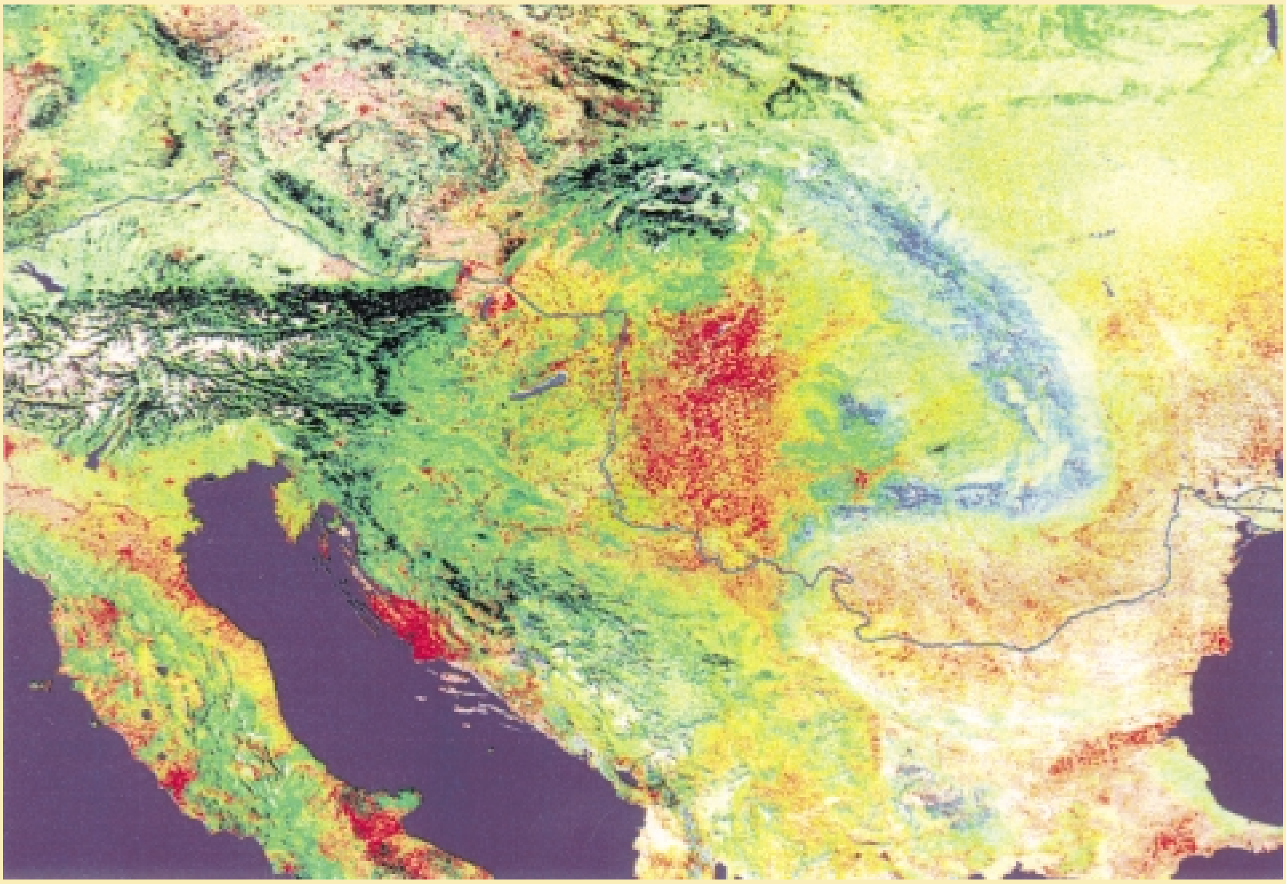
DANUBE POLLUTION REDUCTION PROGRAMME

TRANSBOUNDARY ANALYSIS REPORT

JUNE 1999



Programme Coordination Unit
UNDP/GEF Assistance

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Preface

The Transboundary Analysis Report was prepared in the frame of the UNDP / GEF Danube River Pollution Reduction Programme. The report is an integral part of a set of reports that together constitute the final product of the current stage of the Programme. The respective reports minimize recapitulation of details by cross referencing one another. As a result, the interested reader who wishes to obtain a complete picture of activities, findings and recommendations of the Pollution Reduction Programme should obtain copies of two other main reports of the Programme and three of the supporting reports of the Transboundary Analysis:

- UNDP / GEF Danube River Pollution Reduction Programme, Strategic Action Plan for the Danube River Basin - Revision 1999.
- UNDP / GEF Danube River Pollution Reduction Programme, Danube River Pollution Reduction Programme Report, June 1999.
- UNDP / GEF Danube River Pollution Reduction Programme, Development and Application of the Danube Water Quality Model in Support of the Transboundary Analysis and the Pollution Reduction Programme, June 1999.
- UNDP / GEF Danube River Pollution Reduction Programme, Evaluation of Wetlands and Floodplain Areas in the Danube River Basin, June 1999.
- UNDP / GEF Danube River Pollution Reduction Programme, Thematic Maps of the Danube River Basin - Social and Economic Characteristics with particular attention to Hot Spots, Significant Impact Areas and Hydraulic Structures, June 1999.

The analysis was carried out in accordance with recommendations presented in the Operational Strategy of the Global Environmental Facility, draft GEF documents on the contents of transboundary analyses reports, personal communications with Andrew Hudson of the UNDP / GEF Office in New York, and results of other transboundary analyses, especially the Black Sea Transboundary Diagnostic Analysis. The main sources of information for the Transboundary Analysis were National Review Reports prepared by 11 countries, related contributions made by 2 countries (Austria and Germany), and a Transboundary Analysis Workshop convened in January 1999. An early draft of Chapters 1, 2 and 3 of the Transboundary Analysis Report was presented to this Workshop as background information.

The report was drafted by Donald L. Graybill, international water quality data expert, with major inputs from the UNDP/GEF team of international experts. Conceptual preparation and organization of activities were carried out by Joachim Bendow, UNDP / GEF Project Manager with the assistance of Andy Garner, UNDP/GEF Environmental Specialist. Socioeconomic information was compiled by Reinhard Wanninger, international socio-economic expert. Project information was compiled by Rolf Niemeyer, international water engineering consultant. Application of the Danube Water Quality Model was carried out by Jos van Gils, international water quality modelling expert, supported by a Working Group of international experts who are identified in the report of the DWQM. Sub-river Basin Areas and Sub-river Basins were identified and described and thematic Maps 1 through 12 were produced by Alexander Zinke, environmental management consultant and Ulrich Schwarz, cartographer. Information on significant impact areas (SIAs) and causal chain analyses was compiled by Mihaela Popovici and Alexander Zinke. Ecological and wetlands information was compiled and wetlands maps were produced by WWF - Auen Institute, Germany. The present document was edited by Michael Sokolnikov.

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1. Features of the Danube Basin

Transboundary analysis is a method for characterizing and evaluating problems involving water pollution that originates in one country and is transported across an international border to another country. The method is promoted by the Global Environmenal Facility (GEF) and is intended to provide the technical basis for development of a Pollution Reduction Programme. Transboundary analysis is useful for the Danube River Basin (DRB) which comprises 17 countries. Details of the method, as it is applied to the DRB and the DRB Pollution Reduction Programme, are presented in Chapter 2.

Information in this Chapter 1 is intended to provide an overview of the status of conditions in the DRB, that relate to water quality and pollution, and that are relevant for transboundary analysis. The information is based primarily on findings reported in National Review Reports prepared by 13 countries having large territories - or their entire country - within the basin. Supplemental information is provided from other reference documents to elaborate or summarize basinwide phenomena, which are not addressed or summarized in the reports of the respective countries. The 13 countries are Germany, Austria, Czech Republic, Slovak Republic, Hungary, Slovenia, Croatia, Bosnia and Herzegovina, Yugoslavia, Romania, Bulgaria, Moldova and Ukraine. Four countries with small territories in the basin are not included in the programme and did not submit reports. They are Switzerland, Italy, Poland and Albania.

1.1. Physical and Geographic

The National Review Reports describe the features of the Danube basin within their respective countries. Concise summaries of overall basin features are available from a number of reference documents including Encyclopaedia Britannica (1993). In this section, excerpts have been used liberally as indicated.

The Danube River rises in the Black Forest mountains of Germany, flows about 2,850 km to the Black sea, drains about 817,000 km2 and includes about 300 tributaries, of which 30 are navigable. "Three sections are discernible in the river's basin. The upper course stretches from its source to the gorge, called the Hungarian Gates, in the Austrian Alps and the Western Carpathian Mountains. The middle course runs from the Hungarian Gates to the Iron Gate Gorge in the Southern Romanian Carpathians. The lower course flows from the Iron Gate to the deltalike estuary at the Black Sea" . Some descriptions recognize the delta as a separate fourth section of the basin.

A sketch of the Danube River Basin is presented in the Danube Basin Map, which shows the main river flowing generally in an easterly direction, with several sharp bends that result in southerly flow between Budapest and Belgrade and northerly flow near the entrance to the delta.

The longitudinal profile of the Danube River is presented in Figure 1.1-1 which shows the aforementioned three sections in relation to national boundaries, river kilometers, left and right bank tributaries and elevation changes.

A diagram of the Danube River Basin is presented in Figure 1.1-2 which shows, on the horizontal axis, the area of tributary basins as well as the total area of DRB; on the horizontal axis, the sequence and distance of tributaries from the river mouth, and the sequence, locations and names of gauging stations; and within the diagram, next to the names of the tributaries, the discharges for selected larger tributaries. The largest tributary by area is the Tisa River with 157,000 km2. The largest tributary by mean annual discharge is the Sava with 613m3/s.

The sequence and profiles of Danube primary tributaries are presented in Figure 1.1-3 which shows for each tributary, its name, its elevation at its source and its elevation and river kilometer at the point of its confluence with the Danube River (the horizontal axis denotes river kilometers for the Danube River and the vertical axis denotes elevation above sea level).

A schematic map of the DRB is presented in Figure 1.1-4 which shows the sequence of selected tributaries and water quality monitoring stations that are part of the Trans National Monitoring Network which is measuring water quality and computing pollutant loads for the DRB.

Transboundary relationships within in the basin are summarized in a series of tables. Table 1.1-1 is a matrix of direct transboundary relationships within the basin. The axis labeled "Source Countries" denotes countries which are directly upstream of other countries, and which discharge water and pollution to these other countries. The axis labeled "Direct Recipient Countries" denotes countries which are directly downstream of other countries and which receive water and pollution from them. The "X"s in the matrix denote the various combinations of "Source Countries" and "Direct Recipient Countries" that exist within the Danube Basin. Table 1.1-2 is a matrix of direct and indirect transboundary relationships. This matrix is similar in general arrangement to Table 1.1-1, but the "X"s denote all countries that are downstream of the source country. Annex 1.1A summarizes direct transboundary relationships by country and river. Annex 1.1B summarizes Direct Transboundary Relationships by River and gauging station or monitoring station.

Figure 1.1-5 and Annex 1.1C summarize the distribution of national territories within the Danube Basin and reveals how the area of the basin is widely distributed among 17 countries. On the basis of land area within the basin the dominant country is Romania with more than 232,200 km2 covering more than 28 percent of the basin. The country with the largest percentage of its area within the basin is Hungary (100 percent).

Table 1.1-3 summarizes the distribution of Danube Basin land uses and rainfall by country. Romania has the largest area in the basin and by far the largest land use in the basin in all categories. Austria appears to have the highest precipitation. Map 1 summarizes the relationship between geomorphological regions and annual precipitation within the DRB and shows that average annual rainfall varies from more than 3,000 mm to less than 500 mm in different parts of the basin.

Danube Basin Map

- Catchment boundary
- State boundary
- City
- River
- Water level measuring station
- Hydropower dams

0 100 200 km

Date: January 1996

Prepared by: delft hydraulics

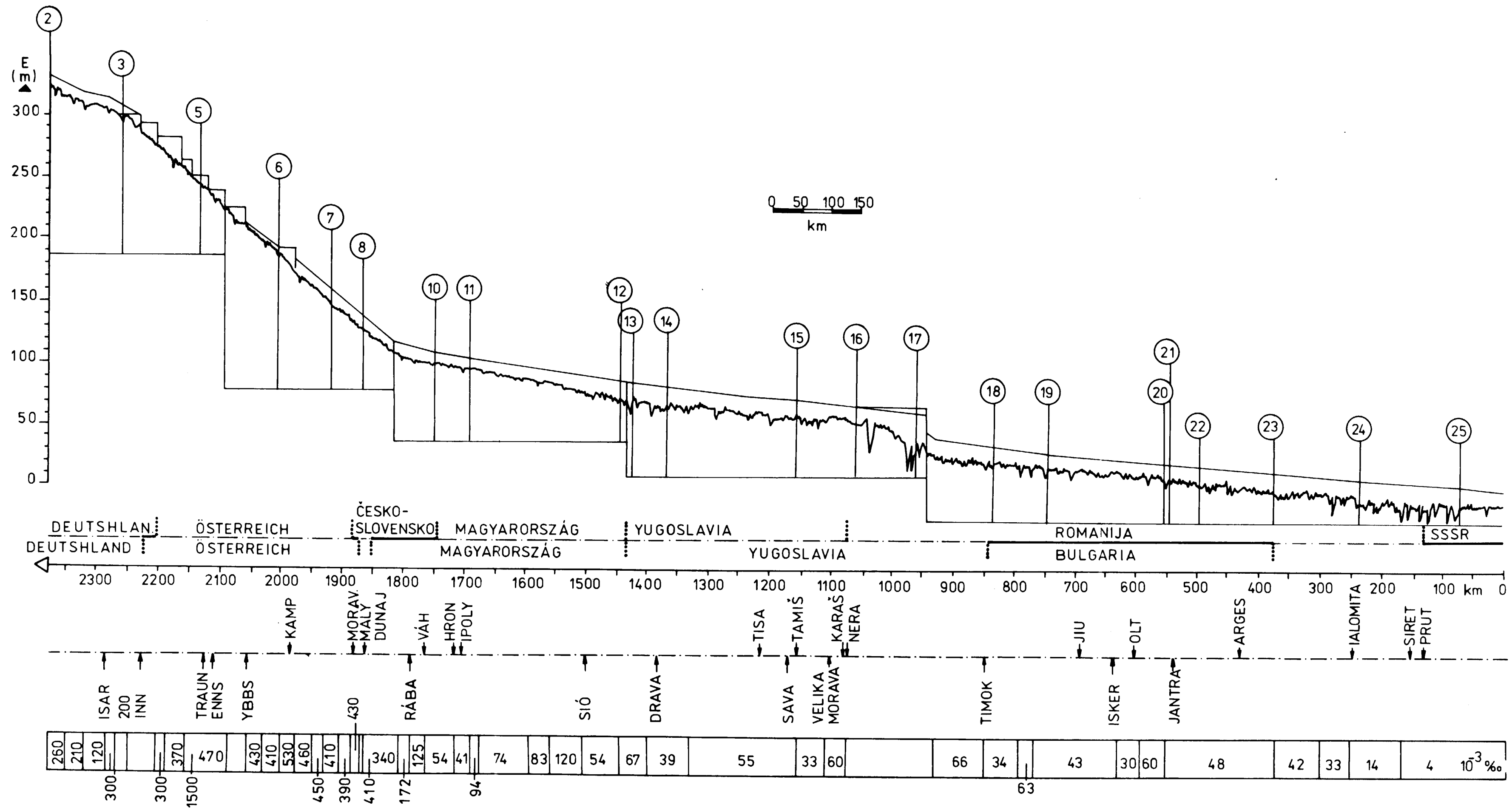


Figure 1.1-1 Longitudinal Profile of the Danube River Basin

Source: Redrawn from Stancik Andrej and Slavoljub Jvanovic at al. 1988, Hydrology of the Danube River

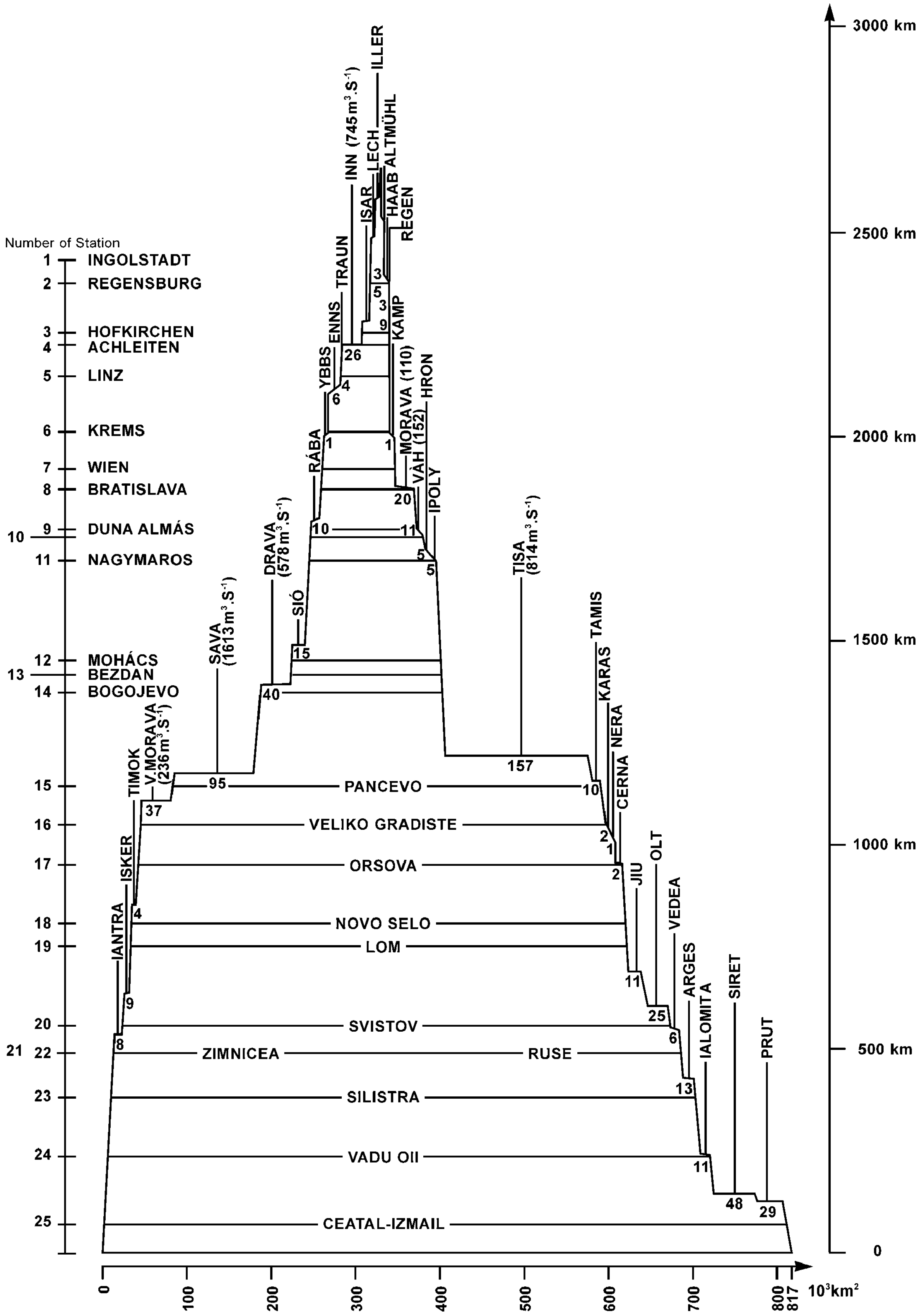


Figure 1.1-2 Diagram of Area, Sequence and Length of Danube Tributary Basins

Source: Redrawn from Stancik Andrej and Slavoljub Jvanovic at al. 1988, Hydrology of the Danube River

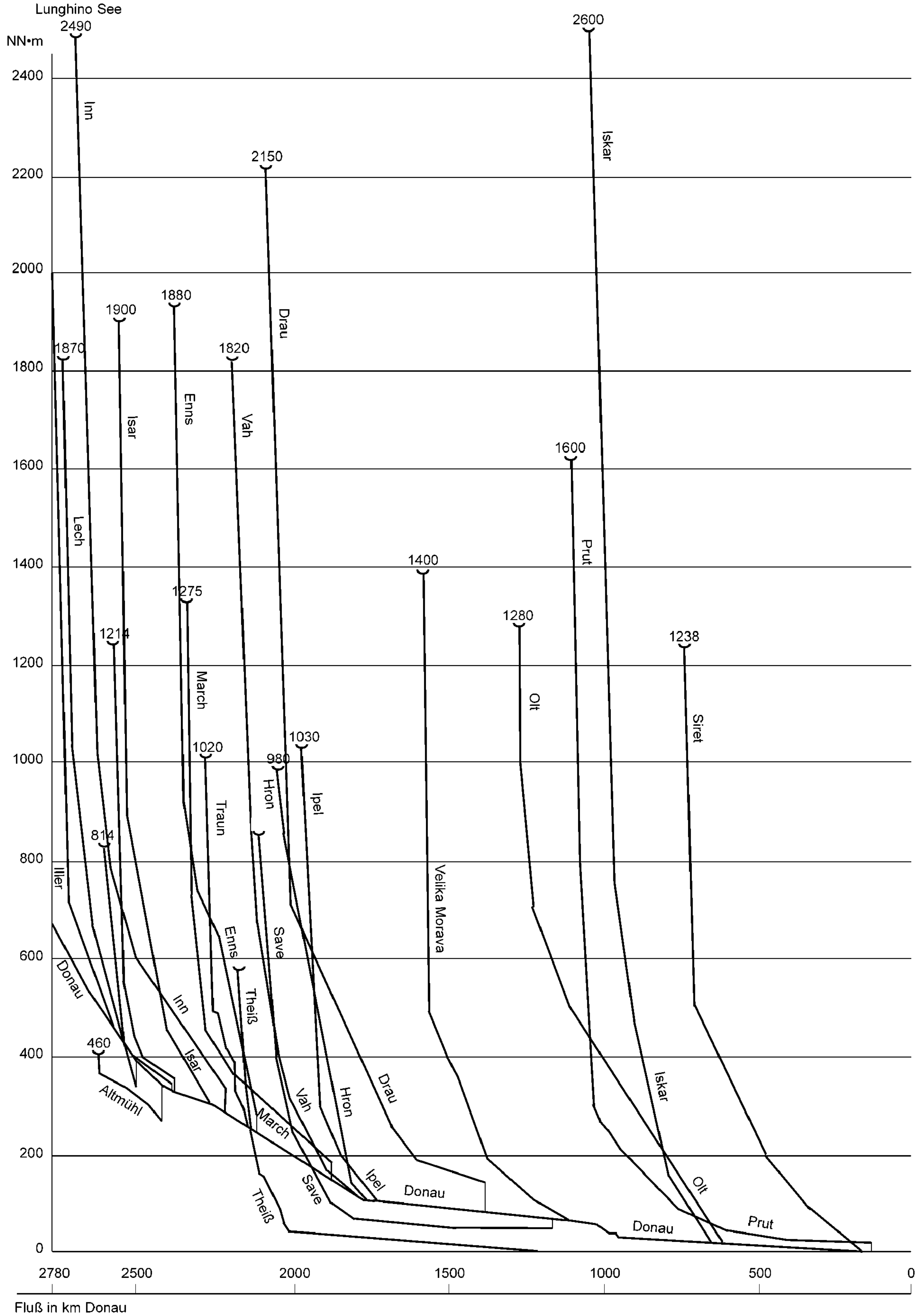
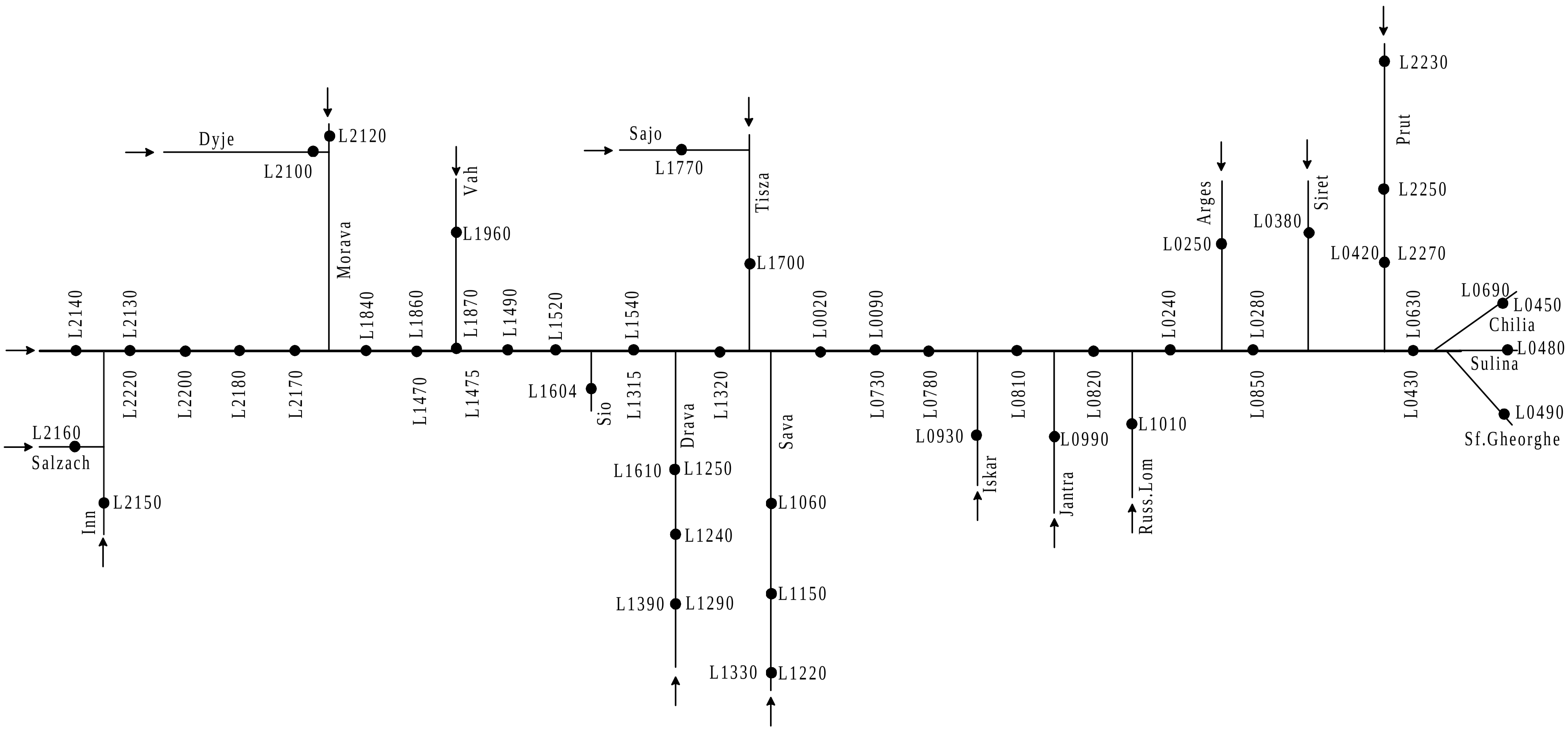


Figure 1.1-3 Profiles and Sequence of Danube Primary Tributaries

Source: Included into the German contribution to the National Reviews

Figure 1.1-4 Schematic Map of the TNMN stations



Source: Project M1: Transboundary assessment of pollution loads and trends, Final Report, (Phare OSS No. 97-5029.00) - Fig. 6.1. Schematic map of the TNMN stations

Table 1.1-1 Matrix of Direct Transboundary Relationships within the Danube Basin

Source Countries	Direct Recipient Countries												
	D	A	CZ	SK	H	SI	HR	BIH	FRY	BG	RO	MD	UA
D		X											
A	X			X	X	X							
CZ		X		X									
SK			X		X								
H				X			X		X				
SI					X		X						
HR					X			X	X				
BIH							X		X				
FRY								X		X	X		
BG									X		X		
RO					X				X	X		X	X
MD											X		X
UA				X	X						X	X	
*		X		X					X				

Note: The asterisk (*) refers to countries with small areas and discharges in the basin, which are not included in the analysis. These countries are Italy, Switzerland, Albania and Poland.

