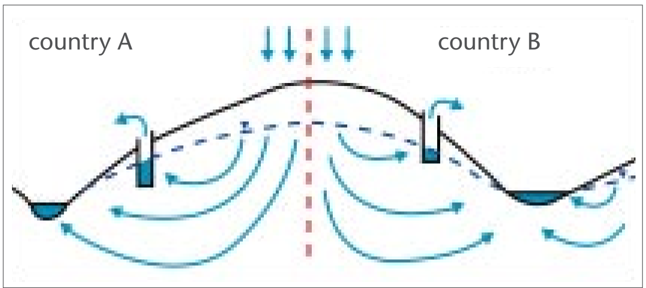
PART 3
TRANSBOUNDARY GROUNDWATERS

Introduction

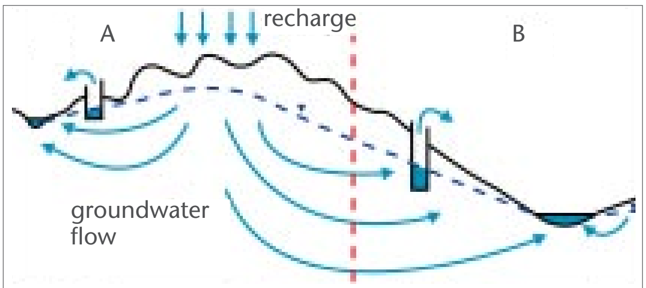
The assessment of the status of transboundary groundwaters sets out the scale and scope of the transboundary groundwaters in two sub-regions: Caucasus and Central Asia (see Section I) and South-Eastern Europe (see Section II). It describes the importance of transboundary groundwaters in supporting human uses; examines the pressure factors on these groundwater bodies; and provides information on status, trends and impacts in relation to both water quantity and quality. The Assessment also provides information about the management measures being taken, planned or needed to prevent, control or reduce transboundary impacts in groundwaters.

The methodology for the assessment of groundwaters broadly follows the guidance provided by UNECE in using the DPSIR framework (see Chapter 2 in Section I of Part 2) 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.

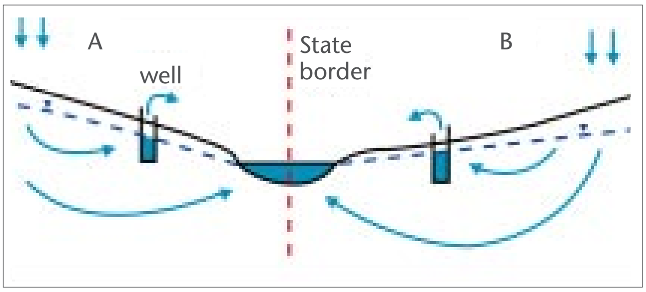
In the following sections, transboundary groundwaters have been classified according to general conceptual models (types) shown in the figure below.



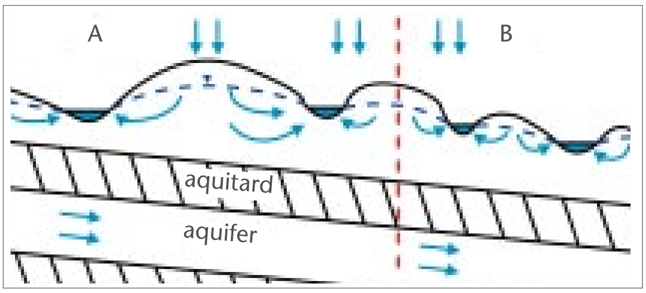
(1) State border follows surface water catchment and groundwater divide, little transboundary groundwater flow.



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



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



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

PART 3

TRANSBOUNDARY GROUNDWATERS

SECTION I

Transboundary Groundwaters in Caucasus and Central Asia

SCALE AND SCOPE OF TRANSBOUNDARY GROUNDWATERS IN CAUCASUS AND CENTRAL ASIA

For transboundary basins in Caucasus and Central Asia during the Soviet Union era, basin plans were developed by regional institutions and included inter-republic and multi-sectoral aspects, as well as allocation of water for various uses. Since independence more than a decade ago, Armenia, Azerbaijan and Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan (the countries of the CACENA region) have been striving to develop fair and rational bases for sharing and using their water resources. These countries have faced extreme economic inefficiencies and ecological damage in their efforts to transition to market economies. In the whole region, one can recognize improving water quality and increasing water quantity to meet basic human needs in these environmentally damaged and economically depressed areas as an urgent and priority task. Agricultural expansion and population growth over the past three decades have placed a great strain on the water resources of the region.

This regional assessment covers transboundary groundwater aquifers from the eight CACENA countries. The assessment is based on current knowledge. Such knowledge is still incomplete and will need to be confirmed and completed by further studies.

All together, 18 aquifers with significant resources were reported as transboundary, bordering or shared by two or more countries. However, only 16 of them were reported by two countries sharing them. The assessment has shown that transboundary groundwaters play a significant role in the CACENA region.

Different types, functions and uses can characterize aquifers. In general, all types of groundwaters can be found in the CACENA countries. However, there are young sediments in river basins as it was found from the available information.

General information on the types, connection with surface water resources and geology of the aquifers is summarized in the following table.

Identified transboundary aquifers

No[1]	Aquifer Name	Countries	Type/link with surface water	Lithology/age	Thickness mean-max (m)	Extent (km^2)
1	Osh Aravoij	UZ/KG	n.a./shallow/deep /medium	Sandy gravel		
2	Almoe-Vorzin	UZ/KG	n.a./medium			
3	Moiansuv	UZ/KG	n.a./shallow-deep /strong-medium	Boulders pebble, loams, sandy, loams	150 -300	1,760
4	Sokh	UZ/KG	n.a./probably shallow /strong			
5	Alazan-Agrichay	AZ/GE	3/shallow/medium	Gravel-pebble, sand, boulder	150 -320	3,050
6	Samur	AZ/RU	3/shallow/strong	Gravel-pebble, sand, boulder	50 -100	2,900
7	Middle and Lower Araks	AZ/IR	3/shallow/strong	Gravel-pebble, sand, boulder	60 -150	1,480
8	Pretashkent	KZ/UZ	4/deep/weak	Sand, clay	200 -320	20,000
9	Chu Basin	KG/KZ	4/deep/weak	Sand, clay, loams	200 -350	
10	Pambak-Debet	GE/AM	3/shallow strong	Sand, clay, loams		
11	Agstev-Tabuch	AM/AZ	1/2/shallow/moderate			500
12	Birata-Urgench	TM/UZ	3/shallow/strong	Sand, loams	10 -50	60,000
13	Karotog	TJ/UZ	2/shallow/moderate			328
14	Dalverzin	UZ/TJ	2/shallow/moderate			
15	Zaforoboi	TJ/UZ	2/shallow/moderate			
16	Zeravshan	TJ/UZ	2/shallow/moderate			88
17	Selepta-Batkin – Nai- Icfor	KG/TJ	2/shallow/moderate			891
18	Chatkal-Kurman	KZ/UZ	4/ deep/weak	Sand, clay		20,000

[1] Aquifers numbered on map below.

Quaternary or neocene sediments form all identified transboundary aquifers. Predominant lithological types are gravel, sand, clay, and loams. Areal extent of the water bodies (in one country) varies greatly and reaches up to 60,000 km^2 (Turkmenistan). Mean thickness of aquifers ranges between 8 and 200 m and maximum thickness ranges between 20 and 350 m depending mainly on stratigraphy and age. Identified aquifers represent large water reservoirs with significant groundwater resources, which can play an important role in the region.

According to the simplified conceptual sketches provided it may be concluded that identified aquifers can be divided into two groups. The first group represents deeper groundwater aquifers with weak or medium link with local surface water systems recharged far from the border (type 4). Only in one case is the State border, which is situated on watershed divided line, identical with the recharge zone. The second group represents shallow groundwater flowing from the neighbouring countries towards the transboundary rivers (type 3). State border follows major rivers and aquifers are connected with the surface waters. From the information available it may be indicated that 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.

In the map below, the locations of the groundwaters covered by this assessment are shown. From this map, it can be seen that several of the countries of the region have their national borders traversed by transboundary groundwaters.

