UNITED
NATIONS

E

Economic and Social Council

Distr.
GENERAL

ECE/MP.WAT/WG.2/2007/18
21 June 2007

ENGLISH ONLY

ECONOMIC COMMISSION FOR EUROPE

MEETING OF THE PARTIES TO THE CONVENTION ON THE PROTECTION AND USE OF TRANSBOUNDARY WATERCOURSES AND INTERNATIONAL LAKES

Working Group on Monitoring and Assessment

Eighth meeting
Helsinki, Finland, 25–27 June 2007
Item 4 of the provisional agenda

ASSESSMENT OF THE STATUS OF TRANSBOUNDARY WATERS IN THE UNECE REGION[1]

PRELIMINARY ASSESSMENT OF TRANSBOUNDARY GROUNDWATERS IN SOUTH-EASTERN EUROPE[2]

Submitted by the Chairperson of the Working Group on Monitoring and Assessment[*]

[1] At their fourth meeting (Bonn, Germany, 20–22 November 2006), the Parties to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (the Water Convention) mandated its Working Group on Monitoring and Assessment with the assessment of transboundary rivers, lakes and groundwaters in the UNECE region. For details, please refer to documents ECE/MP.WAT/WG.2/2007/1 and ECE/MP.WAT/WG.2/2007/3.
[2] This document was prepared by Mr. John Chilton (British Geological Survey) upon the request made by the Working Group on Monitoring and Assessment at its seventh meeting.

[*] The present document was submitted late due to resources constraints in the secretariat and late submission by some countries.

GE.07-23034

Background

1. This assessment was prepared following the respective decisions taken by the fourth meeting of the Parties to the Water Convention and by the Working Group on Monitoring and Assessment (WGMA) at its fifth, sixth and seventh meetings. The overall approach to the task was established by the Groundwater Core Group of the WGMA at its meeting in Paris in April 2006 and accepted by the WGMA at its seventh meeting in Geneva in May 2006.

2. The assessment is based largely on responses to a specifically designed data collection questionnaire prepared by the Groundwater Core Group and distributed in July 2006 to national focal points. The information thus obtained has been supplemented by existing information from the previous UNECE inventory of transboundary groundwaters[3], from a regional inventory on South-Eastern Europe (SEE) undertaken by the International Network of Water-Environment Centres for the Balkans (INWEB)[4], from material presented at the INWEB transboundary groundwaters workshop held in Thessaloniki, Greece, in 2004, and from other sources such as the European Environment Agency (EEA) and the International Commission for the Protection of the Danube River (ICPDR).

Introduction

3. The assessment methodology broadly follows the guidance provided by UNECE[5] in using the DPSIR[6] framework to describe: the pressures acting on groundwaters resulting from human activities; the status in terms of both quantity and quality of groundwaters and the impacts resulting from any deterioration in status; and the responses in terms of management measures that have already been introduced and applied, need to be applied, or are currently planned. This report follows the DPSIR framework, with additional summary material for each transboundary groundwater body being provided in the annex.

4. The assessment for the SEE region has been coordinated and managed for UNECE by the British Geological Survey, and has been undertaken in collaboration with the United Nations Educational, Scientific and Cultural Organization (UNESCO), and the INWEB Chair at the University of Thessaloniki. Further support has been provided by the International Groundwater Assessment Centre (IGRAC). A workshop to review and work on the draft of the assessment was held in Thessaloniki in April 2007, with the support of UNESCO.

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[3] Almássy E and Buzás Z. 1999. Inventory of transboundary groundwaters. UNECE Task Force on Monitoring and Assessment. RIZA, Lelystad.
[4] Characteristics and State of Policies of Aquifers. 2004 UNESCO/ISARM Balkan Programme: Internationally shared aquifers in the Balkan Region. Draft report, UNESCO/INWEB/Aristotle University of Thessaloniki.
[5] UNECE, 2001. Guidelines for Monitoring and Assessment of Transboundary Groundwaters. RIZA, Lelystad.
[6] Driving Forces-Pressures-State-Impact-Responses framework.

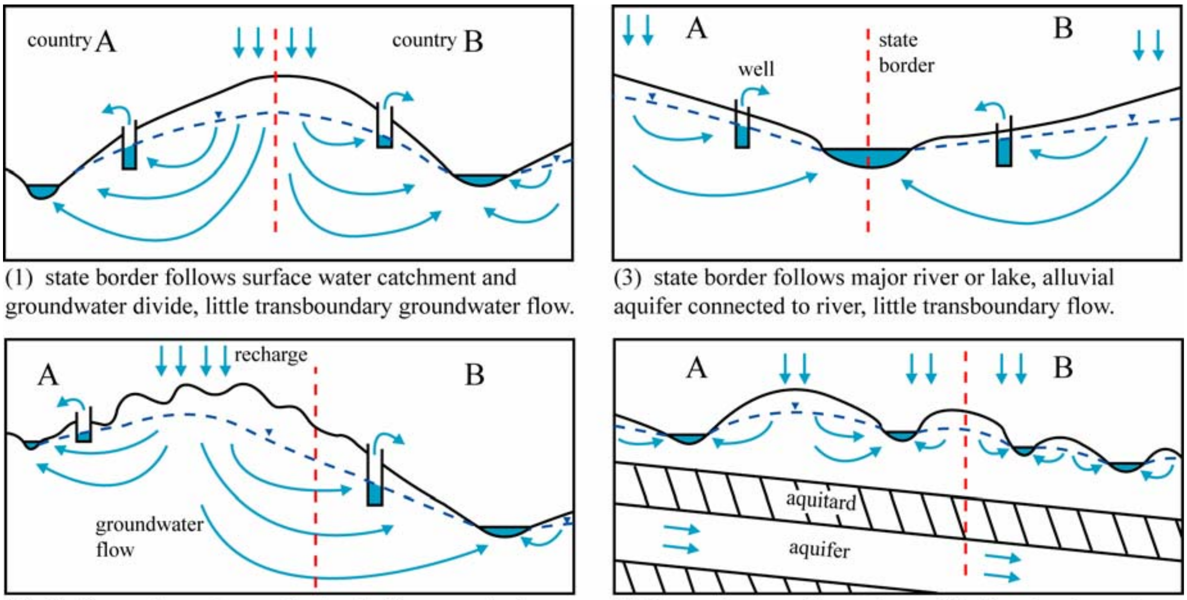
I. OVERVIEW OF TRANSBOUNDARY GROUNDWATERS

A. Scale and scope of transboundary groundwaters

5. This regional assessment covers transboundary groundwaters shared by two or more of the following countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Hungary, Moldova, Montenegro, Romania, Serbia, Slovenia, The former Yugoslav Republic of Macedonia and Turkey. Some transboundary groundwaters in the region have been identified and known for a considerable time and were noted by earlier UNECE and INWEB inventories. However, SEE has seen major conflict and political change in the last fifteen years. Aquifers and groundwaters that for many years were located within a single country are now shared between new countries. Thus, while the previous UNECE inventory recorded 23 transboundary aquifers in the region and the draft INWEB report 47, the present assessment has identified 65. Although in some cases they are not formally recognized as such by one of the countries, and it has been difficult to obtain information for some of the transboundary groundwaters, they are nevertheless included in the inventory as a foundation for future work.

6. Transboundary groundwater resources play a significant role in the SEE region. The physical environment of the region – the geology, topography and major catchments – is such as to promote the occurrence of productive aquifers. These aquifers are mainly of two distinctive main types – the limestones and dolomites of the karstic type area of the Dinaric coast and its mountainous hinterland, and the alluvial sedimentary sequences of the Danube basin, mainly those associated with the Danube River itself and its tributaries. In some locations, the alluvial sediments overlie and are in hydraulic contact with the karstic limestones, or comprise relatively thin aquifers in river or lake sediments overlying ancient metamorphic rocks as, for example, between Greece and The former Yugoslav Republic of Macedonia.

7. The occurrence of transboundary groundwaters can be characterized by the simplified conceptual sketches shown in Figure 1. The karstic aquifers tend to have recharge zones in mountainous areas on the national borders so that groundwater flow is from the border region towards each country (Figure 1, type 1) or have recharge dominantly in one country and flow into the neighbouring country (type 2). This means that, in general, they are not densely populated in the recharge areas, and have rather few pressures from human activities, and some of them cover only a few tens or hundreds of square kilometres (Table 1). Many are characterized by very large discharges from major springs such as the Blue Eye Spring in Albania (18.5 m^3/s), and the Lista Spring in Greece (1.5 m^3/s), both issuing from Mali Gjere/ Mourgana aquifer; and the St. Naum Spring in The former Yugoslav Republic of Macedonia (7.5 m^3/s) and the Tushemisht Spring in Albania (2.5 m^3/s), both issuing in the Prespa and Ohrid Lakes groundwater system.



(1) state border follows surface water catchment and groundwater divide, little transboundary groundwater flow.

(3) state border follows major river or lake, alluvial aquifer connected to river, little transboundary flow.

(2) Surface water and groundwater divides separate from state border, recharge in one country, discharge in adjacent.

(4) Large deep aquifer, recharged far from border, not connected to local surface water and groundwater.

Figure 1. Conceptual models of typical transboundary aquifers

8. In contrast, the alluvial aquifers are, by their very nature, more often in the lowland parts of the major river basins, spread on both sides of the river, which may itself form the national boundary (type 3 in Figure 1). They are often of greater areal extent and several are of sufficient size to satisfy the area criterion of 4000 m^2 for inclusion in the ICPDR assessment[7]. They are more densely populated and the activities in the river valley often impose greater water demands and provide greater pressures on both quantity and quality of the underlying groundwater. The conceptual models indicate that for both main aquifer types the degree of connection of groundwater flow to surface waters is an important consideration for their integrated management, and the assessment confirms these strong linkages for many of the transboundary groundwaters.

Table 1. Transboundary groundwaters in the SEE region

No[1]	Aquifer Name	Countries	Type	Area 1 (km^2)	Area 2 (km^2)	Notes
1	Dragonja	**Croatia**[2] - Slovenia[3]	karstic	20	99	
2	Mirna-Istra	Slovenia → **Croatia**	karstic	?	214	
3	Opatija	Slovenia → Croatia	karstic	?	302	
4	Rijeka	Slovenia → Croatia	karstic	?	460	
5	Cerknica/Kupa	Slovenia - **Croatia**	karstic	238	137	
6	Radovic-Metlika/Zumberak	Slovenia - **Croatia**	karstic	27	158	

[4] ICPDR, 2005. The Danube River Basin District - River basin characteristics, impact of human activities and economic analysis required under Article 5, Annex II and Annex III, and inventory of protected areas required under Article 6, Annex IV of the European Union (EU) Water Framework Directive (2000/60/EC), Part A – Basin-wide overview. International Commission for the Protection of the Danube River, Vienna, 18 March 2005. This publication is referred to in other meeting documents with its short title: “Danube Basin Analysis (WFD Roof Report 2004)”.

No[1]	Aquifer Name	Countries	Type	Area 1 (km^2)	Area 2 (km^2)	Notes
7	Bregana-Obrezje/Sava-Samobor	Slovenia → **Croatia**	alluvial	4	54	
8	Sutla/Bizeljsko	**Croatia** → Slovenia	alluvial	12	180	
9	Ormoz-Sredisce ob Drava/ Drava-Varazdin	Slovenia → **Croatia**	alluvial	27	768	
10	Dolinsko-Ravensko/Mura	Slovenia – (Croatia)[4]	alluvial	449	-	
11	Mura	**Hungary** – (Croatia)	alluvial	300	-	
12	Drava/Drava West	**Croatia → Hungary**	alluvial	262	97	
13	Drava East/Baranja	**Hungary → Croatia**	alluvial	607	955	
14	West Serbia/ SW Backa	**Serbia** → (Croatia)	alluvial	2672	-	
15	Srem/West Srem/Dunav	**Serbia** → (Croatia)	alluvial	627	-	
14	Posavina I/Sava	**BandH → Croatia**	alluvial	250	396	
17	Kupa	**Croatia** – *BandH*[5]	karstic	452	?	
18	Una/Plesevica	**Croatia → BandH**	karstic	1592	108	
19	Krka	BandH→ **Croatia**	karstic	85	414	
20	Glamocko/Cetina	**BandH → Croatia**	karstic	2650	587	
21	Prud & Opaca/Neretva right	**BandH → Croatia**	karstic	2120	862	
22	Trebisnjica/Neretva left	**BandH→ Croatia**	karstic	>2000	242	
23	Bileko lake	**BandH** - *Montenegro*	karstic	>1000	?	
24	Dinaric litoral (west coast)	**Montenegro** – (Croatia)	karstic	200	-	
25	Skadar/Shkodra Lake	**Montenegro - Albania**	karstic	200	450	
26	Beli Drim/Drinhe Bardhe	**Serbia → Albania**	karstic	1000	170	
27	Metohija	*Montenegro* - **Serbia**	alluvial	?	4000?	
28	Pester	*Montenegro*- **Serbia**	karstic	?	407	or >1500
29	Lim	*Montenegro* - **Serbia**	karstic	?	6-800	
30	Tara massif	**Serbia** → (BandH)	karstic	211	<100	
31	Macva-Semberija	**Serbia** - BandH	alluvial	967	>250	
32	Danube –Tisza /NE Backa	**Hungary → Serbia**	alluvial	9545	4020	
33	North and South Banat	**Romania → Serbia**	alluvial	11408	4231+ 4325	
34	Miroc & Golubac	**Serbia** - *Romania*	karstic	300	?	
35	Dacian basin	**Serbia** → *Romania*	alluvial	1-2000	?	
36	Timok/Bregovo Novo	**Serbia** - *Bulgaria*	alluvial	200	137?	
37	Stara Planina/Salasha Montana	*Bulgaria* → **Serbia**	karstic	87?	500	
38	Vidlic/Nishava & Tran	**Serbia** - *Bulgaria*	karstic	285	231?	
39	Zemen	Serbia - *Bulgaria*	karstic	>200?	200?	
40	FYROM-SW Serbia?	Serbia - FYROM	karstic	300	?	
41	FYROM-Central Serbia?	Serbia - FYROM	alluvial	100	?	
42	Tetovo-Gostivar	Serbia - FYROM	karstic	50	?	
43	Korab/Bistra-Stogovo	**Albania** - FYROM	karstic	140	?	
44	Jablanica/Golobordo	**Albania** → *FYROM*	karstic	370	?	

