klinča Selo	Zdenčina	Metal/Machinery	River					
333002	Kontex d.d.	Karlovac	Textile	Sewege					
333009	ŽE-ČE	Karlovac	Metal/Machinery						
333017	ABB d.d.tv.Energetskih	Karlovac	Metal/Machinery	Sewege					
333018	Švarča Restoran Društvene	Karlovac	Restaurant	Sewage					
333021	JP Hrvatske Ceste	Karlovac	Transportation	Sewage					
333023	Karlovačka Industrija Obuće	Karlovac	Foot Factory	Sewage					
335002	Monting-Ventilator	Ogulin	Metal/Machinery	Underground					
355004	DOM Zdravlja "Josip Adamić"	Ivanić Grad		Sewage					
355007	INA Naftaplin radilište	Žutica,	Oil Refinery	mel. canal					
355008	INA Naftaplin Radilište	Žutica	Oil Refinery	mel. canal					
355009	INA Naftaplin, Radilište	Ivanić Grad	Oil Refinery	mel. canal					
355016	Tiskara	Ivanić Grad	Chemistry	Sewage					
355017	TMPK (tvornica met.proiz. i	Ivanić Grad	Metal/Machinery	Sewage					
357002	Lipovica Privredni Pogon	Popovača	Metal/Machinery	River Vlahinička					
357004	Čazmatrans Tehnički Pregled	Kutina	Transportation	Sewage					
357005	Dom Zdravlja	Kutina	Ambulance	Sewage					
357008	INA Petrokemija Metan	Kutina	Oil Refinery	Sewage					
357010	Moslavačko vinogorje d.d.	Voloder	Food/Beveragae	mel. kanal					
357015	Vajda Stočarstvo Zgb. farma	Stružec	Food/Beveragae	mel. kanal					
358001	Čazmatrans Pogon	Novska	Transportation	Sewage					
358002	Trokut d.d. Novska Pogon	Lipovljani		mel. canal					
358003	HŽ Zagreb lokacija kolodvo,	Novska	Transportation	end of canal					
358004	INA Naftaplin Sektor	Novska	Oil Refinery	River					
360015	Metalcrom	Vrbovec	Metal/Machinery	mel. kanal					
361004	Metal elektro	Donja Zelina		River					
361005	Poljoprivredni Kombinat	Zelina	Food/Beverage	River					
362001	Gorica	Dugo Selo							

Table B.4.2 Average Existing Industrial Wastewater Quality 1/4

Factory Name	Code	Out	Sample Number	quantity (l/s)	BOD5 (mg/l)	COD(cr) (mg/l)	Total Suspended Solids (mg/l)	Ph	Oil & Grease (mg/l)	Mineral Oil (mg/l)	Phenol (mg/l)	Anionic Detergents (mg/l)	Cationic Detergent (mg/l)	NH4-N (mg/l)	NO2-N (mg/l)	NO3-N (mg/l)	T-P (mg/l)	T-N (mg/l)
HŽ-glavni kolodvor (railway)	301059	1	8	4.05	8.8	22.0	468.1	7.4	0.68	0.25		0.03						
		2	6	0.94	28.3	100.3	492.7	7.4	9.62	3.17		0.19						
			14	4.98	18.4	60.7	480.2	7.4	5.09	1.70		0.11						
Franck	302048		16	2.67	207.3	517.4	714.3	7.1	49.63	6.59		2.88		6.10		0.46	4.32	12.6
IKOM	302068		10	19.02	25.7	68.1	776.9	5.9	7.10	0.61		0.45	0.01					
Tekstilni kombinat Zagreb	302142	1	1					8.8										
		2	82	0.49	56.8	150.3	670.0	8.8	9.89	1.64		1.50	0.08				2.16	
			178	34.17	232.7	420.8	2027.7	9.5	16.28	1.71		4.13	0.30				1.96	
Tvornica duhana Zagreb	302151		8	6.12	184.1	332.9	549.0	7.2	8.89	2.77	0.01	0.52	0.06					
TOZ	302153	1	4	1.55	91.1	192.0	520.0	7.6	7.12	1.51		1.13	0.00					
		2	34	4.41	718.8	999.5	1074.4	6.7	5.59	0.58		0.17	0.14	1.00				
			68	27.53	928.1	1230.4	1104.7	6.6	9.05	0.80		0.19	0.44	0.91				
UNITAS	302203		4	20.90	196.0	515.0	8338.8	12.0	15.76	0.33		5.41	0.20					
Pliva d.d.	302262		50	10.67	54.8	395.8	683.5	7.7		3.63								
	302263		50	87.29	188.9	1847.1	1498.9	7.4	30.21					29.13				58.5
Mlinar Križevci	303112		8	0.56	186.5	633.8	929.1	7.7	56.88	11.18		3.39		8.11				
RIZ Uslužne djelatnosti	305075		4	0.10	195.0	422.5	542.3	7.7	27.37			12.07	0.05	4.32	0.08	4.64	0.10	
Kraš	305103		28	26.86	191.1	942.5	1117.9	6.9	41.64	3.27		1.69	0.22					
RIZ Tvornica odaš iljača	305218		8	0.39	132.1	313.1	882.6	6.9	10.23		0.11	0.94	0.11	10.82	0.16	2.31		
	306181	1	8	52.41	34.8	164.3	542.6	7.5	21.66	3.23	0.01	0.20						
			16	66.85	40.3	165.8	566.6	7.5	19.46	2.71	0.01	0.47						
	306102		12	15.80	45.8	292.9	858.9	7.2	22.34	2.53		0.69	0.17					
Kraš		2	82	4.93	138.9	438.0	982.4	6.7	76.91			0.28	0.18					
NEVA	306266		32	0.73	249.9	1041.7	598.7	7.4	53.71	8.24		15.87	0.18					
	307063	1	8	2.19	11.5	30.3	396.8	7.8	1.17	0.46		0.08						
			16	7.76	46.5	117.9	512.2	7.7	32.20	12.39		0.65						
		3	48	0.59	105.8	316.8	519.7	7.2	15.50	3.62		4.82						
			236	5.12	73.6	208.2	419.3	7.2	10.59	2.04	0.06	2.41						
Ghetaldus	308050	1	12	1.06	35.8	203.1	1979.5	8.3	14.75	3.78		0.18		9.33		2.48		
		2	12	1.39	38.5	238.3	526.7	7.4	12.33	0.66		0.37		26.46		3.03		
			24	2.45	37.3	223.1	1154.3	7.8	13.38	2.01		0.29		19.06		2.79		
			16	0.93	339.8	789.3	839.3	7.0	59.11	1.83		2.62						
HEP, pogon TE-TO	308056	1	65	44.21	100.6	225.3	460.9	7.5	16.08	0.79		0.73						
		2	8		10.0	21.7	338.2	7.8	0.14	0.05								
			73		12.7	27.8	341.9	7.8	0.62	0.07								
TŽV	308067		15	2.51	41.0	143.1	418.5	7.8	17.93	5.32	0.05	0.88						
	308070		59	62.23	26.8	138.3	702.6	7.4	26.23	3.75								
Tehnika	308141		13	0.86	146.5	323.5	767.9	7.6	19.66	6.15		2.45	0.03					
Pan	308169		4	135.00	117.5	169.7	2228.3	7.6										
	308184		32	28.77	469.7	769.1	1352.8	8.3	52.15	1.91	0.00	1.69		29.62	0.00	5.29		
Ledo	308195		12	3.01	530.8	1296.3	1105.5	6.9	59.17	6.53		1.37	0.10					
	308254		8	8.74	58.8	84.7	424.7	7.2	0.38	0.04		0.30		6.39	0.05	3.34		
Cedevita	308268		48	3.00	274.8	1179.8	1322.3	6.8	10.13			1.17					0.51	7.3

Table B.4.2 Average Existing Industrial Wastewater Quality 2/4

Factory Name	Code	Out	Sample Number	quantity (l/s)	BOD5 (mg/l)	COD(cr) (mg/l)	Total Suspended Solids (mg/l)	Ph	Oil & Grease (mg/l)	Mineral Oil (mg/l)	Phenol (mg/l)	Anionic Detergents (mg/l)	Cationic Detergent (mg/l)	NH4-N (mg/l)	NO2-N (mg/l)	NO3-N (mg/l)	T-P (mg/l)	T-N (mg/l)
Chromos grafičke boje	309021	1	8	0.10	13.9	46.5	717.5	7.5	5.28	0.74	0.02	0.09						
		2	8	0.23	41.8	113.6	1946.5	7.8	2.60	0.77	0.01	0.30						
			16	0.33	33.2	92.9	1568.3	7.7	3.42	0.76	0.01	0.24						
Imes	309069		7	0.50	630.8	950.6	2106.6	7.6	146.03	9.55		0.90						
Pliva Kalinovica	309123		48	4.26	27.8	128.0	512.7	7.6	6.90	1.24								
Ege Goran	309149	1	7	17.00	13.0	24.4	364.0	7.1	12.92			0.04		0.15	0.55			
		2	8	63.00	19.1	38.0	367.5	7.2	8.40			0.05		0.29	0.33			
			15	80.00	2.9	5.3	10.3	0.0	0.00	3.60	0.00	0.00	0.01	0.00	0.07	0.15	0.02	
	309161		5	0.13	2.1	10.1	295.0	7.5	3.26	1.74		0.05	0.08					
	309180		8	0.38	17.3	34.4	562.9	7.4	1.13	0.43	0.01	0.21						
Imunološki zavod Brezje	309233			0.68	39.5	220.8	648.8	7.5	2.97	0.39		0.22		69.41	0.02	1.71		
TOP	309278		8		43.9	83.4	1161.0	5.9										
Prerada kože Ban	309285		6	0.00	139.7	206.5	1641.5	6.6	118.20	50.39								
Agroproteinka	310001		12	3.62	2642.5	4048.3	1608.3	8.1	769.53	29.31	1.70	0.23		2750.08	0.18	13.28		
Sljeme mesna ind.	310135		35	40.79	399.9	614.0	1326.9	7.6	47.79	1.01		0.24						
Badel	310178		7	11.39	1517.7	3655.6	5303.9	6.6	11.29	*		0.78	0.14					
Duma koža	310248		4	2.45	562.5	1570.8	6103.5	8.0	8.78	0.25		0.38		119.30				
Končar el. Lokomotive	311094		8	2.79	157.6	380.8	779.1	7.9	29.34	3.18		2.08						
	311100		8	12.20	29.3	160.1	515.0	7.6	18.75	4.70	0.03	0.61	0.17					
	311133		8	2.46	53.3	107.1	287.5	7.2	1.14	0.06	0.01	0.17		5.03	0.32	1.13		
Robni termin. Jankomir	311134		8	9.03	151.3	258.5	617.0	7.4	29.82	2.58		3.68						
	311156		8	3.56	48.7	220.9	589.0	7.4	24.51	11.26	0.01	0.14	0.00					
TEP	311202		8	1.84	38.9	97.7	983.8	7.3	6.96	2.04		0.44	0.00					
Jedinstvo	311210		8	1.06	185.1	322.2	849.1	7.1	3.27	*	0.01	0.47	0.12	1.22				
Jadran namještaj	312086	1	8	3.60	82.6	112.5	623.6	6.8	1.30	0.51		0.09	0.00					
		2	8	0.59	99.0	137.8	496.8	6.8	1.65	0.17		0.19	0.00					
			16	4.19	84.9	116.0	605.8	6.8	1.35	0.46		0.10	0.00					
	312096	1	8	14.25	7.3	32.0	627.5	7.4	2.41	1.04	0.00	0.08	0.03					
		2	8	11.58	12.2	43.4	603.4	7.4	4.62	2.37	0.01	0.13	0.04					
			16	25.84	9.5	37.1	616.7	7.4	3.40	1.64	0.01	0.10	0.03				0.00	
Ericsson	312118		84	30.31	55.0	198.9	611.9	7.8	12.75	1.83		1.10		7.36		1.77		
ZET	312166		0.385417	12.00	12.0	216.3	12.0	7.7	14.88	12.00		5.52	0.00	0.00		0.00	0.00	
Hep, pogon EL-TO	312224	1	0.4375	0.40	74.0	156.0	352.0	6.5	0.91		0.00	0.00	0.00	0.01				
		2	8	2.71	56.9	146.8	769.6	7.2	3.23	1.83	0.00	0.12	0.02	0.90				
			16	3.27	58.8	146.7	778.5	7.1	3.44	1.91	0.00	0.11	0.02	0.84				
	313017		8	0.68	308.5	757.5	767.6	7.1	52.00	13.53		0.47						
	313029	1	5	0.06	3397.0	5498.8	5607.0	6.5	11.04	1.01	3.77							
		2	15	1.95	74.9	196.9	435.7	7.6	20.47	5.95	0.08	0.64						
			45	8.02	52.8	192.4	561.8	7.4	13.56	3.88	0.06	0.59	0.00	0.00			0.00	
Katran	313090		8	0.36	91.4	153.9	423.1	7.2	1.04	0.27	0.01	0.04	0.00					

Table B.4.2 Average Existing Industrial Wastewater Quality 3/4

Factory Name	Code	Out	Sample Number	quantity (l/s)	BOD5 (mg/l)	COD(cr) (mg/l)	Total Suspended Solids (mg/l)	Ph	Oil & Grease (mg/l)	Mineral Oil (mg/l)	Phenol (mg/l)	Anionic Detergents (mg/l)	Cationic Detergent (mg/l)	NH4-N (mg/l)	NO2-N (mg/l)	NO3-N (mg/l)	T-P (mg/l)	T-N (mg/l)
Nik	313116	1	8	0.18	321.4	1516.3	1443.9	6.9	181.88	67.80	0.23	21.04						
		2	8	0.56	142.1	576.9	876.3	7.8	95.50	12.60	0.15	1.15						
			16	0.75	186.0	807.0	1015.3	7.6	116.66	26.12	0.17	6.02						
TEŽ	313147		8	3.90	54.3	189.8	660.0	7.3	30.00	0.99		0.59			19.70	4.68		
Autobusni kolodvor	313174		8	4.00	339.0	808.4	1157.3	7.6	39.21	2.93		0.83						
Dalekovod	314038	1	8		38.0	185.1	534.0	7.6	11.38	2.48		2.28						
		2	8	0.00	22.3	104.8	293.9	7.6	39.00	3.49								
		3	8	0.00	103.3	268.1	779.0	7.6	16.75	2.83		2.15						
					125.6	341.6	691.0	7.6	26.58	2.93								
ZET Velika Gorica	314163		12	0.32	200.2	683.3	882.4	7.5	111.59	75.97		5.52						
Zračna luka Zagreb	314205	1	8	0.54	85.0	116.1	729.1	7.3	0.49	0.06	0.00	1.36		32.29	0.01	5.78		
		2	8	0.71	87.5	132.8	1048.2	7.6	0.46	0.05	0.00	0.91		35.99	0.01	4.64		
			16	0.63	86.3	124.5	888.6	7.4	0.47	0.06	0.00	1.14		34.14	0.01	5.21		
HŽ Infrastruktura	315062		6	1.49	29.8	136.4	577.2	7.5	121.66	46.13		0.32	1.40					
Inker	315080		12	23.00	42.7	102.0	2566.9	7.6	6.21	0.67		0.45		7.71	0.25	5.93		
Karbon	315089		16	9.37	39.8	212.2	826.4	7.3	11.95	2.79	0.01	0.24	0.06					
Pliva	315127		48	27.09	198.6	1767.9	3706.6	7.5			0.20			107.66				
Viadukt	315157	1	4	7.22	31.2	48.0	918.7	7.7	7.29	3.55		0.07						
		2	8	0.55	387.2	1092.0	1977.8	7.2	209.85	14.09		0.89						
			12	2.77	268.5	744.0	1624.7	7.4	142.33	10.58		0.61						
	315260		8		33.8	44.1	347.0	7.9	4.53	1.16	0.00	0.60		1.51	0.28	9.59		
Bermes	315289		4	0.18	608.2	870.3	4133.0	7.5	6.25	0.94		3.12						
Sımun Mılk	315290		3	0.30	761.03	1065.33	3369.33	7.09	46.28	4.09		0.83						

Table B.4.2 Average Existing Industrial Wastewater Quality 4/4

Factory Name	Code	Out	Sample Number	quantity (l/s)	BOD5 (mg/l)	COD(cr) (mg/l)	Total Suspended Solids	Ph	Oil & Grease (mg/l)	Mineral Oil (mg/l)	Phenol (mg/l)	Anionic Detergents (mg/l)	Cationic Detergent (mg/l)	NH4-N (mg/l)	NO2-N (mg/l)	NO3-N (mg/l)	T-P (mg/l)	Organic-N (mg/l)	T-N (mg/l)
Karlovačka pivovara	333006	1	52	2.50	1,117.5	1,877.8	1,147.0	8.1	5.8		0.02	0.13	0.49						
		2	55	2.86	550.1	1,076.5	1,296.0	8.3	9.4		0.02	0.68	0.45						
		3	64	2.96	722.7	1,442.7	1,687.9	8.8	6.8		0.01	0.33	0.35						
		4	57	3.39	498.5	935.4	1,416.6	9.1	5.7	3.0	0.02	0.36	0.20						
		ave	228	11.72	700.0	1,299.4	1,398.1	8.6	6.9	3.0	0.02	0.38	0.36	-	-	-	-		
		max		11.00	8,980.0	17,513.0	15,640.0	12.0	67.0	3.0	0.12	5.86	5.65	-	-	-	-	-	-
		min		0.20	4.0	15.0	1.0	2.0	1.0	3.0	-	-	-	-	-	-	-	-	-
PPK-Karlovačka	333015	ave	28	2.15	326.6	562.8	1,473.2	7.4	10.2					9.71			6.23		
		max		15.0	712.0	1,250.0	6,996.0	7.9	31.0	-	-	-	-	25.9	-	-	17.2	-	-
		min		0.1	20.0	73.0	450.0	6.5	1.0	-	-	-	-	0.5	-	-	0.5	-	-
Croatia Pumpe d.d.	333027	ave	2	0.10	6.0	19.5	275.0	7.6	17.5	0.8									
		max		0.10	9.0	29.0	294.0	7.7	19.0	0.8	-	-	-	-	-	-	-	-	
		min		0.10	3.0	10.0	256.0	7.5	16.0	0.7	-	-	-	-	-	-	-	-	
Petrokemija	357009	ave	36	-	17.8	52.8	-	7.8	-	0.3	-	-	-	-	-	-	-	-	68.6
		max	-	-	37.0	92.0	-	8.3	-	1.1	-	-	-	-	-	-	-	-	130.0
		min	-	-	3.0	30.0	-	7.2	-	0.1	-	-	-	-	-	-	-	-	30.0
Petrokemija	357016	ave	37		18.7	57.6	397.5	7.6	0.1	0.2									
		max			106.0	285.0	757.0	8.8	0.1	0.6	-	-	-	-	-	-	-	-	-
		min			3.0	19.0	273.0	6.8	0.1	0.1	-	-	-	-	-	-	-	-	-
PIK Vrbovec	360004	2	89	8.05	192.7	394.4	881.1	7.2	70.6	0.3		2.15		3.71	0.22		3.68		22.98
		3	82	7.70	165.2	330.7	1,149.0	7.2	60.9	0.3		0.93		11.48	0.26		4.40		7.26
		ave	171	15.74	179.3	363.3	1,012.1	7.2	65.9	0.3	-	1.55	-	7.51	0.24	-	4.03	-	15.30
		max		30.00	571.0	1,135.0	4,158.0	9.0	534.0	1.0	-	10.00	-	108.00	1.80	-	7.18	-	202.00
		min		3.00	29.0	57.0	219.0	6.6	1.1	0.0	-	-	-	0.08	-	-	0.80	-	0.10
Gavrilović d.o.o.	373001	ave	30	18.89	182.4	244.2	446.8	7.3	24.0			0.16	0.25	0.57	0.08	1.21	3.89	1.43	8.35
		max		40.00	460.0	1,200.0	878.0	7.7	149.0	-	-	1.00	0.51	0.68	0.14	1.32	12.90	2.96	20.46
		min		12.10	17.9	36.7	210.0	6.6	0.1	-	-	-	-	0.51	0.04	1.00	0.38	0.41	1.54
INA Zagreb Rafinerija	374001	1	16		40.3	75.7	353.0	7.5	16.2		1.75								
		2	15		28.4	54.1	567.8	7.2	22.2		0.31								
		3	16		26.8	31.9	276.1	7.1	8.1		1.56								
		4	5		44.2	87.4	436.0	6.7	15.7		1.68								
		ave	52		33.1	57.1	399.3	7.2	15.4	-	1.27	-	-	-	-	-	-	-	
		max			142.0	349.2	763.0	8.5	86.8	-	11.50	-	-	-	-	-	-	-	-
		min			2.2	4.8	197.0	6.0	1.0	-	0.00	-	-	-	-	-	-	-	-
Herbos d.d.	374002	ave	16		201.3	404.2	3,543.6	8.6	7.4										
		max			496.0	1,159.0	12,920.0	10.3	21.3	-	-	-	-	-	-	-	-	-	-
		min			52.6	65.4	149.0	6.8	2.1	-	-	-	-	-	-	-	-	-	-
Termoelektrana Sisak	374003	ave	16		6.4	28.8	471.5	8.4	3.9	2.6	0.03	0.03		1.44	0.03	1.80			
		max			21.9	71.0	3,934.0	12.2	26.0	18.0	0.08	0.08	-	8.63	0.06	8.52	-	-	-
		min			2.7	4.6	132.0	6.8	0.1	0.1	0.01	0.00	-	0.05	0.00	0.56	-	-	-
Podravka Koprivnica	374004	ave	63		661.5	1,451.5	2,437.0	6.8	11.1	6.8		0.23		4.95	0.04	0.53	2.37	11.19	9.92
		max			3,364.0	10,703.0	10,615.0	8.1	64.4	30.0	-	1.75	-	23.20	0.27	3.80	16.60	48.70	51.20
		min			4.6	9.5	237.0	5.5	0.6	0.0	-	0.01	-	0.21	-	0.05	0.04	0.42	0.97
zara Poduzeće Metaval -	374005	ave	177		13.2	28.3	260.9	7.8	4.4	3.8	0.04			1.13	0.06	0.98	0.26	0.36	2.91
		max			51.2	104.0	497.0	8.7	12.2	19.5	0.51	-	-	5.38	1.09	1.54	4.32	2.71	28.80
		min			1.0	4.7	100.0	5.5	0.6	-	0.01	-	-	0.23	0.02	0.04	0.03	0.02	0.21

Table B.4.3 Results of Water Quality Observation of Factory Effluent 1/5

Sample No.	1	2	3	4	5	6	7	8	9
Location	Duga Resa	Duga Resa	Duga Resa	Duga Resa	Duga Resa	Duga Resa	Karlovac	Karlovac	Karlovac
Factory Name	Cotton mill	Cotton mill	Cotton mill	Cotton mill	Cotton mill	Cotton mill	Pivovara-brewery	Pivovara-brewery	Pivovara-brewery
Sampling Site							manhole no.3	manhole no.3	manhole no.3
Remarks	D.R. (1)	D.R. (1)	D.R. (1)	D.R. (2)	D.R. (2)	D.R. (2)			
Code No.									
Sampling Date	20.11.00.	20.11.00	20.11.00	20.11.00.	20.11.00	20.11.00	20.11.00	20.11.00	20.11.00
Sampling Time	11.00	16.30	19.40	11.45	16.45	20.10	13.00	18.05	21.10
Climate	cloudy	cloudy	cloudy	cloudy	cloudy	cloudy	cloudy	cloudy	cloudy
Atmosferic temperature (℃)	9.0	6.0	4.0	9.0	6.0	4.0	10.0	6.0	4.0
Discharge(m^3/s)	0.0132	0.0097	0.0097	0.073	0.0563	0.0563	0.0791	0.0753	0.0753
Color	grey	grey	without	grey	grey	grey	brown	brown	grey
Odor	typical	typical	typical	typical	typical	typical	typical	typical	typical
Water temperature (℃)	21.0	40.0	18.0	37.0	30.0	30.0	20.0	19.0	18.0
EC (μ S/cm)	9679	2378	332	2350	8119	4854	664	952	485
Turbidity (mg/l)	20	35	10	60	45	45	110	90	65
pH	12.0	12.0	8.8	12.0	12.3	12.1	6.7	10.4	9.2
BOD (mg/l)	120	330	33	181	60	120	860	140	120
COD(Mn) (mg/l)	142	512	43	353	126	107	560	123	161
T-N (mg/l)	3.81	4.72	3.71	3.12	7.62	3.89	11.17	6.66	4.93
NH_4^+-N (mg/l)	1.96	3.16	1.92	2.31	2.37	2.34	9.38	3.79	3.97
NO_3^- -N (mg/l)	0.028	0.43	0.30	0.19	0.065	0.055	0.516	0.192	0.265
NO_2^- -N (mg/l)	1.25	0.77	1.25	0.47	1.34	1.274	0.650	1.26	0.67
T-P (mg/l)	0.64	0.95	0.62	0.27	0.96	1.08	14.18	11.83	11.71
PO_4-P (mg/l)	0.51	0.56	0.21	0.23	0.47	0.30	9.41	1.62	4.17
DO (mg/l)	2.4	5.6	10.5	5.8	7.7	2.8	2.0	6.6	4.3
SS (mg/l)	138	107	25	126	250	205	75	381	150
Phenol (mg/l)	0.000	0.000	0.000	0.007	0.001	0.000	0.001	0.057	0.000
Cadmium (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cr (mg/l)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Hg (mg/l)	<0.0001	0.00018	<0.0001	<0.0001	<0.0001	0.00016	0.0013	0.00034	<0.0001
Ni^{2+} (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lead (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Copper (mg/l)	<0.020	<0.020	<0.020	<0.020	<0.020	<0,.020	<0.020	<0.020	<0.020
Zinc (mg/l)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.089	0.066	0.066
Fe (mg/l)	0.070	0.120	0.109	0.105	0.281	0.051	0.299	0.248	0.541
F (mg/l)	0.078	0.0543	0.057	0.061	0.071	0.0602	0.136	0.082	0.089
PCB (mg/l)	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025
Organo-chlorine(Pesticides)	n.d.	n.d	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Detergent (mg/l)	0	22.06	1.077	0.799	0.539	0.555	0.035	0	0
Oil (n-hexane Extract) (mg/l)	0.093	0.058	0.048	0.171	0.059	0.043	0.058	0.215	0.144
Cl (Cloride) (mg/l)	80	60	6	25	50	10	12.5	215	15
Total coliform (MPN/100ml)	0	0	46000	0	0	0	$24*10^7$	0	$75*10^6$
Fecal oliform (MPN/100ml)	0	0	46000	0	0	0	$11*10^7$	0	$11*10^6$

Table B.4.3 Results of Water Quality Observation of Factory Effluent 2/5

Sample No.	10	11	12	13	14	15	16	17	18
Location	Karlovac	Karlovac	Karlovac	Sisak	Sisak	Sisak	Sisak	Sisak	Sisak
Factory Name	PPK KARLOVAC	PPK KARLOVAC	PPK KARLOVAC	HERBOS	HERBOS	HERBOS	SEGESTICA	SEGESTICA	SEGESTICA
Sampling Site									
Remarks									
Code No.									
Sampling Date	20.11.00	20.11.00	20.11.00	21.11.00	21.11.00.	21.11.00.	2000/11/21	2000/11/22	2000/11/22
Sampling Time	12.45	17.30	20.45	10.15	14.45	22.15	11.50	15.50	20.40
Climate	cloudy	cloudy	cloudy	sunny	sunny	clear	sunny	sunny	clear
Atmosferic temperature (℃)	10.0	6.0	20.0	12.1	16.7	13.0	16.2	15.7	13.0
Discharge(m^3/s)	0.0132	0.0097	0.0097	0.0015	0.0015	0.0010	0.0027	0.0027	0.0019
Color	grey	brown	grey	light grey	light grey	light grey	dark brown	dark brown	dark brown
Odor	typical	typical	typical	typical	typical	typical	melasa,yeast	melasa,yeast	melasa,yeast
Water temperature (℃)	18.0	23.0	20.0	15.9	16.4	15.7	43.2	50.2	46.8
EC (μ S/cm)	1516	996	791	737	870	571	3272	7851	6583
Turbidity (mg/l)	55	62	50	136	110	196	262	316	450
pH	7.1	7.4	8.5	8.63	10.32	10.37	6.09	5.32	5.12
BOD (mg/l)	275	290	265	15	15	15	1478	4545	6478
COD(Mn) (mg/l)	139	173	150	15	16	21	1591	6136	8559
T-N (mg/l)	21.57	34.22	9.91	19.48	16.58	22.25	259	791	1050
NH_4^+-N (mg/l)	7.15	9.87	7.05	4.43	4.05	8.34	6.78	7.14	9.96
NO_3^- -N (mg/l)	0.273	0.361	1.43	0.57	0.72	0.53	3.75	14.0	12.6
NO_2^- -N (mg/l)	0.351	0.707	0.782	0.059	0.064	0.075	0.147	0.377	3.71
T-P (mg/l)	3.26	12.97	7.89	2.43	1.86	0.91	12.39	15.71	43.0
PO_4-P (mg/l)	2.74	6.95	2.26	1.05	0.47	0.07	4.53	4.50	8.07
DO (mg/l)	2.1	0.5	2.8	6.3	6.2	6.3	0	0	0
SS (mg/l)	40	88	29	78	108	331	67	182	6729
Phenol (mg/l)	0.004	0.202	0.000	0.025	0.020	0.004	0.195	0.200	0.215
Cadmium (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001	0.0016
Cyanide (mg/l)	0.000	0.000	0.005	0.008	0.014	0.012	0.032	0.036	0.046
Selenium (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cr (mg/l)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.0154	0.0384	0.0308
Hg (mg/l)	0.00013	0.00019	0.00016	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Ni^{2+} (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.108	0.206	0.247
Lead (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.094	<0.050
Copper (mg/l)	<0.020	<0.020	<0.020	0.0258	0.0874	0.104	<0.020	<0.020	0.171
Zinc (mg/l)	0.093	0.052	0.086	0.0388	0.190	0.470	0.476	0.946	1.517
Fe (mg/l)	0.300	0.373	0.264	0.25	0.30	0.33	3.96	6.84	25.9
F (mg/l)	0.136	0.082	0.081	0.092	0.093	0.097	0.073	0.072	0.078
PCB (mg/l)	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025
Organo-chlorine(Pesticides)	n.d.	n.d.	n.d.	0.000074	0.000275	0.001343	n.d.	n.d.	n.d.
Detergent (mg/l)	0.543	0.168	0.700	1.86	0.21	0.16	0.475	0.900	0.450
Oil (n-hexane Extract) (mg/l)	0.089	0.091	0.134	7.6	7.3	15.3	6.7	3.6	13.0
Cl (Cloride) (mg/l)	46	125	143	124	21	28	106	142	142
Total coliform (MPN/100ml)	$11*10^8$	$21*10^6$	$23*10^4$	1600	2700	22	440	24000	40
Fecal oliform (MPN/100ml)	$15*10^7$	$21*10^6$	$9*10^4$	1600	2100	22	<20	24000	<20

Table B.4.3 Results of Water Quality Observation of Factory Effluent 3/5

Sample No.	19	20	21	22	23	24	25	26	27
Location	Sisak	Sisak	Sisak	Sisak	Sisak	Sisak	Petrinja	Petrinja	Petrinja
Factory Name	INA	INA	INA	POWER PLANT	POWER PLANT	POWER PLANT	GAVRILOVIĆ	GAVRILOVIĆ	GAVRILOVIĆ
Sampling Site				siphon	siphon	siphon			
Remarks				cooling water	cooling water	cooling water			
Code No.									
Sampling Date	22.11.00	22.11.00	2000/11/22	22.11.00	22.11.01	22.11.02	28.11.00.	28.11.00.	28.11.00.
Sampling Time	12.10	14.30	22.15	10.15	15.00	22.30	9.30	12.30	14.30
Climate	sunny	sunny	cloudy	sunny	sunny	cloudy	sunny	sunny	sunny
Atmosferic temperature (℃)	14.8	16.7	11.7	12.5	15.8	11.7	5.7	11.1	13.0
Discharge(m^3/s)	0.0465	0.0444	0.0465	6.94	6.94	6.94	0.034	0.0234	0.014
Color	light brown	light brown	light brown	light grey	light grey	light grey	light yellow	light yellow	light yellow
Odor	typical	typical	typical	without	without	without	without	without	without
Water temperature (℃)	31.5	31.6	30.3	13.6	13.6	13.5	24.4	22.5	23.1
EC (μ S/cm)	1074	1034	727	332	332	315	729	421	434
Turbidity (mg/l)	20	22	14	31	37	62	6	10	15
pH	7.46	7.21	7.22	6.94	6.94	6.94	7.47	7.42	7.43
BOD (mg/l)	15.5	11.3	9.0	1.7	2.2	2.1	26	29	19
COD(Mn) (mg/l)	24.5	22.4	22.0	4.3	3.4	4.0	30	30	20
T-N (mg/l)	79.20	78.85	58.56	3.99	3.04	2.72	10.9	5.53	9.43
NH_4^+-N (mg/l)	74.1	74.6	54.2	1.48	0.96	0.66	3.33	2.63	3.05
NO_3^- -N (mg/l)	0.056	0.024	0.122	0.95	0.66	0.79	0.46	0.01	0
NO_2^- -N (mg/l)	<0.01	0.03	0.18	0.016	0.017	0.014	0.080	0.093	0.075
T-P (mg/l)	2.12	2.15	2.30	0.11	0.15	0.20	3.26	2.97	1.96
PO_4-P (mg/l)	1.14	1.09	1.28	0.06	0.05	0.04	1.92	2.44	1.43
DO (mg/l)	1.3	1.4	2.4	9.4	9.4	9.5	2.0	4.2	5.0
SS (mg/l)	25	32	15	25	30	74	75	108	56
Phenol (mg/l)	0.018	0.024	0.012	0.008	0.021	0.006	0.080	0.085	0.039
Cadmium (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide (mg/l)	0.116	0.108	0.090	0.000	0.000	0.000	0.000	0.005	0.0038
Selenium (mg/l)	0.00352	0.0022	0.0019	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cr (mg/l)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Hg (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00037	<0.0001	<0.0001
Ni^{2+} (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lead (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Copper (mg/l)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.0674	<0.020	<0.020
Zinc (mg/l)	0.066	0.028	0.152	0.0394	0.0114	0.0146	0.0716	0.0172	<0.010
Fe (mg/l)	0.37	0.37	0.44	0.15	0.80	1.44	0.71	0.49	0.26
F (mg/l)	0.159	0.149	0.142	0.091	0.088	0.085	0.093	0.088	0.084
PCB (mg/l)	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025
Organo-chlorine(Pesticides)	n.d.*	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Detergent (mg/l)	0,56	0.74	0.04	0	0	0.02	0.84	0.95	0.51
Oil (n-hexane Extract) (mg/l)	4.1	11.1	7.6	4.1	4.0	4.2	10.4	24.9	6.6
Cl (Cloride) (mg/l)	126	126	106	11	11	12	32	12	32
Total coliform (MPN/100ml)	1500	3800	500	2100	2100	1600	>24000	880	1200
Fecal oliform (MPN/100ml)	1200	3800	150	22	1200	760	<20	<20	880

Table B.4.3 Results of Water Quality Observation of Factory Effluent 4/5

Sample No.	28	29	30	31	32	33	34	35	36
Location	Kutina	Kutina	Kutina	Vrbovec	Vrbovec	Vrbovec	Vrbovec	Vrbovec	Vrbovec
Factory Name	PETRO-KEMIJA	PETRO-KEMIJA	PETRO-KEMIJA	PIK VRBOVEC	PIK VRBOVEC	PIK VRBOVEC	PIK VRBOVEC	PIK VRBOVEC	PIK VRBOVEC
Sampling Site	TMG - 2	TMG - 2	TMG - 2	A (slaughter)	A (slaughter)	A (slaughter)	B(knackery)	B (knackery)	B (knackery)
Remarks									
Code No.									
Sampling Date	23.11.00.	23.11.00.	23.11.00.	23.11.00.	23.11.00.	23.11.00.	23.11.00.	23.11.00.	23.11.00.
Sampling Time	11.00	14.15	22.25	10.15	12.15	14.05	10.0	12.0	13.50
Climate	sunny	sunny	cloudy	sunny	sunny	sunny	sunny	sunny	sunny
Atmosferic temperature (℃)	18.0	17.4	10.0	7.5	14.0	16.0	7.5	14.0	16.0
Discharge(m^3/s)	0.0555	0.1077	0.0369	0.049	0.026	0.045	0.0006	0.0006	0.0006
Color	light grey	light grey	light grey	light brown	light brown	light brown	grey	grey	grey
Odor	typical	typical	typical	typical	typical	typical	typical	typical	typical
Water temperature (℃)	23.0	25.3	34.0	28.8	27.2	31.3	29.3	28.0	24.4
EC (μ S/cm)	2820	494	312	939	4510	801	1290	2001	1883
Turbidity (mg/l)	8	13	2	55	50	50	82	80	86
pH	7.39	7.61	7.56	6.83	6.84	7.39	8.49	7.46	7.01
BOD (mg/l)	8.3	3.0	1.6	180	120	93	220	250	340
COD(Mn) (mg/l)	9.7	4.6	5.3	80	51	37	100	120	150
T-N (mg/l)	52.0	24.1	36.1	21.0	32.0	20.0	45.0	40.0	25.0
NH_4^+-N (mg/l)	40.7	9.32	26.0	3.66	3.75	1.92	8.78	9.44	10.07
NO_3^- -N (mg/l)	8.85	9.40	6.9	1.15	1.08	0.68	1.55	3.61	3.64
NO_2^- -N (mg/l)	0.489	0.584	0.806	0.02	0.01	0.03	0.01	0.02	0.02
T-P (mg/l)	10.0	1.77	2.77	5.68	4.86	1.57	2.75	5.95	6.66
PO_4-P (mg/l)	3.85	0.78	1.47	4.09	2.58	0.68	1.16	3.80	3.75
DO (mg/l)	8.0	8.2	7.5	1.5	0.7	2.5	2.3	0	0
SS (mg/l)	27	43	26	169	182	188	677	263	277
Phenol (mg/l)	0.003	0.004	0.004	0.048	0.027	0.017	0.093	0.221	0.293
Cadmium (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide (mg/l)	0.016	0.016	0.020	0.005	0.012	0.004	0.006	0.005	0.006
Selenium (mg/l)	0.000144	<0.0001	0.000124	<0.0001	0.00024	<0.0001	<0.0001	<0.0001	0.00012
Cr (mg/l)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Hg (mg/l)	<0.0001	<0.0001	<0.0001	0.00023	0.00016	0.00023	0.00032	<0.0001	<0.0001
Ni^{2+} (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lead (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Copper (mg/l)	<0.020	<0.020	<0.020	0.03	0.02	0.02	0.02	0.03	0.04
Zinc (mg/l)	0.613	0.463	0.714	0.27	0.28	0.16	0.07	0.12	0.16
Fe (mg/l)	1.41	0.48	0.58	0.57	0.61	0.34	0.75	1.21	1.89
F (mg/l)	2.41	2.68	5.61	0.151	0.122	0.107	0.179	0.210	0.238
PCB (mg/l)	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025
Organo-chlorine(Pesticides)	n.d.*	n.d.	n.d.	n.d*.	n.d.	n.d.	n.d.	n.d.	n.d.
Detergent (mg/l)	0.02	0	0	2.06	4.09	2.09	0.82	1.13	3.41
Oil (n-hexane Extract) (mg/l)	2.4	2.5	2.7	4.05	11.71	4.49	0.34	0.62	3.21
Cl (Cloride) (mg/l)	418	37	43	117	1704	87	312	479	398
Total coliform (MPN/100ml)	880	880	2700	$90*10^{10}$	$90*10^{10}$	$90*10^{10}$	$40*10^{8}$	$90*10^{11}$	$90*10^{9}$
Fecal oliform (MPN/100ml)	760	500	500	$45*10^{8}$	$57*10^{8}$	$42*10^{7}$	$54*10^{7}$	$41*10^{10}$	$30*10^{7}$

Table B.4.3 Results of Water Quality Observation of Factory Effluent 5/5

Sample No.	37	38	39	40	41	42
Location	Sesvete	Sesvete	Sesvete	Svaski Moruf	Svaski Moruf	Svaski Moruf
Factory Name	AGROPRO-TEINKA	AGROPRO-TEINKA	AGROPRO-TEINKA	PLIVA	PLIVA	PLIVA
Sampling Site						
Remarks						composite sample
Code No.						
Sampling Date	24.11.00.	24.11.00.	24.11.00.	24.11.00.	24.11.00.	28/29.11.00.
Sampling Time	13.00	16.30	22.30	10.00	14.45	28.11./8.00-29.11./8.00
Climate	sunny	cloudy	cloudy	cloudy	sunny	-
Atmosferic temperature (℃)	14.5	13.0	9.5	11.0	16.5	-
Discharge(m^3/s)	0.005	0.003	0.001	0.082	0.082	0.082
Color	grey	grey	grey	brown	brown	brown
Odor	typical	typical	typical	typical	tipical	tipical
Water temperature (℃)	22.5	21.9	19.8	23.7	21.4	-
EC (μ S/cm)	2616	5220	5330	3840	4830	5120
Turbidity (mg/l)	480	560	620	100	120	100
pH	5.70	5.85	5.03	9.94	9.09	7.13
BOD (mg/l)	2600	4100	8150	510	350	580
COD(Mn) (mg/l)	1130	1640	3160	270	790	620
T-N (mg/l)	280	700	730	129	228	142
NH_4^+-N (mg/l)	224.87	638.41	481.81	31.18	5.75	0.43
NO_3^- -N (mg/l)	16.55	27.78	43.74	69.24	209.14	72.54
NO_2^- -N (mg/l)	0.08	0.03	0.10	0.93	2.03	20.0
T-P (mg/l)	26.85	31.59	78.68	3.13	3.66	2.88
PO_4-P (mg/l)	15.38	21.97	58.56	1.10	2.99	2.07
DO (mg/l)	0.0	0.0	0.0	0.0	0.0	0.0
SS (mg/l)	1525	2660	5100	91	307	143
Phenol (mg/l)	0.504	2.217	0.533	0.022	0.033	0.016
Cadmium (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide (mg/l)	0.007	0.124	0.100	0.016	0.075	0.630
Selenium (mg/l)	0.00024	0.0001	<0.0001	<0.0001	0.00011	<0.0001
Cr (mg/l)	0.05	0.05	0.05	0.14	<0.020	0.050
Hg (mg/l)	0.00013	<0.0001	<0.0001	0.00021	0.000016	0.00035
Ni^{2+} (mg/l)	<0.050	<0.050	<0.050	0.06	0.06	0.06
Lead (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Copper (mg/l)	0.03	0.03	0.34	1.99	0.30	0.08
Zinc (mg/l)	0.36	0.33	0.94	0.09	0.04	0.07
Fe (mg/l)	3.09	4.48	10.6	3.44	2.99	3.51
F (mg/l)	0.035	0.031	0.028	0.030	0.028	0.032
PCB (mg/l)	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025	<0.000025
Organo-chlorine(Pesticides)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Detergent (mg/l)	0.08	0.10	0.14	1.05	0.88	0.14
Oil (n-hexane Extract) (mg/l)	9.99	12.35	55.61	0.31	0.36	0.17
Cl (Cloride) (mg/l)	305	309	639	525	369	515
Total coliform (MPN/100ml)	$930*10^{17}$	$900*10^{11}$	$900*10^{16}$	$90*10^{6}$	$90*10^{5}$	$20*10^{8}$
Fecal oliform (MPN/100ml)	$40*10^{9}$	$56*10^{8}$	$67*10^{8}$	$40*10^{2}$	$32*10^{5}$	$80*10^{6}$

Table B.4.4 Results of Deposit Quality Observation at Factory Effluent

Sample No.	1	2	3
Location Name	HERBOS	PLIVA	AGROPROTEINKA
Sampling Site		stream Gorjak after PLIVA effluence	channel Črnec between Almeria and Agroproteinka
Remarks			
Code No.			
Sampling Date	21.11.00.	24.11.00.	24.11.00.
Point Depth (cm)	cca 50	10-20	10-20
Color	dark grey	black	grey
Odor	typical	without	typical
Hg (mg/drykg)	102.05	<0.01	0.03
Arsenic (mg/drykg)	<0.01	<0.01	<0.01
Cadmium (mg/drykg)	<1.0	<1.0	<1.0
Lead (mg/drykgl)	64.28	18.59	<10
Selenium (mg/drykg)	0.129	0.04	0.08
Cr (mg/drykg)	65.03	62.42	13539.40
Copper (mg/drykg)	360.9	1075.56	59.19
Zinc (mg/drykg)	639.09	602.39	137.13
Ni (mg/drykg)	28.19	582.51	<10
F (mg/drykg)	9.9	5.09	6.31
PCB (mg/drykg)	20.0	0.37	1.96
Organo-chlorine(Pesticides) (mg/drykg)	10.6	n.d.	n.d.

Table B.4.5 Average Existing Sewerage Wastewater Quality

Sewerage	Code	Inlet /Outlet	Sample Number	BOD5 (mg/l)	COD(cr) (mg/l)	Total Suspended Solids (mg/l)	PH	Mineral Oil (mg/l)	Phenol (mg/l)	Anionic Detergents (mg/l)	Cationic Detergent (mg/l)	NH4-N (mg/l)	NO2-N (mg/l)	NO3-N (mg/l)	PO4-P (mg/l)	T-P (mg/l)
Duga Resa Uga Resa Kod Ljoma	431102	Outlet-A	19	161.1	356.1	281	7.4	0.34		1.46	0.07	34.16				5.36
Duga Resa Kod Vinice	431103	Outlet-C	18	261.7	457.9	236	7.6	0.27		1.80	0.14	55.35				7.11
Duga Resa Kod Doma Sportova	431104	Outlet-D	17	110.3	228.1	153	7.7	0.27		1.82	0.05	20.03				12.81
Duga Resa Kod Mlina	431105	Outlet-G	18	53.1	138.3	108	7.5	0.22		1.71	0.04	8.42				1.53
Kolektor DREŽNIK, Karlovac	433102	Outlet	5	116.6	281.0	142	7.6			2.26	0.04					5.38
Kolector Banija I, Karlovac	433103	Outlet	5	124.0	308.0	162	7.7			2.69	0.03					4.92
Kolector Banija II, Karlovac	433104	Outlet	5	507.0	1019.8	264	8.5			0.76	0.25					1.52
Kolector Grad, Karlovac	433105	Outlet	5	461.0	943.8	243	7.0	0.50	0.189	1.68	0.05					4.17
Ozalj, TRŠKA Cesta	436102	Outlet-BR.1	6	229.8	623.8	159	7.7									
IVANIĆ GRAD	455100	Inlet	4	108.8	210.0	1175	7.8	0.08	0.025	0.93	0.08	8.69	0.009	8.78	1.14	
IVANIĆ GRAD	455101	Outlet	7	38.5	97.7	253	7.6	1.05	0.011	0.99	0.05	6.89	0.025	4.71	1.11	2.14
Kutina	457100	Inlet	6	88.3	130.9	61	7.7					15.33		2.83	4.88	4.15
Kutina	457101	Outlet	7	64.9	105.1	28	7.7					13.07		3.49	4.39	7.25
NOVSKA, BROČICE	458102	Outlet-1	7	68.9	88.1	37	7.6	0.23		0.36		3.54	0.109	8.83	2.01	
NOVSKA, GRAD	458103	Outlet-2	7	64.3	76.3	36	7.6	0.24		0.18		3.64	0.117	7.62	0.45	
Vrbovec, Livadarska Ulica	460102	Outlet-1	42	152.5	301.5	73	7.2	0.49	0.160	5.47	0.01	11.23	0.055	6.23	4.12	
Vrbovec, Livadarska Ulica	460103	Outlet-2	42	94.5	189.6	71	7.2	0.18	0.281	3.80	0.00	11.65	0.158	4.93	2.55	
Vrbovec, Livadarska Ulica	460104	Outlet-3	38	85.7	176.5	58	7.2	0.13	0.143	2.24	0.00	11.86	0.024	2.13	2.58	
SV.Ivan Zelina, Zagrebacka Ulic	461102	Outlet	9	33.7	87.3	43	7.4	0.51	0.006	0.91	0.05	3.03	0.042	0.99		
Sisak, CS Galdovo	474102	Outlet-1	9	212.3	208.5	74	7.4	2.08	0.969	1.46	0.09	10.09	0.124	0.29	0.97	1.41
Sisak, ŽITNA	474103	Outlet-2	8	79.2	115.3	125	7.8	7.03	0.038	2.43	0.73	12.09	0.257	0.80	5.31	6.28
Sisak, MAŽURANIĆEVA	474104	Outlet-3	9	180.2	172.4	246	7.9	1.75	0.039	2.91	0.69	10.55	0.219	0.89	3.24	5.47
Sisak, LADJARSKA	474105	Outlet-4	9	11.2	20.9	28	7.6	0.71	0.014	0.39	0.02	6.84	0.105	1.29	1.13	2.38
Sisak, ŠKOLSKA	474106	Outlet-5	6	33.5	50.0	75	7.7	1.01	0.015	1.29		6.48	0.241	2.62	1.52	3.75

Table B.4.6 Results of Water Quality Observation of Sewerage Effluent 1/5

Sample No.	1	2	3	4	5	6	7	8
Location	Zagreb	Sesvete	Karlovac	Samobor	Velika Gorica	Zapresic	Dugo Selo	Jastrebarsko
Sampling Site	last bridge before Sava riv.	Dumovec-bridge	pump station before Kupa riv.	Celine-bridge	treatment plant	manhole befare Krapina riv.	Puhovec-bridge	manhole Cvjetno naselje str.
Remarks								
Code No.								
Sampling Date	8.12.00.	30.11.00.	29.11.00.	27.11.00.	27.11.00	27.11.00.	27.11.00	29.11.00.
Sampling Time	15.00	10.00	9.30	14.10	12.45	15.20	9.30	12.35
Climate	cloudy	cloudy	cloudy	sunny	sunny	sunny	cloudy	sunny
Atmosferic temperature (C)	15.2	5.5	2.0	14.1	12.7	13.0	9.0	15.0
Discharge(m^3/s)	4.22	0.0171	0.126	0.270	0.139	0.093	0.046	0.025
Color	brown	light grey	light grey	light brown	light grey	light brown	light grey	light grey
Odor	typical	typical	typical	typical	typical	typical	typical	typical
Water temperature (C)	16.5	6.5	18.0	13.5	16.7	15.5	14.8	13.0
EC (μ S/cm)	1109	1170.0	698.0	844.0	1167.0	1084.0	1083.0	773.0
Turbidity (mg/l)	80.00	40.00	55.00	35.00	10.00	35.00	40.00	20.00
pH	8.0	7.24	7.1	7.50	7.67	7.53	7.48	7.5
BOD (mg/l)	190.00	63.00	460.00	32.00	15.00	96.00	70.00	60.00
COD(Mn) (mg/l)	68.0	31.0	138.0	20.0	17.0	50.0	33.0	42.0
T-N (mg/l)	21.5	27.4	37.7	11.1	35.00	15.6	28.00	25.3
NH_4^+-N (mg/l)	15.50	21.66	32.1	7.27	30.28	12.89	24.76	21.34
NO_3^- -N (mg/l)	0.51	0.36	0.629	0.69	0.58	1.54	1.02	0.194
NO_2^- -N (mg/l)	0.03	0.01	0.372	0.19	0.02	0.02	0.01	0.224
T-P (mg/l)	5.60	5.13	8.6	2.19	4.15	4.96	3.91	4.16
PO_4-P (mg/l)	5.0	4.55	5.90	1.73	3.70	10.48	3.36	3.03
DO (mg/l)	0	1.1	0.2	1.4	5.7	1.4	2.2	3.0
SS (mg/l)	370.00	103.00	111.00	110.00	66.00	126.00	120.00	73.00
Phenol (mg/l)	0.033	0.042	0.051	0.013	0.018	0.022	0.024	0.007
Cadmium (mg/l)	<0.005	<0.005	<0.0005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide (mg/l)	0.009	0.005	0.004	0.006	0.003	0.005	0.004	0.002
Selenium (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.002	<0.0001	<0.0001
Cr (mg/l)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Hg (mg/l)	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Ni^{2+} (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lead (mg/l)	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Copper (mg/l)	0.07	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Zinc (mg/l)	0.14	0.07	0.07	0.07	0.03	0.11	0.13	0.080
Fe (mg/l)	0.69	0.24	0.14	0.23	0.14	0.37	0.35	0.07
F (mg/l)	0.129	0.179	0.150	0.181	0.140	0.154	0.203	0.120
PCB (mg/l)	<0.000025	<0.000025	<0.000025	<0.000025	<0.00025	<0.000025	<0.000025	<0.000025
Organo-chlorine(Pesticides) (mg/l)	n.d.*	n.d	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Detergent (mg/l)	2.59	2.24	2.64	2.05	0.16	5.56	2.29	0.078
Oil (n-hexane Extract) (mg/l)	3.37	0.33	0.18	0.48	0.14	3.63	0.11	0.217
Cl (Cloride) (mg/l)	128.000	117.000	48.000	71.000	99.000	78.000	80.000	30.000
Total coliform (MPN/100ml)	$280*10^{10}$	$110*10^{10}$	$11*10^{8}$	$280*10^{8}$	$90*10^{8}$	$150*10^{10}$	$150*10^{11}$	$24*10^{7}$
Fecal oliform (MPN/100ml)	$80*10^{9}$	$820*10^{6}$	$46*10^{7}$	$50*10^{6}$	$30*10^{7}$	$48*10^{7}$	$56*10^{8}$	$23*10^{6}$

Table B.4.6 Results of Water Quality Observation of Sewerage Effluent 2/5

Sample No.	9	10	11						
Location	Petrinja	Duga Resa	Ivancic Grad						
Sampling Site	manhole before Kupa riv	manhole before Mreznica riv.	treatment plant						
Remarks									
Code No.									
Sampling Date	28.11.00.	29.11.00.	8.12.00.						
Sampling Time	11.30	10.40	12.00						
Climate	sunny	sunny	sunny						
Atmosferic temperature (C)	11.0	5.0	12.3						
Discharge(m^3/s)	0.0523	0.0039	0.0817						
Color	light brown	light grey	light brown						
Odor	typical	typical	typical						
Water temperature (C)	13.2	13.0	12.8						
EC (μ S/cm)	652	450.0	974.0						
Turbidity (mg/l)	10.00	35.00	50.00						
pH	7.51	7.1	7.36						
BOD (mg/l)	25	31	43						
COD(Mn) (mg/l)	28.0	28.0	30.0						
T-N (mg/l)	20	8.77	24.9						
NH_4^+-N (mg/l)	15.5	3.02	19.47						
NO_3^- -N (mg/l)	0.22	0.24	0.31						
NO_2^- -N (mg/l)	0.092	1.55	0.35						
T-P (mg/l)	4.24	1.19	3.54						
PO_4-P (mg/l)	3.26	0.84	3.37						
DO (mg/l)	1.0	5.4	7.5						
SS (mg/l)	106	119.00	102.00						
Phenol (mg/l)	0.011	0.004	0.030						
Cadmium (mg/l)	<0.005	<0.005	<0.005						
Cyanide (mg/l)	0.0037	0	0.002						
Selenium (mg/l)	<0.0001	<0.0001	<0.0001						
Cr (mg/l)	<0.020	<0.020	<0.020						
Hg (mg/l)	<0.0001	<0.0001	0.483						
Ni^{2+} (mg/l)	<0.0050	<0.050	<0.050						
Lead (mg/l)	<0.050	<0.050	<0.050						
Copper (mg/l)	<0.050	<0.050	0.12						
Zinc (mg/l)	<0.010	0.10	0.60						
Fe (mg/l)	0.72	<0.030	0.89						
F (mg/l)	0.129	0.0823	0.196						
PCB (mg/l)	<0.000025	<0.000025	<0.000025						
Organo-chlorine(Pesticides) (mg/l)	n.d.	n.d.	n.d.						
Detergent (mg/l)	2.15	0.024	1.18						
Oil (n-hexane Extract) (mg/l)	7.4	0.165	0.47						
Cl (Cloride) (mg/l)	28.000	16.000	199.000						
Total coliform (MPN/100ml)	$24*10^{3}$	$24*10^{6}$	$110*10^{10}$						
Fecal oliform (MPN/100ml)	<20	$23*10^{6}$	$34*10^{9}$						

Table B.4.6 Results of Water Quality Observation of Sewerage Effluent 3/5

Sample No.	12	13	14	15	16	17	18	19
Location	Kutina	Kutina	Kutina	Kutina	Kutina	Kutina	Kutina	Kutina
Sampling Site	after treatment plant	after treatment plant	after treatment plant	after treatment plant	after treatment plant	after treatment plant	after treatment plant	after treatment plant
Remarks								
Code No.								
Sampling Date	8.12.00.	8.12.00.	8.12.00.	8.12.00.	8.12.00.	8.12.00.	8.12.00.	8.12.00.
Sampling Time	11.00	14.00	17.00	20.00	23.00	02.00	05.00	08.00
Climate	cloudy	sunny	cloudy	cloudy	cloudy	cloudy	cloudy	cloudy
Atmosferic temperature (C)	10.2	10.8	7.0	5.4	5.2	5.6	5.5	5.8
Discharge(m^3/s)	0.0383	0.0297	0.03	0.0292	0.0336	0.0253	0.0175	0.015
Color	light grey	light grey	light grey	light grey	light grey	light grey	light grey	light grey
Odor	typical	typical	typical	typical	typical	typical	typical	typical
Water temperature (C)	13.3	13.2	13.2	13.2	13.2	13.1	13.3	13.0
EC (μ S/cm)	793	896.0	910.0	956.0	918.0	878.0	844.0	804.0
Turbidity (mg/l)	35.00	55.00	64.00	70.00	76.00	54.00	43.00	31.00
pH	7.24	8.08	7.91	8.06	7.69	7.69	7.63	7.88
BOD (mg/l)	15	33	39	38	35	37	22	16
COD(Mn) (mg/l)	24.0	41.0	48.0	42.0	44.0	46.0	34.0	24.0
T-N (mg/l)	28.2	37.6	41.9	42.9	34.1	31.7	35.3	29.1
NH_4^+-N (mg/l)	24.6	33.7	36.1	37.6	28.2	26.3	26.0	26.1
NO_3^- -N (mg/l)	0.42	0.21	0.20	0.21	0.20	0.31	0.71	0.86
NO_2^- -N (mg/l)	0.22	0.19	0.69	0.23	0.061	0.36	0.87	0.21
T-P (mg/l)	5.23	6.16	6.29	6.91	6.94	6.59	6.19	5.40
PO_4-P (mg/l)	3.96	4.25	4.24	4.91	5.67	5.43	5.02	4.71
DO (mg/l)	5.8	-	-	-	-	-	-	-
SS (mg/l)	32	59	26	29	58	62	35	26
Phenol (mg/l)	0.031	-	-	-	-	-	-	-
Cadmium (mg/l)	<0.005	-	-	-	-	-	-	-
Cyanide (mg/l)	0.005	-	-	-	-	-	-	-
Selenium (mg/l)	<0.0001	-	-	-	-	-	-	-
Cr (mg/l)	<0.020	-	-	-	-	-	-	-
Hg (mg/l)	<0.0001	-	-	-	-	-	-	-
Ni^{2+} (mg/l)	<0.050	-	-	-	-	-	-	-
Lead (mg/l)	<0.050	-	-	-	-	-	-	-
Copper (mg/l)	0.0102	-	-	-	-	-	-	-
Zinc (mg/l)	0.0514	-	-	-	-	-	-	-
Fe (mg/l)	0.57	-	-	-	-	-	-	-
F (mg/l)	0.140	-	-	-	-	-	-	-
PCB (mg/l)	<0.000025	-	-	-	-	-	-	-
Organo-chlorine(Pesticides) (mg/l)	n.d.	-	-	-	-	-	-	-
Detergent (mg/l)	0.27	-	-	-	-	-	-	-
Oil (n-hexane Extract) (mg/l)	4.4	-	-	-	-	-	-	-
Cl (Cloride) (mg/l)	34.000	-	-	-	-	-	-	-
Total coliform (MPN/100ml)	$>24*10^3$	-	-	-	-	-	-	-
Fecal oliform (MPN/100ml)	440.000	-	-	-	-	-	-	-

Table B.4.6 Results of Water Quality Observation of Sewerage Effluent 4/5

Sample No.	20	21	22	23	24	25	26	27
Location	Sisak	Sisak	Sisak	Sisak	Sisak	Sisak	Sisak	Sisak
Sampling Site	pump station Galdovo	pump station Galdovo	pump station Galdovo	pump station Galdovo	pump station Galdovo	pump station Galdovo	pump station Galdovo	pump station Galdovo
Remarks								
Code No.								
Sampling Date	25.01.2001.	25.01.2001.	25.01.2001.	25.01.2001.	25.01.2001.	26.01.2001.	26.01.2001.	26.01.2001.
Sampling Time	10.00	13.00	16.00	19.00	22.00	01.00	04.00	07.00
Climate	sunny	sunny	cloudy	cloudy	cloudy	rain	rain	rain
Atmosferic temperature(C)	7.9	15.2	13.0	10.2	10.1	11.1	8.7	8.5
Discharge(m^3/s)	0.09	0.09	0.09	0.09	0.10	0.09	0.07	0.15
Color	light yellow	light yellow	light yellow	light yellow	light yellow	light yellow	light yellow	light yellow
Odor	typical	typical	typical	typical	typical	typical and oil	typical and oil	typical and oil
Water temperature(C)	12.2	12.5	12.7	12.5	12.3	12.2	11.9	12.3
EC (μ S/cm)	942	2673.0	2683.0	5726.0	2241.0	2229.0	1071.0	6142.0
Turbidity, NTU *	78.00	139.00	170.00	91.00	94.00	55.00	25.00	106.00
pH	7.45	9.35	8.67	7.70	7.49	7.53	7.57	8.48
BOD (mg/l)	30.00	41.00	37	29.00	28	37.00	18.00	24.00
COD(Mn) (mg/l)	42.0	51.0	49	37.0	36	45.0	24.0	28.0
T-N (mg/l)	42	42.4	40.6	79.1	33.4	38.1	29.9	51.4
NH_4^+-N (mg/l)	21.3	24.8	13.8	11.7	20.8	20.9	20.4	21.2
NO_3^- -N (mg/l)	0.11	0.12	0.10	0.07	0.04	0.03	0.04	0.10
NO_2^- -N (mg/l)	0.07	0.082	0.091	0.108	0.055	0.066	0.051	0.116
T-P (mg/l)	4.73	7.17	8.03	7.21	6.60	6.89	4.73	3.71
PO_4-P (mg/l)	3.19	1.12	2.87	3.84	4.21	4.21	3.28	2.51
DO (mg/l)	1.91	-	-	-	-	-	-	-
SS (mg/l)	133.00	201.00	119.00	101.00	62.00	272.00	23.00	159.00
Phenol (mg/l)	0.053	-	-	-	-	-	-	-
Cadmium (mg/l)	<0.005	-	-	-	-	-	-	-
Aresenic (mg/l)	-	-	-	-	-	-	-	-
Cyanide (mg/l)	0.008	-	-	-	-	-	-	-
Selenium (mg/l)	0.00034	-	-	-	-	-	-	-
Cr (mg/l)	<0.020	-	-	-	-	-	-	-
Hg (mg/l)	<0.0001	-	-	-	-	-	-	-
Ni^{2+} (mg/l)	<0.050	-	-	-	-	-	-	-
Lead (mg/l)	<0.050	-	-	-	-	-	-	-
Copper (mg/l)	0.07	-	-	-	-	-	-	-
Zinc (mg/l)	0.042	-	-	-	-	-	-	-
Fe (mg/l)	0.72	-	-	-	-	-	-	-
F (mg/l)	0.096	-	-	-	-	-	-	-
PCB (mg/l)	<0.000025	-	-	-	-	-	-	-
Organo-chlorine(Pesticides) (mg/l)	n.d.	-	-	-	-	-	-	-
Detergent (mg/l)	1.47	-	-	-	-	-	-	-
Oil (n-hexane Extract) (mg/l)	30.2	-	-	-	-	-	-	-
Cl (Cloride) (mg/l)	64	-	-	-	-	-	-	-
Total coliform (MPN/100ml)	>240000	-	-	-	-	-	-	-
Fecal oliform (MPN/100ml)	>240000	-	-	-	-	-	-	-

1 NTU =2.5 $mgSiO_2/l$

n.d.= less then detection limit

Table B.4.6 Results of Water Quality Observation of Sewerage Effluent 5/5

Sample No.	28	29	30	31	32	33	34	35
Location	Vrbovec	Vrbovec	Vrbovec	Vrbovec	Vrbovec	Vrbovec	Vrbovec	Vrbovec
Sampling Site	manhole Kolodvorska str.	manhole Kolodvorska str.	manhole Kolodvorska str.	manhole Kolodvorska str.	manhole Kolodvorska str.	manhole Kolodvorska str.	manhole Kolodvorska str.	manhole Kolodvorska str.
Remarks								
Code No.								
Sampling Date	30.11.00.	30.11.00.	30.11.00.	30.11.00.	30.11.00.	30.11.00.	30.11.00.	30.11.00.
Sampling Time	11.30	14.30	17.30	20.30	23.30	02.30	05.30	08.30
Climate	sunny	sunny	cloudy	cloudy	cloudy	cloudy	cloudy	cloudy
Atmosferic temperature (C)	9.7	8.2	3.9	2.1	1.2	-1.1	-1.5	-1.0
Discharge(m^3/s)	0.0275	0.0300	0.0286	0.0286	0.0286	0.0275	0.0286	0.0286
Color	light brown	light brown	light brown	light brown	light brown	light brown	light brown	light brown
Odor	typical	typical	typical	typical	typical	typical	typical	typical
Water temperature (C)	13.7	14.0	14.1	13.9	13.9	13.4	12.9	13.7
EC (μ S/cm)	1186	1200.0	1165.0	1202.0	1174.0	964.0	1080.0	1108.0
Turbidity,NTU*	30.00	45.00	45.00	45.00	25.00	20.00	20.00	20.00
pH	7.60	7.83	7.68	7.72	7.73	7.80	7.87	7.85
BOD (mg/l)	77	110	120	120	87	29	31	54
COD(Mn) (mg/l)	39.0	56.0	66.0	54.0	42.0	16.0	16.0	27.0
T-N (mg/l)	26.4	29.2	28.3	27.8	22.5	21.8	21.0	30.4
NH_4^+-N (mg/l)	20.73	21.36	19.82	19.70	15.93	14.16	14.02	21.73
NO_3^- -N (mg/l)	0.59	1.31	1.08	1.08	0.56	0.95	0.95	1.07
NO_2^- -N (mg/l)	0.01	0.10	0.09	0.07	0.04	0.09	0.10	0.11
T-P (mg/l)	6.85	6.79	6.92	7.94	6.61	2.65	2.57	3.99
PO_4-P (mg/l)	5.25	5.40	5.61	5.32	5.07	2.49	2.52	3.87
DO (mg/l)	2.2	-	-	-	-	-	-	-
SS (mg/l)	85	100.00	104.00	100.00	83.00	59.00	64.00	61.00
Phenol (mg/l)	0.025	-	-	-	-	-	-	-
Cadmium (mg/l)	<0.005	-	-	-	-	-	-	-
Cyanide (mg/l)	0.003	-	-	-	-	-	-	-
Selenium (mg/l)	<0.0001	-	-	-	-	-	-	-
Cr (mg/l)	<0.020	-	-	-	-	-	-	-
Hg (mg/l)	<0.0001	-	-	-	-	-	-	-
Ni^{2+} (mg/l)	<0.050	-	-	-	-	-	-	-
Lead (mg/l)	<0.050	-	-	-	-	-	-	-
Copper (mg/l)	0.08	-	-	-	-	-	-	-
Zinc (mg/l)	0.07	-	-	-	-	-	-	-
Fe (mg/l)	0.37	-	-	-	-	-	-	-
F (mg/l)	1,17	-	-	-	-	-	-	-
PCB (mg/l)	<0.000025	-	-	-	-	-	-	-
Organo-chlorine(Pesticides) (mg/l)	n.d.*	-	-	-	-	-	-	-
Detergent (mg/l)	2.94	-	-	-	-	-	-	-
Oil (n-hexane Extract) (mg/l)	0.23	-	-	-	-	-	-	-
Cl (Cloride) (mg/l)	92.000	-		-	-	-	-	-
Total coliform (MPN/100ml)	$150*10^{10}$	-	-	-	-	-	-	-
Fecal oliform (MPN/100ml)	$77*10^{7}$	-	-	-	-	-	-	-

Table B.4.7 Permissible Limits of the Industrial Wastewater Discharged into River and Public Sewerage System

Parameter	II	III	IV	V	Sewerage
Water Temperature (℃)	35	40	45	45	45
PH	6.5 - 8.0	6.0 – 8.5	5.5 – 9.0	5.0– 9.5	5.0 - 9.5
SS (mg/l)	20	30	50	80	80
BOD (mg/l)	25	25	40	80	250
COD-Cr (mg/l)	125	125	200	400	700
TOC (mg/l)	15	17	25	40	-
T-N (mg/l)	5	15	25	35	-
T-P (mg/l)	1	2	4	8	10
Oil and Grease ((mg/l)	25	30	40	50	100
Al (mg/l)	2	3	3.5	4	4
As (mg/l)	0.2	0.3	0.4	0.4	0.5
Ba (mg/l)	2.5	3	4	5	5
Bo (mg/l)	1.5	2	2.5	3	4
Zn (mg/l)	1	1	1.5	2	2
Co (mg/l)	0.5	1	1.25	1.5	2
Sn (mg/l)	0.75	1	1.25	1.5	2
T-Cr (mg/l)	1	1.25	1.5	1.75	2
Cr6+ (mg/l)	0.05	0.1	0.15	0.15	0.2
Mn (mg/l)	2	2.5	3	3.5	4
Ni (mg/l)	1	1.25	1.5	1.5	2
Pb (mg/l)	0.2	0.5	0.75	1	2
Phenol (mg/l)	0.1	0.2	0.3	0.4	0.5
Se (mg/l)	0.02	0.03	0.04	0.05	0.1
Ag (mg/l)	0.1	0.15	0.2	0.3	0.5
Fe (mg/l)	2	3	4	5	10
V (mg/l)	0.05	0.05	0.75	0.75	0.1
Fluorides (mg/l)	5	6	8	9	12
Sulfites (mg/l)	1	2	4	5	10
Sulfides (mg/l)	0.1	0.25	0.5	1	1
Sulfates (mg/l)	-	-	-	-	400
Chlorides (mg/l)	-	-	-	-	1000
Efficacious Cl2 (mg/l)	0.2	0.25	0.3	0.3	0.3
Orthophosphate (mgP/l)	1	2	3	4	-
Ammonium ion (mgN/l)	0.1	0.5	1	3	-
Nitrites (mgN/l)	0.5	1	1.5	2	10
Nitrates (mgN/l)	2	5	7	10	-
Total nitrogen (mgN/l)	5	15	25	35	-
Mineral oils (mg/l)	5	10	15	20	30
Aldehydes (mg/l)	1	1.5	2	2	2
Total aromatic hydrocarbons (mg/l)	0.02	0.05	0.1	0.15	0.2
Total nitrated hydrocarbons (mg/l)	0.01	0.25	0.03	0.05	0.1
Total halogen. hydrocarbons (mg/l)	0.1	0.25	0.5	0.75	1
Total organic-phosphates pesticides	-	0.05	0.1	0.1	0.1
Total organic-chlorides pesticides (	-	0.025	0.05	0.05	0.05
Total active matters (mg/l)	4	5	7	10	20
Anionic detergents (mg/l)	1	2	4	4	10
No-ionic detergents (mg/l)	1	2	4	4	10
Cationic detergents (mg/l)	0.2	0.5	1	1	2
Radioactivity total Beta (mBq/l)	500	750	1000	1500	2000

Table B.5.1 Livestock, Land Area and Rural Population Data of Each Sub-Basin

Basin No.	Sub-Basin Name	Land Use and Livestock								
		Tributary Distance (km)	Sub-Basin Area (km^2)	Livestock (Heads)			Agricultural land Area (km^2)	Pasture Land Area (km^2)	Shrub/Forest Area (km^2)	Population of Rural Area
				Bovine	Pigs	Sheep				
1	Sutla	92	134	2,946	4,590	23	52	21	58	21,140
2	Krapina	75	1,234	27,937	40,481	104	361	207	643	138,199
3	Zagreb Area	63	668	9,404	38,956	556	96	128	290	39,556
4	Upper Kupa	76	1,294	2,664	2,724	535	29	62	248	12,435
5	Dobra	104	1,397	6,429	4,779	1,520	36	157	672	15,738
6	Mreznica	63	459	2,038	648	11,410	11	61	368	2,741
7	Korana	134	1,107	5,023	3,734	1,188	4	366	440	12,064
8	Lower Kupa-Glina	146-100	2,954	26,989	73,144	3,870	153	875	1839	150,916
9	Moatanica	14	66	351	1,607	108	2	16	40	2,510
10	Odra	83	763	9,919	33,344	769	89	240	389	44,177
11	Middle Sava	58	77	720	2,317	103	26	18	22	5,207
12	Zelina Crnec	29-26	417	6,604	21,911	316	63	159	167	74,481
13	Upper Lonja	47	381	7,403	19,793	171	99	91	184	22,877
14	Middle Lonja	16	94	1,746	4,050	60	15	28	47	142
15	Upper Cesma-Glogonica	59-25	2,385	58,070	125,562	25,577	429	632	1259	110,629
16	Moslavina Area	30-31	525	7,850	20,131	2,555	62	152	292	27,829
17	Lower Lonja	33	519	2,768	12,667	853	34	198	261	54,280
18	Una-Sunja	212-69	1,268	6,766	30,963	2,084	20	338	877	27,273
19	Ilova Pakra	85	1,804	26,887	74,846	24,859	126	474	1118	29,551
20	Veliki Strug	45	735	4,608	23,361	2,341	20	198	481	9,043
Total		-	18,280	217,123	539,608	79,001	1,727	4,422	9,696	800,788

Table B 5.2 Unit Pollution Load Generation of Non-point Sources

Sources		Parameter	Unit Load	Reference
Livestock	Bovines	BOD (g/head/day)	640	※-1
		COD (g/head/day)	530	※-1
		T-N (g/head/day)	290	※-1
		T-P (g/head/day)	50	※-1
	Pigs	BOD (g/head/day)	200	※-1
		COD (g/head/day)	130	※-1
		T-N (g/head/day)	40	※-1
		T-P (g/head/day)	25	※-1
	Sheeps	BOD (g/head/day)	64	※-1
		COD (g/head/day)	53	※-1
		T-N (g/head/day)	38	※-1
		T-P (g/head/day)	6	※-1
Agricultural land		BOD ($kg/km^2/day$)	8.57	※-2
		COD ($kg/km^2/day$)	7.4	※-1
		T-N ($kg/km^2/day$)	18.8	※-1
		T-P ($kg/km^2/day$)	0.202	※-1
Pastureland		BOD ($kg/km^2/day$)	1.00	※-5
		COD ($kg/km^2/day$)	0.86	※-5
		T-N ($kg/km^2/day$)	2.19	※-4
		T-P ($kg/km^2/day$)	0.11	※-4
Shrub/Forest		BOD ($kg/km^2/day$)	0.75	※-3
		COD ($kg/km^2/day$)	4.96	※-1
		T-N ($kg/km^2/day$)	1.04	※-1
		T-P ($kg/km^2/day$)	0.082	※-1
Household (After Septic Tank Treatment)		BOD (g/person/day)	4.0	※-3
		COD (g/person/day)	2.3	※-5
		T-N (g/person/day)	0.67	※-5
		T-P (g/person/day)	0.108	※-5

Reference No.

※-1: :Guideline for Basin-wide Water Pollution Control Master Plan ,Japan Sewage Works Association,1996, p41.

※-2:Preparation of Unit Pollutant Load for Enviromental Assessment, Nomura Synthetic Institute Japan

※-3: Preparation of Unit Pollutant Load for Enviromental Assessment,Japan Sewage

※-4:Unit Pollutant Load of Grassland in Switzerland, Kolenbrander. G.J."The Eutrophication of Surbaca Waters by Agriculture and the urban

※-5: Assumed by the Study Team

Table B 5.3 Existing Pollution Load Generation -1/4 (BOD)

(Unit :kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
BOD (Sewerage)	0	1,998	50,856	0	0	2,203	38	1,210	2,742	0	0	1,462	518	391	1,020	0	114	0	2,789	639	65,979
BOD (Industry)	0	231	11,234	0	0	1,654	0	189	727	0	0	858	614	3	120	0	118	0	292	72	16,111
BOD (Livestock)	2,805	25,983	13,845	2,284	5,167	2,164	4,038	32,150	553	13,067	931	8,629	8,708	1,931	63,914	9,214	4,360	10,656	33,768	7,771	251,936
BOD (Agricultural land)	448	3,094	821	250	309	98	36	1,309	15	760	221	538	847	131	3,676	529	290	171	1,081	172	14,796
BOD (Pastureland)	21	207	128	62	157	61	366	875	16	240	18	159	91	28	632	152	198	338	474	198	4,422
BOD (Shrub/Forest)	44	482	217	186	504	276	330	1,379	30	292	17	125	138	35	945	219	195	658	838	361	7,272
BOD (Household)	85	553	158	50	63	11	48	604	10	177	21	298	92	1	443	111	217	109	118	36	3,203
Total	3,402	32,548	77,260	2,831	6,200	6,467	4,857	37,714	4,094	14,536	1,207	12,068	11,006	2,520	70,750	10,225	5,492	11,932	39,360	9,249	363,719

Table B 5.3 Existing Pollution Load Generation -2/4 (COD)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
COD (Sewerage)	0	1,428	24,202	0	0	1,591	27	864	1,959	0	0	1,044	370	279	1,757	0	81	0	1,985	457	36,044
COD (Industry)	0	1,292	8,213	0	0	1,176	0	153	533	0	0	601	446	1	291	0	65	0	270	22	13,063
COD (Livestock)	2,159	20,075	10,078	1,795	4,109	1,769	3,211	24,018	401	9,633	688	6,365	6,506	1,455	48,456	6,913	3,159	7,722	25,297	5,603	189,411
COD (Agricultural land)	387	2,672	709	216	266	85	31	1,131	13	656	191	465	731	113	3,174	457	250	148	933	149	12,776
COD (Pastureland)	18	178	110	53	135	52	315	752	14	207	15	137	78	24	543	131	171	291	408	170	3,803
COD (Shrub/Forest)	290	3,190	1,436	1,230	3,335	1,824	2,183	9,119	200	1,930	111	829	912	232	6,246	1,449	1,293	4,351	5,544	2,387	48,092
COD (Household)	49	318	91	29	36	6	28	347	6	102	12	171	53	0	254	64	125	63	68	21	1,842
Total	2,903	29,153	44,840	3,322	7,882	6,503	5,795	36,385	3,125	12,528	1,017	9,612	9,095	2,106	60,722	9,014	5,143	12,574	34,506	8,808	305,030

Table B 5.3 Existing Pollution Load Generation -3/4 (T-N)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-N (Sewerage)	0	380	9,712	0	0	404	7	222	503	0	0	268	95	72	482	0	21	0	532	121	12,818
T-N (Industry)	0	45	2,275	0	0	86	0	25	707	0	0	614	48	7	80	0	14	0	585	0	4,485
T-N (Livestock)	1,039	9,725	4,307	902	2,113	1,050	1,651	10,900	170	4,240	305	2,804	2,945	671	22,835	3,179	1,342	3,280	11,736	2,360	87,552
T-N (Agricultural land)	984	6,788	1,802	548	677	215	80	2,872	32	1,667	486	1,180	1,857	287	8,065	1,160	635	375	2,370	377	32,459
T-N (Pastureland)	45	454	281	135	343	134	803	1,915	36	526	38	348	199	62	1,384	333	435	740	1,038	433	9,683
T-N (Shrub/Forest)	61	669	301	258	699	382	458	1,912	42	405	23	174	191	49	1,310	304	271	912	1,162	501	10,084
T-N (Household)	14	93	27	8	11	2	8	101	2	30	3	50	15	0	74	19	36	18	20	6	537
Total	2,143	18,154	18,704	1,852	3,843	2,273	3,006	17,948	1,491	6,868	856	5,438	5,351	1,147	34,229	4,995	2,754	5,326	17,444	3,797	157,618

Table B 5.3 Existing Pollution Load Generation -4/4 (T-P)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-P (Sewerage)	0	83	1,137	0	0	93	2	51	114	0	0	61	22	16	70	0	5	0	116	27	1,795
T-P (Industry)	0	9	545	0	0	30	0	30	22	0	0	16	9	1	10	0	2	0	58	1	732
T-P (Livestock)	262	2,409	1,447	205	450	187	352	3,201	58	1,334	95	550	496	102	3,293	519	322	1,125	2,020	828	19,254
T-P (Agricultural land)	11	73	19	6	7	2	1	31	0	18	5	13	20	3	87	12	7	4	25	4	349
T-P (Pastureland)	2	23	14	7	17	7	40	96	2	26	2	17	10	3	70	17	22	37	52	22	486
T-P (Shrub/Forest)	5	53	24	20	55	30	36	151	3	32	2	14	15	4	103	24	21	72	92	39	795
T-P (Household)	2	15	4	1	2	0	1	16	0	5	1	8	2	0	12	3	6	3	3	1	86
Total	282	2,665	3,190	239	531	349	432	3,576	200	1,415	104	678	574	129	3,644	575	385	1,241	2,367	923	23,498

Table B 5.4 2007 Without Project Pollution Load Generation -1/4 (BOD)

(Unit :kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
BOD (Sewerage)	0	3,252	53,249	0	406	5,198	97	1,597	3,881	0	0	1,849	1,200	564	1,559	0	174	0	4,279	1,015	78,320
BOD (Industry)	0	287	24,776	0	30	92	0	206	339	0	0	1,262	279	4	183	0	145	0	412	47	28,063
BOD (Livestock)	2,805	25,983	13,845	2,284	5,167	2,164	4,038	32,150	553	13,067	931	8,629	8,708	1,931	63,914	9,214	4,360	10,656	33,768	7,771	251,936
BOD (Agricultural land)	448	3,094	821	250	309	98	36	1,309	15	760	221	538	847	131	3,676	529	290	171	1,081	172	14,796
BOD (Pastureland)	21	207	128	62	157	61	366	875	16	240	18	159	91	28	632	152	198	338	474	198	4,422
BOD (Shrub/Forest)	44	482	217	186	504	276	330	1,379	30	292	17	125	138	35	945	219	195	658	838	361	7,272
BOD (Household)	85	553	158	50	63	11	48	604	10	177	21	298	92	1	443	111	217	109	118	36	3,203
Total	3,402	33,858	93,195	2,831	6,636	7,900	4,916	38,119	4,844	14,536	1,207	12,860	11,354	2,694	71,352	10,225	5,580	11,932	40,970	9,600	388,012

Table B 5.4 2007 Without Project Pollution Load Generation -2/4 (COD)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
COD (Sewerage)	0	2,324	29,248	0	290	3,707	69	1,141	2,746	0	0	1,321	889	415	1,045	0	125	0	2,875	725	46,919
COD (Industry)	0	1,712	18,899	0	21	67	0	169	301	0	0	963	169	1	117	0	80	0	371	34	22,903
COD (Livestock)	2,159	20,075	10,078	1,795	4,109	1,769	3,211	24,018	401	9,633	688	6,365	6,506	1,455	48,456	6,913	3,159	7,722	25,297	5,603	189,411
COD (Agricultural land)	387	2,672	709	216	266	85	31	1,131	13	656	191	465	731	113	3,174	457	250	148	933	149	12,776
COD (Pastureland)	18	178	110	53	135	52	315	752	14	207	15	137	78	24	543	131	171	291	408	170	3,803
COD (Shrub/Forest)	290	3,190	1,436	1,230	3,335	1,824	2,183	9,119	200	1,930	111	829	912	232	6,246	1,449	1,293	4,351	5,544	2,387	48,092
COD (Household)	49	318	91	29	36	6	28	347	6	102	12	171	53	0	254	64	125	63	68	21	1,842
Total	2,903	30,468	60,572	3,322	8,193	7,510	5,837	36,677	3,680	12,528	1,017	10,250	9,338	2,241	59,837	9,014	5,202	12,574	35,496	9,089	325,746

Table B 5.4 2007 Without Project Pollution Load Generation -3/4 (T-N)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-N (Sewerage)	0	617	11,538	0	74	621	18	293	520	0	0	330	130	105	306	0	32	0	813	192	15,588
T-N (Industry)	0	462	4,712	0	11	103	0	40	328	0	0	1,084	59	37	36	0	17	0	322	23	7,234
T-N (Livestock)	1,039	9,725	4,307	902	2,113	1,050	1,651	10,900	170	4,240	305	2,804	2,945	671	22,835	3,179	1,342	3,280	11,736	2,360	87,552
T-N (Agricultural land)	984	6,788	1,802	548	677	215	80	2,872	32	1,667	486	1,180	1,857	287	8,065	1,160	635	375	2,370	377	32,459
T-N (Pastureland)	45	454	281	135	343	134	803	1,915	36	526	38	348	199	62	1,384	333	435	740	1,038	433	9,683
T-N (Shrub/Forest)	61	669	301	258	699	382	458	1,912	42	405	23	174	191	49	1,310	304	271	912	1,162	501	10,084
T-N (Household)	14	93	27	8	11	2	8	101	2	30	3	50	15	0	74	19	36	18	20	6	537
Total	2,143	18,808	22,967	1,852	3,929	2,508	3,017	18,033	1,129	6,868	856	5,969	5,397	1,210	34,009	4,995	2,768	5,326	17,462	3,891	163,137

Table B 5.4 2007 Without Project Pollution Load Generation -4/4 (T-P)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-P (Sewerage)	0	135	2,011	0	17	170	4	64	145	0	0	77	40	30	59	0	7	0	170	42	2,972
T-P (Industry)	0	19	1,876	0	2	2	0	5	27	0	0	22	1	1	7	0	3	0	24	2	1,990
T-P (Livestock)	262	2,409	1,447	205	450	187	352	3,201	58	1,334	95	550	496	102	3,293	519	322	1,125	2,020	828	19,254
T-P (Agricultural land)	11	73	19	6	7	2	1	31	0	18	5	13	20	3	87	12	7	4	25	4	349
T-P (Pastureland)	2	23	14	7	17	7	40	96	2	26	2	17	10	3	70	17	22	37	52	22	486
T-P (Shrub/Forest)	5	53	24	20	55	30	36	151	3	32	2	14	15	4	103	24	21	72	92	39	795
T-P (Household)	2	15	4	1	2	0	1	16	0	5	1	8	2	0	12	3	6	3	3	1	86
Total	282	2,727	5,395	239	551	398	434	3,564	235	1,415	104	701	584	143	3,630	575	388	1,241	2,387	939	25,932

Table B 5.5 2015 Without Project Pollution Load Generation -1/4 (BOD)

(Unit :kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
BOD (Sewerage)	0	6,313	75,864	0	825	7,994	158	2,274	4,572	0	0	4,160	1,686	820	2,235	0	432	0	5,627	1,470	114,430
BOD (Industry)	0	235	17,149	0	7	3	0	30	484	0	0	0	346	5	263	0	0	0	577	68	19,166
BOD (Livestock)	2,805	25,983	13,845	2,284	5,167	2,164	4,038	32,150	553	13,067	931	8,629	8,708	1,931	63,914	9,214	4,360	10,656	33,768	7,771	251,936
BOD (Agricultural land)	448	3,094	821	250	309	98	36	1,309	15	760	221	538	847	131	3,676	529	290	171	1,081	172	14,796
BOD (Pastureland)	21	207	128	62	157	61	366	875	16	240	18	159	91	28	632	152	198	338	474	198	4,422
BOD (Shrub/Forest)	44	482	217	186	504	276	330	1,379	30	292	17	125	138	35	945	219	195	658	838	361	7,272
BOD (Household)	85	553	158	50	63	11	48	604	10	177	21	298	92	1	443	111	217	109	118	36	3,203
Total	3,402	36,867	108,183	2,831	7,032	10,607	4,977	38,621	5,680	14,536	1,207	13,909	11,906	2,951	72,108	10,225	5,692	11,932	42,483	10,075	415,226

Table B 5.5 2015 Without Project Pollution Load Generation -2/4 (COD)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
COD (Sewerage)	0	5,803	36,680	0	579	5,699	113	1,621	3,257	0	0	3,050	1,247	594	1,568	0	276	0	4,029	1,050	65,567
COD (Industry)	0	168	10,616	0	12	4	0	42	400	0	0	0	216	2	182	0	0	0	514	48	12,203
COD (Livestock)	2,159	20,075	10,078	1,795	4,109	1,769	3,211	24,018	401	9,633	688	6,365	6,506	1,455	48,456	6,913	3,159	7,722	25,297	5,603	189,411
COD (Agricultural land)	387	2,672	709	216	266	85	31	1,131	13	656	191	465	731	113	3,174	457	250	148	933	149	12,776
COD (Pastureland)	18	178	110	53	135	52	315	752	14	207	15	137	78	24	543	131	171	291	408	170	3,803
COD (Shrub/Forest)	290	3,190	1,436	1,230	3,335	1,824	2,183	9,119	200	1,930	111	829	912	232	6,246	1,449	1,293	4,351	5,544	2,387	48,092
COD (Household)	49	318	91	29	36	6	28	347	6	102	12	171	53	0	254	64	125	63	68	21	1,842
Total	2,903	32,403	59,721	3,322	8,473	9,439	5,881	37,030	4,290	12,528	1,017	11,017	9,742	2,421	60,424	9,014	5,274	12,574	36,794	9,428	333,693

Table B 5.5 2015 Without Project Pollution Load Generation -3/4 (T-N)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-N (Sewerage)	0	1,550	14,309	0	159	1,100	29	383	892	0	0	1,891	262	180	439	0	66	0	1,125	278	22,661
T-N (Industry)	0	46	3,699	0	6	5	0	26	1,138	0	0	0	9	11	52	0	0	0	436	13	5,441
T-N (Livestock)	1,039	9,725	4,307	902	2,113	1,050	1,651	10,900	170	4,240	305	2,804	2,945	671	22,835	3,179	1,342	3,280	11,736	2,360	87,552
T-N (Agricultural land)	984	6,788	1,802	548	677	215	80	2,872	32	1,667	486	1,180	1,857	287	8,065	1,160	635	375	2,370	377	32,459
T-N (Pastureland)	45	454	281	135	343	134	803	1,915	36	526	38	348	199	62	1,384	333	435	740	1,038	433	9,683
T-N (Shrub/Forest)	61	669	301	258	699	382	458	1,912	42	405	23	174	191	49	1,310	304	271	912	1,162	501	10,084
T-N (Household)	14	93	27	8	11	2	8	101	2	30	3	50	15	0	74	19	36	18	20	6	537
Total	2,143	19,325	24,725	1,852	4,008	2,888	3,028	18,109	2,312	6,868	856	6,446	5,479	1,259	34,157	4,995	2,785	5,326	17,888	3,968	168,416

Table B 5.5 2015 Without Project Pollution Load Generation -4/4 (T-P)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-P (Sewerage)	0	230	1,745	0	36	268	7	90	176	0	0	133	57	39	85	0	14	0	239	61	3,178
T-P (Industry)	0	10	866	0	1	1	0	2	35	0	0	0	1	2	9	0	0	0	33	3	964
T-P (Livestock)	262	2,409	1,447	205	450	187	352	3,201	58	1,334	95	550	496	102	3,293	519	322	1,125	2,020	828	19,254
T-P (Agricultural land)	11	73	19	6	7	2	1	31	0	18	5	13	20	3	87	12	7	4	25	4	349
T-P (Pastureland)	2	23	14	7	17	7	40	96	2	26	2	17	10	3	70	17	22	37	52	22	486
T-P (Shrub/Forest)	5	53	24	20	55	30	36	151	3	32	2	14	15	4	103	24	21	72	92	39	795
T-P (Household)	2	15	4	1	2	0	1	16	0	5	1	8	2	0	12	3	6	3	3	1	86
Total	282	2,813	4,120	239	568	494	437	3,587	276	1,415	104	734	601	152	3,658	575	391	1,241	2,465	959	25,112

Table B 5.6 2007 With Project Pollution Load Generation -1/4 (BOD)

(Unit :kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
BOD (Sewerage)	0	3,251	10,884	0	406	2,812	97	1,596	2,037	0	0	1,179	440	564	1,559	0	174	0	2,889	1,015	28,903
BOD (Industry)	0	1,062	168	0	30	92	0	221	339	0	0	1,262	12	4	183	0	145	0	412	47	3,977
BOD (Livestock)	2,805	25,983	13,845	2,284	5,167	2,164	4,038	32,150	553	13,067	931	8,629	8,708	1,931	63,914	9,214	4,360	10,656	33,768	7,771	251,936
BOD (Agricultural land)	448	3,094	821	250	309	98	36	1,309	15	760	221	538	847	131	3,676	529	290	171	1,081	172	14,796
BOD (Pastureland)	21	207	128	62	157	61	366	875	16	240	18	159	91	28	632	152	198	338	474	198	4,422
BOD (Shrub/Forest)	44	482	217	186	504	276	330	1,379	30	292	17	125	138	35	945	219	195	658	838	361	7,272
BOD (Household)	85	553	158	50	63	11	48	604	10	177	21	298	92	1	443	111	217	109	118	36	3,203
Total	3,402	34,632	26,222	2,831	6,636	5,514	4,916	38,133	3,000	14,536	1,207	12,190	10,327	2,694	71,352	10,225	5,579	11,932	39,580	9,600	314,509

Table B 5.6 2007 With Project Pollution Load Generation -2/4 (COD)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
COD (Sewerage)	0	2,324	17,670	0	290	1,677	69	1,141	1,212	0	0	938	432	415	1,045	0	125	0	2,271	726	30,335
COD (Industry)	0	1,725	177	0	26	67	0	169	301	0	0	963	11	1	117	0	80	0	371	0	4,007
COD (Livestock)	2,159	20,075	10,078	1,795	4,109	1,769	3,211	24,018	401	9,633	688	6,365	6,506	1,455	48,456	6,913	3,159	7,722	25,297	5,603	189,411
COD (Agricultural land)	387	2,672	709	216	266	85	31	1,131	13	656	191	465	731	113	3,174	457	250	148	933	149	12,776
COD (Pastureland)	18	178	110	53	135	52	315	752	14	207	15	137	78	24	543	131	171	291	408	170	3,803
COD (Shrub/Forest)	290	3,190	1,436	1,230	3,335	1,824	2,183	9,119	200	1,930	111	829	912	232	6,246	1,449	1,293	4,351	5,544	2,387	48,092
COD (Household)	49	318	91	29	36	6	28	347	6	102	12	171	53	0	254	64	125	63	68	21	1,842
Total	2,903	30,481	30,272	3,322	8,198	5,480	5,837	36,677	2,146	12,528	1,017	9,868	8,723	2,241	59,837	9,014	5,202	12,574	34,892	9,055	290,265

Table B 5.6 2007 With Project Pollution Load Generation -3/4 (T-N)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-N (Sewerage)	0	617	7,031	0	74	581	18	293	424	0	0	254	127	145	315	0	32	0	645	192	10,747
T-N (Industry)	0	468	0	0	14	13	0	30	257	0	0	1,084	7	9	37	0	17	0	322	9	2,266
T-N (Livestock)	1,039	9,725	4,307	902	2,113	1,050	1,651	10,900	170	4,240	305	2,804	2,945	671	22,835	3,179	1,342	3,280	11,736	2,360	87,552
T-N (Agricultural land)	984	6,788	1,802	548	677	215	80	2,872	32	1,667	486	1,180	1,857	287	8,065	1,160	635	375	2,370	377	32,459
T-N (Pastureland)	45	454	281	135	343	134	803	1,915	36	526	38	348	199	62	1,384	333	435	740	1,038	433	9,683
T-N (Shrub/Forest)	61	669	301	258	699	382	458	1,912	42	405	23	174	191	49	1,310	304	271	912	1,162	501	10,084
T-N (Household)	14	93	27	8	11	2	8	101	2	30	3	50	15	0	74	19	36	18	20	6	537
Total	2,143	18,814	13,748	1,852	3,932	2,377	3,017	18,023	962	6,868	856	5,893	5,342	1,222	34,019	4,995	2,768	5,326	17,293	3,878	153,327

Table B 5.6 2007 With Project Pollution Load Generation -4/4 (T-P)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-P (Sewerage)	0	136	1,177	0	17	94	4	67	68	0	0	53	23	30	59	0	7	0	128	33	1,894
T-P (Industry)	0	20	15	0	2	2	0	5	27	0	0	22	1	1	7	0	3	0	24	1	129
T-P (Livestock)	262	2,409	1,447	205	450	187	352	3,201	58	1,334	95	550	496	102	3,293	519	322	1,125	2,020	828	19,254
T-P (Agricultural land)	11	73	19	6	7	2	1	31	0	18	5	13	20	3	87	12	7	4	25	4	349
T-P (Pastureland)	2	23	14	7	17	7	40	96	2	26	2	17	10	3	70	17	22	37	52	22	486
T-P (Shrub/Forest)	5	53	24	20	55	30	36	151	3	32	2	14	15	4	103	24	21	72	92	39	795
T-P (Household)	2	15	4	1	2	0	1	16	0	5	1	8	2	0	12	3	6	3	3	1	86
Total	282	2,728	2,701	239	551	322	434	3,566	159	1,415	104	676	567	143	3,630	575	388	1,241	2,345	928	22,994

Table B 5.7 2015 With Project Pollution Load Generation -1/4 (BOD)

(Unit :kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
BOD (Sewerage)	0	578	12,030	0	113	968	33	390	559	0	0	358	259	145	251	0	79	0	455	195	16,412
BOD (Industry)	0	11	79	0	7	3	0	30	453	0	0	0	3	5	42	0	0	0	209	3	844
BOD (Livestock)	2,805	25,983	13,845	2,284	5,167	2,164	4,038	32,150	553	13,067	931	8,629	8,708	1,931	63,914	9,214	4,360	10,656	33,768	7,771	251,936
BOD (Agricultural land)	448	3,094	821	250	309	98	36	1,309	15	760	221	538	847	131	3,676	529	290	171	1,081	172	14,796
BOD (Pastureland)	21	207	128	62	157	61	366	875	16	240	18	159	91	28	632	152	198	338	474	198	4,422
BOD (Shrub/Forest)	44	482	217	186	504	276	330	1,379	30	292	17	125	138	35	945	219	195	658	838	361	7,272
BOD (Household)	85	553	158	50	63	11	48	604	10	177	21	298	92	1	443	111	217	109	118	36	3,203
Total	3,402	30,909	27,279	2,831	6,319	3,581	4,851	36,737	1,637	14,536	1,207	10,107	10,137	2,276	69,902	10,225	5,339	11,932	36,943	8,736	298,886

Table B 5.7 2015 With Project Pollution Load Generation -2/4 (COD)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
COD (Sewerage)	0	915	21,483	0	201	1,723	44	603	999	0	0	639	421	259	179	0	106	0	619	241	28,429
COD (Industry)	0	8	146	0	12	4	0	42	400	0	0	0	6	2	30	0	0	0	251	2	901
COD (Livestock)	2,159	20,075	10,078	1,795	4,109	1,769	3,211	24,018	401	9,633	688	6,365	6,506	1,455	48,456	6,913	3,159	7,722	25,297	5,603	189,411
COD (Agricultural land)	387	2,672	709	216	266	85	31	1,131	13	656	191	465	731	113	3,174	457	250	148	933	149	12,776
COD (Pastureland)	18	178	110	53	135	52	315	752	14	207	15	137	78	24	543	131	171	291	408	170	3,803
COD (Shrub/Forest)	290	3,190	1,436	1,230	3,335	1,824	2,183	9,119	200	1,930	111	829	912	232	6,246	1,449	1,293	4,351	5,544	2,387	48,092
COD (Household)	49	318	91	29	36	6	28	347	6	102	12	171	53	0	254	64	125	63	68	21	1,842
Total	2,903	27,355	34,053	3,322	8,095	5,462	5,811	36,012	2,032	12,528	1,017	8,606	8,706	2,086	58,883	9,014	5,103	12,574	33,120	8,573	285,253

Table B 5.7 2015 With Project Pollution Load Generation -3/4 (T-N)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-N (Sewerage)	0	345	8,847	0	68	580	16	213	336	0	0	278	147	87	201	0	39	0	309	107	11,573
T-N (Industry)	0	6	0	0	6	5	0	26	689	0	0	0	4	11	33	0	0	0	375	3	1,158
T-N (Livestock)	1,039	9,725	4,307	902	2,113	1,050	1,651	10,900	170	4,240	305	2,804	2,945	671	22,835	3,179	1,342	3,280	11,736	2,360	87,552
T-N (Agricultural land)	984	6,788	1,802	548	677	215	80	2,872	32	1,667	486	1,180	1,857	287	8,065	1,160	635	375	2,370	377	32,459
T-N (Pastureland)	45	454	281	135	343	134	803	1,915	36	526	38	348	199	62	1,384	333	435	740	1,038	433	9,683
T-N (Shrub/Forest)	61	669	301	258	699	382	458	1,912	42	405	23	174	191	49	1,310	304	271	912	1,162	501	10,084
T-N (Household)	14	93	27	8	11	2	8	101	2	30	3	50	15	0	74	19	36	18	20	6	537
Total	2,143	18,080	15,565	1,852	3,917	2,368	3,016	17,940	1,306	6,868	856	4,834	5,359	1,167	33,901	4,995	2,759	5,326	17,011	3,786	153,045

Table B 5.7 2015 With Project Pollution Load Generation -4/4 (T-P)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-P (Sewerage)	0	46	1,432	0	9	78	3	36	45	0	0	41	23	0	30	0	2	0	44	20	1,808
T-P (Industry)	0	1	12	0	1	1	0	2	35	0	0	0	1	0	5	0	0	0	19	0	78
T-P (Livestock)	262	2,409	1,447	205	450	187	352	3,201	58	1,334	95	550	496	102	3,293	519	322	1,125	2,020	828	19,254
T-P (Agricultural land)	11	73	19	6	7	2	1	31	0	18	5	13	20	3	87	12	7	4	25	4	349
T-P (Pastureland)	2	23	14	7	17	7	40	96	2	26	2	17	10	3	70	17	22	37	52	22	486
T-P (Shrub/Forest)	5	53	24	20	55	30	36	151	3	32	2	14	15	4	103	24	21	72	92	39	795
T-P (Household)	2	15	4	1	2	0	1	16	0	5	1	8	2	0	12	3	6	3	3	1	86
Total	282	2,620	2,953	239	542	304	433	3,533	144	1,415	104	643	567	112	3,599	575	380	1,241	2,256	915	22,857

Table B 6.1 Existing Pollution Load Runoff -1/4 (BOD)

(Unit :kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
BOD (Sewerage)	0	1,858	48,736	0	0	2,182	26	1,161	2,717	0	0	1,395	438	384	592	0	52	0	1,468	267	61,276
BOD (Industry)	0	170	10,772	0	0	1,639	0	185	727	0	0	826	591	3	67	0	54	0	126	33	15,193
BOD (Livestock)	44	432	265	248	469	1,916	333	2,723	553	1,260	16	131	96	33	562	81	60	646	133	89	10,090
BOD (Agricultural land)	7	51	16	27	28	10	10	111	15	73	4	8	9	2	32	5	4	10	4	2	430
BOD (Pastureland)	0	3	3	7	14	6	30	74	16	23	1	2	1	0	6	1	3	20	2	2	218
BOD (Shrub/Forest)	1	8	4	20	46	28	27	117	30	28	0	2	2	1	8	1	3	40	3	4	373
BOD (Household)	1	9	3	5	6	6	4	51	10	17	0	5	1	0	4	1	3	7	0	0	134
Total	53	2,533	59,799	308	563	5,788	430	4,422	4,068	1,402	22	2,368	1,138	423	1,271	89	178	723	1,736	398	87,714

Table B 6.1 Existing Pollution Load Runoff -2/4 (COD)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
COD (Sewerage)	0	1,503	23,626	0	0	1,582	22	845	1,948	0	0	1,017	338	276	1,253	0	56	0	2,860	583	35,910
COD (Industry)	0	176	8,017	0	0	1,170	0	151	530	0	0	588	436	1	157	0	45	0	273	20	11,563
COD (Livestock)	133	1,270	688	238	495	226	369	3,744	55	1,197	44	384	339	93	2,305	329	181	775	1,567	296	14,730
COD (Agricultural land)	24	169	48	29	32	11	4	132	2	82	12	28	38	7	151	22	14	15	58	8	885
COD (Pastureland)	1	11	8	7	16	7	36	88	2	26	1	8	4	2	26	6	10	29	25	9	321
COD (Shrub/Forest)	18	202	98	163	402	234	251	1,062	27	240	7	50	47	15	297	69	74	437	344	126	4,162
COD (Household)	5	20	6	4	4	1	3	40	1	13	1	10	3	0	12	3	35	6	4	1	174
Total	180	3,351	32,491	440	950	3,230	685	6,061	2,565	1,557	66	2,085	1,205	394	4,201	429	415	1,262	5,132	1,043	67,745

Table B 6.1 Existing Pollution Load Runoff -3/4 (T-N)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-N (Sewerage)	0	380	9,712	0	0	404	7	222	503	0	0	268	95	72	482	0	21	0	532	121	12,818
T-N (Industry)	0	45	2,275	0	0	86	0	25	707	0	0	614	48	7	80	0	14	0	585	0	4,485
T-N (Livestock)	31	292	129	162	380	189	297	1,962	31	763	9	84	88	20	685	95	40	590	352	71	6,273
T-N (Agricultural land)	30	204	54	99	122	39	14	517	6	300	15	35	56	9	242	35	19	68	71	11	1,944
T-N (Pastureland)	1	14	14	24	62	24	24	345	6	95	1	10	6	2	42	10	13	133	31	13	870
T-N (Shrub/Forest)	2	20	9	46	126	69	69	344	8	73	1	5	6	1	39	9	8	164	35	15	1,049
T-N (Household)	0	3	1	1	2	0	1	18	0	5	0	2	0	0	2	1	6	3	1	0	48
Total	64	957	12,194	333	692	810	413	3,433	1,260	1,236	26	1,019	299	111	1,572	150	121	959	1,607	231	27,487

Table B 6.1 Existing Pollution Load Runoff -4/4 (T-P)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-P (Sewerage)	0	83	1,137	0	0	93	2	51	114	0	0	61	22	16	70	0	5	0	116	27	1,795
T-P (Industry)	0	9	545	0	0	30	0	30	22	0	0	16	9	1	10	0	2	0	58	1	732
T-P (Livestock)	3	24	14	12	27	11	21	192	3	80	1	6	5	1	33	5	3	68	20	8	538
T-P (Agricultural land)	0	1	0	0	0	0	0	2	0	1	0	0	0	0	1	0	0	0	0	0	7
T-P (Pastureland)	0	0	0	0	1	0	2	6	0	2	0	0	0	0	1	0	0	2	1	0	16
T-P (Shrub/Forest)	0	1	0	1	3	2	2	9	2	2	0	0	0	0	1	0	0	4	1	0	30
T-P (Household)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Total	3	118	1,696	14	32	136	27	290	141	85	1	82	36	19	116	6	11	74	196	37	3,120

Table B 6.2 2007 Without Project Pollution Load Runoff -1/4 (BOD)

(Unit :kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
BOD (Sewerage)	0	2,792	51,038	0	307	5,142	67	1,526	3,845	0	0	1,765	1,057	554	905	0	80	0	2,264	439	71,780
BOD (Industry)	0	195	23,748	0	24	91	0	202	339	0	0	1,215	269	4	103	0	66	0	160	0	26,414
BOD (Livestock)	44	432	265	248	469	1,916	333	2,723	553	1,260	16	131	96	33	562	81	60	646	133	89	10,090
BOD (Agricultural land)	7	51	16	27	28	10	10	111	15	73	4	8	9	2	32	5	4	10	4	2	430
BOD (Pastureland)	0	3	3	7	14	6	30	74	16	23	1	2	1	0	6	1	3	20	2	2	218
BOD (Shrub/Forest)	1	8	4	20	46	28	27	117	30	28	0	2	2	1	8	1	3	40	3	4	373
BOD (Household)	1	9	3	5	6	6	4	51	10	17	0	5	1	0	4	1	3	7	0	0	134
Total	53	3,491	75,077	308	894	7,199	471	4,804	4,808	1,402	22	3,128	1,435	593	1,619	89	218	723	2,566	537	109,439

Table B 6.2 2007 Without Project Pollution Load Runoff -2/4 (COD)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
COD (Sewerage)	0	2,193	28,554	0	250	3,684	57	1,112	2,732	0	0	1,286	830	410	800	0	86	0	4,123	913	47,030
COD (Industry)	0	1,641	18,446	0	18	66	0	166	299	0	0	942	165	1	17	0	55	0	376	30	22,225
COD (Livestock)	133	1,270	688	238	495	226	369	3,744	55	1,197	44	384	339	93	2,305	329	181	775	1,567	296	14,730
COD (Agricultural land)	24	169	48	29	32	11	4	132	2	82	12	28	38	7	151	22	14	15	58	8	885
COD (Pastureland)	1	11	8	7	16	7	36	88	2	26	1	8	4	2	26	6	10	29	25	9	321
COD (Shrub/Forest)	18	202	98	163	402	234	251	1,062	27	240	7	50	47	15	297	69	74	437	344	126	4,162
COD (Household)	5	20	6	4	4	1	3	40	1	13	1	10	3	0	12	3	35	6	4	1	174
Total	180	5,507	47,849	440	1,218	4,229	720	6,344	3,118	1,557	66	2,709	1,427	528	3,609	429	455	1,262	6,497	1,383	89,526

Table B 6.2 2007 Without Project Pollution Load Runoff -3/4 (T-N)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-N (Sewerage)	0	617	11,538	0	74	621	18	293	520	0	0	330	130	105	306	0	32	0	813	192	15,588
T-N (Industry)	0	462	4,712	0	11	103	0	40	328	0	0	1,084	59	37	36	0	17	0	322	23	7,234
T-N (Livestock)	31	292	129	162	380	189	297	1,962	31	763	9	84	88	20	685	95	40	590	352	71	6,273
T-N (Agricultural land)	30	204	54	99	122	39	14	517	6	300	15	35	56	9	242	35	19	68	71	11	1,944
T-N (Pastureland)	1	14	14	24	62	24	24	345	6	95	1	10	6	2	42	10	13	133	31	13	870
T-N (Shrub/Forest)	2	20	9	46	126	69	69	344	8	73	1	5	6	1	39	9	8	164	35	15	1,049
T-N (Household)	0	3	1	1	2	0	1	18	0	5	0	2	0	0	2	1	6	3	1	0	48
Total	64	1,611	16,457	333	777	1,045	424	3,519	898	1,236	26	1,550	346	174	1,352	150	135	959	1,625	325	33,006

Table B 6.2 2007 Without ProjectPollution Load Runoff -4/4 (T-P)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-P (Sewerage)	0	135	2,011	0	17	170	4	64	145	0	0	77	40	30	59	0	7	0	170	42	2,972
T-P (Industry)	0	19	1,876	0	2	2	0	5	27	0	0	22	1	1	7	0	3	0	24	2	1,990
T-P (Livestock)	3	24	14	12	27	11	21	192	3	80	1	6	5	1	33	5	3	68	20	8	538
T-P (Agricultural land)	0	1	0	0	0	0	0	2	0	1	0	0	0	0	1	0	0	0	0	0	7
T-P (Pastureland)	0	0	0	0	1	0	2	6	0	2	0	0	0	0	1	0	0	2	1	0	16
T-P (Shrub/Forest)	0	1	0	1	3	2	2	9	2	2	0	0	0	0	1	0	0	4	1	0	30
T-P (Household)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Total	3	180	3,901	14	51	186	30	278	177	85	1	105	46	33	102	6	14	74	216	53	5,555

Table B 6.3 2015 Without Project Pollution Load Runoff -1/4 (BOD)

(Unit :kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
BOD (Sewerage)	0	5,429	72,712	0	625	7,904	109	2,176	4,529	0	0	3,984	1,484	805	1,298	0	198	0	2,755	640	104,648
BOD (Industry)	0	105	16,429	0	5	3	0	27	484	0	0	0	333	5	147	0	0	0	216	0	17,754
BOD (Livestock)	44	432	265	248	469	1,916	333	2,723	553	1,260	16	131	96	33	562	81	60	646	133	89	10,090
BOD (Agricultural land)	7	51	16	27	28	10	10	111	15	73	4	8	9	2	32	5	4	10	4	2	430
BOD (Pastureland)	0	3	3	7	14	6	30	74	16	23	1	2	1	0	6	1	3	20	2	2	218
BOD (Shrub/Forest)	1	8	4	20	46	28	27	117	30	28	0	2	2	1	8	1	3	40	3	4	373
BOD (Household)	1	9	3	5	6	6	4	51	10	17	0	5	1	0	4	1	3	7	0	0	134
Total	53	6,039	89,433	308	1,193	9,873	513	5,279	5,637	1,402	22	4,131	1,926	846	2,057	89	270	723	3,114	738	133,647

Table B 6.3 2015 Without Project Pollution Load Runoff -2/4 (COD)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
COD (Sewerage)	0	5,394	35,811	0	499	5,663	93	1,582	3,239	0	0	2,977	1,164	588	1,194	0	191	0	5,768	1,313	65,474
COD (Industry)	0	84	10,362	0	10	3	0	39	398	0	0	0	211	2	34	0	0	0	522	43	11,709
COD (Livestock)	133	1,270	688	238	495	226	369	3,744	55	1,197	44	384	339	93	2,305	329	181	775	1,567	296	14,730
COD (Agricultural land)	24	169	48	29	32	11	4	132	2	82	12	28	38	7	151	22	14	15	58	8	885
COD (Pastureland)	1	11	8	7	16	7	36	88	2	26	1	8	4	2	26	6	10	29	25	9	321
COD (Shrub/Forest)	18	202	98	163	402	234	251	1,062	27	240	7	50	47	15	297	69	74	437	344	126	4,162
COD (Household)	5	20	6	4	4	1	3	40	1	13	1	10	3	0	12	3	35	6	4	1	174
Total	180	7,151	47,021	440	1,459	6,144	756	6,686	3,725	1,557	66	3,457	1,806	706	4,019	429	505	1,262	8,289	1,796	97,455

Table B 6.3 2015 Without Project Pollution Load Runoff -3/4 (T-N)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-N (Sewerage)	0	1,550	14,309	0	159	1,100	29	383	892	0	0	1,891	262	180	439	0	66	0	1,125	278	22,661
T-N (Industry)	0	46	3,699	0	6	5	0	26	1,138	0	0	0	9	11	52	0	0	0	436	13	5,441
T-N (Livestock)	31	292	129	162	380	189	297	1,962	31	763	9	84	88	20	685	95	40	590	352	71	6,273
T-N (Agricultural land)	30	204	54	99	122	39	14	517	6	300	15	35	56	9	242	35	19	68	71	11	1,944
T-N (Pastureland)	1	14	14	24	62	24	24	345	6	95	1	10	6	2	42	10	13	133	31	13	870
T-N (Shrub/Forest)	2	20	9	46	126	69	69	344	8	73	1	5	6	1	39	9	8	164	35	15	1,049
T-N (Household)	0	3	1	1	2	0	1	18	0	5	0	2	0	0	2	1	6	3	1	0	48
Total	64	2,128	18,215	333	856	1,426	435	3,594	2,081	1,236	26	2,027	427	223	1,500	150	152	959	2,051	402	38,285

Table B 6.3 2015 Without Project Pollution Load Runoff -4/4 (T-P)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-P (Sewerage)	0	230	1,745	0	36	268	7	90	176	0	0	133	57	39	85	0	14	0	239	61	3,178
T-P (Industry)	0	10	866	0	1	1	0	2	35	0	0	0	1	2	9	0	0	0	33	3	964
T-P (Livestock)	3	24	14	12	27	11	21	192	3	80	1	6	5	1	33	5	3	68	20	8	538
T-P (Agricultural land)	0	1	0	0	0	0	0	2	0	1	0	0	0	0	1	0	0	0	0	0	7
T-P (Pastureland)	0	0	0	0	1	0	2	6	0	2	0	0	0	0	1	0	0	2	1	0	16
T-P (Shrub/Forest)	0	1	0	1	3	2	2	9	2	2	0	0	0	0	1	0	0	4	1	0	30
T-P (Household)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Total	3	266	2,626	14	69	282	32	301	217	85	1	139	63	42	130	6	17	74	294	73	4,735

Table B 6.4 2007 With Project Pollution Load Runoff -1/4 (BOD)

(Unit :kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
BOD (Sewerage)	0	2,791	10,453	0	307	2,778	67	1,526	2,018	0	0	1,133	325	554	905	0	80	0	926	439	24,301
BOD (Industry)	0	959	164	0	24	91	0	215	339	0	0	1,215	12	4	103	0	66	0	160	0	3,350
BOD (Livestock)	44	432	265	248	469	1,916	333	2,723	553	1,260	16	131	96	33	562	81	60	646	133	89	10,090
BOD (Agricultural land)	7	51	16	27	28	10	10	111	15	73	4	8	9	2	32	5	4	10	4	2	430
BOD (Pastureland)	0	3	3	7	14	6	30	74	16	23	1	2	1	0	6	1	3	20	2	2	218
BOD (Shrub/Forest)	1	8	4	20	46	28	27	117	30	28	0	2	2	1	8	1	3	40	3	4	373
BOD (Household)	1	9	3	5	6	6	4	51	10	17	0	5	1	0	4	1	3	7	0	0	134
Total	53	4,255	10,908	308	894	4,836	471	4,817	2,981	1,402	22	2,495	446	594	1,619	89	218	723	1,228	537	38,895

Table B 6.4 2007 With Project Pollution Load Runoff -2/4 (COD)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
COD (Sewerage)	0	2,193	17,254	0	250	1,665	57	1,112	1,206	0	0	917	382	410	800	0	86	0	3,181	913	30,426
COD (Industry)	0	1,653	174	0	22	66	0	166	299	0	0	942	11	1	17	0	55	0	376	0	3,785
COD (Livestock)	133	1,270	688	238	495	226	369	3,744	55	1,197	44	384	339	93	2,305	329	181	775	1,567	296	14,730
COD (Agricultural land)	24	169	48	29	32	11	4	132	2	82	12	28	38	7	151	22	14	15	58	8	885
COD (Pastureland)	1	11	8	7	16	7	36	88	2	26	1	8	4	2	26	6	10	29	25	9	321
COD (Shrub/Forest)	18	202	98	163	402	234	251	1,062	27	240	7	50	47	15	297	69	74	437	344	126	4,162
COD (Household)	5	20	6	4	4	1	3	40	1	13	1	10	3	0	12	3	35	6	4	1	174
Total	180	5,519	18,277	440	1,222	2,210	720	6,344	1,592	1,557	66	2,339	825	528	3,609	429	456	1,262	5,555	1,353	54,482

Table B 6.4 2007 With Project Pollution Load Runoff -3/4 (T-N)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-N (Sewerage)	0	617	7,031	0	74	581	18	293	424	0	0	254	127	145	315	0	32	0	645	192	10,747
T-N (Industry)	0	468	0	0	14	13	0	30	257	0	0	1,084	7	9	37	0	17	0	322	9	2,266
T-N (Livestock)	31	292	129	162	380	189	297	1,962	31	763	9	84	88	20	685	95	40	590	352	71	6,273
T-N (Agricultural land)	30	204	54	99	122	39	14	517	6	300	15	35	56	9	242	35	19	68	71	11	1,944
T-N (Pastureland)	1	14	14	24	62	24	24	345	6	95	1	10	6	2	42	10	13	133	31	13	870
T-N (Shrub/Forest)	2	20	9	46	126	69	69	344	8	73	1	5	6	1	39	9	8	164	35	15	1,049
T-N (Household)	0	3	1	1	2	0	1	18	0	5	0	2	0	0	2	1	6	3	1	0	48
Total	64	1,617	7,238	333	780	915	424	3,509	732	1,236	26	1,474	290	186	1,362	150	135	959	1,457	312	23,195

Table B 6.4 2007 With ProjectPollution Load Runoff -4/4 (T-P)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-P (Sewerage)	0	136	1,177	0	17	94	4	67	68	0	0	53	23	30	59	0	7	0	128	33	1,894
T-P (Industry)	0	20	15	0	2	2	0	5	27	0	0	22	1	1	7	0	3	0	24	1	129
T-P (Livestock)	3	24	14	12	27	11	21	192	3	80	1	6	5	1	33	5	3	68	20	8	538
T-P (Agricultural land)	0	1	0	0	0	0	0	2	0	1	0	0	0	0	1	0	0	0	0	0	7
T-P (Pastureland)	0	0	0	0	1	0	2	6	0	2	0	0	0	0	1	0	0	2	1	0	16
T-P (Shrub/Forest)	0	1	0	1	3	2	2	9	2	2	0	0	0	0	1	0	0	4	1	0	30
T-P (Household)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Total	3	181	1,207	14	51	110	30	281	100	85	1	81	29	33	102	6	14	74	174	43	2,617

Table B 6.5 2015 With Project Pollution Load Runoff -1/4 (BOD)

(Unit :kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
BOD (Sewerage)	0	975	11,524	0	85	956	22	370	554	0	0	342	221	142	125	0	36	0	314	132	15,800
BOD (Industry)	0	5	77	0	5	3	0	27	453	0	0	0	3	5	20	0	0	0	185	0	783
BOD (Livestock)	44	432	265	248	469	1,916	333	2,723	553	1,260	16	131	96	33	562	81	60	646	133	89	10,090
BOD (Agricultural land)	7	51	16	27	28	10	10	111	15	73	4	8	9	2	32	5	4	10	4	2	430
BOD (Pastureland)	0	3	3	7	14	6	30	74	16	23	1	2	1	0	6	1	3	20	2	2	218
BOD (Shrub/Forest)	1	8	4	20	46	28	27	117	30	28	0	2	2	1	8	1	3	40	3	4	373
BOD (Household)	1	9	3	5	6	6	4	51	10	17	0	5	1	0	4	1	3	7	0	0	134
Total	53	1,485	11,892	308	654	2,925	427	3,473	1,631	1,402	22	490	333	183	757	89	108	723	642	230	27,827

Table B 6.5 2015 With Project Pollution Load Runoff -2/4 (COD)

(Unit:kg/day)

Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
COD (Sewerage)	0	1,333	20,966	0	173	1,711	36	588	993	0	0	623	390	256	127	0	73	0	942	360	28,572
COD (Industry)	0	4	144	0	10	3	0	39	398	0	0	0	5	2	16	0	0	0	246	2	870
COD (Livestock)	133	1,270	688	238	495	226	369	3,744	55	1,197	44	384	339	93	2,305	329	181	775	1,567	296	14,730
COD (Agricultural land)	24	169	48	29	32	11	4	132	2	82	12	28	38	7	151	22	14	15	58	8	885
COD (Pastureland)	1	11	8	7	16	7	36	88	2	26	1	8	4	2	26	6	10	29	25	9	321
COD (Shrub/Forest)	18	202	98	163	402	234	251	1,062	27	240	7	50	47	15	297	69	74	437	344	126	4,162
COD (Household)	5	20	6	4	4	1	3	40	1	13	1	10	3	0	12	3	35	6	4	1	174
Total	180	3,010	21,958	440	1,133	2,193	699	5,693	1,479	1,557	66	1,103	826	374	2,934	429	387	1,262	3,187	802	49,714

Table B 6.5 2015 With Project Pollution Load Runoff -3/4 (T-N)

(Unit:kg/day)

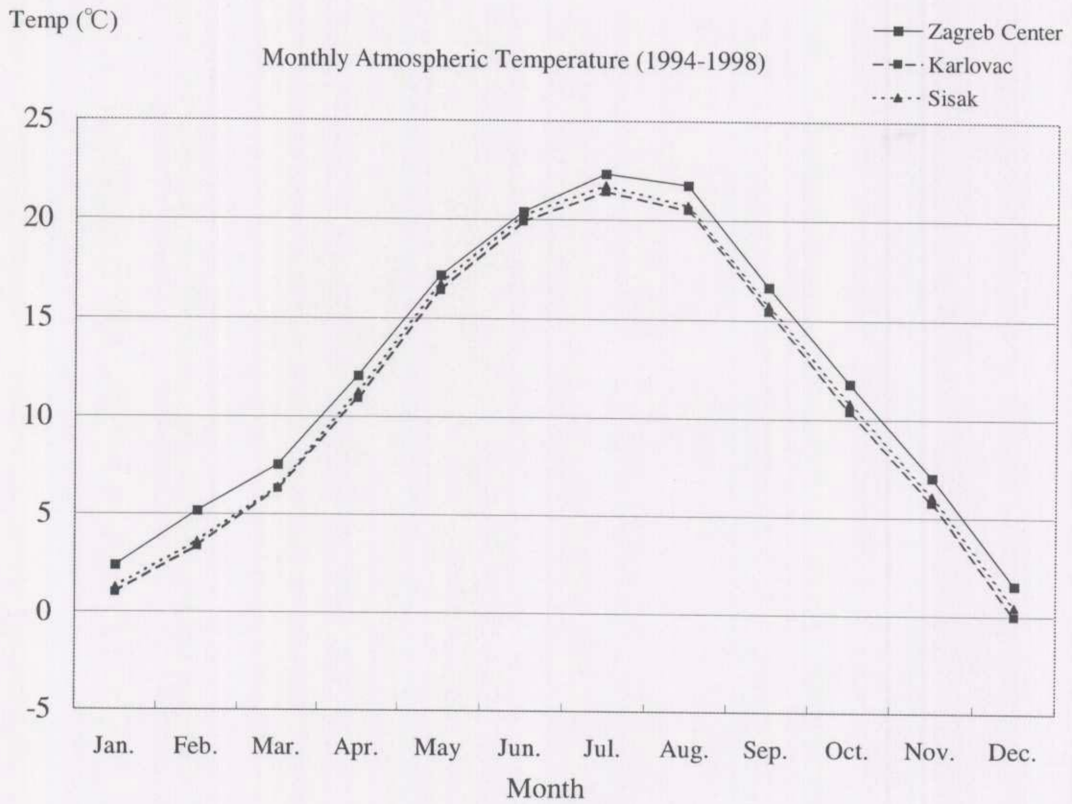
Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-N (Sewerage)	0	345	8,847	0	68	580	16	213	336	0	0	278	147	87	201	0	39	0	309	107	11,573
T-N (Industry)	0	6	0	0	6	5	0	26	689	0	0	0	4	11	33	0	0	0	375	3	1,158
T-N (Livestock)	31	292	129	162	380	189	297	1,962	31	763	9	84	88	20	685	95	40	590	352	71	6,273
T-N (Agricultural land)	30	204	54	99	122	39	14	517	6	300	15	35	56	9	242	35	19	68	71	11	1,944
T-N (Pastureland)	1	14	14	24	62	24	24	345	6	95	1	10	6	2	42	10	13	133	31	13	870
T-N (Shrub/Forest)	2	20	9	46	126	69	69	344	8	73	1	5	6	1	39	9	8	164	35	15	1,049
T-N (Household)	0	3	1	1	2	0	1	18	0	5	0	2	0	0	2	1	6	3	1	0	48
Total	64	883	9,054	333	765	906	422	3,425	1,076	1,236	26	415	307	130	1,244	150	126	959	1,174	220	22,914

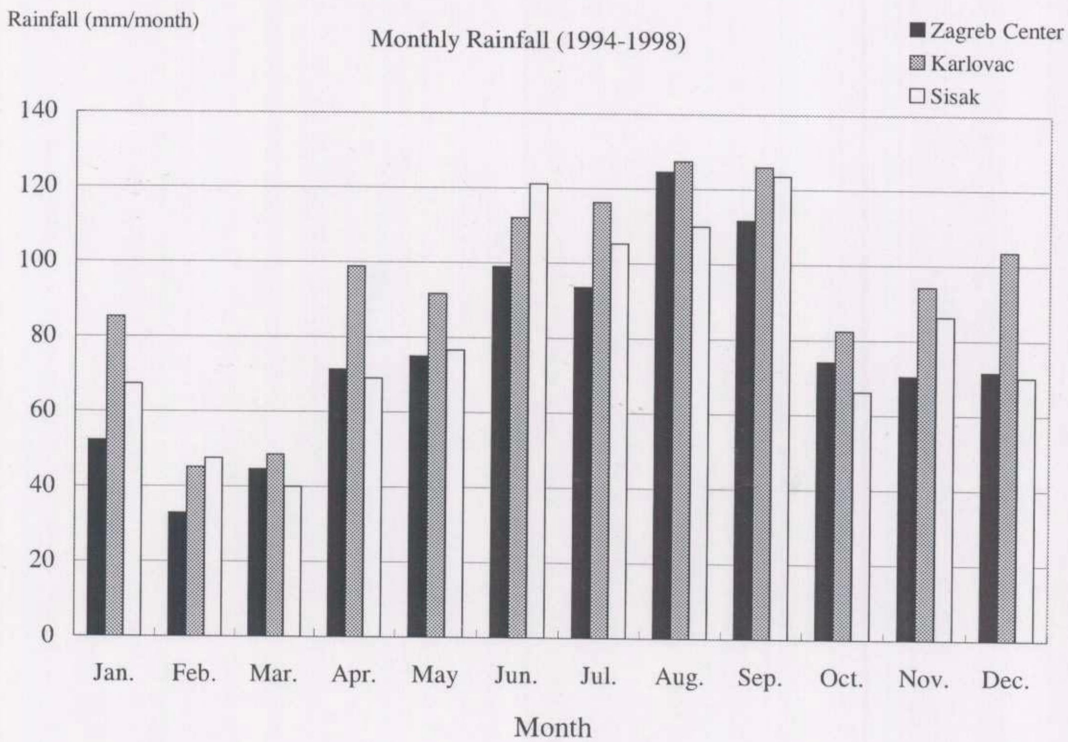
Table B 6.5 2015 With Project Pollution Load Runoff -4/4 (T-P)