Table 1.1-2 Matrix of Direct and Indirect Transboundary Relationships within the Danube Basin

Source Countries	Direct or Indirect Recipient Countries												
	D	A	CZ	SK	H	SI	HR	BIH	FRY	BG	RO	MD	UA
D		X		X	X		X		X	X	X		X
A	X			X	X	X	X		X	X	X		X
CZ		X		X	X		X		X	X	X		X
SK			X		X		X		X	X	X		X
H				X			X		X	X	X		X
SI					X		X	X	X	X	X		X
HR					X			X	X	X	X		X
BIH							X		X	X	X		X
FRY								X		X	X		X
BG									X		X		X
RO					X				X	X		X	X
MD											X		X
UA				X	X					X	X	X	
*		X		X	X		X		X	X	X		X

Note: The asterisk (*) refers to countries with small areas and discharges in the basin, which are not included in the analysis. These countries are Italy, Switzerland, Albania and Poland.

Table 1.1-3 Distribution of Danube Basin Land Uses and Rainfall by Country

Country	Land in Danube Basin (1000 km2)	Arable Land (1000 km2)	Meadows/Pasture (1000 km2)	Forest (1000 km2)	Precipitation (mm/year)
Austria	81	17.8	19.4	34.0	1165
Bulgaria	46	17.0	7.4	11.5	
Bosnia - Herzegovina	38.7				
Croatia		16.2	**2.9		
Czech Rep.	21	13.0	0.84	7.7	450-1150 mean 635
Germany	55.8	12.7		14.3	
Hungary	93	47.4	12.1	16.7	660
Moldova	13	6.6	1.6	1.6	450
Romania	238	92.8	47.6	61.9	515
Slovak Rep.	47	15.04	8.93	17.86	753
Slovenia	16	2.4	2.7	8.2	-
Ukraine	26	6.2	4.9	14.0	975
Yugoslavia	88.9	*63.2			830
Others					

Source: Adapted from "Nutrient Balances for Danube Countries", supplemented by data from national review reports.
* *For the entire country, not just the Danube Basin area.*
** *Grazing area.*

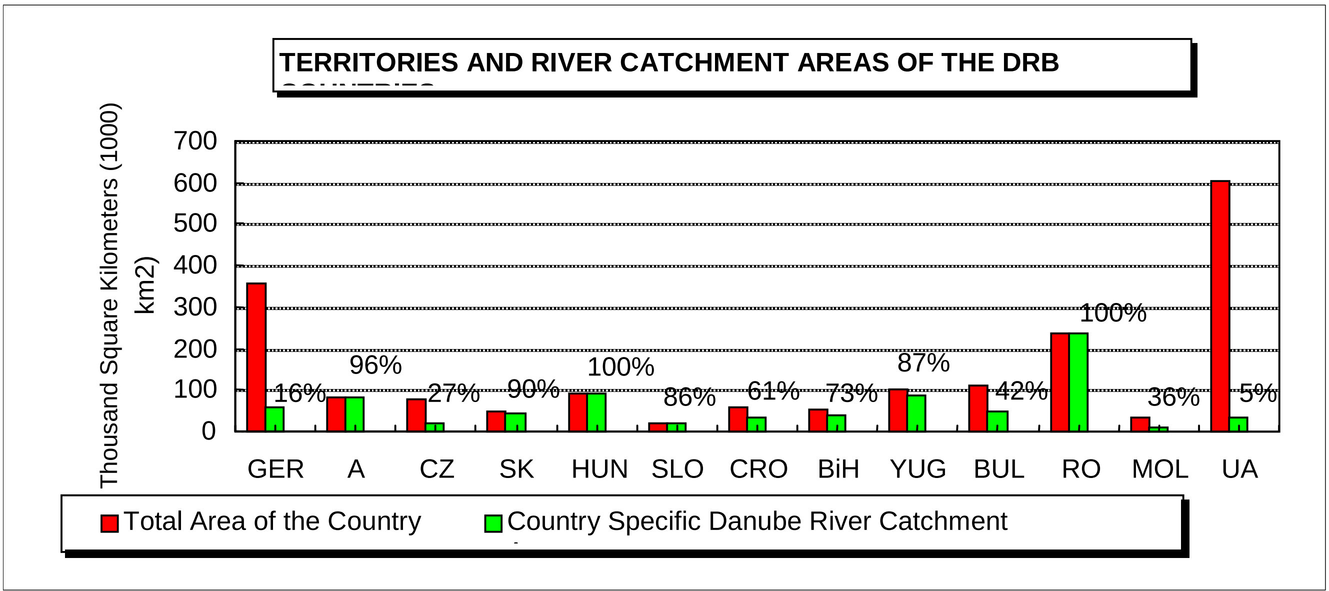
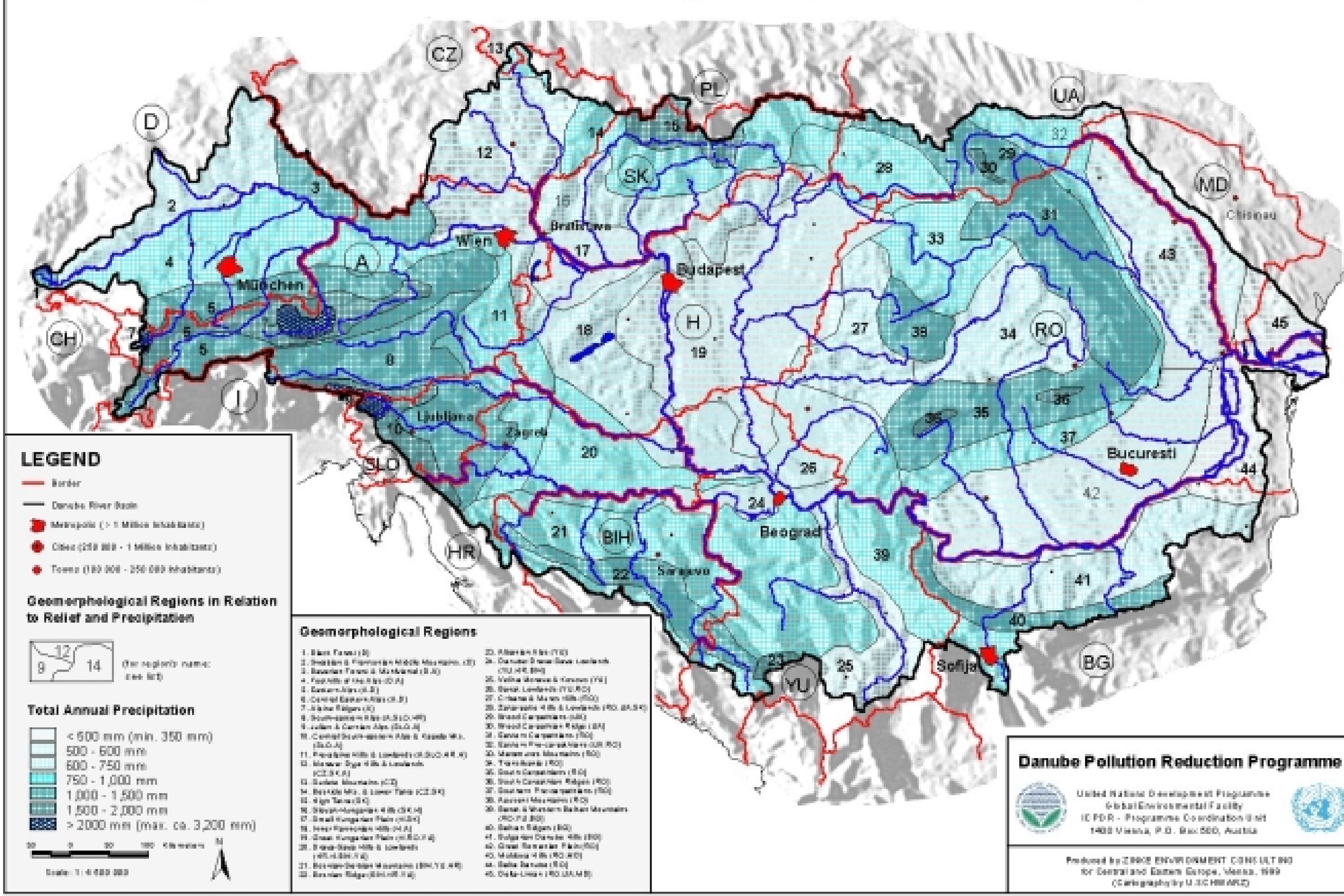


Figure 1.1-5 Territories and River Catchment Area of the DRB Countries

Map 1: Geographical Indicators: Geomorphological Regions and Annual Precipitation



1.2. Hydrological

The upper Danube has a considerable average inclination of the river bed that is about 0.4 percent in Austria and higher in upstream areas; and "a rapid current of two to five miles per hour [three to eight km per hour]. Depths vary from three to 26 feet (one to eight meters)…"

"In the middle course the Danube looks more like a flatbed river, with low banks and a bed that reaches a width of more than one mile [1.6 km]. Only in two sectors - at Visegrad (Hungary) and the Iron Gate - does the river flow through narrow, canyonlike gorges...The Danube enters the Little Alfold plain immediately after emerging from the Hungarian Gates Gorge near Bratislava.... There the river stream slows down abruptly and loses its transporting capacity, so that enormous quantities of gravel and sand settle on the bottom. A principal result of this deposition has been the formation of two islands, one on the...[Slovakian] side of the river and the other on the Hungarian side, which combined have an area of about 730 square miles [1,869 km2] that support some 190,000 inhabitants in more than 100 settlements. The silting hampers navigation and occasionally divides the river into two or more channels....The Danube then flows past Budapest and across the vast Great Alfold plain until it reaches the Iron Gate gorge. The riverbed is shallow and marshy, and low terraces stretch along both banks. River accumulation has built a large number of islands, including Csepel Island near Budapest. In this long stretch the river takes on the waters of its major tributaries - the Drava, the Tisza and the Sava - which [increase the flow by 2.5 times and] create substantial changes in the river's regime....

"Beyond the Iron Gate the lower Danube flows across a wide plain; the river becomes shallower and broader, and its current slows down...The tributaries in this section are comparatively small and account for only a modest increase in the total runoff [about 1,500 m3/s]. They include the Olt, the Siret and the Prut. The river is again obstructed by a number of islands...Near Tulcea, some 50 miles [80 km] from the sea, the river begins to spread out into its delta.

"The river splits into three channels - the Chilia, which carries 63 percent of the total runoff; the Sulina, which accounts for 16 percent; and the Sfintu Gheorghe (St. Geroge), which carries the remainder. Navigation is possible only by way of the Sulina Channel, which has been straightened and dredged along its 39-mile [62-km] length. Between the channels, a maze of smaller creeks and lakes are separated by oblong strips of land... [which] are arable and cultivated, and some are overgrown with tall oak forests. A large quantity of reeds that grow in the shallow-water tracts are used in the manufacture of paper and textile fibres. The Danube Delta covers an area of some 1,600 square miles [4,100 km2] and is a comparatively young formation. About 6,500 years ago the delta was a shallow low cove of the Black Sea coast, but it was gradually filled by river-borne silt; the delta continues to grow seaward at a rate of 80 to 100 feet [24 to 30 m] annually.

"The different physical features of the river basin affect the amount of water runoff in its three sections. In the upper Danube the runoff corresponds to that of the Alpine tributaries, where the maximum occurs in June when melting of snow and ice in the Alps is the most intensive. Runoff drops to its lowest point during the winter months.

"In the middle basin the phases last up to four months with two runoff peaks in June and April. The June peak stems from that of the upper course, reaching its maximum 10 to 15 days later. The April peak is local. It is caused by the addition of waters from the melting snow in the plains and from the early spring rains of the lowland and the low mountains of the area. Rainfall is important; the period of low water begins in October and reflects the dry spells of summer and autumn that are characteristic of the low plains. In the lower basin all Alpine traits disappear completely from the river regime. The runoff maximum occurs in April, and the low point extends to September and October" (Encyclopaedia Britannica, 1993).

Table 1.2-1 summarizes the Danube River probability of annual runoff at selected stations whose locations were shown in Figure 1.1-2. Mean annual discharge near the mouth of the Danube River (station 25) is 6,550 m3/s. The range of variability in annual discharge is suggested by the percent probability, which shows that for a 1 in 20 dry year (95 % probability), annual discharge is 4,600 m3/s; but for a 1 in 20 wet year (5 % probability), annual discharge is 8,820 m3/s.

Figure 1.2-1 summarizes the Danube River seasonal pattern of mean monthly discharges for selected stations from the upper basin to the lower basin. Table 1.2-2 summarizes Danube River mean monthly and annual flows for Danube stations and selected tributary stations. These exhibits reveal notable seasonal differences between discharge at upstream stations (e.g., station 1, where discharge is nearly constant throughout the year) and downstream stations (e.g. station 25 where high discharges occur in April and May and low discharges occur n September and October).

The distribution of runoff by country is summarized in Table 1.2-3. The former Yugoslav countries together were the dominant source of runoff, accounting for more than 2,000 m3/s of discharge (more than 27 percent of the basin total). With 17 countries in the DRB, Austria is the major source, with more than 1,500 m3/s (more than 22 percent of the basin total).

"The river carries considerable quantities of solid particles, nearly all of which consist of quartz grains. The constant shift of deposits in different parts of the riverbed forms shoals. In the stretches between Bratislava and Komarno and in the Sulina Channel, draglines are constantly at work to maintain the depth needed for navigation. The damming of the river has also changed the way in which sediments are transported and deposited..." (Encyclopaedia Britannica, 1993).

The distribution of reservoirs and storage in the DRB is summarized in Table 1.2-4 which was compiled for the Danube Water Quality Model (DWQM). The locations of major hydraulic structures are shown in Map 12.

Table 1.2-1 Probability of Annual Runoff at Selected Stations along the Danube River

No.	Station	Mean discharge (m3, s-1)	Probability %														
			1	2.5	5	10	20	30	40	50	60	70	80	90	95	97.5	99
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
5	Linz	1509	2171	2053	1955	1846	1719	1632	1560	1494	1430	1364	1289	1190	1112	1047	975
6	Krems	1864	2696	2548	2425	2287	2128	2018	1927	1845	1765	1682	1588	1463	1366	1285	1196
7	Vienna	1945	2782	2633	2509	2371	2210	2099	2007	1924	1843	1759	1663	1537	1438	1355	1263
8	Bratislava	2020	3028	2840	2682	2511	2337	2200	2080	1970	1880	1780	1689	1548	1445	1350	1267
13	Bezdan	2479	3701	3469	3279	3069	2830	2667	2534	2416	2302	2186	2057	1890	1762	1659	1547
14	Bogojevo	3060	4594	4308	4073	3816	3522	3322	3159	3013	2873	2730	2571	2366	2209	2032	1944
15	Pancevo	5490	8285	7749	7313	6838	6801	5910	5648	5389	5143	4894	4621	4273	4012	3804	3538
16	V. Gradiste	5746	8742	8168	7701	7191	6617	6230	5917	5640	5376	511	4817	4444	4154	3942	3705
17	Orsova	5699	8500	8000	7550	7100	6560	6210	5890	5640	5350	5060	4789	4370	4150	4000	3860
18	Novo Selo	5842	8400	8300	8002	7560	6800	6390	6000	5660	5400	5100	4800	4380	4100	3940	3800
19	Lom	5766	8600	8400	8000	7500	6800	6300	5900	5500	5300	4900	4600	4200	4000	3800	3700
20	Svistov	6175	9200	8900	8400	7900	7200	6700	6400	6000	5700	5400	5100	4650	4300	4100	3900
21	Zimnicea	6152	9250	8700	8200	7700	7110	6700	6360	6060	5750	5440	5100	4690	4400	4200	4080
22	Ruse	6264	9200	8900	8600	8100	7300	6900	6500	6100	5800	5500	5100	4700	4400	4250	4100
23	Siistra	6300	9420	9000	8580	8000	7200	6800	6400	6010	5780	5400	5050	4690	4420	4390	4300
24	Vade Oii	6216	9450	8920	8430	7890	7260	6840	6480	6150	5850	5530	5180	4740	4480	4260	4440
25	Cearai																
	Izmail	6550	9980	9350	8820	8230	7620	7200	6840	6500	6200	5800	5440	4900	4600	4400	4740

Source: Stancik Andrej and Slavoljub Jovanovic et al. 1988, Hydrology of the Danube River

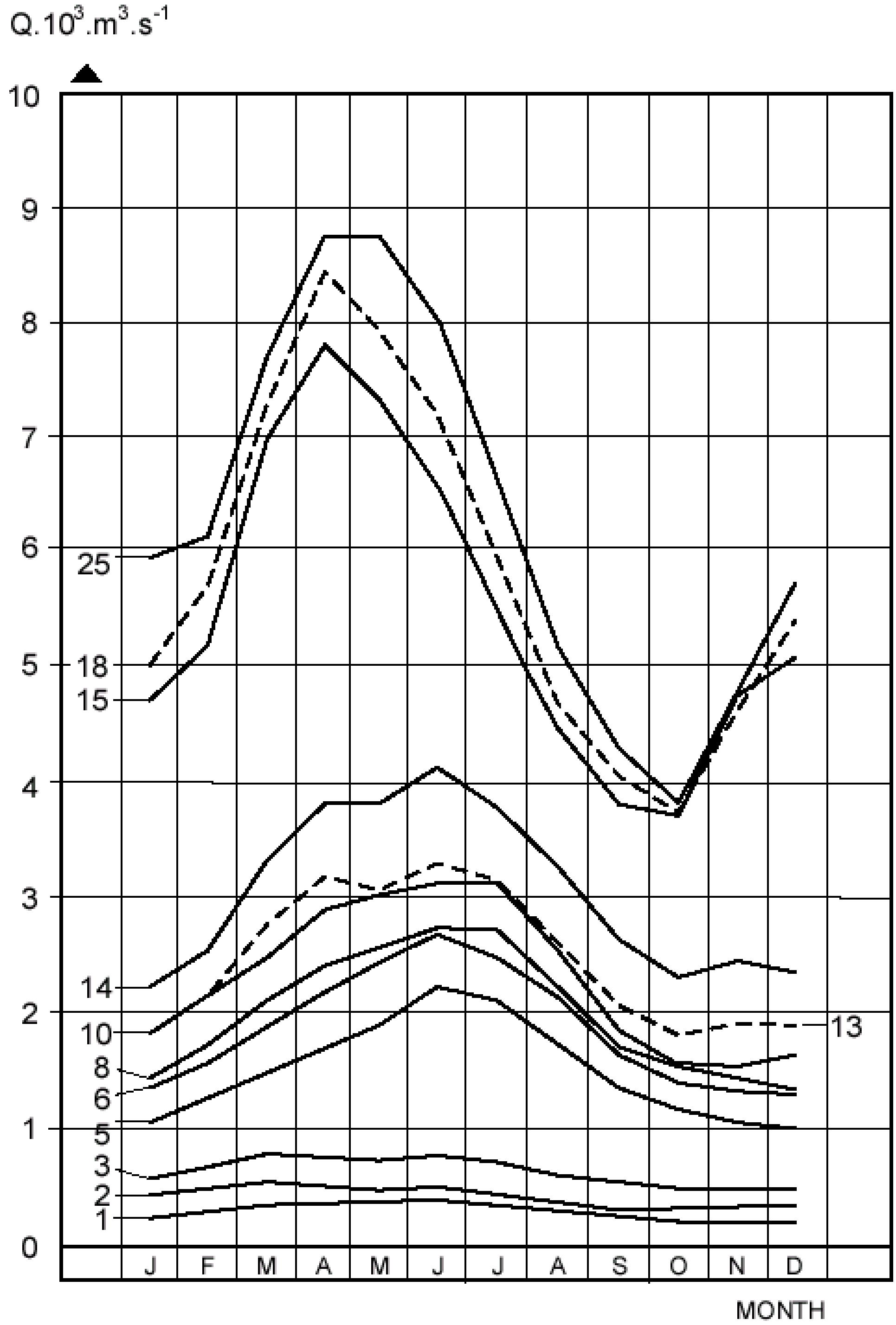


Figure 1.2-1 Seasonal Pattern of Mean Monthly Discharge for Selected Stations along the Danube

Source: Redrawn from Stancik Andrej and Slavoljub Jvanovic at al. 1988, Hydrology of the Danube River

Table 1.2-2 Mean Monthly and Annual flows for Danube River Stations and Selected Tributary Stations

			Month												Annual	
No	Station	River	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	m3/s	l/s km2
1	Ingolstadt	Danube	259	306	437	369	380	400	359	305	263	233	241	235	308	15.39
2	Regnsburg	Danube	408	495	548	537	494	506	468	394	348	329	351	368	435	12.29
3	Hofkirchen	Danube	590	698	771	767	723	764	723	618	536	506	520	537	645	13.58
5	Linz	Danube	1054	1237	1458	1667	1885	2232	2113	1787	1385	1160	1084	1042	1509	19
6	Krems	Danube	1301	1519	1805	2195	2436	2679	2546	2172	1654	1435	1345	1300	1864	19.4
7	Vienna	Danube	1352	1580	1897	2273	2543	2805	2649	2251	1714	1488	1399	1349	1943	19.1
9	Bratislava	Danube	1397	1677	2079	2455	2640	2894	2717	2284	1746	1506	1435	1410	2020	15.38
10	Dunaaimas	Danube	1760	2123	2453	2887	3021	3131	3128	2654	1876	1569	1544	1618	2314	13.48
11	Nagymaros	Danube	1849	2294	2712	3001	2939	3153	2962	2534	1956	1690	1734	1721	2379	12.96
13	Mohacs	Danube	1962	2225	2628	3037	2956	3157	2988	2597	2031	1745	1757	1782	2389	11.43
13	Bezdan	Danube	1773	2106	2731	3117	3087	3306	3092	2686	2122	1834	1922	1906	2479	11.79
14	Bogojevo	Danube	2169	2507	3273	3845	3825	4133	3803	3317	2670	2304	2456	2402	3060	12.16
15	Pancevo	Danube	4682	5155	6952	7871	7306	6573	5468	4421	3916	3701	4797	5124	5490	10.46
16	V. Gradiste	Danube	4884	5555	7327	8293	7703	6920	5759	4609	4002	3844	4935	5311	5746	10.07
17	Orsova	Danube	4867	5439	7315	8266	7641	6824	5637	4540	3914	3766	4882	5290	5699	9.89
18	Sovo Selo	Danube	4952	5684	7325	8476	7914	7174	6040	4695	4065	3734	4697	5426	5842	9.99
19	Lom	Danube	5104	5669	7371	8343	7865	6990	5941	4715	3940	3500	4471	5278	5766	9.79
20	Svistov	Danube	5312	5753	7710	8796	8596	7792	6419	4943	4261	3979	4956	5578	6175	9.5
21	Zimnicea	Danube	5273	5697	7655	8844	8575	7741	6416	4935	4245	3975	4948	5522	6150	9.34
22	Ruse	Danube	5422	5812	7799	8866	8710	7945	6548	5027	4333	4035	4997	5659	6264	9.35
23	Silistra	Danube	5740	5999	7977	8882	8782	7961	6689	5207	4318	3814	4596	5639	6300	9.13
24	Vada Oii	Danube	5454	5661	7692	8737	8719	7987	6639	5058	4312	3965	4809	5573	6216	8.77
25	Ceatal Izmail	Danube	5947	6139	7750	8783	9040	8477	7311	5579	4657	4218	4895	5764	6550	8.12
26	Wernstein	Inn	378	415	508	726	1034	1324	1257	1056	753	564	471	408	743	28.48
27	Salzburg	Salzach	77	80	112	190	291	347	308	264	174	129	107	93	181	40.88
28	Enns	Enns	88	110	166	290	372	318	283	235	147	140	126	118	200	33.81
29	Mor. Jan	Morova	96	137	210	201	125	101	80	69	65	58	86	92	110	4.56
30	Sala	Vah	105	135	219	268	191	159	158	129	102	100	131	121	152	14.31
31	Brehy	Hron	34	45	85	100	66	51	38	29	26	27	48	46	50	13.08
32	Sokolec	Ipel	20	32	60	38	19	16	8	7	6	6	21	24	21	4.34
33	Neubrücke	Drau	130	124	153	241	372	472	385	342	296	236	259	181	266	25.57
34	Landscha	Mur	65	66	98	174	242	240	192	184	135	113	115	88	143	17.15
36	Donji Mihoijac	Drava	374	386	501	572	726	824	681	590	511	465	550	458	554	14.92
37	Vilek	Tisa	158	234	288	431	314	231	193	165	112	109	153	203	216	23.63
38	Tiszabecs	Tisza	171	192	227	388	319	181	155	124	100	114	142	167	188	19.36
39	Szeged	Tisza	727	892	1346	1552	1252	941	692	479	377	337	507	702	813	5.87
40	Senta	Tisa	617	723	1221	1450	1194	881	666	460	406	371	564	644	766	5.4
41	Csenger	Szamos	122	179	229	225	174	134	96	65	54	59	83	103	127	8.31
42	Felsözsolea	Sajo	26	33	60	53	38	32	25	20	14	14	31	31	31	4.81
43	Mako	Maros	143	181	245	328	310	238	162	110	89	78	104	114	175	5.8
44	Semska Mitrovica	Sava	1785	1895	2370	2493	2156	1564	996	647	684	997	1818	1991	1613	18.33
45	Ljubicevski Most	V. Morava	238	370	455	432	359	245	152	90	81	95	143	185	238	6.38
46	Orahovica	Iskar	67	78	90	89	90	76	42	20	34	33	40	51	60	7.17
47	Stoenesti	Olt	96	140	191	273	312	252	178	129	89	82	93	104	162	7.14
48	Storozinec	Siret	2	3	7	11	10	10	7	6	4	2	2	2	6	8.93
49	Lungoci	Siret	83	115	186	328	316	282	195	161	114	93	94	94	172	7.77
50	Tchernovtsy	Prut	25	33	60	120	110	102	85	63	40	29	32	29	61	8.85

