

First delineation of surface water bodies in Slovenia

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ABSTRACT: The process of delineation of surface water bodies (hereinafter called: SWB) - rivers, lakes, transitional waters, and coastal waters - in Slovenia has been underway intensively since the adoption of the Slovene Water Act (hereinafter called: ZV-1) (2002) and establishment of the Institute for Water of the Republic of Slovenia (hereinafter called: IzVRS) (2003). The legal basis is the Slovene Regulation on methodology for SWB delineation, summarizing the provisions of the Water Framework Directive (hereinafter called: WFD) and corresponding Guidelines. In spring 2005, an interdisciplinary expert group of the Institute has elaborated an expert proposal on the first SWB delineation of the Slovene hydrographic network. In the process of delineation, rivers with a catchment area above 100 km² and corresponding wetlands, all natural and artificial lakes with a surface above 0.5 km², transitional waters and coastal waters have been analysed. In this way, 144 SWB on 76 rivers, 3 SWB on 3 natural lakes, 3 SWB of transitional waters and 5 SWB of coastal waters have been delineated.

1 INTRODUCTION

In the expert proposal of the first delineation of SWB, processed according to the provisions of the Water Act (ZV-1) (Uradni list RS 2002) and the WFD (The European Parliament and the Council 2000), in the period of 2004-2005 the following water bodies in Slovenia were delineated into SWBs (WB, AWB and HMWB candidates):

- rivers with a catchment area of $F > 100 \text{ km}^2$ and corresponding wetlands (76 rivers);
- natural lakes with a surface area $>0.5 \text{ km}^2$ (3 natural lakes);
- artificial channels $>3 \text{ km}^1$ (3 artificial channels);
- water reservoirs on rivers and artificial lakes with a water surface area $>0.5 \text{ km}^2$ (18 water reservoirs);
- coastal waters;
- transitional water.

The data on the catchment size of rivers, water surface area of natural lakes, water reservoirs on rivers, artificial lakes and lengths of artificial channels were provided from data bases of the IzVRS, from field literature and through cartographic sources.

According to the provisions laid down in the project scheme for the first SWB delineation shown in Figure 1, the scientific public was included in the work process: representatives of the Ministry of the Environment of the RS, Environmental Agency of the RS, institutions and individuals that cooperate in IzVRS projects that result from the field of WFD as bodies of professional co-operation and consultation. In addition, broad scientific public from the river basin districts of the Danube River and Adriatic Sea was also introduced into the process of the first SWB delineation. The co-operation and consultation with the public took on the form of panel discussions, organized presentations, workshops and working meetings.

The SWB delineation was underway simultaneously to the procedure of surface waters typology. Hence, in the proposal of the first SWB delineation the ecological regionalization of Slovenia based on hydro-ecoregions was considered (Smolar Zvanut et al. 2004), upgraded with the available data

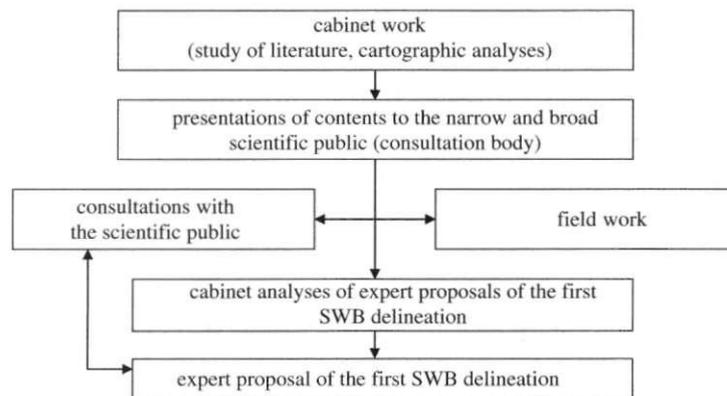


Figure 1. Project scheme of the first SWB delineation.

bases of abiotic factors, size of the catchment area and geology (IzVRS 2005a). In the procedure of the first SWB delineation significant attention was given to the factors of distribution and classification, such as hydromorphological factors, assessment of the chemical status according to the Decree on the chemical status of surface waters for 2002 (RS MOPE ARSO 2004), data on water quality, the existing monitoring network and results of the monitoring, as well as the best possible estimate according to the known or identified pressures.

