Appendix C

Water Quality

Appendix C WATER QUALITY

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C.1 Present Monitoring Network of Water Quality

Based on the Water Law (1998), the Hydro-Meteorological Institute (HMI) now as before, has the responsibility of monitoring surface waters of the major rivers in Macedonia. The monitoring of water quality by HMI is carried out at 60 measuring stations on the river basins, and lakes; 51 measuring points of these are positioned on river courses, while 9 measuring points are based on the large lakes. The quality of surface and ground water is evaluated on the basis of the existing decree. In reality, the work done by HMI falls short of providing a consistent and correct understanding of water quality information. Moreover, the HMI has not been able to carry out monitoring activities since the end of 1996 and will continue until the end of 1998. This means that the monitoring records for water quality parameters in the rivers of Macedonia will not be available for 1997 and 1998. The last 2 years' lack of monitoring has reportedly been due to the lack of funding because of IMF restrictions on public sector spending in Macedonia. In addition to HMI, the other government agencies which are responsible for monitoring activities, are briefly described in the following table:

Action	Activity	Responsible Agencies
Monitoring of river water	O&M of WQMPCS[1]	MAFWE, DWE, MOEn
	O&M of automatic water quality monitoring systems	MAFWE, DWE, MOEn
Monitoring of river bed sediment	Sampling & analysis of river bed sediment	DWE[2], HMI, RIHP
Pollution sources inspection	Monitoring of domestic wastewater (business activities)	DWE, HMI, RIHP
	Monitoring of domestic wastewater (dwellings)	HMI
	Monitoring of industrial wastewater	HMI
	Monitoring of agricultural wastewater (livestock houses)	HMI
	Monitoring of other sources	HMI
Preparation of inventory	Inventory survey	MUPC, MOEn, HMI

Note:

1. Water Quality Monitoring and Pollution Control System
2. Department of Water Economy

Furthermore, the quality of surface waters used for sports and recreation purposes and tourism, on the shores of natural lakes and river beaches is monitored by Republic Institute for Health Protection (RIHP) of the respective regions.

C.2 Regulations and Standards

C.2.1 Water Law 1998 Regulations

Based on the new Water Law (No. 4/98), Article 92, the HMI has an obligation to regularly monitor the conditions of water pollution, and early diagnosis of accidental discharge of hazardous and toxic material to the water bodies. The HMI would carry out regular water quality and quantity analysis in all water bodies, such as rivers, lakes, reservoirs and ground waters, as well as the waters which are used for irrigation.

The methodology and monitored parameters, and the water condition are established in the Ministry of Agriculture, Forestry, and Water Economy (MAFWE) plan, which is a consistent part of the program for the promotion of information system of nature, and environment protection. This plan is prepared by MAFWE, based on the proposal submitted by HMI.

According to Article 91, in order to determine, define and locate the potential and actual water pollutants, the HMI is obliged to record and keep a book of all pollutants and potential pollutants, regarding the industrial waters, atmospheric waters, domestic waters, leached waters and other wastewaters.

The data from the book of actual and potential pollutants is part of the "Pollution Map" of the air, water, natural monuments, soil disintegration, and soil pollution in the Republic of Macedonia. The type and contents of the book of pollutants are in accordance with the law for environment, nature protection, and promotion.

Based on Article 93, the HMI is obliged to submit data, regularly to MAFWE, the Ministry of Health and the Center for Analysis of the Environmental Parameters and Environmental Assessment, in the former Ministry of Urban Planning, Construction and Environment (former MUPCE).

In the case of accidental discharge of toxic and hazardous materials the HMI is obliged to regularly monitor the water conditions of the affected water body, as well as, to inform the above mentioned institutions as soon as possible, within the first twenty-four (24) hours from the accident.

In addition, based on Article 94, the legal and physical entities which discharge wastewaters, into the water body are obliged to install gauging instruments, measure and record the wastewater quality and quantity. These data should be submitted to the Center for Analysis of the Environmental Parameters and Environmental Assessment, in the former MUPCE and the HMI. These organizations are supposed to record the operation and conditions of the gauge instruments and wastewater treatment facilities, and to establish general procedure for their maintenance.

Based upon Article 95 the legal and physical entities have to undertake regular wastewater quality and quantity analysis, before discharge into the water body. The records should be submitted regularly to the HMI. In case of unreliable data submitted, the HMI could request extra analysis. The extra analysis should be undertaken by bonafide and competent entity with the required equipment and experts for undertaking such activity.

If the extra analysis confirms that the legal and physical entities are discharging toxic and hazardous materials above limitations, the HMI is obliged to undertake control analysis, at least 2 times in a month. The expenses for such control analysis will be covered by the legal and physical entity, which discharges the toxic and hazardous materials.

C.2.2 The Current Standards

The monitoring of all the parameters for quality of the surface waters and the level of pollution in Macedonia, are done according pre-1991 to Yugoslavian Standards (JUS). The JUS are used because of the lack of complete new Macedonian standards. It is a GOM policy to bring in all the new regulations based on EU standards. In 1998, the transition is in process and some of the parameters are monitored by, newly introduced Macedonian regulations, the EU or international standards.

There were new regulations introduced (1998) in Macedonia for the quality and pollution of drinking water.

Based on "Regulation for Classification of Waters, No, 9/84 & No.19/92" the surface waters in Macedonia are categorized in four classes:

Class I: Waters that in their present state can be used for drinking and for the production and processing of food products, and surface waters that can be used for quality fish breeding (salmon).

Class II: Waters that in their present state can be used for bathing and recreation, and for water sports, for breeding of other kind of fish (cyprinides), or that by using the usual methods of processing and conditioning (coagulation, filtration, and desinfection) can be used for drinking, and for the production and processing of food products.

Class III: Waters that in their present state can be used for irrigation, and that by using the usual methods of processing and conditioning can be used in the industry branches that do not require drinking water.

Class IV: Waters that can be used for other purposes only by previous processing

C.3 Technical Issues

(1) Monitoring Methods

Although there are 60 monitoring points, monitoring frequency are insufficient for an entire understanding of river water conditions. In particular harmful substances such as heavy metals, microbiological parameters have not been focused on monitoring program. The river bottom sediments are not analyzed at all.

(2) Facilities

The laboratory facilities under HMI, and RIHP are inadequate in some areas of chemical analysis at present. This situation would be abated once the planned EU projects are completed.

(3) Managerial Aspects

An integrated and overall management is necessary. At present, the HMI has very few technically competent people in management positions. This problem must be addressed and attention should be given to capacity building.

C.4 Future Plans for Monitoring of Water Quality

The monitoring situation in the country has remained unsatisfactory. The situation has even appears worst because of discharges from industry make headlines in the local newspapers, about fish-kill and other water quality related mishaps. In fact, in eastern Macedonia the monitoring of heavy metals in rivers Bregalnica, Pchinja, and others is really quite inadequate, in addition to the problems described above.

In consideration to the above, many donor-grant projects are currently, in advance stages of preparation, certainly these would help to make the situation better after the end of 1998. The EU-PHARE, and Swiss Development Agency, are directly assisting HMI in its monitoring activities. These projects will help to provide the HMI with the necessary resources and equipment to achieve an adequate level of monitoring of water quality.

C.5 Current Conditions of Surface Water Quality

C.5.1 Rivers

The Figures C.1 to C.4 provide a long term 1988-1996 picture of the conditions of water quality for Vardar, Bregalnica and Crna rivers. The data for the distribution of concentration of BOD, DO, SS, and $N\text{-}NH_4$, for the 3 rivers is presented in Annex 6.

In addition a brief description and table for 1990 to 1994 ranges in terms of water quality is provided below for most of the important rivers in Macedonia.

Vardar River: at the spring at Vrutok the river has very clean and rapid flow, and a quality of Class I and II. However, during winter and spring the suspended solids make the water quality, Class II and III. The water quality on measuring stations Balin Dol, Sarakinci, and Jegunovce has Class II and sometimes Class

III values. At Sarakinci, the level of chromium becomes 5 times higher and of Cadmium becomes 3 times higher. These high levels of toxic metals places the waters in Class III and IV.

The water quality downwards from Skopje, through Pchinja joining Vardar to Veles to under the mouth of Babuna River are mostly in Class III and IV, the values for lead (Pb) in 1996, were 0.047mg/l making the water quality due to toxic metals to be out of class. The water quality conditions downwards from Demir Kapija to Gevgelija, overall improves and in rainy season the values are in Class II, while in the summer they are in Class III. The toxic metal readings rescind here to Class II.

The table below indicates, the water quality values in Vardar have spanned from Class I to IV from 1990 to 1994. The Class III and IV have mainly been due to untreated wastewater discharges from the industry and households. Similarly, the ranges for water quality are given for other rivers.

The Range of Water Quality in the Rivers by 'Classification of Water'

River	1990	1991	1992	1993	1994
Vardar	I, II, III, IV	I, II, III, IV	I, II, III, IV	I, II, III, IV	I, II, III, IV
Treska	I, II, III	I, II, III	I, II, III, IV	I, II, III	I, II, III,
Bregalnica	II, III, IV	II, III, IV	II, III, IV	II, III, IV	II, III, IV
Crna	II, III, IV	II, III, IV	II, III, IV	II, III, IV	II, III, IV
Crn Drim	II, III	II, III	II, III	I, II, III, IV	II, III
Radika	II, III	II, III	II, III	II, III	II, III
Strumica	III, IV	III, IV	III, IV	III, IV	III, IV

Source: HMI

Treska River: The river has maintained good quality consistently for the last 10 years. The quality of water in terms of heavy metals, and suspended solids deteriorates before it joins Vardar at Saraj to Class III and IV.

Bregalnica River: In 1996 and earlier upstream the river values had stayed in Class II during the rainy season and Class III in the summer. However, beneath Delchevo it worsens to Class III and IV, and had high values of nitrites and heavy metals.