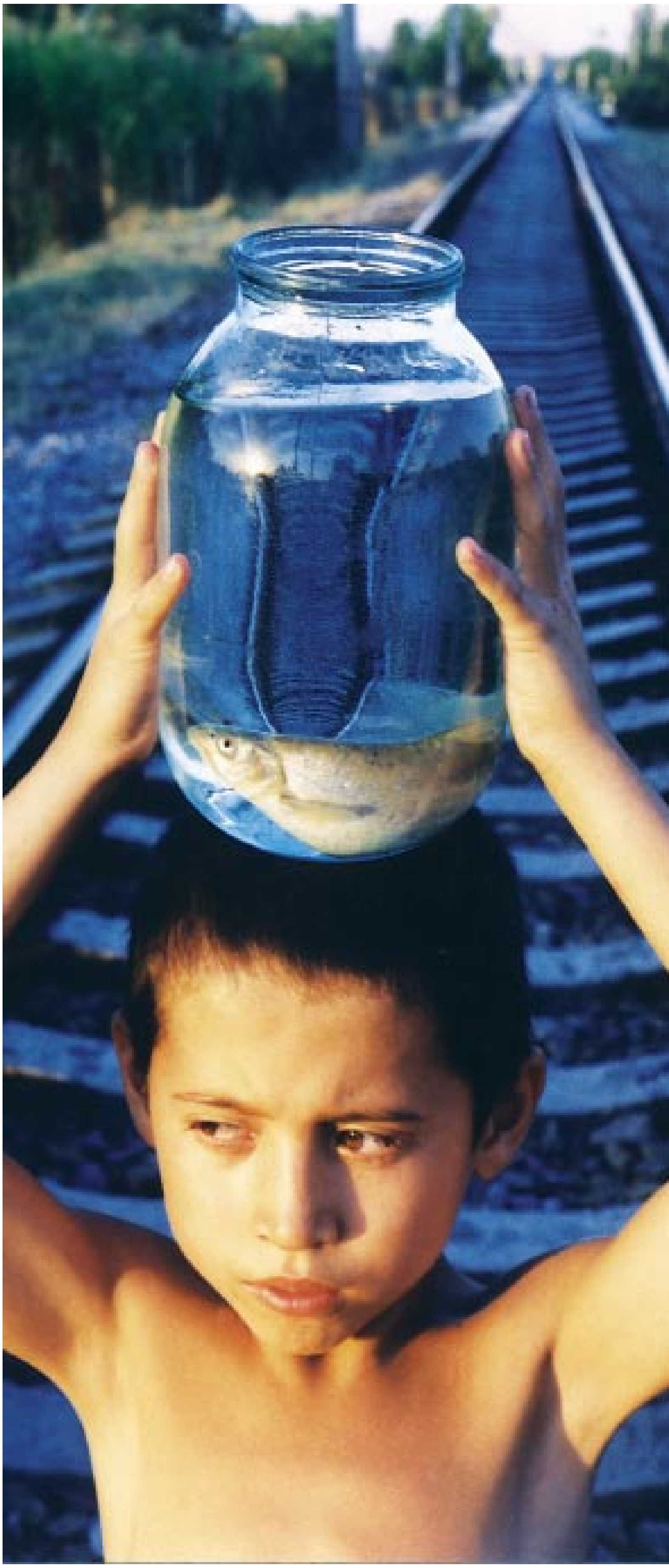
Distribution of transboundary groundwaters in Caucasus and Central Asia

GROUNDWATER USES AND FUNCTIONS

It was recognized during the assessment that groundwater resources are important in total water usage, and direct water abstraction for water supply is the main use of groundwater in all countries. In Georgia, 100% of total water consumption is used from groundwater abstraction. Azerbaijan and Armenia reported that portion of groundwater on total water consumption is 50% from its transboundary aquifers (aquifers No. 5, 6 and 7) and the same data were reported by Turkmenistan (aquifer No. 12). Such use is not surprising, due to the alluvial settings of aquifers, in comparison with the surface water resources.

In all cases the most frequent type of groundwater utilization is drinking water. The assessment has shown that all identified aquifers are utilized for drinking water purposes. But this type of groundwater use compared to the total groundwater abstraction varies to a large extent, from 10% (Azerbaijan, Turkmenistan) to 100% (Kazakhstan). In nine transboundary aquifers (aquifers No. 1, 3, 4, 5, 7, 9, 12, 14 and 17) the percentage of drinking water use on total groundwater abstraction is less than 50%; in seven cases (aquifers No. 6, 8, 10, 11, 13, 16 and 18) it achieves more than 75%. However, there are differences of the groundwater use even between the neighbouring countries (for instance, while in Kazakhstan the groundwater from Pre-Tashkent aquifer was reported to be used predominantly for drinking water purposes, in Uzbekistan it was reported to be used just as a source of mineral water).

Other possible uses indicated the significance of groundwater for agriculture support, reported in five aquifers (aquifers No. 1, 2, 3, 9 and 10) and for maintaining base flow and springs marked in four aquifers (aquifers No. 1, 2, 3 and 11). Other widely reported regional uses include small amounts for industry and spas. The strong linkages to rivers and lakes were confirmed, due to the alluvial aquifers and the consequent need to protect the ecosystems of these associated surface waters was emphasized in the case of Kyrgyzstan (Chu basin).



PRESSURE FACTORS

Chapter 2

PRESSURE FACTORS

It is logical to expect that human activities in the CACENA region might have an impact on both transboundary groundwater quantity and quality. Alluvial settings of the aquifers are likely to be jeopardized by the pollution loads from the agricultural and industrial activities, since the groundwater resources are used for these purposes as indicated by the riparian countries. Furthermore, inefficient irrigation systems and mismanagement of the irrigation water diversions have resulted in elevated water and soil salinity levels and overall environmental degradation. However, recent data from the water bodies' monitoring is very scarce or even no monitoring activities are performed by countries. Therefore, assessment of the pressure factors on the transboundary aquifers is very limited.

AGRICULTURE

Among other types of groundwater utilization, abstraction for irrigation has comparable significance to that for drinking water. Central Asian countries are significantly dependent on irrigated agriculture, and both water quantity and quality have emerged as issues in the republics' development. The assessment shows that twelve out of 18 aquifers are utilized for irrigation. The percentage of total abstraction for irrigation is comparable with drinking water and varies in similar intervals. This finding is not a surprise due to the fact that agriculture is the largest water consumer in the region and a major employer of the region's workforce. In the CACENA region, the poor condition of irrigation infrastructure and bad agricultural practices jeopardize water and land resources. This could be the case for the aquifers with very high percentage of abstraction for agriculture recorded by Azerbaijan (aquifers No. 5, 80-85%, and 7, 55-60%) and Uzbekistan (aquifer No. 3, 50-75%). However, the economic difficulties in the CACENA region have suppressed both the usage of water for irrigation and the application of fertilizers and pesticides. With the expected economic growth and the need to increase crop production, agricultural pressure factors are expected to become more important.

INDUSTRY, MINING, THERMAL SPA

Industrial pressure factors on transboundary aquifers in the CACENA region seem to be rather limited. For industry, water is modestly utilised only from eight aquifers, with a rate of less than 25% of total groundwater abstraction (aquifers No. 2, 3, 5, 6, 9, 10, 12 and 17). For mining, only four cases were recorded with less than 25% of total abstraction (aquifers No. 1, 9, 10 and 11) and for thermal spa two cases less than 25% were indicated (aquifers No. 9 and 12). Heavy metals and organic substances were reported by countries. However, precise and recent data from the monitoring programmes are not available. Country reports were mainly based on the expert judgement of the existing industrial activities in the aquifer recharge areas.

LIVESTOCK

Livestock watering is reported as a minor (less than 25%), but widely employed water use in the majority of the region. However, in the responses, nothing was reported on the type of the animal production (extensive or intensive) in the aquifer areas. Evidence of these pressures may come from pollution by pathogens and nitrogen, but there are no data reported to quantify this pressure factor on the transboundary aquifers in the CACENA region.

Percentage of total groundwater abstraction for different uses in the identified transboundary aquifers

Type of use	Percentage of total groundwater abstraction (aquifer no. refers to summary table above)			
	< 25%	25-50%	50-75%	> 75%
Drinking water	3, 5, 9, 12, 14	1, 4, 7, 17	2, 15	6, 8, 11, 10, 13, 16, 18
Irrigation	1, 6, 9, 10, 12	2, 17	3, 7, 15	5, 14
Industry	2, 3, 5, 6, 9, 10, 12, 17			
Mining	1, 9, 10, 11			
Thermal spa	9, 12			
Livestock	1, 2, 3, 9, 10, 12			

STATUS, TRENDS AND IMPACTS

Chapter 3

STATUS, TRENDS AND IMPACTS

From the inputs by countries in the CACENA region on the transboundary aquifers, one can recognize differences in the significance that countries dedicate to the groundwater resources. For instance, mountain countries such as Kyrgyzstan and Tajikistan have expressed less interest on the groundwaters, due to fact that both surface and groundwater resources are available. In general, most human activities provide some pressures on groundwater systems, and have the potential to affect both water quantity and quality. However, as it was found, the lack of effective, sustainable and comprehensive groundwater monitoring programmes identified in most countries of the CACENA region creates obstacles to the current and prospective evaluation of the groundwater quality and quantity in the aquifers used.

GROUNDWATER QUANTITY

As stated above, groundwater abstraction for water supply and irrigation in the region was identified as the main use of groundwater. The questions on water quantity impacts were oriented to two areas:

- Identify impacts on groundwater level;
- Identify both type and scale of problems associated with groundwater abstraction from the aquifer.

Concerning the trends on the groundwater level, no information was provided by countries. In spite of the fact that most of the participating countries have already established groundwater quantity monitoring network, it might be an indicator that groundwater level is not an issue in the region.