(Unit:kg/day)

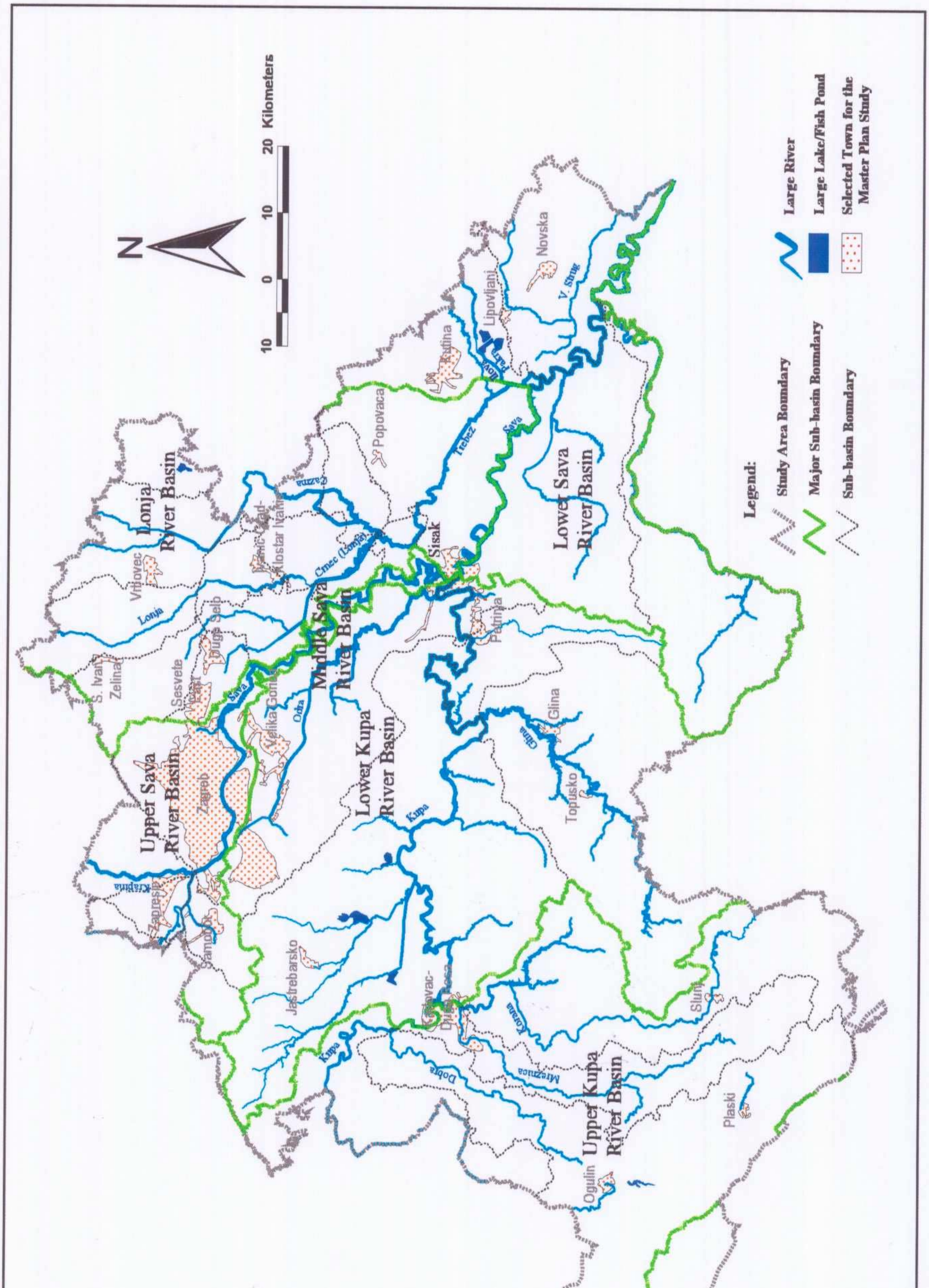
Sub-Basin Name	Sutla	Krapina	Zagreb Area	Upper Kupa	Dobra	Mreznica	Korana	Lower Kupa-Glina	Moatanica	Odra	Middle Sava	Zelina Crnec	Upper Lonja	Middle Lonja	Upper Cesma-Glogonica	Moslavina Area	Lower Lonja	Una-Sunja	Ilova Pakra	Veliki Strug	Sub-Tptal
T-P (Sewerage)	0	46	1,432	0	9	78	3	36	45	0	0	41	23	0	30	0	2	0	44	20	1,808
T-P (Industry)	0	1	12	0	1	1	0	2	35	0	0	0	1	0	5	0	0	0	19	0	78
T-P (Livestock)	3	24	14	12	27	11	21	192	3	80	1	6	5	1	33	5	3	68	20	8	538
T-P (Agricultural land)	0	1	0	0	0	0	0	2	0	1	0	0	0	0	1	0	0	0	0	0	7
T-P (Pastureland)	0	0	0	0	1	0	2	6	0	2	0	0	0	0	1	0	0	2	1	0	16
T-P (Shrub/Forest)	0	1	0	1	3	2	2	9	2	2	0	0	0	0	1	0	0	4	1	0	30
T-P (Household)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Total	3	73	1,459	14	42	92	29	247	86	85	1	47	29	1	71	6	6	74	85	30	2,479

FIGURES

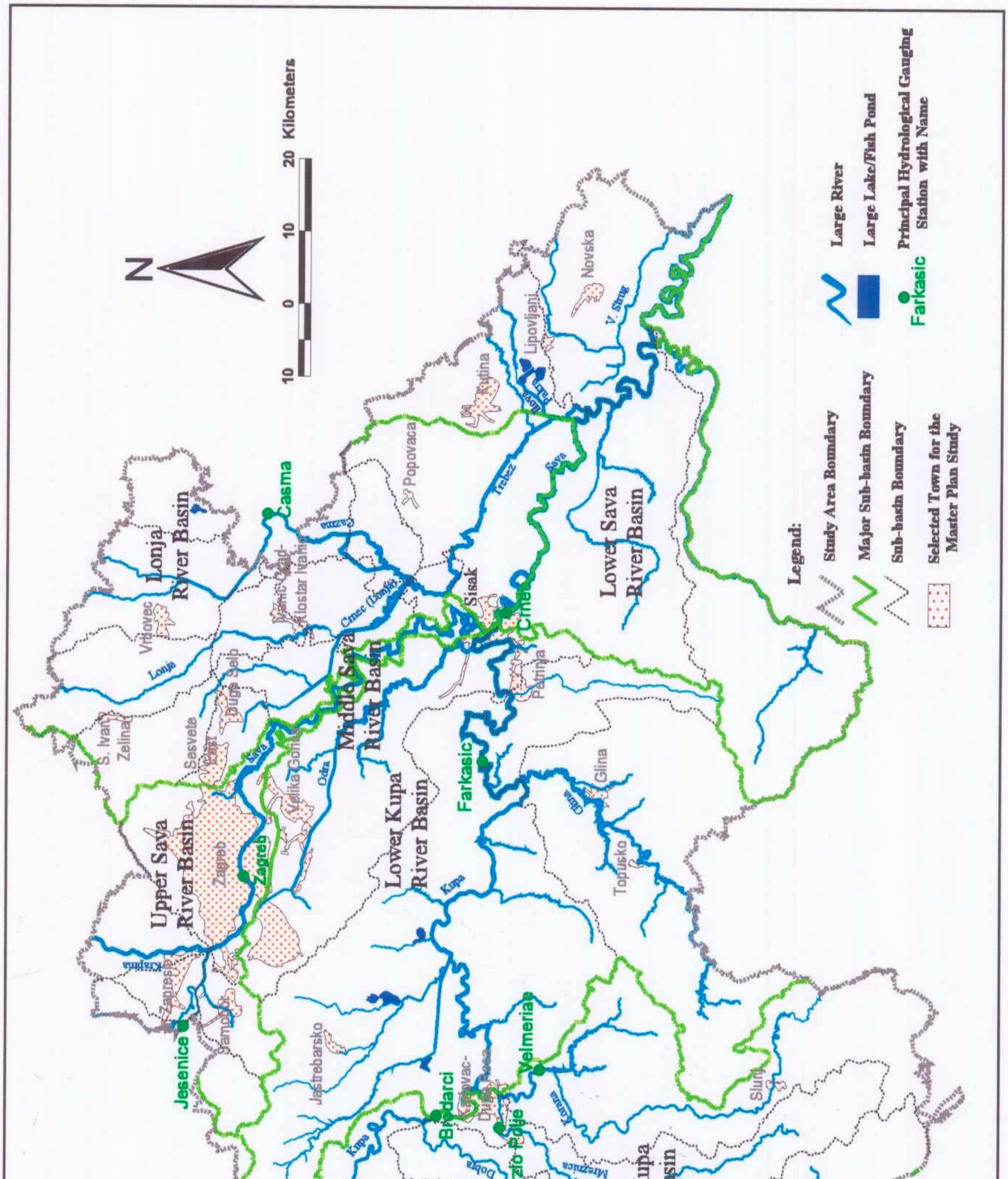




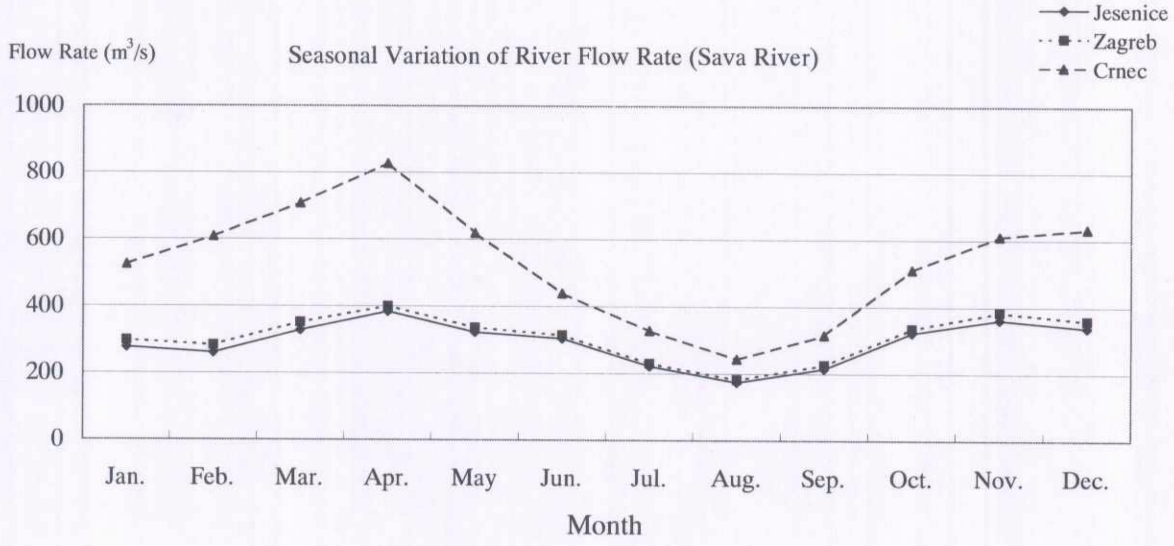
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. B.2.1 Seasonal Variation of Rainfall and Temperature
JAPAN INTERNATIONAL COOPERATION AGENCY	

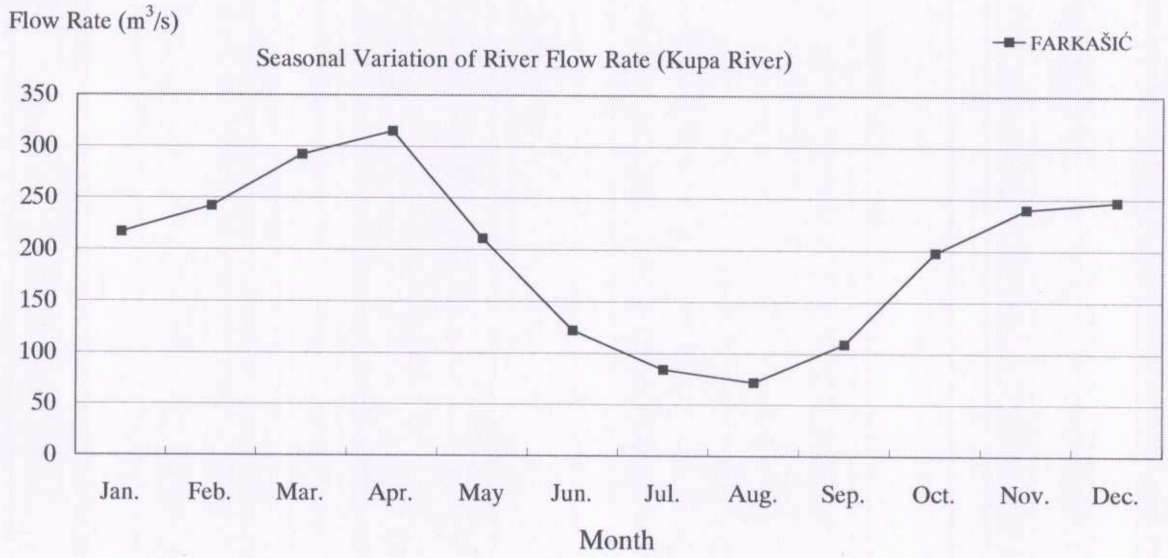


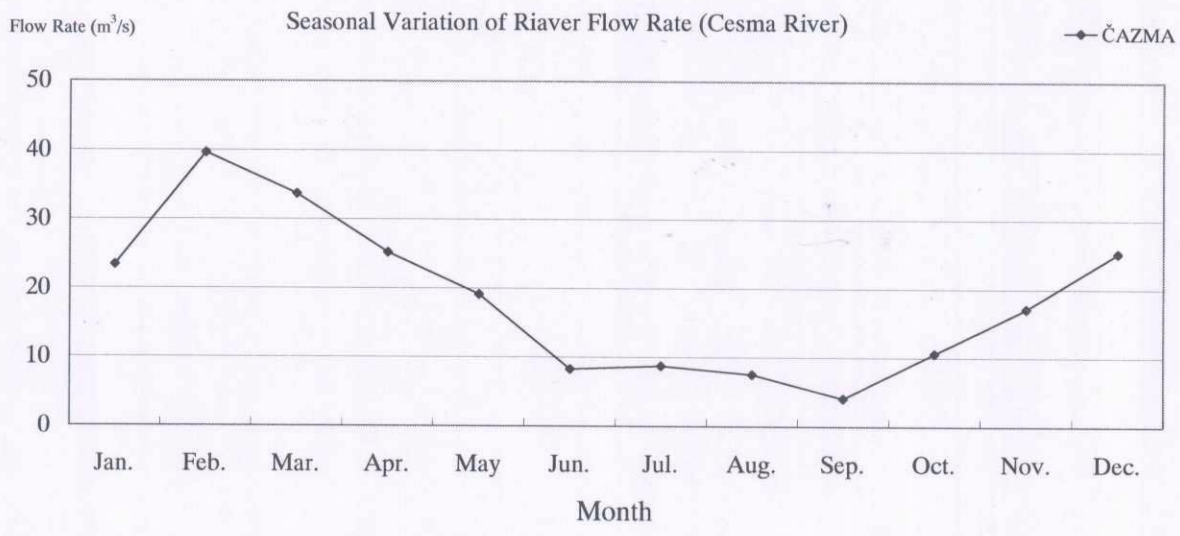
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. B.2.2 Basin Divisions in the Study Area
JAPAN INTERNATIONAL COOPERATION AGENCY	



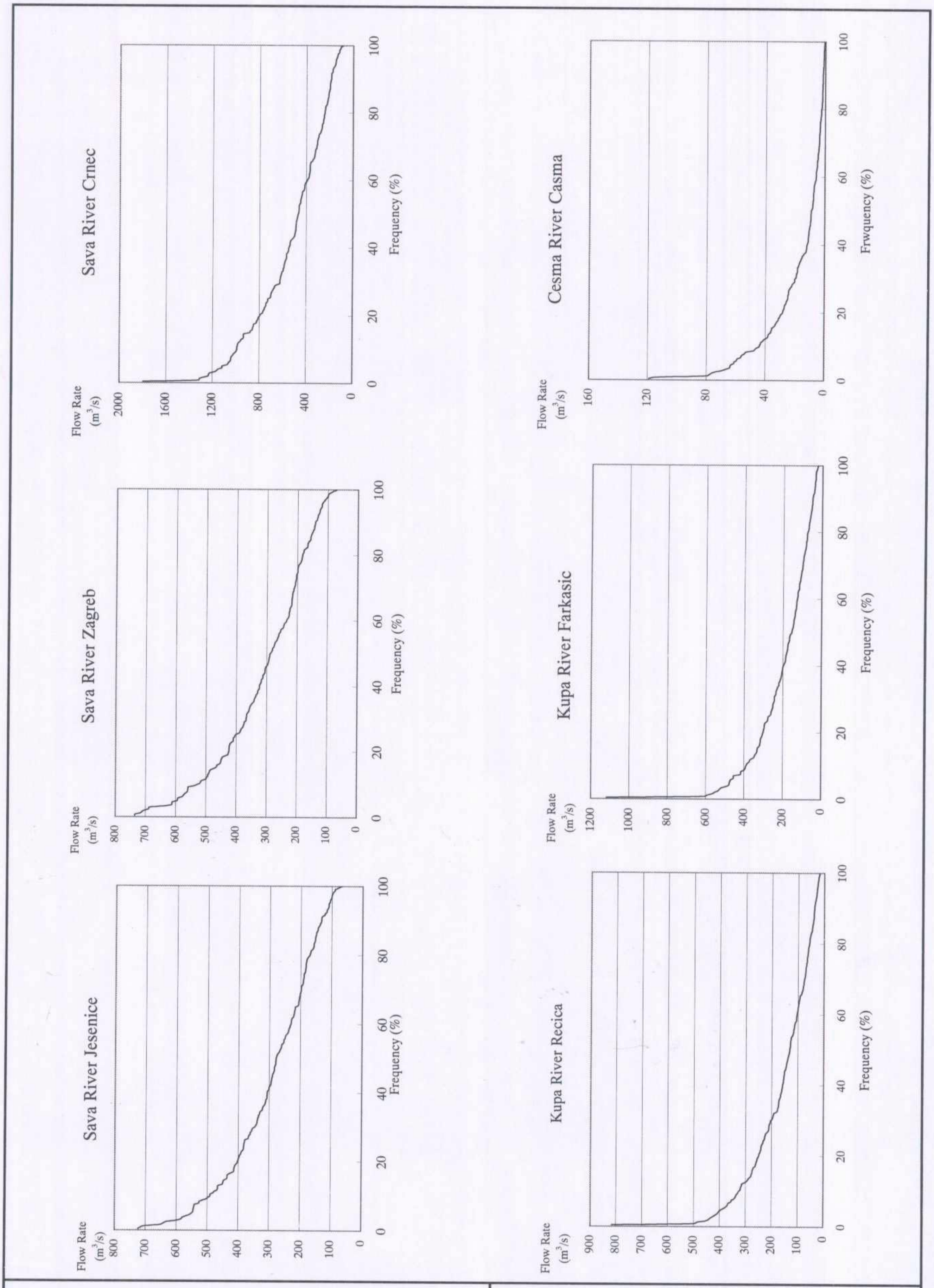
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. B.2.3 Principal Hydrological Gauging Stations
JAPAN INTERNATIONAL COOPERATION AGENCY	



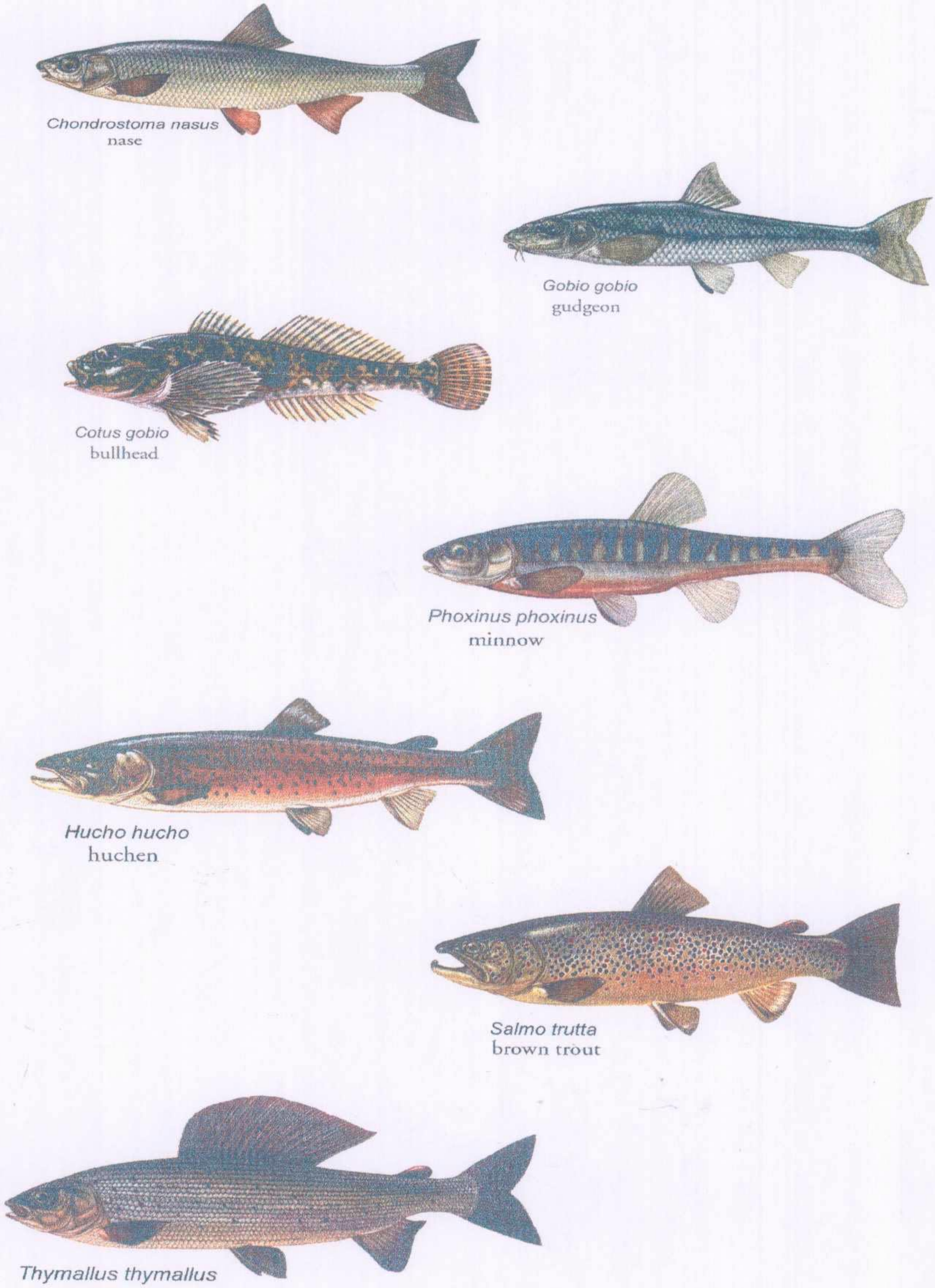




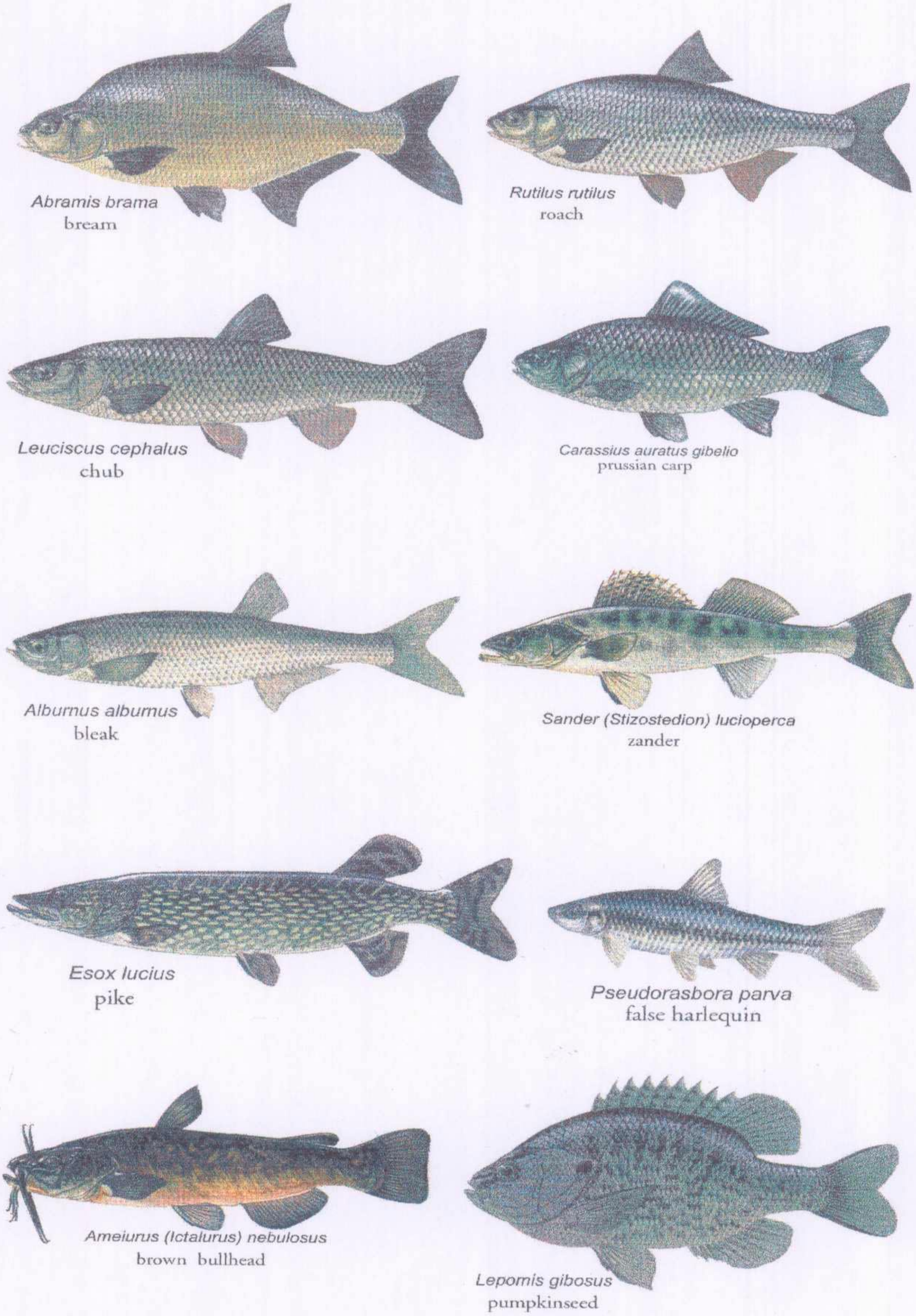
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. B. 2.4 Seasonal Variation of River Flow Rate
JAPAN INTERNATIONAL COOPERATION AGENCY	



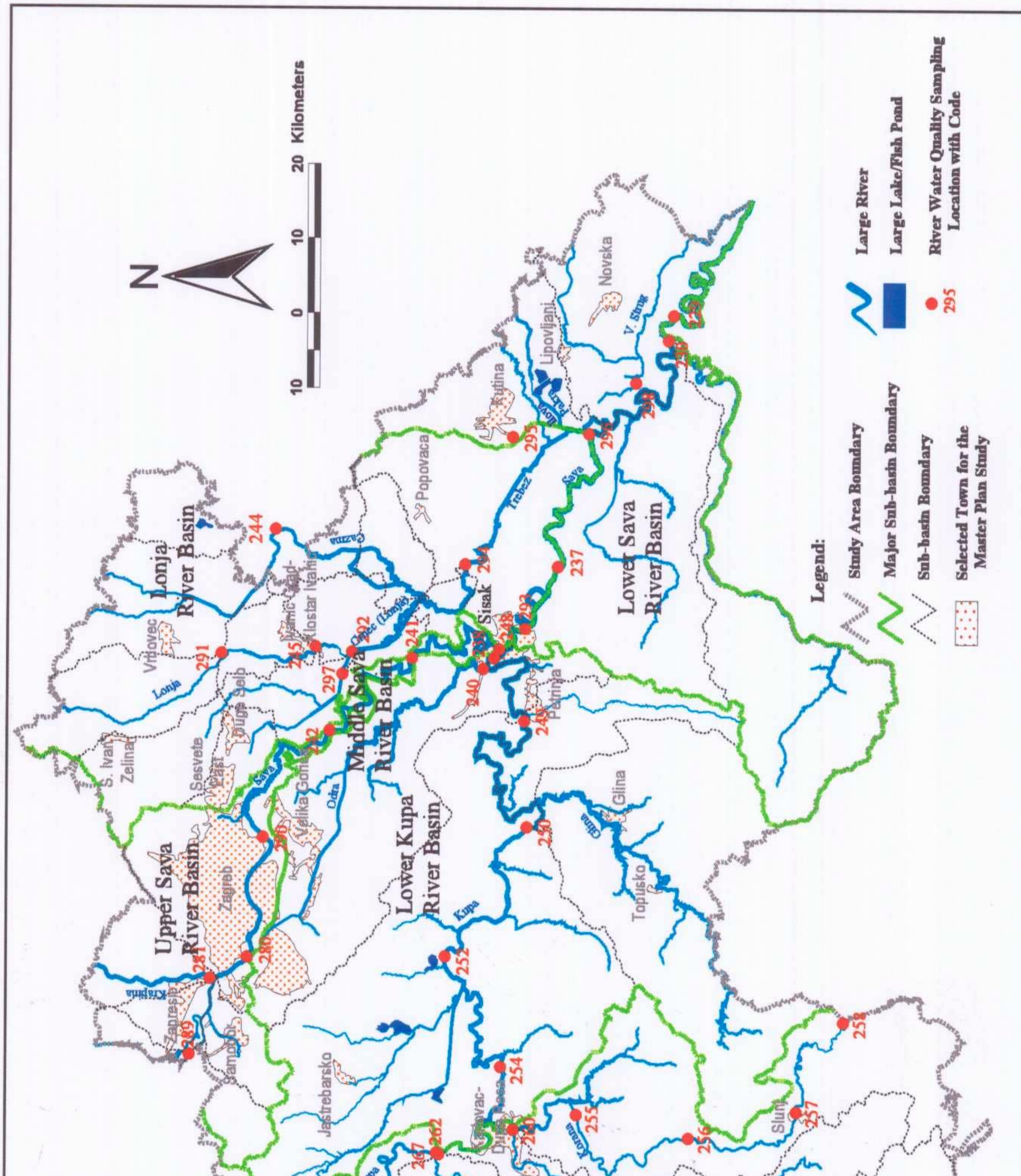
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.B.2.5 Frequency Curve of River Flow Rate
JAPAN INTERNATIONAL COOPERATION AGENCY	



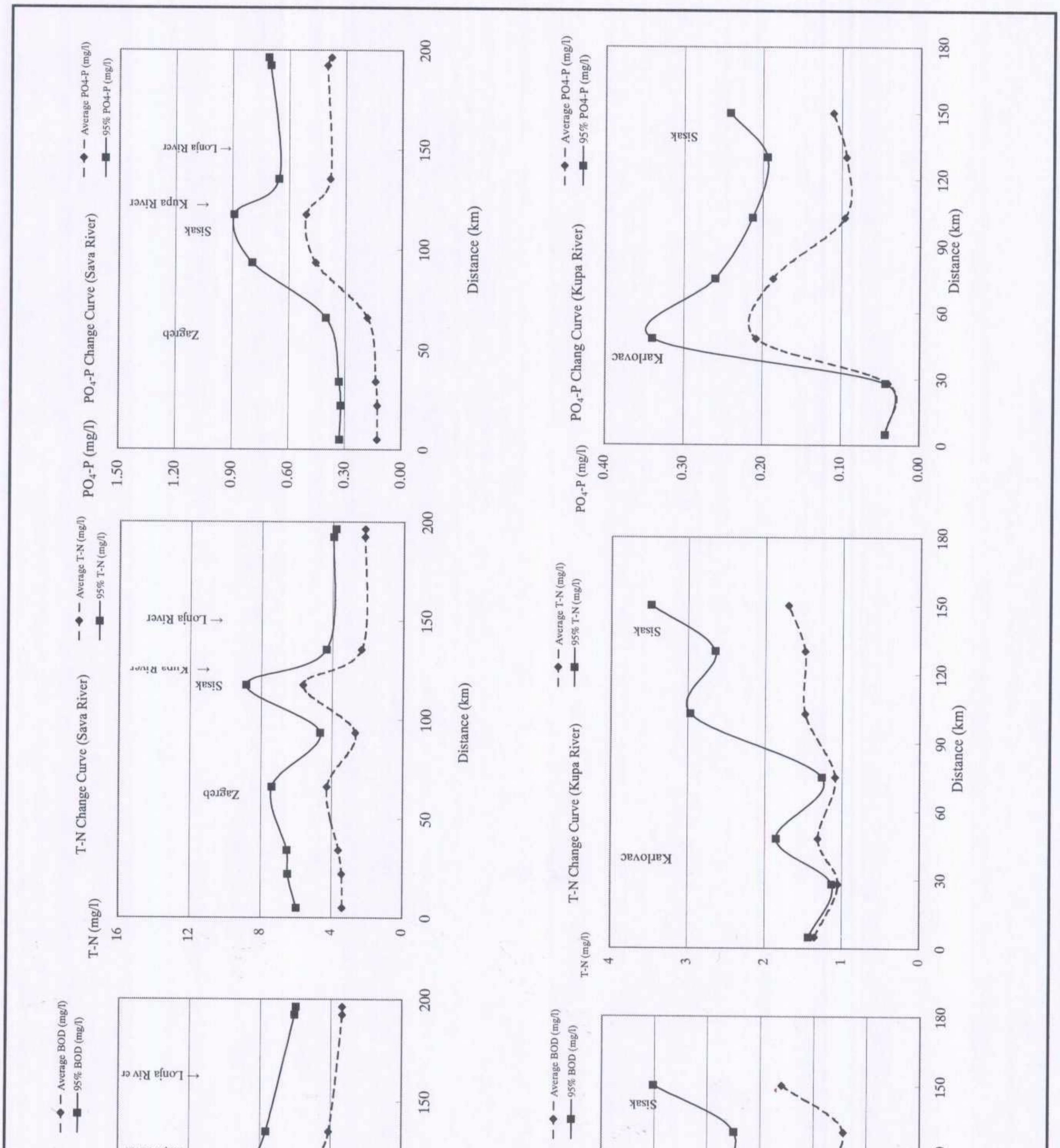
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.B.2.6 Fishes in Sava River Basin (1/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



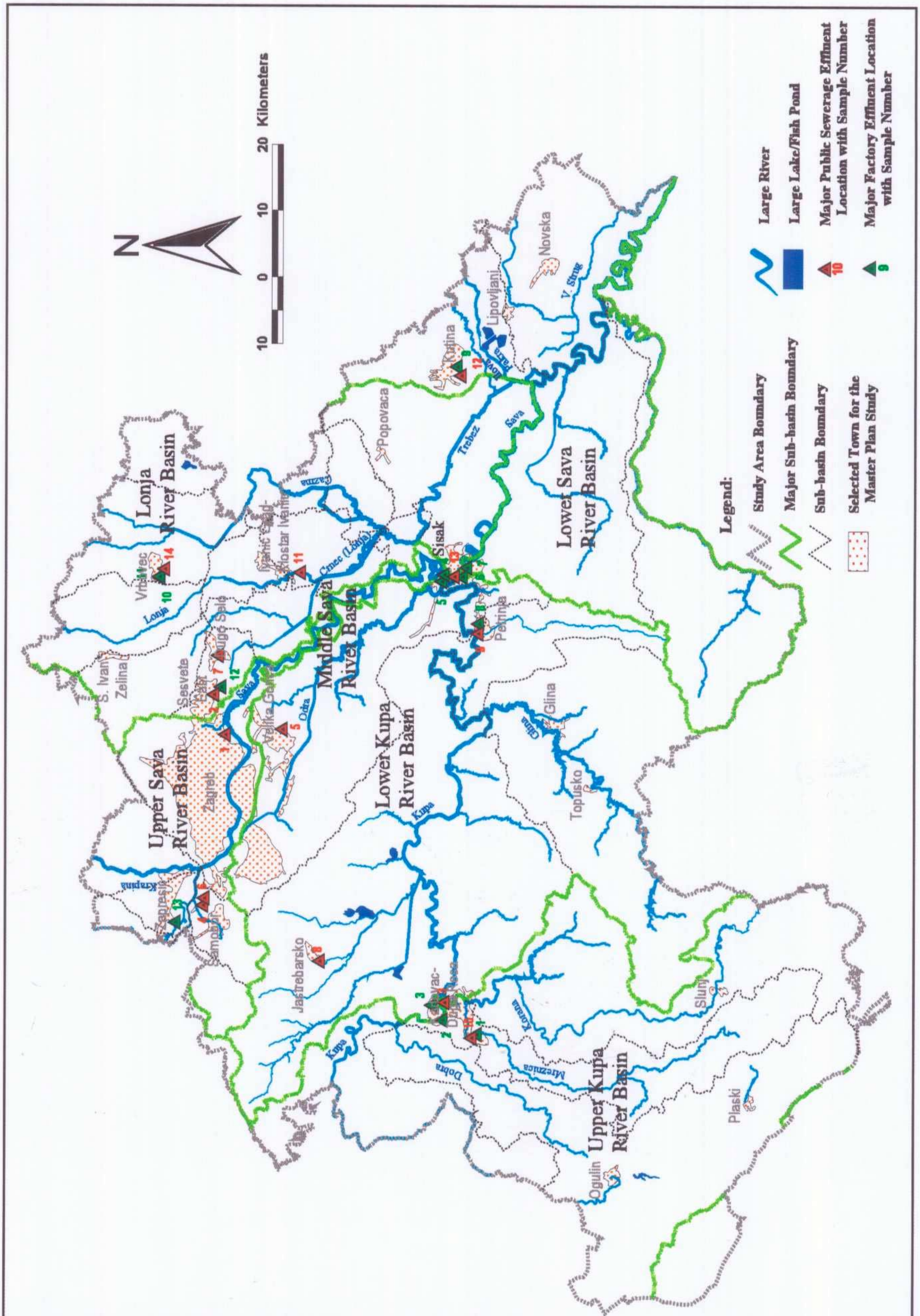
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.B.2.6 Fishes in Sava River Basin (2/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



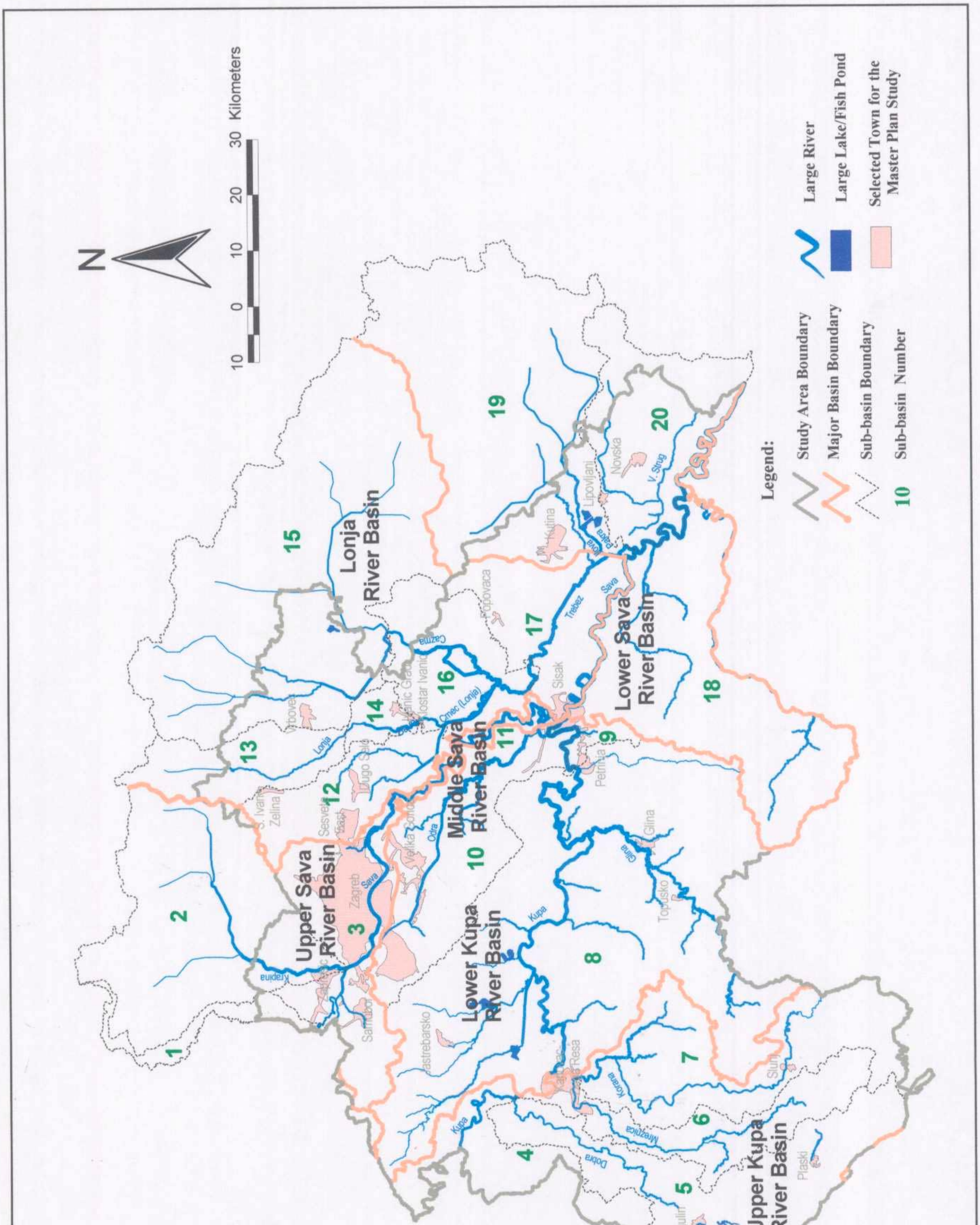
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. B.3.1 River Water Quality Sampling Locations
JAPAN INTERNATIONAL COOPERATION AGENCY	



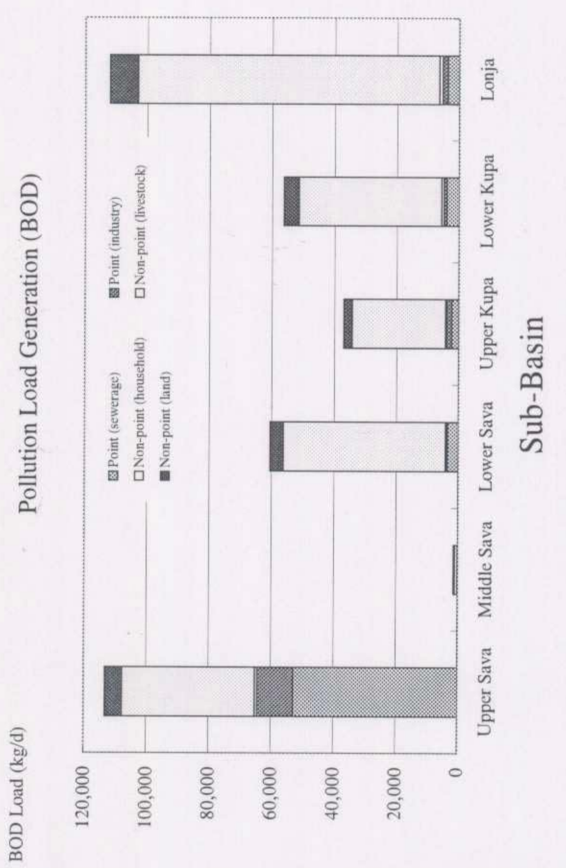
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.B.3.2 Longitudinal Change of River Water Quality
JAPAN INTERNATIONAL COOPERATION AGENCY	

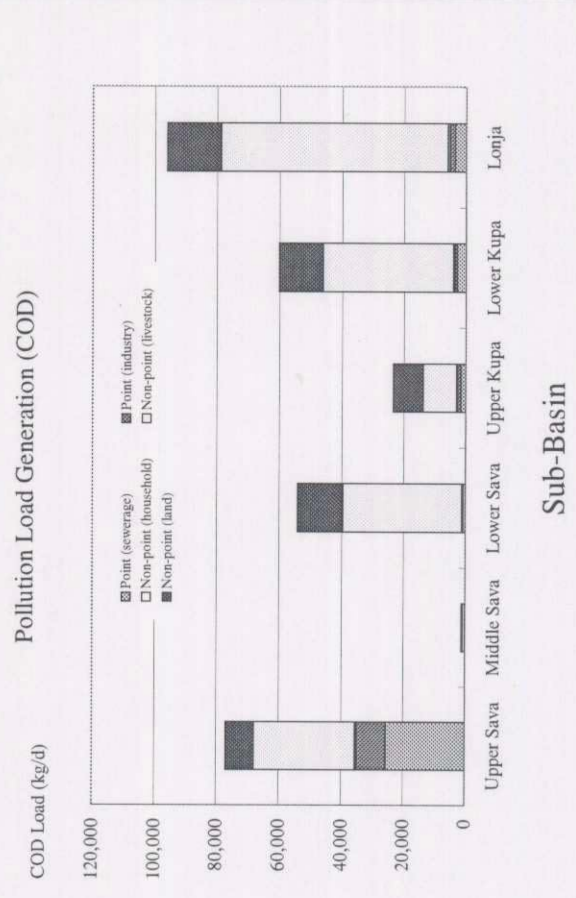


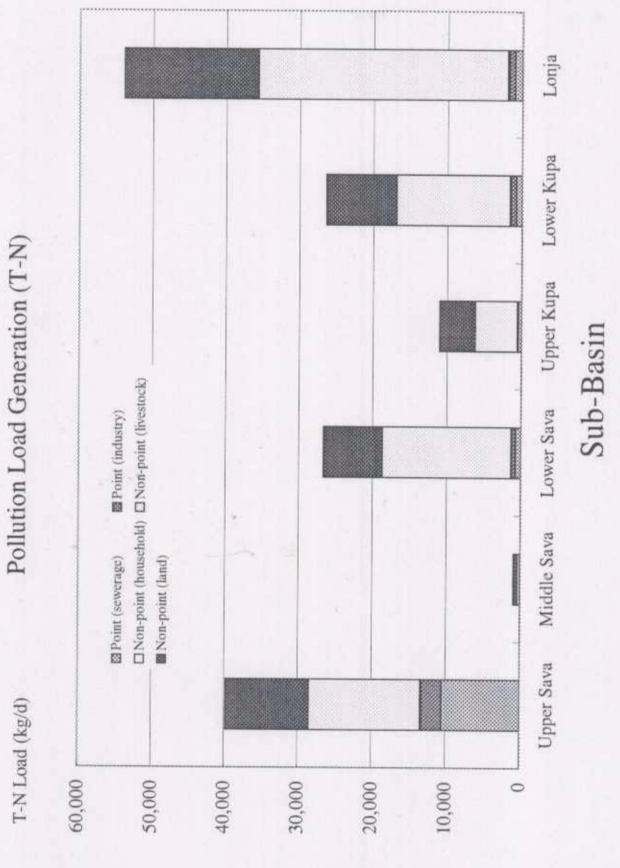
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. B.4.1 Major Factories and Public Sewerage Effluent Locations
JAPAN INTERNATIONAL COOPERATION AGENCY	

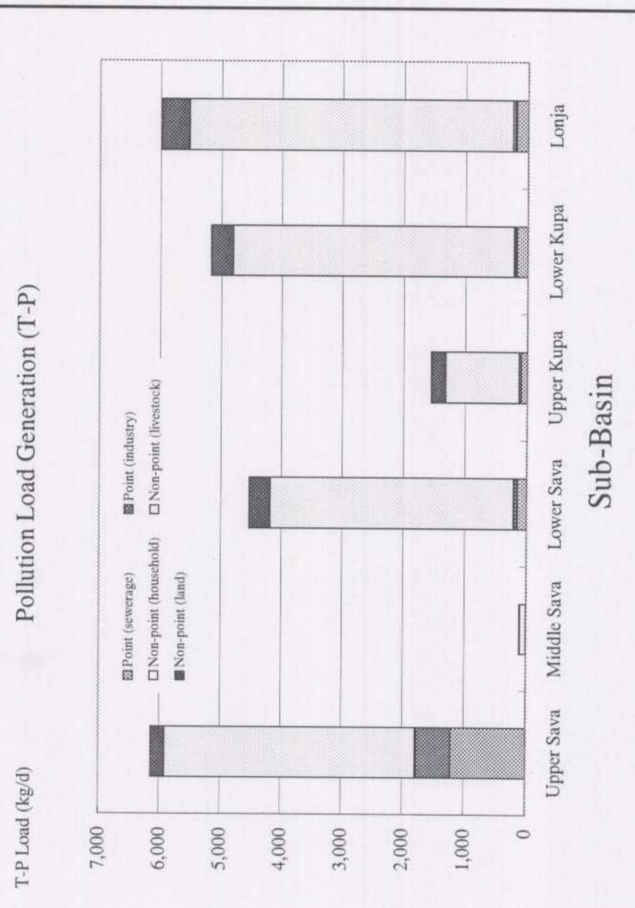


THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. B.5.1 Divided 20 Sub-basins for Simulation.
JAPAN INTERNATIONAL COOPERATION AGENCY	









THE STUDY FOR WATER POLLUTION REDUCTION
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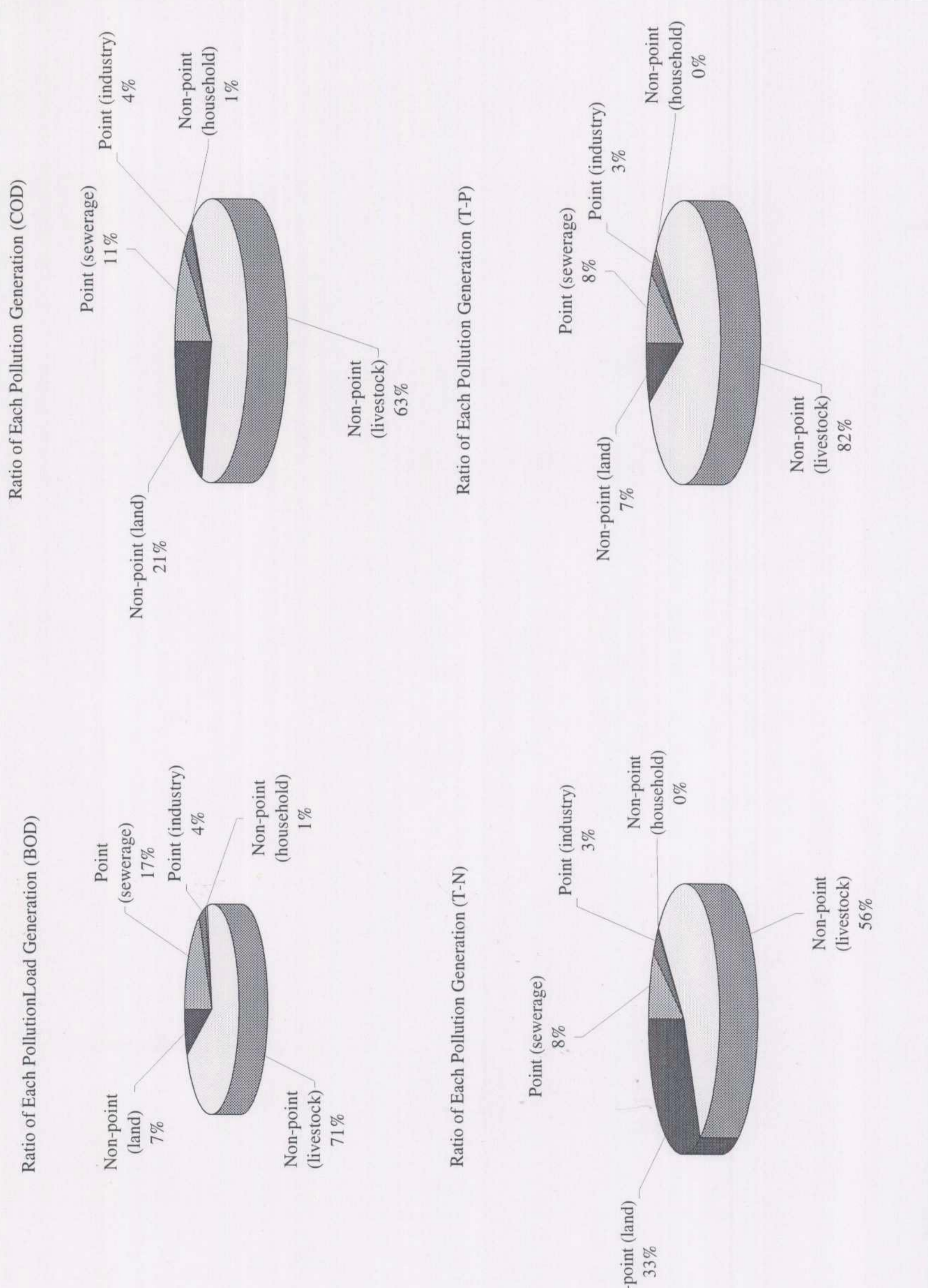
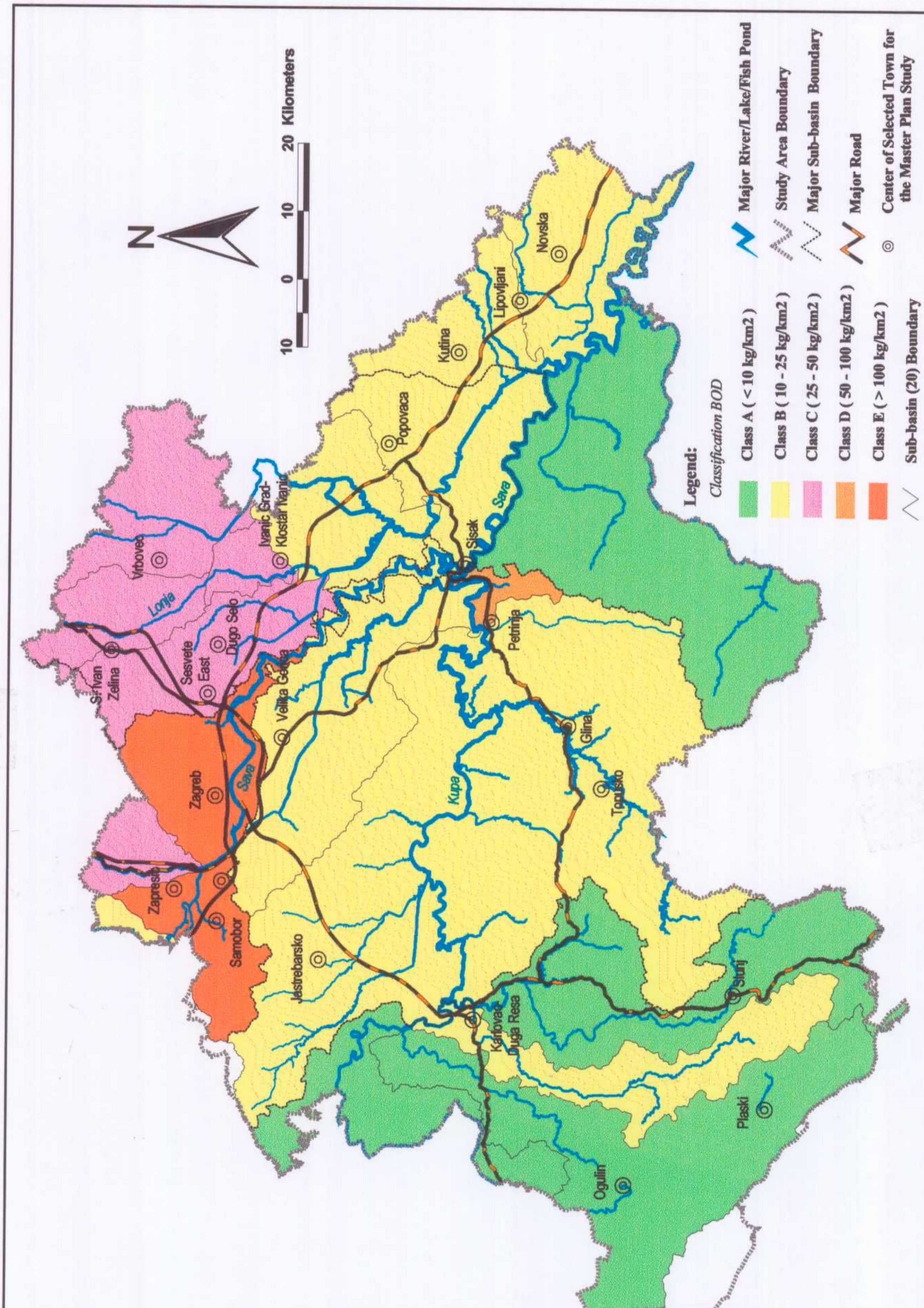
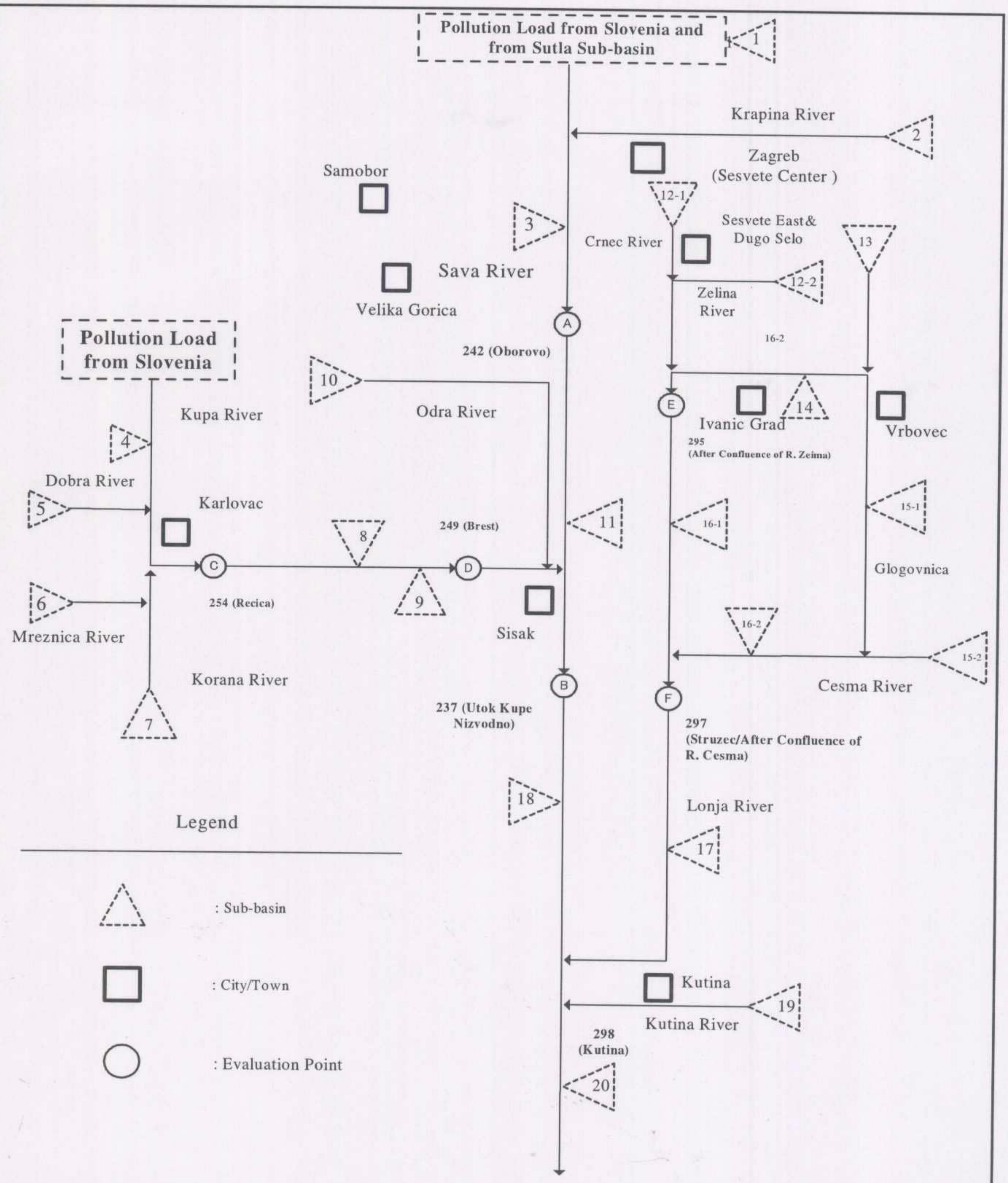
Fig. 5.2 Existing Pollution Load Generation of Each Sub-Basin



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	**Fig. B 5.3 Ratio of Each Pollution Load Generation**
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig B.5.4 EXISTING POLLUTION LOAD GENERATION IN THE OBJECTIVE SAVA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	



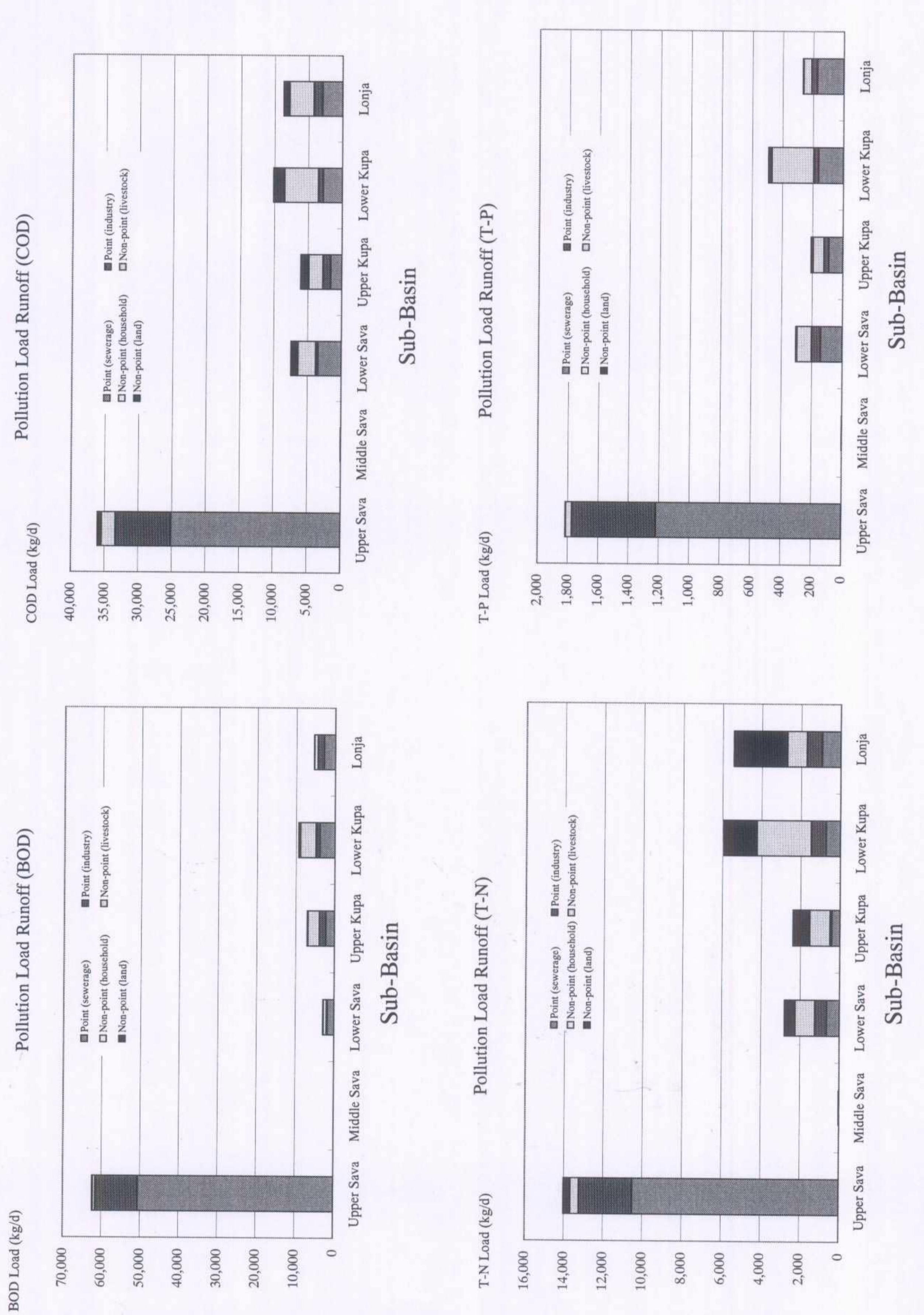
Sub- Basin Name and Name

1 : Sutla	8 : Lower Kupa-Glina	15 : Upper Cesma-Glogonica
2 : Krapina	9 Moatanica	16 : Moslavina Area
3 : Zagreb Area	10 : Odra:	17 : Lower Lonja
4 : Upper Kupa	11 : Middle Sava	18 : Una-Sunja
5 : Dobra	12 : Zelina Crnec	19 : Ilova Pakra
6 : Mreznica	13 : Upper Lonja	20 : Veliki Strug
7 : Korana	14 : Middle Lonja	

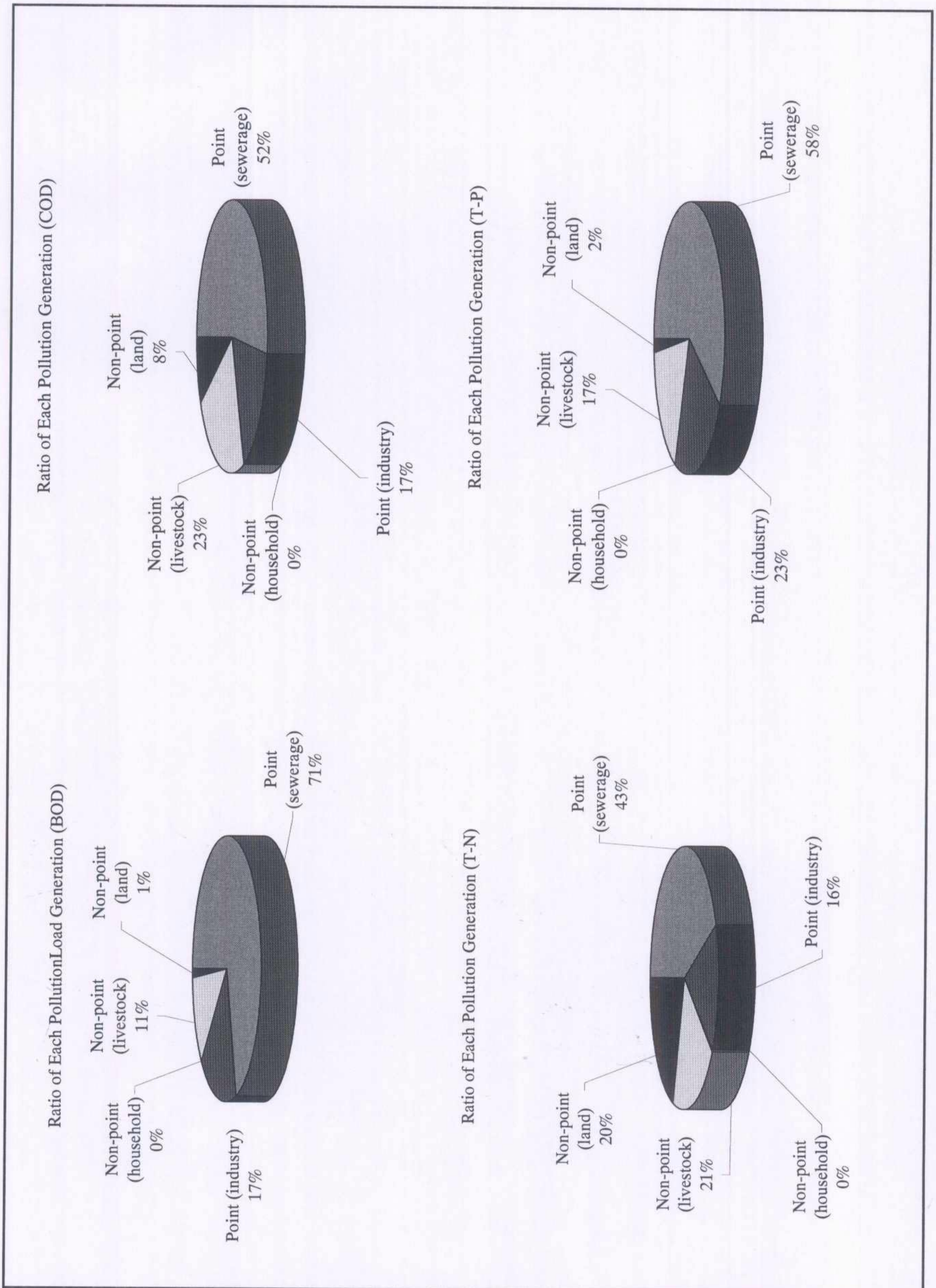
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. B.6.1 Schematic Diagram for the Simulation of Pollution Load Runoff and Water Quality



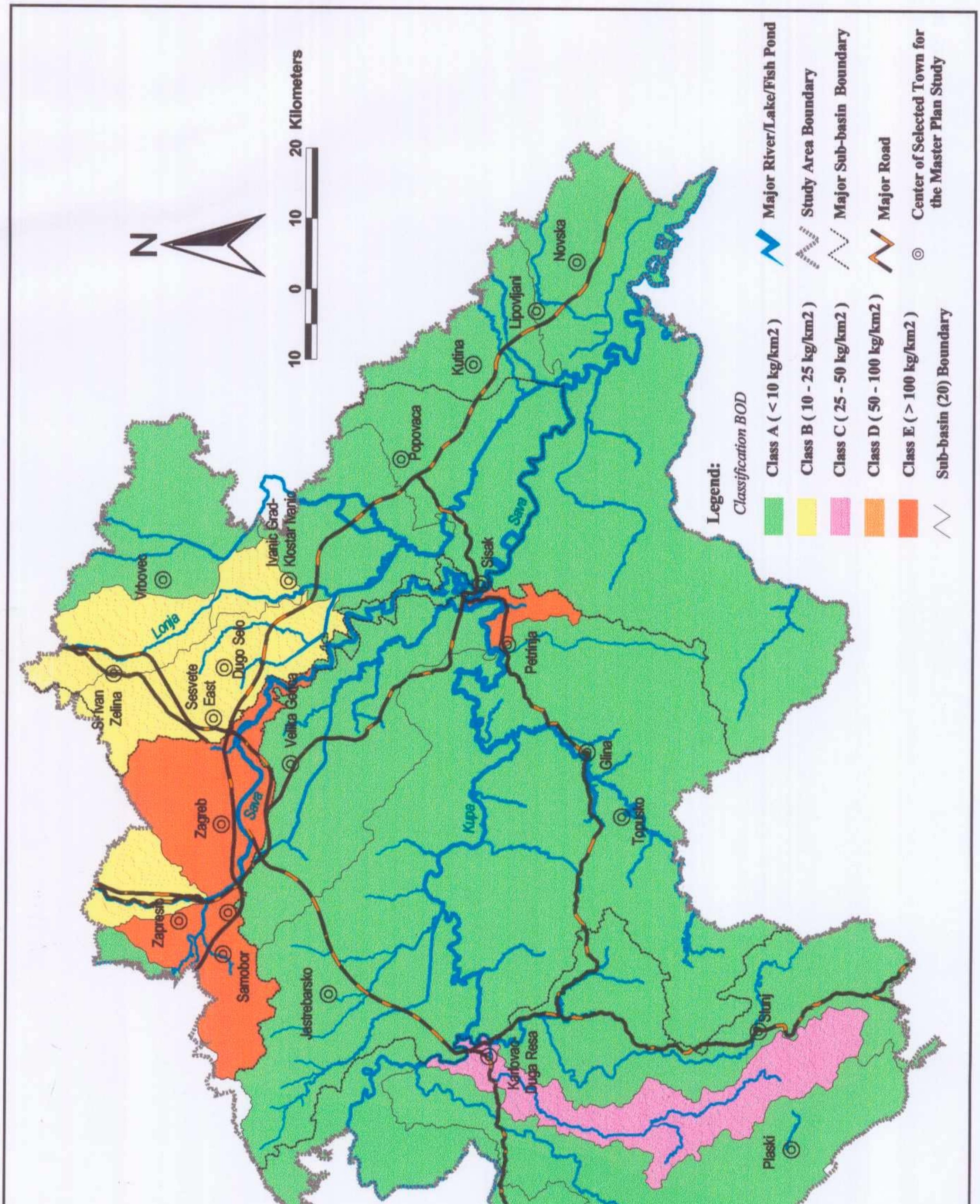
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. 6.2 Existing Pollution Load Runoff of Each Sub-Basin
JAPAN INTERNATIONAL COOPERATION AGENCY	



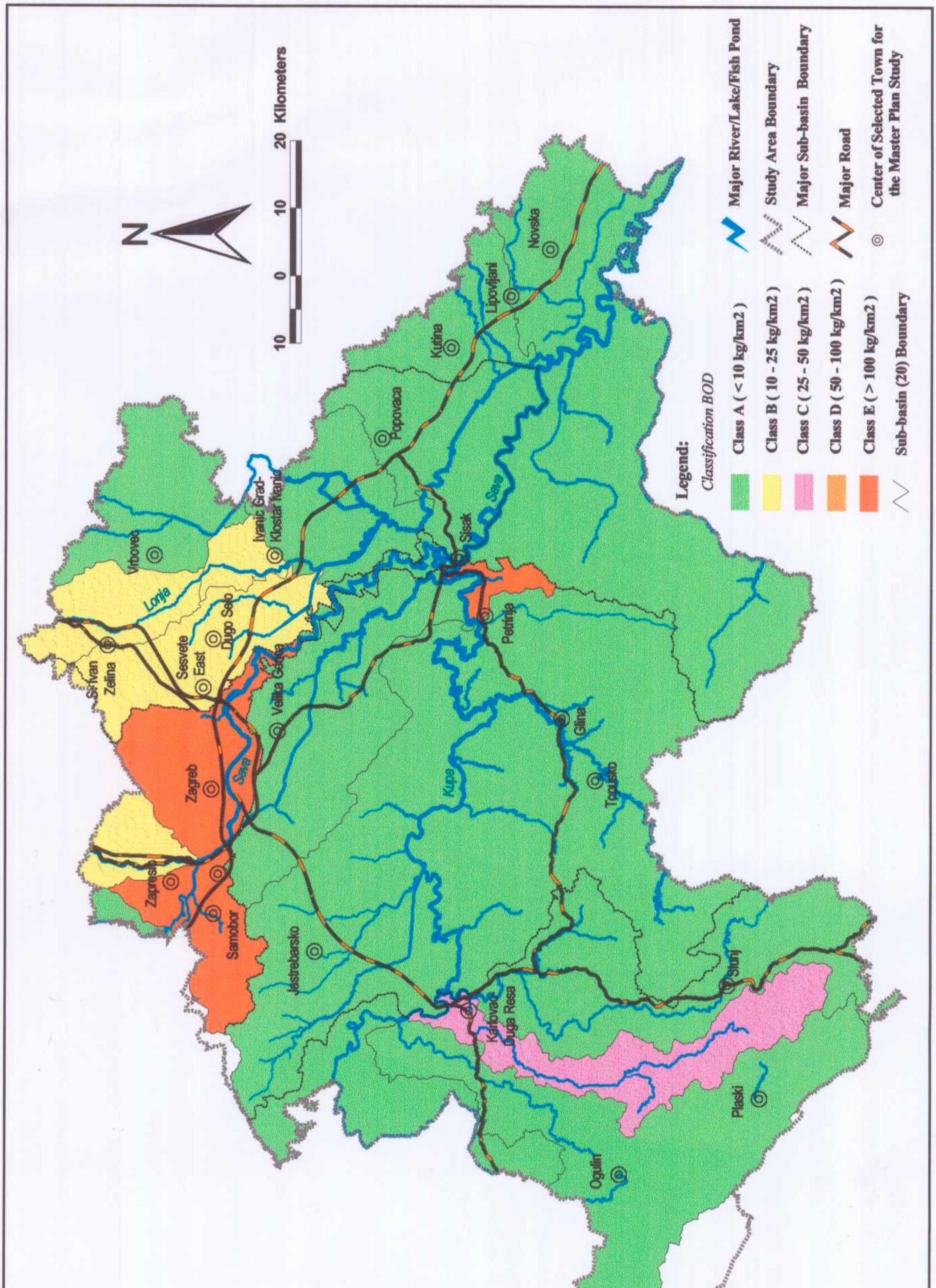
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

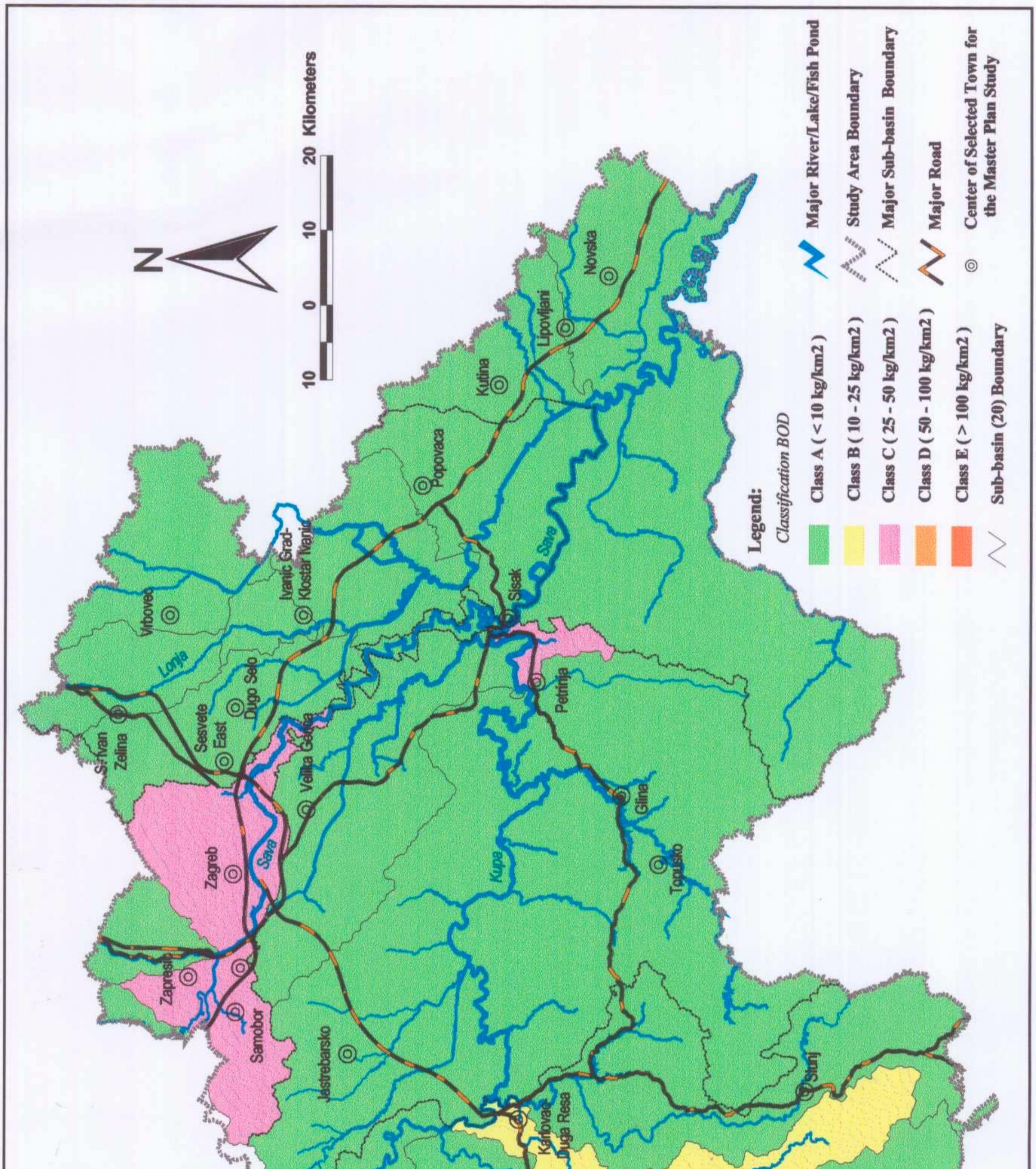
Fig. B 6.3 Ratio of Each Existing Pollution Load Runoff



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig B.6.4 EXISTING POLLUTION LOAD RUNOFF IN THE OBJECTIVE SAVA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig B.6.5. 2015 WITHOUT PROJECT POLLUTION LOAD RUNOFF IN THE OBJECTIVE SAVA RIVER BASIN
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig B.6.6. 2015 WITH PROJECT POLLUTION LOAD RUNOFF IN THE OBJECTIVE SAVA RIVER BASIN
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APPENDIX C

INDUSTRIAL WASTEWATER TREATMENT

APPENDIX C

INDUSTRIAL WASTEWATER TREATMENT

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CHAPTER I PLANNING BASIS

1.1 Objective of the Study

There are a number of large and small industries in the Study Area. Among the large industries in the 24 objective municipalities of the sewerage development master plan study, those found in Zagreb City, Vrbobec, Sisak, Kutina and Karlovac, as well as in other towns, may cause significant river water pollution.

The above-mentioned large industries mostly discharge their wastewaters into the public sewerage systems or the rivers either without or with insufficient treatment. Among the industries in Zagreb City, those located in the service area of the ongoing Zagreb Sewerage Development Project are, however, excluded from this Study because all of them are covered by this project. Only the industries located in the Sesvete East area, a part of Zagreb City, are included.

The study on the wastewater treatment of large industries is presented hereinafter. The major objectives of the study in Appendix C are as follows:

(1) To identify the existing industrial wastewater discharge system;

(2) To estimate the existing and future wastewater quantity and quality, and to evaluate the pollution loads to the public sewerage system and river;

(3) To propose optimum wastewater discharge system through a comparative study on alternatives; namely, (a) Discharge into public sewerage with necessary pre-treatment, and (b) Direct discharge into river with necessary treatment; and

(4) To propose the necessary improvement of existing treatment system, including installation of new treatment system, with the required construction cost roughly estimated for the preparation of a financial policy on the promotion of industrial wastewater treatment.

1.2 Permissible Limits of Industrial Effluent

The permissible limits of major parameters of industrial wastewater effluent into public sewerage or natural recipient (river, brook, canal, lake, etc.) are prescribed in the Decree (NN No. 40/99, as amended by NN No. 6/01). The discharge of industrial wastewater into a Category I natural recipient is not allowed.

The limits of major parameters relevant to the industrial wastewater treatment in this Study are given in the following table. As for the other parameters including heavy metals and other toxic materials, see Table C.1.1.

Recipient/ Parameters	Unit	Natural Recipient				Public Sewerage
		II	III	IV	V	
pH	-	6.5 - 8.0	6.0 - 8.5	5.5 - 9.0	5.0 - 9.5	5.0 - 9.5
TSS	(mg/l)	35	35 - 60	60 - 150	150	*
BOD_5	(mg/l)	25	25	40	80	250
COD_{Cr}	(mg/l)	125	125	200	400	700
T-Phenols	(mg/l)	0.1	0.2	0.3	0.4	10
T-P	(mg/l)	1	2	4	8	10
T-N	(mg/l)	21	31	42	42	-
Oil and Grease	(mg/l)	25	30	40	50	100

Note: * To be determined at sewerage company's option.
1) Sewerage company can change the values of BOD and COD_{Cr} depending on its treatment capacity.
2) Exceptional limits are applied for leather industries

1.3 Selection of Objective Large Industries for the Study

Croatian Waters categorizes point pollution sources into domestic, institutional and industrial wastewater. Industrial wastewater sources include not only factories but also commercial and service industries.

Croatian Waters listed up 147 industrial pollution sources in the objective towns/municipalities of the sewerage master plan study excluding Zagreb City. The average wastewater quantity and quality of each industry during 1998-1999 are shown in Table C.1.2 (1) to Table C.1.2 (16).

Of the 147 industrial pollution sources, 51 industries discharging wastewater of more than 100 m^3/day in principle are categorized as large industries. Among these 51 large industries, 18 large pollutant industries are selected for detailed study in consideration of water pollution effects on the environment in the Study Area. In this Study, the wastewater of smaller industries is dealt as part of the municipal wastewater.

The selected 18 large pollutant industries are listed below. The wastewater quantity and quality (BOD, COD, TSS) of each industry are as shown in Table C.1.2 (1) to Table C.1.2 (16).

Town/Municipality		Code No.	Factory Name	Activity	Existing Recipient
Sesvete East	(2)	310001	**Agroproteinka**	Food/Beverage	Canal
		310246	**Duma Kože**	Leathers	Canal
Vrbovec	(1)	360004	**PIK Vrbovec Mesna Industrija**	Food/Beverage	Canal
Sisak	(6)	374001	**INA Zagreb Rafinerija Nafte Sisak**	Oil Refinery	River
		374002	**Herbos d.d.**	Chemicals	Sewerage
		374003	**Termoelektrana Sisak**	Electricity	River
		374004	**Tvornica Segestica**	Food/Beverage	Sewerage
		374005	**Željezara Poduzeće Metaval**	Metal/Machinery	River
		374006	**Ljudevit Posavbki Mlin Pekare**	Food/Beverage	Sewerage
Kutina	(1)	357009	**Petrokemija Kutina (Industrial)**	Chemicals	Channel
		357016	**Petrokemija Kutina (Sanitary)**	Chemicals	Sewerage
Karlovac and Duga Resa	(6)	333006	**Karlovačka Pivovara**	Food/Beverage	Sewerage
		333015	**PPK-Karlovaćka Industrija Mesna**	Food/Beverage	River
		333005	**Velebit**	Textile	River/Sewerage
		333012	**Lola Ribar**	Textile	River
		333016	**Karlovačka Industrija Mlijeka**	Food/Beverage	River
		331001	**Pamučna Industrija Duga Resa**	Textile	River
Zaprešić	(1)	315127	**Pliva**	Chemicals	River
Petrinja	(1)	373001	**Gavrilović d.o.o.**	Food/Beverage	River

Note: Petrokemija Kutina (one industry) has two (2) separate outlets for industrial and sanitary wastewaters.

The other 33 large industries are listed below. The wastewater quantity and quality (BOD, COD, TSS) of each industry are also shown in Table C.1.2 (1) to Table C.1.2 (16).

Town/Municipality		Code No.	Factory Name	Activity	Existing Recipient
Vrbovec	(2)	360002	Gradip	Clay	Sewerage
		360008	PIK Vrbovec Farma Polijanski	Farm	Lagoon/Land
Karlovac	(7)	333003	Kordun Karlovac	Metal/Machinery	Sewerage
		333008	Že-Če	Metal/Machinery	Sewerage
		333010	Tvornica Plinskih Turbuna	Gas Service	Sewerage
		333011	Adria-Diesel	Metal/Machinery	Sewerage
		333017	ABB Alstom	Metal/Machinery	Sewerage
		333019	Linde Plin d.o.o.	Gas Service	Canal
		333029	Autotransport d.d.	Transportation	Sewerage
Ivanić Grad and Kloštar Ivanić	(4)	355005	INA Naftaplin Pogon Etan	Oil Refinary	Sewerage
		355010	Crosco Naftini Servisi	Shopping Center	Sewerage
		355015	Naftaplin Lječilište	Hospital	Sewerage
		355019	INA Naftaplin Radilišt Oroi	Oil & Gas Service	Brook
Samobor	(7)	309021	Chromos Grafičke Boje	Chemicals	Sewerage
		309047	Fotokemika	Photography	Sewerage
		309069	Imes	Food-Beverage	Sewerage
		309123	Pliva Kalinovica	Chemicals	River
		309180	Chromos Grafičke Boje	Chemiicals	Sewerage
		309233	Imunološki Zavod Brezje	Others	Sewerage
		309278	TOP	Chemicals	River
Zaprešić	(4)	315062	HŽ Infrastrucktura	Transportation	Sewerage
		315080	Inker	Ceramic	River
		315089	Karbon	Chemicals	Sewerage
		315157	Viadukt	Others	River
Velika Gorica	(4)	314038	Dalekovod	Metal/Machinery	Sewerage
		314077	Industrogradnja	Concrete	Sewerage
		314079	Industrogradnja	Concrete	River
		314205	Zraćna Luka Zagreb	Transportation	Sewerage
Jastrebarsko	(2)	332001	Mladina d.d.	Food/Beverage	Sewerage
		332002	Jamnica Zagreb, Jamnička Kiselica	Hospital	Canal
Popovača	(1)	335003	Neutropsihijatrijska Bolnica	Food/Beverage	Sewerage
Ogulin	(2)	335001	Opća Bolnica Oglin	Hospital	Underground
		335004	Bjelolasic	Hotel	Brook

The existing wastewater quantity and pollution load (BOD, COD, TSS) of the 51 large industries are summarized below from the database of Croatian Waters. [See, Table C.1.2 (1) to Table C.1.2 (16)]

Industry		Quantity		BOD		COD		TSS	
		(m^3/d)	(%)	(kg/d)	(%)	(kg/d)	(%)	(kg/d)	(%)
Large Pollutant Industries	(18)	37,515.5	82.0	5,123.8	86.9	12,814.0	88.1	27,204.9	79.9
Other Large Industries	(33)	8,220.6	18.0	774.1	13.1	1,727.5	11.9	6,843.4	20.1
Total	(51)	45,736.1	100.0	5,897.9	100.0	14,541.5	100.0	34,048.3	100.0

As shown in the above table, the wastewater quantity and pollution load of the 18 large pollutant industries represent about 80% to 90% of the total for the 51 large industries.

1.4 Estimation of Existing and Future Wastewater Quantity and Quality

1.4.1 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality of the 18 large pollutant industries are estimated based on the data obtained through the questionnaire survey and the field measurements of effluent in addition to the database of Croatian Waters. The results of the field measurement are given in Appendix B. The existing wastewater quantity and quality of the other 33 large industries are in principle estimated based on the database of Croatian Waters.

1.4.2 Future Wastewater Quantity and Quality

The wastewater quantity and quality are estimated for the target years of the Feasibility Study (2007) and the Master Plan Study (2015). The present year is set at 1999.

(1) Wastewater Quantity

(a) Growth Rate of Industrial Production

Most of the objective large industries have no future production plans. For the industries having no future production plans, industrial production is assumed to increase in proportion to the growth of GDP of Croatia. On the other hand, the growth rate of GDP is projected as follows: 1999-2000 = 0%; 2001-2005 = 3.6%; 2006-2010 = 5.5%; and 2011 2015 = 4.5% (see, Appendix A). The growth ratio (f_I) in the target years to the present year is as shown below.

Target Year	1999	2000	2007	2015
f_I (Growth Ratio to 1999)	1.000	1.000	1.328	1.944

(b) Wastewater Reduction Factor

The unit industrial wastewater quantity per product will decrease in the future according to the technological advancement of the manufacturing process and to the saving on running cost and water use. The decreasing rate of the objective industries will be different per industry; however, most of the objective industries have at present no improvement plan of the manufacturing process such as “Cleaner Production” that may reduce the wastewater quantity. Hence, the wastewater reduction ratio of the industries with no cleaner production plan is estimated by classifying the objective industries into three (3) categories based on the following policies:

(i) Classify the industries by comparing the existing unit wastewater quantity with the standards in Japan. The industry with a higher unit wastewater quantity has room to decrease it in the future (Category A).

(ii) Classify the industries, considering the existing share of cooling water use in the total water use. The industry with a larger cooling water use has room to increase the rate of recycle use, resulting in decrease of unit wastewater quantity (Category B).

(iii) Classify the industries, considering the age of equipment. The industry with old equipment has room to decrease the unit wastewater quantity by improving equipment in the future (Category C).

The unit wastewater quantity of each category is assumed to decrease as follows: Category A: 10% reduction by 2015; Category B: 1% reduction per year; and Category C: 20% reduction by 2015.

The wastewater reduction ratio (f_2) is assumed as follows.

Reduction Ratio (f_2) to 1999		1999	2000	2007	2015
(i)	Category A Industry	1.000	1.000	0.953	0.900
(ii)	Category B Industry	1.000	1.000	0.930	0.850
(iii)	Category C Industry	1.000	1.000	0.907	0.800

As a result, the industrial wastewater quantity in the target years are calculated by category as follows: Q_{xx} (m^3/d) = $Q_{99} \times f_1 \times f_2$; where, Q_{xx}: quantity in target year, and Q_{99}: quantity in 1999.

(2) Wastewater Quality

Without project, the future wastewater quality (effluent quality) is assumed to be the same as the existing one. With project, the future wastewater quality (effluent quality) is estimated on the assumption that industrial wastewater treatment will be implemented for the Study Area to keep pace with the progress of sewage treatment. Hence,

(a) By the year 2007, only the industries located in the five F/S towns of sewerage development; namely, Dugo Selo, Vrbobec, Sisak, Kutina and Karlovac-Duga Resa (see Appendix E), will receive treatment to meet the regulations. Treatment of industries located in the other towns/municipalities will be left until after 2007.

(b) By the year of 2015, wastewaters of all of the 51 large industries will receive treatment to meet the regulations.

1.5 Selection of Wastewater Recipient

Except the cases specified below, industries will discharge their wastewater into the public sewerage, in principle, to promote the pollution control of industrial wastewater at the minimum cost. On the other hand, public sewerage companies can allocate the necessary cost for the industry and as a result, the integral treatment of municipal and industrial wastewaters will attain the target at the minimum cost. The exceptional cases of industry mentioned above are:

(1) The industry is already provided with a high level treatment system and can easily discharge its wastewater into the river with a small improvement as required;

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

(3) The wastewater quality is not appropriate for public sewage treatment; and

(4) The industry is located far from the sewerage system to which connection requires a large additional cost.

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

1.6 Design Concept of Wastewater Treatment System

(1) General

The improvement of the existing or the installation of a new treatment plant is planned to meet the permissible limits of effluent, targeting the year 2015. The improvement or new installation of treatment plant is proposed according to the existing conditions of effluent quality and treatment plant, as follows.

(a) In case the existing wastewater effluent meets the permissible limits:

(i) For industry with no treatment plant, no plan is proposed.

(ii) For industry with treatment plant, extension of the existing plant is proposed to cope with the increasing wastewater quantity.

(b) In case the existing wastewater effluent does not meet the permissible limits:

(i) For industry with no treatment plant, new installation of the optimum treatment plant is proposed.

(ii) For industry with treatment plant, optimum improvement of the existing plant is proposed.

(2) Selection of Wastewater Treatment Process

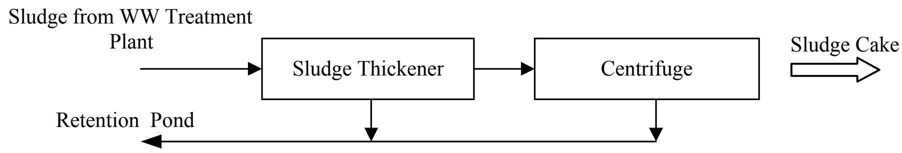
The optimum treatment process varies depending on the wastewater quality and kind of wastewater recipient. However, the following four (4) typical treatment processes are applied in this Study and the adequate process is selected according to the required treatment condition of each industry.

Case	Treatment Process	Applicable Industry
Case 1	Conventional Activated Sludge (AS)	Industry which treats BOD and COD with a normal concentration to discharge into public sewerage or natural recipient
Case 2	Two Stage Activated Sludge (2-AS)	Industry which treats BOD and COD with a high concentration to discharge into natural recipient
Case 3	Chemical Clarification (CT)	Industry which treats TSS, heavy metals, color and insoluble BOD, COD to discharge into public sewerage or natural recipient
Case 4	Conventional Activated Sludge + Chemical Clarification (AS + CT)	Industry which treats BOD, COD, TSS, heavy metals, color and oil to discharge into natural water

The flow diagrams of the above treatment processes are shown in Fig. C.1.1 (1) and Fig. C.1.1 (2) for the Conventional Activated Sludge (AS), Fig. C.1.2 for the Two Stage Activated Sludge (2-AS), Fig. C.1.3 (1) and Fig. C.1.3 (2) for the Chemical Clarification (CT), and Fig. C.1.4 for the Conventional Activated Sludge + Chemical Clarification (AS + CT).

(3) Sludge Treatment

The generated sludge is treated by a combination of thickening and mechanical (centrifuge) dewatering processes in consideration of the limitation of available space in the industry. The sludge cake is transported to the site of final disposal. The flow diagram of sludge treatment is shown below.



1.7 Cost Estimate

The construction cost of a proposed treatment plant is roughly estimated as shown in the following table. The exchange rate at the end of February 2001 is employed; namely, US$1.00 = Kn 8.3 = ¥116.

Item	Breakdown	Remarks
1. Direct Cost	(1) Machanical/Electrical Works	Installation, Piping, Instrument, etc.
	(2) Civil/Architectural Works	Foundation, RC Basin, Paving, Control Room, Warehouse
	(3) Miscellanious Works	Painting, Insulation, Temporary Works, Performance Test
2. Indirect Cost	Engineering/Administration	1. × 10%
3. VAT		1. × 22%
4. Customs Duties		1 (1) × 10%
5. Contingency		1. × 20%
Total		

CHAPTER II WASTEWATER TREATMENT OF LARGE POLLUTANT INDUSTRIES IN SESVETE EAST

2.1 General

Sesvete East is one of the administrative units of Zagreb City that is located in the eastern fringe. It is developed mainly for residential use, and the industrial zone is located south of the railway.

Two (2) industries, Agroproteinka d.d. and Duma Kože d.o.o. (former name: Almeria d.o.o.), are defined as large pollutant industries because both of them discharge large amounts of pollution load. No other industries are listed in the database of Croatian Waters as industrial pollutant source. In this Chapter, wastewater treatment in the above two (2) industries is studied in detail.

2.2 AGROPROTEINKA d.d.

2.2.1 Outline of the Factory

The main features of existing industrial activities are summarized below.

Code No.	310001		
Address	Sesvetski Kraljevec, Industrijiska Cesta b.b.		
Activity	Production of Animal Food		
Main Raw Material	Slaughter Waste	:	1,700-3,400 ton/month
Main Products (1999)	Animal Foods	:	700-800 ton/month
	Grease (Fat)	:	229 ton/month
No. of Employees	57 Persons		
Operation Time	24 Hours Continuous Operation, Mainly Daytime		

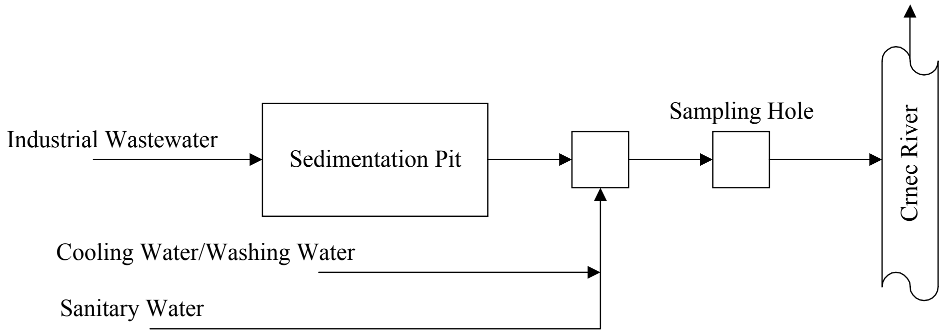
2.2.2 Existing Water Use

Approximately 200 m^3/day is supplied from the municipal water supply system for industrial (boiler, cooling, washing) and domestic (toilet flushing, cooking, bathing) water purposes.

2.2.3 Existing Wastewater Discharge System

Wastewaters from the factory include industrial process wastewater, cooling water, washing water and sanitary wastewater. Wastewaters are discharged into the neighboring canal (SK 45) through one (1) underground outlet. The wastewater discharged into the canal is further drained into the Crnec River (upstream tributary of the Lonja River) by pumps in the downstream at Dugo Selo.

The industrial wastewater is treated by a simple system of grease trap/sedimentation pit. The cooling water, washing water and sanitary wastewater are discharged into the canal without any treatment. The existing wastewater discharge system is illustrated below.



2.2.4 Existing Wastewater Quantity and Quality

The existing industrial wastewater quantity and quality are summarized below based on the database of Croatian Waters, data obtained from the factory and data observed by the Study Team. The effluent quantity and quality vary to a large extent due to the discontinuous operation of the production plant, and wastewater is discharged directly without any equalization.

Quantity(m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	228	7.74	2,230	2,699	1,675	227	45.71	218.5
Min.	150	5.53	820	1,900	466	36	-	23.5
Max.	364	9.03	4,950	4,048	3,095	570	-	798.8
Regulation for Canal (II)		6.5-8.0	25	125	35	21	1	25

In the above table, the canal is assumed as Category II because the canal water finally enters the Lonja River (Category II). The existing effluent quality far exceeds the permissible limits for the canal.

2.2.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The pre-treated wastewater will be discharged into the sewerage of Sesvete East since the construction of a sewage treatment plant has already been determined at the location neighboring to the factory. Besides, the effluent quality of this factory has no problem in sewage treatment.

The sewage treatment plan for Sesvete East proposed by the following report already includes the wastewater of this factory:

"SESVETE ISTOK UREDAJ ZA PROČIŠĆAVANJE OTPADNIH VODA KNJIGA I, HIDROPROJEKT CONCULT, travanj 1999"

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	T-Oil	
1999	1.000	1.00	228	2,230	2,699	1,675	226.6	45.7	213.5	Canal
2007	1.328	0.93	282	2,230	2,699	1,675	226.6	45.7	213.5	Canal
2015	1.944	0.85	377	250	700	200	50.0	10.0	50.0	Sewerage
Regulation for Sewerage				250	700	-	-	10.0	100.0	

Note: Coincidentally, TSS, T-N and T-Oil are treated to the level lower than regulation.

(3) Proposed Wastewater Treatment System

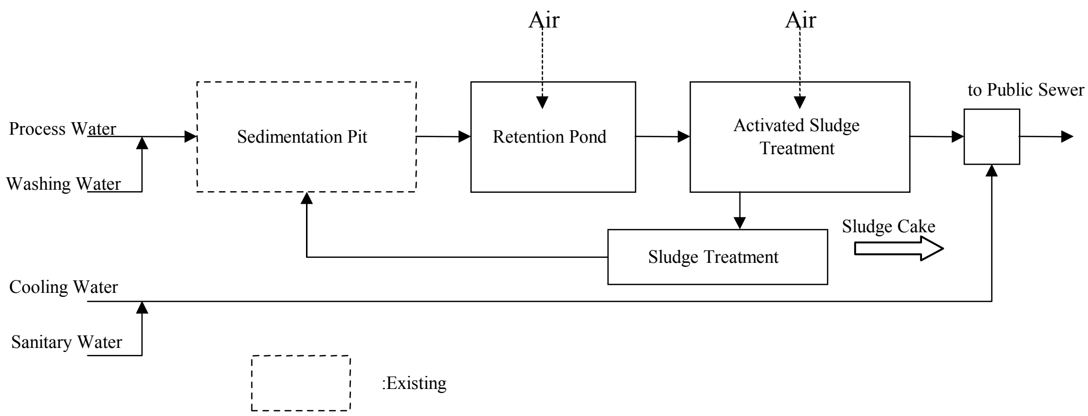
(a) Improvement of Existing Plant

The existing sedimentation pit will be improved to remove coarse floating and sediment matters. It will also reduce about half of BOD, COD, TSS and Oil/Grease. It is especially important to remove Oil and Grease to the possible extent before the succeeding biological treatment.

(b) Installation of Additional Treatment System

A biological treatment system (Conventional Activated Sludge Treatment: AS) is proposed to reduce especially BOD and COD loads. Before the biological treatment system, a retention pond will be provided to equalize the wastewater quantity and quality since they fluctuate due to the discontinuous operation of the production plants.

The proposed treatment system is illustrated below. The detailed flow diagram and layout are shown in Fig. C.2.1 and Fig. C.2.2 respectively.



(c) Specification of Major Equipment

Equipment No.		Specification	Note
Capacity	Treatment Plant	400 m^3/day, 16.7 m^3/h	24h continuous operation
S-2	Retention Pond	200 m^3, 11.7 m × 5.8 m × 3.7 m H, RC	Air bubbling devices
S-3	Aeration Basin	200 m^3, 11.7 m × 5.8 m × 3.7 m H, RC	Aeration unit
S-4	Sedimentation Basin	5.0 m D × 3.5 m H, RC	Center driven rake
S-5	Sludge Thickener	3.0 m D × 3.0 m H, RC	Center driven rake
M-3	Centrifuge	2.5 m^3/h × 7.5 kW, SUS	Horizontal

Note: RC: Reinforced Concrete, SUS: Stainless Steel. For Equipment No., refer to Fig. C.2.1 and. C.2.2.

(d) Required Area

The required area is approx. 24 m × 24 m (576 m^2). (See Fig. C.2.2.)

(4) Estimated Construction Cost

The required construction cost is estimated to be Kn 9.91 million, broken down as follows.

Item	Cost (10^3 Kn)	Remarks
1. Direct Cost		
(1) Mechanical/Electrical Works	4,550	
(2) Civil/Architectural Works	1,630	
(3) Miscellaneous Works	320	
Sub-Total	6,500	
2. Indirect Cost	650	1 × 10%
3. VAT	1,000	1 × 22%
4. Customs Duties	460	1(1) × 10%
5. Contingency	1,300	1 × 20%
Total	9,910	

2.3 DUMA KOŽE d.o.o (former name: ALMERIA)

2.3.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No	310248			
Activity	Leather Processing			
Main Raw Material	Raw Leather	:	30 t/day	
	Chemicals (for Buckling)	:	Lime	(85 t/year)
			Enzyme	(10 t/year)
			Na_2S	(10 t/year)
			Salt	(10 t/year)
	Chemicals (for Tanning)	:	Ammonium Sulfate	(52 t/year)
			Lactic Acid	(11 t/year)
			Salt	(70 t/year)
			Formic Acid	(13 t/year)
			Sulfuric Acid	(25 t/year)
Main Products	Leather	:	200 - 250 t/m (10 t/day)	
No. of Employees	36 Persons			
Operation Time	16 Hours (6:00 - 22:00)			

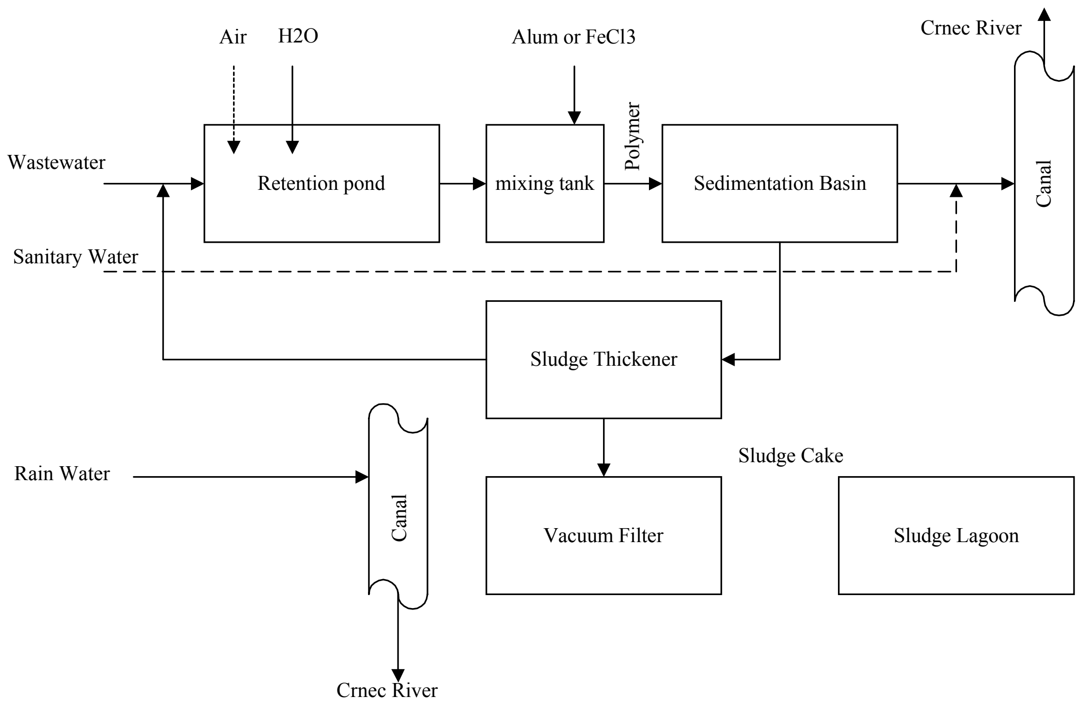
2.3.2 Existing Water Use

The industrial water of 500 m^3/d to 800 m^3/d including office use is supplied from the municipal water supply system. The quantity is measured daily by a flow meter equipped in the underground pit.

2.3.3 Existing Wastewater Discharge System

The wastewater of the factory including industrial process and sanitary wastewater is discharged into the neighboring canal through one (1) outlet. Rainwater is separately discharged into the same canal. The wastewater discharged into the canal is further drained into the Crnec River (upstream tributary of the Lonja River) by pumps in the downstream at Dugo Selo.

The existing wastewater discharge system is illustrated below.



The industrial wastewater is treated by a primary chemical treatment system consisting of retention pond, mixing tank, and sedimentation basin. Aluminum Sulfate $Al_2(SO_4)_3$ or Ferric Chloride ($FeCl_3$) is used for the coagulation in the chemical clarifier and polymer is also added as a coagulant aid. Sludge from the clarifier bottom is dehydrated by a vacuum filter, then disposed to the sludge lagoon.

2.3.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters and data obtained from the factory.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-Cr (mg/l)	Oil/Grease (mg/l)
Ave.	509	7.96	686	2,097	14,111	1,105	2.67	75.5
Min.	141	7.70	445	1,571	6,104	133	1.30	9.1
Max.	871	8.30	1,050	2,500	19,341	3,125	3.73	176.0
Exceptional Regulation for Canal (II)		-	30	300	80	-	1.25	25
Normal Regulation for Canal (II)		6.5-8.0	25	125	35	21.0	1.0	25

In the above table, the canal is assumed as Category II because the canal water finally enters the Lonja River (Category II).

According to the existing regulation as amended by NN No.6/01, exceptional limits are stipulated for the effluent of a leather industry as shown in the above table compared with the normal limits of industrial wastewater. In addition, the exceptional limits of Al (4.0 mg/l) and Cr^{+6} (0.2 mg/l) are further stipulated.

2.3.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The pre-treated wastewater will be discharged into the sewerage of Sesvete East since the construction of a sewage treatment plant has already been determined at the location neighboring to the factory. Besides, the effluent quality of this factory has no problem in sewage treatment. In addition, the previous sewage treatment plan for Sesvete East includes the wastewater of this factory as well as Agroproteinka.

(2) Design Wastewater Quantity and Quality

The factory already has approximately three (3) times the production capacity of the current operation. Industrial production is assumed to increase to two (2) times in 2007 and three (3) times in 2015 of the existing one. On the other hand, the unit wastewater reduction factor in the future is assumed at Category C as defined in the planning basis in Chapter I, Section 1.4.

The normal permissible limits are applied for BOD, COD, TSS and T-N; however, the exceptional limits are applied for Al, T-Cr and Cr+6 for the design of the wastewater treatment plant in this leather factory. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-Cr	T-Oil	
1999	1.000	1.00	509	686	2,097	14,111	1,105	2.67	75.5	Canal
2007	2.000	0.907	923	686	2,097	14,111	1,105	2.67	75.5	Canal
2015	3.000	0.800	1,222	250	700	200	300	2.67	50.0	Sewerage
Exceptional Regulation for Sewerage				-	-	-	-	4.0	100	
Normal Regulation for Sewerage				250	700	-	-	2.0	100	

Note: Coincidentally, TSS, T-N and T-Oil are treated to the level lower than regulation.

In addition to the above, the design wastewater quality in 2015 is set at 4.0 mg/l for Al and 0.2 mg/l for Cr^{+6}.

(3) Proposed Wastewater Treatment System

The existing wastewater quality of T-Cr and Cr^{+6} satisfies the permissible limits. No data are available for the existing quality of Al; however, it can be removed easily by chemical treatment. In addition, the existing quality of T-Oil is lower than the regulation. Hence, the study focuses on the treatment of BOD, COD, TSS and T-N.

The existing treatment system of chemical clarifier removes TSS very efficiently when operated with the proper dosage of coagulant under the proper pH condition. The concentrations of BOD, COD and T-N decrease coincidentally to less than 1/3 with the removal of TSS.

The existing treatment plant has a sufficient capacity to treat TSS to the target level in 2015, as verified below. Moreover, the factory is planning to install a chemical feeding unit at the plant.

Item	Present			2015		
1.Wastewater	Quantity	:	509 m^3/d	Quantity	:	1,222 m^3/d
2. Retention Pond	Volume	:	1,800 m^3	Volume	:	1,800 m^3
	Retention Time	:	3.54 days	Retention Time	:	1.47 days
3. Clarifier	Surface Area	:	78.5 m^2	Surface Area	:	78.5 m^2
	(Inside Diameter)	:	10 m	(Inside Diameter)	:	10 m
	Surface Load	:	0.32 $m^3/m^2/h$	Surface Load	:	0.65 $m^3/m^2/h$
4. Dewatering Filter	4 - 6 h/d			8 - 12 h/d		
Evaluation	Satisfactory			Acceptable		

From the above discussions, no additional plant is considered necessary. The existing wastewater treatment plant will be able to treat the wastewater to the permissible levels in 2015 with a minor improvement of the chemical feeding unit and the operation system.

(4) Estimated Construction Cost

The improvement cost of the existing plant is roughly estimated at approx. Kn 2,000 $\times 10^3$.

(5) Recommendation

The following Jar Test should be conducted as a routine work for the satisfactory operation of the treatment plant.

1. Test Conditions	
(1) Optimum pH Range	Alkali or Acid
(2) Optimum Coagulant Dosage	$Al_2(SO_4)_3$ or $FeCl_3$
(3) Optimum Polymer Dosage	Cation, Anion or Nonion
2. Observation	Floc Size
	Settling Velocity
	Turbidity or Clearness of Supernatant
	Sludge Volume
3. Test Devices	Jar Tester
	pH Meter
	Turbidity Meter
	Electric Conductivity Meter
	Glass Wares, Chemicals (Coagulant, pH Controller, Polymer)

CHAPTER III WASTEWATER TREATMENT OF LARGE POLLUTANT INDUSTRY IN VRBOVEC

3.1 General

There are 20 industries of various sizes and categories in Vrbovec, as listed in Table C.1.2 (2). Among them, three (3) industries (PIK Vrbovec Mesna Industrija, PIK Vrbovec Farma Poljanski and Gradip d.d.) are selected as large industries, and PIK Vrbovec Mesna Industrija is defined as a large pollutant industry, as mentioned in Chapter I.

The wastewater treatment of PIK Vrbovec Mesna Industrija is discussed in this Chapter III. The wastewater treatments of other two (2) large industries are discussed in Chapter VIII. The wastewaters of the remaining 17 small industries are dealt as part of the municipal wastewater. The existing industrial wastewater quantity and pollution loads are summarized below based on the database of Croatian Waters given in Table C.1.2 (2).

Industry	Q		BOD		COD		TSS	
	(m^3/d)	(%)	(kg/d)	(%)	(kg/d)	(%)	(kg/d)	(%)
One Large Pollutant Industry	2,479.9	82.1	444.6	58.4	900.9	63.3	2,509.9	78.3
Two Large Industries	184.8	6.1	216.6	28.4	380.7	26.7	448.4	13.9
17 Small Industries	355.1	11.8	100.6	13.2	142.6	10.0	248.7	7.8
Total	3,019.8	100.0	761.8	100.0	1,424.2	100.0	3,207.0	100.0

3.2 PIK VRBOVEC MESNA INDUSTRIJA

3.2.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No	360004		
Activity	Meat Processingn		
Capital	100 million DM		
Main Raw Materials (1999)	Pig	:	11,153 ton
	Young Cow	:	3,770 ton
	Cow	:	2,818 ton
	Half Products	:	3,834 ton
Main Products (1999)	Meat Products	:	18,780 ton
	Fat	:	2,041 ton
No. of Employees	2,000 Persons		
Operation Time	24 Hours Continuous Operation		

3.2.2 Existing Water Use

The industrial water is supplied from the municipal water supply system for the production process and from surface water for cooling purposes. The existing water use of the factory is summarized below.

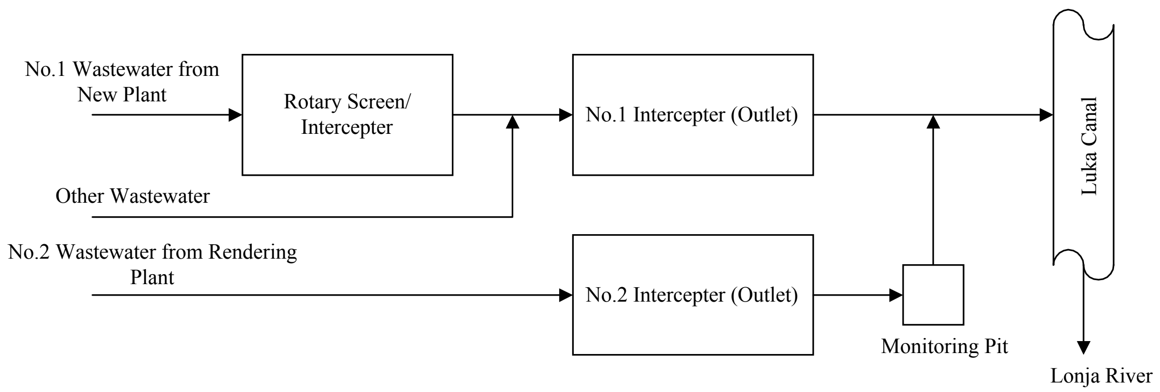
Purpose	Source	Quantity	
		m^3/month	m^3/day
Process	Municipal Water	47,420	1,580
Cooling	River	15,903	530
Total		63,323	2,110

3.2.3 Existing Wastewater Discharge System

The wastewater of the factory is discharged into the neighboring Luka Channel through two (2) interceptors/outlets, No. 1 and No. 2, and finally into the Lonja River.

The No. 1 interceptor (outlet) receives the wastewater including sanitary wastewater from the meat processing plant, while the No. 2 interceptor (outlet) receives the wastewater from the rendering plant that produces animal food out of meat waste.

However, the existing wastewater treatment is insufficient because the system is only provided with a rotary screen and oil interceptors. The existing wastewater discharge system is illustrated below.



3.2.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality of the factory are summarized below based on the database of Croatian Waters, data obtained from the factory and data observed by the Study Team.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	2,132	7.14	186	406	327	19.8	3.86	52.6
Min.	1,361	7.02	131	362	180	15.2	3.50	6.8
Max.	2,632	7.20	249	450	592	24.3	4.04	85.0
Regulation for Channel (II)		6.5-8.0	25	125	35	21	1	25

Note: Quantity is the total for No. 1 and No. 2 outlets, and quality is the average for No. 1 and No. 2 outlets.

The existing wastewater recipient channel (Luka Channel) is assumed as Category II since the wastewater finally flows down to the Lonja River (Category II). The existing effluent quality far exceeds the permissible limits for the channel.

3.2.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The recipient of wastewater will be changed from the Luka Channel to the public sewerage since a sewage treatment plant is proposed at the location near the existing industrial wastewater outlet. Besides, the effluent quality of this factory has no problem in sewage treatment.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	T-Oil	
1999	1.000	1.000	2,132	186	406	327	19.8	3.86	52.6	Canal
2007	1.328	0.930	2,633	186	406	327	19.8	3.86	52.6	Sewerage
2015	1.944	0.850	3,523	186	406	327	19.8	3.89	52.6	Sewerage
Regulation for Sewerage				250	700	-	-	10	100.0	

(3) Proposed Wastewater Treatment System

The wastewater quantity is estimated to increase from 2,132 m^3/d in 1999 to 3,523 m^3/d in 2015. On the other hand, the existing wastewater quality after pre-treatment would meet the permissible limits for discharging into the public sewerage. Hence, only extension of the existing treatment plants is necessary to cope with the increased wastewater in the future.

(4) Estimated Construction Cost

The required construction cost is roughly estimated to be approx. Kn 1,000 $\times$ 10^3.

(5) Recommendations

The floating scum and sludge in the interceptors should be removed manually as a routine work to improve the effluent quality.

CHAPTER IV WASTEWATER TREATMENT OF LARGE POLLUTANT INDUSTRIES IN SISAK

4.1 General

Six (6) industries are listed as industrial pollutant sources in the database of Croatian Waters for Sisak; namely, (1) Industrija Nafte d.d Zagreb Rafinerija Nafte Sisak, (2) Herbos d.d., (3) Termoelektrana Sisak, (4) Segestica, (5) Zeljezara Sisak d.d. Poduzece Metaval, and (6) Ljudevit Posavski Mlin i Pekare. Since all of them discharge a large wastewater quantity and pollution load as shown in Table C.1.2 (3), they are all defined as large pollutant industries as mentioned in Chapter I. Their wastewater treatment systems are then studied in detail in this Chapter IV.

4.2 INDUSTRIJA NAFTE d.d. ZAGREB RAFINERIJA NAFTE SISAK

4.2.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No	374001
Activity	Oil Refinery
Main Raw Materials	Crude Oil : 1,994,278 kl (1998), 2,364,959 kl (1999)
Main Products	Gasoline, Heavy Oil, Fuel Oil
No. of Employees	1,798 Persons
Operation Time	24 Hours Continuous Operation

4.2.2 Existing Water Use

The industrial water is supplied from two (2) sources: the river through the Factory’s own intake system and the municipal water supply system.

The existing water consumption of the factory is summarized below by purpose and by water source.

Source	Purpose	Quantity		Remarks
		m^3/year	m^3/day	
River Water	Process Water	1,265,860		
	Cooling Water	2,267,565		Including make-up water only
	Others	1,443,719		
	Sub-total	4,977,144	13,640	
Municipal Water	Others	577,533	1,580	
Total		5,554,677	15,220	

4.2.3 Existing Wastewater Discharge System

The factory is located on the right bank of the Kupa River just upstream of the confluence with the Sava River. All of the wastewaters of the factory are discharged into the Kupa River and the Sava River through five (5) outlets, No. 1 to No. 5, as follows:

(1) The No. 1 outlet discharges oily wastewater (excluding process wastewater) treated by the API oil separator to Kupa River.

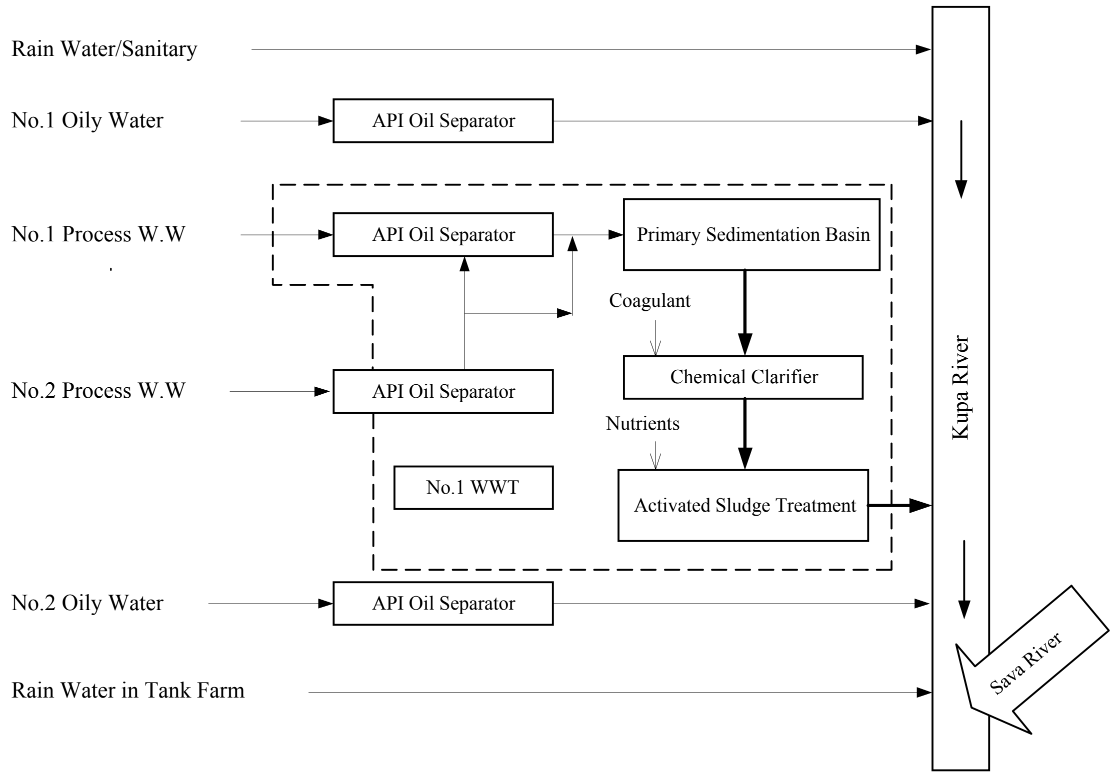
(2) The No. 2 outlet discharges the process wastewater of the entire refinery treated by the system consisting of API oil separator, primary sedimentation, chemical clarifier and activated sludge treatment to Kupa River.

(3) The No. 3 outlet discharges oily wastewater (excluding process wastewater) treated by the API oil separator to Sava River.

(4) The No. 4 outlet discharges oily rainwater on the tank farm with no treatment to Sava River.

(5) The No. 5 outlet discharges rainwater and sanitary wastewater with no treatment to Kupa River.

Process wastewater of the factory is treated at the old treatment plant (No. 1 WWTP) at present. A new plant (No. 2 WWTP) is 90% completed; however, the construction was suspended due to financial constraints.



Note : For detailed system of No.2 WWTP, see the flow chart of Section 4.2.5

4.2.4 Existing Wastewater Quantity and Quality

(1) Agreement with Croatian Waters

The factory has an agreement with Croatian Waters concerning effluent quantity and quality, as follows.

Outlet Number	Quantity	
	m^3/year	m^3/day
No. 1	400,000	1,330
No. 2	1,700,000	5,667
No. 3	1,700,000	5,667
No. 4	320,000	1,067
No. 5	600,000	2,000
Total	4,720,000	15,731

The effluent quality was determined to meet the criteria for a Category III river after 2005, as follows.

Parameter	Before 2005	After 2005
W. Temp. (°C)	-	40
pH	6.0 - 9.0	6.0 - 8.5
BOD (mg/)	40	25
COD (mg/)	125	125
TSS (mg/)	35	30
T-Oil (mg/)	30	30
Phenols (mg/)	0.5	0.2

(2) Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters, data collected from the factory and data observed by the Study Team. Quantity is the total for No. 1 to No. 4 outlets.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	Phenol (mg/l)	Oil & Grease (mg/l)
Ave.	9,399	6.97	26.7	62.0	311	72.2	1.3	7.6
Min.	8,639	6.40	11.9	56.8	24	0.77	12.1	15.4
Max.	10,667	7.30	35.2	67.2	509	0.02		
Agreement (Before 2005)		6.0-9.0	40	125	35	-	0.5	30
Agreement (After 2005)		6.0-8.5	25	125	30	-	0.2	30

As shown in the above table, TSS and Phenols are higher than the permissible limits, while BOD is nearly equal to the values of the agreement.

4.2.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The industrial wastewater is discharged directly into the Kupa and Sava rivers through a full scale but old treatment system at present. It barely meets the permissible limits of the agreement except TSS and Phenols. However, when the new plant becomes operational, the wastewater could be discharged into the river with necessary treatment.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

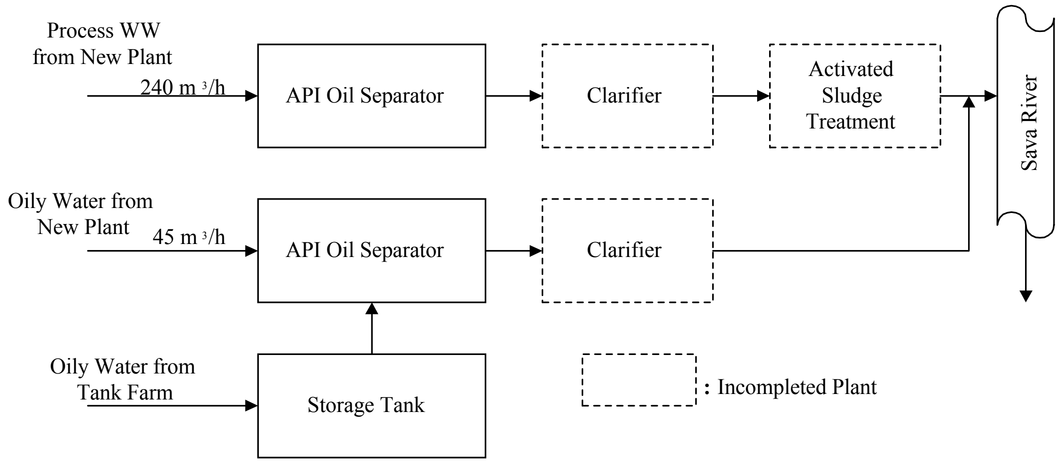
	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-Oil	Phenols	
1999	1.000	1.000	9,399	27	62	311	72	12.1	1.3	River
2007	1.328	0.930	11,608	25	62	35	21	12.1	0.1	River
2015	1.944	0.850	15,531	25	62	35	21	12.1	0.1	River
Regulation for Category II River				25	125	35	21	25.0	0.1	

Note: Design wastewater quality is set to meet the regulation for Category II river.

(3) Proposed Wastewater Treatment System

(a) Construction of New No. 2 WWTP

Construction of the new plant (No. 2 WWTP) has been suspended as mentioned before. In order to improve the effluent quality, the clarifiers and the activated sludge treatment plant need to be completed. The treatment system is as illustrated below.



(b) Improvement of Existing No. 1 WWTP

The existing effluent quality does not meet the permissible limits of the regulation on TSS and Phenols. These substances can be treated to the required level by operational improvement of the existing chemical clarifier and activated sludge treatment. The necessary operational improvements are given below.