Source: Stancik Andrej and Slavoljub Jovanovic et al. 1988, Hydrology of the Danube River

Table 1.2-3 Approximate Distribution of DRB Runoff by Country

Country	Annual Volume of Runoff (km3/yr)	Mean Annual Runoff (m3/s)	Share of Danube Water Resources (%)	Ratio of Outflow minus Inflow ÷ Outflow (%)
Austria	48.44	1,536	22.34	63.77
Bulgaria	7.32	232	3.99	7.35
Czech Republic	3.43	110	1.93	
Germany	25.26	801	11.65	90.71
Hungary	5.58	176	2.57	4.97
Romania	37.16	1,177	17.00	17.35
Slovak Republic	12.91	407	7.21	23.0
Bosnia, Croatia and Slovenia	40.16*	1,274*	16.84*	
Moldova and Ukraine	10.41	330	4.78	9.52
Yugoslavia	23.5	746	10.70	13.19
Switzerland	1.40	44	0.64	86.67
Italy	0.54	17	0.25	100.00
Poland	0.10	3	0.04	100.00
Albania	0.13	4	0.06	100.00
Total	216.34	6,857	100.00	

Source: Adapted and updated from Stancik, Andrej and Slavoljub Jovanovic et al. 1988, Hydrology of the Danube River

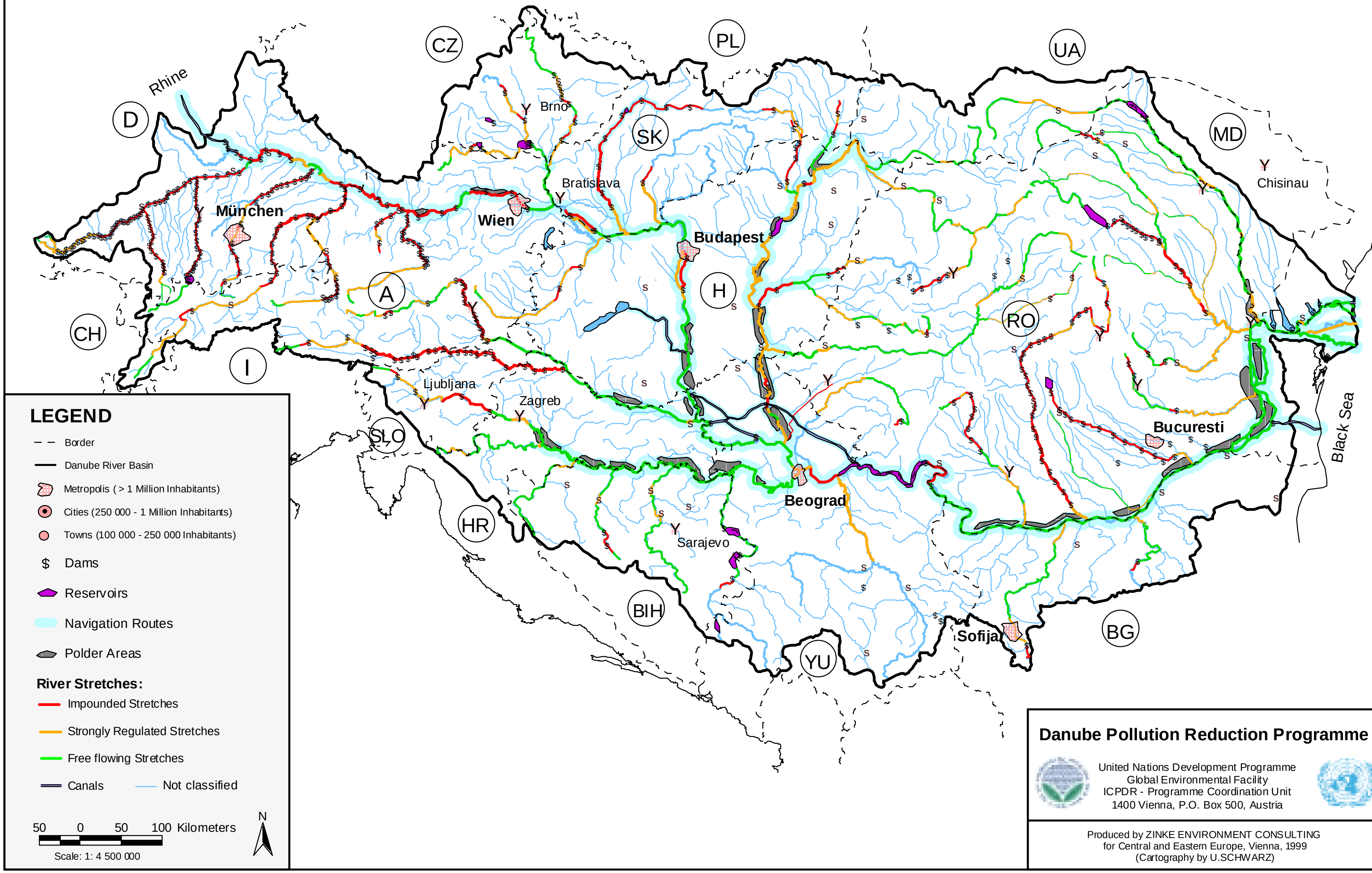
* *Derived by subtraction of current figures for the Federal Republic of Yugoslavia from combined figures for the former Yugoslav countries.*

Table 1.2-4 Data about Floodplains, Wetlands and Reservoirs

	Floodplains	Wetlands	Reservoirs
Germany	No data	Only a map available, no data.	No data
Austria	Total about 370 km2 (flooded 1/30 year).	Reported insignificant.	No quantitative data (reservoirs are included in the DBAM schematisation).
Czech Republic	Total of 410 km2, indicated on map. Extreme flood 1997: 1,946 km2.	Total of 19,000 ha, indicated on map.	Total of 569 Mm3, tabulated. 3 reservoirs > 100 Mm3 (table page 10, NR part A).
Slovakia	Total of 1469 km2, (flooded 1/10 year) total of 2973 km2, (flooded 1/1000 year)	Total of 149,000 ha, indicated on map. 2 areas > 20,000 ha.	Total of 1750 Mm3, tabulated. 5 reservoirs > 100 Mm3 (table 4-10, NR part B).
Hungary	Total of 1500 km2.	Total of 150,000 ha, indicated on map. 2 areas > 20,000 ha.	Total of 385 Mm3, tabulated. 1 reservoir > 100 Mm3 (table 4-8, NR part B).
Slovenia	Total of 664 km2	Estimate 26,000 ha (NR part A).	Total 345 Mm3, listed in table 5 of NR Part A.
Croatia	1805 Mm3 (?) in Sava basin	Total of 68,000 ha, 1 area > 20,000 ha.	Total of 50,6 Mm3 for storage, 159 Mm3 for hydropower
Yugoslavia	16,000 km2 for extreme floods, indicated on map	No quantitative data	Reported total of 6,500 Mm3, including Iron Gates (ca. 3,500 Mm3)
Bosnia-Herzegovina	Total of 1,704 km2	No data	Total of 763 Mm3, 2 bigger than 100 Mm3.
Bulgaria	Reported insignificant.	Total of 8,500 ha	Total of 2,311 Mm3. Some tabulated data.
Romania	Total of 7,452 km2. Tabulated data available.	Total of 293,000 ha, tabulated. 4 areas > 20,000 ha.	Total of about 10,000 Mm3, including Iron Gates (ca. 3,900 Mm3). 17 reservoirs > 100 Mm3 (table 4.5.1, NR part B).
Moldova	Total of 2,000 km2	No data	Total of about 1,000 Mm3. 1 reservoir > 100 Mm3 (tables 3.4.7.3/3.4.7.4, NR part B).
Ukraine	No data	No data	Total of lakes 700 Mm3 (part A), total of reservoirs 22 Mm3 (part B).

Map 12: Major Hydraulic Structures and Description of Rivers in the Danube Basin

Based on Information from National Level and Additional Research 1999



Danube Pollution Reduction Programme

United Nations Development Programme
Global Environmental Facility
ICPDR - Programme Coordination Unit
1400 Vienna, P.O. Box 500, Austria

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for Central and Eastern Europe, Vienna, 1999
(Cartography by U.SCHWARZ)

1.3. Ecological

Data on wetlands and floodplains were briefly summarized from the National Review Reports for the Danube Water Quality Model in previously cited Table 1.2-4. Other wetlands information that is presented in the National Review Reports is briefly described and partially summarized in Annex 1.3A which was produced by the wetlands study (Evaluation of Wetlands and Floodplain Areas in the Danube River Basin - Report and Annex). Selected statistics on fisheries in the Danube River Basin are presented in Table 1.3-1.

Other ecological information related to wetlands and rivers in the Danube Basin has been compiled and presented in the report and annex of the wetlands study (which covers only selected major rivers of the Danube Basin, not the entire basin). Parts of this information which are useful in describing the ecological context of the Danube Basin include:

- a description and map of the Geographical Subdivision of the Danube Basin (Map W2) which shows lowlands, plains / terraces, hills and narrow gorges within the major tributaries of the Danube catchment area; and boundaries between 6 regional subdivisions (I. Montane-Prealpine, II. Submontane-Centraleuropean, III. Pannonic, IV. Illyric, V. Balkanic-Moesic, VI. Pontic-Danubic).
- a table of protected areas by country (Table 1.3-2) that are based on sites of the Ramsar Convention and IUCN categories that were relevant for the wetlands study (I. Scientific reserves / strictly protected areas, II. National parks, IV. Nature reserves > 500 ha and IX. Biosphere reserves).
- a map of Floodplain Areas in the Danube River Basin with Protected Areas along the Studied Rivers (Map W1) which shows the locations of the aforementioned protected areas.
- a map of a Symbolized View of Floodplains in the Danube River Basin (Map W3) which shows the locations of former floodplains, recent floodplains and backwater areas of dams within the study area of the wetlands investigation.
- a map of Ecological Potential of Floodplains in the Danube River Basin (Map W4), which shows specific problem areas and which classifies ecological potential in four categories for very high to low.
- maps of the distribution of Selected Bioindicator Species (for fish and for the white-tailed eagle) (Maps W5 and W6).
- descriptions of the occurrence of bioindicator species and ecological evaluations of the major catchment areas are presented in th wetland study report

Wetlands suitable for restoration are mapped and briefly characterized in terms of their nutrient reduction potential in Section 3.7.

Table 1.3-1 Main Characteristics of Fishery in the DRB

Country	Overall River, Lake, Pond Fishery in the Country			River and Related Pond Fishery in the Danube River Basin			Remarks
	Year	Quantity per Year	Market Value of Catch	Year	Quantity per Year	Market Value of Catch	
		Tons/a	Mln US$		Tons/a	Mln US$	
Bosnia & Hercegovina	--	--	--	--	--	--	Actually not relevant, potentials in hydro-power reservoirs and lakes
Bulgaria	--	--	--	1997	449	--	Registered catch only, 2238 licences for commercial fishing
Croatia	1996	2996	4.511	1996	17996	4.511	2996 tons from river fishery, about 15000 tons from fish farming in ponds; 434 registered fishermen
Czech Republic	--	--	--	--	--	--	River fishery not relevant
Hungary	1996	21124	22.400	1996	13518	22.400	13518 tons from fish farming, 7606 tons from rivers, reservoirs; 2910 people employed in fishery
Moldova	--	--	--	1996	806	0.806	Including fish production from fish farming in ponds
Romania	1996	24781	--		24781	--	Including production from fish farming, not including catch of sport fishing (200000 licences)
Slovakia	1997	2840	--		--	--	River fishery in Danube River Basin not relevant
Slovenia	1996	298	--	1996	267	--	Insignificant from commercial point of view, relevant only from the view of sport fishing
Ukraine	--	--	--	1996	1490	--	Communal fish production in lakes and ponds
Yugoslavia	--	--	--	1997	13375	30.000	12695 tons from fish farming; 680 tons commercial river catch; 3400 persons in commercial fishery
Germany		--	--		--	--	No data
Austria		--	--		--	--	No data
Total		52039			72682		

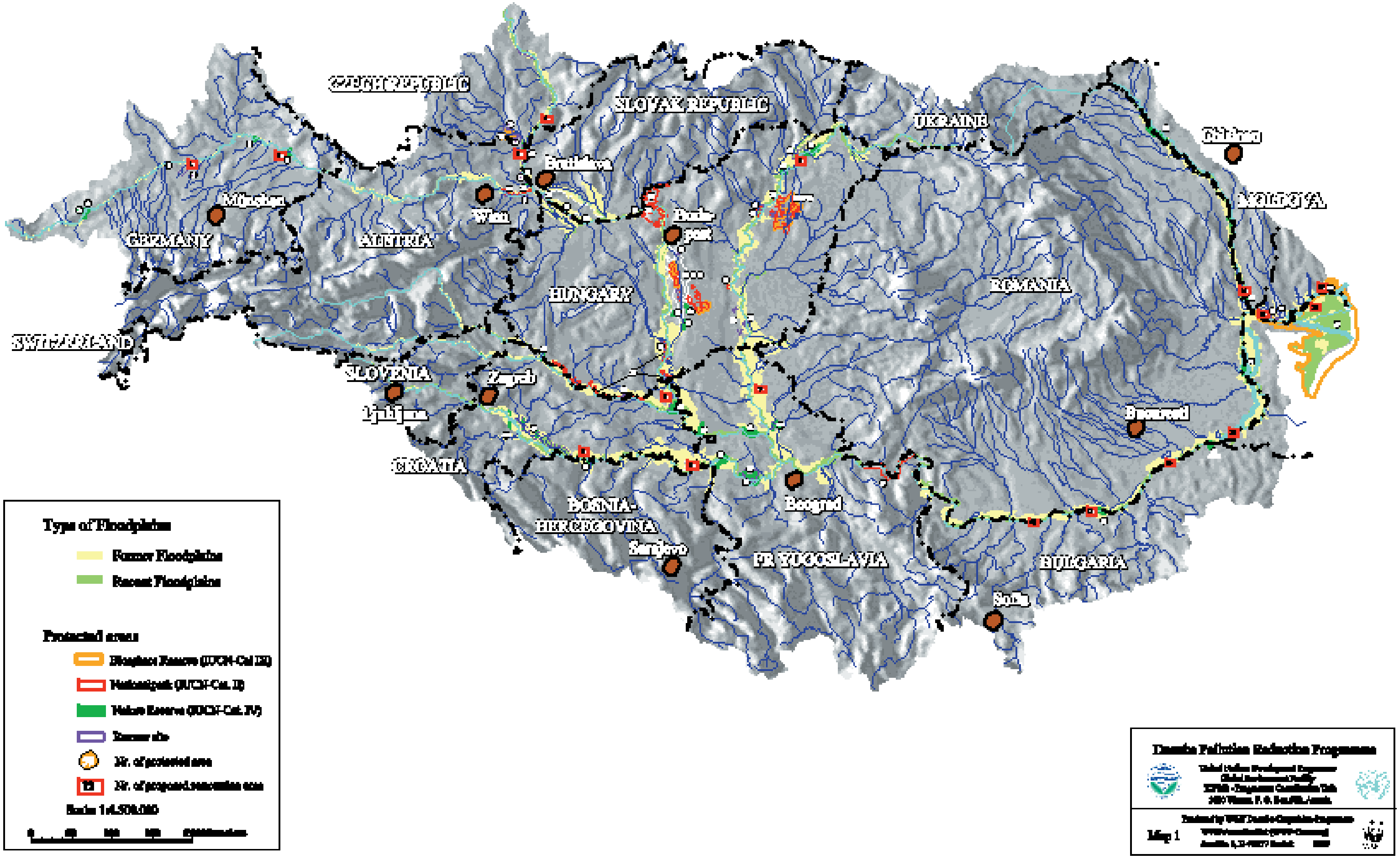
Table 1.3-2 List of Protected Areas Recorded in the Wetlands Study

No.	Country	River	Site	IUCN category and Ramsar-site	Area (ha)	Date of designation
1	Germany	Danube	Donau-Auen & Donau Moos	R	8000	1976
2	Germany	Danube	Lech-Donau Winkel	R	239	1976
3	Germany	Danube	NR Flußlandschaft Donauwiesen I	IV	530	
4	Germany	Danube	NR Flußlandschaft Donauwiesen II	IV	560	
5	Germany	Danube	NR Pfatter	IV	680	
6	Germany	Danube	NR Isar Mündung	IV	980	
7	Austria	Danube	NP Donau-Auen	II	9300	1996
8	Austria	Danube	Untere Lobau	BR	1039	1977
9	Austria	Danube	Untere Lobau	R	1039	1982
10	Austria	Danube-Morava	Donau-March-Auen	R	38500	1982
11	Austria	Morava	NR Untere March-Auen (WWF Reservat)	IV	1166	1978
12	Czech Republic	Dyje	Palava	BR		
13	Czech Republic	Dyje	Mokrady dolního Podyjí (floodplains of lower Dyje river)	R	11500	1993
14	Czech Republic	Morava	Litovelské Pomoraví	R	5122	1993
15	Slovakia	Danube	NR Cícovské mrtve rameno	R	135	1990
16	Slovakia	Danube	NR Súr	IV	568	1952
17	Slovakia		NR Súr	R	1137	1990
18	Slovakia	Danube	Dunajské luhy (Danube floodplains)	R	14335	1993
19	Slovakia	Morava	Moravské luhy (Morava floodplains)	R	4971	1993
20	Slovakia	Morava	NR Horny les	IV	543	1981
21	Hungary	Danube	Gemenc-Béda-Karapancsa	R	18023	1997
22	Hungary	Danube	NP Duna-Ipoly	II	60314	1997
23	Hungary		Szentendrei-sziget	II	1300	1997
24	Hungary	Danube	Ocsa	R	1078	1989
25	Hungary	Danube	NR Császártöltési Vörös-mocsár	IV		
26	Hungary	Danube	NR Szelidi-tó	IV		
27	Hungary	Danube	NR Kiskörösi turjános	IV		
28	Hungary	Danube-Drava	NP Danube-Drava	V	49479	1996
29	Hungary	Drava	Szaporca	R	257	1979
30	Hungary	Tisza	Pusztaszeri	R	5000	1979
31	Hungary	Tisza	Mártélyi	R	2232	1979
32	Hungary	Tisza	NP Kiskunsági	II	35860	1975
33	Hungary	Tisza	NP Kiskunsági	BR	22095	1979
34	Hungary	Tisza	NP Kiskunsági	R	3903	1979
35	Hungary	Tisza	Lakitelek Töserdö	II	600	1975
36	Hungary	Tisza	NP Hortobágyi	II	52213	1973/1996
37	Hungary	Tisza	NP Hortobágyi	BR	53099	1979
38	Hungary	Tisza	NP Hortobágyi	R	23121	1979
39	Hungary	Tisza	Tiszacsegeihullámtér	II	1263	1996
40	Hungary	Tisza	Tiszalake	II	5000	1996
41	Hungary	Tisza	Tiszalake	R	2500	1979
42	Hungary	Tisza	NR Tiszatobi ártér	IV	1000	1977
43	Hungary	Tisza	Tokaj-Bodrog-zug	R	3782	1989
44	Hungary	Tisza	NR Tiszatelek-Tiszaberceli-ártér	IV	1263	1978
45	Croatia	Danube-Drava	Special Zoolog. Reserve Kopacki Rit	Ia	7000	1993
46	Croatia	Drava-Mur	Ornith. Reserve Veliki Pazut	IV	17770	1983

No.	Country	River	Site	IUCN category and Ramsar-site	Area (ha)	Date of designation
47	Croatia	Kupa	Special Ornith. Reserve Crna Mlaka	IV	625	
48	Croatia	Kupa	Special Ornith. Reserve Crna Mlaka	R	625	1993
49	Croatia	Sava	Lonjsko & Mokro Polje	R	50650	1990
50	Yugoslavia	Danube	Special NR Karadjordjevo	IV	2955	1997
51	Yugoslavia	Danube	Special NR Koviljsko-Petrovaradinski Rit	IV	4841	1998
52	Yugoslavia	Danube	NP Djerdap	IV	63608	1974/1993
53	Yugoslavia	Tisza	Special NR Stari Begej-Carska Bara	IV	1767	1986
54	Yugoslavia	Tisza	Special NR Stari Begej-Carska Bara	R	1767	1996
55	Yugoslavia	Sava	Special NR Zasavica	IV	671	1997
56	Yugoslavia	Sava	NR Obedska Bara	IV	9820	1968/1994
57	Yugoslavia	Sava	NR Obedska Bara	R	17501	1977
58	Bosnia	Sava	Ornith. Reserve Bardaca	IV	700	
59	Romania	Danube	Donau-Delta	BR	580000	1990
60	Romania	Danube	NR Small Braila Island	IV	14983	1997
61	Bulgaria	Danube	NR Persin island	IV	1714	1981
62	Bulgaria	Danube	NR Srébarna	IV	1143	1948
63	Bulgaria	Danube	NR Srébarna	R	902	1975
64	Bulgaria	Danube	NR Srébarna	BR	600	1977
65	Moldova	Prut	Prutul de jos	Ia	1691	1991
66	Moldova	Prut	Padurca Domneasca	Ia	6032	1993
67	Ukraine	Danube	Dunaiskie Plavny Donau-Delta	BR	46400	1998
68	Ukraine	Danube	Ismail Islands	R	1366	1996
69	Ukraine	Danube	Kugurluy Lake	R	6500	1995
70	Ukraine	Danube	Kartal Lake	R	500	1995

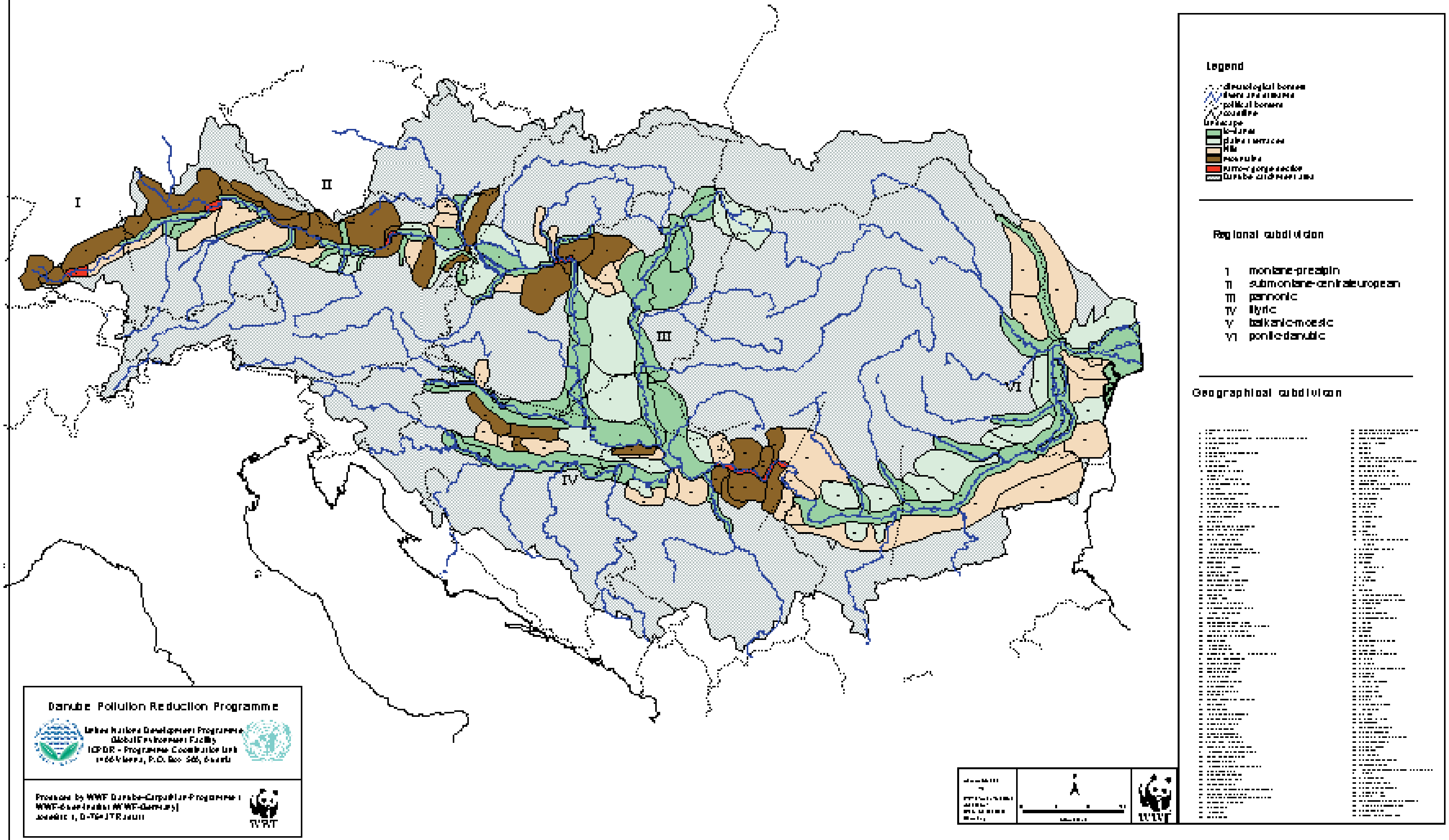
Floodplain areas in the Danube River Basin

with protected areas along the studied rivers (Danube, Morava, Drava, Sava, Tisza and Prut)



