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ASSESSMENT OF THE STATUS OF TRANSBOUNDARY RIVERS, LAKES AND GROUNDWATERS

## ASSESSMENT OF TRANSBOUNDARY RIVERS, LAKES AND GROUNDWATERS IN SOUTH-EASTERN EUROPE DISCHARGING IN THE BLACK SEA

Note by the secretariat

*Summary*

This document was prepared pursuant to decisions taken by the Working Group on Monitoring and Assessment at its tenth meeting (Bratislava, 10–11 June 2009, ECE/MP.WAT/WG.2/2009/2, paras. 8–44) and by the Working Group on Integrated Water Resource Management at its fourth meeting (Geneva, 8–9 July 2009; ECE/MP.WAT/WG.1/2009/2, paras. 44–48). This document contains the draft assessment of the different transboundary rivers, lakes and groundwaters in South-Eastern Europe (SEE) that are located within the Black Sea drainage basin by transboundary basin and aquifer.

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CONTENTS

# I. INTRODUCTION

1. The present document contains the assessments of the different transboundary rivers, lakes and groundwaters in South-Eastern Europe (SEE) which are located within the Black Sea drainage basin. The river basins which assessments are presented in this document are sub-basins of the Danube. The document has been prepared by the secretariat with the assistance of Global Water Partnership Mediterranean (GWP-Med) on the basis of information provided by SEE countries.

2. The present document contains several references to figures, which are not presented here but will be included in the final assessment publication as edited or redrawn, as needed. It should be noted that maps of the basins and maps showing locations of the transboundary aquifers are not referred to here but will be developed for the final assessment, consulting the riparian countries when necessary. For ease of reference, in most cases the numbers in front of the names of the aquifers and groundwater bodies in the tables containing related information refer to the numbering used in the list of transboundary groundwaters in South-Eastern Europe in the First Assessment of Transboundary Rivers, Lakes and Groundwaters. For descriptions of the transboundary aquifer types and related illustrations, Annex V of document ECE/MP.WAT/2009/8 should be referred to.

# II. RESERVOIRS IRON GATE I AND IRON GATE II[1]

**Table 1. Basins of the Iron Gate I and Iron Gate II Reservoirs**

| Area | Country | | Country's share | | Number of inhabitants | Population density |
|---|---|---|---|---|---|---|
| …km$^2$ | Romania | Total (both Reservoirs) | 5,717.91 km$^2$ | | 278,986 | 48.79 |
| | | Reservoir Iron Gate I | 4,489.61 km$^2$ | 78.6 % | | 31 |
| | | Reservoir Iron Gate II | 1,228.30 km$^2$ | 21.4 % | | 63 |
| | Serbia | Total (both Reservoirs) | N/A | N/A | N/A | N/A |
| | | Reservoir Iron Gate I | N/A | N/A | N/A | N/A |
| | | Reservoir Iron Gate II | N/A | N/A | N/A | N/A |

3. Iron Gate is a gorge between the Carpathian and Balkan mountains on the Danube River on the border between Romania and Serbia. Earlier, it was an obstacle for shipping. Iron Gate I (upstream of Drobeta-Turnu Severin) has one of Europe's largest hydroelectric power dams. The dam was built by Romania and the former Yugoslavia between 1970 and 1972.

[1] Based on information from Romania

*Hydrology and hydrogeology*

4. The total area of the Iron Gate I Reservoir is 330 $km^2$ and the total volume 3.5 $km^3$. The reservoir is relatively shallow; the mean depth is 25 m while its deepest point is at 40 m. There are no major water-quality problems in Iron Gate I.

5. Iron Gate II, located downstream of Drobeta-Turnu Severin is smaller (79 $km^2$) than Iron Gate I; the total volume of the lake is 0.8 $km^3$. The reservoir is even shallower than Iron Gate I, the mean depth is 10 m and its deepest point is at 25 m. Iron Gate II has no serious water-quality or water-quantity problems.

**Table 2. Discharge characteristics of the Danube River at the gauging station Baziaş (Romania, 132 km upstream from Iron Gates I)**

| Discharge characteristics | Discharge | Period of time or date |
|---|---|---|
| $Q_{downstrean}$ | 5,677.7 $m^3/s$ | 1999-2007 |
| $Q_{max}$ | 15,800 $m^3/s$ | 1999-2007 |
| $Q_{min}$ | 1,470 $m^3/s$ | 1999-2007 |
| Mean monthly values: | | |
| October: 4,369.3 $m^3/s$ | November: 4,988.3 $m^3/s$ | December: 5,380.6 $m^3/s$ |
| January: 5,041.3 $m^3/s$ | February: 5,566.7 $m^3/s$ | March: 7,319.7 $m^3/s$ |
| April: 8,672.3 $m^3/s$ | May: 7,276.8 $m^3/s$ | June: 5,825.8 $m^3/s$ |
| July: 4,954.5 $m^3/s$ | August: 4,349.10 $m^3/s$ | September: 4,170.3 $m^3/s$ |

**Table 3. Discharge characteristics of the Danube River at the gauging station Orşova (Romania, 11 km upstream from Iron Gates I)**

| Discharge characteristics | Discharge | Period of time or date |
|---|---|---|
| $Q_{downstream}$ | 5,675.7 $m^3/s$ | 1999-2007 |
| $Q_{max}$ | 15,800 $m^3/s$ | 1999-2007 |
| $Q_{min}$ | 1,440 $m^3/s$ | 1999-2007 |
| Mean monthly values: | | |
| October: 4,369.4 $m^3/s$ | November: 4,991.7 $m^3/s$ | December: 5,248.9 $m^3/s$ |
| January: 5,223 $m^3/s$ | February: 5,584.9 $m^3/s$ | March: 7,272.7 $m^3/s$ |
| April: 8,684.4 $m^3/s$ | May: 7,229.8 $m^3/s$ | June: 5,822 $m^3/s$ |
| July: 4,955 $m^3/s$ | August: 4,353.7 $m^3/s$ | September: 4,166.3 $m^3/s$ |

**Table 4. Discharge characteristics of the Danube River at the gauging station Drobeta Turnu Severin (Romania, 12 km downstream from Iron Gates I and 68 km upstream from Iron Gates II)**

| Discharge characteristics | Discharge | Period of time or date |
|---|---|---|
| $Q_{downstream}$ | 5,684.2 $m^3/s$ | 1999-2007 |
| $Q_{max}$ | 15,800 $m^3/s$ | 1999-2007 |
| $Q_{min}$ | 1,490 $m^3/s$ | 1999-2007 |
| Mean monthly values: | | |

| | | |
|---|---|---|
| October: 4,376.5 $m^3/s$ | November: 4,994.8 $m^3/s$ | December: 5,422.4 $m^3/s$ |
| January: 5,218.6 $m^3/s$ | February: 5,591.2 $m^3/s$ | March: 7,351.4 $m^3/s$ |
| April: 8,679.9 $m^3/s$ | May: 7,245.8 $m^3/s$ | June: 5,829.9 $m^3/s$ |
| July: 4,962.2 $m^3/s$ | August: 4,375 $m^3/s$ | September: 4,157.3 $m^3/s$ |

**Table 5. Discharge characteristics of the Danube River at the gauging station Ţigănaşi (Romania, 15 km upstream from Iron Gates II)**

| Discharge characteristics | Discharge | Period of time or date |
|---|---|---|
| $Q_{downstream}$ | 5,683.1 $m^3/s$ | 1999-2007 |
| $Q_{max}$ | 15,800 $m^3/s$ | 1999-2007 |
| $Q_{min}$ | 1,500 $m^3/s$ | 1999-2007 |
| Mean monthly values: | | |
| October: 4,379.1 $m^3/s$ | November: 4,989.1 $m^3/s$ | December: 5,424.1 $m^3/s$ |
| January: 5,219.4 $m^3/s$ | February: 5,588.6 $m^3/s$ | March: 7,350.2 $m^3/s$ |
| April: 8,667.8 $m^3/s$ | May: 7,253.7 $m^3/s$ | June: 5,828.9 $m^3/s$ |
| July: 4,963.7 $m^3/s$ | August: 4,374.8 $m^3/s$ | September: 4,156.7 $m^3/s$ |

6. Floods are an issue of concern in Romania; extreme events usually occur during the high flow period (March – May). Among the most severe floods occurred in 1999 and 2005. The construction of the dams facilitated flood control as well as navigation activities.

*Pressures*

7. The construction of the Iron Gates has caused the alteration of the hydrological regime of the Danube River downstream. Reduction of sediment transport capacity leading to sediment deposition at certain parts and alteration of the character of the aquatic and riparian habitats were among the main effects. While pressure has been exerted on some fish species, others (some rare species) have benefited.

**Table 6. Mean annual water withdrawal by sector**

| | | **Total withdrawal ($\times 10^6$ $m^3$/year)** | **Agriculture** | **Domestic** | **Industry** | **Energy** | **Other** |
|---|---|---|---|---|---|---|---|
| **Romania** | 2007 | 150,239 | 0.016 % | 0.008 % | 0.036 % | 99.93992 %* | 0.00008 % |
| | Projection for 2015 | 154,283 | 0.032 % | 0.011 % | 0.047 % | 99.9099 %* | 0.0001% |
| **Serbia** | | N/A | N/A | N/A | N/A | N/A | N/A |

*Non consumptive use

**Table 7. Water resources (× $10^6$ $m^3$/year) and water resources per capita ($m^3$/year)[2]**

| | | |
|---|---|---|
| **Romania*** | Surface water resources | 1,482,000 |
| | Groundwater resources | 296,000 |
| | Total water resources | 1,778,000 |
| | Total water resources per capita | 3,356,000 |
| **Serbia** | Surface water resources | N/A |
| | Groundwater resources | N/A |
| | Total water resources | N/A |
| | Total water resources per capita | N/A |

*Average for the years 1950 to 2007

**Table 8. Land cover/use (% of the part of the basin extending in each country)**

| | | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|---|
| **Romania** | Iron Gate I Reservoir | 3.7 | 50.6* | 12.6 | 10.1 | 0.8 | 77.49 | 0.6 |
| | Iron Gate II Reservoir | 1.4 | 4.5* | 9.8 | 3.4 | 1.4 | 62.84 | 1.1 |
| **Serbia** | Iron Gate I Reservoir | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | Iron Gate II Reservoir | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

* Forest exploitation is expected to lead to the reduction of forest land area

[Figure 1. Map of land use and land cover in the Romanian territory that drains to the Iron Gates I and II reservoirs.]

8. The main pressure factor in Romania is the discharges of (river) water used by a nuclear plant and a thermal power plant causing thermal pollution as well as sulphide hydrogen pollution (although waste waters are treated). Decreasing forest cover; mining activities, open storage of waste as well as tailing dams; lack of proper sewage collection and treatment facilities in big towns (Drobeta-Turnu Severin lacks both while Orsova lacks a treatment plant); some inappropriate industrial waste water collection and treatment facilities; and uncontrolled dumpsites in the riverbeds especially in rural areas, are pressure factors reported as of low importance by Romania. The construction of new wastewater collection and treatment systems for human settlements and the rehabilitation of the existing systems for human settlements and industries is in progress in accordance with the Urban Waste Water Treatment Directive (91/271/EEC)[3].

[2] Surface water resources: defined as run-off internally generated from precipitation within the part of the basin that is the country's territory plus incoming water flow from adjacent basin country/countries. Groundwater resources defined as estimated annual groundwater recharge derived from precipitation falling on the country's territory within the river basin concerned, plus entering external groundwater flow. It should be noted that external groundwater flow may also originate from outside the basin.

[3] Romania, being a recent EU member country, was given transition a period for its implementation; the final date for the compliance with the Directive for agglomeration of less than 10,000 population equivalent is 31 December 2018.

*Status and transboundary impacts*

9. Pollutants accumulated in the sediments of the reservoirs may be of concern; heavy metals as well as other chemical substances have been detected in the sediments of Iron Gates Reservoirs. The reservoirs also function as phosphorous traps. Concentrations of pollutants in the sediments of both reservoirs for 2007 are given in the table below.

**Table 9. Concentration of heavy metals in the sediments of Iron Gate I and Iron Gate II reservoirs***

| | **Iron Gate I** | **Iron Gate II** |
|---|---|---|
| **Element** | **Concentration (ppm)** | |
| Aluminum | 1,3871.54 | 51,440.61 |
| Arsenic | 141.24 | 66.61 |
| Cadmium | 1.92 | 1.9 |
| Chromium | 80.3 | 127.16 |
| Copper | 111.04 | 97.78 |
| Iron | 33,184.05 | N/A |
| Lead | 1,382.63 | 885.82 |
| Manganese | 891.77 | N/A |
| Mercury | 0.12 | 0.3 |
| Nickel | 125 | 127.68 |
| Zinc | 310.35 | 385.23 |

*Based on information provided by Romania; *source*: Joint Danube Survey, 2007

10. Graphs showing the trends for the period 2004-2008 for BOD, total suspended solids, ammonia and phosphates concentration in the water of both lakes are given below (Figures 2, 3 and 4). The concentration of Total Suspended Solids in the lakes/reservoirs has remained at approximately the same level, 27.5-32.5 mg/l, during the before-mentioned period.

[Figures 2, 3 and 4: Annual mean (?) concentrations (mg/l) of biological oxygen demand (BOD5), ammonia and phosphates in Iron Gates I and II based on data provided by the Monitoring Network of Jiu Water Directorate in Romania.]

*Response measures*

11. The Iron Gates Reservoirs have been assigned to the Jiu River Basin Directorate in Romania; a water management authority and a river basin committee (at the river basin level) have been established. Plans prepared at the Jiu River Basin Directorate level include: a River Basin Management Plan and a River Basin Development Plan (the first focuses on water quality issues and the latter on water quantity issues); a Regional Action Plan for Environment; a Preventing and Fighting Accidental Pollution Plan; and a Drought Periods Water Use Operational Plan. The Rules of Operation of the Iron Gates include water demand management measures and measures aiming to increase water efficiency. There is also a management plan for the “Iron Gates” National Park. Public participation and stakeholders’ involvement are carried out as necessary, pursuant to the EU Water Framework Directive (WFD).

12. Monitoring has been established and functions in accordance with the EU WFD. Iron Gates are covered by the Jiu Water Quality Monitoring System: (i) surveillance and (ii) operational monitoring are carried out. Wastewater discharges and water abstractions are also monitored.

13. Romania participates in the TransNational Monitoring Network (TNMN), established to support the implementation of the Danube River Protection Convention in the field of monitoring and assessment[4]. Cooperation between Serbia and Romania on monitoring of water quality of the Danube River is regulated by the "Methodology on joint examination of the water quality in the transboundary section of rivers which form or are crossed by the Romanian-Serbian state border"[5].

*Transboundary cooperation*

14. Cooperation between Serbia and Romania is based on the 1955 agreement covering hydro-technical issues on shared water courses (see Annex III of document ECE/MP.WAT/2009/8). A Joint Commission on transboundary waters was established the same year to monitor and facilitate its implementation. It convenes once a year. An Agreement signed between the two countries on 16 May 1998, concerns the operation and maintenance of the Hydropower National System and of Navigation in Iron Gates (see also Annex III of document ECE/MP.WAT/2009/8).

15. Efforts to enter into a new legal arrangement on transboundary waters shared by Serbia and Romania date back to 1996 when Romania made a proposal for the initiation of negotiations on a new agreement taking into account the provisions of the UNECE Water Convention and the Danube River Protection Convention. This initiative was followed by communication between the two countries and exchange of draft agreement texts in the period 2006-2007. The most recent draft text incorporates also provisions for the implementation of EU directives and in particular the EU WFD. According to this draft, the agreement is envisaged to touch upon a range of issues related to shared water resources management. The development of cooperation mechanisms is among the provisions.

## III. DRAVA AND MURA RIVERS BASIN[6]

**Table 10. Basins of the Drava and Mura Rivers**

| | **Area** | **Country** | **Country's share** | **Number of inhabitants** | **Population density (persons/k** |
|---|---|---|---|---|---|

[4] The TNMN monitoring network is based on national surface water monitoring networks and includes 79 monitoring locations with up to three sampling points across the Danube and its main tributaries. The minimum sampling frequency is 12 times per year for chemical determinands in water and twice a year for biological parameters.
[5] Agreed by the Romanian-Serbian Hydrotechnic Joint Commission (Novi Sad, 1998); established in the framework of the Agreement on transboundary waters signed on 7 April 1955.
[6] Based on information from Austria, Croatia; Slovenia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information from the Danube Basin Analysis (WFD Roof Report 2004) had been used.

| | Area | Country | Country's share | | Number of inhabitants | Population density (persons/km²) |
|---|---|---|---|---|---|---|
| **Drava** | 41,238 km² | Italy | 165 km² | 0.4% | N/A | N/A |
| | | Austria | 11,815 km² | 28.6% | 610,000 | 54 |
| | | Slovenia | 4,653 km² | 11.3% | N/A | N/A |
| | | Croatia | 6,435 km² | 15.6%- | 590,072 | 92 |
| | | Hungary | N/A | N/A | N/A | N/A |
| **Mura** | 13,800 km² | Austria | 10,313 km² | 74.7% | 800,000 | 75 |
| | | Slovenia | N/A | N/A | N/A | N/A |
| | | Croatia | 620 km² | 4,5% | 101,110 | 163 |
| | | Hungary | N/A | N/A | N/A | N/A |

16. The Drava River[7] (about 890 km long) rises in the Italian Alps (Toblach, ~ 1,450 m a.s.l.); it is navigable for about 100 km from Čađavica to Osijek in Croatia, where it joins the Danube. It is the Danube's fourth largest tributary.

17. Sections of Drava in Hungary and Croatia are some of the most natural and unspoiled waters in Europe, hosting many rare species.

18. The main tributaries of the Drava are: the Gail in Austria, the Meža and Dravinja in Slovenia, and the Bednja in Croatia from the right; the Gurk and the Lavant in Austria, and the Mura (near Legrad) in Croatia from the left.

19. The Mura River[8] (445 km long) is the largest tributary of the Drava. It rises in Austria in the "Niedere Tauern" (~ 1,900 m a.s.l.) and meets the Drava at the Croatian-Hungarian borders.

20. The Drava forms a big part of the Croatian-Hungarian borders while the Mura forms a small part of the Austrian-Slovenian, Slovenian-Croatian and Croatian-Hungarian borders.

*Hydrology and hydrogeology*

21. Dams and associated reservoirs and hydropower plants exist in Austria, Hungary, Slovenia and Croatia (three).

22. The Drava River has a pluvial-glacial (rain-and-ice) water regime characterized by small quantities of water during winter and large quantities of water in the second half of spring and at the beginning of summer.

23. The average flow of the Drava at the point where it enters Slovenia flowing from Austria is 290 $m^3/s$. Its mean discharge in Croatia ranges from 326 $m^3/s$ at the border with Slovenia to 561 $m^3/s$ at the point where it flows into the Danube; the average water flow in Croatia above the

[7] The river is called Drava in Italy, Slovenia and Croatia, Drau in Austria and Dráva in Hungary
[8] The river is called Mura in Slovenia and Croatia, and Mur in Austria

confluence with the Mura is 552 $m^3/s$ (1961-1990). The average flow of the Drava after the confluence with the Mura is 587 $m^3/s$.

24. The average flow of the Mura at the point it enters Slovenia flowing from Austria is 160 $m^3/s$. The discharge of Mura in Croatia ranges from 160 $m^3/s$ (at the point that enters the country) to 182 $m^3/s$ at the point that flows into the Drava River; the average water flow in Croatia is 170 $m^3/s$ (1961-1990).

**Table 11. Discharge characteristics of the Drava River at different monitoring stations**

| **At the Italian-Austrian border** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 8.95 $m^3/s$ | 1951-2000 |
| $Q_{max}$ | 150 $m^3/s$ | 1951-2000 |
| $Q_{min}$ | 1.3 $m^3/s$ | 1951-2000 |

| **Gauging station: Amlach (downstream Spital a/d Drau) - Austria** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 128 $m^3/s$ | 1976–2006 |
| $Q_{max}$ | 985 $m^3/s$ | 1976–2006 |
| $Q_{min}$ | 19.8 $m^3/s$ | 1976–2006 |
| **Mean monthly values:** | | |
| January: 65.3 $m^3/s$ | February: 59.7 $m^3/s$ | March: 64.2 $m^3/s$ |
| April: 85.3 $m^3/s$ | May: 190 $m^3/s$ | June: 248 $m^3/s$ |
| July: 220 $m^3/s$ | August: 166 $m^3/s$ | September: 128 $m^3/s$ |
| October: 129 $m^3/s$ | November: 101 $m^3/s$ | December: 75.2 $m^3/s$ |

| **Gauging station: Lavamünd (at the borders with Slovenia) - Austria** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 290 $m^3/s$ | 1976–2006 |
| $Q_{max}$ | N/A | N/A |
| $Q_{min}$ | N/A | N/A |

| **Gauging station: Varaždin (Croatia)** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 343 $m^3/s$ | 1961-1981 |
| $Q_{max}$ | 1,321 $m^3/s$ | 1961-1981 |
| $Q_{min}$ | 64 $m^3/s$ | 1961-1981 |

| **Gauging station: Botovo - Croatia** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 525 $m^3/s$ | 1961-1990 |
| $Q_{max}$ | 1,565 $m^3/s$ | 1961-1990 |
| $Q_{min}$ | 174 $m^3/s$ | 1961-1990 |

| Gauging station: Terezino Polje - Croatia | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 535 $m^3/s$ | 1961-1990 |
| $Q_{max}$ | 1,511 $m^3/s$ | 1961-1990 |
| $Q_{min}$ | 198 $m^3/s$ | 1961-1990 |

| Gauging station: Donji Miholjac - Croatia | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 546 $m^3/s$ | 1961-1990 |
| $Q_{max}$ | 1,387 $m^3/s$ | 1961-1990 |
| $Q_{min}$ | 222 $m^3/s$ | 1961-1990 |

| Gauging station: Belišće - Croatia | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 558 $m^3/s$ | 1962-1990 |
| $Q_{max}$ | 1,386 $m^3/s$ | 1962-1990 |
| $Q_{min}$ | 234 $m^3/s$ | 1962-1990 |

## Table 12. Discharge characteristics of the Mura River at different monitoring stations

| Gauging station: Bruck a/d Mur (downstream the confluence point with its tributary Mürz) - Austria | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 107 $m^3/s$ | 1971–2006 |
| $Q_{max}$ | 800 m³s | 1971–2006 |
| $Q_{min}$ | 18.7 $m^3/s$ | 1971–2006 |
| **Mean monthly values:** | | |
| January: 52.1 $m^3/s$ | February: 50.7 $m^3/s$ | March: 75.6 $m^3/s$ |
| April: 130 $m^3/s$ | May: 206 $m^3/s$ | June: 173 $m^3/s$ |
| July: 147 $m^3/s$ | August: 116 $m^3/s$ | September: 97.4 $m^3/s$ |
| October: 95.1 $m^3/s$ | November: 77.6 $m^3/s$ | December: 63 $m^3/s$ |

| At the Austrian-Slovenian border | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 160 $m^3/s$ | 1951-2000 |
| $Q_{max}$ | N/A | N/A |
| $Q_{min}$ | N/A | N/A |

| Gauging station: Mureck (roughly in the middle of the Austrian-Slovenian shared border-stretch) | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 148 $m^3/s$ | 1974–2006 |
| $Q_{max}$ | 1,251 $m^3/s$ | 1974–2006 |
| $Q_{min}$ | 28.1 $m^3/s$ | 1974–2006 |

| Gauging station: Mursko Središće - Croatia | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 170 $m^3/s$ | 1961-1990 |
| $Q_{max}$ | 740 $m^3/s$ | 1961-1990 |
| $Q_{min}$ | 62 $m^3/s$ | 1961-1990 |

| Gauging station: Goričan - Croatia | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 169 $m^3/s$ | 1961-1990 |
| $Q_{max}$ | 705 $m^3/s$ | 1961-1990 |
| $Q_{min}$ | 68 $m^3/s$ | 1961-1990 |

25. Karstwasser-Vorkommen Karawanken / Karavanke, Ormoz-Sredisce ob Drava/Drava-Varazdin, Mura, Drava/Drava West, Baranja/Drava East, Černeško-Libeliško, Kučnica, Goričko, Mura – Zala basin / Radgona – Vaš and Kot are transboundary aquifers linked with the surface water system of the Drava and Mura Rivers.