(i) Floating oil in the gravity separators including pump pits should be removed completely.

(ii) The chemical clarifier should be operated under the condition of proper pH and coagulant dosage to remove TSS. In order to operate it under the optimum conditions, Jar Test should be conducted as a routine work.

(iii) The activated sludge treatment plant should be operated under the condition of proper concentration of dissolved oxygen.

Further, floating oil should be removed to the possible extent at the generation source before mixing it with other wastewaters. For this purpose, the existing chemical injection system should be improved.

(4) Estimated Construction Cost

The required construction cost is estimated at approx. Kn 10,300 × 10^3, broken down into Kn 10,000 × 10^3 for completion of the new treatment plant (No. 2 WWTP) and Kn 300 × 10^3 for improvement of the existing treatment plant (No. 1 WWTP).

4.3 HERBOS d.d.

4.3.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	374002			
Activity	Chemicals			
Capital	18 million DM			
Foundation	1946			
Main Raw Materials	Cyanic Chloride	:	950 ton (1998)	800 ton (1999)
	Sodium Lye	:	440 ton (1998)	300 ton (1999)
	Amine	:	700 ton (1998)	600 ton (1999)
Main Products	Pesticides (Atrazin)	:	1,500 ton (1998)	1,250 ton (1999)
	Plant Protection Materials	:	4,300 ton (1998)	4,500 ton (1999)
No. of Employees	340 Persons			
Operation Time	24 Hours Continuous Operation			

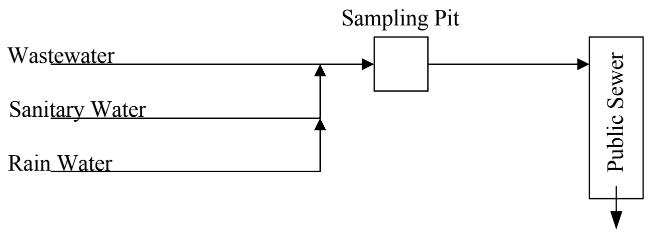
4.3.2 Existing Water Use

The industrial water is supplied from the municipal water supply system, well and river. The existing water consumption of the factory are summarized below by purpose and by water source (1999).

Source	Purpose	Quantity (m^3/year)	Note
Municipal Water	Domestic Use	50,000	
Well Water	Cooling	40,000	Including make-up water only
	Process	30,000	
	Sub-total	70,000	
River Water	Cooling	40,000	Including make-up water only
	Process	30,000	
	Sub-total	70,000	
Total		190,000	

4.3.3 Existing Wastewater Discharge System

All wastewaters of the factory including process wastewater, sanitary wastewater and rainwater are discharged into the public sewerage through one (1) outlet with no treatment. The existing wastewater discharge system is illustrated below.



4.3.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters, data collected from the factory and data observed by the Study Team.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	Oil & Grease (mg/l)	Pesticides (mg/l)
Ave.	604	9.04	205	577	1,406	24.7	10.3	0.4
Min.	526	8.60	15	404	173	19.4	7.4	
Max.	712	9.77	400	750	3,544	30.0	13.3	
Regulation for Sewerage		5.0-9.5	250	700	-	-	100	0.05

The effluent quality meets the regulation for discharge into the public sewerage, except Pesticides (Atrazin).

4.3.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The wastewater is discharged into the public sewerage at present. The existing effluent quality satisfies the permissible limits for public sewerage in all parameters except pesticides (Atrazin).

However, pesticides can be treated easily by activated carbon filter. Hence, the wastewater can be discharged into the public sewerage even in the future after treatment of pesticides.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

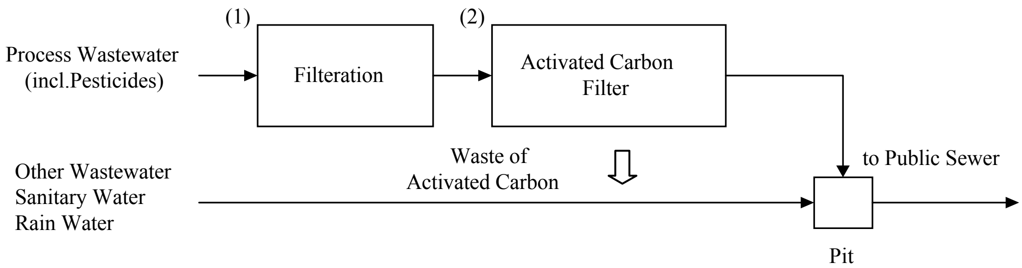
	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-Oil	Pesticides	
1999	1.000	1.000	604	205	577	1,406	24.7	10.3	0.4	Sewerage
2007	1.328	0.907	728	205	577	1,406	24.7	10.3	0.05	Sewerage
2015	1.944	0.800	939	205	577	1,406	24.7	10.3	0.05	Sewerage
Regulation for Sewerage				250	700	-	-	100	0.05	

Note: TSS is treated to the above levels although no regulation is stipulated.

(3) Proposed Wastewater Treatment System

The activated carbon filter treatment process is proposed to treat pesticides to the permissible level. The treatment plant is to be provided at the generation source of pesticides as an in-plant treatment. The design wastewater containing pesticides (Atrazin) is assumed at 30 m^3/d.

On the other hand, other wastewaters are simply treated to remove TSS. The proposed treatment process for process wastewater including pesticides is illustrated below.



(4) Estimated Construction Cost

The required construction cost is roughly estimated to be approx. Kn 1,500 $\times$ 10^3.

4.4 TERMOELEKTRANA SISAK

4.4.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	374003			
Activity	Electric Power Supply			
Main Raw Materials	Fuel Oil	:	358,913 ton (1998)	342,277 ton (1999)
	Natural Gas	:	142.0 million m^3 (1998)	88.1 million m^3 (1999)
Main Products	Output	:	1,828,000 MWH (1998)	1,639,636 MWH (1999)
No. of Employees	229 Persons			
Operation Time	24 Hours Continuous Operation			

4.4.2 Existing Water Use

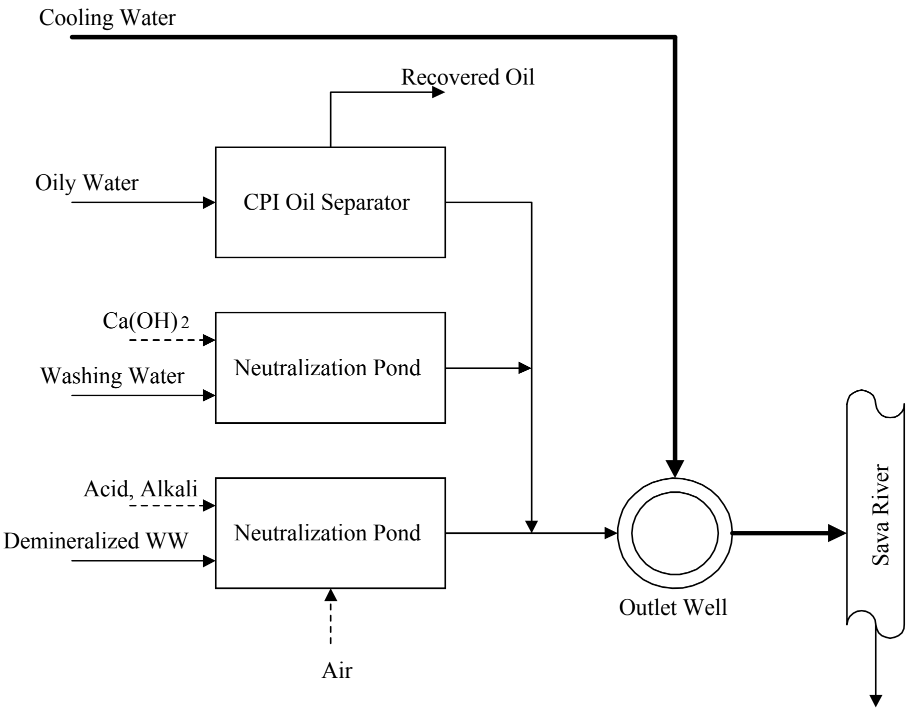
Industrial water is taken from the Sava River while domestic water is supplied from the municipal water supply system. The existing water consumption of the factory is summarized below by purpose and water source.

Source	Purpose	Quantity (m^3/month)	Remarks
River Water	Process Water	16,208	
	Cooling Water	14,909,143	One thorough use (no real consumption)
	Sub-total	14,925,351	
Municipal Water	Others	7,043	
Total		14,932,394	

A large quantity of cooling water is taken from the Sava River by factory pumps. The cooling water is returned to the Sava River after one thorough use.

4.4.3 Existing Wastewater Discharge System

The power station is located on the right bank of the Sava River just downstream of the confluence with the Kupa River. All wastewaters of the power station are discharged into the Sava River through one (1) outlet. The existing wastewater discharge system is illustrated below.



4.4.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality excluding cooling water are summarized below based on the database of Croatian Waters, data collected from the factory and data observed by the Study Team.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	451	7.61	4.5	25.5	178	2.3	0.14	3.0
Min.	-	6.94	2.0	22.2	20	1.5	0.13	0.9
Max.	-	8.40	6.4	28.8	472	3.3	0.15	4.1
Regulation for River (II)		6.5 - 8.0	25	125	35	21	1	25

In addition to the above wastewater, cooling water of 490,325 m^3/d on average is discharged into the river. As shown in the above table, the wastewater quality exceeds the regulation in only TSS.

4.4.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The wastewater is at present discharged directly into the Sava River with pre-treatment and the effluent quality satisfies the permissible limits of the river in all parameters except TSS. Hence, the wastewater will be discharged into the same river as at present.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality excluding cooling water for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	451	5	26	178	2.3	0.14	3.0	River
2007	1.328	0.930	557	5	26	35	2.3	0.14	3.0	River
2015	1.944	0.850	745	5	26	35	2.3	0.14	3.0	River
Regulation for River (II)				25	125	35	21.0	1.00	25	

(3) Proposed Wastewater Treatment system

The wastewater quantity (excluding cooling water) is estimated to increase from 451 m^3/d in 1999 to 745 m^3/d in 2015. The extension of the existing treatment system is proposed to cope with the increasing wastewater quantity (300 m^3/d). TSS will also be treated in the proposed improvement.

(4) Estimated Construction cost

The required construction cost is roughly estimated at approx. Kn 1,000 $\times$ 10^3.

4.5 SEGESTICA (Segestica Proizvodnja Alkohola, Pića i Octa d.o.o.)

4.5.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	374004			
Activity	Brewery			
Capital	77 million Kn			
Main Raw Materials	Maize	:	2,184 ton (1998)	857 ton (1999)
	Sugar	:	353 ton (1998)	319 ton (1999)
	Molasses	:	2,794 ton (1998)	5,113 ton (1999)
Main Products	Juice	:	1,067 kl (1998)	133 kl (1999)
	Syrup	:	3,043 kl (1998)	2,809 kl (1999)
	Vinegar	:	20,816 kl (1998)	24,100 kl (1999)
	Liquor	:	16,984 kl (1998)	12,976 kl (1999)
	Ethyl Alcohol	:	6,339 kl (1998)	10,282 kl (1999)
No. of Employees	159 Persons			
Operation Time	24 Hours Continuous Operation (periodically)			

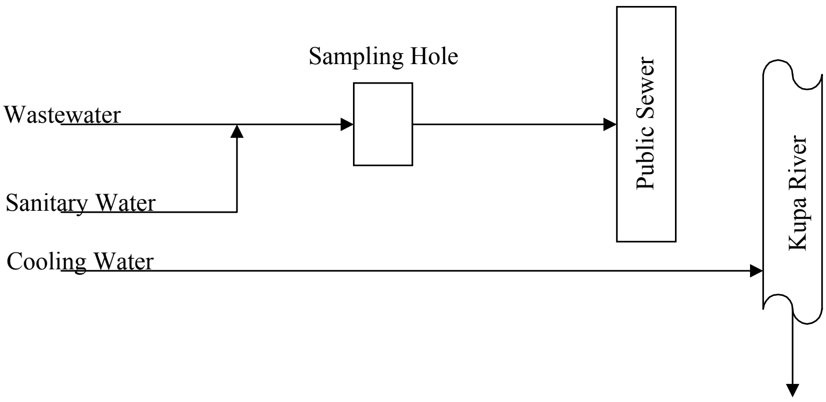
4.5.2 Existing Water Use

The industrial water is supplied from the municipal water supply system and the river. The existing water consumption of the factory is summarized below by purpose and water source.

Source	Purpose	Quantity (m^3/month)	Remarks
Municipal Water			
	Process Water	3,772	
	Raw Material	416	
Sub-Total		4,188	
River Water	Cooling Water	22,333	One thorough use
Total		26,521	

4.5.3 Existing Wastewater Discharge System

As illustrated below, wastewaters including process wastewater and sanitary wastewater are discharged into the public sewerage through one (1) outlet with no treatment. Cooling water is also returned directly to the Kupa River with no treatment.



4.5.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality excluding cooling water are summarized below based on the database of Croatian Waters, data collected from the factory and data observed by the Study Team. The quantity of cooling water discharged into the river is 811 m^3/d on the average.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	204	7.29	866	1,195	692	355	13.04	4.5
Min.	171	5.51	15	85	6	9.9	2.37	1.5
Max.	303	8.40	4,167	2,729	2,437	700	23.70	11.1
Regulation for Sewerage		5.0 - 9.5	250	700	-	-	10	100

As shown in the above table, BOD, COD and T-P exceed the regulation for public sewerage.

4.5.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The wastewater will be discharged into the public sewerage as at present since the effluent quality of this factory has no problem in sewage treatment. Likewise, the cooling water will continue to be discharged into the river even in the future.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality excluding cooling water for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	204	866	1,195	692	355	13.1	4.5	Sewerage
2007	1.328	0.930	252	250	700	200	200	10	4.5	Sewerage
2015	1.944	0.850	337	250	700	200	200	10	4.5	Sewerage
Regulation for Sewerage				250	700	-	-	10	100	

Note: Coincidentally, TSS and T-N are treated to the above level.

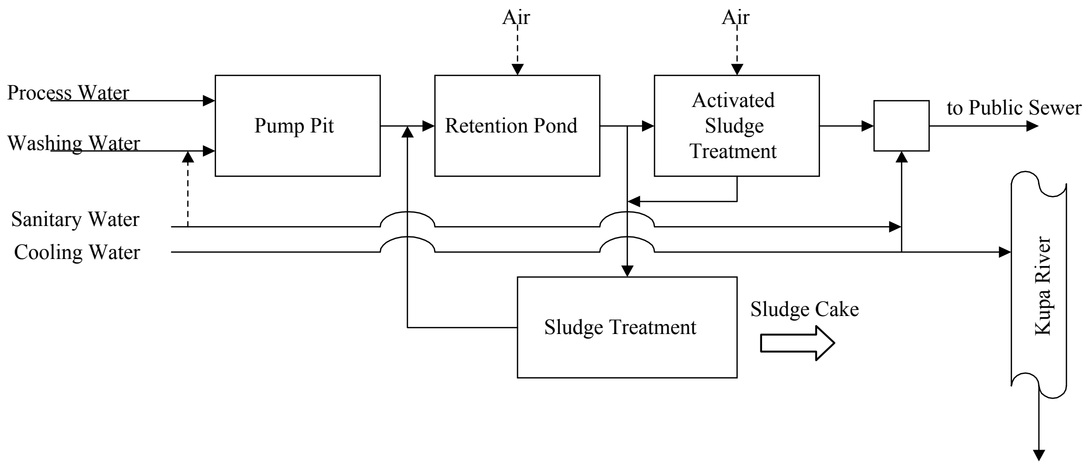
(3) Proposed Wastewater Treatment System

(a) Treatment System

Construction of a biological treatment system (350 m^3/d, Standard Activated Sludge Treatment: AS) is proposed to treat BOD and COD. With this system, TSS, T-N and T-P will be treated coincidentally to the target level.

Further, a retention pond has to be provided before the biological treatment system to equalize the wastewater quantity and quality, because the influent wastewater fluctuates widely due to the discontinuous operation of the factory.

The proposed treatment system is illustrated below. The detailed flow diagram and layout are shown in Fig. C.2.3 and Fig. C.2.4 respectively.



(b) Specification of Major Equipment

Equipment No.	Name	Specification	Note
Capacity	Treatment Plant	350 m^3/day, 15 m^3/h	24 h Continuous operation
S-2	Retention Pond	175 m^3, 12 m × 6 m × 3.2 m H, RC	Air bubbling devices
S-3	Aeration Basin	45 m^3, 8 m × 4 m × 3.2 m H, RC	Aeration unit
S-4	Sedimentation Basin	4.5 m D × 3.0 m H, RC	Center driven rake
S-5	Sludge Thickener	2.5 m D × 2.5 m H, CS	Center driven rake
M-3	Centrifuge	1.5 m^3/h × 3.7 kW, SUS	Horizontal

Note: RC: Reinforced Concrete, CS: Carbon Steel, SUS: Stainless Steel. For Equipment No., see Fig. C.2.3 and Fig. C.2.4

(c) Required Area

The required area is approx. 22m × 23m (506 m^2). (Refer to Fig. C.2.4.)

(4) Estimated Construction Cost

The required construction cost is estimated to be Kn 7.16 million, broken down as follows.

Item	Cost (10^3 Kn)	Remarks
1. Direct Cost		
(1) Mechanical/Electrical Works	3,150	
(2) Civil/Architectural Works	1,130	
(3) Miscellaneous Work	230	
Sub-Total	4,500	
2. Indirect Cost	450	1 × 10%
3. VAT	990	1 × 22%
4. Customs Duties	320	1 (1) × 10%
5. Contingency	900	1 × 20%
Total	7,160	

4.6 ŽELJEZARA SISAK d.d. Poduzeće Metaval

4.6.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	374005			
Activity	Production of Iron and Steel			
Capital	668.6 million Kn			
Foundation	1984			
Main Raw Materials	Steel Ingot	:	61,076 ton (1998)	34,878 ton (1999)
	Steel Band	:	54,420 ton (1998)	31,228 ton (1999)
	Imported Steel	:	25,510 ton (1998)	24,236 ton (1999)
Main Products	Seamless Tube	:	52,375 ton (1998)	37,838 ton (1999)
	Seam Tube	:	35,540 ton (1998)	23,918 ton (1999)
	Proof Seam Tube	:	16,754 ton (1998)	14,799 ton (1999)
No. of Employees	2,056 Persons			
Operation Time	24 Hours Continuous Operation (partly)			

4.6.2 Existing Water Use

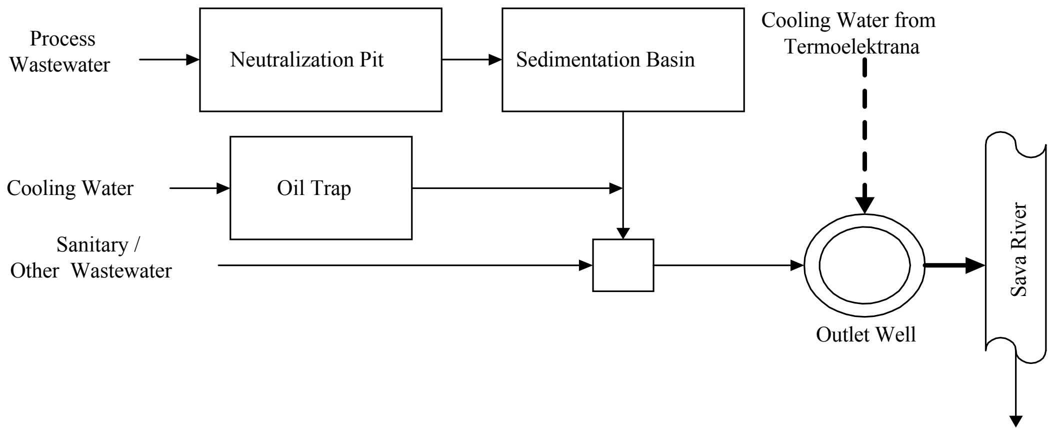
The industrial water including cooling water is taken from the Sava River by factory pumps while domestic water is supplied from the municipal water supply system. The existing water consumption of the factory is summarized below by purpose and water source.

Source	Purpose	Quantity (m^3/month)
River Water	Cooling Water	99,858
Municipal Water	Domestic Use	2,622
Total		102,480

4.6.3 Existing Wastewater Discharge System

Wastewaters including process wastewater, cooling water and sanitary wastewater are discharged into the Sava River along with the cooling water from the TERMOELEKTRANA through one (1) outlet. Process wastewater is treated by neutralization pit and sedimentation basin, while cooling water is treated by the oil trap. However, sanitary and miscellaneous wastewaters are discharged along with other wastewaters with no treatment.

The existing wastewater discharge system is illustrated below.



4.6.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters and data collected from the factory.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	3,182	7.90	12.4	28.3	143	3.0	0.26	4.4
Min.	2,370	7.80	11.5	18.2	25	2.2	-	-
Max.	3,994	8.00	12.4	28.3	261	3.9	-	-
Regulation for River (II)		6.5 - 8.0	25	125	35	21	1	25

As shown in the above table, the effluent quality meets the regulation in all parameters except TSS.

4.6.5 Development of Wastewater Treatment System

(1) Selection of Recipient

Wastewaters will be discharged directly into the Sava River as at present since the existing effluent quality satisfies the permissible limits for the river except TSS.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	3,182	12	28	143	3.0	0.26	4.4	River
2007	1.328	0.907	3,833	12	28	35	3.0	0.26	4.4	River
2015	1.944	0.800	4,949	12	28	35	3.0	0.26	4.4	River
Regulation for River (II)				25	125	35	21.0	1.00	25	

(3) Proposed Wastewater Treatment System

Wastewater quantity is estimated to increase from 3,182 m^3/d in 1999 to 4,949 m^3/d in 2015. Hence, the existing treatment plant needs to be extended to cope with the increasing wastewater quantity by installing one (1) additional train of the same treatment system as the existing one (neutralization pit, sedimentation basin and oil trap). The design capacity of the additional train is 1,800 m^3/d. With the additional train, TSS will be treated coincidentally.

(4) Estimated Construction Cost

The required construction cost is roughly estimated to be approx. Kn 2,000 $\times 10^3$.

4.7 LJUDEVIT POSAVSK MLIN i PEKARE

4.7.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

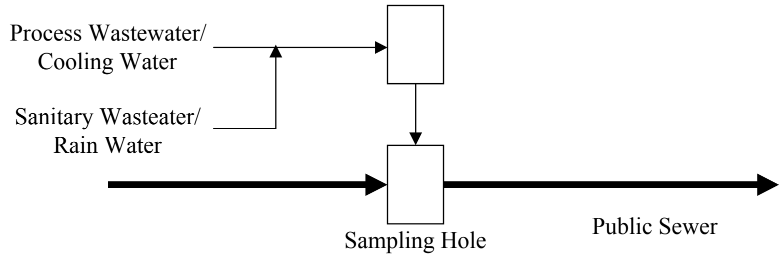
Code No.	374006
Activity	Food/Beverage
Capital	10 million Kn
Foundation	1947
Main Raw Materials	Wheat Flour, Yeast
Main Products	Bread (20,000 pieces/day), Cake
No. of Employees	200 Persons
Operation Time	356 Days Operation (7 a.m. - 3 a.m.)

4.7.2 Existing Water Use

Approximately 25,000 to 30,000 m^3/year is supplied for industrial and domestic purposes from the municipal water supply system.

4.7.3 Existing Wastewater Discharge System

Wastewaters including process wastewater and sanitary wastewater are discharged into the public sewer installed across the factory with no treatment. The existing wastewater discharge system is illustrated below.



4.7.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters and data collected from the factory.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	83	6.43	1,584	2,600	453	-	-	9.3
Min.	74	5.50	885	1,320	356	-	-	1.6
Max.	90	7.80	2,700	3,840	608	-	-	20.7
Regulation for Sewerage		5.0 - 9.5	250	700	-	-	10	100

As shown in the above table, BOD and COD concentrations are extremely higher than the regulation.

4.7.5 Development of Wastewater Treatment System

(1) Selection of Recipient

Wastewaters will be discharged into the public sewerage as at present since the effluent quality of this factory has no problem in sewage treatment.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

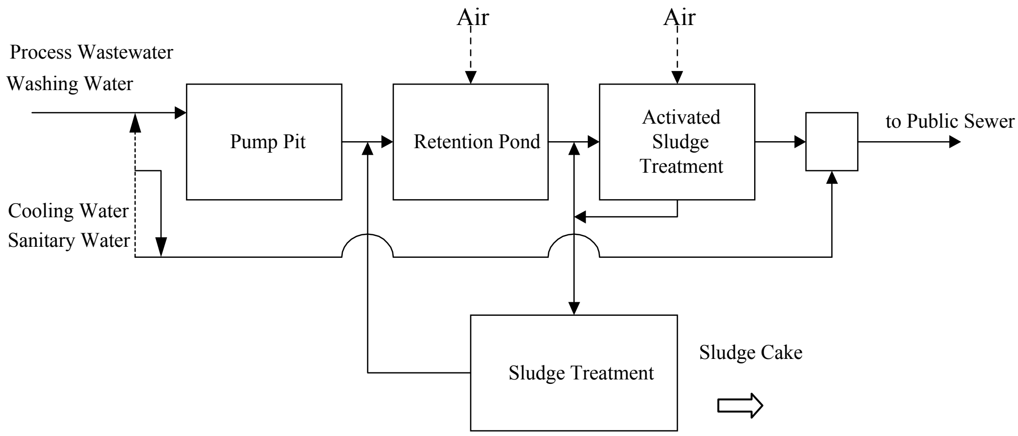
	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	83	1,584	2,600	453	30	5	9.3	Sewerage
2007	1.328	0.930	103	250	700	200	30	5	9.3	Sewerage
2015	1.944	0.850	137	250	700	200	30	5	9.3	Sewerage
Regulation for Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the existing quality value of T-N and T-P.

(3) Proposed Wastewater Treatment System

(a) Treatment System

A new biological treatment plant (Standard Activated Sludge Treatment: AS) with a capacity of 150 m^3/d is proposed to treat BOD and COD, as illustrated below. The detailed flow diagram and layout of the proposed treatment system are shown in Fig. C.2.5 and Fig. C.2.6 respectively.



(b) Specification of Major Equipment

Equipment No.	Name	Specification	Note
Capacity	Treatment Plant	150 m^3/day, 6.5 m^3/h	24h continuous Operation
S-2	Retention Pond	75 m^3, 8 m × 4.0 m × 3.2 m H, RC	Air bubbling devices
S-3	Aeration Basin	52 m^3, 6.5 m × 3.2 m × 3.2 m H, RC	Aeration unit
S-4	Sedimentation Basin	3.0 m D × 3.0 m H, RC	Center driven rake
S-5	Sludge Thickener	1.5m D × 2.5m H, CS	Center driven rake
M-3	Centrifuge	1.0 m^3/h × 3.7 kW, SUS	Screw Decanter

Note: RC: Reinforced Concrete, CS: Carbon Steel, SUS: Stainless Steel. For Equipment No., see Fig. C.2.5 and Fig. C.2.6.

(c) Required Area

The required area is approx. 19m × 17m (323 m^2). (Refer to Fig. C.2.6.)

(4) Estimated Construction Cost

The required construction cost is estimated to be Kn 5.91 million, broken down as follows.

Item	Cost (10^3 Kn)	Note
1. Direct Cost		
(1) Mechanical/Electrical Works	2,770	
(2) Civil/Architectural Works	740	
(3) Miscellaneous Works	190	
Sub-Total	3,700	
2. Indirect Cost	370	1. × 10%
3. VAT	820	1. × 22%
4. Customs Duties	280	1(1) × 10%
5. Contingency	740	1. × 20%
Total	5,910	

CHAPTER V WASTEWATER TREATMENT OF LARGE POLLUTANT INDUSTRY IN KUTINA

5.1 General

There are 11 industries (with 12 outlets) of various sizes and categories in Kutina that are defined as industrial pollutant sources by Croatian Waters, as listed in Table C.1.2 (4). Among them, Petrokemija Kutina is selected as a large pollutant industry because it discharges quite a large wastewater quantity and pollution load, as shown in the table below. The wastewater treatment of Petrokemija Kutina, which has two (2) outlets (one for industrial wastewater and another for sanitary wastewater) is, therefore, presented in detail below.

There are no other large industries. The wastewaters of the remaining 10 small industries are dealt as part of the municipal wastewater of the town in this Study.

The existing industrial wastewater quantity and pollution loads are summarized below based on the database of Croatian Waters given in Table C.1.2 (4).

Industry	Quantity		BOD		COD		TSS	
	(m^3/d)	(%)	(kg/d)	(%)	(kg/d)	(%)	(kg/d)	(%)
One (1) Large Pollutant Industry	11,389.0	98.2	203.3	96.5	604.5	97.6	1,485.3	96.0
Ten (10) Small Industries	205.2	1.8	7.5	3.5	15.2	2.4	61.9	4.0
Total	11,594.2	100.0	210.8	100.0	619.7	100.0	1,547.2	100.0

5.2 PETROKEMIJA KUTINA

5.2.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	357009 (Industrial Wastewater) 357016 (Sanitary Wsatewater)
Activity	Production of Fertilizer
Main Products	Fertilizer (Urea, Ammonium Sulfate, etc.)
No. of Employees	2,000
Operation Time	24 Hours Continuous Operation

5.2.2 Existing Water Use

The industrial water is supplied from the lake located 10 km away from the factory and water consumption is estimated to be 15,000 to 18,000 m^3/d (625 to 720 m^3/h). A large volume of the cooling water is recycled through the cooling towers.

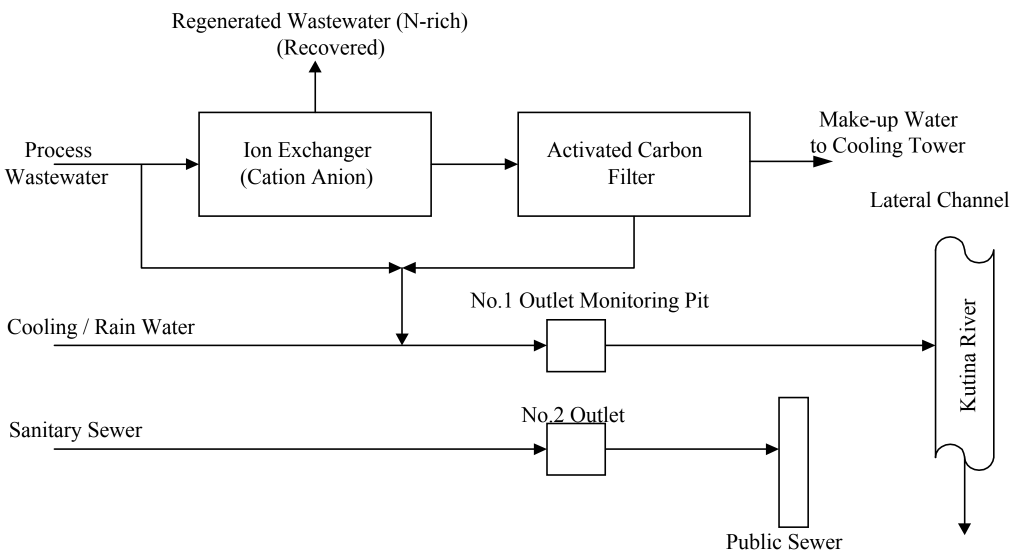
5.2.3 Existing Wastewater Discharge System

The factory discharges three kinds of wastewater; namely, (1) process wastewater, (2) cooling/rain water, and (3) sanitary wastewater. The wastewaters are discharged through two (2) outlets, No. 1 and No. 2.

The Ion Exchange and Adsorption Process (280 $m^3/h \times 2$ trains) is used to treat the process wastewater and the treated water (N: 60 - 80 mg/l) is reused as make-up water of the cooling towers. The N-rich regenerated wastewater is reused as part of raw Nitrogen, and then the effluent of process wastewater is finally discharged into the lateral channel through the No. 1

outlet, together with cooling/rain water. On the other hand, the sanitary wastewater is discharged into the public sewerage through the No. 2 outlet with no treatment.

The existing wastewater discharge system is illustrated below.



5.2.4 Existing Wastewater Quantity and Quality

(1) No. 1 Outlet (Industrial Wastewater)

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters, data collected from the factory and data observed by the Study Team.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	10,388	7.66	11.1	38.8	157	53.0	4.9	1.4
Min.	9,465	7.52	4.3	24.7	32	37.4	-	0.3
Max.	11,987	7.80	17.8	52.8	325	68.6	-	2.5
Regulation for River (II)		6.5 - 8.0	25.0	125	35	21	1	25

In the above table, the recipient channel is assumed as Category II because the wastewater discharged into the channel finally enters the Kutina River (Category II). TSS, T-N and T-P exceed the permissible limits for the channel. The exceedence of TSS is not large, but T-N and T-P need to be reduced.

(2) No. 2 Outlet (Sanitary Wastewater)

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters. The effluent quality satisfies the regulation for public sewerage.

	Quantity (m^3/d)	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	663	7.60	18.7	57.6	398	49.0	-	0.3
Min.	652	-	-	-	-	-	-	-
Max.	674	-	-	-	-	-	-	-
Regulation for Sewerage		5.0 - 9.5	250	700	-	-	10	100

5.2.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The factory discharges a large quantity of process wastewater with low concentrations of organic matter (BOD, COD) but high T-N. Hence, it is not advisable to discharge the process wastewater into the public sewerage (No. 1 Outlet). Process wastewater will be discharged into the channel as presently done, and only the sanitary wastewater will be discharged into the public sewerage as also presently done (No. 2 Outlet).

(2) Design Wastewater Quantity and Quality

(a) No. 1 Outlet (Industrial Wastewater)

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Flow Rate			Quantity (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	10,388	11.1	38.8	157	53	4.9	1.4	Channel
2007	1.328	0.930	12,830	11.1	38.8	35	21	1.0	1.4	Channel
2015	1.944	0.850	17,165	11.1	38.8	35	21	1.0	1.4	Channel
Regulation for River (II)				25.0	125.0	35	21	1.0	25	

(b) No. 2 Outlet (Sanitary Wastewater)

Growth rate of number of employees is used instead of the production growth rate (f_1) in the planning basis in Chapter I, Section 1.4. Since the number of employees is assumed to increase in proportion to $(GDP)^{0.5}$ while unit sanitary wastewater will also increase in the future and the increase rate (f_2) is assumed at 1% per year, f_1 and f_2 in 2007 and 2015 are estimated as follows.

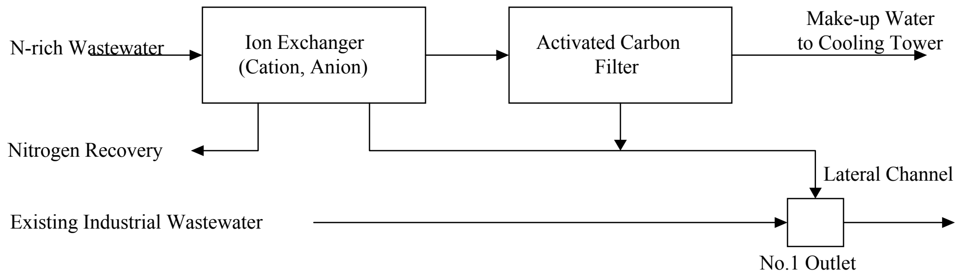
	Flow Rate			Quantity (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	663	18.7	57.6	398	49	5.0	0.3	Sewerage
2007	1.152	1.070	818	18.7	57.6	398	49	5.0	0.3	Sewerage
2015	1.393	1.150	1,063	18.7	57.6	398	49	5.0	0.3	Sewerage
Regulation for Sewerage				250.0	700.0	-	-	10.0	100	

(3) Proposed Wastewater Treatment System

(a) Industrial Wastewater Treatment

The process wastewater quantity including cooling water (No. 1 Outlet) is estimated to increase from 10,388 m^3/d in 1999 to 17,165 m^3/d in 2015. Hence, one (1) additional train with the capacity of 280 m^3/h and of the same treatment system as the existing one will be installed to cope with the increasing wastewater quantity and to treat T-N and T-P to the permissible limits. With this additional train, TSS will be treated coincidentally to the permissible limit.

The proposed treatment system is illustrated below.



(b) Sanitary Wastewater Treatment

No treatment system is proposed.

(4) Estimated Construction Cost

The required construction cost is roughly estimated at approx. Kn $10,000 \times 10^3$.

CHAPTER VI WASTEWATER TREATMENT OF LARGE POLLUTANT INDUSTRIES IN KARLOVAC-DUGA RESA

6.1 General

The industrial wastewater treatment of Karlovac and Duga Resa are studied together in this Study since the municipal wastewaters of both towns are planned to be collected into the treatment plant proposed at the eastern fringe of Karlovac.

There are 32 industries of various sizes and categories in Karlovac and Duga Resa that are defined as industrial pollutant sources by Croatian Waters (see, Table C.1.2 (5) and Table C.1.2 (5a). Among them, 13 industries are selected as large industries and six (6) of these are further selected as large pollutant industries as listed in Chapter I, Section 1.3.

The wastewater treatment of the six (6) large pollutant industries are presented in detail in this Chapter VI, while the wastewater treatment of the other seven (7) large industries are discussed in Chapter VIII. The wastewater of the remaining 19 small industries is dealt as part of the municipal wastewater.

The existing industrial wastewater quantity and pollution loads are summarized below based on the database of Croatian Water given in Table C.1.2 (5) and Table C.1.2 (5a).

Industry	Quantity		BOD		COD		TSS	
	(m^3/d)	(%)	(kg/d)	(%)	(kg/d)	(%)	(kg/d)	(%)
Six Large Pollutant Industries	5,372.5	75.8	2,202.5	97.0	4,236.4	96.0	4,630.2	86.2
Seven Large Industries	1,138.3	16.1	23.4	1.0	77.0	1.7	369.2	6.9
19 Small Industries	574.2	8.1	46.1	2.0	100.5	2.3	374.7	6.9
Total	7,085.0	100.0	2,272.0	100.0	4,413.9	100.0	5,374.1	100.0

6.2 KARLOVAČKA PIVOVARA d.d.

6.2.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	333015		
Activity	Production of Beer		
Factory Area	11 ha		
Main Raw Materials	Malt and Substitute	:	15,000 ton
	Malt and Ferment	:	780,000 kl
Main Products	Beer	:	770,000 kl
	Sugar	:	1,000 ton
	Condensate	:	150 ton
	Masut (fat)	:	4,000,000 ton
	Glycol	:	70 m^3
	NH_3	:	25 ton
No. of Employees	707 Persons		
Operation Time	24 Hours Continuous Operation		

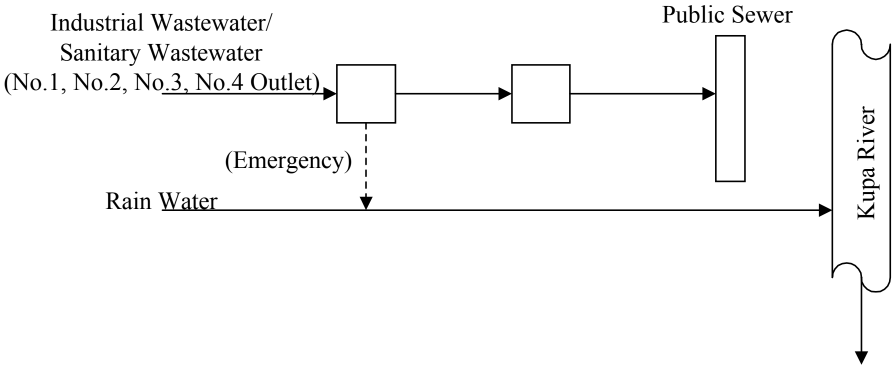
6.2.2 Existing Water Use

The factory uses approximately 819,000 m^3 annually of the municipal water supply and 17,000 m^3 of this amount is consumed for cooling use.

6.2.3 Existing Wastewater Discharge System

All wastewaters of the factory (including process and sanitary wastewaters) are discharged into the public sewerage without any treatment through four (4) outlets that are finally integrated into one (1). In case of emergency, however, wastewaters are discharged directly into the Kupa River. On the other hand, rainwater is discharged directly into the Kupa River.

The existing wastewater discharge system is illustrated below.



6.2.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters, data collected from the factory and data observed by the Study Team.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	2,301	8.29	456	911	595	7.6	7.59	4.2
Min.	1,013	7.50	295	522	185	-	2.60	0.1
Max.	4,412	8.77	700	1,299	1,398	-	12.57	6.9
Regulation for Sewerage		5.0 - 9.5	250	700	-	-	10	100

As shown in the above table, the concentrations of BOD and COD are higher than the regulation for public sewerage.

6.2.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The wastewater will be discharged into the public sewerage as at present since the effluent quality of this factory has no problem in sewage treatment.

(2) Design Wastewater Quantity and Quality

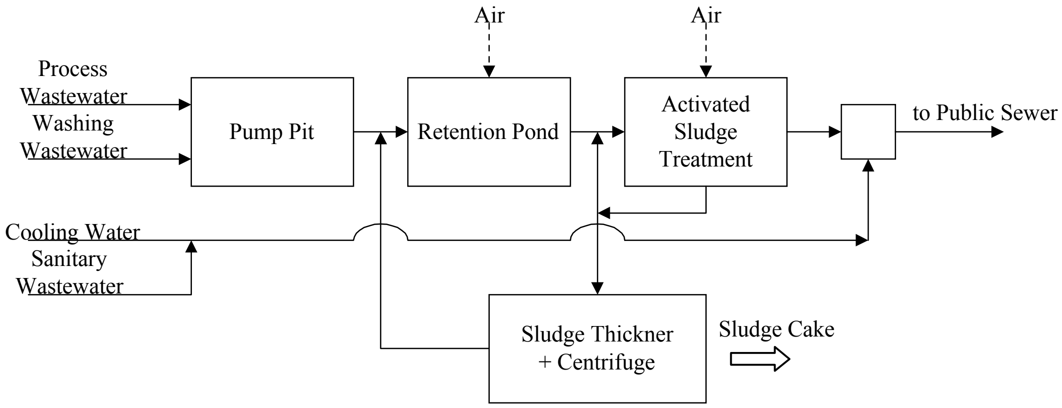
The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	2,301	456	911	595	7.6	7.6	4.2	Sewerage
2007	1.328	0.930	2,842	250	700	200	7.6	7.6	4.2	Sewerage
2015	1.944	0.850	3,802	250	700	200	7.6	7.6	4.2	Sewerage
Regulation for Sewerage				250	700	-	-	10.0	100	

(3) Proposed Wastewater Treatment System

(a) Treatment System

The biological treatment system (Standard Activated Sludge:AS with a capacity of 3,850 m^3/d) is proposed to treat BOD and COD to the permissible limits for public sewerage, as illustrated below. With this system, TSS will be treated coincidentally to the target level. The detailed flow diagram and layout of the treatment plant are shown in Fig. C.2.7 and Fig. C.2.8 respectively.



(b) Specification of Major Equipment

Equipment No.	Name	Specification	Note
Capacity	Treatment Plant	3,850 m^3/day, 160 m^3/h	24h Continuous operation
S-2	Retention Pond	1,280 m^3, 33 m × 11 m × 4.2m H, RC	Air bubbling devices
S-3	Aeration Basin	800 m^3, 27 m × 9 m × 4.2 m H, RC	Aeration unit
S-4	Sedimentation Basin	15 m D × 3.5 m H, RC	Center driven rake
S-5	Sludge Thickener	5.0 m D × 3.7m H, RC	Center driven rake
M-3	Centrifuge	5.0 m^3/h × 22 kW, SUS	Screw decanter

Note: RC: Reinforced Concrete, SUS: Stainless Steel. For Equipment No., see Fig. C.2.7 and Fig. C.2.8.

(c) Required Area

The required area is approx. 44m × 39m (1,716 m^2). (See Fig. C.2.8.)

(4) Estimated Construction Cost

The required construction cost is estimated to be Kn 16.28 million, broken down as follows.

Item	Cost (10^3 Kn)	Note
1. Direct Cost		
(1) Mechanical/Electrical Works	6,170	
(2) Civil/Architectural Works	3,610	
(3) Miscellaneous Work	520	
Sub-Total	10,300	
2. Indirect Cost	1,030	1 × 10%
3. VAT	2,270	1. × 22%
4. Customs Duties	620	1 (1) × 10%
5. Contingency	2,060	1. × 20%
Total	16,280	

6.3 PPK KARLOVČKA MESNA INDUSTRIJA d.d

6.3.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	333015			
Activity	Meat Processing			
Capital	9,673,600 DM			
Foundation	1984			
Main Raw Materials	Pork	:	2,587 ton (1998)	1,969 ton (1999)
	Beef	:	922 ton (1998)	886 ton (1999)
Main Products	Sausage Products	:	2,287 ton (1998)	2,087 ton (1999)
	Smoked Meat Products	:	704 ton (1998)	637 ton (1999)
	Permanent Products	:	367 ton (1998)	341 ton (1999)
	Fresh Meat	:	1,616 ton (1998)	1,233 ton (1999)
No. of Employees	246 Persons			
Operation Time	18 Hours (4:00 - 22:00), 5 Days/Week			

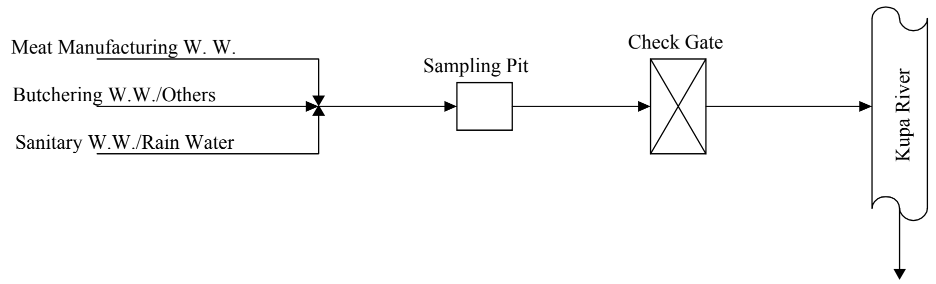
6.3.2 Existing Water Use

The average and maximum quantities of water use in the recent years are shown below. Approximately 70% of the water is used for meat processing, 20% for butchering and 10% for miscellaneous use.

Year	Average		Maximum	
	m^3/month	m^3/day	m^3/month	m^3/day
1998	9,323	466	-	-
1999	6,500	325	8,186	410
2000 (Jan. - Sep.)	6,650	333	8,162	408
Average	7,491	375	8,174	409

6.3.3 Existing Wastewater Discharge System

All wastewaters of the factory (including production process, butchering, sanitary and rain) are discharged without any treatment directly into the Kupa River through one (1) outlet. The existing wastewater discharge system is illustrated below.



6.3.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters, data collected from the factory and data observed by the Study Team.

Flow Rate (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	348	7.54	484	514	606	12.2	5.05	5.8
Min.	243	7.40	249	465	53	5.0	0.90	0.1
Max.	471	7.67	877	563	1,473	21.9	8.04	10.2
Regulation for River II		6.5 - 8.0	25	125	35	21	1	25

As shown in the above table, the concentrations of BOD, COD, TSS and T-P much exceed the regulation for the river.

6.3.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The recipient of wastewater will be changed from the river to the public sewerage since the sewerage system of the town is planned to extend to the location of the factory and the effluent quality of this factory has no problem in sewage treatment.

(2) Design Wastewater Quantity and Quality

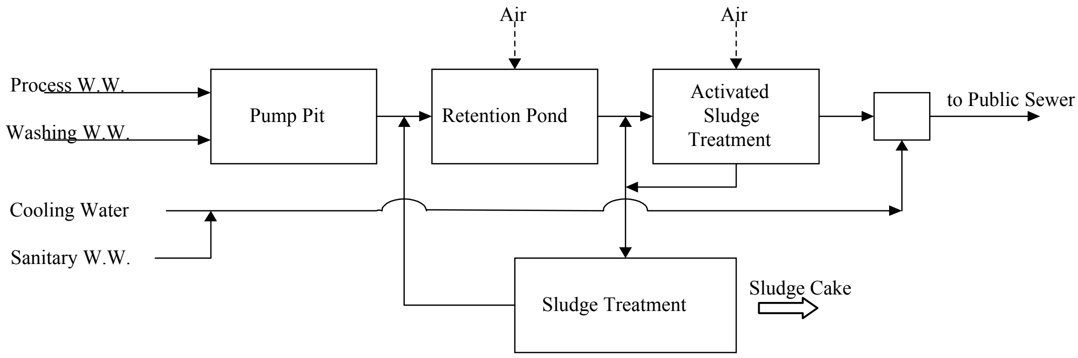
The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quantity (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	348	484	514	606	12.2	5.05	5.8	River
2007	1.328	0.953	440	250	514	200	12.2	5.05	5.8	Sewerage
2015	1.944	0.900	609	250	514	200	12.2	5.05	5.8	Sewerage
Regulation for Sewerage				250	700	-	-	10	100	

(3) Proposed Wastewater Treatment System

(a) Treatment System

The biological treatment system (Standard Activated Sludge: AS with a capacity of 630 m^3/d) is proposed to treat BOD to the permissible limits for public sewerage, as illustrated below. With this system, TSS will be treated coincidentally to the target level. The detailed flow diagram and layout of the treatment plant are shown in Fig. C.2.9 and Fig. C.2.10 respectively.



(b) Specification of Major Equipment

Equipment No.	Name	Specification	Note
Capacity	Treatment Plant	630 m^3/day, 26 m^3/h	24h Continuous operation
S-2	Retention Pond	315m^3, 14.5m × 7.3m × 3.7m H, RC	Air bubbling devices
S-3	Aeration Basin	96m^3, 9.5m × 4.7m × 3.7m H, RC	Aeration unit
S-4	Sedimentation Basin	6m D × 3.5m H, RC	Center driven rake
S-5	Sludge Thickener	2.5m D ×.5m H, CS	Center driven rake
M-3	Centrifuge	1.0m^3/h × 3.7kW, SUS	Screw decanter

Note: RC: Reinforced Concrete, CS: Carbon Steel, SUS: Stainless Steel. For Equipment No., see Fig. C.2.9 and Fig. C.2.10

(c) Required Area

The required area is approx. 27m × 26m (702 m^2). (See Fig. C.2.10.)

(4) Estimated Construction Cost

The required construction cost is estimated to be Kn 7.46 million, broken down as follows.

Item	Cost (10^3 Kn)	Note
1.Direct Cost		
(1) Machinery/Electrical Work	3,060	
(2) Civil/Architecture Work	1,410	
(3) Miscellaneous Work	240	
Sub-Total	4,700	
2. Indirect Cost	470	1. × 10%
3. VAT	1,040	1. × 22%
4. Customs Duties	310	1 (1) × 10%
5. Contingency	940	1. × 20%
Total	7,460	

6.4 VELEBIT

6.4.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

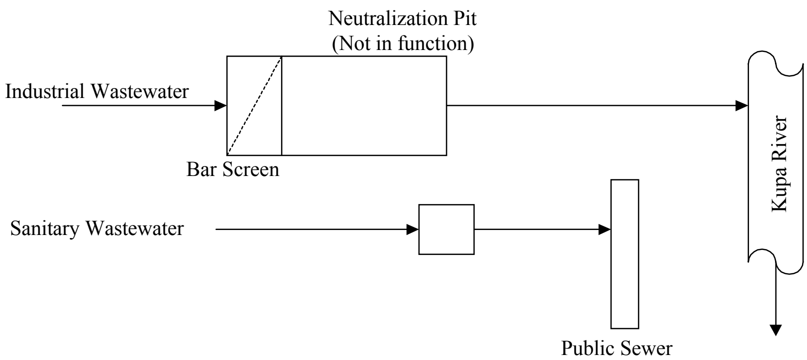
Code No.	333005
Activity	Textile
Capital	35 Million Kn
Foundation	1920
Main Raw Material	Cotton
Main Products	Cotton Cloth
No. of Employees	280 Persons
Operation Time	8 Hours (6:00 - 14:00), 22 Days/Month

6.4.2 Existing Water Use

Approx. 3,500 m^3/month is supplied from the municipal water supply system for industrial and domestic water use.

6.4.3 Existing Wastewater Discharge System

Industrial wastewater is discharged into the Kupa River through a pond that was originally designed as neutralization pit but not functioning at present due to the absence of chemical feeding equipment. On the other hand, sanitary wastewater is discharged into the public sewerage. The existing wastewater discharge system is shown below.



6.4.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters and data collected from the factory.

Flow Rate (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	248	8.0	150	328	256	-	0.35	3.7
Min.	180	-	125	231	76	-	0.07	0.8
Max.	413	-	187	412	346	-	0.63	6.6
Regulation for Sewerage		5.0 - 9.5	250	700	-	-	10	100
Regulation for River II		6.5 - 8.0	25	125	35	21	1	25

As shown in the above table, BOD, COD and TSS do not meet the regulation for the Kupa River (Category II) but meet the regulation for public sewerage.

6.4.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The recipient of industrial wastewater will be change from the river to the public sewerage since the existing sewerage system covers the area of the factory and the effluent quality of this factory has no problem in sewage treatment.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	248	150	328	256	30	0.35	3.7	River/Sewerage
2007	1.328	0.930	306	150	328	256	30	0.35	3.7	Sewerage
2015	1.944	0.850	410	150	328	256	30	0.35	3.7	Sewerage
Regulation for Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the existing value of T-N.

(3) Proposed Treatment System

There is no wastewater treatment plant, but the effluent quality meets the permissible limits of public sewerage. Hence, no treatment system is proposed.

6.5 LOLA RIBAR

6.5.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	3330012
Activity	Textile
Capital	50 Million Kn
Foundation	1937
Main Raw Material	Cotton
Main Products	Cotton, Gauze
No. of Employees	352 Persons
Operation Time	16 Hours (6:00 – 22:00), 22 Days/Month

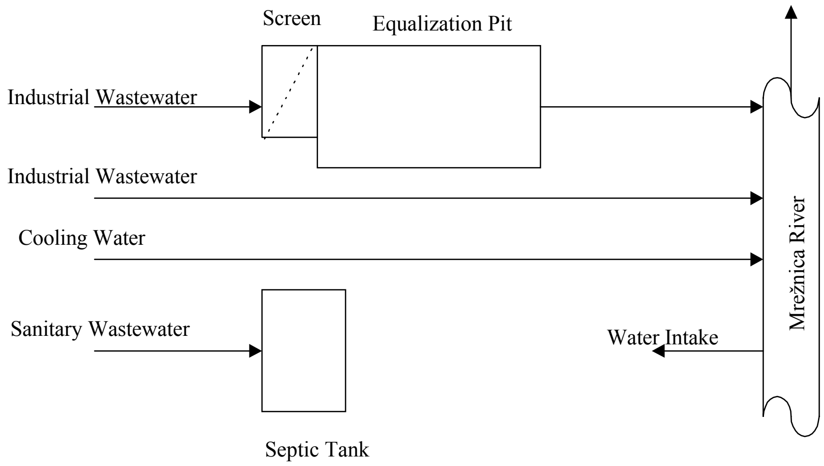
6.5.2 Existing Water Use

Approx. 220 m^3/day of municipal water and 200 m^3/day of river water (treated by sand filtration) are consumed for industrial and domestic water use.

6.5.3 Existing Wastewater Discharge System

Industrial wastewater is discharged directly into the river with no special treatment. Sanitary wastewater is treated by septic tank.

The existing wastewater discharge system is illustrated below.



6.5.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters and data collected from the factory.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	307	8.0	116	243	307	0.1	0.08	2.7
Min.	289		52	93	297	-	-	-
Max.	325		181	393	316	-	-	-
Regulation for River (II)		6.5 - 8.0	25	125	35	21	1	25

As shown in the above table, BOD, COD and TSS do not meet the regulation for the river (Category II) at present.

6.5.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The recipient of wastewater will be changed from the river to the public sewerage since the sewerage system is planned to cover the area of the factory and the effluent quality of this factory has no problem in sewage treatment. However, the cooling water will be discharged into the river as at present.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quantity (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	307	116	243	307	0.1	0.08	2.7	River
2007	1.328	0.930	379	116	243	307	0.1	0.08	2.7	Sewerage
2015	1.944	0.850	507	116	243	307	0.1	0.08	2.7	Sewerage
Regulation for Sewerage				250	700	-	-	10.00	100	

(3) Proposed Wastewater Treatment System

There is no special treatment system, but the existing effluent quality meets the permissible limits of the public sewerage. Hence, no wastewater treatment system is proposed.

6.6 KARLOVAČKA INDUSTRIJA MLIJEKA

6.6.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

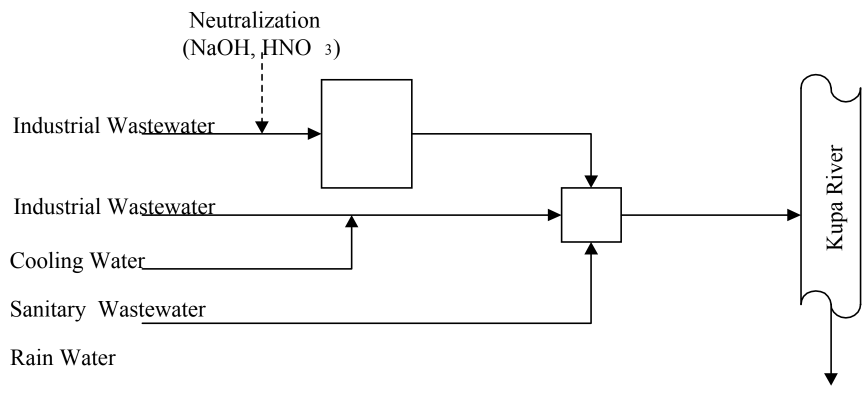
Code No.	333016
Activity	Food/Beverage
Capital	9.728 Million DM
Foundation	1968
Main Raw Material	Milk
Main Products	Milk Processing (200 million liters) Preservation/Production of Dairy Products
No. of Employees	174 Persons
Operation Time	24 Hours, 7 Days/Week

6.6.2 Existing Water Use

Approx. 103,300 m^3/year of municipal water was used for industrial and domestic purposes in 2000. The average unit consumption for wastewater was approx. 4.74 liters/liter-product in the same year.

6.6.3 Existing Wastewater Discharge System

Some industrial wastewater is discharged into the Kupa River with neutralization treatment, but the remaining wastewater including industrial wastewater, cooling water, sanitary wastewater and rainwater is discharged into the river with no treatment. The existing wastewater discharge system is illustrated below.



6.6.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters and the data collected from the factory.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	250	8.15	147	282	294	-	-	15.3
Min.	145	8.0	80	179	200	-	-	9.0
Max.	288	8.3	237	438	344	-	-	19.1
Regulation for River II		6.5 - 8.0	25	125	35	21	1	25

As shown in the above table, pH, BOD, COD and TSS do not meet the regulation for the river (Category II).

6.6.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The recipient of wastewater will be changed from the river to the public sewerage since the sewerage system is planned to cover the area of the factory and the effluent quality of this factory has no problem in sewage treatment.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	250	147	282	294	30.0	5.0	15.3	River
2007	1.328	0.930	309	147	282	294	30.0	5.0	15.3	Sewerage
2015	1.944	0.850	413	147	282	294	30.0	5.0	15.3	Sewerage
Regulation for Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

(3) Proposed Wastewater Treatment System

The effluent quality meets the permissible limits of the public sewerage. However, the wastewater quantity will increase in the future as shown above, so that extension of the existing treatment plant is necessary to cope with the increasing wastewater. Hence, an additional neutralization plant with a capacity of 100 m^3/d is proposed.

(4) Estimated Construction Cost

The required construction cost is roughly estimated to be approx. Kn 500 $\times 10^3$.

6.7 PAMUČNA INDUSTRIJA DUGA RESA d.d.

6.7.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	331001
Activity	Textile (bleaching, dying, manufacturing)
Foundation	1884
Main Raw Material	Cotton
Main Products	Cotton Clothes
Operation Time	24 Hours Continuous Operation, 5 Days/Week

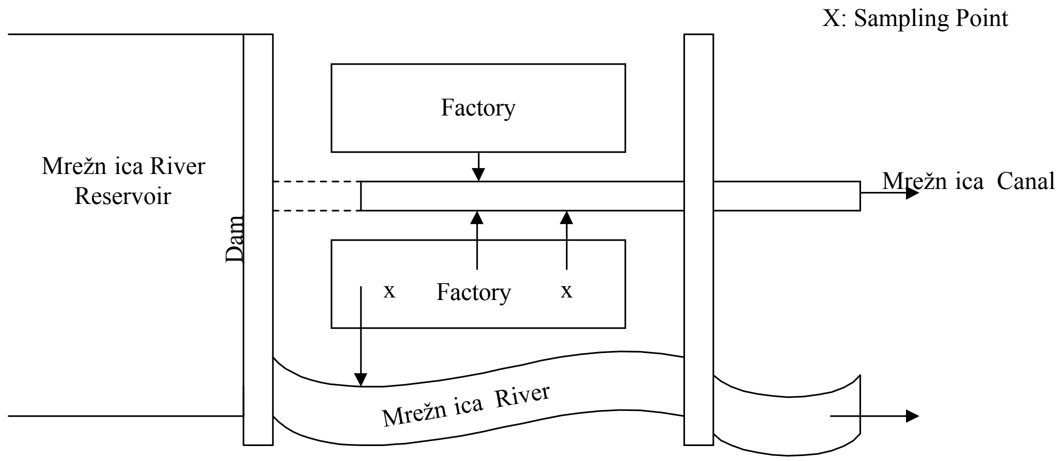
6.7.2 Existing Water Use

The factory is located at the dam site of the Mružnica River and a large quantity of river water (448,640 m^3/year) is used for industrial purposes.

6.7.3 Existing Wastewater Discharge System

The factory is provided with eight (8) outlets to discharge wastewater including sanitary wastewater and rainwater. Most of the wastewater is discharged directly into the Mrežnica River and the bypass canal without any treatment.

The existing wastewater discharge system is illustrated below.



6.7.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality are summarized below based on the database of Croatian Waters, data collected from the factory and data observed by the Study Team.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	2,416	10.35	120	288	277	4.8	0.77	1.1
Min.	1,693	8.8	82	225	178	-	-	0.1
Max.	3,875	11.9	153	351	336	-	-	2.6
Regulation for River (II)		6.5 - 8.0	25	125	35	21	1	25

Note: (1) Quantity is total of No. 1 to No. 8 outlets. (2) Water quality is weighted average of No. 1 to No. 8.

As shown in the above table, the effluent quality exceeds the regulation for the river (Category II) in pH, BOD, COD and TSS.

6.7.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The recipient of wastewater will be changed from the river to the public sewerage since the sewerage system is planned to cover the area of the factory and the effluent quality of this factory has no problem in sewage treatment.

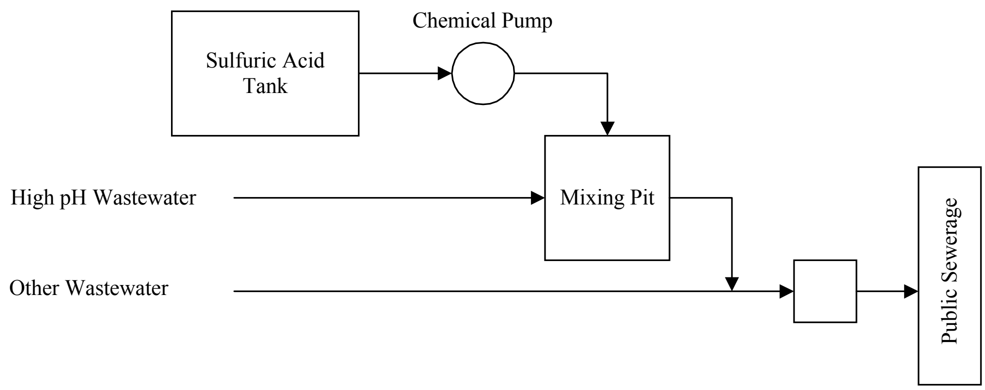
(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	2,416	120	288	277	4.8	0.77	1.1	River
2007	1.328	0.930	2,984	120	288	277	4.8	0.77	1.1	Sewerage
2015	1.944	0.850	3,992	120	288	277	4.8	0.77	1.1	Sewerage
Regulation for Sewerage				250	700	-	-	10	100	

(3) Proposed Wastewater Treatment System

Although there is no treatment system, the existing wastewater quality meets the regulation for public sewerage except pH. Hence, a pH control unit (sulfuric acid injection) will be provided for the outlets of high pH wastewater. The proposed treatment system is illustrated below.



(4) Estimated Construction Cost

The required construction cost is roughly estimated to be approx. Kn 300×10^3.

CHAPTER VII WASTEWATER TREATMENT OF LARGE POLLUTANT INDUSTRY IN OTHER TOWNS

7.1 General

There are two (2) large pollutant industries in towns other than the five F/S towns. They are (1) Pliva in Zaprešić (Chemicals) and (2) Gavlirović in Petrinja (Food/Beverage), which are both representative advanced industries in Croatia. Hence, the watewater treatment of these industries are also studied in detail.

7.2 PLIVA

7.2.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	315127		
Activity	Production of Pharmaceuticals and Chemicals		
Foundation	1993		
Capital	Kn 1,079.4 million		
Main Products (1998)	Pharmaceuticals	:	Kn 1,821.9 million
	Bulk Pharmaceuticals	:	Kn 489.3 million
	Animal Health and Agrochemicals	:	Kn 199.2 million
	Foodstuffs	:	Kn 299.6 million
	Cosmetics and Personal Hygiene	:	Kn 135.4 million
No. of Employees	2,000 Persons		
Operation Time	24 Hours, 5 Days/Week		

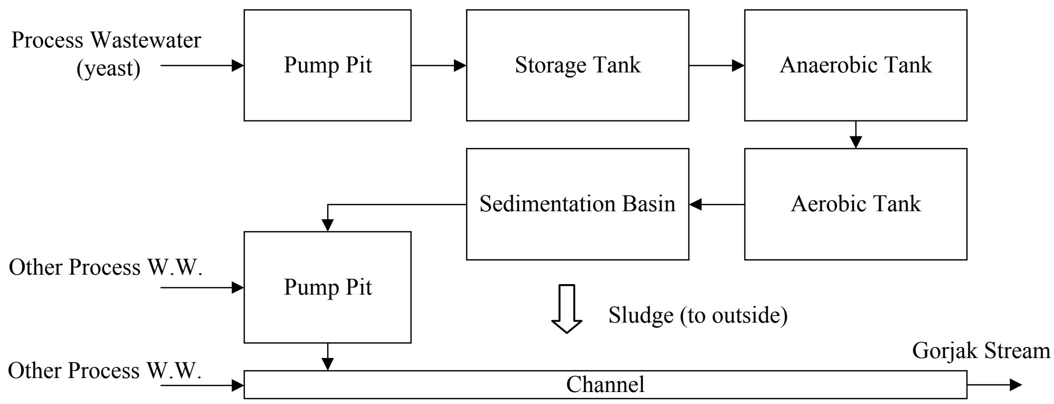
7.2.2 Existing Water Use

Approximately 2,000 m^3/d of well water is used for industrial purposes.

7.2.3 Existing Wastewater Discharge System

The process wastewater of the factory is treated by the biological treatment with a capacity of 50 m^3/h. The treated wastewater is pumped up to the Gorjak Stream through a channel, while the cooling water is discharged directly into the same channel through a separate outlet with no treatment. The Gorjak Stream finally enters the Sava River.

The existing wastewater discharge system is illustrated below.



7.2.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality excluding cooling water are summarized below based on the database of Croatian Waters, data collected from the factory and data observed by the Study Team. In addition to the process wastewater, cooling water of 4,680 m^3/day is discharged directly into the channel as mentioned before.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	1,928	8.11	339	1,768	1,944	166.3	3.22	0.2
Min.	1,210	7.50	199	-	180	-	-	0.2
Max.	2,362	8.72	480	-	3,707	-	-	0.3
Regulation for Stream (II)		6.5 - 8.0	25	125	35	21	1	25

As shown in the above table, BOD, COD, TSS and T-N of the process wastewater far exceed the regulation for the stream (Category II).

7.2.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The recipient of wastewater (process wastewater) will be changed from the stream to the public sewerage since the sewerage system of Zagrešić is planned to receive also the industrial wastewater from the surrounding areas and to treat it by a central sewage treatment plant. Moreover, the effluent quality of this factory has no problem in sewage treatment. However, cooling water will be discharged into the Gorjak Stream as at present.

(2) Design Wastewater Quantity and Quality

The future wastewater quantity and quality (excluding cooling water) for the design of treatment plant are estimated below in accordance with the planning basis in Chapter I, Section 1.4.

	Quantity			Quantity (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	1,928	339	1,768	1,944	166	3.2	0.2	Stream
2007	1.328	0.930	2,381	339	1,768	1,944	166	3.2	0.2	Stream
2015	1.944	0.850	3,186	250	700	200	100	3.2	0.2	Sewerage
Regulation for Sewerage				250	700	-	-	10.0	100	

Note: TSS and T-N are coincidentally treated although no regulation is stipulated.

(3) Proposed Wastewater Treatment System

The existing treatment plant will be able to treat BOD and COD of the existing wastewater quantity to the permissible limits for the public sewerage by improving the treatment system. With the improvement, TSS and T-N will be treated coincidentally to the target level.

However, the wastewater quantity (excluding cooling water) is estimated to increase from 1,928 m^3/d in 1999 to 3,186m^3/d in 2015. Hence, an additional treatment plant of the existing type with a capacity of 1,260 m^3/d (approx. 50 m^3/h) is proposed to cope with the increasing quantity of wastewater.

(4) Estimated Construction Cost

The required construction cost is roughly estimated to be Kn $15,300 \times 10^3$, broken down into approx. Kn $15,000 \times 10^3$ for the construction of a new plant and Kn 300×10^3 for the improvement of the existing plant.

7.3 GAVRILOVIĆ d.o.o.

7.3.1 Outline of the Factory

The main features of the existing industrial activities are summarized below.

Code No.	373001
Activity	Meat Products Processing
Foundation	1821
Main Raw Materials	Pig, Cow
Main Products (1998)	Cooked Sausage, Meat Specialties, Canned Meat, Cured/Smoked and Dried Meat, Ready-to-Eat Meals
Operation Time	16 Hours (6:00-22:00)
Others	Cleaner Production project is ongoing as a joint venture with the Universal Aqua Technologies Inc.

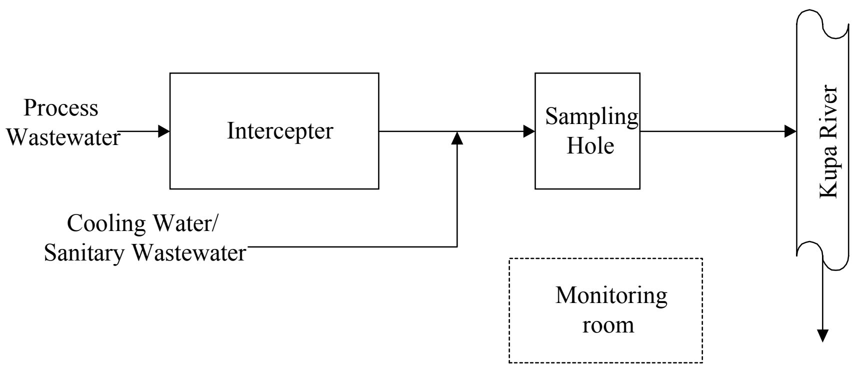
7.3.2 Existing Water Use

Approximately 2,000 m^3/d is supplied from the municipal water supply system of Petrinja. About 50% of this quantity is used in the product sterilization process.

7.3.3 Existing Wastewater Discharge System

The process wastewater of the factory is discharged into the Kupa River through one (1) outlet, with interceptor treatment to remove fat and scum. The cooling and sanitary wastewaters are discharged through the same outlet with no treatment.

The existing wastewater discharge system is illustrated below.



7.3.4 Existing Wastewater Quantity and Quality

The existing wastewater quantity and quality excluding cooling water are summarized below based on the database of Croatian Waters, data collected from the factory and data observed by the Study Team.

Quantity (m^3/d)		pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
Ave.	1,357	7.25	116	234	182	4.8	2.57	13.4
Min.	533	7.02	25	224	19	1.9	1.08	2.1
Max.	2,007	7.44	182	244	447	8.6	3.89	24.0
Regulation for River II		6.5- 8.0	25	125	35	21	1	25

As shown in the above table, the effluent water quality does not meet the regulation for the river (Category II).

7.3.5 Development of Wastewater Treatment System

(1) Selection of Recipient

The recipient of wastewater will be changed from the river to the public sewerage since the sewage treatment plant of Petrinja is proposed near the existing outlet of the industrial wastewater to the river. Besides, the effluent quality of this factory has no problem in sewage treatment.

(2) Design Wastewater Quantity and Quality

Industrial production (f_1) is assumed to increase in proportion to the growth of GDP. On the other hand, this factory has a cleaner production plan to reduce the unit wastewater quantity to 20% by 2007. Hence, the reduction rate (f_2) is assumed in this Study at 20% in 2007 and 25% in 2015. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quantity (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	1,357	116	234	182	4.8	2.57	13.4	River
2007	1.328	0.800	1,442	116	234	182	4.8	2.57	13.4	River
2015	1.944	0.750	1,979	116	234	182	4.8	2.57	13.4	Sewerage
Regulation for Sewerage				250	700	-	-	10	100	

(3) Proposed Wastewater Treatment System

The existing effluent quality satisfies the permissible limits for public sewerage in all parameters, but the effluent quantity will increase in the future as shown above. Hence, the extension of the existing treatment plant is proposed to cope with the increasing wastewater. The extension's capacity is 630 m^3/d (approx. 30 m^3/h).

(4) Estimated Construction Cost

The required construction cost is roughly estimated to be Kn $1,000 \times 10^3$.

CHAPTER VIII WASTEWATER TREATMENT OF OTHER LARGE INDUSTRIES

8.1 General

8.1.1 Objective Industry

Fifty-one (51) large industries are selected for the study on industrial wastewater treatment in the Study Area as mentioned in Chapter I, Section 1.3. The wastewater treatment of 18 large pollutant industries has been described in detail in the preceding Chapters, while the wastewater treatment of the other 33 large industries has been roughly studied as presented in this Chapter VIII.

The objective 33 industries are given below.

Town/Municipality		Name of Industry	
Vrbovec	(2)	1. Gradip	2. PIK Vrbovec Farma Polijanski
Karlovac	(7)	1. Kordum Karlovac 2. Že - Če 3. Trornica Plinskih Turbuna 4. Adria Diesel	5. ABB d.d. Energetskih 6. Linde Plin d.o.o. 7. Autotransport d.d.
Ivanić Grad and Kloštar Ivanić	(4)	1. INA Naftaplin Pogon Etan 2. Crosco Naftini Servisi	3. Naftaplin Lječilišt 4. INA naftaplin Padilišt Oroi
Samobor	(7)	1. Chromos Grafička Boje 2. Fotokemika 3. Imes 4. Pliva Lalinovica	5. Chromos Grafička Boje 6. Imunološki Zavod Brezje 7. TOP
Zaprešić	(4)	1. HŽ Infrastrucktura 2. Inker	3. Karbon 4. Viadukt
Velika Gorica	(4)	1. Dalekovod 2. Industrogradnja	3. Industrogradnja 4. Zraćna Luka Zagreb
Jastrebarsko	(2)	1. Mladina d.d.	2. Jamnica Zagreb, Jamnica Kiselica
Popovača	(1)	1. Neutropsihijatrijska Bolnica	
Oglin	(2)	1. Opća Bolnica Oglin	2. Bjelolasic

8.1.2 Planning Basis

The existing wastewater quantity and quality are estimated based on the database of Croatian Waters during 1998-1999.

The future wastewater quantity and quality for the design of treatment plant are estimated in accordance with the planning basis in Chapter I, Section 1.4. The recipient of wastewater is selected based on the criteria in Chapter I, Section 1.5.

On the other hand, the wastewater treatment system is proposed based on the design policies and concepts in Chapter I, Section 1.6. The construction cost of the proposed wastewater treatment system is roughly estimated based on the assumptions in Chapter I, Section 1.7.

8.2 Other Large Industries in Vrbovec

8.2.1 GRADIP

(1) Existing Wastewater Discharge System

Code No.	360002
Activity	Clay Industry
Wastewater Recipient	Public Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity (m^3/day)	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
110	7.21	74	148	385	-	-	13.9
Regulation for Sewerage	5.0-9.0	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment.

The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	T-Oil	
1999	1.000	1.000	110	74	148	385	30	5.0	13.9	Sewerage
2007	1.328	0.930	136	74	148	385	30	5.0	13.9	Sewerage
2015	1.944	0.850	187	74	148	385	30	5.0	13.9	Sewerage
Regulation for Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

There is no treatment plant at present, but the existing effluent quality meets the permissible limits for public sewerage. Hence, no wastewater treatment plant is necessary.

8.2.2 PIK VRBOVEC FARMA POLJASKI LUG

(1) Existing Wastewater Discharge System

Code No.	360008
Activity	Food/Beverage
Wastewater Recipient	Farmland
Treatment System	Lagoon

The effluent from the industry is discharged into a lagoon for preliminary treatment, and the treated wastewater is sprinkled on the farmland. There is no effluent to the river.

(2) Existing Wastewater Quantity and Quality

Quantity (m^3/d)	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
74.8	6.0	2,786	4,873	5,428	-	-	3.35
Regulation for Land	-	-	-	-	-	-	-

As shown in the above table, there is no regulation for discharging wastewater on farmlands.

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the lagoon and sprinkled on the farmland as at present. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	T-Oil	
1999	1.000	1.000	75	2,786	4,873	5,428	30	5.0	34.2	Land
2007	1.328	0.930	93	2,786	4,873	5,428	30	5.0	34.2	Land
2015	1,944	0.850	124	2,786	4,873	5,428	30	5.0	34.2	Land

Note: The Study Team assumed the values of T-N and T-P.

The existing discharge system is a closed one, which discharges no wastewater into the river. Hence, no additional treatment system is necessary.

8.3 Other Large Industries in Karlovac

8.3.1 KORDUN Karlovac

(1) Existing Wastewater Discharge System

Code No.	333003
Activity	Metal/Machinery
Wastewater Recipient	Sewerage
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity (m^3/day)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
128	30	73	423	-	-	5.9
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	128	30	73	423	30.0	5.0	5.9	Sewerage
2007	1.328	0.930	158	30	73	423	30.0	5.0	5.9	Sewerage
2015	1.944	0.850	212	30	73	423	30.0	5.0	5.9	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing effluent quality meets the permissible limits for public sewerage. However, the wastewater quantity is estimated to increase in the future. Hence, the extension of the existing treatment system is necessary to cope with the increasing wastewater. The extension's capacity is approx. 100 m^3/d.

(4) Estimated Construction Cost

The requiredconstruction cost is estimated to be approx. Kn 500 $\times$ 10^3.

8.3.2 Že-Če

(1) Existing Wastewater Discharge System

Code No.	333008
Activity	Metal/Machinery
Wastewater Recipient	Sewerage
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity (m^3/day)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
305	7	32	285	-	-	6.9
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	305	7	32	285	30.0	5.0	6.9	Sewerage
2007	1.328	0.930	377	7	32	285	30.0	5.0	6.9	Sewerage
2015	1.944	0.850	504	7	32	285	30.0	5.0	6.9	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing effluent quality meets the permissible limits for public sewerage. However, the wastewater quantity is estimated to increase in the future. Hence, the extension of the existing treatment system is necessary to cope with the increasing wastewater. The extension's capacity is approx. 200 m^3/d.

(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 700 $\times$ 10^3.

8.3.3 TVORNICA PLINSKIH TURBINA

(1) Existing Wastewater Discharge System

Code No.	333010
Activity	Metal/Machinery
Wastewater Recipient	Sewerage
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
134	26	73	342	-	-	5.9
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quantity (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	134	26	73	342	30.0	5.0	5.9	Sewerage
2007	1.328	0.930	165	26	73	342	30.0	5.0	5.9	Sewerage
2015	1.944	0.850	221	26	73	342	30.0	5.0	5.9	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing effluent quality meets the permissible limits for public sewerage. However, the wastewater quantity is estimated to increase in the future. Hence, the extension of the existing treatment system is necessary to cope with the increasing wastewater. The extension's capacity is approx. 100 m^3/d.

(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 500 $\times$ 10^3.

8.3.4 ADRIA-DIESEL

(1) Existing Wastewater Discharge System

Code No.	333011
Activity	Metal/Machinery
Wastewater Recipient	Sewerage
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
129	30	97	734	-	-	30.0
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	129	30	97	734	30.0	5.0	30.0	Sewerage
2007	1.328	0.930	159	30	97	734	30.0	5.0	30.0	Sewerage
2015	1.944	0.850	213	30	97	734	30.0	5.0	30.0	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing effluent quality meets the permissible limits for public sewerage. However, the wastewater quantity is estimated to increase in the future. Hence, the extension of the existing treatment system is necessary to cope with the increasing wastewater. The extension's capacity is approx. 100 m^3/d.

(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 500 $\times$ 10^3.

8.3.5 ABB ALSTOM POWER (former name: ABB Power Plants Ltd.)

(1) Existing Wastewater Discharge System

Code No.	333017
Activity	Machinery
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
240	24	62	56	-	-	-
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	240	24	62	56	30.0	5.0	3.0	Sewerage
2007	1.328	0.930	296	24	62	56	30.0	5.0	3.0	Sewerage
2015	1.944	0.850	397	24	62	56	30.0	5.0	3.0	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N, T-P and Oil & Grease.

There is no treatment plant at present, but the existing effluent quality meets the permissible limits of public sewerage. Hence, no wastewater treatment plant is necessary.

8.3.6 LINDE PLIN d.o.o.

(1) Existing Wastewater Discharge System

Code No.	333019
Activity	Gas Service
Wastewater Recipient	Canal
Treatment System	None

(2) Existing Wastewater Quality and Quantity

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
102	19	58	499	-	-	-
Regulation for Canal (II)	25	125	35	21	1	25

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the canal as at present since the industry is located outside of the planned sewerage service area. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	102	19	58	499	30.0	5.0	5.0	Canal
2007	1.328	0.930	126	19	58	499	30.0	5.0	5.0	Canal
2015	1.944	0.850	169	19	58	499	30.0	5.0	5.0	Canal
Regulation for Canal (II)				25	125	35	21	1	25	

Note: The Study Team assumed the values of T-N, T-P and Oil & Grease.

The wastewater is discharged with no treatment and the existing effluent quality meets the regulation for the canal (Category II) except TSS, T-N and TP. However, TSS of less than 500 mg/l is not considered serious to initiate river water pollution. Moreover, the excess in T-N and T-P is not large. Hence, no wastewater treatment system is proposed.

8.3.7 AUTOTRANSPORT d.d.

(1) Existing Wastewater Discharge System

Code No.	333029
Activity	Transportation
Wastewater Recipient	Sewerage
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
104	23	147	244	-	-	5.7
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	104	23	147	244	30.0	5.0	5.7	Sewerage
2007	1.328	0.930	128	23	147	244	30.0	5.0	5.7	Sewerage
2015	1.944	0.850	172	23	147	244	30.0	5.0	5.7	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing effluent quality meets the permissible limits of public sewerage. However, the wastewater quantity is estimated to increase in the future. Hence, the extension of the existing treatment system is necessary to cope with the increasing wastewater. The extension's capacity is approx. 70 m^3/d.

(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 300 $\times$ 10^3.

8.4 Other Large Industries in Ivanić Grad and Kloštar Ivanić

8.4.1 INA NAFTAPLIN POGON ETAN

(1) Existing Wastewater Discharge System

Code No.	355005
Activity	Oil Refinery
Wastewater Recipient	Sewerage
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
460	22	48	733	-	-	4.2
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	460	22	48	733	30.0	5.0	4.2	Sewerage
2007	1.328	0.930	568	22	48	733	30.0	5.0	4.2	Sewerage
2015	1.944	0.850	760	22	48	733	30.0	5.0	4.2	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing effluent quality meets the permissible limits of public sewerage. However, the wastewater quantity is estimated to increase in the future. Hence, the extension of the existing treatment system is necessary to cope with the increasing wastewater. The extension's capacity is approx. 300 m^3/d.

(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 1,000 $\times 10^3$.

8.4.2 CROSCO NAFTINI SERVISI d.o.o

(1) Existing Wastewater Discharge System

Code No.	355010
Activity	Oil Service
Wastewater Recipient	Sewerage
Treatment System	Existing

(2) Existing Wastewater Quality and Quantity

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
200	20	17	494	-	-	10.0
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	200	20	17	494	30.0	5.0	10.0	Sewerage
2007	1.328	0.930	247	20	17	494	30.0	5.0	10.0	Sewerage
2015	1.944	0.850	330	20	17	494	30.0	5.0	10.0	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing effluent quality meets the permissible limits of public sewerage. However, the wastewater quantity is estimated to increase in the future. Hence, the extension of the existing treatment system is necessary to cope with the increasing wastewater. The extension's capacity is approx. 130 m^3/d.

(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 500 $\times 10^3$.

8.4.3 NAFTALAN LJEĆILIŠTE

(1) Existing Wastewater Discharge System

Code No.	355015
Activity	Hospital
Wastewater Recipient	Sewerage
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
117	43	240	662	-	-	169
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	117	43	240	662	30.0	5.0	169	Sewerage
2007	1.328	0.930	144	43	240	662	30.0	5.0	100	Sewerage
2015	1.944	0.850	193	43	240	662	30.0	5.0	100	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing effluent quality almost meets the permissible limits for public sewerage. However, the wastewater quantity is estimated to increase in the future. Hence, the extension of the existing treatment system is necessary to cope with the increasing wastewater. The extension's capacity is approx. 80 m^3/d.

(4) Estimated Construction Cost:

The required construction is estimated to be approx. Kn 300 × 10^3.

8.4.4 INA NAFTAPLIN RADILIŠTE OROI

(1) Existing Wastewater Discharge System

Code No.	355019
Activity	Oil Refinery
Wastewater Recipient	Brook
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
229	13	13	646	-	-	1.9
Regulation for Brook (II)	25	125	35	21	1	25

(3) Proposed Wastewater Treatment System

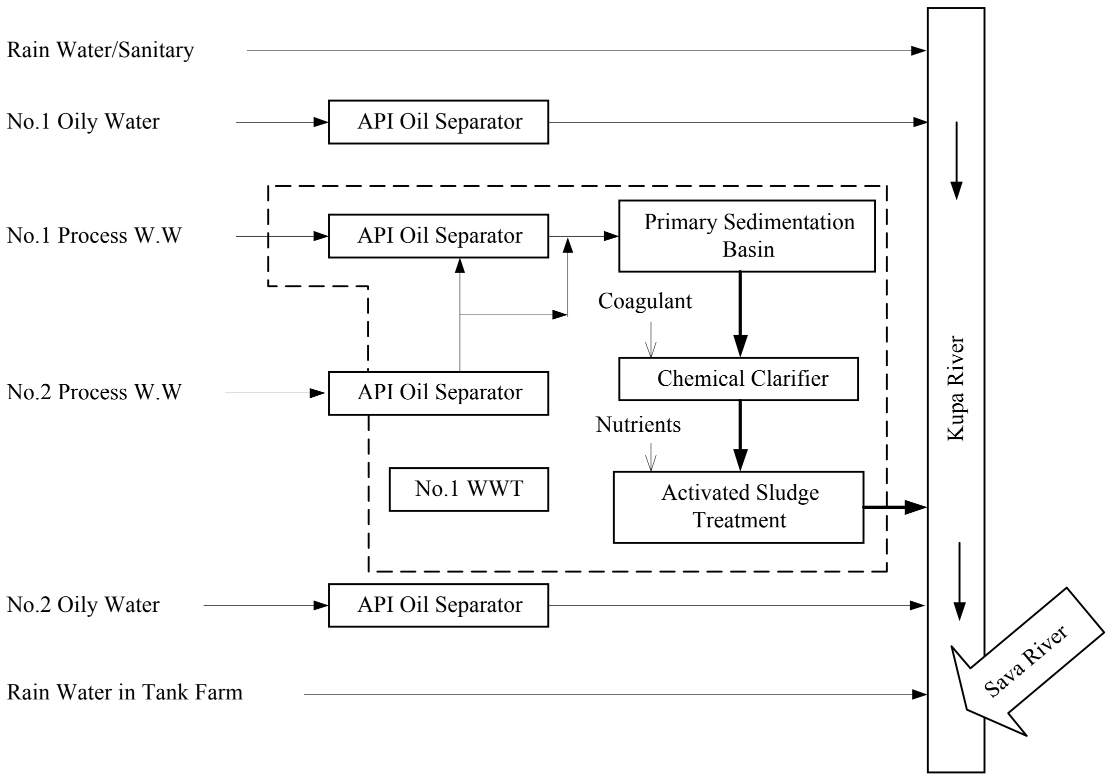
The wastewater will be discharged into the brook as at present since the factory is located outside the planned sewerage service area. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	229	13	13	646	30.0	5.0	1.9	Brook
2007	1.328	0.930	283	13	13	646	30.0	5.0	1.9	Brook
2015	1.944	0.850	378	13	13	35	21.0	1.0	1.9	Brook
Regulation for Brook (II)				25	125	35	21	1	25	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing quality of TSS, T-N and T-P exceed the permissible limits for the canal. Hence, a chemical clarifier with a capacity of 400 m^3/d will be installed to treat TSS. With this facility, T-N and T-P will be reduced coincidentally to the target levels.

The proposed treatment system is illustrated below.



(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 1,500 × 10^3.

8.5 Other Large Industries in Samobor

8.5.1 CHROMOS GRAFIĆKE BOJE

(1) Existing Wastewater Discharge System

Code No.	309021
Activity	Chemicals
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quality and Quantity

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
213	33	93	1,568	-	-	4.2
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	F_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	213	33	93	1,568	30.0	5.0	4.2	Sewerage
2007	1.328	0.930	263	33	93	1,568	30.0	5.0	4.2	Sewerage
2015	1.944	0.850	352	33	93	1,568	30.0	5.0	4.2	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

There is no treatment plant at present, but the existing effluent quality meets the permissible limits of public sewerage. Hence, no wastewater treatment plant is necessary.

8.5.2 FOTOKEMIKA

(1) Existing Wastewater Discharge System

Code No.	309047
Activity	Photography
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
432	-	-	-	-	-	-
Regulation for Public Sewerage	250	700	-	-	10	100

Note: No wastewater quality data are available.

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	432	50	100	300	30.0	5.0	5.0	Sewerage
2007	1.328	0.930	534	50	100	300	30.0	5.0	5.0	Sewerage
2015	1.944	0.850	714	50	100	300	30.0	5.0	5.0	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed all wastewater quality values.

There is no treatment plant at present, but the existing effluent quality meets the permissible limits for public sewerage. Hence, no wastewater treatment plant is necessary.

8.5.3 IMES

(1) Existing Wastewater Discharge System

Code No.	309069
Activity	Food/Beverage
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
89	631	951	2,107	-	-	155.6
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

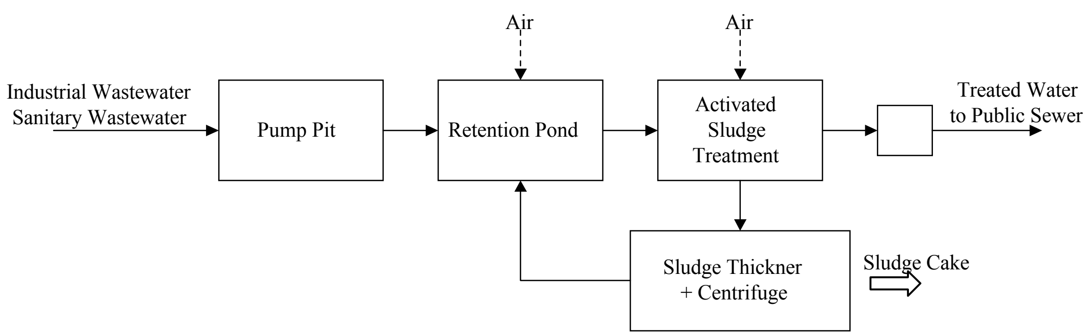
The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	89	631	951	2,107	30.0	5.0	155.6	Sewerage
2007	1.328	0.930	110	631	951	2,107	30.0	5.0	155.6	Sewerage
2015	1.944	0.850	147	250	700	200	20.0	3.0	100.0	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing quality of BOD, COD, TSS and Oil & Grease exceed the permissible limits for the public sewerage. Hence, a standard activated sludge treatment with a capacity of 150 m^3/d is proposed to treat BOD, COD and TSS. With this system, T-N, T-P and Oil & Grease will be reduced coincidentally to the target levels.

The proposed treatment system is illustrated below.



(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 4,200 $\times 10^3$.

8.5.4 PLIVA KALINOVICA

(1) Existing Wastewater Discharge System

Code No.	309123
Activity	Chemicals
Wastewater Recipient	River
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
578	28	128	513	-	-	8.1
Regulation for River (II)	25	125	35	21	1	25

(3) Proposed Wastewater Treatment System

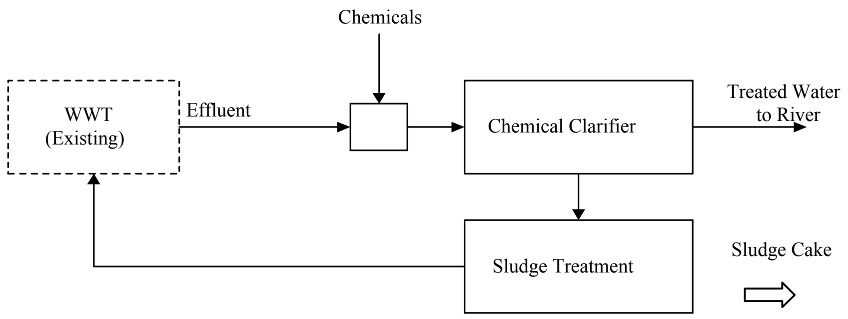
The wastewater will be discharged into the river as at present since the factory is located outside the planned sewerage service area. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	578	28	128	513	30.0	5.0	8.1	River
2007	1.328	0.930	714	28	128	⇨	30.0	5.0	8.1	River
2015	1.944	0.850	955	25	125	35	21.0	1.0	5.0	River
Regulation for River (II)				25	125	35	21	1	25	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing quality of TSS, T-N and T-P exceed the permissible limits for the river. Hence, a chemical clarifier with a capacity of 960 m^3/d will be installed to treat TSS. With this facility, T-N and T-P will be reduced coincidentally to the target levels.

The proposed treatment system is illustrated below.



(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 5,000 × 10^3.

8.5.5 CHROMOS GRAFIĆKE BOJE

(1) Existing Wastewater Discharge System

Code No.	309180
Activity	Chemicals
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
189	18	35	563	-	-	1.5
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	189	18	35	563	30.0	5.0	1.5	Sewerage
2007	1.328	0.930	233	18	35	563	30.0	5.0	1.5	Sewerage
2015	1.944	0.850	312	18	35	563	30.0	5.0	1.5	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

There is no treatment plant at present, but the existing effluent quality meets the permissible limits for public sewerage. Hence, no wastewater treatment plant is necessary.

8.5.6 IMUNOLOŠKI ZAVOD BREZJE

(1) Existing Wastewater Discharge System

Code No.	309233
Activity	Chemicals
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
682	40	221	649	-	-	3.4
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	682	40	221	649	30.0	5.0	3.4	Sewerage
2007	1.328	0.930	842	40	221	649	30.0	5.0	3.4	Sewerage
2015	1.944	0.850	1,127	40	221	649	30.0	5.0	3.4	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

There is no treatment plant at present, but the existing effluent quality meets the permissible limits for public sewerage. Hence, no wastewater treatment plant is necessary.

8.5.7 TOP

(1) Existing Wastewater Discharge System

Code No.	309278
Activity	Metal/Machinery
Wastewater Recipient	River
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
207	44	84	1,161	-	-	-
Regulation for River (II)	25	125	35	21	1	25

(3) Proposed Wastewater Treatment System

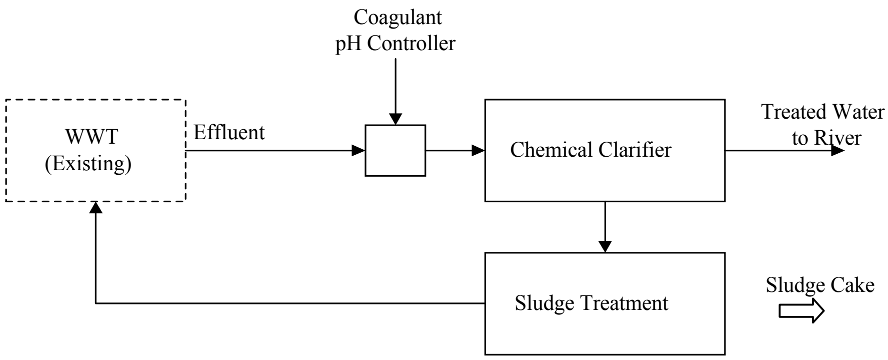
The wastewater will be discharged into the river as at present since the factory is located outside of the planned sewerage service area. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	207	44	84	1,161	30	5.0	5.0	River
2007	1.328	0.930	256	44	84	1,161	30	5.0	5.0	River
2015	1.944	0.850	342	25	84	35	21	1	5.0	River
Regulation for River (II)				25	125	35	21	1	25	

Note: The Study Team assumed the values of T-N, T-P and Oil & Grease.

As shown in the above table, the existing quality of TSS, BOD,T-N and T-P exceed the permissible limits for the river (Category II). Hence, a chemical clarifier with a capacity of 350 m^3/d will be installed to treat TSS. With this facility, BOD, T-N and T-P will be reduced coincidentally to the target levels.

The proposed treatment system is illustrrated below.



(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 2,400 $\times$ 10^3.

8.6 Other Large Industries in Zaprešić

8.6.1 HŽ INFRASTRUCKTURA

(1) Existing Wastewater Discharge System

Code No.	315062
Activity	Transportation
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
275	130	137	577	-	-	167.8
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	F_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	275	130	137	577	30.0	5.0	167.8	Sewerage
2007	1.328	0.930	340	130	137	577	30.0	5.0	167.8	Sewerage
2015	1.944	0.850	454	130	137	577	30.0	5.0	100	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing effluent quality meets the permissible limits of public sewerage except oil and grease. Hence, a treatment plant is proposed to remove oil and grease. The treatment capacity of the plant is 460 m^3/d.

(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 300 $\times 10^3$.

8.6.2 INKER

(1) Existing Wastewater Discharge System

Code No.	315080
Activity	Ceramic Industry
Wastewater Recipient	River
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
391	43	102	2,567	-	-	6.9
Regulation for River (II)	25	125	35	21	1	25

(3) Proposed Wastewater Treatment System

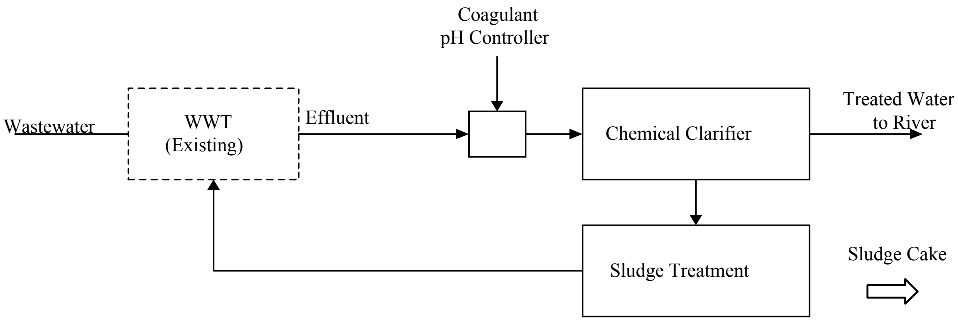
The wastewater will be discharged into the river as at present since the factory is located outside of the planned sewerage service area. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	391	43	102	2,567	30.0	5.0	6.9	River
2007	1.328	0.930	483	25	102	2,567	30.0	5.0	6.9	River
2015	1.944	0.850	646	25	102	35	21	1	5.0	River
Regulation for River (II)				25	125	35	21	1	25	

Note: The Study Team assumed the values of T-N, T-P and Oil & Grease.

As shown in the above table, the existing quality of TSS, BOD, T-N and T-P exceed the permissible limits for the river (Category II). Hence, a chemical clarifier with a capacity of 650 m^3/d will be installed to treat TSS. With this facility, BOD, T-N and T-P will be reduced coincidentally to the target levels.

The proposed treatment system is illustrated below.



(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 3,500 $\times 10^3$.

8.6.3 KARBON

(1) Existing Wastewater Discharge System

Code No.	315089
Activity	Chemicals
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
535	40	212	827	-	-	14.7
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	F_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	535	40	212	827	30.0	5.0	14.7	Sewerage
2007	1.328	0.930	660	40	212	827	30.0	5.0	14.7	Sewerage
2015	1.944	0.850	884	40	212	827	30.0	5.0	14.7	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

There is no treatment plant at present, but the existing effluent quality meets the permissible limits for public sewerage. Hence, no wastewater treatment plant is necessary.

8.6.4 VIADUKT

(1) Existing Wastewater Discharge System

Code No.	315157
Activity	Others
Wastewater Recipient	River
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
242	269	744	1,625	30.0	5.0	152.9
Regulation for River (II)	25	125	35	21	1	25

(3) Proposed Wastewater Treatment System

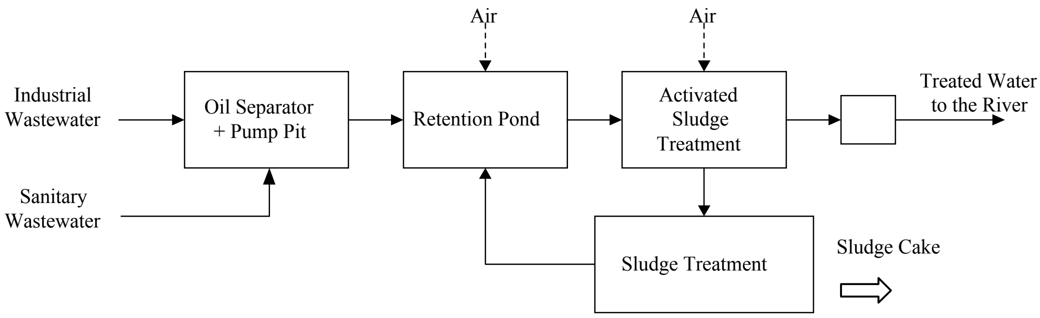
The wastewater will be discharged into the river as at present since the factory is located outside of the planned sewerage service area. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	242	269	744	1,625	30.0	5.0	152.9	River
2007	1.328	0.930	299	269	744	1,625	30.0	5.0	152.9	River
2015	1.944	0.850	400	25	125	35	21	1	25	River
Regulation for River (II)				25	125	35	21	1	25	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing quality of BOD, COD, TSS and Oil & Grease far exceed the permissible limits for the river (Category II). Hence, a standard activated sludge treatment with oil trap is proposed to treat BOD, COD, TSS and Oil & Grease. With this system, T-N and T-P will be reduced coincidentally to the target levels.

The proposed treatment system is illustrated below.



(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 7,500 × 10^3.

8.7 Other Large Industries in Velika Gorica

8.7.1 DALEKOVOD

(1) Existing Wastewater Discharge System

Code No.	314038
Activity	Metal/Machinery
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
192	126	342	691	-	-	29.5
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	192	126	342	691	30.0	5.0	29.5	Sewerage
2007	1.328	0.930	237	126	342	691	30.0	5.0	29.5	Sewerage
2015	1.944	0.850	317	126	342	691	30.0	5.0	29.5	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

There is no treatment plant at present, but the existing effluent quality meets the permissible limits of public sewerage. Hence, no wastewater treatment plant is necessary.

8.7.2 INDUSTRROGRADNJA (314077)

(1) Existing Wastewater Discharge System

Code No.	314077
Activity	Concrete Industry
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
101	-	-	-	-	-	-
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	101	50	100	300	30.0	5.0	5.0	Sewerage
2007	1.328	0.930	125	50	100	300	30.0	5.0	5.0	Sewerage
2015	1.944	0.850	167	50	100	300	30.0	5.0	5.0	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed all wastewater quality values.

There is no treatment plant at present, but the existing effluent quality meets the permissible limits of public sewerage. Hence, no wastewater treatment plant is necessary.

8.7.3 INDUSTROGRADNJA (314079)

(1) Existing Wastewater Discharge System

Code No.	314079
Activity	Concrete Industry
Wastewater Recipient	River
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
240	-	-	-	-	-	-
Regulation for River (III)	25	125	35	31	2	30

Note: No water quality values are available.

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the river as at present since the factory is located outside the planned sewerage service area. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	240	50	100	300	30.0	5.0	5	River
2007	1.328	0.930	296	50	100	300	30.0	5.0	5	River
2015	1.944	0.850	397	50	100	300	30.0	5.0	5	River
Regulation for River (III)				25	125	35	31	2	30	

Note: The Study Team assumed all wastewater quality values.

All wastewater qualities are assumed since no data are available. However, the industry is considered to cause no serious water pollution judging from its activities. Hence, no wastewater treatment plant is proposed.

8.7.4 ZRAĆNA LUKA Zagreb

(1) Existing Wastewater Discharge System

Code No.	314205
Activity	Transportation
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
108	-	-	-	-	-	-
Regulation for Public Sewerage	250	700	-	-	10	100

Note: No water quality values are available.

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	108	87	125	889	30.0	5.0	0.6	Sewerage
2007	1.328	0.930	133	87	125	889	30.0	5.0	0.6	Sewerage
2015	1.944	0.850	178	87	125	889	30.0	5.0	0.6	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed all wastewater quality values.

There is no treatment plant at present, but the existing effluent quality meets the permissible limits of public sewerage. Hence, no wastewater treatment plant is necessary.

8.8 Other Large Industries in Jastrebarsko

8.8.1 MLADINA d.d.

(1) Existing Wastewater Discharge System

Code No.	332001
Activity	Food/.Beverage
Wastewater Recipient	Sewerage
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
109	-	-	-	-	-	-
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	109	230	369	300	30.0	5.0	5	Sewerage
2007	1.328	0.930	135	230	369	300	30.0	5.0	5	Sewerage
2015	1.944	0.850	180	230	369	300	30.0	5.0	5	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed all wastewater quality values.

As shown in the above table, the existing effluent quality meets the permissible limits for public sewerage. However, the wastewater is estimated to increase in the future. Hence, the extension of the existing treatment system is necessary to cope with the increasing wastewater. The extension's capacity is approx. 70 m^3/d.

(4) Estimated Construction Cost

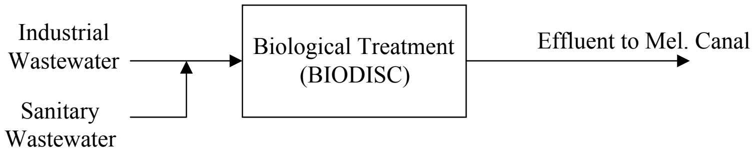
The required construction cost is estimated to be approx. Kn 300 $\times$ 10^3.

8.8.2 JAMNICA ZAGREB, Jamnika Kiselica

(1) Existing Wastewater Discharge System

Code No.	332002
Activity	Food/Beverage
Wastewater Recipient	Canal
Treatment System	Existing

The wastewater is treated by the biological treatment process (biodisc) as illustrated below.



(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
736	68	96	1,232	-	-	0.3
Regulation for Canal (II)	25	125	35	21	1	25

(3) Proposed Wastewater Treatment System

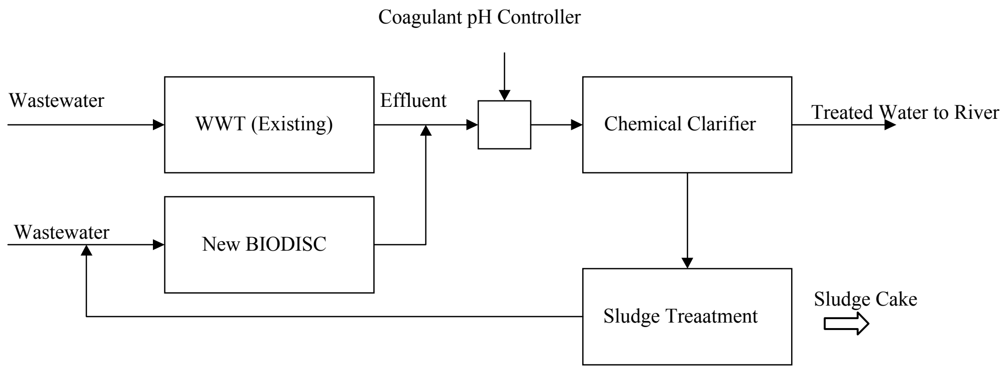
The wastewater will be discharged into the river as at present since the factory is located outside of the planned sewerage service area. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	736	68	96	1,232	30.0	5.0	0.3	Canal
2007	1.328	0.930	908	68	96	1,232	30.0	5.0	0.3	Canal
2015	1.944	0.850	1,216	25	96	35	21	1	0.3	Canal
Regulation for Canal (II)				25	125	35	21	1	25	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing wastewater quality of BOD, TSS, T-N and T-P exceed the permissible limits for the canal (Category II). Hence, the existing treatment system will be improved to treat BOD and TSS. With the improvement, T-N and T-P will be reduced coincidentally to the target levels.

The proposed improvement includes an additional biological treatment (Biodisc) (capacity: 480 m3/d) and a chemical clarifier (capacity: 1,250 m3/d). The proposed treatment system is illustrated below, while the detailed flow diagram and layout are given in Fig. C.2.11 and Fig. C.2.12 respectively.



(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn 5,000 $\times$ 10^3.

8.9 Other Large Industry in Popovača

8.9.1 NEUTROPSIHIJATRIJSKA BOLNICA

(1) Existing Wastewater Discharge System

Code No.	357003
Activity	Hospital
Wastewater Recipient	Sewerage
Treatment System	None

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
452	260	400	473	-	-	6.3
Regulation for Public Sewerage	250	700	-	-	10	100

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the public sewerage as at present since the effluent quality has no problem in sewage treatment. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	452	260	400	473	30.0	5.0	6.3	Sewerage
2007	1.328	0.930	558	250	400	473	30.0	5.0	6.3	Sewerage
2015	1.944	0.850	747	250	400	473	30.0	5.0	6.3	Sewerage
Regulation for Public Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

There is no treatment plant at present, but the existing effluent quality almost meets the permissible limits for public sewerage. Hence, no wastewater treatment plant is necessary.

8.10 Other Large Industries in Ogulin

8.10.1 OPĆA BOLNICA OGLIN

(1) Existing Wastewater Discharge System

Code No.	335001
Activity	Hospital
Wastewater Recipient	Groundsoil
Treatment System	Existing

(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
206	41	126	553	-	-	7.1
Regulation for Groundsoil	-	-	-	-	-	-

Note: Wastewater discharge into the ground is not allowed in this sensitive area.

(3) Proposed Wastewater Treatment System

The wastewater is discharged into the ground with treatment at present. However, this area is designated as a sensitive area where no wastewater discharge into the ground is allowed. Hence, the wastewater will be discharged into the public sewerage because this hospital will be included in the sewerage service area of Ogulin and the effluent quality has no problem in sewage treatment.

The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	206	41	126	553	30.0	5.0	7.1	Groundsoil
2007	1.328	0.930	254	41	126	553	30.0	5.0	7.1	Sewerage
2015	1.944	0.850	340	41	126	553	30.0	5.0	7.1	Sewerage
Regulation for Sewerage				250	700	-	-	10	100	

Note: The Study Team assumed the values of T-N and T-P.

The existing effluent quality meets the permissible limits of public sewerage. However, the wastewater is estimated to increase in the future as shown above. Hence, the extension of the existing treatment system is necessary to cope with the increasing wastewater. The extension's capacity is approx. 135 m^3/d.

(4) Estimated Construction Cost

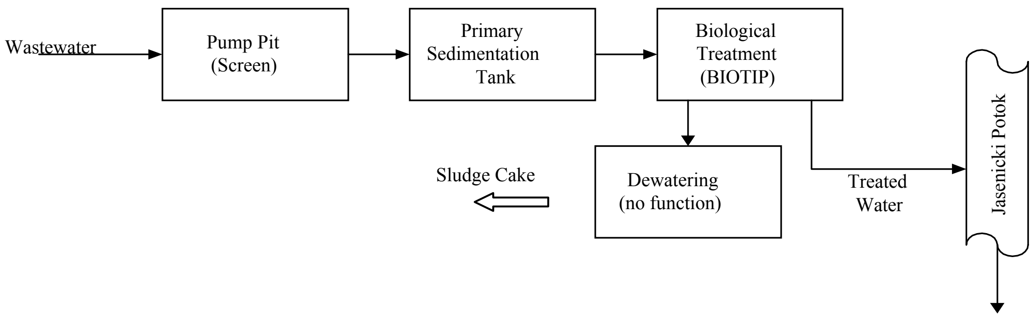
The required construction cost is estimated to be approx. Kn. 500×10^3.

8.10.2 BJELOLASICA

(1) Existing Wastewater Discharge System

Code No.	335004
Activity	Hotel
Wastewater Recipient	Brook
Treatment System	Existing

The wastewater is treated by the biological process (Biotip), as illustrated below.



(2) Existing Wastewater Quantity and Quality

Quantity(m^3/d)	BOD (mg/l)	COD (mg/l)	TSS (mg/l)	T-N (mg/l)	T-P (mg/l)	Oil & Grease (mg/l)
163	99	201	333	30.0	5.0	7.6
Regulation for Brook (II)	25	125	35	21	1	25

(3) Proposed Wastewater Treatment System

The wastewater will be discharged into the brook as at present since the hospital is located outside of the planned sewerage service area in Ogulin. The future wastewater quantity and quality for the design of treatment plant are as estimated below.

	Quantity			Quality (mg/l)						Recipient
	f_1	f_2	Q (m^3/d)	BOD	COD	TSS	T-N	T-P	Oil & Grease	
1999	1.000	1.000	163	99	201	333	30.0	5.0	7.6	Brook
2007	1.328	0.930	201	99	201	333	30.0	5.0	7.6	Brook
2015	1.944	0.850	269	25	125	35	21	1	7.6	Brook
Regulation for Brook (II)				25	125	35	21	1	25	

Note: The Study Team assumed the values of T-N and T-P.

As shown in the above table, the existing wastewater quality of BOD, TSS, T-N and T-P exceed the permissible limits for the brook (Category II). Hence, an additional one (1) train will be constructed in the existing treatment system to treat BOD, COD and TSS. With this facility, T-N and T-P will be reduced coincidentally to the target levels. The capacity of the additional facility is 170 m^3/d.

(4) Estimated Construction Cost

The required construction cost is estimated to be approx. Kn $3,000 \times 10^3$.

TABLES

Table C.1.1 Industrial Effluent Regulation

	Into Natural Recipient				Into Public Sewerage
	Cat II	Cat III	Cat IV	Cat V	
pH	6.5-8.0	6.0-8.5	5.5-9.0	5.0-9.5	5.0-9.5
Temperature	35	40	45	45	45
Colour	none	slightly noticeable	slightly noticeable	slightly noticeable	slightly noticeable
Odour	none	slightly noticeable	noticeable	noticeable	noticeable
Solid Matter	none	none	none	none	none
Despositable Substance	1	2.5	5	10	20
Total Suspended Substances (* not limited)	**35**	**35-60**	**60-150**	**150**	*****
BOD_5 (*depending on WWTP Capacity)	25	25	40	80	**250***
COD_{Cr} (*depending on WWTP Capacity)	125	125	200	400	**700***
Total Organic Carbon	15	**30**	**30**	40	
Toxicity	1	2	3	3	3
Bio Degraqdability	70	70	70	70	70
Al	2	3	3.5	4	4
As	0.2	0.3	0.4	0.4	0.5
Cu	0.1	0.25	0.4	0.5	0.5
Ba	2.5	3	4	5	5
B	1.5	2	2.5	3	4
Zn	0.75	1	1.25	1.5	2
Co	0.5	1	1.25	1.5	2
Sn	0.75	1	1.25	1.5	2
T-Cr	1	1.25	1.5	1.75	2
Cr^{6+}	0.05	0.1	0.15	0.15	0.2
Mn	2	2.5	3	3.5	4
Ni	1	1.25	1.5	1.5	2
Pb	0.2	0.5	0.75	1	2
Se	0.02	0.03	0.04	0.05	0.1
Ag	0.1	0.15	0.2	0.3	0.5
Fe	2	3	4	5	10
V	0.05	0.05	0.075	0.075	0.1
T-Phenols	0.1	0.2	0.3	0.4	**10.0**
F	5	6	8	9	12
Sulfites	1	2	4	5	10
Sulfides	0.1	0.25	0.5	1	1
Sulfates					400
Cl-					1,000
T-P	1	2	4	8	10
Cl_2	0.2	0.25	0.3	0.3	0.3
orth-P	1	2	3	4	
NH4+	**10.0**	**15.0**	**20.0**	**20.0**	**—**
NO^{2-}	0.5	0.5	1	3	
NO3-	**10.0**	**15.0**	**20.0**	**20.0**	**—**
T-N	**21.0**	**31.0**	**42.0**	**42.0**	**—**
Mineral Oil	5	10	15	20	30
Total Oil/Grease	25	30	40	50	100
Aldehydes	1	1.5	2	2	2
Total Ar.Carbohydrate	0.02	0.05	0.1	0.15	0.2
Total Nitrate Carbohydrate	0.01	0.025	0.03	0.05	0.1
Total halogen Carbohydrate	0.1	0.25	0.5	0.75	1
Total organoophosphorous pesticides		0.05	0.1	0.1	0.1
Total organochlorinic pesiticides		0.025	0.05	0.05	0.05
Tot.Pov.active substances	4	5	7	10	20
Detergent anionic	1	2	4	4	10
Detergent nonionic	1	2	4	4	10
Detergent cationic	**0.5**	**1.0**	**1.0**	**2.0**	**5.0**
Radioactivity total Beta	500	750	1000	1500	2000

The figures in bold type are revised values (24.01.2001).

Table C.1.2 (1) Wastewater Quantity and Quality in Sesvete East

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
310001	**Agroproteinka**	**Food/Berverage**	**208.5**	**59.6**	**2,643.0**	**551.1**	**87.4**	**4,048.0**	**844.0**	**79.2**	**1,608.0**	**335.3**	**28.0**
310248	**Duma Kože**	**Leathers**	**141.1**	**40.4**	**562.5**	**79.4**	**12.6**	**1,571.0**	**221.7**	**20.8**	**6,103.5**	**861.2**	**72.0**
	Total		349.6	100.0	1,803.3	630.4	100.0	3,048.3	1,065.7	100.0	3,422.4	1,196.5	100.0

Table C.1.2 (2) Wastewater Quantity and Quality in Vrbovec

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
360010	Galvanotehnika (Galtronik)	Chemicals	8.4	0.3	75.5	0.6	0.1	145.9	1.2	0.1	604.7	5.1	0.2
360014	Galvanotehnika	Chemicals	7.2	0.2	70.7	0.5	0.1	156.7	1.1	0.1	723.8	5.2	0.2
360016	KOS d.o.o. Benzinska	Chemicals	7.3	0.2	83.9	0.6	0.1	167.7	1.2	0.1	397.1	2.9	0.1
360017	Komunalac Vrbovec, d.d. (to River)	Chemicals	14.5	0.5	47.0	0.7	0.1	95.3	1.4	0.1	478.0	6.9	0.2
360019	Komunalac Vrbovec, d.d. (to Sewer)	Chemicals	14.5	0.5	52.9	0.8	0.1	103.3	1.5	0.1	330.4	4.8	0.1
360004	**PIK Vrbovec Mesna Ind.**	**Food/Beverage**	**2,479.9**	**82.1**	**179.3**	**444.6**	**58.4**	**363.3**	**900.9**	**63.3**	**1,012.1**	**2,509.9**	**78.3**
360006	PIK Vrbovec Gradec 183	Food/Beverage	74.7	2.5	189.8	14.2	1.9	360.7	26.9	1.9	322.1	24.1	0.8
360008	**PIK Vrbovec Farma Poljanski**	**Food/Beverage**	**74.8**	**2.5**	**2,785.9**	**208.4**	**27.4**	**4,872.8**	**364.5**	**25.6**	**5,428.2**	**406.0**	**12.7**
360011	PIK Vrbovec-Farma Djurište	Food/Beverage	39.7	1.3	1,686.5	67.0	8.8	1,934.2	76.8	5.4	2,747.2	109.1	3.4
360021	Kalinski, Klaonica Prerada	Food/Beverage	9.2	0.3	116.5	1.1	0.1	232.7	2.1	0.2	412.7	3.8	0.1
360009	GALOKS, Vrbovec	Metal (Zn) Industry	7.6	0.3	89.2	0.7	0.1	208.9	1.6	0.1	1,066.2	8.1	0.3
360013	Jurval	Metal/Machinery	4.8	0.2	156.9	0.8	0.1	327.0	1.6	0.1	776.3	3.7	0.1
360015	Metalcrom	Metal/Machinery	*20.0*	0.7	*50.0*	1.0	0.1	*100.0*	2.0	0.1	*300.0*	6.0	0.2
360012	Hrvatske Šume-Uprava	Mechinery	2.8	0.1	111.7	0.3	0.0	235.2	0.7	0.0	727.5	2.0	0.1
360020	Oprema Vrvovec	Metal Industry	20.5	0.7	25.8	0.5	0.1	46.2	0.9	0.1	303.9	6.2	0.2
360005	PIK"Autoservis"	Transportation	14.4	0.5	60.0	0.9	0.1	116.5	1.7	0.1	431.1	6.2	0.2
360001	Trgovacko drusivo VIND	Wood Industry	2.9	0.1	35.6	0.1	0.0	67.9	0.2	0.0	424.5	1.2	0.0
360007	Šavriać d.d. Tvornica masivnog	Wood Industry	60.0	2.0	79.3	4.8	0.6	153.9	9.2	0.6	379.0	22.7	0.7
360018	PIK "Motel Vrbovec"	Hotel	46.6	1.5	134.2	6.3	0.8	265.1	12.4	0.9	655.8	30.6	1.0
360002	**Gradip d.d.**	**Clay Industry**	**110.0**	**3.6**	**74.0**	**8.1**	**1.1**	**147.4**	**16.2**	**1.1**	**385.1**	**42.4**	**1.3**
[Note] (1) ***Italic Letters*** are assumed by the Study Team.													
	Total of 3 Bold Type Industries		**2,664.7**	**88.2**		**661.2**	**86.8**		**1,281.6**	**90.0**		**2,958.3**	**92.2**
	Total		3,019.8	100.0	252.3	761.8	100.0	471.6	1,424.2	100.0	1,062.0	3,207.0	100.0

Table C.1.2 (3) Wastewater Quantity and Quality in Sisak

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
374002	**Herbos d.d.**	**Chemicals**	**743.1**	**5.6**	**201.3**	**149.6**	**19.3**	**404.3**	**300.4**	**21.2**	**3,543.6**	**2,633.2**	**33.3**
374004	**Tvornica Segestica**	**Food/Beverage**	**260.0**	**1.9**	**661.5**	**172.0**	**22.2**	**1,451.5**	**377.4**	**26.7**	**2,437.0**	**633.6**	**8.0**
			*1,022.4										
374006	**LJUDEVIT POSAVSKI Mlin i PEKARE**	**Food/Beverage**	**86.8**	**0.6**	**1,167.1**	**101.3**	**13.1**	**1,320.1**	**114.6**	**8.1**	**607.9**	**52.8**	**0.7**
374005	**Željezara Poduzeće Metaval**	**Metal/Machinery**	**2,370.5**	**17.7**	**13.2**	**31.3**	**4.0**	**28.3**	**67.2**	**4.7**	**260.9**	**618.5**	**7.8**
			*6,522.4										
374001	**INA Zagreb Rafinerija Nafte**	**Oil Refinery**	**9,653.1**	**72.2**	**33.0**	**318.8**	**41.2**	**56.8**	**548.3**	**38.7**	**398.6**	**3,847.7**	**48.7**
374003	**Termoelektrana Sisak**	**Electric Power Station**	**252.8**	**1.9**	**6.4**	**1.6**	**0.2**	**28.8**	**7.3**	**0.5**	**471.5**	**119.2**	**1.5**
			*494,161.4										
	Total		13,366.3	100.0	58.0	774.7	100.0	105.9	1,415.2	100.0	591.4	7,905.1	100.0

[Note]: *One-through Cooling Water are excluded.