No[1]	Aquifer Name	Countries	Type	Area 1 (km^2)	Area 2 (km^2)	Notes
45	Mali Gjere/Mourgana Mountain	**Greece - Albania**	karstic	200	440	
46	Nemechka/Vjosa-Pogoni	**Albania - Greece**	karstic	550	350	
47	Prespes and Ohrid Lakes Lakes	**Albania, Greece** & FYROM	karstic	750	413	Includes Galicica
48	Pelagonija/Florina	**Greece** - FYROM	alluvial	607	?	
49	Gevgelija/Axios-Vardar	**FYROM** → *Greece*	alluvial	?	?	
50	Dojran Lake	**Greece** - FYROM	alluvial	190	92?	
51	Sandansky-Petrich	*Bulgaria, Greece and FYROM*	alluvial	764?	?	
52	Orvilos-Agistros/Gotze Delchev	**Greece** - *Bulgaria*	karstic	200	202?	
53	Nastan-Trigrad	*Greece-Bulgaria*	karstic	?	228?	
54	Smolyan	*Greece-Bulgaria*	karstic	?	89?	
55	Rudozem	*Greece-Bulgaria*	karstic	?	80?	
56	Erma Reka	*Greece-Bulgaria*	karstic	?	?	
57	Svilegrad Stambolo/ Orestiada/Edirne	*Bulgaria,* **Greece** and *Turkey*	alluvial	665	600	
58	Evros/Meric	*Greece-Turkey*	alluvial	?	2100?	
59	Topolovgrad massif	*Bulgaria - Turkey*	karstic	249	?	
60	Malko Tarnovo massif	*Bulgaria - Turkey*	karstic	?	?	
61	Mures alluvial fan	**Romania → Hungary**	alluvial	2200	4319	Upper & Lower
62	Somes alluvial fan	**Romania → Hungary**	alluvial	1380	976	Upper & Lower
63	Middle Sarmatian Pontian	**Romania** → *Moldova*	alluvial	11964	?	
64	Neogene-Sarmatian	**Bulgaria → Romania**	karstic	4450	2178	
65	U Jurassic - L Cretaceous	**Bulgaria → Romania**	karstic	15 476	11427	

Notes:
[1]Groundwater numbered on Figure 2.
Direction of flow between countries indicted by arrow where known.
Area 1 is first country, area 2 is second.
[2]Bold text indicates questionnaire received during this assessment.
[3]Normal text indicates material provided for Annex1, but no questionnaire received.
[4]Brackets indicates response, but groundwater not considered transboundary
[5]Italic text indicates no information received in this assessment

9. The locations of the groundwaters covered by this assessment are shown in figure 2, indicating for which of them information has been received by questionnaires from either one or both countries sharing the aquifers. From this map, the geographical distinction between the two main aquifer types is clear, and it can be seen that several of the countries of the region have much of their national borders traversed by transboundary groundwaters. Joint assessment, monitoring and management of these groundwaters are, therefore, an important issue for these countries.

Figure 2. Distribution of transboundary groundwaters in the SEE region

B. Groundwater use

10. The assessment immediately confirms the great importance of groundwater in total water usage in the SEE region. This is not surprising, given the general absence of surface waters in karstic areas and the likely quality constraints for drinking water supply on surface waters in large alluvial basins. Where clear and specific information was provided on water usage, many of the transboundary karstic groundwaters were reported to provide 60% to 80% of total water usage in their respective areas, and some of the Dinaric karstic aquifers of Bosnia, Serbia, Croatia, Montenegro and Albania as much as 90% or even 100%. The alluvial aquifers not surprisingly exhibit a greater range of use relative to surface water, with the proportion of groundwater varying from only 15% for some, up to 70% for the important Banat, Backa and Srem Pannonian Basin alluvial aquifers along the River Danube in Serbia, Croatia and Hungary. This aquifer sequence provides 100% of drinking water supply to the Vojvodina region of Serbia.

11. There are also contrasts in the main water uses between the two main aquifer types. In almost all cases where information was provided, drinking water supply is an important function, often comprising more than 50% of the total groundwater use, and generally more dominant for the karstic groundwaters. Irrigated agriculture is widely practised, using 25% to 50% of groundwater, and is more important in the alluvial aquifers. However, perhaps surprisingly, it is reported as significantly greater than 50% only for the Svilengrad alluvial aquifer shared between Bulgaria, Greece and Turkey, where it may comprise up to 90% of groundwater use.

For several of the Dinaric karstic groundwaters, irrigation is important in the narrow coastal plain areas, either directly from groundwater or from rivers and canals receiving major karstic spring discharges.

12. For many of the alluvial aquifers the main uses are comparable on both sides of the border, but for some of the karstic aquifers there is little or no demand for groundwater in the often mountainous catchments and recharge zones of the up-gradient country because of the sparse populations. This means that, for some, there is a completely different picture for use between the countries sharing the transboundary groundwater. For at least four of the karstic aquifers shared by Bosnia and by Montenegro with Croatia and for two in Albania, the large altitude drops within the karstic systems are used to divert discharging groundwater to generate hydroelectric power. The water is then used again lower down for irrigation and drinking water supply. Other widely reported regional uses include small amounts for industry, livestock production and spas. The strong linkages to rivers and lakes were confirmed, both in alluvial settings and for discharging karstic waters, and the consequent need to protect the ecosystems of these associated surface waters was emphasized.

II. PRESSURE FACTORS

13. In all types of groundwater settings, it is logical to think of the likelihood of pollution occurring as the interaction between the pollutant load that is applied or might be applied to the subsurface environment as a result of human activities, and the vulnerability of this environment to pollution. Taking the latter first, vulnerability is determined by the characteristics of the strata separating an aquifer from the land surface, in terms of how easily pollutants can reach the aquifer from the ground surface, and what capacity there is in the soil and geological strata to attenuate the pollutants. Karstic aquifers, with their lack of soil cover and rapid flowpaths leaving little time for attenuation, are almost invariably classified as highly vulnerable. Alluvial aquifers are also likely to be considered as vulnerable, unless they contain a high proportion of clay-rich material to reduce their permeability, are overlain by a protective confining layer of clays and/or the water table is relatively deep. The transboundary groundwaters of the SEE region are likely, therefore, to be highly vulnerable to pollution if the pressure factors outlined below produce significant loadings of mobile and persistent pollutants.

A. Agriculture

14. Globally, agricultural activities provide some of the major pressures on freshwater systems in terms of both quantity and quality. Some 70% of total global water use is for agriculture. Within Europe, 44% of water abstraction is for irrigation, although this is clearly greater in the dry southern countries than in the north and west of the region. Where this heavy usage depends on abstraction of groundwater, severe and sometimes irreversible problems can result[8]. Moreover, intensive cultivation, both with and without irrigation, uses heavy applications of fertilizers and pesticides. Intensive cultivation and animal production can produce increased levels of nutrients and pesticides in groundwaters from infiltrating surface run-off from agricultural land, leaching from the soil through the unsaturated zone, and sometimes from return waters from irrigation schemes. The consequent pollution of freshwater systems is well

[8] Foster S S D and Chilton P J. 2003. Groundwater, the processes and global significance of aquifer degradation. *Phil. Trans. R. Soc. London* B, 358, 1957–1972.

documented from many parts of the world, and in Europe has been one of the main factors behind the adoption by the EU of the Water Framework Directive and Groundwater Directive.

15. Agriculture is indeed an important pressure factor within the SEE region. As mentioned above, many aquifers, especially some of the larger alluvial ones, are used to support irrigated agriculture. This also implies application of fertilizers and pesticides, but it may be that the recent conflicts and political changes and economic difficulties in the region have suppressed both the usage of water for irrigation and the application of fertilizers and pesticides. Water abstraction has indeed been stable or declined slightly in the SEE region in the past decade[9]. With the expected economic growth and the need to increase crop production, agricultural pressure factors are expected to become more important.

16. Livestock watering is reported as a minor but widespread water use in both karstic and alluvial areas. Animal production, however, may take radically different forms in the two; intensive livestock production facilities in the major plains and valleys and distributed grazing in the mountainous areas. Confirmation of these pressures may come from pollution by pathogens and nitrogen.

B. Industry

17. Overall, industrial pressure factors for transboundary groundwaters in the region appear to be rather limited. Groundwater usage by industry is modest, and even where mentioned is usually less than 25% of the total. The presence of heavy metals and organic compounds from industries was reported, including pyrallene from the aluminium processing plant close to Podgorica. The close linkages between surface water and groundwater were illustrated when, in December 1983, high phenol concentrations were observed in the Ibar and Zapadna Morava Rivers. The source was identified as the coal gasification plant at the Obilic mine on the Sitnica tributary in Kosovo. The associated alluvial aquifer was found to be polluted as far as the confluence with the Danube[10], and the municipal supply to Kraljevo was threatened for a considerable time. As for agriculture, however, the recent political changes and economic situation may have resulted in the decline of industrial activities and the closure of manufacturing plant.

18. Where groundwater pollution problems do occur, they are likely to be localized and originate from dispersed small and medium-sized industries, rather than from large sites or complexes of large undertakings. The latter are in any case more likely to be capable of installing pollution abatement technologies and controlling pollution at the source. In addition, these larger enterprises voluntarily carry out self-monitoring in an attempt to demonstrate their compliance with environmental standards. Smaller and medium-sized industries are less able to do this and, where they have been closed and abandoned, it may be difficult to apportion responsibility for monitoring and management of the legacy of pollution of sites and the underlying groundwater.

[9] European Environment Agency.
[10] Filipovic B, Vujasinovic S and Stevanovic Z. 1994. Some general aspects of groundwater protection in Yugoslavia – Symposium, Impact of Industrial Activities on Groundwater Quality, 196–204.

C. Sewerage and waste disposal

19. Disposal of municipal and domestic wastewater is a pressure factor for groundwater where (a) the wastewater is disposed of directly into the ground by septic tank systems or completely untreated; (b) where collected wastewater and/or stormwater drainage is disposed of directly into the ground; or (c) where such wastewater carried by surface water systems infiltrates into the underlying groundwater. All three scenarios are likely to occur in the region, and could lead to pollution of groundwater by pathogens, organic compounds and nutrients.

20. Septic tanks systems are an important or even dominant method of domestic effluent disposal for dispersed rural populations and small villages and towns throughout the region. These installations provide local point sources of pollution with pathogens, chloride and nutrients and, where the population is dense, can provide measurable impacts on groundwater quality. They are, however, unlikely by themselves to produce transboundary impacts.

D. Mining

21. Mining activity needs economically viable and technically feasible mineral deposits provided by the underlying geological strata. In general, valuable mineral deposits are rarer in karstic areas than other rock types and also not common in the alluvial sediments of major river basins, and pressures from mining were not, therefore, anticipated to be a regional problem. Local pressures from the mining industry were reported for the Timok alluvial aquifer shared between Serbia and Bulgaria. The mining of copper from the underlying rocks at Bor polluted the Borska tributary and the Timok River with its associated alluvial aquifer. Near Podgorica in Montenegro, the large aluminium plant referred to above contributes to an increase of aluminium in Shkodra Lake (a Ramsar site) and possibly also in the karst and alluvial groundwater. Quarrying for limestone is likely to be a localised pressure factor in the karstic areas, and open pit gravel extraction, with subsequent use of the water-filled pits for recreational purposes was reported as a pressure factor in Hungary and Croatia.

E. Solid waste disposal

22. Disposal of solid municipal and industrial waste was not widely reported as a pressure factor, although occasionally mentioned as a source of heavy metals and organic pollutants. Landfills generally provide local pressure factors, and may be important in the narrow coastal plain of Croatia.

F. Tourism and recreation

23. Parts of the region have long been recreational and tourist destinations for visitors from Eastern Europe and the countries of the former Soviet Union. Following the recent political changes, closer links with Western Europe, and for some countries of the region membership of the EU, are likely to greatly broaden the catchment area from which visitors will come enjoy the sights of the region. This is already being seen in major winter sports and summer recreation developments in Romania, Bulgaria, Slovenia and Serbia, by widespread reconstruction, and by new development, for example on the Bulgarian and Croatian coasts. The use of mountain areas (the recharge areas of many transboundary groundwaters) and their watercourses for recreational

purposes is increasing. The impact of recreation on mountain ecosystems, especially rivers and lakes but also karstic groundwater systems needs to be monitored and managed. National Park areas are especially vulnerable to such pressures, and may need specific protection in this respect. One which is particularly vulnerable to pollution is the National Park of Mali Thate/Galicica which separates the Ohrid and Prespa Lakes and is shared by Albania, Greece and The former Yugoslav Republic of Macedonia.

G. River regulation

24. Management of surface water discharges by river regulation is normally thought of as a pressure factor for surface waters. However, the construction of dams for hydroelectric power schemes or major structures for flood control, irrigation diversions or to facilitate river transport can modify river flows and river bed morphology sufficiently to affect groundwater flow, discharge and recharge. The silting up of reservoirs can also impact on downstream aquifers. Although outside the region, the Gabcikovo scheme on the Danube between Slovakia and Hungary has a major impact on groundwater, and through this on nearby wetland ecosystems supported by the adjacent alluvial aquifers. Major upstream reservoir construction in one country can create pressures on groundwater further down the surface water catchment where the aquifer is not itself transboundary. The Mesta/Nestos River basin between Bulgaria and Greece is a case where major reservoir construction has modified the hydrological and sedimentation regime so much that it has a major negative impact on the downstream alluvial aquifer of the delta, although there is no actual transboundary aquifer.

III. PRELIMINARY EVALUATION OF STATUS, TRENDS AND IMPACTS

25. From the earlier work by UNECE[11] and INWEB[12], and the discussion of pressure factors above, the most important issues for the status and trends of transboundary groundwater quality in the SEE region were expected to be nutrients, pathogens and organic compounds, and saline intrusion in the coastal regions. Major deterioration of status of groundwater quantity and associated impacts were not anticipated from the previous work and from the assessment of pressure factors. In general, the draft preliminary assessment confirms this picture, but with some local causes for concern.

A. Groundwater quantity

26. From a groundwater quantity point of view, the most common problems reported were increased pumping lifts and reduction in boreholes yields, or the drawing of polluted water into the aquifer. The latter was mostly in the form of saline intrusion in coastal aquifers. The most widespread and severe saline intrusion and salt water upconing problems occur as expected in the Dinaric littoral aquifers of Croatia, Montenegro and Slovenia. Some evidence of degradation of ecosystems was also reported. Information on groundwater quantity problems is summarized in Table 2 and information for each aquifer is provided in the annex 1.