26. The Karstwasser-Vorkommen Karawanken / Karavanke transboundary groundwater body was identified by the two countries following an agreement between Slovenia and Austria (2004), and characterized in accordance with the EU WFD requirements. A “Water supply” commission for Karavanke Mountains has been established; meetings take place twice per year.

27. The Karavanke/Karawanken groundwater body is further divided in five cross-border aquifers: (i) the Kepa/Mittagskogel aquifer (furthest west); (ii) the long, but narrow massif Košuta aquifer - the total length of the aquifer is 60 km; (iii) the Bela/Vellach valley aquifer; (iv) the Mount Olševa/Uschowa, which is an important aquifer - groundwater discharges to the Austrian side; (v) the massif Peca/Petzen (furthest east); water discharged from this aquifer drains to both countries - recharge areas of individual sources within the aquifer are intertwined with each other.

### Table 13. Karstwasser-Vorkommen Karawanken / Karavanke aquifer

| **No. 53[9] Karstwasser-Vorkommen Karawanken / Karavanke[10]** | **Shared by: Austria and Slovenia** |
|---|---|
| According to Austria:[11] Triassic limestone, dolomite, average 700 m and | **Black Sea Basin** |

[9] This is a new aquifer number because Karstwasser-Vorkommen Karawanken / Karavanke aquifer did not appear in the First Assessment of Transboundary Rivers, Lakes and Groundwaters.
[10] Based on information from Slovenia and Austria.
[11] Based on information provided by Austria, the lithologies/formations more specifically are the following: Wettersteinkalk, Dachsteinkalk, Schlerndolomit and Wettersteindolomit.

| | |
|---|---|
| maximum 1,000 m thick, groundwater flow direction from Slovenia to Austria, with medium links to surface waters. It extends to the area of the main border ridge between the two countries.<br>According to Slovenia: Type 2, Limestones and dolomites / carbonate; Triassic rocks form aquifers, barriers to groundwater flow are formed from various rocks from Paleozoic to Tertiary rocks. Thickness is strongly variable; maximum thickness is >1,000 m. Groundwater flow is variable; from one country to the other depending on the aquifer (in Peca aquifer direction is from Austria to Slovenia - in Kosuta aquifer flow is predominately parallel to the state boundary). There are weak links with surface water systems. Pressure condition: partly confined, partly unconfined. Groundwater covers the total of water used in the Slovenian part. | Border length (km): |

| | **Austria** | **Slovenia** |
|---|---|---|
| Area (km$^2$) | 210 | 413.78 |
| Altitude fluctuation (m) | approx. 283 – 2,160 | approx. 450 – 2,236 |
| Number of inhabitants | N/A | 8,719 |
| Population density (persons/km$^2$) | N/A | 21.6 |
| Water uses and functions | Covers about 14% of drinking water supply in the Austrian part (200 l/s out of 1,460 l/s in total) covering related needs of 30,000 inhabitants and up to 15,000 tourists (total hotel beds capacity in the area). It is considered and treated as a drinking water reserve for future use. A part is used for irrigated agriculture. Groundwater supports also ecosystems and maintains baseflow and springs | Drinking water supply; also supports ecosystems and maintaining baseflow and springs (there are several springs with outflow up to 1 m$^3$/s). Water is used locally for spa related tourism. There is also small scale hydropower production |
| Pressure factors | There are no pressure factors | Winter tourism activities and settlements (of local importance). |
| Problems related to groundwater quantity | There are no problems – in good status | Spring water quantity fluctuates significantly due to the karstic geomorphology |
| Problems related to groundwater quality | There are no problems – in good status | Bacteriological quality of groundwater (of local character). Turbidity of spring water is observed during rain season. |
| Transboundary impacts | N/A | N/A |
| Groundwater management measures | In accordance to the EU WFD | Basic measures are implemented; no supplementary or additional measures are foreseen |

| | | |
|---|---|---|
| Trends and future prospects | In line with the target set in EU WFD, the good status is foreseen to be maintained. | It is predicted that climate change will result in diminished infiltration in the southern slopes thus lowered spring yield<br>Vulnerability is high, however anthropogenic activities in the area are not intense hence, the risk is low; tourism development may become a risk factor in the future<br>Establishment of transboundary groundwater protection areas is needed |

## Table 14. Ormoz-Sredisce ob Drava/Drava-Varazdin aquifer

| **No. 9 Ormoz-Sredisce ob Drava/Drava-Varazdin**[12] | | **Shared by: Slovenia and Croatia** |
|---|---|---|
| Type 2, Quaternary sands and gravels of average thickness 50 m and maximum 150 m, groundwater flow from Slovenia to Croatia; strong links with surface water systems | | **Black Sea basin**<br>Border length (km): |
| | **Slovenia** | **Croatia** |
| Area (km$^2$) | 27 | 768 |
| Altitude fluctuation (m) | N/A | 331 - 517 |
| Number of inhabitants | N/A | 4,375 |
| Population density (persons/km$^2$) | N/A | 388.2 |
| Water uses and functions | Drinking water supply | Drinking water supply, agriculture; also supports ecosystems |
| Pressure factors | Agriculture, hydropower schemes, Drava river regulation | Agriculture and population of local communities |
| Problems related to groundwater quantity | None | None |
| Problems related to groundwater quality | None, good chemical status | Nitrate concentrations above the drinking water standard in the first shallow aquifer, in the second, deeper aquifer, the water is of good quality |
| Transboundary impacts | None | None |
| Groundwater management measures | None | Existing protection zones |
| Trends and future prospects | N/A | Agreed delineation of transboundary groundwaters, and development of monitoring programmes are needed |

## Table 15. Dolinsko-Ravensko/Mura aquifer

[12] Based on information from Croatia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters – for which information had been provided by the by the Environment Agency of Slovenia and Croatian Waters

| No. 10 Dolinsko-Ravensko/Mura[13] | | Shared by: Slovenia and Croatia |
|---|---|---|
| Quaternary alluvial sands and gravel, groundwater hydraulically corresponding to surface water systems of the Mura River and in strong connection; groundwater flow from Slovenia to Croatia and from Croatia to Slovenia (?) | | **Black Sea Basin**<br>Border length (km): |
| | **Slovenia** | **Croatia** |
| Area (km$^2$) | 449 | - |
| Altitude fluctuation (m) | N/A | |
| Number of inhabitants | N/A | |
| Population density (persons/km$^2$) | N/A | |
| Water uses and functions | Drinking water supply of town Murska Sobota, local water supply systems | - |
| Pressure factors | Intensive agriculture; pan European transport corridor | - |
| Problems related to groundwater quantity | Degradation of the Mura River due to river regulation and hydropower schemes | - |
| Problems related to groundwater quality | Nitrate, pesticides | - |
| Transboundary impacts | None | - |
| Groundwater management measures | None | - |
| Trends and future prospects | At risk. Delineation of transboundary groundwater systems needs common research and bilateral expert group decision | - |
| Notes: | Probably only part of the Dolinsko-Ravensko groundwater system is relevant | According to existing data, no transboundary groundwater is recognised |

## Table 16. Mura aquifer

| No. 11 Mura[14] | Shared by: Hungary and Croatia |
|---|---|
| Type 3, Quaternary alluvial aquifer of sands and gravels, generally only 5-10 m thick but up to maximum of 30 m in Hungary and 20 m in Croatia, medium links to surface waters of the Mura River, groundwater | **Black Sea basin**<br>Border length (km): 52 |

[13] - Based on information from 1) Croatia; 2) the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Environment Agency of Slovenia and Croatian Waters. In the first Assessment, this aquifer was indicated to be located within the Sava River basin. However, Croatia reports that it is part of the Drava River Basin and on that basis, the information is presented as part of the assessment of Drava and Mura. It was not possible to check this information with Slovenia.

[14] Based on information from Croatia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters – for which information had been provided by the Geological Institute of Hungary and Croatian Waters.

| | | |
|---|---|---|
| flow towards the river. Groundwater provides >80% of total water supply in the Hungarian part of the aquifer. | | |
| | **Hungary** | **Croatia** |
| Area (km$^2$) | 300 | 98 |
| Altitude fluctuation (m) | N/A | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/km$^2$) | N/A | N/A |
| Water uses and functions | >75% drinking water, <25% for industry, irrigation and livestock, maintaining baseflow and support of ecosystems | No demand for groundwater |
| Pressure factors | Agriculture and settlements (fertilisers, pesticides, sewage, traffic), groundwater abstraction | No data |
| Problems related to groundwater quantity | Local and moderate groundwater depletion (at settlements), increased pumping lifts, reduced yields and baseflow, degradation of ecosystems | No data |
| Problems related to groundwater quality | Local but severe nitrate pollution from agriculture, sewers and septic tanks at up to 200 mg/l, pesticides at up to 0.1 µg/l | No data |
| Transboundary impacts | None | N/A |
| Groundwater management measures | Groundwater abstraction management used and effective; transboundary institutions, monitoring, public awareness, protection zones, treatment, need improvement; vulnerability mapping, regional flow modeling, good agricultural practices and priorities for waste water treatment, integration with river basin management need to be introduced | N/A |
| Trends and future prospects | Evaluation of the utilizable resource is needed<br>Exporting drinking water | N/A |

## Table 17. Drava/Drava West aquifer

| | |
|---|---|
| **No. 12 Drava/Drava West**[15] | **Shared by: Hungary and Croatia** |

[15] Based on information from Croatia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters – for which information had been provided by the Geological Institute of Hungary and Croatian Waters.

| Type2, Quaternary alluvial aquifer of sands and gravels, of average thickness 60 m and maximum 70 m in Hungary, 100 m in Croatia, medium to strong links to surface waters, groundwater flow from Hungary to Croatia, but mainly towards the border river | | **Black Sea basin**<br>Border length (km): 31 |
|---|---|---|
| | **Hungary** | **Croatia** |
| Area (km$^2$) | 262 | 97 |
| Altitude fluctuation (m) | N/A | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/km$^2$) | N/A | N/A |
| Water uses and functions | >75% drinking water, <25% for irrigation, industry and livestock | Agriculture; supports ecosystems |
| Pressure factors | Agriculture (fertilizers and pesticides), sewage from settlements, traffic, gravel extraction under water in open pits | Extraction of sand and gravel under water in pits |
| Problems related to groundwater quantity | Local increases in pumping lifts, reduction of borehole yields and baseflow and degradation of ecosystems | Changes in groundwater levels detected |
| Problems related to groundwater quality | Widespread but moderate nitrate at up to 200 mg/l from agriculture, sewers and septic tanks, pesticides at up to 0.1 µg/l | No data |
| Transboundary impacts | None for quantity or quality | None |
| Groundwater management measures | Groundwater abstraction management used and effective; transboundary institutions, monitoring, protection zones need improvement; vulnerability mapping, regional flow modeling, good agricultural practices and priorities for wastewater treatment, integration into river basin management, protection of open pit areas need to be introduced | None |
| Trends and future prospects | - Exporting drinking water<br>- Evaluation of the utilisable resource is needed | Agreed delineation of transboundary groundwaters, and development of monitoring programmes are needed |
| Notes | | Transboundary aquifer under consideration, but not approved |

## Table 18. Baranja/Drava East

| **No. 13 Baranja/Drava East**[16] | **Shared by: Hungary and Croatia** |
|---|---|

[16] Based on information from Croatia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters – for which information had been provided by the Geological Institute of Hungary and Croatian Waters.

| Type 2, Quaternary alluvial aquifer of sands and gravels, of average thickness 60 m and maximum 70 m in Hungary, 100 m in Croatia, medium to strong links to surface waters, groundwater flow from Hungary to Croatia. Groundwater provides 20% of total supply in the Croatian part and >80% in the Hungarian part | | **Black Sea basin**<br>Border length (km): 67 |
|---|---|---|
| | **Hungary** | **Croatia** |
| Area (km$^2$) | 607 | 955 |
| Altitude fluctuation (m) | N/A | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/km$^2$) | N/A | N/A |
| Water uses and functions | >75% drinking water, >25% for irrigation, industry and livestock, maintaining baseflow and spring flow | Supports ecosystems |
| Pressure factors | Agriculture (fertilizers and pesticides), sewers and septic tanks, traffic | None |
| Problems related to groundwater quantity | Local and moderate increases in pumping lifts, reductions in borehole yields and baseflow | None |
| Problems related to groundwater quality | Widespread but moderate nitrate at up to 200 mg/l, local and moderate pesticides up to 0.1 µg/l, widespread but moderate arsenic up to 50 µg/l | Naturally-occurring iron |
| Transboundary impacts | None for quantity or quality | None |
| Groundwater management measures | Control of groundwater abstraction by regulation used and effective; transboundary institutions, water use efficiency, monitoring, public awareness, protection zones, effluent treatment and data exchange need improvement; vulnerability mapping, regional flow modeling, better agricultural practices, priorities for wastewater treatment, integration with river basin management and arsenic removal need to be applied | Need to establish protection zones |
| Trends and future prospects | Evaluation of the utilisable resource and status of groundwater quality are needed and so are joint monitoring (mainly quantitative) and joint modeling | Agreed delineation of transboundary groundwaters, and development of monitoring programmes are needed |
| Notes | | Transboundary aquifer under consideration, but not approved |

**Table 19. Černeško-Libeliško aquifer**

| **No. 54[17] Černeško-Libeliško[18]** | | **Shared by: Austria (?) and Slovenia** |
|---|---|---|
| Type 2, Quaternary silicate/carbonate gravel and sand alluvial of average thickness 25 m and maximum 35 m. Dominant groundwater flow direction is from Austria to Slovenia. Pressure condition: unconfined. The depth of groundwater levels is at 20-30 m. There are strong links with surface water systems | | **Black Sea basin**<br>Border length (km): |
| | **Austria** | **Slovenia** |
| Area (km$^2$) | | 11.27 |
| Altitude fluctuation (m) | | 331 - 517 |
| Number of inhabitants | | 4,375 |
| Population density (persons/km$^2$) | | 388.2 |
| Water uses and functions | | Support ecosystems and maintain baseflow and springs |
| Pressure factors | | Municipal wastewater and agriculture |
| Problems related to groundwater quantity | | N/A |
| Problems related to groundwater quality | | Nitrate pollution (bellow quality standards) from municipal wastewater and agriculture; also pesticides pollution from agriculture |
| Transboundary impacts | | None |
| Groundwater management measures | | Basic measures are implemented, supplementary measures are not foreseen. Groundwater dependent terrestrial ecosystems criteria for hydrogeological characterization are to be defined |
| Trends and future prospects | | Decreased intensity of significant pressures is expected till 2015. Transboundary groundwater flow characterization is needed. |
| Notes | Austria expresses uncertainty about the location of this groundwater body | |

[17] This is a new aquifer number as this aquifer did not appear in the First Assessment of Transboundary Rivers, Lakes and Groundwaters.

[18] - Based on information from Slovenia, the Černeško-Libeliško and Kučnica are part of the alluvial aquifers system of Drava and Mura rivers at Austrian – Slovenian borders.

## Table 20. Kučnica aquifer

| No. 55[19] Kučnica[20] | | Shared by: Austria (?) and Slovenia |
|---|---|---|
| Type 2, Quaternary carbonate-silicate alluvial of average thickness 10 m and maximum 15 m. Groundwater flow direction from Austria to Slovenia. Pressure condition: unconfined. The depth of groundwater levels is at 1.5–4 m. There are medium links with surface water systems. | | **Black Sea basin**<br>Border length (km): |
| | **Austria** | **Slovenia** |
| Area (km$^2$) | | 448.96 |
| Altitude fluctuation (m) | | 148 - 324 |
| Number of inhabitants | | 61,292 |
| Population density (persons/km$^2$) | | 136.52 |
| Water uses and functions | | Water is used for agriculture; supports ecosystems and maintains baseflow and springs |
| Pressure factors | | Municipal wastewater, agriculture and industry |
| Problems related to groundwater quantity | | N/A |
| Problems related to groundwater quality | | Nitrate pollution (above national quality standards) from municipal wastewater and agriculture, synthetic substances pollution (threshold values are set for certain substances) as well as pesticides pollution from agriculture |
| Transboundary impacts | | None |
| Groundwater management measures | | Basic measures are implemented, supplementary measures are foreseen. Additional measures are necessary, mostly related to agriculture and pesticides use. Groundwater dependent terrestrial ecosystems criteria for hydrogeological characterization are to be defined |
| Trends and future prospects | | Transboundary groundwater flow characterization is needed. Development of measures for adaptation to climate change effects is also needed. There is a need for continuous data exchange between the two countries. |

[19] This is a new aquifer number as this aquifer did not appear in the First Assessment of Transboundary Rivers, Lakes and Groundwaters.

[20] - Based on information from Slovenia, theČerneško-Libeliško and Kučnica are part of the alluvial aquifers system of Drava and Mura rivers at Austrian – Slovenian borders.

| | | |
|---|---|---|
| Notes | Austria reported that the aquifer does not extend in the country's territory | |

### Table 21. Goričko aquifer

| **No. 56[21] Goričko[22]** | | **Shared by: Slovenia and Hungary** |
|---|---|---|
| Type 1, Tertiary/Quaternary silicate-carbonate sand and silt with clay alternations of average thickness >100 m and maximum >300 m. Groundwater flow direction is from north-west to south-east. Pressure condition: partly confined, partly unconfined. The depth to groundwater levels is at 0-115 m. There are weak links with surface water systems. The aquifer is recharged from the hills of Goričko and discharges through springs at the basin fringe; it recharges the deep thermal aquifer south of Goričko | | **Black Sea basin**<br>Border length (km): |
| | **Slovenia** | **Hungary** |
| Area ($km^2$) | 493.51 | |
| Altitude fluctuation (m) | 171 - 413 | |
| Number of inhabitants | 22,523 | |
| Population density (persons/$km^2$) | 45.64 | |
| Water uses and functions | Water is used for drinking water supply and agriculture; it also supports ecosystems and maintains baseflow and springs | |
| Pressure factors | Abstraction for drinking water supply, municipal wastewater and agriculture | |
| Problems related to groundwater quantity | There is a negative trend in groundwater level; it is due to the rapid increase of groundwater abstractions for drinking water supply as well as of thermal water from deeper part of adjacent aquifer (which is recharged by this aquifer) during the past decade | |
| Problems related to groundwater quality | Widespread nitrate (wastewater and agriculture) and pesticides (agriculture) pollution. Elevated background concentrations for $NH_4$, Fe, Mn and As at local level | |
| Transboundary impacts | None | |
| Groundwater management measures | N/A | |

[21] This is a new aquifer number as this aquifer did not appear in the First Assessment of Transboundary Rivers, Lakes and Groundwaters.
[22] Based on information from Slovenia. According to Slovenia, Goričko and Mura – Zala basin / Radgona – Vaš are part of the Goričko aquifer system.

| | | |
|---|---|---|
| Trends and future prospects | Water and thermal water demand is expected to increase. Decrease of infiltration is expected due to climate change and increase of pumping from boreholes may result from a further drop of groundwater levels. Shallow groundwater is affected by pollution and therefore alternative water supply (deeper boreholes or development of more remote resources) has to be identified and used; this is expected to cause increase of drinking water supply costs.<br>Enhanced information exchange between Slovenia and Hungary has to be established, possibly followed by joint management of the aquifer | |

**Table 22. Mura – Zala basin / Radgona – Vaš aquifer**

| **No. 5** [23] **Mura – Zala basin / Radgona – Vaš** [24] | | | **Shared by: Slovenia, Austria (?) and Hungary** |
|---|---|---|---|
| Type 4, Paleozoic to Tertiary silicate – carbonate clay, silt, sand, marl, sandstone, marlstone, Mesozoic limestone and dolomite, Palaeozoic metamorphic rocks, average thickness >1,000 m. Pressure condition: confined. The dominant groundwater flow direction is not known. There are weak to medium links with surface water systems. | | | **Black Sea basin**<br>Border length (km): |
| | **Slovenia** | **Austria** | **Hungary** |
| Area ($km^2$) | > 493.51 | | |
| Altitude fluctuation (m) | 171 - 413 | | |
| Number of inhabitants | 22,523 | | |
| Population density (persons/$km^2$) | 45.64 | | |
| Water uses and functions | Thermal water for spa and heating | | |
| Pressure factors | Spa related tourism, urbanization; thermal water abstractions | | |
| Problems related to groundwater quantity | Widespread and moderate, locally severe drop of groundwater level or discharge due to groundwater abstractions | | |

[23] This is a new aquifer number as this aquifer did not appear in the First Assessment of Transboundary Rivers, Lakes and Groundwaters.