Table C.1.2 (4) Wastewater Quantity and Quality in Kutina

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
357009	**Petrokemija Kutina - Tech.**	**Chemicals**	**10,726.0**	**92.5**	**17.8**	**190.9**	**90.6**	**52.8**	**566.3**	**91.4**	**113.9**	**1,221.7**	**79.0**
357016	**Petrokemija Kutina - Sanitary**	**Chemicals**	**663.0**	**5.7**	**18.7**	**12.4**	**5.9**	**57.6**	**38.2**	**6.2**	**397.5**	**263.6**	**17.0**
357010	Moslavaćko Vinogorje	Food/Beverage	*20.0*	0.2	*50.0*	1.0	0.5	*100.0*	2.0	0.3	*300.0*	6.0	0.4
357015	VAJDA stoćarstvo Zagreb	Food/Beverage	*20.0*	0.2	*50.0*	1.0	0.5	*100.0*	2.0	0.3	*300.0*	6.0	0.4
357004	Čzmatrans Tehnički Pregled	Transportation	*20.0*	0.2	13.2	0.3	0.1	28.3	0.6	0.1	260.9	5.2	0.3
357011	Čazmatrans Autokuća	Transportation	8.9	0.1	69.6	0.6	0.3	145.6	1.3	0.2	399.3	3.6	0.2
357005	Dom Zdravlja	Ambulance	*20.0*	0.2	*50.0*	1.0	0.5	*100.0*	2.0	0.3	*300.0*	6.0	0.4
357006	Crosco Naftni Servisi	Oil Service	47.3	0.4	11.3	0.5	0.3	24.6	1.2	0.2	324.7	15.4	1.0
357008	INA Petrokemija Metan	Oii & Gas	*20.0*	0.2	*50.0*	1.0	0.5	*100.0*	2.0	0.3	*300.0*	6.0	0.4
357014	Naftaplin Skladište	Oil & Gas	9.0	0.1	6.6	0.1	0.0	16.1	0.1	0.0	203.1	1.8	0.1
357012	Autopraonica vl Zoran Kramarić	Car Wash	*20.0*	0.2	*50.0*	1.0	0.5	*100.0*	2.0	0.3	*300.0*	6.0	0.4
357013	Autopraonica Spužvica, v1 Damir	Car Wash	*20.0*	0.2	*50.0*	1.0	0.5	*100.0*	2.0	0.3	*300.0*	6.0	0.4
[Note] (1) *Italic Letters* are assumed by the Study Team.													
(2) Total **Load of Petrokemija (357009/357016)**			**11,389.0**	**98.2**		**203.3**	**96.5**		**604.5**	**97.6**		**1,485.3**	**96.0**
	Total		11,594.2	100.0	18.2	210.8	100.0	53.4	619.7	100.0	133.4	1,547.2	100.0

Table C.1.2 (5) Wastewater Quantity and Quality in Karlovac

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m³/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
333004	Karlovaćka Industrija Kože	Leather	72.4	1.4	250.7	18.2	0.9	628.9	45.5	1.2	2,473.0	179.0	3.8
333007	KA-Plast	Chemicals	1.6	0.0	*50.0*	0.1	0.0	*100.0*	0.2	0.0	*300.0*	0.5	0.0
333013	Kemijsko Gradevinska Industrija KOI	Chemicals	26.1	0.5	89.4	2.3	0.1	255.1	6.7	0.2	511.8	13.4	0.3
333014	Boneja-prerada Kože	Leather	14.6	0.3	135.2	2.0	0.1	258.5	3.8	0.1	297.4	4.3	0.1
333019	**Linde Plin d.o.o.**	**Gas**	**101.2**	**2.0**	**18.6**	**1.9**	**0.1**	**57.4**	**5.8**	**0.2**	**498.8**	**50.5**	**1.1**
333006	**Karlovaćka Pivovara**	**Food/Berverage**	**2,360.7**	**46.4**	**700.0**	**1,652.5**	**83.8**	**1,299.4**	**3,067.5**	**82.4**	**1,398.1**	**3,300.5**	**69.7**
333015	**PPK-Karlovaćka Industrija Mesna**	**Food/Berverage**	**314.8**	**6.2**	**326.6**	**102.8**	**5.2**	**562.8**	**177.2**	**4.8**	**1,473.2**	**463.8**	**9.8**
333016	**Karlovaćka Industrija Mlijeka**	**Food/Beverage**	**224.1**	**4.4**	**237.0**	**53.1**	**2.7**	**438.0**	**98.1**	**2.6**	**338.3**	**75.8**	**1.6**
333003	**KORDUN Karlovac**	**Metal/Machinery**	**127.2**	**2.5**	**30.0**	**3.8**	**0.2**	**72.6**	**9.2**	**0.2**	**422.5**	**53.7**	**1.1**
333008	**Že-Če**	**Metal/Machinery**	**304.6**	**6.0**	**7.3**	**2.2**	**0.1**	**31.9**	**9.7**	**0.3**	**284.7**	**86.7**	**1.8**
333009	Že-Če	Metal/Machinery	*20.0*	0.4	38.1	0.8	0.0	198.8	4.0	0.1	1,068.8	21.4	0.5
333010	**Tvornica Plinskih Turbina**	**Metal/Machinery**	**133.5**	**2.6**	**25.5**	**3.4**	**0.2**	**73.1**	**9.8**	**0.3**	**341.4**	**45.6**	**1.0**
333011	**Adria-Diesel**	**Metal/Machinery**	**128.2**	**2.5**	**30.3**	**3.9**	**0.2**	**97.0**	**12.4**	**0.3**	**733.3**	**94.0**	**2.0**
333017	**ABB ALSTOM POWER**	**Metal/Machinery**	**240.0**	**4.7**	**24.0**	**5.8**	**0.3**	**62.0**	**14.9**	**0.4**	**56.0**	**13.4**	**0.3**
333026	Liga d.o.o.	Metal/Machinery	*20.0*	0.4	1.0	0.0	0.0	20.0	0.4	0.0	202.0	4.0	0.1
333027	Croatia Pumpe d.d.	Metal/Machinery	41.2	0.8	6.0	0.2	0.0	19.5	0.8	0.0	275.0	11.3	0.2
333028	TPK Strojevi Kamanje	Metal/Machinery	7.5	0.1	9.3	0.1	0.0	33.0	0.2	0.0	311.3	2.3	0.0
333002	Kontex d.d.	Textile	70.9	1.4	192.0	13.6	0.7	243.5	17.3	0.5	528.0	37.4	0.8
333005	**Velebit**	**Textile**	**209.7**	**4.1**	**186.8**	**39.2**	**2.0**	**412.2**	**86.4**	**2.3**	**344.6**	**72.3**	**1.5**
333012	**Lola Ribar**	**Textile**	**323.9**	**6.4**	**180.9**	**58.6**	**3.0**	**392.6**	**127.2**	**3.4**	**315.6**	**102.2**	**2.2**
333025	Beti Trikolazac Žakanje	Textile	11.6	0.2	35.0	0.4	0.0	108.5	1.3	0.0	459.0	5.3	0.1
333021	JP Hrvatske Ceste	Transportation	*20.0*	0.4	*50.0*	1.0	0.1	*100.0*	2.0	0.1	*300.0*	6.0	0.1
333022	Automehanika d.d.	Transportation	20.1	0.4	22.2	0.4	0.0	59.3	1.2	0.0	315.7	6.3	0.1
333029	**Autotransport d.d.**	**Transportation**	**103.6**	**2.0**	**23.0**	**2.4**	**0.1**	**147.0**	**15.2**	**0.4**	**244.0**	**25.3**	**0.5**
333001	Finvest-Corp. d.d. PC Impregnacija	Wood Industry	86.9	1.7	12.9	1.1	0.1	36.3	3.2	0.1	274.4	23.8	0.5
333018	Švarća Restoran Društvene	Restaurant	*20.0*	0.4	*50.0*	1.0	0.1	*100.0*	2.0	0.1	*300.0*	6.0	0.1
333023	Karlovaćka Industrija Obuće	Shoe Factory	57.6	1.1	4.0	0.2	0.0	22.5	1.3	0.0	341.0	19.6	0.4
333020	Merkur Lok Autopraonice	Car Wash	21.9	0.4	18.7	0.4	0.0	55.3	1.2	0.0	449.0	9.8	0.2
333024	Arka Obrt za Trgovinu i Pranje Motor	Car Wash	6.4	0.1	8.0	0.1	0.0	30.0	0.2	0.0	138.0	0.9	0.0
[Note] (1) *Italic Letters* are assumed by the Study Team.													
(2) Total Load of 12 Bold Type Industries			**4,571.5**	**89.8**		**1,929.6**	**97.9**		**3,633.5**	**97.6**		**4,383.7**	**92.6**
	Total		5,090.3	100.0	387.3	1,971.4	100.0	731.7	3,724.6	100.0	930.3	4,735.4	100.0

Table C.1.2 (5a) Wastewater Quantity and Quality in Duga Resa

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
331001	**Pamućna Industrija Duga Resa**	**Textile**	**1,939.3**	**97.2**	**152.8**	**296.3**	**98.6**	**350.7**	**680.0**	**98.7**	**317.4**	**615.6**	96.4
331002	Specijalna Bolnica i Gerijatrija	Hospital	35.4	1.8	115.3	4.1	1.4	245.7	8.7	1.3	550.4	19.5	3.0
331004	Autopraona 2D-Mag	Car Wash	*20.0*	1.0	6.0	0.1	0.0	30.0	0.6	0.1	188.0	3.8	0.6
[Note] (1)	*Italic Letters* are assumed by the Study Team.												
	Total		1,994.7	100.0	150.7	300.5	100.0	345.6	689.3	100.0	320.3	638.8	100.0

Table C.1.2 (5 & 5a) Wastewater Quantity and Quality in Karlovac and Duga Resa

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
	Total of **Karlovac**		5,090.3	71.8	387.3	1,971.4	86.8	731.7	3,724.6	84.4	930.3	4,735.4	88.1
	Total of **Duga Resa**		1,994.7	28.2	150.7	300.5	13.2	345.6	689.3	15.6	320.3	638.8	11.9
[Note] (1)	Total Load of 13 Bold Type Industries		**6,510.8**	**91.9**	**341.9**	**2,225.9**	**98.0**	**662.5**	**4,313.5**	**97.7**	**767.8**	**4,999.3**	**93.0**
	Total		7,085.0	100.0	320.7	2,272.0	100.0	623.0	4,413.9	100.0	758.5	5,374.2	100.0

Table C.1.2 (6) Wastewater Quantity and Quality in Sveti Ivan Zelina

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
361003	Iskra	Chemicals	23.8	19.5	139.1	3.3	19.7	285.1	6.8	21.2	1,189.9	28.3	31.4
361008	Tiskara Zelina	Chemicals	12.0	9.8	145.0	1.7	10.4	272.9	3.3	10.2	831.5	10.0	11.1
361009	Klaonica i Prerada Mesa	Food/Beverage	17.3	14.2	412.1	7.1	42.5	721.3	12.5	38.9	1,295.3	22.4	24.9
361010	Klaonica br. 25	Food/Beverage	*5.8*	4.8	323.7	1.9	11.2	657.7	3.8	11.9	1,306.7	7.6	8.4
361002	Endi International	Textile	*20.0*	16.4	*50.0*	1.0	6.0	*100.0*	2.0	6.2	*300.0*	6.0	6.7
361007	Zelinka d.d. Modna	Textile	18.5	15.2	42.5	0.8	4.7	80.7	1.5	4.7	274.3	5.1	5.6
361001	Čazmatrans Čazma, PJ Zelina	Transportation	16.2	13.3	41.3	0.7	4.0	85.5	1.4	4.3	412.6	6.7	7.4
361006	Drvna Industrija Zelina	Car Wash	*8.4*	6.9	30.1	0.3	1.5	96.6	0.8	2.5	482.9	4.1	4.5
[Note] (1)	***Italic Letters*** are assumed by the Study Team.												
	Total		122.0	100.0	137.4	16.8	100.0	262.6	32.0	100.0	738.5	90.1	100.0

Table C.1.2 (7) Wastewater Quantity and Quality in Ivanić Grad and Kloštar Ivanić

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
355001	Croatia Baterije	Chemicals	13.8	1.0	42.0	0.6	1.7	462.3	6.4	7.6	3,277.9	45.2	5.4
355013	Ivanićplast	Chemicals	36.9	2.7	41.5	1.5	4.4	83.5	3.1	3.7	269.5	9.9	1.2
355014	Ivasim	Chemicals	15.6	1.1	56.9	0.9	2.5	123.8	1.9	2.3	517.1	8.1	1.0
355016	Tiskara	Chemicals	11.0	0.8	49.1	0.5	1.5	94.4	1.0	1.2	324.5	3.6	0.4
355021	Ivakem	Chemicals	6.3	0.5	517.0	3.3	9.3	835.0	5.3	6.2	1,740.0	11.0	1.3
355002	Agroposavina	Food/Beverage	*20.0*	1.5	*50.0*	1.0	2.9	*100.0*	2.0	2.4	*300.0*	6.0	0.7
355003	Agroprerada	Food/Beverage	12.2	0.9	62.9	0.8	2.2	111.6	1.4	1.6	401.0	4.9	0.6
355017	TMPK	Metal/Machinery	26.0	1.9	24.7	0.6	1.8	19.2	0.5	0.6	440.5	11.5	1.4
355005	**INA Naftaplin Pogon ETAN**	**Oil Refinery**	**459.4**	**33.7**	**21.9**	**10.0**	**28.8**	**47.5**	**21.8**	**25.9**	**732.7**	**336.6**	**40.0**
355006	Crosco Naftni Servisi	Waste Oil Refining	59.2	4.3	9.8	0.6	1.7	16.0	0.9	1.1	412.6	24.4	2.9
355007	INA Naftaplin Radilište Žutica	Oil Refinery	17.3	1.3	9.6	0.2	0.5	21.5	0.4	0.4	324.5	5.6	0.7
355008	INA Naftaplin Radilište Žutica	Oil Refinery	6.4	0.5	5.7	0.0	0.1	10.8	0.1	0.1	247.9	1.6	0.2
355009	INA Naftaplin Radilište Žutica	Oil Refinery	16.2	1.2	12.6	0.2	0.6	21.4	0.3	0.4	274.3	4.4	0.5
355010	**Crosco Naftni Servisi**	**Shopping Center**	**199.4**	**14.6**	**20.2**	**4.0**	**11.5**	**16.7**	**3.3**	**4.0**	**493.4**	**98.4**	**11.7**
335019	**INA Naftaplin Radilišt OROI**	**Oil & Gas Service**	**228.9**	**16.8**	**13.0**	**3.0**	**8.5**	**12.7**	**2.9**	**3.4**	**645.5**	**147.8**	**17.6**
355022	INA Naftaplin Pogon Izgradnje	Oil & Gas Service	54.2	4.0	10.2	0.6	1.6	21.1	1.1	1.4	577.0	31.3	3.7
355024	Crosco Naftni Servisi Žutica	Oil Service	35.3	2.6	10.9	0.4	1.1	12.4	0.4	0.5	121.0	4.3	0.5
355015	**Naftaplin Lječilište**	**Hospital**	**116.4**	**8.5**	**43.2**	**5.0**	**14.4**	**239.8**	**27.9**	**33.1**	**662.1**	**77.1**	**9.2**
355004	DOM Zdravlja "Josip Admić"	Clinic	*20.0*	1.5	*50.0*	1.0	2.9	*100.0*	2.0	2.4	*300.0*	6.0	0.7
355012	Ivakarton	Cardboard Factory	8.1	0.6	74.0	0.6	1.7	154.0	1.2	1.5	392.9	3.2	0.4
355023	Ekoprom	Others	2.1	0.2	45.2	0.1	0.3	88.2	0.2	0.2	293.6	0.6	0.1
[Note] (1) *Italic Letters* are assumed by the Study Team.													
(2) Total of 4 Bold Type Industries			**1,004.1**	**73.6**		**22.1**	**63.2**		**56.0**	**66.4**		**659.8**	**78.4**
	Total		1,364.7	100.0	25.6	34.9	100.0	61.7	84.3	100.0	616.5	841.3	100.0

Table C.1.2 (8) Wastewater Quantity and Quality in Samobor

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
309021	**Chromos Grafičke Boje**	**Chemicals**	**212.4**	**8.9**	**33.2**	**7.1**	**5.0**	**92.9**	**19.7**	**5.0**	**1,568.3**	**333.1**	**19.2**
309123	**Pliva Kalinovica**	**Chemicals**	**577.9**	**24.1**	**27.8**	**16.1**	**11.5**	**128.0**	**74.0**	**18.7**	**512.7**	**296.3**	**17.0**
309180	**Chromos Grafičke Boje**	**Chemicals**	**187.3**	**7.8**	**17.3**	**3.2**	**2.3**	**34.4**	**6.4**	**1.6**	**562.9**	**105.4**	**6.1**
309069	**Imes**	**Food/Beverage**	**88.3**	**3.7**	**630.8**	**55.7**	**39.7**	**950.6**	**83.9**	**21.2**	**2,106.6**	**186.0**	**10.7**
309149	Ege Goran	Metal/Machinery	5.0	0.2	17.8	0.1	0.1	35.1	0.2	0.0	366.8	1.8	0.1
309278	**TOP**	**Metal/Machinery**	**206.6**	**8.6**	**43.9**	**9.1**	**6.5**	**83.4**	**17.2**	**4.4**	**1,161.0**	**239.9**	**13.8**
309047	**Fotokemika**	**Photography**	**432.1**	**18.0**	***50.0***	**21.6**	**15.4**	***100.0***	**43.2**	**10.9**	***300.0***	**129.6**	**7.5**
309233	**Imunološki Zavod Brezje**	**Pharmacy/Drug**	**682.1**	**28.5**	**39.5**	**26.9**	**19.2**	**220.8**	**150.6**	**38.0**	**648.8**	**442.5**	**25.4**
309285	Prerada Kože i Krazna Ban	Leather Manufacture	2.8	0.1	139.7	0.4	0.3	206.5	0.6	0.1	1,641.5	4.6	0.3
[Note] (1) *Italic Letters* are assumed by the Study Team.													
(2) Total of 7 Bold Type Industries			**2,386.7**	**99.7**		**139.7**	**99.7**		**395.1**	**99.8**		**1,732.9**	**99.6**
	Total		2,394.5	100.0	58.5	140.2	100.0	165.3	395.9	100.0	726.4	1,739.3	100.0

Table C.1.2 (9) Wastewater Quantity and Quality in Zaprešić

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
315089	**Karbon**	**Chemicals**	**534.3**	**14.2**	**39.8**	**21.3**	**3.7**	**212.2**	**113.4**	**2.6**	**826.4**	**441.5**	**4.2**
315127	**Pliva**	**Chemicals**	**2,282.7**	**60.8**	**198.6**	**453.3**	**78.6**	**1,767.9**	**4,035.6**	**91.2**	**3,706.6**	**8,461.1**	**80.4**
315043	Dubravica	Food/Beverage	15.1	0.4	*50.0*	0.8	0.1	*100.0*	1.5	0.0	*300.0*	4.5	0.0
315289	Bermes	Food/Beverage	9.3	0.2	608.2	5.7	1.0	870.3	8.1	0.2	4,133.0	38.4	0.4
315290	Šimun Milk	Food/Beverage	8.0	0.2	761.0	6.1	1.1	1,065.3	8.5	0.2	3,369.3	27.0	0.3
315062	**HŽ Infrastrucktura**	**Transportation**	**274.5**	**7.3**	**29.8**	**8.2**	**1.4**	**136.4**	**37.4**	**0.8**	**577.2**	**158.4**	**1.5**
315080	**Inker**	**Ceramics**	**391.0**	**10.4**	**42.7**	**16.7**	**2.9**	**102.0**	**39.9**	**0.9**	**2,566.9**	**1,003.7**	**9.5**
315157	**Viadukt**	**Others**	**241.5**	**6.4**	**268.5**	**64.8**	**11.2**	**744.0**	**179.7**	**4.1**	**1,624.7**	**392.4**	**3.7**
[Note] (1) ***Italic Letters*** are assumed by the Study Team.													
(2) Total of 5 Bold Type Industries			**3,724.0**	**99.1**		**564.3**	**97.8**		**4,406.0**	**99.6**		**10,457.1**	**99.3**
	Total		3,756.4	100.0	153.6	576.8	100.0	1,177.7	4,424.1	100.0	2,802.4	10,527.0	100.0

Table C.1.2 (10) Wastewater Quantity and Quality in Velika Gorica

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
314038	**Dalekovod**	**Metal/Machinery**	**191.7**	**28.7**	**125.6**	**24.1**	**43.0**	**341.6**	**65.5**	**49.6**	**691.0**	**132.5**	**37.3**
314163	ZET Velica Gorica	Transportation	27.7	4.1	200.2	5.5	9.9	683.3	18.9	14.3	882.4	24.4	6.9
314205	**Zraćna Luka Zagreb**	**Transportation**	**108.0**	**16.2**	**86.3**	**9.3**	**16.6**	**124.5**	**13.4**	**10.2**	**888.6**	**96.0**	**27.0**
314077	**Industrogradnja**	**Concrete**	**100.8**	**15.1**	***50.0***	**5.0**	**9.0**	***100.0***	**10.1**	**7.6**	***300.0***	**30.2**	**8.5**
314079	**Industrogradnja**	**Concrete**	**240.0**	**35.9**	***50.0***	**12.0**	**21.4**	***100.0***	**24.0**	**18.2**	***300.0***	**72.0**	**20.3**
[Note] (1) *Italic Letters* are assumed by the Study Team.													
(2) Total of 4 Bold Type Industries			**640.5**	**95.9**		**50.4**	**90.1**		**113.0**	**85.7**		**330.7**	**93.1**
	Total		668.2	100.0	83.8	56.0	100.0	197.5	131.9	100.0	531.5	355.1	100.0

Table C.1.2 (11) Wastewater Quantity and Quality in Jastrebarsko

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
332001	**Mladina d.d.**	**Food/Beverage**	**108.6**	**11.9**	**229.7**	**24.9**	**30.9**	**368.5**	**40.0**	**32.8**	***300.0***	**32.6**	**3.4**
332002	**Jamnica Zagreb, Jamnička Kiselica**	**Food/Beverage**	**735.5**	**80.9**	**67.7**	**49.8**	**61.7**	**95.6**	**70.3**	**57.7**	**1,231.6**	**905.8**	**94.0**
332006	Klaonica i Prerada Mesa, VL. M.	Food/Beverage	38.1	4.2	120.0	4.6	5.7	225.5	8.6	7.1	437.5	16.7	1.7
332003	Iteks Klinća Selo	Metal/Machinery	*20.0*	2.2	*50.0*	1.0	1.2	*100.0*	2.0	1.6	*300.0*	6.0	0.6
332005	Maček-Tvornica Vijaka, Pogon Cabdi	Metal/Machinery	3.1	0.3	48.7	0.2	0.2	189.1	0.6	0.5	491.1	1.5	0.2
332004	Palma - Zagreb	Funeral	4.1	0.5	50.8	0.2	0.3	91.3	0.4	0.3	329.7	1.4	0.1
[Note]: *Italic Letters* are assumed by the Study Team.													
(2) Total of 2 Bold Type Industries			**844.1**	**92.8**		**74.8**	**92.6**		**110.3**	**90.5**		**938.4**	**97.4**
	Total		909.4	100.0	88.0	80.7	100.0	134.0	121.9	100.0	1,060.0	964.0	100.0

Table C.1.2 (12) Wastewater Quantity and Quality in Petrinja

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
373001	**Gavrilović d.o.o.**	**Food/Beverage**	**2,275.5**	**100.0**	**182.4**	**415.0**	**100.0**	**244.2**	**555.7**	**100.0**	**446.8**	**1,016.8**	**100.0**
	Total		2,275.5	100.0	182.4	415.0	100.0	244.2	555.7	100.0	446.8	1,016.8	100.0

Table C.1.2 (13) Wastewater Quantity and Quality in Popovača

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
357002	Lipovica Privredni Pogon	Metal/Machinery	*20.0*	4.1	62.0	1.2	1.0	116.0	2.3	1.3	297.4	5.9	2.7
357003	**Neuropsihijatrijska Bolnica**	**Hospital**	**452.2**	**93.3**	**259.7**	117.4	**98.7**	**400.4**	181.1	**98.6**	**472.4**	213.6	95.4
357007	INA Naftaplin Autotransporta	Transportation	12.5	2.6	22.4	0.3	0.2	27.4	0.3	0.2	349.0	4.4	1.9
	Total		484.7	100.0	245.4	119.0	100.0	379.1	183.7	100.0	462.0	223.9	100.0

Table C.1.2 (14) Wastewater Quantity and Quality in Ogulin

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
335005	Prehrambeni Kombinat Sloboda d.d.	Food/Beverage	36.6	8.6	457.0	16.7	39.5	669.0	24.5	28.5	586.0	21.4	10.9
335002	Monting-Ventilator	Metal/Machinery	*20.0*	4.7	50.0	1.0	2.4	*100.0*	2.0	2.3	*300.0*	6.0	3.1
335001	**Opća Bolnica Oglin**	**Hospital**	**205.5**	**48.1**	**40.9**	**8.4**	**19.8**	**126.3**	**26.0**	**30.2**	**552.9**	**113.6**	**57.8**
335003	TAL	Car Wash	2.2	0.5	57.1	0.1	0.3	331.0	0.7	0.8	620.4	1.4	0.7
335004	**Bjelolasica**	**Hotel**	**163.1**	**38.2**	**98.9**	**16.1**	**38.0**	**200.4**	**32.7**	**38.1**	**332.7**	**54.3**	**27.6**
[Note] : *Italic Letters* are assumed by the Studyz Team.													
	Total		427.4	100.0	99.2	42.4	100.0	200.9	85.9	100.0	460.2	196.7	100.0

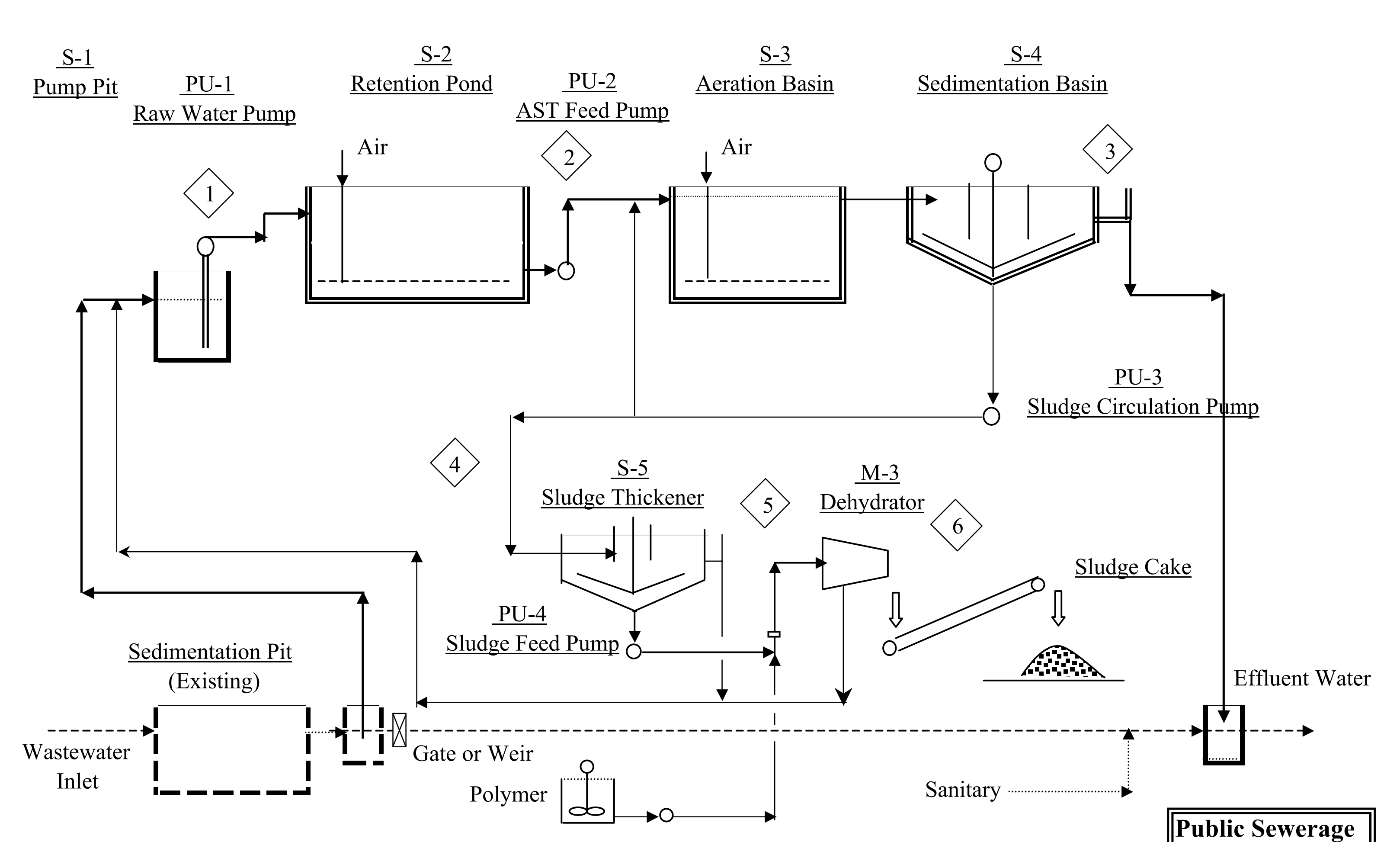
Table C.1.2 (15) Wastewater Quantity and Quality in Novska

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
358006	Milka Nova d.o.o.	Food/Beverage	18.0	15.4	2,046.8	36.8	89.7	3,156.0	56.8	86.0	3,353.1	60.4	57.8
358001	Čazmatrans Pogon	Transportation	*20.0*	17.1	*50.0*	1.0	2.4	*100.0*	2.0	3.0	*300.0*	6.0	5.8
358003	HŽ Zagreb Lokacija Kolodvor	Transportation	5.8	5.0	32.5	0.2	0.5	97.0	0.6	0.9	694.0	4.0	3.9
358005	HŽ Zagreb Lokacija vuča	Transportation	27.2	23.2	27.2	0.7	1.8	76.5	2.1	3.1	740.0	20.1	19.3
358007	Motoremont d.o.o.	Transportation	6.1	5.2	*50.0*	0.3	0.7	*100.0*	0.6	0.9	*300.0*	1.8	1.8
358004	INA Naftaplin Sektor Proizvodnje	Oil & Gas Service	*20.0*	17.1	*50.0*	1.0	2.4	*100.0*	2.0	3.0	*300.0*	6.0	5.8
358002	Trokut d.d.	Furniture	*20.0*	17.1	*50.0*	1.0	2.4	*100.0*	2.0	3.0	*300.0*	6.0	5.8
[Note] : *Italic Letters* are assumed by the Study Team.													
	Total		117.1	100.0	350.8	41.1	100.0	564.1	66.1	100.0	891.0	104.3	100.0

Table C.1.2 (16) Wastewater Quantity and Quality in Glina

Code No.	Industry Name	Activity	Quantity		BOD			COD			TSS		
			m^3/d	%	mg/l	kg/d	%	mg/l	kg/d	%	mg/l	kg/d	%
371001	Vivera d.o.o. Pliva Grupa	Food/Beverage	*65.7*	100.0	8.4	0.6	100.0	39.3	2.6	100.0	300.0	19.7	100.0
	Total		65.7	100.0	8.4	0.6	100.0	39.3	2.6	100.0	300.0	19.7	100.0

FIGURES

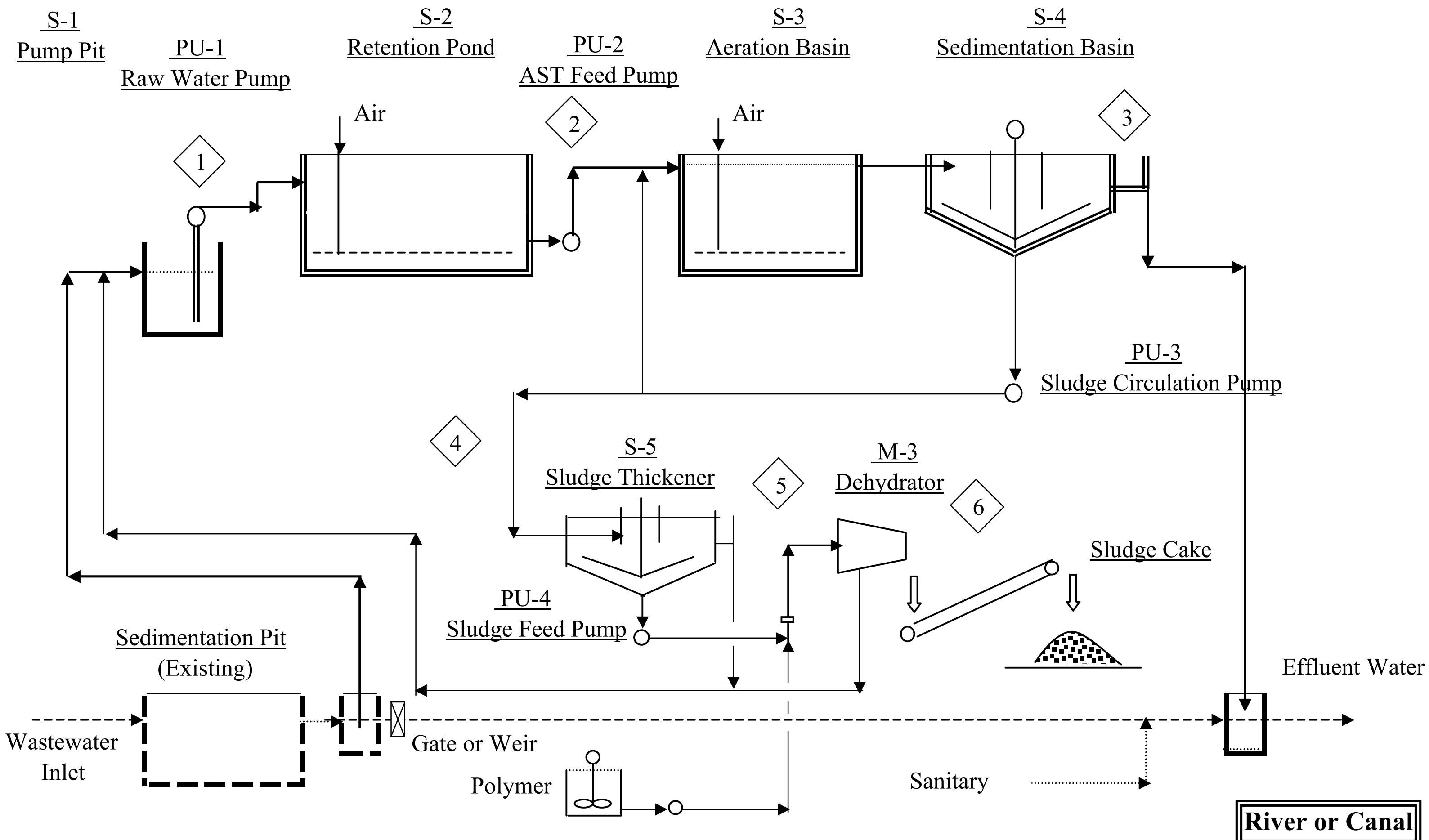


	1 Raw Water	2 Aerat. Basin Feed Water	3 Treated Water	4 Thickener Feed Sludge	5 Dehydrator Feed Sludge	6 Sludge Cake	Regulation to Public Sewer
Flow Rate (m^3/d)	Q	Q	Q	0.1Q	-	0.005Q	-
BOD (mg/l)	400 - 2000	360 - 1800	<250	-	-	-	250
COD (mg/l)	800 - 2500	720 - 22500	700	-	-	-	700
TSS (mg/l)	500 - 2000	500 - 2000	200	1.5 %	5.0%	20.0%	-
Oil & Grease (mg/l)	200 - 300	200 - 300	<100	-	-	-	100

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. C.1.1 (1)
Flow Diagram of Conventional Activated Sludge Treatment (CASE-1) [AS]

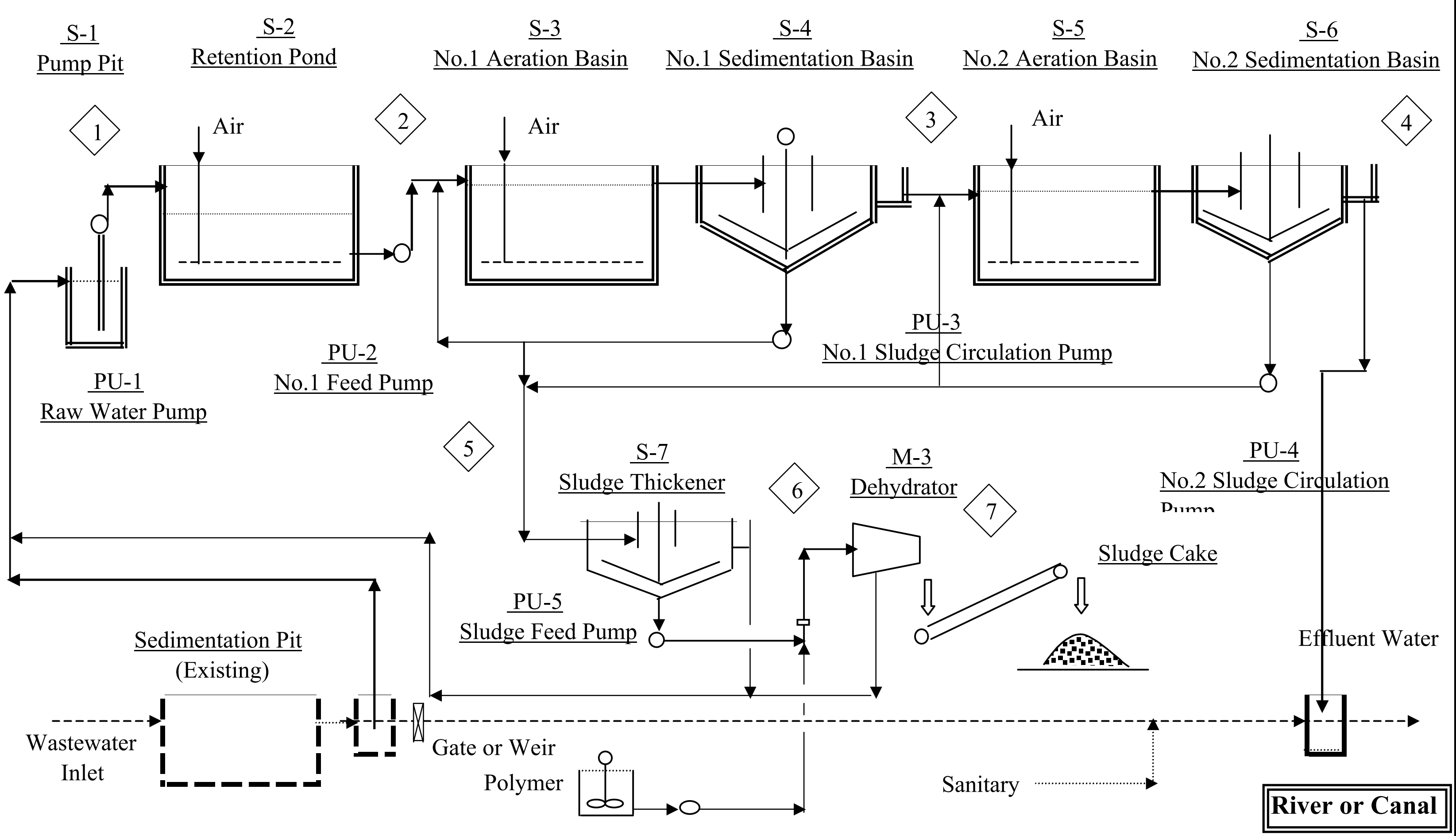


	1 Raw Water	2 Aerat. Basin Feed Water	3 Treated Water	4 Thickener Feed Sludge	5 Dehydrator Feed Sludge	6 Sludge Cake	Regulation to River of Canal (Category II)
Flow Rate (m^3/d)	Q	Q	Q	0.1Q	-	0.005Q	-
BOD (mg/l)	30 - 1000	27 - 900	<25	-	-	-	25
COD (mg/l)	150 - 2000	135 - 1800	125	-	-	-	125
TSS (mg/l)	300 - 2000	300 - 2000	35	1.0 %	3.0 %	15.0 %	35
Oil & Grease (mg/l)	30 - 100	30 - 100	<25	-	-	-	25

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. C.1.1 (2)
Flow Diagram of Conventional Activated Sludge Treatment (CASE-1A) [AS-A]

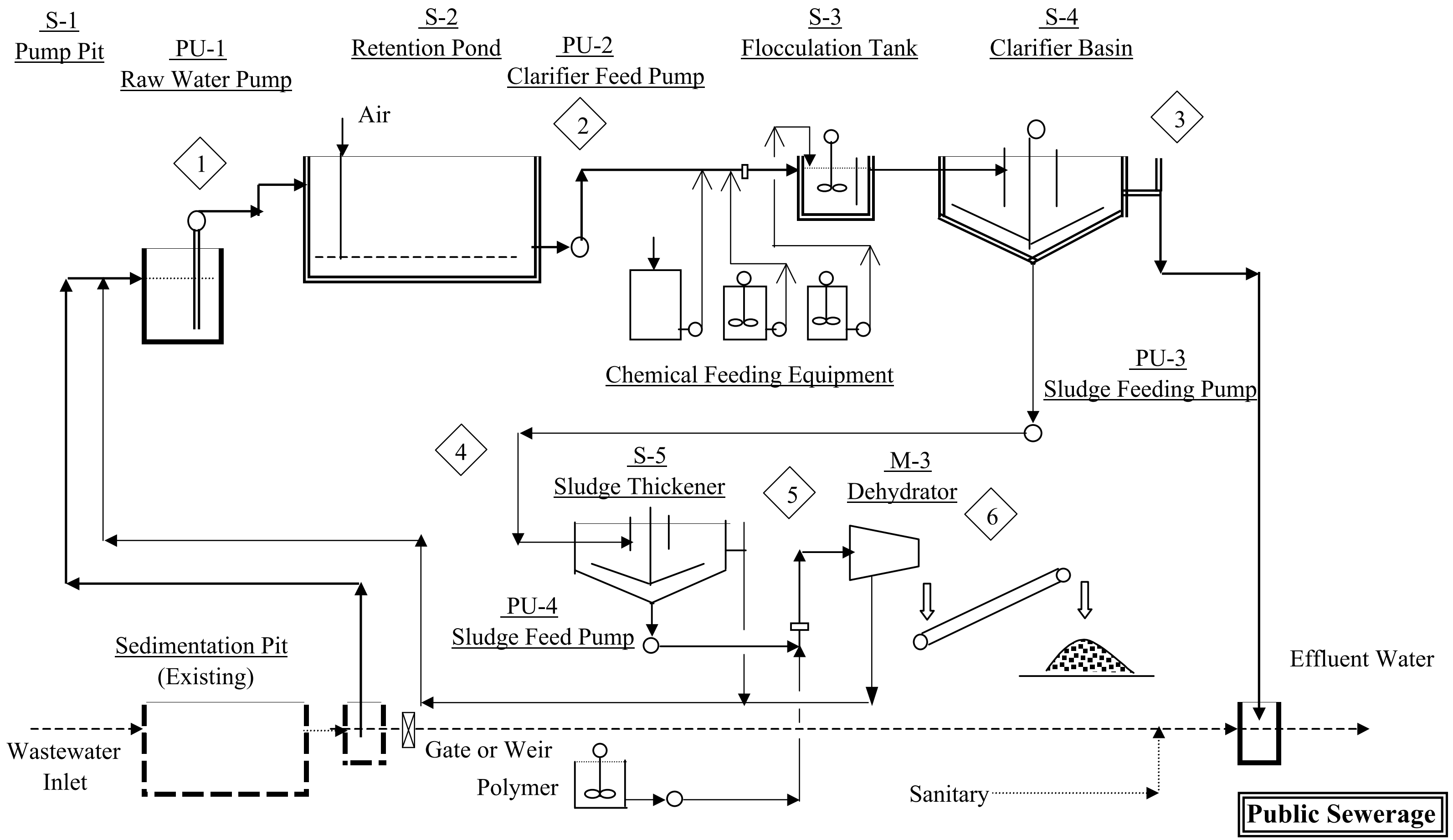


	1 Raw Water	2 No.1 A.B. Feed Water	3 No.2 A.B. Feed Water	4 Treated Water	5 Thickener Feed Sludge	6 Dehydrator Feed Sludge	7 Sludge Cake	Regulation to River or Canal (Category II)
Flow Rate (m^3/d)	Q	Q	Q	Q	0.1Q	-	0.005Q	-
BOD (mg/l)	1500 - 3000	1350 - 2700	250	<25	-	-	-	25
COD (mg/l)	2000 - 4000	1800 - 3600	700	125	-	-	-	125
TSS (mg/l)	2000 - 4000	2000 - 4000	200	35	1.5%	5.0%	20.0%	35
Oil & Grease (mg/l)	200 - 300	200 - 300	<100	<25	-	-	-	25

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. C.1.2
Flow Diagram of 2 Stage Activated Sludge Treatment (CASE-2) [2-AS]

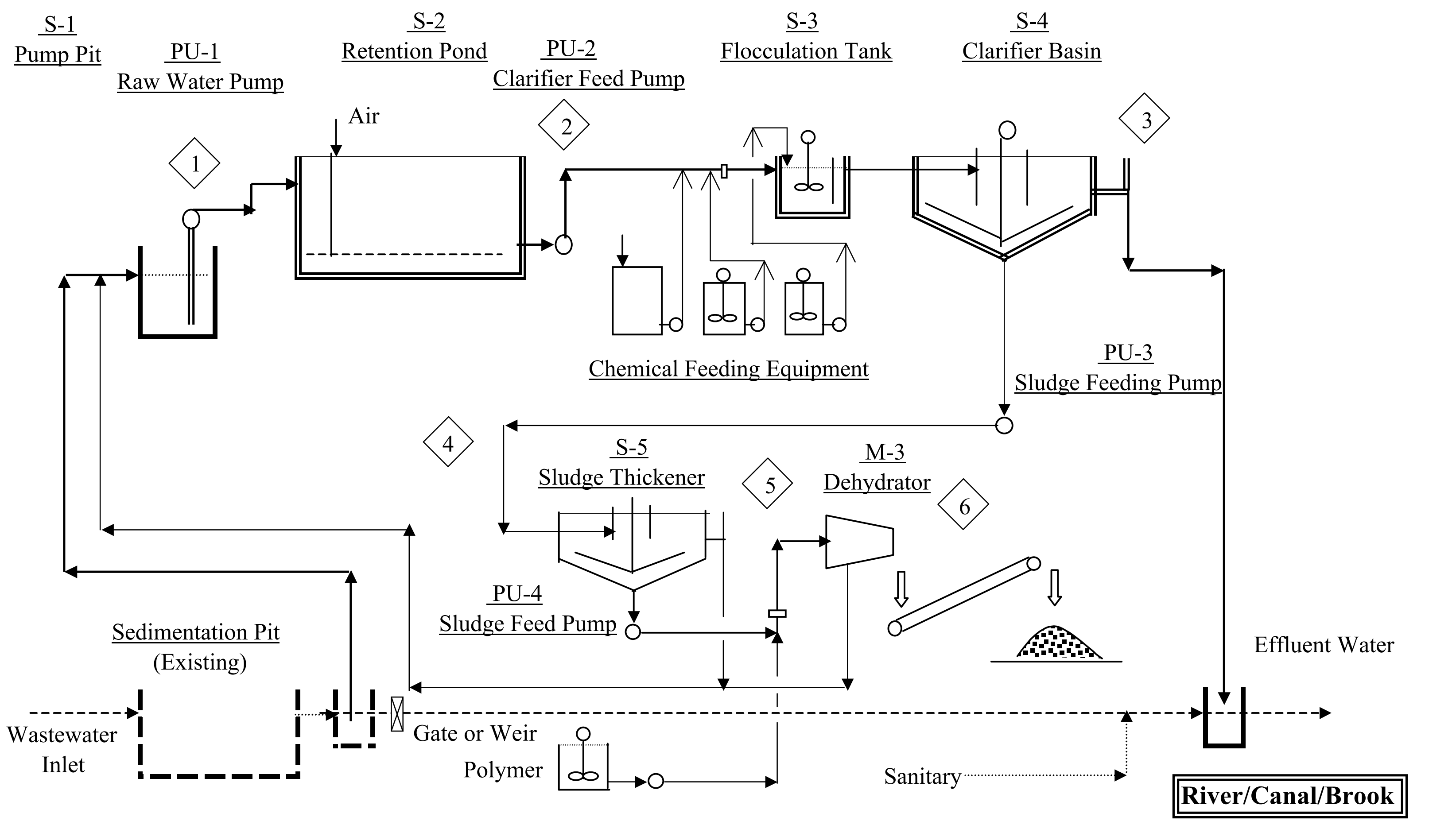


	1 Raw Water	2 Clarifier Feed Water	3 Treated Water	4 Thickener Feed Sludge	5 Dehydrator Feed Sludge	6 Sludge Cake	Regulation to Public Sewer
Flow Rate (m^3/d)	Q	Q	Q	0.1Q		0.005Q	-
BOD (mg/l)	400 - 2000	360 - 1800	<250	-	-	-	250
COD (mg/l)	800 - 2500	720 - 2250	700	-	-	-	700
TSS (mg/l)	500 - 2000	500 - 2000	200	1.5%	5.0%	20.0%	-
Oil & Grease (mg/l)	200 - 300	200 - 300	<100	-	-	-	100

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. C.1.3 (1)
Flow Diagram of Chemical Clarification System
(CASE-3) [CT]



	1 Raw Water	2 Clarifier Feed Water	3 Treated Water	4 Thickener Feed Sludge	5 Dehydrator Feed Sludge	6 Sludge Cake	Regulation to the River (Category II)
Flow Rate (m^3/d)	Q	Q	Q	0.1Q		0.005Q	-
BOD (mg/l)	30 - 100	30 - 100	<250	-	-	-	25
COD (mg/l)	50 - 200	50 - 200	700	-	-	-	125
TSS (mg/l)	100 - 500	100 - 500	200	1.0%	3.0%	15.0%	35
Oil & Grease (mg/l)	30 - 50	30 - 50	<100	-	-	-	25

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

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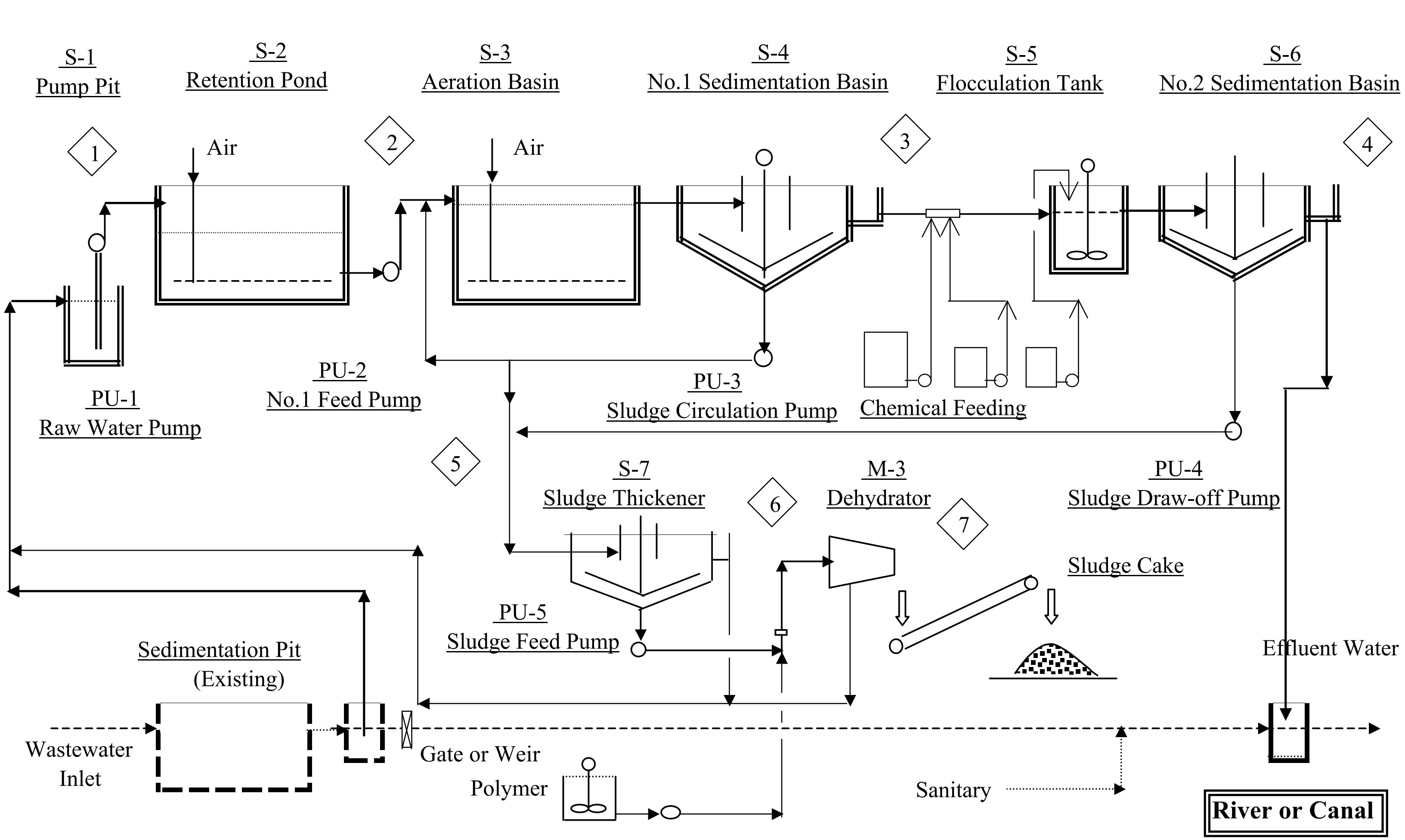
Fig. C.1.3 (2)
Flow Diagram of Chemical Clarification System
(CASE-3A) [CT-A]

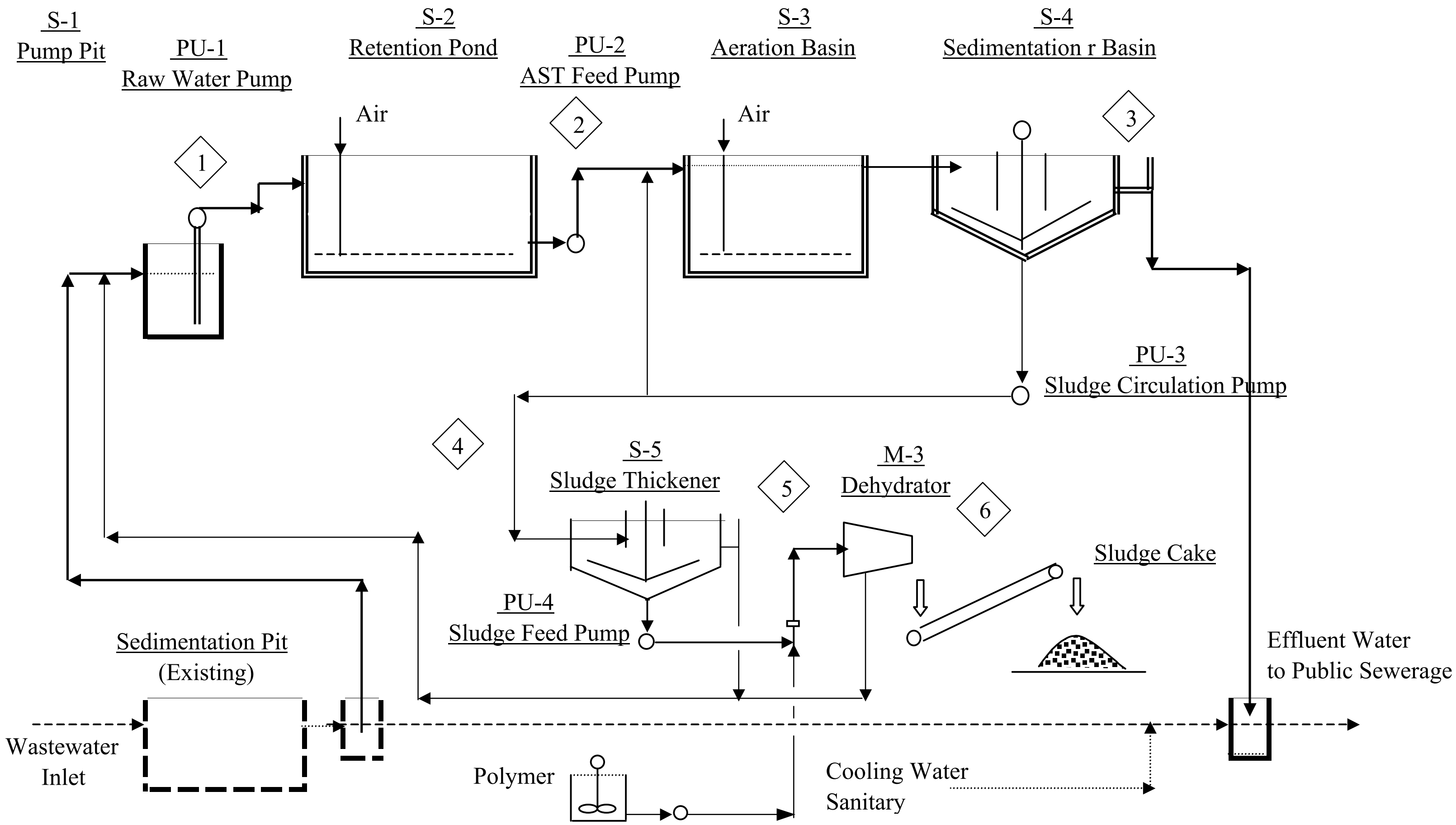


	1 Raw Water	2 A. Basin Feed Water	3 C.F. Tank Feed Water	4 Treated Water	5 Thickener Feed Sludge	6 Dehydrator Feed Sludge	7 Sludge Cake	Regulation to River or Canal (Category II)
Flow Rate (m^3/d)	Q	Q	Q	Q	0.1Q	-	0.005Q	-
BOD (mg/l)	100 - 300	90 - 270	20 - 40	<25	-	-	-	25
COD (mg/l)	200 - 500	180 - 450	50 - 100	125	-	-	-	125
TSS (mg/l)	200 - 1500	200 - 1500	50 - 100	<35	1.5%	5.0%	20.0%	35
Oil & Grease (mg/l)	50 - 100	200 - 300	10 - 30	<10	-	-	-	25

THE STUDY FOR WATER POLLUTION REDUCTION
ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. C.1.4
Flow Diagram of Activated Sludge +
Chemical Clarification Treatment (CASE-4)
[AS + CT]

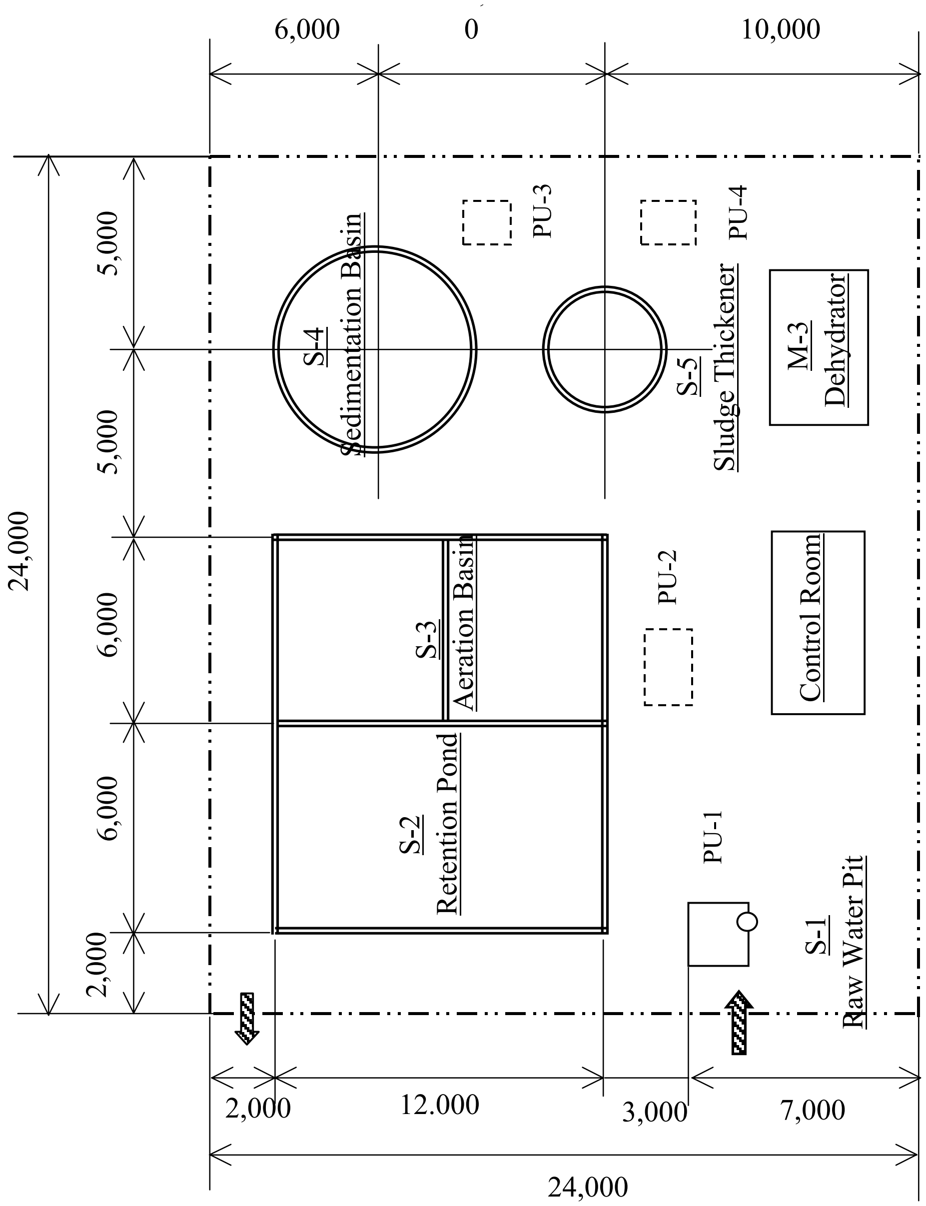


	1 Raw Water	2 Aerat. Basin Feed Water	3 Treated Water	4 Thickener Feed Sludge	5 Dehydrator Feed Sludge	6 Sludge Cake	Regulation to Public Sewer
Flow Rate (m^3/d)	400	400	400	48	14.0	3.5	
Flow Rate (m^3/h)		16.7	16.7	2.0	2.3	0.6	
pH (-)	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	-	5.0 - 9.5
BOD (mg/l)	2,230	1,784	250	-	-	-	250
TSS (mg/l)	1,675	1,340	200	1.5 %	5.0 %	20.0 %	-

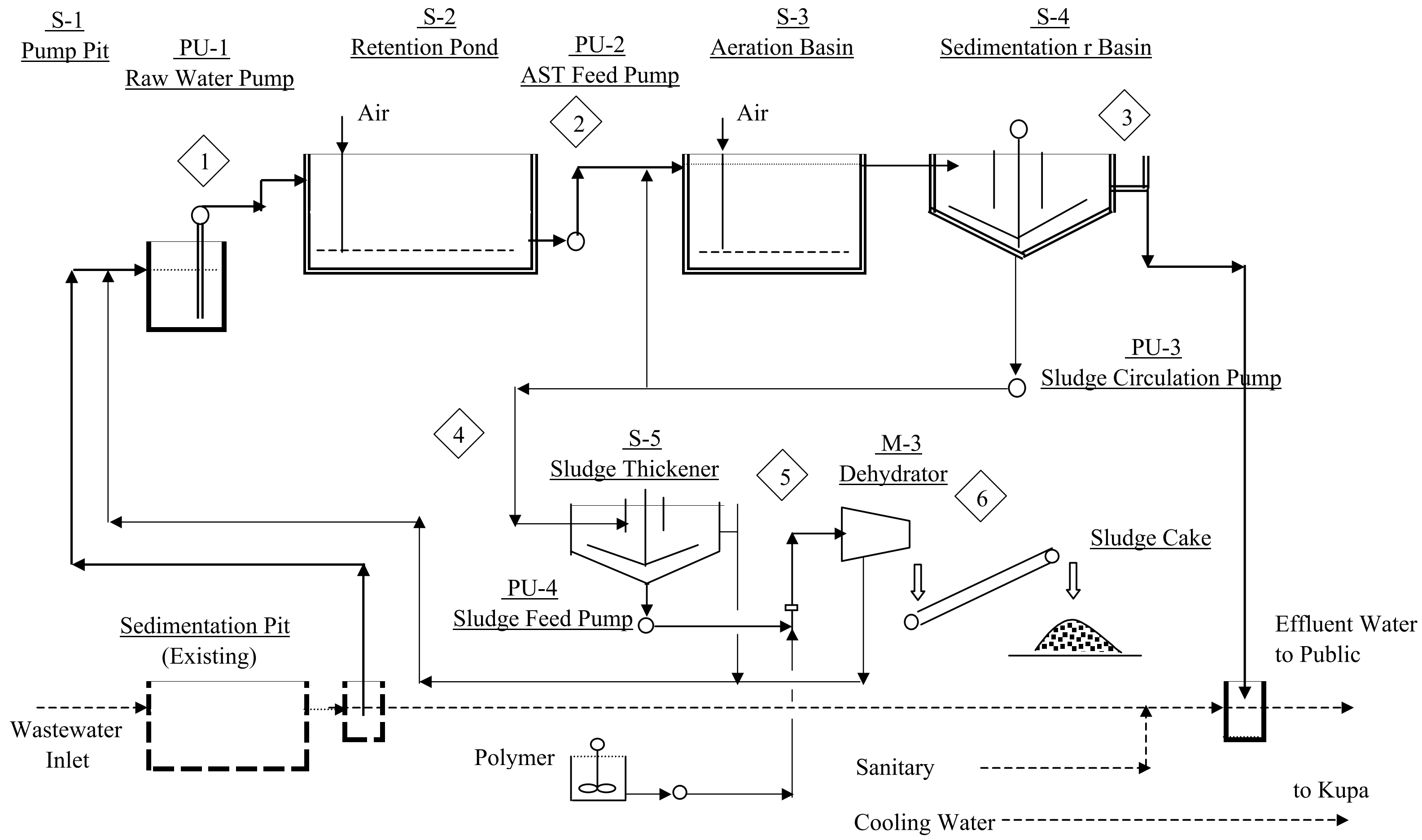
THE STUDY FOR WATER POLLUTION REDUCTION
ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. C.2.1 Flow Diagram of WWTP
of AGROPROTEINKA



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. C.2.2 Layout of WWTP of AGROPROTEINKA
JAPAN INTERNATIONAL COOPERATION AGENCY	

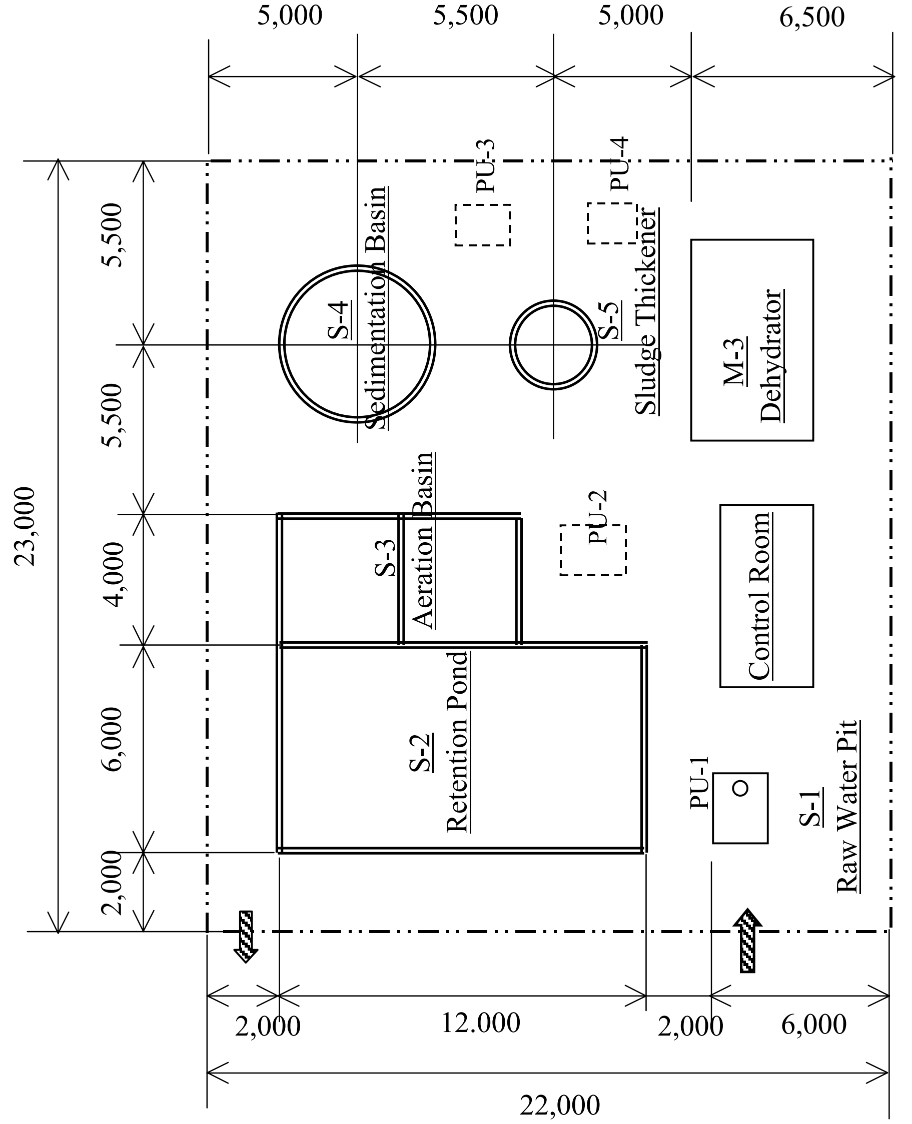


	1 Raw Water	2 Aerat. Basin Feed Water	3 Treated Water	4 Thickener Feed Sludge	5 Dehydrator Feed Sludge	6 Sludge Cake	Regulation to Public Sewer
Flow Rate (m^3/d)	350	350	347.9	27.3	8.2	2.1	
Flow Rate (m^3/h)		14.6	14.5	1.2	1.4	0.35	
pH (-)	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	-	5.0 - 9.5
BOD (mg/l)	866	693	250	-	-	-	250
TSS (mg/l)	1,195	1,195	200	1.5 %	5.0 %	20.0 %	-

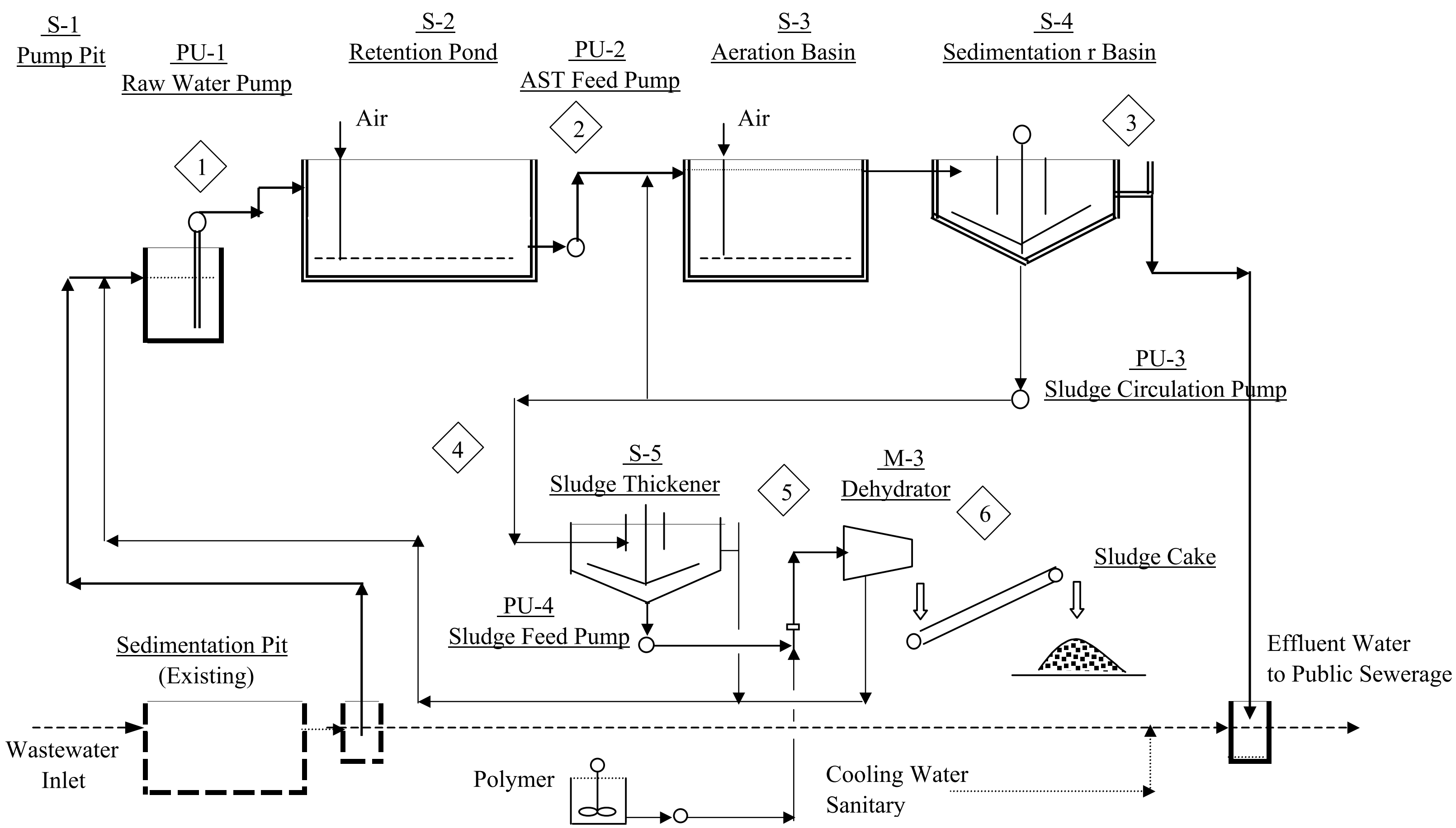
THE STUDY FOR WATER POLLUTION REDUCTION
ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. C.2.3 Flow Diagram of WWTP of SEGESTICA



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. C.2.4 Layout of WWTP of SEGESTICA
JAPAN INTERNATIONAL COOPERATION AGENCY	

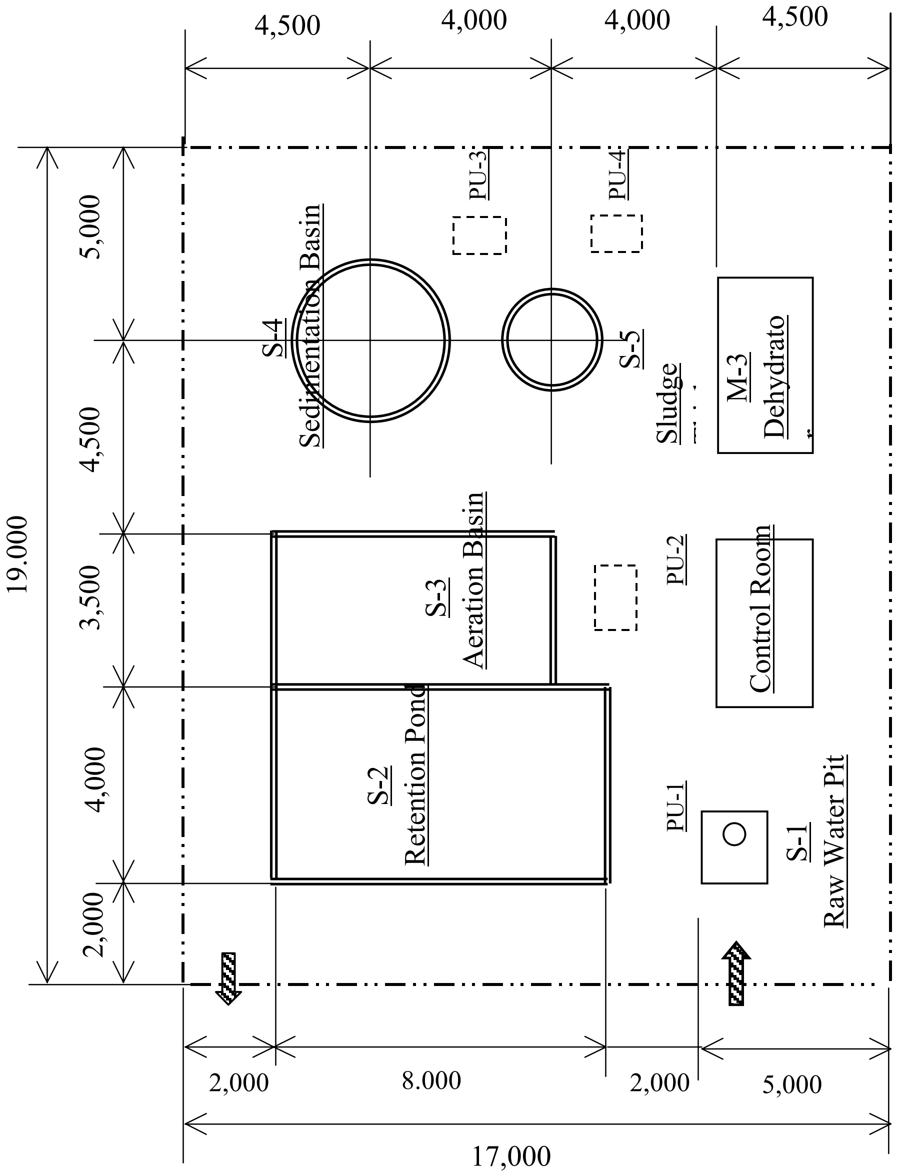


	1 Raw Water	2 Aerat. Basin Feed Water	3 Treated Water	4 Thickener Feed Sludge	5 Dehydrator Feed Sludge	6 Sludge Cake	Regulation to Public Sewer
Flow Rate (m^3/d)	150	150	149.6	5.6	1.7	0.4	
Flow Rate (m^3/h)		6.3	6.3	0.3	0.5	0.1	
pH (-)	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	-	5.0 - 9.5
BOD (mg/l)	1,583	1,267	250	-	-	-	250
TSS (mg/l)	356	356	200	1.5 %	5.0 %	20.0 %	-

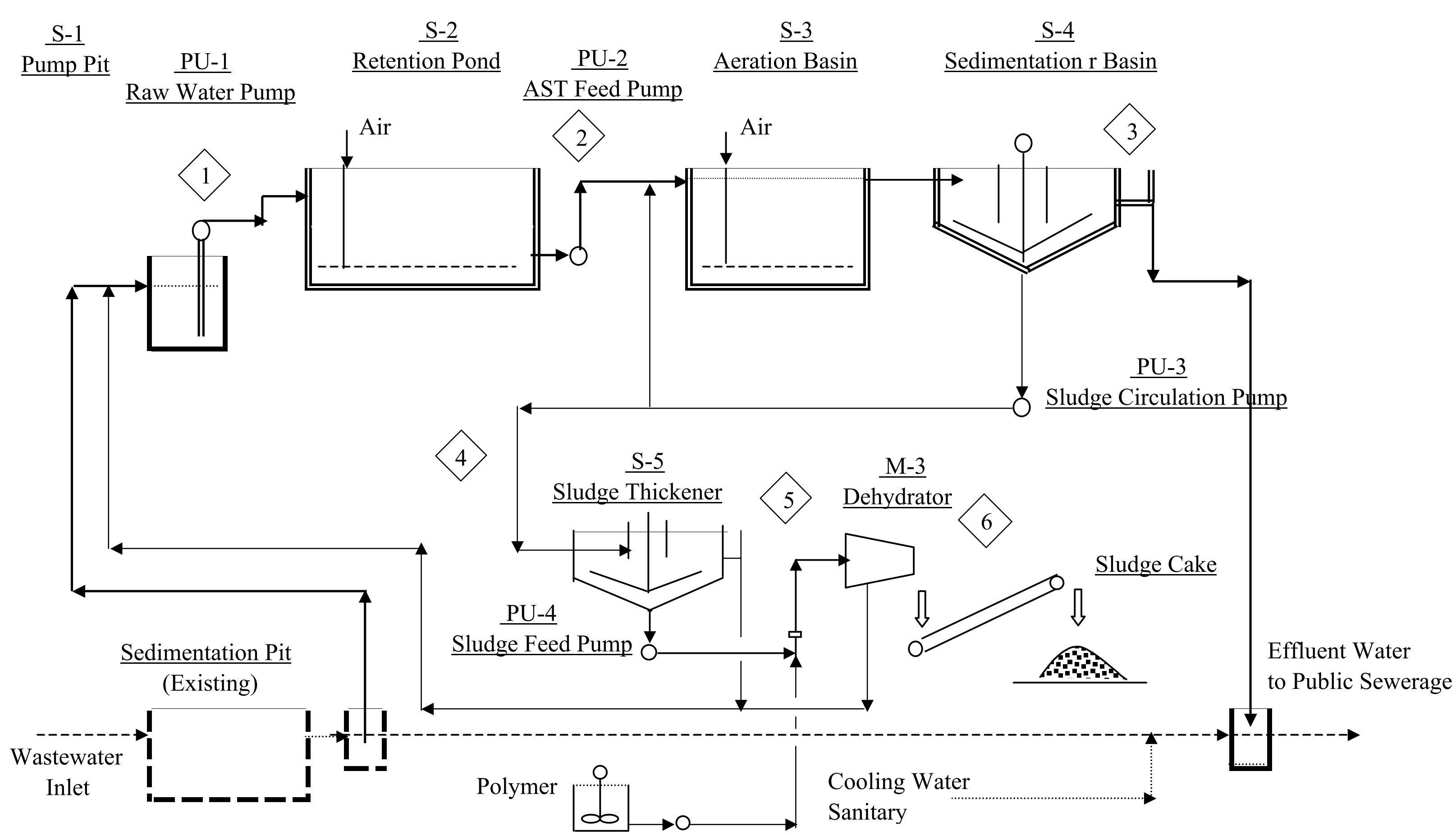
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. C.2.5 Flow Diagram of WWTP of LJUDEVIT POSAVSKI MLIN i PEKARE



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. C.2.6 Layout of WWTP of LJUDEVIT POSAVSKI MLIN i PEKARE
JAPAN INTERNATIONAL COOPERATION AGENCY	



	1 Raw Water	2 Aerat. Basin Feed Water	3 Treated Water	4 Thickener Feed Sludge	5 Dehydrator Feed Sludge	6 Sludge Cake	Regulation to Public Sewer
Flow Rate (m^3/d)	3,840	3,840	2,993	122	36.7	9.2	
Flow Rate (m^3/h)		16.0	125	5.1	4.6	1.2	
pH (-)	4 - 10	6 - 9	6 - 9	6 - 9	6 - 9	-	5.0 - 9.5
BOD (mg/l)	456	410	250	-	-	-	250
TSS (mg/l)	595	536	200	1.5 %	5.0 %	20.0 %	-

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

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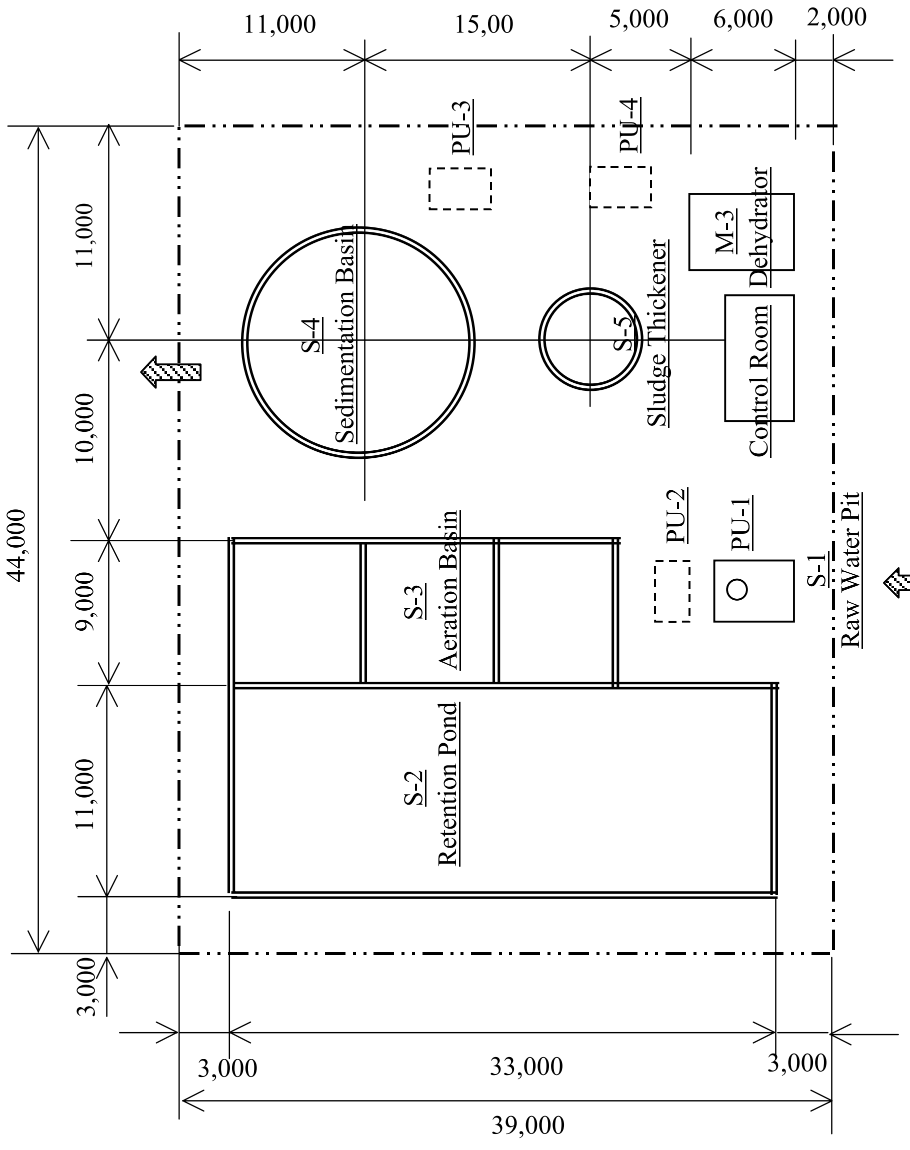
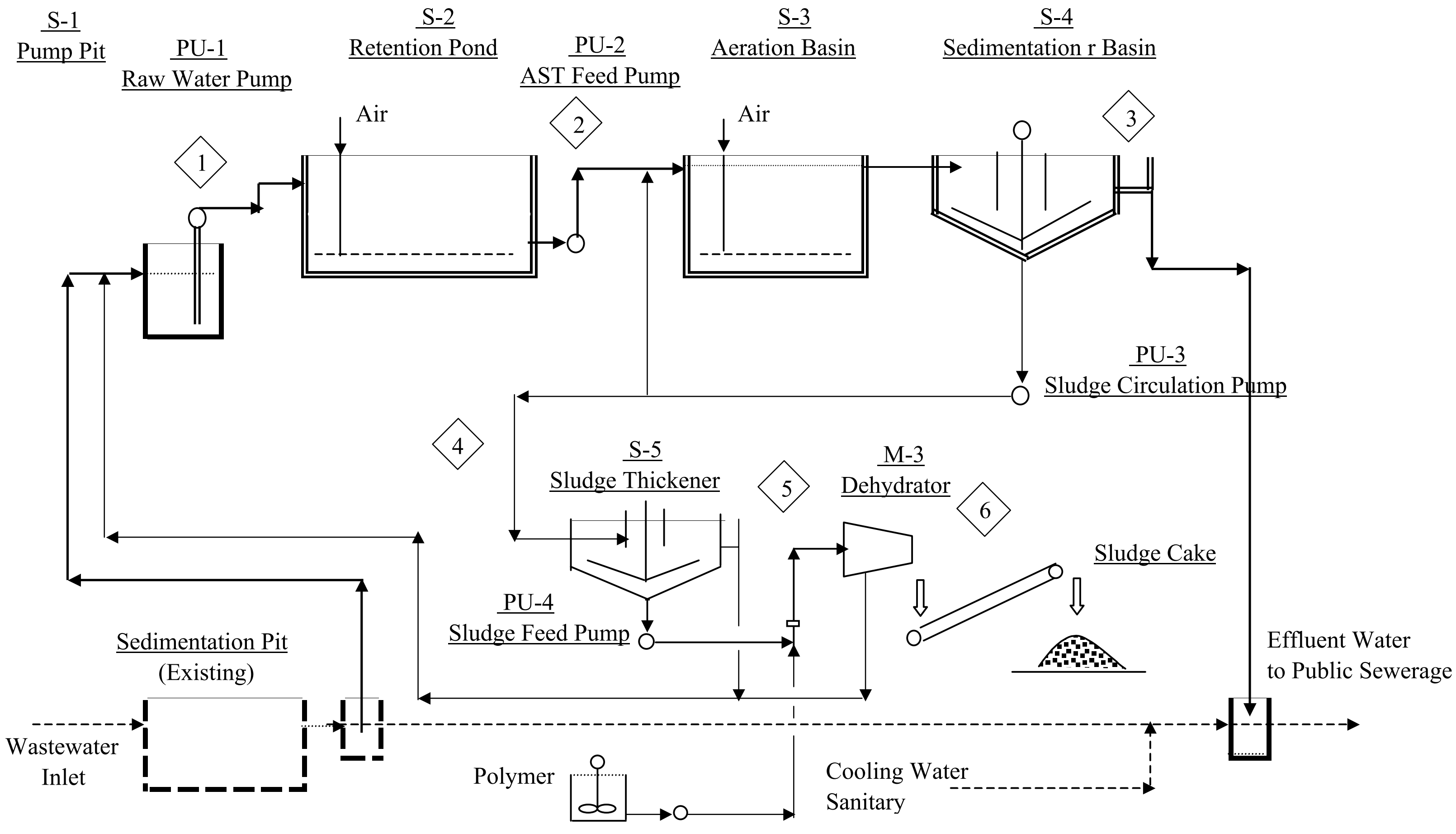
Fig. C.2.7 Flow Diagram of WWTP of Karlovačka PIVOVARA



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. C.2.8 Layout of WWTP of Karlovačka PIVOVARA
JAPAN INTERNATIONAL COOPERATION AGENCY	

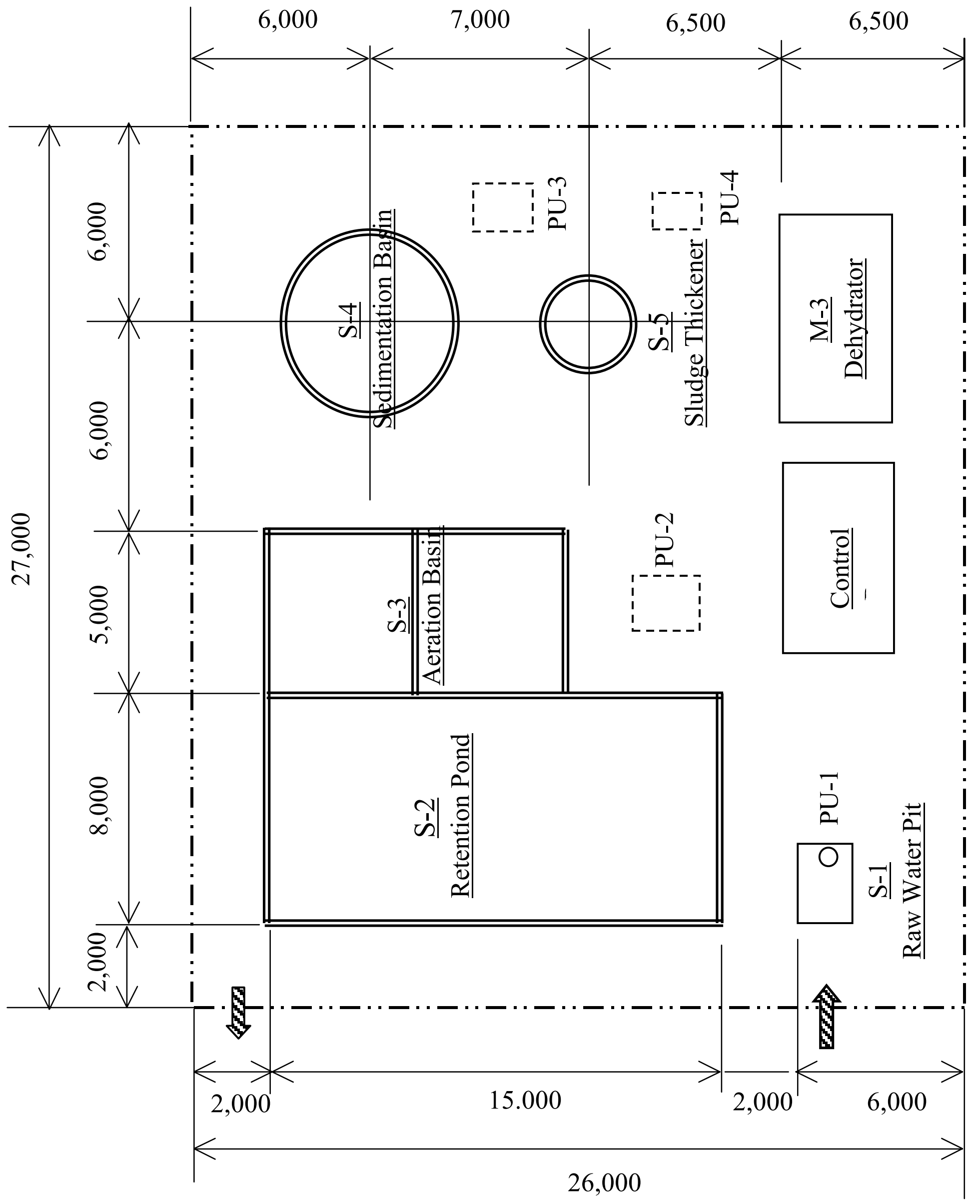


	1 Raw Water	2 Aerat. Basin Feed Water	3 Treated Water	4 Thickener Feed Sludge	5 Dehydrator Feed Sludge	6 Sludge Cake	Regulation to Public Sewer
Flow Rate (m^3/d)	625	625	623.8	20.2	6.0	1.2	
Flow Rate (m^3/h)		26.0	26.0	0.9	1.0	0.15	
pH (-)	6 - 9	6 - 9	6 - 9	6 - 9	6 - 9	-	5.0 - 9.5
BOD (mg/l)	484	436	250	-	-	-	250
TSS (mg/l)	514	514	200	1.5 %	5.0 %	20.0 %	-

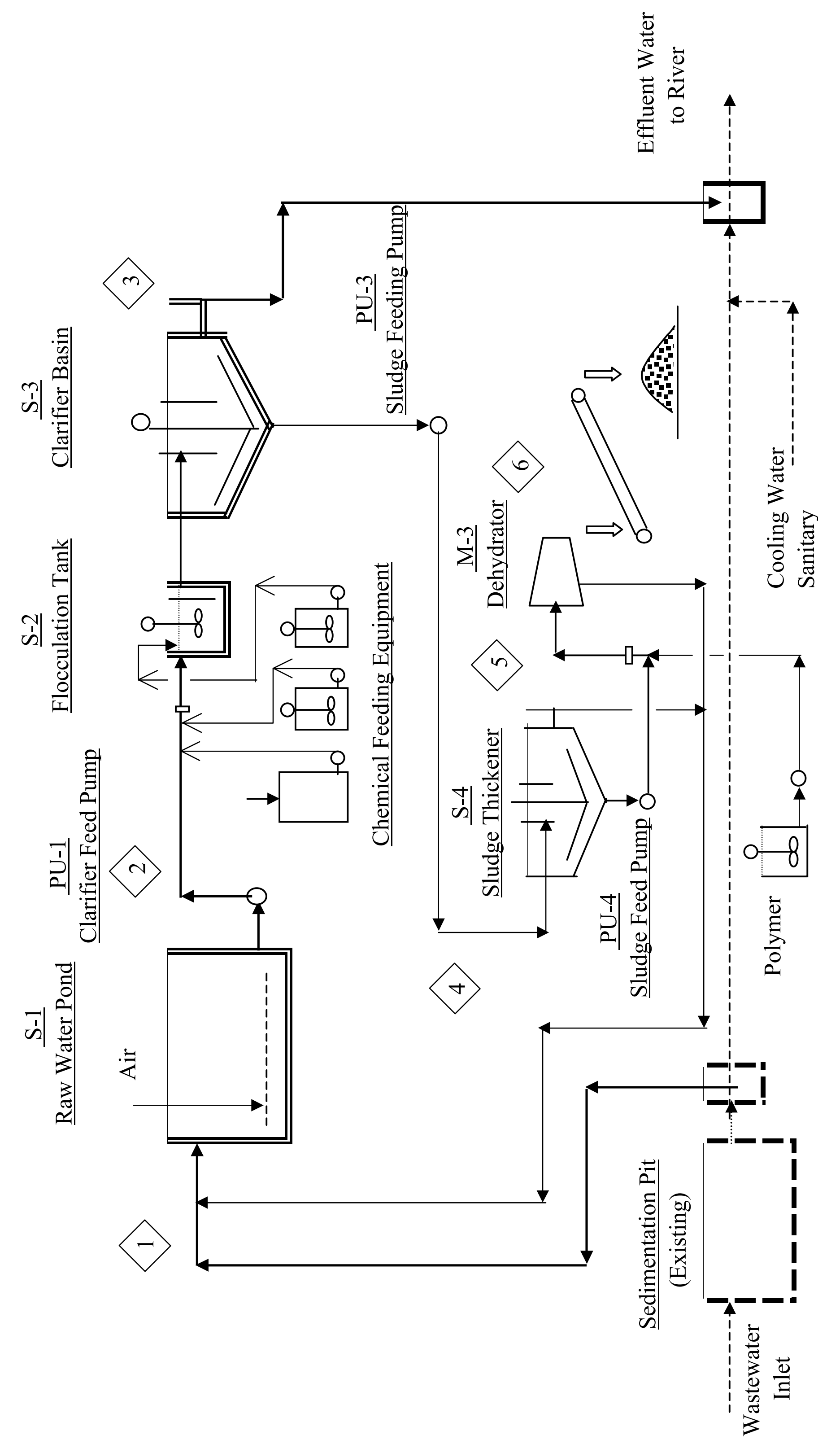
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. C.2.9 Flow Diagram of WWTP of PPK Karlovačka Ind. Mesna



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. C.2.10 Layout of WWTP of PPK Karlovačka Ind. Mesna
JAPAN INTERNATIONAL COOPERATION AGENCY	

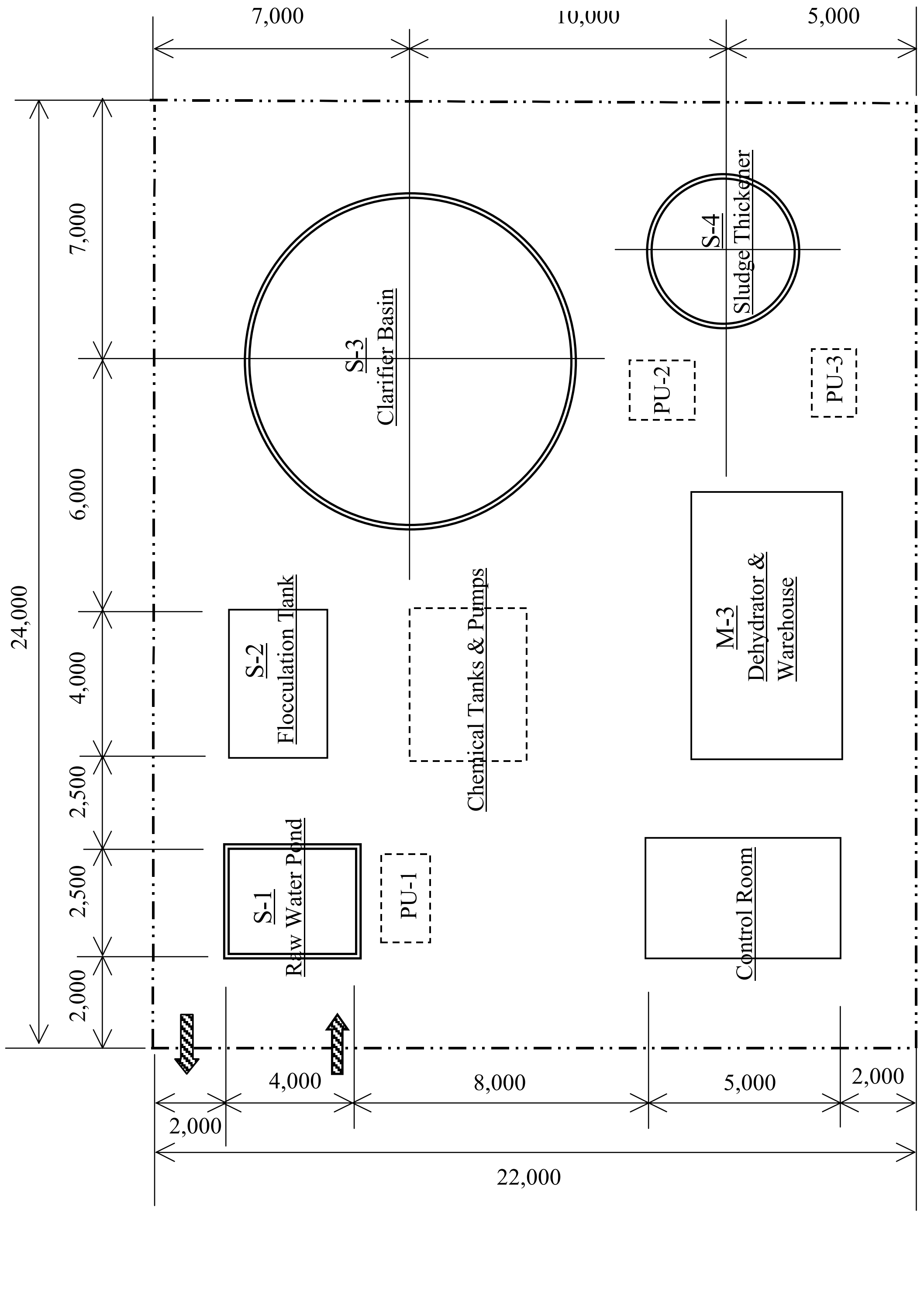


	1 Raw Water	2 Clarifier Feed Water	3 Treated Water	4 Thickener Feed Sludge	5 Dehydrator Feed Sludge	6 Sludge Cake	Regulation to River (Category II)
Flow Rate (m^3/d)	1,230	1,230	1,230	98	29.4	7.4	
Flow Rate (m^3/h)		51.3	12.5	4.1	1.5	1.0	
pH (-)	6 - 9	6.5 - 8.0	6.5 - 8.0	6.5 - 8.0	6.5 - 8.0	-	6.5 - 8.0
BOD (mg/l)	68	68	25	-	-	-	25
TSS (mg/l)	1,232	1,232	35	1.5 %	5.0 %	20.0 %	35

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. C.2.11 Flow Diagram of WWTP of JAMNICA Zagreb



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. C.2.12 Layout of WWTP of JAMNICA Zagreb
JAPAN INTERNATIONAL COOPERATION AGENCY	

APPENDIX D

SEWERAGE DEVELOPMENT (MASTER PLAN STUDY)

APPENDIX D

SEWERAGE DEVELOPMENT

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CHAPTER I PLANNING BASIS

1.1 Planning Basis

1.1.1 Objectives and Target Year

The Master Plan of Sewerage Improvement in the Sava River Basin aims to reduce pollution load, targeting the year 2015.

1.1.2 National Policy on Sewerage Improvement

The government had established a national sewerage improvement program under the National Water Protection Plan [Decree (NN) No. 8/99]. In this program, the construction of public sewerage systems and wastewater treatment plants are to be implemented in three (3) stages: short term program up to 2005, medium term program up to 2010, and long term program up to 2025, as stated below. The discharge of sewerage wastewater into a Category I watercourse is not permitted irrespective of the treatment level.

(1) The construction of public sewerage systems from which wastewater is to be discharged into the watercourse should be completed by:

(a) 2005, for facilities greater than 15,000 PE (person equivalent) that discharge wastewater into either a Category III or Category watercourse;

(b) 2010, for facilities of between 2,000 PE and 15,000 PE that discharge wastewater into either a Category III or Category IV watercourse; and

(c) 2005, for facilities of over 10,000 PE that discharge wastewater into a Category II watercourse.

In connection with the above stipulations, however, the target year for facilities smaller than 10,000 PE that discharge wastewater into a Category II watercourse has not been determined yet.

(2) As regards the construction of a wastewater treatment plant, it can go ahead when the construction of at least 70% of the total capacity of the sewerage system is completed.

(3) The construction of secondary treatment plants (biological treatment) from which wastewater is to be discharged into the water course should be completed by:

(a) 2010, for facilities greater than 15,000 PE that discharge effluent into either a Category III or Category IV watercourse;

(b) 2025, for facilities of between 2,000 PE and 15,000 PE that discharge effluent into either a Category III or Category IV water course; and

(c) 2005, for facilities of over 10,000 PE that discharge effluent into a Category II watercourse.

In connection with the above stipulations, however, the target year of facilities smaller than 10,000 PE that discharge effluent into a Category II watercourse has not been determined yet.

1.1.3 Objective Urban Centers

Twenty-four (24) urban centers consisting of 22 sewerage systems had been selected for the Master Plan study on sewerage improvement based on the National Water Protection Plan (see, Fig. D.1.1 and Table D.1.1). These urban centers meet either of the following criteria:

(1) Urban centers are expected to discharge the wastewater of over 2,000 PE in 2015.

(2) Urban centers are located in areas that may affect drinking water sources.

1.1.4 Permissible Limits of Wastewater Quality

(1) Industrial Wastewater Discharging into Sewerage

The permissible limits of major parameters of industrial wastewater discharged into public sewerage systems are shown below as prescribed in NN No. 40/99, as amended by NN No. 4/01. For the other parameters including heavy metals and other toxic materials, see Appendix C.

Parameter/Category		Sewerage
pH		5.0 - 9.5
TSS	(mg/l)	*
BOD	(mg/l)	250 [1)]
CODCr	(mg/l)	700 [1)]
T-P	(mg/l)	10
T-N	(mg/l)	-
Oil and Grease	(mg/l)	100

* To be determined at sewerage company's option.

1) Sewerage company can change the values depending on its treatment capacity.

(2) Sewerage Effluent into Natural Recipient

The permissible limits of effluent (TSS, BOD, COD_{Cr}, T-N, T-P) discharged from the sewage treatment plant into watercourses are prescribed NN No. 40/99. They vary according to the size of treatment plant and the category of receiving water, as follows.

(Unit: mg/l)

Category	Plant Size	TSS	BOD	COD_{Cr}	T-P	T-N
Water Course II (Sensitive)	< 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
Water Course III (Less sensitive area)	< 10,000 PE	120-150	-	-	-	-
	≥ 10,000 PE	35	25	125	-	-
Water Course IV (Less sensitive)	< 10,000 PE	Appropriate				
	10,000 PE - 50,000 PE	120-150	-	-	-	-
	≥ 50,000 PE	35	25	125	-	-
Lake V (Sensitive area)	All Plant Sizes	35	25	125	1	10

As mentioned before, wastewater discharge into a Category I watercourse (very sensitive area) is not allowed irrespective of the treatment level. In line with the above-mentioned regulations and the National Water Protection Plan, the permissible limits of effluent of the objective wastewater treatment plants are as shown in Table D.1.2.

1.2 Sewerage Service Area and Population Projection

1.2.1 Sewerage Service Area

The Master Plan includes the extension of secondary/tertiary sewer networks and the construction of transport collectors/mains and sewerage treatment plants. A realistic plan is formulated so that it can be completed by 2015 and a high priority is given to urban centers with high population densities.

The design service areas of the 22 sewerage systems in the 24 urban centers in the Master Plan are prepared based on the conclusions of meetings with the local governments concerned and Croatian Waters from the 3rd to the 23rd of January 2001. The design sewerage service areas are delineated based on the following principles:

(1) Urban centers with sewer networks already provided are included.

(2) Areas neighboring urban centers and with sufficient population densities are included, in principle.

(3) Areas located along a proposed transport collector are included, even if they are sparsely populated.

1.2.2 Population Projection

Populations of the Master Plan towns/municipalities are projected based on the recent studies of relevant organizations of Zagreb City and the three counties covered by the Study (refer to Tables A.2.1, A.2.2 and A2.3 in Appendix A).

1.3 Wastewater Quantity and Pollution Load

1.3.1 Design Wastewater Quantity

Most wastewaters are generated from human activities including those in business, schools/institutions and factories. Wastewater quantities are estimated, in principle, using the data on water consumption or the measured discharge wastewater amount, if possible. The quantity of wastewater is measured as the sum of domestic, institutional and industrial wastewaters, and groundwater that infiltrate into the sewer.

There are various sizes of industries in the Study Area. In this Study, the wastewater of large industries mentioned in Appendix C is counted as industrial wastewater and individually estimated. As for the wastewater of small industries, it is counted as municipal wastewater, which is defined as the total of domestic, commercial, institutional and industrial wastewater.

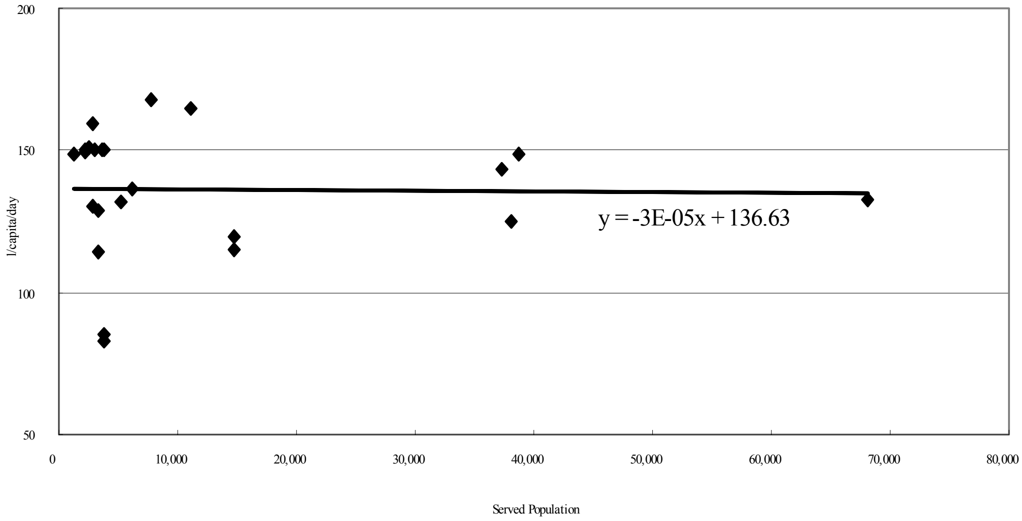
(1) Municipal Water per Capita

(a) Present Domestic Water Consumption

At present, water consumption in municipalities consists of water used for domestic, institutional and industrial purposes. Water supply is generally categorized into domestic and industrial water supply to establishment including institutional and industrial ones.

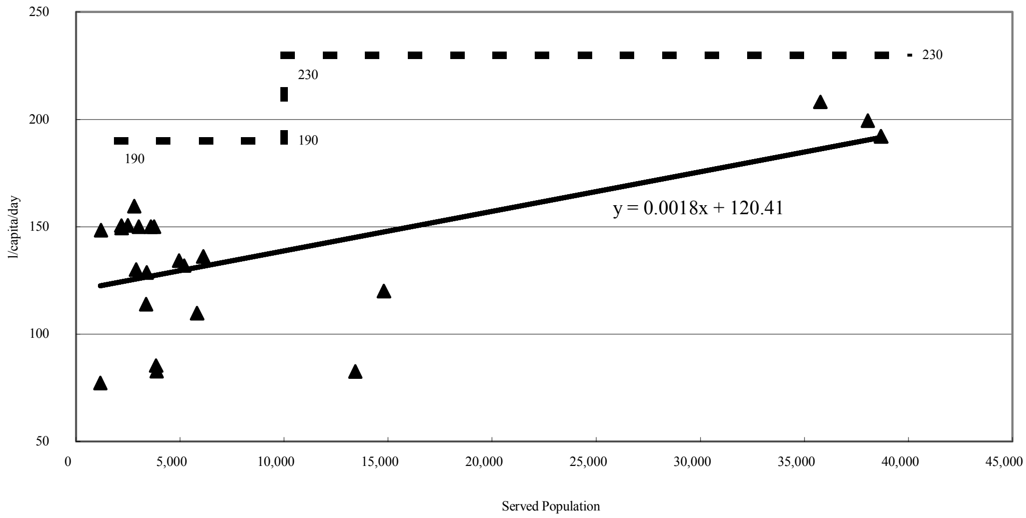
The daily average domestic water consumption in the Study Area at present ranges from 80 to 170 l/capita/day (hereinafter, lcd) or mostly less than 150 lcd, as illustrated in the figure below. It is nearly constant irrespective of population size.

The water supply service area may cover not only the urban center of the municipality but also the surrounding rural area. Therefore, the average per capita water consumption in the urban center may be larger than the values shown in the figure. However, the sewerage service area in this figure is limited to the urban center and thus the existing average per capita water consumption is assumed at 170 lcd.



(b) Present Municipal Water Consumption

Municipal water consists of domestic, commercial, institutional and industrial water supply to small industries. The municipal water consumption varies according to population size as illustrated in the figure below. It increases in proportion to the population because districts with high population densities have different kinds of activity. The daily average municipal water consumption per capita is categorized into two classes according to population in the Study Area; namely, 190 lcd for towns of less than 10,000 in population and 230 lcd for towns of more than 10,000 in population.



(c) Future Projection

Municipal water consumption will increase according to the improvement of living standard in the future and it is assumed that the annual growth rate is 2.0%. The municipal water consumption in 2015 will thus be 1.37 times larger than in 1999 (= 1.02^{16}).

(2) Wastewater Flow

(a) Return Rate of Consumed Water

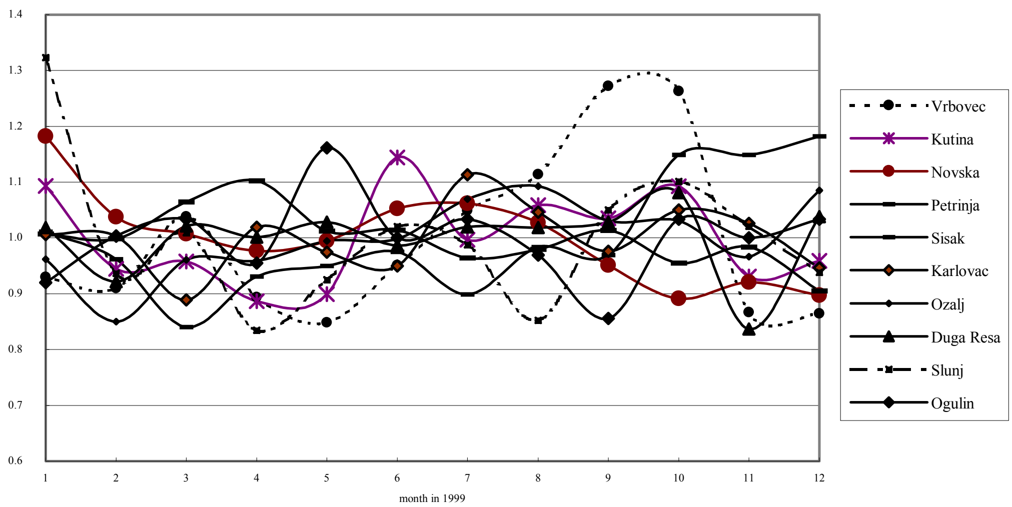
The amount of wastewater discharged into a sewer is inevitably less than the supplied one due to loss in cooking, washing, bathing, laundry, garden watering, car washing and others. The return rate of consumed water generally varies from 60% to 100% depending on the lifestyle and income level. In this Study, 80% is adopted.

(b) Variation

(i) Daily Maximum

Daily wastewater flow fluctuates throughout the year. Therefore, the capacity of a treatment plant is designed to meet the daily maximum wastewater flow in the month when most water consumption occurs. Such a design daily maximum wastewater flow is usually estimated by multiplying the daily average wastewater flow in the year by a certain rate for practical purposes.

The ratio of existing daily maximum domestic water consumption in a month to the daily average one in a year in the Study Area ranges from 1.10 to 1.30 and mostly less than 1.2 as shown in the figure below. In this Study, 1.3 is adopted for safety.



(ii) Hourly Maximum

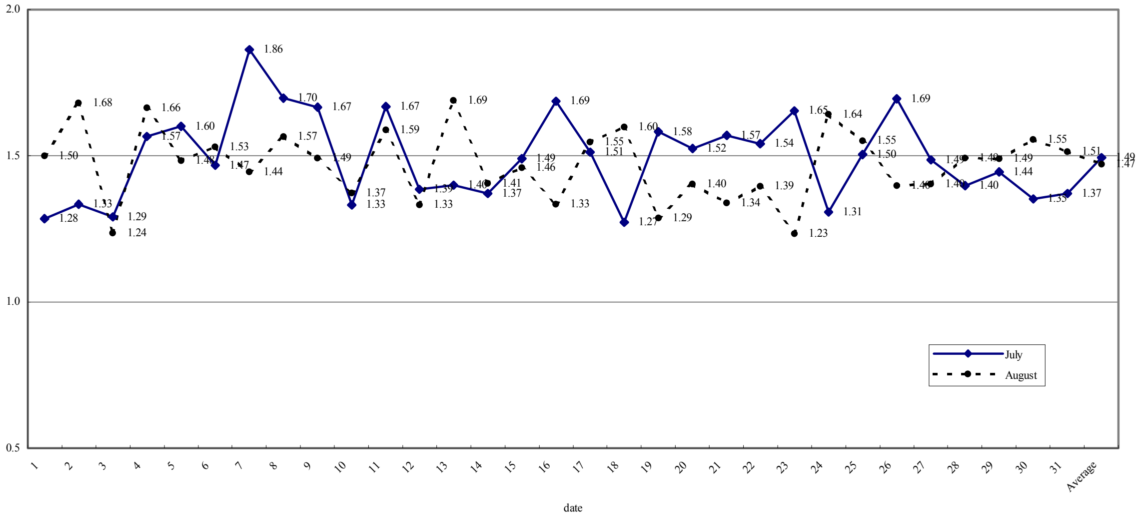
Hourly wastewater flow also fluctuates throughout the day. Therefore, the capacity of pump and sewer pipe is designed to meet the hourly maximum wastewater flow in a day. Such a design hourly maximum wastewater flow is usually estimated by multiplying the daily maximum wastewater flow by a certain rate for practical purposes.

The rate varies depending on the water use pattern and size of sewerage service area of each town. However, the rate in the master plan study is determined based on the influent data of the wastewater treatment plant in Kutina, because only this plant has an hourly data among the functioning treatment plants in the Study Area. Moreover, this treatment plant does not collect any industrial wastewater from large industries except the sanitary wastewater of the Petrokemija factory.

For analysis of the rate, only the data in July and August 1999 is used because the sewerage system of the town is a combined one that collects both sanitary wastewater and storm water (refer to Chapter VII, Subsection 7.1.3). Besides, storm water is negligible in the dry season, i.e., July and August.

The hourly municipal wastewater flow of the town in July and August 1999 is obtained by subtracting the groundwater and sanitary wastewater of the factory from the influent data of the treatment plant. In this calculation, the groundwater and sanitary wastewater of the factory is assumed as constant.

The rates of hourly maximum municipal wastewater flow to the daily maximum one in July and August in 1999 are 1.49 and 1.47 on average, respectively. The calculated rates of each day during two months are illustrated in the figure below. Based on the analysis, the value of 1.5 is adopted in this Study.



(3) Groundwater

The quantity of groundwater infiltrating into the sewer pipe depends on soil condition, groundwater level, sewer pipe material, type of pipe joint, local construction skill and method. It is very difficult to estimate the quantity of groundwater because there is little quantitative data to draw a conclusion. In Croatia, it is usually determined based on the experience of other countries.

The Sewerage Department of Karlovac Water Supply & Sewerage Company had estimated the existing groundwater infiltration rate at 35% of the dry weather flow based on measurements of pump discharge together with sewer field experience. This rate is rather high but considered reasonable since the existing sewer pipelines are old and damaged in many places.

On the other hand, the groundwater infiltration rate in Kutina can be estimated by using the wastewater inflow data of the treatment plant, since the inflow is measured everyday. The estimation can be done based on the data during July and August 1999 to avoid the influence of storm water, since the sewerage system of the town is a combined one. In fact, storm water in July and August is negligible. The infiltration rate is estimated, as shown in the table below.

Items		Unit	July	August	Remarks
Actual Inflow into the Treatment Plant	(1)	m^3/month	84,337	88,788	
Water Consumption	(2)	m^3/month	93,971	99,849	
Wastewater Estimation	(3)	m^3/month	65,268	69,351	(3) = (2)×0.8
Infiltration Estimation	(4)	m^3/month	19,069	19,437	(4) = (1)-(3)
Infiltration Rate	(5)	%	29.2	28.0	(5) = (4)/(3)

In this Study, the infiltration rate of 30% is applied for all the objective municipalities, based on the above analysis for Kutina. It is assumed as constant irrespective of the passage of time.

(4) Summary of Municipal Wastewater Projection per Capita

The projected municipal wastewater quantity per capita including groundwater in 2015 is summarized as follows.

(Unit: l/capita/day)

			<10,000	≥10,000
Daily Average	Domestic Wastewater	(1)	190	190
	Institutional/Industrial Wastewater in Small Factory	(2)	30	70
	Municipal	(3)=(1)+(2)	220	260
	Infiltration	(4)	70	70
	Total	(5)=(3)+(4)	290	330
Daily Maximum	Domestic Wastewater	(1)	240	240
	Institutional/Industrial Wastewater in Small Factory	(2)	30	90
	Municipal	(3)=(1)+(2)	270	330
	Infiltration	(4)	70	70
	Total	(5)=(3)+(4)	340	400
Hourly Maximum	Domestic Wastewater	(1)	370	370
	Institutional/Industrial Wastewater in Small Factory	(2)	40	130
	Municipal	(3)=(1)+(2)	410	500
	Infiltration	(4)	70	70
	Total	(5)=(3)+(4)	480	570

(5) Industrial Wastewater

There are various sizes of industries in the Study Area. In this Study, the industrial wastewater in the large industries mentioned in Appendix C is counted individually. The quantity for the small industries is included in the municipal wastewater.

1.3.2 Pollution Load

(1) Domestic Wastewater

BOD load is used as a representative index of organic substances. There are several reports on the unit BOD load of domestic wastewater stemming from field investigations. The unit generated BOD load reported by previous studies ranges between 32 and 60 g/capita/day. In this Study, 60 g/capita/day is adopted since this value is adopted widely in Croatia and it is the value prescribed in the ATV Standard. With regard to COD_{Cr}, TSS, T-N and T-P loads, 120 g/capita/day, 70 g/capita/day, 11 g/capita/day and 2.5 g/capita/day are adopted for the same reason, respectively.

(2) Commercial Wastewater, Institutional Wastewater, and Industrial Wastewater in the Small Industries

The BOD concentration in the wastewater shown above is assumed at 200 mg/l. The concentration of COD_{Cr}, TSS, T-N and T-P is also assumed at 400 mg/l, 233.3 mg/l, 36.7 mg/l and 8.3 mg/l in proportion to the BOD load in domestic wastewater, respectively.

(3) Industrial Wastewater

The unit load generated in the various activities is in a wide range. However, BOD concentration of wastewater discharged into the sewerage system must be less than 250 mg/l after pre-treatment in the industries.

1.3.3 Collection and Transport System

(1) Collection System

Wastewater is collected through sewer network systems consisting of main and secondary/tertiary sewers of either the separate or combined system type. In the separate system, sewers collect only wastewater while storm water is discharged into natural watercourses through street ditches and gutters. Although his system requires less diameter of sewer pipe resulting in saving of pipe construction cost, the installation/improvement of the storm water drainage system is separately necessary.

On the other hand, in the combined system of sewer network, both wastewater and storm water are collected by sewers. This system requires a large diameter of sewer pipe since storm water quantity is far larger than the wastewater quantity. The diameter sharply grows with increasing catchment area of storm water.

The urban centers of the Study Area are mostly covered by combined systems and only some fringe areas are served by separate systems at present. In this Study, the combined system is proposed for the sewerage improvement of urban centers in coordination with the existing system. The separate system is however proposed for the fringe areas where no sewerage system is provided, since such areas are not densely populated and storm water can be discharged easily into the natural watercourse.

(2) Transport Collector

Wastewater collected through sewer networks is conveyed to the treatment plant through transport collectors. However, it is not economical to convey all the combined flow of wastewater and storm water to the treatment plant under the combined system. In Croatia, the combined flow exceeding twice the quantity of hourly maximum dry weather wastewater flow is discharged into the nearest water body through an overflow chamber.

Hence, the transport collector is designed to carry twice the quantity of hourly maximum dry weather wastewater flow (2Q) at maximum. For this purpose, an overflow chamber is proposed at the location of connection with the collection system.

1.4 Selection of Treatment Process

1.4.1 Permissible Limits of Treatment Plant Effluent

As shown in Table D.1.2, the plant size in the objective 22 sewerage systems is less than 100,000 PE except Zagreb City, and the receiving rivers are classified into either Category II or Category III. The permissible limits of effluent quality from 21 treatment plants (excluding Zagreb City) are summarized below.

(Unit : mg/l)

Plant Size	Category	TSS	BOD	COD_{Cr}	T-P	T-N
< 10,000 PE	II	60	40	150	-	-
	III	120-150	Adequate	-	-	-
≥ 10,000 PE	II	35	25	125	2	15
	III	35	25	125	-	-

The treatment plant construction project in Zagreb City is ongoing at present. The design capacity of the plant is 1,500,000 PE and its receiving water is Category III. Hence, the permissible limits of the plant of Zagreb City are as follows.

Plant Size	Category	TSS	BOD	COD_{Cr}	T-P	T-N
1,500,000 PE	III	35	25	125	-	-

1.4.2 Removal of Nutrients

As mentioned before, a treatment plant with the capacity of more than 10,000 PE shall treat the nutrients of phosphorus (P) and nitrogen (N) up to T-P<2mg/l and T-N<15mg/l when the effluent from the plant is discharged into a Category II river.

Generally, the conventional activated sludge process (AS) can coincidentally remove approximately 40% of T-P and about 30% of T-N. However, an advanced process shall be applied to treat T-P and T-N up to the above-mentioned level. Biological nutrient removal is a relatively low-cost process and the recent experiences have shown that the biological process is reliable and effective in removing nutrients.

The principle of the biological phosphorus (P) removal is to expose microorganisms to the alternating anaerobic and aerobic conditions. The exposure to these circumstances forces the microorganisms to keep their uptake of phosphorus above normal level. The most typical process is AO (Anaerobic and Oxic) system. This process is comparatively simple and does not require additional large construction and operation/maintenance costs. Further, its operation is not complicated. On the other hand, it has an advantage of preventing the inflow in the secondary sedimentation tank from bulking.

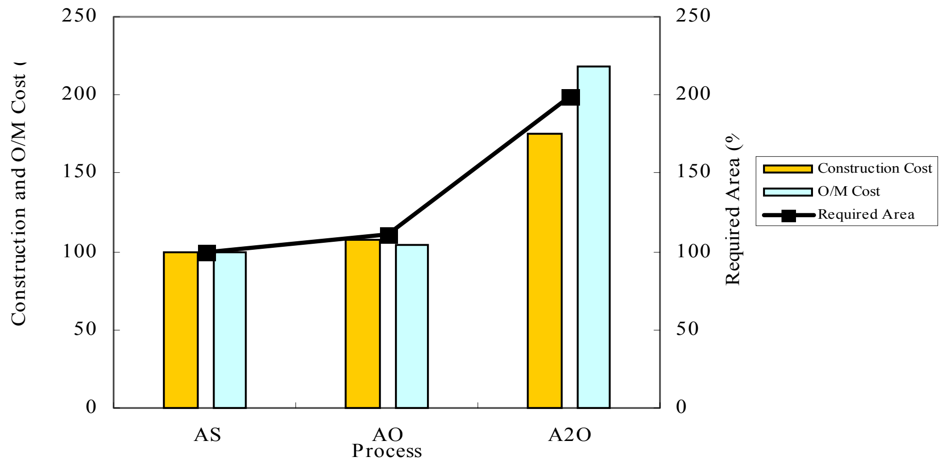
Nitrogen (N) in wastewater is existent in many different forms and undergoes numerous transformations. The nitrogen is removed through two (2) stages of chemical change: nitrification and denitrification. In the first stage, ammonia is converted aerobically to nitrate (NO_3^-) [nitrification]. In the second stage, ammonia is converted to nitrogen gas (N_2) [denitrification].

Both phosphorus and nitrogen can be removed through the process of a combination of anaerobic, anoxic and aerobic zones or compartments. This A_2O (Anaerobic Anoxic and Oxic) process is a modification of the AO process. An anoxic zone for denitrification is attached to the AO process. However, this treatment of both phosphorus and nitrogen requires additional high construction and operation/maintenance costs and a sophisticated operation technology. On the other hand, the sludge production of this system is not large and it is on the same level as that of the conventional activated sludge system.

The treatment processes of the above three (3) methods: AS, AO and A_2O are shown in Fig. D.1.2. Treatment efficiency of organic materials and nutrients by the above three (3) processes are compared as follows for the typical influent quality (BOD: 200 mg/l, TSS: 200 mg/l, T-P: 5 mg/l, T-N: 30 mg/l).

Treatment Process	Effluent Removal/Concentration		
	AS Process	AO Process	A_2O Process
BOD	< 25 mg/l	< 25 mg/l	< 25 mg/l
TSS	< 35 mg/l	< 35 mg/l	< 35 mg/l
T-P	Coincidentally, 40%	< 2.0 mg/l	< 2.0 mg/l
T-N	Coincidentally, 30%	Coincidentally 30%	< 15 mg/l

The indices of the required construction and operation/maintenance costs of the above three (3) processes for a treatment plant with the capacity of 10,000 m^3/day are roughly compared as illustrated in the figure below. The details are given in Table D.1.3.



The main objective of the above advanced treatment is to prevent or mitigate eutrophication problems (excessive growth of plankton), which are liable to occur in stagnant water areas like lakes and reservoirs due to the excessive concentration of nutrients (T-P, T-N). In the Study Area, however, there are no potential water areas, except Lonjsko Polje, where eutrophication problems may be caused by the wastewater of the objective urban centers.

The process of eutrophication and its relationship to nutrients input are complicated. In lakes and reservoirs, phosphorus is generally more critical than nitrogen for growth of plankton, although the presence of nitrogen is also important. (Decree on Water Classification N.N. No. 77/98 classifies eutrophic degree in T-P.) Therefore, the control of T-P is given higher priority over that of T-N.

From the above discussions, the removal of nutrients in the Study Area is proposed as follows:

(1) Only treatment of T-P is considered in the Master Plan (target year: 2015).

(2) Treatment of T-N is considered as one of the long-term measures defined in the National Water Protection Plan. It will not be included in the Master Plan but will be implemented by 2025.

1.4.3 Applicable Treatment Process

The applicable treatment processes are selected from among those widely developed, in consideration of the following conditions:

(1) The treatment plant with a size of less than 10,000 PE shall be designed to treat the wastewater to BOD 40mg/l when the effluent is discharged into a Category II river. In this case, the biological processes, which require a high operation/maintenance technology, are not recommended.

(2) The treatment plant with a size larger than 10,000 PE shall be designed to treat the wastewater to BOD 25mg/l when the effluent is discharged into either Category II or

Category III rivers. Such a large plant is proposed for large urban centers and requires a large land space near the urban area. Hence, treatment processes that require a large land space, such as aerated lagoon, are not recommended.

(3) The treatment plant with a size larger than 10,000 PE shall be designed to treat the wastewater to BOD 25mg/l and T-P 2mg/l when the effluent is discharged into a Category II river. In this case, the applicable processes are limited from the technological aspect.

From the above considerations, the following applicable treatment processes are selected for the study on alternatives.

Plant Size	Category II		Category III	
< 10,000 PE	Activated Sludge	(AS)	Sedimentation	
	Oxidation Ditch	(OD)		
	Contact Aeration	(CA)		
	Aerated Lagoon	(AL)		
	Trickling Filter	(TF)		
	Accelerator	(AA)		
≥10,000 PE	Anaerobic Oxic Process	(AO)	Activated Sludge	(AS)
	Activated Sludge with Coagulation	(AS+CO)	Oxidation Ditch	(OD)
	Cyclic Activated Sludge Technology	(CAST)	Cyclic Activated Sludge Technology	(CAST)

The characteristics of the above-mentioned processes are described below. Their flow diagrams are given in Fig. D.1.3.

(1) Activated Sludge (AS)

This is the most basic biological treatment process consisting of two (2) stages. The first stage is composed of physical settling of solids, while the second stage is normally a biological process. Settled wastewater and recycled activated sludge enter the head of the aeration tank and are aerated by an air diffuser or a mechanical aerator. During the aeration, adsorption, flocculation and oxidation of organic matters occur. Activated sludge is separated in a secondary sedimentation tank.

The aeration tank treats organic materials during a short retention time (about 6 hours). Hence, it does not require a large land space.

Primary sedimentation tank is needed to cope with the fluctuation of sewage quantity and quality, and to equalize/mitigate the load. Excess sludge produced in the primary and secondary treatment stages is normally stabilized in a separate anaerobic digester and is dewatered mechanically or on drying beds. (Refer to Fig. D.1.2).

The highest removal efficiency of BOD_5 is expected (usually can treat to less than 20 mg/l). The treatment process is more mechanical including the equipment of pumps, sludge scrapers, blower, etc., which requires a comparatively complicated operation and maintenance.

(2) Oxidation Ditch (OD)

Oxidation ditch was developed in Holland to apply for the sewage treatment of small communities of 200-15,000 people. This is a special adaptation of the activated sludge process. It consists of ring-shaped or oval-shaped channel equipped with mechanical aeration devices. Screened wastewater enters the ditch, is aerated, and circulates at a velocity of about 0.3 m/s.

The sewage in the ditch circulates together with activated sludge. The contained organic substances are adsorbed and assimilated by activated sludge during the circulation (retention time: about 24 hours). This long retention time requires a large land space of treatment plant, on the other hand, makes the treatment process flexible to the fluctuation of influent quantity and quality.

Primary sedimentation tank is not necessary. However, secondary sedimentation tanks are used for most applications. Sludge treatment facilities are also required as well as the activated sludge process.

(3) Trickling Filter (TF)

The trickling filter consists of beds of a highly permeable medium to which microorganisms are attached and through which wastewater is percolated and trickled. The filter media usually consists of either rock or a variety of plastic packing materials. Rock filter beds are usually circular and a rotary distributor sprinkles the wastewater over the top of the bed. Trickling filter of plastic media is built in round, square, and other shapes with various depths. A population of microorganisms attached to the filter media degrades the organic materials existent in the wastewater. Organic materials from the liquid are adsorbed onto the biological film or slime layer. In the outer portion of the biological slime layer (0.1 to 0.2mm), aerobic microorganism degrades the organic materials. As the microorganisms grow, the thickness of the slime layer increases, and the diffused oxygen is consumed before it can penetrate the full depth of the slime layer. Thus, anaerobic environment is established near the surface of the media.