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[11] See footnote 3.
[12] See footnote 4.

Table 2. Summary of reported groundwater quantity problems in the SEE region

Problem	**Increasing scale of problem** →			
	1. Local and moderate	2. Local but severe	3. Widespread but moderate	4. Widespread and severe
Increased pumping lifts or costs	•••••••••••	•••••		•••
Reduction of borehole yields	•••••••	••••	•••••	
Reduced baseflow and springflow	•••••••••	•••	••	
Degradation of ecosystems	••••••••	••	••••••	•••
Sea water intrusion		•		••
Salt water upconing				•••
Polluted water drawn into aquifer	•••••••	••	•••	••••
Land subsidence	•			
Other				
Use for energy production		•		
Notes: • karstic aquifer • alluvial aquifer				

27. Each spot represents where a box was specifically scored for each transboundary groundwater, distinguishing between the alluvial and karstic aquifers. However, it should be noted that a complete lack of groundwater quantity problems was reported for 11 of the transboundary groundwaters in the region. For some of these, it was explicitly stated that there were no problems, but for others it is unclear whether this is the case or whether the question was left unanswered, and further clarification is required.

28. Trends of groundwater level decline were reported for some of the alluvial transboundary groundwaters in the region. Declines of 0.1 m/yr and locally 0.5 m/yr were reported by Serbia for the Backa aquifer shared between Serbia and Hungary. Similar declines of 0.2 m/yr were reported by Serbia for the West Srem shared with Croatia and of up to 0.6 m/yr locally within the Banat aquifer shared with Romania. The latter local effects were confirmed by the response from Romania. For the White Drin (Beli Drim) groundwater in Serbia, declines of up to 0.3 m/yr were reported, but these do not affect the neighbouring Drini Bardhe groundwater in the lower part of the Drin River basin in Albania because the aquifers are not in direct hydraulic connection. For the Svilengrad/Stambolo/Orestiada aquifer shared between Greece, Bulgaria and Turkey, annual groundwater abstraction was reported to be significantly greater than annual replenishment, although there was no report of declining groundwater levels. Widespread but moderate problems of reduced baseflow and springflow and associated degradation of ecosystems were reported by Greece for the Dojran Lake aquifer. Moreover, declining inflow has resulted in reduction of lake level and area, with 75% of the volume of water reported as having been lost between 1988 and 2002. Groundwater abstraction to replenish the lake has been partially successful, and has been assisted by recent wet years.

29. Reports of transboundary impacts caused by groundwater quantity problems are rare in the region. The heavy water demand for irrigation in the Svilengrad/Stambolo/Orestiana aquifer shared between Greece, Bulgaria and Turkey was reported by Greece to have transboundary impacts on groundwater levels. Transboundary impacts in terms of groundwater quantity were also reported by The former Yugoslav Republic of Macedonia for the Bitolsko and Gevgelija aquifers, and by Serbia for the Banat and Backa aquifers, although none of these appear large.

B. Groundwater quality

30. In general, both alluvial and karstic aquifers have reported groundwater quality problems. Of the questionnaires received, only two specifically reported that there were no groundwater quality issues at all, and several more were incomplete. One problem specific to the alluvial aquifers is that of arsenic of natural origin. Concentrations of up to 300 µg/l in the Backa, Banat and Baranja aquifers shared by Serbia, Hungary, Romania and Croatia, respectively, exceed the drinking water standard of 10 µg/l and affect the use of this groundwater for potable supply. In some locations, expensive arsenic removal or importation water either directly for supply or for dilution of local high arsenic contents is needed.

31. Groundwater quality problems in the SEE region are summarized in Table 3, using a similar approach to that for quantity presented in Table 2. Each spot represents a reported quality problem. The picture is, however, incomplete because some responses to the questionnaire did not score quality problems on the scale of 1 to 4 as requested. The most commonly reported anthropogenic groundwater quality problems are elevated nitrate concentrations and the presence of pathogens. These are mostly reported as local and of only moderate severity. The former are reported to originate from both agriculture and waste disposal; the latter mainly from human waste but occasionally from livestock. The questionnaire did not ask for detailed information on monitoring programmes or monitoring results, and the few indications of concentration ranges provided indicate some local nitrate concentrations above drinking water standards in the Sarmatian and Lower Cretaceous aquifers shared by Bulgaria and Romania.

Table 3. Summary of reported groundwater quality problems in the SEE region

Problem	**Increasing scale of problem** →			
	1. Local and moderate	2. Local but severe	3. Widespread but moderate	4. Widespread and severe
Salinization or saline intrusion	•		•••	••
Nitrogen	••••••••••••	••••	••••••	
Pesticides	•••••••••••			
Heavy metals	••••	•••••	•	•
Pathogens	••••••••••••••	••••	••	
Industrial organic compounds	•••	•	•	•
Hydrocarbons	•••	•	•	
Other				
Arsenic			••••	•••••
Other natural salts and minerals	•		••••	
Organic matters	••	•	•••	••
Notes: • karstic aquifer • alluvial aquifer				

32. The most severe groundwater quality problems are probably caused by saline intrusion on the Adriatic coast. The Timok alluvial aquifer is affected by widespread pollution by heavy metals and industrial organic compounds originating from the mining industry. There are few reported instances of transboundary impacts of pollution of groundwater. These include the Svilengrad and Gevgelija aquifers, where intensive agriculture with irrigation has also caused transboundary quantity impacts, and the Una/Plesevica and Miroc/Golubac aquifers where waste

disposal has produced negative transboundary impacts on groundwater quality. In the Lim aquifer, pollution in the upper part of the river is reported to cause groundwater quality problems lower in the basin.

IV. PRELIMINARY EVALUATION OF MANAGEMENT RESPONSES

33. The DPSIR framework (see para. 3) also considers responses in the context of management measures already being applied or required in the future. The emerging preliminary evaluation of management responses appears to be realistic, and broadly reflects modest rather than unduly optimistic views of the current situation in the region. Few responses considered management measures to be already implemented and effective.

34. In the management of groundwater resources, some of the Bulgarian responses considered groundwater abstraction management by licensing to be effective, but for most such measures need to introduced, or implemented better where they were being used. Similarly, increased efficiency of groundwater usage as a management measure was occasionally reported as being used but needing improvement, and more often not yet used but recognised as necessary. In almost all cases where existing groundwater quantity monitoring is undertaken, it was recognised as inadequate and in need of improvement, and many transboundary groundwaters were reported as needing monitoring to be introduced.

35. For groundwater quality, the most widely reported tasks needed or needing improvement were the treatment of urban and industrial wastewaters, and in several instances these were currently planned. Protection zones for public water supplies were reported as being used, but needing improvement, or needing to be introduced. Delineation of protection zones is, however, particularly problematic for karstic groundwaters. As for groundwater quantity, monitoring of groundwater quality was widely recognised as needing improvement, and occasionally not yet implemented at all.

36. The Water Framework Directive and Groundwater Directive will require EU Member States (and their neighbours which also decide to do so) to integrate groundwater into river basin management; and this is reflected in the response that such integration is planned. While the ICPDR is the dominant water management institution in the SEE region, and is recognized in the responses as contributing to the management of water resources, it is generally reported as used but needing improvement. Other specific bilateral agreements on cooperation in the field of water management are those between Croatia and Hungary and between Croatia and Bosnia and Herzegovina. Most responses, however, refer to the need for transboundary agreements to facilitate the management of transboundary groundwaters.

V. CONCLUSIONS

37. The geology and physical conditions are such that highly productive karstic and alluvial aquifers occur widely in the region. The former are located mainly on the Dinaric coast and its mountainous hinterland, the latter in the plains of the lower Danube basin. Both are, by their mode of occurrence, more or less strongly connected to the associated surface water systems, and by their characteristics highly vulnerable to pollution.

38. The assessment confirms that groundwater is important for all water uses in the region, providing in excess of 50% of drinking water supplies in (to be completed) of the (to be completed) groundwaters, and 100% in (to be completed)

39. The ICPDR is an established and important driver of and facilitator for collaboration in water management in the region, and widely referred to as such. However, there is a clear need for bilateral agreements to facilitate the joint identification, monitoring, data exchange and management of transboundary groundwaters, particularly outside the Danube Basin.

40. Overall, the quantity and quality status of transboundary groundwaters in the SEE region is good, with the exception of a small number of potential hot spots identified in this assessment. However, this may reflect a 10- to15-year period in which human activities causing pressure factors have been suppressed by the regional economic and political situation. However, demographic growth and economic development is beginning an upward trend, and agricultural expansion and intensification and increased tourism in particular are likely to provide increasing pressure factors for both quantity and quality status. Moreover, the impact on water resources in the region of climate change, particularly the effects on rainfall, recharge, floods and droughts and surface-water groundwater interactions, remains unpredictable.

41. The assessment confirms the expected general scarcity of data on transboundary groundwaters in the region. While there is some existing data, most of this originates from short-term, project-based activities, and there is an urgent need to develop systematic monitoring of groundwater quantity and quality in the region.

<u>Annex</u>

FACTS AND FIGURES ON TRANSBOUNDARY GROUNDWATERS IN SEE

No. 1 Aquifer: Secovlje-Dragonja/Dragonja		**Shared by: Slovenia and Croatia**
Type 5, Predominantly limestones, weak to medium links to surface waters Groundwater flows from Slovenia to Croatia and Slovenia to Croatia Part of the Istra system		Mediterranean Sea Basin Border length (km): 21?
	Slovenia	Croatia
Area (km²)	20	99
Water uses and functions	Provides part of regional drinking water supply for the town of Piran	Drinking water supply
Pressure factors	Tourism and transport	Communities
Problems related to groundwater quantity	None	None
Problems related to groundwater quality	Pollution from urbanisation and traffic	Local, moderate pathogens
Transboundary impacts	None	None
Groundwater management measures	Pumping station disconnected from water supply system	Existing protection zones
Status and what is most needed	Delineation and enforcement of drinking water protection zones	Agreed delineation of transboundary groundwater and monitoring
Future trends and prospects		
GWB identification	GWS ID 50811	HR 502
Notes		Transboundary groundwater under consideration but not approved

No. 2 Aquifer: ?[13]/Mirna-Istra		**Shared by: Slovenia and Croatia**
Type 5, Cretaceous karstic limestones, weak to medium links to surface water systems, groundwater flow from Slovenia to Croatia Part of the Istra system		Mediterranean Sea basin Border length (km): 26?
	Slovenia	Croatia
Area (km²)	?	214
Water uses and functions	? Drinking water supply	Drinking water supply
Pressure factors	Sparsely populated	None?
Problems related to groundwater quantity	-	None
Problems related to groundwater quality	-	-
Transboundary impacts	-	-
Groundwater management measures	-	Existing protection zones
Trends and future prospects	-	
GWB	Not identified	HR 507, HR 516
Status and what is most needed		
Notes	Not clear which groundwater systems in both countries correspond to each other; delineation of transboundary groundwaters by common research and bilateral expert group decision is needed	Transboundary groundwater under consideration, but not approved

[13] The question mark "?" indicates the missing data or data that require further clarification

No. 3 Aquifer: ?/Opatija		**Shared by: Slovenia and Croatia**
Type ? Predominantly limestones, groundwater flows from Slovenia to Croatia		Mediterranean Sea Basin Border length (km): 21?
	Slovenia	Croatia
Area (km²)	?	302
Water uses and functions	Drinking water	Drinking water supply
Pressure factors	Main highway from Trieste to Rijeka – possibility of accidental spillage	None?
Problems related to groundwater quantity	-	None
Problems related to groundwater quality	-	Local problems with salinity
Transboundary impacts	-	-
Groundwater management measures	Protection zones of karst source Rizana	Existing protection zones
Status and what is most needed		Agreed delineation of transboundary groundwater systems and monitoring
GWB identification	Not identified	HR 515
Future trends and prospects	-	-
Notes	Not clear which groundwater systems in both countries correspond to each other; delineation of transboundary groundwaters by common research and bilateral expert group decision is needed	Transboundary groundwater under consideration, but not approved

No. 4 Aquifer: ?/Rijeka		**Shared by: Slovenia and Croatia**
Type? Predominantly limestones Groundwater flows from Slovenia to Croatia Part of the Istra system		Mediterranean Sea basin Border length (km): 36?
	Slovenia	Croatia
Area (km²)	?	460
Water uses and functions	Local drinking water supply	Drinking water supply
Pressure factors	Main road from Ljubljana to Rijeka – possible accidental spills	None
Problems related to groundwater quantity	-	None
Problems related to groundwater quality	-	None
Transboundary impacts	-	None
Groundwater management measures		Existing protection zones of the city of Rijeka
Status and what is most needed		
GWB identification		HR 517, HR 518
Future trends and prospects		
Notes	Not clear which groundwater systems in both countries correspond to each other; delineation of transboundary groundwaters by common research and bilateral expert group decision is needed	Transboundary groundwater under consideration, but not approved

No. 5 Aquifer: Cerknica/Kupa		**Shared by: Slovenia and Croatia**
Type 5, Triassic and Cretaceous limestones and dolomites, weak to medium links to surface water systems, groundwater flow from Croatia to Slovenia and Slovenia to Croatia		Black Sea basin Border length (km): 32
	Slovenia	Croatia
Area (km^2)	238	137
Water uses and functions	Local drinking water supply, first karst spring of the Ljubljanica River (a karstic river with 7 surface and 6 underground stretches)	Drinking water supply
Pressure factors	None, sparsely populated, forested with some extensive agriculture	None, very scattered population
Problems related to groundwater quantity	None	None
Problems related to groundwater quality	None, good chemical status	Occasional bacteriological pollution
Transboundary impacts	None for quantity or quality	None
Groundwater management measures	None	Existing protection zones
Trends and prospects		
GWB identification	GWS ID 11823	HR 343 and HR 344
Status and what is most needed	Not t risk. It is unclear which groundwater systems in the two countries correspond to each other; delineation of transboundary groundwater systems needs common research and bilateral decision to propose a transboundary groundwater, if appropriate	Agreed delineation of transboundary groundwaters, and monitoring
Notes		Transboundary aquifer under consideration, but not approved