[24] Based on information from Slovenia. According to Slovenia, Goričko and Mura – Zala basin / Radgona – Vaš are part of the Goričko aquifer system.

| | | | |
|---|---|---|---|
| Problems related to groundwater quality | N/A | | |
| Transboundary impacts | Possibly | | |
| Groundwater management measures | Optimization of basic measures or supplementary measures is foreseen | | |
| Trends and future prospects | Water and thermal water demand increase due to tourism (spa) and urbanization development. This in combination with the expected decrease of infiltration due to climate change may result in further drop of groundwater levels in the long term. Higher costs for further abstraction of thermal water, is expected. Trilateral cooperation for further characterization of the deep thermal aquifer is needed. Research for modeling and heat availability assessment is needed and so is improvement of existing re-injection technologies | | |
| Notes | | Austria reported that the aquifer does not extend in the country's territory | |

## Table 23. Kot aquifer

| | | | |
|---|---|---|---|
| **No. 58[25] Kot[26]** | | | **Shared by: Slovenia, Hungary and Croatia** |
| Type 2, Quaternary gravel - silicate/carbonate alluvial, of average thickness 20 m. Pressure condition: unconfined. Groundwater flow from Slovenia to Croatia. There are strong links with surface water systems | | | **Black Sea basin**<br>Border length (km): |
| | **Slovenia** | **Hungary** | **Croatia** |
| Area ($km^2$) | 448.96 | | |

[25] This is a new aquifer number as this aquifer did not appear in the First Assessment of Transboundary Rivers, Lakes and Groundwaters.
[26] Based on information from Slovenia. According to Slovenia, Kot is part of the alluvial aquifers' system of Drava and Mura Rivers at Hungarian – Slovenian – Croatian borders.

| | | | |
|---|---|---|---|
| Altitude fluctuation (m) | 148 - 324 | | |
| Number of inhabitants | 61,292 | | |
| Population density (persons/km$^2$) | 136.52 | | |
| Water uses and functions | Drinking water supply and agriculture; also supports ecosystems | | |
| Pressure factors | Municipal wastewater and agriculture | | |
| Problems related to groundwater quantity | N/A | | |
| Problems related to groundwater quality | Nitrate (wastewater and agriculture) and pesticides (agriculture) pollution | | |
| Transboundary impacts | N/A | | |
| Groundwater management measures | Nitrates have to be monitored through operational monitoring. Advanced analysis of nitrogen surplus distribution as well as further development and optimization of environmental program is needed and so is adaptation measures to climate change effects | | |
| Trends and future prospects | Information exchange among the three countries sharing the aquifer is needed | | |

*Status, pressures and transboundary impact*[27]

**Table 24. Drava River Basin - Land cover/use (% of the part of the basin extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| Italy | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Austria | 0.87 | 53 | 3.7* | 8.8 | 2.9 | 5.5 | |
| Slovenia | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Croatia | 0.76 | 30.31 | 45.65 | 4.6 | 2.84 | 15.83 | |
| Hungary | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

[27] Information about the status, pressures and impacts for the shared groundwater bodies in the basin is given in the tables above.

* The area used for primary sector activities is around 18% of the basin's area.

**Table 25. Mura River Basin - Land cover/use (% of the part of the basin extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Austria** | 0.15 | 58 | 6.3* | 9.7 | 5.0 | 14.5 | |
| **Slovenia** | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **Croatia** | 0.08 | 13.95 | 53.44 | 0 | 6.16 | 26.37 | 0 |
| **Hungary** | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

* The area used for primary sector activities is around 24% of the basin's area.

**Box 1: Assessment of Ramsar sites in the basin: Drava-Danube confluence (Croatia, Hungary, Serbia)[28]**

**General description of the wetland**

The wetland where the Drava River enters the Danube is the largest and best preserved flood retention area on the Middle Danube. It represents a naturally functioning inner delta with typical floodplain habitats, featuring a unique combination of lakes, marshes, wet grasslands, reed beds, willow shrubs and riverine forests. The entire area beyond the river embankments is flooded annually, for a duration of one to three months, between March and May, depending on upstream snow melt in the Alps.

**Main wetland ecosystem services**

The wetland is important for water flow regulation and flood control (although this role was more significant before the river embankments were constructed), purification of the river waters, sedimentation of transported matters and groundwater recharge. The presence of vast forest and wetland areas humidifies the regional climate.

**Supporting socio-economic services**

The wetland is used for timber production, hunting, fishing and tourism. Wetland water is used for irrigated agriculture and fish pond farming. Wetland groundwater aquifers provide important drinking water supply. Leisure and tourist activities, such as nature tours and village tourism, are developing rapidly.

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[28] *Sources*: (1) Latest Information Sheet on Ramsar Wetlands (RIS), available at the Ramsar Sites Information Service (http://ramsar.wetlands.org/Database/Searchforsites/tabid/765/language/en-US/Default.aspx): **Nature Park Kopacki rit (Kopački rit) Ramsar site**; Croatia (RIS updated in 2007); **Béda-Karapancsa Ramsar site**; Hungary (RIS updated in 2006); **Gornje Podunavlje Ramsar site**; Serbia (RIS submitted in 2007). (2) Environmental Status Report (Environmental Assessment), Social Impact Assessment (Public Consultation) – Final report within the DDNP Component of the Reduction of Nutrient Discharges Project (GEF # TF 051 289); prepared by VITUKI, Environmental and Water Management Research Centre, VTK Innosystem Ltd.

**Cultural values of the wetland area**

Local life has always been connected to the rivers, their forests and marshland. A number of traditional events are connected with fishing Local. *Phragmites* reed is used for constructions. *Typha* reed serves to make bags and mats. This use avoids the overgrowing of the open water surfaces.

**Biodiversity values**

The wetland holds an exceptionally rich biodiversity. Including a large number of threatened species, as well as a number of natural habitats of European Union interest. The wetland is important for large numbers of waterbirds. Several species of birds of prey depend on the floodplain and its forest.

The floodplain is the most significant fish spawning ground on the Middle Danube, with more than 50 species, including Sterlet (*Acipenser ruthenus*) and wild Carp (*Cyprinus carpio*), two vulnerable species of the IUCN Red List. The wetland is also an important foraging, nursery, and overwintering area and a migratory route for fish.

**Pressure factors and transboundary impacts**

The most significant pressures on the wetland ecosystem stems from water management, timber plantations and logging, agricultural and industrial effluents polluting the water, household sewage and urban wastewater runoffs, disturbance through fishing, hunting and leisure activities, and the spread of alien invasive species. Transformations of water bodies for navigation purposes put further pressures on the wetland ecosystem.

River regulation and flood control measures had serious impacts on the hydrological regime. The river channels were shortened and narrowed, resulting in significant increase of water flow speed and erosion force, leading to the degradation of the river bed and a lowering of the river water level. This resulted in shorter inundation periods of the natural floodplain and lowered groundwater levels. These processes together with amelioration and hydrotechnical activities for agricultural purposes lead to the loss of alluvial habitats and the deterioration of the living conditions for fish, amphibians and shorebirds. The continuous aggradation in the floodplain due to the sediments carried by the river and deposited in inundation areas enhances desiccation problems. The construction of protective levees along the Danube in the 1960s prevented the temporary inundation of large areas on the Serbian side. Increased nutrient content of the water inflows resulted in eutrophication of the floodplain waterbodies.

Forestry plantations are increasingly replacing native gallery woodlands and wet meadows. Non sustainable levels of fishing and hunting may threaten specific populations. High numbers of wild boar and red deer prevent natural forest regeneration. The abandonment of fish farming ponds and of mowing of wet meadows leads to the loss of these habitats. The occasional burning of reed beds reduces this habitat and creates unnecessary carbon release into the atmosphere.

The wetland was an area of armed conflict during the 1990s, and this resulted in the temporary suspension of conservation measures, infrastructure destruction, creation of un-mapped minefields and the abandonment of traditional settlements in the protected floodplain. A new phase of wetland conservation and management started in 1997, when Croatia created the Kopački Rit Nature Park, followed in 2001 by the proclamation of the Special Nature Reserve Gornje Podunavlje on the Serbian side. However, intensive timber exploitation and illegal waterfowl hunting continue to exert pressures on the ecosystem.

**Transboundary wetland management**

The core wetland area benefits in all three countries from a specific legal protection status and was designated for inclusion to the Ramsar List of Wetlands of International Importance.

The Croatian Ramsar site (N° 583; 23,894 ha) coincides with the **Nature Park Kopački rit**,. With the financial support of the Global Environment Facility, an ecological research, monitoring and education centre was installed and a new visitor centre was opened. The Serbian Ramsar site (N° 1737; 22,480 ha) includes the **Gornje Podunavlje Special Nature Reserve** (19,648 ha). The Hungarian Ramsar site **Béda-Karapancsa** (N° 901; 1,150 ha) forms part of the Duna-Dráva National Park.

A number of wetland restoration and management activities are implemented on Croatian and Hungarian side, also as a part of transboundary cooperation. With the declaration of the Serbian Ramsar site, increasingly also the management of the Gornje Podunavlje Reserve is developed in consultation and cooperation with the Hungarian and Croatian neighbors. At a wider scale, the area is intended to become part of the planned Transboundary Biosphere Reserve along the Drava and Mura rivers, with parts in Austria, Croatia, Hungary, Serbia and Slovenia.

28. Floods are reported to be a continuous threat, requiring protection measures along the watercourses.

29. Regulation of the flow of water also due to the construction and operation of hydropower production infrastructure influences the water regime in the downstream parts in Croatia.

30. Rather big portions of the Drava (72%) and Mura Rivers (37%) in Austria have been assessed as heavily modified (according to the EU WFD); according to Austria the same is true for the parts of the rivers that extend downstream in Slovenia.

31. Austria reports that agricultural activities affect groundwater in the Mura in limited areas and with decreasing tendency; it is of low importance. In Slovenia, nitrogen and pesticides pollution due to agriculture and livestock breeding is an important issue for what concerns surface and particularly groundwater quality. In the eastern part (Mursko and Dravsko fields), $NO_3$ concentrations are between 31 and 242 mg/l while some pesticides' concentrations are elevated, exceeding EU drinking water standards. Concentrations of ammonium nitrogen in Mura have decreased in the past few years, as observed at Spielfeld monitoring station on the Austrian side of the border with Slovenia (Figure 5). Potassium and zinc concentrations are increasing in the Dravsko field. An assessment of the state and changes of water quality along the Mura River from 1989 to 1994 showed that the water quality improved to quality classes 2 to

3 probably due to rehabilitation measures taken in Austria. The situation is similar in the Drava River.

[Figure 5. Ammonium nitrogen concentration (mg/l) in Mura at Spielfeld monitoring station. Data provided by Austria.]

32. Groundwater from alluvium in the Drava basin is significantly discharged into the Drava River, thus the pressures from diffuse pollution sources have an important impact in terms of nitrogen loads entering the river.

33. There are controlled and uncontrolled dumpsites in areas where groundwater resources of the alluvial aquifers of Drava and Mura are highly vulnerable to pollution. Uncontrolled landfills sometimes pollute surrounding soil and groundwater in Croatia. Industrial pollution in Slovenia (major chemical industry) in the Drava sub-basin is reported to decline.

*Responses*

34. The parts of the basins of Drava and Mura Rivers that fall within the territory of Austria are managed in accordance to the EU WFD which is fully implemented. Austria has taken all the necessary measures: a river basin management plan has been prepared for each of the Drava and Mura basins in conformity with the EU WFD covering both surface water and groundwater resources, permit and licensing systems are in place and enforced, vulnerability mapping for land use planning exists, good agricultural practices have been developed and implemented, protection zones for drinking water supply have been established. Water protection is integrated in agricultural policy and in licensing procedures for industrial plants as well as in hydropower development planning and licensing. Economic instruments are used in line with EU WFD and stakeholders are involved as necessary. Wastewater treatment infrastructure is in place. Austria reports that there is no urgent necessity for measures to adapt to climate change; scenarios have been developed and consequences investigated. Monitoring, assessment and reporting are being implemented in line with the EU directives. Joint monitoring with neighbouring countries is not practiced but information and data in the boundary region are harmonized.

35. Slovenia is an EU Member State and water resources management is practised according to the principles of the EU *acquis communautaire* and in particular the EU WFD. In Slovenia water quality monitoring is carried out in 18 different water bodies; 84 sampling points are used.

36. A number of water resources management plans and measures are implemented in Croatia. Croatia has initiated the transposition of the EU WFD in its legal framework; legal acts that will fully transpose the EU WFD are going to be adopted soon (within 2009 – see also Annex I of document ECE/MP.WAT/2009/8). The preparation of a River Basin Management Plan in accordance to the EU WFD is underway. Monitoring in Croatia is conducted 26 times per year, using one station on the Mura River and four on the Drava River.

37. Monitoring in both rivers (quality - once per month using one monitoring station on the Mura River and three monitoring stations on the Drava River) is conducted also jointly by Croatia and Hungary in accordance with the work plan of the Water Protection Sub-commission under the Croatian-Hungarian Commission for Water Management (see below).

*Transboundary cooperation*

38. Cooperation between Austria and Slovenia on the Drava and Mura Rivers dates back to 1954 (Slovenia was then within the state of Yugoslavia) and covers all issues that might have a negative effect on the rivers. There is a permanent Austrian – Slovenian Commission dealing with all related issues.

39. A Croatian - Hungarian Water Management Commission has been created under the Agreement on Water Management Relations signed by the two countries in 1994. Sub-commissions have been set up among others for Drava and Danube water management; Mura River; water use and pollution control; water quality control.

40. There is also an agreement between Slovenia and Hungary.

41. The 1996 agreement between Slovenia and Croatia covers also water resources in the Drava and Mura basins (see Annex III of document ECE/MP.WAT/2009/8).

42. A project is developed by Croatia for the preparation of an Integrated River Basin Management Plan for the Drava River.

*Trends*

43. Croatia reports that decrease in precipitation has resulted in decrease of groundwater levels in the basin.

## IV. SAVA RIVER BASIN[29]

44. The basin of the Sava River covers considerable parts of Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro and a small part of Albania. Large part of the population of each of the first 4 riparian countries live in the basin ranging from around 25% to around 75% of the total number of inhabitants (Bosnia and Herzegovina: 74,99%, Slovenia: 61.4%, Croatia: 49.75%, Serbia: 24.9%).

[29] Based on information from 1) International Sava River Basin Commission (ISRBC); (ii) ISRBC annual report (April 2008 - March 2009); 3) Bosnia and Herzegovina; 4) Croatia; 5) the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the ISRBC

**Table 26. Basin of the Sava River**

| Area | Country | Country's share | | Number of inhabitants | Population density |
|---|---|---|---|---|---|
| 97,713.2 $km^2$ | Slovenia | 11,734.8 $km^2$ | 12.0 % | 1,230,000 | 104 |
| | Croatia | 25,373.5 $km^2$ | 26.0 % | 2,210,000 | 87.1 |
| | Bosnia and Herzegovina | 38,349.1 $km^2$ | 39.2 % | 2,882,000 | 75 |
| | Serbia | 15,147.0 $km^2$ | 15.5 % | 1,854,000 | 122 |
| | Montenegro | 6,929.8 $km^2$ | 7.1 % | - | - |
| | Albania | 179.0 $km^2$ | 0.2 % | - | - |

*Hydrology and hydrogeology*

45. The Sava River emerges in the mountains of western Slovenia and flows into the Danube in Belgrade, Serbia. The river is the third longest (about 945 km) tributary to the Danube and the largest by discharge (1,722 $m^3/s$, at its mouth). In Croatia, the average discharge of the Sava River immediately upstream the mouth of Sutla River is around 290 $m^3/s$; it is 314 $m^3/s$ in Zagreb, and around 1,179 $m^3/s$ at the point that Sava exits Croatia.

**Table 27. Discharge characteristics of the Sava River at different monitoring stations**

| Gauging station: Čatež (Sava) - Slovenia | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time** |
| $Q_{av}$ | 227 $m^3/s$ | 1926-65 |
| $Q_{max}$ | 3,520 $m^3/s$ | 1926-65 |
| $Q_{min}$ | 45,8 $m^3/s$ | 1926-65 |
| $Q_{av}$ | 317 $m^3/s$ | Average for: - |
| **Mean monthly values:** | | |
| January: 279 $m^3/s$ | February: 255 $m^3/s$ | March: 375 $m^3/s$ |
| April: 362 $m^3/s$ | May: 349 $m^3/s$ | June: 304 $m^3/s$ |
| July: 225 $m^3/s$ | August: 189 $m^3/s$ | September: 242 $m^3/s$ |
| October: 358 $m^3/s$ | November: 480 $m^3/s$ | December: 368 $m^3/s$ |

| Gauging station: Zagreb (Sava River)-Croatia | | | | |
|---|---|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time** | **Discharge** | **Period of time** |
| $Q_{av}$ | 314 $m^3/s$ | 1926-65 | 322 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 3,139 $m^3/s$ | 1926-65 | 2,711 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 45 $m^3/s$ | 1926-65 | 51.5 $m^3/s$ | 1965-2005 |

| Mean monthly values | | | | | |
|---|---|---|---|---|---|
| Period of time: 1926-65 | | | Period of time: 1965-2005 | | |
| January: 288 $m^3/s$ | February: 282 $m^3/s$ | March: 382 $m^3/s$ | January: 310 $m^3/s$ | February: 309 $m^3/s$ | March: 358 $m^3/s$ |
| April: 357 $m^3/s$ | May: 351 $m^3/s$ | June: 295 $m^3/s$ | April: 431 $m^3/s$ | May: 343 $m^3/s$ | June: 300 $m^3/s$ |
| July: 229 $m^3/s$ | August: 179 $m^3/s$ | September: 224 $m^3/s$ | July: 242 $m^3/s$ | August: 193 $m^3/s$ | September: 250 $m^3/s$ |
| October: 339 $m^3/s$ | November: 485 $m^3/s$ | December: 365 $m^3/s$ | October: 342 $m^3/s$ | November: 412 $m^3/s$ | December: 379 $m^3/s$ |

| **Gauging station: Slavonski Brod (Sava River) -Croatia** | | | | |
|---|---|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time** | **Discharge** | **Period of time** |
| $Q_{av}$ | 1,016 $m^3/s$ | 1926-65 | 1,033 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 3,230 $m^3/s$ | 1926-65 | 3,530 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 116 $m^3/s$ | 1926-65 | 168 $m^3/s$ | 1965-2005 |

| Mean monthly values | | | | | |
|---|---|---|---|---|---|
| Period of time:1926-65 | | | Period of time:1965-2005 | | |
| January: 1,182 $m^3/s$ | February: 1,204 $m^3/s$ | March: 1,445 $m^3/s$ | January: 1,242 $m^3/s$ | February: 1,240 $m^3/s$ | March: 1,309 $m^3/s$ |
| April: 1,415 $m^3/s$ | May: 1,187 $m^3/s$ | June: 899 $m^3/s$ | April: 1,556 $m^3/s$ | May: 1,214 m3/s | June: 871 $m^3/s$ |
| July: 619 $m^3/s$ | August: 422 $m^3/s$ | September: 440 $m^3/s$ | July: 634 $m^3/s$ | August: 488 $m^3/s$ | September: 608 $m^3/s$ |
| October: 756 $m^3/s$ | November: 1317 $m^3/s$ | December: 1,322 $m^3/s$ | October: 836 $m^3/s$ | November: 1092 $m^3/s$ | December: 1323 $m^3/s$ |

| **Gauging station: Županja (Sava River) - Croatia** | | | | |
|---|---|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time** | **Discharge** | **Period of time** |
| $Q_{av}$ | 1,194 $m^3/s$ | 1926-65 | 1,033 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 3,835 $m^33/s$ | 1926-65 | 3,530 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 165 $m^3/s$ | 1926-65 | 168 $m^3/s$ | 1965-2005 |

| Mean monthly values | | | | | |
|---|---|---|---|---|---|
| Period of time:1926-65 | | | Period of time:1965-2005 | | |
| January: 1,372 $m^3/s$ | February: 1,410 $m^3/s$ | March: 1,726 $m^3/s$ | January: 1,425 $m^3/s$ | February: 1,452 $m^3/s$ | March: 1,536 $m^3/s$ |
| April: 1,706 $m^3/s$ | May: 1,453 $m^3/s$ | June: 1,071 $m^3/s$ | April: 1,816 $m^3/s$ | May: 1,454 $m^3/s$ | June: 1,028 $m^3/s$ |
| July: 729 $m^3/s$ | August: 495 $m^3/s$ | September: 504 $m^3/s$ | July: 729 $m^3/s$ | August: 545 $m^3/s$ | September: 669 $m^3/s$ |
| October: 852 $m^3/s$ | November: 1,505 $m^3/s$ | December: 1,525 $m^3/s$ | October: 916 $m^3/s$ | November: 1,204 $m^3/s$ | December: 1,499 $m^3/s$ |

| **Gauging station: Jesenice (Sava River) - Croatia** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 298 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 4,075 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 48.7 $m^3/s$ | 1965-2005 |
| **Mean monthly values:** | | |
| January: 284 $m^3/s$ | February: 281 $m^3/s$ | March: 329 $m^3/s$ |
| April: 397 $m^3/s$ | May: 324 $m^3/s$ | June: 283 $m^3/s$ |
| July: 225 $m^3/s$ | August: 178 $m^3/s$ | September: 230 $m^3/s$ |
| October: 318 $m^3/s$ | November: 384 $m^3/s$ | December: 344 $m^3/s$ |

| **Gauging station: Jasenovac (Sava River) - Croatia** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 849 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 2,741 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 134 $m^3/s$ | 1965-2005 |
| **Mean monthly values:** | | |
| January: 974 $m^3/s$ | February: 1,006 $m^3/s$ | March: 1,090 $m^3/s$ |
| April: 1,287 $m^3/s$ | May: 985 $m^3/s$ | June: 687 $m^3/s$ |
| July: 509 $m^3/s$ | August: 407 $m^3/s$ | September: 516 $m^3/s$ |
| October: 720 $m^3/s$ | November: 917 $m^3/s$ | December: 1,102 $m^3/s$ |

| **Gauging station: Sremska Mitrovica (Sava River) - Serbia** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 1,330 $m^3/s$ | 1926-65 |
| $Q_{max}$ | 5,540 $m^3/s$ | 1926-65 |
| $Q_{min}$ | 212 $m^3/s$ | 1926-65 |
| **Mean monthly values:** | | |
| January: 1,830 $m^3/s$ | February: 1,820 $m^3/s$ | March: 2,360 $m^3/s$ |
| April: 2,460 $m^3/s$ | May: 2,170 $m^3/s$ | June: 1,500 $m^3/s$ |
| July: 1,000 $m^3/s$ | August: 651 $m^3/s$ | September: 636 $m^3/s$ |
| October: 1070 $m^3/s$ | November: 1,960 $m^3/s$ | December: 2,040 $m^3/s$ |