Crna River: The water quality, after the river receives wastewater from Bitola, have been in Class III and IV. The pollution comprises less of toxic metals and more of organic pollution.

Strumica River: Below Radovish, the water quality has stayed in Class III and during the summer Class IV. The river has high amounts of ammonium, nitrates, nitrites and toxic metals. During the summer, below Radovish the riverbed has been dry for past three years.

Crn Drim which receives waters from Ohrid lake and Radika Rivers are located in the western Macedonia and are in better condition than all other rivers except Treska, in some places.

C.5.2 Natural Lakes

There are three large natural lakes in the country, as well as numerous mountain lakes a brief description of the three large lake is provided in this section.

Lake	Water mark at normal level (El. (m))	Water surface (km^2)	Maximum Depth (m)	Total water quantity (Bil. m^3)
1) Ohrid Lake	693.7	353.9	300	50.683
2) Prespa Lake	853.7	319.9	54	4.775
3) Dojran Lake	148.0	42.7	10	0.427

Source: HMI, Water Quality Data

(1) Ohrid Lake: In 1996, the surface water quality readings were taken at 5 places for this vital and important lake. The measuring stations were located at Sveti Naum, Hotel Metropol dock, the public beach at Grasnica, Hotel Biser, and Kalista. The quality of water had shown marked improvement where the systems of collectors for the wastewater had been installed. The surface water near the beach area in Grasnica still had lower class readings. Overall, the water had no color, odor, or visible wastes on the surface. The summer pH was higher at 8.2 to 8.7. Suspended solids were low in all except Grasnica where the reading were > 200mg/l (Class III). The dissolved oxygen for all 5 stations was high, making for Class I readings. The toxic substances were absent at all the 5 stations. However, E. Coli were detected at locations, highest numbers being at Grasnica.

(2) Prespa Lake: In 1996, the surface water quality of Prespa Lake overall, had Class II category. The lake has two monitoring stations at Pretor and Otsevo. At both these stations the dissolved oxygen readings were high (8 mg/l), values for Class I category. The suspended solid readings had been in Class II. The lake water had low microbiological readings, only E.Coli was detected making for Class II value. However, the chemical indicators of fecal pollution, nitrites sometimes show values of Class III or IV at both the measuring stations. This condition had likely been due to domestic and agricultural runoffs into the lake. The lake had no toxic chemical readings.

(3) Dojran Lake: In 1996, the surface water quality of Dojran Lake overall, had Class III and IV categories. The lake has two monitoring stations

located at Star and Nov Dojrans. The water quality had reportedly improved in 1996, implying that the water quality was worse in the past. The lake is the smallest of the natural lakes and due to a sudden withdrawal from the Greek side catastrophic environmental conditions have prevailed in the lake. The pH value remains high and the lake had high content of dissolved solids (530-840 mg/l), as well as high suspended solids (>100 mg/l). The water quality had ranged between Class III and IV and out of class. The dissolved oxygen contents were also affected because of high level of organic pollution. The toxic chemicals were present at both monitoring stations making the water quality to be in Class III and IV.

C.5.3 Reservoirs

There are eighteen large artificial lakes and reservoirs in Macedonia, as well as, 100 small ones, with a reported net accumulation of over 500 million m^3. The large reservoirs help to sediment the pollutants flowing in from the upstream, and generally improve the quality of water. A brief description of the key reservoirs is provided below:

(1) Debar Lake: The surface water quality of the Debar lake reservoir which is near Shpilje dam, in 1996 had satisfied in full the requested legal water quality regulations of Class II. It had maintained this condition for the last many years. However, during the summer (dry) period there was an increase of the organic and microbiological pollution.

(2) Lipkovo Lake: The surface water quality of the lake Lipkovo near the dam was mostly in Class II in 1996. During the nineties the water quality had remained constant. The lake water was sometimes turbid, during August 1996 monitoring, the pH was 8.4 and suspended solids were present even with Class II values. The dissolved oxygen contents were between Class I and II.

(3) Kalimanci Reservoir: The surface water quality in the reservoir near the dam had Class I and II, the monitoring was for the first time carried out here in 1996. The pH of the surface water was 8.7 to 9 in (May &August), although there were no visible wastes, colors or smells. The suspended solids and dissolved oxygen were of Class II. However, the toxic chemicals had a Class III or IV reading.

(4) Tikves Lake: In 1996, the surface water quality near the dam had showed Class II category. The lake is almost 30 km long. The quality was slightly better close to the measuring station Skocivir. The dissolved

oxygen readings were in Class I and II. The surface water had high levels of zinc (0.227 mg/l) and other toxic chemicals, in categories of Class III or IV.

(5) Mavrovo Lake: In 1996, the surface water quality on the banks and on the measuring station, near the dam were in Class I and II. The dissolved oxygen was at Class I, and high ammonium ion (1.4 mg/l) was in Class III or IV category. In addition, the surface water had no toxic substances.

C.6 Current Conditions of Wastewater Discharged

C.6.1 Current Wastewater Treatment Activities

Based upon the available data, only 6% of the wastewater in Macedonia is treated before it is discharged into the sewer systems and/or to the rivers. There are only three wastewater treatment plants built in Macedonia, only for the treatment of discharges into lakes Ohrid, Prespa and Dojran. Only Vranishte (Ohrid) plant has a substantial capacity which would be expanded to 180,000 under the on-going GEF project, the other plants are relatively smaller.

A $ 12 million treatment plant in Bitola is under construction. Only about 20 industrial plants have large pretreatment facilities, and more than 50 percent of them do not function. In addition, there is no centralized wastewater treatment facility for domestic sewage in Macedonia. Overall, the wastewater treatment is the most deficient sector amongst all of infrastructure development in the country. The monitored record of wastewater and its analyses conducted by HMI are compiled in Annex 7

To ascertain the degree of water pollution, BOD, Dissolved Oxygen (DO), Suspended Solids (SS), Ammonical-Nitrogen, and pH is analyzed. Of these BOD is the most suitable parameter to know the organic pollution of the river water. The calculation of BOD load of industrial, agricultural and domestic wastewater has been elaborated for 1997, 2005, 2015 and 2025 and presented in Annex 8.

This Study has set the goals for discharges of (BOD_5) without nitrification from urban wastewater equal to the EU requirements:

Sector	Concentration	Minimum % Reduction
1. Industry	25 mg/l	70-90
2. Domestic	8 mg/l	80-95

The overall reduction to be achieved by implementing the master-plan are set for all river surface waters to be 6 mg /l of BOD_5 discharge. Tables C.1 and C.2 provide the European Union and Macedonian the current regulations respectively.

Wastewater untreated and discharged into surface water in Macedonia has become a leading problem of water resources management in Macedonia. It has led to intense degradation of water quality, to eutrophication through unconnected areas and toxic contamination through poorly controlled industrial pre-treatment. The problem will intensify, when the industry in the country revives. There will be an increase of wastewater contamination. The discharge of uncontrolled wastewater is a very high priority issue for the control pollution in Vardar and other rivers.

C.6.2 Domestic Wastewater Discharges

The domestic wastewater results principally from household activities, with some additions of other wastes. The table below provides domestic and industrial wastewater discharge data by cities (former municipality) for 1996 and projections for 2025.

Domestic and Industrial Wastewater Discharged in the Rivers

Former Municipality	Population 1996	Wastewater discharged 1996 (10^3 m^3/year)	Population projection 2025	Wastewater discharged 2025 (10^3 m^3/year)
Skopje	558,213	52,551	705,608	83,660
Gostivar	115,276	6,470	133,918	8,847
Tetovo	179,883	15,664	214,130	19,394
Kichevo	53,741	3,765	61,924	6,739
Makedonski Brod	12,152	433	10,406	573
Kumanovo	131,558	6,689	147,546	8,968
Kratovo	10,905	841	9,553	935
Kriva Palanka	25,307	1,279	22,078	1,394
Veles	66,829	12,221	71,525	12,977
Sveti Nikole	21,616	1,156	21,114	1,448
Shtip	51,353	4,519	60,055	7,889
Probishtip	16,766	1,336	17,740	2,012
Kochani	48,676	2,465	55,379	3,130
Vinica	19,438	904	22,154	1,171
Delchevo	26,149	1,227	29,310	1,623
Berovo	19,913	1,035	20,347	1,231
Demir Hisar	10,456	394	7,696	413
Krushevo	12,134	588	11,766	674
Bitola	108,789	13,140	113,578	14,054
Prilep	95,310	5,111	98,017	5,892
Kavadarci	42,494	3,695	48,831	4,301
Negotino	23,542	2,208	27,833	2,950
Valandovo	12,271	568	14,335	776
Gevgelija	34,983	1,917	41,331	2,665
Ohrid	61,533	3,688	70,788	4,648
Struga	65,216	2,875	75,162	4,064
Debar	24,995	1,265	31,593	1,754
Resen	17,708	953	17,235	1,091
Radovish	31,237	1,431	35,590	1,871
Strumica	92,955	4,531	107,455	6,107
Total	1,991,398	154,919	2,303,997	213,251

Source: Study Team's estimation (result of pollutant load analysis)

C.6.3 Existing Treatment Facilities and Measures for Domestic Wastewater

In Macedonia, the most significant wastewater treatment plants which handles domestic and pretreated industrial wastewater discharges is situated in the catchment of Lake Ohrid, located in the towns of Vraniste. The other two plants are in the catchment of Lakes Prespa and Dojran, of a smaller capacity.

There have been plans for the design and construction of watsewater systems in Skopje, Strumica, Bitola and Prilep. The Bitola and Prilep wastewater systems are in the implementation phase now, financed through a World Bank loan. A national and Skopje's wastewater treatment master plan is under preparation. In addition, the proceeding sections have compiled all the available information about the on-going and planned activities.