No. 6 Aquifer: Radovic-Metlika/Zumberak		**Shared by: Slovenia and Croatia**
Type 5, Triassic dolomites, weak to medium links with surface water systems, groundwater flow from Croatia to Slovenia		Black Sea basin Border length (km): 12?
	Slovenia	Croatia
Area (km^2)	27	158
Water uses and functions	Drinking water supply to the town of Metlika (captured source Metliski Obrh)	Dominantly drinking water supply
Pressure factors	Agricultural activities	None
Problems related to groundwater quantity	None	None
Problems related to groundwater quality	Excessive pesticide content	None
Transboundary impacts	None for quantity or quality	None
Groundwater management measures	None	Need to establish protection zones
Trends and future prospects		
GWB identification	GWS ID 22931	HR 265
Status and what is most needed	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, and monitoring
Notes		Transboundary aquifer under consideration, but not approved

No. 7 Aquifer: Bregana-Obrezje/Sava-Samobor		**Shared by: Slovenia and Croatia**
Type 5, Quaternary alluvial sands and gravels, 5-10 m thick, strong link to surface waters of the Sava River, groundwater flow from Slovenia to Croatia		Black Sea Basin Border length (km): 7
	Slovenia	Croatia
Area (km^2)	4	54
Water uses and functions	Local drinking water supply	Dominantly drinking water, and some industry
Pressure factors	Surface water hydroelectric power schemes and associated river regulation on the Sava, transport routes	Agriculture, waste disposal from communities extraction of river gravel and river regulation
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		
GWB identification	GWS ID 12417	HR 188 and HR 189
Status and what is most needed	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, and monitoring
Notes	Very small part in Slovenia	Transboundary aquifer under consideration, but not approved Provides approx 1 m^3/s supply to Zagreb by bank filtration

No. 8 Aquifer: Bizeljsko/Sutla		**Shared by: Slovenia and Croatia**
Type 5, Triassic dolomites, weak links to surface water systems, groundwater flow from Croatia to Slovenia		Black Sea Basin Border length (km): 4?
	Slovenia	Croatia
Area (km^2)	180	12
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	None
Future trends and prospects		
GWB identification	GWS ID 12415	HR 073 and HR 078
Status and what is most needed	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 monitoring
Notes	Area uncertain – possibly only part of the Bizeljsko groundwater system is relevant	Transboundary aquifer under consideration, but not approved

No. 9 Aquifer: Ormoz-Sredisce ob Dravi/Drava-Varazdin		**Shared by: Slovenia and Croatia**
Type 5, Quaternary sands and gravels, average thickness 5-10 m, strong links to surface water systems groundwater flow from Slovenia to Croatia		Black Sea basin Border length (km): 26?
	Slovenia	Croatia
Area (km²)	27	768
Water uses and functions	Drinking water supply	Drinking water supply
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	
Groundwater management measures	None	
Future trends and prospects		
GWB identification	GWS ID 32716	HR 037 and HR 038
Status and what is most needed	-	Agreed delineation of transboundary groundwaters, and monitoring
Notes		Transboundary aquifer under consideration, but not approved

No. 10 Aquifer: Dolinsko-Ravensko/Mura?		**Shared by: Slovenia and Croatia**
Type? 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 Border length (km):
	Slovenia	Croatia
Area (km²)	449	-
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	-
Future trends and prospects		
GWB identification	GWS ID 42813	None
Status and what is needed	At risk Delineation of transboundary groundwater systems needs common research and bilateral expert group decision to propose a transboundary groundwater, if appropriate	-
Notes:	Probably only part of the Dolinsko-Ravensko groundwater system is relevant	According to existing data, no transboundary groundwater is recognised

No. 11 Aquifer: Mura		**Shared by: Hungary and Croatia**
Type 3/4, Quaternary alluvial aquifer of sands, silts and gravels generally only 5-10 m thick but up to 30 m in Hungary and 150 m in Croatia, strong links to surface waters of the Mura River, groundwater flow towards the river Groundwater provides 90% of total water supply in the Croatian part and >80% in Hungary		Black Sea Basin Border length (km): 52
	Hungary	Croatia
Area (km^2)	300	
Water uses and functions	>75% drinking water, <25% each for industry, irrigation and livestock, maintaining baseflow and support of ecosystems	-
Pressure factors	Agriculture and settlements (fertilisers, pesticides, sewage, traffic), groundwater abstraction	-
Problems related to groundwater quantity	Local and moderate (at settlements) increased pumping lifts, reduced yields and baseflow, degradation of ecosystems	-
Problems related to groundwater quality	Local but severe nitrate from agriculture, sewers and septic tanks at up to 200 mg/l, pesticides at up to 0.1 µg/l	
Transboundary impacts	None	
Groundwater management measures	Groundwater abstraction management used and effective, transboundary institutions, monitoring, public awareness, protection zones, treatment need improvement, vulnerability mapping, regional flow modelling, good agricultural practices and priorities for waste water treatment, integration with river basin management need to be introduced	
Status and what is most needed	? Evaluation of the utilisable resource	
Future trends and prospects	Exporting drinking water	
Notes	(Total groundwater body is 1933 km^2)	According to existing data, no transboundary groundwater is recognised

No. 12 Aquifer: Drava/Drava West		**Shared by: Hungary and Croatia**
Type 3/4, Quaternary alluvial aquifer of sands and gravels, of average thickness 10 m and maximum 70 m, medium to strong links to surface waters, groundwater flow from Hungary to Croatia, but mainly towards the border river.		Black Sea Basin Border length (km): 31
	Hungary	Croatia
Area (km^2)	262	97
Water uses and functions	>75% drinking water, <25% each for irrigation, industry and livestock	Local drinking water supply
Pressure factors	Agriculture (fertilisers 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 modelling, good agricultural practices and priorities for waste water treatments integration to the river basin management, protection of open pit areas need to introduced	None
Future trends and prospects	Evaluation of the utilisable resource	
GWB identification		HR 039
Status and what is most needed	? Exporting drinking water	Agreed delineation of transboundary groundwaters, and monitoring
Notes		Transboundary aquifer under consideration, but not approved

No. 13 Aquifer: Baranja/Drava East		**Shared by: Hungary and Croatia**
Type 4, Pleistocene and Holocene fluvial sands and gravels average thickness of 50 – 100 m and up to 200 m, weak to medium links to surface water systems, groundwater flow from Hungary to Croatia Groundwater provides 90% of total supply in the Croatian part and >80%in the Hungarian part		Black Sea Basin Border length (km): 67
	Hungary	Croatia
Area (km^2)	607	955
Water uses and functions	>75% drinking water, >25% each for irrigation, industry and livestock, maintaining baseflow and spring flow	Drinking water supply
Pressure factors	Agriculture (fertilisers 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 at up to 0.1 µg/l, widespread but moderate arsenic at up to 50 µg/l	Naturally-occurring iron at 1-4 mg/l and arsenic at up to 500 µg/l
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 modelling, better agricultural practices, priorities for wastewater treatment, integration with river basin management and arsenic removal need to be applied	Vulnerability mapping, then good agricultural practices and priorities for wastewater treatment, integration into river basin management, and need to establish protection zones
Future trends and prospects	Evaluation of the utilisable resource, status of groundwater quality	
GWB identification		HR 042 and HR 043
Status and what is most needed	? Joint monitoring (mainly quantitative) and joint modelling is needed	Agreed delineation of transboundary groundwaters, and monitoring
Notes		Transboundary aquifer under consideration, but not approved

No. 14 Aquifer: West Serbia - South West Backa		**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, groundwater flow from Serbia to Croatia Groundwater is about 70% of total water use in the Serbian part		Black Sea Basin Border length (km):
	Serbia	Croatia
Area (km^2)	2672	-
Water uses and functions	50-75% drinking water, <25% each for irrigation, industry and livestock	-
Pressure factors	Abstraction	-
Problems related to groundwater quantity	Local increase in pumping lifts and reduction in borehole yields	-
Problems related to groundwater quality	Widespread naturally-occurring arsenic at 10-80 µg/l. Local ammonium and pathogens from sanitation	No data, but probably naturally-occurring iron
Transboundary impacts	None for quantity or quality	-
Groundwater management measures	Existing quantity and quality monitoring need to be improved, other management measures needed	-
GWB identification	CS_DU2	
Status and what is most needed	Current status is reported as poor, possible quantitative risk, no qualitative risk	
Notes	Part of the Pannonian Basin.	According to existing data, no transboundary groundwater is recognised
Future trends and prospects		

No. 15 Aquifer: Srem/West Srem/Dunav		**Shared by: Serbia and Croatia**
Type 3, Sequence of 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 S and SW direction Groundwater provides about 70% of total supply in the Serbian part		Black Sea Basin Border length (km):
	Serbia	Croatia
Area (km^2)	627 / >3500	
Water uses and functions	50-75% drinking water, <25% each for irrigation, industry and livestock	-
Pressure factors	Groundwater abstraction, agriculture, industry	-
Problems related to groundwater quantity	Local and severe increased pumping lifts and reduction of borehole yields	-
Problems related to groundwater quality	Local, moderate 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	-
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	-
Trends and future prospects		
Status and what is most needed	?	-
Notes:	Two responses from Serbia	According to existing data, no transboundary groundwater is recognised

No. 16 Aquifer: Sava/Posavina I?	**Shared by: Croatia and Bosnia and Herzegovina**	
Type 4, Quaternary alluvial sands, gravels, clays and marls averaging around 100 m thick in Croatia, less in BiH, weak to medium links to surface water systems, groundwater flow generally from south to north Groundwater is 100% of total water use in the Bosnian part	Black Sea Basin Border length (km): 85	
	Bosnia and Herzegovina	Croatia
Area (km^2)	250	396
Water uses and functions	Dominantly drinking water, smaller amounts (<25% each) for industry and livestock	Drinking water supply
Pressure factors	Wastewater, industry and agriculture	Agriculture
Problems related to groundwater quantity	None	None
Problems related to groundwater quality	None	Naturally-occurring iron and managanese
Transboundary impacts	None	No data
Groundwater management measures	Sava Commission. 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
Future trends and prospects		
GWB identification	TBGWB 14 ?	HR 243 and HR 244
Status and what is most needed	?	?
Notes	In lower aquifer (depth 90 to 115 m), naturally-occurring iron is <0.7 mg/l	Transboundary aquifer under consideration, but not approved

No. 17 Aquifer: Kupa	**Shared by: Bosnia Herzegovina and Croatia**	
Type 5, Triassic and Cretaceous karstic limestones and dolomites, strong links to surface water systems, groundwater flow from …… to …..	Black Sea Basin Border length (km): 130	
	Bosnia and Herzegovina	Croatia
Area (km^2)	?	452
Water uses and functions	No data	Dominantly drinking water and HEP
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	_	Need to establish protection zones
Future trends and prospects		
GWB identification		HR 361
Status and what is most needed	_	Agreed delineation of transboundary groundwaters, and monitoring
Notes	Possible transboundary aquifer should be considered	Transboundary aquifer under consideration, but not approved

No. 18 Aquifer: Una/Plesevica		**Shared by: Bosnia and Herzegovina and Croatia**
Type 5, Thick Palaeolithic, Mesozoic and Cenozoic limestones and dolomites in hydraulic contact with overlying alluvial sediments, strong links with surface waters, flow from Croatia to BiH towards the Una River.		Black Sea Basin Border length (km): 130
	Bosnia and Herzegovina	Croatia
Area (km^2)	108	1592
Water uses and functions	>75% to support ecosystems and fishing, 25-50% of abstraction is for drinking water supply	Dominantly drinking water supply
Pressure factors	Solid waste disposal	Sewage from 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	Nitrogen and pathogens
Transboundary impacts	Yes, for quality only	Sinkholes in BiH 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 Korenički Izvor, Stipinovac and Mlinac
Future trends and prospects		-
GWB identification		HR 359 and HR 360
Status and what is most needed	?	Agreed delineation of transboundary groundwaters, and monitoring
Notes		Transboundary aquifer under consideration, but not approved.

No. 19 Aquifer: Krka		**Shared by: Bosnia and Herzegovina and Croatia**
Type 5, Cretaceous karstic limestone, strong links to surface water system, groundwater flow from BiH to Croatia		Mediterranean Sea Basin Border length (km): 42
	Bosnia and Herzegovina	Croatia
Area (km^2)	85	414
Water uses and functions	>95% to support ecosystems, <5% of abstraction is for drinking water supply	Drinking water supply and hydroelectric power
Pressure factors	Solid waste disposal	Population in communities and industry
Problems related to groundwater quantity	Reduced springflow and ecosystem degradation	None
Problems related to groundwater quality	Polluted water locally drawn into the aquifer	Occasionally, local and moderate pathogens
Transboundary impacts	No data (possibly for quality only)	Sinkholes in BiH with transboundary effects in Croatia
Groundwater management measures	Quantity and quality monitoring need to be improved, as do abstraction control, protection zones and wastewater treatment	Need to establish protection zones
Future trends and prospects		
GWB identification		HR 546, HR 547 and HR 548
Status and what is most needed	Not at risk	Agreed delineation of transboundary groundwaters, and monitoring
Notes		Transboundary aquifer under consideration, but not approved

No. 20 Aquifer: Cetina		**Shared by: Bosnia Herzegovina and Croatia**
Type 5, Palaeolithic, Mesozoic and Cenozoic karstic limestones of average thickness 500 m and maximum 1000 m, in hydraulic connection with recent sediments, groundwater flow from BiH to Croatia towards the Cetina River, strong links to surface water system		Mediterranean Sea Basin Border length (km): 70
	Bosnia and Herzegovina	Croatia
Area (km^2)	2650	587
Water uses and functions	Up to 50% for HEP, smaller amounts for drinking water, irrigation, industry, mining and livestock	Drinking water supply
Pressure factors	Solid waste disposal, wastewater, agriculture, industry	None
Problems related to groundwater quantity	Widespread but moderate degradation of ecosystems, and polluted water drawn into the aquifer	None
Problems related to groundwater quality	Local and moderate nitrogen, pesticides, heavy metals, pathogens, organics, hydrocarbons	Local and moderate pathogens
Transboundary impacts	None for quantity or quality	Sinkholes in BiH with transboundary effects in Croatia
Groundwater management measures	Quantity and quality monitoring need to be improved, as do abstraction control and protection zones	Existing protection zones used, but needed at Vukovića Vrelo
Future trends and prospects		
GWB identification		HR 558
Status and what is most needed	? eed to improve protection of upper catchment, vulnerability mapping planned, and improved wastewater treatment needed	Agreed delineation of transboundary groundwaters, and monitoring
Notes:		Transboundary aquifer under consideration, but not approved Includes the Glamočko-Kuprečko and other Poljes with very large springs Intensive agriculture in the coastal delta region