**Table 28. Discharge characteristics of some of the tributaries of Sava River**[30]

| **Gauging station: Kupari (Kupa River) - Croatia** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 13.5 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 197 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 0.311 $m^3/s$ | 1965-2005 |
| **Mean monthly values:** | | |
| January: 14.2 $m^3/s$ | February: 12.7 $m^3/s$ | March: 14.6 $m^3/s$ |
| April: 21.2$m^3/s$ | May: 14.0 $m^3/s$ | June: 8.61 $m^3/s$ |
| July: 4.94 $m^3/s$ | August: 4.71 $m^3/s$ | September: 10.8 $m^3/s$ |
| October: 16.8 $m^3/s$ | November: 20.7 $m^3/s$ | December: 19.0 $m^3/s$ |

| **Gauging station: Kamanje (Kupa River) - Croatia** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 77.2 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 1,146 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 5.24 $m^3/s$ | 1965-2005 |
| **Mean monthly values:** | | |
| January: 82.7 $m^3/s$ | February: 83.6 $m^3/s$ | March: 99.8 $m^3/s$ |
| April: 113 $m^3/s$ | May: 69.4 $m^3/s$ | June: 50.2 $m^3/s$ |
| July: 33.2 $m^3/s$ | August: 33.2 $m^3/s$ | September: 57.3 $m^3/s$ |
| October: 86.7 $m^3/s$ | November: 110 $m^3/s$ | December: 109 $m^3/s$ |

| **Gauging station: Farkašić (Kupa River) - Croatia** | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 203 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 1,603 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 24.1 $m^3/s$ | 1965-2005 |
| **Mean monthly values:** | | |
| January: 230 $m^3/s$ | February: 254 $m^3/s$ | March: 291 $m^3/s$ |
| April: 326 $m^3/s$ | May: 191$m^3/s$ | June: 127 $m^3/s$ |
| July: 83.5 $m^3/s$ | August: 85.4 $m^3/s$ | September: 119 $m^3/s$ |
| October: 189 $m^3/s$ | November: 258 $m^3/s$ | December: 282 $m^3/s$ |

[30] Based on information from Croatia

| Gauging station: Zelenjak (Sutla River) - Croatia | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 5.86 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 185 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 0.002 $m^3/s$ | 1965-2005 |
| **Mean monthly values:** | | |
| January: 6.01 $m^3/s$ | February: 7.00 $m^3/s$ | March: 8.72 $m^3/s$ |
| April: 7.72 $m^3/s$ | May: 4.64 $m^3/s$ | June: 4.27 $m^3/s$ |
| July: 3.24 $m^3/s$ | August: 2.94 $m^3/s$ | September: 4.01 $m^3/s$ |
| October: 6.38 $m^3/s$ | November: 7.60 $m^3/s$ | December: 7.87 $m^3/s$ |

| Gauging station: Bregana Remont (Bregana River) - Croatia | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 1.36 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 67.8 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 0.289 $m^3/s$ | 1965-2005 |
| **Mean monthly values:** | | |
| January: 1.39 $m^3/s$ | February: 1.43 $m^3/s$ | March: 1.86 $m^3/s$ |
| April: 1.82 $m^3/s$ | May: 1.41 $m^3/s$ | June: 1.16 $m^3/s$ |
| July: 1.02 $m^3/s$ | August: 0.921 $m^3/s$ | September: 1.06 $m^3/s$ |
| October: 1.25 $m^3/s$ | November: 1.41 $m^3/s$ | December: 1.64 $m^3/s$ |

| Gauging station: Hrvatska Kostajnica (Una River) - Croatia | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 218 $m^3/s$ | 1965-2005 |
| $Q_{max}$ | 1,501 $m^3/s$ | 1965-2005 |
| $Q_{min}$ | 29.1 $m^3/s$ | 1965-2005 |
| **Mean monthly values:** | | |
| January: 245 $m^3/s$ | February: 280 $m^3/s$ | March: 307 $m^3/s$ |
| April: 364 $m^3/s$ | May: 256 $m^3/s$ | June: 175 $m^3/s$ |
| July: 116 $m^3/s$ | August: 93.6 $m^3/s$ | September: 116 $m^3/s$ |
| October: 156 $m^3/s$ | November: 216 $m^3/s$ | December: 293 $m^3/s$ |

46. The morphology of the terrain of the basin varies. While rugged mountains (the Alps and the Dinarides) dominate in the upper part, the middle and lower parts of the basin are characterized by flat plains and low mountains. The areas in the south, in Croatia, Bosnia and Herzegovina, Montenegro and Albania, drained by tributaries ending in the middle section of the Sava watercourse, are characterised by mountainous landscape. Elevation varies between 2,864 m a.s.l. (Triglav, Slovenian Alps) and about 71 m a.s.l. at the mouth of the Sava.

47. The Sava receives water from a number of rivers, many of which are also transboundary. The most important is the Drina (itself transboundary); its main tributaries are the Piva, Tara, Lim and Uvac Rivers. The most important tributaries of the hydrographical network of Sava are presented in the table below.

**Table 29. Rivers of the Hydrographical network of Sava River Basin**

| River | Sub-Basin Area | Country(ies) that the sub-basin is extending in | Length (km) |
|---|---|---|---|
| Ljubljanica | 1,860.0 | SI | 41.0 |
| Savinja | 1,849.0 | SI | 93.9 |
| Krka | 2,247.0 | SI | 94.6 |
| Sotla/Sutla | 584.3 | SI, HR | 88.6 |
| Krapina | 1,237.0 | HR | 65.6 |
| Kupa/Kolpa | 10,225.6 | HR,SI | 297.2 |
| Lonja | 4,259.0 | HR | 82.8 |
| Ilova (Trebež) | 1,796.0 | HR | 100.3 |
| Una | 9,828.9 | BA,HR | 214.6 |
| Vrbas | 6,273.8 | BA | 249.6 |
| Orljava | 1,618.0 | HR | 99.5 |
| Ukrina | 1,504.0 | BA | 80.7 |
| Bosna | 10,809.8 | BA | 281.6 |
| Tinja | 904.0 | BA | 99.4 |
| Drina | 20,319.9 | ME, AL, BA, RS | 346.0 |
| Bosut | 2,943.1 | HR, RS | N/A |
| Kolubara | 3,638.4 | RS | 86.6 |

AL: Albania, BA: Bosnia and Herzegovina, HR: Croatia, ME: Montenegro, RS: Serbia, SI: Slovenia

48. The Sava basin hosts large lowland forest complexes and the largest complex of alluvial wetlands in the Danube basin (Posavina - Central Sava basin).

[Figure 9. Corine 2000 Land cover/use in the Sava River Basin[31]]

**Table 50. Land cover/use (% of the basin)**

| | |
|---|---|
| Lakes/reservoirs | 0,63 |
| Forests and semi natural areas | 54,71 |
| Agricultural areas | 42,36 |
| Urban/industrial areas | 2,23 |
| Wetlands | 0,08 |

49. Sava is a fine example of a river, where some of the floodplains are still intact, supporting both mitigation of floods and biodiversity. There are six Ramsar sites designated; a number of areas of ecological importance are under national protection status.

[31] Source: EEA, Copenhagen, 2004 [http://www.eea.europa.eu]

**Table 51. Designated Ramsar sites, their surface areas, designation years and countries where they are located.**

| Ramsar Site | Area ($km^2$) | Year of designation | Country |
|---|---|---|---|
| Bardača Wetland | 35.00 | 2007 | Bosnia and Herzegovina |
| Lonjsko Polje & Mokro Polje | 505.60 | 1993 | Croatia |
| Crna Mlaka | 6.25 | 1993 | |
| Cerkniško Jezero and its environs | 72.5 | 2006 | Slovenia |
| Obedska Bara | 175.01 | 1977 | Serbia |
| Zasavica | 19.13 | 2008 | |

**Table 52. Mean annual total water use in the Sava River Basin, 2003-2005**

| Total withdrawal | Agriculture | Domestic | Industry | Energy |
|---|---|---|---|---|
| $4{,}896.9 \times 10^6$ $m^3$/year | 11.2 % | 16 % | 5.9 % | 66.9 % |

50. The Sava River Basin is characterized by diverse geological structure and complex tectonic setting under which two main units stand out, determining the type of aquifers that occur: the Pannonian basin with dominant inter-granular aquifers and the Dinarides with mostly limestone aquifers. A number of aquifers exist in the basin[32] (illustrated below – a list of the aquifers per country/entities, is also given).

[Figure 6. Important Groundwater Bodies at national level, as identified by the riparian countries and entities[33]]

51. The following transboundary aquifers were identified as hydraulically linked to the surface waters of the Sava River basin and included in the First Assessment:

(a) No.5 Cerknica/Kupa, shared by Croatia and Slovenia;[34]

(b) No. 6 Radovica-Metlika/Zumberak, shared by Slovenia and Croatia;[35]

(c) No. 7 Bregana-Obrezje/Sava-Samobor, shared by Slovenia and Croatia;[36]

(d) No. 8 Bizeljsko/Sutla, shared by Slovenia and Croatia;[37]

[32] Bosnia and Herzegovina, Croatia, Slovenia and Serbia identified the most important groundwater bodies for the needs of the Sava River Basin Analysis Report, being prepared by the ISRBC. According to the ISRBC secretariat, information related to groundwater bodies was incomplete. As far as the issue of transboundary groundwater bodies is concerned, this will be reconsidered in the next phase of the preparation of the Sava River Basin Management Plan (coordinated by the ISRBC).
[33] Based on information from the ISRBC Secretariat.
[34] According to Croatia this transboundary aquifer is under consideration but not approved.
[35] According to Croatia this transboundary aquifer is under consideration but not approved.
[36] According to Croatia this transboundary aquifer is under consideration but not approved.
[37] According to Croatia this transboundary aquifer is under consideration but not approved.

(e) No. 15 Srem-West Srem/Sava, shared by Serbia and Croatia;

(f) No. 16 Posavina I/Sava, shared by Bosnia and Herzegovina and Croatia;

(g) No. 17 Kupa, shared by Bosnia and Herzegovina and Croatia;[38]

(h) No. 18 Pleševica/Una, shared by Bosnia and Herzegovina and Croatia;

(i) No. 29 Lim, shared by Serbia and Montenegro;

(j) No. 30 Tara massif, shared by Serbia and Bosnia and Herzegovina;[39]

(k) No. 31 Macva-Semberija, shared by Serbia and Bosnia and Herzegovina.

52. Since the first Assessment, further research by some of the countries has revealed the existence of additional transboundary groundwater bodies that form part of the earlier identified aquifers. Information on the transboundary aquifers that have been identified as hydraulically linked with the surface water systems of Sava River Basin either already in the First Assessment or after are given in the tables below. It is likely that the list is not exhaustive. There is no information available regarding which of/ and at what extent the transboundary aquifers given in the text below coincide with the "national" aquifers/groundwater bodies included in the list of Figure 6. "Important Groundwater Bodies at national level, as identified by the riparian countries and entities", presented above.

**Table 30. Cerknica/Kupa aquifer**

| **No. 5 Cerknica/Kupa** [40] | | **Shared by: Croatia and Slovenia** |
|---|---|---|
| According to Croatia: represents none of the illustrated transboundary aquifer types, Triassic and Cretaceous limestones and dolomites with some alluvium in the river valley, groundwater flow from Croatia to Slovenia and Slovenia to Croatia. Weak to medium links with surface waters systems.<br>According to Slovenia: Type 2, Mesozoic carbonates, dominantly karstic limestones, weak to medium links to surface water systems, groundwater flow from Croatia to Slovenia. Pressure condition: unconfined. | | **Black Sea basin**<br>Border length (km): 32 |
| | **Croatia** | **Slovenia** |
| Area (km$^2$) | 137 | 237.58 |
| Altitude fluctuation (m) | N/A | 530 - 1200 |
| Number of inhabitants | N/A | 10,635 |

[38] According to Croatia this transboundary aquifer is under consideration but not approved.

[39] According to both countries there are negligible conditions for nomination as a transboundary groundwater.

[40] Based on information from Slovenia, Croatia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Environment Agency of Slovenia and Croatian Waters. Part of the Kolpa - carbonate fissured and karst aquifers of Kolpa and Ljubljanica area; Kupa/Kolpa (shared by Slovenia and Croatia) and Ljubljanica (Slovenia) Rivers are tributaries to Sava. Cerknica/Kupa and Kočevje Goteniška gora are part of the same system.

| | | |
|---|---|---|
| Population density (persons/km$^2$) | N/A | 44.76 |
| Water uses and functions | Drinking water supply; supports ecosystems | Local drinking water supply |
| Pressure factors | None, very scattered population | None, sparsely populated, forested with some extensive agriculture and pasture |
| Problems related to groundwater quantity | None | None |
| Problems related to groundwater quality | Occasional bacteriological pollution | None, good chemical status |
| Transboundary impacts | None | None for quantity or quality |
| Groundwater management measures | Existing protection zones | None |
| Trends and future prospects | Delineation of transboundary groundwater is needed (through common research), and development of monitoring programmes | Not at risk. It is unclear which groundwater systems in the two countries correspond to each other; delineation of transboundary groundwater needs common research and bilateral decision to propose a transboundary groundwater, if appropriate |
| Notes | Transboundary aquifer under consideration, but not approved | In the basin of the Kolpa/Kupa River, within that of the Sava River |

## Table 31. Kočevje Goteniška gora aquifer

| **No. 5.1**[41] **Kočevje Goteniška gora** [42] | | **Shared by: Slovenia and Croatia** |
|---|---|---|
| Type 2, Mesozoic carbonates, dominantly karstic limestones, weak to medium links to surface water systems. Pressure condition: unconfined | | **Black Sea Basin**<br>Border length (km): |
| | **Slovenia** | **Croatia** |
| Area (km$^2$) | 594.52 | |
| Altitude fluctuation (m) | 189 – 1,280 | |
| Number of inhabitants | 18,167 | |
| Population density (persons/km$^2$) | 30.56 | |
| Water uses and functions | Local drinking water supply | |
| Pressure factors | N/A | |
| Problems related to groundwater quantity | N/A | |
| Problems related to groundwater quality | N/A | |
| Transboundary impacts | N/A | |

[41] This is a new aquifer/groundwater body number as this groundwater body did not appear in the First Assessment of Transboundary Rivers, Lakes and Groundwaters.
[42] Based on information from Slovenia. Part of the Kolpa - carbonate fissured and karst aquifers of Kolpa and Ljubljanica area; Kupa/Kolpa (shared by Slovenia and Croatia) and Ljubljanica (Slovenia) Rivers are tributaries to Sava. Cerknica/Kupa and Kočevje Goteniška gora are part of the same system

| | | |
|---|---|---|
| Groundwater management measures | N/A | |
| Trends and future prospects | N/A | |

**Table 32. Radovica-Metlika/Zumberak aquifer**

| **No. 6 Radovica-Metlika/Zumberak** [43] | | **Shared by: Slovenia and Croatia** |
|---|---|---|
| According to Slovenia: Type 2, Upper Triassic dolomites, Upper Jurassic limestones, Cretaceous predominantly carbonate flysch, karstic limestones of average thickness > 1,000 m. Pressure condition: partly confined, partly unconfined. Groundwater flow from Croatia to Slovenia. Recharge area is both in Croatia and Slovenia; the discharge area is in Slovenia. Possible drainage to surface water systems. Groundwater covers the total of the water used in the Slovenian part<br>According to Croatia: represents none of the illustrated transboundary aquifer types, Triassic dolomites, groundwater flow direction from Croatia to Slovenia | | **Black Sea basin**<br>Border length (km): 12 |
| | **Croatia** | **Slovenia** |
| Area (km$^2$) | 158 | 26.65 |
| Altitude fluctuation (m) | 250 – 1,000 | 126 - 573 |
| Number of inhabitants | N/A | 2,539 |
| Population density (persons/km$^2$) | N/A | 95.27 |
| Water uses and functions | Dominantly drinking water supply; supports ecosystems | Drinking water supply (town of Metlika; minimum yield of the Obrh spring discharge is about 50 l/s, maximum yield > 1000 l/s) |
| Pressure factors | None | Agricultural activities, lack of sewerage in the spring recharge area, illegal dump sites |
| Problems related to groundwater quantity | None | Spring water quantity fluctuates significantly due to the karstic geomorphology; water scarcity in summer; possible problem regarding the surface stream hydrological minimum during drought |
| Problems related to groundwater quality | None | Excessive pesticide content, possible microbiological pollution; turbidity of water is observed during rain season |
| Transboundary impacts | None | None |

[43] Based on information from Slovenia, Croatia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Environment Agency of Slovenia and Croatian Waters. Part of the Kolpa - Carbonate fissured and karst aquifers of Kolpa and Ljubljanica area; Kupa/Kolpa (shared by Slovenia and Croatia) and Ljubljanica (Slovenia) Rivers are tributaries to Sava

| | | |
|---|---|---|
| Groundwater management measures | Need to establish protection zones | Wastewater treatment infrastructure and septic tank systems being developed in the recharge area (in progress); un-controlled dump site inventory and appropriate addressing of the issue is planned for the future |
| Trends and future prospects | Agreed delineation of transboundary groundwaters, and development of monitoring programmes are needed | - Possible additional and more frequent discharge reduction in drought seasons as a consequence of climate change<br>- It is unclear which groundwater systems in the two countries correspond to each other; delineation of transboundary groundwater systems needs common research and bilateral expert group decision to propose a transboundary groundwater, if appropriate<br>- Establishment of transboundary water protection areas is needed; the bilateral water commission will discuss this issue |
| Notes | Transboundary aquifer under consideration, but not approved | |

### Table 33. Bregana-Obrezje/Sava-Samobor

| **No. 7 Bregana-Obrezje/Sava-Samobor**[44] | | **Shared by: Slovenia and Croatia** |
|---|---|---|
| According to the riparian countries represents none of the illustrated transboundary aquifer types, Quaternary alluvial sands and gravels, 5-10 m thick in Slovenia and of 20-30 m mean and 50 m maximum thickness in Croatia. Strong link with surface waters of the Sava River, groundwater flow from Slovenia to Croatia. | | **Black Sea Basin**<br>Border length (km): 7 |
| | **Slovenia** | **Croatia** |
| Area (km$^2$) | 4 | 54 |
| Altitude fluctuation (m) | N/A | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/km$^2$) | N/A | N/A |
| Water uses and functions | Local drinking water supply | Dominantly drinking water supply (for Samobor and part of Zagreb), and some industry |
| Pressure factors | Surface water hydropower schemes and associated river regulation on the Sava; transport routes | Agriculture, population, extraction of gravel and river regulation |

[44] Based on information from Croatia, Slovenia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Environment Agency of Slovenia and Croatian Waters.

| | | |
|---|---|---|
| Problems related to groundwater quantity | None | Changes in groundwater level detected |
| Problems related to groundwater quality | None, chemical status good | Hydrocarbons - oils and occasionally nitrogen, iron and manganese |
| Transboundary impacts | None | From hydropower plants and extraction of gravel |
| Groundwater management measures | None | Existing protection zones |
| Trends and future prospects | It is unclear which groundwater systems in the two countries correspond to each other; delineation of transboundary groundwater systems needs common research and bilateral expert group decision to propose a transboundary groundwater, if appropriate | Agreed delineation of transboundary groundwaters (common research and a relevant bilateral decision is needed) as well as development of monitoring programmes are needed |
| Notes | Very small part in Slovenia | Transboundary aquifer under consideration, but not approved |

## Table 34. Bregana aquifer

| **No. 7.1[45] Bregana [46]** | | **Shared by: Slovenia and Croatia** |
|---|---|---|
| Type 2, Quaternary carbonate gravel and sands. Pressure condition: unconfined. Dominant groundwater flow from Slovenia to Croatia. | | **Black Sea Basin**<br>Border length (km): |
| | **Slovenia** | **Croatia** |
| Area (km$^2$) | 15.59 | |
| Altitude fluctuation (m) | 131 - 173 | |
| Number of inhabitants | 1,956 | |
| Population density (persons/km$^2$) | 125.47 | |
| Water uses and functions | Local drinking water supply | |
| Pressure factors | N/A | |
| Problems related to groundwater quantity | N/A | |
| Problems related to groundwater quality | N/A | |
| Transboundary impacts | N/A | |
| Groundwater management measures | N/A | |
| Trends and future prospects | N/A | |

[45] This is a new aquifer number because as this aquifer did not appear in the First Assessment of Transboundary Rivers, Lakes and Groundwaters.
[46] Based on information from Slovenia. The Bregana groundwater body (No. 7.1) forms part of the Bregana-Obrezje/Sava-Samobor aquifer.

**Table 35. Bizeljsko/Sutla aquifer**

| **No. 8 Bizeljsko/Sutla** [47] | | **Shared by: Slovenia and Croatia** |
|---|---|---|
| According to the riparian countries represents none of the illustrated transboundary aquifer types, Triassic dolomites, weak links to surface water systems, groundwater flow from Slovenia to Croatia. Groundwater covers 100% of water used in the Croatian part. | | **Black Sea Basin**<br>Border length (km): 4? |
| | **Slovenia** | **Croatia** |
| Area (km$^2$) | 180 | 12 |
| Altitude fluctuation (m) | N/A | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/km$^2$) | N/A | N/A |
| Water uses and functions | Drinking water | Local drinking water supply |
| Pressure factors | None | None |
| Problems related to groundwater quantity | None | Local lowering of groundwater levels detected |
| Problems related to groundwater quality | None, good chemical status | No data |
| Transboundary impacts | None | Indications that water supply abstraction for Podčetrtek impacts on groundwater levels |
| Groundwater management measures | None | Existing protection zones |
| Trends and future prospects | It is unclear which groundwater systems in the two countries correspond to each other; delineation of transboundary groundwater systems needs common research and bilateral expert group decision to propose a transboundary groundwater, if appropriate. | Need for coordination between areas on both sides - agreed delineation of transboundary groundwaters, and development of monitoring programmes |
| Notes | Area uncertain – possibly only part of the Bizeljsko groundwater system is relevant | Transboundary aquifer under consideration, but not approved |

53. The Bizeljsko/Sutla transboundary aquifer is further divided in five transboundary aquifers[48]:

(a) Boč;
(b) Rogaška;
(c) Atomske toplice;
(d) Bohor;

[47] Based on information from the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Environment Agency of Slovenia and Croatian Waters. Part of carbonate and sandy aquifers of Sotla/Sutla River shared by Slovenia and Croatia; Sotla/Sutla River is a tributary to Sava.

[48] Based on information from Slovenia. The numbers assigned to these aquifers presented in the tables below are new since these did not appear in the First Assessment of Transboundary Rivers, Lakes and Groundwaters.

(e) Orlica.