The biological community in the filter includes aerobic, anaerobic, and facultative bacteria, as well as fungi, algae, and protozoan. Higher animals such as worms, insect larvae, and snails are also present. Variation in the individual population of the biological community occurs throughout the filter depth with changes in organic and hydraulic loading, influent water composition, pH, temperature, air availability and other factors.

The major operational problems of trickling filter are associated with cold weather operation. Efficiency is reduced by approximately 30% per 10°C, and freezing may cause partial plugging of the filter medium and overloading the remaining open area. In northern climates, fiberglass covers are employed to prevent ice formation. However, the treatment efficiency is limited and it is 80% at most even under normal temperature.

(4) Aerated Lagoon (AL)

Aerated lagoon biologically treats the wastewater by mechanical aeration or diffuser aeration in a lagoon. The required retention time is usually several days although it varies mainly depending on the wastewater temperature. Hence, a large land space is required for construction of the aerated lagoon.

The wastewater is usually treated by a series of aerated pond followed by maturation pond. All the solids are maintained in suspension in the aerated pond and those are settled in the maturation pond.

Nitrification may be achieved seasonally or throughout the year, depending on the design and operating conditions, and on the wastewater temperature. Generally, with higher wastewater temperature and lower loading (resulting in longer retention time of sludge), higher degree of nitrification can be achieved. Hence, sludge treatment facilities are not necessary. Usually, sedimentation and sludge digestion is accomplished by providing a large and shallow settling basin.

(5) Cyclic Activated Sludge Technology (CAST)

Cyclic activated sludge technology is a combination of the processes of filling and drawing wastewater in one (1) basin. Aeration and sedimentation/clarification are carried out sequentially in the same tank. This system has usually five (5) steps of processes that are carried out in the following sequence: (1) filling, (2) reaction (aeration), (3) settling (sedimentation/clarification), (4) drawing (decantation) and (5) idling. Sludge wasting is another important step that greatly affects the performance of operation. A special wasting process is not set in the five (5) basic steps and it is usually performed during the settling or idling steps.

A unique feature of this process is that no activated sludge return is necessary. Both aeration and settling occur in the same chamber, no sludge is lost in the reaction step and hence, necessary sludge content can be maintained in the aeration chamber.

However, operation rule of the plant must be changed according to the fluctuation of influent quantity and quality to obtain satisfactory results. Usually an automatic operation is required.

(6) Contact Aeration (CA)

Contact aeration is one of the aerobic attached growth biological treatment processes like trickling filter. It is used for the removal of carbonaceous BOD and nitrification (conversion of ammonia to nitrate). Typically, the main part of this process is a container (reactor) packed with a medium to which microorganisms can be attached. Wastewater is introduced from the bottom of the container through an appropriate underdrain system or inlet chamber. Air required for the process is also introduced with the wastewater.

(7) Aeroaccelator (AA)

In this process, reaction and settlement are carried out in one (1) basin. The basin is divided into the reactor and settlement sections by partition. The wastewater is discharged into the reactor section and then, moves into the settlement section continuously through the partition. Although it requires less site area, its operation is a little complicated and sometimes requires an automatic control system.

(8) Anaerobic Oxic Process (AO)

The AO process is used for the removal of both organic substances and phosphorus. This process is a single sludge suspended growth system that combines anaerobic and aerobic sections in sequence. Settled sludge is returned to the anaerobic reactor and mixed with the incoming wastewater. In the anaerobic zone, the phosphorus contained in cell mass (cell mass contained in return sludge) is released as soluble phosphorus. Then, the cell mass takes the soluble phosphorus in the aerobic zone. Some BOD reduction also occurs in this stage.

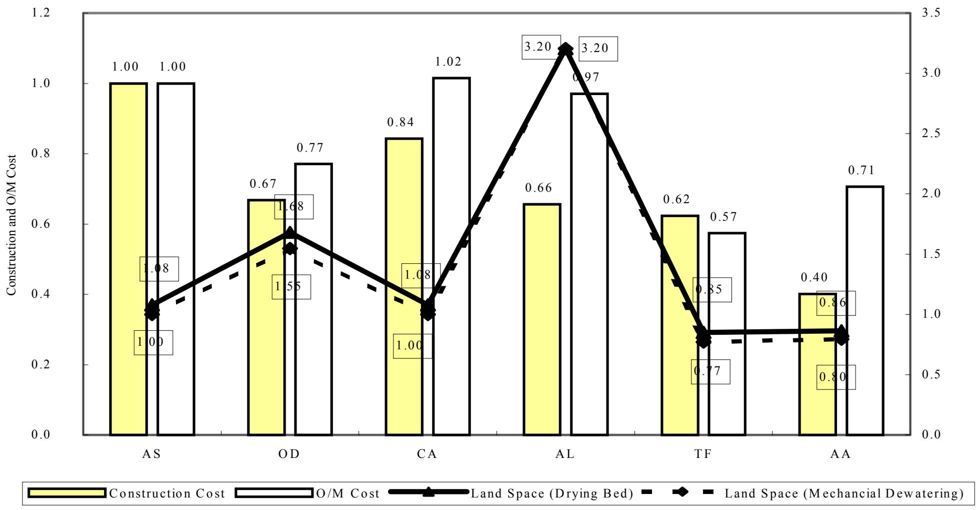
Removal efficiency of phosphorus is dependent on the ratio of BOD to phosphorus in the effluent. This process is expected to treat phosphorus up to 1mg/l when the ratio of BOD to phosphorus in the influent exceeds 10 to 1. (Refer to Subsection 1.4.2 and Fig. D.1.2.)

1.4.4 Selection of Optimum Treatment Process

The optimum treatment process is selected from among the applicable ones listed in the table in Subsection 1.6.3 by comparing their required construction costs, O&M costs and land space, as well as technical problems in operation. In this comparison, the treatment processes are designed to treat the inflow of 1,500 m^3/d for the case of small plant size and 10,000 m^3/d for the case of large plant size. The results of comparison are described below. For more detail, see Table D.1.4.

(1) Case A: Plant Size <10,000 PE, Category II

The required construction cost, O&M cost and land space of the six (6) processes (AS, OD, CA, AL, TF and AA) are compared in index as shown in the figure below. In this cost comparison, sludge treatment cost is not included. On the other hand, the required land space varies according to the sludge treatment method. Then, the required land space of the treatment plant is estimated for two (2) cases of sludge treatment: (a) Thickener + Drying Bed and (b) Thickener + Mechanical Dewatering. Both cases are also shown in the figure below.



(a) The construction and O&M costs of TF and AA are comparatively small. However, their treatment efficiency is limited. The maximum efficiency is 80%. Besides, the treatment efficiency of TF is considered to further decrease in winter season because the low temperature has a very serious influence on biological filter processes. They cannot meet the permissible limit when the influent quality exceeds BOD 200 mg/l. TF and AA are not recommended because such a case may frequently occur.

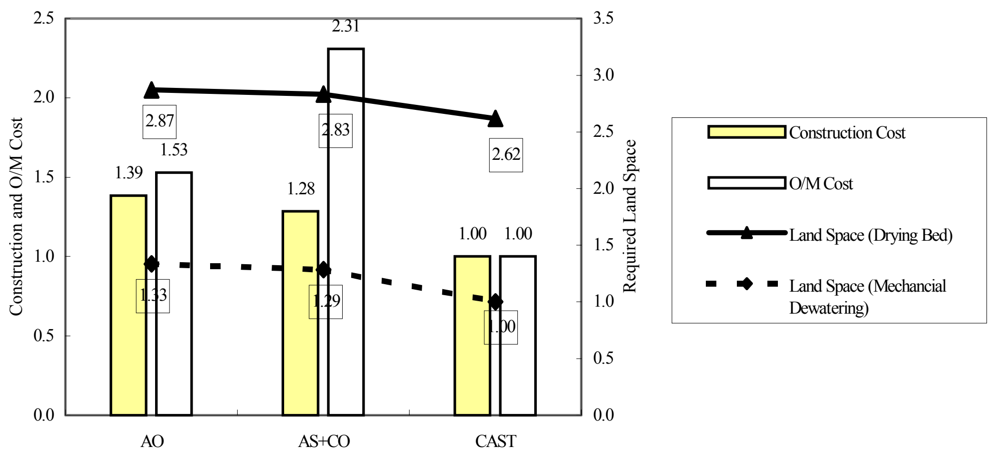
(b) AL requires a large land space and O&M cost although the construction cost is comparatively small. The treatment efficiency varies depending on the water temperature due to a long retention time. The treatment efficiency may lower considerably in winter season. It is not reliable except in Topusko where the influent water temperature is high due to the wastewater from the hot spring resort.

(c) The construction and O&M costs of AS is high although the required land space is small. Further, it requires a comparatively high technology in operation.

(d) OD is the most widely used process in small towns or villages. The operation is easy. Therefore, this process is proposed in the Master Plan.

(2) Case B: Plant Size ≥10,000 PE, Category II

The required construction cost, O&M cost and land space of the three (3) processes (AO, AS+CO and CAST) are compared in index in the same way as Case A. The results are shown in the figure below.



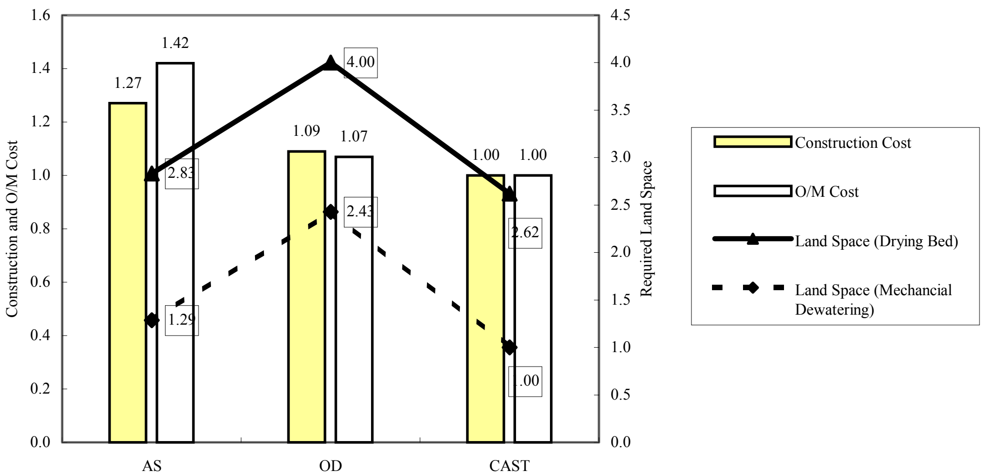
(a) The construction and O&M costs of CAST are both the smallest. However, it requires a high level technology in its operation, especially in the case of combined sewer system. The plant operation rule must be changed according to the fluctuation of the influent quantity and quality. Usually, an automatic control system must be installed for a satisfactory operation. However, experienced operators are also necessary to operate the automatic control system corresponding to the fluctuation of the influent. Therefore, this system is not recommended.

(b) AS+CO requires a higher O&M cost due to the additive input. Further, it produces a large quantity of sludge. On the other hand, AO is the most widely used process for removal of T-P. Therefore, AO is proposed in the Master Plan.

(c) In operating the Anaerobic Oxic Process, it is better that the sludge from the primary sedimentation tank is treated by gravity and excess sludge is treated by the mechanical thickening process. Besides, the supernatant from the sludge treatment process such as thickener and dewatering facilities must be treated by coagulation process before returning to the primary sedimentation tank because the supernatant from these facilities has a high concentration of phosphorus due to the release in the anaerobic condition.

(3) Case C: Plant Size ≥10,000 PE, Category III

The required construction cost, O&M cost and land space of the three (3) processes (AS, OD and CAST) are compared in index in the same way as Case A. The results are shown in the figure below.



(a) CAST is not recommended from the reasons mentioned above.

(b) OD cannot meet the future requirement of T-P removal. On the other hand, AS can easily meet the requirement only by construction of a partition in the biological reactor tank. Besides, OD requires a larger land space. It is usually not suitable in urban areas.

(c) AS is the most prevailing process for the treatment plant of a larger capacity. Therefore, AS is proposed in the Master Plan.

1.4.5 Selection of Optimum Sludge Treatment

The wastewater treatment produces a large quantity of sludge every day. Since the supernatant from the sludge treatment facilities like the thickener and the digestion tank is returned to the wastewater treatment process, the efficiency of sludge treatment process has a close relationship with that of the wastewater one.

The sludge treatment process is as important as the wastewater treatment process in designing a sewerage treatment plant. The sludge treatment process consists of the following three (3) kinds of unit processes: thickening, digestion and dewatering, and the most cost effective sludge treatment process is obtained through the optimum combination of these unit processes.

(1) Thickening

Thickening is a process to condense the sludge extracted from the treatment plant so that the size of the subsequent processes can be minimized. Sludge extracted from treatment plant has a high water content of approximately 99%. A normal thickening process can reduce the water content of sludge to about 97%, resulting in decrease of the sludge volume to one-third.

There are two types of thickening, namely the gravity method and the mechanical one. Since a mechanical sludge thickener such as centrifugal and floatation thickener requires a high capital and O&M cost, the gravity sludge thickening method is adopted due to its simple structure, far cheaper investment and O&M costs, and easy operation and maintenance.

(2) Digestion

Digestion process has the following major functions: (i) reduction of disease population existent in sludge, (ii) reduction of total solid mass by emitting carbon dioxide and methane gas, and (iii) improvement of dewater ability.

However, the required volume of digestion tank is much affected by temperature. Normally, the temperature in digestion tank must be maintained at about 35°C. Therefore, heating by steam or external heat exchanger is necessary in a cold winter season and as a result, O&M cost of the digestion tank increases in winter season. Besides, the digestion tank must be provided with sludge mixer, gasholder with desulfer equipment, etc., requiring a complicated technology of operation and maintenance.

(3) Dewatering

The purpose of dewatering is to reduce the sludge volume of final disposal. There are two (2) types of dewatering process: (i) air-drying and (ii) mechanical method.

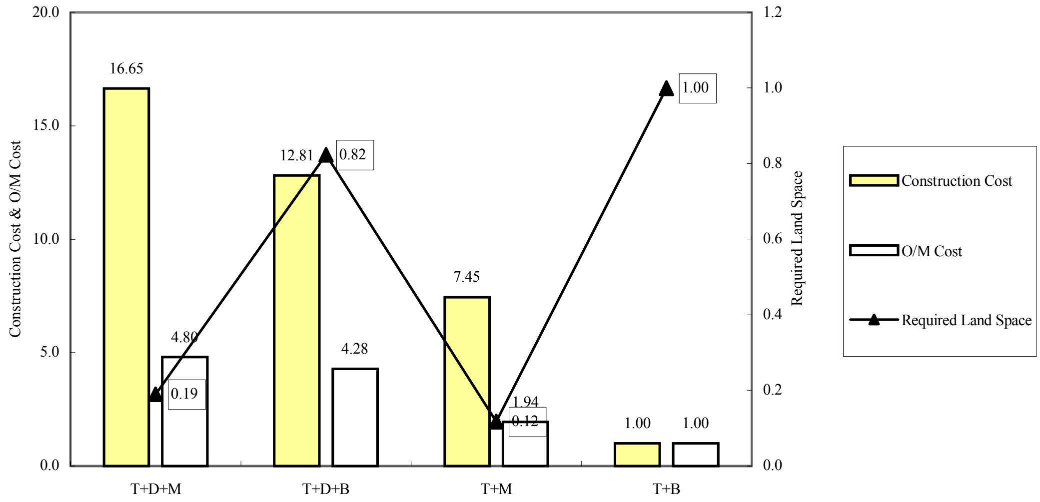
Air-drying removes moisture by evaporation and infiltration into underlain sand bed. The operation and maintenance of this method is simple and easy. However, it requires a large land space because more than 20 days is necessary to reduce the moisture content to less than 80%.

A variety of equipment is applicable for mechanical dewatering such as (i) vacuum filter, (ii) pressure filter, (iii) belt filter, and (iv) centrifuges. These equipment are used in such circumstances as air drying method can not be applied due to: (i) available land space is limited, or (ii) odor emitted from air drying is not acceptable, or (iii) weather condition does not permit the use of air dying. Among the mechanical equipment, centrifuge generally consumes more power and need more O&M cost than any other filter type. In selecting the mechanical equipment, the capital cost, O&M cost and simple operation should be compared comprehensively.

The dewatering mechanism of belt press filter and centrifuge is shown in Fig.D.1.4.

The construction cost, operation and maintenance cost and required land space are compared for four (4) alternative sludge treatment processes prepared by combining the above-mentioned three (3) kinds of unit processes. The cost of each sludge treatment process is shown in Table D.1.5. In this alternative preparation, gravity-thickening process is used for all the alternatives because it is essentially necessary to reduce the required capacity of the subsequent processes.

The comparison results are shown below in terms of index. In this comparison, belt filter equipment is adopted as the mechanical dewatering equipment.



Note: T: Thickener, D:Digestion Tank, M: Mechanical Dewatering (belt filter), B: Drying Bed

As evident from the above comparison, the alternatives including digester (T+D+M, T+D+B) require larger construction and O&M costs, compared to the other processes (T+M, T+B). Digester requires a large energy in winter, and a high investment cost and O&M technology.

Alternative (T+B) is definitely economical in construction and O&M costs. However, it requires a large land space and emits foul odor that may affect the people living in the areas surrounding the treatment plant. Hence, (T+M) is applied for treatment plant with a size larger than 10,000 PE, while (T+B) is proposed for treatment plant with a size of less than 10,000 PE in this Study.

1.5 Cost Estimate

1.5.1 General

The estimation is made for the Master Plan study under the following conditions:

(1) The estimation is based on the economic conditions as of February 2001.

(2) Exchange rates at the end of February 2001 is US$1.00 = Kn 8.3 = JP¥116.

(3) The cost to clear the landmines if they exist in the site is excluded from the estimation.

1.5.2 Cost Items

Project investment cost is broken down as follows:

(1) Direct Construction Cost

(2) Land Acquisition Cost

(3) Engineering Cost

(4) Government Administration Cost

(5) Custom Duties

(6) VAT

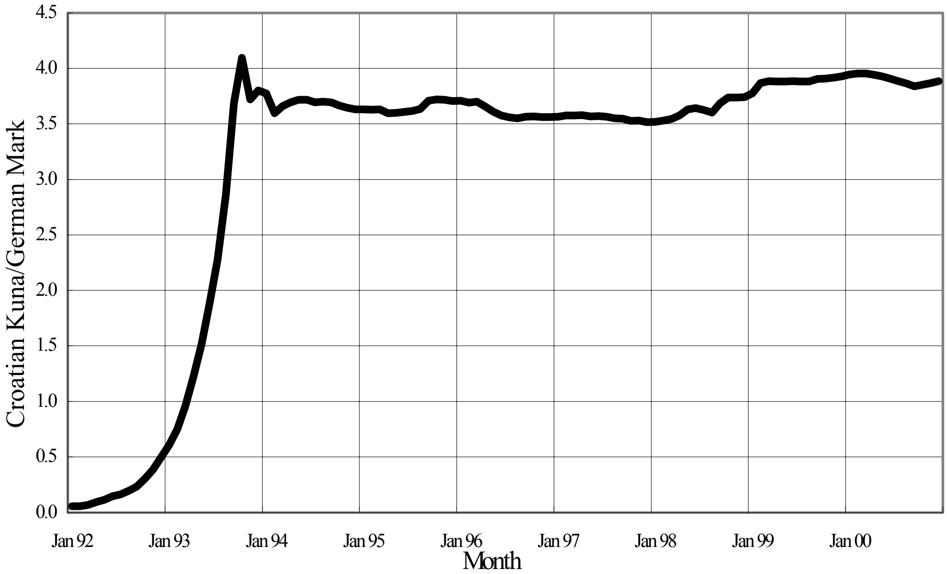
(7) Contingency

1.5.3 Foreign and Local Currency

All costs are indicated in this report as Croatian Kuna (Kn) instead of dividing them into foreign and local currency portions for the reasons stated below.

(1) Records in the past show that the exchange rate between the Croatian and German currencies has varied in a narrow range since 1994, as shown in the figure below, which is between Kn 3.5 and Kn 3.9 per German Mark.

(2) No restriction is applied to the exchange of Croatian Kuna to another foreign currency and vice versa for purchasing or construction purposes.



1.5.4 Direct Construction Cost

The estimated direct construction cost consists of the following three (3) parts.

(1) Transport Collector/Main Sewer

Cost for the transport collector and main sewer includes cost for the pipelines, manholes, lifting pump stations, crossing of river, highway or railroad and other associated works.

Unit rates applied to the estimation for civil works are quoted from official unit rate tables issued by Croatian Waters as of March 2000 also considering several previous contracts for construction of collectors.

Prices for lift pumps and manhole pumps are gathered from manufactures in Croatia and surrounding countries such as Austria and Germany for estimation purposes.

Volumes of major work items are calculated based on the proposed length and size of pipelines with some assumptions on depth. Miscellaneous work items such as protection of existing facilities or diversion of traffic are taken into consideration as a certain ratio to the major work items. The ratio is determined based on the previous contracts of similar works.

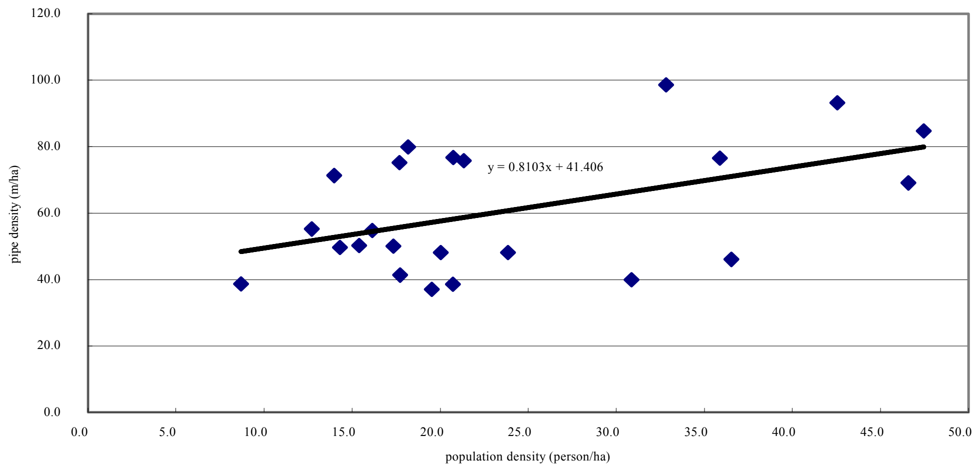
In this cost estimate, material of pipes is supposed to be PVC for small diameter pipes, 200 mm and 250 mm, and reinforced concrete pipes for 300 mm or over.

There are few sewer pipes crossing beneath a river in Croatia. Consequently, the price data for this work is not available. The estimation is made based on prices for similar works of gas pipelines.

(2) Secondary/Tertiary Sewer

It is difficult to estimate the length of secondary/tertiary sewer in the extension area of sewerage service in detail. Hence, the secondary/tertiary sewer length in the extension area is estimated by assuming the pipe density. The existing average pipe density (including main sewer and secondary/tertiary one) of the urban centers in the Study

Area is shown below. It ranges from 40 m/ha to 100 m/ha increasing in proportion to the population density.



The length of secondary/tertiary sewer in the extension area is estimated through the following steps. Firstly, total length of the sewer pipes including main sewer is estimated from the above relationship between pipe density and population density. Then, the length of the secondary/tertiary sewer is obtained by subtracting the main sewer length from the total sewer length. In this cost estimate, the minimum size of secondary/tertiary sewer is assumed at 200 mm.

(3) Wastewater Treatment Plant

Cost for the wastewater treatment plant is estimated in either of the two manners described below.

(a) Cost for the Five FS Urban Centers

Dimensions of major facilities such as sedimentation tank, biological treatment tank, pump stations and other buildings, as well as the required mechanical and electrical equipment, are determined by performing basic engineering as discussed in detail in the proposed structural plans in Chapter IV to VIII. The work volumes and necessary equipment are estimated based on the basic design.

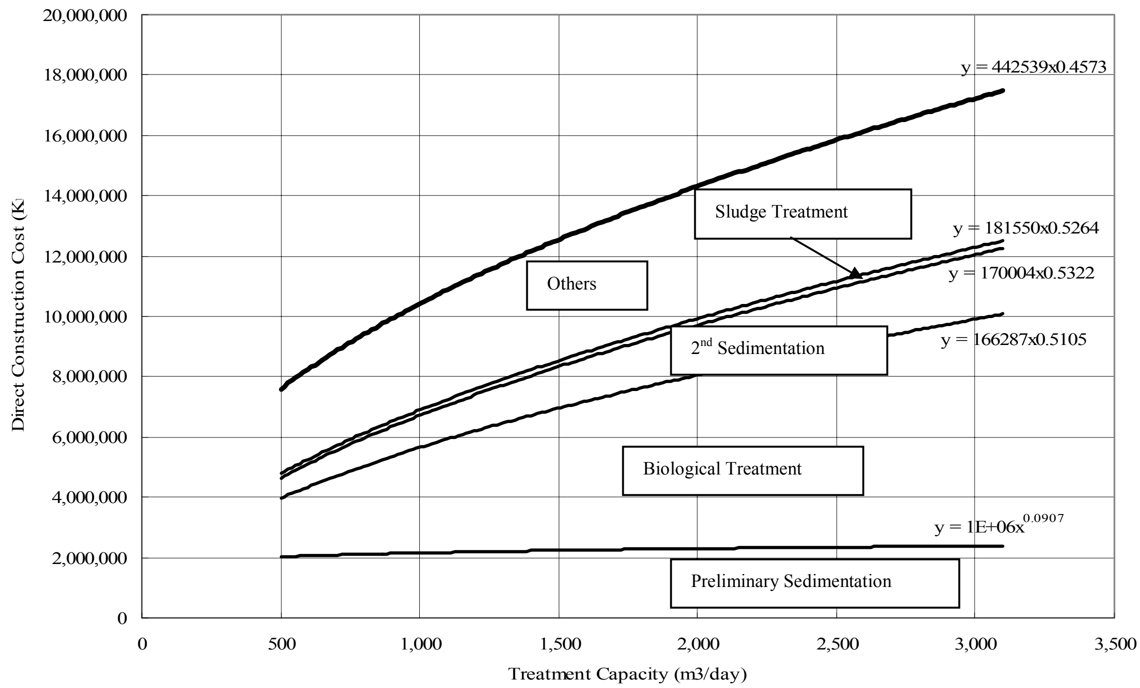
Miscellaneous work items such as pipes, connecting facilities or roads are estimated with ratios to the major items.

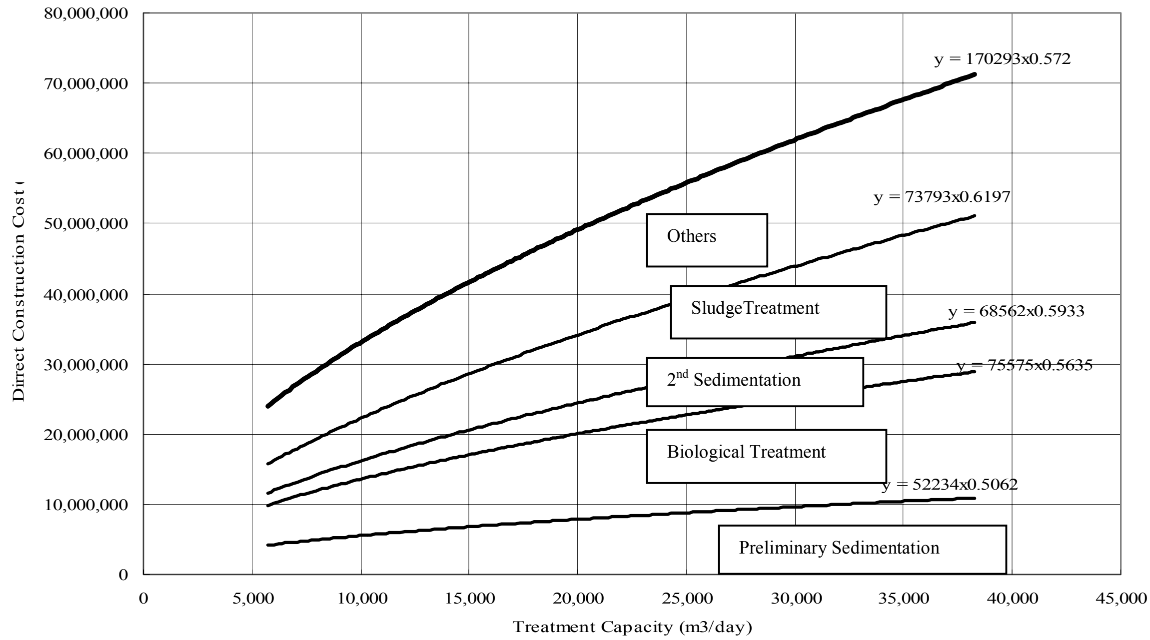
Unit rates for the works are quoted from the official unit rate tables and the construction financial report for the Čakovec wastewater treatment plant, which was completed in 1998 and whose operation has been successful so far. This report is fully utilized as a reference material to represent actual construction cost and its proportion on facilities.

(b) Cost for Other Local Urban Centers

Two (2) construction cost–treatment capacity curves, one of which is for the AO (Anaerobic Oxic) process and the other for the OD (Oxidation Ditch) process, are established to estimate construction cost. The curve for the AO process is obtained from the results of cost estimate for the five FS urban centers and that for the OD process from a similar exercise for small sized urban centers.

The construction cost curves with the breakdown into major facilities are shown below.





1.5.5 Other Costs Associated with Construction

Other costs associated with construction, except the land acquisition cost, are estimated in proportion to the direct construction cost at the percentages shown in the table below.

Cost Item	Ratio
Engineering Cost	10% of Direct Construction Cost
Government Administration Cost	3% of Direct Construction Cost
Customs Duties	10% of Mechanical/Electrical Items and Works
VAT	22% of Direct Construction and Engineering Cost
Contingency	20% of Direct Construction Cost

The ratios for Engineering Cost and Government Administration Cost are determined based on experiences of similar projects and the local practice, respectively.

Customs duties of 20% are applied to imported goods not produced in Croatia. Supposing that customs duties are applied to half of the mechanical and electrical works, the rate of 10% is applied to all mechanical and electrical works. The rate of 22% for VAT, which is applied as of February 2001, is taken into account.

Land acquisition costs are estimated based on interview with local water supply & sewerage companies to the extent that information is available.

CHAPTER II SEWERAGE IMPROVEMENT OF ZAGREB

2.1 Existing Sewerage System

2.1.1 Service Area, Population and Industries

The City of Zagreb consisting of 70 settlements is the capital of the Republic of Croatia. The administrative area, as well as the existing population (1991, 1999) and future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		64,003.5	-	64,003.5
Population	(1991)	777,826	-	777,826
	(1999)	935,000	-	935,000
	(2015)	998,000	-	998,000

Public sewerage services started in 1892 when the city had a population of 40,000. At present, the sewer network covers 75% of the city and the service area is about 25,600 ha including 235 ha of industrial zone. The total population in the above service area is, however, approximately 825,000 (household number is about 250,000), of which 25,000 inhabitants are still using the septic tank.

About 230 industries are connected to the existing sewerage system. However, most of the industries are not provided with the appropriate pre-treatment system.

2.1.2 Sewer Network

Grad Zagreb is divided into two (2) areas by the Sava River, the left and right side areas. The sewerage system on the left bank discharges into the Sava River south of the settlement of Ivanja Reka, while that on the right bank discharges into the Sava River at the settlement of Jakuševac. There is no treatment plant on the sewerage system.

The main sewers in both areas are given below. The existing sewerage system is shown in Fig. D.2.1.

Area	Coverage	Main Sewers
Left Side of River	North Zagreb and Western Part of Sesvete	Kostanjek-Dolec-Sigetje, Medpotoki-Dubje, Veliki Potok-Črnomerec, Kraljevac-Donje Prekrižje, Branovec-Jelševec, Savica-Šanci, Struge-Bogdani and Jelkovec
Right Side of River	New Zagreb	Main sewer (collector) from Remetinec to collecting canals of Rajtarićeva - Rainfall and sewage in the town area is discharged through the existing sewerage system and Črnec canal into Sava River without any treatment. Main sewer onNaletelićeva Street and areas of Brezovica-Obrež (with 3 pump stations: Botinec, Obrež and Dupci), Blato, Hrvatski Leskovac, Lučko, Ježdovec and Stupnik with pump station “Blato”.

The combined drainage system has been designed and constructed in the last few decades for 140 l/sec/ha of rainfall with 25 minutes of duration time and a 3-year return period. The total length of the existing pipes is approximately 1,500 km, broken down into 1,000 km of primary/secondary collectors and 500 km of tertiary sewers (constructed by the local government). In 1999, a new sewer of 37 km was built. The maximum and minimum diameters of pipe are 800-540 cm and 20 cm, respectively. All sewers are made of either concrete or reinforced concrete.

The outfalls of the existing sewerage system are GOK Gruščina and collector Južni Zagreb Jakuševac. There are 12 pumping stations on the existing system, which are located at Jakznševec, Zaprude, Klara, Buzin 1, Buzin 2, Petruševac, Ivanja Reka, Kajzerica, Miramarska, Struge, Dubli and Botinec. The capacity of pumps is from 72 m^3/h to 300 m^3/h, and all pump heads are nearly 10 m.

2.1.3 Wastewater Flow and Quality

The sewerage system has been receiving a large quantity of industrial wastewater in addition to the domestic one. However, the domestic ratio has increased while the industrial ratio decreased due to changes economic structure in recent years. At present, the ratio of domestic and industrial wastewater is nearly 1:1 with a rising trend of the domestic one.

The domestic and industrial wastewater discharged into the sewerage system in 1999 is estimated to be 121,620 m^3/day and 114,480 m^3/day, respectively. The historical changes of domestic and industrial wastewater discharges during the recent 11 years (1987–1999) is shown in the following table.

(Unit:$10^3 \times m^3$/day)

	1987	1988	1989	1990	1991	1994	1995	1996	1997	1998	1999
Domestic	92.84	81.74	107.77	89.16	66.47	121.79	130.15	124.60	126.30	127.30	121.62
Industrial	172.23	178.92	173.18	163.39	187.60	175.61	172.54	167.97	171.60	122.38	114.48
Total	265.07	260.66	280.95	252.55	254.07	297.39	302.68	292.57	297.90	249.68	236.10

The observation of wastewater quality was made at the sewerage outfall of South Zagreb, which is located at Jakuševac. The receiving river of the wastewater (Zagreb-Sisak of Sava River) is Category III. There is no important water use in the downstream of the sewage effluent. The average, maximum and minimum values in 1998, 1999 and 2000 are given below.

Year	No.	Quantity (l/s)	Temperature (°C) Air	Water	pH	COD_{Cr} (mg/l)	BOD (mg/l)	SO_4 (mg/l)	NH_4 (mg/l)	NO_2 (mg/l)	NO_3 (mg/l)	PO_4 (mg/l)	Cl (mg/l)
		0.325	25.9	23.2	7.7	441.2	141.2	84.6	23.4	0.1	0.2	5.9	37.5
1998	26	0.353	38.0	25.0	7.9	802.0	261.0	110.0	40.7	0.3	0.7	10.2	56.0
		0.284	16.0	21.0	7.3	261.0	67.0	28.0	4.7	0.0	0.0	1.5	12.0
		0.337	25.3	22.5	7.8	697.1	281.2	89.2	28.2	0.1	0.8	6.2	48.9
1999	39	0.602	34.0	24.0	8.4	3,124.0	1,202.0	138.0	47.3	0.6	5.2	11.0	105.0
		0.306	18.0	20.0	7.1	200.0	62.0	23.0	11.4	0.0	0.0	2.5	18.0
		0.270	25.8	22.8	7.7	421.6	183.7	60.7	29.4	0.3	0.5	5.5	49.6
2000	43	0.710	34.0	25.0	8.0	772.0	368.0	133.0	42.4	0.3	1.2	9.4	73.0
		0.213	19.0	18.0	7.4	150.0	87.0	25.0	15.8	0.3	0.0	2.0	22.0

Note: "No." is sampling number; Upper row values are average, Middle row are maximum, and Lower row are minimum.

The JICA Study team also analyzed the quantity and quality of wastewater at the last bridge before the Sava River on December 8, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time		15:00	COD_{Mn}	mg/l	68.0
Flow	m^3/sec	0.0275	TSS	mg/l	370.0
pH		4.22	T-N	mg/l	21.5
BOD	mg/l	190.0	T-P	mg/l	5.6

2.2 Ongoing Sewerage Improvement Project

2.2.1 Summary of Proposed Improvement Works

The sewerage improvement system project of Zagreb City is also reflected in Fig. D.2.1. Improvement works include the following in consideration of the existing system conditions.

(1) Sewage collectors to collect wastewater from settlements or part of town where sewer networks are not provided.

(2) Necessary equipment for better functioning of the system and for proper protection from natural disasters.

(3) Drainage canals and sewer networks for expanded urban area.

(4) Reconstruction/rehabilitation of existing facilities.

(5) Wastewater treatment plant construction.

Main sewers (collector), drainage canals and public sewer networks are to be built in line with the improvement of Zagreb City, especially the suburban areas. According to the existing sewerage improvement plan, a sewer network for a total length of 230 km including all the above-mentioned facilities will be constructed. Of this network, about 150 km of new sewers will be installed in the west and southwest areas, and 100 km of new sewers will be installed at areas on left side of the Sava River.

Reconstruction and repair of existing facilities are given the first priority. The most urgent facility to be repaired is the main sewer (collector) “GOK” Zagreb-Ivanja Reka. However, the work involves difficult technical problems and requires a large cost.

2.2.2 Sewerage Improvement Plan

The central wastewater treatment project of Zagreb (CWWTPZ) is presently ongoing. The treatment plant is proposed at a location extending from the eastern part of Struga to the mouth of the stream Vugrov between the major main sewer and the Sava River. The wastewaters in the right bank side of Zagreb City will be conveyed to the treatment plant located in the left bank. GOK will be closed from Radnička Street to CWWTPZ and a diversion will be constructed from the intake of the stream Bliznec into GOK.

The construction contract for the wastewater treatment plant (WWTP) in Zagreb was concluded with “ZOV” on December 16, 2000. The concessionaire “ZOV” consists of three firms, namely, RWE and SHW in Germany and Vodoprivreda in Zagreb, with SHW as the leading firm.

The main features of the ongoing CWWTPZ are as follows:

(1) Catchment Area

The associated catchment area for the wastewater treatment plant is as follows:

(a) The left riverside: nine (9) district office areas, part of Samobor town, Sv. Nedjelja, Ivanja Reka, and part of Sesvete;

(b) The right riverside: Novi Zagreb area including outlying housing development and the villages.

(2) Target Year

Target year is 2015. The presumed construction period is 2000-2005 and the period of 10 to 15 years is the depreciation period for electro-engine equipment. After that period, the electro-engine equipment must be replaced with one with a new capacity or with the same capacity as the installed one.

(3) Served Population and Industry

The number of inhabitants to be served by the facility is 935,000 composed of 761,600 on the left riverside and 173,400 on the right riverside.

The population equivalent (PE) of industrial wastewater in 2015 is estimated to be 565,000 PE.

The served population equivalent of both domestic and industrial wastewater in 2015 is estimated to be 1,500,000 PE.

(4) Hydraulic load

Hydraulic load is estimated based on water consumption in Zagreb area in 1989 and 1995. According to the "Izmjene i dopune vodnogospodarske osnove grada Zagreba" (modifications and supplementations of water management of Zagreb town), daily water consumption in 2015 is 283,040 m^3, consisting of 228,480 m^3 on the left riverside and 54,560 m^3 on the right riverside of Sava River. The quantity of wastewater is summarized as follows:

	Unit	Present (1997)	Future (2015-2020)
Water Consumption/Household	m^3/day	208,000	283,000
Water Consumption/Industry	m^3/day	90,000	172,500
Population Served	Per Capita	750,000	935,000
Wastewater Flow	m^3/day	238,000	442,370
Population Equivalent	PE	1,000,000	1,500,000

(5) Pollution Load

The organic pollution load into the treatment plant is as follows:

Item	Present Load (1997) (kg/day)	Future (2015-2010)	
		Load (kg/day)	Medium Daily Concentration (mg/l)
BOD_5	60,000	90,000	203
COD_{Cr}	103,050	191,540	433
TSS	91,000	136,430	308
T-N	13,000	19,640	44
T-P	3,000	4,500	10

(6) Main Facilities

The main facilities given below are required.

Type	Name/Location	Diameter (cm)	Length (m)
Collector 1	Collector Culinecka	-	1,200
Collector 2	Inlet Pipe to Spillway	600/200 - 1000/400	5,950
Collector 3	Spillway	1200/400 - 1400/400	4,200
Collector 4	Inlet Pipe to Pumping Station	160 - 300/200	4,200
Collector 5	Collector II Paralelna	200/210	4,100
Collector 6	Force Main	100	4,200
Collector 7	Force Main - WWTP	140	2,200
Drainage	Channel to Sava River (Open)		2,150
Mičevac Pump Station	Capacity: 1.5 m^3/sec		
Wastewater Treatment Plant	Biological Treatment Process		

2.2.3 Wastewater Treatment Plant

(1) Surface Area

The treatment site has been approved under Location Permit UP/1-350-05/96-02/36. The site covers a total area of 100.3 ha as given in the following table. However, the land has not been acquired yet. A transmission line of 110 kV will cross over Plot P1 and no construction is allowed under the line. The area covered by the transmission line is approximately 2.5 ha.

Plot No.	Purpose	Area (ha)
P1	Technical Process	92.8
P2	Separation Structure	0.5
P3	Administration and Operation Facilities	17.0
Total		100.3

(2) Effluent Quality

The receiving water of the CWWTPZ in the Sava River is classified as Category III (less sensitive area) at present. The effluent from the proposed treatment plant shall conform to the following permissible limits of water quality.

Parameter	Concentration (mg/l)	Lowest Reduction Rate (%)
BOD_5 at 20°C	25	70 - 90
COD_{Cr}	125	75
Total Dissolved Substances	35	90

The proposed treatment is the activated sludge process. The concessionaire is expected to propose the optimum wastewater treatment.

(3) Sludge Disposal

The sludge from the treatment plant will be transported to the location chosen by the concerned authorities of Zagreb. Sludge is to be transported from the wastewater treatment plant after stabilization, with maximal content of organic matters of 55%. Without excess water, the minimum solid content of sludge would be 30%.

2.2.4 Construction Cost

Total construction cost of the project is approximately 350 million DM, including construction cost of main collectors, pumping station, and wastewater treatment plant, and land acquisition.

2.2.5 Schedule

The first construction phase is scheduled for 2.5 years, and the second is 6 years.

CHAPTER III SEWERAGE IMPROVEMENT OF SESVETE EAST

3.1 Existing Sewerage System

3.1.1 Service Area and Population

Sesvete is one of the settlements in Zagreb City. The settlement is located in the eastern part of the city and the population is increasing due to the increasing commuters to central Zagreb. Sesvete East covers a part of the Sesvete settlement; i.e., the south-eastern fringe area consisting of eight (8) communities; namely, Sesvestsaka Selnica, Popovec, Sesvetska Sela, Kobiljak, Kraljevaćki Novaki, Dumovec, Dumovečki Lug and Sesvetski Kraljevec. Sesvete East is divided into two (2) areas by the railway. The northern part is mostly residential and the southern part is an industrial zone.

The sewerage system of Sesvete East is independent from that of Zagreb. The existing served population and area of the sewerage system is approximately 11,900 and 554.7 ha, respectively. For the existing service area, see Fig. D.3.1.

3.1.2 Existing Industries

There are two (2) industries registered by Croatian Waters as industrial pollutant. They are listed below and described in Appendix C. The wastewater of the factories is discharged into a neighboring canal with simple or full-scale pre-treatment. The discharged industrial wastewater is finally drained into the Črnec River (upstream tributary of the Lonja River) at Dugo Selo in the downstream. For location of the industries, see Fig. D.3.1.

Code Number	Industry Name	Activity	Pre treatment	Quantity (m^3/year)		Recipient
				1998	1999	
310001	**Agroproteinka**	**Food/Beverage**	**No**	**25,463**	**19,562**	**River**
310248	**Duma Kože**	**Leather**	**Yes**	**31,614**	**31,242**	**River**

3.1.3 Sewer Network

The sewer network collects the municipal wastewater of the service area and discharges it into the Črnec River with no treatment. The system is a combined one and excess rainwater overflows into the local streams. The sewer network is almost completed and the total sewer pipe length is about 42 km. The sewerage service company has been maintaining, repairing and monitoring the sewerage system under the supervision of the local government since 1991. For the existing sewer network, see Fig. D.3.1.

3.1.4 Wastewater Flow and Quality

The JICA Study Team analyzed the quantity and quality of wastewater at the last Dumovec Bridge on November 30, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time		09:30	COD_{Mn}	mg/l	31.0
Flow	m^3/sec	0.126	TSS	mg/l	103.0
pH	-	7.1	T-N	mg/l	27.4
BOD	mg/l	63.0	T-P	mg/l	5.13

3.2 Planning Basis

3.2.1 Service Area, Population and Industries

(1) Service Area and Population

The service area in the Master Plan covers all the eight (8) communities mentioned above and it becomes 836.8 ha with the extension of 282.1 ha. For the extension area, see Fig. D.3.1.

The population in Master Plan service area is approximately 14,800 in 1999. The population growth rate is assumed at 0.95%, which is adopted in the surburban area of Zagreb City. By using this rate, the population in 2015 is estimated to be 17,600.

(2) Industry

Two (2) industries registered by Croatian Waters as industrial pollutant sources are within the Master Plan service area. They should discharge their industrial wastewaters into the municipal treatment plant after necessary pre-treatment so as to comply with the national regulation in all the parameters.

(3) Collection System

The existing service area is collected by combined system, while the proposed extension is to be a separate one.

3.2.2 Wastewater Flow and Quality

(1) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	5,808
Daily Maximum	7,040
Hourly Maximum	10,032

(2) Industrial Wastewater Flow

The wastewater quantity of the above two (2) industries is as estimated individually below. The existing and future daily averages were obtained from Subsections 2.2.5 and 2.3.5 in Appendix C. The future daily maximum and hourly maximum are calculated based on the daily average, considering the operation hour of the industries.

Name of Industry	Quantity (m^3/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
Agroproteinka	228	377	377	564
Duma Kože	509	1,222	1,222	1,833
Total	737	1,598	1,598	2,397

(3) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is projected as follows. In the following table, hourly maximum in rainy period was estimated based on the assumption that the transport collector conveys two times of the dry weather wastewater flow (2Q) to the treatment plant.

Items	Quantity (m^3/day)		
	Municipal	Industry	Total
Daily Average	5,808	1,598	7,407
Daily Maximum	7,040	1,598	8,639
Hourly Maximum (dry)	10,032	2,398	12,430
Hourly Maximum (rainy)	17,132	2,398	19,530

(4) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are summarized below. For the estimation of pollution load of the municipal and industrial wastewaters in the table below, see Subsection 1.3.2 in Appendix D and Subsections 2.2.5 and 2.3.5 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 1,772.6 kg/day. It is equivalent to 29,600 PE when the conversion rate of Person Equivalent is assumed as 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industry	Total	
BOD	1,372.8	399.8	1,772.6	205.2
COD_{Cr}	2,745.6	1,119.3	3,864.9	447.4
TSS	1,601.6	319.8	1,921.4	222.4
T-N	251.7	80.0	331.6	38.4
T-P	57.2	16.0	73.2	8.5

3.3 Proposed Structural Plan

3.3.1 Transport Collector

To transport the wastewater of the eight (8) communities to the treatment plant, seven (7) transport collectors (T1, T0, T2, T3, T4, T5, T6) and one (1) lift pump with the capacity of 2.6 l/sec are designed by the local government. The dimensions of each collector are shown below.

Transport Collector	Length (m)	Diameter (cm)	Slope (‰)
T1	2,492	100-120	1.0
	1,764	60-80	1.25-1.7
	130	60	7.0
T0	1,000	40	2.0
T2	559	40-50	2.0-2.5
T3	815	40-50	1.8-2.5
	20	30	3.0
T4	61	40	2.5
T5	460	30	3.0
	760	10	Force Main
T6	1,377	40-60	1.25-2.0
Total	9,438		

Among the seven (7) transport collectors that finally transport the wastewater into the treatment plant, T1 is the most important. The uppermost 1.0 km of T1 has already been completed and the remaining part of 1.2 km will follow soon.

For the route of transport collectors, see Fig. D.3.1.

3.3.2 Secondary/Tertiary Sewer

It is necessary to install 3,270 m of PVC sewer pipes with diameter of 200 mm to serve the service extension area of 282.1 ha.

3.3.3 Treatment Plant

(1) Location

The construction of a wastewater treatment plant is proposed at the left bank of the Črnec River by the local government. The required surface area of the treatment plant is 36,190 m^2, for which environmental impact assessment (EIA) has been completed. For location of the treatment plant, see Fig. D.3.1.

(2) Treatment Process

Since the capacity of the treatment plant is 29,600 PE and the recipient of effluent from the treatment plant is Lonja-Strug (Category II), Anaerobic Oxic treatment with thickener and mechanical sludge dewatering is proposed based on the selection criteria of the treatment process discussed in Sections 1.4.4 and 1.4.5.

The required surface area is approximately 2.45 ha.

(3) Main Facilities

The main facilities with specification and number are shown below. The effluent is discharged into the Črnec River. The layout of wastewater treatment plant is shown in Fig. D.3.2.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse Screen 2m W	1
	Fine Screen 1m W	1
	Archimedical Screw Pump 5.0 m^3/min × 6m H × 8kw	3
Grit Oil/Sand Removal	2m W × 10m L	2
Parshall Flume	0.3048m (1 ft)	1
Primary Sedimentation Tank	3.0m W × 19.0m L × 3.0m D (Effective Depth)	4
Aeration Tank	5m W × 32.0m L × 5m D	4
Secondary Sedimentation Tank	∅15m × 3.5m D (Effective Depth)	2
Sludge Thickener	∅7m × 4.0m D	1
Mechanical Dewatering	Belt Press Filter 1.5m W × 1.5kw Polymer Mixing 0.4kw	2
Blower	Roots Blower 14m^3/min × 18.5kw (Building: 8m × 15m)	3
Return Sludge	Archimedical Screw Pump 3m^3/min × 3m H × 3.5kw	3
Administration Building	10m W × 10m L	1

3.4 Cost Estimate

The total construction cost is estimated at approx. Kn 66.5 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	9,349.6	14.1	22.6
		Secondary/Tertiary Sewer	1,612.2	2.4	3.9
		Sub-Total	10,961.8	16.5	26.5
	Treatment Plant	Preliminary Treatment	5,135.2	7.7	12.4
		Biological Reactor	7,342.9	11.0	17.8
		Secondary Sedimentation	2,335.7	3.5	5.6
		Sludge Treatment	5,453.2	8.2	13.2
		Others	10,131.6	15.2	24.5
		Sub-total	30,398.6	45.7	73.5
	Sub-total		41,360.4	62.2	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		4,136.0	6.2	-
	Administration		1,240.8	1.9	-
	Customs Duty		1,521.7	2.3	-
	VAT		10,009.2	15.0	-
	Sub-total		16,907.8	25.4	-
Contingency			8,272.1	12.4	-
Total			66,540.3	100.0	-

CHAPTER IV SEWERAGE IMPROVEMENT OF DUGO SELO

4.1 Existing Sewerage System

4.1.1 Service Area and Population

Dugo Selo belongs to Zagreb County and consists of nine (9) settlements. The total administrative area and existing population (1999) and future projection (2015) are shown below compared with the population in 1991.

Item		Urban Center	Rural Area	Total
Area (ha)		299.6	4,922.3	5,221.9
Population	(1991)	6,508	3,461	9,969
	(1999)	10,570	4,756	15,326
	(2015)	12,301	5,535	17,836

The town is divided into two parts by the railway. The part north of the railway is highly developed and the existing sewerage system serves not only the densely populated central urban area (299.6 ha) but also the western settlement of Kopčevec and some surrounding areas. Hence, the existing service area and population of the sewerage system covers approximately 515.9 ha and 9,100, respectively. For the existing service area, see Fig. D.4.1.

4.1.2 Existing Industries

There is no industry registered by Croatian Waters as industrial pollutant in the town.

4.1.3 Sewer Network

The existing sewer network is of the combined type (see Fig. D.4.1). Construction started in 1950 and in the recent four (4) years, 4,000 m of sewer pipe had been installed. With diameters ranging from 30 cm to 120 cm, the total length of the sewer network is 16,541 m. The unit pipe length is 2.5 m with rubber ring.

The sewer network collecting municipal wastewater in the service area discharges the wastewater into the neighboring canals at six (6) outfalls and finally into the Črnec River with no treatment. All wastewaters of the sewerage area are discharged by gravity with no pump. The sewer network is not in good condition; the pipes and manholes are choked with mud here and there in lowland areas.

As for storm water drainage, the sewer is designed to cope with rainfall of 20 minutes duration and two-year return period. There are two (2) overflow chambers of rainwater.

4.1.4 Wastewater Flow and Quality

The JICA Study team analyzed the quantity and quality of wastewater at the Puhovec Bridge on November 27, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time	-	09:30	COD_{Mn}	mg/l	33.0
Flow	m^3/sec	0.046	TSS	mg/l	-
PH	-	7.48	T-N	mg/l	28.0
BOD	mg/l	70.0	T-P	mg/l	3.91

4.2 Planning Basis

4.2.1 Service Area, Population and Industries

(1) Service Area and Population

The extension area is near the fringe of the existing service area where future improvement is expected. It consists of the northeastern settlement of Kozinščak, the former Puhova (now included in urban center of Dugo Selo) and the remaining area of the urban center of Dugo Selo. With the 556.1 ha of extension, the total service area will be 1,072.0 ha and in accordance with the expanded area and the increase of population, the service population will be 14,200. For the extension area, see Fig. D.4.1.

(2) Industry

There is no industry registered by Croatian Waters as industrial pollutant in the Master Plan service area.

(3) Collection System

Both the existing and the proposed extension service areas will be served by the combined system.

4.2.2 Wastewater Flow and Quality

(1) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows. In the table, hourly maximum in rainy period is estimated based on the assumption that the transport collector conveys twice the quantity of dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)
Daily Average	4,686
Daily Maximum	5,680
Hourly Maximum (dry)	8,094
Hourly Maximum (rainy)	15,194

(2) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are summarized below. For the estimation of pollution load of municipal wastewater in the table below, refer to Subsection 1.3.2 in Appendix D.

As shown in the table, the total BOD load generated in the Master Plan service area is 1,107.6 kg/day. It corresponds to 18,500 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)	Concentration (mg/l)
BOD	1,107.6	195.0
COD_{Cr}	2,215.2	390.0
TSS	1,292.2	227.5
T-N	203.1	35.8
T-P	46.2	8.1

4.3 Proposed Structural Plan

4.3.1 Transport Collector

The planned sewerage service area is divided into three (3) parts: middle, east and west. The wastewater of the service area is collected and transported to the treatment plant by three (3) transport collectors; namely, Transport Collector 1, Transport Collector 2 and Transport Collector 3.

Connected to Transport Collector 1 midway to the treatment plant, Transport Collector 2 is to collect wastewater from the eastern part. Also connected to Transport Collector 1 midway to the treatment plant, Transport Collector 3 is to collect wastewater from the western part. Transport Collector 1, on the other hand, is to collect wastewater from the middle part and finally transport all the collected wastewaters of the service area, including the wastewaters conveyed by Transport Collectors 1 and 2, to the treatment plant proposed at the south of

Puhovec on the left bank of the Črnec River. For the route of transport collectors, see Fig. D.4.1.

Main features of the three transport collectors are as follows:

	Diameter (mm)	Material	Length (km)
Transport Collector 1	800	Concrete	0.89
	1,200	Concrete	1.43
Transport Collector 2	800	Concrete	0.50
Transport Collector 3	800	Concrete	1.80
	1,000	Concrete	0.83

4.3.2 Secondary/Tertiary Sewer

There are seven (7) areas extension; namely, the west part of Kopcevec, Dolnje Polje, Crnovcak, Puhovec, Kazinscak, the north of Dubrava and Brezik, as shown in Fig. D.4.1, and the combined system is proposed for all of them. At each existing outfall and connection point with the proposed transport collector, a combined sewer overflow (C.S.O.) is proposed to take in 2Q for discharge to the transport collector.

The required secondary/tertiary sewer is estimated as follows.

Diameter (mm)	Material	Length (km)	Combined/Separate
400	Concrete	29.11	Combined

4.3.3 Treatment Plant

(1) Location

The treatment plant is to be located near the Črnec River and on the southern part of the town (Puhovec) 2.5 km from the center in accordance with the existing Municipality and County Area Plan. This proposed site is private wasteland of 100 m in ground elevation. For location of the treatment plant, see Fig. D.4.1.

(2) Treatment Process

The capacity of the treatment plant (18,500 PE) is larger than 10,000 PE and the recipient of effluent from the plant (Lonja Strug) is Category II. Therefore, Anaerobic Oxic treatment with thickener and mechanical sludge dewatering is proposed (Refer to Sections 1.4.4 and 1.4.5). The required surface area is approximately 1.39 ha.

(3) Main Facilities

The main facilities with specification and number are shown below. The effluent is discharged into the Črnec River. The layout of wastewater treatment plant is shown in Fig. D.4.2.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse Screen 2m W	1
	Fine Screen 1m W	2
	Archimedical Screw Pump 3.6m^3/min × 6m H × 6kw	3
Grit Oil/Sand Removal	2m W × 10m L	2
Parshall Flume	0.3048m (1 ft)	1
Primary Sedimentation Tank	3.0m W × 12.0m L × 3.0m D (Effective Depth)	4
Aeration Tank	5m W × 20.0m L × 5m D	4
Secondary Sedimentation Tank	∅12m × 3.5m D (Effective Depth)	2
Sludge Thickener	∅5m × 4.0m D	1
Mechanical Dewatering	Belt Press Filter 1.5m W × 1.5kw Polymer Mixing 0.4 kw	2
Blower	Roots Blower 10m^3/min × 22kw (Building 7m × 15m)	3
Return Sludge	Archimedical Screw Pump 2m^3/min × 3m H × 3.0kw	3
Administration Building	10m W × 10m L	1

4.4 Cost Estimate

The total construction cost is estimated at approx. Kn 91.0 million, broken down as follows.

Cost	Facilities		Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	8,770.7	9.6	15.5
		Secondary/Tertiary Sewer	22,829.8	25.1	40.2
		Sub-total	31,600.6	34.7	55.7
	Treatment Plant	Preliminary Treatment	4,341.1	4.8	7.6
		Biological Reactor	5,666.3	6.2	10.0
		Secondary Sedimentation	1,687.2	1.9	3.0
		Sludge Treatment	4,317.9	4.7	7.6
		Others	9,141.9	10.1	16.1
		Sub-total	25,154.4	27.7	44.3
	Sub-total		56,755.0	62.4	100.0
Land Acquisition			186.8	0.2	-
Indirect Cost	Engineering		5,675.5	6.2	-
	Administration		1,702.7	1.9	-
	Customs Duties		1,549.7	1.7	-
	VAT		13,734.7	15.1	-
	Sub-total		22,662.6	24.9	-
Contingency			11,351.0	12.5	-
Total			90,955.3	100.0	-

CHAPTER V SEWERAGE IMPROVEMENT OF VRBOVEC

5.1 Existing Sewerage System

5.1.1 Service Area and Population

Vrbovec is one of the urban centers in Zagreb County consisting of 41 settlements. The administrative area and existing population (1999) and future projection (2015) are shown below compared with the population in 1991.

Item		Urban Center	Rural Area	Total
Area (ha)		237.5	15,667.4	15,904.9
Population	(1991)	4,149	9,154	13,303
	(1999)	4,190	9,245	13,435
	(2015)	4,366	9,633	13,999

Vrbovec is located in the catchment area between the Lonja and Glogovnica rivers. It is also situated along the regional road Zagreb-Bjelovar. Establishment of the food processing industry resulted in the urban, industrial and commercial development of the town.

The existing sewerage system serves not only the densely populated central urban area (237.5 ha) but also the western settlement of Martinska Ves, the northern settlement Celine and some surrounding areas. Hence, the existing service area and population of the sewerage system covers about 392.6 ha and 5,000, respectively. For the existing service area, see Fig. D.5.1.

5.1.2 Existing Industries

There are 20 industries registered by Croatian Waters as industrial pollutants, as listed in the table below. Among them, eight (8) industries are served by the sewerage system and the others directly discharge wastewater into the rivers or streams. The food/beverage company "PIK Vrbovec Mesna" discharges a great portion (90%) of the total wastewater quantity of the above registered industries. "PIK Vrbovec Mesna" is one of the biggest companies of meat processing in the country and is the most serious pollutant source in the Sava River Basin. The wastewater is discharged into the Luka Canal after pre-treatment with sedimentation and fat catching. In the table, the three (3) industries in bold characters are the large ones described in Appendix C.

Code Number	Industry Name	Activity	Pre-treatment	Wastewater (m^3/year)		Recipient
				1998	1999	
360010	Galvanotehnika (Galtronik)	Chemicals	No	2,217	1,959	Sewerage
360014	Galvanotehnika	Chemicals	No	2,279	1,318	Sewerage
360016	KOS d.o.o.Benzinska	Chemicals	Yes	1,689	1,940	Brook
360017	Komunalac	Chemicals	Yes	3,614	3,623	Canal
360019	Komunalac	Chemicals	Yes	3,614	3,623	Sewerage
360004	**PIK Vrbovec Mesna Ind.**	**Food/Beverage**	**No**	**624,851**	**615,095**	**Canal Luka**
360006	PIK Svinjogojska Farma	Livestock	Yes	24,180	13,143	Črnec Brook
360008	**PIK Farma Poljanski Lug**	**Livestock**	**Yes**	**12,133**	**25,246**	**Land**
360011	Govedarska Farma Djunadi	Livestock	No	11,563	8,250	Mel Canal
360021	Kalinski, Klaonica Prerada	Food/Beverage	Yes	1,900	2,660	Sewerage
360009	Galoks	Metal (Zn)	Yes	1,834	1,926	River
360013	Jurval d.o.o.	Metal/Machinery	Yes	1,490	868	River/Sewage
360015	Metalcrom	Metal/Machinery	No	-	-	Mel. Canal
360012	Hrvatske Šume	Machinery	No	810	580	Sewerage
360020	Oprema	Metal	Yes	4,935	5,314	Mel. Canal
360005	PIK "Autoservis"	Transportation	Yes	3,443	3,755	Canal Luka
360001	Trgovacki Drusivo Vind	Wood Industry	No	-	705	Mel. Canal

Code Number	Industry Name	Activity	Pre-treatment	Wastewater (m^3/year) 1998	1999	Recipient
360007	Šavrić d.d.Tvornica Masivnog Namještaja Pogon	Wood Industry	No	12,985	-	River
360018	PIK "Motel Vrbovec"	Hotel	No	10,291	12,975	Sewerage
360002	**Gradip d.d.**	**Clay**	**No**	**27,474**	**27,484**	**Sewerage**

5.1.3 Sewer Network

Municipal wastewater, including those of domestic, institutional and small industries in the town, is discharged into the neighboring two (2) brooks, mostly into Luka Brook and partially into Kolešnica Brook, through four (4) main collectors. The PIK meat factory directly discharges industrial wastewater into the Luka Brook through two (2) collectors with simple pre-treatment, while the other two large industries discharge wastewater into the sewerage or on lands with no treatment or with simple pre-treatment.

The sewer network is of combined type constructed since 1977. The total length of the existing sewer pipes is approximately 28 km and the number of sewer connections is 1,100 as of May 2000. The sewer pipes are made of concrete with diameters of 30-120 cm. All wastewaters are discharged by gravity into the channel. The sewerage system is not provided with pumps or treatment plant. The sewer network is still under expansion.

The location of the existing sewer network is shown in Fig. D.5.1. Maintenance of the sewerage system is carried out by "Komunlac d.o.o.Vrvobec".

5.1.4 Wastewater Flow and Quality

Wastewater discharge into the existing sewerage system is roughly estimated at 250,000 m^3/year. The authorized laboratory "Veterinary Institute Krizevci," analyzes the sewage quality at the three (3) outfalls and sends the results to Croatian Waters.

The sewage quality during the recent four (4) years (1996-1999) is given below.

Stream	Outfall	Location	No.*		Flow (l/s)	T (°C)	BOD_5 (mg/l)	COD_{Cr} (mg/l)	TSS (mg/l)	TVS (mg/l)	SS (mg/l)	pH
Kalešnica	No. 1	Livadarska Ulica	42	ave	1.65	9.4	152.5	301.5	487.4	273.0	73.2	7.2
				max	3.00	16.0	283.0	457.0	806.0	520.0	182.0	7.3
				min	0.20	3.0	81.0	157.0	268.0	135.0	16.0	7.1
Luka	No. 2	Kolodvorska Ulica	44	ave	38.36	11.5	94.5	189.6	463.9	269.6	71.1	7.2
				max	85.00	18.0	160.0	317.0	856.0	579.0	169.0	7.4
				min	3.50	4.0	50.0	87.0	298.0	90.0	22.0	7.1
	No. 3	Zagrebačka Ulica	38	ave	3.01	10.6	85.7	176.5	468.0	291.7	58.4	7.2
				max	5.50	19.0	128.0	253.0	1.182.0	816.0	138.0	7.3
				min	1.50	3.0	9.0	91.0	99.0	49.0	20.0	7.1

* Sampling number

The JICA Study Team also analyzed the quantity and quality of wastewater in the manhole at Kolodvorska every three (3) hours from November 30, 2000 to December 1, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	1	2	3	4	5	6	7	8
Day	-	30.11	30.11	30.11	30.11	30.11	1.12	1.12	1.12
Sampling Time	-	11:30	14:30	17:30	20:30	23:30	02:30	05:30	08:30
Flow	m^3/sec	0.0275	0.0300	0.0286	0.0286	0.0286	0.0275	0.0286	0.0286
pH	-	7.60	7.83	7.68	7.72	7.73	7.80	7.87	7.85
BOD	mg/l	77.0	110.0	120.0	120.0	87.0	29.0	31.0	54.0
COD_{Mn}	mg/l	39.0	56.0	66.0	54.0	42.0	16.0	16.0	27.0
TSS	mg/l	85.0	100.0	104.0	100.0	83.0	59.0	64.0	61.0
T-N	mg/l	26.4	29.2	28.3	27.8	22.5	21.8	21.0	30.4
T-P	mg/l	6.85	6.79	6.92	7.94	6.61	2.65	2.57	3.99

5.2 Planning Basis

5.2.1 Service Area, Population and Industries

(1) Service Area and Population

Vrbovec plans to improve all its infrastructure including roads, water supply being delivered from Zagreb City at 12 l/s, sewerage, and electricity based on the new city plan prepared at the beginning of January 2001. The target year is 2015.

Based on the plan, three (3) districts will be served by the sewerage system. At present, the first district is home to several people, while the second district is important for industrial employees. The third one where some people already stay on weekends is planned to be a combination of agricultural and residential zone.

Besides these three districts, some parts of the western settlement of Luka and the northern three settlements of Vrbovečki Pavlovec, Cerje and Topolovec will be served due to their high population density. Thus, the service area will expand by 397.9 ha to 790.5 ha. Accordingly, the served population in the Master Plan service area will be 8,400 inhabitants.

For the extension area, see Fig. D.5.1.

(2) Industry

Among the 20 industries registered by Croatian Waters as industrial pollutant, one (1) big industry, "PIK", and eight (8) other industries in the existing service area will fall under the Master Plan service area. All industries should discharge their industrial wastewater into the municipal treatment plant after pre-treatment in order to comply with the national regulation in all parameters.

Among the above nine (9) industries that are to be served by the proposed sewerage system, two (2) large industries (PIK and Gradip) are dealt as sources of industrial wastewater and the other seven (7) small industries are included in the sources of municipal wastewater in this Study. For location of the two (2) industries, see Fig. D.5.1.

(3) Collection System

The wastewater collection system in the existing service area is the combined type, while that in the proposed extension area will be the separate type.

5.2.2 Wastewater Flow and Quality

(1) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	2,436
Daily Maximum	2,856
Hourly Maximum (dry)	4,032

(2) Industrial Wastewater Flow

The wastewater quantity of each of the two (2) industries mentioned above is estimated individually as shown below. The existing and future daily averages were obtained from Subsections 3.2.5 and 8.2.1 in Appendix C, while the future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the industries.

Industry Name	Quantity (m^3/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
PIK	2,132	3,523	3,523	3,523
Gradip	110	187	187	281
Total	2,242	3,710	3,710	3,803

(3) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is as projected in the following table. The hourly maximum in rainy period was estimated based on the assumption that the transport collector conveys twice of the quantity of dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)		
	Municipal	Industry	Total
Daily Average	2,436	3,710	6,146
Daily Maximum	2,856	3,710	6,566
Hourly Maximum (Dry)	4,032	3,803	7,835
Hourly Maximum (Rainy)	6,287	7,326	13,613

(4) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal and industrial wastewaters, see Subsection 1.3.2 in Appendix D and Subsections 3.2.5 and 8.2.1 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 1,223.5 kg/day. It is equivalent to 20,400 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industry	Total	
BOD	554.4	669.1	1,223.5	186.3
COD_{Cr}	1,108.8	1,458.0	2,566.8	390.9
TSS	646.8	1,224.0	1,870.8	284.9
T-N	101.6	75.4	177.0	27.0
T-P	23.1	14.5	37.6	5.7

5.3 Proposed Structural Plan

5.3.1 Transport Collector

There are three (3) outfalls in Vrbovec at present. The first one discharges wastewater from PIK to the Luka Canal, while the second one discharges wastewater from most of the existing service areas to the Koprivnica Canal. On the other hand, the third one discharges wastewater from the western part of the existing area to the Luka Canal.

To collect and transport the wastewater from the three (3) outfalls, three (3) transport collectors are proposed. Transport Collector 1 will carry the wastewater of the first outfall to the proposed treatment plant, and Transport Collector 2 will independently carry the wastewater of the second outfall to the proposed treatment plant. As for Transport Collector 3, it will carry the wastewater of the third outfall to Transport Collector 1, which will finally discharge all wastewaters into the treatment plant.

For the route of transport collectors, see Fig. D.5.1. No main sewer is proposed.

Main features of transport collectors are as follows.

Location	Diameter (mm)	Material	Length (km)
Transport Collector 1	400	Concrete	0.59
Transport Collector 2	400	Concrete	0.85
Transport Collector 3	350	Concrete	0.44
Total			1.88

5.3.2 Secondary/Tertiary Sewer

There are seven (7) extension areas; namely, Luka, Topolovec, Cerje, Vrbovecki Pavlovec, Borovec, Grobisce and Posjecevina, as shown in Fig. D.5.1. The separate system is proposed for each of the extension areas.

The Luka area is to be connected directly with Transport Collector 1, while the Grobisce area is to be connected with the existing combined main sewer leading to Transport Collector 3. On the other hand, the Posjecevina area is to be connected directly with Transport Collector 1 and the Topolovec area is to be connected with the existing combined main sewer leading to Transport Collector 2. Similarly, the Cerje area is to be connected with the existing combined main sewer leading to Transport Collector 2, and the Vrbovecki Pavlovec area is to be connected with the existing combined main sewer also leading to Transport Collector 2. Besides, the Borovec area is to be connected with the existing combined main sewer leading to Transport Collector 2.

Five (5) manhole type lift pumps are proposed to transport the wastewater of the low-lying extension areas to the existing sewers by force. The required head and capacity of lift pumps are given in the table below. For the location of pumps, see Fig. D.5.1.

Pump Station	Head (m)	Capacity (l/sec)
1	6.0	6
2	5.0	1
3	12.5	41
4	15.0	3
5	5.0	1

The required secondary/tertiary sewers are estimated as follows.

Diameter (mm)	Material	Length (km)	Combined/Separate
200	Concrete	20.3	Separate
100	PVC	3.4	Separate, by force

5.3.3 Treatment Plant

(1) Location

The proposed site is located on the southwestern part of the town, about 2.0 km from the center. Currently it is used for agriculture and has a ground elevation of about 110.8 m. The site is near the railway and the land is owned privately according to the existing Municipal and County Area Plan. For the location of treatment plant, see Fig. D.5.1.

(2) Treatment Process

The capacity of the treatment plant (20,400 PE) is larger than 10,000 PE and the recipient of effluent from the plant (Lonja Strug) is Category II. Therefore, the Anaerobic Oxic treatment with thickener and mechanical sludge dewatering is proposed (Refer to Subsections 1.4.4 and 1.4.5).

The required surface area is about 1.24 ha.

(3) Main Facilities

The main facilities together with the specification and number of units are given below. The effluent is discharged into the Luka Canal. The layout of the wastewater treatment plant is shown in Fig. D.5.2.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse Screen 2m W	1
	Fine Screen 1m W	2
	Archimedical Screw Pump, $3.6m^3/min \times 6m\ H \times 6kw$	3
Grit Oil/Sand Removal	2m W × 10m L	2
Parshall Flume	0.3048m (1 ft)	1
Primary Sedimentation Tank	3.0m W × 12.0m L × 3.0m D (Effective Depth)	4
Aeration Tank	5.0m W × 20.0m L × 5m D	4
Secondary Sedimentation Tank	∅12m × 3.5m D (Effective Depth)	2
Sludge Thickener	∅6.0m × 4.0m D	1
Mechanical Dewatering	Belt Press Filter 1.5m W × 1.5kw Polymer Mixing 0.4kw	2
Blower	Roots Blower $34m^3/min \times 60kw$ (Building 7m × 15m)	3
Return Sludge	Archimedical Screw Pump $2.3m^3/min \times 3m\ H \times 5.5kw$	4
Administration Building	10m W × 10m L	1

5.4 Cost Estimate

The total construction cost is estimated at approx. Kn 78.2 million, broken down as follows.

Item	Facilities		Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	4,127.0	5.3	8.5
		Secondary/Tertiary Sewer	19,104.3	24.4	39.3
		Sub-total	23,231.3	29.7	47.8
	Treatment Plant	Preliminary Treatment	4,298.8	5.5	8.8
		Biological Reactor	6,176.6	7.9	12.7
		Secondary Sedimentation	1,899.7	2.4	3.9
		Sludge Treatment	4,346.0	5.6	8.9
		Others	8,633.7	11.0	17.8
		Sub-total	25,354.9	32.4	52.2
	Sub-total		48,586.1	62.1	100.0
Land Acquisition			199.2	0.2	-
Indirect Cost	Engineering		4,858.6	6.2	-
	Administration		1,457.6	1.9	-
	Customs Duties		1,602.0	2.0	-
	VAT		11,757.8	15.0	-
	Sub-total		19,676.0	25.2	-
Contingency			9,717.2	12.4	-
Total			78,178.6	100.0	-

CHAPTER VI SEWERAGE IMPROVEMENT OF SISAK

6.1 Existing Sewerage System

6.1.1 Service Area and Population

Sisak is the political and economic center of Sisak-Moslavina County consisting of 31 settlements. The administrative area and population including future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		1,769.6	40,373.1	42,142.7
Population	(1991)	45,792	15,621	61,413
	(1999)	44,175	25,108	69,283
	(2015)	44,842	25,487	70,328
Household	(1991)	15,882	5,011	20,893

The town has developed on the flood plains of the Sava, Kupa and Odra rivers. The Sava and Kupa rivers run through the town with large meandering, finally joining at the southern part of the town. On the other hand, the Odra River joins with Kupa River at the northern fringe. These rivers almost enclose the entire urban area of the town.

The Kupa River separates the urban center of the town into two (2) parts. The central business area is located on the low-lying land encompassed by the right bank of Sava River and the left bank of Kupa River, while the industrial zone has developed on the southern end of the left bank of Kupa River.

Sisak is the second biggest industrial center of Croatia after Zagreb. The advantages of transportation including railway connections and highway networks as well as inland navigation on the Danube River have developed the heavy industries of oil refinery and steel industry in Sisak.

The sewerage system covers almost all the urban area of the town. The existing service area and population are 943.6 ha and 39,400 persons or 89% of the total urban population of 44,200 inhabitants. For the existing service area, see Fig. D.6.1.

6.1.2 Existing Industries

There are six (6) industries registered by Croatian Waters as industrial pollutant, as listed in the table below (see, Appendix C). Among them, three (3) industries are served by the sewerage system and the others directly discharge wastewater into the rivers. For the location of the six (6) industries, see Fig. D.6.1.

INA Zagreb Rafinerja Nafte is the largest industrial pollutant. It is the largest company in Croatia dealing with oil and gas exploration/production, refining, transport and distribution of gas and oil products. All industries connected with the sewerage system do not have the necessary pre-treatment capacity.

Code Number	Industry Name	Activity	Pre-treatment	Wastewater (m^3/year) 1998	1999	Recipient
374002	Herbos d.d.	Chemicals	Yes	213,668	157,871	Sewerage
374004	Tvornica Segestica	Food/Beverage	No	80,194 (296,800)	45,265 (214,396)	Sewerage
374006	Žitokombinat Mlin i Pekare	Food/Beverage	No	19,550	23,833	Sewerage
374005	Željezara Poduzeće Metaval	Metal/Machinery	Yes	592,607 (1,630,600)	-	Sava River
374001	INA Zagreb Rafinerija Nafte	Oil Refinery	Yes	3,153,183	3,893,603	Kupa & Sava River
374003	Termoelektrana (420 MW)	Electricity	Yes	85,667 (181,828,109)	98,838 (178,909,717)	Sava River

Note: Figures in parentheses represent cooling water.

6.1.3 Sewer Network

Construction of the sewerage system started in 1946 and construction work is still ongoing. The sewerage system of the town is of combined type. Domestic, institutional and industrial wastewaters including those of some large industries are discharged through nine (9) outfalls into the Sava, Kupa and Odra rivers.

The sewerage service area is divided into two (2) areas: Old Sisak encompassed by the Sava, Kupa and Odra rivers, and New Sisak extending on the right banks of the Kupa and Sava rivers. Old Sisak covers Zeleni Brijeg, Galdovo Kaptolsko, 22 Lipanj and Vrbina areas, and New Sisak includes Viktorovac, Eugen Kvaternik, Caprag and Ivan Buic Viktorovac, Eugen Kvaternik, Caprag and Ivan Buic areas.

The sewerage service areas, outfalls, receiving rivers and major pollutant sources are given below.

Collection Area		Outfall		Recipient	Potential Contaminator
Old Sisak	Zeleni Brijeg, Galdovo, Kaptolsko, 22 Lipanj, Vrbina	1. PS Galdovo		Sava River	Petrol Station on Rimska Street, Autopromet, Mill and Bakers, Herbos, Segestica, Railway Station, Hotel Panonija, Catering Facilities, Workshops
		9. PS Odra		Odra River	Ina-Trgovina, Petro Station on Sagrebacka Street, Catering Facilities, Workshops
New Sisak	Viktorovac, Eugen Kvaternik, Caprag, Ivan Buicna	Northern Urban Area	3. Žitna	Kupa River	Residential Building, Catering Facilities, Workshops
			4. Mažuranićeva	Kupa River	Residential Building, Sisak Hospital
			5. Pedišićeva	Kupa River	Residential Building
			6. Victorovac	Kupa River	Metal Faculty, Craft and Elementary School
		South Industrial and Urban Area	7. Školska	Kupa River	Residential Building, Catering Facilities, Workshops
			8. Novo Praćno	Kupa River	Residential Building, Workshops
			2. Željezara	Sava River	Residential Building, Catering Facilities, Workshops, Technical and Elementary School, Petrol Station in M Cvetkovic Street, Sisak Suburb Railway Station

The entire area of Old Sisak is drained through two (2) outfalls each with a pumping station; namely, the PS Galdovo that discharges into the Sava River and the PS Odra that discharges into the Odra River. On the other hand, all of New Sisak is drained by gravity through seven (7) outfalls.

The main features of the two (2) pumping stations are given below.

PS Name	Pump Number	N (kw)	Capacity (l/sec)	Head (m)
P.S. Galdovo	No.1	125	800 - 1,500	4 - 5.5
	No.2	125	800 - 1,500	4 - 5.5
	No.3	125	800 - 1,500	4 - 5.5
	No.4	40	500 - 700	4 - 5.5
	No.5	40	500 - 700	4 - 5.5
	Total	455	3,400 - 5,900	
P.S. Odra	No.1	90	1,060	9
	No.2	90	1,060	9
	No.3	4.5	20.4	9
	No.4	4.5	20.4	9
	No.5	4.5	20.4	9
	Total	193.5	2,181	

The total length of the existing sewer pipes is approximately 77 km consisting of 22 km of main collectors and 55 km of secondary sewers. They are mainly made of concrete and reinforced concrete, and partly of asbestos-cement. The maximum and minimum diameters are 200 cm and 20 cm, respectively. Due to the low slope of the existing sewer pipe, a lot of sediment had accumulated inside. Pipe joints are not the water resistant type.

For the existing sewer network, see Fig. D.6.1.

6.1.4 Wastewater Flow and Quality

The municipal wastewater (including domestic and institutional) and industrial wastewater (including those of three large industries: Singlestick, Herbos and Mini i Pekoe Ljudevit) are discharged into the above nine (9) outfalls with no treatment. The town observed the flow discharge of the nine (9) outfalls several times in 1998. The average wastewater quantity, served population and receiving river of each outfall are given below.

Outfall No.	Served Population	Wastewater Discharge		Recipient
		m^3/day	m^3/year	
1	16,637	3,120	1,138,800	Sava River (II)
2	8,068	2,707	988,055	
3	4,832	580	211,700	Kupa River (II)
4	930	325	211,700	
5	200	24	8,760	
6	250	34	12,410	
7	6,922	2,389	871,985	
8	500	29	10,585	
9	1,300	156	56,940	Odra River (II)
Total	39,379	9,364	3,417,860	

Note: (II) denotes the category of river water

The wastewater quality was analyzed at five (5) outfalls several times each during 1997 to 1999. The average, maximum and minimum values of quality at each outfall are given below.

River	Outfall	No.*		Flow (l/s)	T (°C)	BOD_5 (mg/l)	COD_{Cr} (mg/l)	TSS (mg/l)	TVS (mg/l)	SS (mg/l)	pH
Sava	PS Galdovo	9	Ave	124.8	15.8	212.3	208.5	1,036.7	613.8	74.3	7.4
			Max	136.0	23.0	463.0	567.0	2,631.0	1,255.0	152.0	8.1
			Min	108.0	8.8	18.5	41.1	308.0	169.0	37.0	6.5
Kupa	Žitna	8	Ave	69.4	13.4	79.2	115.3	689.0	291.8	124.5	7.8
			Max	89.6	21.0	169.0	261.0	1,729.0	352.0	239.0	8.2
			Min	47.0	8.6	12.0	40.0	322.0	223.0	51.0	7.3
	Mažuranićeva	9	Ave	0.0	16.8	180.2	172.4	821.4	477.7	246.3	7.9
			Max	0.0	25.2	247.0	404.0	1,888.0	958.0	1,374.0	10.3
			Min	0.0	9.5	86.0	40.0	446.0	295.0	37.0	6.5
	Ladjarska	9	Ave	36.6	12.2	11.2	20.9	387.6	268.8	27.7	7.6
			Max	36.9	19.0	19.2	34.3	708.0	504.0	86.0	8.4
			Min	35.9	6.0	6.0	11.0	282.0	188.0	5.0	7.0
	Školska	6	Ave	50.5	13.8	33.5	50.0	362.7	225.0	74.7	7.7
			Max	55.0	24.0	50.5	82.7	457.0	276.0	142.0	8.1
			Min	46.0	9.5	17.0	24.0	273.0	182.0	34.0	7.0

* No. of sampling

The JICA Study Team also analyzed the quantity and quality of wastewater in the manhole at the Galdovo pumping station at Kolodvorska every three (3) hours from January 25, 2001 to January 26, 2001 and the results for major parameters are given below. For the other parameters, see Table B.4.3 in Appendix B.

	Unit	1	2	3	4	5	6	7	8
Day		25.01	25.01	25.01	25.01	25.01	26.01	26.01	26.01
Sampling Time		10:00	13:00	16:00	19:00	22:00	01:00	04:00	07:00
Flow	m^3/sec	0.09	0.09	0.09	0.09	0.10	0.09	0.07	0.15
pH		7.45	9.35	8.67	7.70	7.49	7.53	7.57	8.48
BOD	mg/l	30.0	41.0	37.0	29.0	28.0	37.0	18.0	24.0
COD_{Mn}	mg/l	42.0	51.0	49.0	37.0	36.0	45.0	24.0	28.0
TSS	mg/l	133.0	201.0	119.0	101.0	62.0	272.0	23.0	159.0
T-N	mg/l	42.0	42.4	40.6	79.1	33.4	38.1	29.9	51.5
T-P	mg/l	4.73	7.17	8.03	7.21	6.60	6.89	4.73	3.71

6.2 Planning Basis

6.2.1 Service Area, Population and Industries

(1) Service Area and Population

Since almost all urban centers are already served by sewerage system, the extension will cover some portions of the northwestern four (4) settlements (Staro Pračno, Žabno, Odra Sisačka, Stupno) and portion of the eastern settlement (Budaševo). With the extension involving some 1,436.4 ha, the total service area will be 2,380.0 ha. For the extension area, see Fig. D.6.1.

Served population in the Master Plan service area will be 52,400 in accordance with the area extension and increase of population.

(2) Industry

Among the six (6) industries located in the Master Plan service area, the three (3) big industries (Zeljezara, INA, Termoelektrana) will continue to directly discharge their wastewaters into the river even after completion of the municipal sewerage system. The remaining three (3) industries (Herbos, Segestica, Mlin i Pekare) will discharge their wastewater into the sewerage system as at present. All the three (3) industries should discharge their industrial wastewater into the municipal sewerage system after pre-treatment in order to comply with the national regulation in all parameters.

(3) Collection System

The existing service area has the combined system, while the proposed extension will have the separate type.

6.2.2 Wastewater Flow and Quality

(1) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	17,292
Daily Maximum	20,960
Hourly Maximum	29,868

(2) Industrial Wastewater Flow

The wastewater quantity of the three (3) industries to be served by the sewerage system is as estimated below. The existing and future daily averages were obtained from Subsections 4.3.5, 4.5.5 and 4.7.5 in Appendix C. The future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the industries.

Industry Name	Quantity (m^3/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
Herbos	604	939	939	939
Segestica	204	337	337	506
Mini i Pekave Ljudevit	83	137	137	137
Total	891	1,413	1,413	1,582

(3) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the transport collector conveys twice the quantity of dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)		
	Municipal	Industry	Total
Daily Average	17,292	1,413	18,705
Daily Maximum	20,960	1,413	22,373
Hourly Maximum (dry)	29,868	1,582	31,450
Hourly Maximum (rainy)	55,268	3,164	55,432

(4) Quality of Wastewater

The pollution load and influent quality expected into the treatment plant are given in the table below. For the estimation of pollution load of municipal and industrial wastewater, see Subsection 1.3.2 in Appendix D and Subsections 4.3.5, 4.5.5 and 4.7.5 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 4,398.2 kg/day. This is equivalent to 73,400 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industrial	Total	
BOD	4,087.2	311.0	4,398.2	196.6
COD_{Cr}	8,174.4	873.6	9,048.0	404.4
TSS	4,768.4	564.5	5,332.9	238.3
T-N	749.3	94.7	844.0	37.7
T-P	170.3	5.7	176.0	7.9

6.3 Proposed Structural Plan

6.3.1 Transport Collector/Main Sewer

At present, wastewaters are directed to the Galdovo pumping station for discharge into the Sava River in Old Sisak and to the six (6) outfalls in New Sisak for discharge into the Kupa River. Out of the six (6) outfalls in New Sisak, the one at Isput Pedisceva is not out of operation.

A New Sisak Transport Collector along the right bank of the Kupa River is proposed to collect wastewaters to the functioning five (5) outfalls and direct them to the treatment plant proposed in New Sisak. Another collector named Old-New Transport Collector coming from the Galdovo pumping station is to be connected to the New Sisak Transport Collector near the railway bridge. In addition to these new transport collectors, a supplemental pipe with the diameter of 1,700 mm is to be installed for approximately 0.53 km in Old Sisak to resolve the present shortfall of capacity for the design flood.

(1) Study on Alternatives

Alternatives are considered on two (2) points. One point is the route of the collector from Stupno, Zabno and St. Pracno, which are all settlements on the west bank of the Odra River, and the other point is the way in which the Old-New Transport Collector will cross the Kupa River to join the New Sisak Transport Collector. The former point is wheter to connect the collector from the west bank to New Sisak by crossing the Kupa River or to Old Sisak by crossing the Odra River. The latter point is whether to cross the Kupa River by siphon installed beneath the riverbed or by a pressured pipe attached to the existing railway bridge over the river.

Combination of the two (2) points makes the following four (4) alternatives:

(a) Alternative 1

The area on the west bank of the Odra River is to be connected with the New Sisak crossing the Kupa River and the Old-New Transport Collector crossing the Kupa River by siphon.

(b) Alternative 2

The area on the west bank of the Odra River is to be connected with the New Sisak crossing the Kupa River and the Old-New Transport Collector crossing the Kupa River by hanging on the existing railway bridge.

(c) Alternative 3

The area on the west bank of the Odra River is to be connected with the Old Sisak crossing the Odra River and the Old-New Transport Collector crossing the Kupa River by siphon.

(d) Alternative 4

The area on the west bank of the Odra River is to be connected with the Old Sisak crossing the Odra River and the Old-New Transport Collector crossing the Kupa River by hanging on the existing railway bridge.

The above alternatives are shown in Fig. D.6.2. The results of comparison among the four (4) alternatives are summarized as follows:

Alternative		1	2	3	4
Transport Collector (mm)	New Sisak	∅450 – ∅1,000 5.78 km	∅450 – ∅1,000 5.78 km	∅450 – ∅1,000 5.78 km	∅450 – ∅1,000 5.78 km
	Old-New	∅800 0.56 km	∅400 0.5 km	∅800 0.56 km	∅400 0.5 km
Kupa River Crossing of Old-New Transport Collector		Siphon	Railway Bridge	Siphon	Railway Bridge
Route from the West Bank of the Odra River		To New Sisak	To New Sisak	To Old Sisak	To Old Sisak
Pumping Station		1 (22 kw × 2)	1 (75 kw × 2) 1 (18.5 kw × 3)	1 (22 kw × 2)	1 (75 kw × 2) 1 (18.5 kw × 3)
Siphon		2	1	2	1
Constructability		Not easy for the Siphon	Easy	Not easy for the Siphon	Easy
Construction Cost ($\times 10^6$ kn)		10.4	8.4	8.9	6.8
Annual O&M Cost ($\times 10^3$ kn/year)		64	300	64	300
Total Present Value Cost ($\times 10^6$ kn)		11.2	12.1	9.6	10.5

In the above table, the total cost including construction and O&M costs of the four (4) alternatives is compared in terms of present value at the discount rate of 5%. Since crossing of the Kupa River by hanging the collection on the existing railway bridge would require a large pumping station to transport the wastewater by pressure, Alternative 4 would require a large annual O&M cost although the construction cost is the lowest.

From the above discussions, Alternative 3 is recommended. For details of the cost comparison, see Table D.6.1.

(2) Transport Collector

The main features of proposed transport collectors are summarized in the following table. As for route, see Fig. D.6.1.

Diameter (mm)	Material	Length (km)	Location
800	Concrete	0.37	Old - New Transport Collector
500 × 2	Concrete	0.19	Old - New Transport Collector with siphon
450	Concrete	1.42	New Sisak Transport Collector (Žitna - Victorovac)
500	Concrete	0.36	New Sisak Transport Collector (Victrobac - Rail Bridge)
600	Concrete	0.89	New Sisak Transport Collector (Rail Bridge - Školska)
1,000	Concrete	3.11	New Sisak Transport Collector (Školska - WWTP)
Total		6.34	

(3) Pumping Station

One (1) pumping station with two (2) lift pumps and with the following head and capacity is required. For the location of pumping station, see Fig. D.6.1.

Pumping Station	Head (m)	Capacity (l/second)
1	6.0	168

(4) Main Sewer

A main sanitary sewer in the Stupno, Zabno, and St. Pracno areas is proposed to connect with the "Old Sisak Transport Collector" crossing the Odra River. Its diameter ranges from 250 mm to 450 mm and its length is 3.8 km. A sanitary sewer in Pogorelac is also proposed to connect with the "New Sisak Transport Collector".

A pressured main sanitary sewer in the Galdovo and Goricica areas is proposed to connect with the proposed treatment plant by running along a bridge near Crnac. Its diameter ranges from 250 mm to 300 mm and its length is 4.93 km. A pressured sanitary sewer in Moscenica is also proposed to connect the proposed manhole type pumping station and discharge into the existing combined main.

The main features of main sewers for the extension are as shown in the following table. As for routes, see Fig. D.6.1.

Diameter (mm)	Material	Length (km)	Combined/Separate
250	Concrete	3.10	Main Sewer in Stupno
400	Concrete	0.40	Main Sewer in Stupno – Old Sisak
150 × 2	Concrete	0.10	Main Sewer with Siphon in the Odra River
Sub-total		3.60	
250	Concrete	1.50	Main Sewer in Galdovo
300	Concrete	2.00	Main Sewer in Galdovo
150	PVC	0.73	Main Sewer (Pressured) in Galdovo
Sub-total		4.23	
Total		7.83	

6.3.2 Secondary/Tertiary Sewer

There are eight (8) sewer extension areas; namely, Stupno, Zabno, St. Pracno, Galdovo, Goricica, Crnac, Pogorelac and Moscenica, and a separate system is proposed for all of them. The length and diameter of sewer is 36.55 km and 200 mm, respectively.

Furthermore, six (6) manhole lift pumps with the following head and capacity are required. For the location of manhole lift pumps, see Fig. D.6.1.

Pump Station	Head (m)	Capacity (l/sec)
1	6	32
2	6	47
3	5	16
4	5	16
5	28	16
6	10	5

6.3.3 Treatment Plant

(1) Location

The proposed location of the treatment plant is on the southeastern part of Sisak nearby the oil refinery "INA" on the right side of the Sava River. Presently, it is wasteland with the ground elevation of about 98.5 m. Since the town owns the treatment plant site of 9 ha, no cost for land acquisition will be required. Floods sometimes occur in this area. For the location of treatment plant, see Fig. D.6.1.

(2) Treatment Process

The capacity of the treatment plant (73,400 PE) is larger than 10,000 PE and the recipient of effluent from the plant (the Lower Sava) is Category II. Therefore, Anaerobic Oxic treatment with thickener and mechanical sludge dewatering is proposed (refer to Subsections 1.4.4 and 1.4.5).

The required surface area is 6.34 ha.

(3) Main Facilities

The main facilities together with specification and number of units are shown below. Effluent of the wastewater treatment plant is discharged into the Kutina River. The layout of the plant is shown in Fig. D.6.3.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse Screen, 2m W Fine Screen, 1m W	1 2
	Archimedical Screw Pump, 12.0m^3/min × 10m H × 19kw	5
Grit Oil/Sand Removal	5m W × 17m L	2
Parshall Flume	0.3048m (1 ft)	1
Primary Sedimentation Tank	4.0m W × 18.0m L × 3.0m D (Effective Depth)	8
Aeration Tank	5m W × 39.0m L × 5m D	8
Secondary Sedimentation Tank	∅17m × 3.5m D (Effective Depth)	4
Effluent Pumping Station	Vertical Axial Flow Pump, 10.0m^3/min × 6m H × 15kw (Building, 10m × 13m)	5
Sludge Thickener	∅10m × 4.0m D	2
Mechanical Dewatering	Belt Press Filter, 2.0m W × 2.2kw Polymer Mixing, 0.75kw	4
Blower	Roots Blower 20m^3/min × 60kw (Building, 10m × 25m)	3
Return Sludge	Archimedical Screw Pump, 6m^3/min × 3m H × 5.5kw	4
Administration Building	10m W × 15m L	1

6.4 Cost Estimate

The total construction cost is estimated at approx. Kn 159.8 million, broken down as follows.

Cost		Facilities	Cost (×10^3 Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	17,751.1	11.1	17.8
		Secondary/Tertiary Sewer	25,398.0	15.9	25.5
		Sub-Total	43,149.1	27.0	43.3
	Treatment Plant	Preliminary Treatment	8,202.3	5.1	8.2
		Biological Reactor	13,923.3	8.7	14.0
		Secondary Sedimentation	5,136.3	3.2	5.2
		Sludge Treatment	10,055.3	6.3	10.1
		Others	19,179.4	12.0	19.2
		Sub-Total	56,496.7	35.4	56.7
	Sub-total		99,645.8	62.4	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		9,964.6	6.2	-
	Administration		2,989.4	1.9	-
	Customs Duties		3,151.2	2.0	-
	VAT		24,114.3	15.1	-
	Sub-total		40,219.4	25.2	
Contingency			19,929.2	12.5	-
Total			159,794.4	100.0	-

CHAPTER VII SEWERAGE IMPROVEMENT OF KUTINA

7.1 Existing Sewerage System

7.1.1 Service Area and Population

Kutina, consisting of 23 settlements is situated in the Moslavina region of Sisak-Moslavina County midway of the main railway between Zagreb and Vinkovci. The establishment of the industrial complexes of Petrokemija, Čajara and Glinara resulted in the urbanization of the town whose administrative area and population including future projection (2015), are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		901.9	28,615.9	29,517.8
Population	(1991)	14,992	9,837	24,829
	(1999)	16,800	6,252	23,052
	(2015)	19,679	7,323	27,002

The sewerage system serves 548.9 ha covering the central urban area, the western settlement Repušnica and some surrounding areas. The existing served population is 16,100. The wastewater of the town is discharged into a lateral canal of the Kutina river system with preliminary treatment. The Kutina River runs through the town from the northern hilly areas to the southern lowlands and finally empties into the Sava River through the Lonjsko Polje reserved areas.

For the existing service area, see Fig. D.7.1.

7.1.2 Existing Industries

There are 12 industries registered by Croatian Waters as industrial pollutants, as given in the table below. Six (6) of them discharge wastewater into the public sewerage, and the others discharge it directly into the rivers and canals. The wastewater quantity of "Petrokemija" is enormous compared to the others. Most of the registered industries are provided with pre-treatment plant, but plant capacity is insufficient and hence, the wastewater quality does not meet the permissible limits of the government regulation. The industries in bold characters are the large ones described in Appendix C.

Code Number	Industry Name	Activity	Pre-treatment	Wastewater (m3/year) 1998	Wastewater (m3/year) 1999	Recipient
357009	**Petrokemija Kutina - Tech.**	**Chemicals**	**Yes**	**4,375,377**	**3,454,549**	**Trebež River**
357016	**Petrokemija Kutina - Sanitary**	**Chemicals**	**Yes**	**245,817**	**238,120**	**Sewerage**
357010	Moslavačko Vinogorje	Food/Beverage	Yes	-	-	Mel. Canal
357015	VAJDA Stočarstvo Zgb	Food/Beverage	Yes	-	-	Mel. Canal
357004	Čazmatrans Tehnički Pregled	Transportation	Yes	-	-	Sewerage
357011	Čazmatrans Autokuća	Transportation	Yes	2,223	-	Sewerage
357005	Dom Zdravlja	Ambulance	Yes	-	-	Sewerage
357006	Crosco Naftni Servisi	Oil Service	Yes	11,804	-	Brook
357008	INA Petrokemija Metan	Oil & Gas	-	-	-	Sewerage
357014	Naftaplin Skaladište	Oil & Gas	Yes	2,252	-	Mel. Canal
357012	Autopraonica vl. Zoran Kramarić	Car Wash	Yes	-	-	River
357013	Autopraonica Spužvica, vl. Damir Korica	Car Wash	Yes	-	-	Sewerage

"Petrokemija" is one of the biggest chemical industries in Croatia. It produces chemical fertilizer (about 1 million ton/year), carbon black and bentonite clays. Most of the raw materials are imported and the fertilizers are produced from raw phosphates, sulphur, and natural gas. The plant also produces ammonia, nitric acid, sulphuric acid, phosphoric acid, urea and nitrogen. The consumption of fertilizers for agriculture in the country decreased by more than 40% in 1998 compared with that in 1988. Due to this negative trend, the industry is not in full operation. Almost all of the industrial wastewaters of the town come from this industry.

The process wastewater system of Petrokemija is not connected to the public sewerage system. It is discharged into the Kutinski Canal after treatment in the industry. The sanitary wastewater system is however connected to the public sewerage.

Process wastewater containing ammonia and nitrates is treated by the ion-exchange method. Wastewater from sulphuric acid production, phosphoric (both through neutralization by lime), and urea (hydrolister stripper, recycling released ammonia back into the processes) are treated separately. However, the existing capacity of the process wastewater treatment system is insufficient, and it is only partially working. Hence, the effluent quality does not meet the standards.

7.1.3 Sewerage System

(1) Sewer Network

The existing sewerage system in the urban area is of combined type. The wastewater of this urban area is collected and transported to the treatment plant located at the southern fringe of Grad Kutina. On the other hand, some fringe areas covering small settlements are served by the separate sewerage system and wastewater is discharged into the neighboring streams with no treatment.

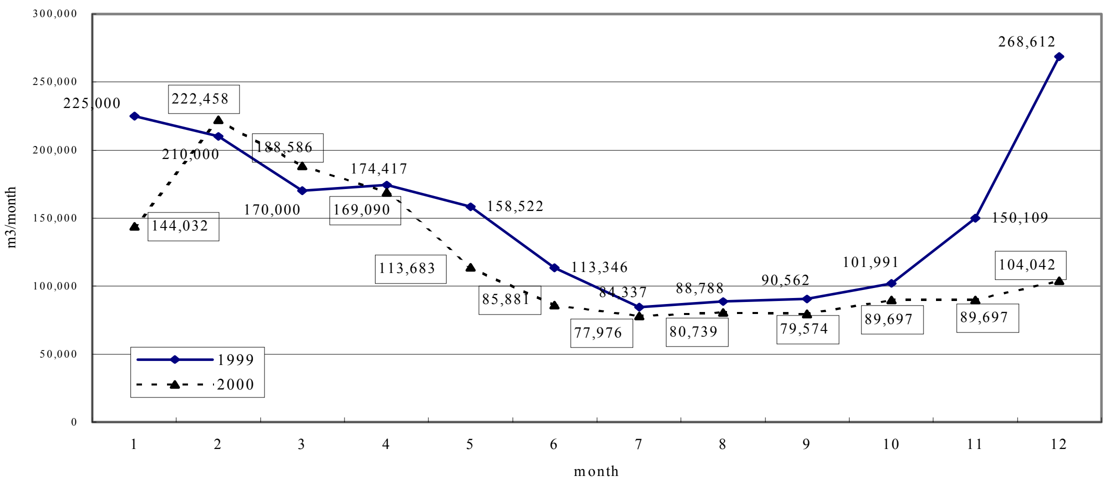
Total length of the existing sewer pipes is 45 km and diameter is 30-180 cm. The sewerage system is not provided with pumps. All the wastewater is collected and transported by gravity.

For the existing sewer networks and location of the treatment plant, see Fig. D.7.1.

(2) Treatment Plant

The surface area of the central wastewater treatment plant is 5 ha. Only mechanical facilities (preliminary treatment) were constructed in June 1990 as the first stage of the project and started operation in November of the same year. The second stage project of biological treatment is further expected.

The monthly wastewater flow into the treatment plant based on the measurement device in 1999 and 2000 are shown in the figure below. Due to the combined system, a lot of wastewater including storm water is discharged into the treatment plant. The annual quantity including storm water was 1,860,000 m^3 in 1999, with "Petrokemija" sharing 230,000 m^3 of sanitary wastewater. In 2,000, it was 1,446,000 m^3.



The treatment plant treats wastewater at 150 m^3/hour or 3,600 m^3/day on average in the dry season. The existing plant includes the following facilities:

(a) Rainwater spillway of the retention basin

(b) Inlet pumping station of screw pumps with a stage I capacity

(c) Automatic fine grids with a final capacity
(d) Aerated sand and fat trap with a final capacity
(e) Measuring device with a final capacity
(f) Transformer station with a final capacity
(g) Administrative building
(h) Other infrastructures

The treatment plant does not receive the wastewater quantity and load designed for Stage I due to the inadequate collection system for wastewater. The fats collected into a concrete shaft (tank) are dumped on the solid waste disposal site of the town. The treatment efficiency of the plant is low (10-15%) because it is provided with only the preliminary treatment process.

The sewerage system is operated and maintained by Moslavina d.o.o. Kutina.

7.1.4 Wastewater Flow and Quality

The wastewater quantity and the quality of effluent from the treatment plant are analyzed periodically and the results are sent to Croatian Waters. The data on the analyzed effluent during 1998-1999 are summarized below.

Outfall/address	No.		Flow (l/s)	T (°C)	BOD5 (mg/l)	CODCr (mg/l)	TSS (mg/l)	SS (mg/l)	pH
Inlet of Treatment Plant	7	Ave	-	9.8	88.3	130.9	449.6	60.8	7.7
		Max	-	18.5	246.0	424.0	565.0	204.0	8.5
		Min	-	1.0	35.6	36.5	350.0	28.6	7.1
Outfall to Lat. Canal Kutina-Ilova	7	Ave	52.36	9.9	64.9	105.1	423.0	27.9	7.7
		Max	87.20	19.0	166.0	313.0	475.0	33.7	8.5
		Min	40.50	1.0	22.6	28.5	369.0	23.2	7.1

The JICA Study Team also analyzed the quantity and quality of wastewater at the effluent outlet of the treatment plant every three (3) hours from December 8, 2000 to December 9, 2000, and the results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

	Unit	1	2	3	4	5	6	7	8
Day	-	8 Dec.	8 Dec.	8 Dec.	8 Dec.	8 Dec.	9 Dec.	9 Dec.	9 Dec.
Sampling Time	-	11:00	14:00	17:00	20:00	23:00	2:00	5:00	8:00
Flow	m^3/sec	0.0383	0.0297	0.030	0.0292	0.0336	0.0253	0.0175	0.015
pH	-	7.24	8.08	7.91	8.06	7.69	7.69	7.63	7.88
BOD	mg/l	15.0	33.0	39.0	38.0	35.0	37.0	22.0	16.0
COD_{Mn}	mg/l	24.0	41.0	48.0	42.0	44.0	46.0	34.0	24.0
TSS	mg/l	32.0	59.0	26.0	29.0	58.0	62.0	35.0	26.0
T-N	mg/l	28.2	37.7	41.9	42.9	44.0	46.0	34.0	29.1
T-P	mg/l	5.23	6.16	6.29	6.91	6.94	6.59	6.19	5.40

On the other hand, the government regulates the permissible limits of effluent quality as follows.

Parameter	Permissible Limits of Effluent
Total Oil and Fats	25.0 mg/l
Mineral Oil	-
BOD_5	80% of Influent
COD_{Mn}	-
TSS	60.0 mg/l

7.2 Planning Basis

7.2.1 Service Area, Population and Industries

(1) Service Area and Population

The extension area is proposed to be the surrounding area neighboring the existing service area, because it could be served easily by extending the sewer pipe. Besides the remaining urban center of Kutina, the extension area includes some parts of the western settlement of Repušnica, the eastern two settlements of Husain and Batina, and the northern two settlements of Kutinska Slatina and Šartovac. With the extension of 753.7 ha, the total service area will be 1,302.6 ha. For the extension areas, see Fig. D.7.1.

The served population in the Master Plan service area will be 24,800 according to the area extension and increase of population.

(2) Industry

Six (6) industries will be served by the proposed sewerage system. Among them, only one (1) large factory (Petrokemija) is dealt in this Study as the source of industrial wastewater and the other small five (5) industries are included in the sources of municipal wastewater. For location of the Petrokemija industry, see Fig. D.7.1.

Petrokemija will discharge only sanitary wastewater into the public sewerage even in the future. The process wastewater will be discharged into the neighboring canal as at present with the necessary treatment.

(3) Collection System

Wastewaters of existing service area will be collected by the existing combined system. Wastewaters of the proposed extension area will be by the separate one.

7.2.2 Wastewater Flow and Quality

(1) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	8,184
Daily Maximum	9,920
Hourly Maximum	14,136

(2) Industrial Wastewater Flow

The wastewater quantity of the Petrokemija is as estimated below. The existing and future daily averages were obtained from Subsection 5.2.5 in Appendix C. The future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the industry.

Industry Name	Quantity (m^3/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
Petrokemija	663	1,063	1,063	1,063

(3) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the transport collector conveys twice of the quantity of dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)		
	Municipal	Industry	Total
Daily Average	8,184	1,063	9,247
Daily Maximum	9,920	1,063	10,983
Hourly Maximum (dry)	14,136	1,063	15,199
Hourly Maximum (rainy)	23,986	2,126	26,112

(4) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are as summarized in the table below. For the estimation of pollution load of municipal and industrial wastewaters, see Subsection 1.3.2 in Appendix D and Subsection 5.2.5 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 1,974.3 kg/day. It is equivalent to 32,900 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industry	Total	
BOD	1,954.4	19.9	1,974.3	177.9
COD_{Cr}	3,868.8	61.2	3,930.0	357.8
TSS	2,256.8	423.1	2,679.9	244.0
T-N	354.6	52.1	406.9	37.0
T-P	80.6	5.3	85.9	7.8

7.3 Proposed Structural Plan

7.3.1 Main Sewer

It is not necessary to construct a new transport collector in Kutina, because the existing main sewers have enough capacity to carry wastewater from the extension area. One (1) main sewer with the diameter of 400 mm for a total length of 0.18 km is however proposed to integrate the eastern fringe area that is not currently covered by the treatment plant and discharge the wastewater directly into the neighboring brook.

7.3.2 Secondary/Tertiary Sewer

There are 12 areas of sewer extension: Repusnica, Lipa, Vinogradsvia, Kutinska Slatina, Sartvac, Misinka, Novo Brdo, Husain, Batina, Kutinsko Selo and Radricko Nasclje. The separate system is proposed for all the extension areas.

The western part, Repusnica, is connected to an existing combined main with the diameter of 800 mm. A manhole type pumping station is proposed on the low part. Lipa is connected by gravity to an existing combined main with the diameter of 800 mm, while Vinogradsvia is connected to an existing combined main, which was originally designed to receive this area.

The northern part, Kutinska Slatina and Sartovac, is connected to an existing main, which was originally designed to receive this area. On the other hand, the eastern part, Misinka, Novo Brdo and Husain, is connected to an existing combined main. Since some parts of Husain are already covered by a combined system that discharges into a stream, a combined sewer overflow (C.S.O.) is proposed at the connection point to take in 2Q.

The ground slope in Kitinsko Selo declines from north to south, so that near the highway a manhole type of pumping station is proposed to pump wastewater to the treatment plant by pressure. Radnicko Nasclje is connected directly to the treatment plant inlet channel.

As shown in Fig. D.7.1, six (6) lift pumps are proposed. Their required head and capacity are shown below.

Pump Station	Head (m)	Capacity (l/sec)
1	5.0	4
2	15.0	5
3	5.0	2
4	5.0	1
5	5.0	2
6	5.0	1

The summary of extension sewers is as follows:

Diameter (mm)	Material	Length (km)	Combined/Separate
200	Concrete	40.35	Separate
100	PVC	5.7	Separate, Pressure

7.3.3 Treatment Plant

(1) Location

The existing plant is located at the southern part of the town nearby the Kutina highway interchange where ground elevation is about 100 m. "MOSLAVINA d.o.o. Kutina", the public service company in charge of water supply, wastewater and solid waste disposal, owns the land of the existing wastewater treatment plant that has enough space for the extension works. Therefore, no cost for land acquisition will be required.

(2) Treatment Process

The capacity of the treatment plant (32,900 PE) is larger than 10,000 PE and the recipient of effluent from the plant, Lonja Strug, is Category II. Therefore, Anaerobic Oxic treatment with thickener and mechanical sludge dewatering is proposed (refer to Subsections 1.4.4 and 1.4.5).

The required surface area is 2.81 ha including the existing plant area.

(3) Main Facilities

The main facilities, together with the specification and number of units, are given in the table below. The effluent is discharged into the Sava River. The layout of wastewater treatment plant is shown in Fig. D.7.2.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse Screen, 2m W Fine Screen, 1m W	(1) (2)
	Archimedical Screw Pump $12.0m^3/min \times 6m\ H \times 19kw$ $9.0m^3/min \times 6m\ H \times 14kw$	 (2) (1)
Grit Oil/Sand Removal	5m W × 17m L	(1)
Parshall Flume	0.3048m (1 ft)	(1)
Primary Sedimentation Tank	4.0m W × 18.0m L × 3.0m D (Effective Depth)	4
Aeration Tank	5m W × 64.0m L × 5m D	4
Secondary Sedimentation Tank	∅17m × 3.5m D (Effective Depth)	2
Sludge Thickener	∅8m × 4.0m D	2
Mechanical Dewatering	Belt Press Filter 1.5m W × 2.2kw Polymer Mixing 0.75kw	2
Blower	Roots Blower $34m^3/min \times 60kw$ (Building 10m × 25m)	3
Return Sludge	Archimedical Screw Pump $9m^3/min \times 5m\ H \times 5.5kw$	3
Administration Building	10m W × 15m L	1

Note: Number of units in parenthesis are existing.

7.4 Cost Estimate

The total construction cost is estimated at approx. Kn 84.0 million, broken down as follows.

Cost	Facilities		Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	292.6	0.3	0.6
		Secondary/Tertiary Sewer	27,535.6	32.8	52.5
		Sub-Total	27,828.2	33.1	53.0
	Treatment Plant	Preliminary Treatment	1,567.0	1.9	3.0
		Biological Reactor	8,005.1	9.5	15.3
		Secondary Sedimentation	2,568.1	3.1	4.9
		Sludge Treatment	5,027.6	6.0	9.6
		Others	7,472.9	8.9	14.2
		Sub-total	24,640.9	29.3	47.0
	Sub-total		52,469.1	62.5	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		5,246.9	6.2	-
	Administration		1,574.1	1.9	-
	Customs Duties		1,480.5	1.8	-
	VAT		12,697.5	15.1	-
	Contingency		20,999.0	25.0	-
	Sub-total		10,493.8	12.5	-
Total			83,961.9	100.0	-

CHAPTER VIII SEWERAGE IMPROVEMENT OF KARLOVAC AND DUGA RESA

8.1 Existing Sewerage System

The sewerage systems of Karlovac and Duga Resa are independent of each other at present. However, the two systems are planned to be integrated into one to treat the wastewater of both towns through the central treatment plant proposed on the right bank of the Kupa River immediately downstream of Karlovac. Since the transport collector between Duga Resa and the treatment site is mostly completed, the existing systems of the two towns are described together below.

8.1.1 Service Area and Population

(1) Karlovac

Karlovac, consisting of 56 settlements, is the administrative center of Karlovac County. The administrative area and population including future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		952.0	39,203.4	40,155.4
Population	(1991)	59,999	13,427	73,426
	(1999)	52,000	8,000	60,000
	(2015)	53,000	7,000	60,000

The town had developed on the flood plains of the Kupa, Korana and Mrežnica rivers. The three (3) rivers join at the town, and Dobra joins the Kupa River in the upstream. The town is linked to Zagreb City by a superhighway and a railway. This had resulted in the intensive urbanization and development of industries. In the upstream after Karlovac, the town of Duga Resa is located along the Mrežnica River.

Approximately 28,200 inhabitants, or 54% of the urban population (47% of total population), are served by the sewerage system. The sewerage system covers 965.7 ha including the urban center and some surrounding areas. The served settlements and communities are roughly divided into four (4) districts: Grad (Dubovac, Borlin, Novi Centar, Grabik, Zvjezda, Rakovac, Gaza and Luščić), Banija (Banija and Drežnik), Švarča and South Industrial Zone. Domestic and industrial wastewater, and part of storm water are mainly discharged into the Kupa and Mrežnica rivers through public sewers and several industrial sewers. All the remaining people of the town (approximately 32,000) treat wastewater by septic tanks.

(2) Duga Resa

Duga Resa, consisting of 28 settlements, is located immediately upstream after Karlovac along the Mrežnica River. The administrative area and population including future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		184.6	5,979.3	6,163.9
Population	(1991)	7,513	6,575	14,088
	(1999)	8,266	7,234	15,500
	(2015)	8,425	7,075	15,500

Only some parts of the urban center of Duga Resa and some parts of the northwestern settlement Petrakovo Brdo are covered by the sewerage system, and the existing service area and population are 133.1 ha and 3,800 inhabitants, respectively.

8.1.2 Existing Industries

(1) Karlovac

A number of industries (29) are registered by Croatian Waters as industrial pollutants, as given in the table below. Among them, 19 industries are served by the sewerage system and the others directly discharge into the rivers or streams. Karlovačka Pivovara, which produces beer, is the largest pollution source. A large quantity of wastewater from the industry is discharged into the public sewerage with no treatment. The industries in bold characters are the large ones described in Appendix C.

Code Number	Industry Name	Activity	Pre-treatment	Wastewater (m^3/year) 1998	Wastewater (m^3/year) 1999	Recipient
333007	KA-Plast	Chemicals	Yes	-	381	Sewerage
333013	Kemijsko Građevinska Industrija	Chemicals	Yes	7,423	5,631	Sewerage
333019	**Linde Plin d.o.o.**	**Chemicals**	**No**	**27,304**	**23,288**	**Mel Canal**
333004	Karlovačka Industrija Kože	Leather	No	18,100	-	Kupa River
333014	Boneja-prerada Kože	Leather	No	5,438	1,833	Sewerage
333006	**Karlovačka Pivovara**	**Food/Beverage**	**No**	**585,015**	**595,347**	**Sewerage**
333015	**PPK-Karlovačka Industrija Mesa**	**Food/Beverage**	**No**	**93,094**	**64,282**	**Kupa River**
333016	**Karlovačka Industrija Mlijeka**	**Food/Beverage**	**Not Work**	**73,493**	**38,531**	**Kupa River**
333003	**Kordun**	**Metal/Machinery**	**Yes**	**35,869**	**27,689**	**Sewerage**
333008	**ZE-CE**	**Metal/Machinery**	**Yes**	**74,497**	**77,799**	**Sewerage**
333009	ŽE-ČE	Metal/Machinery	-	-	-	Sewerage
333010	**Tvornica Plinskih Turbina**	**Metal/Machinery**	**Yes**	**33,372**	**-**	**Sewerage**
333011	**Adria-Diesel**	**Metal/Machinery**	**Yes**	**37,000**	**27,067**	**Sewerage**
333017	**ABB d.d.tv.Energetskih Trojenja**	**Metal/Machinery**	**No**	**-**	**-**	**Sewerage**
333026	Liga d.o.o.	Metal/Machinery	Yes	-	-	Sewerage
333027	Croatia Pumpe d.d.	Metal/Machinery	No	-	10,281	Sewerage
333028	TPK Strojevi Kamanje	Metal/Machinery			-	Mel Canal
333002	Kontex d.d.	Textile	Yes	-	-	Sewerage
333005	**Velebit**	**Textile**	**Yes**	**48,117**	**56,717**	**Kupa River**
333012	**Lola Ribar**	**Textile**	**Yes**	**85,762**	**76,177**	**Mrežnica R.**
333025	Beti Trikolazac Žakanje	Textile	Yes (Bio)	-	-	Žakanje Brook
333021	JP Hrvatske Ceste	Transportation	No	-	-	Sewerage
333022	Automehanika d.d.	Transportation	Yes	-	5,010	Canal Ilovac
333029	**Autotransport d.d.**	**Transportation**	**Yes**	**-**	**25,888**	**Sewerage**
333001	Finvest-Corp d.d. Čabar-PC Impregnacija	Wood Industry	Yes	30,637	12,796	Mel. Canal, Polive-Mlaka
333018	Švarča Restoran Društvene	Restaurant	No	-	-	Sewerage
333023	Karlovačka Industrija Obuće	Shoes Factory	No	-	-	Sewerage
333020	Merkur-Lok Autopraonice	Car Wash	Yes	4,103	6,818	Sewerage
333024	Arka Obrt za Trgovinu i Pranje Motornih Vozila	Car Wash	Yes	-	-	Mel Canal

(2) Duga Resa

The industries registered by Croatian Waters as industrial pollutants in Duga Resa are listed below. A large quantity of industrial wastewater is discharged into the Mrežnica River from Pamučna Industrija with no treatment. The industry in bold characters is the large one described in Appendix C.

Code Number	Industry Name	Activity	Pre-treatment	Wastewater (m^3/year) 1998	1999	Recipient
331001	**Pamučna Industrija**	**Textile**	No	**520,977**	**448,640**	**Mrežnica River**
331002	Specijalna Bolnica i Gerijatrija	Hospital	Yes	8,837	-	Mrežnica River
331004	Autopraona 2D-Mag	Car Wash	No	-	-	Sewerage

8.1.3 Sewer Network

The municipalities of Karlovac and Duga Resa established a Master Plan of integrated sewerage improvement in 1989. The main components of the project are: (i) the construction of a central treatment plant on the right bank of the Kupa River (Strong district of Gornje Mekušje settlement), 3 km east of the urban center of Karlovac Town; (ii) the intercept of all the wastewaters discharged from Duga Resa Town, Švarča and the South Industrial Zone of Karlovac into the Mrežnica River and their transport to the treatment plant; and (iii) the collection of all the wastewaters of the Grad and Banija areas of Karlovac and transport them to the treatment plant.

On the other hand, the domestic water of Karlovac Town is supplied from the wells located on the right and left banks of the lower Korana River (after the confluence with Mrežnica River). Since the wastewaters of Duga Resa, Švarča and the South Industrial Zone are potential pollution sources to these groundwater sources/wells, construction of the transport collector between Duga Resa and the treatment plant (South Transport Collector) is considered essential to protect the sources of domestic water of Karlovac Town.

With regard to the South Transport Collector, the planned total length and diameter are 11 km and 80-120 cm, respectively. It is almost completed except the siphon crossing the Korana River. The transport collector connecting Duga Resa with the siphon under the Mrežnica River is under construction.

The existing sewerage systems of the two (2) towns, Karlovac and Duga Resa, are both the combined type. The systems cover a total area of 1,098.8 ha; namely, 965.7 ha for Karlovac and 133.1 ha for Duga Resa. The existing sewerage systems in Karlovac and Duga Resa are shown in Fig. D.8.1.

(1) Karlovac

Construction of the sewerage system started in 1920. The combined sewer system of the town covers 965.7 ha, serving 28,200 inhabitants at present. The total sewer length is approximately 90 km of circular or egg-shaped pipe with diameter of 30-300 cm. The whole system is subdivided into four (4) systems: Grad, Banija (Banija I, Banija II and Drežnik), Švarča, and South Industrial Zone. The main features of these subsystems are described below.

(a) Grad

The Grad system is a combined one covering 617 ha in Dubovac, Borlin, Novi Centar, Grabik, Rakovac, Music, Zvijezda (old center) and Gaza. Approximately 70% of this subsystem has been completed. The wastewater of the coverage area is discharged into the Kupa River by gravity at Gaza during normal time. However, during high river water level exceeding +380 cm, the wastewater is discharged to the river by the pumping station (Šanac), which has a capacity of 2.5 m^3/s, through a force main of 600 m with the diameter of 140/210 cm.

The total sewer length of this subsystem is 69,500 m. The sewer pipes are made of concrete with the diameter of 30/40 cm to 140/210 cm. The diameter of the Grad outfall is 140/210 cm.

Connected to the sewerage system are 16,917 people, and the industries of Kaplast, Pivovara, Industrija Obuce, Autotransport and others.

(b) Banija

The Banija subsystem covers 113.5 ha on the left bank of the Kupa River. The wastewater is drained by gravity into the Kupa River through the outfalls of Banija I, Banija II and Drežnik during normal time. A lower part of the sewer network is affected by backwater during high river water level.

(i) Banija I

The total sewer length of Banija I is 4,285 m; namely, 305 m of main sewer and 3,980 m of secondary/tertiary sewer. The sewer pipes are made of concrete with diameters of 40 cm, 40/60 cm, 30/45 cm and 50/75 cm. The diameter of the outfall is 50/75 cm. Connected to the sewerage system are 3,511 inhabitants, and the industries of Kemijsko Gradevinska Industrija, Kordun and others.

(ii) Banija II

The total sewer length of Banija II is 4,719 m; namely, 299 m of main sewer and 4,420 m of secondary/tertiary sewer. The sewer pipes are made of concrete with diameters of 40 cm to 60/90 cm. The diameter of the outfall is 90/130 cm. Connected to the sewerage system are 2,629 inhabitants, and the industries of Kontex and others.

(iii) Drežnik

The total sewer length of Drežnik is 2,710 m including 20 m of main sewer. The sewer pipes are made of concrete with diameters of 40 cm, 50 cm and 60 cm. The diameter of the outfall is 60/90 cm. Connected to the system are 1,143 inhabitants. No industry is connected.

(c) Švarča

The total sewer pipe of Švarča is 4,064 m long; namely, 1,080 m of main sewer and 2,984 m of secondary/tertiary sewer. The sewerage system serves 4,000 inhabitants.

(d) South Industrial Zone

The South Industrial Zone has seven (7) subsystems mostly serving industries. Every subsystem has its own outfall into the Mrežnica River. The industries of ABB, Adria-Diesel, Croatia Pumpe, Tvornica Plinskih Turbina, ZE -ČE, Švarča Restaurant Drustvene Prehrane and others are connected to these subsystems.

Since most of the trunk sewers of the town are old and not sealed, caving of roads often occur resulting in unpredictable and high expenses for restoration. The reconstruction of sewage pipe in the Grad area is urgent. The major problems in the sewer maintenance are as follows:

(a) Groundwater infiltration into sewers and foul water dispersion into groundwater during dry time.

(b) Excess water inflow from the external catchments that causes flooding in the urban areas.

(c) Risk of groundwater pollution in the Mekušje area by the wastewater discharge into the Mrežnica River. The wells existing in the Mekušje area supply the drinking water of Karlovac.

(2) Duga Resa

Duga Resa Town is served by the combined sewerage system with a total sewer length of 9,200 m at present. The Duga Resa sewerage system that connects with the South Transport Collector is under construction. The wastewater of the town is at present directly discharged through outfalls into the Mrežnica River because the siphon crossing the Korana River in the South Transport Collector is not yet completed.

8.1.4 Wastewater Flow and Quality

(1) Karlovac

There are five (5) major sewage outfalls in the town; namely, Grad, Drežnik, Banija I, Banija II and Švarča. The outfalls of Grad, Banija I and Banija II discharge both domestic and industrial wastewater. However, Drežnik and Švarča drain only domestic wastewater.

The town observed the wastewater discharge of the above outfalls several times in 1999. The wastewater quantity, served population and served industries of each outfall are given below.

Outfall	Average Wastewater		Served Population		Served Industries
	m^3/day	m^3/year	Household	Population	
Grad	11,012	3,549,087	4,229	16,917	Kaplast, Pivovara, Industrija Obuce, Autotransport and Others
Banija I	1,223	336,960	878	3,511	Kemijsko Gradevinska Industrija, Kordun and Others
Banija II	533	141,299	657	2,629	Kontex and Others
Drežnik	166	60,653	286	1,143	None
Švarča	584	213,408	1,000	4,000	None
Total	13,518	4,301,407	7,050	28,200	

Source: Croatian Waters

The authorized laboratory periodically analyzes the wastewater quality of the above outfalls, and the results are sent to Croatian Waters. The quality of wastewater discharged by the outfalls (Grad, Banija I, Banija II and Drežnik) into the KupaRiver (Category II) during 1998 to 1999 is summarized below.

Outfall	No.*		Flow (l/s)	Flow (l/s)	T (°C)	BOD_5 (mg/l)	COD_{Cr} (mg/l)	TSS (mg/l)	TVS (mg/l)	SS (mg/l)	pH
Grad	5	Ave	231.0	17.0	461.0	943.8	762.0	415.2	242.6	49.2	7.0
		max	399.0	20.3	554.0	1,546.0	1,116.0	650.0	371.0	90.0	7.3
		min	158.0	14.0	423.0	615.0	548.0	230.0	134.0	13.0	6.6
Banija I	5	Ave	14.8	16.7	124.0	308.0	579.2	352.4	162.0	35.8	7.7
		max	16.1	19.1	222.0	547.0	850.0	574.0	202.0	61.0	8.2
		min	12.3	11.5	43.0	139.0	320.0	148.0	75.0	19.0	7.4
Banija II	7	Ave	8.0	19.1	507.0	1,019.8	2,095.0	1,438.4	263.6	71.4	8.5
		max	12.8	28.0	950.0	2,490.0	4,776.0	3,340.0	418.0	141.0	9.2
		min	3.3	5.6	82.0	275.0	1,122.0	682.0	101.0	33.0	7.6
Drežnik	5	Ave	3.5	15.9	116.6	281.0	523.2	319.6	142.4	29.6	7.6
		max	5.7	19.0	214.0	498.0	806.0	518.0	249.0	73.0	7.8
		min	2.6	10.4	37.0	99.0	312.0	162.0	55.0	9.0	7.5

* Sampling number

The JICA Study Team also analyzed the quantity and quality of wastewater at the pumping station before the Kupa River on November 29, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time		09:30	COD_{Mn}	mg/l	138.0
Flow	m^3/sec	0.126	TSS	mg/l	111.0
pH		7.1	T-N	mg/l	37.7
BOD	mg/l	460.0	T-P	mg/l	8.6

(2) Duga Resa (1996-1999)

The authorized laboratory periodically analyzes the wastewater quality at outfalls, and the results are sent to Croatian Waters. The quality of wastewater discharged by the four (4) outfalls (A, C, D and G) into the Mrežnica River (Category II) during 1996 to 1999 is summarized below.