No. 21 Aquifer: Neretva right		**Shared by: Bosnia and Herzegovina and Croatia**
Type 5, Cretaceous and Neogene layered and massive limestones and dolomites, marls, clays, sandstones, breccias and conglomerates average thickness 250-600 m and up to 600-1000 m, strong link to surface waters, groundwater flow from BiH to Croatia		Mediterranean Sea basin Border length (km): ?
	Bosnia and Herzegovina	Croatia
Area (km^2)	>1600	862
Water uses and functions	Dominantly drinking water supply and HEP, some irrigation	Drinking water supply
Pressure factors	Agriculture, sanitation, waste disposal and industry	None
Problems related to groundwater quantity	Widespread but moderate drawing of polluted water into the aquifer, reduced springflow and ecosystem degradation	None
Problems related to groundwater quality	Nitrogen, pathogens and organic compounds, widely but moderate	Occasionally local and moderate pathogens – microbiological pollution
Transboundary impacts	Possibly for quality	Improved connection with sink points in BiH and wells and springs in Croatia
Groundwater management measures	Groundwater quantity monitoring used but needs improvement, as do protection zones and wastewater treatment	Existing protection zones for the Opačac and Prud spring systems
Future trends and prospects		Increased road construction and urbanisation in the Neretva delta, which needs protection of its wetlands, lakes and wildlife
GWB identification		HR 565, 566, 567, 569, 598, 573, 574
Status and what is most needed	? Need to improve protection of upper catchment, vulnerability mapping planned	Agreed delineation of transboundary groundwaters monitoring are needed
Notes		Transboundary aquifer under consideration, but not approved

No. 22 Aquifer: Trebisnjica/Neretva left		**Shared by: Bosnia and Herzegovina and Croatia**
Type 5, Jurassic, Cretaceous and Eocene layered and massive limestones, marls, clays with coals, sandstones, breccias and conglomerates over 1000 m thick, groundwater flow from BiH to Croatia, weak to medium links to surface water systems		Mediterranean Sea Basin Border length (km): 124
	Bosnia and Herzegovina	Croatia
Area (km²)	>2000	242
Water uses and functions	HEP and drinking water supply and also to support ecosystems	Dominantly drinking water supply – Slano and the Ombla spring
Major pressure factors	Agriculture, sanitation, waste disposal	None
Problems related to groundwater quantity	Widespread but moderate drawing of polluted water into the aquifer, reduced springflow and ecosystem degradation	None
Problems related to groundwater quality	Nitrogen and pathogens, widely but moderate	Natural saline intrusion and occasionally microbiologic pollution
Transboundary impacts	Decline of groundwater levels and increased groundwater pollution	Improved connection with sink points in BiH and wells and springs in Croatia
Groundwater management measures	Transboundary agreements and data exchange used, but need improvement, monitoring is needed	Need to establish protection zones
Trends and future prospects		Increased development pressures on the Neretva delta
GWB identification		HR 576, 576a, 577, 578, 580, 581, 585, 586
Status and what is most needed	? Need to improve protection of upper catchment, vulnerability mapping planned, and improved wastewater treatment needed. Evaluation of the utilisable resource	Agreed delineation of transboundary groundwaters and monitoring are needed
Notes		Transboundary aquifer under consideration, but not approved Supplies Dubrovnik

No. 23 Aquifer: Bileko Lake		**Shared by: Bosnia and Herzegovina and Montenegro**
Type 5, Thick Triassic, Jurassic and Cretaceous limestones and dolomites, weakly linked to surface waters, groundwater flow from Montenegro to BiH Groundwater provides 100% of total water usage		Mediterranean Sea Basin Border length (km): 90
	Bosnia and Herzegovina	Montenegro
Area (km²)	>1000	?
Water uses and functions	>75% for HEP, small amounts for drinking water and irrigation	
Pressure factors	None	
Problems related to groundwater quantity	Local, moderate degradation of ecosystems	
Problems related to groundwater quality	None mentioned	
Transboundary impacts	None for quantity or quality	
Groundwater management measures	Existing groundwater quality monitoring needs improvement, other measures need to be applied	
Trends and future prospects		
Notes		
Status and what is most needed	?	

No. 24 Aquifer: Dinaric litoral (west coast)		**Shared by: Montenegro and Croatia**
Type 2, Jurassic and Cretaceous karstic limestones, average thickness 500 m and maximum greater than 1000 m, weakly connected to surface water systems Groundwater provides 100% of total water use		Mediterranean Sea basin Border length (km):
	Montenegro	Croatia
Area (km^2)	200	-
Water uses and functions	25-50% each for drinking water supply and industry, <25% each for irrigation and livestock	-
Pressure factors	Abstraction of groundwater	-
Problems related to groundwater quantity	Widespread and severe saline intrusion at the coast	-
Problems related to groundwater quality	High salinity from the above	-
Transboundary impacts	None for quantity or quality	-
Groundwater management measures	Existing control of abstraction, efficiency of water use, groundwater monitoring, public awareness, protection zones and agricultural practices need to be improved, other measures need to be introduced	-
Future trends and prospects		-
Status and what is most needed	?	-
Notes		According to existing data, no transboundary groundwater is recognised

No. 25 Aquifer: Dinaric east coast/Skadar/Shkodra lake		**Shared by: Albania and Montenegro**
Type 2, Jurassic, Cretaceous and lesser Palaeogene massive and stratified limestones and dolomites, average thickness of 500 m and maximum 1000 m, strong links to surface water systems, groundwater flow in both directions Groundwater is 100% of total water use in Montenegro, 80-90% in Albania		Mediterranean drainage basin Border length (km): 35 (excluding the lake border)
	Montenegro	Albania
Area (km²)	200	About 450
Water uses and functions	25-50% for drinking water supply, <25% each for irrigation, industry and livestock	50-75% for irrigation, <25% for drinking water supply, industry and livestock
Pressure factors	Groundwater abstraction	Industry, waste disposal, sanitation and sewer leakage
Problems related to groundwater quantity	Widespread and severe sea water intrusion at the coast	Local and moderate degradation of ecosystems around Shkodra Lake
Problems related to groundwater quality	Widespread and severe increased salinity	Local and moderate pathogens from waste disposal, sanitation and sewer leakage
Transboundary impacts	None for quality or quantity	Shkodra Lake is moderately polluted mainly by industrial wastewater and less by sewage effluents
Groundwater management measures	Abstraction management, efficient water use, monitoring, protection zones and good agricultural practices used but need improving, wastewater treatment needed	Detailed hydrogeological and groundwater vulnerability mapping, monitoring of groundwater quantity and quality (particularly the large karst springs and those used for public water supply), public awareness campaigns, delineation of protection zones and wastewater treatment are all needed. Investigation of the relationships between karst groundwater and groundwater of the alluvial deposits with Shkodra Lake
Future prospects and trends		To increase collaboration, to build transboundary institutions and to create joint programmes for protecting karst and alluvial groundwater, as well as protecting Shkodra Lake and the surrounding wetlands. Improvement of village water supply is needed (and irrigation too)
Status and what is most needed	?	No significant risk at the moment, but the area around the Shkodra Lake is developing rapidly. Long term measures to protect surface and groundwater are needed
Notes		The realization of large planned engineering projects in this area could deeply influence surface and groundwaters.

No. 26 Aquifer: Beli Drim/Drini Bardhe		**Shared by: Serbia and Albania**
Type 3, Lower and Upper Cretaceous karstic and dolomitised limestone, Miocene to Quaternary multilayer sequence 100 to 200 m thick, medium to strong links to surface waters, groundwater flow from Serbia to Albania Groundwater is 30 % of total water use in the Serbian part and 60-70% in the Albanian		Mediterranean Sea Basin Border length (km): 30
	Serbia	Albania
Area (km²)	1000	170
Water uses and functions	25-50% for irrigation, <25% for drinking water and industry, maintain baseflow	75% for irrigation, <25% each for drinking water and livestock, maintain baseflow
Pressure factors	Abstraction of groundwater	Waste disposal, sanitation, sewer leakage
Problems related to groundwater quantity	None	No problems
Problems related to groundwater quality	Nitrogen, pesticides and pathogens	Local and moderate pathogens
Transboundary impacts	None for quantity or quality	None for quantity or quality
Groundwater management measures	Numerous management measures mentioned as needed	Monitoring of groundwater quantity and quality (particularly the big karst springs and those used for public water supply), public awareness campaigns, delineation of protection zones and wastewater treatment are needed, together with detailed hydrogeological and vulnerability mapping
Future trends and prospects		Better evaluation of the quantity and quality of groundwater
Status and what is most needed	?	Not at risk, the population is small and at the moment the industry is not developed
Notes	Water level decline of 0.3 m/yr reported	

No. 27 Aquifer: Metohija		**Shared by: Serbia and Montenegro**
Type 4, Tertiary (Miocene) alluvial sediments, average thickness 100 m and maximum 200 m, weak links to surface water systems Groundwater is 20% of total water use		Basin……. Border length (km):
	Serbia	Montenegro
Area (km²)	4000	?
Water uses and functions	25-50% for irrigation, <25% each for drinking water, industry and livestock, maintaining baseflow and spring flow	
Pressure factors	Agriculture and local small industries	
Problems related to groundwater quantity	None mentioned	
Problems related to groundwater quality	Pesticides and industrial organic compounds	
Transboundary impacts	None for quantity or quality	
Groundwater management measures	Several mentioned as needed	
Future trends and prospects		
Status and what is most needed	?	
Notes		

No. 28 Aquifer: Pester		**Shared by: Serbia and Montenegro**
Type2, Middle Triassic karstic limestones up to 1000 m thick, weak links to surface water systems, dominant groundwater flow is towards the south west Groundwater provides 80% of total water use		Mediterranean Sea Basin Border length (km):
	Serbia	Montenegro
Area (km^2)	407 / >1,500	
Water uses and functions	Irrelevant groundwater resource (no demand for groundwater)	
Pressure factors	<25% for drinking water, industry and mining	
Problems related to groundwater quantity	None reported	
Problems related to groundwater quality	None reported	
Transboundary impacts	None	
Groundwater management measures	None reported as being in use, a whole range of measures mentioned as needing to be applied, including monitoring of quantity and quality	
Notes	2 questionnaires differ on water uses	
Trends and future prospects		
Notes		
Status and what is needed	?	

No. 29 Aquifer: Lim		**Shared by: Serbia and Montenegro**
Type 1, Triassic-Cretaceous karstic limestone with overlying Quaternary alluvium of average thickness 200 m and maximum 400 m, medium connection to surface water, groundwater flow relatively equally shared in both Groundwater is 40% of total water use in the Serbian part		Black Sea Basin Border length (km):
	Serbia	Montenegro
Area (km^2)	600-800	?
Water uses and functions	25-50% for drinking water, <25% each for irrigation, mining and thermal spas, and HEP at Potpec	
Pressure factors	Waste disposal, mining and industry	
Problems related to groundwater quantity	None mentioned	
Problems related to groundwater quality	Local but severe nitrogen, heavy metals, pathogens, industrial organics and hydrocarbons	
Transboundary impacts	None for quantity, yes for quality due to pollution from (or of) Lim River in the upper catchment	
Groundwater management measures	Abstraction management and protection zones used but need to be improved, other measures needed	
Future trends and prospects		
Status and what is most needed	?	
Notes		

No. 30 Aquifer: Tara Massif		**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? Groundwater is 10% of total water use		Black Sea Basin Border length (km): 117?
	Serbia	Bosnia and Herzegovina
Area (km²)	211	>100
Water uses and functions	Drinking water and fish breeding	Drinking water, mostly small amounts for supplying villages
Pressure factors	Sanitation and septic tank leakage	Wastewater, mining activity
Problems related to groundwater quantity	Local and severe degradation of ecosystems, local but moderate drawing of polluted water into the aquifer	Local moderate loading of polluted water into the aquifer
Problems related to groundwater quality	Pathogens	Bacteriological contamination
Transboundary impacts	None for quantity or quality	None
Groundwater management measures	Groundwater abstraction management and quantity monitoring need improvement, other management measures need to be introduced or are currently planned	Protection zones needed for some significant but as yet unused karst springs
Future trends and prospects		
Status and what is most needed	? Important to provide protection for National Park	?
Notes	Negligible conditions for nomination as a transboundary groundwater	Negligible conditions for nomination as a transboundary groundwater

No. 31 Aquifer: Macva-Semberija		**Shared by: Serbia and Bosnia and Herzegovina**
Type 3/4, Lower Pleistocene alluvial sands, sandy gravels with clayey lenses of 35-60 m average thickness and maximum 75-100 m, overlying multiple aquifer sequence, including karstified Triassic limestones, strong links to surface water systems, dominant flow from the Drina River to the Sava Groundwater is 40-60% of total water use in the Serbian part, and 100% in the Bosnia part		Black Sea basin Border length (km):
	Serbia	Bosnia and Herzegovina
Area (km²)	967 / >2000	>250
Water uses and functions	50-75% drinking water, <25% each for irrigation, industry and livestock, and support of ecosystems	Drinking water, irrigation, industry and livestock
Pressure factors	Agriculture and sanitation, some industry	Agriculture and sanitation
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, minor for 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	Sava Commission, 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
Future trends and prospects		
Status and what is most needed	?	?
Notes	Drina River forms the boundary	