From the inputs received, it can be deduced that mostly local impacts on quantity status of groundwater were observed. However, some countries also recorded widespread impacts (reduction of borehole yields, spring flow, polluted water drawn into aquifers) characterized as moderate (Turkmenistan, Uzbekistan) and severe (Kazakhstan, Uzbekistan, Turkmenistan). The main types of quantity impact caused by over-exploitation of groundwater resources occur as reduction of borehole yields, base flow and spring flow (aquifers No. 3, 8, 12, 13, 14, 15, 16, 17 and 18), polluted water being drawn into an aquifer (1, 2, 3, 9 and 12) degradation of ecosystems (3 and 9), and salt water upcoming (9 and 12). Information on groundwater quantity problems is summarized in the table below.

Groundwater quantity problems				
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		12	12	
Reduction of borehole yields	3, 13, 17, 18		12	8
Reduced base flow and spring flow	14, 15, 16			3, 12
Degradation of ecosystems	3, 9,			
Sea water intrusion				
Salt water upcoming	9	12		
Polluted water drawn into aquifer	1, 3, 9,		2, 12	
Land subsidence				
Decline of piezometric level				8

GROUNDWATER QUALITY

In general, countries have reported problems with groundwater quality. The assessment of the groundwater quality impact has shown occurrences of seven groups of pollutants: salinization, nitrogen substances, pesticides, heavy metals, pathogens, organic compounds, and hydrocarbons. There are four aquifers (aquifers No. 5, 6, 7 and 8) without any indication of groundwater quality impacts. In seven aquifers (1, 2, 3, 4, 12, 13 and 17), at least one kind of pollution was recorded as caused by human activities. In 3 cases, the natural origin of salinization was indicated (9, 10 and 12).

As the most frequent source of pollution, agriculture was recognized influencing five aquifers by nitrogen substances, pesticides and hydrocarbons (aquifers No. 1, 2, 12, 13 and 17). The level of agricultural pollution was recorded from “moderate” to “serious”. This is in direct connection with the current situation in the agriculture practices of the CACENA region, where where old-fashioned technologies and methods for farming are applied.

Industry is the main pollution source causing groundwater contamination by heavy metals, industrial organic compounds and hydrocarbons. Heavy metals originate also from ore mining (aquifers No. 1, 2 and 12). The level of impact on water quality by these pollutants varies between “slight” to “serious”.

There were identified other contaminants influencing four aquifers (aquifers No. 1, 2, 3 and 14): radioactive elements coming from disposal of waste products of extracting enterprises and sulphates and hardness. Groundwater quality problems in CACENA region are summarized in the following table.

Groundwater quality problems			
Problem	Nature of problem		Typical range of concentration
	Natural origins	From which human activities	
Salinization	9, 10 and 12	Irrigation: 4 and 17	1.00 – 3.00 g/l
Nitrogen species		Agriculture: 2, 12, 13 and 17	Values are not available
Pesticides		Agriculture: 1, 2 and 12	Values are not available
Heavy metals		Industry: 1 Ore mining: 2 and 12	Values are not available
Pathogens		Sewer leakage: 12	Values are not available
Industrial organic compounds		Industry: 12	Values are not available
Hydrocarbons		Agriculture: 1 and 2 Industry: 3 and 12	0.2 – 0.0015 mg/l
Radioactive elements		Disposal of waste products of extracting enterprises: 1 and 2	Values are not available
Sulphates and hardness		3 and 14	Values are not available

Concerning the situation on transboundary effects, the countries have reported different impact on groundwater quantity and quality. From the preliminary evaluation it may be concluded, that there are very few evidences of the decline of groundwater level caused by human activities in neighbouring countries. Only in two cases transboundary quantity impacts were observed (aquifers No. 1 and 8), while others were recorded without any evidence of water quantity transboundary effects. There was not any correlation found between types of aquifers and water-quantity impacts.

From the point of view of quality, the situation seems to be more serious. Most countries have indicated significant impact on groundwater quality caused by human activities in the neighbouring countries. There was no evidence of the geographical distribution in the aquifers. It may be remarked, that this evaluation can be understood as a very rough and preliminary estimation, because transboundary impact assessment can be influenced by many factors (mainly data availability) and probably does not reflect the real situation in the region.

MANAGEMENT RESPONSES

The assessment of the current situation in the region is not very optimistic, since most of the basic measures related to the sustainable water management have not been implemented so far or are being used insufficiently and have to be approved or introduced. In spite of the fact that most of the necessary measures are not in place, it was indicated that currently only a few measures are being planned for implementation (e.g. increasing efficiency of groundwater use and integrated river basin management, good agricultural practices, data exchange between countries). If this picture reflects the real situation, future perspectives for the groundwater sector seem to be questionable.

In some countries, certain management measures have already implemented and proved to be effective. In almost all cases groundwater quality and quantity monitoring has been introduced, even in some cases effectively (e.g. aquifers No. 2, 4, and 9). However it was widely recognized that measures were inadequate and needed to be improved (e.g. in Armenia, Azerbaijan, Georgia, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan). As a consequence of the inadequate monitoring activities, there is a lack of proper water assessment and planning activities of the transboundary aquifers in the majority of the responding countries. A similar situation was identified in the delineation of protection zones and vulnerability mapping. These were occasionally reported as being used and used effectively (aquifers No. 3, 8, 9 and 18), but otherwise needed to be improved.

In the management of groundwater resources, in the majority of the aquifers, management abstraction by licensing is being used, but considered to be insufficient where this were being applied, and that the abstraction needed to be better monitored.

For groundwater quality the most widely reported tasks that need to be applied were the treatment of urban and industrial wastewaters. Only two countries (Kyrgyzstan and Turkmenistan) reported these measures to be currently effective. In many instances, implementation or improvement of good agricultural practices is also needed, since within the region no country has implemented this measure effectively.

For the introduction or improvement of transboundary cooperation management measures based on integrated river basin management need to be implemented (see the table below). In this connection, the establishment of transboundary legal frameworks and institutions (e.g. agreements and joint bodies) was recorded as the main task for improvement. Only Turkmenistan reported existence of transboundary institutions. Also data exchange is currently widely considered to be insufficient, and there is a need for it to be introduced.

Groundwater management measures				
Management Measures	**Already used and effective**	**Used, but need to be improved**	**Need to be applied**	**Currently planned**
Transboundary legal framework and institutions (joint bodies, agreements, treaties, etc.)	12	1, 2, 4	5, 6, 7, 8, 11	
Groundwater abstraction management by regulation (licensing, taxation)		5, 6, 7, 8, 12	1, 2, 18	
Groundwater abstraction management by incentives or disincentives (subsidies, credits, energy prices, energy supply, etc.)		4, 5, 6, 7, 8, 9	2, 12	
Increasing efficiency of groundwater use		4, 5, 6, 7, 8, 9	1, 2	12
Monitoring of groundwater quantity	4, 9,	1, 2, 3, 5, 6, 7 8, 12, 15, 18	11, 13, 14, 16, 17	
Monitoring of groundwater quality	2, 4, 9,	1, 3, 5, 6, 7, 8, 18	11, 12, 13, 14, 16, 17	
Public awareness campaigns		5, 6, 7, 12	1, 4, 8, 9,	
Protection zones for public supplies	3, 8, 18	4, 5, 6, 7, 9,	12	
Vulnerability mapping for land use planning	8, 9, 18	5, 6, 7	1, 2, 3, 4, 12	
Good agricultural practices		5, 6, 7, 12	1, 3, 4, 9,	2
Groundwater integrated into river basin management		3, 4	1, 5, 6, 7, 9	12
Wastewater reuse or artificial recharge		9, 12	3, 4, 5, 6, 7	
Treatment of urban wastewater	9, 12	11,	3, 4, 5, 6, 7	
Exchange of data between countries		2	3, 5, 6, 7, 9, 12	
Treatment of industrial effluents	9,	12	1, 2, 3, 5, 6, 7	
Rendering of waste products and recultivation of grounds			1	
Neutralization of radioactive elements and rehabilitation of territory				2

Water management in CACENA countries is a complex and critical issue. The application of the Integrated Water Resources Management (IWRM) principles by the CACENA countries will require groundwater to be integrated into River Basin Management Planning. Sustainable transboundary cooperation will most likely be achieved by creating a basis for assessing the national and regional benefits from technical investments, but these must be complemented by supportive national policy and institutional reforms, as well as capacity- building to strengthen regional institutions.

CONCLUSIONS

Based on the available information delivered by the CACENA countries on the transboundary groundwater aquifers, the following conclusions can be made:

- The groundwater resources are very dominant in the CACENA countries;
- Groundwater resources are used in the CACENA region mainly for drinking water supply. Therefore, it is necessary to protect and improve both groundwater quality and quantity in the CACENA region as precondition for the sustainability of the environment and human beings' security;
- Along with agriculture, the direct water abstraction for water supply is the main use of groundwaters in CACENA countries;
- The majority of the basic measures to improve the groundwater management have not been implemented so far;
- Only scarce data are available from the transboundary groundwater monitoring programmes;
- There is a lack of water management planning approach in the transboundary bodies;
- Implementation or improvement of good agricultural practices is also needed;
- There is a need to establish transboundary institutions for proper cooperation and data exchange;
- Water management is a critical and important issue in the CACENA countries, which are focusing on the national demands rather the transboundary ones;
- There is a need for supportive policy and institutional reforms and capacity-building for the regional or transboundary institutions;
- It is highly recommended that pilot projects be prepared for the monitoring and assessment of the transboundary groundwater aquifers in the CACENA region, and that the case studies are carried out with a central focus on upgrading and building the capacity of the existing infrastructure in the monitoring and assessment of the transboundary groundwater aquifers. There is also a great need to better coordinate donors' activities.