Outlet (Location)	No.*		Flow (l/s)	T (°C)	BOD_5 (mg/l)	COD_{Cr} (mg/l)	TSS (mg/l)	TVS (mg/l)	SS (mg/l)	VS (mg/l)	pH
A (Kod Ljoma)	19	Ave	0.12	15.3	154.3	356.1	1,138.2	318.3	281.4	41.0	7.4
		Max	0.20	21.0	493.0	758.0	3,278.0	628.0	1,117.0	152.0	7.9
		Min	0.10	10.0	28.0	94.0	368.0	156.0	30.0	9.0	7.1
(Kod Vinice)	19	Ave	0.11	13.6	261.7	457.9	1,124.5	358.3	235.8	44.5	7.6
		Max	0.20	20.0	477.0	812.0	7,998.0	832.0	443.0	204.0	8.3
		Min	0.10	6.0	64.0	158.0	360.0	172.0	60.0	12.0	7.1
(Kod Doma Sportova)	19	Ave	0.41	13.5	110.3	228.1	457.2	261.4	153.2	34.9	7.7
		Max	4.00	17.0	295.0	528.0	740.0	390.0	305.0	121.0	8.2
		Min	0.10	8.0	11.0	26.0	200.0	74.0	13.0	5.0	7.0
(Kod Mlina)	19	Ave	0.15	12.9	53.1	138.3	453.9	295.6	108.4	19.4	7.5
		Max	0.30	19.0	293.0	627.0	1,000.0	600.0	210.0	41.0	8.1
		Min	0.10	8.0	14.0	26.0	324.0	182.0	23.0	3.0	7.1

* Sampling number

The JICA Study Team also analyzed the quantity and quality of wastewater in the manhole before the Mrežnica River on November 29, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time		10:40	COD_{Mn}	mg/l	28.0
Flow	m^3/sec	0.0039	TSS	mg/l	119.0
pH		7.1	T-N	mg/l	8.77
BOD	mg/l	31.0	T-P	mg/l	1.19

8.2 Planning Basis

8.2.1 Service Area, Population and Industries

(1) Service Area and Population

(a) Karlovac

The first priority is given to the pollution control of the Mrežnica River. Almost all of the areas along both sides of the Mrežnica River are residential zones and some industries are located at the right bank in the southwestern settlement of Mala Švarča. Due to this situation, the southwestern three (3) settlements of Turanj, Mala Švarča and Lugorište on the right bank and the remaining area in Švarča on the left bank will be covered by the sewerage system.

The Gornje Mekušje settlement near the treatment site will also be served since it is located along the route of the South Transport Collector.

A meat factory, "PPK", is located along the Kupa River and discharges wastewater with high organic load directly into the Kupa River at present. The district of 42.8 ha including this factory and the surrounding area will be covered by the Master Plan service area since it is near the existing service area and can be covered easily by extending the existing sewer pipe.

Further, there is a plan to construct an industrial zone in the northern suburbs of Banija located on the left bank of the Kupa River. The surface area is 322.2 ha and the quantity generated in this area will be included in designing only the transport collector/main sewer and not the treatment plant because the construction of industrial zone will start only after 2015.

With the extension of 1,012.6 ha, the total service area in Karlovac will be 1978.3 ha and served population in the Master Plan service area will be 55,800 according to the extension of service area and increase of population. This area does not include the future industrial zone mentioned above.

(b) Duga Resa

The urban center of Duga Resa, together with the suburban northern two (2) settlements of Gornje Mrzlo Polje and Donje Mrzlo Polje, the northwestern settlement of Petrakovo Brdo, and the southeastern settlement of Mrežnički Varoš, will be included in the Master Plan service area. With the extension of 71.9 ha, the total service area in Duga Resa will be 205.1 ha. Service population in the Master Plan service area will be 10,900 according to the area extension and increase of population.

For the extension areas of Karlovac and Duga Resa, see Fig. D.8.1.

(2) Industry

All industries to be served by the proposed Master Plan sewerage system should discharge their wastewaters into sewerage system after pre-treatment in compliance with the national regulation in all the quality parameters. For the location of the 12 large industries in Karlovac and Duga Resa, see Fig. D.8.1.

(a) Karlovac

In addition to the 19 industries in the existing service area, three (3) other industries in the extension service area, which are registered by Croatian Waters among the industrial pollutants, will be covered.

Among the above 22 industries to be covered by the proposed Master Plan service area, 11 large industries (Kordun, Pivovara, PPK, KIM, ABB, Ze-Če, TPT, Adria Diesel, Velebit, Lola Ribar and Autotransport) are dealt in this Study as sources of industrial wastewater, and the other smaller industries are included in the sources of municipal wastewater.

(b) Duga Resa

Among the three (3) industries registered by Croatian Waters as industrial pollutant, only one (1) industry, "Pamučna Industrija," which discharges wastewater into the Mrežnica River at present, will be served under the Master Plan service area. This is a large industry and it is dealt as a source of industrial wastewater.

(3) Collection System

Wastewaters of the existing service areas are collected by the combined system, while the proposed extension is by the separate one in principle.

8.2.2 Wastewater Flow and Quality

(1) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)		
	Karlovac	Duga Resa	Total
Daily Average	18,414	3,597	22,011
Daily Maximum	22,320	4,360	26,680
Hourly Maximum	31,806	6,213	38,019

(2) Industrial Wastewater Flow

The wastewater quantity of the 12 large industries is estimated as shown below. The existing and future daily averages were obtained from Chapter 6 and Section 8.3 in Appendix C. The future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the industries.

Town	Industry Name	Quantity (m^3/day)			
		1999	2015		
		Daily Average	Daily Average	Daily Maximum	Hourly Maximum
Karlovac	Kordun	128	212	212	318
	Pivovara	2,301	3,802	3,802	3,802
	PPK	348	609	609	914
	KIM	250	510	510	765
	ABB	240	397	397	596
	Ze-Če	305	504	504	756
	TPT	134	221	221	332
	Adria Diesel	129	213	213	320
	Velebit	248	410	410	615
	Lola Ribar	307	507	507	760
	Autotransport	104	172	172	258
Duga Resa	Pamučna Industrija	2,417	3,992	3,992	3,992
Total		6,911	11,595	11,595	13,427

(3) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the transport collector conveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)				
	Municipal		Industry		Total
	Karlovac	Duga Resa	Karlovac	Duga Resa	
Daily Average	18,414	3,597	7,603	3,992	33,606
Daily Maximum	22,320	4,360	7,603	3,992	38,275
Hourly Maximum (Dry)	31,806	6,213	9,435	3,992	51,446
Hourly Maximum (Rainy)	52,356	9,313	15,766	7,984	85,419

(4) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal and industrial wastewaters, see Subsection 1.3.2 in Appendix D, and Chapter 6 and Section 8.3 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 7,015.5 kg/day. It is equivalent to 117,000 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)					Concent-ration (mg/l)
	Municipal		Industry		Total	
	Karlovac	Duga Resa	Karlovac	Duga Resa		
BOD	4,352.4	850.2	1,333.9	479.0	7,015.5	183.3
COD_{Cr}	8,704.8	1,700.4	3,495.3	1,149.7	15,050.1	393.2
TSS	5,077.8	991.9	1,829.3	1,105.8	9,004.7	235.3
T-N	797.9	155.9	117.3	19.2	1,090.3	28.5
T-P	181.4	35.4	43.5	3.1	263.3	6.9

8.3 Proposed Structural Plan

8.3.1 Transport Collector/Main Sewer

(1) General

The proposed integrated sewerage system for Karlovac and Duga Resa is divided into three (3) parts; namely, the Grad area, the Banija area and the Karlovac-Duga Resa area. Wastewaters of the three (3) areas are to be transported through the respective transport collectors to a central treatment plant proposed at a site east of Karlovac Town (settlement Gornje Mekušje).

(a) Karlovac-Duga Resa

The wastewater of Karlovac-Duga Resa area is to be conveyed through the South Transport Collector to the treatment plant. The South Transport Collector is almost complete except the siphon that will cross the Korana River. The remaining works should be completed and, in addition, some sub-transport collectors and main sewers are necessary in order to connect the proposed service area to the South Transport Collector.

Wastewater in the left bank area of Duga Resa is discharged into the Mrežnica River through several outfalls at present. Hence a sub-transport collector is proposed to intercept the wastewater and to discharge it into the South Transport Collector. On the other hand, the right bank area of Duga Resa is provided with no sewer at present. Hence, a main sewer is proposed to connect the area to the South Transport Collector.

Wastewater in the Švarča area on the left bank of the Mrežnica River is discharged into the river through an outfall at present. A sub-transport collector is thus proposed to connect the Švarča area to the South Transport Collector. For crossing the Mrežnica River, a siphon is also proposed.

(b) Grad

Wastewater in the Grad area on the right bank of the Kupa River is discharged into the river through an outfall located at Gaza area at present. A transport collector (Grad Transport Collector) is thus proposed to intercept the wastewater and to transport it to the treatment plant.

(c) Banija

Wastewater in the Banija area on the left bank of the Kupa River is discharged into the river through four (4) outfalls at present. A transport collector (Banija Transport Collector) with a sub-transport collector (covering part of Banija area: Drežnik) is thus proposed to intercept the wastewater and to transport it to the treatment plant.

(2) Alternative Study on Banija and Grad Transport Collectors

Alternatives are considered for the route of Banija Transport Collector and the method of transport (with or without lift pump) of Grad Transport Collector. The following four (4) alternatives are prepared by combining the route and method of transport.

(a) Alternative 1

The Banija Transport Collector is to be connected to the Grad Transport Collector after crossing the Kupa River by siphon. Then the wastewater of both areas is to be transported to the treatment plant through the Grad Transport Collector, which will be provided with siphon to cross the Korana River but without a lift pump at the midway.

(b) Alternative 2

Wastewater of the two (2) areas is to be separately transported to the treatment plant. The Banija Transport Collector will run along the left bank of the Kupa River to bypass the urban center of the town, and cross the river by siphon in the downstream near the treatment plant. A lift pump is provided in the midway.

The Grad Transport Collector will be the same as Alternative 1 although the discharge capacity is to be different.

(c) Alternative 3

The route of Banija Transport Collector will be the same as Alternative 1. However, a lift pump is to be installed on the Grad Transport Collector immediately after the connection with Banija Transport Collector.

(d) Alternative 4

The route of Banija Transport Collector is the same as Alternative 2. A lift pump is to be constructed in the midway. On the other hand, the Grad Transport Collector is to be provided with a lift pump.

For the routes of the Banija-Grad alternative transport collectors, see Fig. D.8.2. The main features, constructivity and required total cost (including construction and O&M costs) of the above four (4) alternatives are compared in the following table.

Item	Alt. 1	Alt. 2	Alt. 3	Alt. 4
Pipe Diameter (mm)	300 - 1,700	300 - 1,700	300 - 1,700	300 - 1,700
Pipe Length (m)	8,120	10,950	8,120	10,950
Number of Pumping Stations	0	1	1	2
Number of Siphons	2	2	2	2
Constructivity	Not easy in the Urban Center	Easy	Not easy in the Urban Center	Easy
Construction Cost ($\times 10^6$ Kn)	46.5	59.0	23.2	41.8
Annual O&M Cost ($\times 10^3$ Kn)	111	175	175	216
Total Present Value Cost ($\times 10^6$ Kn)	47.9	61.2	25.3	44.5

In this cost comparison, the total cost is estimated in terms of present value at 5% discount rate. For the calculation of present cost values, see Table D.8.1.

As evident in the above table, Alternative 3 is recommendable.

(3) Proposed Transport Collector and Main Sewer

As mentioned before, five (5) transport collectors/sub transport collectors/main sewer are proposed to transport the wastewater of Banija, Grad, Švarča and Duga Resa to the central treatment plant in the settlement Gornje Mekušje. The proposal is as elaborated further below.

Transport collectors and sub-transport collectors are planned to discharge two (2) times of the design dry weather wastewater flow (2Q), as mentioned in Chapter I Subsection 1.3.3. The design dry weather wastewater flow is estimated for each sewerage service area, targeting the year 2015. On the other hand, the north suburban area of Banija is expected to develop for industrial purposes in the future after 2015. The relevant three (3) transport collectors: Drežnik Sub-Transport Collector, Banija Transport Collector and Grad Transport Collector will then be designed to include an additional wastewater flow generated from the suburban areas based on the request of the local government. The additional design wastewater flow is assumed at a quantity equivalent to 30,000 people or 15,000 m^3/day in hourly maximum.

The Drežnik Sub-Transport Collector will collect the wastewater of Drežnik area (part of Banija area) at two (2) outfalls. It will be connected with the Banija Transport Collector, and the diameter of pipes would range from 300 mm to 350 mm for a length of 2.88 km.

The Banija Transport Collector will collect the wastewater of Banija area at two (2) outfalls (Banija 1 and Banija 2) and further receive the wastewater from the Drežnik Sub-Transport Collector. Thereafter, it will cross the Mrežnica River by siphon in order to connect with the Grad Transport Collector. The diameter of pipes would range from 700 mm to 800 mm for a length of 2.46 km.

The Grad Transport Collector will collect the wastewater of Grad area at the Šanac pumping station and is to be connected with the Banija Transport Collector from that location. It will run to the wastewater treatment plant, crossing the Korana River by siphon in the midway. The diameter of pipes would range from 1,300 to 1,700 mm for a length of 2.48 km.

The Švarča Sub-Transport Collector will run along the left bank of the Mrežnica River, collecting the wastewater of Švarča area at the existing outfall and the future connection points of sewer networks. It will cross the Kupa River by siphon in order to connect with the existing South Transport Collector at Turanj.

The Duga Resa Sub-Transport Collector will collect wastewater from the left bank of the Mrežnica River in Duga Resa Town at the existing outfalls and connect with the existing South Transport Collector. The diameter of pipes would range from 400 to 1,200 mm for a length of 1.83 km.

The right bank of the Mrežnica River in Duga Resa will be served by the separate system. The main sewer, with diameter and length of 300 mm and 1.25 km, is proposed to connect with the existing South Transport Collector.

The proposed transport collectors, sub-transport collectors and main sewer are summarized below. For their routes, see Fig. D.8.1.

Town		Diameter (mm)	Material	Length (km)	Location
Karlovac	Drežnik Sub T.C.	300 - 350	Concrete	2.88	Drežnik - Banija
	Banija T.C.	700 - 800	Concrete	2.46	Banija - Grad
		500 × 2	Concrete	0.17	Kupa River (Siphon)
	Grad T.C.	1,300 - 1,700	Concrete	2.48	Grad - Treatment Plant
		750 × 2	Concrete	0.13	Korana River (Siphon)
	Švarča T.C.	400 - 600	Concrete	3.69	Švarča - South T.C.
		400 × 2	Concrete	0.13	Mrežnica (Siphon)
Karlovac-Duga Resa	South T.C. (Existing)	800 - 1,200	Asbestos	9.95	Duga Resa - Treatment Plant
Duga Resa	Duga Resa Sub T.C.	400 - 1,200	Concrete	1.83	Left Bank of Mrežnica River
	Duga Resa Main Sewer	300	Concrete	1.25	Right Bank of Mrežnica River

Note: T.C.: Transport Collector   Existing

(4) Pumping Station

Six (6) lift pumps with the following heads and capacities are required.

Pump Station	Head	Capacity (l/sec)
1	4.5	670
2	6.0	40
3	4.0	60
4	1.5	20
5	2.0	18
6	2.0	7

8.3.2 Secondary/Tertiary Sewer

(1) Karlovac

The sewer extension in Karlovac Town is proposed for the six (6) areas: Banija, Grad, Gornje Mekušje, Turanj, Logolište and Švarča.

The fringe areas of Banija and Grad are to be collected by the combined system to coordinate with the existing combined system in the neighboring areas. Švarča area is also to becollected by the combined system since part of the area is already covered by the combined one.

The sewers of Banija and Grad will be connected to the Banija and Grad Transport Collectors, respectively. The sewers in Švarča will be connected with the Švarča Sub-Transport Collector, which will connect with the South Transport Collector.

The other three (3) areas are to be collected by the separate system. They are also to be connected with the South Transport Collector.

The sewer extension in the north suburban industrial area of Banija is not included in the Master Plan since the land development of the area is expected only after 2015.

(2) Duga Resa

There are three (3) areas for sewer extension in Duga Resa Town: the east side of Duga Resa, Gornje Mrzlo Polje Mrežničko and Donje Mrzlo Polje Mrežničko. These three areas are to be covered by the separate system. The east side of Duga Resa and Donje Mrzlo Polje Mrežničko are to be connected with the South Transport Collector, while Gornje Mrzlo Polje Mrežničko is to be connected with the Švarča Sub-Transport Collector.

The proposed secondary/tertiary sewers in the extension areas are summarized below.

Town	Diameter (mm)	Material	Length (km)	Combined/Separate
Karlovac	250	Concrete	24.9	Separate
	400	Concrete	10.9	Combined
Duga Resa	250	Concrete	11.6	Separate
Total			47.4	

8.3.3 Treatment Plant

(1) Location

The proposed site is located in the settlement of Gornje Mekušje on the eastern part of the town and the right side of the Kupa River. It is wasteland with a ground elevation of about 107.8 m. This site with remaining landmines is privately owned. However, Karlovac Town has a plan to clear the area of landmines by the end of 2002. This location is in accordance with the existing Municipal and County Area Plan. For location of the treatment plant, see Fig. D.8.1.

(2) Treatment Process

The capacity of the treatment plant (117,000 PE) is larger than 10,000 PE and the recipient of effluent from the plant, Lower Kupa, is Category II. Therefore, Anaerobic Oxic treatment with thickener and mechanical sludge dewatering is proposed (refer to Section 1.4.4 and 1.4.5).

The required surface area is approximately 6.90 ha.

(3) Main Facilities

The main facilities, together with the specification and number of units, are shown in the table below. The effluent is discharged into the Kupa River. The layout of the wastewater treatment plant is shown in Fig. D.8.3.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse Screen, 2m W Fine Screen, 1m W	1 3
	Archimedical Screw Pump 12.0 m^3/min × 10m H × 19kw	5
Grit Oil/Sand Removal	2m W × 10m L	2
Parshall Flume	1.2192 m (4 ft)	1
Primary Sedimentation Tank	6.5m W × 19.0m L × 3.0m D (Effective Depth)	8
Aeration Tank	5m W × 64.0m L × 5m D	8
Secondary Sedimentation Tank	∅22 m × 3.5m D (Effective Depth)	4
Effluent Pumping Station	Vertical Axial Flow Pump 15 m^3/min × 6m H × 22kw	5
Sludge Thickener	∅10 m × 4.0m D	2
Mechanical Dewatering	Belt Press Filter, 2.0m W × 2.2kw (Drive) Polymer Mixing, 0.75kw	6
Blower	Roots Blower, 34 m^3/min × 60kw (Building, 10m × 25m)	5
Return Sludge	Archimedical Screw Pump 9 m^3/min × 3m H × 5.5kw	4
Administration Building	13m W × 20m L	1

8.4 Cost Estimate

The total construction cost is estimated at approx. Kn 259.9 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	51,471.1	19.8	31.8
		Secondary/Tertiary Sewer	33,251.0	12.8	20.6
		Sub-Total	84,722.1	32.6	52.4
	Treatment Plant	Preliminary Treatment	11,060.6	4.3	6.8
		Biological Reactor	17,187.7	6.6	10.6
		Secondary Sedimentation	6,633.4	2.6	4.1
		Sludge Treatment	15,665.7	6.0	9.7
		Others	26,477.0	10.2	16.4
		Sub-total	77,024.4	29.6	47.6
	Sub-total		161,746.5	62.2	100.0
Land Acquisition			1,452.5	0.6	-
Indirect Cost	Engineering		16,174.6	6.2	-
	Administration		4,852.4	1.9	-
	Customs Duties		4,159.6	1.6	-
	VAT		39,142.6	15.1	-
	Sub-total		64,329.3	24.8	-
Contingency			32,349.3	12.4	-
Total			259,877.6	100.0	-

8.5 Replacement of Major Damaged Sewers in Karlovac

Authorities of Karlovac Town had inspected and surveyed a total of 10 km of defective sewers in the old section of the town and found that the replacement of 5 km of damaged sewers is necessary and should be given the first priority. The diameter of damaged pipes ranges from 800 mm to 1,400 mm and depth is 7 m on the average.

However, the replacement of damaged sewers in Karlovac is dealt separately from the sewerage development projects proposed by this Study including the plan for Karlovac and Duga Resa. The replacement cost is therefore not included in the proposed sewerage development and it is estimated at Kn 58.9 million, broken down as follows:

Items		Cost ($\times 10^3$ Kn)
Direct Cost	Replacement of Pipe	40,000
Indirect Cost	Engineering	4,000
	Administration	1,200
	Custom Duties	0
	VAT	9,680
	Sub-total	14,880
Contingency		4,000
Total		58,880

CHAPTER IX SEWERAGE IMPROVEMENT OF LOCAL URBAN CENTERS

9.1 Sveti Ivan Zelina

9.1.1 Existing Sewerage System

(1) Service Area and Population

Sveti Ivan Zelina, consisting of 63 settlements, is situated in the northeast of Zagreb City. The urban center had developed on the saddle of a hill. The administrative area and population including future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		144.2	18,323.7	18,467.9
Population	(1991)	2,535	13,017	15,552
	(1999)	2,560	13,146	15,707
	(2015)	2,668	13,698	16,365

Some parts of the urban center of Sveti Ivan Zelina, the northeastern settlement of Biškupec Zelinski, the southern settlement of Blaževdol, and the eastern settlement of Donja Topličica are served by the sewerage system. The served population and service area are approximately 3,200 inhabitants and 251.4 ha, respectively.

(2) Existing Industries

Eight (8) industries are registered by Croatian Waters as industrial pollutants. Only one (1) of them is served by the sewerage system and the others directly discharge into the rivers or streams as shown below.

Code Number	Industry Name	Activity	Pretreat-ment	Wastewater (m^3/year) 1998	Wastewater (m^3/year) 1999	Recipient
361003	Iskra	Chemicals	No	8,033	3,864	Brook Zelina
361008	Tiskara Zelina	Chemicals	Yes	2,054	3,944	River
361009	Klaonica i Prerada Mesa	Food/Beverage	Yes	-	-	Brook Oreščak
361010	Klaonica br. 25	Food/Beverage	Yes	-	-	Brook Oreščak
361002	Endi International	Textile	No	-	-	River
361007	Zelinka d.d. Modna Konfekcija	Textile	Yes	5,773	3,437	Brook Zelina
361001	Čazmatrans, PJ	Transportation	Yes	-	-	Brook Topličica
361006	Drvna Industrija Zelina	Car Wash	No	2,005	2,150	Sewerage

(3) Sewer Network

The existing sewerage system is shown in Fig. D.9.1. The urban center of the town is hydrographically divided into two (2) zones.

The north zone is a catchment of the Lonja River and its wastewater is discharged through the Topličica Brook into the Lonja River. The main collector with the diameter of 30 to 60 cm is constructed under the V. Nazora Street.

The south zone is a catchment of the Zelina River and its wastewater is discharged through the Zelina Brook into the Zelina River. The main sewer with the diameter of 30 to 100 cm is constructed under the main road, Zagreb-Varaždin.

The sewer network of the town is of combined type and made of concrete. The 5.2 km of existing pipe was installed 20 years ago and the new 3-km Collector I is now being constructed with completion expected in 2002. There is neither pumping station nor treatment plant.

(4) Wastewater Quality of Sewerage System

The authorized laboratory analyzed the wastewater quality at the outfall to the Zelina River along Zagrebačka Street during 1998 to 1999. The results are summarized below.

Sample Number		Flow (l/s)	Temp. (°C)	BOD_5 (mg/l)	COD_{Cr} (mg/l)	TSS (mg/l)	TVS (mg/l)	SS (mg/l)	VS (mg/l)	pH
	Ave	11.6	15.2	33.7	87.3	422.0	258.7	43.0	21.6	7.4
9	Max	61.5	19.0	80.0	175.0	522.0	362.0	107.0	67.0	7.5
	Min	1.4	8.0	10.0	31.0	301.0	208.0	4.0	2.0	7.3

9.1.2 Planning Basis

(1) Service Area, Population and Industry

For topographic reasons, two (2) main collectors (Collector I and II) have been designed and the upstream part of Collector I is presently being constructed as mentioned in the preceding subsection. Collector I is planned along the Zelina River to collect wastewater generated in the southern part of the town, while Collector II is planned along the Lonja River to collect wastewater in the northern part. With regard to the treatment plant site, three (3) alternatives were proposed, as follows:

(a) One (1) treatment plant is installed at the end of Collector I in the settlement of Donja Zelina or Paukovec. The wastewater in Collector II is lifted up by pump and transported to the treatment plant. Effluent is discharged into the Zelina River.

(b) One (1) treatment plant is installed at the end of Collector II in the settlement of Brezovec Zelinski or Sveta Helena. The wastewater in Collector I is lifted up by pump and transported to the treatment plant. The effluent is discharged into the Lonja River.

(c) Two (2) treatment plants are installed: one at the end of Collector I and the other at the end of Collector II in the settlements mentioned above. The wastewater flows by gravity into each treatment plant and discharged into the Zelina and Lonja rivers, individually.

The superhighway from Zagreb to Goričani will be constructed very soon east of the urban center. Along this highway, there are plans of constructing the sports-recreational center “Bazeni” in Sveti Ivan Zelina Building, the business center and thermal sanatorium in Krečaves, and the industrial zone in Marionvec-Obrež-Sveta Helena area. These plans were proposed by an Italian company and permission may be issued soon, although the areas are not supplied with water by the water network yet. The wastewater generated in these areas will be collected by Collector II.

Alternative (b) is adopted and one treatment plant in the settlement of Sveta Helena with one pumping station near the Zelina River is proposed in consideration of the future improvement plan, the ground configuration, and construction and O&M costs of pumping station and treatment plant.

The extension of service area (see Fig. D.9.1) consists of three (3) parts; namely, districts along the Zelina [western three (3) settlements: Šulinec, Marinovec Zelinski and Obrež Zelinski]; the district along the Lonja River (eastern settlement: Donja Zelina); and the settlements at the treatment plant site [southern two (2) settlements: Sveta Helena and Brezovec Zelinski]. With the extension of 317.4 ha, the total service area will be 568.9 ha. The served population in the Master Plan service area will be 7,000 according to the area extension and increase of population.

The wastewater of the existing service area is collected by the combined system, while the proposed extension is by the separate one. Among the eight (8) industries registered by Croatian Waters as industrial pollutant, the Master Plan service area will cover only the Drvna Industrija Zelina.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The wastewater quantity of Drvna Industrija Zelina, which is to be served by the sewerage system, is small and hence, it is included in the municipal wastewater.

The municipal wastewater flow is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the main sewer conveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)
Daily Average	2,030
Daily Maximum	2,380
Hourly Maximum (dry)	3,360
Hourly Maximum (rainy)	5,287

(b) Wastewater Quality

The expected pollution load and influent quality into the treatment plant are summarized in the table below. For the estimation of pollution load of the municipal wastewater, see Subsection 1.3.2 in Appendix D.

As shown in the table, the total BOD load generated in the Master Plan service area is 462.0 kg/day. It is equivalent to 7,700 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Item	Load (kg/day)	Concentration (mg/l)
BOD	462.0	194.1
COD_{Cr}	924.0	388.2
TSS	539.0	226.5
T-N	84.7	35.6
T-P	19.3	8.1

9.1.3 Proposed Structural Plan

(1) Main Sewer

The main features of the proposed main sewer in the Master Plan service area are as given below. No transport collector is installed, but one (1) lift pump with the capacity of 19 l/sec is required to transport the wastewater in Collector I along the Zelina River to the treatment plant. For location of the proposed main sewer with lift pump, see Fig. D.9.1.

Pipe	Diameter (mm)	Material	Length (m)
Main Sewer	200	PVC	2,750
	250	PVC	4,600
	300	PVC	9,020
Total			16,370

(2) Secondary/Tertiary Sewer

It is necessary to install 1,470 m of PVC sewer pipe with the diameter of 200 mm to serve the extension area of 317.4 ha.

(3) Treatment Plant

The location and layout of wastewater treatment plant are shown in Fig. D.9.1 and Fig. D.9.2. The capacity of the treatment plant (7,700 PE) is smaller than 10,000 PE and the recipient of effluent from the plant (Lonja Strug) is Category II. Therefore, Oxidation Ditch with thickener and sludge drying bed is proposed. (Refer to Subsections 1.4.4 and 1.4.5).

The required surface area is approximately 1.73 ha. The main facilities, together with the specification and number of units, are shown below.

Facilities	Specification	No. of Unit
Influent Pumping Station and Screen	Coarse Screen, 1m W	1
	Fine Screen, 0.6m W	1
	Archimedical Screw Pump, 2.0 m^3/min × 6m H × 4kw	2
Grit Oil/Sand Removal	1.4m W × 5m L	1
Parshall Flume	0.3048 m (1 ft)	1
Oxidation Ditch	4.5m W × 2.5m D; V = 3,060 m^3	4
Secondary Sedimentation Tank	∅13 m × 3.5m D (Effective Depth)	2
Sludge Thickener	∅3 m × 4.0m D	2
Drying Bed	Approx. 10m W × 55m L	1
Mechanical Aerator	Vertical, 15kw	4
Return Sludge	Archimedical Screw Pump, 1.7 m^3/min × 3 m H × 2.2kw	3
Administration Building	10m W × 10m L	1

9.1.4 Cost Estimate

The total construction cost is estimated at approx. Kn 43.6 million, broken down as follows.

Cost		Facilities	Cost (×10^3 Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	10,773.5	24.7	39.0
		Secondary/Tertiary Sewer	726.2	1.7	2.7
		Sub-total	11,499.7	26.4	42.6
	Treatment Plant	Preliminary Treatment	2,334.9	5.4	8.7
		Biological Reactor	6,444.8	14.8	23.9
		Secondary Sedimentation	1,849.8	4.2	6.9
		Sludge Treatment	226.2	0.5	0.8
		Others	4,636.7	10.6	17.2
		Sub-total	15,492.4	35.5	57.4
	Sub-total		26,992.1	61.9	100.0
Land Acquisition			400.0	0.9	-
Indirect Cost	Engineering		2,699.2	6.2	-
	Administration		809.8	1.9	-
	Customs Duties		778.2	1.8	-
	VAT		6,532.1	15.0	-
	Sub-total		10,819.3	24.8	-
Contingency			5,398.4	12.4	-
Total			43,609.8	100.0	-

9.2 Ivanić Grad and Kloštar Ivanić

9.2.1 Existing Sewerage System

Ivanić Grad and Kloštar Ivanić are administratively independent of each other. However, their sewerage systems are integrated to treat wastewater by the treatment plant located at the southern suburbs of the Ivanić Grad urban center.

(1) Service Area and Population

Ivanić Grad and Kloštar Ivanić consist of 22 and 11 settlements, respectively. The administrative area and population including future projection (2015) are shown below.

Town/Municipality	Item		Urban Center	Rural Area	Total
Ivanić Grad	Area (ha)		504.3	16,852.5	17,356.8
	Population	(1991)	7,104	6,390	13,494
		(1999)	7,815	7,029	14,844
		(2015)	9,095	8,181	17,276
Kloštar Ivanić	Area (ha)		316.5	7,441.9	7,758.4
	Population	(1991)	2,568	2,203	4,771
		(1999)	2,594	2,225	4,818
		(2015)	2,702	2,318	5,021

The served population and service area of Ivanić Grad are 5,700 inhabitants and 523.5 ha consisting of some parts of the urban center and the surrounding area. Those of Kloštar Ivanić are 600 inhabitants and 138.0 ha covering part of the urban center. These areas are served by an integrated sewerage system.

(2) Existing Industries

There are 21 industries registered by Croatian Waters as industrial pollutants, as listed below, and all of them are in Ivanić Grad. Thirteen (13) of these industries are served by the sewerage system, while the remaining eight (8) discharge wastewaters directly into the canal.

The industries in bold characters in the table below are the large ones described in Appendix C.

Code Number	Industry Name	Activity	Pretreat-ment	Wastewater (m^3/y) 1998	1999	Recipient
355001	Croatia Baterije	Chemicals	Yes	-	3,447	Sewerage
355013	Ivanićplast	Chemicals	Yes	-	-	Sewerage
355014	Ivasim	Chemicals	Yes	3,490	4,311	Sewerage
355016	Tiskara	Chemicals	-	-	-	Sewerage
355021	Ivakem	Chemicals	Yes	-	1,577	Sewerage
355002	Agroposavina	Food/Beverage	-	-	-	Mel. Canal
355003	Agroprerada	Food/Beverage	Yes	-	3,033	Mel. Canal
355017	TMPK	Metal/Machinery	Yes	-	96,611	Sewerage
355005	**INA Naftaplin Pogon ETAN**	**Oil Product**	**Yes**	**114,828**	**-**	**Sewerage**
355006	Crosco Naftni Servisi	Oil Product	Yes	14,800	14,800	Sewerage
355007	INA Naftaplin Radilište Žutica	Oil Product	Yes	-	-	Mel Canal
355008	INA Naftaplin Radilište Žutica	Oil Product	Yes	-	-	Mel Canal
355009	INA Naftaplin Radilište Žutica ZuticaCrosco, Pogon	Oil Product	Yes	-	-	Mel Canal
355010	**Crosco Naftni Servisi**	**Oil Product**	**Yes**	**36,114**	**63,546**	**Sewerage**
335019	**INA Naftaplin Radilište OROI**	**Oil Product**	**Yes**	**64,116**	**50,335**	**Brook**
355022	INA Naftaplin Pogon Izgradnje	Oil Product	Yes	-	-	Sewerage
355024	Crosco Naftni Servisi Žutica	Oil Product	Yes	-	8,820	Ditch

Code Number	Industry Name	Activity	Pretreat-ment	Wastewater (m^3/y) 1998	1999	Recipient
355015	**Naftalan Lječilište**	**Hospital**	**Yes**	**29,080**	**7,737**	**Sewerage**
355004	DOM Zdravlja “Josip Adamić”	Clinic	Yes	-	-	Sewerage
355012	Ivakarton	Cardboard Mfg.	Yes	-	-	Sewerage
355023	Ekoprom	Others	No	-	519	Canal

(3) Sewer Network

The sewerage network systems of Kloštar Ivanić and Ivanić Grad are integrated, as shown in Fig. D.9.3. Since Kloštar Ivanić is located upstream of Ivanić Grad, its wastewater is discharged by gravity through the main collector from Kloštar Ivanić to Ivanić Grad into the treatment plant located downstream of Ivanić Grad.

The sewer network of Ivanić Grad covers aproximately 70% of the urban center. The Main Collector "K-2" runs through the central part of the town to the treatment plant, receiving the wastewater of Kloštar Ivanić and collecting that of Ivanić Grad. The sewer network is of combined type made of concrete pipe with diameters of 50 cm to 120 cm. The total sewer length is 26 km; namely, 14 km of main collector and 12 km of secondary/tertiary collector. The system is provided with some rainfall retention basins, but there is no pumping station.

The sewerage system of Kloštar Ivanić is of combined type with a total length of 9,750 m covering only the central part of the urban area. No pumping station is provided.

(4) Treatment Plant

The layout of the existing treatment plant is shown in Fig. D 9.4. The treatment plant is located near the Lonja River, south area of the settlement of Ivanič Grad, and the surface area is about 4 ha. The treatment plant of only the mechanical process (First Phase) was constructed in December, 1995 and it includes two retention basins. The existing plant has at present the following major equipment and facilities, and a biological process is expected to be provided in the future.

(a) Rainwater spillway
(b) Coarse mechanical screen (grate)
(c) Main entrance pump station with screw pump (two levels)
(d) Fine automatic screen
(e) Aerating grit chamber and oil (fat) trap
(f) Measuring device
(g) Drain pipe to the Lonja River
(h) Administration building
(i) Others

The observed quality of influent and effluent of the treatment plant during the second half of 1999 are shown below. The effluent is discharged into the Lonja River.

Recipient	No.		Flow (l/s)	Temp. (°C)	BOD_5 (mg/l)	COD_{Cr} (mg/l)	TSS (mg/l)	TVS (mg/l)	SS (mg/l)	VS (mg/l)	pH
Influent	4	ave	51.6	11.3	108.8	210.0	1,831.1	472.8	1,175.0	77.9	7.8
		max	80.0	19.4	150.0	383.1	5,180.0	660.0	4,368.0	120.0	8.0
		min	23.2	3.0	60.0	74.8	455.0	288.0	80.0	30.2	7.6
Effluent	8	ave	142.0	11.5	38.5	97.7	798.4	610.5	252.8	174.7	7.6
		max	283.0	18.2	115.0	150.0	2,189.0	1,467.0	1,628.0	1,199.0	7.8
		min	23.2	4.3	8.3	48.0	409.0	262.0	12.0	3.0	7.4

The JICA Study Team also analyzed the quantity and quality of effluent in the treatment plant on December 8, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time	-	12:00	COD_{Mn}	mg/l	30.0
Flow	m^3/sec	0.0817	TSS	mg/l	102.0
PH	-	7.36	T-N	mg/l	24.9
BOD	mg/l	43.0	T-P	mg/l	3.54

Besides the above-mentioned municipal treatment plant, there is a non-functional treatment plant (BIO DISK) in the settlement of Graberje Ivaničko where the industrial area of " INA Naftaplin" is located. This plant was constructed for "INA" and its employees.

9.2.2 Planning Basis

(1) Served Area, Population and Industries

Since only about 70% of the urban center of Ivanić Grad is covered by the sewerage system, the service area will be extended to cover the remaining area of the urban center, the western settlement of Jalševec Breški, the southeastern settlement of Donji Šarampov, and the surrounding area. The total service area in Ivanić Grad is proposed to be 862.7 ha with the extension of 339.2 ha. Served population in the Master Plan service area will be 10,600 according to the area extension and increase of population.

With the small extension of 11.8 ha, the total service area in Kloštar Ivanić will be 149.8 ha. Served population in the Master Plan service area will be 800 according to the area extension and increase of population.

The existing service area is collected by combined system, while the proposed extension is by separate one. For the extension area, see Fig. D.9.3.

Among the 21 industries registered by Croatian Waters as industrial pollutant, the Master Plan service area will cover the 13 industries discharging into the existing sewerage system. Among the above 13 industries, only three (3) large industries (INA Naftaplin, Crosco Naftni Servici and Naftaplin Ljeciliste) are dealt as sources of industrial wastewater and the other smaller industries are included in the sources of municipal wastewater in this Study. For location of the three (3) industries, see Fig. D.9.3.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)		
	Ivanić Grad	Kloštar Ivanić	Total
Daily Average	3,498	232	3,730
Daily Maximum	4,240	272	4,512
Hourly Maximum	6,042	384	6,426

(b) Industrial Wastewater Flow

The wastewater quantity of the three (3) large industries is estimated as shown below. The existing and future daily averages were obtained from Subsection 8.4.1, 8.4.2 and 8.4.3 in Appendix C. The future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the industries.

Industry Name	Quantity (m³/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
INA Naftaplin	460	760	760	1,140
Crosco Naftni Servici	200	330	330	495
Naftaplin Lječilište	117	193	193	290
Total	777	1,283	1,283	1,926

(c) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the main sewer conveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m³/day)				
	Municipal		Industry		Total
	Ivanić Grad	Kloštar Ivanić	Ivanić Grad	Kloštar Ivanić	
Daily Average	3,498	232	1,283	-	5,013
Daily Maximum	4,240	272	1,283	-	5,795
Hourly Maximum (dry)	6,042	384	1,926	-	8,352
Hourly Maximum (rainy)	9,792	671	3,849	-	14,312

(d) Quality of Wastewater

The expected pollution load and quality of influent into the treatment plant are summarized in the table below. For the estimation of pollution load of the municipal and industrial wastewater, see Subsection 1.3.2 in Appendix D and Subsection 8.4.1, 8.4.2 and 8.4.3 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 911.2 kg/day. It is equivalent to 15,200 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)					Concentration (mg/l)
	Municipal		Industrial		Total	
	Ivanić Grad	Kloštar Ivanić	Ivanić Grad	Kloštar Ivanić		
BOD	826.8	52.8	31.6	-	911.2	157.2
COD_{Cr}	1,653.6	105.6	88.4	-	1,847.6	318.8
TSS	964.6	61.6	847.9	-	1,874.1	323.4
T-N	151.6	9.7	38.5	-	199.8	34.5
T-P	34.5	2.2	6.4	-	43.1	7.4

9.2.3 Proposed Structural Plan

(1) Main Sewer

The design features of the main sewer in the Master Plan service area in Ivanić Grad and Kloštar Ivanić are as follows. There is no transport collector, and lift pump is not required. For the route of proposed main sewers, see Fig. D.9.3.

	Pipe	Diameter (mm)	Material	Length (m)
Ivanić Grad	Main Sewer	200	PVC	2,370
Kloštar Ivanić	Main Sewer	200	PVC	320
Total				2,690

(2) Secondary/Tertiary Sewer

It is necessary to install 10,980 m and 260 m of PVC sewer pipes with the diameter of 200 mm to serve the extension areas of 339.2 ha in Ivanić Grad and 11.8 ha in Kloštar Ivanić, respectively.

(3) Treatment Plant

The existing treatment plant within the existing plant site presently owned by "IVAKOP d.o.o" is enlarged. The location and layout of the wastewater treatment plant are shown in Fig. D.9.3 and Fig. D.9.4, respectively.

The capacity of the treatment plant (15,200 PE) is larger than 10,000 PE and the recipient of effluent from the plant (Lonja Strug) is Category II. Therefore, Anaerobic Oxic treatment with thickener and mechanical sludge dewatering is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area including the existing one is approximately 3.17 ha. The main facilities, together with the specification and number of units, are shown below.

Facilities	Specification	No. of Units*
Influent Pumping Station and Screen	Coarse Screen, 1.6m W Fine Screen, 0.8m W	(1) (2)
	Archimedical Screw Pump 7.5 m^3/min × 9.8m H × 19kw	(2)
Grit Oil/Sand Removal	4 m W × 20 m L	(1)
Parshall Flume	0.3048 m (1 ft)	(1)
Primary Sedimentation Tank	3.0 m W × 12.0 m L × 3.0 m D (Effective Depth)	4
Aeration Tank	5 m W × 17.0 m L × 5m D	4
Secondary Sedimentation Tank	∅13 m × 3.5m D (Effective Depth)	2
Sludge Thickener	∅6 m × 4.0m D	1
Mechanical Dewatering	Belt Press Filter, 1.5m W × 1.5kw (Drive) Polymer Mixing, 0.4kw	2
Blower	Roots Blower, 11 m^3/min × 18.5kw (Building, 8m × 15m)	5
Return Sludge	Archimedical Screw Pump, 2.1 m^3/min × 3m H × 3.5kw	3
Administration Building	10m W × 10m L	1

* No. of units in parentheses are the existing ones.

9.2.4 Cost Estimate

The total construction cost is estimated at approx. Kn 43.4 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	1,401.7	3.2	5.2
		Secondary/Tertiary Sewer	5,543.1	12.8	20.7
		Sub-total	6,944.8	16.0	25.9
	Treatment Plant	Preliminary Treatment	933.9	2.2	3.5
		Biological Reactor	5,266.4	12.1	19.7
		Secondary Sedimentation	1,899.7	4.4	7.1
		Sludge Treatment	4,453.2	10.3	16.6
		Others	7,298.7	16.8	27.2
		Sub-total	19,851.8	45.8	74.1
	Sub-total		26,796.6	61.8	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		2,679.7	6.2	-
	Administration		803.9	1.9	-
	Customs Duties		1,240.7	2.9	-
	VAT		6,484.8	15.0	-
	Sub-total		11,209.0	25.8	-
Contingency			5,359.3	12.4	-
Total			43,365.0	100.0	-

9.3 Samobor

9.3.1 Existing Sewerage System

(1) Service Area and Population

The town of Samobor consisting of 78 settlements is located in the western suburbs of Zagreb City. The administrative area and population including future projectioin (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		557.1	24,528.0	25,085.1
Population	(1991)	14,170	20,847	35,017
	(1999)	16,154	23,766	39,920
	(2015)	18,800	27,659	46,459

The existing sewerage system covers almost all parts of the urban center of Samobor (Grad Samobor), the northwestern four (4) settlements of Bregana, Klokočevec Samoborski, Lug Samoborski and Podvrh, the northern settlements of Gradna and Bobovina, the northeastern settlement of Hrastina Samoborska, and their surrounding areas. The total service area is 1,518.3 ha and the total served population is 15,400.

(2) Existing Industries

There are nine (9) industries registered by Croatian Waters as industrial pollutant, as listed below. Among them, six (6) industries are served by the sewerage system, while the remaining three (3) industries directly discharge into the rivers. The industries in bold characters are the large ones described in Appendix C.

Code Number	Industry Name	Activity	Wastewater (m^3/year) 1998	1999	Recipient
309021	**Chromos Grafičke Boje**	**Chemicals**	**-**	**53,082**	**Sewerage**
309123	**Pliva Kalinovica**	**Chemicals**	**101,775**	**187,151**	**River**
309180	**Chromos Grafičke Boje**	**Chemicals**	**-**	**46,818**	**Sewerage**
309069	**Imes**	**Food/Beverage**	**-**	**22,058**	**Sewerage**
309149	Ege Goran	Metal/Machinery	-	1,246	Sewerage
309278	**TOP**	**Metal/Machinery**	**50,075**	**53,229**	**River**
309047	**Fotokemika**	**Photo Products**	**-**	**108,027**	**Sewerage**
309233	**Imunološki Zavod Brezje**	**Pharmaceuticals**	**177,561**	**163,471**	**Sewerage**
309285	Prerada Kože i Krazna Ban	Leather Manufacture	-	700	River

(3) Sewer Network

The existing sewerage system is shown in Fig. D.9.5. The sewerage system of the town is integrated by gravity to treat the wastewater by the central treatment plant located northeast of the Samobor urban center (close to the settlement Gradna). The treated wastewater is finally discharged into the Sava River.

The main collectors of the system are the South Collector, North Collector and Park Collector in the urban center of Samobor, and the Bregana Collector that runs from the industrial complex TRZ-Bregana in Slovenia through the Bregana settlement to the treatment plant. On the way to the treatment plant, this collector receives the wastewater of TRZ-Bregana and the four (4) settlements of Bregana, Klokočevec Samoborski, Lug Samoborski and Bovovica. The industrial complex TRZ-Bregana in Slovenia is a potential pollution source of heavy metals. The heavy metals have to be pre-treated by the industrial complex to satisfy the regulations of Croatia.

The sewer system is of combined type and it has a total length of 83.8 km with pipe diameters of 30 cm to 120 cm. The condition of the sewerage system is very good because some repairs have been done since 1983. The system will be completed by 2005.

(4) Treatment Plant

The wastewater treatment plant of conventional biological process was constructed in stages with gradual upgrade at a southeastern location on the urban center of Samobor close to the settlement Gradna during the period 1977-1983. The plant was expanded to treat the wastewater of 20,000 to 25,000 PE, meeting the needs of Grad Samobor, Bregana settlement and their surrounding areas. The treated wastewater is discharged into the neighboring open channel (Samobor-Sava open channel).

The major features of the plant are as follows:

(a) Coarse screen (grate)

(b) One screw pump (the other is broken) with the diameter of 63 cm (Q = 63 l/s, H = 5.0 m, N = 7.5kW)

(c) Primary sedimentation tanks (three hoppers) with a total volume of 250 m^3.

(d) Two (2) aeration tanks with a total volume of 1,000 m^3, mechanically aerated by two (2) turbines with a capacity of 22 kW

(e) Four (4) secondary sedimentary tanks with a total volume of 500 m^3

(f) Thickener and digester of excess sludge

However, the plant has not been operated since 1995 due to: (i) overloading caused by unexpected large quantity of groundwater inflow; (ii) heavy metal contamination of inflow; and (iii) damage of equipment and financial constraint of operation cost.

The JICA Study Team analyzed the quantity and quality of wastewater at Celine Bridge on November 27, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time	-	14:10	COD_{Mn}	mg/l	20.0
Flow	m^3/sec	0.270	TSS	mg/l	110.0
pH	-	7.50	T-N	mg/l	11.1
BOD	mg/l	32.0	T-P	mg/l	2.19

9.3.2 Planning Basis

(1) Service Area, Population and Industries

The district between the northern part of the urban center and the Sava River is a protected area for water source. To protect this area from pollution, the sewerage system will served the seven (7) settlements; namely, part of Hrastina Samoborska, whole area of Farkaševec Samoborski, Domaslovec, Vrbovec Samoborski, Medsava, Savrašćak and Celine Samoborske.

With the extension of 395.9 ha, the total service area will be 1,914.2 ha. Served population in the above area will be 29,200 according to the area extension and increase of population. The existing service area is collected by the combined system, while the proposed extension is by the separate one. For the extension area, see Fig. D.9.5.

The Master Plan service area will cover only the six (6) industries discharging into the existing sewerage system. Every industry should discharge its industrial wastewater into the municipal treatment plant after pre-treatment in compliance with the national regulation in all the parameters. Among the above six (6) industries, four (4) large industries (Chromos Graficke, Chromos Graficke, Imes and Fotokemika) are dealt as the sources of industrial wastewater and the other smaller industries are included in the sources of municipal wastewater in this Study. For location of the four (4) industries, see Fig. D.9.5.

(2) Wastewater Flow and Quality

(a) Municipality Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	9,636
Daily Maximum	11,680
Hourly Maximum	16,644

(b) Industrial Wastewater Flow

The wastewater quantity of the four (4) large industries is estimated as shown below. The existing and future daily averages were obtained from Subsection 8.5.1, 8.5.2, 8.5.3 and 8.5.5 in Appendix C. The future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the industries.

Industry Name	Quantity (m^3/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
Chromos Graficke	212	353	353	528
Chromos Graficke	189	312	312	468
Imes	89	148	148	221
Fotokemika	432	715	715	1,071
Total	923	1,528	1,528	2,288

(c) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the transport collector coveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)		
	Municipal	Industry	Total
Daily Average	9,636	1,528	11,164
Daily Maximum	11,680	1,528	13,208
Hourly Maximum (dry)	16,644	2,288	18,932
Hourly Maximum (rainy)	29,694	4,575	34,269

(d) Quality of Wastewater

The expected pollution load and quality of influent into the treatment plant are summarized in the table below. For the estimation of pollution load of the municipal and industrial wastewater, see Subsection 1.3.2 in Appendix D and Subsection 8.5.1, 8.5.2, 8.5.3 and 8.5.5 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 2,367.4 kg/day. It is equivalent to 39,500 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industrial	Total	
BOD	2,277.6	89.8	2,367.4	179.2
COD	4,555.2	218.3	4,773.5	361.4
TSS	2,657.2	972.1	3,629.3	274.8
T-N	417.6	44.5	462.1	35.0
T-P	94.9	7.3	102.2	7.7

9.3.3 Proposed Structural Plan

(1) Transport Collector/Main Sewer

The design features of the transport collector/main sewer in the Master Plan service area are as follows. For the route of proposed transport collectors/main sewers, see Fig. D.9.5.

Pipe	Diameter (mm)	Material	Length (m)
Transport Collector	700	Concrete	2,020
	800	Concrete	220
Main Sewer	200	PVC	4,300
	250	PVC	1,460
	300	PVC	1,230
Total			9,230

Four (4) lift pumps with the following capacity are required.

Pump Station	Capacity (l/sec)
A1	4.1
A2	10
B2	5
D	21

(2) Secondary/Tertiary Sewer

It is necessary to install 10,540 m of PVC sewer pipes with the diameter of 200 mm to serve the extension area of 395.9 ha.

(3) Treatment Plant

The existing treatment plant is improved and its capacity will increase from 22,000 PE to 39,500 PE. To accommodate the proposed treatment plant, land of 1.31 ha is required including the existing site. The necessary land could be made available by extending the existing site, and the extension area is privately owned. The location and layout of wastewater treatment plant are shown in Fig. D.9.5 and Fig. D.9.6 respectively.

The capacity of the treatment plant (39,500 PE) is larger than 10,000 PE and the recipient of effluent from the plant (Upper Sava) is Category II. Therefore, Anaerobic Oxic treatment with thickener and mechanical sludge dewatering is proposed (refer to Subsection 1.4.4 and 1.4.5).

The main facilities, together with the specification and number of units, are shown below. The effluent is discharged into the Sava River through an open channel.

Facilities	Specification	No. of Units*
Influent Pumping Station and Screen	Coarse Screen 2m W	1
	Fine Screen, 1m W	1
	Archimedical Screw Pump 6 m^3/min × 6m H × 8kw	4
Grit Oil/Sand Removal	1m W × 11m L	2
Parshall Flume	0.6096 m (2 ft)	1
Primary Sedimentation Tank	8.8m W × 11.8m L × 3.0m D (Effective Depth)	(1)
Aeration Tank	5m W × 21.0m L × 5m D	8
Secondary Sedimentation Tank	∅19 m × 3.5m D (Effective Depth)	2
Sludge Thickener	8.8m W × 11.8m L × 3.0m D	(1)
Mechanical Dewatering	Belt Press Filter, 1.5m W × 1.5kw Polymer Mixing, 0.4kw	3
Blower	Roots Blower, 16 m^3/min × 22kw (Building, 8m × 17m)	4
Return Sludge	Archimedical Screw Pump, 5 m^3/min × 3m H × 5.0kw	4
Administration Building	10m W × 10m L	1
Retention Basin	11.8m W × 10.9m L × 4.0m D	(2)
Digestion Tank as by Pass Line	V1 = 750 m^3, V2 = 200 m^3	(1 each)

* Number of Units in parentheses are the existing ones.

9.3.4 Cost Estimate

The total construction cost is estimated at approx. Kn 58.5 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	3,997.0	6.8	11.0
		Secondary/Tertiary Sewer	5,193.5	8.9	14.4
		Sub-total	9,190.4	15.7	25.4
	Treatment Plant	Preliminary Treatment	2,661.8	4.6	7.4
		Biological Reactor	8,737.3	14.9	24.1
		Secondary Sedimentation	2,886.3	4.9	8.0
		Sludge Treatment	4,886.6	8.4	13.5
		Others	7,822.0	13.4	21.6
		Sub-total	26,994.0	46.2	74.6
	Sub-total		36,184.5	61.9	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		3,618.4	6.2	-
	Administration		1,085.5	1.9	-
	Customs Duties		1,603.5	2.7	-
	VAT		8,756.6	15.0	-
	Sub-total		15,064.1	25.8	-
Contingency			7,236.9	12.4	-
Total			58,485.4	100.0	-

9.4 Zaprešić

9.4.1 Existing Sewerage System

(1) Service Area and Population

The wastewaters of Zaprešić and Brdovec are discharged by an integrated sewerage system although they are administratively independent of each other. The town and municipality are located in the northwestern suburbs of Zagreb City and they consist of 9 and 13 settlements, respectively. The sewerage system is managed by one (1) management organization.

The administrative area and population of the town and municipality are shown below.

Town/Municipality	Item		Urban Center	Rural Area	Total
Zaprešić	Area (ha)		319.7	4,940.4	5,260.1
	Population	(1991)	15,678	5,042	20,720
		(1999)	18,071	5,812	23,883
		(2015)	21,031	6,764	27,795
Brdovec	Area (ha)		142.4	3,615.0	3,757.4
	Population	(1991)	1,901	6,861	8,762
		(1999)	2,258	8,148	10,406
		(2015)	2,627	9,483	12,111

The total served population and area of Zaprešić and Brdovec are 13,300 inhabitants and 948.9 ha, including the entire area of the urban center of Zaprešić and Brdovec and the western suburb settlements of Lužnica, Šibice and Savski Marof.

(2) Existing Industries

There are eight (8) industries registered by Croatian Waters as industrial pollutant in Zaprešić and Brdovec, as listed below. Among them, three (3) industries are served by the sewerage system, while the remaining five (5) discharge directly into the rivers. The industries in bold characters are the large ones described in Appendix C.

Code Number	Industry Name	Activity	Wastewater (m^3/year)		Recipient
			1998	1999	
315043	Dubravica	Food/Beverage	3,776	735	River
315289	Bermes	Food/Beverage	-	2,305	River
315290	Šimun Milk	Food/Beverage	-	1,991	Sewerage
315089	**Karbon**	**Chemicals**	**162,140**	**105,007**	**Sewerage**
315127	**Pliva**	**Chemicals**	**532,472**	**608,883**	**River**
315062	**HŽ Infrastrucktura**	**Transportation**	**63,781**	**73,444**	**Sewerage**
315080	**Inker**	**Ceramics**	**85,677**	**109,792**	**River**
315157	**Viadukt**	**Others**	**53,761**	**66,955**	**River**

Among the above industries, Pliva is the largest pollution source. Pliva is one of the biggest chemical companies in Croatia, producing bulk pharmaceuticals, animal health products, agrochemicals, foodstuff, cosmetics and hygiene products. Health care products account for 82% of the total turnover. It is an international company with affiliated companies in Bosnia-Herzegovina, Poland, Slovenia, Switzerland and the United States of America. A large quantity of wastewater is generated in the production process at each location.

(3) Sewer Networks

The existing sewerage system is shown in Fig. D.9.7. The urban centers of the town and municipality are served by the combined sewerage systems, while separate ones serve the surrounding areas. Three (3) main collectors, Zaprešić Collector, Harmica-Zaprešić Collector and East Transport Collector, along with secondary/ tertiary ones, collect the sewage of the service area. All of the main collectors converge at a location in the southeast fringe of the urban center of the town to discharge the wastewater into the lower end of the Krapina River (immediately upstream of the confluence with the Sava River) with neither treatment nor pumping station.

The wastewater of Pliva used to be discharged into the Krapina River through the Harmica-Zaprešić Collector. At present, however, wastewater is discharged with pre-treatment into the Sava River (upstream of the confluence with Krapina River) through the neighboring stream due to lack of capacity of the Harmica-Zaprešić Collector. This collector also collects the wastewater of the settlements along it.

There are some troubles with the existing sewerage system, which is only about 70% waterproof. The total sewer length is 47.5 km with diameters of 20 cm to 130/195 cm.

(4) Wastewater Flow and Quality

The JICA Study Team also analyzed the quantity and quality of wastewater in the manhole before Krapina River on November 27, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time		15:20	COD_{Mn}	mg/l	50.0
Flow	m^3/sec	0.093	TSS	mg/l	126
pH		7.53	T-N	mg/l	15.6
BOD	mg/l	96.0	T-P	mg/l	4.96

9.4.2 Planning Basis

(1) Service Area, Population and Industries

The southern settlements along the main collector such as Jaborje, Brdovecki, Prudnice and the surrounding areas will be served by the sewerage system. The chemical industry Pliva had requested the municipality to allow it to discharge its wastewater into the sewerage system and the municipality had agreed. Since the Harmica-Zaprešić

Collector is in bad condition and the capacity is too small, it will be necessary to install a new main collector from the industry to the treatment plant.

In addition, there is a plan to construct the Shopping Center (City) Zagreb-Zaprešić, to be financed by an Italian company, on the left side of the Krapina River. A sports/physical fitness center and a business center are set up as annexes to the Shopping Center Zagreb-Zaprešić and the total area is 98.7 ha consisting of 35.5 ha of buildings, 35.0 ha of car park, 11.9 ha of road, and 16.3 ha of green space. The designed water supply is 48.4 l/sec. The land area has been purchased and the construction permit may be issued this summer of 2001. Completion of construction is expected by 2008. The Master Plan service area will cover Pliva and Shopping City Zagreb – Zaprešić.

With the extension of 542.4 ha, the total service area will be 1,491.2 ha. Service population in the Master Plan service area will be 30,500 according to the area extension and increase of population. The existing service area is collected by the combined system in principle, while the proposed extension is by the separate one. For the extension area, see Fig. D.9.7.

Among the above five (5) industries to be served by the proposed sewerage system, three (3) large industries (Kardon, Pliva, HZ Inflastructura) are dealt as the sources of industrial wastewater and the remaining two (2) industries (Šimun Milk and Shopping Center) are included in the sources of municipal wastewater in this Study.

Every industry should discharge its industrial wastewater into the municipal treatment plant after pre-treatment to comply with the national regulation in all the parameters. For location of the three (3) large industries and shopping center, see Fig. D.9.7.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	12,009
Daily Maximum	14,144
Hourly Maximum	21,273

(b) Industrial Wastewater Flow

The wastewater quantity of the four (4) large industries is estimated as shown below. The existing and future daily averages are obtained from Subsection 7.2.5, 8,6,1 and 8.6.3 in Appendix C. The future daily maximum and hourly maximum are calculated based on the daily average, considering the operation hour of the industries.

Industry Name	Quantity (m^3/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
Karbon	535	884	884	1,326
Pliva	1,928	3,262	3,262	3,262
HZ Inflastructura	275	454	454	681
Total	2,738	4,600	4,600	5,269

(c) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the transport collector conveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)		
	Municipal	Industry	Total
Daily Average	12,009	4,600	16,609
Daily Maximum	14,144	4,600	18,744
Hourly Maximum (dry)	21,273	5,269	26,542
Hourly Maximum (rainy)	28,635	14,426	43,061

(d) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are summarized in the table below. For the estimation of pollution load of the municipal and industrial wastewater, see Subsection 1.3.2 in Appendix D and Subsection 7.2.5, 8.6.1 and 8.6.3 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 3,677.7 kg/day. It is equivalent to 61,300 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industry	Total	
BOD	2,379.0	1,298.7	3,677.7	196.2
COD_{Cr}	4,758.0	3,004.8	7,762.8	414.1
TSS	2,775.5	2,073.1	4,848.6	258.7
T-N	436.2	437.6	873.8	46.6
T-P	99.1	28.9	128.0	6.8

9.4.3 Proposed Structural Plan

(1) Transport Collector/Main Sewer

The design features of the transport collector/main sewer in the Master Plan service area are as follows. For route of proposed transport collectors/main sewers, see Fig. D.9.7.

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Pipe	Diameter (mm)	Material	Length (m)
Transport Collector	1,000	Concrete	220
Main Sewer	400	Concrete	3,060
	500	Concrete	2,490
	600	Concrete	2,660
Total			8,430

Three (3) lift pumps are required to transport the wastewater in Shopping Center (City) Zagreb-Zaprešić to the treatment plant. The capacity of each pump is as follows.

Pump Station	Capacity (l/second)
1	39
2	39
3	39

(2) Secondary/Tertiary Sewer

It is necessary to install 19,220 m of PVC sewer pipes with the diameter of 200 mm to serve the extension area of 542.4 ha.

(3) Treatment Plant

The site of the treatment plant is 280 m away from the Sava River and owned by CUP Zajarki. The effluent is discharged usually by gravity into the Sava River. In case of high water level, a pump might be required. The location and layout of wastewater treatment plant are shown in Fig. D.9.7 and Fig. D.9.8 respectively.

The capacity of the treatment plant (61,300 PE) is larger than 10,000 PE and the recipient of effluent from the plant (Upper Sava) is Category II. Therefore, Anaerobic Oxic treatment with thickener mechanical sludge dewatering is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area is approximately 2.69 ha. The main facilities, together with the specification and number of units, are as shown below.

Facilities	Specification	No. of Unit
Influent Pumping Station and Screen	Coarse Screen 2 m W	1
	Fine Screen, 1 m W	2
	Archimedical Screw Pump 6.0 m^3/min × 6 m H × 11 kw	5
Grit Oil/Sand Removal	2 m W × 10 m L	2
Parshall Flume	0.3048 m (1 ft)	1
Primary Sedimentation Tank	4.0 m W × 30.0 m L × 3.0 m D (Effective Depth)	4
Aeration Tank	5 m W × 33.0 m L × 5 m D	8
Secondary Sedimentation Tank	∅16 m × 3.5 m D (Effective Depth)	4
Effluent Pumping Station	Vertical Axial Flow Pump 8.0 m^3/min × 5 m H × 11 kw (Building, 9 m × 13 m)	5
Sludge Thickener	∅4 m × 4.0 m D	2
Mechanical Dewatering	Belt Press Filter 1.5 m W × 1.5 kw Polymer Mixing, 0.4 kw	3
Blower	Roots Blower, 22 m^3/min × 37 kw (Building, 9 m × 20 m)	5
Return Sludge	Archimedical Screw Pump 4.4 m^3/min × 3 m H × 5.0 kw	4
Administration Building	10 m W × 15 m L	1

9.4.4 Cost Estimate

The total construction cost is estimated at approx. Kn 106.3 million, broken down as follows.

Cost		Facilities	Cost (×10^3 Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	9,266.2	8.7	14.0
		Secondary/Tertiary Sewer	9,466.2	8.9	14.3
		Sub-total	18,732.5	17.6	28.3
	Treatment Plant	Preliminary Treatment	7,600.5	7.2	11.5
		Biological Reactor	11,708.9	11.0	17.7
		Secondary Sedimentation	4,145.6	3.9	6.3
		Sludge Treatment	9,275.9	8.7	14.0
		Others	14,614.1	13.8	22.1
		Sub-total	47,345.0	44.6	71.7
	Sub-total		66,077.5	62.2	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		6,607.7	6.2	-
	Administration		1,982.3	1.9	-
	Customs Duties		2,380.1	2.2	-
	VAT		15,990.7	15.0	-
	Sub-total		26,961.0	25.4	-
Contingency			13,215.5	12.4	-
Total			106,253.9	100.0	-

9.5 Velika Gorica

9.5.1 Existing Sewerage System

(1) Served Area and Population

The town of Velika Gorica consisting of 59 settlements is located along the southern suburbs of Zagreb City. Some parts of the international airport "PLESO" are located in the town and wastewater generated in the terminal building is discharged into the sewerage system in Velika Gorica. The main activities are agriculture, health recreation, tourism, and storage services. The administrative area and population of the town are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		700.6	32,164.6	32,865.2
Population	(1991)	31,614	25,270	56,884
	(1999)	36,502	29,178	65,680
	(2015)	42,482	33,957	76,439

The sewerage system covers not only the town of Velica Golica but also the eastern part of Zagreb. The existing sewer networks cover 1,452.7 ha, consisting of the urban center of the town, the western seven (7) settlements of Gornja Lomnica, Gradići, Petrovina Turopoljska, Donja Lomnica, Velica Mlaka, Veliko Polje and Mičevec in Velika Gorica, and the three (3) settlements of Hrašće Turopojsko, Odra, Mala Mlaka in Zagreb City and its surrounding areas where 37,400 people live. Among the population mentioned above, 33,500 inhabitants are served by the sewerage system.

(2) Existing Industries

There are five (5) industries registered by Croatian Waters as industrial pollutant, as listsed below. Among them, four (4) industries are served by the sewerage system, while only (1) industry directly discharges into the river. The industries in bold characters below are the large ones described in Appendix C.

Code Number	Industry Name	Activity	Wastewater in 1999 (m^3)	Recipient
314038	**Dalekovod**	**Metal/Machinery**	**47,911**	**Sewerage**
314163	ZET Velika Gorica	Transportation	3,299	Sewerage
314205	**PLESO Zagreb Airport**	**Transportation**	**193,259**	**Sewerage**
314077	**Industrogradnja**	**Concrete**	**25,200**	**Sewerage**
319079	**Industrogradnja**	**Concrete**	**60,000**	**River**

(3) Sewer Networks

The existing sewerage system is shown in Fig. D.9.9. The sewerage system is of separate type with a total length of 143.3 km. It is composed of 34.3 km gravitational main sewer with diameter of 25 cm to 80 cm, 13.3 km of force main, and 95.7 km of secondary/tertiary sewers with thediameter of 25 cm.

The wastewater is collected into the central treatment plant located at the eastern fringe of the town and then, the treated wastewater is discharged into the Sava River by a 10.85 km force main with the diameter of 60 cm at the settlement of D. Bukevje.

(4) Treatment Plant

The layout of the existing treatment plant is shown in Fig. D.9.10. The central treatment plant, which has the biological process, is located at the eastern fringe of the urban center, nearby the Lake Čiče. Operational since 1973, the plant has a treatment capacity of 35,000 PE. The treatment plant is functioning well.

The quantity of inflow into the treatment plant during the second half of 1999 was measured as follows.

Period	Quantity (m^3/day)	Period	Quantity (m^3/day)
Jul. 1999	14,100	Oct. 1999	11,700
Aug. 1999	12,000	Nov. 1999	11,200
Sep. 1999	12,000	Dec. 1999	15,900

The quality of influent and effluent in the treatment plant was analyzed in July, 2000 with results as follows.

Parameter	Unit	Influent			Effluent		
		Max	Average	Min	Max	Average	Min
Temperature (air)	°C	36	23	5	10	-	-
Temperature (water)	°C	21.5	20.6	18	22.5	20.6	18.8
PH		8.1	7.6	6.8	8.0	7.8	7.5
COD_{Cr}	mg/l	2,745	754	428	89	55.6	32
BOD_5	mg/l	1,800	287	158	41	18.2	10
Evaporated Residue	mg/l	2,565	1,154	690	731	615	462

The JICA Study Team also analyzed the quantity and quality of effluent in the treatment plant on November 27, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time	-	12:45	COD_{Mn}	mg/l	17.0
Flow	m^3/sec	0.139	SS	mg/l	66.0
PH	-	7.67	T-N	mg/l	35.0
BOD	mg/l	15.0	T-P	mg/l	4.15

9.5.2 Planning Basis

(1) Service Area, Population and Industries

Velika Gorica has a sufficient quantity of groundwater, and only 10% of water abstracted from wells is used in Velika Gorica and the other 90% is delivered to Zagreb. Water supply covers all the existing sewerage area. High priority is given to water source protection.

Based on this policy, the following 14 northeastern settlements near the water source will be served by the sewerage system: Velika Kosnica, Novaki Šćitarjevski, Sasi, Obrezina, Drenje Šćitarjevsko, Šćitarjevo, Trnje, Lekneno, Bapća, Mala Kosnica, Petina, Selnica Šćitarjevska, Črnkovec and Kobilići. The southwestern settlement of Lukavec is added to the service area since it is located near the existing one.

With the extension of 558.1 ha, the total service area will be 2,010.8 ha. Service population in the Master Plan service area will be 62,400 according to the area extension and increase of population. The existing and the proposed extension of service area will both be collected by the separate system. For the extension area, see Fig. D.9.9.

The Master Plan service area will cover only the four (4) industries discharging into the existing sewerage system. Every industry should discharge its industrial wastewater into the municipal treatment plant after pre-treatment to comply with the national regulation in all the parameters.

Among the above four (4) industries to be served by the proposed sewerage system, three (3) large industries (Dalekovod, PLESO Airport and Industrogradinja) are dealt as the sources of industrial wastewater and the remaining one (1) small industry is included in the sources of municipal wastewater in this Study. For location of the large industry, see Fig. D.9.9.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	20,592
Daily Maximum	24,960
Hourly Maximum	35,568

(b) Industrial Wastewater Flow

The wastewater quantity of the three (3) large industries is estimated as shown below. The existing and future daily averages were obtained from Subsection 8.7.1, 8.7.2 and 8.7.4 in Appendix C. The future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the industries.

Industry Name	Quantity (m^3/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
Dalekovod	192	317	317	476
PLESO Airport	108	167	167	250
Industrogradinja	101	178	178	267
Total	401	662	662	993

(c) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is projected as follows. Hourly maximum flow to the treatment plant is constant irrespective of weather condition since all the sewer pipes are of separate type.

Item	Quantity (m^3/day)		
	Municipal	Industrial	Total
Daily Average	20,592	662	21,254
Daily Maximum	24,960	662	25,622
Hourly Maximum (dry)	35,568	993	36,561
Hourly Maximum (rainy)	35,568	993	36,561

(d) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are summarized in the table below. For the estimation of pollution load of the municipal and industrial wastewater, see Subsection 1.3.2 in Appendix D and Subsection 8.7.1, 8.7.2 and 8.7.4 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 4,931.0 kg/day. It is equivalent to 82,200 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industrial	Total	
BOD	4,867.2	63.8	4,931.0	192.5
COD_{Cr}	9,734.4	147.4	9,881.8	385.7
TSS	5,678.4	427.4	6,105.8	238.3
T-N	892.3	19.9	912.2	35.6
T-P	202.8	3.3	206.1	8.0

9.5.3 Proposed Structural Plan

(1) Main Sewer

The design of main collector in the Master Plan service area is as follows. There is no transport collector. For the route of proposed main sewers, see Fig. D.9.9.

Pipe	Diameter (mm)	Material	Length (m)
Main Sewer	200	PVC	16,190
	250	PVC	1,470
	300	PVC	200
	400	Concrete	3,640
Total			21,500

Seven (7) lift pumps with the following capacity are required.

Pump Station	Capacity (l/sec)
A1-1	1
A1-2	2
A2	2
A3	11
D1	2.5
E	30
F	1

(2) Secondary/Tertiary Sewer

It is necessary to install 13,980 m of PVC sewer pipes with the diameter of 200 mm to serve the extension area of 558.1 ha.

(3) Treatment Plant

The town owns the site of the existing WWTP. The location and layout of the wastewater treatment plant are shown in Fig. D.9.9 and Fig. D.9.10, respectively.

The capacity of the treatment plant (82,200 PE) is larger than 10,000 PE and the recipient of effluent from the plant (Middle Sava) is Category III. Therefore, Activated Sludge process with thickener and mechanical sludge dewatering is proposed (refer to Subsection 1.4.4 and 1.4.5). The effluent is discharged into the Sava River through the existing force main of 10.85 km.

The required surface area is approximately 2.43 ha including the existing one. The main facilities, together with the specification and number of units, are shown below.

Facilities	Specification		No. of Unit*
Influent Pumping Station and Screen	Coarse screen 1.5 m W	(Existing)	(1)
	Fine screen 1.2 m W	(Existing)	(2)
	Archimedical Screw Pump 19.2 m^3/min × 6 m H × 30 kw 15.0 m^3/min × 6 m H × 22 kw		 2 2
Grit Oil/Sand Removal	1.85 m W × 15.5 m L		2
Parshall Flume	0.3048 m (1 ft)	(Existing)	(2)
	0.3048 m (1 ft)		1
Primary Sedimentation Tank	4.2 m W × 19.2 m L × 1.8 m D	(Block 1)	1
	6.0 m W × 38.9 m L × 3.2 m D	(Block 2)	(1)
	3.0 m W × 17.0 m L × 3.0 m D	(Block 3)	4
Aeration Tank	10.9 m W × 11.8 m L × 4.0 m D	(Block 1)	2
	9.5 m W × 9.5 m L × 4.3 m D	(Block 2)	(4)
	5.0 m W × 23.0 m L × 5.0 m D	(Block 3)	4
Secondary Sedimentation Tank	8.8 m W × 11.8 m L × 3.0 m D	(Block 1)	2
	9.0 m W × 43.5 m L × 3.6 m D	(Block 2)	(1)
	8.0 m W × 43.5 m L × 3.6 m D	(Block 2)	(1)
	∅15 m × 3.5 m D (Effective Depth)	(Block 3)	2
Sludge Thickener	8.8 m W × 11.8 m L × 3.0 m D	(Block 1)	1
Mechanical Dewatering	Belt Press Filter 2.0 m W × 2.2 kw Polymer Mixing 0.75 kw	(Block 1)	4
Effluent Pumping Station	Vertical Axial Flow Pump 12.7 m^3/min × 6 m H × 44 kw	(Existing)	(2)
Blower	Rotary Type Blower 20 m^3/min × 37 kw (Building 5 m × 5 m)	(Block 1)	2
	Rotary Type Blower 21 m^3/min × 37 kw (Building 5 m × 5 m)	(Block 2)	(3)
	Root Blower 14 m^3/min × 22 kw (Building 7 m × 13 m)	(Block 3)	3
Return Sludge	Submerged Pump 2.1m^3/min×5 m H×7.4 kw	(Block 1)	2
	Archimiedical Screw Pump 3.0 m^3/min × 4 m H × 3.7 kw	(Block 2)	(3)
	Archimiedical Screw Pump 3.0 m^3/min × 4 m H × 3.7 kw	(Block 3)	3
Digestion Tank(as Bypass)			(1)
Administration Building	10 m W × 15 m L		1

* Figures in parenthesis are the existing ones.

9.5.4 Cost Estimate

The total construction cost is estimated at approx. Kn 77.5 million, broken down as follows.

Cost		Facilities	Cost (×10^3 Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	12,174.0	15.7	25.4
		Secondary/Tertiary Sewer	6,886.8	8.9	14.3
		Sub-Total	19,060.8	24.6	39.7
	Treatment Plant	Preliminary Treatment	4,020.0	5.2	8.4
		Biological Reactor	9,357.7	12.1	19.5
		Secondary Sedimentation	4,263.1	5.5	8.9
		Sludge Treatment	5,015.4	6.5	10.4
		Others	6,301.0	8.1	13.1
		Sub-total	28,957.2	37.4	60.3
	Sub-total		48,018.0	62.0	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		4,801.8	6.2	-
	Administration		1,440.5	1.9	-
	Customs Duties		2,020.4	2.6	-
	VAT		11,620.3	15.0	-
	Sub-total		19,883.1	25.7	-
Contingency			9,603.6	12.4	-
Total			77,504.6	100.0	-

9.6 Jastrebarsko

9.6.1 Existing Sewerage System

(1) Service Area and Population

Jastrebarsko, consisting of 56 settlements, is situated beween Zagreb City and Karlovac Town along the superhighway and the railway. The administrative area and population including future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		242.0	22,408.1	22,650.1
Population	(1991)	5,380	12,515	17,895
	(1999)	5,434	12,639	18,073
	(2015)	5,661	13,170	18,831

The existing sewerage system, with a total area of 409.1 ha and connected to 5,300 inhabitants, covers almost all the urban center of the town, the northern two (2) settlements of Donja Reka and Zdihovo, the southern two (2) settlements of Cvetković and Čabdin, and the surrounding settlements.

(2) Existing Industries

An industrial estate has developed in the southern suburbs of the town. There are six (6) industries registered by Croatian Waters as pollutant sources, most of them directly discharging into the neighboring streams. The industries in bold characters below are the large ones described in Appendix C.

Code Number	Industry Name	Activity	Pretreat-ment	Wastewater (m^3/year) 1998	1999	Recipient
332001	**Mladina d.d.**	**Food/Beverage**	**Yes**	**1,819**	**27,144**	**Sewerage**
332002	**Jamniča Kiselica**	**Food/Beverage**	**Yes**	**186,026**	**183,876**	**Mel Canal**
332006	Klaoniča i Prerada Mesa	Food/Beverage	Yes	-	9,512	Stiper Brook
332003	Iteks Klinča Selo	Metal-Machinery	Yes	-	-	Brook
332005	Maček-Tvornica Vijaka	Metal/Machinery	Yes	-	769	Sewerage
332004	Palma-Zagreb	Funeral	No	-	-	Brook Reka

(3) Sewer Networks

The sewer networks are of combined type. The wastewater is discharged by two (2) main collectors: G1 and G2. The G1 collector runs through the central part of the town and collects the wastewater of the urban center, while the G2 collector collects wastewater from the eastern part of the town. Both collectors discharge wastewater by gravity into the Bresnica Brook at the same location near the superhighway interchange.

The total sewer length is 33 km and pipe diameters are 30 cm to 120 cm. The sewer is made of concrete. The existing sewerage system is shown in Fig. D.9.11.

(4) Wastewater Flow and Quality

The JICA Study Team also analyzed the quantity and quality of wastewater in the manhole at Cvjetno Naselje Street on November 29, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time		12:35H	COD_{Mn}	mg/l	42.0
Flow	M^3/sec	0.025	SS	mg/l	73.0
pH		7.5	T-N	mg/l	25.3
BOD	mg/l	60.0	T-P	mg/l	4.16

9.6.2 Planning Basis

(1) Service Area, Population and Industries

To cover the districts adjoining the existing service area in the urban center of Jastrebarsko, the service area will be extended by 213.9 ha to become 623.o ha. Served population in the Master Plan service area will be 8,100 according to the area extension and increase of population. The existing service area is collected by the combined system as at present, while the proposed extension area is by the separate one. For the extension area, see Fig. D.9.11.

Only the two (2) industries discharging into the existing sewerage system will be covered under the Master Plan service area. Every industry should discharge its industrial wastewater into the municipal treatment plant after pre-treatment to comply with the national regulation in all the parameters.

Among the above two (2) industries, one (1) large industry (Mladina) is dealt as a source of industrial wastewater and another small industry is included in the sources of municipal wastewater in this Study.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	2,349
Daily Maximum	2,754
Hourly Maximum	3,888

(b) Industrial Wastewater Flow

The wastewater quantity of the one (1) large industry is estimated as shown below. The existing and future daily averages were obtained from Subsection 8.8.1 in Appendix C. The future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the industries.

Industry Name	Quantity (m^3/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
Mladina	109	180.0	180.0	270.0

(c) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the transport collector conveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)		
	Municipal	Industrial	Total
Daily Average	2,349	180	2,529
Daily Maximum	2,754	180	2,934
Hourly Maximum (dry)	3,888	270	4,158
Hourly Maximum (rainy)	6,758	540	7,298

(d) Quality of Wastewater

The expected pollution load and quality of influent into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal and industrial wastewater, see Subsection 1.3.2 in Appendix D and Subsection 8.8.1 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 575.9 kg/day. It is equivalent to 9,600 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industrial	Total	
BOD	534.6	41.3	575.9	196.3
COD_{Cr}	1,069.2	66.4	1,135.6	387.1
TSS	623.7	54.0	677.7	231.0
T-N	98.0	5.4	103.4	35.2
T-P	22.3	0.9	23.2	7.9

9.6.3 Proposed Structural Plan

(1) Transport Collector/Main Sewer

The design features of the transport collector/main sewer in the Master Plan service area are as follows. One (1) lift pump with the capacity of 3.3 l/sec is required. For the route of transport collectors/main sewers, see Fig. D.9.11.

Pipe	Diameter (mm)	Material	Length (m)
Transport Collector	600	Concrete	1,820
	800	Concrete	130
Main Sewer	200	PVC	2,150
Total			4,100

(2) Secondary/Tertiary Sewer

It is necessary to install 3,650 m of PVC sewer pipes with the diameter of 200 mm to serve the extension area of 213.9 ha.

(3) Treatment Plant

The location and layout of the wastewater treatment plant are shown in Fig. D.9.11 and Fig. D.9.12, respectively. The government owns the site of the treatment plant.

The capacity of the treatment plant (9,600 PE) is smaller than 10,000 PE and the recipient of effluent from the plant (Kupcina) is Category II. Therefore, Oxidation Ditch process with thickener and sludge drying bed is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area is approximately 1.67 ha. The main facilities, together with the specification and number of unit, are shown below. The effluent is discharged into the Kupa River through the Bresnica Brook.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse Screen 2 m W	1
	Fine Screen 0.6 m W	3
	Archimedical Screw Pump $2.0\ m^3/min \times 6\ m\ H \times 4$ kw	3
Grit Oil/Sand Removal	2 m W × 5 m L	1
Parshall Flume	0.3048 m (1 ft)	1
Oxidation Ditch	4.5 m W × 2.5 m D, V = 3,780 m^3	4
Secondary Sedimentation Tank	∅14 m × 3.5 m D (Effective Depth)	2
Sludge Thickener	∅4 m × 4.0 m H	1
Drying Bed	Approx. 15 m W × 50 m L	1
Mechanical Aerator	Vertical, 22 kw	4
Return Sludge	Archimedical Screw Pump $2.2\ m^3/min \times 3\ m\ H \times 2.4$ kw	3
Administration Building	10 m W × 10 m L	1

9.6.4 Cost Estimate

The total construction cost is estimated at approx. Kn 36.0 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	3,540.1	9.8	15.8
		Secondary/Tertiary Sewer	1,794.2	5.0	8.0
		Sub-total	5,334.3	14.8	23.8
	Treatment Plant	Preliminary Treatment	2,379.6	6.6	10.6
		Biological Reactor	7,405.2	20.5	33.1
		Secondary Sedimentation	2,112.2	5.9	9.4
		Sludge Treatment	239.0	0.7	1.1
		Others	4,912.3	13.6	21.9
		Sub-total	17,048.3	47.3	76.2
	Sub-total		22,382.5	62.1	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		2,238.3	6.2	-
	Administration		671.5	1.9	-
	Customs Duties		854.2	2.4	-
	VAT		5,416.6	15.0	-
	Sub-total		9,180.5	25.5	-
Contingency			4,476.5	12.4	-
Total			36,039.6	100.0	-

9.7 Petrinja

9.7.1 Existing Sewerage System

(1) Service Area and Population

Petrinja, consisting of 55 settlements, is located immediately upstream of Sisak along the Kupa River. The urban center of the town is divided into two (2) parts: east and west, by the Petrinjčica River that runs through the urban center from the south to the north before finally joining the Kupa River. Most of the urban area, with ground elevation ranging from 100 m to 120 m, is located on the east bank of the Petrinjčica River. All of the area is covered by water supply although the network is old.

The administrative area and population including future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		939.5	37,101.8	38,041.3
Population	(1991)	18,706	16,445	35,151
	(1999)	12,545	11,028	23,573
	(2015)	14,466	12,718	27,184

The sewerage system serves most of the urban center and a small part of the northeastern settlement of Nova Drenčina. The service area and population are 418.5 ha and 10,300 inhabitants, respectively.

(2) Existing Industries

There is only one (1) industry (Gavrilović) registered by Croatian Waters as industrial pollutant in the town, as listed below. Gavrilović is one of the largest meat processing industries of the country. It is located in the eastern fringe of the urban center (Senjak). The main products are cooked sausages, meat specialities, canned meat and ready-to-serve meals. The industry covers a total area of 4.7 ha and employs about 250 people as described in Section 7.3, Appendix C.

Code Number	Industry Name	Activity	Pre-Treatment	Wastewater (m^3/year)		Recipient
				1998	1999	
373001	**Gabrilović**	**Food/Beverage**	**Yes**	**535,745**	**602,003**	**Kupa River**

(3) Sewer Network

The town is divided into east and west by a watershed. Since there is no sewerage system in the east side, there is a plan to integrate the future sewerage system of this area with the system of the west side of Sisak.

The existing sewerage system is of combined one. Construction started in 1913, hence, some portions are old and some were destroyed by the war. Since the system was planned when the population was only 5,000, the diameter of existing pipe is too small to serve the population of 13,000 persons who now live in the urban center. At present, the sewerage service area is less than one-half of the urban center of the town.

The wastewater of the town is discharged into the Kupa River through two (2) outfalls that are both located at the mouth of the Petrinjčica River. The Gavrilović industry installed its own pipe of 2.5 km in length and discharges industrial wastewater through it into the Kupa River. The storm water collected by the combined sewer spills into the Petrinjčica River before the final disposal of wastewater into the Kupa River.

The total sewer length is 33 km, consisting of 11 km of main sewer and 22 km of secondary/tertiary sewer. All of the sewer networks are gravitational and the maximum diameter is 180/120 cm.

The existing condition of the sewer network is not satisfactory. The wastewater quantity sometimes exceeds the capacity of the sewer pipes in the core area of the town when it rains heavily.

The water supply and sewerage company Puro Privreda manages the sewerage system, which consists of three (3) major sub-systems as described below. The existing sewerage system is shown in Fig. D.9.13.

(a) Right Bank of the Petrinjčica River

The main collector of this sub-system is installed along the Petrinjčica River and the secondary collectors are provided beneath the Matija Gubec Street, the Ljudevit Gaj Street, the Katarina Zrinski Street and the Stjepan Radić Street. The discharging point of the main collector is located at the mouth of the Petrinjčica River.

The sewer network of approximately 16.5 km in total length is made up of finished round sections of concrete pipe with diameter of 30 cm to 60 cm, egg-shaped sections of 40/60 cm and 50/75 cm, and egg-shaped sections with a bigger diameter of 120/180 cm. The sewer network is provided with about 300 manholes.

(b) Southern Left Bank of the Petrinjčica River

The southern part of the left bank of the Petrinjčica River is connected with the main collector of the Right Bank of Petrinjčica River sub-system. There are approximately 2 km of sewers with about 50 manholes. The sewers are made of concretes pipes with the diameter of 30/80 cm.

(c) Northern Left Bank of the Petrinjčica River

The main collector of this sub-system is placed beneath the Kupska Street and it crosses under the Petrinjčica River to discharge into the Kupa River at the right side river mouth of the Petrinjčica River. Approximately 2.5 km of sewers are made up of concrete pipe with diameters of 20/50 cm, 40/60 cm and 50/75 cm. The sewer networks are provided with about 50 manholes.

(4) Wastewater Flow and Quality

The JICA Study Team also analyzed the quantity and quality of wastewater in the manhole before Kupa River on November 28, 2000. The results for major parameters are shown below. For other parameters, see Table B.4.3 in Appendix B.

Parameter	Unit	Value	Parameter	Unit	Value
Sampling Time	-	11:30	COD_{Mn}	mg/l	28.0
Flow	m^3/sec	0.0523	TSS	mg/l	106.0
PH	-	7.51	T-N	mg/l	20.0
BOD	mg/l	25.0	T-P	mg/l	4.24

9.7.2 Planning Basis

(1) Service Area, Population and Industries

Since only less than one-half of the urban center is being served by the existing sewerage system, the service area will be extended to cover the east side of the urban center. With an extension of 231.3 ha, the service area will thus cover a total area of 649.8 ha and service population in the Master Plan service area will be 13,100 according to the area extension and increase of population. The existing service area is collected by the combined system, while the proposed extension area is by the separate one. For the extension area, see Fig. D.9.13.

The meat-processing factory Gabrilović, which is registered by Croatian Waters as industrial pollutant, will be covered under the Master Plan service area. The factory should discharge its industrial wastewater into the municipal treatment plant after pre-treatment in compliance with the national regulation in all the parameters. For location of the industry, see Fig. D.9.13.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	4,323
Daily Maximum	5,240
Hourly Maximum	7,467

(b) Industrial Wastewater Flow

The wastewater quantity of the Gabrilović factory is estimated as shown below. The existing and future daily averages were obtained from Subsection 7.3.5 in Appendix C. The future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the factories.

Industry Name	Quantity (m^3/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
Gavrilović	1,357	1,979	1,979	2,969

(c) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is projected as follows. In the following table, hourly maximum in rainy period is estimated based on the assumption that the transport collector conveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)		
	Municipal	Industrial	Total
Daily Average	4,323	1,979	6,302
Daily Maximum	5,240	1,979	7,219
Hourly Maximum (dry)	7,467	2,969	10,436
Hourly Maximum (rainy)	13,417	2,969	16,386

(d) Quality of Wastewater

The expected pollution load and quality of influent into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal and industrial wastewater, see Subsection 1.3.2 of this Appendix D and Subsection 7.3.5 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 1,249.4 kg/day. It is equivalent to 20,900 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industrial	Total	
BOD	1,021.8	227.6	1,249.4	173.1
COD_{Cr}	2,043.6	463.1	2,506.7	342.7
TSS	1,192.1	360.2	1,552.3	215.0
T-N	187.3	9.5	196.8	27.3
T-P	42.6	5.7	47.7	6.6

9.7.3 Proposed Structural Plan

(1) Transport Collector/Main Sewer

The design features of the transport collector/main sewer in the Master Plan service area are as follows. A lift pump is not required. For route of the transport collectors/main sewers, see Fig. D.9.13.

Pipe	Diameter (mm)	Material	Length (m)
Transport Collector	600	Concrete	1,120
Main Sewer	200	PVC	2,770
Total			3,890

(2) Secondary/Tertiary Sewer

It is necessary to install 7,130 m of PVC sewer pipe with the diameter of 200 mm to serve the extension area of 231.3 ha.

(3) Treatment Plant

The proposed wastewater treatment site is a privately owned with remaining landmines. The location and layout of the wastewater treatment plant are shown in Fig. D.9.13 and Fig. D.9.14, respectively.

The capacity of the treatment plant (20,900 PE) is larger than 10,000 PE and the recipient of effluent from the plant (Lower Kupa) is Category II. Therefore, Anaerobic Oxic process with thickener and mechanical sludge dewatering is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area is approximately 1.48 ha. The main facilities, together with the specification and number of units, are shown below. The effluent is discharged into the Kupa River.

Facilities	Specification	No. of Unit
Influent Pumping Station and Screen	Coarse Screen, 2 m W	1
	Fine Screen, 1 m W	1
	Archimedical Screw Pump 4.0 m^3/min × 6 m H × 7 kw	3
Grit Oil/Sand Removal	2 m W × 10 m L	1
Parshall Flume	0.3048 m (1 ft)	1
Primary Sedimentation Tank	3.0 m W × 16.0 m L × 3.0 m D (Effective Depth)	4
Aeration Tank	5 m W × 24.0 m L × 5 m D	4
Secondary Sedimentation Tank	Ø14 m × 3.5 m D (Effective Depth)	2
Sludge Thickener	Ø6 m × 4.0 m D	1
Mechanical Dewatering	Belt Press Filter, 1.5 m W × 1.5 kw Polymer Mixing, 0.4 kw	2
Blower	Roots Blower, 13 m^3/min × 22 kw (Building, 7 m × 15 m)	3
Return Sludge	Archimedical Screw Pump 2.6 m^3/min × 3 m H × 7.2 kw	3
Administration Building	10 m W × 10 m L	1

9.7.4 Cost Estimate

The total construction cost is estimated at approx. Kn 55.6 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	3,089.4	5.6	9.1
		Secondary/Tertiary Sewer	3,507.2	6.3	10.3
		Sub-total	6,596.6	11.9	19.4
	Treatment Plant	Preliminary Treatment	4,689.0	8.4	13.8
		Biological Reacto	6,590.1	11.9	19.4
		Secondary Sedimentation	2,044.8	3.7	6.0
		Sludge Treatment	4,821.4	8.7	14.2
		Others	9,286.0	16.7	27.3
		Sub-total	27,431.3	49.3	80.6
	Sub-total		34,027.9	61.2	100.0
Land Acquisition			722.0	1.3	-
Indirect Cost	Engineering		3,402.8	6.1	-
	Administration		1,020.8	1.8	-
	Custom Duties		1,371.6	2.5	-
	VAT		8,234.8	14.8	-
	Sub-total		14,029.9	25.2	
Contingency			6,805.6	12.2	-
Total			55,585.4	100.0	-

9.8 Glina

9.8.1 Existing Sewerage System

(1) Service Area and Population

Glina, consisting of 67 settlements, is located in the middle reaches of the Glina River that joins the Kupa River upstream of Petrinja. The administrative area and population including future projection (2015) are shown below. Due to enormous damage caused by the recent war, population decreased from 23,000 to 14,000 and employee number from 3,000 and 2,000 people.

Item		Urban Center	Rural Area	Total
Area (ha)		458.5	53,975.2	54,433.7
Population	(1991)	6,933	16,107	23,040
	(1999)	4,098	9,519	13,617
	(2015)	4,490	10,430	14,920

The sewerage system covers the central urban area of the town and has a total area of 175.2 ha. The served population is 2,000 inhabitants.

(2) Existing Industries

There is only one (1) industry, Vivera d.o.o. Pliva Grupa, registered by Croatian Waters as industrial pollutant in the town, as listed below.

Code Number	Industry Name	Activity	Pre-Treatment	Wastewater (m^3/year) 1998	Wastewater (m^3/year) 1999	Recipient
37100011	Vivera d.o.o. Pliva Grupa	Food/Beverage	Yes	-	-	Sewerage

(3) Sewer Network

The existing sewerage system is shown in Fig. D.9.15. The wastewater of the town is discharged by gravity into the Glina River through two (2) major outfalls. The sewerage system is of combined type with a total sewer length of 38.4 km. The sewer pipes are mostly made of concrete pipe with the diameter of 100 cm.

9.8.2 Planning Basis

(1) Service Area, Population and Industries

Since the existing sewerage system covers less than half of the urban center of Glina, an extension is planned to cover the remaining area of the urban center as well as the surrounding area. With the extension of 304.8 ha, the total service area will be 480.0 ha. Service population in the above area will be 5,200 according to the area extension and increase of population. The existing service area is collected by the combined system, while the proposed extension area is by the separate one. For the extension area, see Fig. D.9.15.

Only the industry named Vivera d.o.o. Pliva Grupa, which is located within the existing sewerage system, is covered under the Master Plan service area. However, it is included in the sources of municipal wastewater in this Study since its pollution load is small. This industry should discharge its industrial wastewater into the municipal treatment plant after pre-treatment in compliance with the national regulation in all the parameters.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is as projected in the following table. Hourly maximum in rainy period was estimated based on the assumption that the main sewer conveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)
Daily Average	1,508
Daily Maximum	1,768
Hourly Maximum (dry)	2,496
Hourly Maximum (rainy)	3,767

(b) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal wastewater, see Subsection 1.3.2 in Appendix D.

As shown in the table, the total BOD load generated in the Master Plan service area is 343.2 kg/day. It is equivalent to 5,800 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)	Concentration (mg/l)
BOD	343.2	194.1
COD_{Cr}	686.4	388.2
TSS	400.4	226.5
T-N	62.9	35.6
T-P	14.3	8.1

9.8.3 Proposed Structural Plan

(1) Main Sewer

The design features of main sewer in the Master Plan service area are as follows. There is no transport collector, and no lift pump is required. For the route of proposed main sewers, see Fig. D.9.15.

Pipe	Diameter (mm)	Material	Length (m)
Main Sewer	200	PVC	5,410

(2) Secondary/Tertiary Sewer

It is necessary to install 12,710 m of PVC sewer pipe with the diameter of 200 mm to serve the extension area of 304.8 ha.

(3) Treatment Plant

The treatment plant with a surface area of 1.5 ha is sited alongshore in the right bank of the Glina River, downstream from the town in the settlement of Jukinac. At present, the site is privately occupied, used for agriculture and partly grassland. Since agricultural production and quality are not so good at this location, land acquisition may not be difficult. There is no settlement near the site. The location and layout of the wastewater treatment plant are shown in Fig. D.9.15 and Fig. D.9.16, respectively.

The capacity of the treatment plant (5,800 PE) is smaller than 10,000 PE and the recipient of effluent from the plant (Glina River) is Category II. Therefore, Oxidation Ditch process with thickener and sludge drying bed is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area is approximately 1.64 ha. The main facilities, together with the specification and number of units, are shown below.

Facilities	Specification	No. of Unit
Influent Pumping Station and Screen	Coarse Screen, 1.5 m W	1
	Fine Screen, 0.6 m W	2
	Archimedical Screw Pump 1.5 m^3/min × 6m H × 3.7 kw	2
Grit Oil/Sand Removal	2 m W × 5 m L	1
Parshall Flume	0.3048 m (1 ft)	1
Oxidation Ditch	4.5 m W × 2.5 m D, V = 2,250 m^3	4
Secondary Sedimentation Tank	∅11 m × 3.5 m D (Effective Depth)	2
Sludge Thickener	∅4 m × 4.0 m D	1
Drying Bed	Approx. 15 m W × 30 m L	1
Mechanical Aerator	Vertical, 15 kw	4
Return Sludge	Archimedical Screw Pump 1.5 m^3/min × 3 m H × 1.7 kw	3
Administration Building	8 m W × 8 m L	1

9.8.4 Cost Estimate

The total construction cost is estimated at approx. Kn 36.6 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	2,808.6	7.7	12.4
		Secondary/Tertiary Sewer	6,259.1	17.1	27.7
		Sub-total	9,067.7	24.8	40.1
	Treatment Plant	Preliminary Treatment	2,272.9	6.2	10.1
		Biological Reactor	5,290.7	14.5	23.4
		Secondary Sedimentation	1,532.1	4.2	6.8
		Sludge Treatment	209.2	0.6	0.9
		Others	4,216.5	11.5	18.7
		Sub-total	13,521.5	36.9	59.9
	Sub-total		22,589.2	61.7	100.0
Land Acquisition			418.0	1.1	-
Indirect Cost	Engineering		2,258.9	6.2	-
	Administration		677.7	1.9	-
	Customs Duties		676.1	1.8	-
	VAT		5,466.6	14.9	-
	Sub-total		9,079.3	24.8	-
Contingency			4,517.8	12.3	-
Total			36,604.3	100.0	-

9.9 Topusko

9.9.1 Existing Sewerage System

(1) Service Area and Population

Topusko, consisting of 16 settlements, is located upstream of Glina in the Glina River Basin. The administrative area and population including future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		91.7	19,565.8	19,657.5
Population	(1991)	1,587	5,237	6,824
	(1999)	1,116	3,684	4,800
	(2015)	1,227	4,050	5,277

Topusko has developed as a resort area with hot spring facilities in the medical recreation center enjoyed by many people in summer. The inhabitants mostly occupy themselves in catering or working for the recreation center. The other occupation is agriculture.

With regard to the hot water supply, 8.5 km of water supply network has been installed to deliver groundwater at 45 l/s. Repair of the water supply system would require Kn 3 Million, which will be funded mostly from the USA. The temperature ranges from 60°C to 82°C. The groundwater is abstracted from a depth of 250 m. The technology for agriculture in green houses by using hot water has been proposed by the Netherlands.

The sewerage system covers a little part of the urban center of the municipality. The existing served area and population are 33.8 ha and 500 habitants, respectively.

(2) Existing Industries

There are no industries registered by Croatian Waters as industrial pollutant in the municipality.

(3) Sewer Networks

The existing sewerage system is shown in Fig. D.9.17. Most of the wastewater is discharged into the Glina River through the treatment plant, which is not functioning at present, while wastewater in a southern small part of the service area is discharged directly into the same river through another outfall. Seventy percent (70%) of the sewer network is of combined type and 30 % of it is of separate type. Total sewer length is 6.5 km with the diameter of 25 cm to 70/120 cm. All of the sewer networks are gravitational.

(4) Treatment Plant

The layout of the existing treatment plant is shown in Fig. D.9.18. The sewage treatment plant was constructed on the right bank of the Glina River in the eastern suburbs of the urban center in 1987. The plant has not been working since 1990 due to the damage caused by the internal war and the capacity is too big requiring a lot of energy. The treatment plant was designed to receive not only domestic wastewater but also storm water (three times of domestic wastewater) during rainfall (8.4 hours after the beginning of rainfall). Water in excess of the design quantity spills into the drain before the treatment plant, and wastewater including storm water is discharged through a pipe of 60 cm in diameter.

The treatment plant of aerated lagoon with sedimentation tank was designed to treat the following wastewater quantity and pollution load.

Items	Unit	First Stage	Second Stage
Design Population	PE	6,000	12,000
Hydraulic Load (average)	m^3/day	1,300	2,600
Hydraulic Load (Maximum)	m^3/day	1,900	3,800
COD_{Cr} Load	kg/day	360	720

Of the above plan, only the first stage was constructed. The major constructed facilities are summarized below.

Facilities		Specification		
Pumping Station	Wastewater	Quantity	:	2 × dry flow type
		Type	:	Screw Pump
		Diameter		50 cm
		Head		5.0 m
		Number of unit		2 Pumps
	Storm water	Quantity	:	3 × dry flow
		Type	:	Screw Pump
		Diameter	:	80 cm
		Head	:	4m
		Number of Units	:	2 Pumps
Automatic Coarse Screen		0.8 m of width with 2 cm of interval screen		
Circular Grit Chamber		Circular grit chamber with Dia.300 cm of electromechanical mixer		
Measuring Device		Ventury flow meter and pH meter		
Aerated Lagoon		First lagoon for treating wastewater with activated sludge of 1.3kg SS/m^3 Second lagoon for only aeration with no return sludge		
Sedimentation Tank		Two rectangular sedimentation tanks in series		

9.9.2 Planning Basis

(1) Service Area, Population and Industries

Since the existing service area is a very small part of the urban center of Topusko, it will be extended to cover the entire urban center and the surrounding areas. The total service area will thus be 83.8 ha with the extension of 50.0 ha. Service population in the Master Plan service area will be 1,600 according to the area extension and increase of population. The existing service area is collected by the combined system in principle, while the proposed extension area is by the separate one. For the extension area, see Fig. D.9.17.

There is no industry registered by Croatian Waters as industrial pollutant in Topusko.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the main sewer coveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)
Daily Average	464
Daily Maximum	544
Hourly Maximum (dry)	768
Hourly Maximum (rainy)	1,055

(b) Quality of Wastewater

The expected pollution load and quality of influent into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal wastewater, see Subsection 1.3.2.

As shown in the table, the total BOD load generated in the Master Plan service area is 105.6 kg/day. It is equivalent to 1,800 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)	Concentration (mg/l)
BOD	105.6	194.1
COD_{Cr}	211.2	388.2
TSS	123.2	226.5
T-N	19.4	35.6
T-P	4.4	8.1

9.9.3 Proposed Structural Plan

(1) Transport Collector/Main Sewer

The design features of the main sewer in the Master Plan service area are as follows. There is no transport collector, and no lift pump is required. For the route of proposed main sewers, see Fig. D.9.17.

Pipe	Diameter (mm)	Material	Length (m)
Main Sewer	200	PVC	3,660

(2) Secondary/Tertiary Sewer

The sewerage improvement system is also shown in Fig. D.9.17. It is necessary to install 630 m of PVC sewer pipe with the diameter of 200 mm to serve the extension area of 50.0 ha.

(3) Treatment Plant

The location and layout of wastewater treatment plant are shown in Fig. D.9.17 and Fig. D.9.18, respectively.

The capacity of the treatment plant (1,800 PE) is smaller than 10,000 PE and the recipient of effluent from the plant (Glina River) is Category II. Therefore, Oxidation Ditch process with thickener and sludge drying bed is proposed (refer to Subsection 1.4.4 and 1.4.5). However, the structure of the aerated lagoon still exists so that it is better to adopt the aerated lagoon by rehabilitating the mechanical and electrical equipment.

The surface area is the same as the existing one, approximately 3.94 ha. The main facilities, together with the specification and number of units, are shown below.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse screen, 1.4 m W	1
	Fine screen, 0.8 m W	2
	Archimedical Screw Pump 0.4 m^3/min × 5 m H × 4.6 kw	3
Grit Oil/Sand Removal	0.5 m W × 8.5 m L	2
Parshall Flume	0.3048 m (1ft)	1
Aerated Lagoon	V1 = 1,000 m^2 × 2.0 m D V2 = 510 m^2 × 1.8 m D	2
Sedimentation Tank	V1 = 510 m^2 × 1.6 m D V2 = 500 m^2 × 1.4 m D	2
Administration Building	7 m W × 10 m L	1

9.9.4 Cost Estimate

The total construction cost is estimated at approx. Kn 6.5 million, broken down as follows.

Cost		Facilities	Cost (×10^3 Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	1,907.7	29.5	47.1
		Secondary/Tertiary Sewer	312.7	4.8	7.7
		Sub-Total	2,220.4	34.4	54.8
	Treatment Plant	Preliminary Treatment	404.3	6.3	10.0
		Biological Reactor	1,282.1	19.9	31.7
		Secondary Sedimentation	0.0	0.0	0.0
		Sludge Treatment	0.0	0.0	0.0
		Others	142.9	2.2	3.5
		Sub-total	1,829.3	28.3	45.2
	Sub-total		4,049.7	62.7	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		405.0	6.3	-
	Administration		121.5	1.9	-
	Customs Duties		91.5	1.4	-
	VAT		980.2	15.2	-
	Sub-total		1,598.0	24.7	-
Contingency			809.9	12.5	-
Total			6,457.6	100.0	-

9.10 Popovača

9.10.1 Existing Sewerage System

(1) Service Area and Population

Popovača, consisting of 13 settlementss is located along Superhighway No. 1 between Ivanić Grad and Kutina. The administrative area and population including future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		203.6	21,356.7	21,560.3
Population	(1991)	3,596	8,226	11,822
	(1999)	3,462	7,921	11,383
	(2015)	3,604	8,243	11,847

The water and gas supply systems are almost completed, and there is a plan to install a sewerage system. The water supply system covers 92% of the area, and it will be97% in the near future.

The sewerage system covers 122.5 ha, representing a part of the urban center and the surrounding eastern settlement of Podbrde. The total served population is 1,800 inhabitants.

(2) Existing Industries

There are three (3) industries registered by Croatian Waters as industrial pollutant, as listed below. The industry in bold characters is the large one described in Subsection 8.9.1, Appendix C.

Code Number	Industry Name	Activity	Pre-treatment	Wastewater (m^3/y)		Recipient
				1998	1999	
357002	Lipovica Privredni Pogon	Metal/Machinery	Yes	-	-	Vlahinička
357003	**Neuropsihijatrijska Bolnica**	**Hospital**	**No**	**101,481**	**124,575**	**Sewerage**
357007	INA Naftaplin Autotransporta	Transportation	Yes	2,000	1,122	Brook

(3) Sewer Network

The existing sewerage system is shown in Fig. D.9.19. The sewerage system of combined type discharges the wastewater of part of Popovača (urban center) and Voloder (surrounding settlement) into the neighboring channels with no treatment. The discharged wastewater finally enters the Lonja River by gravity.

The total sewer length is 9.4 km, with the diameter of 30 cm to 60 cm. In some other settlements, the sewerage is partially under construction or preparation. The existing sewerage system is provided with three (3) major outfalls and a number of rainwater spillways.

With regard to the existing sewerage system, there is no serious problem at present because the installation started only in 1970 and mostly in 1990. However, connection is not water resistant and the diameter of pipes is small. Last year (1999), 0.8 km of new pipes were installed. There is no wastewater treatment plant.

9.10.2 Planning Basis

(1) Service Area, Population and Industries

The service area will be extended to cover the district in the urban center of Popovača and the western surrounding settlement of Donja Vlahinićka by extending the sewer pipe since only a small part of the urban center is covered by the existing sewerage system at present. With the extension of 56.3 ha, the total service area will be 178.8 ha. Service population in the Master Plan service area will be 3,600 according to the area extension and increase of population. The existing service area is collected by the combined system, while the proposed extension area is by the separate one. For the extension area, see Fig. D.9.19.

Among the industries registered by Croatian Waters as industrial pollutant, the Master Plan service area will cover only the Neuropsihijatrijska Bolnica hospital, which is located in the existing sewerage service area. For the location of the hospital, see Fig. D.9.19.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	1,044
Daily Maximum	1,224
Hourly Maximum	1,728

(b) Industrial Wastewater Flow

The wastewater quantity of the Neuropsihijatrijska Bolnica hospital is estimated as shown below. The existing and future daily averages were obtained from Subsection 8.9.1 in Appendix C. The future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the hospital.

Industry Name	Quantity (m^3/day)			
	1999	2015		
	Daily	Daily	Daily	Hourly
Neuropsihijatrijska	452	747	747	1,121

(c) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the transport collector conveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)		
	Municipal	Industrial	Total
Daily Average	1,044	747	1,791
Daily Maximum	1,224	747	1,971
Hourly Maximum (dry)	1,728	1,121	2,849
Hourly Maximum (rainy)	2,835	2,241	5,076

(d) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal and industrial wastewater, see Subsection 1.3.2 of this Appendix D and Subsection 8.9.1 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 431.8 kg/day. It is equivalent to 7,200 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industry	Total	
BOD	237.6	194.2	431.8	219.1
COD_{Cr}	475.2	298.8	774.0	392.7
TSS	277.2	353.3	630.5	319.9
T-N	43.6	22.4	66.0	33.5
T-P	9.9	3.7	13.6	6.9

9.10.3 Proposed Structural Plan

(1) Transport Collector/Main Sewer

The design features of the transport collector/main sewer in the Master Plan service area are as follows. One (1) lift pump with the capacity of 1.7 l/second is required. For the route of proposed transport collector and main sewers, see Fig. D.9.19.

Pipe	Diameter (mm)	Material	Length (m)
Transport Collector	400	Concrete	110
Main Sewer	200	PVC	3,710
Total			3,820

(2) Secondary/Tertiary Sewer

It is necessary to install 680 m of PVC sewer pipe with the diameter of 200 mm to serve the extension of 56.3 ha.

(3) Treatment Plant

The location and layout of wastewater treatment plant are shown in Fig. D.9.19 and Fig. D.9.20, respectively. The effluent is discharged into the Lonja River through Jelenska Brook.

The capacity of the treatment plant (7,200 PE) is smaller than 10,000 PE and the recipient of effluent from the plant (Lonja-Strug) is Category II. Therefore, Oxidation Ditch process with thickener and sludge drying bed is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area is approximately 1.38 ha. The main facilities, together with the specification and number of unit, are shown below.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse screen, 1.5 m W	1
	Fine screen, 0.6 m W	1
	Archimedical Screw Pump 2.0 m^3/min × 6m H × 4 kw	2
Grit Oil/Sand Removal	2 m W × 5 m L	1
Parshall Flume	0.3048 m (1 ft)	1
Oxidation Ditch	4.5 m W × 2.5 m D, V = 1,400 m^3	4
Secondary Sedimentation Tank	∅12 m × 3.5 m H (Effective Depth)	2
Sludge Thickener	∅3 m × 4.0 m H	1
Drying Bed	Approx. 10 m W × 65 m L	1
Mechanical Aerator	Vertical, 15 kw	4
Return Sludge	Archimedical Screw Pump 1.5 m^3/min × 3 m H × 1.7 kw	3
Administration Building	8 m W × 8 m L	1

9.10.4 Cost Estimate

The total construction cost is estimated at approx. Kn 26.7 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	2,004.1	7.5	12.1
		Secondary/Tertiary Sewer	334.7	1.3	2.0
		Sub-Total	2,338.9	8.7	14.1
	Treatment Plant	Preliminary Treatment	2,295.4	8.6	13.9
		Biological Reactor	5,686.6	21.3	34.4
		Secondary Sedimentation	1,641.4	6.1	9.9
		Sludge Treatment	215.3	0.8	1.3
		Others	4,373.9	16.4	26.4
		Sub-total	14,212.5	53.2	85.9
	Sub-total		16,551.4	61.9	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		1,655.1	6.2	-
	Administration		496.5	1.9	-
	Customs Duties		712.4	2.7	-
	VAT		4,005.4	15.0	-
	Sub-total		6,869.6	25.7	-
Contingency			3,310.3	12.4	-
Total			26,731.3	100.0	-

9.11 Lipovljani

9.11.1 Existing Sewerage System

(1) Service Area and Population

Lipovljani, consisting of four (4) settlements, is located along Superhighway No. 1 near Kutina. The administrative area and population including future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		268.5	10,591.6	10,860.1
Population	(1991)	2,430	1,436	3,866
	(1999)	2,245	1,326	3,571
	(2015)	2,457	1,452	3,909

The population and the area served by the existing sewerage system are 800 inhabitants and 59.9 ha, respectively. Only 22% of the urban center is served by the sewerage system.

Water supply in settlement exists only at its center. It is however inadequate and each household has an individual well. A new water supply network for the entire settlement has to be constructed and connected to the regional network.

(2) Existing Industries

There are small industrial facilities, wood processing industry and mechanical workshops. There is no industry registered by Croatian Waters as industrial pollutant in the municipality.

(3) Sewer Networks

The existing sewerage system of combined type for a total of about 4,500 m sewer length is provided for only part of the urban center as shown in Fig. D.9.21. In the remaining part of the settlement, wastewater is collected in sumps by two (2) main collectors and discharged by gravity into the neighboring Subocka River with no treatment. Main Collector I is 320 m long with diameters of 80 and 100 cm and it is partially broken. Main Collector II is 950 m long with diameters of 40 and 80 cm, but since it is not in good condition, improvement is necessary.

9.11.2 Planning Basis

(1) Served Area, Population and Industries

Since only a small part of the urban center is served by the sewerage system, the service area will be extended to cover the entire urban area. The total service area will thus be 328.4 ha with the extension of 268.5 ha in the neighboring district. Service population in the Master Plan service area will be 3,000 according to the area extension and increase of population. The existing service area is collected by the combined system, while the proposed extension is by the separate one. For the extension area, see Fig. D.9.21.

There is no industry that discharges wastewater into the sewerage system.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the transport collector coveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)
Daily Average	870
Daily Maximum	1,020
Hourly Maximum (dry)	1,440
Hourly Maximum (rainy)	1,932

(b) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal wastewater, see Subsection 1.3.2.

As shown in the table, the total BOD load generated in the Master Plan service area is 194.1 kg/day. It is equivalent to 3,300 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)	Concentration (mg/l)
BOD	198.0	194.1
COD_{Cr}	396.0	388.2
TSS	231.0	226.5
T-N	36.3	35.6
T-P	8.3	8.1

9.11.3 Proposed Structural Plan

(1) Transport Collector/Main Sewer

The design features of the transport collector/main sewer in the Master Plan service area are as follows. No lift pump is required. For the route of proposed transport collector and main sewers, see Fig. D.9.21.

Pipe	Diameter (mm)	Material	Length (m)
Transport Collector	250	Concrete	120
Main Sewer	200	PVC	5,050
Total			5,170

(2) Secondary/Tertiary Sewer

It is necessary to install 9,420 m of PVC sewer pipe with the diameter of 200 mm to serve the extension area of 268.5 ha.

(3) Treatment Plant

The wastewater treatment plant is planned at the end of Collector K0-2 near the superhighway. This area is privately owned and used for agriculture. The land has yet to be acquired by the government. The effluent is to be discharged into the Sava River through the Subocka River at the south of the highway.

The location and layout of the wastewater treatment plant are shown in Fig. D.9.21 and Fig. D.9.22, respectively. The capacity of the treatment plant (3,300 PE) is smaller than 10,000 PE and the recipient of effluent from the plant (Lonja-Strug) is Category II. Therefore, Oxidation Ditch process with thickener and sludge drying bed is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area is approximately 1.08 ha. The main facilities, together with the specification and number of units, are shown below.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse Screen, 1 m W	1
	Fine Screen, 0.6 m W	1
	Archimedical Screw Pump 0.7 m^3/min × 6 m H × 1.8 kw	2
Grit Oil/Sand Removal	2 m W × 3 m L	1
Parshall Flume	0.3048 m (1 ft)	1
Oxidation Ditch	4.5 m W × 2.5 m L, V = 1,375 m^3	4
Secondary Sedimentation Tank	∅9 m × 3.5 m H (Effective Depth)	2
Sludge Thickener	2.0 m W × 2.0 m L × 2.0 m D	1
Drying Bed	Approx. 10 m W × 25 m L	1
Mechanical Aerator	Vertical, 11 kw	4
Return Sludge	Archimedical Screw Pump 0.8 m^3/min × 3 m H × 1.0 kw	3
Administration Building	8 m W × 8 m L	1

9.11.4 Cost Estimate

The total construction cost is estimated at approx. Kn 28.3 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main	2,510.7	8.9	14.2
		Secondary/Tertiary Sewer	4,642.1	16.4	26.3
		Sub-total	7,152.9	25.3	40.5
	Treatment Plant	Preliminary Treatment	2,162.4	7.6	12.2
		Biological Reactor	3,672.4	13.0	20.8
		Secondary Sedimentation	1,081.1	3.8	6.1
		Sludge Treatment	181.2	0.6	1.0
		Others	3,418.8	12.1	19.3
		Sub-total	10,515.8	37.2	59.4
	Sub-total		17,668.7	62.4	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		1,766.9	6.2	-
	Administration		530.1	1.9	-
	Custom Duties		525.8	1.9	-
	VAT		4,275.8	15.1	-
	Sub-total		7,098.5	25.1	-
Contingency			3,533.7	12.5	-
Total			28,301.0	100.0	-

9.12 Novska

9.12.1 Existing Sewerage System

(1) Service Area and Population

Novska, consisting of 23 settlements, is located at the lowermost part of the Study Area. The administrative area and population including future projection (2015) are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		388.6	31,416.6	31,805.2
Population	(1991)	8,053	9,178	17,231
	(1999)	5,747	6,649	12,296
	(2015)	8,276	9,432	17,706

The town of Novska was established in accordance with the General Urban Plan, consisting of residential blocks, individual houses, public institutions and industrial zones. The sewerage service area consists of most of the urban center and the southern suburban settlement of Bročice and eastern settlement of Stari Grabovac. The total service area and population are 380.1 ha and 4,000 inhabitants, respectively.

(2) Existing Industries

There are seven (7) industries registered by Croatian Waters as industrial pollutant in the town, as listed below. Among them, three (3) industries are served by the sewerage system, while the other four (4) industries directly discharge wastewater into the river.

Code Number	Industry Name	Activity	Pre-treatment	Wastewater (m^3/y) 1998	1999	Recipient
358006	Milka.Nova	Food/Beverage	Yes	-	4,490	Sewerage
358001	Čazmatrans Pogon	Transportation	No	-	-	Sewerage
358003	HŽ Zagreb, Lokacija Kolodvor	Transportation	Yes	-	-	River
358005	HŽ Zagreb, Lokacija vuča	Transportation		6,780	-	Canal
358007	Motoremont	Transportation	Yes	-	1,526	Sewerage
358004	INA Naftaplin Sektor Proizvodnje	Oil Refinery	Yes	-	-	Brook
358002	Trokut d.d.	Furniture	Yes	-	-	Mel.Canal

(3) Sewer Network

The existing sewerage system is shown in Fig. D.9.23. It covers almost all of the urban center of Novska and the surrounding area. The wastewater in 409.1 ha is collected by the four (4) main sewers, KI, KII, KIII and KIV, and is discharged into the Novjančica River with no treatment or pumping. Most of the main sewers are completed. The total sewer length, including main, secondary and tertiary sewers, is 44 km with diameters of 30 cm to 100 cm.

The results of the sewerage monitoring study show that the existing sewerage network is in bad condition and a large quantity of groundwater infiltration and sedimentation exist in many sections of pipes.

(4) Wastewater Quality

The wastewater quality was analyzed at the two (2) outfalls into the Novljančica River in 1998 and 1999. The results are summarized below.

Outlet	No.*		Temp. (°C)	BOD_5 (mg/l)	COD_{Cr} (mg/l)	TSS (mg/l)	TVS (mg/l)	SS (mg/l)	VS (mg/l)	pH
Outlet 1	7	Ave	7.0	7.0	7.0	7.0	7.0	7.0	6.0	7.0
		max	10.6	68.9	88.1	671.6	483.3	36.9	24.1	7.6
		Min	16.0	110.0	145.2	780.6	620.0	67.2	51.2	8.1
Outlet 2	7	Ave	11.5	64.3	76.3	689.9	476.1	36.2	21.8	7.6
		max	16.2	120.0	166.0	888.0	568.0	48.0	30.8	8.0
		Min	6.0	20.0	22.4	466.0	320.0	14.0	11.8	7.1

* Number of samples

9.12.2 Planning Basis

(1) Service Area, Population and Industries

As mentioned above, almost all areas of the urban center is served by the existing sewerage system, which is planned to cover the neighboring areas through the installation of new sewer pipes connected to the existing ones. The total service area will thus be 540.6 ha with the extension of 160.5 ha. Service population in the Master Plan service area will be 9,000 according to the area extension and increase of population. The existing service area is collected by the combined system, while the proposed extension is by the separate one. For the extension area, see Fig. D.9.23.

The Master Plan service area will cover the three (3) industries located in the existing sewerage system. Every industry should discharge its industrial wastewater into the municipal treatment plant after pre-treatment to comply with the national regulation in all the parameters. However, the above three (3) industries are included in the sources of municipal wastewater in this Study since their pollution loads are small.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the transport collector coveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)
Daily Average	2,610
Daily Maximum	3,060
Hourly Maximum (dry)	4,320
Hourly Maximum (rainy)	7,477

(b) Quality of Wastewater

The expected pollution load and influent quality into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal wastewater, see Subsection 1.3.2.

As shown in the table, the total BOD load generated in the Master Plan service area is 594.0 kg/day. It is equivalent to 9,900 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)	Concentration (mg/l)
BOD	594.0	194.1
COD_{Cr}	720.7	235.5
TSS	653.4	213.5
T-N	108.9	35.6
T-P	17.8	5.8

9.12.3 Proposed Structural Plan

(1) Transport Collector/Main Sewer

The design features of the transport collector/main sewer in the Master Plan service area are as follows. No lift pump is required. For the route of proposed transport collectors and main sewers, see Fig. D.9.23.

Pipe	Diameter (mm)	Material	Length (m)
Transport Collector	600	Concrete	370
	400	Concrete	2,230
Main Sewer	200	PVC	440
	250	PVC	610
Total			3,650

(2) Secondary/Tertiary Sewer

It is necessary to install 5,490 m of PVC sewer pipe with the diameter of 200 mm to serve the extension area of 160.5 ha.

(3) Treatment Plant

The location and layout of wastewater treatment plant are shown in Fig. D.9.23 and Fig. D.9.24, respectively. The effluent is discharged into the Sava River through the Novjanica Brook.

The capacity of the treatment plant (9,900 PE) is smaller than 10,000 PE and the recipient of effluent from the plant (Lonja-Strug) is Category II. Therefore, Oxidation

Ditch process with thickener and sludge drying bed is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area is approximately 1.46 ha and all the land is possessed by Hrvatske Šume Zagreb (Croatian Forests, Zagreb).

The main facilities, together with the specification and number of units, are shown below.

Facilities	Specification	No. of Unit
Influent Pumping Station and Screen	Coarse Screen, 1.5m B	1
	Fine Screen, 0.6m B	1
	Archimedical Screw Pump 2.6 m^3/min × 6m H × 4.4 kw	2
Grit Oil/Sand Removal	2 m B × 5m L	1
Parshall Flume	0.3048 m (1 ft)	1
Oxidation Ditch	4.5 m B × 2.5m D, V = 3,871 m^3	4
Secondary Sedimentation Tank	∅14 m × 3.5m H (Effective Depth)	2
Sludge Thickener	∅4 m × 4.0m H	1
Drying Bed	Approx. 25m W × 30m L	1
Mechanical Aerator	Vertical, 22 kw	4
Return Sludge	Archimedical Screw Pump 2.5 m^3/min × 3m H × 2.9 kw	3
Administration Building	8 m W × 8m L	1

9.12.4 Cost Estimate

The total construction cost is estimated at approx. Kn 37.2 million, broken down as follows.

Cost	Facilities		Cost (×10^3 Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	3,052.5	8.2	13.2
		Secondary/Tertiary Sewer	2,699.9	7.3	11.7
		Sub-Total	5,752.5	15.5	24.9
	Treatment Plant	Preliminary Treatment	2,388.7	6.4	10.3
		Biological Reactor	7,614.8	20.5	32.9
		Secondary Sedimentation	2,169.3	5.8	9.4
		Sludge Treatment	241.6	0.6	1.0
		Others	4,964.9	13.3	21.5
		Sub-total	17,379.3	46.7	75.1
	Sub-total		23,131.8	62.1	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		2,313.2	6.2	-
	Administration		694.0	1.9	-
	Customs Duties		869.0	2.3	-
	VAT		5,597.9	15.0	-
	Sub-total		9,474.0	25.4	-
Contingency			4,626.4	12.4	-
Total			37,232.1	100.0	-

9.13 Ogulin

9.13.1 Existing Sewerage System

(1) Service Area and Population

Ogulin is located in the watershed of the Dobra River. The administrative area and population including future projection (2015), are shown below. The town consists of 48 settlements with sufficient water supply covering all areas. Surplus water is delivered to Plaški; the water quality is good and the preservation of water sources is in high priority.

Item		Urban Center	Rural Area	Total
Area (ha)		430.6	53,002.9	53,433.5
Population	(1991)	10,857	5,875	16,732
	(1999)	10,252	5,548	15,800
	(2015)	10,449	5,351	15,800

As to sewerage, however, service population is zero, because secondary sewer pipes are not yet installed although the main sewer is already installed.

(2) Existing Industries

There are five (5) industries registered by Croatian Waters as industrial pollutant in the town, as listed below. They discharge industrial wastewater into the ground or the stream. The industries in bold characters below are the large ones described in Appendix C.

Code Number	Industry Name	Activity	Pre-treatment	Wastewater (m^3/y) 1998	Wastewater (m^3/y) 1999	Recipient
335005	Prehrambeni Kombinat Sloboda	Food/Beverage		-	9,144	Septic Tank
335002	Monting-Ventilator	Metal/Machinery	Yes	-	-	Groundwater
335001	**Opća Bolnica**	**Hospital**	**Yes**	**46,307**	**56,409**	**Groundwater**
335003	TAL	Car Wash	No	537	-	Groundwater
335004	**Bjelolasica**	**Hotel**	**Yes**	**49,900**	**-**	**Jasenački Brook**

(3) Sewer Network

The existing sewerage system is shown in Fig. D.9.25. The total length of the main sewer with diameters of 25 cm to 80 cm is 675 m. Wastewater and storm water are discharged by gravity into the ground through many holes in the Karst geological formation and may spring out in downstream rivers as potential pollution sources. The urban center of the town is prone to frequent floods due to lack of infiltration capacity of the holes.

9.13.2 Planning Basis

(1) Service Area, Population and Industries

The town is divided mainly into two (2) areas by the railway, and the southern area has a high population density. This area and some parts of the northern area are covered by the existing sewerage system. The total service area will be 467.6 ha and service population in the Master Plan service area will be 10,400 according to the area extension and increase of population. The existing service area is covered by the combined system, while the proposed extension area is by the separate system. For the extension area, see Fig. D.9.25.

Of the above five (5) industries registered by Croatian Waters, the Master Plan service area will cover only one (1) industry, Opća Bolnica hospital. For location of the hospital, see Fig. D.9.25.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipality wastewater is projected as follows.

Item	Quantity (m^3/day)
Daily Average	3,432
Daily Maximum	4,160
Hourly Maximum	5,928

(b) Industrial Wastewater Flow

The wastewater quantity of Opća Bolnica hospital is estimated as shown below. The existing and future daily averages were obtained from Subsection 8.10.1 in Appendix C. The future daily maximum and hourly maximum were calculated based on the daily average, considering the operation hour of the hospital.

Industry Name	Quantity (m^3/day)			
	1999	2015		
	Daily Average	Daily Average	Daily Maximum	Hourly Maximum
Opca Bolnica	206	340	340	510

(c) Total Wastewater Flow

The total wastewater flow composed of municipal and industrial wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the main sewer conveys two (2) times of the dry weather wastewater flow (2Q) to the treatment plant.

Item	Quantity (m^3/day)		
	Municipal	Industrial	Total
Daily Average	3,432	340	3,772
Daily Maximum	4,160	340	4,500
Hourly Maximum (dry)	5,928	510	6,438
Hourly Maximum (rainy)	6,278	1,020	7,298

(d) Quality of Wastewater

The expected pollution load and quality of influent into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal and industrial wastewater, see Subsection 1.3.2 of this Appendix D and Subsection 8.10.1 in Appendix C, respectively.

As shown in the table, the total BOD load generated in the Master Plan service area is 825.1 kg/day. It is equivalent to 13,800 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)			Concentration (mg/l)
	Municipal	Industrial	Total	
BOD	811.2	13.9	825.1	183.4
COD_{Cr}	1,622.4	42.8	1,665.2	370.1
TSS	946.4	188.0	1,134.4	252.1
T-N	148.7	10.2	158.9	35.3
T-P	33.8	1.7	35.5	7.9

9.13.3 Proposed Structural Plan

(1) Main Sewer

The design features of the main sewer in the Master Plan service area are as follows. There is no transport collector. For the route of proposed main sewers, see Fig. D.9.25.