**Table 36. Boč aquifer**

| **No. 8.1 Boč** [49] | | **Shared by: Slovenia and Croatia** |
|---|---|---|
| Type 4, Kenozoic carbonates – limestones and dolomites. Pressure condition: unconfined. | | **Black Sea Basin** |
| | | Border length (km): |
| | **Slovenia** | **Croatia** |
| Area ($km^2$) | 47.89 | |
| Altitude fluctuation (m) | 243 - 971 | |
| Number of inhabitants | 2,137 | |
| Population density (persons/$km^2$) | 44.62 | |
| Water uses and functions | Local drinking water supply | |
| Pressure factors | N/A | |
| Problems related to groundwater quantity | N/A | |
| Problems related to groundwater quality | N/A | |
| Transboundary impacts | N/A | |
| Groundwater management measures | N/A | |
| Trends and future prospects | N/A | |
| Notes | This transboundary aquifer has not been yet characterized in detail in accordance to the EU WFD | |

**Table 37. Rogaška aquifer**

| **No. 8.2 Rogaška**[50] | | **Shared by: Slovenia and Croatia** |
|---|---|---|
| Type 4, Kenozoic carbonates – silicates. Pressure condition: confined | | **Black Sea Basin** |
| | | Border length (km): |
| | **Slovenia** | **Croatia** |
| Area ($km^2$) | 178.45 | |
| Altitude fluctuation (m) | 192 - 940 | |
| Number of inhabitants | 21,368 | |
| Population density (persons/$km^2$) | 119.74 | |
| Water uses and functions | Local drinking water supply | |
| Pressure factors | N/A | |
| Problems related to groundwater quantity | N/A | |

[49] Based on information from Slovenia. Part of carbonate and sandy aquifers of Sotla/Sutla River shared by Slovenia and Croatia; Sotla/Sutla River is a tributary to Sava.
[50] Based on information from Slovenia. Part of carbonate and sandy aquifers of Sotla/Sutla River shared by Slovenia and Croatia; Sotla/Sutla River is a tributary to Sava.

| | | |
|---|---|---|
| Problems related to groundwater quality | N/A | |
| Transboundary impacts | N/A | |
| Groundwater management measures | N/A | |
| Trends and future prospects | N/A | |
| Notes | This transboundary aquifer has not been yet characterized in detail, in accordance to the EU WFD | |

### Table 38. Atomske toplice aquifer

| **No. 8.3 Atomske toplice**[51] | | **Shared by: Slovenia and Croatia** |
|---|---|---|
| Type 4, Mesozoic carbonate rocks. Fissured aquifers, including karst aquifers. Dominant groundwater flow from Croatia to Slovenia (Kuna Gora) and from Slovenia to Croatia (Rudnica). Pressure condition: partly confined, partly unconfined. Possibly recharged in the areas where carbonate rocks outcrop (Rudnica, Kuna gora) and discharged at the foothills where impermeable rocks intersect the flow. Low drainage to surface water systems. | | **Black Sea Basin**<br>Border length (km): |
| | **Slovenia** | **Croatia** |
| Area (km$^2$) | 51.22 | |
| Altitude fluctuation (m) | 190 - 678 | |
| Number of inhabitants | 2,384 | |
| Population density (persons/km$^2$) | 46.54 | |
| Water uses and functions | Local drinking water supply and thermal water abstractions | |
| Pressure factors | N/A | |
| Problems related to groundwater quantity | N/A | |
| Problems related to groundwater quality | N/A | |
| Transboundary impacts | N/A | |
| Groundwater management measures | N/A | |
| Trends and future prospects | N/A | |

[51] Based on information from Slovenia. Part of carbonate and sandy aquifers of Sotla/Sutla River shared by Slovenia and Croatia; Sotla/Sutla River is a tributary to Sava.

**Table 39. Bohor aquifer**

| **No. 8.4 Bohor**[52] | | **Shared by: Slovenia and Croatia** |
|---|---|---|
| Type 4, Mesozoic, dominantly Triassic, and Tertiary carbonate rocks of average >500 m thickness and maximum >1,000 m. Dominant groundwater flow from Slovenia to Croatia. Pressure condition: partly confined, partly unconfined. Weak links to surface water systems. Recharge takes place in the Kozjansko region in Slovenia, where carbonate rocks outcrop; aquifer discharges in river valleys in Slovenia and Croatia, where warm thermal water outflows from fissures in the anticline fold apex. | | **Black Sea Basin**<br>Border length (km): |
| | **Slovenia** | **Croatia** |
| Area ($km^2$) | 153.15 | |
| Altitude fluctuation (m) | 175 - 957 | |
| Number of inhabitants | 6,775 | |
| Population density (persons/$km^2$) | 44.24 | |
| Water uses and functions | Local drinking water supply | |
| Pressure factors | N/A | |
| Problems related to groundwater quantity | N/A | |
| Problems related to groundwater quality | N/A | |
| Transboundary impacts | N/A | |
| Groundwater management measures | N/A | |
| Trends and future prospects | The identification of the common transboundary water body should be carried out by the two countries. Possibilities for development and management of regional water source are to be discussed | |

**Table 40. Orlica aquifer**

| **No. 8.5 Orlica**[53] | **Shared by: Slovenia and Croatia** |
|---|---|
| Type 4, Mesozoic, dominantly Triassic, and Tertiary carbonate rocks of average thickness >500 m and maximum >1,000 m. Dominant groundwater flow from Slovenia to Croatia. Pressure condition: partly confined, partly unconfined. Weak links to surface water systems. Recharge takes place in the Orlica massif in Slovenia, where carbonate rocks outcrops; aquifer discharges in river valleys in Slovenia and Croatia, where warm thermal water outflows from fissures in the anticline fold apex. | **Black Sea Basin**<br>Border length (km): |

[52] Based on information from Slovenia. Part of carbonate and sandy aquifers of Sotla/Sutla River shared by Slovenia and Croatia; Sotla/Sutla River is a tributary to Sava.

[53] Based on information from Slovenia. Part of carbonate and sandy aquifers of Sotla/Sutla River shared by Slovenia and Croatia; Sotla/Sutla River is a tributary to Sava.

| | Slovenia | Croatia |
|---|---|---|
| Area (km$^2$) | 179.72 | |
| Altitude fluctuation (m) | 133 - 689 | |
| Number of inhabitants | 17,572 | |
| Population density (persons/km$^2$) | 97.77 | |
| Water uses and functions | Local drinking water supply | |
| Pressure factors | N/A | |
| Problems related to groundwater quantity | N/A | |
| Problems related to groundwater quality | N/A | |
| Transboundary impacts | N/A | |
| Groundwater management measures | N/A | |
| Trends and future prospects | The identification of the common transboundary water body should be carried out by the two countries. Possibilities for development and management of regional water source are to be discussed. | |

## Table 41. Srem-West Srem/Sava aquifer

| No. 15 Srem-West Srem/Sava [54] | | Shared by: Serbia and Croatia |
|---|---|---|
| Type 3, Sequence of Pliocene (Pontian, Paludine) and Eopleistocene sands, gravely sands and gravels of the Danube valley, of average thickness 80-150 m and up to 250-400 m, upper, shallow unconfined part has medium to strong links to surface water system, deeper parts confined or semi-confined by silts and clays, groundwater flow from Serbia to Croatia and also parallel to the river in a south and south-west direction within each country. Groundwater provides about 70% of total supply in the Serbian part | | Black Sea Basin<br>Border length (km): |
| | Serbia | Croatia |
| Area (km$^2$) | 627 | N/A |
| Altitude fluctuation (m) | N/A | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/km$^2$) | N/A | N/A |
| Water uses and functions | 50-75% drinking water, <25% each for irrigation, industry and livestock | Supports agriculture |
| Pressure factors | Groundwater abstraction, agriculture, industry | N/A |

[54] Based on information from Croatia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Directorate of Water, Serbia, University of Belgrade and Croatian Waters.

| | | |
|---|---|---|
| Problems related to groundwater quantity | Local and severe increased pumping lifts and reduction of borehole yields | N/A |
| Problems related to groundwater quality | Local, moderate nitrate and pesticides from irrigated agriculture, heavy metals, organics and hydrocarbons from industry, naturally occurring iron and manganese | Naturally occurring iron |
| Transboundary impacts | None for quantity or quality | N/A |
| Groundwater management measures | Existing quantity and quality monitoring need to be improved, as do abstraction control, protection zones and wastewater treatment, other management measures not yet used but needed | N/A |
| Trends and future prospects | Possible qualitative risk, no quantitative risk | N/A |
| Notes | | A transboundary aquifer probably exists, but no detailed research has been conducted hence, there is no data available |

## Table 42. Posavina I/Sava aquifer

| **No. 16 Posavina I/Sava**[55] | | **Shared by Bosnia and Herzegovina and Croatia** |
|---|---|---|
| According to Bosnia and Herzegovina: represents none of the illustrated transboundary aquifer types, Quaternary alluvial sands, gravels, clays and marls averaging about 100 m thick, weak to medium links to surface water systems.<br>According to Croatia: Type 3, Quaternary alluvial sands and gravels of thickness around 100 m in Croatia and 5-10 m in Bosnia and Herzegovina, medium links to surface water systems.<br>Groundwater flow generally from south to north from Bosnia and Herzegovina to Croatia. Groundwater is 100% of total water use in the part in Bosnia and Herzegovina. | | Black Sea Basin<br>Border length (km): 85 |
| | **Bosnia and Herzegovina** | **Croatia** |
| Area (km$^2$) | Not defined | 396 |
| Altitude fluctuation (m) | N/A | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/km$^2$) | N/A | N/A |

[55] Based on information from Bosnia and Herzegovina, Croatia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Directorate of Waters and Institute of Geological Research, Republic Srpska, Bosnia and Herzegovina and Croatian Waters.

| | | |
|---|---|---|
| Water uses and functions | Dominantly drinking water, smaller amounts (<25% each) for industry and livestock | Regional water supply system of eastern Slavonia |
| Pressure factors | Wastewater, industry and agriculture | Agriculture |
| Problems related to groundwater quantity | None | None |
| Problems related to groundwater quality | Naturally occurring iron at 1-4 mg/l in the upper aquifer (15 to 60 m) | Naturally-occurring iron and manganese |
| Transboundary impacts | None | No data |
| Groundwater management measures | Abstraction management, quantity and quality monitoring, protection zones and agricultural measures are used but need improvement, water use efficiency and wastewater treatment are needed or planned | Existing protection zones |
| Trends and future prospects | Common delineation of transboundary aquifer and development of monitoring programmes is needed | N/A |
| Notes | - In lower aquifer (depth 90 to 115 m), naturally-occurring iron is <0.7 mg/l<br>- There is no new relevant information since the first assessment about this transboundary aquifer | Transboundary aquifer under consideration, but not approved |

[Figure 7. Conceptual sketch of the Posavina I/Sava groundwater body (provided by Bosnia and Herzegovina; sketch is a result of exchange of unofficial data between Bosnia and Herzegovina, and Croatia)]

**Table 43. Kupa aquifer**

| **No. 17 Kupa** [56] | | **Shared by: Bosnia and Herzegovina and Croatia** |
|---|---|---|
| According to Bosnia and Herzegovina: represents none of the illustrated transboundary aquifer types, Triassic and Cretaceous karstic limestones and dolomites, groundwater flow generally from south to north. Strong links to surface water systems (associated with Kupa River).<br>According to Croatia: Type 2, Triassic and Cretaceous karstic limestones and dolomites, groundwater flow generally from east to west from Bosnia and Herzegovina to Croatia. Strong links to surface water systems (associated with Korana River). Groundwater is 20% of total water used in the Croatian part. | | Black Sea Basin<br>Border length (km): 130 |
| | **Bosnia and Herzegovina** | **Croatia** |

[56] Based on information from Bosnia and Herzegovina, Croatia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by Croatian Waters.

| | | |
|---|---|---|
| Area (km$^2$) | N/A | 100 |
| Altitude fluctuation (m) | N/A | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/km$^2$) | N/A | N/A |
| Water uses and functions | No data | Dominantly drinking water; also supports ecosystems |
| Pressure factors | No data | No data |
| Problems related to groundwater quantity | No data | No data |
| Problems related to groundwater quality | No data | No data |
| Transboundary impacts | N/A | N/A |
| Groundwater management measures | N/A | N/A |
| Trends and future prospects | Agreed delineation of possible transboundary groundwater is needed | Agreed delineation of transboundary groundwaters, and development of monitoring programmes are needed. Need to establish protection zones |
| Notes | Possible transboundary aquifer should be considered. There is no clear indication (based on field research) that this aquifer is transboundary | Transboundary aquifer under consideration, but not approved |

### Table 44. Pleševica/Una aquifer

| **No. 18 Pleševica/Una** [57] | | **Shared by: Bosnia and Herzegovina and Croatia** |
|---|---|---|
| According to Bosnia and Herzegovina: Type 2, Thick Mesozoic (dominantly Cretaceous), Neocene (dominantly Miocene) and Quaternary limestones and dolomites, of average thickness 1,000 m and maximum over 1,500 m, in hydraulic contact with overlying alluvial sediments, strong links with surface waters; flow from Croatia (swallow holes in Krbavsko, Lapačko and Koreničko fields and the area of National Park Plitvice) to Bosnia and Herzegovina (towards the strong karstic springs in the Una River watershed (Klokot I and II, Privilica, ostrovica, Žegar etc).<br>According to Croatia: represents none of the illustrated transboundary aquifer types, Thick Palaeozoic, Mesozoic and Cenozoic limestones and dolomites of average thickness 200 m and maximum 500 m, in hydraulic contact with overlying alluvial sediments, strong links with surface waters, flow from Croatia to Bosnia and Herzegovina. Groundwater is 25% of total water use in the Croatian part | | Black Sea Basin<br>Border length (km): 130 |
| | **Bosnia and Herzegovina** | **Croatia** |
| Area (km$^2$) | N/A | 1,564 |

[57] Based on information from Bosnia and Herzegovina, Croatia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Public Enterprise for the Sava Catchment Area, Bosnia and Herzegovina, and Croatian Waters.

| | | |
|---|---|---|
| Altitude fluctuation (m) | N/A | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/km$^2$) | N/A | N/A |
| Water uses and functions | >75% to support ecosystems and fishing, 25-50% of abstraction is used for drinking water supply | Dominantly drinking water supply; also supports ecosystems |
| Pressure factors | Wastewater from septic pits is the main pressure factor. PCBs from former military airport Željava and relay station in Plješevica mountain might be an issue of concern; more research is needed in this regard. Solid waste disposal is also a pressure factor | Communities |
| Problems related to groundwater quantity | Polluted water locally drawn into the aquifer | None |
| Problems related to groundwater quality | Local but severe nitrogen, heavy metals and pathogens | N/A |
| Transboundary impacts | Yes, for quality only | Sinkholes in Bosnia and Herzegovina with transboundary effects in Croatia |
| Groundwater management measures | Many used but need improving, others needed or currently planned | Protection zones exist at Klokot, Privilica, Toplica, Ostrovica and need to be established in Koreni_ki Izvor, Stipinovac and Mlinac |
| Trends and future prospects | Delineation of transboundary groundwaters needs common research and bilateral decision to propose a transboundary groundwater, if appropriate. Development of monitoring programmes is needed | |
| Notes | A number of dye tests were performed from 1970 to 1990; fictive velocity of tracer ranged from 1 to 15 cm/s | Transboundary aquifer under consideration, but not approved. |

**Table 45. Lim aquifer**

| **No. 29 Lim**[58] | | **Shared by: Montenegro and Serbia** |
|---|---|---|
| Type 1, Triassic karstic limestone and dolomite (main aquifer), covered by mostly impermeable diabase-chert formation, limited fissured aquifer in peridotites and in Triassic clastic rocks, Quaternary alluvium; average thickness of the carbonate rocks is 200 m and maximum 500 m, medium connection to surface water. Groundwater flow direction relatively equally shared in both countries; perpendicular to the Lim valley in the karstic aquifer, and parallel to the stream in the alluvium. Karstic-fissured part: Recharge in the mountains and drainage along the foothill or on local impermeable barriers; Porous part: Recharge from precipitation and rivers, drainage into rivers. The covering layer constitutes of thin soil layer in the mountain-hilly area and thick and fertile soil in the Lim valley. The depth of groundwater levels are at >100 m in karstic aquifers, and at 2-5 m in the alluvium. Pressure condition: unconfined. Predicted infiltration area: ~ 40 % in the carbonate and fissured rocks; in impermeable rocks runoff is prevailing; in the valley infiltration from precipitation is assumed to be 15-20%. Groundwater resources amount to ~ 35 × $10^6$ $m^3$/year (average for the years 1980 to 2000). Groundwater covers 40% of total water use in the Serbian part. | | **Black Sea Basin**<br>Border length (km): |
| | **Montenegro** | **Serbia** |
| Area ($km^2$) | | 600-800 (of which ~ 150 karstic aquifer) |
| Altitude fluctuation | | 400-1800 m a.s.l. |
| Number of inhabitants | | ~ 100,000 |
| Population density (persons/$km^2$) | | 5-50 |
| Water uses and functions | See table 46 below | See table 46 below |
| Pressure factors | Waste disposal, agriculture and industry | Untreated urban wastewater, inappropriate waste disposal, industry (illegal discharges of untreated wastewater may pose a threat to the groundwater quality - this has to be evaluated) and rather intensive mining |
| Problems related to groundwater quantity | None reported | None reported |
| Problems related to groundwater quality | Pollutants from industry | Local but severe nitrogen, heavy metals, pathogens, industrial organic and hydrocarbons pollution of surface water and groundwater is possible |
| Transboundary impacts | | Pollution of Lim River occurring at the upper catchment area has impacts at transboundary level |

[58] Based on information from Serbia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Directorate of Water, Serbia and the Department of Hydrogeology, University of Belgrade.

| | | |
|---|---|---|
| Groundwater management measures | Abstraction management, protection zones and vulnerability mapping for land use planning need to be applied, together with monitoring of groundwater quantity and quality | Abstraction management and protection zones already in use need to be improved; other measures are also needed. Adequate precautionary measures to minimize impacts from small industry and tourism development are needed. Having in mind the special characteristics of karstic aquifers, protection measures are necessary to avoid any possible deterioration of the quality of groundwater nearby and along the border area between Serbia and Montenegro (in the remote and non-populated mountain zone - neither heavily polluted nor the pollution threats are significant). |
| Trends and future prospects | | Current status is most probably good (according to limited data). Quality of groundwater in alluvium and terrace deposits along Lim River valley and downstream in Prijepolje plain is under risk (due to the aforementioned pressure factors as well as due to the polluted surface waters). Water reserves are estimated to be sufficient to sustain medium and long term projected development in the area - nevertheless, possible longer dry episodes as a consequence of climate change, may have a negative impact on the recharge of the karstic aquifer hence, to the volume of water resources available in the area. Great potential for hydropower development; 6 hydropower plants with total capacity of more than 50 MW are planned to be constructed at the Lim valley (an environmental impact assessment will be prepared prior to their construction). Systematic joint monitoring at transboundary level, that will assist to assess the qualitative and quantitative status of the surface and groundwater resources as well as in management planning, should be established along the Lim valley. Common efforts towards environmental protection should be crystallized in a joint strategy. |

**Table 46. Mean annual total renewable water resources in the Lim aquifer, annual total withdrawals and withdrawal by sector**

| | | Mean annual total renewable water resources | Total withdrawal | Agri-culture | Domes-tic water supply | Industry | Energy | Other |
|---|---|---|---|---|---|---|---|---|
| **Montenegro** | | | | <25% | | | | |
| **Serbia** | 2007 | $25 \times 10^6$ $m^3$/year | ~$10 \times 10^6$ $m^3$/year | 12 % | 60 % | 12 % | 10 % | 6 % |
| | Prospects for 2025 | - | $12 \times 10^6$ $m^3$/year | 15 % | 50 % | 15 % | 15 % | 5 % |

**Table 47. Land cover/use in the Lim aquifer area (% of the part of the basin extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Montenegro** | | | | | | | |
| **Serbia** | * | 35 | 20 | 35 | 10 | ** | |

* Priboj Lake is an artificial reservoir near the border area.
** There are two zones planned to be declared as" Landscape of particular importance": Ozren – Jadovnik and Kamena gora. Few others "geo-heritage" sites are nearby.

| **No. 30 Tara Massif** [59] | | **Shared by: Serbia and Bosnia and Herzegovina** |
|---|---|---|
| Type 3, Triassic and Jurassic karstified limestones of 250-300 m average thickness and maximum 600 m, strong links to surface water systems, groundwater flow from Serbia to Bosnia and Herzegovina (generally perpendicular to Drina River). The recharge area is estimated at 75-80 $km^2$, while the discharge area is punctually located and present as major karst springs (Perucac spring, and one submerged spring in artificial reservoir of Bajina Basta reversible hydropower plant). Carbonate rocks are covered with a thin layer of skeletoidal soil with relatively high content of humus. Depth of groundwater levels varies from 100 to over 300 m. Pressure condition: Unconfined. According to Serbia groundwater resources of Tara Massif amount to $4.47 \times 10^7$ $m^3$/year. Groundwater covers 10% of the water being used in the Serbian part | | **Black Sea Basin**<br>Border length (km): 117 (?) |
| | **Serbia** | **Bosnia and Herzegovina** |
| Area ($km^2$) | 211 | >100 |
| Altitude fluctuation | 800 - 1,540 m a.s.l. | |

[59] Based on information from Serbia and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Directorate of Water, Serbia, the Department of Hydrogeology, University of Belgrade, the Directorate of Water and Institute of Geological Research, Republic Srpska, Bosnia and Herzegovina, and the Public Enterprise for the Black Sea Basin.

| | | |
|---|---|---|
| Number of inhabitants | N/A | |
| Population density (persons/km$^2$) | 1-5 | |
| Water uses and functions | 80% of groundwater for drinking purposes, 10% is for irrigated agriculture; also supports fish breeding and ecosystems. Total water withdrawals were $6 \times 10^6$ m$^3$/year in 2008 (not taking into account water used for hydropower generation; the figure corresponding to total water withdrawals is $1.15 \times 10^9$ m$^3$/year) | Drinking water, mostly small amounts for supplying villages |
| Pressure factors | Hydropower (Bajina Basta reversible hydropower plant system - including two reservoirs located at the top of the Tara plateau); intensive tourism activities at zones that are highly vulnerable to pollution; lack of sewage collection and treatment facilities (apart from a small wastewater facility treating wastewater in a touristic area); partially uncontrolled dumpsites | Wastewater, mining activity |
| Problems related to groundwater quantity | Moderate to strong environmental impacts (related to the Bajina Basta reversible hydropower plant system) | Local moderate drawing of polluted water into the aquifer |
| Problems related to groundwater quality | Issues related to intensive tourism activities at zones that are highly vulnerable to pollution; continuous bacterial pollution due to leakage of septic tanks; potential pollution for an extended period of time due to uncontrolled dumpsites; accidental pollution has occurred as a result of the existence of an important regional road with moderate traffic | Bacteriological contamination |
| Transboundary impacts | None reported | None for quantity or quality |
| Groundwater management measures | Groundwater abstraction management and quantity monitoring in use needs improvement. Assessment of the vulnerability of karst groundwater is necessary as a basic tool for groundwater protection and development planning in an area that is almost entirely a National Park; establishment of an integrated monitoring system is essential in this regard | Protection zones needed for some significant but as yet unused karst springs |

| | | |
|---|---|---|
| Trends and future prospects | Estimated reserves of groundwater can sustain drinking water supply and further economic development, particularly with regard to fish breeding, tourism and some minor hydropower generation | |
| Notes | Controlled quarrying in the area has relatively negative impacts | |
| | Negligible conditions for nomination as a transboundary groundwater | |

### Table 48. Land cover/use in the area of the Tara aquifer (% of the part of the basin extending in each country)

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Serbia** | | 80 | < 5 | 15 | < 5 | * | |
| **Bosnia and Herzegovina** | | | | | | | |

* National Park Tara covers 192 km² or 91% of the area.