FACTS AND FIGURES ON TRANSBOUNDARY GROUNDWATERS IN CAUCASUS AND CENTRAL ASIA

Aquifer No. 1: Osh Aravoij	Shared by: Uzbekistan and Kyrgyzstan	
Type 5, Medium links to surface water systems, groundwater flows from Uzbekistan to Kyrgyzstan		
	Uzbekistan	Kyrgyzstan
Area (km^2)		
Water uses and functions (percentage of total abstraction)	Drinking water supply (25-50%), irrigation, mining, livestock (<25%)	Drinking water supply (25-50%), irrigation
Pressure factors	Agriculture, industry, waste disposal	Agriculture
Problems related to groundwater quantity	Polluted water drawn into aquifer	Lack of relevant data to be quantified
Problems related to groundwater quality	Serious problems with pesticides, moderate problems with heavy metals, slight problems with hydrocarbons and radioactive elements	Lack of relevant data to be quantified
Transboundary impacts	Decline of groundwater level, groundwater pollution	Lack of relevant data to be quantified
Groundwater management measures	Need to be improved: transboundary institutions, monitoring of groundwater quantity and quality, need to be applied: abstraction management, efficiency of use, mapping, good agricultural practices, integrated river basin manage ment, treatment of industrial effluents, data exchange	Need to improved: transboundary institutions, monitoring of groundwater quantity and quality
Status and what is most needed	Improvement of the monitoring of groundwater quantity and quality	Improvement of the monitoring of groundwater quantity and quality
Future trends and prospects	Expected pressure on the water resources due to economic growth and climate change	Expected pressure on the water resources due to economic growth and climate change

Aquifer No. 2: Almoe-Vorzin	Shared by: Uzbekistan and Kyrgyzstan	
Type 5, Medium links to surface water systems Groundwater flows from Uzbekistan to Kyrgyzstan		
	Uzbekistan	Kyrgyzstan
Area (km^2)		
Water uses and functions (percentage of total abstraction)	Drinking water (50-75%), irrigation (25-50%), industry, livestock (<25%)	Drinking water supply (25-50%), irrigation
Pressure factors	Agriculture, ore mining, waste disposal	Agriculture
Problems related to groundwater quantity	Polluted water drawn into aquifer	Lack of relevant data to be quantified
Problems related to groundwater quality	Nitrogen species, pesticides, heavy metals, hydrocarbons	Lack of relevant data to be quantified
Transboundary impacts	Groundwater pollution	Lack of relevant data to be quantified
Groundwater management measures	Effective: quality monitoring Need to be improved: quantity monitoring, transboundary institutions, data exchange Need to be applied: abstraction management, mapping, treatment of industrial effluents	Need to improved: transboundary institutions, monitoring of groundwater quantity and quality
Status and what is most needed	Good agricultural practices, neutralization of radioactive elements	Enhancement of monitoring programme
Future trends and prospects		Improvement of the monitoring of groundwater quantity and quality

Aquifer No. 3: Moiansuv		Shared by: Uzbekistan and Kyrgyzstan
Type 5, Strong, medium links to surface water system, average thickness 50 m		
	Uzbekistan	Kyrgyzstan
Area (km^2)	1,760	Not identified yet
Water uses and functions (percentage of total abstraction)	Irrigation (50-75%), drinking water, industry, livestock (<25%)	Drinking water supply, irrigation
Pressure factors	Industry	Agriculture
Problems related to groundwater quantity	Reduction of borehole yields, degradation of ecosystem, polluted water	Lack of relevant data to be quantified
Problems related to groundwater quality	Hydrocarbons, sulphates	Lack of relevant data to be quantified
Transboundary impacts	Groundwater pollution	Lack of relevant data to be quantified
Groundwater management measures	Effective: protection zones Need to be improved: transboundary institutions, quality and quantity monitoring, integrated river basin management Need to be applied: mapping, good agricultural practices, treatment of urban and industrial wastewater	Need to improved: transboundary institutions, monitoring of groundwater quantity and quality
Status and what is most needed		Enhancement of monitoring programme
Future trends and prospects	Improvement of the monitoring programme of both quality and quantity	Improvement of the monitoring of groundwater quantity and quality

Aquifer no. 4: Sokh		Shared by: Uzbekistan and Kyrgyzstan
Type 5, Strong links to surface water systems		
	Uzbekistan	Kyrgyzstan
Area (km²)		
Water uses and functions		Drinking water supply, irrigation
Pressure factors	Irrigation	Agriculture
Problems related to groundwater quantity		Lack of relevant data to be quantified
Problems related to groundwater quality	Salinization (1-3 g/l)	Lack of relevant data to be quantified
Transboundary impacts	Groundwater pollution	Lack of relevant data to be quantified
Groundwater management measures	Effective: quantity and quality monitoring Need to be improved: transboundary institutions, abstraction management, protection zones, integrated river basin management. Need to be applied: mapping, good agricultural practices, urban wastewater treatment and reuse	Need to improved: transboundary institutions, monitoring of groundwater quantity and quality
Status and what is most needed		Enhancement of monitoring programme
Future trends and prospects		Improvement of the monitoring of groundwater quantity and quality

Aquifer No. 5: Alazan-Agrichay		Shared by: Azerbaijan and Georgia
Type 3, Medium links to surface waters Groundwater flows from Greater Caucasus to Alazani river		
	Azerbaijan	Georgia
Area (km^2)	3,050	Not identified yet
Water uses and functions (percentage of total abstraction)	Irrigation (80 – 85%) Drinking water supply (10 – 15%) Industry (3-5%)	Drinking water supply
Pressure factors	No substantial problems	No substantial problems
Problems related to groundwater quantity	No substantial problems	No substantial problems
Problems related to groundwater quality	No substantial problems	No substantial problems
Transboundary impacts	Lack of relevant data	Lack of relevant data
Groundwater management measures	Need to be improved: integrated management, abstraction management, efficiency of use, monitoring, agricultural practices, protection zones, mapping Need to be applied: treatment of urban and industrial wastewater, transboundary institutions, data exchange	Need to be improved: control of the use of groundwater resources. Need to be applied: treatment of urban and industrial wastewater, monitoring programmes both quantity and quality, data exchange
Status and what is most needed	Joint monitoring programme	Joint monitoring programme
Future trends and prospects	Increased water demands	Increased water demands by economic growth (irrigation, drinking water and industry)

Aquifer No. 6: Samur	Shared by: Azerbaijan and the Russian Federation (Samur river)	
Type 3, Gravel – pebble, sand, boulder		
	Azerbaijan	Russian Federation
Area (km²)	2,900	
Water uses and functions (percentage of total abstraction)	Drinking water (90-92%), irrigation (5-8%), industry (2-3%)	
Pressure factors	None	
Problems related to groundwater quantity	None	
Problems related to groundwater quality	None substantial problem	
Transboundary impacts	Groundwater pollution	
Groundwater management measures	Need to be improved: abstraction management, quantity and quality monitoring, protection zones, good agricultural practices, mapping Need to be applied: transboundary institutions, data exchange, integrated river basin management, treatment of urban and industrial wastewater	
Status and what is most needed	Joint monitoring programme	
Future trends and prospects	Increased use of water due to economic growth	

Aquifer No. 7: Middle and Lower Araks	Shared by: Azerbaijan and Islamic Republic of Iran (Araks river)	
Type 3, Gravel – pebble, sand, boulder		
	Azerbaijan	Islamic Republic of Iran
Area (km²)	1,480	
Water uses and functions (percentage of total abstraction)	Irrigation (55-60%), drinking water (40-45%)	
Pressure factors	None	
Problems related to groundwater quantity	None	
Problems related to groundwater quality	None	
Transboundary impacts	None	
Groundwater management measures	Need to be improved: abstraction management, quantity and quality monitoring, protection zones, good agricultural practices, mapping Need to be applied: transboundary institutions, data exchange, integrated river basin management, treatment of urban and industrial wastewater	
Status and what is most needed	Joint monitoring programme	
Future trends and future prospects	Increased use of water due to economic growth	

Aquifer No. 8: Pretashkent		Shared by: Uzbekistan and Kazakhstan
Type 4, Large deep groundwater (artesian type)		
	Uzbekistan	Kazakhstan
Area (km²)		
Water uses and functions	Mineral water and partly as drinking water source	Drinking water supply
Pressure factors	Not recognized	Water abstraction on both sides of the aquifer
Problems related to groundwater quantity	Not recognized	Reduction of borehole yields
Problems related to groundwater quality	There are no problems with pollution	There are no problems with pollution
Transboundary impacts	Not recognized	Decline of the groundwater levels were observed
Groundwater management measures	Licensing of the groundwater abstraction and monitoring programme in place It is urgently needed to establish the transboundary institutions and data exchange	Licensing of the groundwater abstraction and monitoring programme in place It is urgently needed to establish the transboundary institutions and data exchange
Status and what is most needed	Enhancement of monitoring programme	To enhance monitoring programme and assessment methods as mathematical modelling for making water balance
Future trends and prospects	Increased economic activities and climate change can have a pressure on the groundwater resources	Increased economic activities and climate change can have a pressure on the groundwater resources