(1) Vraniste wastewater treatment plant

In 1996, approximately 20,000 in Ohrid and 14,000 in Struga 'population equivalent p.e. were connected to the treatment plant in Vraniste which has been in operation since 1988. This plant has an aerated grit removal tank, an activated sludge process with aeration by brush aerator followed by sedimentation in settling tanks. Most of the equipment for this operating plant is made in the region, by Unioninvest, Sarajevo. At present, about two thirds of the capacity of the plant is utilized during the high use season, and only one third during the rest of the year. The treatment plant requires pretreatment of wastewater from the industry. The plant has plans to include biological digester and a de-watering system for the sludge. In addition, it is understood that only the hotels along Lake Ohrid's shore have their own pre-treatment facilities, the quality of wastewater discharge is not however, monitored. The Vraniste wastewater treatment plant has a capacity of 120,000 p.e., this summer (1998) it had been working at over capacity at 130,000 p.e. Under the GEF project the plant capacity will be extended to 180,000 p.e., annually.

(2) Resen wastewater treatment plant

The treatment plant in Resen near the Prespa Lake has been operational since 1988, and has a capacity for 12,000 p.e. It connects the towns of Resen and Ezerani through a primary collector system. Most of the water can be transported through gravitation, hence only one pump is required here. The sludge is disposed off in the wetlands nearby. There are plans to increase the capacity of this plant by another 50,000 'population equivalent' in the future.

(3) New Dojran wasterwater treatment plant

This has a designed capacity of, 6000 p.e. wastewater treatment plant for discharges into Dojran Lake, the plant is located near the town of New Dojran.

The lake has gone through a large and alarming reduction of water, which was released from the Greek side, due to the lowering of water level the wastewater treatment plant has not been functioning.

(4) The World Bank Water Supply and Sewerage Project (WSSP)

The WSSP project is expected to be effective in Fiscal Year 1999. The WSSP objectives would be: (i) to improve water supply services in locations where conditions are particularly severe; (ii) to prevent pollution of the Lake Ohrid and reduce pollution of the Vardar River catchment basin; (iii) to commercialize the water supply and sewerage services; and (iv) to decentralize water supply and sewerage operations.

The sewerage treatment portion of the project would include the following proposed facilities: Sewerage Treatment Plant for Bitola (US$12.0 million); Sewerage Treatment Plant for Prilep (US$8.0 million); Extension of the Sewerage System of the proposed Lake Ohrid Protection Agency.

(5) Austrian assistance for a small wastewater treatment system

Makedonski Brod has small wastewater treatment project for a population of 5,300 people, supported by Austrian Government's assistance for design and financing construction. This project according MUPC will be used as an example for implementing other treatment systems in smaller cities in Macedonia.

(6) Preliminary study for Skopje wastewater treatment project assisted by the Czech Government

A preliminary study was conducted in 1997 for Skopje city by Czech assistance, which proposes a complete treatment system including the design costing approximately $ 90 million.

C.6.4 Existing Wastewater Treatment in the Industry

In Macedonia, only less than 20 large factories have pre-treatment plants built on the premises. Many small factories also have treatment plants, these are basic "mechanical" systems. The entire capacity provides treatment to only about 6% of all wastewater generated in Macedonia. In addition, current and reliable data on their operations is very difficult obtain and questionable. Reportedly more than 50% of the installed systems are mostly out of order, and the factories discharge untreated wastewater into Vardar and other rivers, sometimes with catastrophic consequences. Out of 20 large factories equipped with pre-treatment plants, a table below by data prepared by HMI, provides information of 11 factories' treatment and discharges.

Selected Installed Wastewater Treatment Plants in the Industry

Name & Location of Industrial Plant	Untreated Wastewater Discharged m³/year 1994	Amount of Treated Wastewater Discharged m³/year 1994	Type of Treatment Method of the Plant
1.GOTEKS, Cotton &Wool, Gostivar		480,000	Mechanical & Biological
2. Slaughter House, GORNI POLOG, Gostivar		524,886	Mechanical & Chemical
3. Teteks, Yarn & Fabrics, Tetovo		1,200,000	Mechanical (Sedimentation)
4. JUGOCHROM, Jegunovce, Tetovo	12,000,000	142,560	Mechanical & Chemical
5. KPK, Leather & Fur Kumanovo	133,029	532,119	Mechanical (Non-Functional Part of Time)
6. OKTA, Petroleum Refinery, Skopje	30,000	1,570,000	Biological
7. RUDNICI I ZELEZARINA, Iron & Steel, Skopje	5,680,000	47,820,000	Mechanical (Sedimentation)
8. ZLETOVO, Lead & Zinc, Veles	7,838,950	387,500	Mechanical & Chemical
9. Chemical Industry (CIV), Veles	49,275	4,092,000	Mechanical & Chemical
10. BLAGOS GOREV Fuel Oil, Veles	518,000	376,400	Mechanical
11. TEC Powerplant, Negotino		670,000	Mechanical

C.6.5 System for Production and Wastewater Treatment at OHIS

The information in the tables below was provided by OHIS at request. It provides valuable information on one of the most important industrial facility on the east side of Skopie's industrial corridor. It has been independently confirmed, that the wastewater system's filter plant does not function at all. There were similar reports in the print media, in view of this, the data should be considered with caveats. The existing electrolysis system is also obsolete and discharges mercury into the Vardar river.

Overall Feature of Present Production at OHIS

	Products	Unit	Production capacity	Present production	%
1	Polyacrylic fiber Malon	m^2	30,000	12,336	41.1
2	Polyvinylchloride PVC powder	tons	55,000	12,565	22.8
3	Artificial leather	tons	2,000,000	239,362	12.0
4	Foils	tons	4,000	824	22.6
5	Granulates and Compounds	tons	16,500	6,783	41.1
6	PVC pipes	tons	10,000	1,895	19.0
7	Rubber fillers	tons	1,100	821	74.6
8	PVA emulsions and finished products	tons	25,000	3,177	12.7
9	Detergents	tons	30,000	22,645	75.5
10	Plant protection agents	tons	4,000	108	2.7
11	Hydrochloride acid	tons	27,000	5,310	19.2
12	Monochloracetic acid	tons	4,000	1,788	44.7
13	Sodium hydroxide	tons	10,000	1,648	41.2
14	Sodium-hypochloride	tons	5,000	2,492	49.8
				Average percentage:	34.2

Wastewater Treatment System at OHIS

No.	Type of Wastewater	Remarks	Effluence
1	Atmospheric and cooling plant wastewater	Waters with altered temperature	Atmospheric water collecting channel
2	Technological process wastewater	Contains organic matters with pH from 1 to 12	acid proof collecting channel
3	"Biljana" factory* industrial wastewater	It has a local physical and chemical treatment (sedimentation, flotation, neutralization)	Collecting channel
4	Sanitary and fecal wastewater	Mainly from settlement Pintija in Skopje	Collecting channel
5	"Hemteks" factory for polyester fiber wastewater	Not a OHIS unit	Collecting channel

Notes:

1. No.1 & 3 are directly discharged through channels into Vardar River.
2. No. 2,4 & 5 are processed through a wastewater treatment facility.
3. Total quantity of OHIS wastewater is 1,800-2,000 m^3/hour.
4. 23-25 % of the total amount goes through the wastewater treatment plant.
5. 25-27 % are physically and chemically treated at source.
6. About 50 % of the remaining wastewater does not require any treatment.
7. The wastewater treatment facility is designed to treat waste water physically and chemically (with bars, neutralization), and biologically with a oxygen processing by maturing the excess biological sediment and squeezing out water, and transport it to landfill.
8. The facility reportedly functions 24 hours a day.

* Biljana factory is within OHIS and it is producing detergents, pesticides, cosmetics, and others.

C.7 Biological Minimum from the Ecological Standpoint

C.7.1 General

In Macedonia, the ecological water demand has been and is determined by a rule of thumb formula. The "biological minimum" for all of the river-beds has been determined in the National Development Strategy to be 10% of the annual mean river flow in a given time period. According to the NEAP, the river maintenance flow is not well defined and does not take into account the need to maintain fish life in the river.

The National Development Strategy's Chapter on "Water Supply Industry and Water Resources" has calculated the ecological water demand presented below:

Total Water Needs in Macedonia

	Current needs (1995) m^3 / year	Future needs (2025) m^3 / year
Population	361,546,333	590,932,817
Industry	270,134,297	843,021,100
Agriculture	950,000,000	2,416,184,980
Ecological	653,200,000	653,200,000
Total	2,234,880,630	4,503,338,879

Source: National Development Strategy, 1998

C.7.2 Definition

Given the recommendation of the National Development Strategy 1998, the JICA Study accepts the rule of 10% of the annual mean river flow. However, adjustments would be made on a, case by case, basis in the seasons of low water levels, in rivers where 10% of the existing flow will be too small.

The water supply in the rivers during the low water levels is insufficient and some rivers dry up altogether. The Study definition should consider those low flow rivers to be set aside cases, where a critical flow will be determined not on the basis of the informal Macedonian formula of 10% of the average river flow but on the actual "biological minimum". For this, studies would need to be carried out to determine the availability of reservoir water and other sources of water during the dry period. In addition, consideration will be given for satisfying key requirements of water quality target level (less than 6 mg/l of BOD), and the preservation of aquatic life.

C.7.3 Composition of River Maintenance Flow

Thr Vardar and other river basins in Macedonia, are supporting water requirements for domestic uses, agriculture, mining and industry, hydropower and recreational fishing. The utilization of water resources are regulated by the new Water Law (No.4 / 98) in accordance with general order of importance. The beneficial uses of water are relatively limited in scope due to the water quality and quantity in the rivers during the dry season.