### Table 49. Macva-Semberija aquifer

| **No. 31 Macva-Semberija**[60] | | **Shared by: Serbia and Bosnia and Herzegovina** |
|---|---|---|
| Alluvial aquifer: Type 3, Quaternary alluvial gravels, sandy gravels, sands, with clayey lenses, of 35-60 m average thickness and maximum 75-100 m. There is no transboundary flow. Drina river is a hydraulic boundary (and country border) dividing the body into two separate aquifers. In Semberija (Bosnia and Herzegovina) groundwater flow is from south to north (towards Sava River). The Semberija alluvium aquifer is mainly recharged by the Drina River.<br>Thermo-mineral aquifer: Type 4, Mesozoic limestones with maximum thickness of more than 1,000 m.<br>Strong links to surface water systems. Groundwater is 40-60% of total water use in the Serbian part, and 100% in the part in Bosnia and Herzegovina | | Black Sea basin<br>Border length (km): 87? |
| | **Serbia** | **Bosnia and Herzegovina** |
| Area (km²) | 967 | 250 |
| Altitude fluctuation (m) | N/A | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/km²) | N/A | N/A |

[60] Based on information from Bosnia and Herzegovina and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Directorate of Water, Serbia, the Department of Hydrogeology, University of Belgrade, and the Directorate of Waters and Institute of Geological Research, Republic Srpska, Bosnia and Herzegovina.

| | | |
|---|---|---|
| Water uses and functions | 50-75% drinking water, <25% for irrigation, industry and livestock, and support of ecosystems | Drinking water, irrigation, industry and livestock |
| Pressure factors | Agriculture and waste water, some industry | Agriculture and waste water |
| Problems related to groundwater quantity | Local and moderate increase in pumping lifts, no declines in groundwater levels | Local and moderate increase in pumping lifts, no significant declines in groundwater levels |
| Problems related to groundwater quality | Local and moderate nitrogen and pesticides from agriculture, local and moderate heavy metals and organics from industry, natural Fe and Mn in alluvium | Local and moderate nitrogen and pesticides from agriculture |
| Transboundary impacts | None for quantity or quality | None |
| Groundwater management measures | Abstraction control, monitoring of groundwater, protection zones and wastewater treatment need improvement, other management measures need to be introduced or are currently planned | Groundwater abstraction regulation and quantity monitoring, protection zones, and good agricultural practices used and effective, water use efficiency, public awareness, wastewater treatment need to be applied |
| Trends and future prospects | Possibly at chemical risk, not at quantitative risk | Research regarding the exploitation of the thermo-mineral aquifer has been conducted for the last two years. There are significant possibilities for the groundwater to be used for energy production and agriculture; more intensive cooperation between Bosnia and Herzegovina and Serbia regarding the equitable and sustainable utilisation of this aquifer is needed. Agreed delineation of transboundary groundwater, and development of monitoring programmes are needed. |
| Notes | Drina River forms the boundary, within the Sava river basin. Information refers to the alluvial aquifer | |

[Figure 8. Conceptual sketch of the Macva-Semberija aquifer (provided by Bosnia and Herzegovina).]

*Pressures*[61]

54. Hydropower generation, agriculture and industry are the main economic sectors, sharing the major part of the available water resources in the basin. The construction of water regulation structures and weirs at its tributaries- drainage networks, and flood protection systems, in combination with water abstractions have caused hydrological and morphological alterations,

[61] Information about the status, pressures and impacts for the shared aquifers is given in the tables above.

including disconnection of adjacent wetland/floodplains. Interruption of river and habitat continuity and loss of wetland areas in the lower-middle and lower Sava areas are among the impacts. Erosion is an issue of local character reported by Croatia.

**Table 53. Major reservoirs in the Sava River basin (capacity over 50 Mm$^3$)**

| Category (capacity range) Mm$^3$ | Country | Location | | Reservoir | | | Dam height m |
|---|---|---|---|---|---|---|---|
| | | River Basin | River | Name | Volume Mm$^3$ | Purpose* | |
| 50-100 | BA | Vrbas | Vrbas | Bočac | 52.7 | EP | 52 |
| | BA | Sava | Spreca | Modrac | 88 | IW,DW,FP,EP | 28 |
| | RS | Drina | Drina | Zvornik | 89 | EP | 42 |
| 100-200 | BA | Drina | Drina | Višegrad | 161 | EP | 48.16 |
| | RS | Drina | Beli Rzav | Lazici | 170 | EP | 131 |
| 200-500 | RS | Kolubara | Jablanica | Rovni | 270 | DW,IR | 12 |
| | RS | Drina | Uvac | Kokin Brod | 273 | EP | 82 |
| | RS | Drina | Drina | Bajina Basta | 340 | EP | 90 |
| >500 | ME | Drina | Piva | Mratinje | 880 | EP, FP | 220 |

* Legend for the purpose: IR – irrigation, DR – drainage, DW - drinking water supply, IW - industrial water supply, R – recreation, EP - electricity production, FP - flood production

55. Organic, nutrient and hazardous substances pollution are also important pressure factors. Untreated municipal and industrial wastewater and agricultural runoff are the main pollution sources. Unsustainable disposal of wastes (including these from mining activities) is also of concern in this regard. Sediment management, both in terms of quality and quantity, is an additional issue. Invasive species is a potential threat to the biological diversity.

*Status and transboundary impact*

56. The risk assessment[62] carried out by the ISRBC for the Sava and its tributaries for impacts, except from hazardous substances pollution, from organic, nutrient and other pollution as well as by hydro-morphological alterations has shown that the risk is rather high for the Sava – 83% of the water body is at risk while the 10% is possibly at risk. With regard to its tributaries, 33% are at risk.

*Response measures*

57. Addressing the identified issues will need time and the investment of considerable resources at national level. A step to address the issue of hazardous substance pollution will be made by the establishment of a cadastre of industrial emissions of dangerous and harmful substances. Action at national level and adoption of appropriate management approaches and instruments is necessary for addressing the aforementioned issues. The necessary cooperation to deal in an integrated way with the range of managerial challenges in the Sava River Basin is conducted through the International Sava River Basin Commission (ISRBC) established under the Framework Agreement on the Sava River Basin (FASRB).

[62] The risk assessment took into consideration data available from Croatia, Serbia and Slovenia.

58. The FASRB was signed by Bosnia and Herzegovina, Federal Republic of Yugoslavia[63], Republic of Croatia and Republic of Slovenia in 2002, and entered into force in 2004. The FASRB integrated all aspects of the water resources management and became the framework of cooperation among the signatory parties over Sava River Basin. The four parties to the FASRB financially support, on an equal basis, the operation and the work under the ISRBC and its Secretariat. Costs of activities that fall under the interest of a certain country(ies) may be financed by them. Additional resources for specific activities under the work-programme have been raised by the ISRBC Secretariat from the European Commission and the international donor community.

59. Having the Secretariat as its administrative and executive body, the ISRBC has worked for the achievement of the goals of the Agreement. In this regard a set of activities for the rehabilitation of the Sava river waterway and the development of navigation, that is a priority issue, have been implemented and relevant work is on-going. While navigation is important for the economic development in the basin, the interventions in the watercourse for rehabilitation of navigation and the construction of related hydro-engineering structures may become additional pressure factors. ISRBC is cooperating with joint management bodies of international watercourses elsewhere in Europe with the aim to use available experience and develop appropriate action for the minimization of impacts.

60. The process for the preparation of a River Basin Management Plan (RBMP - in accordance with the EU WFD) has been initiated; the Sava River Basin Analysis Report being a first step towards this direction was concluded. The Analysis deals with all main surface and underground water bodies; it looks at the hydrological and morphological characteristics, it assesses the quantitative and qualitative status of waters and deals also with monitoring and economic issues. A Programme of Measures (to be developed by 2010) would be the step following the preparation of the RBMP. The Analysis provides the basic information background also for the preparation of the Sava River Basin Flood Risk Management Plan (in accordance with the EU Flood Directive).

61. A number of integrated information systems, the Geographical Information System, the River Information Services (for the improvement of navigation safety) and the Flood Forecasting and Early Warning Sytem are planned to be prepared by 2012 (according to the Strategy of implementation of the FASRB). The Accident Emergency Warning System is in place; enhancement of the capacities of the countries is needed before the latter becomes fully operational.

62. With regard to monitoring, there are 90 quality and 148 quantity monitoring stations in total operating in the signatory parties of the FASRB. Bilateral agreements regarding exchange of information/data exist between some countries. Agreement of all countries on the provision of the most relevant data is eventually aimed at. There are also twelve Trans-national Monitoring Network stations (in the framework of ICPDR) operating in the Sava River Basin.[64] Individual countries are responsible for different stations. In addition to monitoring the riparian countries

[63] Republic of Serbia is the successor country after the dissolution of the State Union of Serbia and Montenegro that succeeded the Federal Republic of Yugoslavia.
[64] Nine of them on Sava and three on Sava main tributaries.

are planning and implementing water resources management measures at national level in line with the national legal framework and strategic planning documents and with varied success.

63. A project linked to climate change adaptation (being executed by the World Bank) will, among others, provide input for the planning of appropriate adaptation measures to be incorporated in the Programme of Measures; the aim is to address issues linked to the impacts of climate change in the basin.

64. Cooperation among the parties to the FARSB through the ISRBC represents the most advanced effort of its kind in the South-Eastern Europe showing the way to the riparian countries of other shared basins. The participation of Montenegro in this will be an additional step towards the integrated management of the basin. Montenegro has already been approached in this regard by the ISRBC.

## V. NISAVA RIVER BASIN[65]

**Table 54. Basin of the Nisava River**

| Area | Country | Country's share | | Number of inhabitants | Population density (persons/km$^2$) |
|---|---|---|---|---|---|
| 4,163.1 km$^2$ | Bulgaria | 1,151.3 km$^2$ | 27.7% | 13,970* <br> ~3,500** | 20* <br> 8** |
| | Serbia | 3,010 km$^2$ | 72.3% | 300,000 | 100 persons/km$^2$ |

* Nisava sub-basin
** Erma sub-basin

65. The basin of the Nisava River is shared by Bulgaria and Serbia. The Nisava River has its source at the southern side of the Stara Planina Mountain in Bulgaria and flows in the Juzna Morava River near the city of Nis in Serbia. The Nisava basin is part of the Velika Morava River basin, a right-bank tributary of the Danube River.

66. Major transboundary tributaries include the Visočica[66], Gaberska[67] and Jerma/Erma[68] Rivers.

67. The basin is characterized by a diverse relief. The highest altitude is 2,169 m a.s.l. while the lowest one is 173 m a.s.l.; the average elevation is 700-800 m a.s.l. In terms of geology, the basin is dominated by karstic formations of the Karpato–Balcanides region.

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[65] Based on information from Bulgaria and Serbia. Bulgaria and Serbia reported that parts of the Stara Planina / Salasha Montana aquifer are hydraulically linked to the surface water system of the Nisava and Timok Rivers Basins – see respective part of the assessment for additional information.
[66] The sub-basin covers 441 km$^2$, 25 % of which is in Bulgaria.
[67] The sub-basin covers 258 km$^2$, 77% of which is in Bulgaria.
[68] Called Jerma in Serbia and Erma in Bulgaria. The sub-basin covers 800 km$^2$, 55% of which is in Bulgaria.

*Hydrology*

**Table 55. Discharge characteristics for the Nisava River at different gauging stations in Serbia**

| Gauging station Dimitrovgrad* | | |
|---|---|---|
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 1.97 $m^3/s$ | 1946–1991 |
| $Q_{max,1\%}$ | 257 $m^3/s$ | 1946–1991 |
| $Q_{min}$ | 0.37 $m^3/s$ | 1946–1991 |
| **Gauging station Nis**** | | |
| **Discharge characteristics** | **Discharge** | **Period of time or date** |
| $Q_{av}$ | 30.66 $m^3/s$ | 1946–1991 |
| $Q_{max,1\%}$ | 988 $m^3/s$ | 1946–1991 |
| $Q_{min}$ | N/A | N/A |

* 142 km from the mouth of the river; near the border with Bulgaria.
** 21.8 km from the mouth of the river

68. There is high risk of floods and droughts in the Serbian part due to the basin's geomorphologic and hydrological characteristics.

69. Serbia reports that the flow of the river has decreased by ~0.42 $m^3/s$ (average value) after the diversion of the Nisava River, in Bulgaria, towards the Brzija River in 1953.

*Pressures*

70. The Serbian part is dominated by forestland. Areas under protection status include the Sicevacka gorge and Stara Planina - Vidlič Mounting Nature Park in Serbia and NATURA 2000 sites in Bulgaria.

**Table 56. Land cover/use (% of the part of the basin extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Bulgaria** | | | | | | | |
| **Serbia** | | 83 | 15 | 1 | 1 | | |

71. Hydromorphological changes in the Nisava River in Serbia include bank reinforcement, and hydrotechnical structures for flood protection in the areas of major settlements (Nis, Pirot, Dimitrovgrad); the pressure was reported as of minor importance for the basin. The Pirot hydropower plant (capacity 80 MW) and the Zavoj reservoir (capacity 180,000,000 $m^3$) have been brought into use in 1990 on the Visočica River.

72. The major pressure in the Serbian part stems from the lack of wastewater treatment plants. The most significant sources of pollution are the cities of Nis (emission level higher than

150,000 p.e.) and Pirot (emission level higher than 100,000 p.e.). Management of solid waste is an issue of concern. Pressures in Bulgaria derive from coal mining effluent disposal in the surface water. Such effluents have high concentration of suspended solids and of iron.

*Transboundary cooperation*

73. As far as bilateral cooperation is concerned, an agreement was signed between Yugoslavia and Bulgaria in 1958. A new modern bilateral agreement on the management of transboundary waters shared by Serbia and Bulgaria appears to be needed (see also the assessment of the Timok River basin).

## A. STARA PLANINA/SALASHA MONTANA AQUIFER[69]

**Table 57. Stara Planina/Salasha Montana aquifer**

| **No. 34 Stara Planina/Salasha Montana** | | **Shared by: Serbia and Bulgaria** |
|---|---|---|
| Type 2, Triassic and Cretaceous karstic limestones with some overlying Quaternary alluvium, average thickness 100 – 200 m and maximum 400 m, medium links to surface water systems, groundwater flow from north east to south west, from Bulgaria to Serbia | | **Black Sea Basin**<br>Border length (km): - |
| | **Serbia** | **Bulgaria** |
| Area ($km^2$) | | |
| Number of inhabitants | 11,000 | |
| Population density (persons/$km^2$) | 18 | |
| | The Salasha Montana and Nisava karst basins are part of the West Balkan Nature Park which may become an agreed transboundary park | |

74. The information regarding Serbia included here concerns the part of the aquifer system that is hydraulically linked with the surface waters of both the Nisava River Basin (in the South; shared by Bulgaria and Serbia) and the Timok River Basin (in the North); this is further divided in four groundwater bodies (its characteristics and uses are given in the table below, table no. 58).

[69]Based on information provided by Bulgaria and Serbia. Bulgaria reports that:
- “Karst waters in West Balkan Karst Basin” is hydraulically linked with the surface water systems of Timok River Basin (shared by Bulgaria and Serbia); there is no available information with regard to the hydraulic connection of this body with Nisava River basin.
- “Karst waters in Godech massif” is hydraulically linked with the surface water systems of Nisava River Basin
- “Fissured waters in Volcanogenic- sedimentary formation” is hydraulically linked with the surface water systems of Timok River Basin; there is no information available with regard to the hydraulic connection of this body with the Nisava River basin.

The three above-mentioned groundwater bodies are part of the Stara Planina/Salasha Montana aquifer system. The Vidlic/Nishava, which in the first Assessment was reported as a part of the Stara Planina/Salasha Montana aquifer system, is actually a separate transboundary aquifer, in the Nisava River Basin.

**Table 58. Characteristics and uses of groundwater bodies in the part of Stara Planina/Salasha Montana in the territory of Serbia.**

| Groundwater body / National identification code | Karst waters in Nisava Basin / RS_NI_GW_K1 | Karst waters in Nisava Basin / RS_NI_GW_K2 | Fissured waters in Nisava Basin / RS_NI_GW_P1 | Fissured waters in Timok Basin / RS_BTIM_GW_P 4 |
|---|---|---|---|---|
| **Area (km$^2$)** | 285 | 337 | 110 | 456 |
| **Type** | Karst | Karst | Fissured | Fissured |
| **Predominant lithology / lithologies** | Limestones, dolomitic and sandy limestones | Karstic limestones dolomitic limestones | Conglomerates, quartz sandstones | Magmatic – metamorphic complex |
| **Stratigraphy and age** | Jurassic and Cretaceous karstic limestones | Triassic and Jurassic karstic limestones | Cambrian, Permian and lower Triassic deposits | Mesozoic and Paleozoic |
| **Thickness** | average:150 m; max: 400 m | 100 m - 500 m | 100 m – 500 m | 600 m -900 m |
| **Covering layer** | Soil | Soil | Soil | Soil, loess |

75. Bulgaria reported that there are four groundwater bodies in the area which are not hydraulically connected hence do not form one aquifer system (identified in accordance with the EU WFD); its characteristics and uses are given in the table below (table no. 59).

**Table 59. Characteristics and uses of groundwater bodies in the part of Stara Planina/Salasha Montana in the territory of Bulgaria.**

| Groundwater body / National identification code | Karst waters in West Balkan Karst Basin / BG1G0000TJK044 | Karst waters in Godech massif / BG1G00000TJ046 | Fissured waters in Volcanogenic-sedimentary formation / BG1G00000K2038 | Porous groundwater in alluvial quaternary of Bregovo – Novo selo low land / BG1G0000Qal001 |
|---|---|---|---|---|
| **Area (km$^2$)** | 3,339 | 1,836 | 2,109 | 137 |
| **Type** | Karst | Karst | Fissured | Porous |
| **Predominant lithology / lithologies** | Limestones, marl limestones, clayey limestones and marble | Karstic limestones and dolomites | Magmatic and volcanogenic rocks, sediments | Sands, clayey sands, pebbles |
| **Stratigraphy and age** | Triassic and Jurassic karstic limestones | Triassic and Jurassic karstic limestones | Triassic and Jurassic karstic limestones | Quaternary |
| **Thickness** | average:150 m; max: 300 m | max: 600 m | max: 200 m | average: 13 m |
| **Covering layer** | Soil | Fissured sediments | Soil | Soil, loess |
| **Pressure condition** | Unconfined | Unconfined | Unconfined | Unconfined |

| | | | | |
|---|---|---|---|---|
| **Water flow ($x10^3$ $m^3$/year)** | 298,646 | 92,400 | 13,245 | 17,345 |
| **Total withdrawal ($x10^3$ $m^3$/year)** | 8,862 | 7,511 | 2,729 | 2,460 |
| **Uses and functions** | 80-90% of groundwater is used for drinking purposes and industry | | 29 % of groundwater is used for drinking purposes | |
| **Trends and future prospects** | In good condition; no additional management measures are needed. | | | |

76. In Serbia the area is sparsely populated. More than half is covered by forests; crop production is the second most important land use.

**Table 60. Land cover/use (% of the part of the aquifer extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Bulgaria** | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **Serbia** | 0.84 | 52.92 | 22.83 | 22.41 | 0.37 | | 0.63 (bare rocks) |

77. Groundwater covers 50% of the water being used in the Serbian part. While 25-50% of groundwater is used for drinking purposes, less than 25% is used for irrigation, industry, thermal spa and livestock. Groundwater also supports ecosystems.

78. Water abstraction is not a significant pressure factor in Serbia. Wastewater is collected and treated in the largest settlement (Dimitrovgrad) while in rural areas mainly septic tanks are being used. Communal waste disposal and agriculture activities may put, locally, groundwater quality at a risk. Moderate nitrogen and pathogen pollution observed may have an effect on groundwater quality; the concern is bigger in areas where groundwater is used for drinking purposes.

79. The construction of a regional waste disposal site in the town of Pirot (commenced in 2008), which would also serve the town of Dimitrovgrad, should be followed by the termination of operation and sanitation of local dump sites, to minimize risks for groundwater quality. There is a need for the establishment of systematic quantity and quality monitoring.

80. According to Serbia, no intensive bilateral cooperation is needed for the management of the transboundary aquifer.

## B. VIDLIC/NISHAVA AQUIFER[70]

**Table 61. Vidlic/Nishava aquifer**

<table>
<tr><td colspan="2">No. 59 Vidlic/Nishava</td><td>Shared by: Serbia and Bulgaria</td></tr>
<tr><td colspan="2" rowspan="2">Lower Cretaceous, karstified dolomite/limestone, average thickness 200 m and maximum 400 m, groundwater flow from north-east to south-west</td><td>Black Sea Basin</td></tr>
<tr><td>Border length (km):</td></tr>
<tr><td></td><td>Serbia</td><td>Bulgaria</td></tr>
<tr><td>Area (km$^2$)</td><td>285</td><td></td></tr>
<tr><td>Number of inhabitants</td><td>N/A</td><td></td></tr>
<tr><td>Population density (persons/km$^2$)</td><td>N/A</td><td></td></tr>
<tr><td>Water uses and functions</td><td>Drinking water supply (50-75%); abstractions for industry and livestock both make up less than 25%. Also support ecosystems</td><td></td></tr>
</table>

[Figure 10 Conceptual sketch of the Vidlic/Nishava aquifer (provided by Serbia)]

81. In Serbia pathogens is a concern to groundwater quality, local but severe in nature, originating from farming. No transboundary impacts have been observed in Serbia.

82. Serbia indicated the need for a number of groundwater management measures, namely the following: transboundary institutions, groundwater abstraction management by regulation, monitoring of both groundwater quantity and quality, exchange of data, establishment of protection zones for public water supplies, good agricultural practices as well as treatment or urban wastewater and industrial effluents. Furthermore, groundwater needs to be integrated into river basin management.

# VI. TIMOK RIVER BASIN[71]

**Table 62. Basin of the Timok River**

| Area | Country | Country's share | | Number of inhabitants | Population density |
|---|---|---|---|---|---|
| 4,739.5 km$^2$ | Serbia | 4,607 | 97.2 % | 200,000 | 43.4 |
| | Bulgaria | 132.5 | 2.8 % | 5,703 | 43 |

[70] Based on information from Serbia only, provided for the first Assessment, where Vidlic aquifer was erroneously referred to as part of the Stara Planina/Salasha Montana system.
[71] - Based on information from Bulgaria, Serbia and the "Environmental and Risk Assessment of the Timok River basin" report elaborated by Ventzislav Vassilev, Svetoslav Cheshmedjiev, Momir Paunović and Vladica Simić in the framework of the ENVSEC Timok project, implemented by REC and UNECE. Bulgaria and Serbia reported that parts of the Stara Planina / Salasha Montana aquifer are hydraulically linked to the surface water system of the Timok and the Nisava Rivers Basins – see respective part of the assessment for additional information.