Aquifer No. 9: Chu Basin	Shared by: Kyrgyzstan and Kazakhstan	
Type 4, Quaternary sand, gravel, weak links to surface water systems, groundwater flow from Kyrgyzstan to Kazakhstan		
	Kyrgyzstan	Kazakhstan
Area (km²)		
Water uses and functions (percentage of total abstraction)	Drinking water, irrigation, industry, mining, livestock, thermal spa (<25%)	Drinking water 50%, irrigation 50%
Pressure factors	Water abstraction	Water abstraction
Problems related to groundwater quantity	Degradation of ecosystems, salt water upcoming	None
Problems related to groundwater quality	Salinization	None
Transboundary impacts	None	Not quantified yet
Groundwater management measures	Effective: quantity, quality monitoring, mapping, urban and industry wastewater treatment. Need to be improved: transboundary institutions, abstraction management, protection zones. Need to be applied: good agricultural practices, integrated river basin management, data exchange	Effective: quantity, quality monitoring Need to be improved: transboundary institutions, abstraction management Need to be applied: good agricultural practices, integrated river basin management, data exchange
Status and what is most needed	Enhancement of the monitoring programme	Enhancement of the monitoring programme
Future trends and prospects	Lack of data and information to make proper predictions	Lack of data and information to make proper predictions

Aquifer No. 10: Pambak-Debet	Shared by: Georgia and Armenia	
Type 3		
	Georgia	Armenia
Area (km^2)		
Water uses and functions (percentage of total abstraction)	Drinking water supply 100%	Drinking water up to 90%, irrigation and mining industry
Pressure factors	Lack of data	Mining industry and agriculture
Problems related to groundwater quantity	Lack of data	Lack of data
Problems related to groundwater quality	Lack of data	Lack of data on the pollution from the agricultural and industrial activities
Transboundary impacts	Lack of data to evaluate these effects	Lack of data
Groundwater management measures	Effective: controlled water abstraction Need to be improved: urban and industrial wastewater treatment, Need to be applied: transboundary institutions to be set up, monitoring programme to be enhanced	It is important to make controlled water abstraction. Need to be improved: urban and industrial wastewater treatment, Need to be applied: transboundary institutions to be set up, monitoring programme to be enhanced and data exchange
Status and what is most needed	Joint monitoring programme	Joint monitoring programme
Future trends and prospects	Increased use of water as consequence of the economic growth	

Aquifer No. 11: Agstev-Tabuch	Shared by: Armenia and Azerbaijan	
Type 1, 2, Moderate connections with surface water systems.		
	Armenia	Azerbaijan
Area (km²)	500	500
Water uses and functions (percentage of total abstraction)	Drinking water up to 75%, irrigation up to 25% and mining industry	Irrigation 80%, drinking water 15%, industry 5%
Pressure factors	Mining industry and waste disposal	Mining industry
Problems related to groundwater quantity	Lack of data	Lack of data
Problems related to groundwater quality	Lack of data on the pollution from the agricultural and industrial activities	Heavy metals
Transboundary impacts	Lack of data	Moderate pollution by heavy metals
Groundwater management measures	It is important to make controlled water abstraction. Need to be improved: urban and industrial wastewater treatment, Need to be applied: transboundary institutions to be set up, monitoring programme to be enhanced and data exchange	It is important to make controlled water abstraction Need to be improved: urban and industrial wastewater treatment, Need to be applied: transboundary institutions to be set up, monitoring programme to be enhanced and data exchange
Status and what is most needed	Great need to organize joint monitoring programme on both sides and to set up the regular data exchange	Great need to organize joint monitoring programme on both sides and to set up the regular data exchange
Future trends and prospects		Increased use of water by economic growth

Aquifer No. 12: Birata-Urgench		Shared by: Uzbekistan and Turkmenistan
Type 3, Quaternary sand, loam, groundwater flow from Uzbekistan to Turkmenistan		
	Uzbekistan	Turkmenistan
Area (km²)		
Water uses and functions	Drinking water supply	Drinking water supply
Pressure factors	Water abstraction	Water abstraction
Problems related to groundwater quantity	Widespread/moderate reduction of borehole yields, widespread/serious reduction of base flow, spring flow	Widespread/moderate reduction of borehole yields, widespread/serious reduction of base flow, spring flow
Problems related to groundwater quality	Salinization (natural origins and irrigation) as results of waste water and drainage waters	Salinization (natural origins and irrigation) as results of waste water and drainage waters
Transboundary impacts	Need to be investigated	Need to be investigated
Groundwater management measures	Joint quantity and quality monitoring, data exchange	Joint quantity and quality monitoring, data exchange
Status and what is most needed	Improvement of the groundwater monitoring programme	Improvement of the groundwater monitoring programme
Future trends and prospects	Lack of information for making trends prediction	Lack of information for making trends prediction

Aquifer No. 13: Karotog		Shared by: Tajikistan and Uzbekistan
Type 2, Moderate connections with surface water bodies		
	Tajikistan	Uzbekistan
Area (km²)	328	Necessary to be corrected
Water uses and functions	Drinking water supply	Drinking water supply
Pressure factors	Water abstraction	Water abstraction
Problems related to groundwater quantity	Change of water resources on the edge of sustainability	Change of water resources based on the water abstraction on the Tajikistan territory
Problems related to groundwater quality	Negligible local contamination by nitrate (agriculture)	Negligible local contamination by nitrate (agriculture)
Transboundary impacts	Necessary to be investigated	Necessary to be investigated
Groundwater management measures	Joint monitoring of the groundwater	Joint monitoring of the groundwater
Status and what is most needed	Enhancement of the monitoring network of groundwater	Enhancement of the monitoring network of groundwater
Future trends and prospects	Not sufficient information to make predictions	Not sufficient information to make predictions

Aquifer No. 14: Dalverzin	Shared by: Uzbekistan and Tajikistan	
Type 2, Moderate connections with surface water bodies		
	Uzbekistan	Tajikistan
Area (km^2)		
Water uses and functions	Irrigation	Drinking water supply and irrigation
Pressure factors	Water abstraction	Water abstraction
Problems related to groundwater quantity	Water resources are recharged in the course of year	Water resources are recharged in the course of year
Problems related to groundwater quality	Moderate increase in mineralization and hardness	Moderate increase in mineralization and hardness
Transboundary impacts	Necessary to be investigated	Necessary to be investigated
Groundwater management measures	Monitoring of the groundwater status	Monitoring of the groundwater status
Status and what is most needed	Enhancement of the representative monitoring network of transboundary waters	Enhancement of the representative monitoring network of transboundary waters
Notes		
Future trends and prospects	Lack of information for making predictions and trends	Lack of information for making predictions and trends

Aquifer No. 15: Zaforoboi	Shared by: Tajikistan and Uzbekistan	
Type 2, Moderate connections with surface water bodies		
	Tajikistan	Uzbekistan
Area (km^2)		
Water uses and functions	Drinking water and irrigation	Drinking water and irrigation
Pressure factors	Water abstraction	Water abstraction
Problems related to groundwater quantity	Natural resources are recharged in the autumn and winter period	Natural resources are recharged in the autumn and winter period
Problems related to groundwater quality	No contamination	Moderate pollution
Transboundary impacts	Necessary to be investigated	Necessary to be investigated
Groundwater management measures	Existing monitoring network of groundwater programme, necessary to be improved	Monitoring network of groundwater programme, necessary to be improved
Status and what is most needed	Enhancement of the representative monitoring network of transboundary waters	Enhancement of the representative monitoring network of transboundary waters
Notes		
Future trends and prospects	Lack of information for making predictions and trends	Lack of information for making predictions and trends

Aquifer No. 16: Zeravshan	Shared by: Tajikistan and Uzbekistan	
Type 2, Moderate connections with surface water bodies		
	Tajikistan	Uzbekistan
Area (km^2)	88	To be corrected
Water uses and functions	Drinking water supply	Drinking water and technological water
Pressure factors	Moderate water abstraction	Moderate water abstraction
Problems related to groundwater quantity	Change of water resources on the edge of natural sustainability	Change of water resources on the edge of natural sustainability
Problems related to groundwater quality	Significant effect of the industrial activities on the territory of Tajikistan	Lack of data for evaluation
Transboundary impacts	Necessary to be investigated	Necessary to be investigated
Groundwater management measures	Need to organize complex monitoring programme	Existing monitoring programme of the groundwater
Status and what is most needed	Enhancement of the complex monitoring network of transboundary waters	Development of the complex monitoring network of transboundary waters
Future trends and prospects	Lack of information for making predictions and trends	Lack of information for making predictions and trends