Pipe	Diameter (mm)	Material	Length (m)
Main Sewer	200	PVC	1,630
	250	PVC	1,480
	300	PVC	930
Total			4,040

Five (5) lift pumps with the following capacities are required.

Pump Station	Capacity (l/sec)
Ogulin	16.1
Lomost	3.8
Proce	10.7
Pescenica	5.9
Centar	16.8

(2) Secondary/Tertiary Sewer

It is necessary to install 5,930 m of PVC sewer pipe with diameters of 200 mm to serve the extension area of 467.6 ha.

(3) Treatment Plant

The treatment plant is to be located in the area of Galga, southeast from the urban center and near the settlement of Otok Oštarijski. The site is owned by the Ministry of Defense. The location and layout of the wastewater treatment plant are shown in Fig. D.9.25 and Fig. D.9.26, respectively.

The capacity of the treatment plant (13,800 PE) is larger than 10,000 PE and the recipient of effluent from the plant (Dobra River) is Category II. Therefore, Anaerobic Oxic treatment with thickener and mechanical sludge dewatering is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area is approximately 1.28 ha. The main facilities, together with the specification and number of units, are shown below. The effluent is drained into the ground.

Facilities	Specification	No. of Units
Influent Pumping Station and Screen	Coarse Screen, 2 m W Fine Screen, 1 m W	1 2
	Archimedical Screw Pump 1.7 m^3/min × 6 m H × 4.3 kw	3
Grit Oil/Sand Removal	2 m W × 10 m L	1
Parshall Flume	0.3048 m (1 ft)	1
Primary Sedimentation Tank	3.0 m W × 19.0 m L × 3.0 m D (Effective Depth)	4
Aeration Tank	5 m W × 15.0 m L × 5 m D	4
Secondary Sedimentation Tank	∅11 m × 3.5 m D (Effective Depth)	2
Sludge Thickener	∅5 m × 4.0 m D	1
Mechanical Dewatering	Belt Press Filter, 1.5 m W × 1.5 kw Polymer Mixing, 0.4 kw	2
Blower	Roots Blower, 8 m^3/min × 15 kw (Building, 7 m × 13 m)	3
Return Sludge	Archimedical Screw Pump 1.6 m^3/min × 3 m H × 2.2 kw	3
Administration Building	10 m W × 10 m L	1

9.13.4 Cost Estimate

The total construction cost is estimated at approx. Kn 42.5 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	2,505.2	5.9	9.5
		Secondary/Tertiary Sewer	2,916.5	6.9	11.1
		Sub-total	5,421.7	12.8	20.6
	Treatment Plant	Preliminary Treatment	3,691.3	8.7	14.0
		Biological Reactor	4,957.2	11.7	18.8
		Secondary Sedimentation	1,440.8	3.4	5.5
		Sludge Treatment	3,486.6	8.2	13.2
		Others	7,357.2	17.3	27.9
		Sub-total	20,933.1	49.3	79.4
	Sub-total		26,354.8	62.0	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		2,635.5	6.2	-
	Administration		790.6	1.9	-
	Customs Duty		1,060.8	2.5	-
	VAT		6,377.9	15.0	-
	Sub-total		10,864.8	25.6	-
Contingency			5,271.0	12.4	-
Total			42,490.5	100.0	-

9.14 Plaški

9.14.1 Existing Sewerage System

(1) Sewerage System and Served Area/Population

Plaški, consisting of 8 settlements, is located in the uppermost reaches of the Kupa River. The town is drained into the Dretulja River whose catchment area is closed. The administrative area and population including future projection (2015), are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		195.4	15,546.7	15,742.1
Population	(1991)	2,271	2,046	4,317
	(1999)	1,720	1,550	3,270
	(2015)	1,753	1,517	3,270

Plaški has approximately 600 m of drainage pipe used only for storm water. All households use the septic tank.

(2) Existing Industries

The main activities in the municipality are wood industry, agriculture, tourism and hunting. There was a big paper industry that stopped operating in 1989. There are no industries registered by Croatian Waters as industrial pollutant in the municipality.

9.14.2 Planning Basis

(1) Service Area, Population and Industries

The district with high population density in the urban center of Plaški will be given priority in the sewerage system services. No industry will be served by the proposed sewerage system.

The total service area will be 51.8 ha. Served population in the Master Plan service area will be 800 according to the area extension and increase of population. All the area is covered by the separate system. For the proposed service area, see Fig. D.9.27.

(2) Wastewater Flow and Quality

(a) Municipality Wastewater Flow

The quantity of municipal wastewater is projected as follows. Hourly maximum flow to the treatment plant is constant irrespective of weather condition since all the area is served by the separate system.

Item	Quantity (m^3/day)
Daily Average	232
Daily Maximum	272
Hourly Maximum (dry)	384
Hourly Maximum (rainy)	384

(b) Quality of Wastewater

The expected pollution load and quality of influent into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal wastewater, see Subsection 1.3.2.

As shown in the table, the total BOD load generated in the Master Plan service area is 52.8 kg/day. It is equivalent to 900 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)	Concentration (mg/l)
BOD	52.8	194.1
COD_{Cr}	105.6	388.2
TSS	61.6	226.5
T-N	9.7	35.6
T-P	2.2	8.1

9.14.3 Proposed Structural Plan

(1) Main Sewer

The design features of the main sewer in the Master Plan service area are as follows. No lift pump is required, and there is no transport collector. For the route of proposed main sewers, see Fig. D.9.27.

Pipe	Diameter (mm)	Material	Length (m)
Main Sewer	200	PVC	2,380

(2) Secondary/Tertiary Sewer

It is necessary to install 1,610 m of PVC sewer pipe with the diameter of 200 mm to serve the extension area of 51.8 ha.

(3) Treatment Plant

The church owns the proposed site of the treatment plant, which has a total area of 2.4 ha. There is no settlement near the site, and in spring and rainy season, some parts are flooded due to melted snow and storm water.

The location and layout of wastewater treatment plant are shown in Fig. D.9.27 and Fig. D.9.28, respectively. The capacity of the treatment plant (900 PE) is smaller than 10,000 PE and the recipient of effluent from the plant (Dretulja River) is category II. Therefore, Oxidation Ditch process with thickener and sludge drying bed is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area is approximately 0.19 ha. The main facilities, together with the specification and number of units, are shown below.

Facilities	Specification	No. of Unit
Influent Pumping Station and Screen	Coarse screen, 0.6 m W	1
	Fine screen, 0.6 m W	1
	Submerged Pump 0.5 m^3/min × 6m H × 1.5 kw	2
Grit Oil/Sand Removal	0.6 m W × 1 m L	1
Parshall Flume	0.0762 m (0.3 ft)	1
Oxidation Ditch	3.0 m W × 2.5 m L, V = 359 m^3	1
Secondary Sedimentation Tank	Ø6 m × 3.5 m H (Effective Depth)	1
Sludge Thickener	1.0 m W × 1.0 m L × 2.0 m D	1
Drying Bed	Approx. 6 m W × 10 m L	1
Mechanical Aerator	Vertical, 7.5 kw	1
Return Sludge	Submerged Pump 0.5 m^3/min × 3 m H × 0.75 kw	3
Administration Building	5 m W × 5 m L	1

9.14.4 Cost Estimate

The total construction cost is estimated at approx. Kn 12.4 million, broken down as follows.

Cost		Facilities	Cost ($\times10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	1,150.2	9.3	15.0
		Secondary/Tertiary Sewer	790.0	6.4	10.3
		Sub-total	1,940.2	15.7	25.2
	Treatment Plant	Preliminary Treatment	1,918.4	15.5	25.0
		Biological Reactor	1,527.2	12.3	19.9
		Secondary Sedimentation	467.7	3.8	6.1
		Sludge Treatment	128.1	1.0	1.7
		Others	1,703.4	13.8	22.2
		Sub-total	5,744.9	46.4	74.8
	Sub-total		7,685.1	62.1	100.0
Land Acquisition			0.0	0.0	-
Indirect Cost	Engineering		768.5	6.2	-
	Administration		230.6	1.9	-
	Customs Duties		287.2	2.3	-
	VAT		1,859.8	15.0	-
	Sub-total		3,146.1	25.4	-
Contingency			1,537.0	12.4	-
Total			12,368.2	100.0	-

9.15 Slunj

9.15.1 Existing Sewerage System

(1) Service Area and Population

Slunj, consisting of 25 settlements, has developed on the riverbank in the upstream reaches of the Korana River. This town has a well where much groundwater of superior quality is abstracted so that protection of the groundwater is given high priority. There is a plan to construct a new highway across the town, which is expected to develop tourism and other activities.

The administrative area and population, including future projection (2015), are shown below.

Item		Urban Center	Rural Area	Total
Area (ha)		126.9	39,127.5	39,254.4
Population	(1991)	2,026	8,070	10,096
	(1999)	1,304	5,196	6,500
	(2015)	1,329	5,171	6,500

The sewerage system of combined type covers a small part of the urban center and some parts of the northern two (2) settlements, Donje Taborište and Gornje Taborište. The total service area is 62.2 ha and the served population is 600 inhabitants.

(2) Existing Industries

There are some industries engaged in electrical, metal, textile and other activities that do not require a lot of water. There are no industries registered by Croatian Waters as industrial pollutant in the town.

(3) Sewer Network

The existing sewerage system is shown in Fig. D.9.29. The wastewater from the left bank at the lower end of the urban center is discharged with no treatment into the Korana River. On the other hand, the wastewater from the catchment of the two (2) retention basins at the right bank is also discharged with no treatment into the Korana River. The Korana River is the source of potable water of Karlovac Town.

The sewerage system is of combined type. The total sewer length is 2.3 km with diameters of 30 cm to 100 cm. All the wastewater is drained by gravity, but the diameter of sewer pipe is too small. There is a plan to install a bypass pipe.

9.15.2 Planning Basis

(1) Service Area, Population and Industries

Slunj is located upstream of the Korana River and water pollution control is given high priority as stated above. At present, sewer pipes are installed in only a small part of the urban center so that the sewerage service area will be extended to cover the entire area of the urban center and the southern settlement of Podmelnica near the water source. The northern settlement of Rastoke is also included in the service area because it has a famous landscape, which is has a potential for tourism.

The total service area will be 219.1 ha with the extension of 156.9 ha. Service population in the Master Plan service area will be 2,400 according to the area extension and the increase of population. There is no industry that discharges wastewater with high pollution load. The existing service area is collected by the combined system, while the proposed extension area is by the separate one. For the extension area, see Fig. D.9.29.

(2) Wastewater Flow and Quality

(a) Municipal Wastewater Flow

The quantity of municipal wastewater is as projected in the following table. Hourly maximum in rainy period is estimated based on the assumption that the transport collector conveys two (2) times of the dry weather wastewater flow to the treatment plant.

Item	Quantity (m^3/day)
Daily Average	696
Daily Maximum	816
Hourly Maximum (dry)	1,152
Hourly Maximum (rainy)	1,480

(b) Quality of Wastewater

The expected pollution load and quality of influent into the treatment plant are summarized in the table below. For the estimation of pollution load of municipal wastewater, see Subsection 1.3.2.

As shown in the table, the total BOD load generated in the Master Plan service area is 158.4 kg/day. It is equivalent to 2,700 PE when the conversion rate of Person Equivalent is assumed at 60 g/capita/day.

Parameter	Load (kg/day)	Concentration (mg/l)
BOD	158.4	194.1
COD_{Cr}	316.8	388.2
TSS	184.8	226.5
T-N	29.0	35.6
T-P	6.6	8.1

9.15.3 Proposed Structural Plan

(1) Transport Collector/Main Sewer

The design features of the transport collector/main sewer in the Master Plan service area are as follows. One lift pump with the capacity of 2 l/sec is required. For the route of proposed transport collector and main sewers, see Fig. D.9.29.

Pipe	Diameter (mm)	Material	Length (m)
Transport Collector	250	PVC	580
Main Sewer	100	DIN	260
	200	PVC	930
Total			1,770

(2) Secondary/Tertiary Sewer

It is necessary to install 7,010 m of PVC sewer pipe with the diameter of 200 mm to serve the extension area of 156.9 ha.

(3) Treatment Plant

The treatment plant is planned on a location of about 500 m downstream from the settlement of Rastoke at the right bank of the Korana River. The total area for the candidate treatment site is approximately 1.5 ha including access road. About seventy percent (70%) of the land is publicly owned, and the rest is private (local roads). There is no settlement near the site and no flooding occurs in this area.

The location and layout of wastewater treatment plant are shown in Fig. D.9.29 and. Fig. D.9.30, respectively. The capacity of the treatment plant (2,700 PE) is smaller than 10,000 PE and the recipient of effluent from the plant (Lower Korana River) is Category II. Therefore, Oxidation Ditch process with thickener and sludge drying bed is proposed (refer to Subsection 1.4.4 and 1.4.5).

The required surface area is approximately 0.36 ha. The main facilities, together with the specification and number of units, are shown below.

Facilities	Specification	No. of Unit
Influent Pumping Station and Screen	Coarse screen, 0.6 m W Fine screen, 0.6 m W	1 1
Grit Oil/Sand Removal	0.6 m B × 1.0 m L	1
Parshall Flume	0.1524 m (0.6 ft)	1
Oxidation Ditch	4.5 m W × 2.5 m D, V = 1,035 m^3	2
Secondary Sedimentation Tank	∅8 m × 3.5 m D (Effective Depth)	2
Sludge Thickener	1.5 m W × 1.5 m D × 2.0 m D	1
Drying Bed	Approx. 5 m W × 35 m L	1
Mechanical Aerator	Vertical, 11 kw	2
Return Sludge	Submerge Pump 0.5 m^3/min × 3 m H × 0.75 kw	3
Administration Building	5 m W × 5 m L	1

9.15.4 Cost Estimate

The total construction cost is estimated at approx. Kn 23.4 million, broken down as follows.

Cost	Facilities		Cost ($\times 10^3$ Kn)	Rate (%)	
Direct Cost	Pipe	Transport Collector/Main Sewer	1,490.3	6.4	10.3
		Secondary/Tertiary Sewer	3,448.2	14.7	23.9
		Sub-Total	4,938.4	21.1	34.2
	Treatment Plant	Preliminary Treatment	2,119.1	9.0	14.7
		Biological Reactor	3,166.8	13.5	21.9
		Secondary Sedimentation	938.5	4.0	6.5
		Sludge Treatment	170.9	0.7	1.2
		Others	3,100.4	13.2	21.5
		Sub-total	9,495.7	40.5	65.8
	Sub-total		14,434.1	61.6	100.0
Land Acquisition			259.2	1.1	-
Indirect Cost	Engineering		1,443.4	6.2	-
	Administration		433.0	1.8	-
	Customs Duties		476.6	2.0	-
	VAT		3,493.1	14.9	-
	Sub-total		5,846.1	25.0	-
Contingency			2,886.8	12.3	-
Total			23,426.3	100.0	-

CHAPTER X SUMMARY OF WASTEWATER AND POLLUTION LOAD

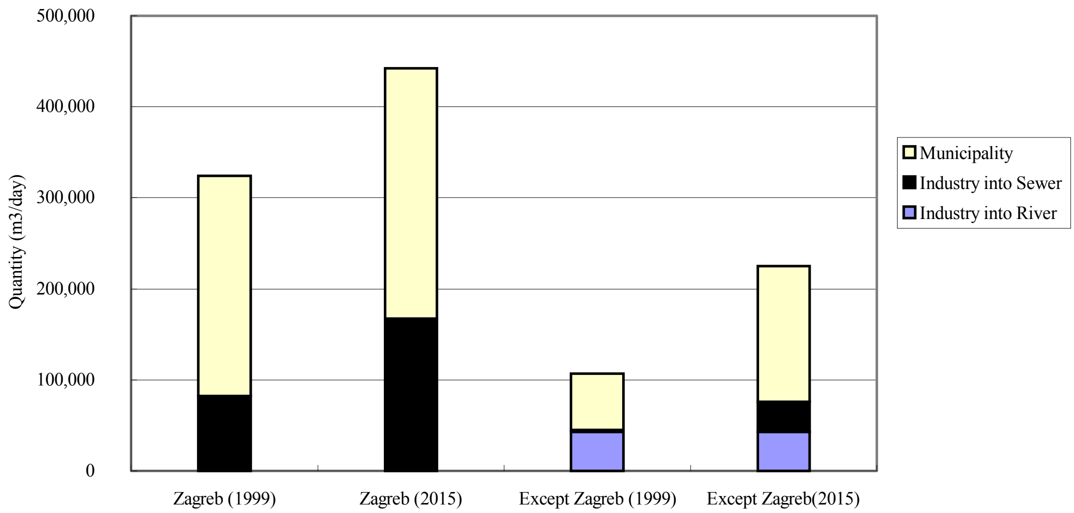
Wastewater is generated from municipal and industrial sources and industrial wastewater is discharged into the municipal sewerage system or directly into the watercourse. The wastewater quantity and pollution load without project in 1999 and 2015 and with project in 2015 in each urban center are summarized in Table D.10.1, Table D.10.2 and Table D.10.3.

10.1 Wastewater Quantity

The quantity of wastewater in Zagreb City is very large. Therefore, wastewater quantity in the entire Sava River Basin is divided into two parts in this Study; namely, the part consisting of Zagreb City only and the part excluding Zagreb City. The total quantity is predicted at 667,764 m^3/day in 2015, which is 1.54 times larger than the quantity in 1999.

In 1999, the rates of municipal and industrial wastewater quantity are 70.4% and 29.6%, and in 2015 the rates will be 63.6% and 36.4%, respectively. The trend shows that the rate of municipal wastewater is more than two-thirds in both parts, as easily observed in the figure below.

Area	Category		1999		2015	
			Quantity (m^3/day)	Rate (%)	Quantity (m^3/day)	Rate (%)
Zagreb City	Municipal		241,725	56.1	274,860	41.2
	Industrial	Sewerage	82,506	19.1	167,510	25.1
		River	0	0.0	0	0.0
		Sub-total	82,506	19.1	167,510	25.1
	Total		324,231	75.2	442,370	66.3
Area excluding Zagreb City	Municipal-		61,829	14.3	149,726	22.4
	Industrial	Sewerage	1,841	0.4	32,643	4.9
		River	43,164	10.1	43,025	6.4
		Sub-total	45,005	10.5	75,668	11.3
	Total		106,834	24.8	225,348	33.7
Total	Municipal		303,554	70.4	424,586	63.6
	Industrial	Sewerage	84,347	19.6	200,153	30.0
		River	43,164	10.1	43,025	6.4
		Sub-total	127,511	29.6	243,178	36.4
	Total		431,065	100.0	667,764	100.0



10.2 Discharge of BOD Load

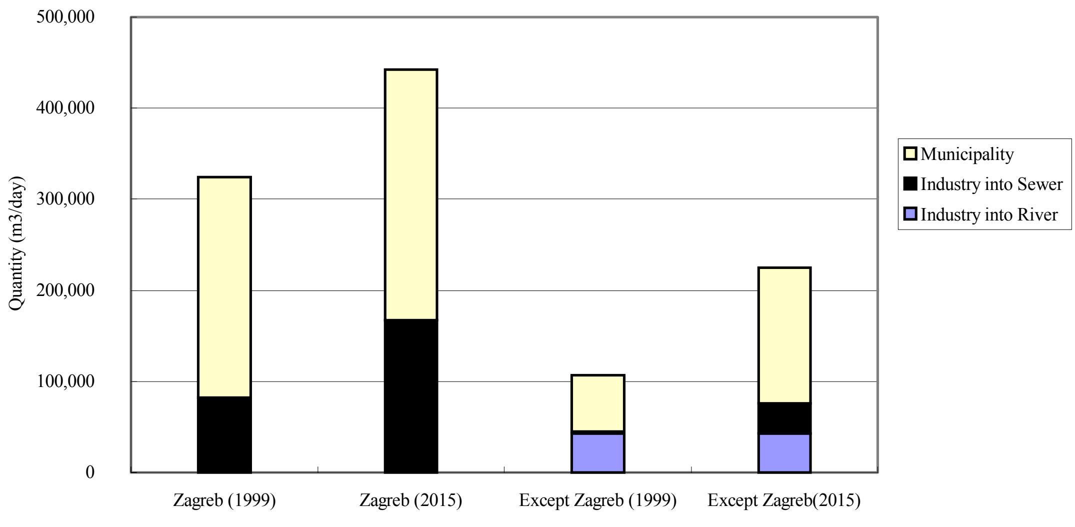
10.2.1 Discharge Without Project

BOD load is the most essential parameter in monitoring the wastewater pollution load in the Sava River Basin. BOD loads generated in municipal and industrial wastewaters without any countermeasure or improvement project such as sewerage system are shown in the table below.

In 1999, the rates of municipal and industrial wastewaters were 73.5% and 26.5%, and in 2015, they will be 65.3% and 34.7%, respectively. The rate of municipal wastewater BOD load is more than two-thirds in both Zagreb City and the part excluding Zagreb City. This trend can be easily observed in the figure below.

BOD load generated in Zagreb City contributes to more than 70% of the total BOD load in the Master Plan service area. The BOD loads generated in each municipality in 1999 and in 2015 are shown in Table D.10.1 and Table D.10.3, respectively.

Area	Category		1999		2015	
			BOD Load (kg/day)	Rate (%)	BOD Load (kg/day)	Rate (%)
Zagreb City	Municipal Wastewater		49,500.0	58.9	56,100.0	45.4
	Industrial Wastewater	Sewerage	17,100.0	20.3	33,900.0	27.4
		River	0.0	0.0	0.0	0.0
		Sub-total	17,100.0	20.3	33,900.0	27.4
	Total		66,600.0	79.2	90,000.0	72.8
Area excluding Zagreb City	Municipal Wastewater		12,310.9	14.6	24,657.0	19.1
	Industrial Wastewater	Sewerage	38.4	0.1	7,845.9	6.4
		River	5,147.5	6.1	1,144.2	0.9
		Sub-total	5,185.9	6.2	8,990.1	7.3
	Total		17,496.9	20.8	3,3647.1	27.2
Total	Municipal Wastewater		61,810.9	73.5	80,757.0	65.3
	Industrial Wastewater	Sewerage	17,138.4	20.4	41,745.9	33.8
		River	5,147.5	6.1	1,144.2	0.9
		Sub-total	22,285.9	26.5	42,890.1	34.7
	Total		84,096.8	100.0	123,647.1	100.0

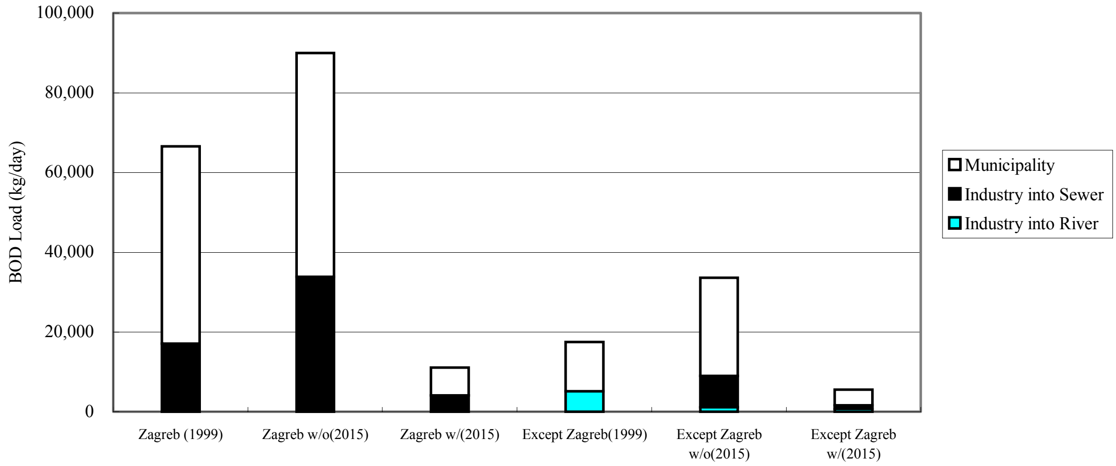


10.2.2 Discharge With Project

With the improvement of sewerage system in the Master Plan service area, the total BOD load will decrease from 123,647.1 kg/day to 16,610.8kg/day or 87%. The BOD loads generated in each municipality in 1999 and in 2015 are shown in Table D.10.1 and Table D.10.2, respectively.

Area	Category		1999 BOD Load (kg/day)	1999 Rate (%)	2015 BOD Load (kg/day)	2015 Rate (%)
Zagreb City	Municipal Wastewater		49,500.0	58.9	6,871.5	41.4
	Industrial Wastewater	Sewerage	17,100.0	20.3	4,187.8	25.2
		River	0.0	0.0	0.0	0.0
		Sub-total	17,100.0	20.3	4187.8	25.2
	Total		66,600.0	79.2	11,059.3	66.6
Area excluding Zagreb City	Municipal Wastewater		12,310.9	14.6	3,950.5	23.8
	Industrial Wastewater	Sewerage	38.4	0.1	830.2	5.0
		River	5,147.5	6.1	770.8	4.6
		Sub-total	5,185.9	6.2	1,601.0	9.6
	Total		17,496.9	20.8	5,551.5	33.4
Total	Municipal Wastewater		61,810.9	73.5	10,822.0	65.2
	Industrial Wastewater	Sewerage	17,138.4	20.4	5,018.0	30.2
		River	5,147.5	6.1	770.8	4.6
		Sub-total	22,285.9	26.5	5,788.8	34.8
	Total		84,096.8	100.0	16,610.8	100.0

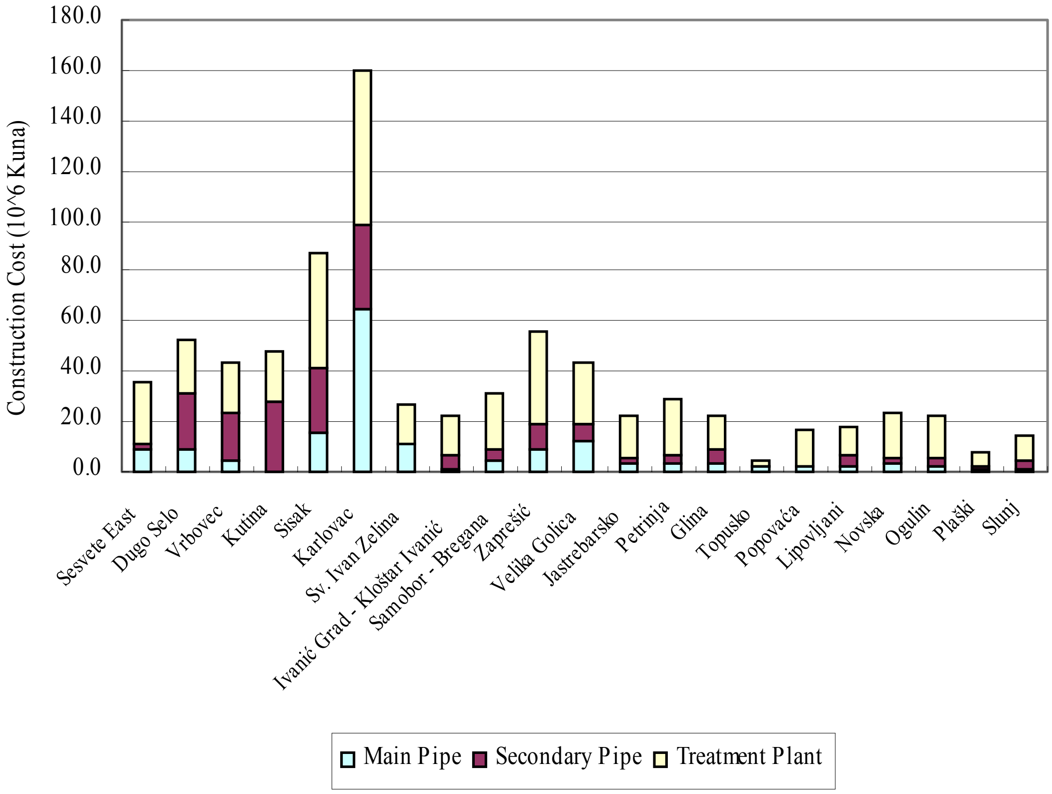
The figure below shows the comparison of BOD load in 1999 and 2015 between Zagreb City and the area excluding Zagreb City.



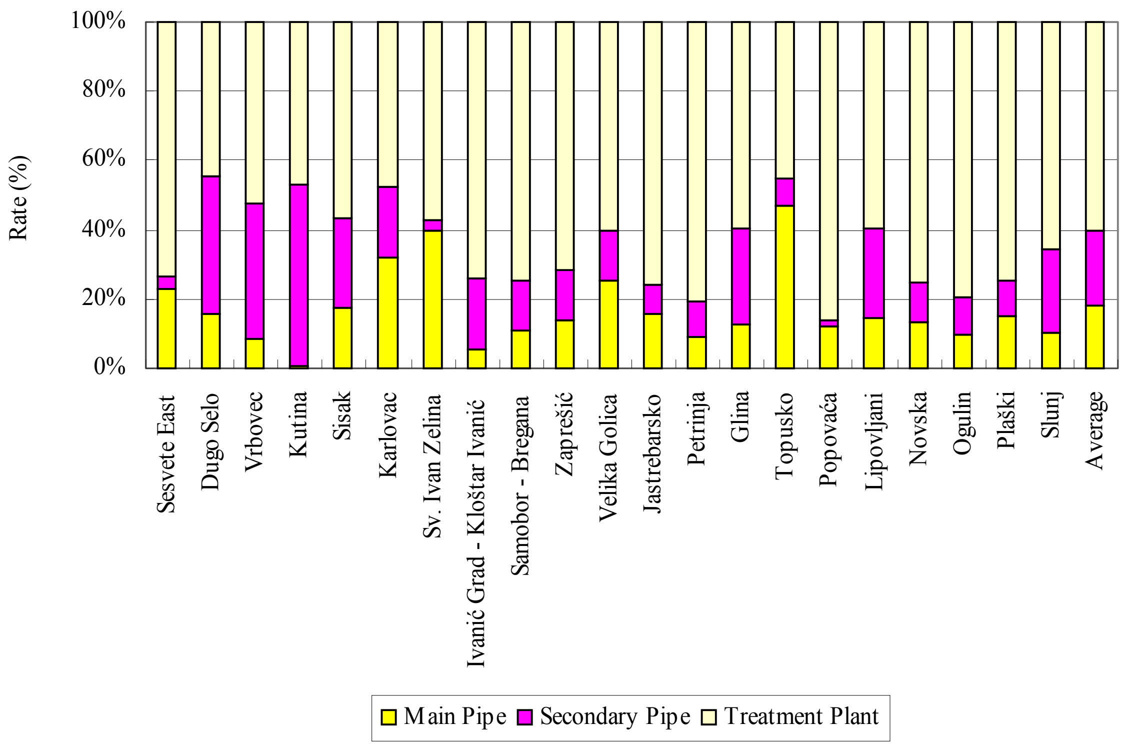
10.3 Total Cost of Municipal Sewerage System

The construction cost is composed of direct cost, land acquisition cost, indirect cost and contingency. Direct cost is the summary of construction costs of transport collector/main sewer network and treatment plant. Details of construction cost for each urban center are given in Table D.10.4.

The construction cost of the sewerage system in Karlovac-Duga Resa is the largest among all urban centers, totaling approximately 161.7 million Kuna. The direct construction cost of each urban center is as graphically compared below.



The rate of construction cost of transport collector/main sewer, secondary/tertiary sewer and wastewater treatment plant in each urban center is also graphically shown below. The average for each facility is 18.0%, 21.6% and 60.4%.



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TABLES

Table D.1.1 Selected Objective Urban Centers for Master Plan Study on Sewerage Development

Name of City/Town/Municipality	Urban Center				Drainage System [5]	Existing Sewer Length (km)	Treatment Process [6]
	Area (ha)	Population					
		1991	1999	2015			
1 Zagreb [1]	63,378.0	766,010	920,200	980,400	C	1,500.0	
2 Sesvete-East	625.5	11,816	14,800	17,600	C	42.0	
3 Dugo Selo	299.6	6,508	10,570	12,301	C	16.5	
4 Vrbovec	237.5	4,149	4,190	4,366	C	28.0	
5 Sisak	1,769.6	45,792	44,175	44,842	C	77.0	
6 Kutina	901.9	14,992	16,800	19,679	C	45.0	M
7 Karlovac -	952.0	59,999	52,000	53,000	C	90.0	
Duga Resa	184.6	7,513	8,266	8,425	C	9.2	
8 Sv. Ivan Zelina	144.2	2,535	2,560	2,668	C	5.2	
9 Ivanić Grad -	504.3	7,104	7,815	9,095	C	26.0	M
Kloštar Ivanić	316.5	2,568	2,594	2,702	C	9.8	
10 Samobor	557.1	14,170	16,154	18,800	C	83.8	M+B (×)
11 Zaprešić [2]	462.1	17,579	20,329	23,658	C	47.5	
12 Velika Gorica	700.6	31,614	36,502	42,482	S	143.3	M+B
13 Jastrebarsko	242.0	5,380	5,434	5,661	C	33.0	
14 Petrinja	939.5	18,706	12,545	14,466	C	33.0	
15 Glina	458.5	6,933	4,098	4,490	C	38.4	
16 Topusko [3]	91.7	1,587	1,116	1,227	C and S	6.5	M+B (×)
17 Popovaća	203.6	3,596	3,462	3,604	C	9.4	
18 Lipovljani [4]	268.5	2,430	2,245	2,457	C	4.5	
19 Novska	388.6	8,053	5,747	8,276	C	44.0	
20 Ogulin [4]	430.6	10,857	10,252	10,449	C	0.7	
21 Plaški [4]	195.4	2,271	1,720	1,753	None	0.0	
22 Slunj [4]	126.9	2,026	1,304	1,329	C	2.3	

Note: 1) Sesvete - East is excluded in Zagreb City
2) Zapresic is including Municipality Brdovec
3) Health Resort Area
4) Sensitive Area
5) C: combined system, S: separate system
6) M:Mechancal, B:Biological, (×): Not Working

Table D.1.2 Permissible Limits of Effluent Quality of Objective Sewage Treatment Plant

Objective Sewerage System	Urban Center Population (2015)	Plant Size (PE)	Receiving Water (Category)		Permissible Limits of Effluent Quality				
					SS (mg/l)	BOD (mg/l)	COD (mg/l)	T-P (mg/l)	T-N (mg/l)
1 Zagreb[1)]	981,188	> 100,000	Middle Sava	(III)	35	25	125	-	-
2 Sesvete-East	16,812	10,000 - 100,000	Lonja-Strug	(II)	35	25	125	2	15
3 Dugo Selo	12,301	10,000 - 100,000	Lonja-Strug	(II)	35	25	125	2	15
4 Vrbovec	4,366	10,000 - 100,000 [3)]	Lonja-Strug	(II)	35	25	125	2	15
5 Sisak	44,842	10,000 - 100,000	Lower Sava	(II)	35	25	125	2	15
6 Kutina	19,679	10,000 - 100,000	Lonja-Strug	(II)	35	25	125	2	15
7 Karlovac -Duga Resa [2)]	61,425	10,000 - 100,000	Lower Kupa	(II)	35	25	125	2	15
8 Sveni Ivan Zelina	2,668	< 10,000	Lonja-Strug	(II)	60	40	150	-	-
9 Ivanić Grad -Kloštar Ivanić [2)]	11,797	10,000 - 100,000	Lonja-Strug	(II)	35	25	125	2	15
10 Samobor	18,000	10,000 - 100,000	Upper Sava	(II)	35	25	125	2	15
11 Zaprešić [2)]	23,658	10,000 - 100,000	Upper Sava	(II)	35	25	125	2	15
12 Velika Gorica	42,482	10,000 - 100,000	Middle Sava	(III)	35	25	125	-	-
13 Jastrebarsko	5,661	< 10,000	Kupcina	(II)	60	40	150	-	-
14 Petrinja	14,466	10,000 - 100,000	Lower Kupa	(II)	35	25	125	2	15
15 Glina	4,490	< 10,000	Glina	(II)	60	40	150	-	-
16 Topusko	1,227	< 10,000	Glina	(II)	60	40	150	-	-
17 Popovaća	3,604	< 10,000	Lonja-Strug	(II)	60	40	150	-	-
18 Lipovljani	2,457	< 10,000	Lonja-Strug	(II)	60	40	150	-	-
19 Novska	8,276	< 10,000	Lonja-Strug	(II)	60	40	150	-	-
20 Ogulin	10,449	10,000 - 100,000	Dobra	(II)	35	25	125	2	15
21 Plaški	1,753	< 10,000	Dretulja	(II)	60	40	150	-	-
22 Slunj	1,329	< 10,000	Lower Korana	(II)	60	40	150	-	-

Note: 1): Sesvete East is excluded in Zagreb Zagreb.
2): Ivanic Grad - Klostar Ivanic, Karlovac - Duga Resa and Zapresic including municipality Brdovec are an integrated system of two(2) urban centers respectively.
3): Pollution load including industry is expected to be larger than 10,000.

Table D.1.3 Treatment Process with Removing Nutrients

(1) Designed Quantity and Quality

Parameter		Unit	Influent	Effluent
Quantity		m^3/day	10,000	
Quality	BOD	mg/l	200	25
	SS	mg/l	200	35
	T - P	mg/l	5	2
	T - N	mg/l	30	15

(2) Proposed Treatment Process

Target Parameter		BOD, SS	BOD, SS, T - P	BOD, SS, T - P, T - N
Proposed Treatment Process		A. Conventional Activated Sludge Process	B. Anaerobic-Oxic Activated Sludge Process	C. Anaerobic-Anoxic-Oxic Activated Sludge Process
Removal Rate	BOD	<25mg/l	<25mg/l	<25mg/l
	SS	<35mg/l	<35mg/l	<35mg/l
	T-P	【approximately 40%】	<2.0mg/l	<2mg/l
	T-N	【approximately 30%】	【approximately 30%】	<15mg/l
Note		Occurrence of bulking	Preservation of anaerobic condition Less occurrence of bulking	Sophisticated technology for controlling sludge and adequate circulation rate of flow

Note: The figures in 【 】 shows the expected value which is coincidently removed.

(3) Outline of Major Facilities/Equipment

Name of Facilities		Unit	A	B	C
Main Basin	Primary Sedimentation Tank	m^2	250	250	250
	Aeration Tank (H=5m)	m^2	500	625	1,542
	Final Sedimentation Tank	m^2	400	400	500
	Total	m^2	1,150	1,275	2,292
Main Equipment	Blower	KgO_2/day	887	887	2,040
	Pump/Motor for Returning Sludge, Circulating and Agitating Wastewater	m^3/day	5,000	5,500	10,000
	Sludge Scraper in the Sedimentation Tank	m^2	650	650	750
Excess Sludge		Kg/day	2,260	2,260	1,750

(4) Comparison of Each Treatment Process

Items		A	B	C
Required Site Area		100	111	199
Construction Cost	Civil	100	110	186
	Mechanical	100	102	175
	Electricity	100	110	140
	Total	100	108	172
Operation and Maintenance Cost	Electricity	100	104	218
	Sludge Disposal	100	100	77

Table D.1.4 Comparison of Each Wastewater Treatment Process

(1) PE<10,000

Items		Unit	AS	OD	CA	AL	TF	AA
Construction Cost	Civil	Kn	790,000	1,400,000	1,200,000	1,200,000	500,000	380,000
	Mechanical	Kn	2,280,000	1,200,000	1,950,000	1,200,000	1,650,000	950,000
	Electricity	Kn	1,500,000	450,000	700,000	600,000	700,000	500,000
	Sub-total	Kn	4,570,000	3,050,000	3,850,000	3,000,000	2,850,000	1,830,000
O/M Cost	Personality	Kn/y	249,600	166,400	130,524	166,400	166,400	166,400
	Electricity	Kn/y	124,830	122,202	249,600	197,100	48,618	98,112
	Sub-Total	Kn/y	374,430	288,602	380,124	363,500	215,018	264,512
Land Space	Drying Bed	m^2	4,750	7,400	4,750	14,100	3,750	3,800
	Mechanical Dewatering	m^2	4,400	6,800	4,400	14,100	3,400	3,500

Note: Q=1,300 m^3/day, BOD 200 mg/l → 25 mg/l

(2) PE≧10,000

Items		Unit	AS	OD	CAST	AO	AS+CO
Construction Cost	Civil	Kn	3,400,000	8,900,000	3,400,000	3,300,000	4,000,000
	Mechanical	Kn	11,800,000	7,500,000	12,000,000	6,200,000	12,200,000
	Electricity	Kn	7,550,000	3,100,000	7,600,000	8,400,000	8,600,000
	Sub-total	Kn	22,750,000	19,500,000	17,900,000	24,800,000	23,000,000
O/M Cost	Personality	Kn/y	499,200	416,000	499,200	499,200	499,200
	Electricity	Kn/y	1,217,640	876,000	1,300,860	709,560	1,349,040
	Chemical	Kn/y	-	-	990,000	-	-
	Sub-Total	Kn/y	1,716,840	1,292,000	1,208,760	1,848,240	2,790,060
Land Space	Drying Bed	m^2	23,800	33,600	22,000	24,100	23,800
	Mechanical	m^2	10,800	20,400	8,400	11,200	10,800

Note: Q=10,000 m^3/day, BOD 200 mg/l → 25 mg/l, P 5mg/l → 2 mg/l

Table D.1.5 Comparison of Each Sludge Treatment Process

Items		Unit	T+D+M	T+D+B	T+M	T+B
Construction Cost	Civil	Kn	7,964,000	6,307,000	2,731,000	242,500
	Mechanical	Kn	2,900,000	2,200,000	1,800,000	360,000
	Electricity	Kn	1,500,000	1,000,000	1,000,000	140,000
	Sub-total	Kn	12,364,000	9,507,888	5,531,000	742,500
O/M Cost	Personality	Kn/y	416,000	332,800	249,600	166,400
	Electricity	Kn/y	412,341	405,588	84,461	6,132
	Sub-Total	Kn/y	828,341	738,388	334,061	172,532
Required Land Space		m^2	2,900	12,600	1,800	15,300

Note: Q=10,000 m^3/day, BOD 200mg/l → 25mg/l, SS 200mg/l → 35 mg/l

Table D.6.1 Comparison of Alternatives in Sisak by Present Value

(Unit: Kuna)

Year	Alternative 1			Alternative 2			Alternative 3			Alternative 4		
	Initial Cost for Transport Collector	O/M Cost	Present Value (5%)	Initial Cost for Transport Collector and Pumping Station	O/M Cost	Present Value (5%)	Initial Cost for Transport Collector	O/M Cost	Present Value (5%)	Initial Cost for Transport Collector and Pumping Station	O/M Cost	Present Value (5%)
0	10,366,947			8,391,458			8,850,565			6,758,254		
1		64,000	60,952		300,000	285,714		64,000	60,952		300,000	285,714
2		64,000	58,050		300,000	272,109		64,000	58,050		300,000	272,109
3		64,000	55,286		300,000	259,151		64,000	55,286		300,000	259,151
4		64,000	52,653		300,000	246,811		64,000	52,653		300,000	246,811
5		64,000	50,146		300,000	235,058		64,000	50,146		300,000	235,058
6		64,000	47,758		300,000	223,865		64,000	47,758		300,000	223,865
7		64,000	45,484		300,000	213,204		64,000	45,484		300,000	213,204
8		64,000	43,318		300,000	203,052		64,000	43,318		300,000	203,052
9		64,000	41,255		300,000	193,383		64,000	41,255		300,000	193,383
10		64,000	39,290		300,000	184,174		64,000	39,290		300,000	184,174
11		64,000	37,419		300,000	175,404		64,000	37,419		300,000	175,404
12		64,000	35,638		300,000	167,051		64,000	35,638		300,000	167,051
13		64,000	33,941		300,000	159,096		64,000	33,941		300,000	159,096
14		64,000	32,324		300,000	151,520		64,000	32,324		300,000	151,520
15		64,000	30,785		300,000	144,305		64,000	30,785		300,000	144,305
16		64,000	29,319		300,000	137,433		64,000	29,319		300,000	137,433
17		64,000	27,923		300,000	130,889		64,000	27,923		300,000	130,889
18		64,000	26,593		300,000	124,656		64,000	26,593		300,000	124,656
19		64,000	25,327		300,000	118,720		64,000	25,327		300,000	118,720
20		64,000	24,121		300,000	113,067		64,000	24,121		300,000	113,067
Sub-total	10,366,947		797,581	8,391,458		3,738,663	8,850,565		797,581	6,758,254		3,738,663
Total	11,164,528			12,130,122			9,648,147			10,496,917		

Table D.8.1 Comparison of Alternatives in Karlovac and Duga Resa by Present Value

(Unit: Kuna)

Year	Alternative 1			Alternative 2			Alternative 3			Alternative 4		
	Initial Cost for Transport Collector	O/M Cost	Present Value (5%)	Initial Cost for Transport Collector and Pumping Station	O/M Cost	Present Value (5%)	Initial Cost for Transport Collector	O/M Cost	Present Value (5%)	Initial Cost for Transport Collector and Pumping Station	O/M Cost	Present Value (5%)
0	46,531,509			59,024,488			23,164,276			41,783,745		
1		110,960	105,676		175,200	166,857		175,200	166,857		216,080	205,790
2		110,960	100,644		175,200	158,912		175,200	158,912		216,080	195,991
3		110,960	95,851		175,200	151,344		175,200	151,344		216,080	186,658
4		110,960	91,287		175,200	144,137		175,200	144,137		216,080	177,770
5		110,960	86,940		175,200	137,274		175,200	137,274		216,080	169,304
6		110,960	82,800		175,200	130,737		175,200	130,737		216,080	161,242
7		110,960	78,857		175,200	124,511		175,200	124,511		216,080	153,564
8		110,960	75,102		175,200	118,582		175,200	118,582		216,080	146,251
9		110,960	71,526		175,200	112,935		175,200	112,935		216,080	139,287
10		110,960	68,120		175,200	107,558		175,200	107,558		216,080	132,654
11		110,960	64,876		175,200	102,436		175,200	102,436		216,080	126,338
12		110,960	61,787		175,200	97,558		175,200	97,558		216,080	120,321
13		110,960	58,844		175,200	92,912		175,200	92,912		216,080	114,592
14		110,960	56,042		175,200	88,488		175,200	88,488		216,080	109,135
15		110,960	53,374		175,200	84,274		175,200	84,274		216,080	103,938
16		110,960	50,832		175,200	80,261		175,200	80,261		216,080	98,989
17		110,960	48,411		175,200	76,439		175,200	76,439		216,080	94,275
18		110,960	46,106		175,200	72,799		175,200	72,799		216,080	89,786
19		110,960	43,911		175,200	69,333		175,200	69,333		216,080	85,510
20		110,960	41,820		175,200	66,031		175,200	66,031		216,080	81,438
Sub-total	46,531,509		1,382,807	59,024,488		2,183,379	23,164,276		2,183,379	41,783,745		2,692,834
Total	47,914,316			61,207,867			25,347,655			44,476,579		

Table D.10.1 Wastewater Quantity and Pollution Load in 1999

Name	Municipal Sewerage System											
	Municipal Wastewater						Industrial Wastewater					
	Quantity	Load (kg/day)					Quantity	Load (kg/day)				
	(m^3/day)	BOD	COD	TSS	T-N	T-P	(m^3/day)	BOD	COD	TSS	T-N	T-P
Zagreb	241,725	49,500.0	99,000.0	57,750.0	9,075.0	2,062.5	82,506	17,100.0	34,200.0	19,950.0	3,135.0	712.5
Sesvete-East	3,487	828.2	1,656.5	966.3	151.8	34.5						
Dugo Selo	2,666	633.4	1,266.7	738.9	116.1	26.4						
Vrbovec	1,215	316.0	632.0	368.7	57.9	13.2						
Sisak	11,544	2,742.2	5,484.5	3,199.3	502.7	114.3						
Kutina	4,717	1,008.5	2,017.0	915.1	184.9	42.0	663	11.2	34.4	237.5	29.2	3.0
Karlovac -	8,263	1,962.7	3,925.4	2,289.8	359.8	81.8						
Duga Resa	1,113	264.5	529.0	308.6	48.5	11.0						
Sv. Ivan Zelina	778	202.2	404.5	235.9	37.1	8.4						
Ivanić Grad -	1,670	357.0	714.1	324.0	65.5	14.9	777	17.2	48.2	462.1	21.0	3.5
Kloštar Ivanić	146	34.1	68.3	31.0	6.3	1.4						
Samobor	4,512	1,071.8	2,143.7	1,250.5	196.5	44.7						
Zaprešić	3,897	925.7	1,851.4	1,080.0	169.7	38.6						
Velika Gorica	10,958	274.0	1,369.8	383.5	219.2	32.9	401	10.0	50.1	14.0	8.0	1.2
Jastrebarsko	1,288	335.0	669.9	390.8	61.4	14.0						
Petrinja	3,018	716.9	1,433.8	836.4	131.4	29.9						
Glina	486	126.4	252.8	147.5	23.2	5.3						
Topusko	122	31.6	63.2	36.9	5.8	1.3						
Popovaća	437	113.8	227.5	132.7	20.9	4.7						
Lipovljani	194	50.6	101.1	59.0	9.3	2.1						
Novska	1,172	278.4	556.8	324.8	51.0	11.6						
Ogulin	0	0.0	0.0	0.0	0.0	0.0						
Plaški												
Slunj	146	37.9	75.8	44.2	7.0	1.6						
Sub-Total	303,554	61,810.9	124,444	71,813.8	11,500.9	2,596.9	84,347	17,138.4	34,332.7	20,663.6	3,193.2	720.2

Name	River						Total					
	Industry											
	Quantity	Load (kg/day)					Quantity	Load (kg/day)				
	(m^3/day)	BOD	COD	TSS	T-N	T-P	(m^3/day)	BOD	COD	TSS	T-N	T-P
Zagreb							324,231	66,600.0	133,200.0	77,700.0	12,210.0	2,775.0
Sesvete-East	737	857.6	1,682.7	7,564.4	614.0	15.5	4,224	1,685.9	3,339.2	8,530.7	765.8	50.0
Dugo Selo							2,666	633.4	1,266.7	738.9	116.1	26.4
Vrbovec	2,317	613.6	1,247.3	1,146.6	47.8	9.2	3,532	929.6	1,879.3	1,515.3	105.7	22.3
Sisak	13,923	727.2	1,491.6	4,413.8	706.6	25.6	25,467	3,469.5	6,976.1	7,613.1	1,209.3	139.9
Kutina	10,388	115.3	403.1	1,630.9	550.6	50.9	15,768	1,135.0	2,454.4	2,783.5	764.7	95.9
Karlovac -	7,111	1,654.4	3,292.8	2,893.5	85.5	29.8	15,374	3,617.2	7,218.2	5,183.3	445.4	111.6
Duga Resa							1,113	264.5	529.0	308.6	48.5	11.0
Sv. Ivan Zelina							778	202.2	404.5	235.9	37.1	8.4
Ivanić Grad -	229	3.0	3.0	147.9	6.9	1.1	2,676	377.3	765.3	934.0	93.3	19.5
Kloštar Ivanić							146	34.1	68.3	31.0	6.3	1.4
Samobor	2,183	129.9	377.2	1,220.4	60.3	10.9	6,695	1,201.8	2,520.9	2,470.8	256.8	55.6
Zaprešić	3,013	721.7	3,618.1	4,576.6	353.2	11.6	6,910	1,647.4	5,469.5	5,656.5	522.9	50.2
Velika Gorica	240	6.0	24.0	8.4	5.0	1.2	11,599	290.0	1,443.9	406.0	232.2	35.3
Jastrebarsko	845	32.6	110.9	58.5	18.7	4.2	2,133	367.5	780.8	449.2	80.1	18.2
Petrinja	1,357	156.1	317.5	247.0	6.5	3.5	4,375	872.9	1,751.3	1,083.3	137.9	33.4
Glina							486	126.4	252.8	147.5	23.2	5.3
Topusko							122	31.6	63.2	36.9	5.8	1.3
Popovaća	452	117.5	180.8	213.8	13.6	2.3	889	231.3	408.3	346.5	34.4	7.0
Lipovljani							194	50.6	101.1	59.0	9.3	2.1
Novska							1,172	278.4	556.8	324.8	51.0	11.6
Ogulin	369	12.5	46.3	119.6	10.6	1.8	369	12.5	46.3	119.6	10.6	1.8
Plaški												
Slunj							146	37.9	75.8	44.2	7.0	1.6
Sub-Total	43,164	5,147.5	12,795.4	24,241.4	2,479.2	167.7	431,065	84,096.9	171,571.8	116,718.8	17,173.4	3,484.8

Table D.10.2 Wastewater Quantity and Pollution Load in 2015 (without Project)

Name	Municipal Sewerage System											
	Municipal Wastewater						Industrial Wastewater					
	Quantity	Load (kg/day)					Quantity	Load (kg/day)				
	(m^3/day)	BOD	COD	TSS	T-N	T-P	(m^3/day)	BOD	COD	TSS	T-N	T-P
Zagreb	274,860	56100.0	112,200	65450.0	10285.0	2337.5	167,510	33,900.0	67,800.0	39,550.0	6,215.0	1,412.5
Sesvete-East	7,040	1372.8	2,745.6	1601.6	251.7	57.2	1,599	1,679.0	3,580.1	17,875.1	1,435.7	29.5
Dugo Selo	5,680	1107.6	2,215.2	1292.2	203.1	46.2						
Vrbovec	2,856	554.4	1,108.8	646.8	101.6	23.1	3,710	669.1	1,458.0	1,224.0	75.4	14.5
Sisak	20,960	4087.2	8,174.4	4768.4	749.3	170.3	1,413	484.3	944.5	702.7	142.8	6.0
Kutina	9,920	1741.0	3,481.9	1579.8	319.2	72.5	1,063	17.9	55.1	380.8	46.9	4.8
Karlovac - Duga Resa	26,680	5202.6	10,405.2	6069.7	953.8	216.8	11,595	2,738.7	5,447.2	4,684.0	136.1	48.5
Sv. Ivan Zelina	2,380	462.0	924.0	539.0	84.7	19.3						
Ivanić Grad - Klostar Ivanic	4,512	791.6	1,583.3	923.6	145.1	33.0	1,283	28.5	79.6	593.5	34.6	5.8
Samobor	11,680	2277.6	4,555.2	2657.2	417.6	94.9	1,528	145.8	255.2	1,252.4	45.8	12.4
Zaprešić	12,200	2379.0	4,758.0	2775.5	436.2	99.1	6,544	1,589.0	6,794.4	7,788.0	653.9	33.4
Velika Gorica	24,960	624.0	3,120.0	873.6	499.2	74.9	662	16.6	82.8	23.2	13.2	2.0
Jastrebarsko	2,754	534.6	1,069.2	623.7	98.0	22.3	180	41.3	66.4	54.0	5.4	0.9
Petrinja	5,240	1021.8	2,043.6	1192.1	187.3	42.6	1,979	227.6	463.1	360.2	9.5	5.1
Glina	1,768	343.2	686.4	400.4	62.9	14.3						
Topusko	544	105.6	211.2	123.2	19.4	4.4						
Popovaća	1,224	237.6	475.2	277.2	43.6	9.9	747	194.2	298.8	353.3	22.4	3.7
Lipovljani	1,020	198.0	396.0	231.0	36.3	8.3						
Novska	3,060	594.0	1,188.0	693.0	108.9	24.8						
Ogulin	4,160	811.2	1,622.4	946.4	148.7	33.8	340	13.9	42.8	188.0	10.2	1.7
Plaški	272	52.8	105.6	61.6	9.7	2.2						
Slunj	544	105.6	211.2	123.2	19.4	4.4						
Total	424,314	80,704.2	########	93,849.1	15,180.6	3,411.6	200,153	41,745.9	87,367.9	75,029.2	8,847.0	1,580.7

Name	River						Total					
	Industrial Wastewater											
	Quantity	Load (kg/day)					Quantity	Load (kg/day)				
	(m^3/day)	BOD	COD	TSS	T-N	T-P	(m^3/day)	BOD	COD	TSS	T-N	T-P
Zagreb							442,370	90,000.0	180,000	105,000	16,500.0	3,750.0
Sesvete-East							8,639	3,051.8	6,325.7	19,476.7	1,687.4	86.7
Dugo Selo							5,680	1,107.6	2,215.2	1,292.2	203.1	46.2
Vrbovec	124	345.5	604.3	673.1	3.7	0.6	6,690	1,569.0	3,171.1	2,543.9	180.7	38.2
Sisak	21,225	484.1	1,120.9	5,029.4	1,137.9	35.4	43,598	5,055.6	10,239.8	10,500.5	2,030.0	211.7
Kutina	17,165	190.5	666.0	600.8	360.5	17.2	28,148	1,949.4	4,203.0	2,561.3	726.5	94.5
Karlovac - Duga Resa	169	3.2	9.8	84.3	5.1	0.8	38,444	7,944.5	15,862.2	10,838.0	1,095.0	266.1
Sv. Ivan Zelina							2,380	462.0	924.0	539.0	84.7	19.3
Ivanić Grad - Klostar Ivanic	378	4.9	4.9	244.2	11.3	1.9	6,173	825.0	1,667.8	1,761.3	191.1	40.6
Samobor	2,082	69.0	368.4	764.8	53.9	10.4	15,290	2,492.4	5,178.8	4,674.5	517.3	117.7
Zaprešić							18,744	3,968.0	11,552.4	10,563.5	1,090.0	132.5
Velika Gorica	397	9.9	39.7	13.9	8.3	2.0	26,019	650.5	3,242.5	910.7	520.8	78.9
Jastrebarsko	1,216	30.4	116.7	42.6	25.5	6.1	4,150	606.3	1,252.4	720.3	128.9	29.3
Petrinja							7,219	1,249.4	2,506.7	1,552.3	196.8	47.7
Glina							1,768	343.2	686.4	400.4	62.9	14.3
Topusko							544	105.6	211.2	123.2	19.4	4.4
Popovaća							1,971	431.8	774.0	630.5	66.0	13.6
Lipovljani							1,020	198.0	396.0	231.0	36.3	8.3
Novska							3,060	594.0	1,188.0	693.0	108.9	24.8
Ogulin	269	6.7	33.6	9.4	5.6	1.3	4,769	831.9	1,698.9	1,143.8	164.6	36.8
Plaški							272	52.8	105.6	61.6	9.7	2.2
Slunj							544	105.6	211.2	123.2	19.4	4.4
Total	43,025	1,144.2	2,964.3	7,462.5	1,611.9	75.7	667,492	123,594	253,613	176,341	25,639.5	5,068.0

Table D.10.3 Wastewater Quantity and Pollution Load in 2015 (with Project)

Name	Municipal Sewerage System											
	Municipal Wastewater						Industrial Wastewater					
	Quantity	Load (kg/day)					Quantity	Load (kg/day)				
	(m^3/day)	BOD	COD	TSS	T-N	T-P	(m^3/day)	BOD	COD	TSS	T-N	T-P
Zagreb	274,860	6,872	34,358	9,620	5,497	824.6	167,510	4,187.8	20,938.8	5,862.9	3,350.2	502.5
Sesvete-East	7,040	176.0	880.0	246.4	140.8	21.1	1,599	40.0	199.9	56.0	24.0	3.2
Dugo Selo	5,680	142.0	710.0	198.8	85.2	11.4						
Vrbovec	2,856	71.4	357.0	100.0	42.8	5.7	3,710	92.8	463.8	129.9	55.7	7.4
Sisak	20,960	524.0	2,620.0	733.6	314.4	41.9	1,413	35.3	176.6	49.5	21.2	2.8
Kutina	9,920	248.0	1,240.0	347.2	148.8	19.8	1,063	26.6	132.9	37.2	15.9	2.1
Karlovac - Duga Resa	26,680	667.0	3335.0	933.8	400.2	53.4	11,595	289.9	1,449.4	405.8	173.9	23.2
Sv. Ivan Zelina	2,380	95.2	357.0	142.8	47.6	9.5						
Ivanić Grad - Klostar Ivanic	4,512	112.8	564.0	157.9	67.7	9.0	1,283	32.1	160.4	44.9	19.2	2.6
Samobor	11,680	292.0	1,460.0	408.8	175.2	23.4	1,528	38.2	191.0	53.5	22.9	3.1
Zaprešić	12,200	305.0	1,525.0	427.0	183.0	24.4	6,544	163.6	818.0	229.0	98.2	13.1
Velika Gorica	24,960	624.0	3,120.0	873.6	499.2	74.9	662	16.6	82.8	23.2	13.2	2.0
Jastrebarsko	2,754	110.2	413.1	165.2	55.1	11.0	180	7.2	27.0	10.8	3.6	0.7
Petrinja	5,240	131.0	655.0	183.4	78.6	10.5	1,979	49.5	247.4	69.3	29.7	4.0
Glina	1,768	70.7	265.2	106.1	35.4	7.1						
Topusko	544	21.8	81.6	32.6	10.9	2.2						
Popovaća	1,224	49.0	183.6	73.4	24.5	4.9	747	29.9	112.1	44.8	14.9	3.0
Lipovljani	1,020	40.8	153.0	61.2	20.4	4.1						
Novska	3,060	122.4	459.0	183.6	61.2	12.2						
Ogulin	4,160	104.0	520.0	145.6	62.4	8.3	340	8.5	42.5	11.9	5.1	0.7
Plaški	272	10.9	40.8	16.3	5.4	1.1						
Slunj	544	21.8	81.6	32.6	10.9	2.2						
Sub-total	424,314	10,811.3	53,378.4	15,190.1	7,966.8	1,182.6	200,153	5,017.7	25,042.3	7,028.5	3,847.8	570.3

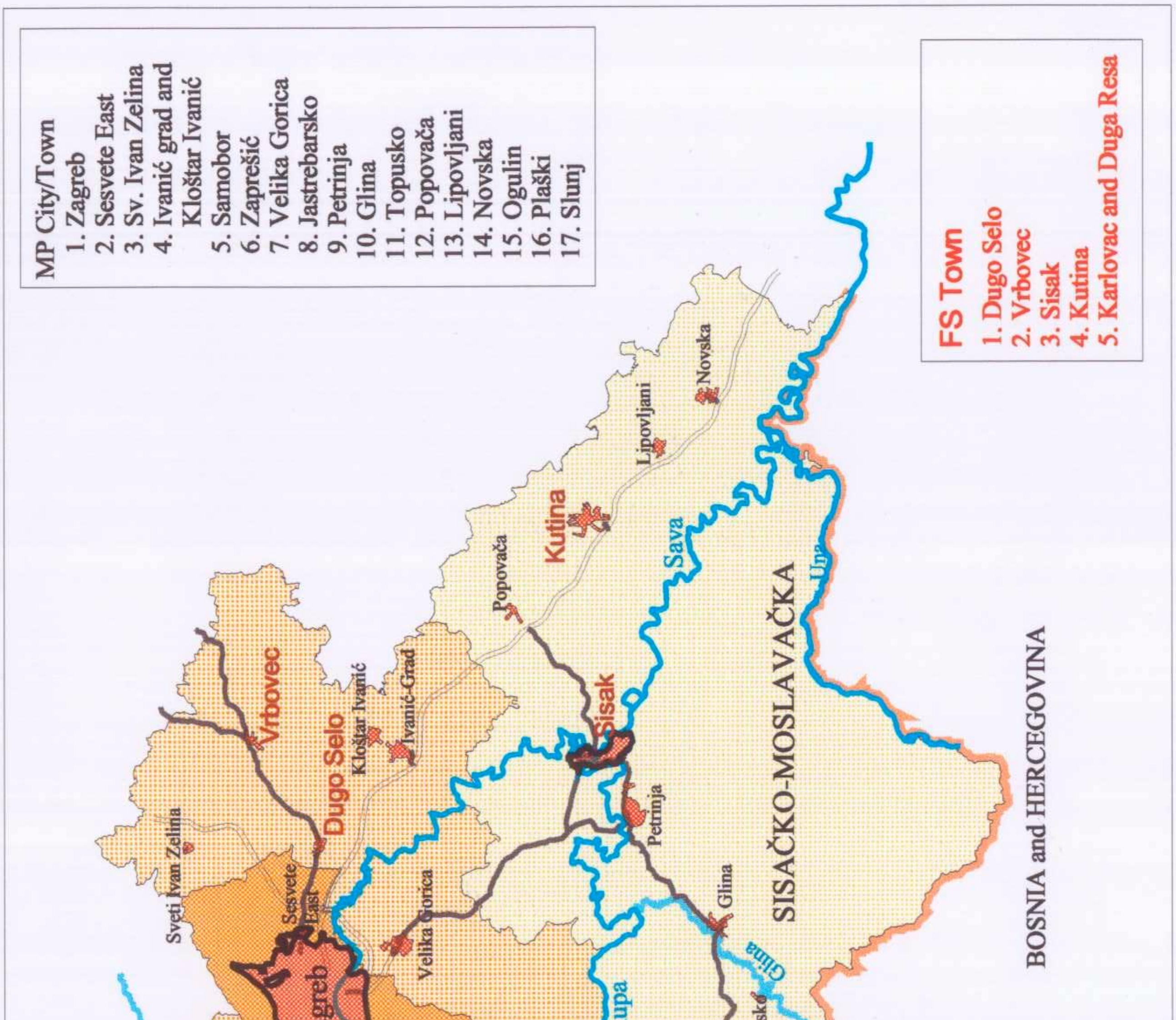
Name	River						Total					
	Industrial Wastewater											
	Quantity	Load (kg/day)					Quantity	Load (kg/day)				
	(m^3/day)	BOD	COD	TSS	T-N	T-P	(m^3/day)	BOD	COD	TSS	T-N	T-P
Zagreb							442,370	11,059.3	55,296.3	15,483.0	8,847.4	1,327.1
Sesvete-East							8,639	216.0	1,079.9	302.4	164.8	24.3
Dugo Selo							5,680	142.0	710.0	198.8	85.2	11.4
Vrbovec	124	3.1	15.5	4.3	3.7	0.6	6,690	167.3	836.3	234.2	102.2	13.8
Sisak	21,225	453.0	1,120.9	742.9	342.7	35.4	43,598	1012.3	3,917.5	1525.9	678.3	80.1
Kutina	17,165	190.5	666.0	600.8	360.5	17.2	28,148	465.1	2,038.9	985.2	525.2	39.1
Karlovac - Duga Resa	169	3.2	9.8	84.3	5.1	0.8	38,444	960.1	4,794.2	1424.0	579.2	77.4
Sv. Ivan Zelina							2,380	95.2	357.0	142.8	47.6	9.5
Ivanic Grad - Kloster Ivanic	378	4.9	4.9	244.2	11.3	1.9	6,173	149.8	729.3	447.0	98.3	13.5
Samobor	2,082	69.0	368.4	764.8	53.9	10.4	15,290	399.2	2,019.4	1227.1	252.0	36.8
Zaprešić							18,744	468.6	2,343.0	656.0	281.2	37.5
Velika Gorica	397	9.9	39.7	13.9	8.3	2.0	26,019	650.5	3,242.5	910.7	520.8	78.9
Jastrebarsko	1,216	30.4	116.7	42.6	25.5	6.1	4,150	147.8	556.8	218.6	84.2	17.8
Petrinja							7,219	180.5	902.4	252.7	108.3	14.4
Glina							1,768	70.7	265.2	106.1	35.4	7.1
Topusko							544	21.8	81.6	32.6	10.9	2.2
Popovaća							1,971	78.8	295.7	118.3	39.4	7.9
Lipovljani							1,020	40.8	153.0	61.2	20.4	4.1
Novska							3,060	122.4	459.0	183.6	61.2	12.2
Ogulin	269	6.7	33.6	9.4	5.6	1.3	4,769	119.2	596.1	166.9	73.1	10.3
Plaški							272	10.9	40.8	16.3	5.4	1.1
Slunj							544	21.8	81.6	32.6	10.9	2.2
Sub-total	43,025	770.8	2375.6	2507.2	816.7	75.7	667,492	16,599.8	80,796.3	24,725.9	12,631.3	1,828.7

Table 10.4 Construction Cost of Sewerage System in Master Plan

Name	Direct Cost									
	Pipe			Wastewater Treatment Plant						Sub-total
	Main	Network	Sewer	Preliminary	Biological	Sedimentation	Sludge	Others	Sub-total	
1 Sesvete East	9,349,554	1,612,223	10,961,777	5,135,206	7,342,936	2,335,684	5,453,239	10,131,557	30,398,622	41,360,399
2 Dugo Selo	8,770,728	22,829,835	31,600,562	4,341,106	5,666,272	1,687,235	4,317,892	9,141,940	25,154,445	56,755,008
3 Vrbovec	4,127,012	19,104,256	23,231,268	4,298,797	6,176,612	1,899,722	4,346,022	8,633,710	25,354,862	48,586,130
5 Sisak	292,566	27,535,639	27,828,205	8,202,335	13,923,316	5,136,298	10,055,286	19,179,423	56,496,658	84,324,863
4 Kutina	17,751,108	25,398,030	43,149,138	11,060,636	17,187,661	6,633,389	15,665,689	26,476,980	77,024,356	120,173,495
6 Karlovac - Duga Resa	51,471,089	33,251,035	84,722,123	1,567,029	8,005,121	2,568,149	5,027,643	7,472,941	24,640,883	109,363,006
7 Sv.Ivan Zelina	10,773,491	726,164	11,499,655	2,334,934	6,444,801	1,849,813	226,203	4,636,697	15,492,448	26,992,103
8 Ivanić Grad - Kloštar Ivanić	1,401,657	5,543,142	6,944,799	933,886	5,266,364	1,899,722	4,453,165	7,298,663	19,851,800	26,796,599
9 Samobor	3,996,962	5,193,464	9,190,426	2,661,811	8,737,320	2,886,309	4,886,561	7,822,028	26,994,030	36,184,456
10 Zaprešić	9,266,236	9,466,235	18,732,472	7,600,513	11,708,908	4,145,574	9,275,916	14,614,077	47,344,989	66,077,460
11 Velika Golica	12,173,953	6,886,821	19,060,773	4,019,994	9,357,659	4,263,096	5,015,399	6,301,045	28,957,194	48,017,967
12 Jastrebarsko	3,540,075	1,794,180	5,334,255	2,379,625	7,405,216	2,112,218	238,957	4,912,278	17,048,294	22,382,549
13 Petrinja	3,089,424	3,507,226	6,596,650	4,689,009	6,590,081	2,044,794	4,821,381	9,285,989	27,431,254	34,027,904
14 Glina	2,808,574	6,259,107	9,067,682	2,272,891	5,290,740	1,532,127	209,249	4,216,503	13,521,510	22,589,192
15 Topusko	1,907,743	312,670	2,220,414	404,286	1,282,143	0	0	142,857	1,829,286	4,049,699
16 Popovaća	2,004,148	334,733	2,338,882	2,295,384	5,686,574	1,641,412	215,296	4,373,872	14,212,537	16,551,418
17 Lipovljani	2,510,714	4,642,139	7,152,853	2,162,399	3,672,371	1,081,104	181,156	3,418,818	10,515,847	17,668,700
18 Novska	3,052,541	2,699,929	5,752,470	2,388,708	7,614,819	2,169,275	241,605	4,964,875	17,379,282	23,131,751
19 Ogulin	2,505,163	2,916,521	5,421,684	3,691,273	4,957,234	1,440,821	3,486,591	7,357,220	20,933,139	26,354,822
20 Plaški	1,150,223	789,980	1,940,203	1,918,353	1,527,230	467,723	128,115	1,703,444	5,744,866	7,685,069
21 Slunj	1,490,284	3,448,156	4,938,440	2,119,121	3,166,778	938,504	170,865	3,100,439	9,495,707	14,434,147
Total	153,433,243	184,251,487	337,684,730	76,477,298	147,010,155	48,732,967	78,416,228	165,185,359	515,822,008	853,506,738

Name	Land Acquisition	Indirect Cost					Contingency	Total
		Engineering	Admini-stration	Custom Duties	VAT	Sub-total		
1 Sesvete East	0	4,136,040	1,240,812	1,521,731	10,009,217	16,907,800	8,272,080	66,540,279
2 Dugo Selo	186,750	5,675,501	1,702,650	1,549,714	13,734,712	22,662,577	11,351,002	90,955,336
3 Vrbovec	199,200	4,858,613	1,457,584	1,602,000	11,757,844	19,676,040	9,717,226	78,178,597
5 Sisak	0	5,246,909	1,574,073	1,480,471	12,697,519	20,998,972	10,493,818	115,817,652
4 Kutina	Municipality	9,964,580	2,989,374	3,151,200	24,114,283	40,219,436	19,929,159	180,322,090
6 Karlovac - Duga Resa	1,452,500	16,174,648	4,852,394	4,159,600	39,142,648	64,329,290	32,349,296	207,494,093
7 Sv.Ivan Zelina	400,000	2,699,210	809,763	778,222	6,532,089	10,819,285	5,398,421	43,609,809
8 Ivanić Grad - Kloštar Ivanić	0	2,679,660	803,898	1,240,714	6,484,777	11,209,049	5,359,320	43,364,968
9 Samobor	0	3,618,446	1,085,534	1,603,471	8,756,638	15,064,089	7,236,891	58,485,436
10 Zaprešić	0	6,607,746	1,982,324	2,380,149	15,990,745	26,960,965	13,215,492	106,253,917
11 Velika Golica	Municipality	4,801,797	1,440,539	2,020,371	11,620,348	19,883,055	9,603,593	77,504,616
12 Jastrebarsko	Government	2,238,255	671,476	854,215	5,416,577	9,180,523	4,476,510	36,039,582
13 Petrinja	722,000	3,402,790	1,020,837	1,371,563	8,234,753	14,029,943	6,805,581	55,585,428
14 Glina	418,000	2,258,919	677,676	676,075	5,466,584	9,079,255	4,517,838	36,604,285
15 Topusko	0	404,970	121,491	91,464	980,027	1,597,952	809,940	6,457,592
16 Popovaća	0	1,655,142	496,543	712,427	4,005,443	6,869,554	3,310,284	26,731,257
17 Lipovljani	0	1,766,870	530,061	525,792	4,275,825	7,098,549	3,533,740	28,300,989
18 Novska	0	2,313,175	693,953	868,964	5,597,884	9,473,975	4,626,350	37,232,077
19 Ogulin	Government	2,635,482	790,645	1,060,757	6,377,867	10,864,751	5,270,964	42,490,538
20 Plaški	Government	768,507	230,552	287,243	1,859,787	3,146,089	1,537,014	12,368,172
21 Slunj	259,200	1,443,415	433,024	476,585	3,493,064	5,846,088	2,886,829	23,426,264
Total	3,637,650	85,350,674	25,605,202	28,412,732	206,548,631	345,917,239	170,701,348	1,373,762,974

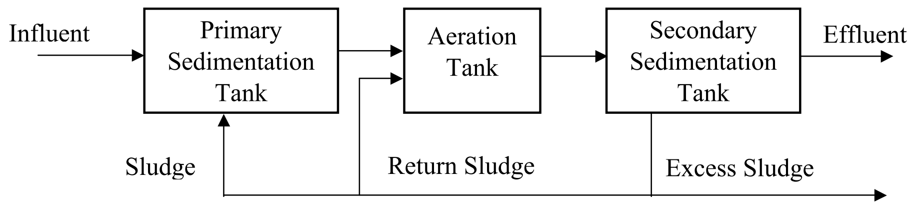
FIGURES



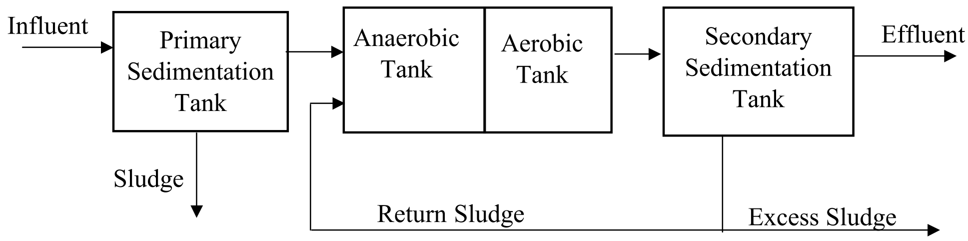
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

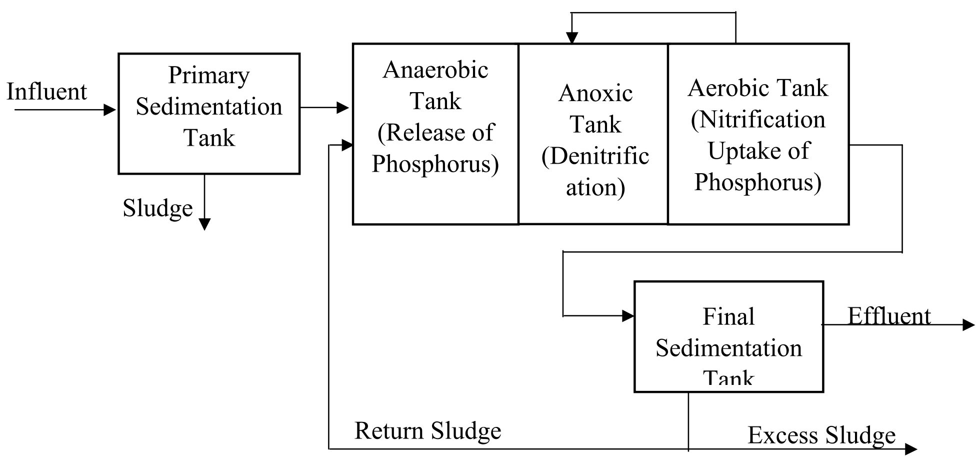
Fig. D.1.1 Objective Urban Centers for M/P and F/S



Activated Sludge

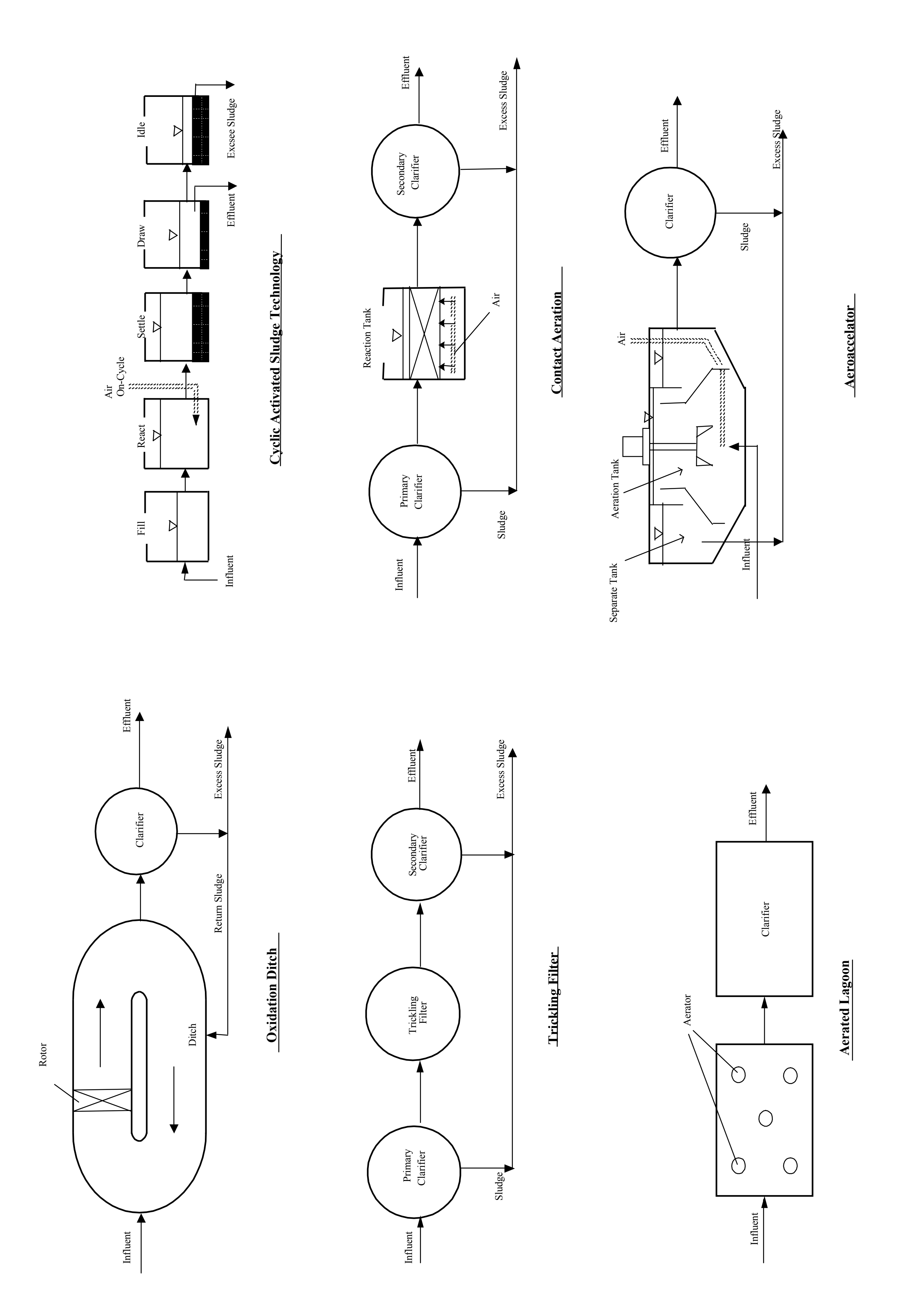


Activated Sludge with AO

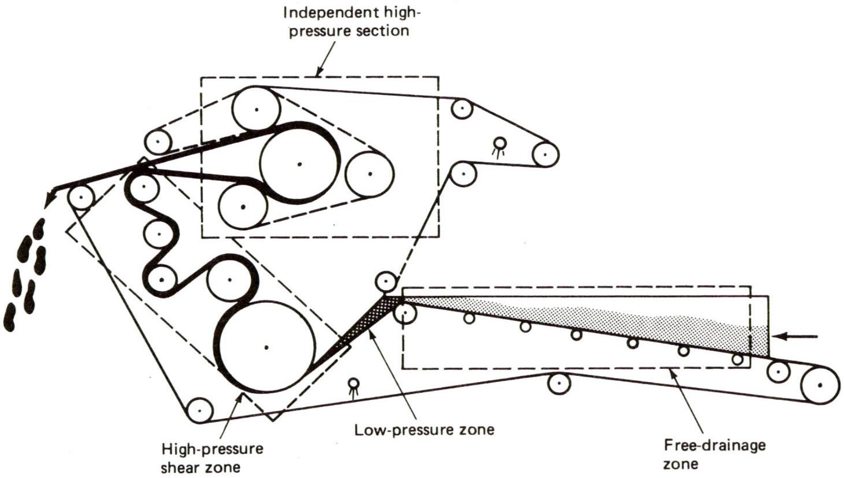


Activated Sludge with A_2O

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.1.2 Tratment Process for Removal Nutrient
JAPAN INTERNATIONAL COOPERATION AGENCY	

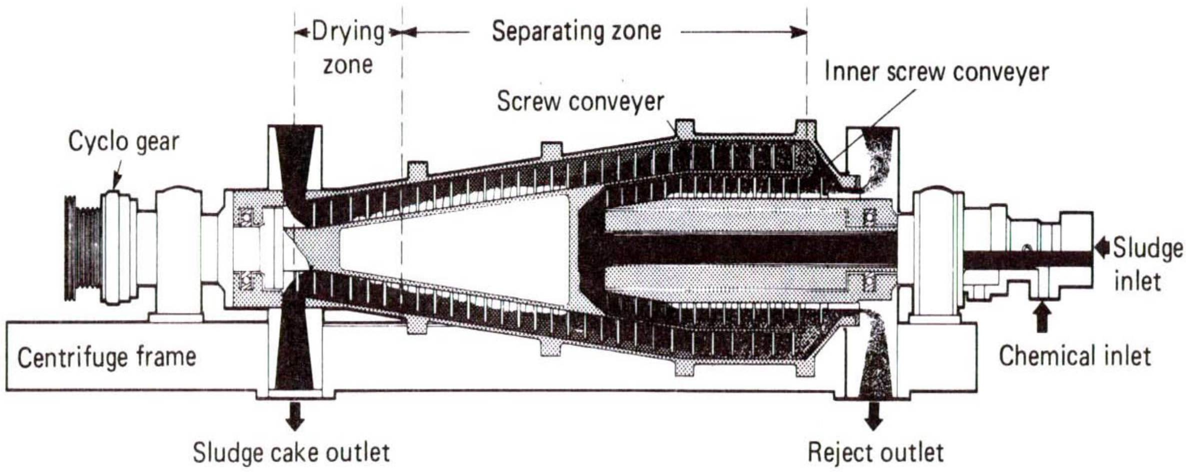


THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.1.3 Alternatives of Treatment Process
JAPAN INTERNATIONAL COOPERATION AGENCY	



Belt Press Filter

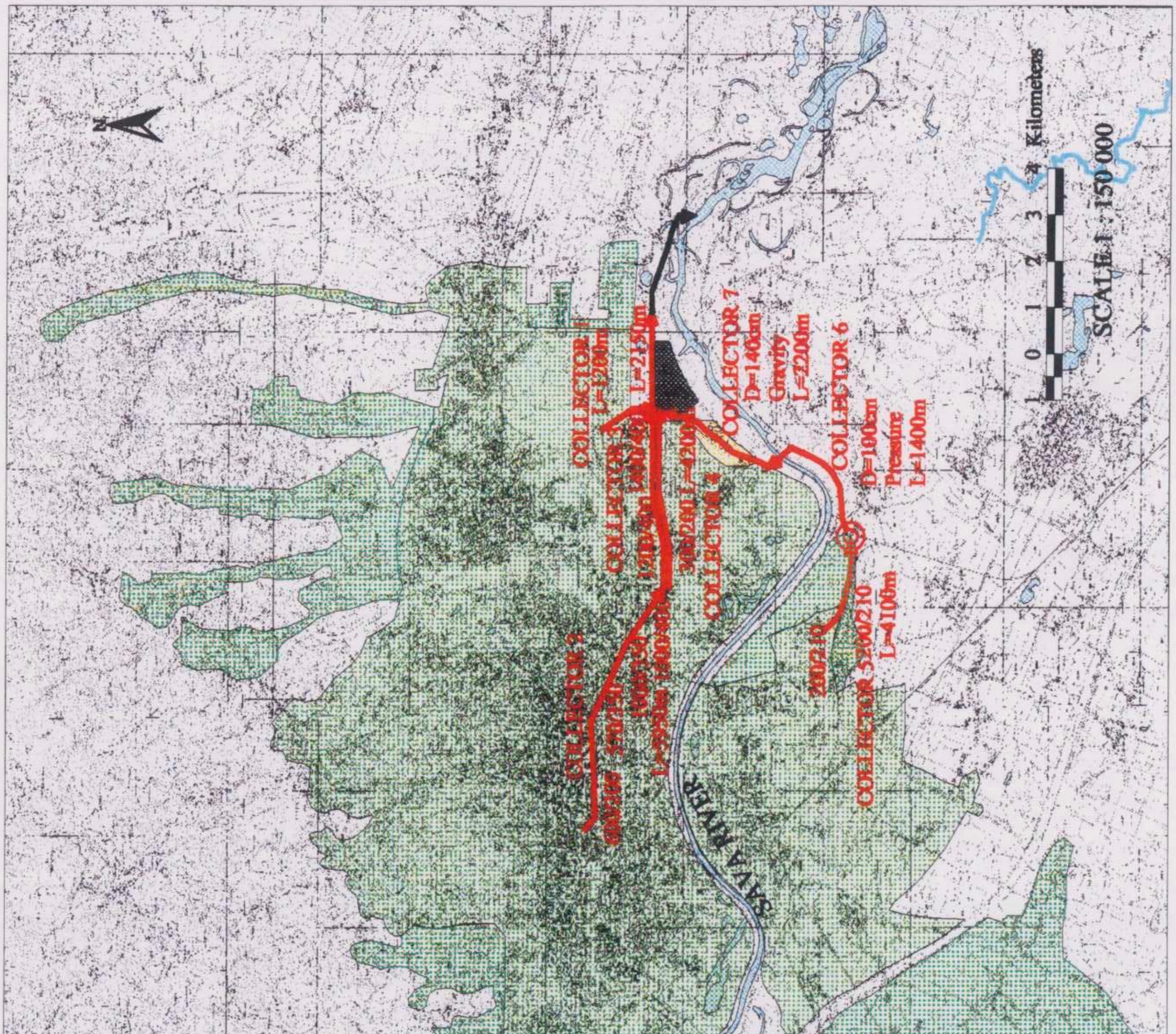
This machine consists of one or more endless woven belts which pass over and around a number of cylinders. The chemically conditioned sludge is fed to an open belt surface on which gravity drainage occurs as the bet moves forward. At the end of the gravity drainage section, provided the sludge has been properly conditioned, the solid content should be 10 % or more. At this moisture contents, it behaves as a solid and can be subjected to pressure, shear, and vacuum in subsequent sections of the machine. A second belt is usually brought down toward the moving sludge at the end of the gravity zone and gradually applied pressure to the solids, squeezing out additional moisture. As the paired belts move around the rollers, their speed relative to each other varies and sludge mass is sheared, aided in the release of free water. The pressure gradually increases through the machine, and, in some designs, a partial vacuum applied. The belt then separate, and the sludge cake is dislodged by scraping the belt or by passing it around a very small radius roller.



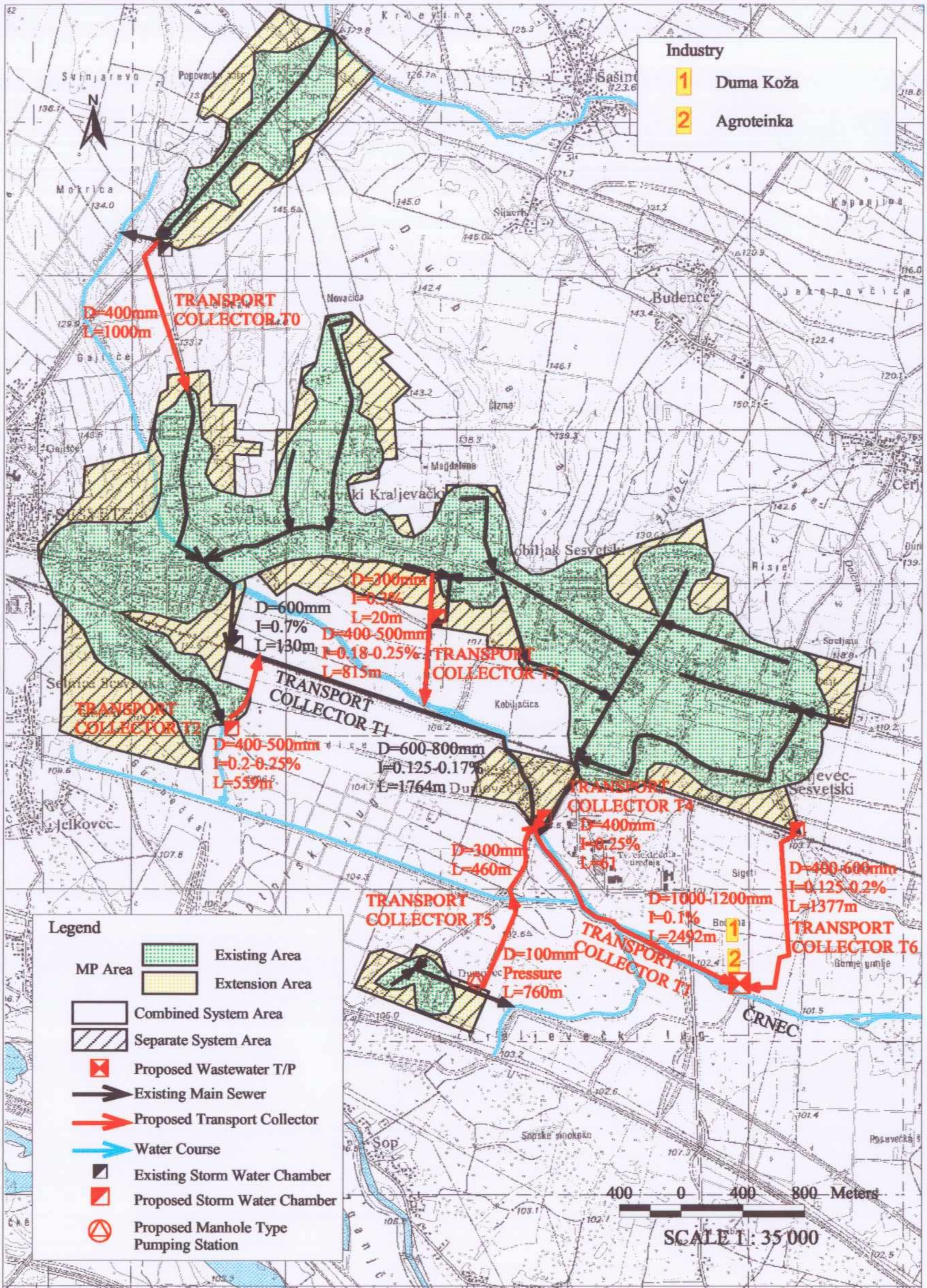
Centrifuge

The screw conveyers or scroll rotates at a speed slightly higher than that of the bowl and thus carries the solids through the device and up the ramp to the sludge cake outlet. The variables subject to control include the bowl diameter, length, and speed: The ramp slope and length, the pool depth, the scroll speed and pitch, the feed point of the sludge and chemicals, the retention time, and the sludge conditionings. Recovery of fine particles and light sludges can be improved by reducing the clearance between the scroll and ramp, sometimes by precoating with gypsum. In general, increased solids recovery in centrifuges is associated with increased moisture content in the dewatered sludge.

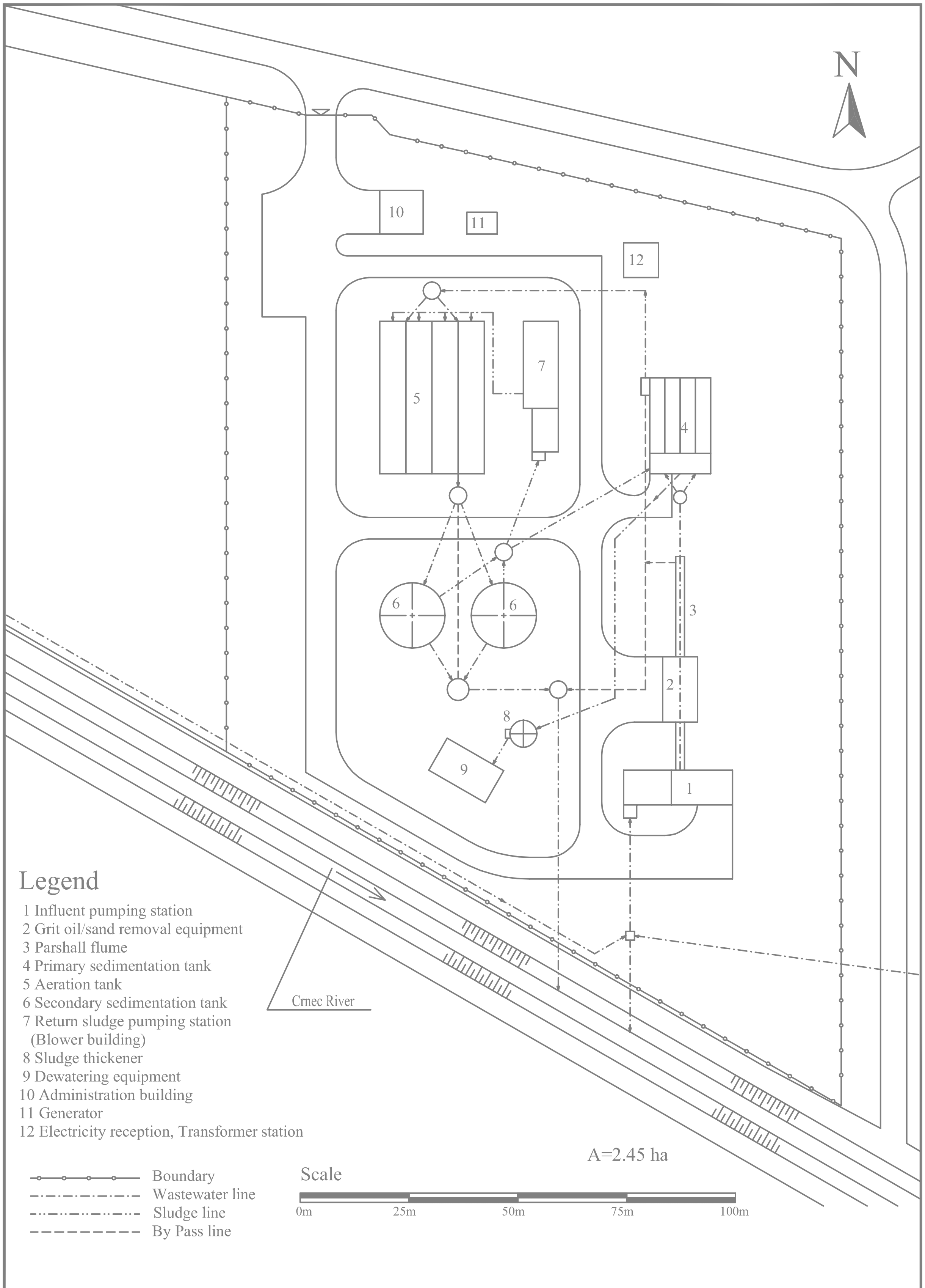
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.1.4 Dewatering Mechanism of Belt Press Filter and Centrifuge
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.2.1 Sewerage Development System in Zagreb
JAPAN INTERNATIONAL COOPERATION AGENCY	



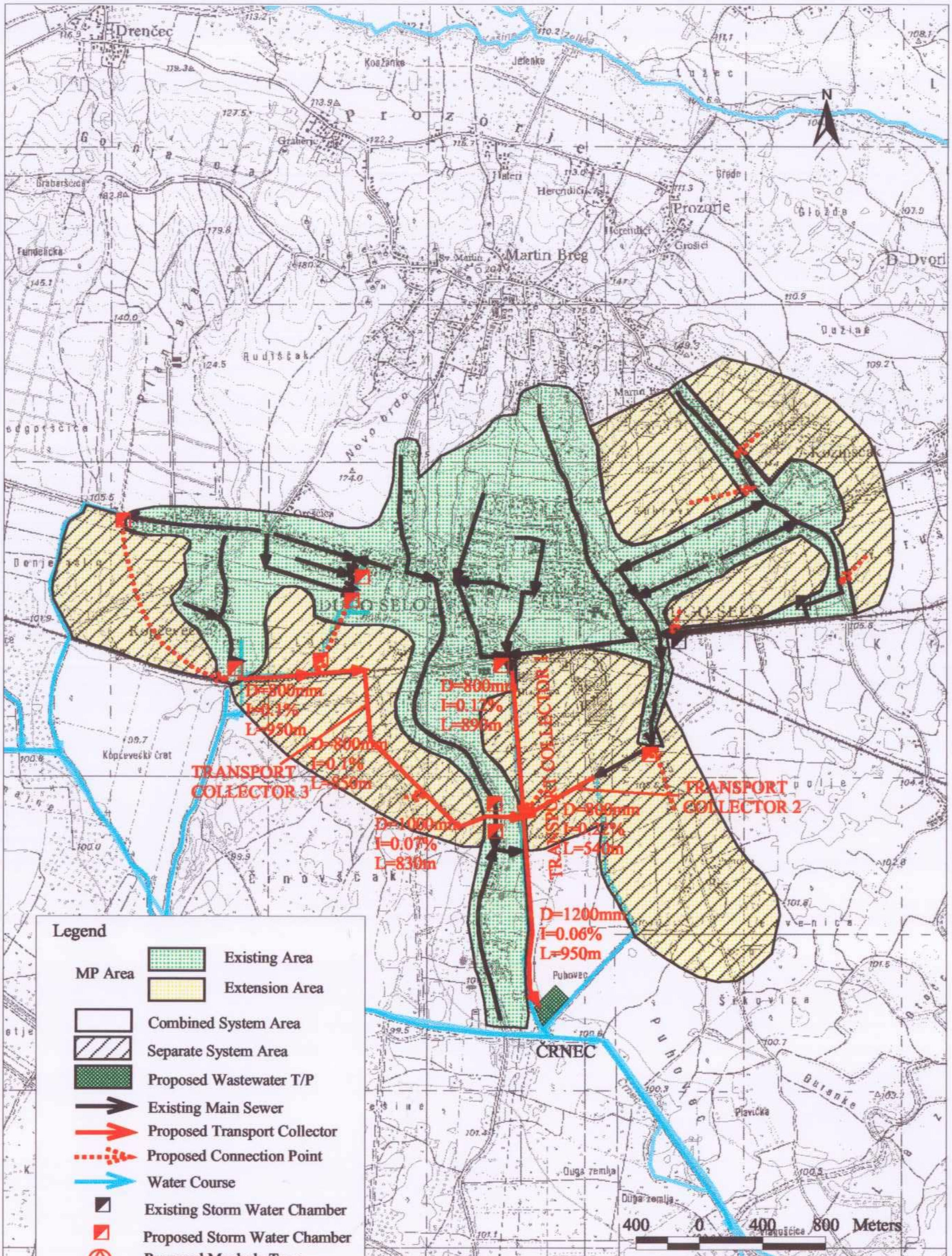
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.3.1 Sewerage Development System in Sesvete East
JAPAN INTERNATIONAL COOPERATION AGENCY	



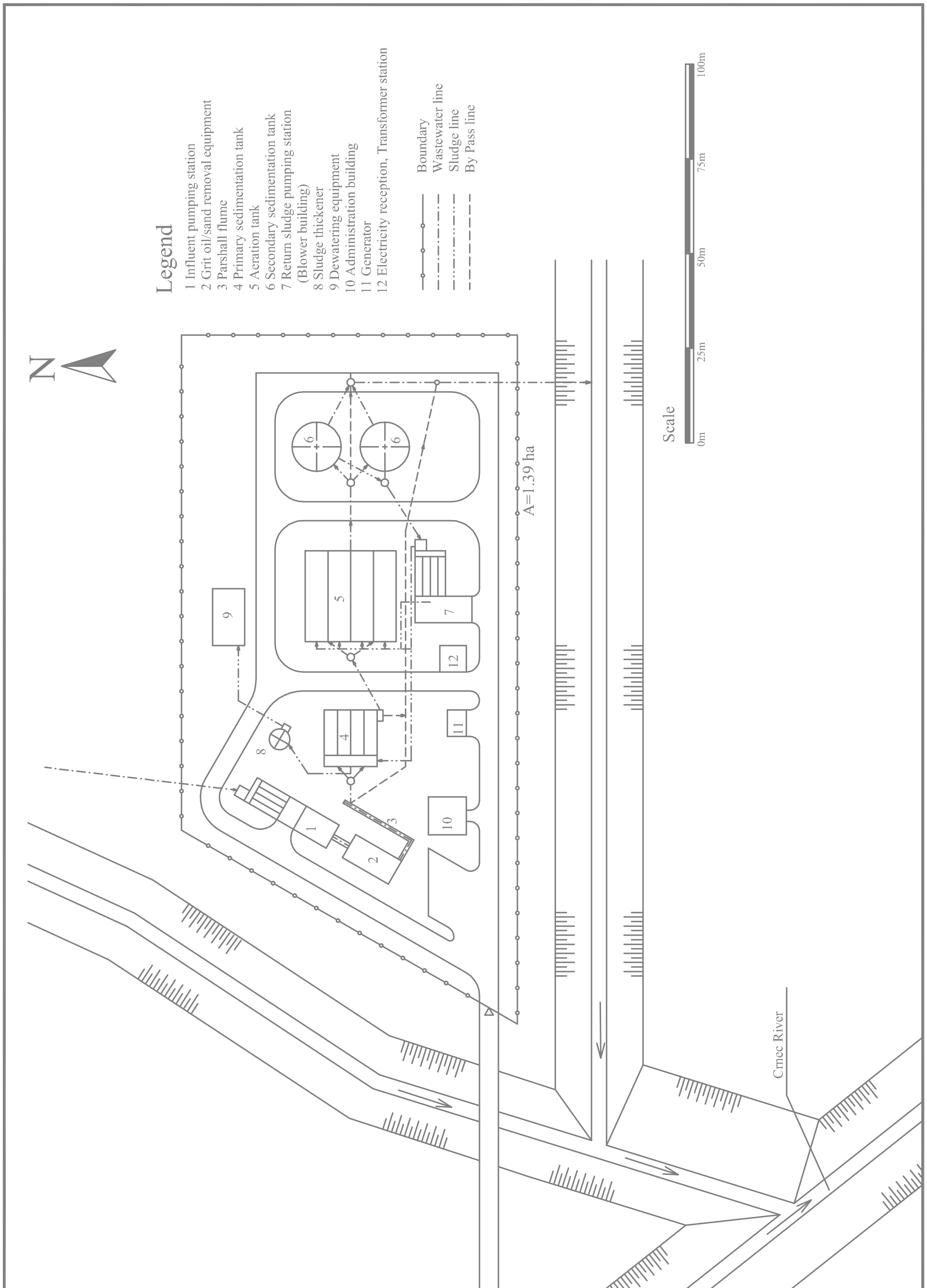
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

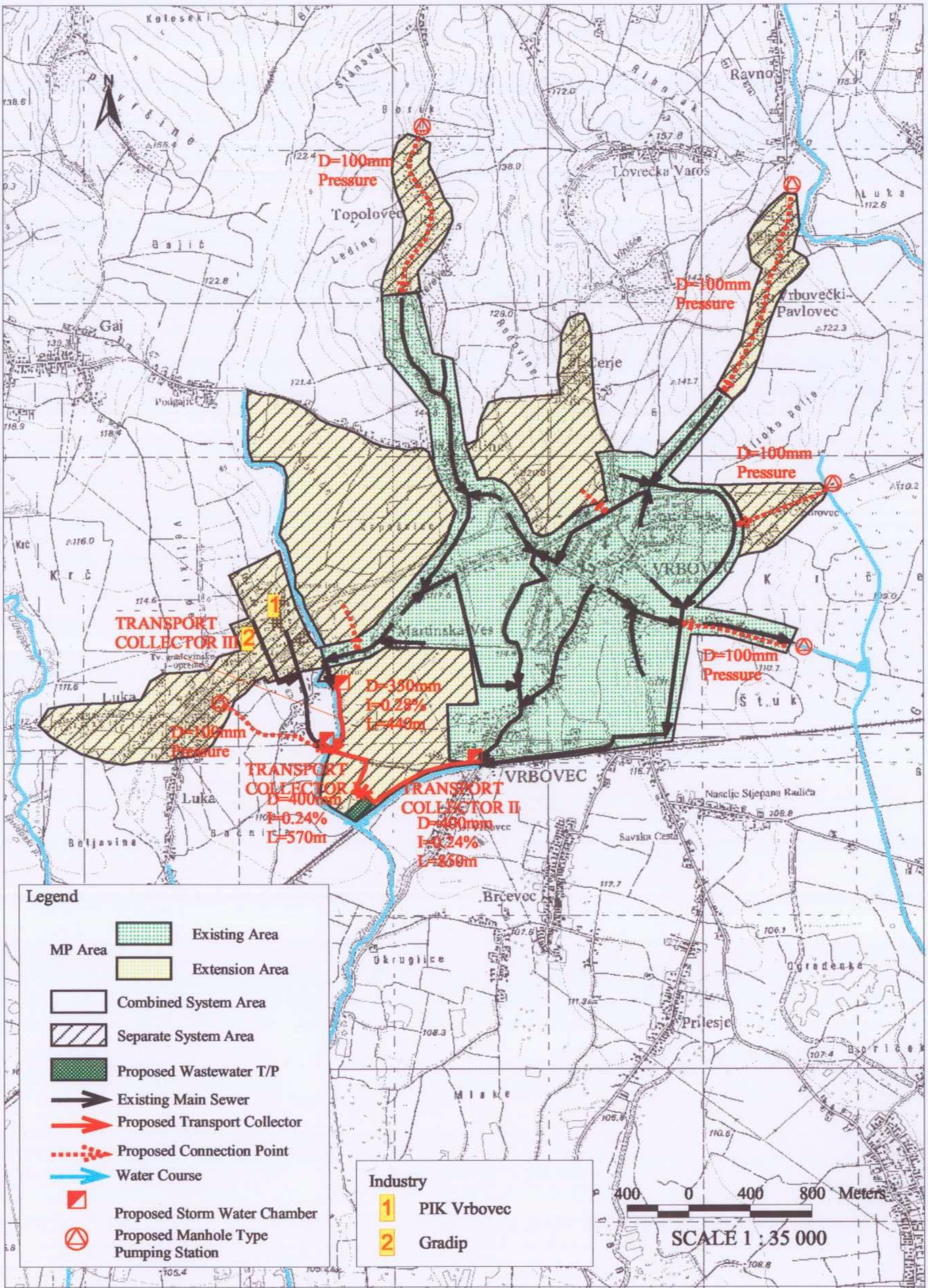
Fig.D.3.2
Layout of Wastewater Treatment Plant in Sesvete East



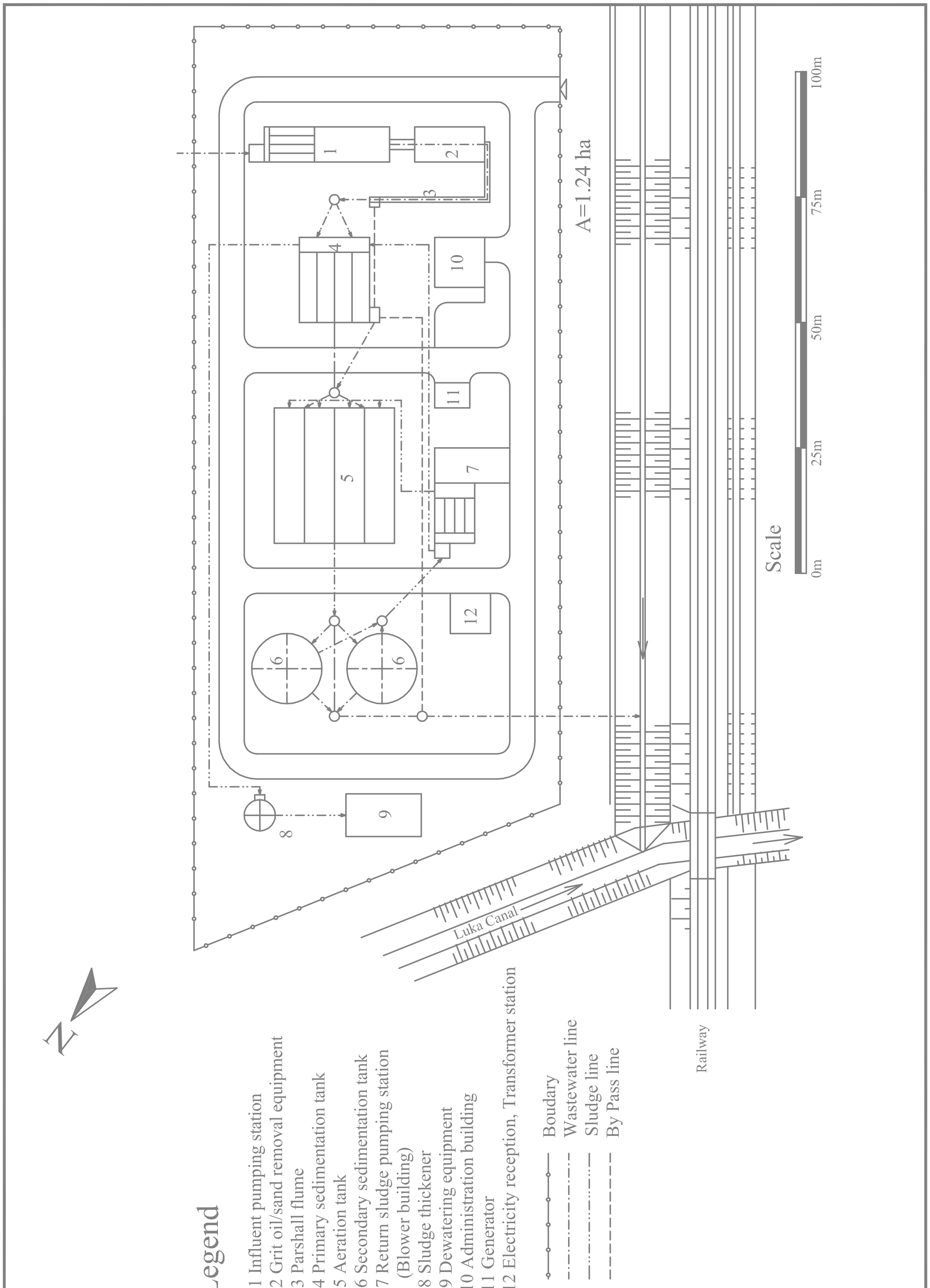
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.4.1 Sewerage Development System in Dugo Selo
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.4.2 Layout of Wastewater Treatment Plant in Dugo Selo
JAPAN INTERNATIONAL COOPERATION AGENCY	



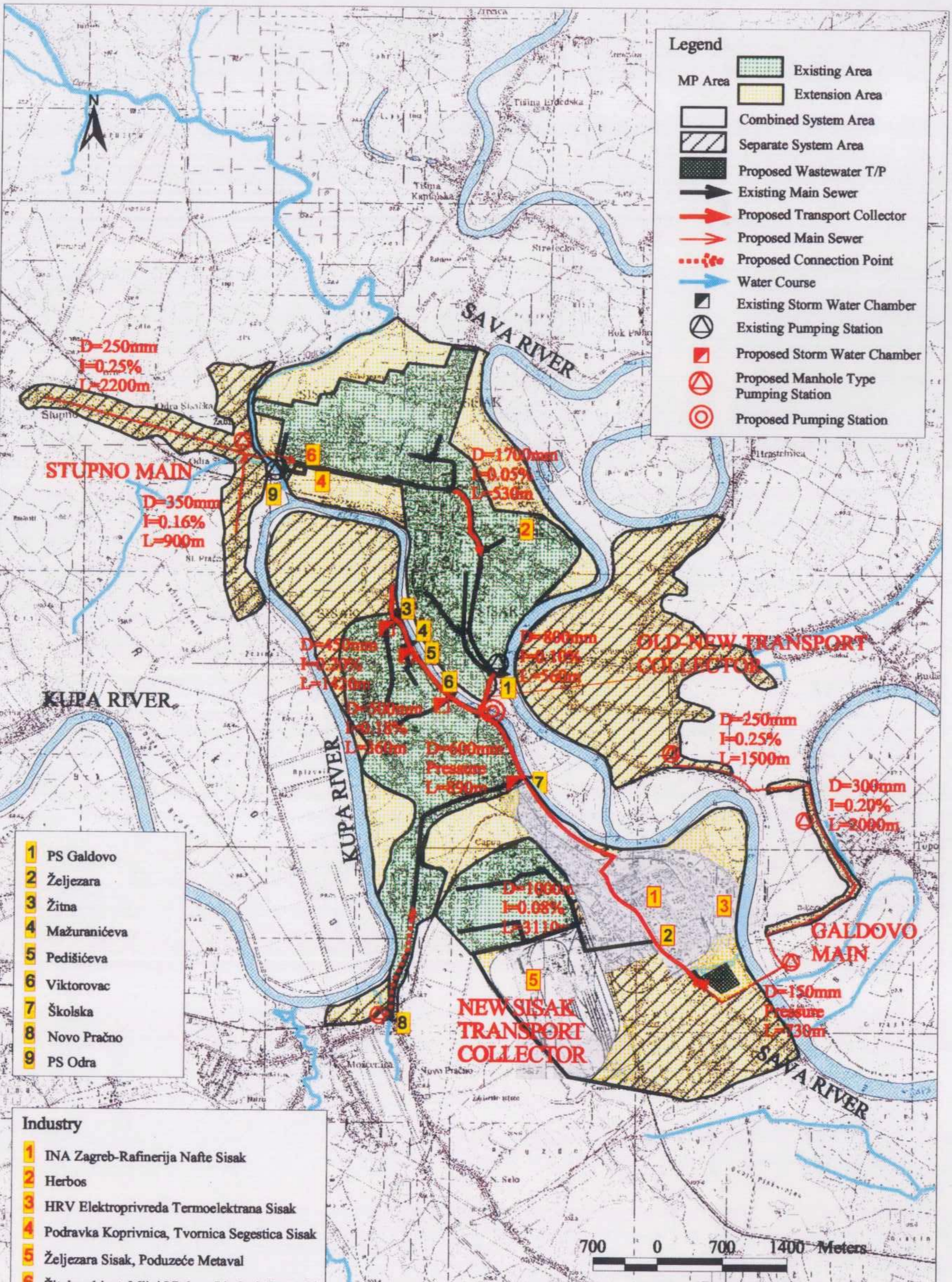
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.5.1 Sewerage Development System in Vrbovec
JAPAN INTERNATIONAL COOPERATION AGENCY	



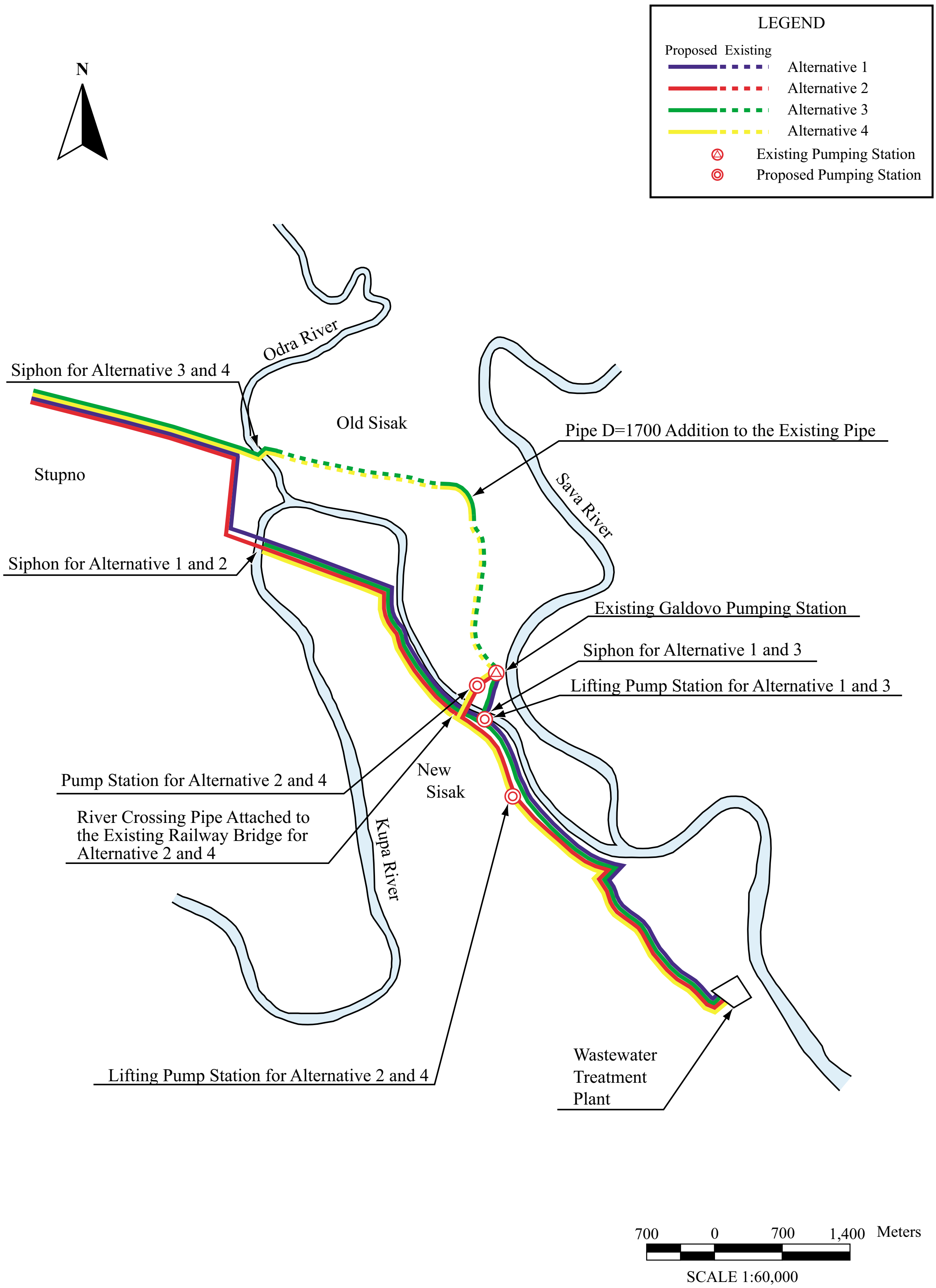
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

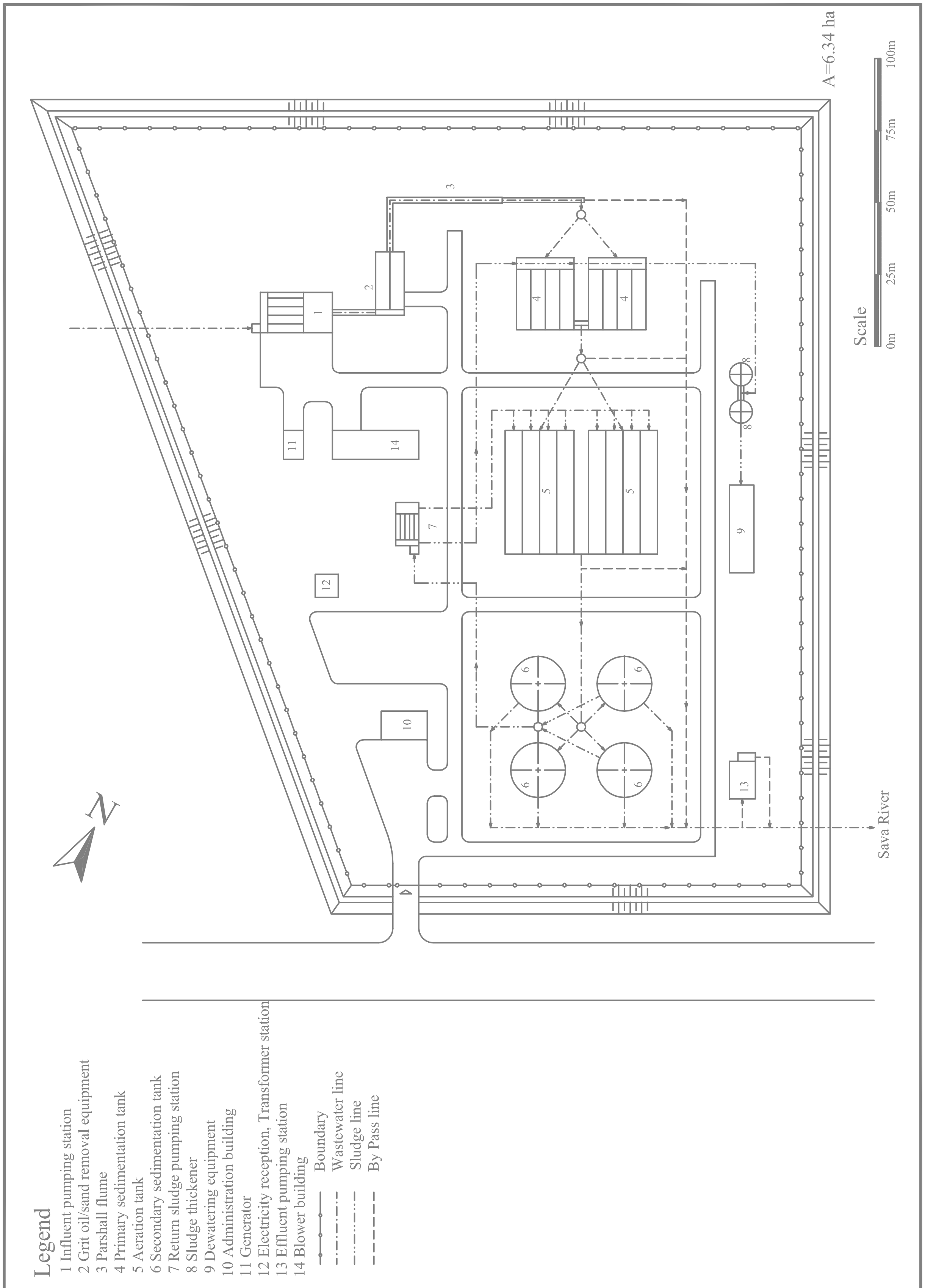
Fig.D.5.2
Layout of Wastewater Treatment Plant in Vrbovec



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.6.1 Sewerage Development System in Sisak
JAPAN INTERNATIONAL COOPERATION AGENCY	



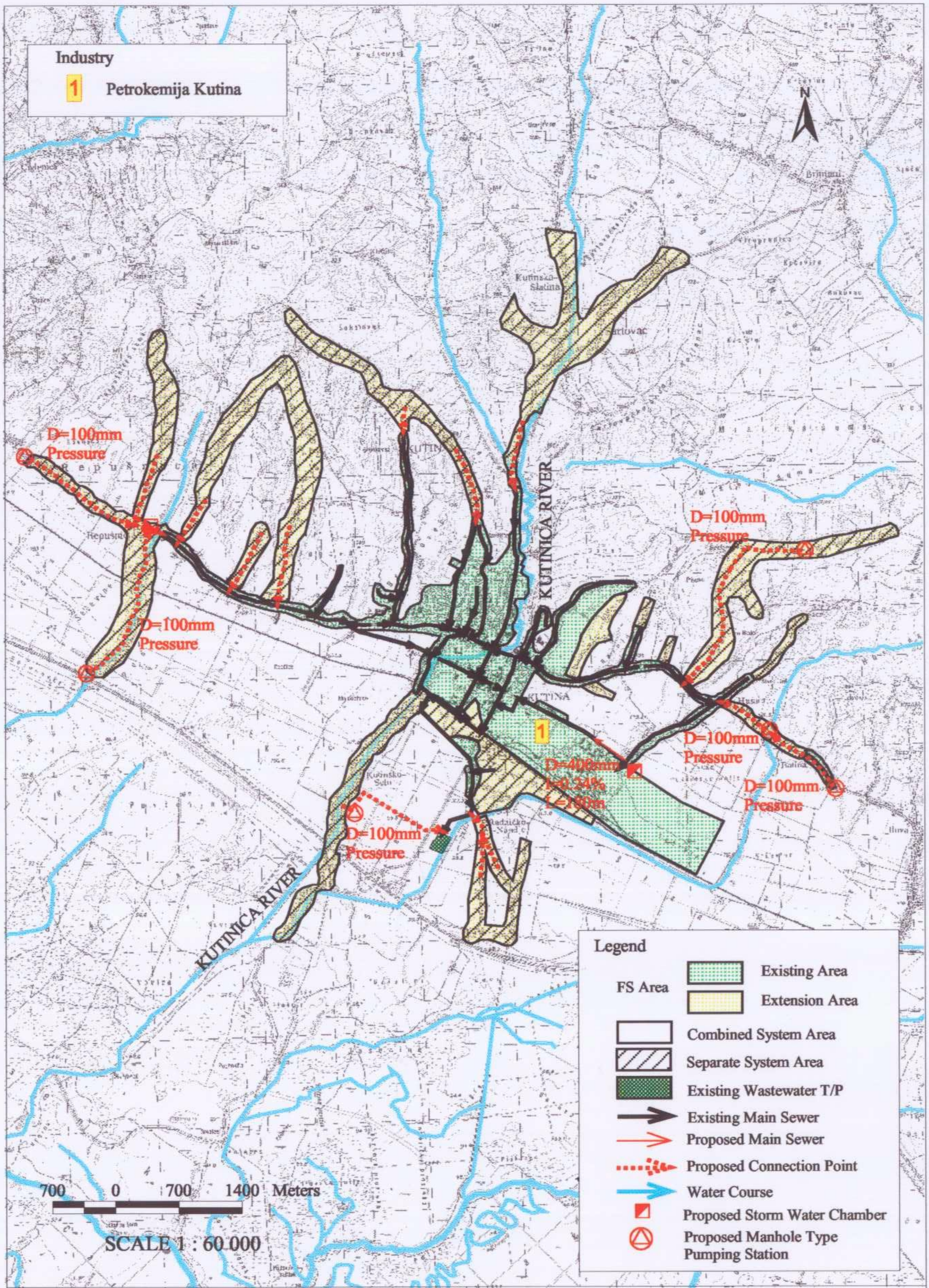
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig- D.6.2 Alternatives of Collectors in Sisak
JAPAN INTERNATIONAL COOPERATION AGENCY	