No. 32 Aquifer: Northeast Backa/Danube-Tisza Interfluve		**Shared by: Serbia and Hungary**
Type 5, Part of North Panonian 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 (estimated at 145 l/sec). Groundwater is 80% of total use and provides 100% of drinking water supply in Vojvodina, Serbia, >80% of total supply in the Hungarian part		Black Sea Basin Border length (km): 169
	Serbia	Hungary
Area (km^2)	4020	9545
Water uses and functions	>75% drinking water, <25% each for irrigation, industry and livestock	>75% drinking water, <25% each for irrigation, industry and livestock, support of ecosytems
Pressure factors	Abstraction of groundwater	Abstraction, agriculture, sewers and septic tanks
Problems related to groundwater quantity	Local and severe increased pumping lifts and reduction in borehole yields, local and moderate land subsidence	Local and moderate increased pumping lifts, reduced borehole yields and baseflow, and degradation of ecosystems
Problems related to groundwater quality	Widespread and severe naturally occurring arsenic at 10-50 µg/l, widespread but moderate nitrogen and pathogens from sanitation, organic compounds, natural Fe	Widespread and severe naturally occurring arsenic at 10-200 µg/l, widespread but moderate nitrate at up to 200 mg/l, pesticides at up to 0.1 µg/l
Transboundary impacts	Insufficient information to know, or possibly for quantity	None
Groundwater management measures	Abstraction management effective, water efficiency, existing monitoring, protection zones, agricultural practices need to be improved, other measures need to be introduced	Groundwater abstraction regulation used and effective, water use efficiency, monitoring, public awareness, protection zones and wsastewater treatment needed, vulnerability mapping, regional flow modelling, good agricultural practices and priorities for wastewater treatment, integration with river basin management, arsenic treatment or import of arsenic free water are needed
GWB identification	CS_DU1	
Future trends and prospects		Evaluation of the utilisable resource
Status and what is most needed	Current status is reported as poor, possible quantitative risk, no quality risk	? Joint monitoring (mainly quantitative) and joint modelling is needed
Notes	Groundwater abstraction in both countries exceeds recharge, local declines in groundwater level of 0.5 m/yr, and 0.1 my/r more widely	

No. 33 Aquifer: North and South Banat		**Shared by: Serbia and Romania**
Type 4 or 5, Thick (up to 2000 m) alluvial aquifer of sands and gravels of Tertiary to Pleistocene age, confined aquifer with weak links to surface water systems, groundwater flow (estimated at 365 l/sec) from Romania to Serbia Groundwater is up to 90% of total water use		Black Sea Basin Border length (km): 225
	Romania	Serbia
Area (km^2)	11408	4231 (N) + 4325 (S)
Water uses and functions	50% drinking water, 30% for industry and 20% for irrigation	>75% drinking water, >10% each for irrigation, industry, livestock and spa
Pressure factors	None mentioned	Sanitation, irrigated agriculture, waste disposal, industry, oilfields
Problems related to groundwater quantity	Local and moderate increases in pumping lifts	Local, severe increase in pumping lifts and decrease of borehole yields, and declining groundwater levels of 0.5 m/yr locally (Kikinda) Some degradation of ecosystems
Problems related to groundwater quality	None mentioned	Local, moderate, nitrogen, pesticides & pathogens, more widespread heavy metals, and organic pollutants. Widespread high natural arsenic concentrations (10-80 µg/l), Fe and Mn
Transboundary impacts	Reported as none for quantity and quality	Yes, declining groundwater levels and quality
Groundwater management measures	None reported as already in use, a wide range of measures are currently planned	Monitoring of quantity and quality needs improvement, other measures need to be introduced or are planned
GWB identification	RO_BA18	CS_TS1 (N) and CS_DU3 (S)
Status and what is most needed	Not at risk for quality or quantity	Current status is reported as poor for North Banat and good for South Banat Not at risk for quality and possibly at risk for quantity
Future trends and prospects		
Notes	Part of Pannonian Basin. Very important aquifer, provides 100% of drinking water supplies in Vojvodina	Separate groundwater bodies in Serbia as North is in Tisza catchment and South in Danube

No. 34 Aquifer: Miroc and Golubac		**Shared by: Serbia and Romania**
Type 1, Jurassic and Cretaceous karstic limestones average thickness 100 m and maximum thickness 300 m, weak links to surface water systems, groundwater flow from the border into both countries Groundwater is about 15% of total water use		Black Sea Basin Border length (km):
	Serbia	Romania
Area (km^2)	300	?
Water uses and functions	Drinking water	
Pressure factors	Waste disposal and industry	None?
Problems related to groundwater quantity	None mentioned	
Problems related to groundwater quality	Local and moderate nitrogen, pathogens and organics from waste disposal, local but severe heavy metals from industry	
Transboundary impacts	None for quantity, yes for quality	
Groundwater management measures	Protection zones and treatment need improvement, other measures need to be introduced	
Future trends and prospects		
Status and what is most needed	?	?
Notes		

No. 35 Aquifer: Dacian basin		**Shared by: Serbia and Romania**
Type 4, Tertiary, Badenian-Pleistocene alluvial sediments, sands, conglomerates and gravels average thickness 300 m and maximum 2000 m, medium links to surface water systems, groundwater flow from Serbia to Romania Groundwater is 25% of total water use		Black Sea Basin Border length (km):
	Serbia	Romania
Area (km^2)	1000-2000	?
Water uses and functions	<25% each for drinking water, irrigation and industry	
Pressure factors	Waste disposal	
Problems related to groundwater quantity	None mentioned	
Problems related to groundwater quality	Local and moderate nitrate, pathogens, hydrocarbons, organics, salinity from waste disposal	Naturally-occurring Fe at 1-4 mg/l and arsenic at up to 500 µg/l
Transboundary impacts	None for quantity or quality	
Groundwater management measures	Protection zones need to be improved, other measures need to be introduced	
Future trends and prospects		
Status and what is most needed	?	?
Notes		

No. 36 Aquifer: Timok		**Shared by: Serbia and Bulgaria**
Type 3, Quaternary alluvial sediments, sands, gravels and conglomerates of average thickness 5 m and maximum 20 m, strong links to surface water systems of the Timok River, groundwater flow equally shared Groundwater is about 15% of total water use		Black Sea Basin Border length (km): 234?
	Serbia	Bulgaria
Area (km^2)	200	?
Water uses and functions	Drinking water and irrigation	
Pressure factors	Mining and waste disposal	
Problems related to groundwater quantity	None mentioned	
Problems related to groundwater quality	Widespread and severe heavy metals and industrial organic compounds from mining, local pathogens and organics from waste disposal	
Transboundary impacts	None	
Groundwater management measures	Monitoring, protection zones and waste water treatment need to be improved, other management methods need to be introduced	
Future trends and prospects		
Status and what is most needed	?	?
Notes		

No. 37 Aquifer: Stara Planina/Salasha Montana		**Shared by: Serbia and Bulgaria**
Type 2, Triassic and Cretaceous karstic limestones with some overlying Quaternary alluvium, average thickness 100 m and maximum 400 m, medium links to surface water systems, groundwater flow from Bulgaria to Serbia Groundwater is about 50% of total water use		Black Sea Basin Border length (km):
	Serbia	Bulgaria
Area (km^2)	500	87?
Water uses and functions	25-50% drinking water, <25% each for irrigation, industry, thermal spa and livestock	
Pressure factors	Waste disposal and industry	
Problems related to groundwater quantity	Local and moderate reduction in baseflow and degradation of ecosystems, with polluted water drawn into aquifer	
Problems related to groundwater quality	Local and moderate nitrogen and pathogens from waste disposal, more severe heavy metals from industry and organic pollutants from waste disposal	
Transboundary impacts	Not for quantity or quality	
Groundwater management measures	Abstraction management, protection zones and treatment of industrial effluents need improvement, other measures need to be introduced or are currently planned	
GWB identification		BG063?
Trends and future prospects		
Status and what is most needed		
Notes		Part of the West Balkan Nature Park, which may become accepted as a transboundary park

No. 38 Aquifer: Vidlic?/Nishava and Tran		**Shared by: Serbia and Bulgaria**
Type 5, Lower Cretaceous karstified dolomitic limestones average thickness 200 m and maximum 400 m, strong links to surface water systems, groundwater flow from…… Proportion groundwater of total water use unknown		Black Sea Basin Border length (km):
	Serbia	Bulgaria
Area (km²)	285	203 + 28?
Water uses and functions	50-75% drinking water, <25% each for industry and livestock, and support of ecosytems	
Pressure factors	Agriculture	
Problems related to groundwater quantity	None mentioned	
Problems related to groundwater quality	Local but severe pathogens from farming	
Transboundary impacts	None for quantity or quality	
Groundwater management measures	Many management measures need to be applied	
GWB identification		BG082 and BG131?
Trends and future prospects		
Status and what is most needed	?	?
Notes		The Nishava karst basin is part of the West Balkan Nature Park which may become an agreed transboundary park

No. 39 Aquifer: Zemen		**Shared by: Serbia and Bulgaria**
Type ?, Middle and Upper Triassic dolomites and dolomitic limestones on Paleozoic crystalline formations		Mediterranean Sea Basin Border length (km): ?
	Serbia	Bulgaria
Area (km²)	>200?	180 – 217?
Water uses and functions	Only surface water from the confluence of the Strymen river	Water supply
Pressure factors	Shortage of water	
Problems related to groundwater quantity	Difficulty of meeting water supply demands	
Problems related to groundwater quality	Local and moderate nitrogen and pathogens from waste disposal	
Transboundary impacts	None for quantity or quality	
Groundwater management measures	Abstraction management needed	
GWB identification		BG 134
Status and what is most needed	Bringing water supply from outside the aquifer	
Future trends and prospects		
Notes	Catchment of the River Struma	

No. 40 Aquifer: FYROM-SW Serbia		**Shared by: FYROM and Serbia**
Type 5, Mesozoic and Paleozoic rocky masses (generally schists and limestones) with karstic aquifers, minor alluvial sediments, thickness of aquifers is variable, depending on the tectonic characteristics, groundwater flow occurs in both directions, but more from Serbia to FYROM		Mediterranean Sea Basin Border length (km):
	FYROM	Serbia
Area (km^2)		300
Water uses and functions	Water for drinking, little irrigation and mining	50% for drinking water supply, 50% for agriculture
Pressure factors	Local leakage of groundwater from wells and groundwater from springs	Agriculture
Problems related to groundwater quantity	Local reduction of boreholes yields and spring discharges	None
Problems related to groundwater quality	Local from agriculture	Local?
Transboundary impacts	Only for quantity of groundwater	None for quantity, local for quality
Groundwater management measures	Monitoring of quantity and quality, protection zones, hydrogeological mapping, good agricultural practices, exchange of data between countries are used, other measures need to be applied or are planned.	Abstraction management used, other measures planned, such as monitoring
Status and what is most needed		Water supply only from ….
Future trends and prospects	?	
Notes	After definition of the border between the two counties, all data must be defined and data must be exchanged	

No. 41 Aquifer: FYROM – Central Serbia		**Shared by: FYROM and Serbia**
Type 5, Mesozoic, Paleozoic, rocky masses (generally schists and limestones) with karstic aquifers, minor alluvial sediments, thickness of aquifers is variable depending on the tectonic characteristics, groundwater flows from Serbia to FYROM		Mediterranean Sea basin Border length (km): 50
	FYROM	Serbia
Area (km^2)		100
Water uses and functions	Water for drinking, little irrigation and mining	More than 50% surface water
Pressure factors	Local leakage of groundwater from wells and groundwater from springs	Waste disposal and industry
Problems related to groundwater quantity	Local reduction of boreholes yields and spring discharges	Local reduction of baseflow in summer periods
Problems related to groundwater quality	Local from agriculture	Moderate pollution drawn in to the aquifer system
Transboundary impacts	Only for quantity of groundwater	None
Groundwater management measures	Monitoring of quantity and quality, protection zones, hydrogeological mapping, good agricultural practice, exchange of data between countries are used, other measures need to be applied or are planned.	No management measures in place
Status and what is most needed	?	?
Future trends and prospects		
Notes	After definition of the border between the two counties, all data must be defined and data must be exchanged	

No. 42 Aquifer: Tetovo - Gostivar		**Shared by: Serbia and FYROM**
Type 2 and 5, Paleozoic rocky masses (generally schists) with karstic aquifers, minor alluvial sediments, thickness of aquifers is variable from 100 to 300 m, depending on the tectonic characteristics, groundwater flow occurs in both directions, but more from Serbia to FYROM		Mediterranean Sea basin Border length (km): 15
	Serbia	FYROM
Area (km^2)	50	
Water uses and functions	50% drinking water, 50% support of ecosystems	Drinking water, irrigation, mining and industry
Pressure factors	Agriculture	Local leakage of groundwater from wells and groundwater from springs
Problems related to groundwater quantity	None	Reduction of groundwater level in boreholes and discharges of springs
Problems related to groundwater quality	Local only from farming	None for quality
Transboundary impacts	None	Only for quantity of groundwater
Groundwater management measures	No management measures introduced	
Status and what is most needed	?	After definition of the border between the two countries, all data must be defined and data must be exchanged
Future trends and prospects		
Notes		Vrutok spring (2.6-7.7 m^3/sec) supplies Skopje

No. 43 Aquifer: Korab/Bistra - Stogovo		**Shared by: Albania and FYROM**
Type 2 and 5 Mesozoic and Paleozoic schists and flysch sediments, containing Triassic evaporites (anhydrite and gypsum) and Triassic and Jurassic karstic limestones. Minor alluvial sediments with free (unconfined) groundwater, total aquifer thickness from 500 to 700 m, maximum 2000 m, strong links to surface waters, groundwater flow occurs in both directions, but more from FYROM to Albania Groundwater provides >90% of total supply in Albania and FYROM		Mediterranean Sea basin Border length (km): 25
	Albania	FYROM
Area (km^2)	About 140	?
Water uses and functions	25-50 % for thermal spa, < 25 % each for drinking, irrigation and livestock	Drinking water, irrigation, mining
Pressure factors	Waste disposal, sanitation and sewer leakage	Groundwater abstraction, agriculture
Problems related to groundwater quantity	No problems	Local reduction of discharge from springs
Problems related to groundwater quality	Pathogens from waste disposal, sanitation and sewer leakage	None for quality
Transboundary impacts	None for quality and quantity	Only for quantity
Groundwater management measures	Detailed hydrogeological mapping and vulnerability mapping, public awareness campaigns, delineation of protection zones and wastewater treatment are all needed. To increase the collaboration, to build up transboundary institutions and to create a joint programme for quantity and quality monitoring of the sulphur thermo-mineral springs issuing in both countries.	Quantity and quality monitoring need to be improved, protection zones and all water activities, transboundary agreements and data exchange used, but need improvement
Status and what is most needed	Not at risk at the moment Intensification of use of sulphur thermo-mineral groundwater by deep boreholes	?
Future trends and prospects	Delineation the protection zones of the sulphur thermo-mineral springs and to improve the capture structures.	
Notes	Comparative study of the thermo-mineral springs of Albania and FYROM is needed. There are large fresh water karst springs issuing at high elevations	