83. The Timok River basin is shared by Serbia and Bulgaria. The river starts at the confluence of the Beli Timok and the Crni Timok (in Serbia) near the city of Zajecar; its total length is 180 km. At a distance of 17.5 km before it empties into the Danube, the Timok forms the border between the two countries, passing next to the Bulgarian town of Bregovo. The basin is characterized by a diverse relief including mountains, valleys, depressions and narrow passages. The highest altitude is 2,070 m a.s.l.; the average elevation is 472 m.

*Hydrology*

**Table 63. Discharge characteristics of the Timok River at the gauging station Tamnic* (Serbia)**

| Discharge characteristics | Discharge | Period of time or date |
|---|---|---|
| $Q_{av}$ | 31 $m^3/s$ | 1950 - 1980 |
| $Q_{max,1\%}$ | 1,050 $m^3/s$ | 1950 - 1980 |
| $Q_{min}$ | 2.2 $m^3/s$ | 1950 - 1980 |

*58.89 m a.s.l; distance from river mouth 38.4 km; discharge area covering: 4,191 $km^2$.

84. The mean value for discharge was 31 $m^3/s$ for the period 1950 -1980; the average water flow for the same period was 980,294.4 × $10^3$ $m^3$/year.

*Pressures and transboundary impacts*

**Table 64. Land cover/use (% of the part of the basin extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Serbia** | | ~30 | 45-60 | 24 | ~10 | | |
| **Bulgaria** | | ~ 15.46 | ~ 71.97 | ~ 2.36 | ~3.96* | ** | |

* The extend of the industrial areas is unknown.
** There are areas designated as Natura 2000 sites.

85. Copper and gold mining activities in Serbia, especially in the Bor area, are the major pressure factor and it is of transboundary importance. Unsustainable operation, storage practices, effluent and waste management have resulted in severe pollution of the surface water and groundwater. Pressure stems from: (i) air pollutants from the smelters, and dust e.g. from the tailings; (ii) storm water infiltration into the ground and leakage from the underground pipeline connecting Cerovo open pit to Bor; (iii) past and current waste dumping; (iv) past and current illegal discharges of effluents, drainage waters and, wastewaters from the smelting complex (electrolyte solutions etc.) into surface waters.

86. Heavy metals (Cu, As, Zn, Fe and Ni) were detected on the generated effluents in the Bor area in 2005, in concentrations above limits set in Serbia; the pH was found to be highly acidic.

87. The Crni Timok (“Black Timok”) River with its tributaries drain the highly polluted area of Bor. Contamination of the Borska River is clearly visible between Bor and Slatina. Accidental incidents that took place in the past at the Bor tailings pond have had as an outcome the deposition of tailings at the riverbanks. An accidental pollution incident had resulted in severe

contamination of over 40 $km^2$ of the most fertile agricultural land at the banks of Borska and Timok Rivers in Serbia and in Bulgaria (4.5 $km^2$) with heavy metals and other toxic substances. Old plans for the re-cultivation of the contaminated soils have not been realized yet due to financial constraints.

88. The water of Borska River is still acidic and contains elevated levels of suspended solids and copper concentrations as far as 10 km from the metallurgical complex. The Kriveljska stream south of the Veliki Krivelj mine and tailings ponds is also acidic and contains high levels of suspended solids, iron, copper and zinc. Pollutants have been accumulated in the rivers' sediments.

89. Untreated urban wastewater is also a major source of pollution in both countries and results in impacts on the water-related ecosystems.

90. Human health is at risk due to the bioaccumulation of heavy metals in the fish species that are fished and eaten.

*Responses*

91. In Bulgaria the implementation of the EU WFD is on-going. Water resources are still not managed at the scale of the river basin in Serbia. A new water law in accordance to the EU legislation is expected to be adopted soon; it is part of the overall effort of Serbia to enhance natural resources management framework also in accordance with the EU standards.

92. Reduction of pollution from the mining industry is a priority for Serbia. The privatization process of the mining sector in the area will continue, with the assistance of the World Bank.

93. Reduction of pollution caused by urban wastewater discharges is also a priority; the construction of sewage networks and wastewater treatment plants is necessary in both countries.

94. Sustainable use and management of groundwater is another important future task.

95. Two agreements were signed in 1954 and 1961 concerning issues linked with the position of the riverbed of Timok hence, the border between the two countries. An agreement was signed between Yugoslavia and Bulgaria under which a Mixed Commission was established. Quality and allocation of transboundary waters were the main issues discussed. The last meeting of the Commission took place in 1982; activities stopped ever after (see Annex III of document ECE/MP.WAT/2009/8.

96. A project led by the Regional Environmental Center for Central and Eastern Europe (REC), in cooperation with UNECE, under the ENVSEC initiative, has resulted in (i) publishing of the Environment and Risk Assessment of the Timok River Basin, prepared by Serbian and Bulgarian experts and (ii) establishing the Timok River Forum, a multistakeholder platform to facilitate transboundary cooperation, in particular at the local level.

97. There is also an on-going cooperation between the two countries in the framework of the Convention for the Protection of the Danube River.

*Trends*

98. The situation in the Timok River basin calls for joint action; the two riparian countries should initiate a realistic dialogue to define the priority and long term objectives and actions taking into account the economic development prospects in the area and the need to reduce or even eliminate the risks to the environment and human health in the long term.

99. Management of environmental and technological risks and natural disasters is one of the priorities of an eventually enhanced cooperation and so is reduction of pollution from industry and urban waste water as well as from agriculture (through the introduction of agricultural good practices). Cooperation for the restoration of polluted and degraded lands is needed.

100. Both countries reported that the on-going discussions about the Timok River should result in the preparation and conclusion of an agreement on the management of transboundary water courses.

## VII. TRANSBOUNDARY AQUIFERS WHICH ARE NOT CONNECTED TO SURFACE WATERS ASSESSED IN THE SEE ASSESSMENT (OR INFORMATION CONFIRMING A CONNECTION HAS NOT BEEN BY PROVIDED BY THE COUNTRIES CONCERNED)[72]

### A. SOUTH WESTERN BACKA/DUNAV AQUIFER[73]

**Table 65. South Western Backa/Dunav aquifer**

| **No. 14 South Western Backa/Dunav** | | | **Shared by: Serbia and Croatia** |
|---|---|---|---|
| Type 3, Eopleistocene alluvial aquifer of mainly medium and coarse grained sands and some gravels, of average thickness 20 m and up to 45 m, partly confined with medium links to surface water systems. Dominant groundwater flow direction from Serbia to Croatia. In Serbia the groundwater body provides 70% of the total water used in the area. | | | **Black Sea Basin**<br>Border length (km): - |
| | **Serbia** | **Croatia** | |
| Area (km$^2$) | 440.74 | - | |
| Number of inhabitants | 32,543 | - | |
| Population density (persons/km$^2$) | 74 | - | |

[72] Most of the aquifers referred to here are connected with surface waters of a basin that will be assessed later with the neighbouring sub-region. Middle Sarmatian – Pontian aquifer which is transboundary between Moldova and Romania will assessed later with the neighbouring sub-region.
[73] Based on information from Serbia and Croatia.

| | | |
|---|---|---|
| Water uses and functions | 50-75% of the groundwater is used for drinking water supply (covering the total of drinking water needs in the area) and less than 25% for irrigation, industry and livestock. Groundwater also supports ecosystems | - |
| Notes: | Part of the Panonian Basin, within the Danube basin | According to existing data, no transboundary groundwater is recognized |

101. Groundwater abstraction is the main pressure in Serbia. Groundwater covering drinking water supply in West Backa is being abstracted through wells that reach a depth that varies from 30 to 230 meters; with an exception of the Danube riparian zone, these wells exploit deep horizons with a natural renewal rate that does not meet consumption. Groundwater depletion has been observed in some deep wells (Pliocene sediments) while groundwater level has dropped (< 5 m - from the 1960s until 2000) in the Quaternary aquifer; the phenomenon is of local scale, in the vicinity of well fields.

**Table 66. Land cover/use in the area of the South Western Backa/Dunav aquifer (% of the part of the aquifer extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Serbia** | 10.49* | 29.51 | 52.07 | 4.69 | 3.23 | | |
| **Croatia** | - | - | - | - | - | - | - |

* Watercourses and water bodies included

102. Natural background water quality is an important aquifer-wide issue in Serbia; there are natural organic compounds, ammonia, iron and manganese at high concentrations. There is widespread naturally-occurring arsenic at concentrations that range between 10 and 100 µg/l (provisional WHO drinking water guideline value is 10 µg/l[74]). Ammonium pollution and pathogens are the result of inappropriate sanitation systems.

**Table 67. Range of concentrations of characteristic quality parameters in drinking water in towns and villages in the Serbian area[75]**

| Town/village | Population | Fe (mg/l) | Mn (mg/l) | $NH_3$ (mg/l) | $KMnO_4$ consumption (mg/l) | As (mg/l) |
|---|---|---|---|---|---|---|
| Apatin | 19,289 | 1.6-2.7* | 0.09-0.3* | 2.2* | 11* | 0.006-0.012** |
| Prigrevica | 4,786 | | | Connected to Apatin waterworks | | |

[74] Guidelines for drinking-water quality, third edition incorporating the first and second addenda, Volume 1 Recommendations. World Health Organization, Geneva. 2008.

[75] *Source*: Project 353 Final Report: Sustainable solutions to improve quality of drinking water affected by high arsenic contents in 3 Vojvodinian regions (AP Vojvodina, Provincial Secretariat for Env. Protection and Sust. Development, 2006) – Provided by the Ministry of Agriculture, Forestry and Water Management, Serbia

| | | | | | | |
|---|---|---|---|---|---|---|
| Svilojevo | 1,354 | Not Detected | Not Detected | Not Detected | Not Detected | Not Detected |
| Sonta | 4,994 | 1-3* | 0.1-0.13* | 1.5* | 12-26* | 0.001-0.26* |
| Bogojevo | 2,120 | 0.1-0.5* | | 0.08-0.23* | 9.6-45.6* | 0.134* |

* concentrations exceeding limits set for drinking water
** concentrations below limits set for drinking water

103. The construction of the regional water supply system of Banat, which will use groundwater from the Danube alluvium and serve more than 200,000 inhabitants of Western and Mid Backa Region (work is in preparatory phase – field investigations and some studies have been completed), is included in the Danube River Basin Management Plan and Programme of Measures (final draft) prepared by ICPDR. It is among the measures planned to provide a solution with regard to the drinking water supply related problems and reduce or even eliminate the quantitative risk that the aquifer is currently under. The groundwater body is not at risk as far as quality is concerned. Nevertheless, its status was reported by Serbia as poor.

104. A transboundary approach has not been considered so far by Serbia; it is suggested that decisions at transboundary level regarding this aquifer are not needed.

## B. NORTHEAST BACKA/DANUBE-TISZA INTERFLUVE OR BACKA/DANUBE-TISZA INTERFLUVE[76]

**Table 68. Northeast Backa/Danube -Tisza Interfluve or Backa/Danube-Tisza Interfluve aquifer**

<table>
<tr><td colspan="3">No. 32 Northeast Backa/Danube -Tisza Interfluve or Backa/Danube-Tisza Interfluve</td><td>Shared by: Serbia and Hungary</td></tr>
<tr><td colspan="3" rowspan="2">According to the riparian countries represents none of the illustrated transboundary aquifer types. Part of North Pannonian basin, Miocene and Eopleistocene alluvial sediments, partly confined, predominantly sands with clayey lenses of average thickness 50-100 m and maximum 125-150 m in Serbia, average 250 m and maximum 700 m in Hungary, medium to strong links to surface waters, groundwater flow from Hungary to Serbia. Groundwater covers 80% of the total water use in the Serbian part and is >80% of total supply in the Hungarian part</td><td>Black Sea Basin</td></tr>
<tr><td>Border length (km): -</td></tr>
<tr><td></td><td>Serbia</td><td colspan="2">Hungary</td></tr>
<tr><td>Area (km$^2$)</td><td>5,648.01</td><td colspan="2">9,545</td></tr>
<tr><td>Number of inhabitants</td><td>530,000</td><td colspan="2"></td></tr>
<tr><td>Population density (persons/km$^2$)</td><td>93</td><td colspan="2"></td></tr>
</table>

[76] Based on information from Serbia; references to Hungary included here was based on information from the First Assessment of Transboundary Rivers, Lakes and Groundwaters– for which information had been provided by the Directorate of Water and the Jaroslav Cerni Institute, Serbia and the IAH National Committee of Serbia and the Geological Institute of Hungary. Northeast Backa/Danube-Tisza Interfluve is the name of the aquifer used in the First Assessment; Backa/Danube-Tisza Interfluve is the name of the aquifer used under this assessment by Serbia.

| | | |
|---|---|---|
| Water uses and functions | 75% for drinking water supply (100% of drinking water supplied in Voivodina comes from the aquifer) and less than 25% for irrigation, industry and livestock; also supports ecosystems. | >75% for drinking water, <25% for irrigation, industry and livestock; also supports ecosystems |
| Notes: | Groundwater abstraction in both countries exceeds recharge. There have been local declines in groundwater level of 0.5 m/yr, and 0.1 my/r more widely observed | Importation of arsenic-free drinking water had been reported as planned in the First Assessment |

[Figure 11. Conceptual sketch of the Northeast Backa/Danube-Tisza Interfluve aquifer (provided by Serbia).]

105. Over-abstraction of groundwater is the main pressure factor in the Serbian part. Groundwater depletion is observed on most of the wells in the Pliocene and Quaternary aquifer (near the borders with Hungary). Groundwater levels have dropped down (from the 1960s until 2000) about 5-10 m at the regional level and more than 15 m locally. Severe reduction in borehole yields, and moderate land subsidence have been observed locally. Abstraction of groundwater exerts pressure also in the Hungarian part; local and moderate increased pumping lifts, reduced borehole yields and baseflow, as well as degradation of ecosystems due to issues related to groundwater quantity were reported.

**Table 69. Land cover/use in the area the Northeast Backa/Danube-Tisza Interfluve aquifer (% of the part of the aquifer extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Hungary** | | | | | | | |
| **Serbia** | 1.79* | 3.45 | 86.60 | 3.04 | 5.12 | | |

* Watercourses and water bodies included

106. Natural background water quality is an important aquifer-wide issue; chemical compounds and elements are detected in concentrations above limits set in Serbia for drinking water. There are natural organic compounds, ammonia, and arsenic detected in high concentrations; for arsenic this ranges between 10 and 50 µg/l. At least at the groundwater quality monitoring point of Subotica-Mikićevo in Serbia, a consistent increasing trend in electric conductivity, commonly indicative of an increased concentration of dissolved solids, since 1998 until 2007 (the end of data available) can be observed (Table 70). This may be related to the abstraction, declining water levels and possible drawing in of a component of groundwater with higher salinity from a deeper aquifer. There is also widespread but moderate nitrogen and pathogens pollution due to inappropriate sanitation and naturally occurring iron.

107. Widespread and severe naturally occurring arsenic at 10-200 µg/l, widespread but moderate nitrate at up to 200 mg/l and pesticides at up to 0.1 µg/l were reported by Hungary.

**Table 70. Selected groundwater quality determinands at Subotica-Mikićevo and Sombor monitoring stations (Serbia).**

| Date | El. conduct (mS/ $cm^{-1}$) | Ammo-nium ion (mg/l) | Nitrates (mg/l) | Sul-phates (mg/l) | Chlori-des (mg/l) | Lead (µg/l) | Iron (mg/l) | Manga-nese (mg/l) | Arsenic (µg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Subotica-Mikićevo (M-1) (Y=7383831,195; X=5096152,886) | | | | | | | | | |
| Dec 1992 | 710 | 0.46 | 0.20 | 27 | 22.0 | 18 | 0.23 | 0.06 | |
| June 1993 | 699 | 0.50 | 0.01 | 19 | 24.0 | 23 | 0.19 | 0.09 | |
| Nov 1993 | 714 | 0.30 | 0.04 | 30 | 22.0 | 0 | 0.10 | 0.00 | |
| Oct 1996 | 822 | 0.16 | 0.73 | 35 | 24.7 | 0 | 0.09 | 0.04 | |
| Oct 1997 | 763 | 1.25 | 0.27 | 30 | 17.4 | 6 | 1.02 | 0.26 | |
| Oct 1998 | 607 | 1.93 | 0.03 | 14 | 8.5 | | | | |
| Nov 2002 | 798 | 0.00 | 0.60 | 37 | 30.0 | | 0.05 | 0.04 | |
| Sep 2004 | 907 | 0.87 | 0.03 | 69 | 69.0 | | 0.11 | 0.10 | |
| Sep 2005 | 900 | 1.16 | 0.40 | 77 | 84.0 | 1 | | | 7 |
| Oct 2006 | 1,020 | 0.70 | 0.06 | 91 | 94.0 | 2 | 0.27 | 0.20 | 31 |
| Oct 2007 | 1,413 | 0.83 | 0.07 | 185 | | | | | |
| Sombor-S-1/D (Y=7354827,999; X=5070824,306) | | | | | | | | | |
| Dec 1992 | 1,034 | 0.75 | 0.63 | 20 | 2.0 | 28 | 0.02 | 0.09 | |
| June 1993 | 1,072 | 0.70 | 0.01 | 35 | 2.0 | 0 | 0.35 | 0.09 | |
| Oct 1993 | 1,090 | 1.30 | 0.00 | 25 | 2.0 | 18 | | | |
| May 1996 | 778 | 0.21 | 0.29 | 17 | 7.0 | 15 | 0.12 | 0.03 | |
| Apr 1997 | 1,086 | 1.04 | 0.04 | 27 | 29.5 | 17 | 0.46 | 0.08 | |
| Apr 1998 | 793 | 0.00 | 1.00 | 30 | 25.5 | 0 | 0.11 | 0.00 | |
| Nov 2002 | 909 | 0.02 | 0.20 | 18 | 23.0 | | 0.07 | 0.06 | |
| Sep 2003 | 1075 | 1.63 | 0.00 | 41 | 22.0 | | 0.23 | 0.05 | |
| Sep 2004 | 1,105 | 0.35 | 0.03 | 25 | 23.0 | | 0.15 | 0.05 | |

| Date | El. conduct (mS/ cm$^{-1}$) | Ammo-nium ion (mg/l) | Nitrates (mg/l) | Sul-phates (mg/l) | Chlori-des (mg/l) | Lead (μg/l) | Iron (mg/l) | Manga-nese (mg/l) | Arsenic (μg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Nov 2005 | 873 | 1.48 | 0.09 | 17 | 21.0 | 2 | | | 1 |
| Oct 2006 | 968 | 1.50 | 0.05 | 34 | 25.0 | 6 | 0.10 | 0.09 | 2 |
| Oct 2007 | 1,030 | 1.42 | 0.28 | 40 | | | | | |

*Source*: Annual Reports, Hydro Meteorological Institute of the Republic of Serbia.

108. In Serbia abstraction management and water use efficiency measures have been taken, protection zones system established and best agricultural practices and monitoring implemented. Nevertheless, as reported, this range of measures needs to be improved and other measures need to be introduced as well. In Hungary groundwater abstraction regulation is used and effective; water use efficiency measures, monitoring, public awareness, protection zones and wastewater treatment and exchange of data need to be improved; and vulnerability mapping, regional flow modeling, good agricultural practices, integration with river basin management and arsenic treatment or import of arsenic free water are needed.

109. According to Serbian assessments, the current status of the aquifer is poor; there is a possible risk related to quantity, but not related to quality. There is a possibility to use groundwater from the Danube alluvium instead of groundwater from deeper aquifers.

110. The evaluation of the utilisable resource is a necessary action according to Hungary.

111. Bilateral cooperation concerning groundwater is in an inception phase. With what concerns its enhancement regarding this specific groundwater body, Serbia reported the two following areas in which international cooperation/organizations can be of support: (i) establishment/improvement of bilateral cooperation regarding the sustainable management of the transboundary aquifer; (ii) share of experience aiming to address the issue of naturally occurring arsenic.c

112. Hungary suggested that joint monitoring (mainly quantitative) and joint modelling is needed.

## C. NORTH AND SOUTH BANAT OR NORTH AND MID BANAT[77]

### Table 71. North and South Banat or North and Mid Banat aquifer

<table>
<tr><td colspan="2">No. 33 North and South Banat or North and Mid Banat</td><td>Shared by: Serbia and Romania</td></tr>
<tr><td colspan="2" rowspan="2">Type 4 according to Romania and closest to type 4 according to Serbia ( also see the conceptual sketch provided by Serbia in figure 12), Thick (up to 2,000 m) alluvial aquifer of sands and gravels of Tertiary to Pleistocene age in a deep tectonic depression, forming a confined aquifer sequence with Quaternary lacustrine and alluvial sediments above. Weak links to surface water systems. Dominant groundwater flow from Romania to Serbia. The depth of groundwater levels is at 10-30 m.</td><td>Black Sea Basin</td></tr>
<tr><td>Border length (km): 255 (according to Serbia); 267 (according to Romania)</td></tr>
<tr><td></td><td>Serbia</td><td>Romania</td></tr>
<tr><td>Area (km²)</td><td>2,559.5*</td><td>11,393</td></tr>
<tr><td>Altitude fluctuation (m)</td><td>N/A</td><td>70 – 250 m</td></tr>
<tr><td>Number of inhabitants</td><td>135,000</td><td>857,580</td></tr>
<tr><td>Population density (persons/km²)</td><td>53</td><td>75.27</td></tr>
<tr><td rowspan="2">Notes:</td><td colspan="2">Part of the Panonian Basin</td></tr>
<tr><td>- Separate groundwater bodies in Serbia as North and Mid Banat (both in Tisza catchment)<br>- It is a very important aquifer – provides 100% of drinking water supplies in Vojvodina.</td><td></td></tr>
</table>

* Only groundwater bodies – the regional aquifer extents at about 20,000 $km^2$

[Figure 12… Conceptual sketch of North and South Banat or North and Mid Banat aquifer. (Provided bySerbia)]

### Table 72. Land cover/use in the area of the North and South Banat or North and Mid Banat aquifer (% of the part of the aquifer extending in each country)

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Romania** | 0.27 | 19.03 | 72.04 | 3.01 | 5.57 | 6.44 | |
| **Serbia** | 2.00* | 1.93 | 81.72 | 9.74 | 4.61 | | |

* Watercourses and water bodies included

113. As reported by Romania, the covering layer of the aquifer is mineral soil (the thickness of the unsaturated zone varies from 0 to 50 m). Groundwater is recharged by precipitation and from rivers in the outcropping zone towards the mountains as well as through the overlying younger porous-permeable strata; discharge is partially through wells. The estimated recharge is $112 \times 10^6$ $m^3$/year (average for the years 1995-2007).