The river maintenance flow could be defined as the minimum water flow, which shall satisfy concurrently the following compositions for beneficial uses during the dry season:

-Water quality : Assimilative capacity of the rivers

-Recreational uses	:	Water depth for fishing and sports activity
-Aesthetics	:	Water surface in the rivers
-Preservation of biota	:	Water depth for aquatic life in the rivers

(1) Water Quality: The water quality during the dry season deteriorates in most rivers mainly due to low flow conditions combined with high pollution loads from indusrty and domestic discharges.

(2) Recreational Uses: The river waters have an important role in providing recreational fishing, and swimming. In a period when the economy is in transition and for a country that is land locked the potential of the rivers to provide recreation is quite large.

(3) Aesthetics: Little systematic aesthetic use of river waters is made at present. Other countries use their river waters to enhance the aesthetic value of the surroundings. Macedonia certainly has unspoiled rivers in the west, and Vardar and eastern rivers could provide the aesthetic benefit.

(4) Preservation of Biota: Apart from the clean western rivers and the Vardar until Gostivar, many rivers in the country have only the most hardy flora and fauna. Almost all the large fish have become extinct in the rivers of the country.

C.7.4 Current Regulation

The "Water Law" of the Republic of Macedonia (No.4/98), in the Article 107, describes the "biological minimum" as, "the water balance between the water in and from the reservoir, the capacity for the big flood waters, as well as, providing the minimum flow downstream of the dam are regulated by the 'Water Right' document."

The determination of quantitative minimum for the river maintenance flow, has since March 1998, become the responsibility of MAFWE.

C.7.5 Water Requirement

The river flows are recorded daily, and provide information on daily basis, mean monthly flow records are adopted for the preparation of each sub-basin's maintenance flow requirement in the following table below:

River Basin/Gauging Station (Catchment area: km²)	Monthly average	10% of average
1. Vardar		
1) Sarakinci (1083)	19.37	1.9
2) Radusha (1450)	23.76	2.4
3) Skopje (4650)	59.05	5.9
4) Veles (8820)	74.70	7.5
5) Demir Kapjia (21350)	126.34	12.7
6) Gevgelia (22301)	136.00	13.6
2. Treska		
1) Makedonski Brod (886)	10.83	1.1
2) Zdunje (1605)	18.33	1.8
3) Sveta Bogorodica (1880)	23.34	2.3
3. Pchinja		
1) Pelince (567)	4.58	0.5
2) Trnovec (614)	3.95	0.4
3) Kumanovo (135)	0.47	0.1
4) Katlanovska Banja (2794)	11.89	1.1
4. Bregalnica		
1) Ochi Pale (846)	4.61	0.5
2) Laki (73)	0.90	0.1
3) M. Kamenica (105)	1.34	0.1
4) Shtip (2897)	11.24	0.1
5. Crna		
1) Dolenci (217)	2.45	0.2
2) Skochivir (3975)	20.34	2.0
3) Rasimbegov M (4526)	22.39	2.2
6. Strumica		
1) Sushevo (520)	1.65	0.2
2) Novo Selo (1401)	3.81	0.4
7. Crn Drim		
1) Boshkov Most (751)	18.75	1.9
2) Globocica (-)	23.38	2.3

The eastern Macedonia mostly has critical flow related problems, and it gets less rainfall than the western part. Many of the critical flow involving rivers, in the eastern Macedonia (Bregalnica, Pchinja, Strumica and others) during the low flow will have to be analyzed on a case by case basis. These rivers will not be able to correctly provide river maintenance flow using the established 10% of the mean annual flow. There will not be enough water in many of the rivers during the dry season.

According to the MOEn in overall terms, the Bregalnica is considered to be the river with the most acute biological minimum related problems. Two years ago its biological function was totally disrupted. Similarly, Kamenica close to Kalimanci dam had become almost dry two years ago. The dam has now been filled up and the biological function of the river has been resumed.

In Kochani, the rice growing area, the river-bed comprises of volcanic rocks which results in quick flows of water during the rainy season, thus creating a shortage of critical flow.

The western parts of Macedonia do not have any the problems related to river maintenance flow. The right side tributaries of the Vardar, and Treska have biological minimum flow even during the summer months. With the construction of Kozjak dam the situation will improve further in this region.

Many of the new development projects under consideration will make maintaining the minimum ecological flow an integral part of the project design.

C.8 Pollutant Load Analysis

C.8.1 Objective

The pollutant load analysis and projection of water quality was carried out to clarify the present and future situation of the river water quality in river.

C.8.2 Conditions for Analysis

The following points were assumed taking account of representing actual field measurement of river water quality.

(1) Unit per capita BOD_5[1] concentration

The rate dominantly used in Macedonia of 54 mg/lit is to be applied.

(2) Quantity of industrial wastewater

In this analysis, it was assumed that industrial wastewater was equivalent to quantity of the return flow of industrial water. Based on the return flow rate in industrial sector, the quantity of effluent in every case of, 1996 2005, 2015 and 2025 was estinated. Further, by using the consumption records of industrial water sub-divided by type of activity in 1994, the total quantity of wastewater was divided into total 32 types. In order to estimate the above 4 cases, the shares of quantity in 1994 were maintained.

(3) Unit BOD_5 concentration in effluent by type of industry

The unit BOD_5 concentration was referred to the standards, which was normally applied and referred in Macedonia. The standards has been prepared and published in Germany[2]. Therefore, the figures were applied based on the standards and also were referred to the Japanese Guideline in case those are not available in the standards as tabulated in Table C.3.

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[1] The BOD_5, biological oxygen demand, is the amount of oxygen required for the decomposition of the organic substances by microorganisms in 5 days at 20°C. Usually total BOD is designated as BOD_{20}, which is BOD in 20 days. Since a certain relation exits between BOD5 and BOD20 in domestic wastewater, when BOD_5 is known, BOD_{20} can easily be calculated.

[2] Referred to, "Waste Water Technology (Origin, Collection, Treatment and Analysis of Waste Water), edited by Institute Fresenius GmbH, Taunussetein-Neuhof, W. Fresenius and W. Schneider, Berlin,1989" (Section 2.4 P.44~203)

(4) Discharge ratio (D-ratio) and residual purification ratio (PR-ratio)

As the result of calibration based on the present BOD_5 concentration at major monitoring sites, the discharge ratio (D-ratio) of 0.25 is applied to all sub-blocks. The rate of residual purification ratio (PR-ratio) of 0.7 was applied.

C.8.3 Projected BOD_5 Load and Concentration

(1) Output of analysis

Detailed enumeration on the projection of population, BOD_5 load by respective water uses, applied discharges for calculation of concentration, etc. is compiled in the Annex 8 with division of sub-basins and schematic model for analysis.

(2) BOD_5 load from domestic wastewater

In the NEAP sector study report "Part VIII Water Quality", projection of pollutant load and required treatment and their effectiveness such as mechanical, mechanical-chemical, biological methods were examined. Table C.4 tabulates the population in three major river basins estimated in NEAP and JICA Study, showing the NEAP's bigger estimate of around 220,000 at year 2025. On the contrary, the baseline population in 1994 by NEAP is about 800,000 lower than JICA's value, although which is the extracted values at year 1997 level from the records of Statistical Office. Table C.5 shows the BOD_5 load projection (effluent into river) by two estimates. These are not significantly different in the magnitude of total load in 2025, i.e. 10%.

(3) BOD_5 load from industrial wastewater

Total BOD_5 load from industrial wastewater by former municipalities is summarized in Table C.6. This shows that intensive pollutant in terms of BOD_5 load is existing and will occur in Skopje, Tetovo, Kumanovo, Kriva Palanka, Veles, Sveti Nikole, Shtip, Bitola, Prilep, Kavadarci, Gevgelija and Strumica. Among them, a sharp increase from present level to year 2025 happens in Skopje, Kriva Palanka, Veles, Sveti Nikole, Shtip, Prilep and Gevgelija.

(4) Overall BOD_5 load by water uses

The total load by water uses at present (1997), 2005, 2015 and 2025 is summarized in Table C.7. As for the share of pollutant load in the each sector of water use, agricultural load is dominant, 60% of the total at present. Further, the increasing rates from the present level to year 2025 are 14%, 74%, and 26% for the domestic, industrial, and agricultural pollutants respectively.

C.8.4 Predicted Water Quality Deterioration in Rivers

After calculation of the BOD_5 load by sub-basins, concentration was estimated at representative points (base points) where are located at major hydrological stations. The results are in details shown in Annex 8. Table C.8 presents the predicted concentration at the selected base points. The result of water quality prediction clarified that notable deterioration will take place in the Vardar mainstream between Skopje and the confluence with the Crna River, Pchinja downstream (after the Confluence of Kumanovska River), the Bregalnica middle to downstream (after Kalimanci dam) and the Strumica River (all stretches). Figure C.5 shows the required water quality in the Law and estimated water quality, BOD_5 (mg/l), in 1996 and 2025 for comparison.

C.8.5 Findings through Analyses

The pollutant load analysis in this Master Plan Study was conducted to grasp the global picture of future water quality condition without no efficient treatment activity in the target areas and accordingly to estimate the approximate cost for reduction of pollutant to the allowable level for conservation of river water quality. Since available data is limited especially the reliable measurements of quantitative industrial and agricultural wastewater at field, theoretical approaches was obliged with some assumptions.

Therefore to elaborate the analysis, systematic and periodical qualitative /quantitative monitoring of wastewater is essential. Further, in order to determine the allowable limit of stream load, simultaneous water quality monitoring would be recommendable to study capability of self-purification of the rivers. It should be noted that strengthening and improvement of the present water quality monitoring network is indispensable to establish an economical level of wastewater treatment to reduce the investment cost.