Aquifer No. 17: Salepta- Batkin- Nai-Icfor (Syr Darya)	Shared by: Kyrgyzstan and Tajikistan	
Type 2, Moderate connections with surface water bodies		
	Kyrgyzstan	Tajikistan
Area (km^2)		891
Water uses and functions	Irrigation and drinking water	Irrigation, drinking water and technological water
Pressure factors		Water abstraction
Problems related to groundwater quantity	Over exploitation registered	Water abstraction on the territory of Kyrgystan
Problems related to groundwater quality	Contamination by nitrates and salinization	Increased mineralization, hardness and sulphates
Transboundary impacts	Necessary to be investigated	Necessary to be investigated
Groundwater management measures	Special monitoring is not performed	Monitoring is done partly
Status and what is most needed	Enhancement of the complex monitoring network of transboundary waters	Enhancement of the complex monitoring network of transboundary waters
Future trends and prospects	Lack of information for making predictions and trends	Lack of information for making predictions and trends

Aquifer No. 18: Chhatkal-Kurman		Shared by: Kazakhstan and Uzbekistan
Type 4, Weak link to surface waters, groundwater flow from Kazakhstan to Uzbekistan		
	Kazakhstan	Uzbekistan
Area (km^2)	20,000	
Water uses and functions (percentage of total abstraction)	Drinking water (100%)	Drinking water (100%)
Pressure factors	Water abstraction	Water abstraction
Problems related to groundwater quantity	Reduction of borehole yields, decline of groundwater level	Reduction of borehole yields, decline of groundwater level
Problems related to groundwater quality	None	None
Transboundary impacts	Decline of groundwater level	Decline of groundwater level
Groundwater management measures	Effective: protection zones, mapping Need to be improved: quantity and quality monitoring, abstraction management Need to be applied: transboundary institutions	Enhancement of the monitoring programme
Status and what is most needed	Joint monitoring programme	Joint monitoring programme
Future trends and prospects		Lack of information to make predictions

PART 3
TRANSBOUNDARY GROUNDWATERS

SECTION II

Transboundary Groundwaters in South-Eastern Europe

SCALE AND SCOPE OF TRANSBOUNDARY GROUNDWATERS IN SOUTH-EASTERN EUROPE

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 the earlier UNECE inventory and the inventory by the International Network of Water-Environment Centers for the Balkans (INWEB). However, South-Eastern Europe (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 INWEB reported 47, the present assessment covers 51. The requirement of the Water Framework Directive (WFD) to identify and characterise groundwater bodies as a basis for their integration into river basin management plans has helped to stimulate interest in and knowledge of potential transboundary groundwaters in the region. While this applies particularly to EU member States, it is also significantly influencing the work of those institutions responsible for groundwater in candidate countries and others in EU neighbours.

The assessment has not taken a fixed view as to the minimum size of groundwater to be included; small aquifers can provide a locally critical resource. Thus, some of the 51 groundwaters covered by this assessment are included because one country considers them important even though the neighbouring country does not and may not even recognise them as transboundary groundwaters. In addition, some 10 - 15 further potential transboundary groundwaters in the region, including some previously identified by the INWEB inventory, are not included in the assessment because of their very small size and/or because both neighbouring countries considered them either to be unimportant or not actually transboundary. It is also quite possible for a geological formation which is an aquifer to be crossed by national borders in two different situations where transboundary groundwater flow is hydraulically unlikely. The first occurs where the national border coincides with a major watershed and the hydraulic gradient and hence groundwater flow is strongly away from the border into both countries. The second occurs where an extensive alluvial aquifer stretches each side of a major river (such as the Danube) which forms the national political border and also provides such a dominant hydraulic barrier that transboundary groundwater flow is unlikely. In such cases, a “boundary” rather than transboundary groundwater has been recognised, and several have been excluded on this basis at the request of the countries concerned. However, modification of groundwater flow patterns by human activities and the greater hydrogeological knowledge gained from WFD characterisation means these situations should be kept under review and reconsidered in future assessments.

Transboundary groundwater resources play a significant role in SEE. 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 larger tributaries. In some locations, the alluvial sediments overlie and are in hydraulic contact with the karstic limestones, or comprise relatively thin aquifers of river or lake sediments overlying ancient metamorphic rocks as, for example, between Greece and The former Yugoslav Republic of Macedonia.

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 (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 (see table below). 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.

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). They are often of greater areal extent and several are of sufficient size to satisfy the area criterion of 4000 km^2 for inclusion in the ICPDR assessment.[1] 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 hydrogeolgical models for both main aquifer types indicate that 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.

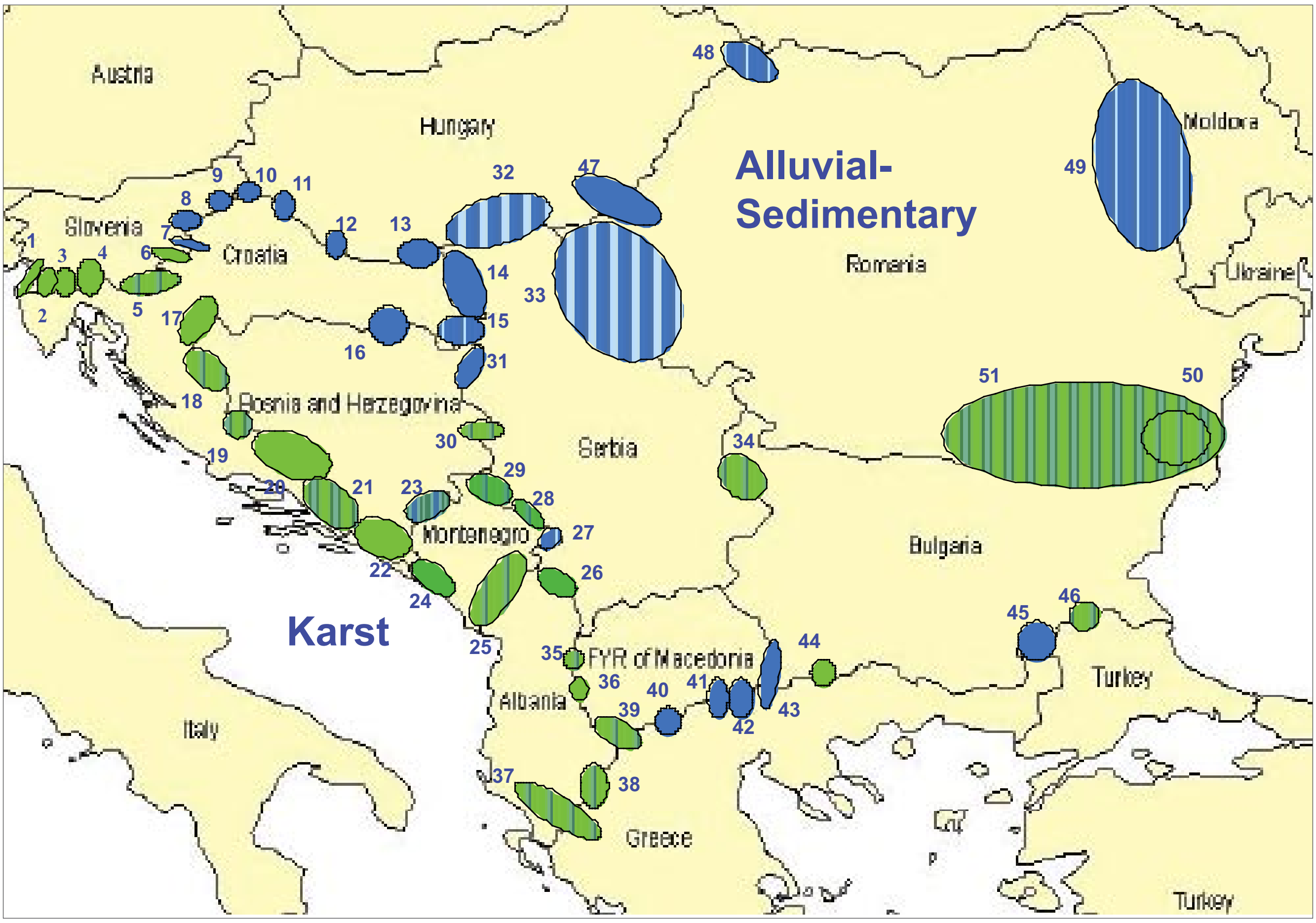
[1] ICPDR, 2005. The Danube River Basin District - River basin characteristics, impact of human activities and economic analysis required under Article 5, Annex II and Annex III, and inventory of protected areas required under Article 6, Annex IV of the European Union (EU) Water Framework Directive (2000/60/EC),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