2 MATERIALS AND METHODS

2.1 Rules on delineation of surface water bodies and heavily modified water bodies

Rules on delineation of SWB are laid down in Guidelines (CIS 2003a), based on the WFD (The European Parliament and the Council 2000). The contents of the WFD are summarized and legally provided by the Rules on delineation of surface water bodies (Uradni list RS 2003) (hereinafter called: the Rules). As an expert consensus of the consultation body of the first SWB delineation and related to the experience of other EU member countries, a minimum length of a water body in Slovenia was established as 3 km.

2.2 Methodology of the delineation of water bodies and heavily modified water bodies

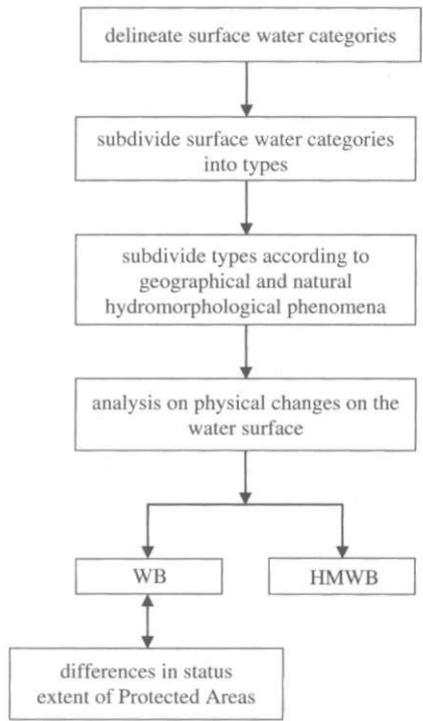
The methodology of the delineation of SWB is provided in the Guidelines (CIS 2003a), based on the WFD (The European Parliament and the Council 2000), and as to contents it is summarized and legally provided by the Rules (Uradni list RS 2003). As the methodological basis for the delineation of surface water bodies the provisions of Articles 4 (»Delineation of surface water bodies and criteria used«) and 5 (»Classification of water bodies«) of the Rules (Uradni list RS 2003) were adopted. The procedure of SWB delineation is shown in Figure 2.

2.2.1 Category of surface water

The surface water bodies are identified as falling within one of the following surface water categories, as set out in the Water Framework Directive (The European Parliament and the Council 2000): rivers, lakes, transitional waters and coastal waters.

2.2.2 Type of surface water

Based on the study of classification of surface waters in the period of 2004-2005 in the process of the first SWB delineation the results of the study of ecological regionalization based on hydro-ecoregions



significance (VGI 1994, 2002), which were categorized as class 3, 3-4, and 4 (class four as the worst class of the categorization), respectively (»first HMWB candidate list«). In the second part, all those river reaches were selected, which were categorized as class 1-2, 2 or 2-3 (as class 1 streams were categorized only completely natural streams) (»second HMWB candidate list«), and it was established that:

- the river channel contained obstacles for animal migration;
- after abstraction of water for permitted use there less water in the natural channel left than the analytically determined ecologically acceptable flow (Q_{ec});
- the water force in the reach is used for the production of peak load power; due to any reason supporting the specified uses there is no natural flood regime in the reach;
- the use of the natural lake as water reservoir with a monthly fluctuation of water level > 1 m.

As the criteria for determination of important anthropogenic physical changes of hydromorphological characteristics of rivers and lakes due to the mentioned anthropogenic the following criteria were determined:

- length of the cross-section profile of a water reservoir for specific use is 1000 m or more;
- the length of the derivational channel is 1000 m or more and/or the residual water in the natural channel is smaller than the analytically determined ecologically acceptable flow (Q_{ec});
- flood-prevention measures (dams, double-trapezoid profiles) are in the close vicinity of the river channel, and the natural floodplain is separated from the central part of the river corridor;
- the buildings in the urbanized area are at a distance from the river channel of less than 15 m on rivers of order 1 (ZV-1) and less than 5 m on rivers of order 2 (ZV-1), on both banks of the river reach of at least 1000 m in length;
- morphological changes and/or fortifications of lake bed, natural coastal line and banks and/or other reason of blockage of the coastal lake belt and/or built-up land or other kind of anthropogenic modification of the coastal belt in a width of 15 m from the edge of the water level, on 30% or more of the lake coast.