No. 44 Aquifer: Jablanica/Golobordo		**Shared by: Albania and FYROM**
Type 2, karstic limestones of average thickness 700 m and maximum 1500 m, weak links to surface waters, groundwater flow occurs in both directions Groundwater is 70-80% of total water use in Albania		Mediterranean Sea Basin Border length (km): 50
	Albania	FYROM
Area (km^2)	250	?
Water uses and functions	25-50% for irrigation, <25% each for drinking water and industry	Drinking water supply, thermal water and industry, also HEP
Pressure factors	Modest pressures from waste disposal, sanitation and sewer leakage	Sanitation and sewer leakage
Problems related to groundwater quantity	Local and moderate polluted water drawn into aquifer	Local reduction of groundwater yields from wells and discharges from springs
Problems related to groundwater quality	Local and moderate pathogens from waste disposal	None mentioned
Transboundary impacts	None for quantity or quality	None for quantity and quality
Groundwater management measures	No management measures in place, many need to be introduced, detailed hydrogeological and vulnerability mapping, groundwater monitoring, public awareness, delineation of protection zones and wastewater treatment are all needed	Monitoring of quantity and quality, protection zones, hydrogeological mapping, good agricultural practices, exchange of data between countries, other measures, need to be applied or are planned
Trends and future prospects	The use of a large karst spring for the production of the electricity by Electric Power Station is planned	
Status and what is most needed	Not at risk at the moment, the population is small and the industry is not developed	?
Notes	Surface karst phenomena are very well developed on Klenja plateau	

No. 45 Aquifer: Mourgana Mountain/Mali Gjere		**Shared by: Greece and Albania**
Type 5, karstic aquifer developed in Jurassic and Cretaceous limestones in large anticlines with flysch in synclines. Average thickness about 3000 m, maximum >4000 m. Thickness of alluvial gravels in the Drinos River 20-80 m. Strong links to surface water systems. Little groundwater flow across the border. The Drinos River flowing from Greece to Albania recharges the alluvial aquifer which contributes to the Bistritsa (Blue Eye) Spring (average discharge 18.5 m^3/s) in Albania. The Lista Spring (average 1.5 m^3/s) issues in Greece. Groundwater provides about 90% of total water use		Mediterranean Sea Basin Border length (km): 20
	Greece	Albania
Area (km^2)	200?	440
Water uses and functions	No major water uses due to small population, some local livestock, minor irrigation and fish farming from springs	Provides 100% of drinking water supply and spa use, and >75% for irrigation, industry and livestock
Pressure factors	None, low population in mountain area	Minor from waste disposal and sewer leakage
Problems related to groundwater quantity	None	Some local and moderate drawing of polluted water into the aquifer. No declines in groundwater level
Problems related to groundwater quality	None	Widespread but moderate salinisation – the alluvial groundwater has high sulphate (300 - 750 mg/l), which contributes to increased average sulphate (135 mg/l) in Blue Eye Spring
Transboundary impacts	Neither for quantity or quality	None
Groundwater management measures	Existing abstraction control and monitoring need to be improved, other management measures are needed or planned	No measures employed, those needed include detailed hydrogeological and groundwater vulnerability mapping, public awareness, delineation of protection zones and wastewater treatment. Also to increase collaboration, to build up transboundary institutions and to create a joint basin wide programme for quantity and quality monitoring
Trends and future prospects		Increased use of groundwater in alluvial deposits and…………
Status and what is most needed	?	Small risk at the moment, but with increasing tendency because the area is rapidly developing, both industrial and agricultural
Notes		According to a preliminary proposal, about 4.5 m^3/s of water from Blue Eye spring will be exported to Puglia - Italy through an undersea water supply pipeline.

No. 46 Aquifer: Vjosa-Pogoni/Nemechka		**Shared by: Albania and Greece**
Type 1, Succession of large anticlines containing karstic limestones of mainly Jurassic and Cretaceous age and synclines with formations of Palaeocene and Eocene flysch; average thickness about 2500 m, maximum more than 4000 m, the complicated geological structures and hydrogeological conditions which bring these formations together produce large karst springs, groundwater discharges towards both countries, weak links to surface waters. Groundwater provides more than 90% of total water use		Mediterranean Sea Basin Border length (km): 37
	Greece	Albania
Area (km^2)	350	550
Water uses and functions	Water supply with minor irrigation and fish farming; support of ecosystems	25-50% irrigation, <25% each for drinking water, livestock and industry, maintaining baseflow and springs and supporting ecosystems
Pressure factors	Minimal due to very small population	Minor waste disposal and sewer leakage
Problems related to groundwater quantity	None	Local and moderate degradation of ecosystems
Problems related to groundwater quality	Some high natural concentrations of metals	Local and moderate pathogens
Transboundary impacts	None for quantity or quality	None for quantity or quality
Groundwater management measures	Existing abstraction control and monitoring need improvement, other measures need to be applied or are planned	None already used, but a range of measures need to be applied, detailed hydrogeological and vulnerability mapping, groundwater monitoring, public awareness, delineation of protection zones and wastewater treatment
Trends and future prospects		
Status and what is most needed	?	No risk at the moment, the population is small and industry is not developed
Notes	Large spring discharges of Kalama, Gormou and Drinou	Large karst groundwater quantities (average about 8 m^3/s) discharge in the Vjosa River gorge in Albanian territory. There are also other large karst springs, the Glina sulphate spring is a well known bottled karst spring

No. 47 Aquifer: Prespes and Ohrid Lakes		**Shared by: Albania, FYROM and Greece**	
Type 5, Mainly Triassic and Jurassic massive limestones, about 400 m thick and up to 550 m maximum, including Galicica mountain between the lakes, medium to strong links to surface water systems, groundwater flow dominantly from the basin of the Small Prespa Lake to the Big Prespa Lake and from there to the Ohrid lake basin. Groundwater movement is interconnected between all three countries. Groundwater provides greater than 80% of total water use			Mediterranean Sea Basin Border length (km): 40 (GR/AL), 20 (GR/FYROM)
	Albania	FYROM	Greece
Area (km^2)	750	?	413
Water uses and functions	25-50% for irrigation and <25% each for drinking water and industry industry, support for baseflow and ecosystems	Drinking water, industry and ecosystems	Irrigation, water supply (no figures given) and support of ecosystems
Pressure factors	Minor sanitation and sewer leakage	Minor sanitation	Tourism
Problems related to groundwater quantity	Widespread but moderate degradation of ecosystems, and polluted water drawn into aquifer	Local and moderate reduction of groundwater level, yields of wells and discharges of springs	None significant
Problems related to groundwater quality	Local and moderate nitrogen and pathogens in both groundwater and lakes, but the trend is increasing	None mentioned	None significant
Transboundary impacts	A slight increase in the phosphorus in Lake Ohrid	None mentioned	?
Groundwater management measures	No management measures in place, many need to be introduced:- transboundary institutions, water use efficiency, monitoring of groundwater and lakes, protection zones, vulnerability mapping, priorities for wastewater treatment, integration with Prespa and Ohrid lakes basin management	Monitoring of groundwater, must be improved with agreements, data exchange, hydrogeological databases, planned together	Abstraction management, monitoring, public awareness and data exchange need improvement, other measures need introducing or are planned
Trends and future prospects	Increasing groundwater use by the growing population and intensive development of tourism. Increasing collaboration of all three countries to protect groundwater and surface water resources in a basin-wide way		
Status and what is most needed	Small risk at the moment. Increasing risk of contamination of karst water and of the lakes in the future by the increasing population and tourism	?	?
Notes	Ohrid lake is intensively recharged from Prespa Lake through the Mali Thate-Galicica karst massive. Large karst springs with average discharge about 10 m^3/s issue near the Albanian-FYROM border at the edge of Lake Ohrid		Monitoring is important in relation to the ecosystems supported by Prespa Lake Natura 2000 site

No. 48 Aquifer: Pelagonia/Florina/Bitolsko		**Shared by: Greece and FYROM**
Type 3/4, Quaternary and Neogene unconfined shallow alluvial sands and gravels with some clay and silt and cobbles, with confined Pliocene gravel and sand aquifer, total up to 300 m thick,, overlying Palaeozoic and Mesozoic schists		Mediterranean Sea Basin Border length (km): 45?
	Greece	FYROM
Area (km^2)	607	?
Water uses and functions	Water supply and irrigation	Drinking water supply, support of ecosystems and agriculture and maintaining baseflow and springs
Pressure factors	Agriculture, coal mining	Groundwater abstraction
Problems related to groundwater quantity	None	Widespread and severe increase of pumping lifts, degradation of ecosystems and drawing of polluted water into aquifer, widespread but moderate reduction of borehole yields, local but severe reduction in baseflow and spring flow
Problems related to groundwater quality	Nitrate, heavy metals	Salinization, nitrogen, pesticides, heavy metals, pathogens, industrial organic compounds and hydrocarbons
Transboundary impacts	None	None for quantity or quality
Groundwater management measures	Existing abstraction controls, water use efficiency, monitoring and wastewater treatment need to be improved, other measures are mentioned as needed or currently planned	Increasing efficiency of groundwater use, monitoring of quantity and quality, public awareness, protection zones, vulnerability mapping, good agricultural practices, exchange of data between countries and treatment of industrial effluents need to be improved, other measures need to be applied or are planned
Trends and future prospects		
Status and what is most needed	?	?
Notes		

No. 49 Aquifer: Gevgelija		**Shared by: FYROM and Greece**
Type 1 or 5, Quaternary alluvial sediments, sands with gravel, partly clayey and silty with cobbles of bedrock - diabases, biotite gneisses and shists. Average thickness of 10 m and maximum 60-100 m. Very shallow water table. Medium link with surface water systems, groundwater flow from FYROM to Greece.		Mediterranean Sea Basin Border length (km):
	FYROM	Greece
Area (km^2)	?	?
Water uses and functions	Maintaining baseflow and springs and support of ecosystems	
Pressure factors	Abstraction of groundwater, agriculture	
Problems related to groundwater quantity	Extensive and severe increases in pumping lifts, reduction in borehole yields, degradation of ecosystems and drawing in of polluted water, local and severe reduction of baseflow and springflow	
Problems related to groundwater quality	Salinization of natural origins and Nitrogen, pesticides, heavy metals, pathogens, industrial organics and hydrocarbons	
Transboundary impacts	Observed both decline of groundwater levels and increased groundwater pollution	
Groundwater management measures	Existing efficiency of groundwater use, monitoring of quantity and quality, public awareness, protection zones, vulnerability mapping, agricultural practice, data exchange and treatment need improvement, other measures need to be applied or are planned	
Status and what is needed	?	?
Trends and future prospects		
Notes		

No. 50 Aquifer: DOJRAN LAKE		**Shared by: Greece and FYROM**
Type 3, Quaternary and Upper Eocene alluvial aquifer overlying metamorphic rocks, sedimentary sequences and carbonate formations -Precambrian, older Paleozoic and Green Metamorphic Complex. Unconfied, with strong links with surface water systems, groundwater flow is generally towards the lake. The catchment of the Lake covers a total of 280 km^2		Mediterranean Sea basin Border length (km):
	Greece	FYROM
Area (km^2)	190	92
Water uses and functions	Maintaining baseflow and springs and support of ecosystems and support of agriculture –irrigation	Irrigation and water supply
Pressure factors	Groundwater abstraction for irrigation	?
Problems related to groundwater quantity	Widespread but moderate reduction in borehole yields, baseflow and degradation of ecosystems, the lake volume and area has declined drastically	Declining groundwater levels, reduction of water from the lake, degradation of associated ecosystems
Problems related to groundwater quality	Heavy metals	None
Transboundary impacts	?	For quantity only
Groundwater management measures	Existing groundwater abstraction control, monitoring of groundwater quantity and quality, data exhange and wastewater treatment need to be improved, other management measures are needed or currently planned	Existing efficiency of groundwater and lake water use, monitoring of quantity and quality of the lake, level of the lake, wells on both sides, public awareness, protection zones, vulnerability mapping, data exchange and treatment need improvement or are planned measures.
Status and what is needed	?	
Trends and future prospects		
Notes		Serious decline in lake level and area, losing 75% of volume between 1988 and 2002, groundwater abstraction to help recover lake levels has been tried

No. 51 Aquifer: Sandansky - Petrich		**Shared by: Bulgaria, Greece and FYROM**	
Type 5, Pliocence and Quaternary alluvial sands, gravels, clays and sandy clays of the Sandansky (up to 1000 m thick) and Petrich (up to 400 m) valleys, with aquifer with free level of ground water from 10 to 100 m, thermal water is characterized from 100 to 300 m in Paleozoic rocky masses with schists and Paleozoic limestones with karst aquifers with different quantity of groundwater, flow occurs in both directions but more from FYROM to Bulgaria and Greece			Mediterranean Sea Basin Border length (km): BG/GR – 18, BG/FYROM 5
	Bulgaria	Greece	FYROM
Area (km^2)	768	?	?
Water uses and functions	Drinking water, irrigation and industry		Drinking water, irrigation and industry, thermal springs, agriculture
Pressure factors			
Problems related to groundwater quantity			None mentioned
Problems related to groundwater quality			
Transboundary impacts			
GWB identification	BG 141		
Groundwater management measures			Protection zones need to be improved, monitoring systems, exchange of data and other measures need to be introduced
Status and what is needed	?	?	?
Future trends and prospects			
Notes	Alluvium of Struma River and tributaries		

<table>
<tr><td colspan="2">No. 52 Aquifer: GOTZE DELCHEV/ ORVILOS-AGISTROS</td><td>Shared by: Greece and Bulgaria</td></tr>
<tr><td colspan="2" rowspan="2">Type? Karstic marble aquifer formed in the Proterozoic crystalline schist of the Rodopi with thick marbles overlying gneiss, some Pleistocene alluvial sediments at the edges.
Groundwater levels at 650 m in the east part of the system and at 305 m in the west part show there is more than one aquifer with unknown hydrogeological relation between them which is under further investigation</td><td>Mediterranean Sea Basin</td></tr>
<tr><td>Border length (km): 22</td></tr>
<tr><td></td><td>Greece</td><td>Bulgaria</td></tr>
<tr><td>Area (km²)</td><td>200</td><td>202</td></tr>
<tr><td>Water uses and functions</td><td>No direct uses</td><td></td></tr>
<tr><td>Pressure factors</td><td>None mentioned</td><td></td></tr>
<tr><td>Problems related to groundwater quantity</td><td>None</td><td></td></tr>
<tr><td>Problems related to groundwater quality</td><td>None</td><td></td></tr>
<tr><td>Transboundary impacts</td><td>None</td><td></td></tr>
<tr><td>Groundwater management measures</td><td>Existing groundwater abstraction regulation and monitoring of groundwater quantity need to be improved, other management measures are needed or planned</td><td></td></tr>
<tr><td>GWB identification</td><td></td><td>BG163</td></tr>
<tr><td>Status and what is needed</td><td>?</td><td></td></tr>
<tr><td>Trends and future prospects</td><td></td><td></td></tr>
<tr><td>Notes</td><td></td><td>Within the Mesta and Struma river catchments. Large springs (eg Petrovo)</td></tr>
</table>