Table C.1 Current European Union (EU) Running Water Quality Regulations

E.U. RUNNING WATER STANDARDS AND PARAMETERS

	I Excellent Blue	II Good Green	III Fair Yellow	IV Poor Orange	V Bad Red
Oxygen regime:					
DO% epilimnion	90-110	70-90, 110-120	50-70, 120-130	30-50, 130-150	<30, >150
Hypolimnion	90-70	70-50	50-30	30-10	<10
Total	90-70	70-50, 110-120	50-30, 120-130	30-10, 130-150	<10, >150
DO mg/l	>7.00	7.00-6.00	6.00-4.00	4.00-3.00	<3.00
BOD_5 mg/l O_2	<3.00	3.00-5.00	5.00-9.00	9.00-15.0	>15.0
COD-Mn mg/l O_2	<3.00	3.00-10.0	10.0-20.0	20.0-30.0	>30.0
Eutrophication:					
Total P µg/l P	<10(<15)	10-25(15-40)	25-50(40-75)	50-125(75-190)	>125(>190)
Total N µg/l N	<300	300-750	750-1500	1500-2500	>2500
Chlorophyll a µg/l	<2.5(4.0)	2.5-10(4-15)	10-30(15-45)	30-110(45-165)	>110(>165)
Acidification:					
PH	6.5-8.5	6.5-6.3	6.3-6.0	6.0-5.3	<5.3
Alkalinity mg/l $CaCO_3$	>200	200-100	100-20	20-10	<10
Harmful substances:					
Heavy metal and cyanides:					
Aluminium µg/l (pH<6.5)	n.a.		<5	5-75	>75
µg/l (pH>6.5)	n.a.		<100	100-500	>500
Arsenic µg/l	<10		10-50	50-100	>100
Cadmium(1 µg/l	<0.07		0.07-0.7	0.7-1.8	>1.8
Chromium(2 VI µg/l	<1		1-11	11-16	>16
Copper(1 µg/l	<2		2-6.5	6.5-9.2	>9.2
Lead µg/l	<0.1		0.1-1.3	1.3-34	>34
Mercury(2 µg/l	<0.003		0.003-0.012	0.012-2.4	>2.4
Nickel(1 µg/l	<15		15-88	88-790	>790
Zinc(1 µg/l	<45		45-59	59-65	>65
Cyanides µg/l	<0.5		0.5-5.0	5.0-22	>22
Others:					
Dieldrin µg/l	0		<0.0019	0.0019-2.5	>2.5
Chlordane µg/l	0		<0.0043	0.0043-2.4	>2.4
DDT and metabolites µg/l	0		<0.001	0.001-1.1	>1.1
Endrin µg/l	0		<0.0023	0.0023-0.18	>0.18
Heptachlor µg/l	0		<0.0038	0.0038-0.52	>0.52
Lindane µg/l	0		<0.08	0.08-2.0	>2.0
Malathion µg/l	0		0	<0.1	>0.1
Parathion µg/l	0		<0.013	0.013-0.065	>0.065
Pentachlorophenol(3 µg/l	0		<3.5	3.5-5.5	>5.5
PCBs µg/l	0		<0.001	0.001-2.0	>2.0
Toxaphene µg/l	0		<0.2	0.2-730	>730
Radioactivity(4					
Microbial pollution					
Median No/100 ml					
Thermo-tolerant coliforms	<10	10-30	30-100	100-1000	>1000
Fecal streptococci	<10	10-30	30-100	100-1000	>1000

(1 Calculated for standard hardness of 50mg CaCO3/l. Adjustment for different levels of hardness, see table below.
(2 Calculated for standard hardness of 50mg CaCO3/l. Adjustment formula for different levels of hardness curently under development.
(3 Calculated for standard pH of 6.5l. Adjustment formula for different pH values, see table below.
(4 Ranges will be specified according to test results.

Table C.2 Macedonian Surface Water Quality Regulations

Based on "Regulation for Classification of Waters, No, 9/84 & No.19/92" the surface waters in Macedonia are categorized in four classes: Class I: Waters that in their present state can be used for drinking and for the production and processing of food products, and surface waters that can be used for quality fish breeding (salmon). Class II: Waters that in their present state can be used for bathing and recreation, and for water sports, for breeding of other kind of fish (cyprinides), or that by using the usual methods of processing and conditioning (coagulation, filtration, and desinfection) can be used for drinking, and for the production and processing of food products. Class III: Waters that in their present state can be used for irrigation, and that by using the usual methods of processing and conditioning can be used in the industry branches that do not require drinking water. Class IV: Waters that can be used for other purposes only by previous processing.

Table C.3 Unit BOD_5 Load by Type of Industry

No.	Type of industry	Unit BOD_5 load (mg/lit)		Applied unit BOD_5 load (mg/lit)
		A	B	
1	Thermal power station cooling	-	-	-
2	Extraction of coal	-	-	-
3	Petroleum products industry	n.a.	20~200	100
4	Extraction of iron ore	-	-	-
5	Iron and steel industry	n.a.	50~100	70
6	Non-ferrous ore mining	-	-	-
7	Non-ferrous metal production	-	-	-
8	Non-ferrous metal processing	-	-	-
9	Extraction of non-metal minerals	-	-	-
10	Processing of non-metal minerals	-	-	-
11	Manufacture of metal products	n.a.	50~100	70
12	Machine industry	-	-	-
13	Manufacture of transport equipment	n.a.	20~120	70
14	Manufacture of electrical equipment	-	-	-
15	Basic chemical industry	n.a.	100~1,000	500
16	Chemical products industry	n.a.	100~2,000	1,000
17	Stone, gravel and sand quarrying	-	-	-
18	Construction materials industry	-	-	-
19	Lumber industry	n.a.	20~240	130
20	Finished wood products industry	n.a.	20~240	130
21	Paper and paper products	n.a.	300~700	500
22	Textile fiber and fabric industry	540	150~200	300
23	Finished textile products industry	-	-	-
24	Leather and fur industry	1,200	80~2,500	1,200
25	Leather footwear and accessories	-	-	-
26	Food products industry	1,000~20,000	200~4,000	1,500
27	Beverages industry	5~450	250~350	300
28	Fodder industry	n.a.	800~1,200	1,000
29	Tobacco industry	n.a.	50~250	150
30	Printing	n.a.	3,000~20,000	3,000
31	Recycling of industrial waste	-	-	-
32	Miscellaneous manufacturing	-	-	-

Note:
- , Negligible small
n.a, Data not available

Source:
A: "Waster Water Technology, Origin, Collection, Treatment and Analysis of Waste Water, Institute Fresenius GmbH, Berlin, 1989"
B: "Guideline for Planning and Research of Sewerage Treatment, Japanese Association of Sewerage Treatment, 1996"

Table C.4 Comparison of Estimated Population in NEAP and JICA M/P for BOD_5 Load Projection

Name of river basin	A 1994	B 1997	A 2000	B 2005	A 2010	B 2015	A 2025	B 2025
Vardar	*1,020,872*	1,647,420	*1,530,100*	1,716,277	*1,497,200*	1,801,366	*2,226,200*	1,876,978
	(1.)	(1.)	*(1.499)*	(1.04)	*(1.47)*	(1.09)	*(2.18)*	(1.14)
Strumica	*48,255*	119,950	*52,136*	125,618	*63,000*	132,021	*71,000*	137,709
	(1.)	(1.)	*(1.08)*	(1.05)	*(1.31)*	(1.1)	*(1.47)*	(1.15)
Crn Drim	*79,829*	179,960	*93,530*	188,719	*119,500*	198,387	*143,000*	206,979
	(1.)	(1.)	*(1.172)*	(1.05)	*(1.5)*	(1.1)	*(1.79)*	(1.15)
Total	*1,148,956*	1,947,330	*1,675,766*	2,030,614	*1,679,700*	2,131,774	*2,440,200*	2,221,666
	(1.)	(1.)	*(1.459)*	(1.04)	*(1.46)*	(1.09)	*(2.12)*	(1.14)

Note: A, NEAP (data for "Water Quality")
B, JICA M/P Study

Table C.5 Comparison of BOD_5 Load Projection (by domestic wastewater)

Unit: kg/day

Name of river basin	A 1994	B 1997	A 2000	B 2005	A 2010	B 2015	A 2025	B 2025
Vardar	*55,130*	88,961	*82,625*	92,679	*84,154*	97,274	*120,215*	101,357
	(1.)	(1.)	*(1.499)*	(1.04)	*(1.53)*	(1.09)	*(2.18)*	(1.14)
Strumica	*2,606*	6,477	*2,816*	6,783	*3,402*	7,129	*3,834*	7,436
	(1.)	(1.)	*(1.08)*	(1.05)	*(1.31)*	(1.1)	*(1.47)*	(1.15)
Crn Drim	*4,312*	9,718	*5,050*	10,191	*6,435*	10,713	*7,722*	11,177
	(1.)	(1.)	*(1.17)*	(1.05)	*(1.49)*	(1.1)	*(1.79)*	(1.15)
Total	*62,048*	105,156	*90,491*	109,653	*93,991*	115,116	*131,771*	119,970
	(1.)	(1.)	*(1.46)*	(1.04)	*(1.51)*	(1.09)	*(2.12)*	(1.14)