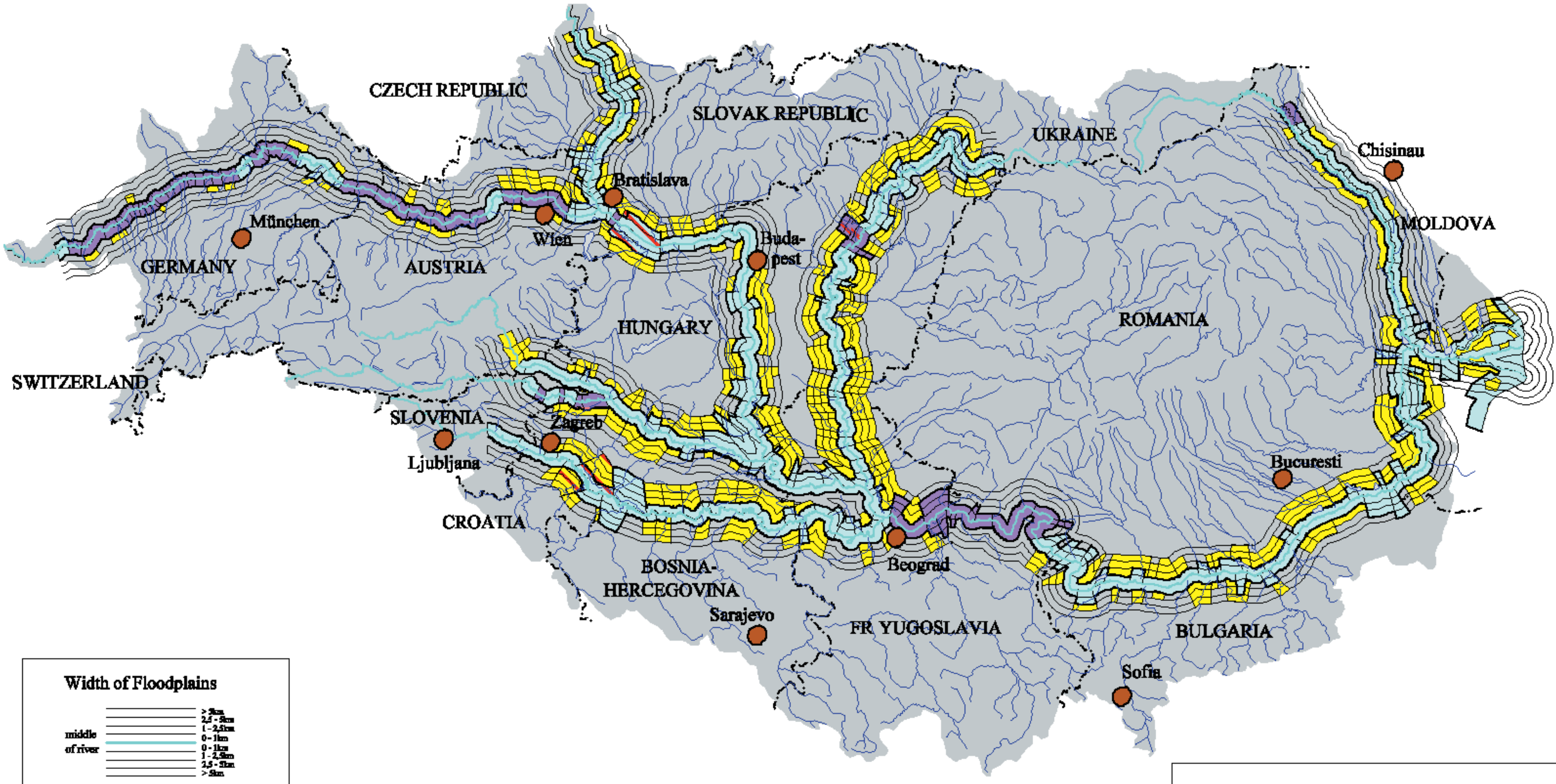
Map W2

Geographical subdivison of the Danube river basin



Map W3

Symbolized view of floodplains in the Danube River Basin



Width of Floodplains

middle of river

Type of Floodplains

- Former Floodplains
- Recent Floodplains
- Back water area of dams

Scale: 1:4.500.000

0 50 100 150 kilometers

Area of historical floodplains in the study area: 41600 km
Area of remaining floodplains in the study area: 8000 km
A floodplain loss of more than 80%

Danube Pollution Reduction Programme

United Nations Development Programme
Global Environment Facility
ICPDR - Programme Coordination Unit
1400 Vienna, P. O. Box 500, Austria

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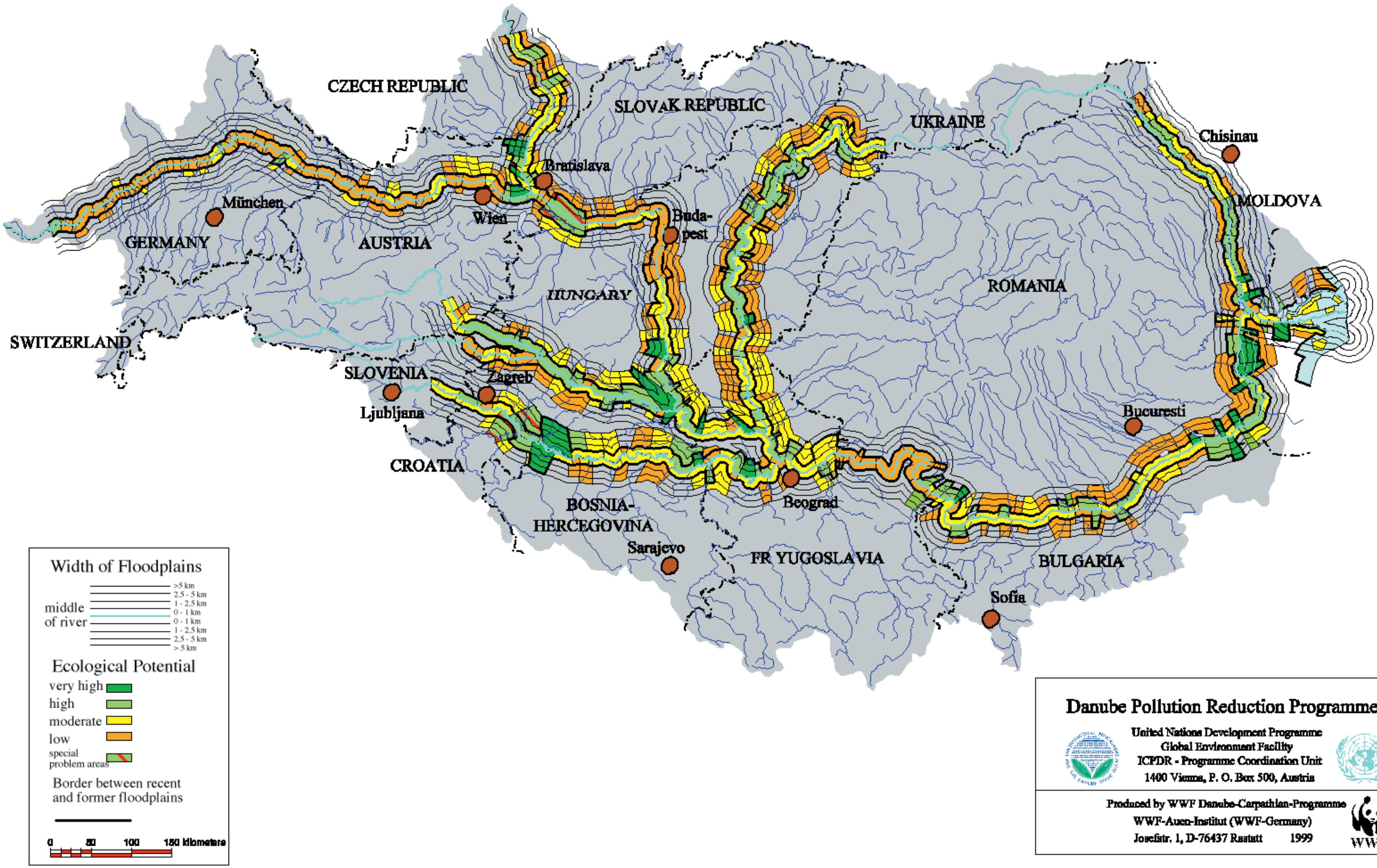
Map W4

Ecological potential of floodplains in the Danube River Basin



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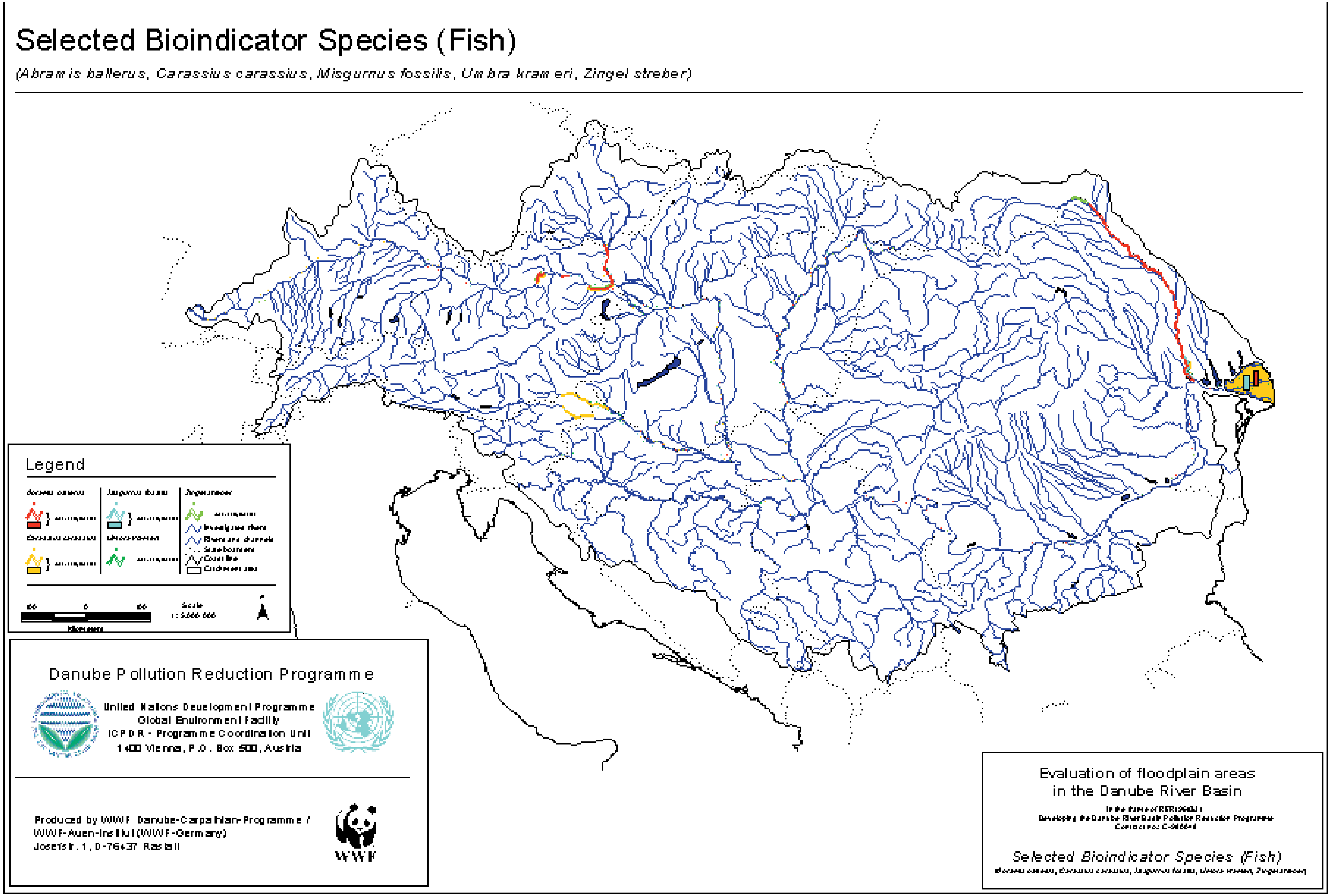
Map W5


Selected Bioindicator Species (Fish)
(Abramis ballerus, Carassius carassius, Misgurnus fossilis, Umbra krameri, Zingel streber)
Legend
Scale
Danube Pollution Reduction Programme
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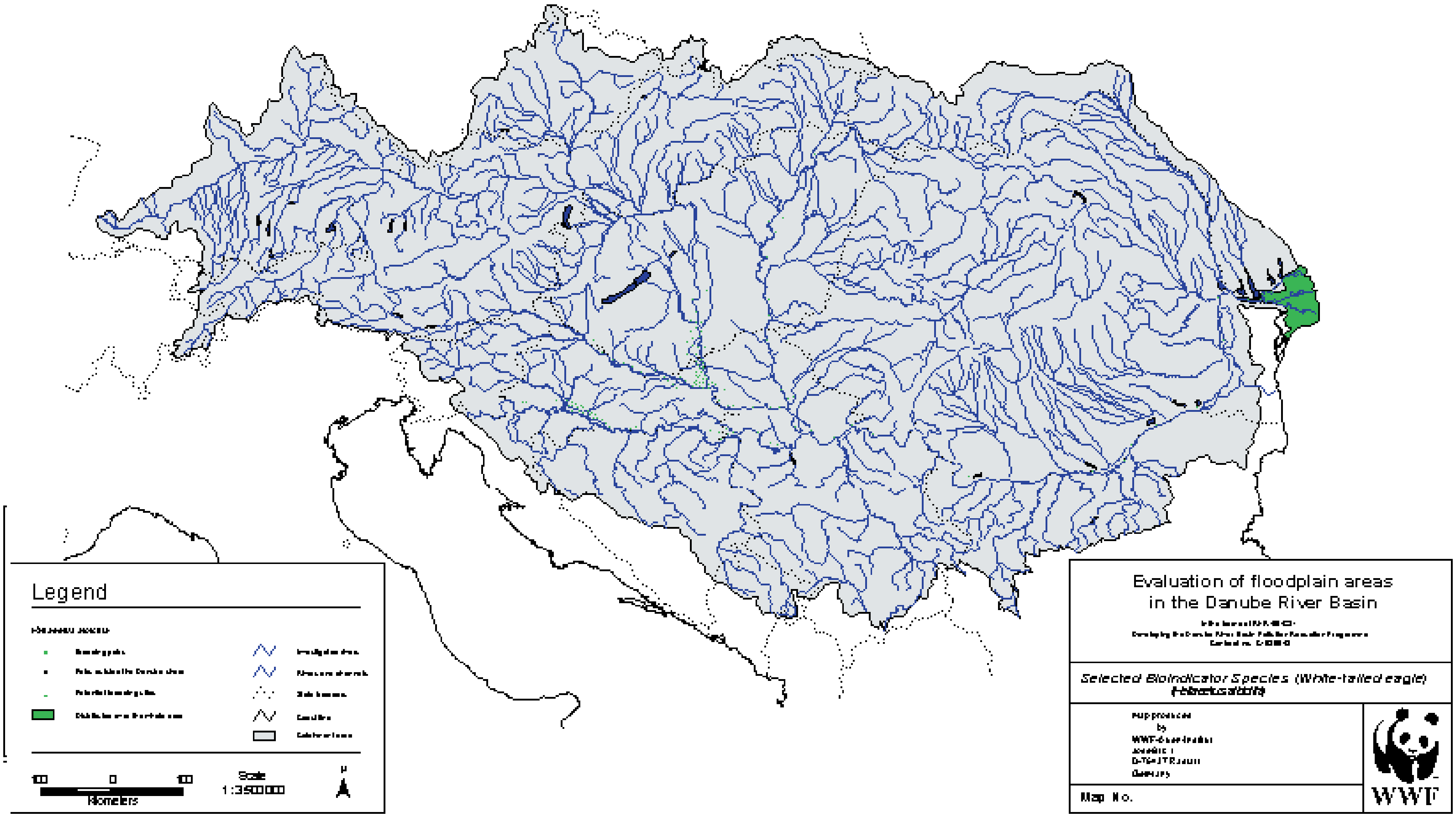
Evaluation of floodplain areas
in the Danube River Basin
Selected Bioindicator Species (Fish)

Map W6

Selected Bioindicator Species (White-tailed eagle)

(Haliaeetus albicilla)



1.4. Population Development

Present and projected populations for countries and areas within the Danube Basin are summarized in Figure 1.4-1 and Annex 1.4A which reveal large differences in total populations, the ratio of rural to urban populations, population density and the fraction of each country's population within the Danube Basin. A notable similarity among all countries is the low rate of projected population growth to year 2020. The present and projected percentages of the DRB population connected to sewerage systems is presented by country in Figure 1.4-2.

On the basis of limited data, mostly from six countries (Slovenia, Croatia, Czech Republic, Slovak Republic, Hungary and Romania) a particular economic and environmental problem appears to involve unknown dump sites for municipal and non-municipal waste (for which only fragmentary data on waste volume and composition are available). Water quality and health risks are increased by the proximity of many of these sites to river banks.

Water mediated health and social problems are summarized by country (excluding Germany and Austria) as follows:

Czech Republic

In 1996 there were no reported cases of water-borne infection from drinking water abstracted by public water supply systems although there were occasional cases of water-borne infections in certain periods from bathing in water courses and reservoirs. Potential hazards may result from accidental pollution of water courses. In 1995, for example, 243 such cases were registered. An extreme case was the summer flood in 1997, in which numerous drinking water resources were depreciated, waste water treatment plants flooded and various industrial chemicals and wastes got under water.

Slovak Republic

About 75% of the population are supplied by ground water sources. About 90% of irrigation water is surface water. The primary problems regarding both the surface and ground water are high nitrite contaminations from agrochemicals and untreated waste water discharge. The main problem regarding the surface waters of the Danube River systems are high pollution by nutrients and contamination by different industrial substances, including oil substances. At the time being there are no significant health hazards through pollution of water used for drinking purposes. Diseases caused by hygienic quality of drinking water are not frequent and only in exceptional cases it has come to epidemics.

Hungary

Public water supply is principally ensured by groundwater (95%). Approximately 65% of the groundwater resources is vulnerable to human activity. Problems with the water resources are iron, manganese, nitrate in some cases and arsenic with natural origin. The water consumption decreased to about 60% from its maximum in the last 8 years. Problems can be experienced due to the changes of ownership, the level of operation security and quality assurance. The microbiological quality of bathing waters is often below the requirements.

Slovenia

Surface water is a minor source of public water supply. There are no serious health hazards. Some cases of pollution in water used for drinking purposes include organic solvents, pesticides, heavy metals from industrial spillage and agricultural runoff.

Croatia

Public water supply is mainly ensured by ground water (90%). There are no reports of serious problems with water-related diseases except for occasional epidemics of enterocolitis and hepatitis A.

Bosnia and Herzegovina

As a consequence of the war, public water supply and sewerage systems are damaged or partly under construction. Only one third of the population is currently supplied with hygienically correct potable water. In 1996, 14 infection and parasite epidemics (including 4 epidemics of enterocolitis and 2 epidemics of hepatitis A) were recorded. Presently the situation has improved but still has to be considered as unstable.

Federal Republic of Yugoslavia

Problems include inadequate water quality in municipal water supply systems from inferior raw water quality, inadequate water treatment and disinfection. About 50 municipal water supply systems (for which microbiological inadequacy is higher than 5% and physical and chemical inadequacy higher than 20%) do not use water from watercourses or impounding reservoirs, but ground water from different water bearing strata. In a large number of small settlements the quality of drinking water is not satisfactory due to the absence of water treatment and casual disinfection on one side, and worn-out piping and periodic supply interruptions, on the other. Most frequent causes of inadequate water quality are elevated contents of iron, manganese and organic matters, the absence of residual chlorine, an increase in the total number of bacteria, and period increases in coliform bacteria, including E.coli. The number of epidemics of contagious diseases peaked in 1995 when there were reports of 396 epidemics involving 6850 affected persons, and appears to be decreasing since that time.

Romania

Surface water can principally not be used for drinking purposes without proper treatment.

Water quality of shallow wells and boreholes is considered a serious health problem in rural areas due to the high nitrite concentration usually exceeding 50 mg/l. Significantly increased occurrence of diseases mediated by water from the Danube River system or groundwater sources is reported for:

- Infant methemoglobinemia (caused by nitrite intoxication);
- Communicable diseases such as dysentery, acute diarrhoea , cholera, viral hepatitis (due to microbial contamination of surface water and water from shallow aquifers and rural wells);
- Communicable diseases (due to water shortage, respectively periodic intermittence of tap water supply combined with faecal contamination);
- Diseases due to intoxication from industrial and agrochemical substances in water used for drinking purposes; either from permanent pollution or from occasional accidents and spillage); and
- Diseases from elevated content of toxic cyanobacteria in surface waters.

Bulgaria

Public water supply in the Danube Basin is mainly ensured by ground water (65%) and surface water (35%). Water for public water supply systems is treated or disinfected. Elevated levels of iron and manganese in the region of Svistov are found in water from the public water supply systems (due to worn-out piping systems) as well as contamination of water sources with ammonia, petroleum products and chromium-6+, elevated levels of coliform bacteria in most towns of the DRB and elevated nitrite levels in different areas of the DRB. In Svistov region there is a treatment plant to remove the manganese.

Moldova

Public water supply is mainly ensured by ground water (80-85%). There are elevated levels of hydrocarbons, sodium and fluorides in water from public water supply systems. Water from shallow wells is often polluted with nitrogen compounds. On average 38% of centralized water supply sources do not meet sanitary-chemical standards and 11% do not correspond to microbiological standards. Of the decentralized water supply sources, 70% do not meet sanitary-chemical standards and 12% do not meet microbiological standards. There are significant incidences of hepatitis A, dysentery and enteritis. Exact data on water-borne diseases are, however, not available.

Ukraine

Regarding centralized water supply systems about 18% of water quality tests did not meet sanitary-chemical standards and about 15% of the tests did not meet bacteriological standards (figures for Odessa Region, 1996). At the time being there are no exact data on health hazards mediated by surface or ground water utilization in DRB part of Ukraine. A recognized problem is the use of hypo chlorinated water with high concentration of heavy metals and other toxic substances, which are supposed to lead to endocrine system diseases, metabolism disturbances, nervous system diseases, etc.