The rules for delineation of HMWB candidates in the areas of transitional water and coastal water are analogous to the procedure of delineation of other surface water bodies. The first selection of areas with the HMWB status of coastal waters and transitional water was made on the basis of the study of hydromorphological pressures on the coastal area (IzVRS 2005c). It determined that the anthropogenically modified parts of the coastal area consist of municipal mooring points (local ports), ports (sport, tourist ports), ports for public transportation, military ports, trade ports, industrial ports, tourism (swimming baths), areas of river outflows, urbanized areas and areas of cultural heritage. Based on the results of the study, the criteria for the identification of important anthropogenic physical changes of hydromorphological characteristics were determined:

- filling-in of the sea bed - modification of bays and reduction of flow;
- solid piers and piers on piles with solid upper part;
- filling-in of the sea and solid piers in a length of 1000 m or more;
- excavation for mooring points and transportation lines;
- maintenance of transportation lines and excavation of channels;
- coastal arrangements and concrete coastal arrangements, fitted with coastal elements.

Besides the data from the studies mentioned previously, the criteria were based on expert knowledge, acquired with the study of available sources, field work, verifications and co-operation with professional consultation body. An in-depth verification of the adequacy of the given criteria and current results will be possible with the use of GIS computer tools.

2.2.5 *Subdivision of surface water bodies*

In the first delineation of SWB, among the delineation factors mentioned above the assessment of the chemical water status was considered, provided by the Decree on the chemical status of surface waters for 2002 (RS MOPE ARSO 2004), data on water quality, the existing monitoring network

and results of the monitoring, as well as the best possible estimate according to the known or identified pressures.

2.3 Provisions of grouping and naming the water bodies

Based on the provisions of grouping the SWB (CIS 2003a, Uradni list RS 2003, RS MOPE 2004) as the principles of SWB grouping the following was considered:

- similarity of natural (ecological, hydrological and hydromorphological) characteristics of the catchment area or river basin;
- similar type of pressures identified on SWB within the same category of SWB (WB, AWB or HMWB);
- similarity of extent of pressures identified on SWB.

This way, SWBs were grouped on the basis of: SWB classification into hydro-ecoregions (Smolar Zvanut et al. 2004), proposal of the SWB category in the first SWB delineation (WB, AWB or HMWB), and similarity of type of hydromorphological pressures (river regulation, water storage reservoir, water abstraction) or water status (good/bad chemical status), as well as according to the quantity of the hydromorphological pressures identified.

The SWBs of the first delineation were named in two ways: with their own geographic (descriptive) name and with a code. The criteria for the selection of geographical names and WB codes were:

- simplicity and legibility of SWB description in the local geographical context for a wider, non-professional public;
- possibility of understandable translations of SWB descriptions into English or other foreign languages;
- possibility of grouping the SWB codes in case of SWB grouping;
- possibility of adding new (additional) codes of SWBs in case of establishing new (additional) SWBs.

Geographical names of SWB were attributed according to the geographical context if the starting and end point of WB, AWB or HMWB (e.g. WB Kolpa Primostek - Kamanje; HMWB Paka Velenje - Skorno), or according to the location and specifics of the AWB (e.g. AWB HPP Zlatolicje Channel) or HMWB candidate (e.g. HMWB Vogrscek reservoir Vogrsfiek). In case there is only one WB designated for a river, the SWB attribution contained the proper name of the river (e.g. WB Prečna; HMWB Baca). Similarly, names of WBs of lakes (e.g. WB Lake Bohinj), WBs of transitional water (e.g. WB Skočjanski zatok; HMWB Rizana Dekani - outflow) and WBs of coastal water (e.g. WB Sea - Piran Bay; HMWB Sea - Koper Bay) were designated.

Geographical names of SWB groups (WB, AWB and HMWB) were named in the geographical, locational and technical context (e.g. gWB Goricko; gAWB Derivations Drava, gHMWB Mola Klivnik; gHMWB Mura reservoirs etc.).