Note: A, NEAP (data for "Water Quality")
B, JICA M/P Study

Table C.6 BOD$_5$ Load from Industrial Wastewater by Former Municipality

Unit: kg/day

No.	Name of former municipality	Sub-basin No.	BOD load from industrial waster water 1997	2005	2015	2025	Increasing rate
1	Skopje	6,7	21,781	26,658	34,592	48,888	2.24
2	Gostivar	1	542	578	618	667	1.23
3	Tetovo	2	2,288	2,325	2,364	2,405	1.05
4	Kicevo	4	-	-	-	-	-
5	M. Brod	5	7	9	11	15	2.14
6	Kumanovo	12	1,338	1,557	1,870	2,383	1.78
7	Kratovo	17	-	-	-	-	-
8	Kriva Palanka	10	771	862	972	1,115	1.45
9	Veles	8	8,016	8,383	10,183	12,441	1.55
10	Sv. Nikole	18	715	869	1,027	1,274	1.78
11	Stip	17	2,556	2,836	3,500	3,906	1.53
12	Probistip	17	-	-	-	-	-
13	Kocani	17	178	196	214	231	1.30
14	Vinica	17	-	-	-	-	-
15	Delcevo	15	44	49	53	58	1.32
16	Berovo	15	397	439	481	527	1.33
17	Demir Hisar	19	9	10	11	12	1.33
18	Krusevo	19	29	31	34	37	1.28
19	Bitola	20	1,936	1,957	1,978	1,999	1.03
20	Prilep	19	1,926	2,149	2,410	2,743	1.42
21	Kavadarci	24	1,757	1,811	1,865	1,919	1.09
22	Negotino	24	373	388	408	435	1.17
23	Valandovo	25	230	253	275	298	1.30
24	Gevgelija	25	1,019	1,153	1,323	1,568	1.54
25	Ohrid	29	-	-	-	-	-
26	Struga	30	-	-	-	-	-
27	Debar	30	-	-	-	-	-
28	Resen	29	740	814	886	958	1.29
29	Radovis	26	98	108	118	128	1.31
30	Strumica	27,28	1,925	2,131	2,357	2,617	1.36
	Total		48,675	55,566	67,550	86,624	1.78

Table C.7 BOD_5 Load Projection by Water Use

Unit:kg/day

Souce of pollutant	1997	2005	2015	2025
Domestic waste water	105,156	109,656	115,117	119,970
(increasing rate)	(1.00)	(1.04)	(1.09)	(1.14)
(share)	(0.26)	(0.25)	(0.24)	(0.23)
Industrial waste water	48,676	55,566	67,550	86,624
(increasing rate)	(1.00)	(1.14)	(1.39)	(1.78)
(share)	(0.12)	(0.13)	(0.14)	(0.17)
Agricultural waste water	230,145	242,554	261,171	289,660
(increasing rate)	(1.00)	(1.05)	(1.13)	(1.26)
(share)	(0.56)	(0.56)	(0.55)	(0.55)
Non-point source	27,955	27,955	27,955	27,955
(increasing rate)	(1.00)	(1.00)	(1.00)	(1.00)
(share)	(0.07)	(0.06)	(0.06)	(0.05)
Total	411,932	435,731	471,793	524,209
(increasing rate)	(1.00)	(1.06)	(1.15)	(1.27)
(share)	(1.00)	(1.00)	(1.00)	(1.00)

Table C.8 Result of Water Quality Prediction (BOD_5 concentration)

River name	Station No.	1997		2005			2015			2025		
		BOD_5 (mg/lit)	Class (I~IV)*	BOD_5 (mg/lit)	Rate of increase	Class (I~IV)*	BOD_5 (mg/lit)	Rate of increase	Class (I~IV)*	BOD_5 (mg/lit)	Rate of increase	Class (I~IV)*
Vardar mainstream	ST3	2.6	II-	2.7	104%	II-	2.9	112%	II-	3.0	115%	II-
	ST5	3.1	II+	3.2	103%	II+	3.3	106%	II+	3.5	113%	II+
	ST8	4.8	III-	5.3	110%	III-	6.0	125%	III+	7.1	148%	IV-
	ST10	6.3	III+	6.8	108%	III+	7.7	122%	IV-	9.0	143%	IV-
	ST12	7.0	III+	7.6	109%	IV-	8.5	121%	IV-	9.8	140%	IV-
	ST14	5.7	III+	6.1	107%	III+	6.8	119%	III+	7.7	135%	IV-
	ST16	5.7	III+	6.1	107%	III+	6.7	118%	III+	7.6	133%	IV-
Lepenec	ST30	8.8	IV-	10.7	122%	IV-	13.7	156%	IV+	18.9	215%	IV+
Treska	ST23	2.7	II-	2.8	104%	II-	3.0	111%	II-	3.1	115%	II+
	ST27	2.2	II-	2.2	100%	II-	2.4	109%	II-	2.4	109%	II-
Pchinja	ST38	7.1	IV-	7.5	106%	IV-	8.0	113%	IV-	8.5	120%	IV-
	ST42	23.9	>IV	25.6	107%	>IV	27.8	116%	>IV	30.7	128%	>IV
	ST35	10.8	IV-	11.4	106%	IV-	12.3	114%	IV-	13.2	122%	IV-
Bregalnica	ST50	4.0	II+	4.3	108%	III-	4.6	115%	III-	4.9	123%	III-
	ST51	5.0	III-	5.4	108%	III-	5.8	116%	III+	6.2	124%	III+
	ST52	8.6	IV-	9.3	108%	IV-	10.2	119%	IV-	11.0	128%	IV-
	ST53	7.3	IV-	7.9	108%	IV-	8.6	118%	IV-	9.3	127%	IV-
Crna	ST62	12.2	IV-	12.6	103%	IV-	13.2	108%	IV-	13.9	114%	IV+
	ST63	11.6	IV-	11.9	103%	IV-	12.4	107%	IV-	12.8	110%	IV-
	ST64	9.8	IV-	10.0	102%	IV-	10.4	106%	IV-	10.7	109%	IV-
	ST66	8.2	IV-	8.4	102%	IV-	8.8	107%	IV-	9.1	111%	IV-
Strumica	ST102	18.5	IV+	19.7	106%	IV+	21.0	114%	>IV	22.3	121%	>IV
	ST103	17.6	IV+	19.1	109%	IV+	20.7	118%	>IV	22.4	127%	>IV
	ST104	25.1	>IV	26.8	107%	>IV	28.7	114%	>IV	30.8	123%	>IV
Crn Drim	ST87	2.0	II-	2.1	105%	II-	2.2	110%	II-	2.3	115%	II-
	ST98	4.8	III-	4.8	100%	III-	5.1	106%	III-	5.3	110%	III-
	ST89	2.5	II-	2.5	100%	II-	2.6	104%	II-	2.8	112%	II-

Note:*, The maximum approved level of BOD_5 in water is regulated in the Ambient Standard as follows (Official Gazette of SRM No.9-84)

Class	
Class I	2
II	4
III	7
IV	20

BOD_5 (mg/lit)

Class II- : 2.0~3.0
II+ : 3.1~4.0
III- : 4.1~5.5
III+ : 5.6~7.0
IV- : 7.1~13.5
IV+ : 13.6~20.0
>IV : over 20.1