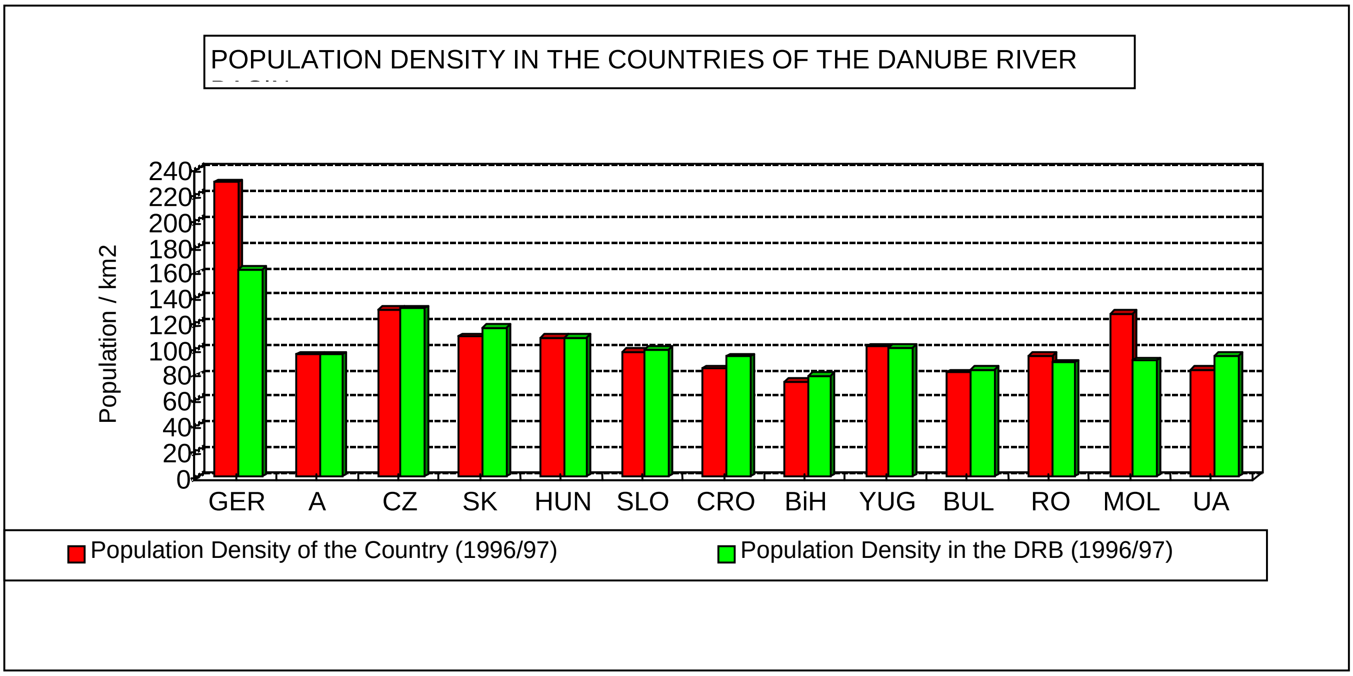


Figure 1.4-1 Population Density in the Countries of the Danube River Basin

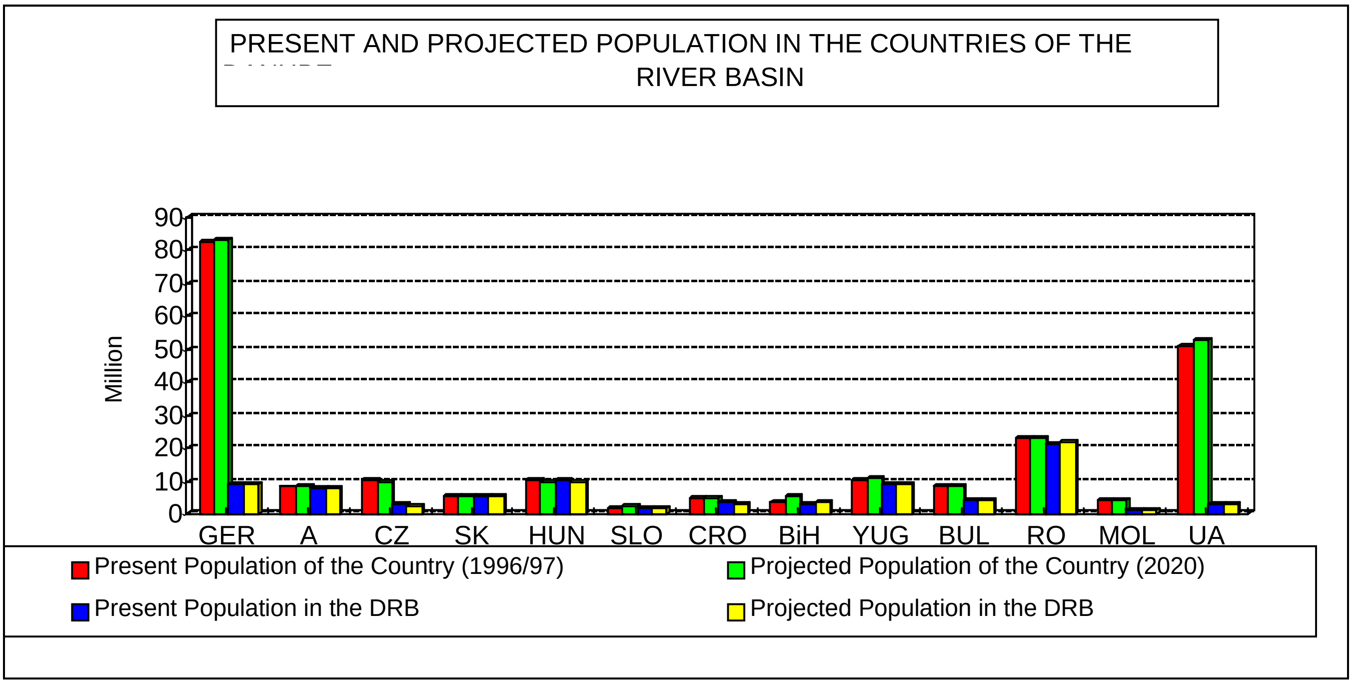


Figure 1.4-2 Present and Projected Population in the Countries of the DRB

1.5. Social and Economic

Main economic indicators (GDP, per capita GDP, inflation and exchange rates) for the DRB countries are summarized in Figures 1.5-1 and 1.5-2 and Annex 1.5A which reveal large differences in GDP between Germany and the other countries, in per capita GDP between Germany and Austria and the other countries and high inflation in Bulgaria, Romania, Ukraine and Yugoslavia. In 1997 the GDP of Germany (US$ 2,034 billion) was more than 1000 times the GDP of Moldova (US$ 1.9 billion). In 1996 and 1997 in Germany and Austria, per capita GDP exceeded US$ 25,000 while for Moldova it was less than US$ 500. For Ukraine and Bosnia and Herzegovina is was less that $ 1,000.

Not yet revealed in these tables is the extent to which activities and production in the agricultural and industrial sectors have declined in the eastern block countries during the economic transition. This information is partially available in form of agricultural production indices for 1987 to 1998 (Table 1.5-1) which show the largest declines to be in Croatia (about 55 % of earlier levels) and Moldova (about 61 % of earlier levels)

Table 1.5-1 Production Indices for Agriculture 1989-1991 = 100

Country /year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Austria	97.4	103.2	99.2	100.0	100.7	99.4	100.3	104.1	104.7	99.6	100.7	99.9
Bulgaria	106.2	105.4	110.2	101.7	88.1	87.4	69.9	69.0	78.0	63.8	60.5	60.6
Croatia						64.7	61.2	56.6	58.2	60.0	54.3	55.2
Czech Republic							98.7	81.4	85.9	84.7	80.1	80.2
Germany	101.1	101.2	101.1	101.6	97.3	94.0	90.1	88.2	89.9	91.8	103.4	93.9
Hungary	100.1	105.1	102.7	96.7	100.6	78.5	71.0	71.7	70.8	79.7	61.4	79.8
Moldova Republic						74.6	79.9	62.7	65.9	59.4	62.8	61.4
Romania	105.8	110.9	108.0	94.7	97.3	79.3	96.8	93.8	101.7	91.9	99.5	93.6
Slovakia							81.4	77.2	73.1	75.9	77.2	66.9
Slovenia						75.7	85.9	93.6	98.1	102.7	98.3	101.3
Yugoslavia						94.6	89.3	92.5	96.4	101.9	100.5	101.2

Data reported for cargo shipping and passenger transport on the Danube River and navigable tributaries are very incomplete in the National Review Reports but are described in detail in Annuaire Statistique De La Commission Du Danube Pour 1996.

Domestic water demand in the DRB is summarized by country for the present and future time periods in Figures 1.5-3 and 1.5-4 and Annex 1.5B. Domestic waste water generation is summarized by country and type of sewer system for the present and future time periods in Figures 1.5-5 and 1.5-6 and Annex 1.5C. Abstraction of raw water is summarized by country and type of use for the present and future years in Figure 1.5-7 and Annex 1.5D.

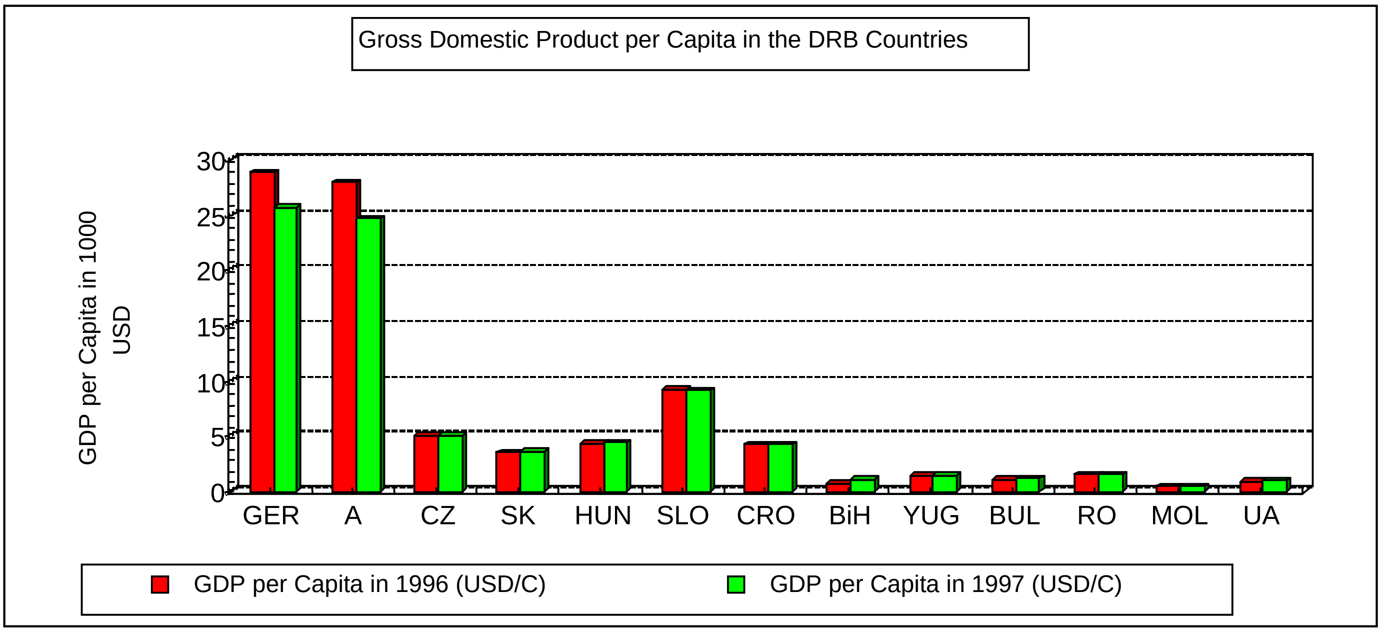


Figure 1.5-1 Gross Domestic Product per Capita in the DRB Countries

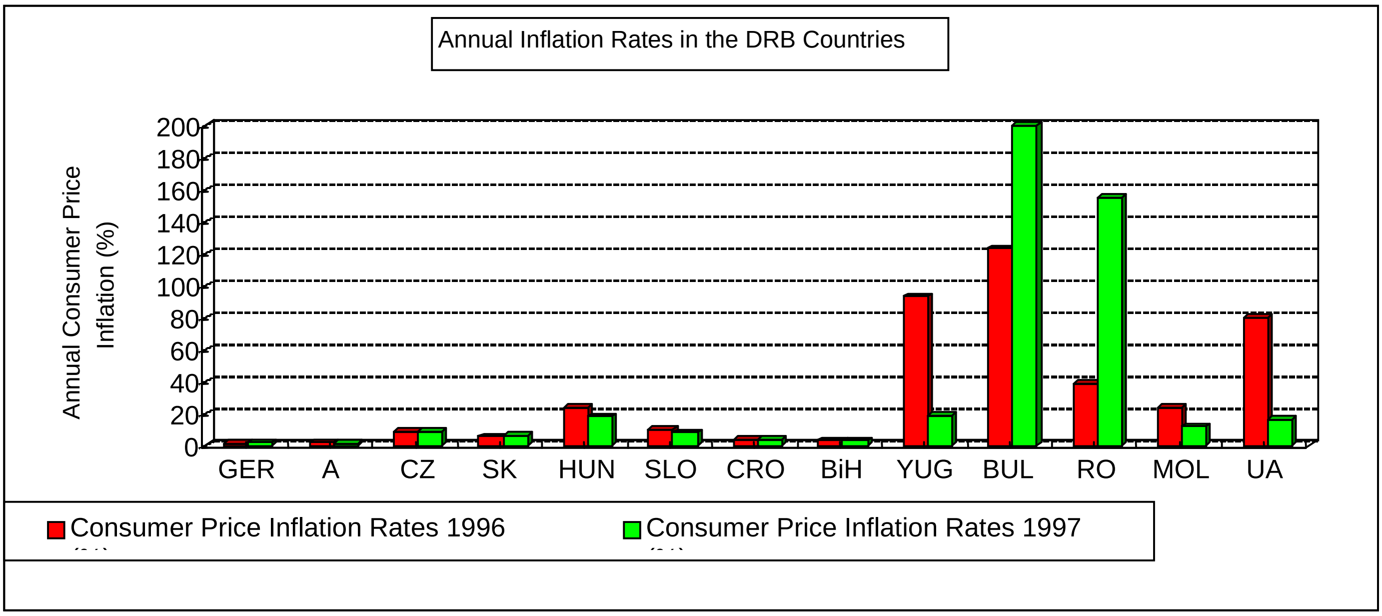


Figure 1.5-2 Annual Inflation Rate in the DRB Countries

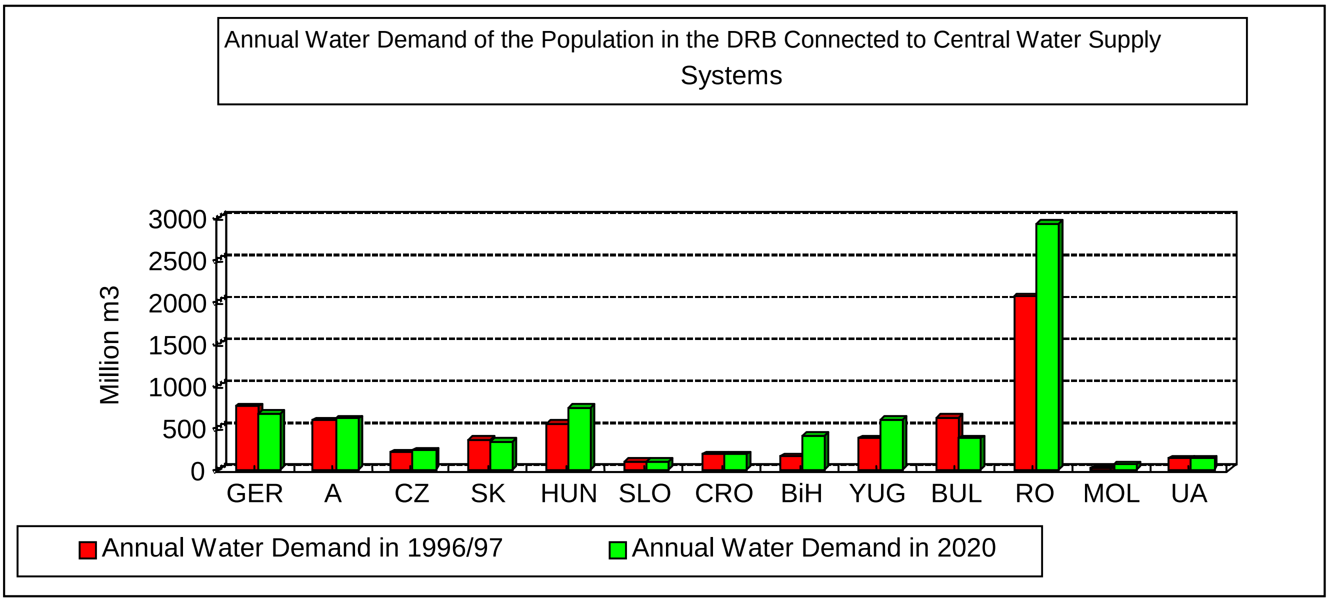


Figure 1.5-3 Annual Water Demand for the Population in the DRB Connected to Central Water Supply Systems

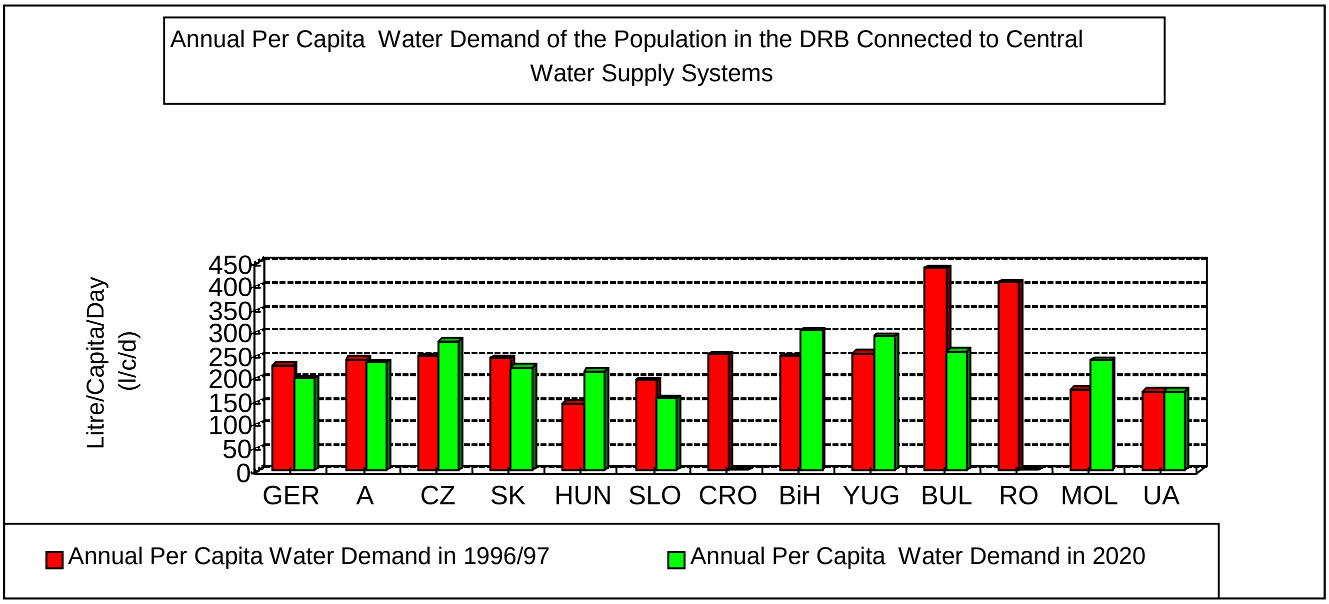


Figure 1.5-4 Annual per Capita Water Demand of the Population in the DRB Connected to Central Water Supply System

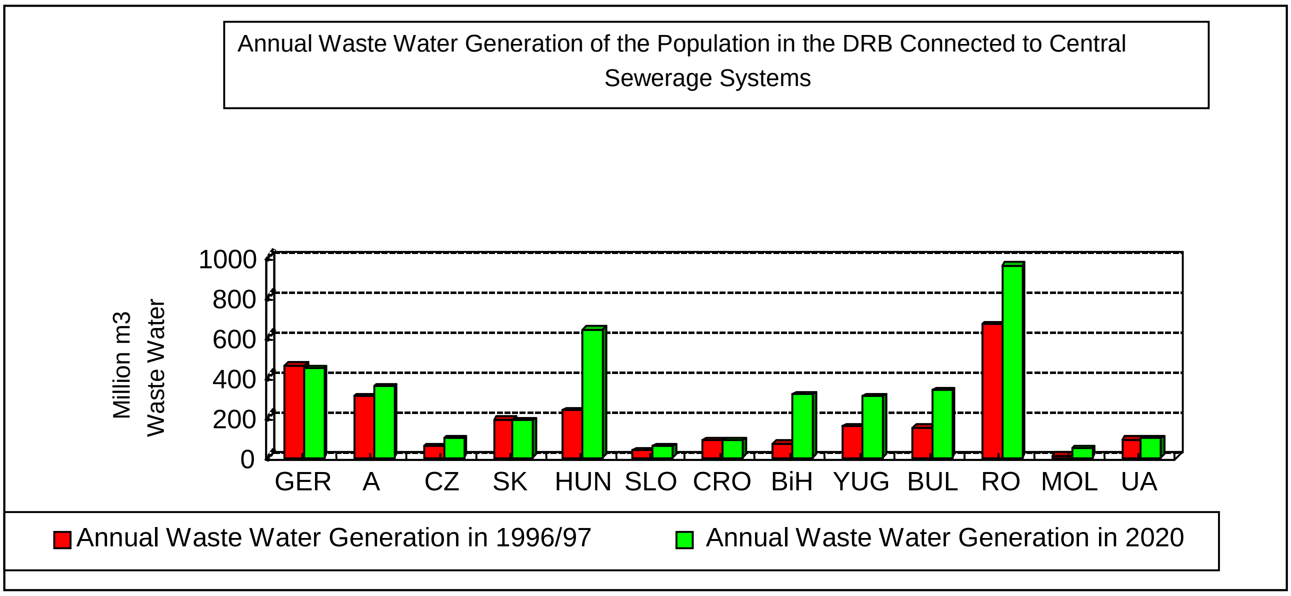


Figure 1.5-5 **Annual Waste Water Generation of the Population in the DRB Connected to Central Water Supply System**

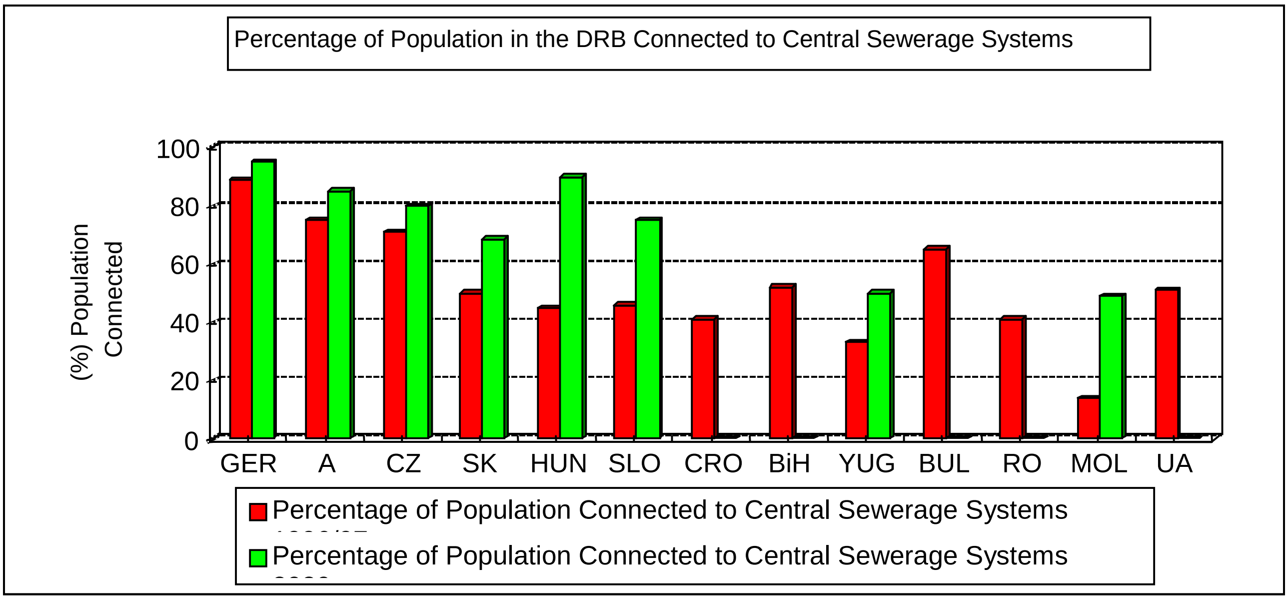


Figure 1.5-6 **Percentage of Population in the DRB Connected to Central Sewerage Systems**

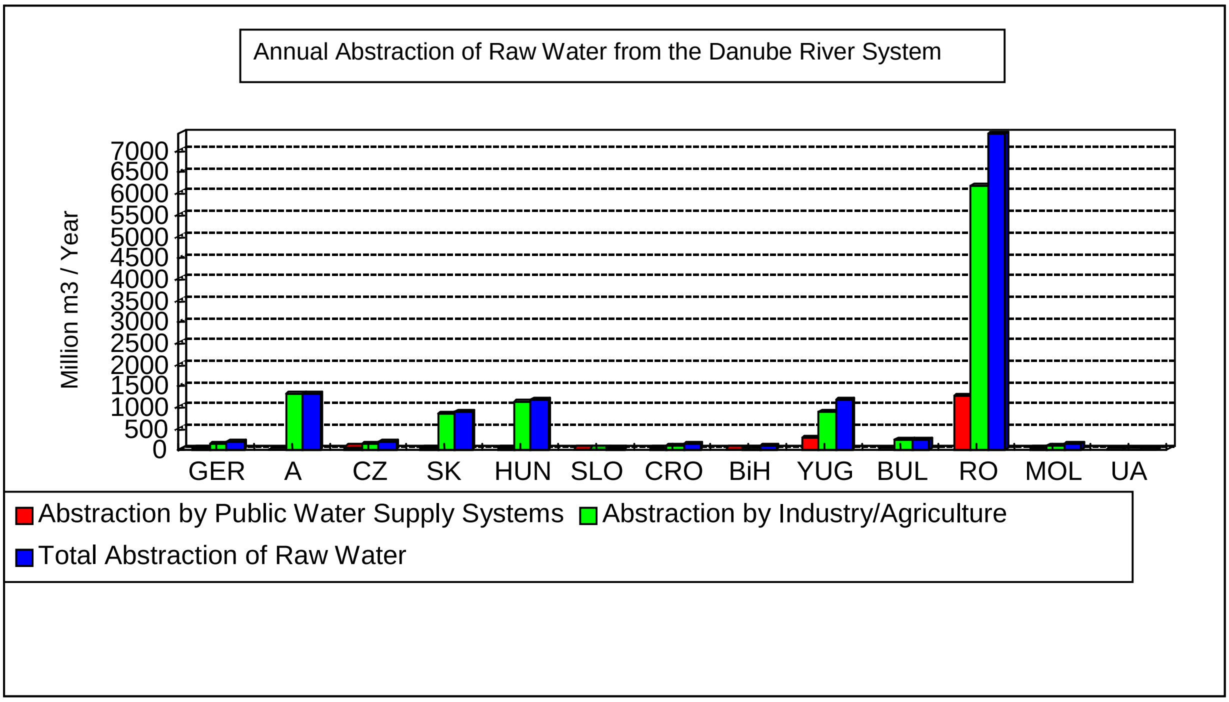


Figure 1.5-7 Annual Abstraction of Raw Water form the Danube River System

1.6. Legal and Institutional Framework of the Basin

As revealed above by the Danube Basin Map and Tables 1.1-3 and 1.1-4, national boundaries within the Danube Basin do not follow closely the boundaries of basin tributaries. The resulting numerous transboundary situations (summarized above) set the stage for a complicated legal and institutional setting at the international level. The legal and institutional framework for water quality therefore involves not only the national framework in each country, but also bilateral and multilateral framework conventions among basin countries.