The water bodies were assigned a unique information code according to the Pfafstetter coding system. The code was composed of two parts: the first part equals the code of the river where the WB was defined, the second part describes the extent of the WB on the river. The code consists of the SI abbreviation and hydrographic area code (HGO), where the water course stands for the main river (e.g. SI6 is the code of the Sofia River, SI66 stands for the Nadiza River and SI628 stands for the Baca River). Since there are usually several water bodies on a river, the river also contains a second part, starting with the abbreviation WB followed by a numerical part. The numerical part was added only when there were several WB designations on a river.

3 RESULTS

In the procedure of expert proposal of the first SWB delineation 155 SWBs on rivers, lakes, transitional water and coastal water were identified. Among these we identified 144 SWBs on 76 line



Figure 3. Expert proposal of the first SWB delineation in Slovenia, scale 1 : 1,000,000 (approximate scale).

Table 1. Proportion of all SWB categories on rivers in River Basins.

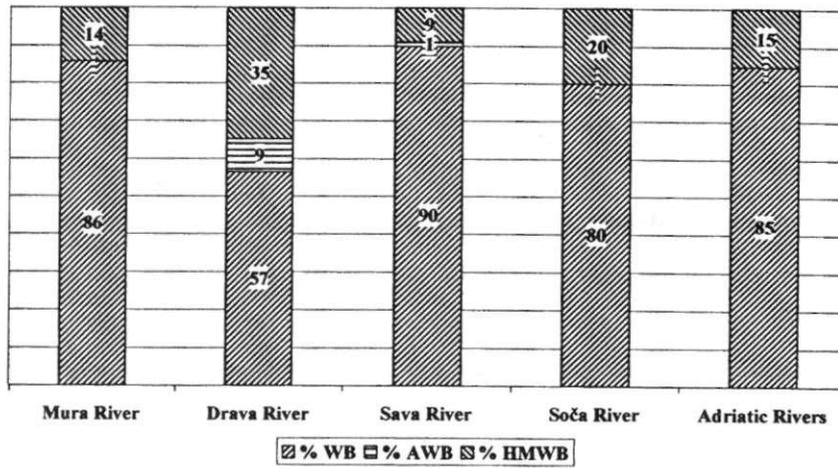
	SWB	%	WB	%	AWB	%	HMWB	%
Mura River	14	100.00	12	85.71	0	0.00	2	14.29
Drava River	23	100.00	13	56.52	2	8.70	8	34.78
Sava River	79	100.00	71	89.87	1	1.27	7	8.86
Sofia River	15	100.00	12	80.00	0	0.00	3	20.00
Adriatic Rivers	13	100.00	11	84.62	0	0.00	2	15.38
TOTAL	144	100.00	119	82.64	3	2.08	22	15.28

Table 2. Proportion of specific SWB categories on rivers in River Basins.

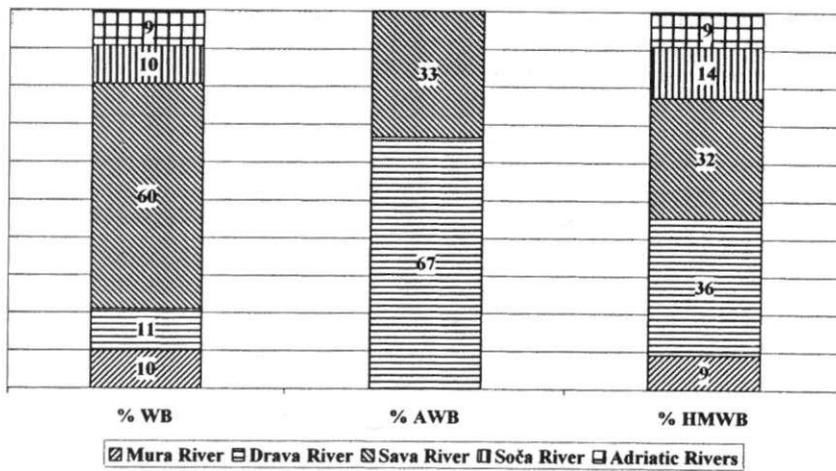
	SWB	%	WB	%	AWB	%	HMWB	%
Mura River	14	9.72	12	10.08	0	0.00	2	9.09
Drava River	23	15.97	13	10.92	2	66.67	8	36.36
Sava River	79	54.86	71	59.66	1	33.33	7	31.82
Sofia River	15	10.42	12	10.08	0	0.00	3	13.64
Adriatic Rivers	13	9.03	11	9.24	0	0.00	2	9.09
TOTAL	144	100.00	119	100.00	3	100.00	22	100.00