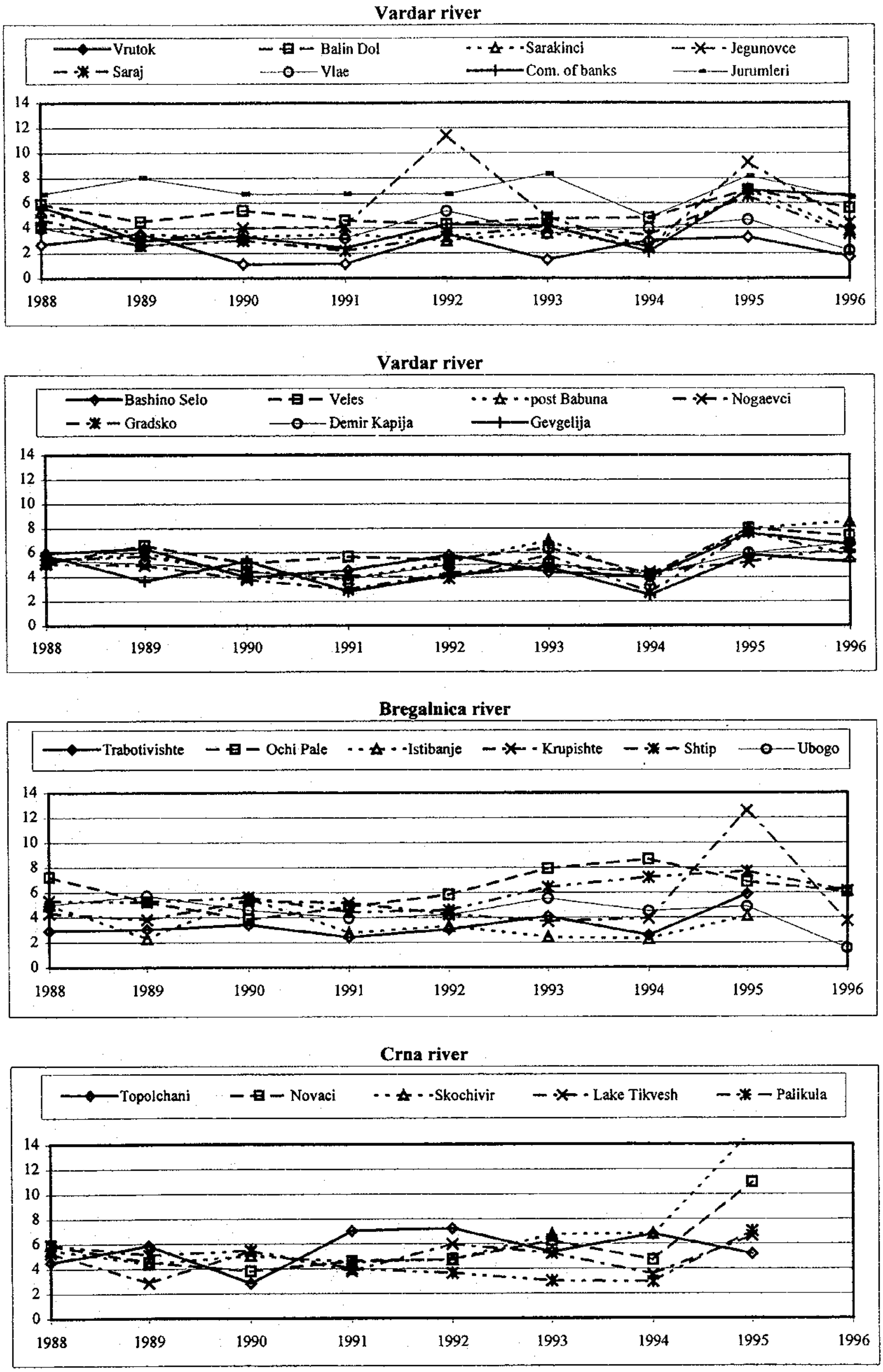
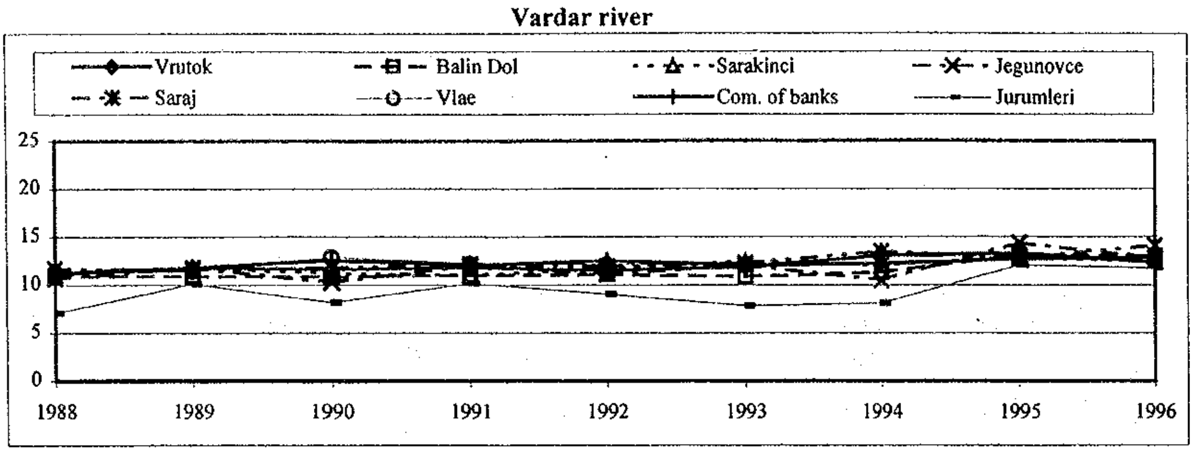
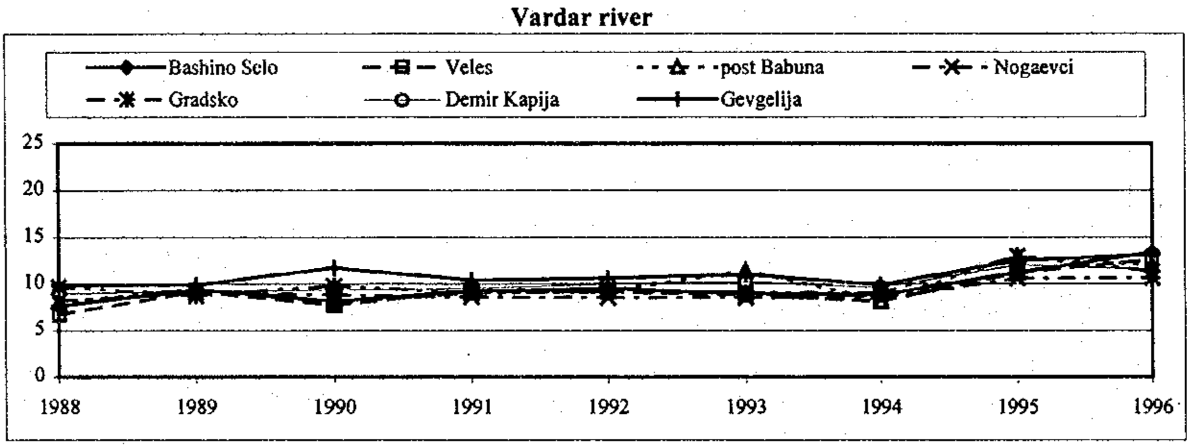
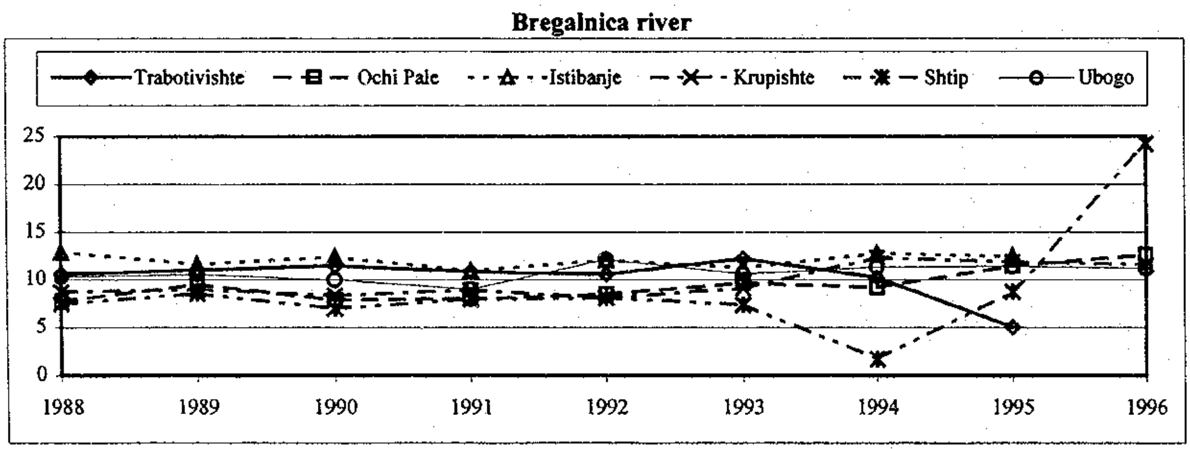


Figure C.1 Concentration of the Biochemical Oxygen Demand (BOD, mg/l)







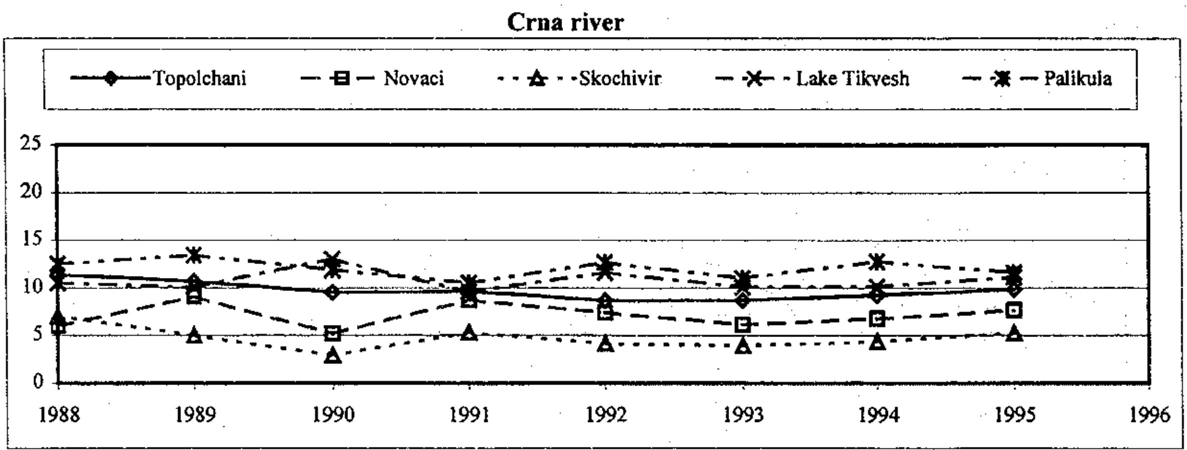


Figure C.2 Concentration of the Dissolved Oxygen (DO, mg/l)