General impressions that have emerged to date are briefly outlined in the following paragraphs.

In the DRB countries the primary competence for the environmental and water related legislation is with the national government, respective the relevant federal ministries. These are usually the ministry of environment and, if separated, the ministry responsible for water management. A particular feature for all DRB countries is the harmonization of the national environmental legislation with EU regulations and standards. Germany and Austria are already EU members. Hungary, Czech Republic and Slovenia are approaching harmonization. In the other countries the time frame for the envisaged harmonization is determined by the actual status of environmental and water management legislation and the economic capability and affordability of the particular country. The allocation of legal competence between state / district level and municipal / community level is very different in the various DRB countries. It usually depends on historical features and especially on the federal structure of the particular country according to which the competencies of the ministries and authorities on state / district level are basically defined.

In most of the DRB countries there is a rather clear hierarchy and allocation of responsibilities and tasks regarding environmental management of water resources and ecosystems. In the majority of DRB countries, the leading responsibility for water management is not with the Ministry of Environment, but with another ministry, sometimes together with construction, transport, communication, industry, etc. This is mainly caused by the fact that the ministries responsible for water management are usually "old" ministries and the ministries of environment have in most of the countries been established rather recently. In DRB countries special subjects which are from their nature closely related to the management of water resources and ecosystems are invested in other ministries or sub-bodies of ministries. These subjects include:

- waterway infrastructure and water transport;
- hydro-electric power utilization;
- water related recreation and tourism; river fishery;
- agriculture and forestry.

Thus there is sometimes a kind of competition between a number of ministries, especially regarding the allocation of budgets and the responsibility for subordinated institutions and organizations.

In most of the DRB countries, independent of the distribution of responsibility with one or more ministries, there are Environment and Water Inspectorates which usually act as sub-bodies of the ministries on the regional level or the level of river catchment areas.

In the DRB countries there are in addition various authority departments, institutes and organizations dealing with special administrative, fiscal, scientific, statistical, nuclear, medical, health and similar features. Some of them had essential importance in the former systems and are now in the position that their tasks have been streamlined or allocated to other administrative units or that there is not enough money to maintain their scientific standards or even existence.

Especially in countries which are currently in the critical phase of transition, responsibilities and tasks are not always reasonably defined and sometimes overlapping, allocated to different ministerial or sub-ministerial authorities as well as to state, semi-state or in privatized institutes and organizations. A particular problem in this context is that mechanisms of coordination and cooperation are not always appropriately defined or standardized, occasionally resulting in overlapping activities on the one side and critical gaps on the other side.

Countries in which the legal framework for environmental management of water resources and ecosystems is in general terms considered as fully adequate and consistent with international requirements include Germany and Austria. The country specific particularities in other DRB countries can be summarized as follows:

Austria

Responsibilities for management of water, environment and pollution at the federal level are divided among the Ministries of Agriculture (water management affairs), Environment (general environmental issues except water), Health (bathing water), Economy (maintenance of navigable rivers), Traffic (navigation on rivers and lakes) and Consumers (drinking water quality); and among the federal and Lander levels. The legal framework and authorities for management do not coincide with river basin boundaries. Hydrological measurements and water quality measurements are made by different services/units with the same competent ministry (Agriculture and Forestry). The proposal and approval process for large investment projects in water pollution abatement or control involves the federal development of a "catalogue" of prioritized projects, decisions about the allocation of investment funds by the "Fund-Commission" at regularly-held meetings and implementation of the federal part of the promotion by the Austrian Kommunal Kredit Bank AG. Public participation is realized by the composition of Fund-Commission members, including political representatives of the federal, provincial and local level. Public access to environmental information is guaranteed by the Federal Act on Information on Environmental Data, by publications, by Parliamentary reports and by Internet home page.

Germany

Most responsibilities for management of water, environment and pollution lie with the Ministry for the Environment, which cooperates with other relevant ministries, especially the ministries for agriculture, transport and health. The primary responsibility for water management lies with the federal states. Basin-wide management is addressed in specific work groups of the federal states, and exist for each river basin. Hydrological and water quality measurements are made by the same organization. Public participation is a part of decision making for environmental projects. There is public access to environmental information and Germany has signed the Arhus convention.

Czech Republic

Based on the Competency Act No. 122/1997 Stat. in full version , the Ministry of Agriculture became the central state authority for water management including maintenance for watercourses, control of land water regime and use of water. In this context, the Ministry of the Environment transferred to Ministry of Agriculture as of 4 June 1997 all rights and responsibilities of the shareholder of the Elbe, Vltava, Ohre, Odra and Morava River Board corporations. Ministry of the Environment remains the central state authority for protection of natural accumulation of water, of water resources and protection of surface and groundwater quality. It ensures central management protection against floods. Management of water, environment and pollution for the main river basins has coincided with river basin boundaries for 31 years. Under this arrangement, river basin administrations make recommendations to district offices. Hydrological measurements and water quality measurements are made together, mostly by the national network of the Hydrometeorological Institute in the Ministry of Environment. However, the Water Resources Institute and the River Basin Administration make some measurements for special purposes (excluding groundwater). Responsibility for the control of discharge of wastewater is with both municipalities and industries and both can make proposals for funding for pollution control projects from the national environmental budget. For old projects (e.g., abandoned waste sites) environmental impact assessments can be carried out to define the scope of the pollution problem, and money for cleanup can be requested from a fund created with proceeds from the privatization (sale) of national property. The Czech Republic is a signatory to the Danube River Protection Convention (Sofia), the Ramsar Convention (wetlands of international importance), the Convention on Climate Change (Rio de Janeiro), the Convention on Biological Diversity (Rio de Janeiro) and the Convention on Wildlife and Habitats Protection (Bern). Bilateral agreements include the Bilateral convention of the Czech Republic and Austria for the basis of water management question on shared waters (7-12-67 and carried forward); and preparations between the Czech Republic and the Slovak Republic to update former agreements with the federation.

Slovak Republic

At the national level, the Ministry of Environment has a section responsible for the protection of water quality and quantity and its rational use, including state administration in water management; and the Ministry of Soil Management has a section responsible for water management. At the local level, these responsibilities are distributed among four water authorities. In 1996 a new territorial - administrative division of state administration was established in connection with a new territorial-administrative division of the Slovak Republic. For this reason, regional and district authorities are responsible for state administration of water management.

Environmental legislation related to water management is mainly formed by the following acts:

- The Water Act - 1973
- The Act on State Administration in Water Management - 1974, as amended in 1993
- The Act on the National Environment - 1991
- Environmental Impact Assessment Act - 1994

Within each catchment area, hydrological measurements and water quality measurements are made by the same organization. Boundaries of management of water, environment and pollution coincide with river basin boundaries. Public participation in decision making for environmental projects is assured by the environmental impact assessment procedure (for large-scale projects) and by the permitting procedure (for smaller projects). Public access to environmental information has been assures in a act on public access to environmental information was entered into force in 1998.

Hungary

The responsibility for environmental protection has been allocated to the Ministry of Environment, but all the ministries should consider the environmental consequences of their activities. The water sector has been divided so the water quality belongs to the environmental ministry and the water quantity and the so-called water management belongs to the Ministry of Transport. Management of irrigation is the responsibility of the Ministry of Agriculture since July 1998. On the regional level, the responsibilities are allocated to the Environmental Protection Inspectorates and the District Water Authorities. Significant strengthening of the environmental institutional system is recognized as a fundamental precondition for the implementation of the National Environmental Plan and the practical enforcement of the principle of sustainable development. In a majority of cases, boundaries of management of water, environment and pollution coincide with river basin boundaries. Hydrological measurements and water quality measurements are made by different entities, i.e., the regional water authorities and the regional environmental inspectorates respectively. The proposal and approval process for large investment projects in water pollution abatement and control involves the development of a preliminary design, which is the basis of a preliminary permit for water rights; detailed design which is the basis for a license on water rights and land use; application for funding to various central funds. Public participation in decision making for environmental projects occurs through appeals against the preliminary design and through public hearings which are part of the environmental impact assessment process. Public access to environmental information is assured through an act which was entered into force in 1998, as well a through the Arhus convention which Hungary has signed.

Slovenia

The responsibility for water management is with the Ministry of the Environment and Physical Planning. The professional water management is organized in 8 river catchments (Water Act, 1981), i.e., management of water, environment and pollution coincides with river basin boundaries. The inspectorates of the Ministry of the Environment are responsible for the control of the conditions of water users. At the national level, responsibilities cover permitting for water abstraction and pollution discharges. At the local level, responsibilities cover water supply systems and waste water treatment plants. Hydrological measurements and water quality measurements are made by the same organization. The proposal and approval process for large investment projects in water pollution abatement and control involves declaration of candidate projects in a "National Environmental Plan". Public participation in decision making for environmental projects is assured through the Environment Protection Act of 1993 which required the environmental impact assessment process to include public presentation and public discussion. The public has access to environmental information. Slovenia is signatory to the Danube River Protection Convention (Sofia), the Transboundary Watercourses Convention (Helsinki), the Ramsar Convention (wetlands of international importance), the Convention on Climate Change (Rio de Janeiro), the Convention on Biological Diversity (Rio de Janeiro) and the Convention on Wildlife and Habitats Protection (Bern). Bilateral agreements included the Joint Commission for the Drava River (between Slovenia and Austria); the Joint Commission of the Mura (between Slovenia and Austria); the Joint Commission for Water Management (between Slovenia and Hungary); and the Joint Commission of the Adriatic (between Slovenia, Italy and Croatia).

The urgent task is the preparation of a new Water Act that will replace the outdated one from 1981. A general task is future harmonization of national legislation with EU regulations and standards.

Croatia

Due to the fact that Croatia is an independent state only since 1990, the legal and institutional structures are still in the process of transformation, including in the fields of water management and environmental protection. In this context, the responsibility for environmental protection is with the Ministry of Construction and Environmental Protection and the subordinated State Directorate Nature for Environmental Protection. The responsibility for water management is with the Ministry of Agriculture and Forestry and the subordinated State Directorate for Water Management. A particular institutions is the "JVP", and umbrella organization for all water and waste water utilities in the country. Boundaries of management of water, environment and pollution do coincide with river basin boundaries but hydrological measurements and water quality measurements are made by different organizations. The proposal and approval process for large investment projects in water abatement or control usually begins with the submittal of proposals from local authorities or state authorities. The proposals are then reviewed by the Water Management Agency and the State Water Directorate. Public participation in decision making for environmental projects is mostly a paper process.

Bosnia and Herzegovina

Since the promulgation of a new constitution in 1994, environmental legislation has not progressed far beyond the constitutional phase. Allocation of competence and responsibilities between national level, canton level and municipal level are just provisionally determined. General matters are usually regulated by laws, procedures, standards, etc., usually accompanied by "books of rules". Responsibilities for management of water, environment and pollution are distributed between the Ministry of Water Management and the Ministry of Environment; and between two levels - the Federation of Bosnia and Herzegovina (FBiH) and the Republic of Srpska (RS). Boundaries of management of water, environment and pollution do not coincide with river basin boundaries. Hydrological measurements and water quality measurements are made by different organizations, i.e., FBiH and RS respectively. The proposal and approval process for large investments in water pollution abatement or control involves the respective ministries and final approval of the entity Governments. Public participation is not yet a part of the decision making process for environmental projects. Public access to environmental information is limited. BiH has not yet signed the Arhus Convention.

Federal Republic of Yugoslavia

The legal framework for environmental protection and the protection of water resources and ecosystems is a composite of federal and republican laws and regulations and consequently characterized by discrepancies. The particular administrative structure of the country calls for basic coordination between the legislation of the republics, in each of which the system of environmental protection has been rather well developed and the federation which is authorized to lay down the fundamentals of the system of environmental protection. National and local responsibilities are divided along the following lines:

- Federal level - planning and transboundary issues
- Republic level - planning and operational activities
- Local level - operational activities

In addition, numerous laws and regulation regarding environmental issues that were adopted long ago, have been frequently amended and need revision. Water management is overlapping since each of the following ministries is responsible for one segment:

- Federal Ministry of Agriculture (water regime)
- Federal Ministry of Development, Science and Environment (environment-system issues)
- Federal ministry of Health and Social Affairs (drinking water quality)
- Ministries of Agriculture, Forestry and Water Management of Republic of Serbia and Montenegro
- Ministries of Environment of Republic of Serbia and Montenegro
- Ministries of Health of Republic of Serbia and Montenegro

Quality control of surface waters of inter-state and inter-republican watercourses is performed by the Federal Weather Bureau, while the control of other watercourses is performed by the republican weather bureaus. Boundaries of management of water, environment and pollution coincide with river basin boundaries. The proposal and approval process for large investment project in water pollution abatement and control is regulated by the Investment Law, the Water Law and the Environmental Law. There is some public participation in decision making for environmental projects, but there is need for improvement. The country has not signed the Arhus Convention, but water quality data can be obtained by request, in accordance with provisions of the Water Law.

Romania

In Romania the Ministry of Water, Forests and Environmental Protection is responsible for all environmental and water related issues. "Apele Roane", a public utility with branches in each of the country's 12 river basins is responsible for 70,000 km of watercourses, 150 multi-purpose lakes and dikes and raw water supply to municipalities, industry and agriculture, whereas the water and waste water services are under the responsibility of the respective municipalities under the Ministry of Public Works. The national company "Romanian Waters" and its branches are responsible for the management of water pollution. The Environmental Protection Agencies are responsible for environmental pollution on the local level. The environmental and water-related legislation is in the process of transformation. The reorganization of the legislation framework reflects the need to manage all the natural resources as part of an integrated system and strategy, which involves cooperation between all relevant authorities and institutions on the different administrative levels. One of the main concerns is the harmonization of the national environmental and water-related legislation with international requirements, especially regulations and standards. Hydrological and water quality measurements are both made by the same organization, namely the National Water Authorities, which reports to the Ministry of Water, Forests and Environmental Protection. The boundaries of water management coincide with the river basin boundaries. The boundaries of other environmental management coincide with the country's boundaries. Public participation in decision making for environmental projects exists in accordance with Water Law 107/96 and the Environmental Law 137/95, which require investments to be discussed in public debates. Public access to environmental information is assured by the same laws.

Bulgaria

The Ministry of Environment and Waters has one of the leading roles in the implementation of national environmental policy. This is the central state administration authority coordinating all environmental issues. The Ministry of Regional Development and Public Works develops the strategic and policy documents for water supply and waste water drainage in settlements. The Ministry of Health issues regulations for the standards of drinking water and through its Regional

Hygienic Epidemiological Inspectorates controls quality in the water supply system. The Ministry of Agriculture, Forest and Agrarian Reform has a leading role in agricultural and forestry management and owns almost all of the large irrigation facilities through its government-owned company "Irrigation Systems Inc." The 15 Regional Environmental and Water Inspectorates implement the legislation concerning all elements of the environment - water, air, soil and biodiversity. They perform the supervision of environmental protection, namely setting and permitting effluent standards, control of permitted limits for wastewater discharges from municipal facilities, observation and evaluation of the level of pollution and charging fines when permit requirements are violated. Local municipal authorities (Water Supply and Sewerage Co.) are responsible among other things for management of municipal solid waste collection, transport, treatment and disposal. The river basin authorities are envisaged under the new Water Act as the institution carrying out adequate management based on democratic principles and participation of the public. In the Basin Councils all social groups concerned with water management (including state institutions, regional and municipal administrations, non-governmental ecological organizations, water users and polluters) are equally represented. Hydrological and water quality measurements are made by different organizations. The National Institute of Meteorology and Hydrology makes the hydrological measurements. Three other entities (Ministry of Environment and Water, National Centre for Environment and sustainable Development and Ministry of Health) make water quality measurements. The boundaries of management of water and environment and pollution do not coincide with river basin boundaries. Instead, management is organized on a regional / administrative basis. The proposal and approval process for large investment projects in water pollution abatement or control involves municipalities and other making proposals by filing application forms with the National Environmental Protection Fund, with the National Eco Trust Fund, or to the state budget. Water supply and sewerage companies may apply to EU PHARE, EBRD, EIB or World Bank for soft loans. Public participation in decision making for environmental projects is achieved through the EIA procedure which includes public hearings for EIA reports. Public access to environmental information is achieved through monthly newsletters issues by the Ministry of Environment and Water, bulletins and publications of the this ministry as well a the National Centre for Environment and Sustainable Development and the Annual Book for the Status of the Environment.

Moldova

The Ministry of Environmental Protection is the leading authority regarding environmental protection and issues of water-related ecosystems. "Apele Moldovei", a subdivision of the Ministry of Agriculture and Forestry is responsible for surface water resources and the issues of water balance. Jointly with the two ministries and their sub-bodies various institutes are responsible for particular environmental and water-related aspects. The Ministry of Health is responsible for drinking water. According to the Constitution, the President has major responsibilities for the state of the environment. Hydrological measurements and water quality measurements are made by the same institution,i.e., the Hydrometeorological Service. Boundaries of management of water, environment and pollution do not coincide with river basin boundaries. In spite of the complex system of environmental legislation (with a high number of decrees, laws and regulations elaborated and amended since 1990), enforcement remains problematic due to the economic situation and shortage of technical competence. The proposal and approval process for large investment projects in water pollution abatement and control involves proposal by local authorities to sectoral authorities (ministries) and approval by the central government. Public participation in decision making exists in the form of involvement of NGOs and public institutions in project development, through the law on environmental impact assessment. The country's constitution provides for free access to environmental information.

Ukraine

The overall responsibility and guidance for all environmental and water-related issues is with the Ministry of Environmental Protection and Nuclear Safety. The management of water resources on the national level is carried out by the Cabinet of Ministers, supported by authorized bodies such as departments of the Ministry of Environment (pollution prevention), the State Committee for Water Management (irrigation, watercourses), the State Committee for Architecture (municipal wastewater, drinking water supply), the State Committee for Hydrometeorology (surface water monitoring), the State Committee for Geology (groundwater), sub-bodies of these committees, and the Ministry of Health (sanitary-hygiene control of bathing water and drinking water). The basic principles for the protection of the environment in the Ukraine are regulated by the "Law of Protection of the Environment, 1996" and the "Law on Sanitary and Epidemiological Security of the Population, 1994. The main water related issues are regulated by the "Water Code of Ukraine, 1995". In addition there are a number of regulations, rules, norms, etc. regulating in detail particular issues. The proposal and approval process for large investment projects in water pollution abatement and control includes preparation of an environmental impact assessment and focuses on requirements set by sources of financing. Hydrological measurements and water quality measurements are not made by the same organization. Boundaries of management of water, environment and pollution do not yet coincide, but river basin management is being introduced. Public participation in decision making for environmental projects and access to environmental information are both very limited at the present time. Ukraine is signatory to the Black Sea Convention and the Convention on Biological Diversity (Rio de Janeiro) and is in the process of approving the Transboundary Watercourses Convention (Helsinki). There are bilateral agreements between Ukraine and Moldova on the common use and protection of water resources of the Dnister River; between Ukraine and Slovakia on cooperation in environmental protection; between Ukraine and Hungary on cooperation in environmental protection; and between Ukraine and Romania on cooperation in environmental protection.

A summary of the status of selected international conventions is presented in Table 1.6-1.

Table 1.6-1 Danube States which Have Signed or Ratified Relevant International Conventions as of Mid 1999

	Europe Association or Accession Agreement		Transboundary Watercourses Convention*		Black Sea Convention**		Ramsar Convention***		Convention on biological diversity		Danube River Protection Convention	
in force since												
	Association signed	Accession ratified	signed	ratified	signed	ratified	signed	ratified	signed	ratified	signed	ratified
Austria		+	+	+			+	+	+	+	+	+
Bosnia-Herzegovina												
Bulgaria	+		+		+	+	+	+	+	+	+	+
Croatia				+			+	+	+	+	+	+
Czech Republic	+						+	+	+	+	+	+
European Union			+	+							+	+
Germany		+	+	+			+	+	+	+	+	+
Hungary	+		+	+			+	+	+	+	+	+
Moldova			+	+	+	+	+	+	+	+	+	+
Romania	+		+	+	+	+	+	+	+	+	+	+
Slovakia	+	+		+			+	+	+	+	+	+
Slovenia	+						+	+	+	+	+	+
Ukraine					+	+	+	+****	+	+	+	
Yugoslavia												

* Convention on the protection and use of transboundary watercourses and international lakes
** Convention on the protection of the Black Sea against pollution
*** Convention on wetlands of international importance, especially as wildfowl habitat
**** 1997 through declaration of continuity after the USSR

2. Objective, Approach and Context of the Transboundary Analysis

2.1. Main Objective

The main objective of the transboundary analysis is to provide the technical basis for development of a Pollution Reduction Programme for the protection of the Danube River Basin. Technical basis refers to all aspects of:

- detection, characterization, comparison, and evaluation of pollution sources, water quality and pollution loads throughout the basin (including evaluation of data quality);
- discovery and characterization of areas and issues that are sensitive to pollutant concentrations or loads;
- discovery and evaluation of effects of pollutant concentrations and loads on sensitive areas and issues, including national effects as well as transboundary effects;
- discovery and evaluation of immediate causes of pollution;
- discovery and evaluation of root causes of water quality problem situations;
- identification of alternative (structural and non-structural) interventions to reduce pollution and eliminate water quality problems, based on all of the aforementioned considerations;
- development of criteria for basinwide evaluation of possible interventions to reduce pollution;
- preliminary ranking of possible interventions, and
- determination of stakeholders and evaluation of constraints to interventions.

This is to be distinguished from the objective of the Pollution Reduction Programme which is to carry forward this technical evaluation to identify and prioritize possible interventions on the basis of comparative costs and benefits.

2.2. General Approach

The approach for accomplishing the objective of the Transboundary Analysis comprises the following choices and arrangements of work.

- **Participating Countries**
  The participating countries had earlier been defined to include the 13 countries with large territories in the Danube Basin. They included Austria, Germany, Czech Republic, Slovak Republic, Hungary, Slovenia, Croatia, Bosnia and Herzegovina, Federal Republic of Yugoslavia, Romania, Bulgaria, Moldova and Ukraine. Four countries with very small areas in the DRB did not participate.
- **Target Oriented Planning**
  Target oriented planning was adopted as the methodology for conducting workshops. This methodology incorporates the logical framework methodology to guide the work in planning groups, the team approach as a framework for multi-sectoral analysis and the visualization technique which is used to document the contributions by individual participants and the results of the discussions.
- **National Experts**
  Groups of national experts, each with a national coordinator, were engaged within each country to update National Review Reports.

- **DWQM Working Group**

  A group of experts in water quality and river basin modelling were engaged to assist in the development and application of the Danube Water Quality Model.

- **International Consultants**

  Four international consultants with specialties in river basin modelling, water quality data, socio-economics and engineering were engaged to assist in the development of National Review Reports, the development of the DWQM, the preparation of the Transboundary Analysis, and the preparation of the Pollution Reduction Program. Additional national and international consultants were engaged to contribute to the revision of the Strategic Action Plan, to serve as facilitators for various workshops and to prepare special reports and maps involving wetlands rehabilitation, causal chain analysis and identification and description of Sub-river Basin areas, Sub-river Basins and significant impact areas.

- **Pollution Parameters**

  Pollution parameters that were emphasized were concentrations and loads of N, P, COD and BOD. Quality of data was evaluated. Incidental observations involving notable concentrations of sediment and persistent toxics are to be recorded and addressed.

- **Focus on Hot Spots**

  Pollution sources that were emphasized were high priority hot spots and diffuse sources that presumably were good targets for future interventions. Priority was determined by each country on the basis of multidisciplinary evaluations and comparisons that examined emissions; conditions of receiving waters; sensitive areas or issues downstream; national and transboundary effects; and other considerations noted above in the discussion of objective. The decision to focus on hot spots rather than total pollution loads was made with intention of concentrating attention on specific promising pollution targets for the Pollution Reduction Programme. Attention to total loads was provided within the context of the DWQM activities. Power plants (including nuclear facilities) were not included among the hot spots, either on the basis of their discharge of hot water, or on the basis of their potential to become a major source of chemical or radionuclide pollutants.

- **Focus on Transboundary Situations and Issues and on Significant Impact Areas**

  Attention was focused on transboundary pollution problems, including problems involving the Black Sea. Special attention was given to Sub-river Basin Areas and Sub-river Basins (which are addressed below in Section 2.3) and to Significant Impact Areas (which are addressed below in Section 2.7).

- **National Review Reports**

  National Review Reports were prepared by each country and reviewed by the International Consultants. The reports focused on socio-economic conditions, water quality, water environmental engineering and financing mechanisms for proposed projects. Socio-economic conditions and water quality covered information that was required for the preparation of the DWQM and the Transboundary Analysis. Water environmental engineering and financing mechanisms covered additional information that was required for development of the Pollution Reduction Programme.

- **DWQM**

  The DWQM was further developed and refined and applications were initiated. Main purposes of the DWQM were (i) to serve a focal point for debate about physical and biological processes that affect the dynamics of nutrients, for example in groundwater, flood plains, wetlands and storage reservoirs; and (ii) to assist in evaluating pollution reduction scenarios, if the resolution of the model could be improved beyond the range of variabilities in the river system.