objects of surface water bodies (rivers, reservoirs and artificial channels) in a total length of 2.629km', i.e. 119 WB (2,299.4km'), 3 AWB (43.2km') and 22 HMWB candidates (287.3 km'). On three natural lakes we identified 3 SWB (all WB), 3 SWB on the transitional water (1 WB and 2 HMWB candidates) and 5 SWB on coastal water (4 WB and 1 HMWB candidate). The expert proposal of the first SWB delineation is shown in Figure 3.

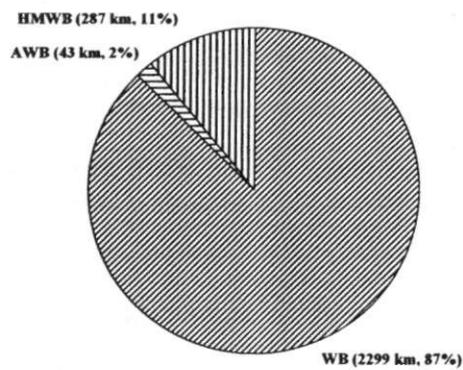
The data of the expert proposal of the first SWB delineation on rivers, water reservoirs on rivers and artificial channels are presented in detail in Tables 1-2 and Graphs 1-3. Tables 3¹ present the



Graph 1. Proportion of all SWB categories on rivers in River Basins



Graph 2. Proportion of specific SWB categories on rivers in River Basins



Graph 3. Proportion of SWB categories on rivers in total

Table 3. Proportion of specific SWB categories on rivers in the Danube River Basin District.

	Entire hydrographic network	Danube RBD	%
SWB*	155	119	76.7
SWB**	144	116	80.5
length of SWB (km')	2629.9	2237.2	85.1
WB	119	96	80.6
length of WB (km')	2299.4	1975.3	85.9
AWB	3	3	100.0
length of AWB (km')	43.2	43.2	100.0
HMWB	22	17	77.3
length of HMWB (km')	287.3	218.7	76.1

*Number of all SWBs (rivers, lakes, transitional water and coastal water)

**Number of SWBs considered in the statistical calculation (rivers, artificial channels and water reservoirs).

Table 4. Proportion of specific SWB categories on rivers in the Adriatic Sea River Basin District.

	Entire hydrographic network	Adriatic Sea RBD	%
SWB*	155	36	23.2
SWB**	144	28	19.4
length of SWB (km')	2629.9	392.7	14.9
WB	119	23	19.3
length of WB (km')	2299.4	324.1	14.1
AWB	3	0	0
length of AWB (km')	43.2	0	0
HMWB	22	5	22.7
length of HMWB (km')	287.3	68.6	23.8

*Number of all SWBs (rivers, lakes, transitional water and coastal water)

**Number of SWBs considered in the statistical calculation (rivers, artificial channels and water reservoirs).

data of expert proposal of the first SWB delineation of the Danube River Basin District and the Adriatic Sea River Basin District separately.

Tables 5-6 give a comparison of selected values of the expert proposal of the first SWB delineation in Slovenia to the SWB delineation on 8 pilot river basins in 7 European countries and additional study results in EU countries. Tables show similar values (number of SWBs, density of SWB, minimum, maximum and average length of SWB) of the expert proposal in Slovenia in relation to the results of European case examples and studies.

The expert proposal of WB grouping is represented in Table 7. The table gives data on the proposal of rivers and lakes SWB (WB and HMWB candidates) grouping. The reduction of the number of rivers and lakes SWB after grouping amounted to 15%.