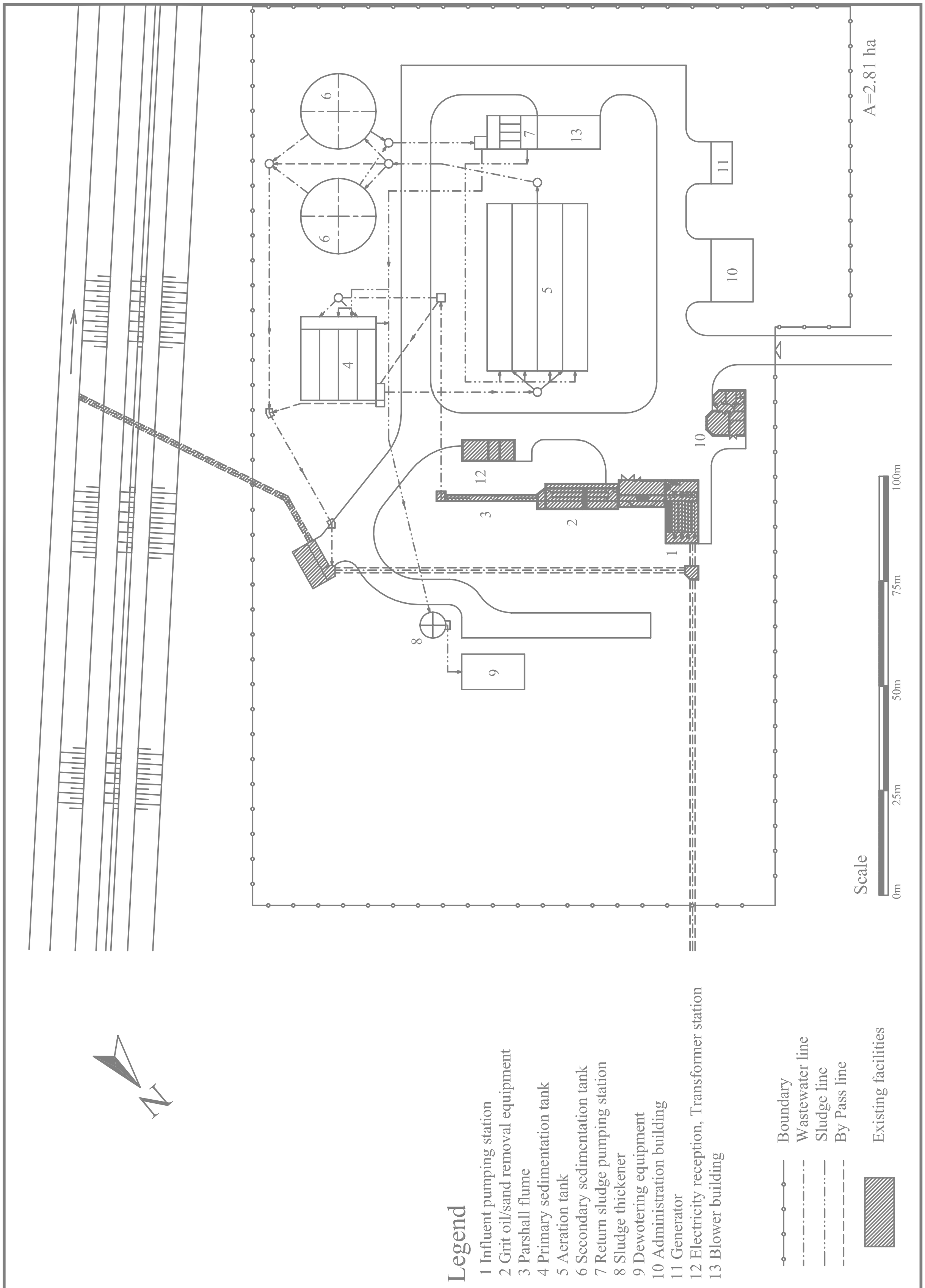
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.D.6.3
Layout of Wastewater Treatment Plant in Sisak



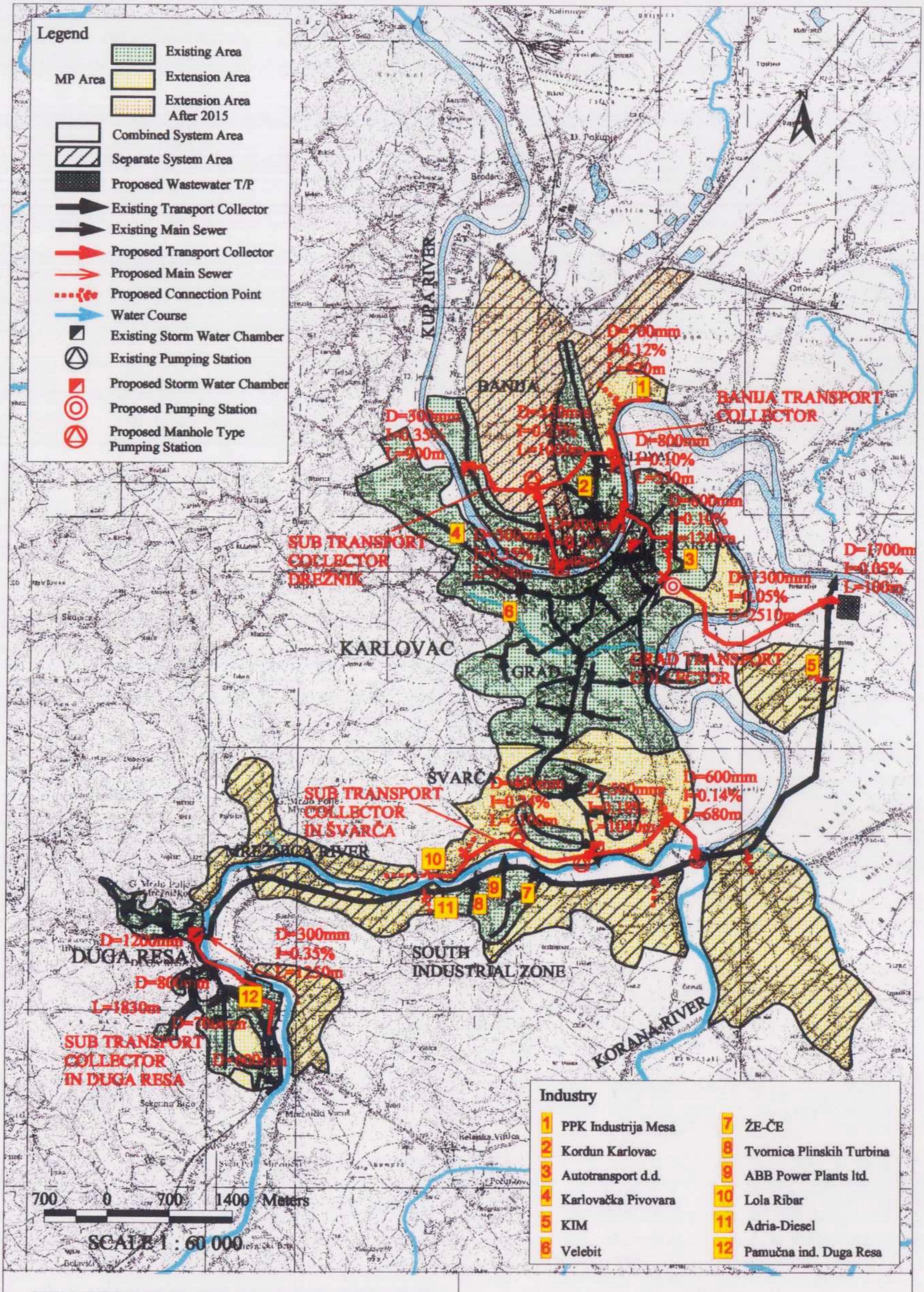
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.7.1 Sewerage Development System in Kutina
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

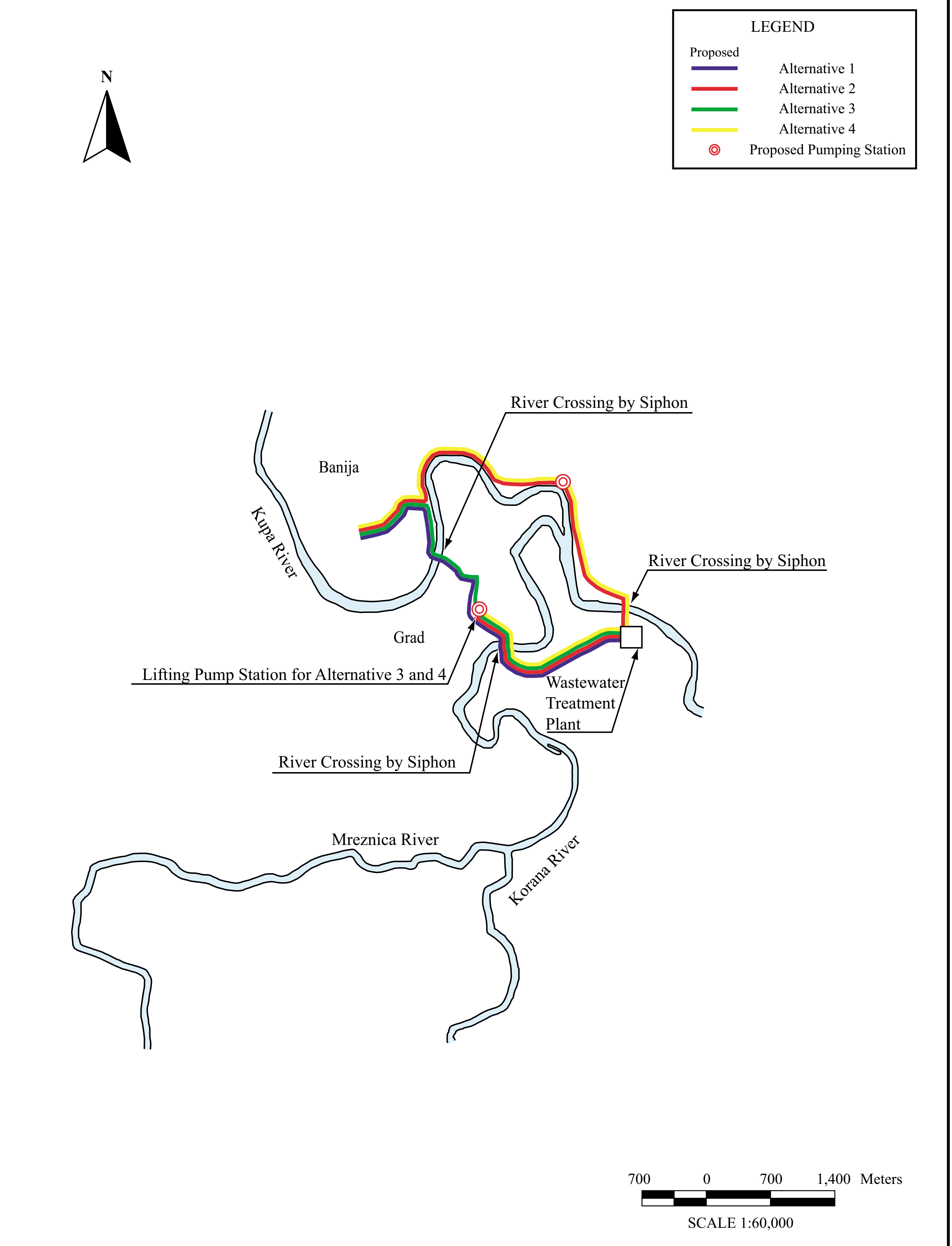
Fig.D.7.2
Layout of Wastewater Treatment Plant in Kutina



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

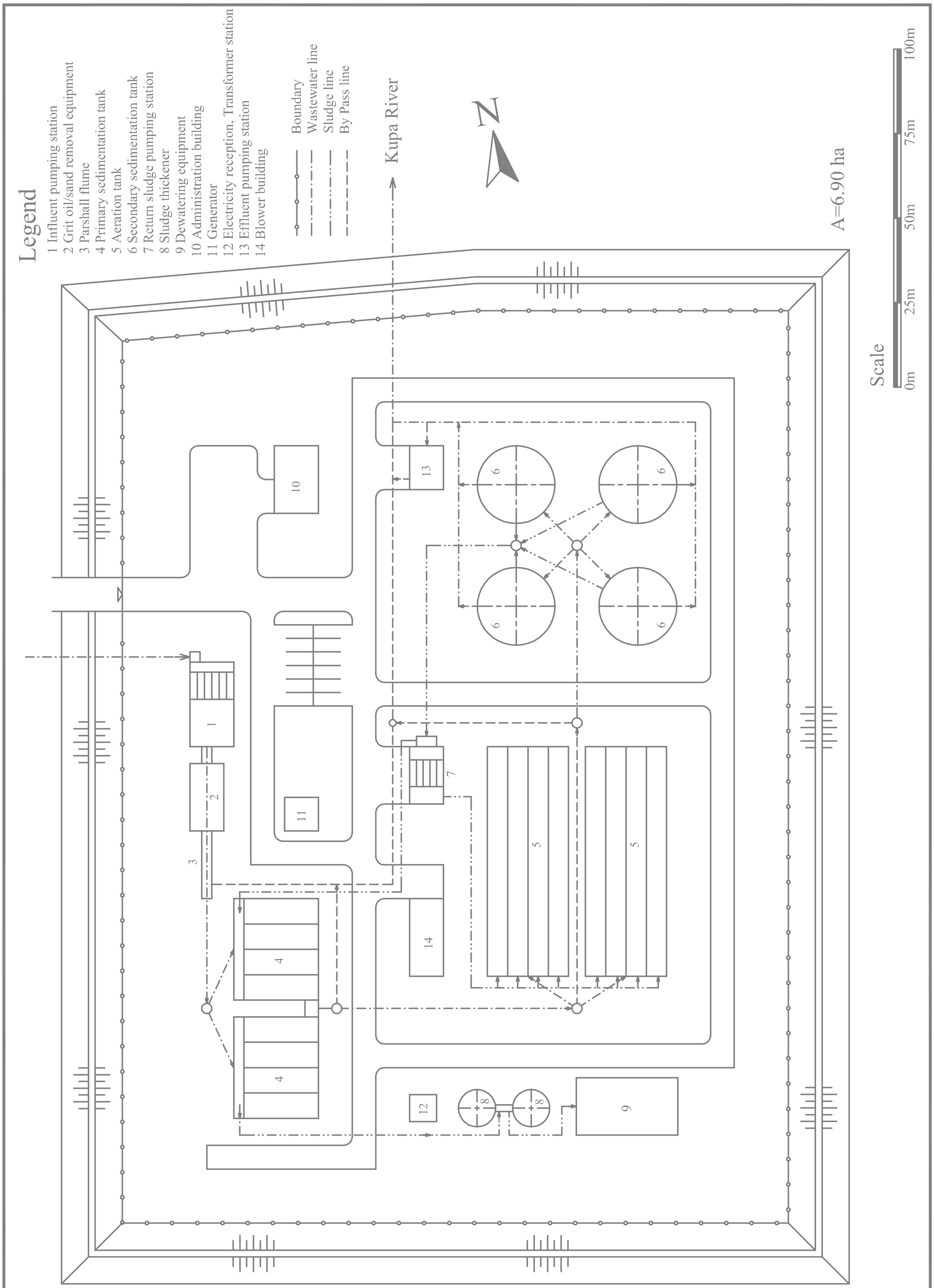
Fig.D.8.1 Sewerage Development System in Karlovac and Duga Resa



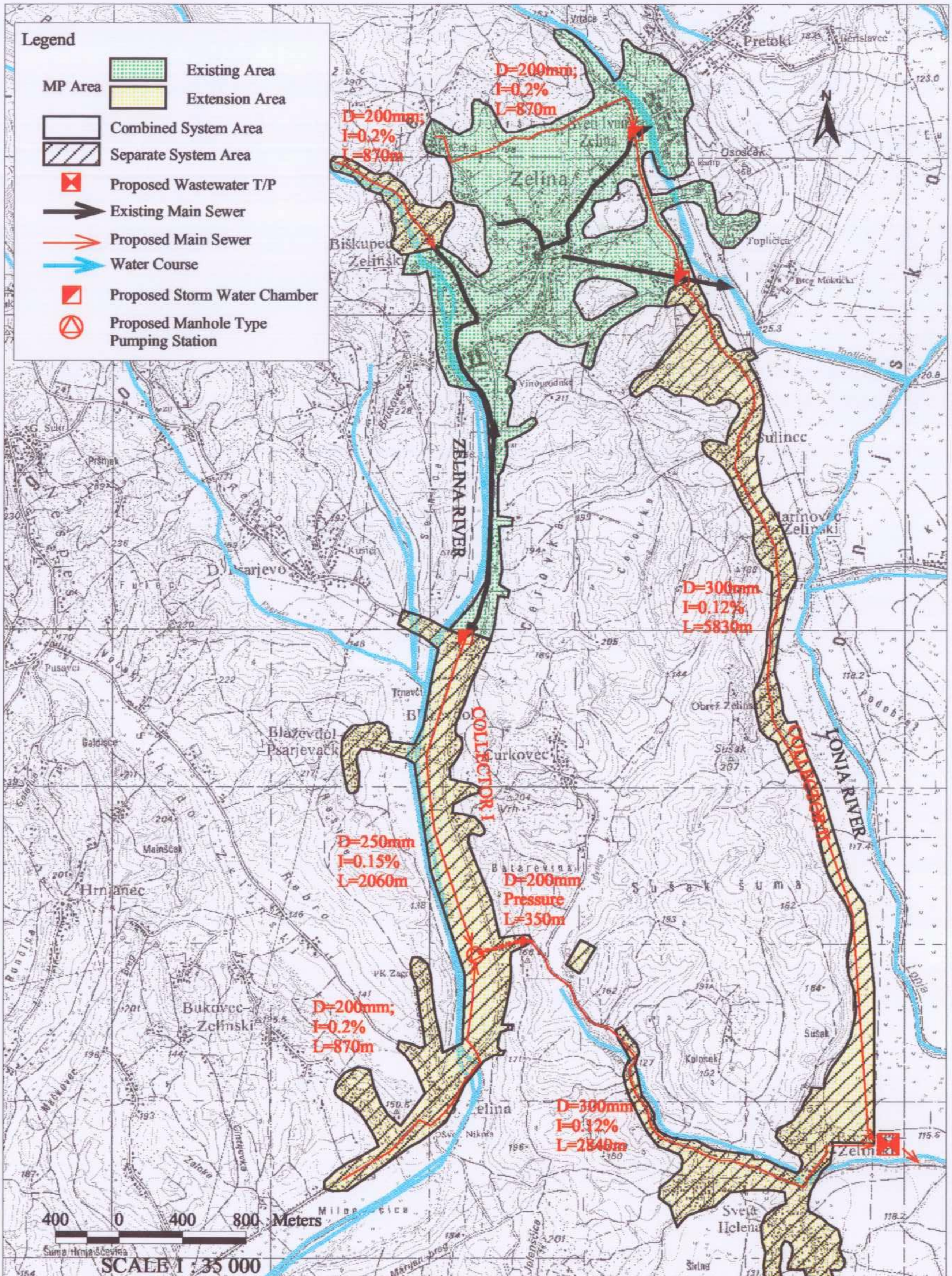
THE STUDY FOR WATER POLLUTION REDUCTION
ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

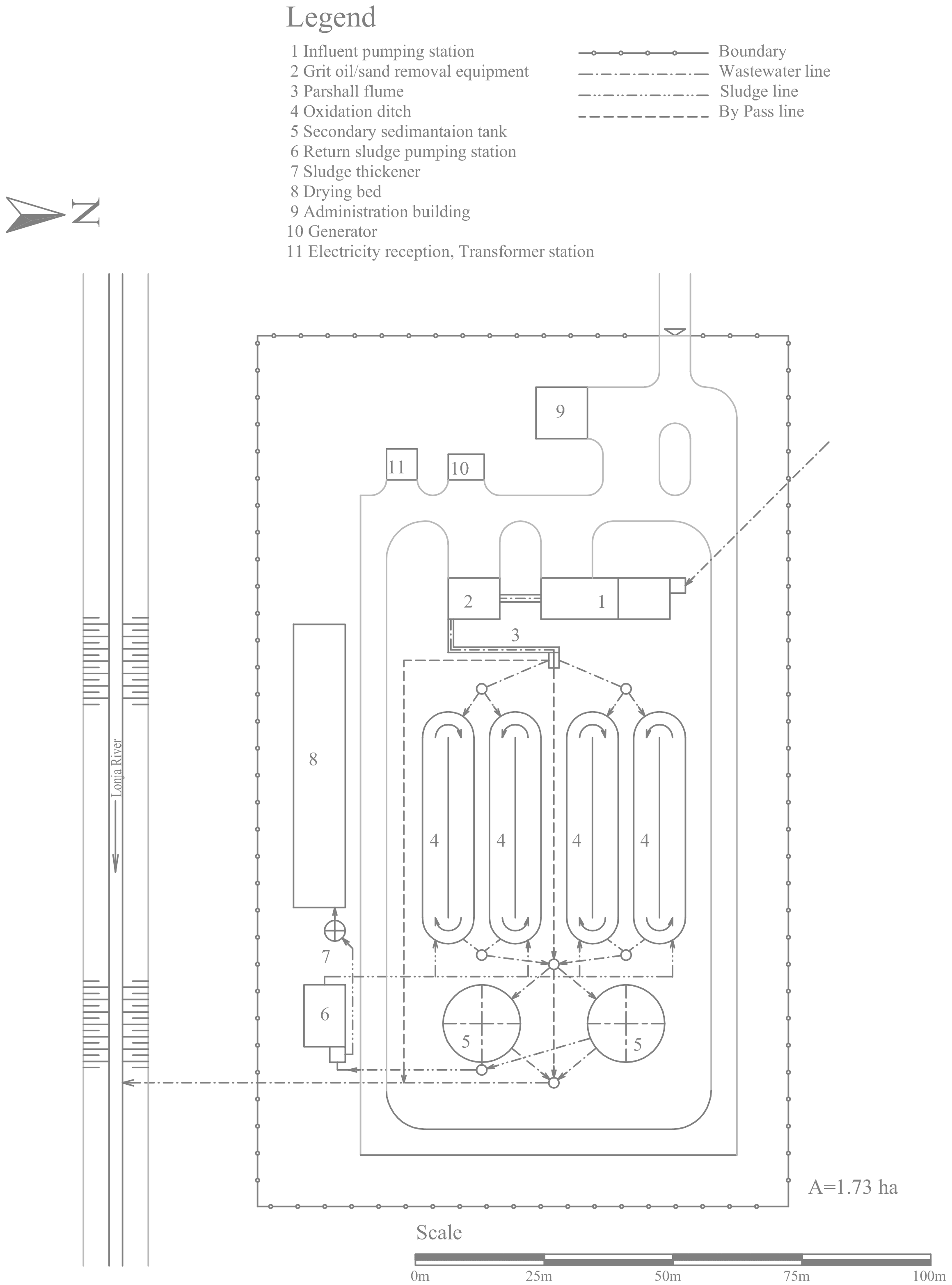
Fig- D.8.2
Alternatives of Collectors in Karlovac and Duga Resa



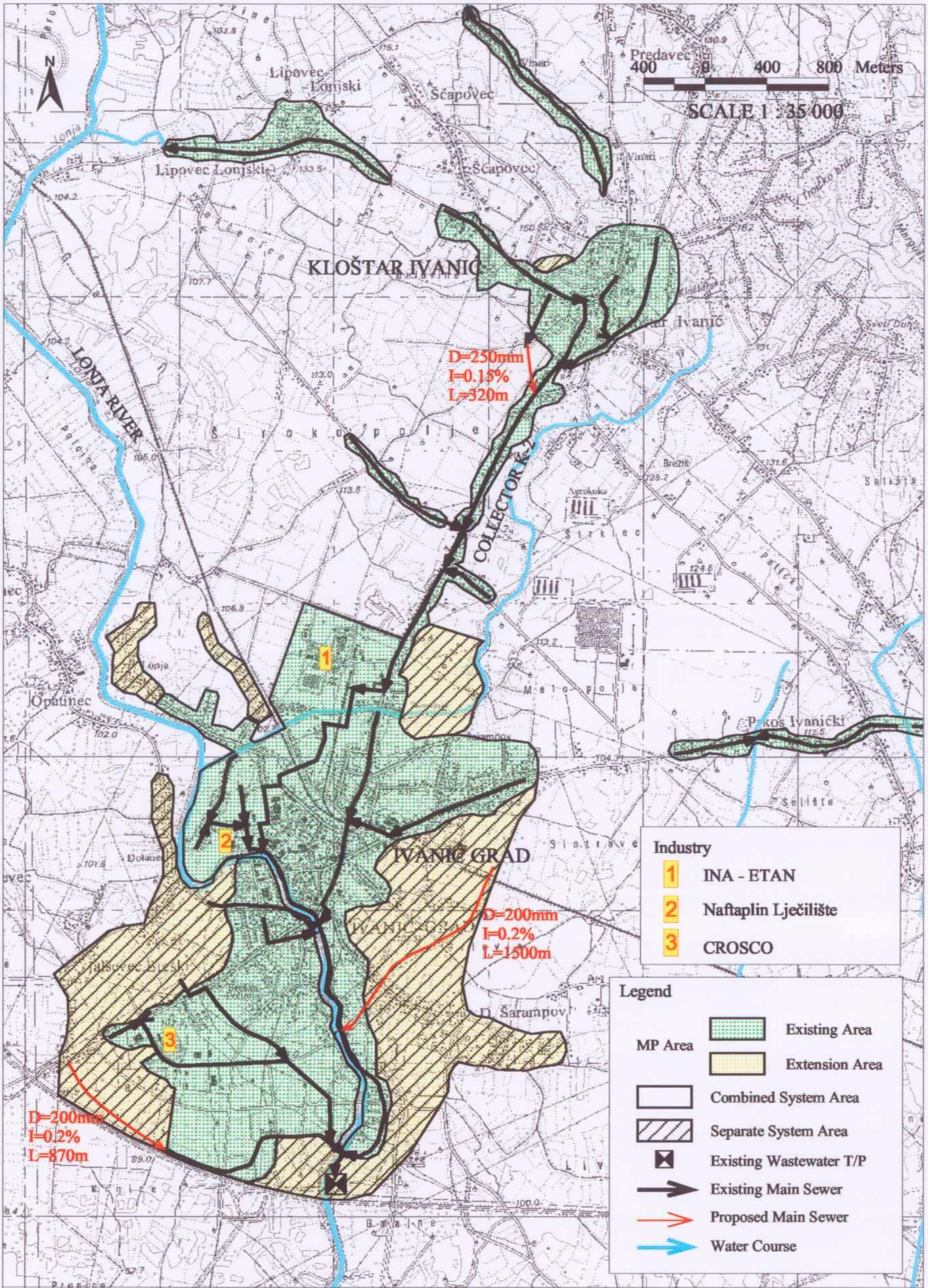
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.8.3 Layout of Wastewater Treatment Plant in Karlovac - Duga Resa
JAPAN INTERNATIONAL COOPERATION AGENCY	



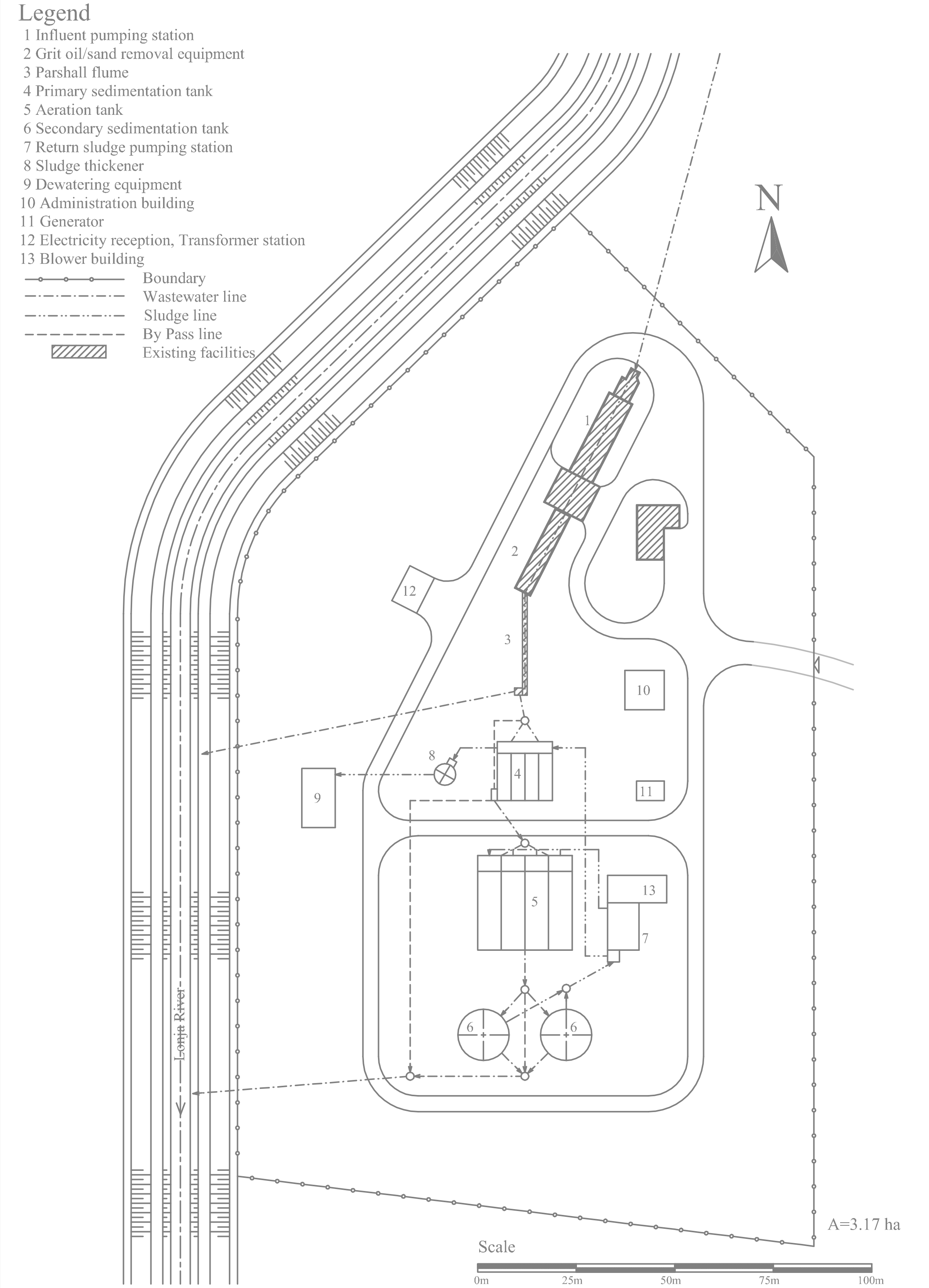
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.1 Sewerage Development System in Sveti Ivan Zelina
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.9.2 Layout of Wastewater Treatment Plant in Sveti Ivan Zelina
JAPAN INTERNATIONAL COOPERATION AGENCY	



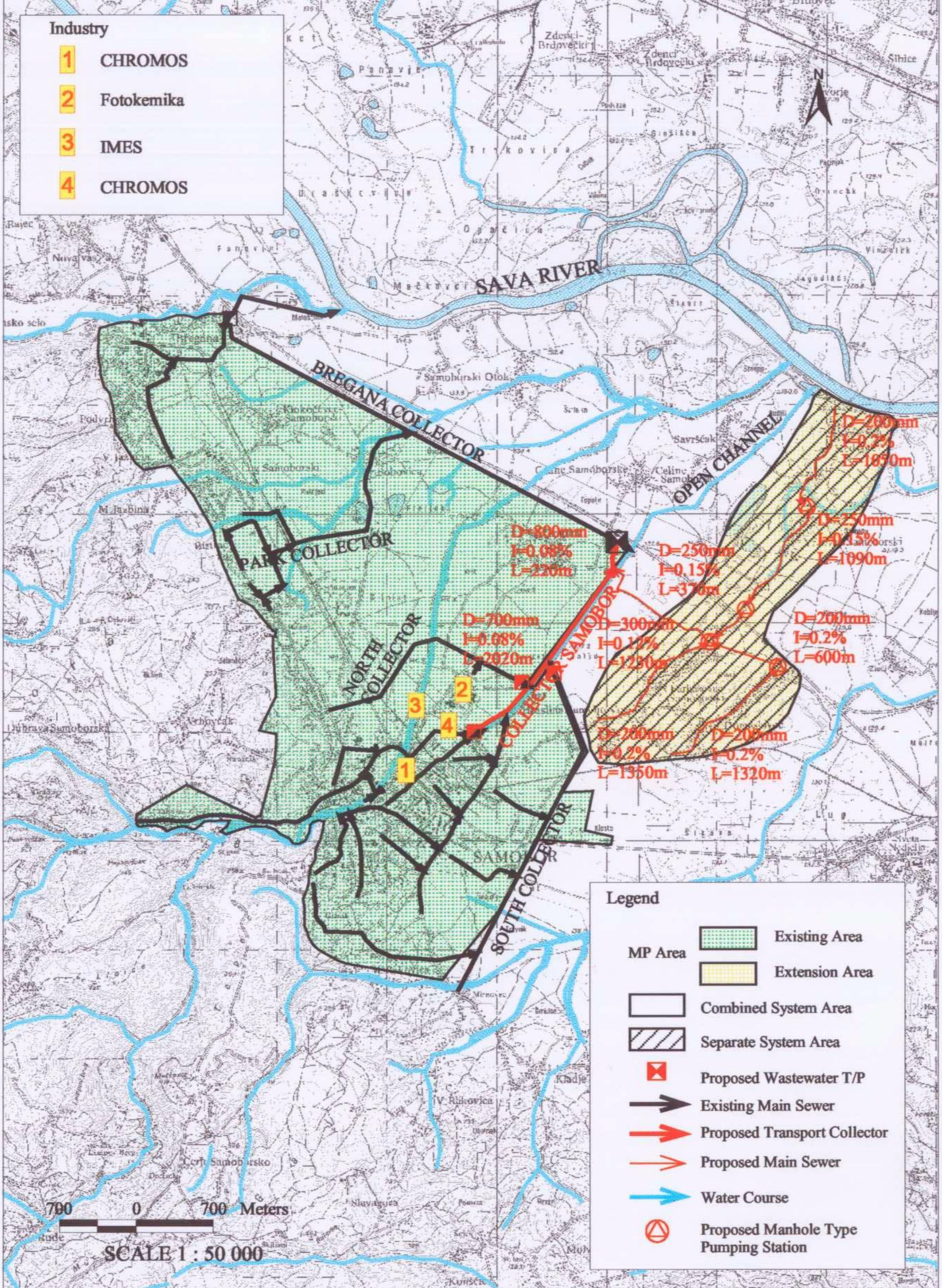
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.3 Sewerage Development System in Ivanić Grad and Kloštar Ivanić
JAPAN INTERNATIONAL COOPERATION AGENCY	



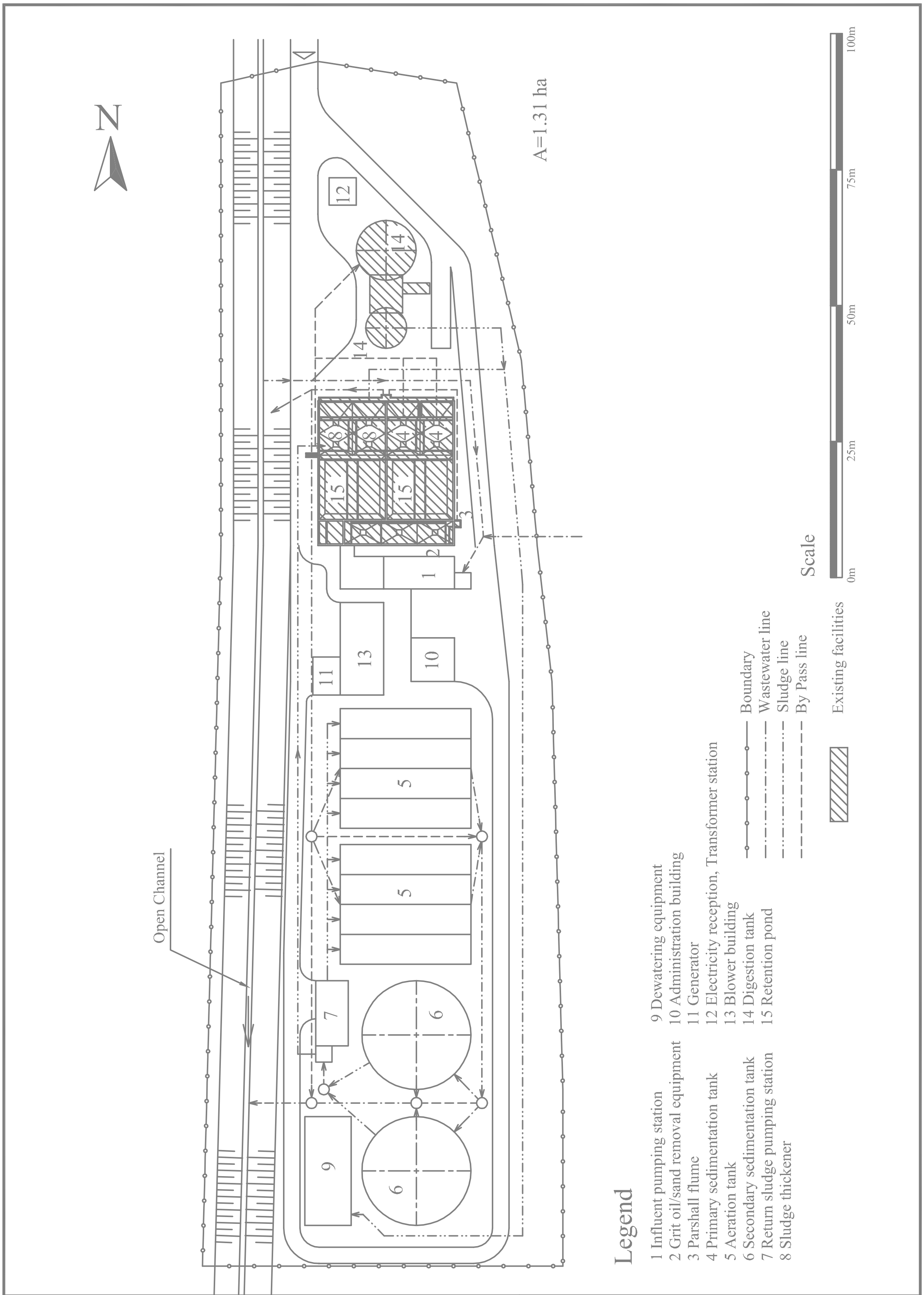
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

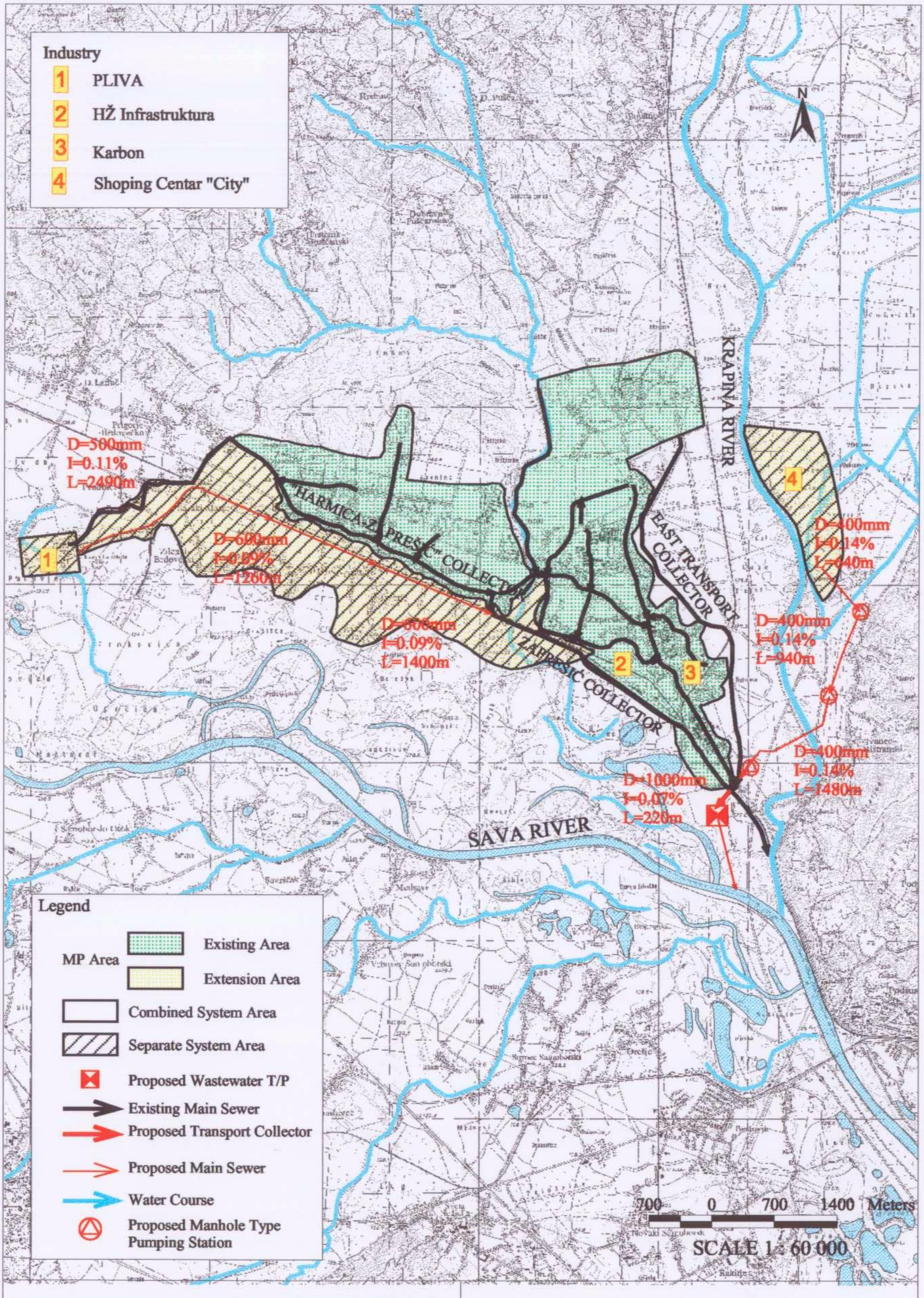
Fig.D.9.4
Layout of Wastewater Treatment Plant in Ivanic Grad and Klostar Ivanic



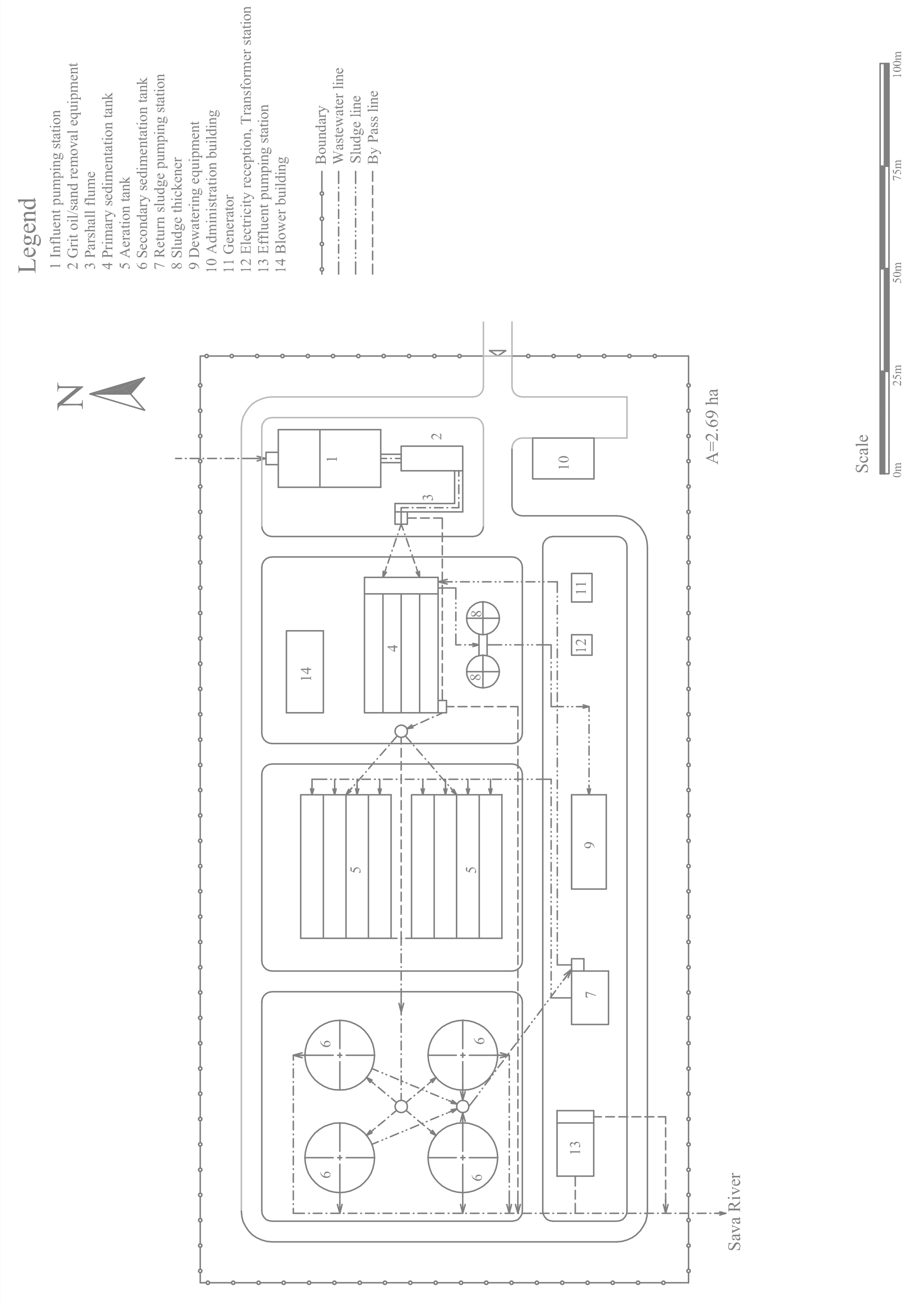
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.5 Sewerage Development System in Samobor
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.9.6 Layout of Wastewater Treatment Plant in Samobor
JAPAN INTERNATIONAL COOPERATION AGENCY	



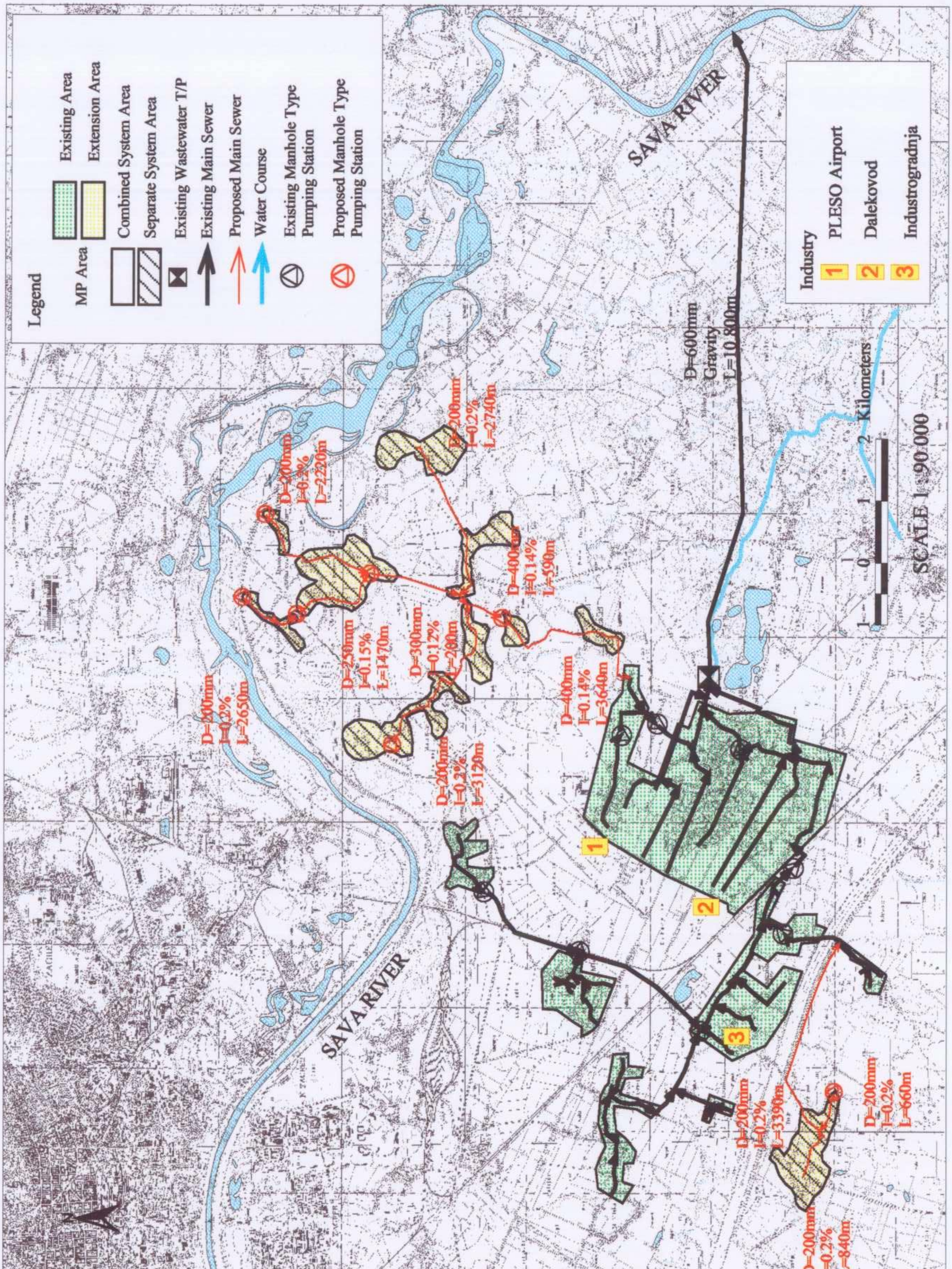
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.7 Sewerage Development System in Zaprešić
JAPAN INTERNATIONAL COOPERATION AGENCY	



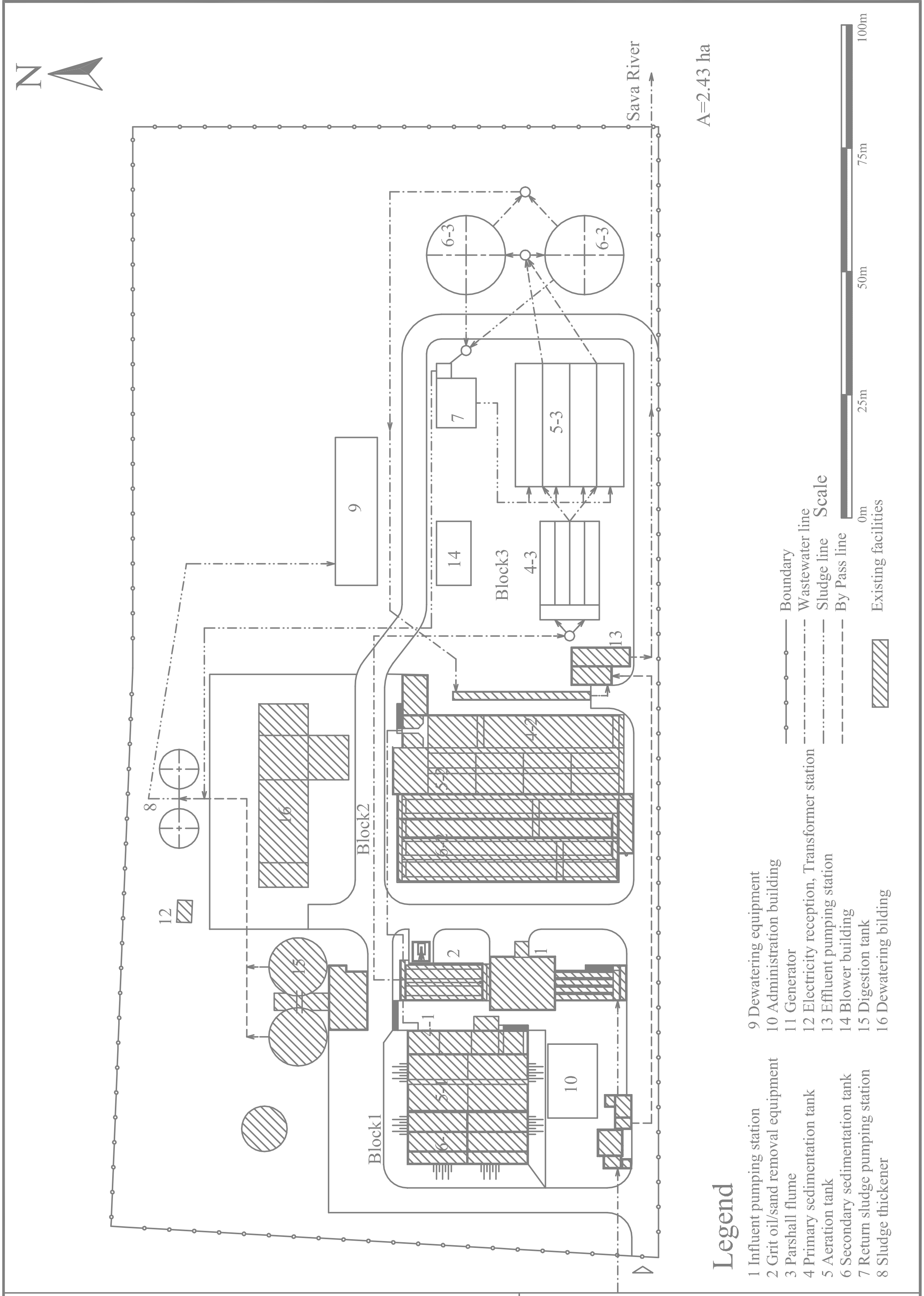
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

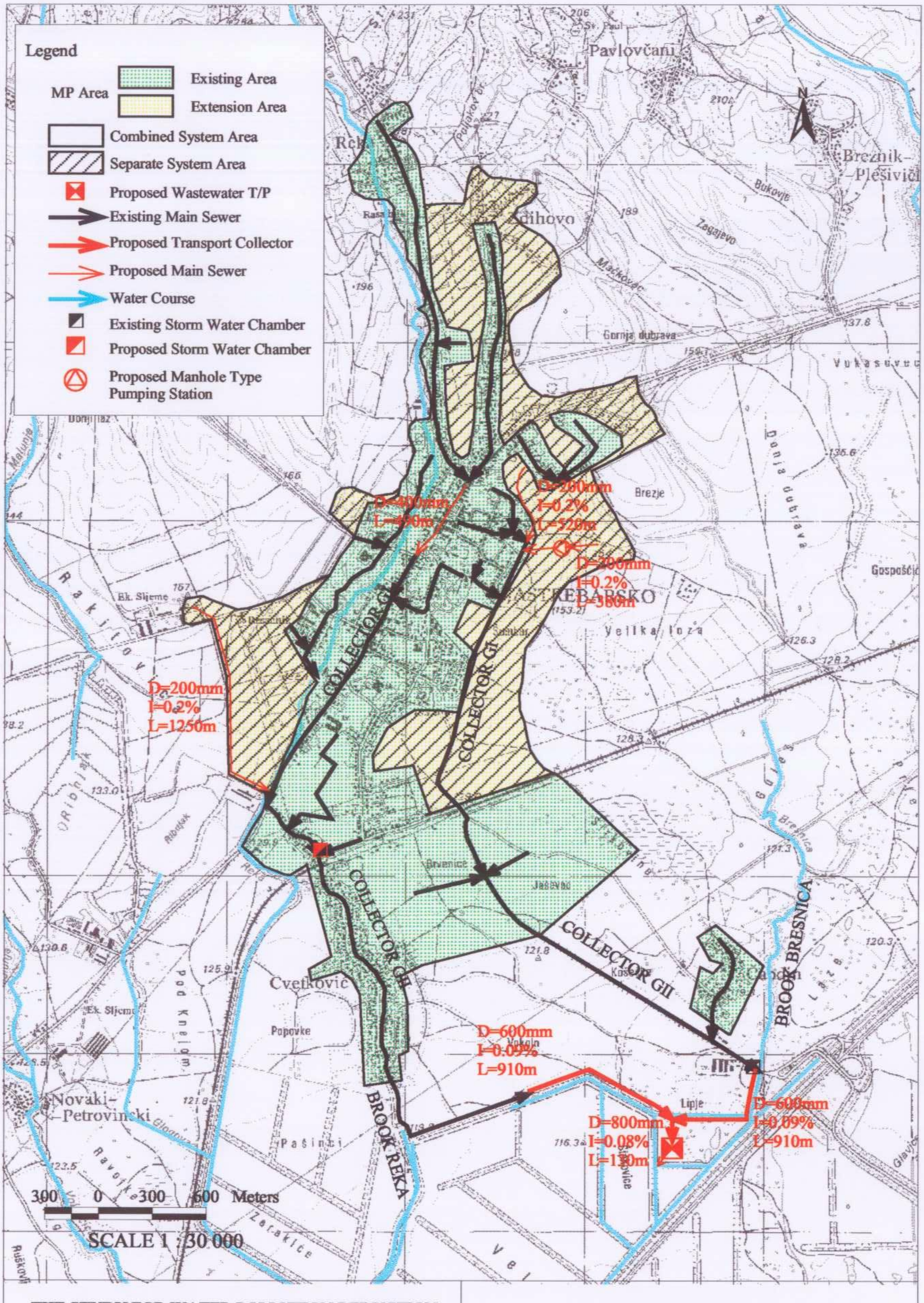
Fig.D.9.8
Layout of Wastewater Treatment Plant in Zapresic



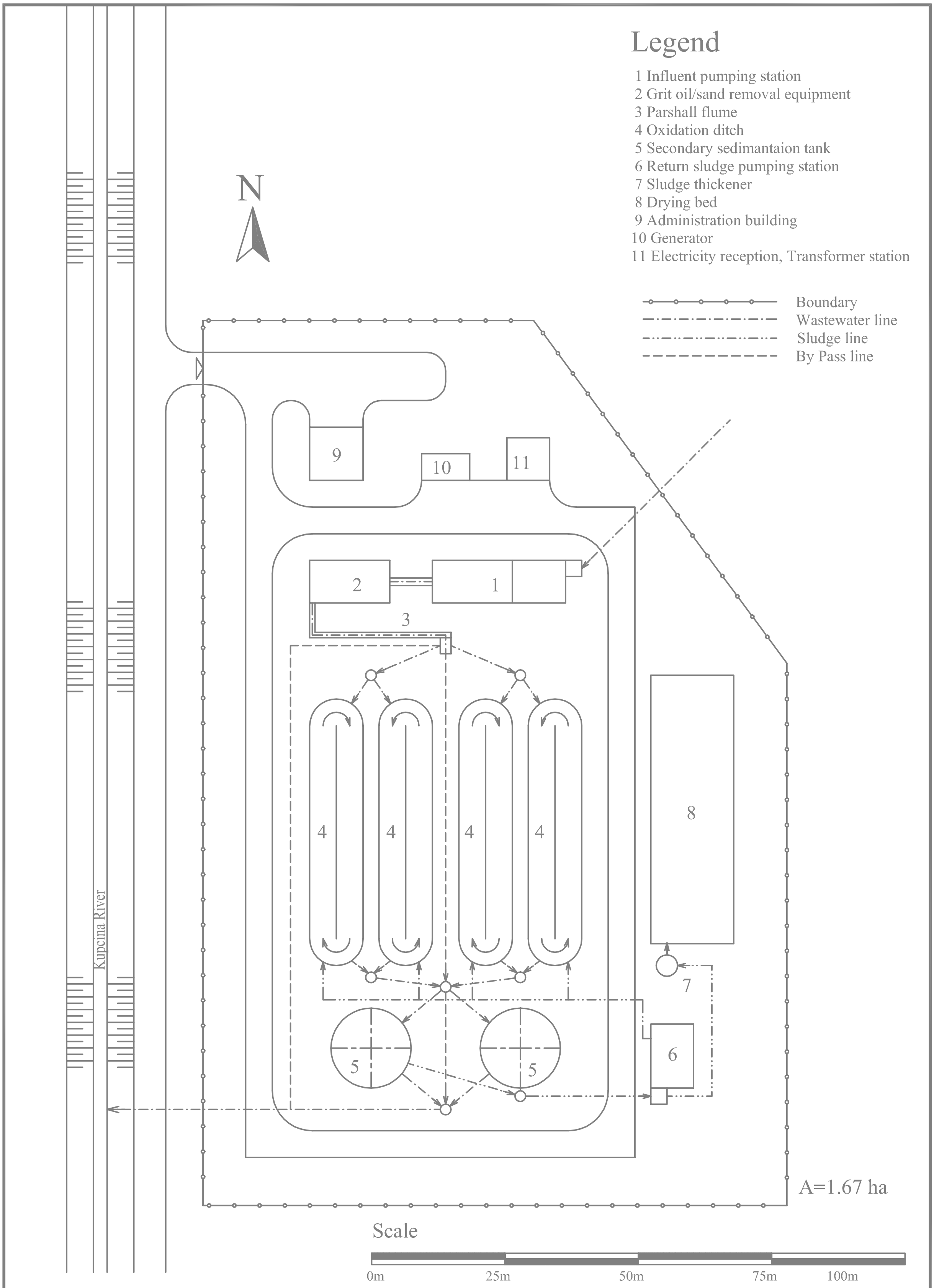
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.9 Sewerage Development System in Velika Gorica
JAPAN INTERNATIONAL COOPERATION AGENCY	



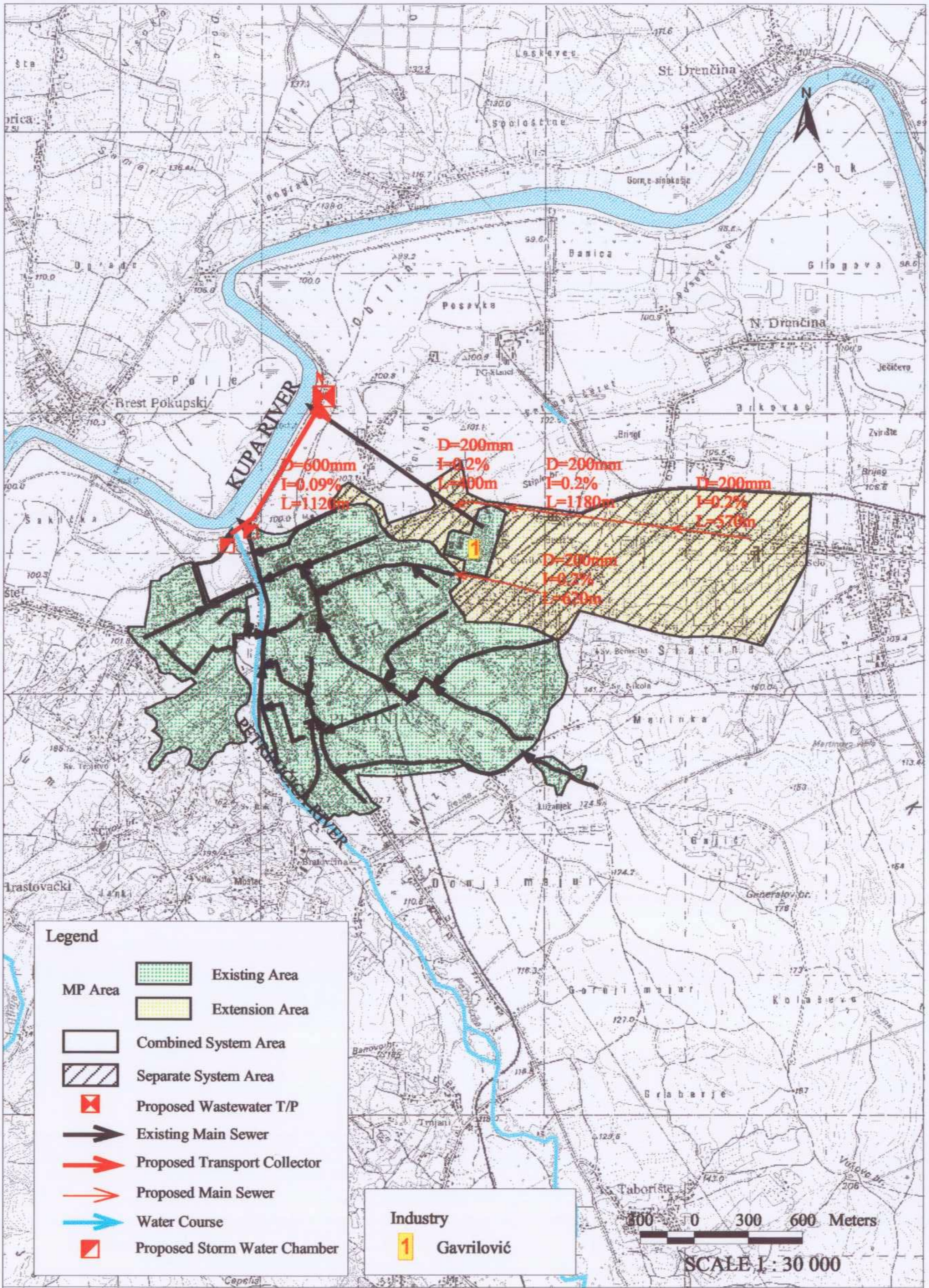
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.9.10 Layout of Wastewater Treatment Plant in Velika Gorica
JAPAN INTERNATIONAL COOPERATION AGENCY	



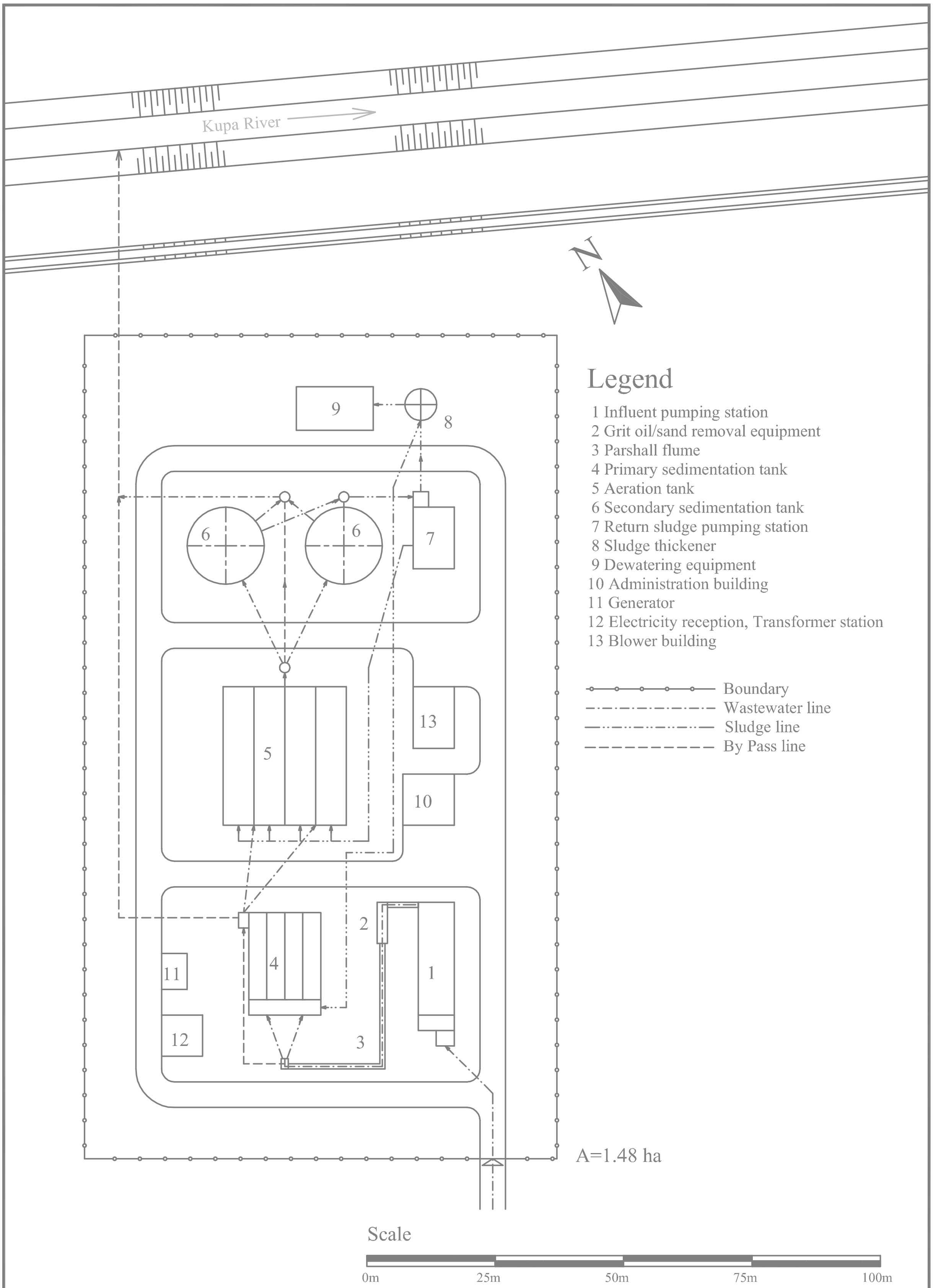
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.11 Sewerage Development System in Jastrebarsko
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.9.12 Layout of Wastewater Treatment Plant in Jastrebarsko
JAPAN INTERNATIONAL COOPERATION AGENCY	



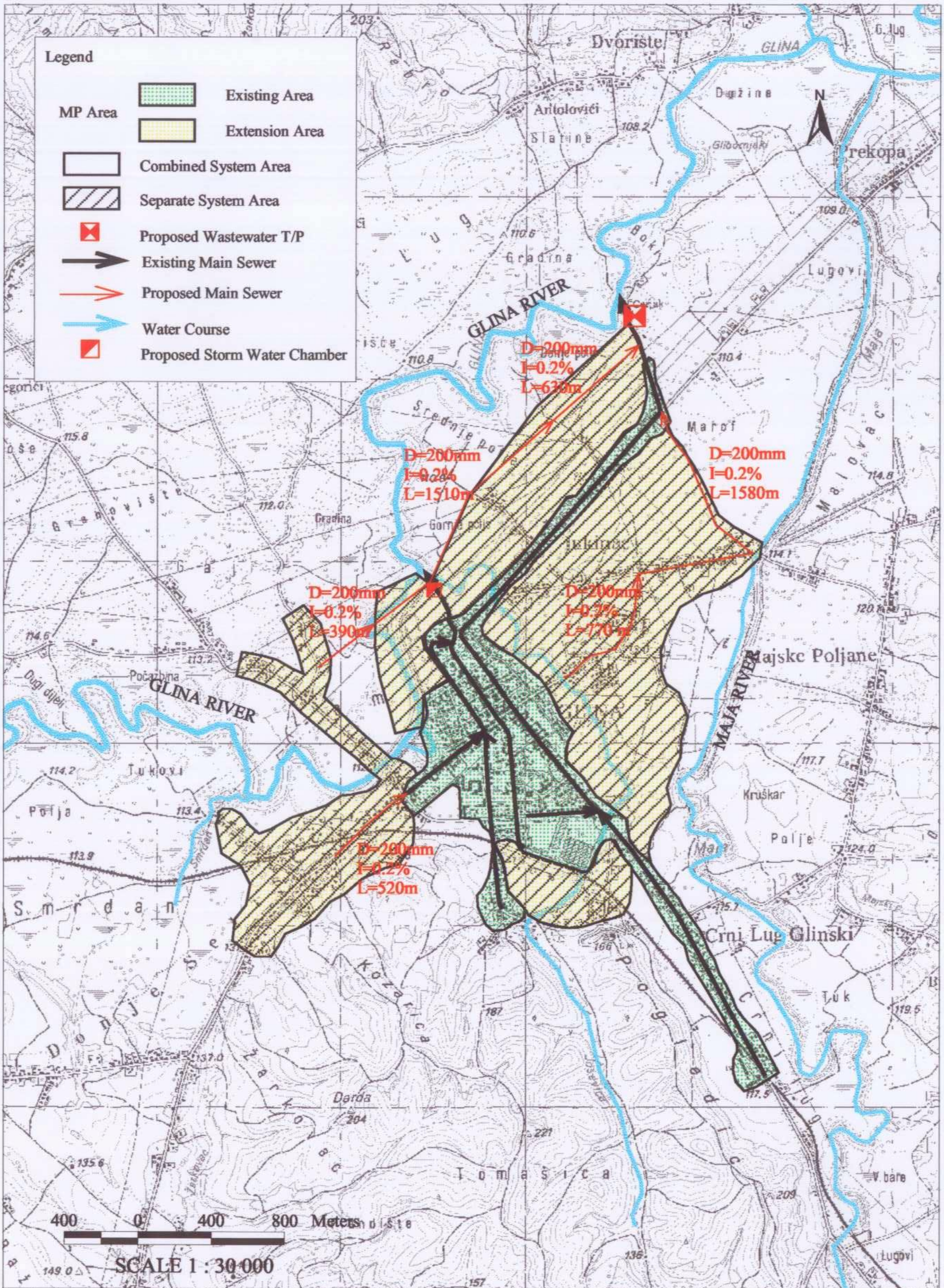
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.13 Sewerage Development System in Petrinja
JAPAN INTERNATIONAL COOPERATION AGENCY	



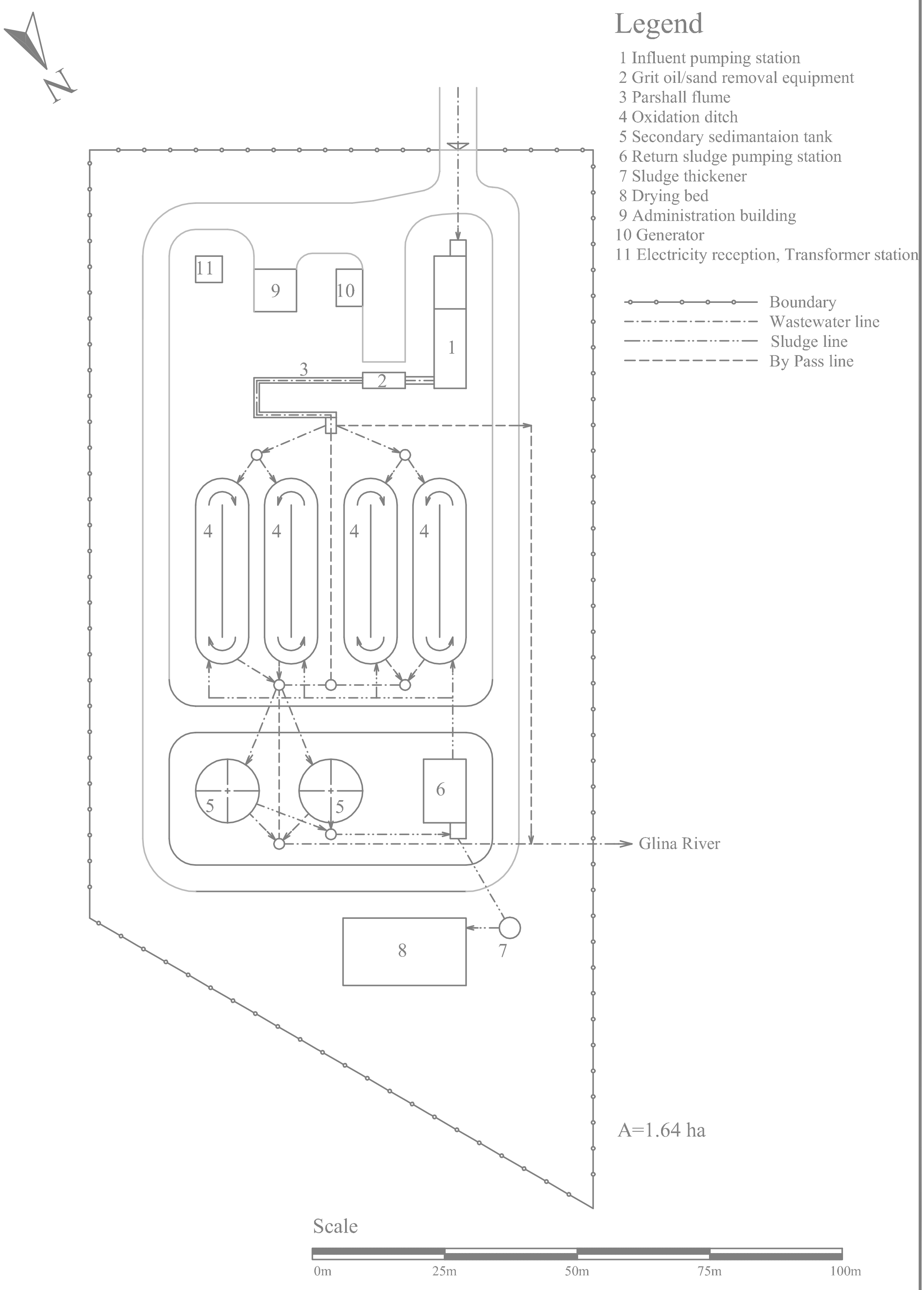
THE STUDY FOR WATER POLLUTION REDUCTION
ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.D.9.14
Layout of Wastewater Treatment Plant
in Petrinja



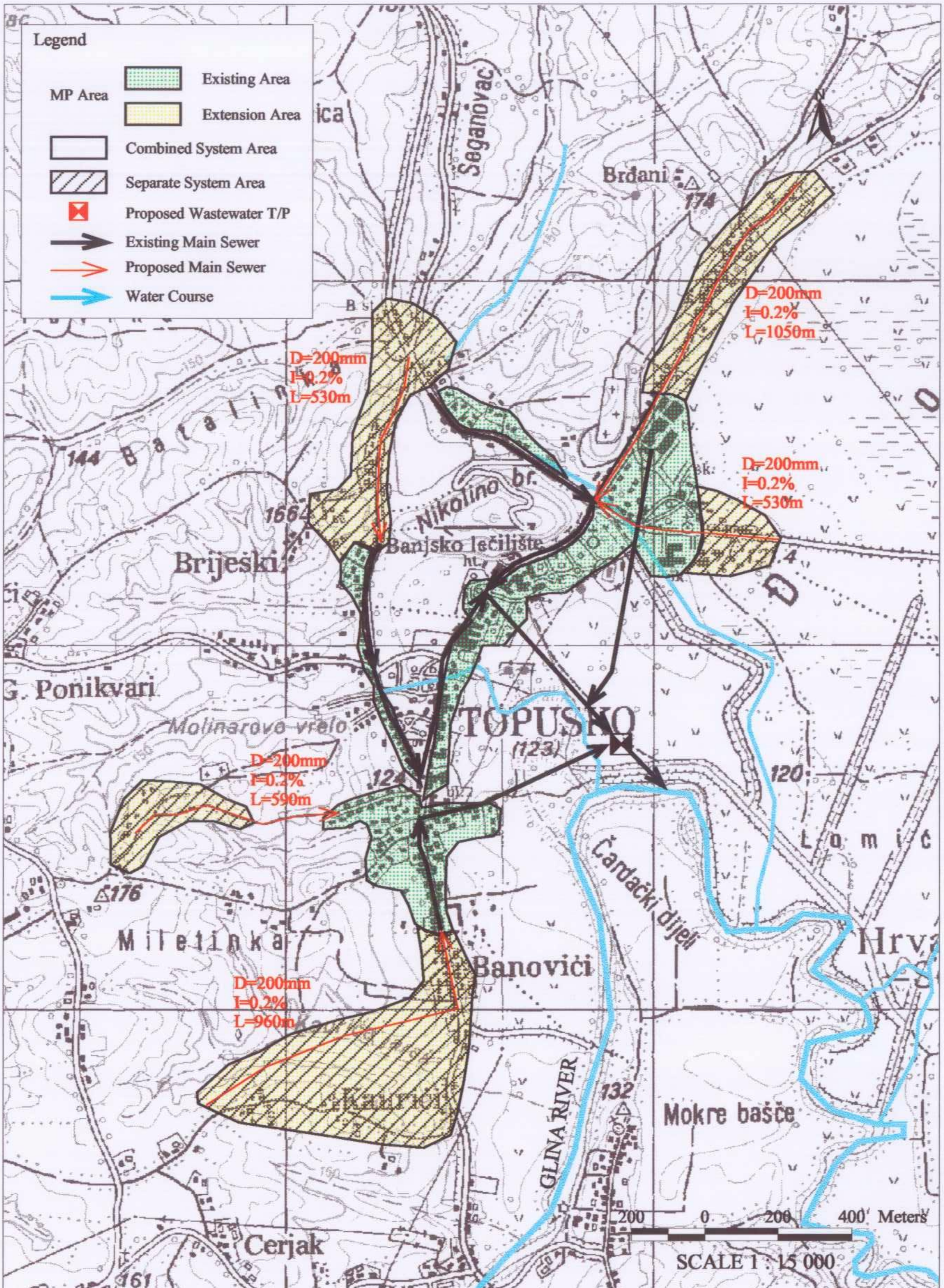
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.15 Sewerage Development System in Glina
JAPAN INTERNATIONAL COOPERATION AGENCY	



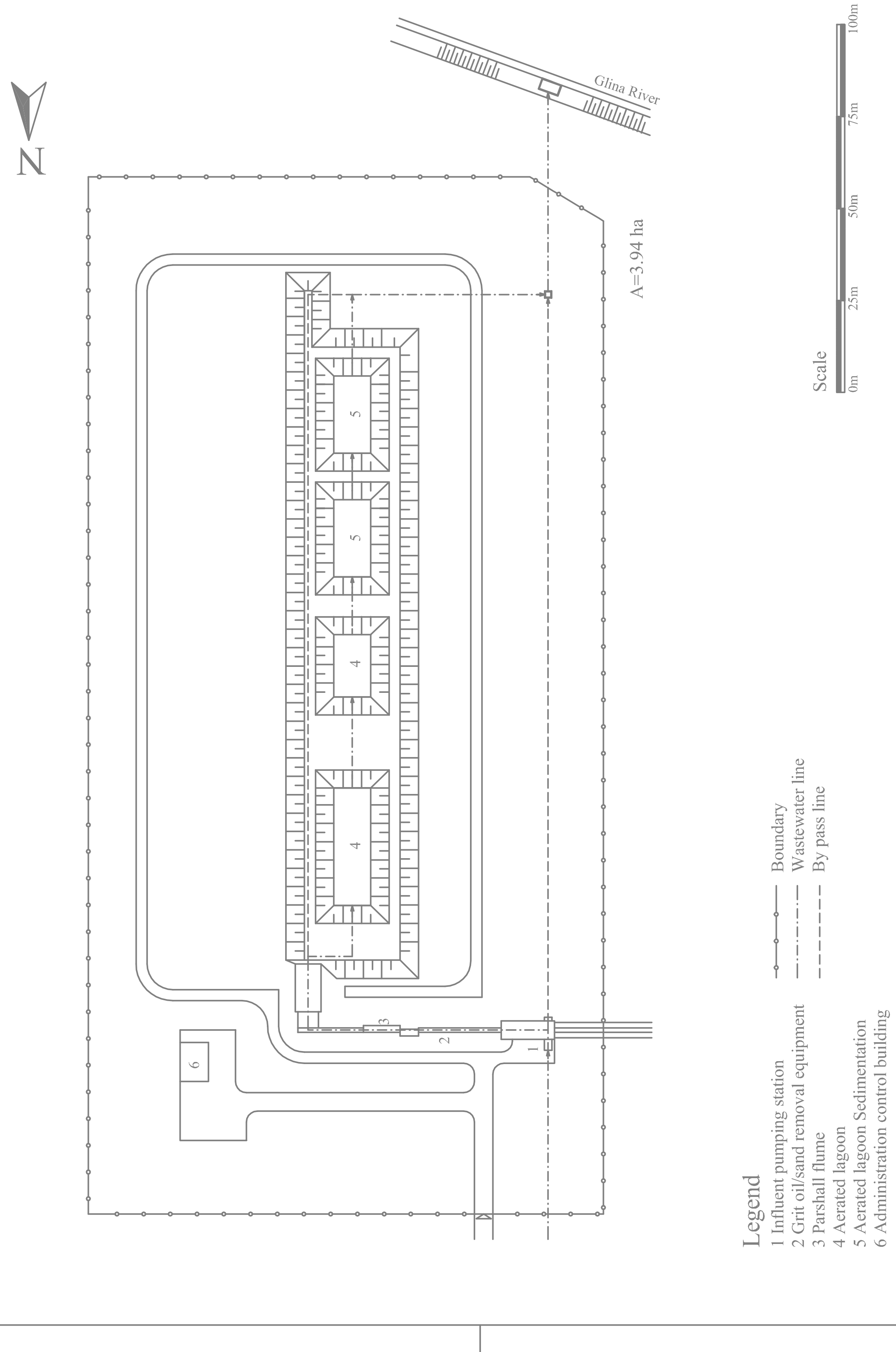
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.D.9.16
Layout of Wastewater Treatment Plant in Glina



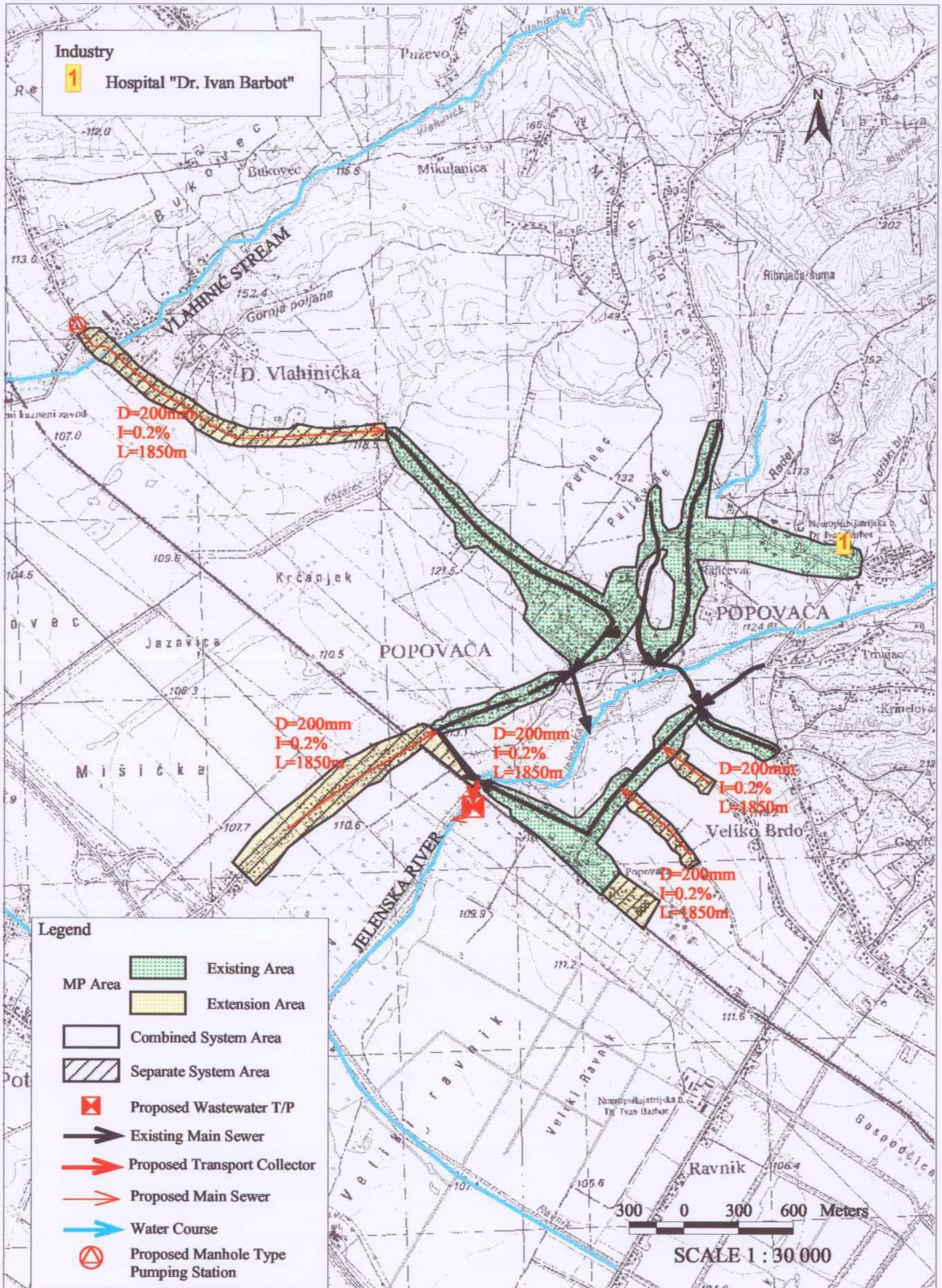
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.17 Sewerage Development System in Topusko
JAPAN INTERNATIONAL COOPERATION AGENCY	



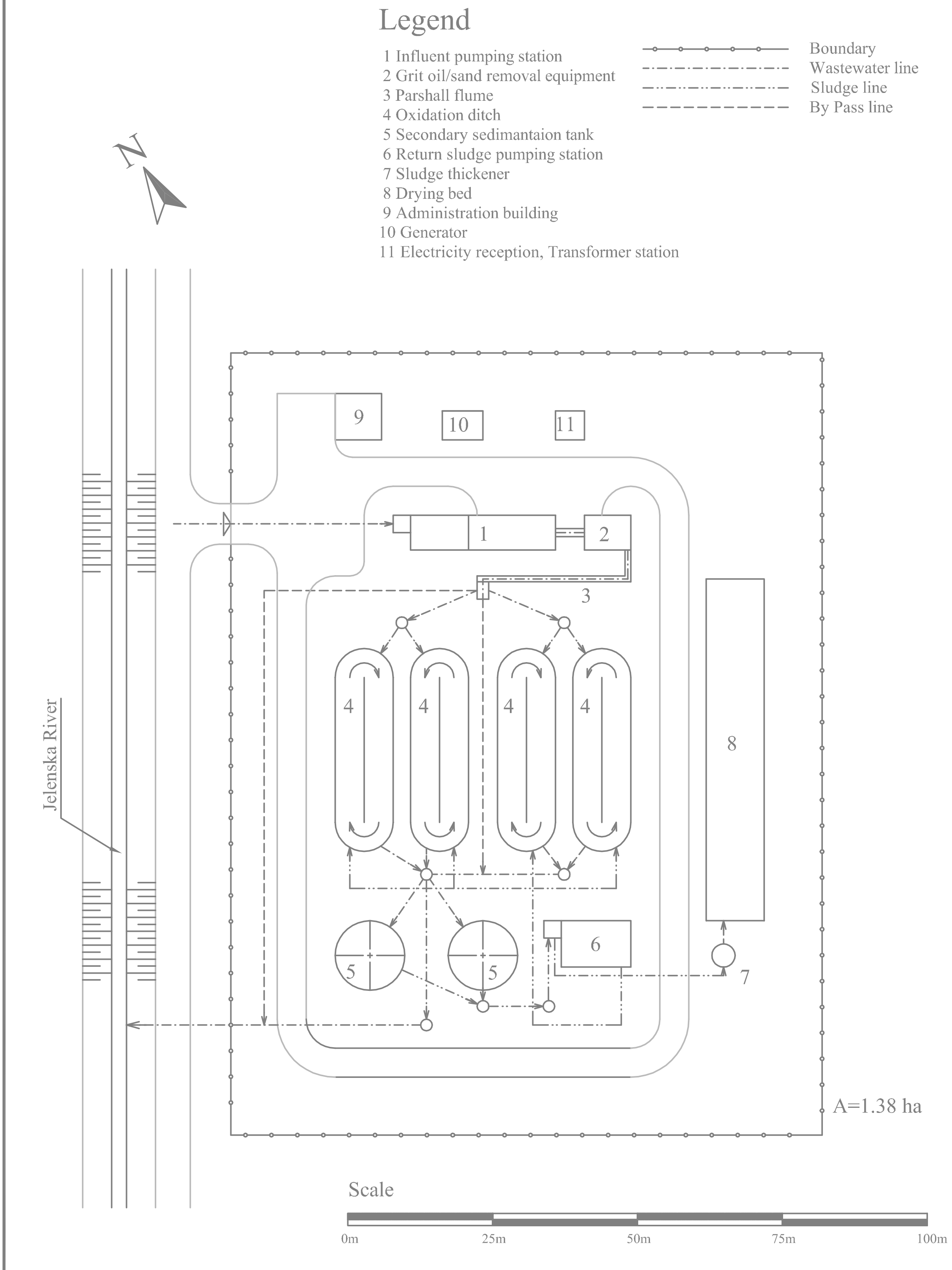
THE STUDY FOR WATER POLLUTION REDUCTION
ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.D.9.18
Layout of Wastewater Treatment Plant
in Topusko



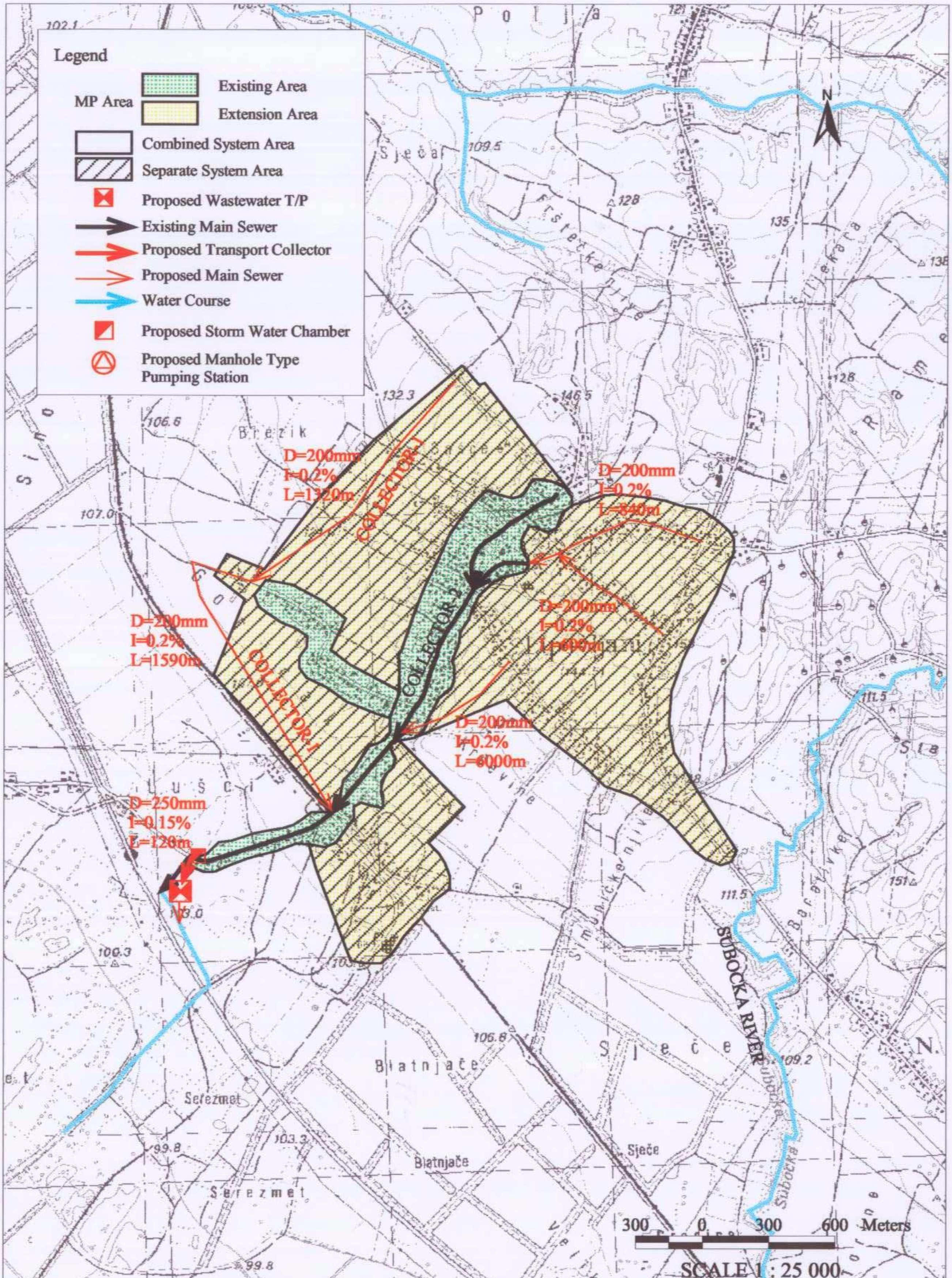
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.19 Sewerage Development System in Popovača
JAPAN INTERNATIONAL COOPERATION AGENCY	



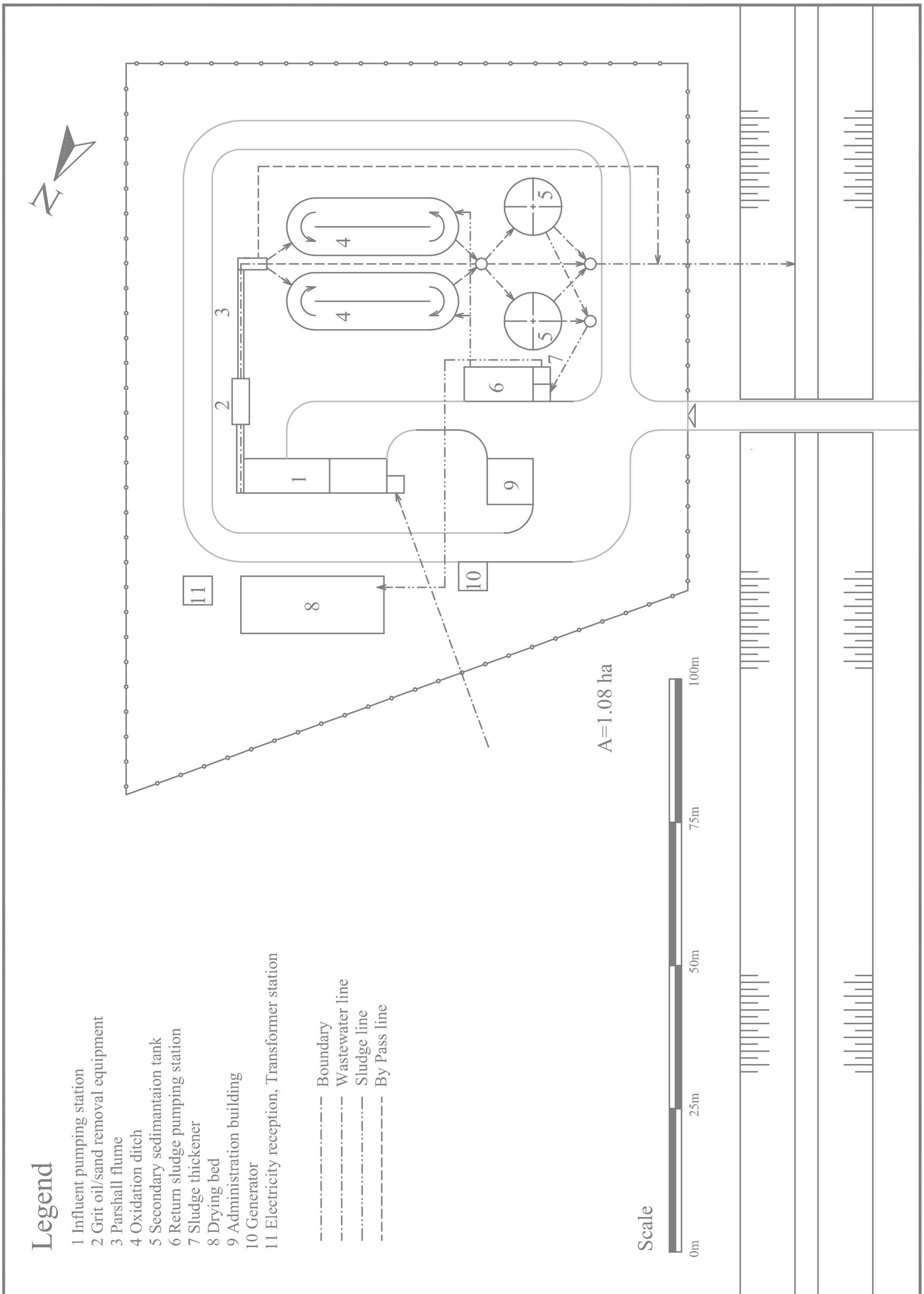
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

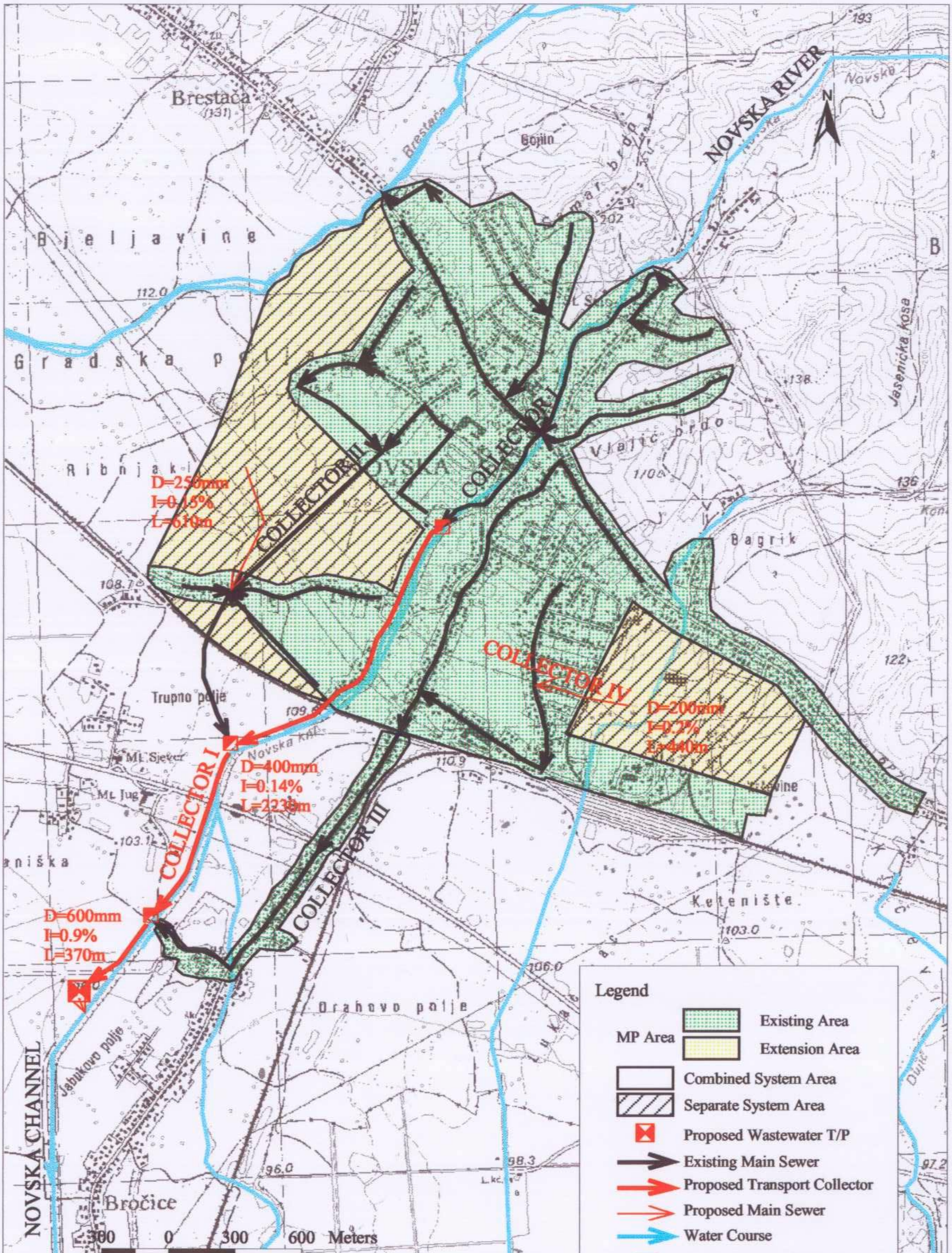
Fig.D.9.20
Layout of Wastewater Treatment Plant in Popovaca



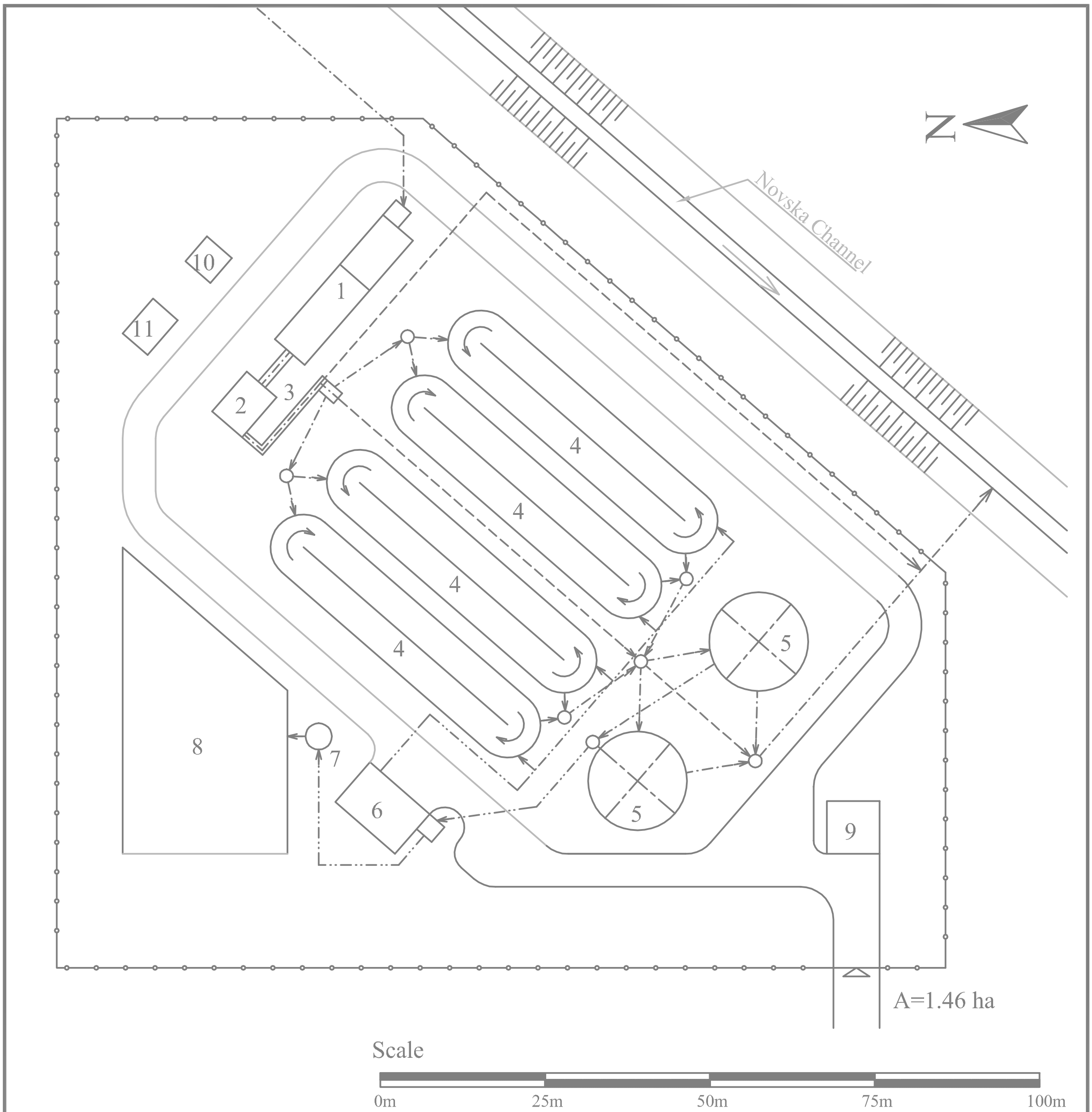
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.21 Sewerage Development System in Lipovljani
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.9.22 Layout of Wastewater Treatment Plant in Lipovljani
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.23 Sewerage Development System in Novska
JAPAN INTERNATIONAL COOPERATION AGENCY	



Legend

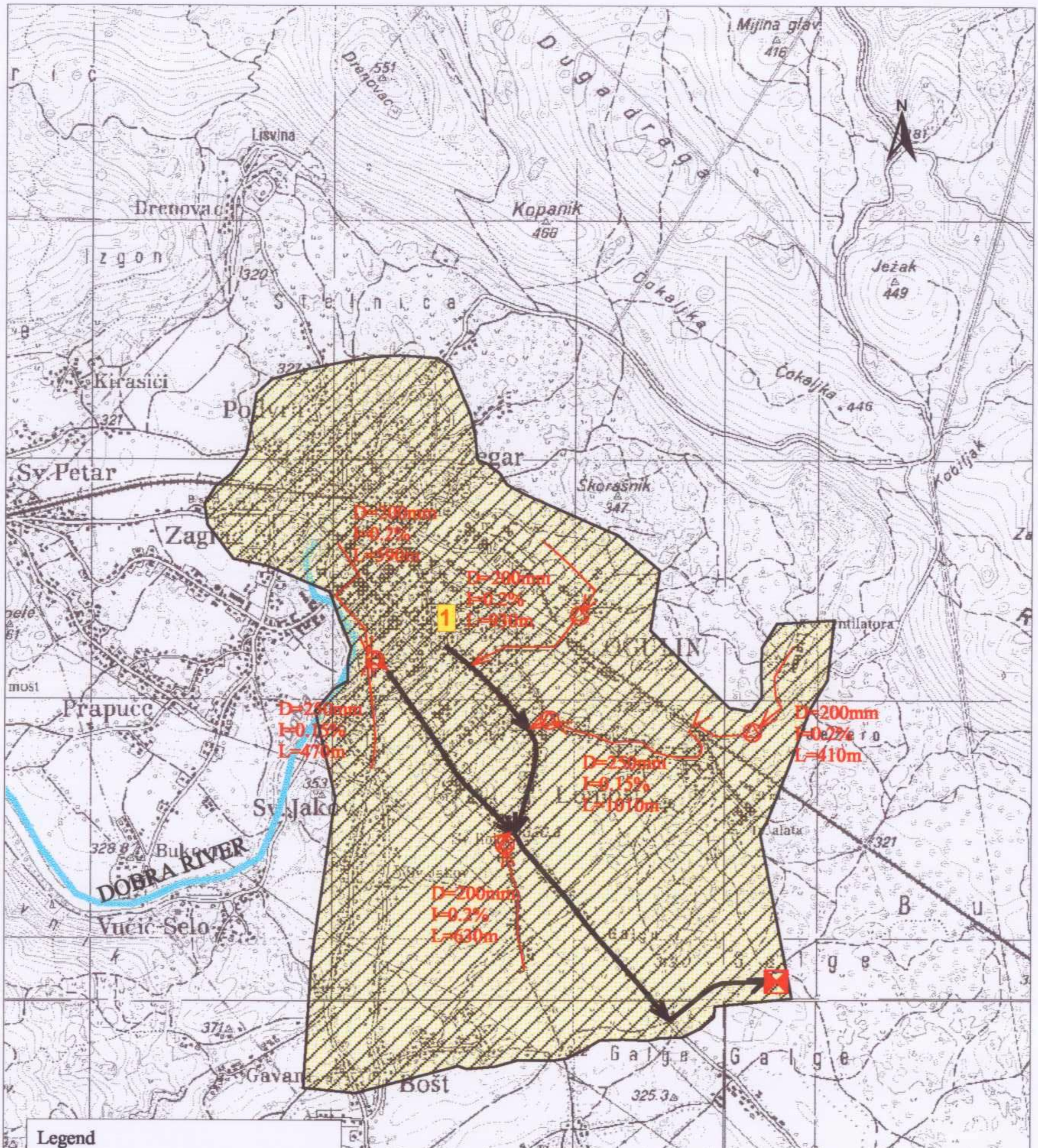
1 Influent pumping station
2 Grit oil/sand removal equipment
3 Parshall flume
4 Oxidation ditch
5 Secondary sedimantaion tank
6 Return sludge pumping station
7 Sludge thickener
8 Drying bed
9 Administration building
10 Generator
11 Electricity reception, Transformer station

Boundary
Wastewater line
Sludge line
By Pass line

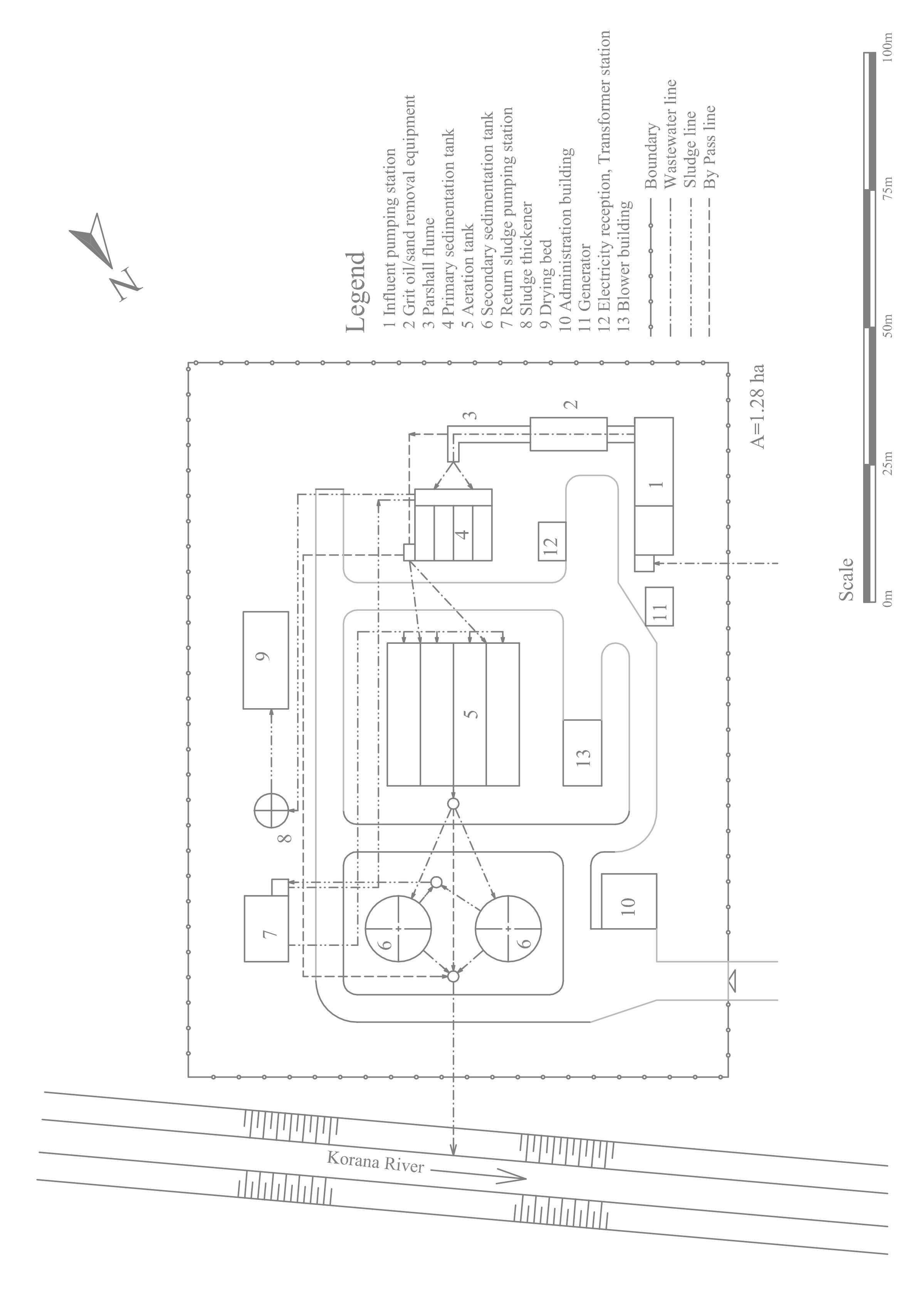
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

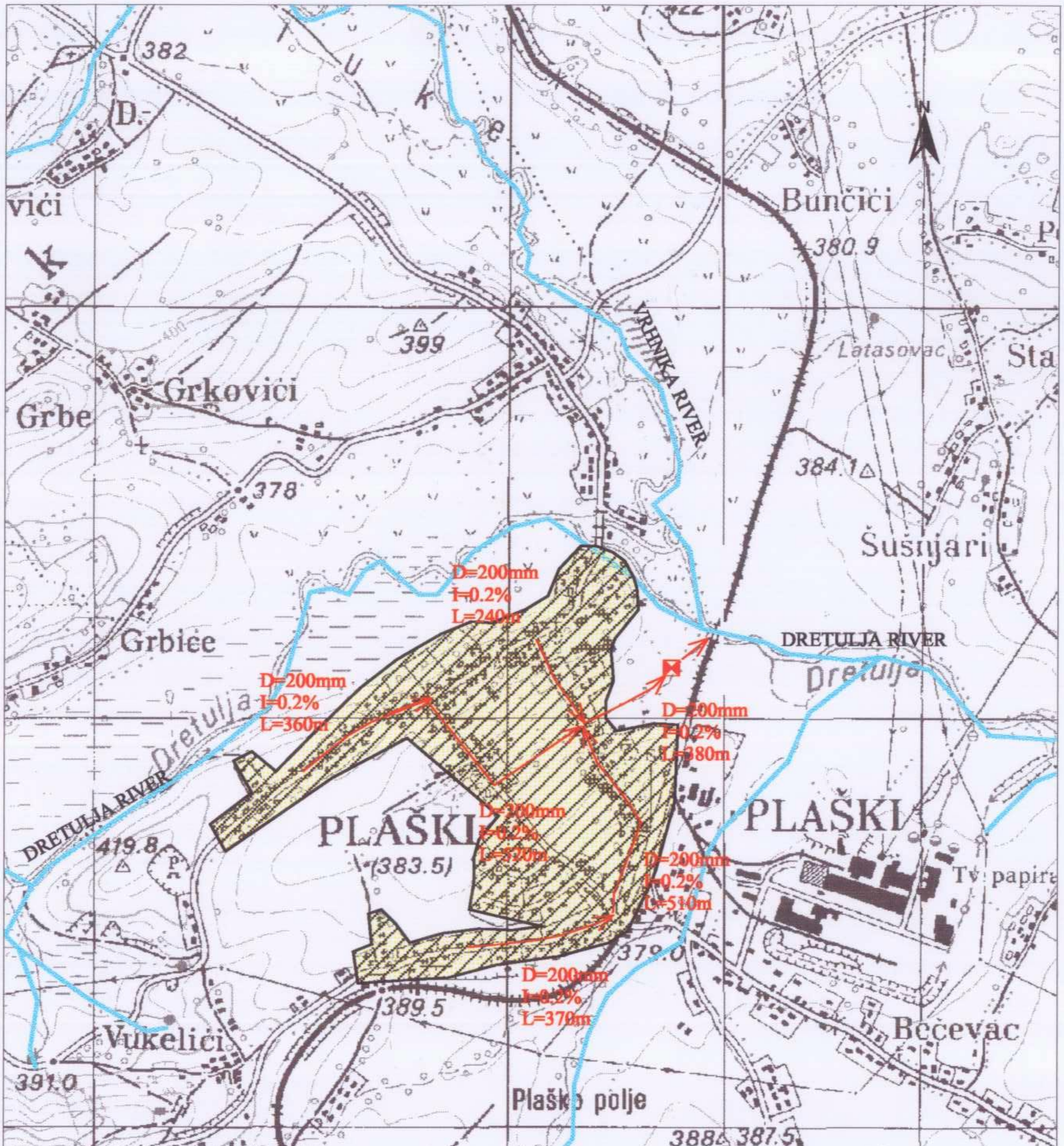
Fig.D.9.24
Layout of Wastewater Treatment Plant in Novska



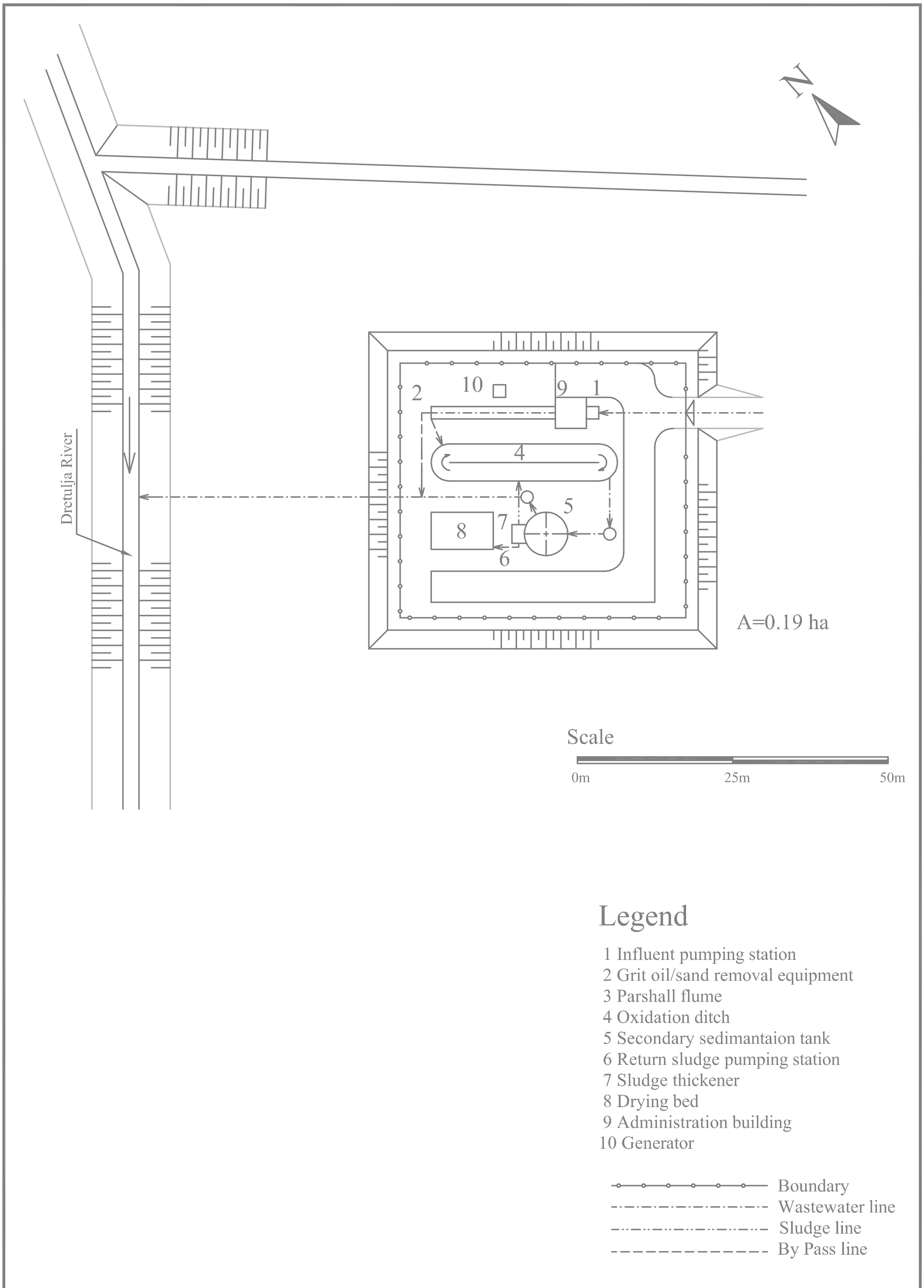
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.25 Sewerage Development System in Ogulin
JAPAN INTERNATIONAL COOPERATION AGENCY	



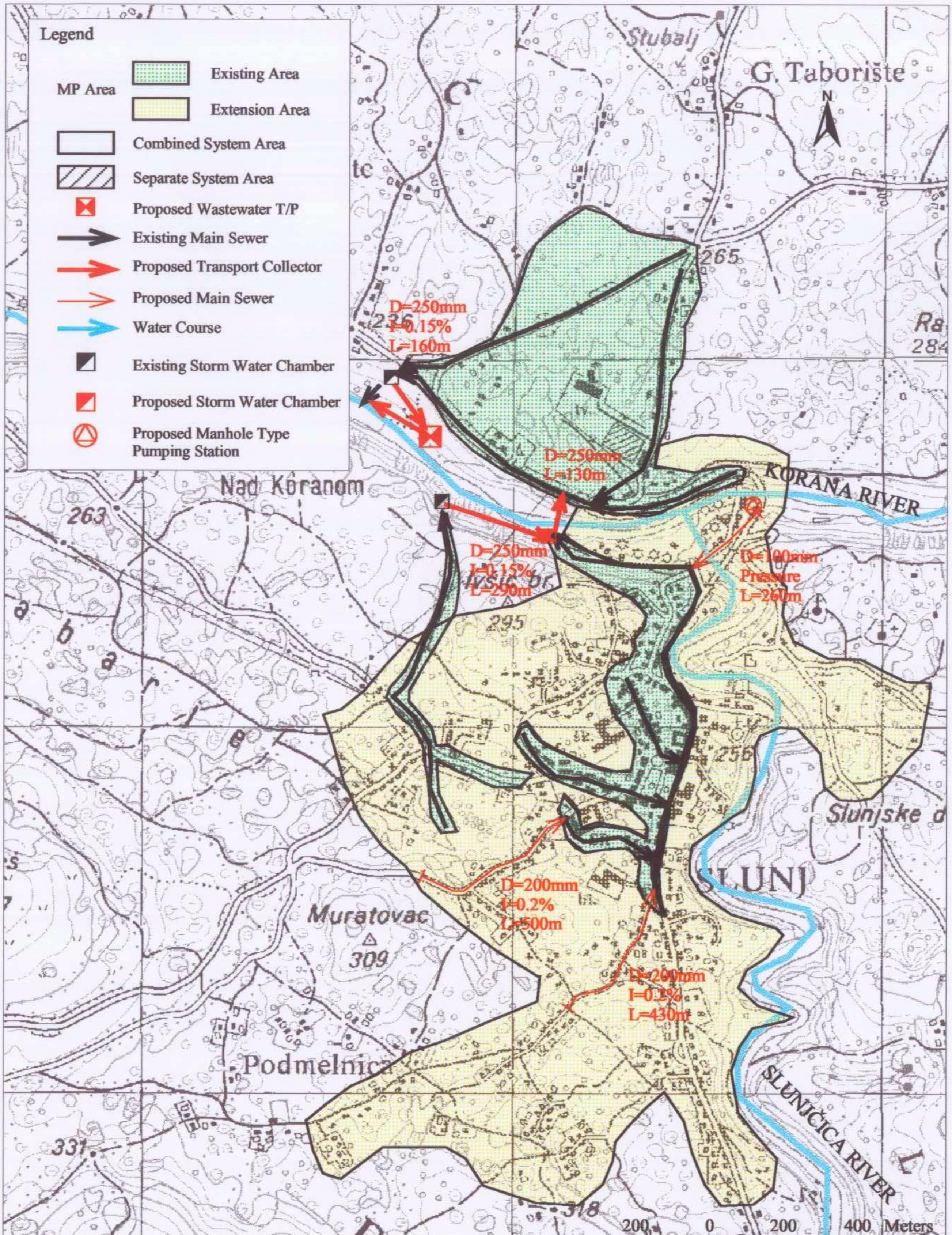
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.9.26 Layout of Wastewater Treatment Plant in Ogulin
JAPAN INTERNATIONAL COOPERATION AGENCY	



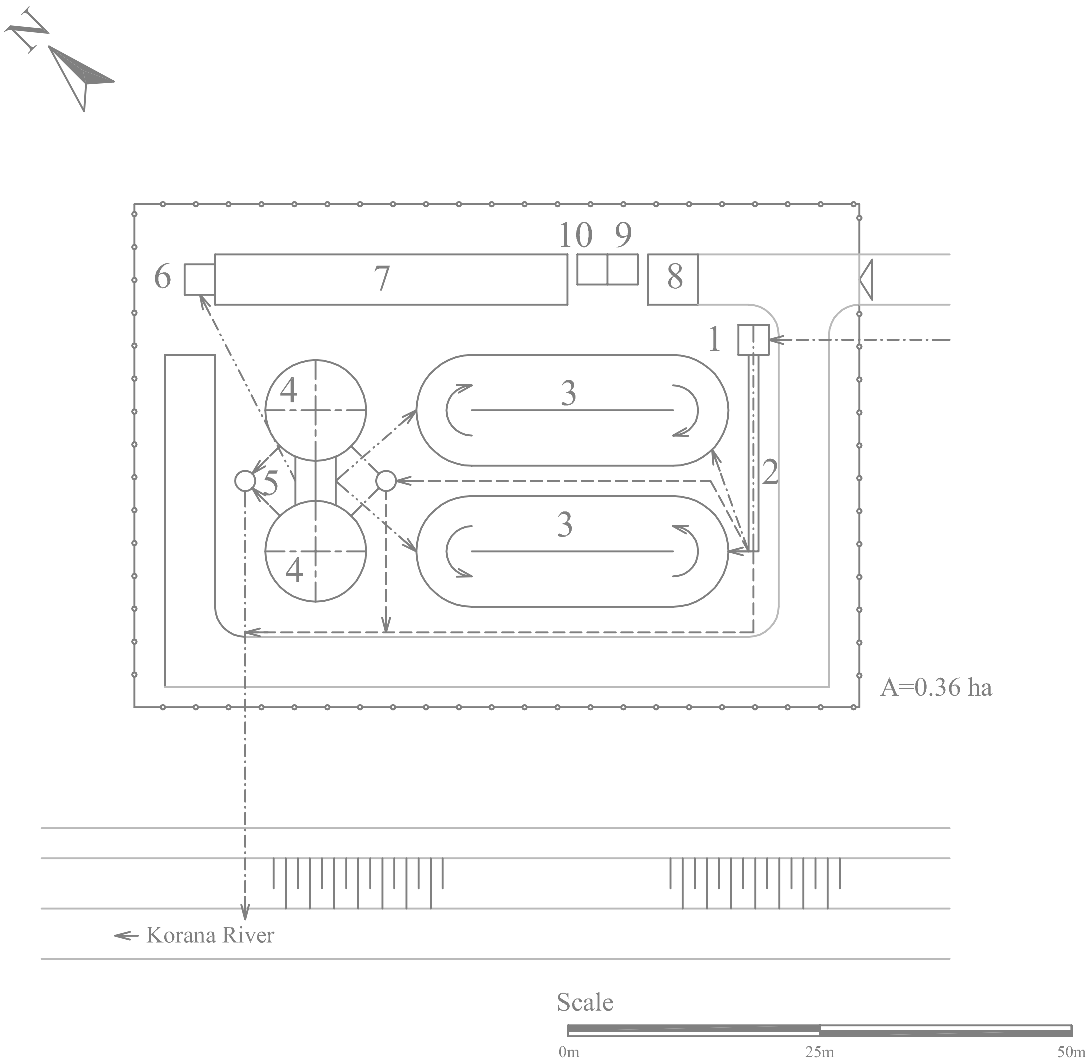
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.27 Sewerage Development System in Plaški
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.D.9.28 Layout of Wastewater Treatment Plant in Plaski
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig. D.9.29 Sewerage Development System in Slunj
JAPAN INTERNATIONAL COOPERATION AGENCY	



Legend

1 Grit oil/sand removal equipment	—o—o—o—o—o—	Boundary
2 Parshall flume	—·—·—·—·—·—	Wastewater line
3 Oxidation ditch	—··—··—··—··—	Sludge line
4 Secondary sedimantaion tank	– – – – – – – –	By Pass line
5 Return sludge pumping station		
6 Sludge thickener		
7 Drying bed		
8 Administration building		
9 Generator		
10 Electricity reception, Transformer station		

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.D.9.30
Layout of Wastewater Treatment Plant in Slunj