- **Evaluation of Wetlands and Floodplain Areas**
  Wetlands of selected major rivers were investigated to identify and evaluate potential restoration areas of former floodplains.
- **Inception Workshop**
  Programme activities and milestones were planned at an Inception Workshop in late November 1997.
- **Review Preparation Workshop**
  Detailed TOR for the National Experts and the National Review Reports were developed during a planning workshop in late January 1998.
  National Planning Workshops
  A National Review Workshop was convened in each country to review the findings of each National Review Report in a public forum within the country that prepared the report and to conduct a causal chain anaysis for each country.
- **Transboundary Workshop**
  A Transboundary Workshop reviewed the findings of the National Review Reports in an international forum and made recommendations for the Transboundary Report concerning the analysis of problems and the design of alternative interventions to reduce pollution and transboundary effects.
- **Transboundary Report**
  The Transboundary Report was drafted following the workshop, taking into consideration the results and recommendations of the workshop. The present final report is the 4th revision after the workshop.

2.3. Definition of Regions and Development of the Sub-river Basin Approach

In response to initial findings of the Transboundary Analysis, comparative information about the 13 participating countries, and expectations concerning forthcoming EU directives, the decision was made to group the 13 countries into three socio-economic categories; and to extend the analysis of pollution, transboundary effects and pollution reduction scenarios beyond the country to country approach to a Sub-river Basin approach.

The 13 countries were grouped as follows:

- **Upper Danube River Basin**
  This area includes Germany and Austria whose market-oriented economies, membership in the EU and high level of economic development set them apart from all of the other countries.
- **Central Danube River Basin**
  This area includes the countries that are in economic transition but that are not directly associated with the Black Sea; and some of these countries that are moving fastest toward joining the EU. The countries are Czech Republic, Slovak Republic, Hungary, Slovenia, Bosnia and Herzegovina, Croatia and Federal Republic of Yugoslavia.
- **Lower Danube River Basin**
  This area includes the countries that are in economic transition and that are directly associated with the Black Sea. The countries are Bulgaria, Romania, Ukraine and Moldova.

The Sub-river Basin approach was described in a 15 January 1999 Draft Report titled "Danube River Sub-Basin Areas" and in the 3 March 1999 Draft Report titled "Transboundary Areas in the Danube River Basin". The Sub-river Basin areas comprised, within a single country, "new physical-geographical units of several similar hydrographic parts (basins of mostly the Danube's first-order tributaries)". There are 32 Sub-river Basin areas. Following elucidation of these areas, the areas were grouped into larger "Sub-river Basins" that often included more than one country. These "Sub-river Basins" were initially revealed during the Transboundary Workshop in late January 1999, where they were amended slightly. At present there are 15 Sub-river Basins which serve to elevate local and national river basin management needs to the attention and of the entire Danube Basin.

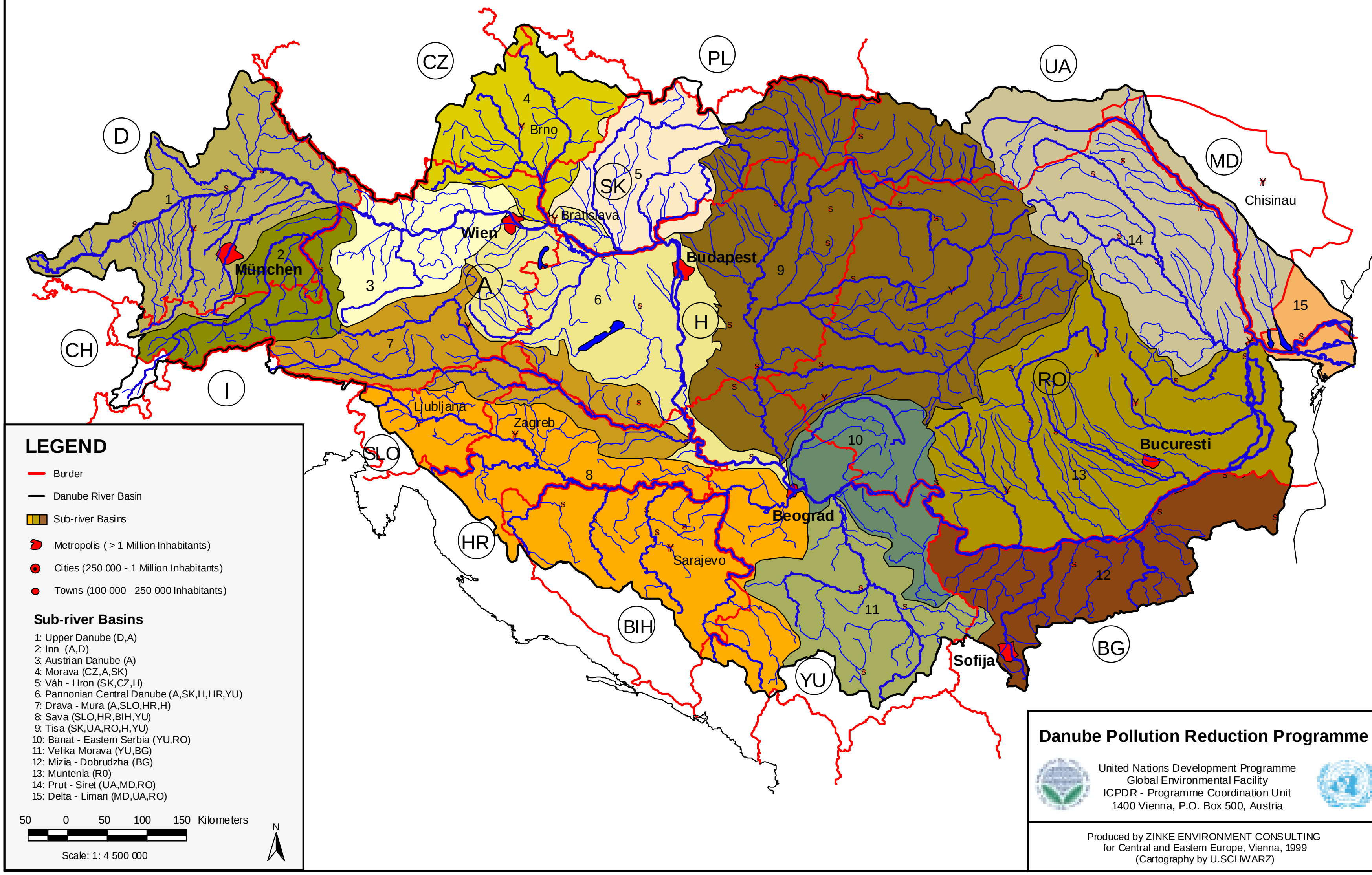
The Sub-river Basin Areas are mapped Annex 2.3A (Map 3) and described in detail in the report titled “Thematic Maps of the Danube River Basin – Social and Economic Characteristics with particular attention to Hot Spots, Significant Impact Areas and Hydraulic Structures”.

The Sub-river Basins are presented in Map 2 and described in detail in the report titled "Transboundary Areas in the Danube River Basin, Thematic Maps on Socio-Economic Issues, Hot Spots and Significant Impact Areas".

Supporting maps present population density by Sub-river Basin areas (Map 4); land use for selected Sub-river Basin areas (Map 5); agricultural indicators of livestock density and rates of fertilizer application by country (Map 6); and agricultural indicators of total livestock and total fertilizer by country (Map 7)

Map 2: Sub-river Basins

Based on Transboundary Analysis Workshop 1999



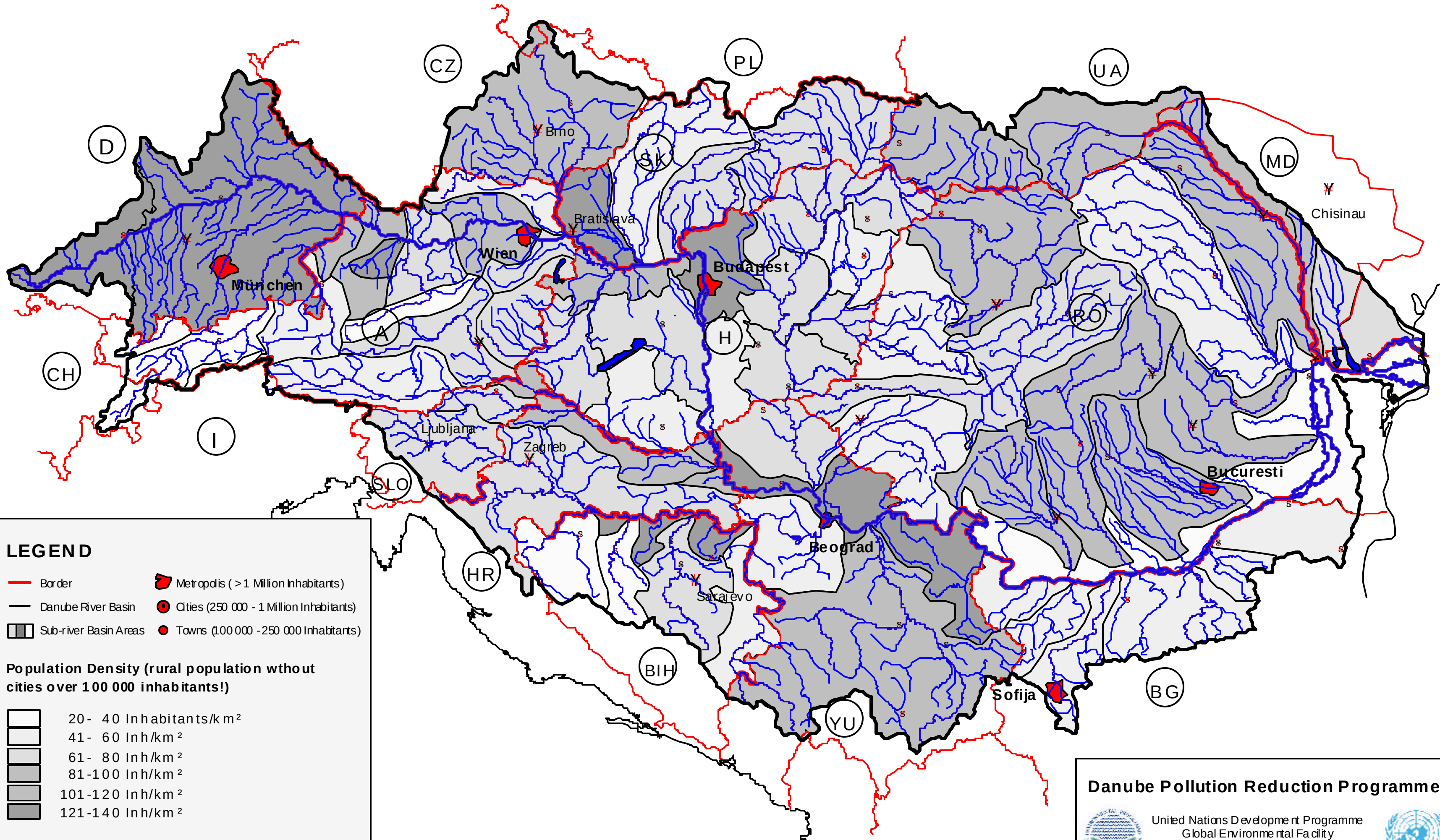
Danube Pollution Reduction Programme

United Nations Development Programme
Global Environmental Facility
ICPDR - Programme Coordination Unit
1400 Vienna, P.O. Box 500, Austria

Produced by ZINKE ENVIRONMENT CONSULTING
for Central and Eastern Europe, Vienna, 1999
(Cartography by U.SCHWARZ)

Map 4: Population Density in the Danube Sub-river Basin Areas

Based on National Planning Workshop Reports 1998



LEGEND

- Border
- Danube River Basin
- Sub-river Basin Areas
- Metropolis (>1 Million Inhabitants)
- Cities (250 000 - 1 Million Inhabitants)
- Towns (100 000 - 250 000 Inhabitants)

Population Density (rural population wthout cities over 100 000 inhabitants!)

- 20 - 40 Inhabitants/km²
- 41 - 60 Inh/km²
- 61 - 80 Inh/km²
- 81 - 100 Inh/km²
- 101 - 120 Inh/km²
- 121 - 140 Inh/km²

50 0 50 100 150 Kilometers

N

Scale: 1: 4 500 000

Danube Pollution Reduction Programme

United Nations Development Programme
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1400 Vienna, P.O. Box 500, Austria

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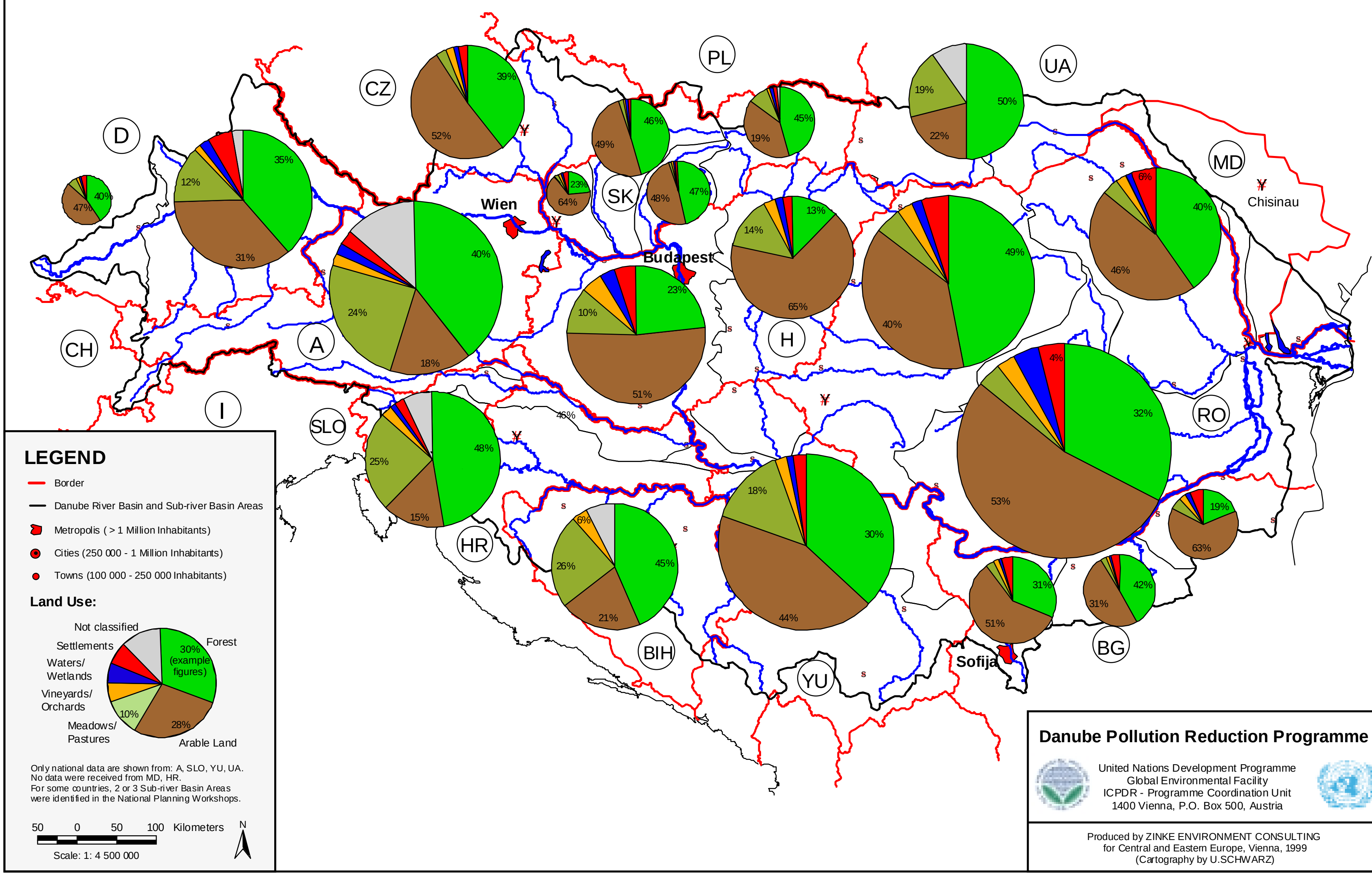
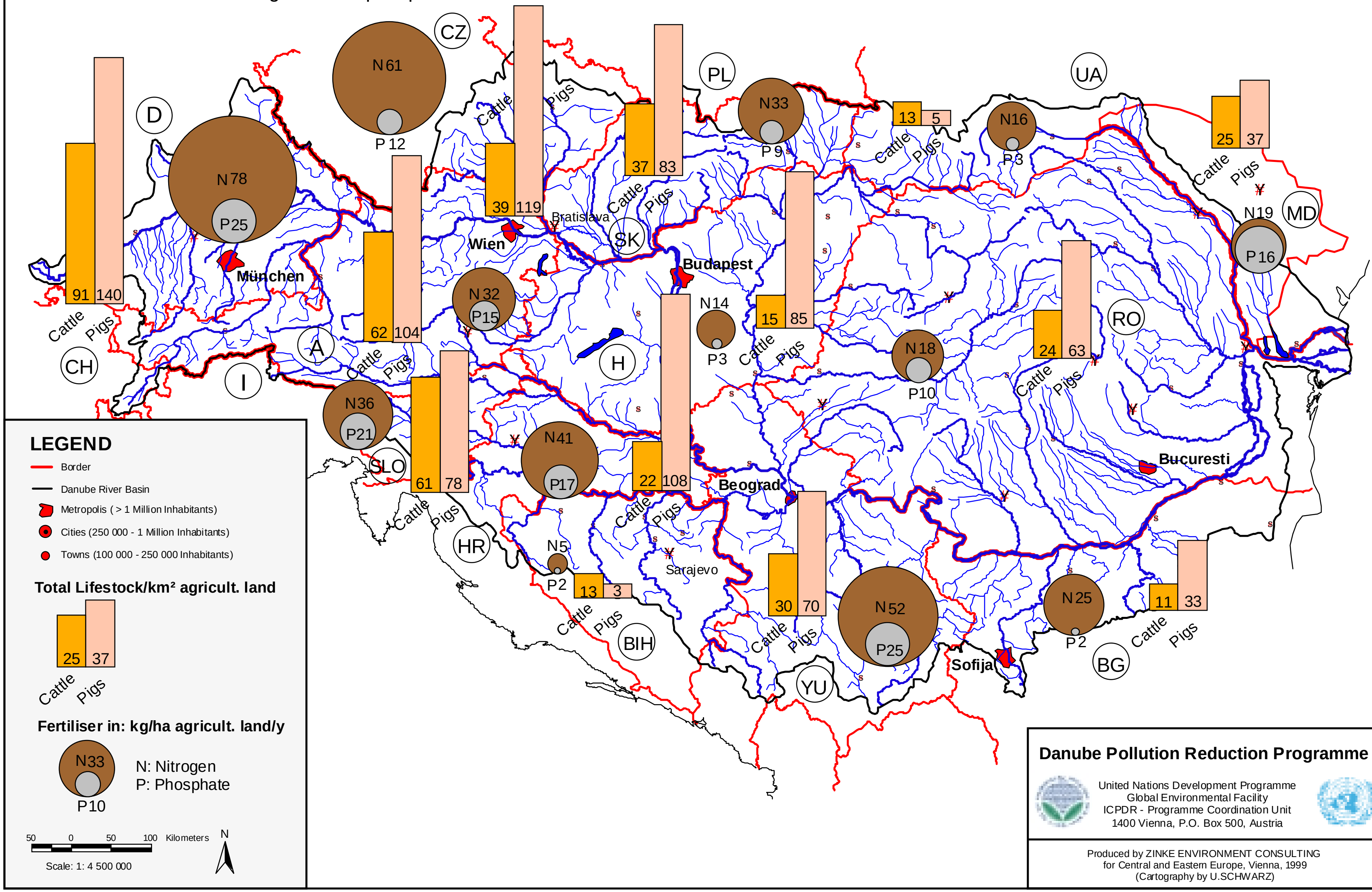
Map 5: Land Use in the Danube Sub-river Basin Areas

Based on CORINE Land Use Data, National Planning Workshop Reports 1998 and Updates May 1999



Map 6: Agricultural Indicators I (Lifestock/Fertiliser) in the Danube Basin Countries

Based on National Planning Workshop Reports 1998



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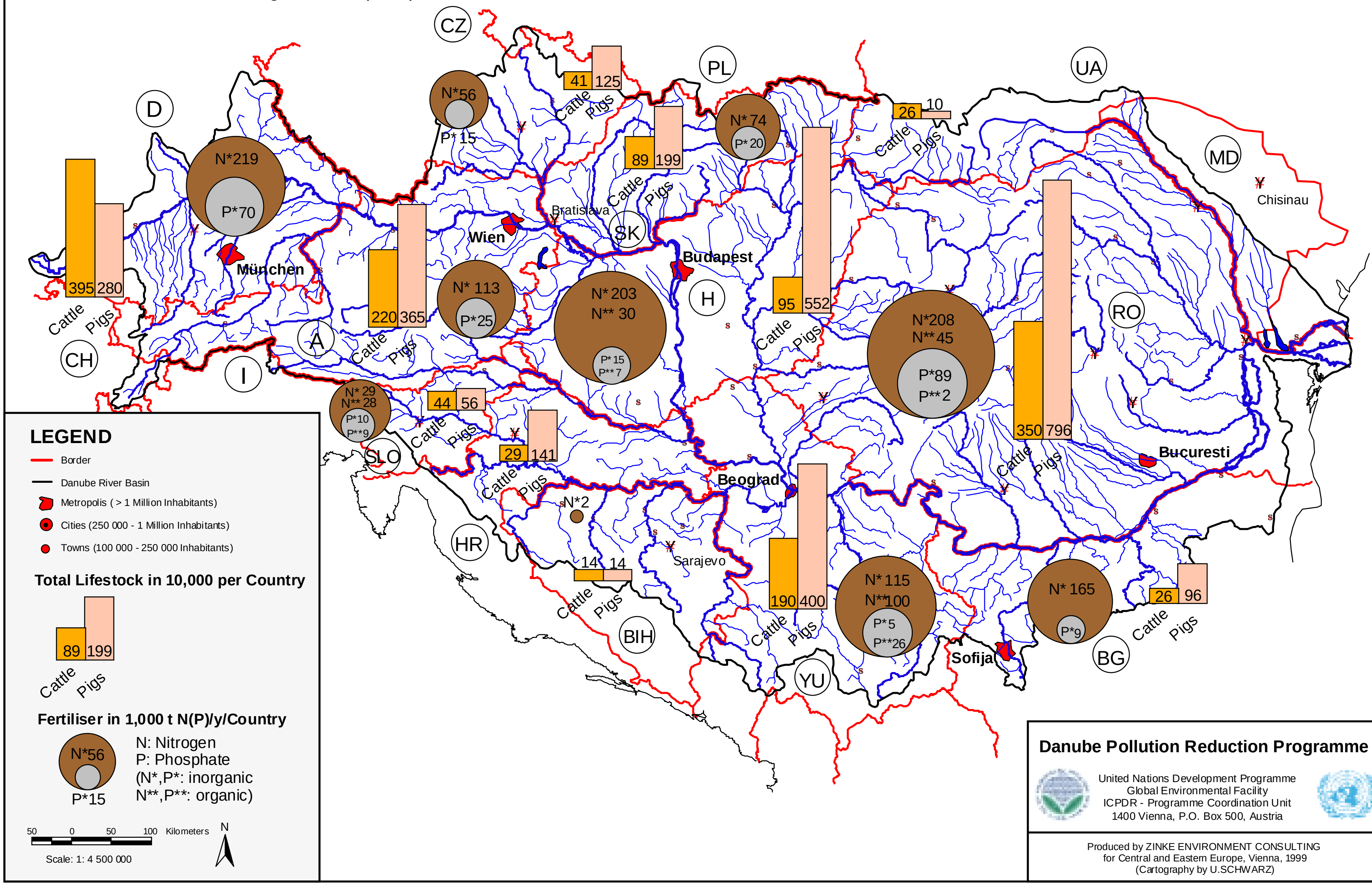
Map 7: Agricultural Indicators II (Total Lifestock, Total Fertiliser per Country)

Based on National Planning Workshop Reports 1998



2.4. Use of Transboundary Analysis in the Danube River Pollution Reduction Programme

Within the context of the overall Danube Pollution Reduction Programme, the Transboundary Analysis is used:

i. as the main project activity for basinwide identification and description of worthwhile targets for further consideration in the pollution reduction programme,
ii. as the main project activity for identification of immediate causes of pollution and root causes of transboundary pollution problems,
iii. along with the pollution reduction activity, as a project activity for identification of possible interventions to reduce transboundary pollution, by responding to the immediate and root causes of the problems, and
iv. along with other project activities in general, as an activity for determining requirements for monitoring to evaluate the effectiveness of the interventions and the future conditions of river water and sensitive items.

Worthwhile targets emerge from the identification and description of the most serious water pollution problems in the basin, where seriousness can be defined from several perspectives. For example, seriousness can be based on types of substances discharged, the quantities of substances discharged, the capacity of the receiving waters to dilute the discharges, the capacity of the receiving waters to transform or eliminate the pollutants (for denitrificaton or oxidation of BOD), the proximity of other countries downstream, the proximity of users and sensitive uses downstream and the proximity and sensitivity of sensitive biota downstream. Effects that are dependent on concentration of pollutants can be reduced by dilution. Effects that are dependent on pollutant loads cannot. In general, the seriousness of problems near the source is more closely linked with concentration, while the seriousness of problems in remote areas, such as the Black Sea is more closely linked with loads, especially for N and P which change more slowly, during longitudinal succession, than BOD and COD.

In the present Transboundary Analysis the most serious pollution problems were identified at the national level as hot spots that were evaluated and ranked on the basis of the perspectives just mentioned, in three sectors (municipal, agricultural and industrial), and at three levels of priority (high priority, medium priority and low priority). Diffuse sources were considered, but in practice there was a bias of attention toward point sources because of the paucity of data on diffuse sources, as well as uncertainties associated with the economic transition.

In the context of this bias, possible interventions were identified and initial estimates of their pollution reduction potential were made by each country. Initial criteria for ranking of possible interventions were established by the participants of the Transboundary Workshop. Initial tentative ranking of possible interventions was carried out by the participants of the Workshop. Projects included in this initial ranking were subsequently arranged by sector in order of numtient reduction (N + P), with largest reductions listed first.