Transboundary groundwaters in SEE					
No[1]	Aquifer Name	Countries	Area 1 (km²)	Area 2 (km²)	Notes
1	Secovlje-Dragonja/Istra	Croatia - Slovenia	20	99	These four are all parts of the Istra groundwater system
2	Mirna/Istra	Slovenia ⟶ Croatia	...	214	
3	Opatija/Istra	Slovenia ⟶ Croatia	...	302	
4	Rijeka/Istra	Slovenia ⟶ Croatia	...	460	
5	Cerknica/Kupa	Slovenia ⟶ Croatia	238	137	
6	Radovic-Metlika/Zumberak	Slovenia ⟶ Croatia	27	158	
7	Bregana-Obrezje/Sava-Samobor	Slovenia ⟶ Croatia	4	54	
8	Sutla/Bizeljsko	Croatia ⟶ Slovenia	12	180	
9	Ormoz-Sredisce ob Drava/ Drava-Varazdin	Slovenia ⟶ Croatia	27	768	
10	Dolinsko-Ravensko/Mura	Slovenia – Croatia	449	-	
11	Mura	Hungary – Croatia	300	-	
12	Drava/Drava West	Croatia ⟶ Hungary	262	97	
13	Drava East/Baranja	Hungary ⟶ Croatia	607	955	
14	SW Backa/Dunav	Serbia - Croatia	2672	-	
15	Srem -West Srem/Sava	Serbia - Croatia	627	-	
16	Posavina I/Sava	Bosnia and Herzegovina ⟶ Croatia	250	396	
17	Kupa	Croatia – Bosnia and Herzegovina	452	...	
18	Una/Plesevica	Croatia ⟶ Bosnia and Herzegovina	1,592	108	
19	Krka	Bosnia and Herzegovina ⟶ Croatia	85	414	
20	Glamocko/Cetina	Bosnia and Herzegovina ⟶ Croatia	2,650	587	
21	Neretva right	Bosnia and Herzegovina ⟶ Croatia	2,120	862	
22	Trebisnjica/Neretva left	Bosnia and Herzegovina ⟶ Croatia	>2,000	242	
23	Bileko lake	Bosnia and Herzegovina - Montenegro	>1,000	...	
24	Dinaric littoral (west coast)	Montenegro – Croatia	200	-	
25	Skadar/Shkodra Lake	Montenegro - Albania	200	450	
26	Beli Drim/Drini Bardhe	Serbia ⟶ Albania	1,000	170	
27	Metohija	Montenegro - Serbia	...	1,000	
28	Pester	Montenegro- Serbia	...	407	
29	Lim	Montenegro - Serbia	...	6-800	
30	Tara massif	Serbia ⟶ Bosnia and Herzegovina	211	<100	
31	Macva-Semberija	Serbia - Bosnia and Herzegovina	967	>250	
32	Danube –Tisza /NE Backa	Hungary ⟶ Serbia	9,545	4,020	

Transboundary groundwaters in SEE					
No[1]	Aquifer Name	Countries	Area 1 (km^2)	Area 2 (km^2)	Notes
33	North and South Banat	Romania → Serbia	11,408	8,556	4231(N) + 4325 (S)
34	Stara Planina/Salasha Montana	Bulgaria →Serbia	87 or 231	785	Includes Vidlic/ Nishava and Tran
35	Korab/Bistra-Stogovo	Albania - The former Yugoslav Re-public of Macedonia	140	...	
36	Jablanica/Golobordo	Albania → The former Yugoslav Republic of Macedonia	370	...	
37	Mali Gjere/Mourgana Mountain	Greece - Albania	200	440	
38	Nemechka/Vjosa-Pogoni	Albania - Greece	550	350	
39	Prespa and Ohrid Lakes	Albania, Greece and The former Yugoslav Republic of Macedonia	750	413	Includes Galicica mountain
40	Pelagonija/Florina	Greece - The former Yugoslav Republic of Macedonia	607	...	
41	Gevgelija/Axios-Vardar	The former Yugoslav Republic of Macedonia → Greece	...	...	
42	Dojran Lake	Greece - The former Yugoslav Republic of Macedonia	190	92?	
43	Sandansky-Petrich	Greece - The former Yugoslav Repub-lic of Macedonia	764?	...	
44	Orvilos-Agistros/Gotze Delchev	Bulgaria, Greece and The former Yugoslav Republic of Macedonia	200	202?	
45	Svilegrad Stambolo/ Ores-tiada/Edirne	Greece - Bulgaria	665	600	
46	Topolovgrad massif	Bulgaria, Greece and Turkey	249	...	
47	Maros/Mures alluvial fan	Romania → Hungary	2,200	4,319	Upper & Lower
48	Samos/Somes alluvial fan	Romania → Hungary	1,380	976	Upper & Lower
49	Middle Sarmatian - Pontian	Romania → Moldova	11,964	...	
50	Neogene-Sarmatian	Bulgaria → Romania	4,450	2,178	
51	U Jurassic - L Cretaceous	Bulgaria → Romania	15,476	11,427	

Notes: [1] Groundwater numbered on map below.
Direction of flow between countries indicted by arrow where known.
Area 1 is first country, area 2 is second.
Shaded groundwaters are karstic, those with no shading are alluvial sediments.

The locations of the groundwaters covered by this assessment are shown in the map below. 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.



Distribution of transboundary groundwaters in the SEE region

GROUNDWATER USE

The assessment immediately confirms the great importance of groundwater in total water usage in SEE. 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 groundwaters of Bosnia and Herzegovina, Serbia, Croatia, Montenegro and Albania as much as 90% or even 100%. The alluvial groundwaters not surprisingly exhibit a greater range of use relative to surface water, with the proportion of groundwater in total usage varying from only 15-25% for some up to 70% for the important Banat, Backa and Srem Pannonian Basin alluvial groundwaters in Serbia, Croatia and Hungary. This large aquifer sequence provides 100% of drinking water supply to the Vojvodina region of Serbia.

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.

For many of the alluvial groundwaters, the main uses are comparable on both sides of the border, but in some of the karstic areas 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 six of the karstic aquifers (three shared by Bosnia and Herzegovina and Croatia, and the others shared by Bosnia and Herzegovina and Montenegro, Albania and The former Yugoslav Republic of Macedonia, and Serbia and Montenegro) 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.

PRESSURE FACTORS

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 SEE are likely, therefore, to be highly vulnerable to pollution if the pressure factors outlined below produce significant loadings of mobile and persistent pollutants. The only exception would be the deeper confined groundwaters of the thick alluvial sequences, particularly those shared by Hungary, Serbia and Romania.

AGRICULTURE

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,[1] 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.[2] 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 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.[3]

Agriculture is indeed an important pressure factor within SEE. 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 is likely 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. Deterioration of the operation and maintenance of irrigation schemes since the late 1980s and a sharp decline in the area under irrigation has decreased the use of water for this purpose.[4] Water abstraction has indeed been stable or declined slightly in SEE in the past decade.[5] With the expected economic growth and the need to increase crop production, agricultural pressure factors are expected to become more important.

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 local pollution of groundwater by pathogens and nitrogen.

INDUSTRY

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 in groundwater 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 locally polluted and the municipal supply to Kraljevo was threatened for a considerable time,[6] although there was no transboundary impact. As for agriculture, the recent political changes and difficult economic situation have resulted in the decline of industrial activities and the closure of manufacturing plants. In some cases these former industrial plants which are not working at the present could represent potential pollution hot spots.

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.

[1] European Environment Agency. Europe's environment: the fourth assessment, 2007.
[2] 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.
[3] Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration.
[4] World Bank 2003. Water Resources Management in South Eastern Europe, Volume I, Issues and Directions, Volume II, Country Water Notes and Water Fact Sheets.
[5] European Environment Agency. Europe's environment: the fourth assessment, 2007.
[6] Filipovic B, Vujasinovic S and Stevanovic Z. 1994. Some general aspects of groundwater protection in Yugoslavia – Symposium, Impact of Industrial Activities on Groundwater Quality, Constanza, 196–204.

SEWERAGE AND WASTE DISPOSAL

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; (b) where collected, untreated 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.

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.

MINING

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. Near Podgorica in Montenegro, the large aluminium plant referred to above contributes to an increase of aluminium in Skadar Lake (a Ramsar site) and possibly also in the karst and alluvial groundwater. The tailings pond accident in January 2000 at Baia Mare in north west Romania released 100,000 m^3 of cyanide-rich tailings waste into the nearby river system and thence into the Somes, Tisza and finally the Danube. The tailings contained 50-100 tons of cyanide as well heavy metals, disrupting drinking water supplies at 24 locations for 2.5 million people, and causing major fish kills.[7] Some shallow private groundwater supplies close to the spill were seriously affected, but deeper municipal supplies drawing from the confined aquifers were largely unaffected and transboundary groundwater impacts have not been observed. 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.

SOLID WASTE DISPOSAL

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.

TOURISM AND RECREATION

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 area from which visitors will come to 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.

RIVER REGULATION

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

[7] Regional Environmental Centre for Central and Eastern Europe 2000. The cyanide spill at Baia Mare, Romania. UNEP/WWF.

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 groundwater.

STATUS, TRENDS AND IMPACTS

Chapter 3

STATUS, TRENDS AND IMPACTS

From the earlier work by UNECE and INWEB, and the discussion of pressure factors above, the most important issues for the status and trends of transboundary groundwater quality in SEE 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 assessment confirms this picture, but with some local causes for concern.