4 CONCLUSION AND FURTHER RESEARCH WORK

The expert proposal of the first SWB delineation was defined according to the provisions of the Rules (Uradni list RS, 2003) and according to the existing databases available at the time of the basic

Table 5. Comparison of selected values of the first SWB delineation in Slovenia to the results of 8 European pilot river basins.

	river basin size in Slovenia (km ²)	number of SWB (n_{SWB})	density of SWB (n_{SWB}/km^2)
expert proposal on first SWB delineation of the Slovene hydrographic network			
Mura River	2340	14	0.006
Drava River	5166	23	0.004
Sava River	12,391	79	0.006
Sofia River	1535	15	0.010
Adriatic Rivers	688	13	0.019
delineation of SWB on pilot river basins			
Cecina River (I)	903	8	0.009
Odense River (DK)	1160	280	0.241
Suldal River (N)	1460	288	0.249
Pinios River (GR)	9500	7	0.001
Marne River (F)	12,730	51	0.004
Somes River (RO/H)	16,046	413	0.026
Tevere River (I)	17,400	160	0.009
Oulujoki River (SU)	22,841	85	0.004

Sources: SURS 1999, Gundebien & Whalley 2003.

Table 6. Comparison of selected values of the first SWB delineation in Slovenia to 8 European pilot river basins and study results in 18 European countries.

	number of SWBs (n_{VTPv})	n_{SWBmin} (km)	n_{SWBmax} (km)	n_{SWBave} (km)
Pilot studies 2003 (8)	7-413	0.5-3	12-542	
Mannheim questionnaire (18)	311-10,200	5	45-100	21.3
First delineation SWB SI 0305	144	3 (1.24)	85	18.3

Sources: Gundebien & Whalley 2003, IFOK 2004.

Table 7. Review of the expert proposal of rivers and lakes SWB (WB and HMWB candidates) grouping in the first SWB delineation.

Number of SWB groups	15
Number of WB groups	10
Average WB group size ($n_{WB}/group$)	2,7
Major WB group ($n_{WBmax}/group$)	5
Number of AWB groups	1
Average AWB group size ($n_{AWB}/group$)	2
Major AWB group ($n_{AWBmax}/group$)	2
Number of HMWB groups	4
Average HMWB group size ($n_{HMWB}/group$)	2
Major HMWB group ($n_{HMWBmax}/group$)	2
Number of SWB	144
Number of SWBs after grouping	122
Reduction	15%

identification of SWB. In making the expert proposal of the first SWB delineation the following parameters were considered:

- category of surface water (river, lake, transitional water, coastal water);
- type of surface water based on the ecological regionalization of Slovenia into hydro-ecoregions (Smolar Zvanut et al. 2004), upgraded with the factors of abiotic classification, partly computer-processed, partly analysed in cabinet work;
- geographical and natural hydromorphological phenomena (sinking and draining of rivers, intermittent lakes and wetlands);
- physical changes on surface waters, separated according to the criteria for rivers, lakes, transitional water, coastal water, as described in the article.

For the purposes of the first SWB delineation among the breakdown factors, the assessment of the chemical status of water based on the Decree on the chemical status of surface waters for 2002 (RS MOP ARSO, 2004) was considered, data on water quality, the existing monitoring network and results of the monitoring, as well as the best possible estimate according to the known or identified pressures.

In the following period activities in terms of SWB delineation will be oriented towards expansion of the presented expert proposal of the first SWB delineation to rivers, natural lakes, artificial channels, and water storage reservoirs of lesser size, according to their natural importance or their significantly different state. With step five of the protocol for defining the HMWB candidates the basic premises and findings of the first delineation will be harmonized also from the biological point of view (check of hydromorphological changes as the reason for failing to achieve good ecological status; use of biologic characteristics and status indicators under certain loads etc.).

The expert proposal of the first SWB delineation (WB, AWB and HMWB) according to available databases and scientific professional bases optimally complies with the Slovene legal provisions from the field of SWB delineation (Uradni list RS 2003). In addition to the proper fulfillment of the professional contents stated above it provides a solid basis for further research within the implementation of the WFD in the period of 2004-2009. The expert proposal of the first SWB delineation may be the subject to revision in terms of number or type of SWB, primarily in the light of HMWB candidates.

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