The relative size and importance of the transboundary components that are consistent with the criteria for GEF intervention were also evaluated by listing the top 25 and the top 5 projects on the basis of reduction N, P, BOD and COD; proposing measures for possible interventions involving diffuse sources; and describing relationships between Significant Impact Areas, hot spots and projects.

Use of the Transboundary Analysis includes investigation and discovery of core problems, immediate and root causes of pollutant discharges and immediate and ultimate effects of pollutant discharges. For point sources, immediate causes of pollutant discharges may include, for example,

- absence of central wastewater treatment facilities,
- insufficient designed capacity of treatment facilities,
- low design standards for treatment (for example, primary vs. secondary),
- bypassing of treatment facilities to avoid operating costs,
- improper operator performance at treatment facilities,
- frequent flooding of treatment facilities,
- discharge of industrial wastes to municipal treatment facilities without pre-treatment
- overloading of treatment facilities due to infiltration and inflow or stormwater,
- discharges by mobile sources such as ships, and
- breakdown of treatment facilities.

For diffuse sources, immediate causes may include, for example,

- overflow or leakage of on-site septic tanks
- removal of vegetation through fire or deforestation,
- improper cultivation of steep slopes, or
- excess use of fertilizer and pesticides (either at the present time or as a result of groundwater or soil that was contaminated during past decades).

For both types of sources, root causes of transboundary problems may include, for example, absence or weakness of

- public awareness and a constituency that demands pollution control,
- attention at the local level to pollutant loads,
- policies, legislation, regulations or clear mandates that require pollution control,
- standards and institutions that facilitate the enforcement of pollution control,
- incentives that encourage pollution control,
- requirements to consider downstream uses and users in the planning, siting and implementation of activities which have the potential to pollute,
- economic collapse,
- war,
- bilateral or international agreements that cover mobile sources such as ships, or
- bilateral or international agreements that facilitate discover (through quality controlled monitoring) and resolution of cross-border problems.

Immediate effects are direct changes in water quality, i.e., unacceptable concentrations of various pollutants in receiving waters used for various purposes including drinking water, recreation, fisheries, wildlife, irrigation or industrial water supply.

Ultimate effects may include, for example:

- degradation of biodiversity fisheries and wildlife, especially in wetlands
- aesthetic degradation of recreation areas
- clogging or blocking of structures by sediment deposits
- public health risks from chemical pollutants
- public health risks from pathogenic pollutants

- increased costs of water treatment for various uses including public water supply or industrial water supply
- loss of use of water (due to high cost of treatment) for various purposes including public water supply, irrigation or industrial water supply

In response to the discovery of the causes and effects, the use of the Transboundary Analysis also includes identification of possible structural and non-structural solutions that target the causes. Structural solutions include

- construction of new central municipal treatment facilities,
- construction of new central treatment facilities for clusters of industrial plants,
- construction of new treatment facilities for old industrial plants (retrofitting)
- conversion of industrial processes to reduce pollution
- expansion of the capacity of treatment facilities,
- repair of damaged facilities,
- upgrading of central treatment facilities along the continuum from primary treatment to secondary treatment to phosphorous removal to nitrogen removal,
- upgrading of collection systems to minimize infiltration and inflow of stormwater,
- upgrading of on-site systems to reduce overflow and leakage, or
- construction or rehabilitation of wetlands.

Non-structural solutions may include for example,

- development and enforcement of strict standards for pre-treatment of industrial wastes, prior to discharge into municipal treatment systems,
- development and enforcement of strict standards to be applied to all on-site sewage systems constructed in the future,
- development and enforcement of strict policies of waste minimization to be applied to all new industrial facilities constructed in the future,
- development of strong financial incentives for polluting industries to rapidly convert existing processes that are consistent with waste minimization.
- development of national and local policies, legislation, administrative apparatus or financial incentives to control land use in ways that reduce rapid runoff, erosion and sedimentation,
- campaigns to raise public awareness and build a constituency for pollution control,
- institution building and operator training to improve the efficiency of operation of existing treatment facilities,
- strengthening of institutions responsible for inspection, monitoring, laboratory testing, and performance testing,
- development or strengthening of institutions for managing water resources by catchment area,
- development of international agreements to achieve uniform treatment of polluting industries and eliminate safe havens for serious polluters,
- training and institutional strengthening to support all of the measures.

Most of the activity involving interventions (project development) occurred as part of the Pollution Reduction Programme and mostly involved structural solutions for high priority point-source hot spots. During the Transboundary Workshop further attention was given to non-structural solutions and diffuse sources, but to date the details of many of proposed measures (including wetland rehabilitation) are not as well developed as the details of possible structural solutions.

Use of the Transboundary Analysis also involves development of suggestions for further strengthening water quality monitoring to evaluate the future effectiveness of interventions and to refine and expand the knowledge of transboundary transport of pollutants. For the TNMN stations, this activity is already progressing well under the direction of MLIM Sub-Group, but further suggestions are presented in Section 5.1.3.

2.5. The Approach and Use of the DWQM in the Transboundary Analysis

The approach and present status of the DWQM are presented in the 15 January 1999 report titled "Danube Water Quality Model Simulation in Support to the Transboundary Analysis" (as amended following the workshop in May 1999) which is available as a separate volume.

The approach involved:

- **Schematization of the river basin** (dividing the river network into segments) as shown in Figure 2.5-1.
- **Set up of the water balance model** that, for each segment, computed inflows and outflows, water volume, streamflow velocity and water depth. The set up was done in three steps (i) mapping of the catchment of the Danube, (ii) computation of flows, and (iii) computation of the remaining segment characteristics.
- **Set up of the water quality model** by introducing pollution sources in four ways, i.e., as (i) point source emissions, (ii) distributed emissions causing constant loads in the river, (iii) distributed emissions causing constant concentrations in the river, and (iv) distributed emissions causing concentrations proportional to the river flow; and by modeling the behavior and nitrogen and phosphorus and computing in-stream nutrient loads by methods explained in detail in the report.
- **Running the model for two scenarios** of assumed conditions about 1994 to 1997 point-source and diffuse-source emissions and immission/emission ratios - a "low scenario" and a "high scenario".
- **Rerunning the model on the basis of partially updated information** on estimates of nitrogen and phosphorus emissions to surface water in the Danube Basin for the year 1996/97 (Kroiss and Zessner, 1999).
- **Rerunning the model to compute the effects of the pollution reduction programme** on nutrient loads in the Danube River and major tributaries to the Black Sea.

"Questions about diffuse sources of pollution are addressed under the discussions of distributed emissions. The discussions use the November 1997 report of the Nutrient Balances project as the main starting point and apply some adjustments and additions to the data (which used 1992 as the target year for its data base and which covered all Danube countries except Croatia, Yugoslavia and Bosnia-Herzegovina). The discussions conclude that:

- "neither the Nutrient Balances project nor the present National Reviews provide a complete picture of homogeneous quality for all Danube countries;
- there are apparent inconsistencies between data from the Nutrient Balances project and from the present National Reviews;
- it is therefore dangerous to interpret the difference between the information in the Nutrient Balances project and the present National Reviews as 'the apparent change of conditions between 1992 and 1994-1997'."

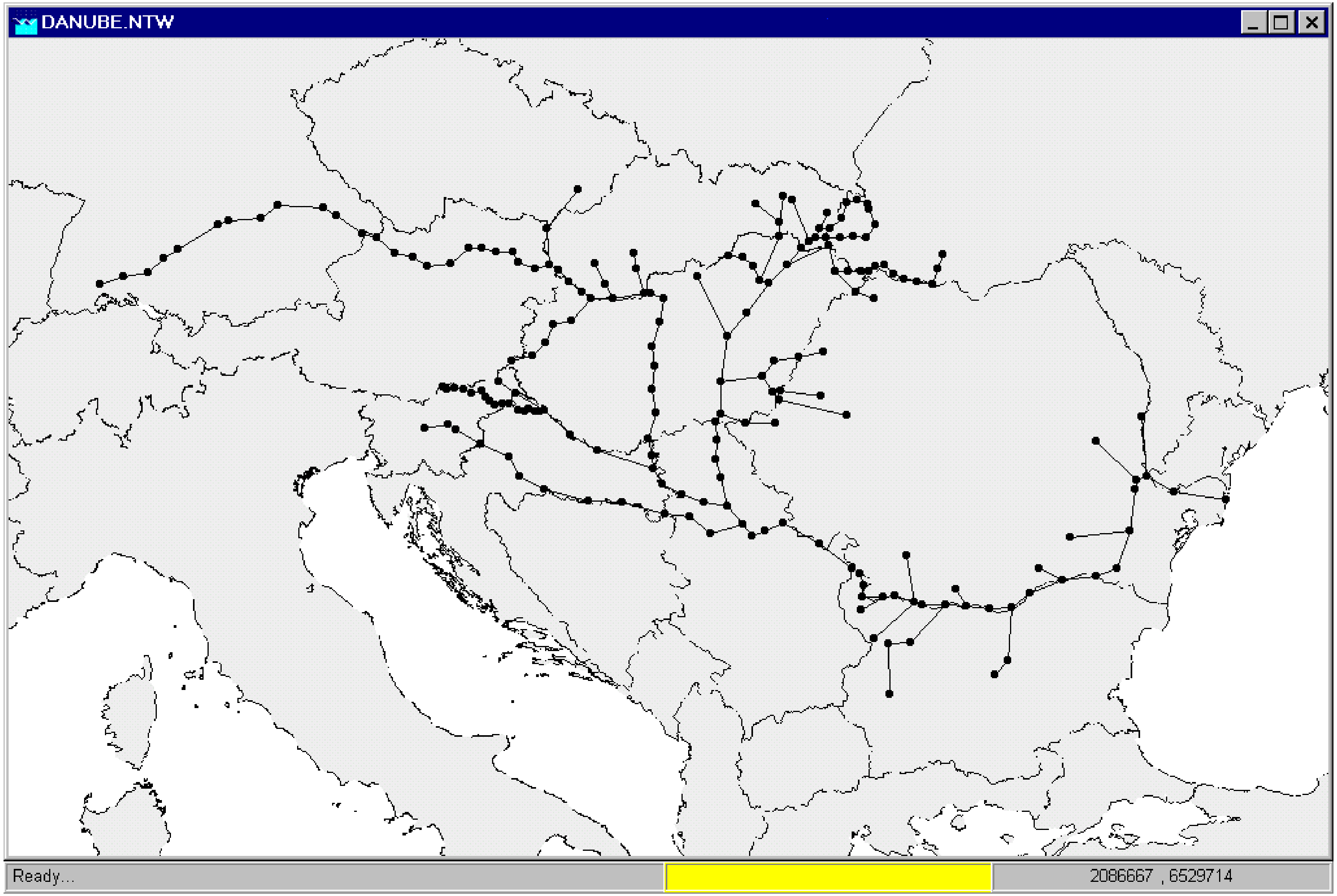
For this reason data from the Nutrient Balances project were partially updated. The adjustments are based on information in the National Review Reports, Kroiss and Zessner (1999) and other sources.

Data for Croatia, Yugoslavia and Bosnia-Herzegovina have been estimated based on specific emission factors obtained from the Nutrient Balances project."

Details concerning the estimation of diffuse sources and introduction of the estimates into the DWQM are explained in detail in the aforementioned report and its appendices. The estimates are included among the results which are presented below in Section 3.3.

In the long term it is expected that the model will continue to be used for running other scenarios that may emerge. However, an equally important purpose will be to serve as the driving force and focal point for defining and justifying further research on hydrological and chemical processes in the river basin and progressive refinement of the capability for modelling pollutant loads and transport.

Figure 2.5-1 Map of the Danube Area with the River Network Schematization



2.6. Analysis of Effect on Black Sea Ecosystems

The National Review Reports do not address the complex topic of effects on Black Sea Ecosystems. A recent and detailed summary of information on this topic is presented in the undated [1998?] Report on the Ecological Indicators of Pollution in the Black Sea, by the Romanian Marine Research Institute, Constanta, from which numerous excerpts are quoted below.

For the complex Black Sea ecosystems and biotic communities described in these excerpts, short-term analyses involving few parameters, such as this Transboundary Analysis, have little basis for offering technically competent predictions of specific effects that may be caused by particular interventions in the Danube Basin. Reductions of nitrogen and other nutrients (except silicates) seem clearly to be desirable since Black Sea levels are still significantly elevated; and improvements in recent years may be associated with the economic transition in Eastern Europe, which can be expected to reverse itself. However, even if details of the pattern of reduction could be known, the manner in which the reduction may manifest itself in Black Sea ecosystems could take many directions. These directions cannot be anticipated in an analysis such as this Transboundary Analysis.

According to the Romanian report, "The last thirty years represent a period of strong intensification of the antrhopic pression on the Black Sea environment, and high eutrophication, which considerably changed the structure and functioning of the coastal ecosystems, mainly in its northwestern [shelf], affecting both the qualitative and quantitative state of the benthic and planktonic communities."

"The principal cause of the long-term ecological changes on the North Western shelf waters of the Black Sea in the last three decades are the shifts in the nutrient and organic matter loads from the Danube, which transports more than 2/3 of the river input of the..[Black Sea]. From a comparison with historical data, it could be noticed that dissolved inorganic nitrogen increased by a factor [of] 4 or 5 as phosphorus increased nearly 2 times. At the same time the silica discharge was less than a half the estimated silica input before 1970.

"On the Romanian shelf the substantial increase of inorganic nitrogen and phosphorus and decrease in that of silicate were recorded. The highest stocks have been reached in 70' ($45.7x10^3$ tones PO4, $1464.0x10^3$ tons SiO4), they were considerably decreasing during 80' ($7.0x10^3$ tones PO4, $336.9x10^3$ SiO4, $183.2x10^3$ tons dissolved inorganic nitrogen) and slightly during 90' ($5.2x10^3$ tones PO4, $208.0x10^3$ tones SiO4, $83.4x10^3$ tones dissolved inorganic nitrogen)."

These changes were accompanied by increased frequencies and amplitudes of algal blooms between the 1960s and 1990 and a seasonal shift from late winter-early spring and autumn blooms to late spring-summer blooms with extended durations and remarkable changes in taxonomic composition of the bloom-producing species. "The decrease in Si/P and Si/N ratios and enrichment of the nutritive base with a surplus of organic matter seems to be responsible for dramatic shifts in phytoplankton species composition. from diatoms (silicaceous) to the dino flagellates and cocolithophorids (non-silicaceous)."

"The chlorophyll a as an indicator of both the phytoplankton quantity and its physiological status have recorded the high levels in 80', because [of] the high densities of algal cells. As a consequence of huge quantities of phytoplanktonic cells, chlorophyll a and suspended matter (especially in inshore area), Secchi disk values were reduced during the study period....

"Simultaneously with the beginning of eutrophication, the dissolved oxygen...presented a much more different regime...[compared] to the previous period. The main characteristic is the reduction of the dependence on thermal regime and the increase on the biological ones.

"In 1969-1975 the oxygenation degree registered an important increase in the coastal zone, subject to the fertilizing impact of the Danube...This suggests a higher photosynthetic rate in the euphotic zone caused by the higher nutrient concentrations as a result of increased nutrient inputs of the Danube.

"Since 1976 the oxygen content continually decreased...In the last three years the lowest level of coastal waters oxygenation has been recorded, annual mean decreasing below 6.00 cm^3/l.

"In the actual ecological situation, as eutrophication phenomenon has become chronic, a permanent accumulation of the nonmineralized organic carbon in the water column and in the superficial sediment, due to the increased sedimentation of particulate organic matter both produced in photic layer as planktonic production and introduced by land-based sources, has been recorded. The greatest part of organic particulate matter is enzymatically decomposed by microorganisms, using dissolved oxygen and often leads to suboxic or anoxic conditions. The resulting oxygen deficiency during the warm period (very frequent below 3.0 cm^3/l, corresponding to undersaturations below 50%) has caused the death of the benthic fauna which represent a new amount of organic matter requiring oxydation. This fact amplifies the oxygen reduction down to the generation of the hydrogen sulfide, even in the near shore waters. In the same time these processes represent a potential source of nutrients for the water above, which maintains the eutrophication process.

"For the marine area between the shore and the 50 m isobath, the results of the research made east of Constantza have shown similar modifications to those recorded in the coastal zone....

"Due to strong thermohaline stratification during summer, typical for outer estuaries, the oxygen input into the bottom layers is mainly controlled by eddy diffusion, which often does not compensate the oxygen demand of the benthos...Supersaturating up to 150% prevails in surface layers due to high phytoplankton production, whereas suboxic conditions < 50% are found below the thermocline.

"These biochemical shifts, together with the invasion by opportunistic organisms such as *Mnemiopsis leidyi* have put additional stress on the ecosystems of the Black Sea which induced drastic changes in the taxonomic composition of the zooplankton species....

"A significant decline has been observed in the zooplankton beginning 1989...This considerable diminution of the fodder zooplankton biomass was a consequence of the immigrant predator *Mnomiopsis leidyi*, added at the other antrhopic influences.

"In the last two years 1996-1997 the fodder zooplanktonic biomasses were a little higher than in previous years, even in summer months....

"A qualitative and quantitative decline in the macrophyta algae was also observed...Today the small number of component species has made the vegetation very uniform , in majority opportunistic species with short life cycles.

"The most affected, especially by hypoxia conditions were the zoobenthic communities. The zoobenthos recorded in the last three decades was greatly diminished, both qualitatively and quantitatively...

"In total, from 79 macrobenthos species measured in 1961, only 26 species remained in 1987. The standing stock of the zoobenthos measured in 1989 represented only 26% of the stock recorded in 1960.

"The diversity reduction was compensated in the 1976-1986 years by an increase of the macrobenthos densities and total biomass as a result of the proliferation of opportunistic species...After that, an intensification of frequency of blooms has determined a strong decline of the benthic biomass....

"After 1990, when the phytoplankton did not bloom as much as in previous years, emphasized only a slight improvement of the qualitative structure of the zoobenthos....

"In the last three years a slight increasing tendency of the silica content (even if it is still 2-3 times less than 60') parallel with a continuous decrease of nitrogen and phosphorus were recorded. While nitrogen still maintains it values 3-5 time higher than 60', phosphorus presented values similar to those before 60', frequently the diminution reaching the exhaustion state. These were reflected in the reduction of total microplankton quantity and of their bloom events, and in returning of diatoms to the dominant role as a group. Large N/P ratio suggests phosphorus as a limiting nutrient of the algal production in the Romanian shelf waters....

"Even if in the last three years the lowest level of the coastal waters oxygenation has been recorded, suboxic areas from the Romanian shelf restricted after 1990, in good agreement with microplankton species bloom frequency and intensity reduction...

"In the last three years only a slight improvement of the qualitative structure of the zoobenthos was recorded. Benthic communities are now characterized by considerable instability, the perpetuation and intensification of the unfavorable conditions has also affected the more tolerant species. Though, the last three years reflects perceptible improvement in the state of some biotic components, the whole ecosystem is still disturbed and continues to be damaged by consequences of many years of intense eutrophication process."

2.7. Analysis of Effects on Significant Impact Areas within the Danube Basin

Significant Impact Areas (SIAs) are defined as places in the Danube River Basin where there are particular notable combinations of cumulative effects involving pollutant source / pollutant recipient interactions. Significance is derived from the simultaneous presence of (a) one or more sources of potent or large loads of pollutants and (b) conditions of recipient water wherein the local context of flow conditions and uses causes the presence of the pollutants to be important.

Fifty-one SIAs were identified by country representatives during the Transboundary Workshop, based on their technical knowledge of the Danube River and tributaries, as well as drafts of wetlands maps provided by the study team for the wetlands study. Information about the SIAs are presented in Section 3.6.

Examples of categories of effects on significant impact areas include the following:

- Effects on downstream users / stakeholders (national, regional and global)
- Effects on Danube wetlands (national, regional and global)
- Effects on Danube biota (national, regional and global)
- Effects on the Danube delta (regional and global)
- Effects on the Black Sea chemistry and biota (regional and global)

Analysis of effects of hot spots and possible interventions on SIAs was carried out by comparing locations of hotspots, projects and SIAs and features of pollutant discharges, interventions and the SIAs. Basinwide ranking of SIAs was attempted and included on the agenda of the Pollution Reduction Programme workshop, but was rejected by a working group and a plenary due to the great diveristy of SIAs and the resulting difficulty of making technically competent analyses of relative importance. Results of the anaysis are presented in Sections 3.6 and 5.2.3 respectively.

2.8. Analysis of Potential for Reduction of Water Pollution

The original approach for identifying possible interventions was proposed and discussed during the Inception Workshop in November 1997 and the Review Preparation Workshop in January 1998. It involved the systematic identification of interventions following the ranking of hot spots. It presumed that most interventions would evolve from the lists of high priority hot spots for each country and that interventions would eventually be ranked over the entire basin on the basis of criteria to be developed during the Transboundary Analysis or the development of the Pollution Reduction Program.

In practice, the identification of interventions was somewhat less systematic - possible interventions for reducing water pollution were identified in several different ways. Most national review reports followed the original approach rather closely, with the result that most of the projects proposed in these documents did indeed involve high priority hot spots. However, during the National Planning Workshops, some projects were suggested, which did not involve high priority hot spots, and in a few cases, did not even involve hot spots. The wetlands study was intended to identify wetlands rehabilitation projects, but the level of detail was generally lower than for most structural projects associated with hot spots. During the Transboundary Workshop, it was realized that few non-structural projects had been proposed, so additional proposals for non-structural projects were solicited from the participants.

During the Transboundary Workshop, in response to this situation, lists of hot spots, the EMIS emissions inventory, and lists of potential projects were circulated to participants who, in regional working groups, were asked to reconcile the lists to insure that each intervention was justified and that each high priority hot spot and EMIS source was given adequate consideration.

Participants in the Workshop developed criteria for unified ranking of proposed projects and, on the basis of these criteria, carried out preliminary ranking, approximately as follows. The criteria for this preliminary ranking, were (i) t/y of reduction of total-N, (ii) t/y of reduction of total-P, (iii) t/y of reduction of BOD, (iv) t/y of reduction of BOD divided by discharge in m3/s, t/y of reduction of COD and (vi) judgment concerning effects on SIAs. It was initially agreed in a plenary that efforts would not be made during the Transboundary Workshop to rank all potential projects. Rather, efforts would be made, in regional working groups, to identify approximately the ten most important projects in each sector in each region and then to rank these on a regional basis.

However, the regional working groups were not all able to reach agreement on only 10 projects, so the number of the most important projects was somewhat higher than suggested during the plenary. Also, the groups were unable to agree on a regional ranking, so projects were listed by country, without any explicit ranking (but the listings were in the perceived order of importance of each country).

Following the workshop lists of these projects were arranged on the basis of N and P removal by sector to identify those projects in each sector which have the largest nutrient reduction.

Further ranking of projects on the basis of cost effectiveness was carried out by sector for each country and is presented in the report of the Pollution Reduction Programme.

2.9. Analysis of Potential for Wetland Rehabilitation and Management

A detailed description of the approach and methodology of the wetlands investigation is presented in the report. The approach used for this analysis comprised choices and applications of work that are briefly summarized as follows:

- **Study Area -** The area of the analysis was limited to the Danube River and it larger tributaries (Morava, Drava, Tisza, Sava and Prut).
- **Background Information** - Potential available information that was reviewed to ascertain availability and gaps in information included general spatial data, historical maps, current maps, topographical maps, thematic maps, landuse data, remote sensing data, hydrological data, bioindicators, protected areas and evidence of nutrient reduction. In addition, wetlands information in the National Reviews was reviewed and summarized.
- **General Description of the Basin -** The Danube Basin was briefly characterized through (i) description of geographic subdivisions of the study area; (ii) a table comparing water levels and average, maximum and minimum discharges for selected stations near the

mouths of the major tributaries; (iii) an evaluation of the distribution of bioindicator species that are associated with high quality wetlands and (iv) a discussion of the problem of deepening of the river channel.

- **Definition of Sections -** Floodplains that were investigated were divided into lengths of minimum 15 km and widths of 1 km intervals on each bank.
- **Data on landuse, floodplain type and size -** The most widely applicable data for describing and evaluating the ecological potential and rehabilitation potential of floodplains were found to be the current CORINE-Land Cover data, elaborated in some places through satellite image classification. Land use categories were forest, swampland / water, meadows, farmland and settlement. Floodplain types were recent floodplain, outlet section / polder and former floodplain.
- **Evaluation of Ecological Potential -** Ecological potential was evaluated on the basis of scores from multiplication of floodplain type x width x landcover, derived form weighting factors that were assigned to the aforementioned parameters as follows:
  - Floodplain type - recent floodplains (4) > polder / diversion stretch (2) > former floodplain (1)
  - Floodplain width - over 5 km (4) > 2.5 - 5 km (3) > 1 - 2.5 km (2) > 0 - 1 km (1)
  - Landcover - forests (4) = swamp/waters (4) > meadows (3) > heterogeneous agriculture (2) > farmland (1) > settlements (0)
- **Evaluation of Rehabilitation Potential -** Rehabilitation potential was evaluated using ecological potential as a starting point, considering only former floodplains with more than 1 km width, and evaluating the following additional parameters on a 4-level scale for the following factors:
  - Number of settlements (few > many)
  - Extent to which areas are connected (connected > not connected)
  - Size of former floodplain structures (larger > smaller)
- **Nutrient Reduction Potential -** Nutrient reduction potential was estimated on the basis of expert judgment for all the rehabilitation projects described in the wetlands report. Figures on nutrient reduction of wetlands were quoted from several studies reported in the technical literature (for N and P reduction in kg/ha/yr in wetlands). These figures are highly variable from study to study (see Section 3.8) and the wetlands report duly acknowleges many uncertainties concerning the possibilities for nutrient reduction through rehabilitation of Danube wetlands. One of the main items of missing information is river cross sections and elevations that would be useful in estimating (for each site) the distribution of river water between the main river channel and the wetland area under various conditions (flow and elevation) of discharge.