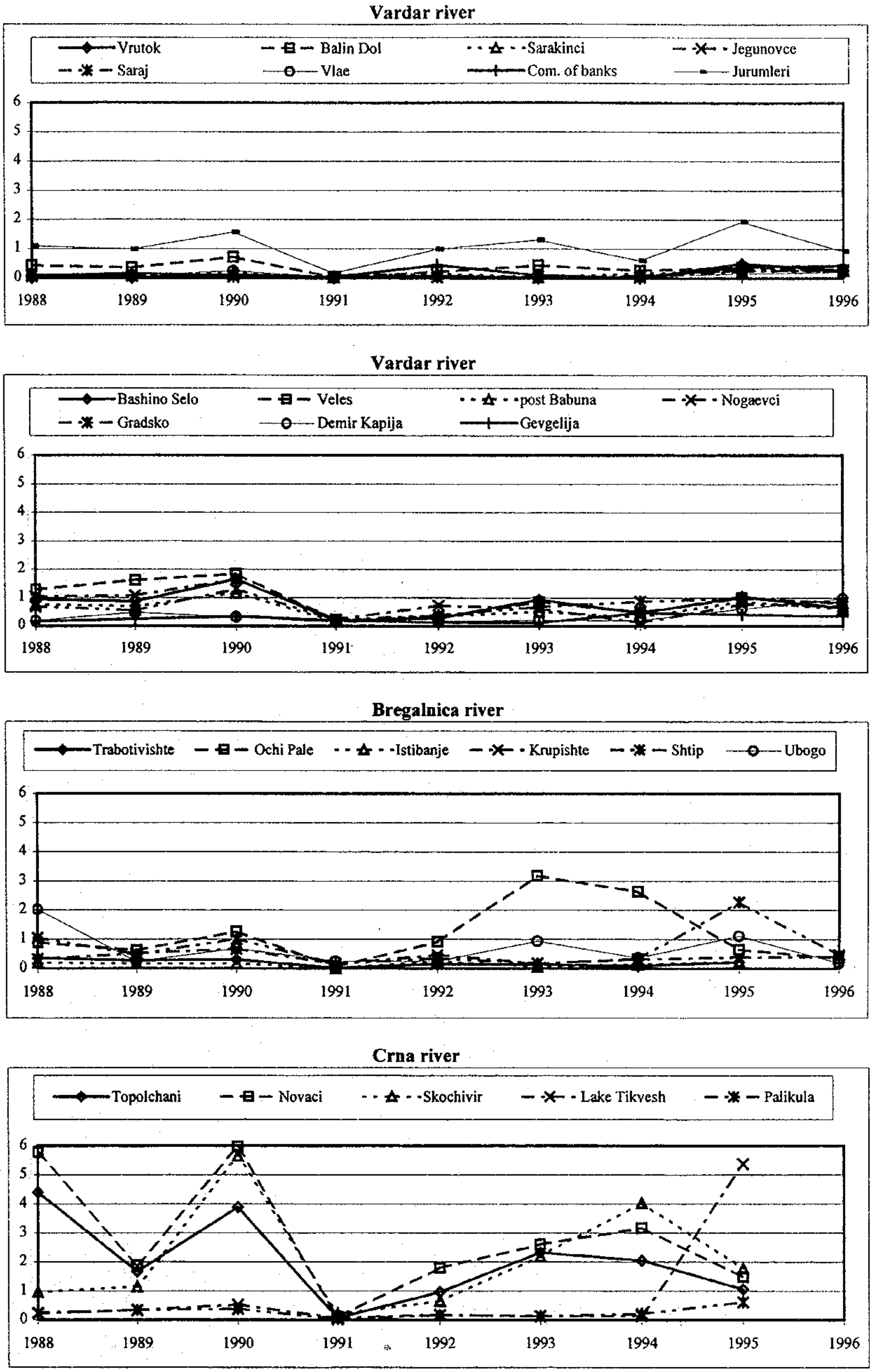


Figure C.3 Concentration of the Ammonical Nitrogen (N-NH4, mg/l)

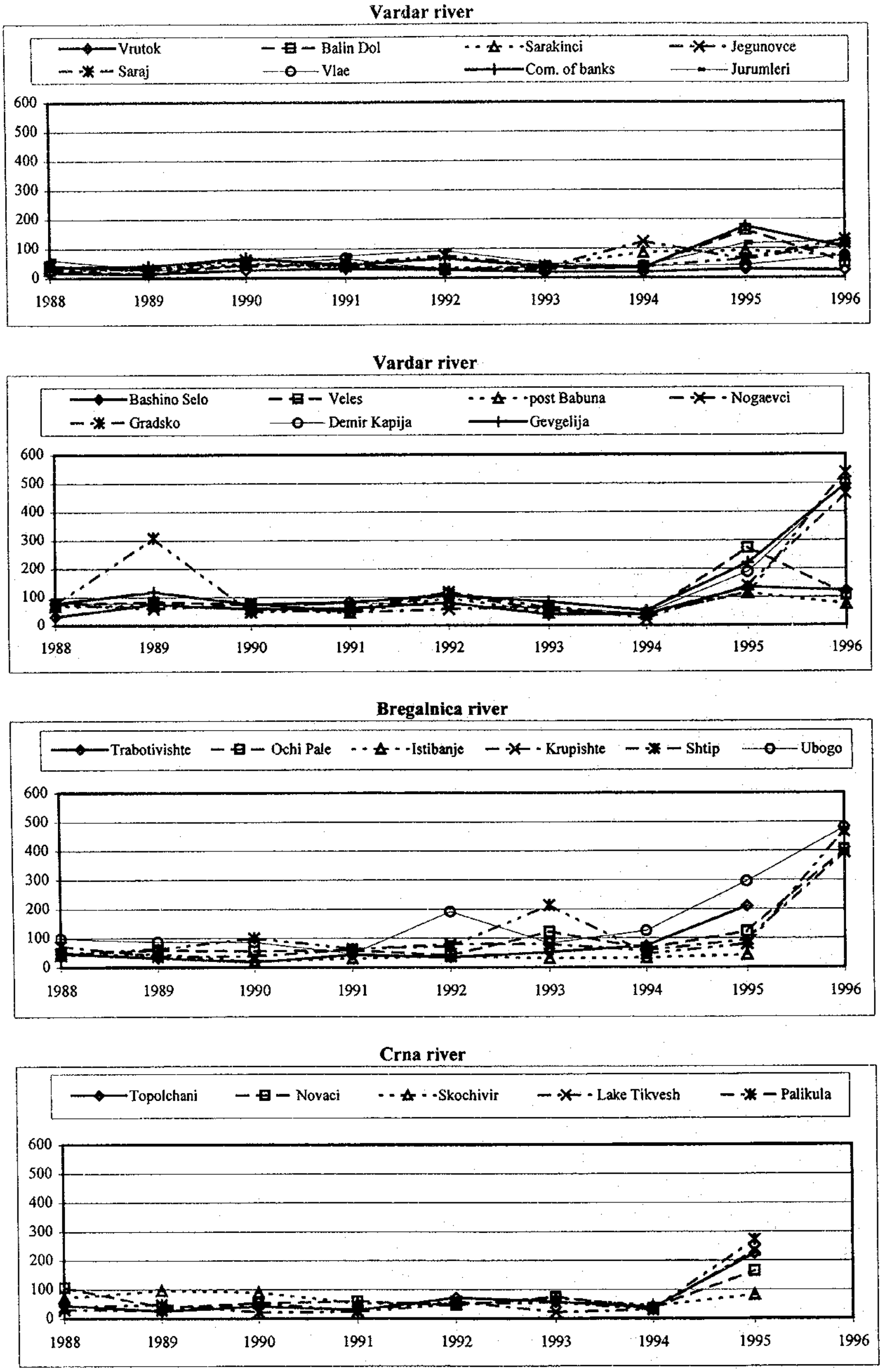


Figure C.4 Concentration of the Total Suspended Solids (SS, mg/l)

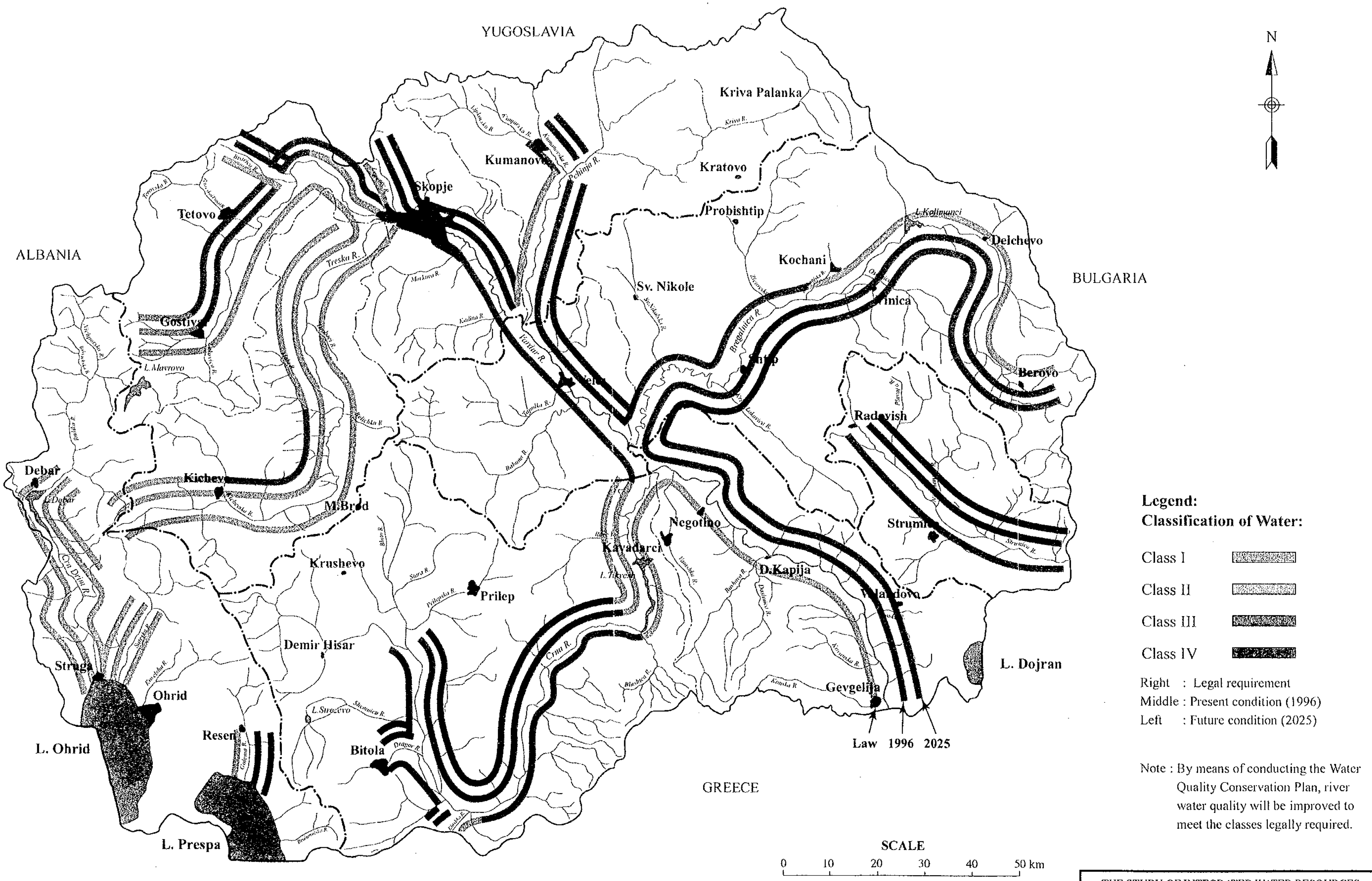


Figure C.5 Water Quality Legally Required and Estimated Water Quality 1996

THE STUDY OF INTEGRATED WATER RESOURCES DEVELOPMENT AND MANAGEMENT MASTER PLAN IN THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA

JAPAN INTERNATIONAL COOPERATION AGENCY