No. 53 Aquifer: Nastan- Trigrad		**Shared by: Greece and Bulgaria**
Type? Proterozoic marbles, gneisses and schists, faulted to give complicated bloc structure, unconfined, groundwater flow from SE to NW		Mediterranean Sea Basin Border length (km):
	Greece	Bulgaria
Area (km^2)		228
Water uses and functions		Drinking water supply, irrigation and the Beden Mineral Spa
Pressure factors		
Problems related to groundwater quantity		
Problems related to groundwater quality		
Transboundary impacts		
Groundwater management measures		
GWB identification		BG 168
Status and what is needed		
Future trends and prospects		
Notes		Large spring discharges, including warm springs, due to deep faulting

No. 54 Aquifer: Smolyan		**Shared by: Greece and Bulgaria**
Type ? Proterozoic and Paleogene marbles, schists, gneisses and sandstones and conglomerates of the Rhodopean massif, heavily faulted into blocks, up to 500 m thick, in some parts the Paleogene provides confining layers.		Mediterranean Sea Basin Border length (km):
	Greece	Bulgaria
Area (km^2)		89
Water uses and functions		
Pressure factors		
Problems related to groundwater quantity		
Problems related to groundwater quality		
Transboundary impacts		
Groundwater management measures		
		BG 171
Status and what is needed		
Future trends and prospects		
Notes		Spring discharges form headwaters of River Arda

No. 55 Aquifer: Rudozem	**Shared by: Greece and Bulgaria**	
Type? Karstic limestone		Mediterranean Sea Basin
		Border length (km):
	Greece	Bulgaria
Area (km^2)		80?
Water uses and functions		
Pressure factors		
Problems related to groundwater quantity		
Problems related to groundwater quality		
Transboundary impacts		
Groundwater management measures		
GWB identification		BG 153?
Status and what is needed		
Future trends and prospects		
Notes		Within the Arda catchment?

No. 56 Aquifer: Erma Reka	**Shared by: Greece and Bulgaria**	
Type? Karstic limestones		Mediterranean Sea Basin
		Border length (km):
	Greece	Bulgaria
Area (km^2)		
Water uses and functions		
Pressure factors		
Problems related to groundwater quantity		
Problems related to groundwater quality		
Transboundary impacts		
Groundwater management measures		
Status and what is needed		
Future trends and prospects		
Notes		

No. 57 Aquifer: SVILENGRAD STAMBOLO/ORESTIADA		**Shared by: Greece, Bulgaria and Turkey**
Type 4, Quaternary and Upper Neogene lake and river alluvial sands, clayey sands, gravels, sandy clays and clays, overlying the metamorphic rocks of the Rodopi Massif. Strong links with surface water systems and discharge towards the rivers Ardas and Evros.		Mediterranean Sea Basin Border length (km):
	Greece	Bulgaria
Area (km^2)	600	665
Water uses and functions	90% for irrigation and 10% for drinking water supply, maintaining baseflow and springs and support of ecosystems	Drinking water supply, irrigation and industry
Pressure factors	Agriculture	
Problems related to groundwater quantity	Although abstraction is reported to greatly exceed recharge, no problems were mentioned	
Problems related to groundwater quality	Nitrogen and pesticides from agriculture	
Transboundary impacts	**Observed decline in groundwater levels and pollution**	
Groundwater management measures	Existing groundwater abstraction regulation, monitoring of groundwater quantity and quality and effluent reuse and treatment need to be improved, other measures need to be applied or are planned	
GWB identification		BG149
Status and what is needed		
Trends and future prospects		
Notes	Alluvial sediments of Maritza River	

No. 58 Aquifer: Evros/Meric		**Shared by: Greece and Turkey**
Type? Limestone. Groundwater flow from Turkey to Greece		Mediterranean Sea Basin Border length (km): 105?
	Greece	Turkey
Area (km^2)		2100
Water uses and functions		Public water supply, industry and agriculture
Pressure factors		Urban and industrial effluents, agriculture
Problems related to groundwater quantity		
Problems related to groundwater quality		Local increases in salinity, pesticides and industrial waste
Transboundary impacts		
Groundwater management measures		
Status and what is needed		
Notes		Leaking distribution networks causing groundwater level rise
Future trends and prospects		

No. 59 Aquifer: Topolovgrad Massif		**Shared by: Bulgaria and Turkey**
Type 2, Proterozoic and Paleozoic gneisses and schists, Triassic and Jurassic karstic limestones, dolomites, marbles, schists, sandstones, in a narrow synclinal structure with complicated, faulted bloc structure, medium links with surface water systems: Dominant groundwater flow direction: from W-SW to E-NE towards Turkey Proportion groundwater of total use is not known		Mediterranean Sea Basin Border length (km):
	Bulgaria	Turkey
Area (km^2)	249	
Water uses and functions	25 – 50 % Drinking water supply, < 25 % each for irrigation and livestock **Maintaining baseflow and springs and** support of ecosystems and of agriculture	
Pressure factors		
Problems related to groundwater quantity	None mentioned	
Problems related to groundwater quality	Nitrate in NE part	
Transboundary impacts	None for quantity or quality	
Groundwater management measures	Existing groundwater abstraction by regulation needs to be improved, several other measures mentioned as needing to be applied or currently planned, including monitoring of quality and quantity	
GWB identification	BG 125	
Status and what is needed		
Trends and future prospects	?	
Notes	Tundzha River in the catchment of the Meric River	

No. 60 Aquifer: Malko Tarnovo Massif		**Shared by: Bulgaria and Turkey**
Type? Middle and Upper Triassic and Middle Jurassic limestones, dolomites, marbles, schists, sandstones and flysch sediments, part confined, part unconfined,		Black Sea Basin Border length (km):
	Bulgaria	Turkey
Area (km^2)	305	
Water uses and functions		
Pressure factors		
Problems related to groundwater quantity		
Problems related to groundwater quality		
Transboundary impacts		
Groundwater management measures		
GWB identification	BG 126 and BG 127	
Status and what is needed		
Future trends and prospects		
Notes		

No. 61 Aquifer: Pleistocene Mureş/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 SE (Romania) to NW (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 use in Hungary.		Black Sea Basin Border length (km):
	Romania	Hungary
Area (km^2)	2200	4319
Water uses and functions	75 % for drinking water supply, 15% for industry and 10 % for irrigation (shallow), 45%, 35% and 20% respoectively for the confined aquifer	>75% drinking water, <25% each for irrigation, industry and livestock, support of agriculture and ecosystems
Pressure factors	Groundwater abstraction	Groundwater abstraction, agriculture, septic tanks
Problems related to groundwater quantity	Local and moderate increased pumping lifts and local small drawdowns only around two important catchments	Local and moderate increase in pumping lifts, reduction in yields and reduced baseflow, local but severe degradation of ecosystems
Problems related to groundwater quality	None mentioned	Widespread but moderate nitrate at up to 200 mg/l, local and moderate pesticides at up to 0.1 µg/l, widespread and severe arsenic at up to 300 µg/l
Transboundary impacts	None for quantity or quality	No
Groundwater management measures	Vulnerability mapping for land use planning needs to be applied , range of other measures currently planned	Groundwater abstraction by regulation is already used and effective, transboundary agreements, improved efficiency, monitoring, public awareness, protection zones and wastewater treatment and arsenic removal need improvement, vulnerability mapping, good agricultural practices and priorities for wastewater treatment, integration with river basin management need to be applied
GWB identification	RO_MU20 and RO_MU22	HU_P.2.12.1 and HU_P.2.12.2
Status and what is needed	Not at risk for quantity or quality	Possibly at risk for quantity and quality Evaluation of the utilisable resources, quality status, joint monitoring (mainly quantitative) and joint modelling is needed, including for estimation of the amount of transboundary groundwater flow
Notes		
Trends and future prospects		Water importation because of arsenic may be required

No. 62 Aquifer: Pleistocene Someş/Szamos alluvial fan		**Shared by: Romania and Hungary**
Type 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) Holocene unconfined upper part (ROSO01) and the confined Lower Pleistocene (ROSO13), varying from 40 m thick in the west to 130 m are considered separate groundwater bodies. 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 Border length (km): 64
	Romania	Hungary
Area (km^2)	1,380	976
Water uses and functions	Upper, 40% industry, 30% each irrigation and drinking water; lower, 75% for drinking water supply and 25 % for industry, minor agricultural use	>75% drinking water supply, less than 10% each for irrigation, industry and livestock, maintaining baseflow and support of ecosystems
Pressure factors	Agriculture	Agriculture, sewers and septic tanks
Problems related to groundwater quantity	Local and moderate increased pumping lifts and small drawdowns only around two major wellfields near Satu-Mare	Local and moderate increases in pumping lifts, reduction in borehole yield, reduced spring flow and degradation of ecosystems
Problems related to groundwater quality	None mentioned	Widespread but moderate nitrate, up to 200 mg/l, local and moderate pesticides up to 0.1 μg/l and widespread but moderate arsenic at up to 50 μg/l
Transboundary impacts	None for quantity or quality	None
Groundwater management measures	Vulnerability mapping for land use planning needs to be applied, and a range of other measures are currently planned	Groundwater abstraction control by regulation effective, control by financial mechanisms, water use efficiency, monitoring, public awareness, protection zones, wastewater treatment, data exchange and arsenic removal all need improvement, vulnerability mapping and improved agricultural practices, integration into river basin management are needed
GWB identification	ROSO01 and ROSO13	HU_P.2.12
Status and what is needed	Not at risk for quantity or quality	Not at risk Evaluation of the utilisable resources, quality status
Notes	Considered as two separate groundwater bodies in RO, one in HU	More information is needed about groundwater inflow from Ukraine
Trends and future prospects		Joint monitoring (mainly quantitative) is needed and the existing joint modelling should be updated

No. 63 Aquifer: Middle Sarmantian Pontian		**Shared by: Romania and Moldova**
Type 4, Middle Sarmatian – Pontian sediments from the Central Moldovian Plateau, predominantly sands, sandstones and limestones, confined conditions provided by overlying clays up to 50 m thick, with weak links with surface water systems, dominant groundwater flow direction: from.East (Romania) to West (Moldova)		Black Sea Basin Border length (km):
	Romania	Moldova
Area (km^2)	11,964	9662
Water uses and functions	50 % dinking water supply, 25 % industry and 15% irrigation, minor spa	
Pessure factors	None mentioned	
Problems related to groundwater quantity	None mentioned	
Problems related to groundwater quality	Local, moderate to severe salinity	
Transboundary impacts	None for quantity or quality	
Groundwater management measures	Transboundary institutions already used and effective for this groundwater, other management measures need to be applied or are currently planned	
GWB identifcation	RO_PR05	
Status and what is needed		
Trends and future prospects		
Notes	Within the Prut and Siret river basins	

No. 64 Aquifer: 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, up to 250 m thick, weak to medium links with surface water systems, largely unconfined groundwater, dominant groundwater flow from W-SW (Bulgaria) to E-NE (Romania)		Black Sea Basin Border length (km): 90
	Bulgaria	Romania
Area (km^2)	4450	2,178
Water uses and functions	25 – 50 % for drinking water, < 25 % each for irrigation, industry and livestock, also maintaining baseflow and springs, support of ecosystems and agriculture	50 % drinking water supply, 30 % irrigation and 20% for industry
Pressure factors	Agriculture, solid waste disposal	Agriculture, some industry
Problems related to groundwater quantity	Local and moderate reduction of borehole yields	None mentioned
Problems related to groundwater quality	Local and moderate concentrations (10 – 100 mg/l) of nitrogen from agricultural sources	None reported
Transboundary impacts	None for quantity or quality	No
Groundwater management measures	Control of abstraction used and effective, transboundary agreements, monitoring, protection zones, vulnerability mapping, effluent treatment used but need improvement, other measures needed or currently planned	None reported as already in use, a range of measures are currently planned
GWB Identification	BSGW01	RODL04
Status and what is needed	Possibly at risk for quality, not for quantity Improved monitoring needed	Not at risk for quantity or for quality Improved monitoring needed
Notes	Groundwater provides about 30 % of total water use	
Trends and future prospects		

No. 65 Aquifer: Upper Jurassic – Lower Cretaceous		**Shared by: Bulgaria and Romania**
Type 4, Upper Jurassic –Lower Cretaceous karstic limestones, dolomites and dolomitic limestones, 600-800 m thick in Bulgaria, weak links with surface water systems, largely confined by overlying marls and clays, groundwater flow from Bulgaria to Romania Groundwater is about 40% of total water use		Black Sea Basin Border length (km): 290
	Bulgaria	Romania
Area (km²)	15, 476	11,427
Water uses and functions	25-50% for drinking water supply, <25 % for irrigation	70 % for drinking water supply, 15% each for irrigation and industry
Pressure factors	Agriculture	
Problems related to groundwater quantity	Local but severe increased pumping lifts	Local and moderate increased pumping lifts
Problems related to groundwater quality	Local and moderate concentrations (30 – 60 mg/l) of nitrogen species from agriculture	None mentioned
Transboundary impacts	None for quantity or quality	None
Groundwater management measures	Groundwater abstraction regulation already used and effective, transboundary institutions, monitoring of groundwater quantity and quality, protection zones, vulnerability mapping, good agricultural practices and wastewater and effluent treatment used but need improvement, exchange of data is needed	No management measures reported as being in use, a range of measures is currently planned
GWB identification	BG_DGW02	RODL06
Status and what is needed	Not at risk for quantity or quality Improved monitoring is needed	Not at risk for quantity or quality Improved monitoring is needed
Trends and future prospects		
Notes	Connected to Srebarna Lake	Connected to Sintghiol Lake