[77] Based on information from Romania and Serbia. North and South Banat is the name of the aquifer used in the First Assessment; North and Mid Banat is the name of the aquifer used in this assessment by Serbia.

**Table 73. Mean annual water withdrawal by sector from the North and South Banat or North and Mid Banat aquifer**

| | | Total withdrawal | Agriculture | Domestic | Industry | Energy | Other |
|---|---|---|---|---|---|---|---|
| **Romania** | 2008 | 36,130.54 $m^3$/year | 5.1 % | 74.32 % | 19.94 % | - | - |
| | Prospects for 2015 | 78,146 $m^3$/year | 3.25 % | 73.54 % | 22.42 % | - | - |
| **Serbia** | | N/A | - | - | - | - | - |

114. In Serbia the abstracted groundwater covers 90% of the water being used; 75% of the abstracted groundwater is used for drinking water supply (covering the total of drinking water supply in the area) and less than 10% for irrigation, industry, livestock and spa; it also supports ecosystems.

115. Over-abstraction of groundwater is a pressure factor in Serbia. Severe increase in pumping lifts locally led to the local decrease of borehole yields and decline of groundwater levels of 0.5 m/yr (in Kikinda). Groundwater depletion has been observed on most of the wells in North part of Banat, near the borders with Romania. Groundwater level has dropped down (from the 1960's until 2000) about 5-10 m in the area; a drop of more that 15 m has been observed locally. Romania reports that there are no transboundary impacts; there are no increases observed in the pumping lifts in the border area and the yields exploited in the Romanian part of this area decreased during the last decade. The increase of pumping lifts locally is of concern though and the impacts should be studied further in cooperation with Serbia.

116. In Serbia, natural/background groundwater quality does not meet national standards due to the occurrence of natural organic compounds, ammonia, boron and arsenic in high concentrations (for arsenic, more than 100 µg/l in some parts of Banat). According to Serbia this is an important issue for all this groundwater body. Romania reported that arsenic appears to be an issue at the rural areas near the border; studies on the issue are at an initial stage.

**Table 74. Groundwater quality at Kikinda, Serbia (K-1/D) 0111/D (Y=7456747,00; X=5078282,00)**

| Date | El. conduct ($mS/cm^{-1}$) | Ammonium ion (mg/l) | Nitrates (mg/l) | Sulphates (mg/l) | Chlorides (mg/l) | Lead (µg/l) | Iron (mg/l) | Manganese (mg/l) | Arsenic (µg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Dec 1992 | 920 | 0.36 | 2.51 | 32 | 10.0 | 26 | 0.08 | 0.07 | |
| June 1993 | 921 | 0.00 | 0.00 | 22 | 11.0 | 38 | 0.070 | 0.09 | |
| Nov 1993 | 907 | 0.50 | 0.02 | 56 | 11.0 | 26 | 0.8 | 0.03 | |
| June 1996 | 964 | 0.23 | 0.12 | 56 | 13.0 | 10 | 0.143 | 0.112 | |
| June 1997 | 986 | 0.09 | 0.62 | 17 | 13.5 | 3 | 0.286 | 0.074 | |

| Date | El. conduct (mS/cm$^{-1}$) | Ammonium ion (mg/l) | Nitrates (mg/l) | Sulphates (mg/l) | Chlorides (mg/l) | Lead (μg/l) | Iron (mg/l) | Manganese (mg/l) | Arsenic (μg/l) |
|---|---|---|---|---|---|---|---|---|---|
| Mar 1998 | 993 | 0.14 | 0.97 | 19 | 12.9 | | 0.264 | 0.021 | |
| Oct 2002 | 930 | 0.18 | 1.30 | 15 | 10.0 | | 0.053 | 0.033 | |
| Sep 2003 | 1113 | 2.25 | 0.00 | 17 | 10.0 | | 0.101 | 0.176 | |
| Sep 2004 | 965 | 1.11 | 0.05 | 17 | 12.0 | | 0.11 | 0.20 | |
| Sep 2005 | 887 | 0.57 | 0.04 | 21 | 10.0 | 1,00 | | | |
| Oct 2006 | 949 | 1.72 | 0.06 | 30 | 11.0 | 5,00 | 0.43 | 0.43 | 130 |

Based on information provided by Serbia; Source: Annual Reports, Hydro Meteorological Institute of the Republic of Serbia.

117. Sanitation, irrigated agriculture, waste disposal, industry and oilfields are the main pressure factors in Serbia.

118. In Romania, quality[78] and quantity monitoring has been established according to the requirements of the EU WFD; the necessary measures for the sustainable management of the water resources are provided under this directive. In Serbia monitoring of quantity and quality needs improvement; a wide range of other measures need to be introduced or are planned including the construction of the regional water supply system of Banat. This will use groundwater from the Danube alluvium (area between Kovin and Dubovac). Timeframe for the construction of this system is still uncertain due to Serbia's current investment capacity; project preparation activities (studies etc.) are expected to be completed by 2015. This is one of the supplementary (according to EU WFD) measures included in the Danube River Basin Management Plan and Programme of Measures (final draft version), as well as in the Tisza River Basin Management Plan (currently under preparation). At the time being, groundwater supplied to local municipalities and industry is being abstracted through wells, the depth of which is between 60 and 250 m.

119. Serbia reports that the construction of the regional water supply system will solve the issue of providing adequate supply of drinking water of good quality; it will also reduce or even eliminate the quantitative risk that the aquifer is currently under. The aquifer is under low qualitative risk because of the good natural protection of deep ground water from surface pollution.

120. Romania's assessment, slightly differentiate: the aquifer is in good status and there is no risk either in terms of quality or quantity.

121. For what concerns enhancement of cooperation between the two countries, Serbia reported that assistance can be of support in the establishment / improvement of bilateral

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[78] The following parameters are monitored: pH, conductivity, chlorides, $SO_4$, calcium, Mg, Na, K, $HCO_3$, $CO_3$, $CBO_5$, CCOMn, $NO_2$, $NO_3$, $NH_4$, dissociating oxygen, Fe, Mn, Cu, Zn, $PO_4$, As, Cd, Cr, Ni, Pb, CN.

cooperation between Serbia and Romania regarding the sustainable management of the transboundary aquifer; Romania reported that this should be done through the revision of the existing 1955 Agreement for bilateral cooperation between the two countries. Sharing of experience between the two countries with the aim to address the issue of naturally occurring arsenic is also a field in which, according to Serbia, assistance would be of help.

## D. PLEISTOCENE MURE/MAROS ALLUVIAL FAN[79]

**Table 75. Pleistocene Mure/Maros alluvial fan**

| **No. 47 Pleistocene Mure/Maros alluvial fan** | | | **Shared by: Romania and Hungary** |
|---|---|---|---|
| Type 4, Pleistocene and Holocene alluvial sediments, predominantly pebbles, sands and silts, weak to medium links with surface water systems, mean thickness 200 m and maximum 500 m, groundwater flow from south-east (Romania) to north-west (Hungary). In Romania the shallow (15-30 m) upper part is considered to be a separate aquifer (ROMU 20) than the deeper, confined part of the sequence (ROMU22). Groundwater is 80% of total use in Hungary. | | | **Black Sea Basin**<br>Border length (km): |
| | **Romania** | **Hungary** | |
| Area (km$^2$) | 2,200 | 4,319 | |
| Water uses and functions | 75% for drinking water supply, 15% for industry and 10% for irrigation (shallow), and 45%, 35% and 20% respectively for the confined aquifer | >75% drinking water, <25% for irrigation, industry and livestock, support of agriculture and ecosystems | |

122. Groundwater abstraction exerts pressure on the aquifer in Romania; local and moderate increase of pumping lifts has led to small drawdowns locally.

123. Groundwater abstraction - there is moderate increase in pumping lifts locally - is a pressure factor also in Hungary and so are agriculture and septic tanks. There is reduction in borehole yields and reduced baseflow. Local but severe degradation of ecosystems are due to problems related to groundwater quantity. Widespread but moderate nitrate pollution (up to 200 mg/l), moderate pesticide pollution locally (up to 0.1 µg/l) and widespread and severe arsenic pollution (up to 300 µg/l) have been observed.

124. There are no transboundary impacts.

125. Management measures in Hungary pertaining to groundwater abstraction regulation are considered efficient, while water use efficiency, monitoring, delineation of protection zones, arsenic removal, wastewater treatment, and public awareness need to be improved; good agricultural practices, as well as integration of groundwater management with river basin management need to be applied. Both countries stress the need for vulnerability mapping.

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[79] Based on information from the First Assessment of Transboundary Rivers, Lakes and Groundwaters – for which information had been provided by the National Institute of Hydrology and Water Management, Romania, and the Geological Institute of Hungary, supplemented by the Danube Basin Analysis (WFD Roof Report 2004).

126. Transboundary agreement need to be improved according to Hungary.

127. Romania considers the water body to be in good status, with no imminent risk. According to Hungary the aquifer is possibly at risk in terms of both quality and quantity. Hungary considers evaluation of the quality status and the utilisable resources, joint monitoring (mainly quantitative) and joint modeling, including the estimation of the amount of transboundary groundwater flow, as needed. There is a potential need to import water to compensate for the local needs, due to the presence of arsenic in water.

## E. SOMES/SZAMOS ALLUVIAL FAN AQUIFER[80]

**Table 76. Somes/Szamos alluvial fan aquifer**

| **No. 48 Somes/Szamos alluvial fan** | | **Shared by: Romania and Hungary** |
|---|---|---|
| Type 2 / $4^*$, Holocene-Lower Pleistocene alluvial sediments of sands, clayey sands, gravels and even boulders, weak to medium links with surface water systems. In Romania, the shallow (15-30 m) Upper Pleistocene – Lower Holocene unconfined upper part (ROSO01) and the confined Lower Pleistocene (ROSO13), varying from 40 m thick (in the east) to 130 m (in the west) are hosting separate groundwater bodies. The covering layer is soil (unsaturated zones of 1-20 m). The depth of groundwater levels is at 5-20 m. Estimated groundwater recharge amounts to $141 \times 10^6$ $m^3$/year (average for the years 1995-2007). Mean thickness 180 m and maximum 470 m in the Hungarian part. Dominant groundwater flow from East (Romania) to West (Hungary). More than 80% of total water use is from groundwater in the Hungarian part. | | **Black Sea Basin**<br>Border length (km): 35 |
| | **Romania** | **Hungary** |
| Area ($km^2$) | 1,390 | 976 |
| Altitude fluctuation (m) | 100 - 150 | N/A |
| Number of inhabitants | N/A | N/A |
| Population density (persons/$km^2$) | 97 | N/A |
| Water uses and functions | Upper aquifer: 50% of the groundwater is used for industry, 42% for drinking water supply and 8% for irrigated agriculture. Lower aquifer: 68% of the groundwater is used for drinking water supply and 32% for industry; a minor share is used for agriculture. There are some thermal water abstractions. Groundwater also supports ecosystems | >75% drinking water supply, less than 10% each for irrigation, industry and livestock, maintaining baseflow and support of ecosystems |
| Notes: | It is considered as two separate groundwater bodies in Romania | |

[80] Based on information from Romania and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention - for which information had been provided by the National Institute of Hydrology and Water Management, Romania, and the Geological Institute of Hungary, supplemented by the Danube Basin Analysis (WFD Roof Report 2004). Pleistocene Some/Szamos alluvial fan is the name of the aquifer used in the First Assessment; Somes/Szamos alluvial fan is the name of the aquifer used in this assessment by Romania.

| | |
|---|---|
| | More information is needed about groundwater inflow from Ukraine[81] |

[*] Romania reports that the unconfined upper part of the aquifer is of Type 2 while the confined lower part of the aquifer is of Type 4.

**Table 77. Land cover/use in the area of the Somes/Szamos alluvial fan aquifer (% of the part of the basin extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Romania** | 0.74 | 33.76 | 54.61 | 8.09 | 2.15 | 0.02 | 0.63 |
| **Hungary** | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

128. Local and moderate increases of pumping lifts and small drawdown have been observed around two major well fields near Statu-Mare in Romania; nevertheless, groundwater abstractions are reported to be effectively controlled. In Hungary there are local and moderate increases in pumping lifts observed, as well as reduction in borehole yields and spring flow, and degradation of ecosystems.

**Table 78. Total annual water withdrawal and mean annual water withdrawal by sector from the Somes/Szamos alluvial fan aquifer**

| | | Total withdrawal | Agriculture | Domestic | Industry | Energy | Other |
|---|---|---|---|---|---|---|---|
| **Romania** | 2005 | 17.624 × $10^6$ $m^3$/year | 2 % | 72 % | 26 % | 0 | 0 |
| | 2006 | 17.603 × $10^6$ $m^3$/year | 1 % | 66 % | 33 % | 0 | 0 |
| | 2007 | 18.421 × $10^6$ $m^3$/year | 0 | 63 % | 37 % | 0 | 0 |
| **Hungary** | | | | | | | |

129. In Romania 45% of the total population in the area is not connected to a sewerage system. Agriculture (practiced in accordance with the EU legislation – also, without the use of fertilizers in some areas) is a pressure factor: cases of maximum concentration values for $NH_4$ and $PO_4$ exceeding threshold values for drinking water have been recorded in certain wells in the area. Also industry and waste are of concern: cases of maximum concentration values for $NH_4$, organic substances and Pb exceeding threshold values for drinking water have been recorded in certain wells in the area. All are of low importance though. Some nutrient and pesticide pollution has been observed.

130. Agriculture, sewers and septic tanks exert pressure on the quality of the groundwater of the aquifer in Hungary. There is widespread but moderate natural arsenic occurrence (up to 50 µg/l), widespread but moderate nitrate (up to 200 mg/l) and local and moderate pesticide pollution (up to 0.1 µg/l).

[81] Ukraine is to be consulted about this.

131. Quality[82] and quantity monitoring of the water bodies have been established in Romania according to the requirements of the EU WFD.

132. Both Romania and Hungary consider that vulnerability mapping is needed in order to improve land use planning. According to Hungary, groundwater abstraction regulations exist and relevant control is effective. However, application of financial mechanisms, water use efficiency, monitoring, public awareness, protection zones, wastewater treatment, data exchange and arsenic removal need to be improved. Improved agricultural practices and integration into river basin management are also needed according to Hungary, as well as evaluation of the utilizable groundwater resources and their quality status. Hungary also calls for joint monitoring (mainly quantitative) and update of existing joint modelling.

133. The aquifer is in good status not being under risk in terms of either quantity or quality.

## F. NEOGENE – SARMATIAN AQUIFER[83]

**Table 79. Neogene – Sarmatian aquifer**

| **No. 50 Neogene - Sarmatian** | | **Shared by: Bulgaria and Romania** |
|---|---|---|
| Type 1 or Type 4, Neogene – Sarmatian oolitic and organogenic limestones in Romania, limestones, marls and sands in Bulgaria, with some sands and clays, average thickness 80 m (Bulgaria) and 75 m (Romania) and up to 250 m or 150 m respectively, weak to medium links with surface water systems, largely unconfined groundwater, dominant groundwater flow from W-SW (Bulgaria) to E-NE (Romania). Groundwater levels at depth that ranges between 5 and 100 m. | | **Black Sea Basin**<br>Border length (km): 110 (according to Bulgaria); 90 (according to Romania) |
| | **Bulgaria** | **Romania** |
| Area ($km^2$) | 4,850.8* | 2,178 |
| Altitude fluctuation (m) | 1 - 200 | 75 – 20 |
| Number of inhabitants | 422,193 | N/A |
| Population density (persons/$km^2$) | 41 | 101.1 |

* Bulgaria reported that the part of the aquifer extended in its territory consists of three distinctive groundwater bodies. Their areal extent is as follows: BG2G000000N015 - 1,079.3 $km^2$; BG2G000000N016 - 1,364.8 $km^2$; BG2G000000N017 - 2,406.7 $km^2$

134. Groundwater resources amount to 174,078,720 $m^3$/year (average for the years 2007-2008) in Bulgaria and to 155,000,000 $m^3$/year (average for the years 1995-2007) in Romania.

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[82] The following parameters are monitored : pH, conductivity, chlorides, $SO_4$, calcium, Mg, Na, K, $HCO_3$, $CO_3$, $CBO_5$ (biochemical consumption of oxygen), CCOMn, $NO_2$, $NO_3$, $NH_4$, dissociating oxygen, Fe, Mn, Cu, Zn, $PO_4$, As, Cd, Cr, Ni, Pb, CN.

[83] Based on information from Bulgaria, Romania and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Black Sea and Danube Basin Directorates of Bulgaria and the National Institute of Hydrology and Water Management, Romania, supplemented by the Danube Basin Analysis (WFD Roof Report 2004).

Groundwater is 13% of total water use in the Bulgarian part; apart from the uses seen in the table below (Table 80), groundwater supports also ecosystems. In Romania water is used for drinking water supply (mainly), agriculture and some industry.

**Table 80. Mean annual water withdrawal by sector from the Neogene – Sarmatian aquifer**

| | | Total withdrawal | Agriculture | Domestic | Industry | Energy | Other |
|---|---|---|---|---|---|---|---|
| **Bulgaria** | 2008 | 23,557.392 $m^3$/year | 22 % | 67 % | 11 % | 0 % | 0 % |
| **Romania** | 2007 | 20,632.112 $m^3$/year | N/A | N/A | N/A | N/A | N/A |

**Table 81. Land cover/use in the area of the Neogene – Sarmatian aquifer (% of the part of the aquifer extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Bulgaria** | 0.07 | 5.9 | 87.5 | 2.3 | 3.0 | * | 1.23 |
| **Romania** | 5.39 | 4.31 | 78.67 | 0.49 | 3.1 | 0.16 | 7.88 |

* As reported, there is no information available

135. Agriculture is the main pressure factor; nitrogen species have been detected locally at moderate concentrations (10 -100 mg/l) in Bulgaria.

136. Bulgaria reports that the two out of the three groundwater bodies (BG2G000000N016 and BG2G000000N017) are in good status.

137. In Bulgaria, wastewater and agriculture runoff treatment, vulnerability mapping and monitoring[84] of groundwater quantity and quality are used but need improvement. The measures included in the River Basin Management Plan (to which the groundwater body(ies) were appointed) aiming to improve the water status are mainly oriented towards addressing pressure stemming from agriculture. These include: (i) implementation of best agriculture practices with regard to fertilizers and pesticides/herbicides use; (ii) cultivation of specific crops; (iii) rehabilitation of irrigations systems; (iv) setting up of protection zones; (v) establishment of operational monitoring; and (vi) control of illegal discharges.

138. There is on-going cooperation between the two countries through the working groups established under the 2005 agreement (see Annex III of document ECE/MP.WAT/2009/8). Exchange of data is reported as needed.

139. Both countries agree that the water body is not at risk.

[84] Relevant measures are being taken in accordance with the EU WFD.

## G. UPPER JURASSIC – LOWER CRETACEOUS AQUIFER[85]

### Table 82. Upper Jurassic – Lower Cretaceous aquifer

| **No. 51 Upper Jurassic – Lower Cretaceous** | | **Shared by: Bulgaria and Romania** |
|---|---|---|
| Type 4, Upper Jurassic – Lower Cretaceous karstic limestones, dolomites and dolomitic limestones, mean thickness 500 m and maximum 1000 m in Bulgaria mean 350 m and maximum 800 m in Romania, weak links with surface water systems, largely confined by overlying marls and clays, groundwater flow from north-west (Bulgaria) to south-east (Romania). | | **Black Sea Basin**<br>Border length (km): 280 (according to Bulgaria); 290 (according to Romania) |
| | **Bulgaria** | **Romania** |
| Area (km$^2$) | 18,720 * | 11,427 |
| Altitude fluctuation (m) | 18 - 150 | 17 - 250 |
| Number of inhabitants | 400,056 | N/A |
| Population density (persons/km$^2$) | 84 | N/A |
| Notes | Connected to Srebarna Lake | Connected to Sintghiol Lake |

*Bulgaria reported that the part of the aquifer extending in its territory consists of three distinctive groundwater bodies delineated according to the definition of EU WFD. Their areal extent is as follows: BG2G000J3K1040 – 3,422 km$^2$; BG2G000J3K1041 – 6,327 km$^2$; BG1G0000J3K048 – 8,971 km$^2$.

140. Groundwater resources amount to 400,885,632 m$^3$/year (average for the years 2007-2008) in the Bulgarian part; groundwater is 35% of total water use. Apart from the uses shown in the table below (Table 83), groundwater supports also ecosystems. Groundwater resources amount to 1,677,000,000 m$^3$/year in the Romanian part (average for the years 1995-2007); groundwater is used mainly for drinking water supply as well as (some) for irrigation and industry.

### Table 83. Mean annual water withdrawal by sector from the Upper Jurassic – Lower Cretaceous aquifer

| | | Total withdrawal | Agriculture | Domestic | Industry | Energy | Other |
|---|---|---|---|---|---|---|---|
| **Bulgaria*** | … | 115,194,701 m$^3$/year | 10 % | 82 % | 1 % | 1 % | 6 % ** |
| **Romania** | 2007 | 95,121,720 m$^3$/year | N/A | N/A | N/A | N/A | N/A |

* Figures presented here refer only to BG2G000J3K1040 and BG2G000J3K1041 groundwater bodies.
** Thermal spa.

[85] Based on information from Bulgaria, Romania, and the First Assessment of Transboundary Rivers, Lakes and Groundwaters under the UNECE Water Convention – for which information had been provided by the Black Sea and Danube Basin Directorates of Bulgaria and the National Institute of Hydrology and Water Management, Romania, supplemented by the Danube Basin Analysis (WFD Roof Report 2004).

**Table 84. Land cover/use in the area of the Upper Jurassic – Lower Cretaceous aquifer (% of the part of the aquifer extending in each country)**

| | Lakes / reservoirs | Forests | Cropland | Grassland | Urban / industrial areas | Protected areas | Other forms of land use |
|---|---|---|---|---|---|---|---|
| **Bulgaria** | 0.3 | 0.8 | 78 | 7 | 9 | * | 4.9 |
| **Romania** | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

* As reported, there is no information available

141. Bulgaria reports that there are no pressures affecting either the quality or the quantity of groundwater; there are also no pressures in the Romanian part. In Bulgaria, the measures included in the River Basin Management Plan (to which the groundwater body(ies) were appointed) aiming to preserve the good status include: (i) implementation and enforcement of the water use permitting/licensing system (ii) setting up protection zones (iii) control of illegal discharges in the aquifer's recharge area (appropriate measures are taken in accordance with the national legislation). Improvement of monitoring is necessary (appropriate measures are taken in accordance with the EU WFD).

142. Both countries agree that the groundwater body is not at risk.

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