GROUNDWATER QUANTITY

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 up-coning problems occur as expected in the Dinaric littoral groundwaters of Albania, Croatia, Montenegro and Slovenia. Some evidence of degradation of ecosystems was also reported. Reported information on quantity problems is summarized in the table below and information for each groundwater is provided in the last chapter below.

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				
Declining groundwater levels	••••	•••	•	
Use for energy production	•			

Notes: • karstic groundwater • alluvial groundwater

Each spot represents the specific scoring for each transboundary groundwater, distinguishing between the alluvial and karstic groundwaters. However, it should be noted that a complete lack of quantity problems was reported for 12 of the transboundary groundwaters in the region, and for others there was no data from which to make a judgement. Trends of water level decline were reported for some of the alluvial transboundary groundwaters in the region. Declines of 0.1 m/year and locally 0.5 m/year were reported by Serbia for the Backa groundwater shared between Serbia and Hungary. Similar declines of 0.2 m/year were reported by Serbia for the West Srem shared with Croatia and of up to 0.6 m/year 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/year were reported. However, these do not affect the 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 groundwater 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 water 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 surface water and groundwater inflows have resulted in major 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 recovery has been assisted by the more recent wet years.

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 groundwater 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 groundwaters, although none of these appear large.

GROUNDWATER QUALITY

In general, both alluvial and karstic groundwaters have reported groundwater quality problems. For only three was it specifically reported that there were no groundwater quality issues at all, and several more are incomplete or report a lack of data. 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 groundwaters shared by Serbia, Hungary, Romania and Croatia, respectively, exceed the drinking water standard of 10 µg/l and affect their use for potable supply. In some locations, expensive arsenic removal or importation of water either directly for supply or for dilution of local high arsenic contents is needed.

Groundwater quality problems in SEE are summarized in the table below, using a similar approach to that for quantity presented in the table above. Each spot represents a reported quality problem. 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 assessment did not ask for detailed information on monitoring programmes or monitoring results, and the few indications of concentration ranges that were provided indicate some local nitrate concentrations above drinking water standards in the Sarmatian and Lower Cretaceous groundwaters shared by Bulgaria and Romania and in the Somes and Mures groundwaters shared between Hungary and Romania.

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 (Fe, Mn)	••		••••	
Organic matters	••	•	••	••

Notes: • karstic groundwater • alluvial groundwater

The most severe local groundwater quality problems are probably caused by saline intrusion on the Adriatic coast. There are few reported instances of transboundary impacts of pollution of groundwater. These include the Svilengrad and Gevgelija groundwaters, where intensive agriculture with irrigation has also caused transboundary quantity impacts, and the Una/Plesevica where waste disposal has produced negative transboundary impacts on groundwater quality. In the Lim groundwater, pollution in the upper part of the river is reported to cause groundwater quality problems lower in the basin.

MANAGEMENT RESPONSES

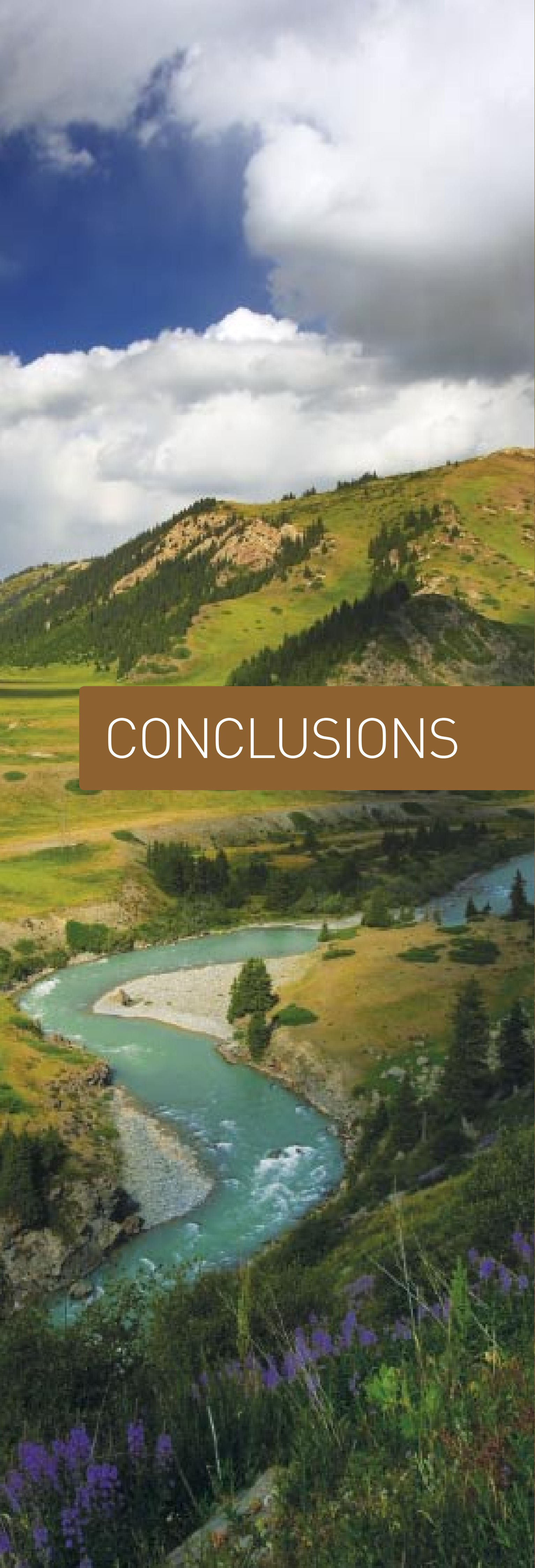
The DPSIR framework also considers responses in the context of management measures already being applied or required in the future. The emerging preliminary evaluation of management responses appears to be realistic, and broadly reflects modest rather than unduly optimistic views of the current situation in the region. Few responses considered management measures to be already implemented and effective, some were reported as used but needing improvement and many more as needing to be introduced.

In the management of groundwater resources, some of the Bulgarian responses considered groundwater abstraction management by licensing to be effective, but for most countries 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.

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, along with groundwater vulnerability mapping to assist in land use planning. 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.

The Water Framework Directive and Groundwater Directive will require EU member States (and their neighbours who also decide to do so) to integrate groundwater into river basin management; and this is reflected in the response that such integration is recognised as being needed and is planned. While the long-established 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. More recently, the Framework Agreement on the Sava River Basin, signed in 2002 and ratified in 2004, has led to the establishment of the Sava River Basin Commission.[1] Specific bilateral agreements on cooperation in the field of water management include 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 process of managing of transboundary groundwaters, initially with the establishment of formal data exchange between countries.

[1] Source: International Sava River Basin Commission.



CONCLUSIONS

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.

The assessment confirms that groundwater is important for all water uses in the region, providing in excess of 50% of total water use in more than half of the 51 assessed groundwaters, and more than 75% in about ten of them.

The ICPDR is an established and important driver of and facilitator for collaboration in water management in the region, and was widely referred to as such. This is seen in the more recent establishment within the Danube basin of specific frameworks for cooperation on the Sava and Tisza. 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.

Overall, the quantity and quality status of transboundary groundwaters in SEE is good, with the exception of a small number of potential hot spots identified in this assessment. However, this may reflect a 10- to 15-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 interactions between surfacewaters and groundwaters, remains unpredictable.

FACTS AND FIGURES ON TRANSBOUNDARY GROUNDWATERS IN SOUTH-EASTERN EUROPE

No. 1 Groundwater: Secovlje-Dragonja/Istra[1]		Shared by: Slovenia and Croatia
Type 5, Predominantly limestones of Cretaceous age, weak to medium links to surface waters Groundwater flows from both Slovenia to Croatia and Slovenia to Croatia. Part of the Istra system, in the valley of the Dragonja River		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 bacteriological pollution
Transboundary impacts	None	None
Groundwater management measures	Pumping station has been 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 systems and development of monitoring programmes
Future trends and prospects		
GWB[2] identification	GWS ID 50811	HR 502
Notes		Transboundary groundwater under consideration but not approved

No. 2 Groundwater: Mirna/Istra[3]		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	Local drinking water supply	Drinking water supply
Pressure factors	Sparsely populated	No data
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		Agreed delineation of transboundary groundwater systems and development of monitoring programmes
Notes	Not clear which groundwater systems in both countries correspond to each other; delineation of transboundary groundwaters by common research and bilateral expert agreement decision is needed	Transboundary groundwater under consideration, but not approved

[1] Based on information provided by the Environment Agency of Slovenia and Croatian Waters.
[2] EU Water Framework Directive, Regulation 2: Identification of Groundwater Bodies.
[3] Based on information provided by the Environment Agency of Slovenia and Croatian Waters.

No. 5 Groundwater: Cerknica/Kupa[4]		Shared by: Slovenia and Croatia
Type 5, Triassic and Cretaceous limestones and dolomites with some alluvium in the river valley, 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 (km²)	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 and pasture	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 at risk. It is unclear which groundwater systems in the two countries correspond to each other; delineation of transboundary groundwaters needs common research and bilateral decision to propose a transboundary groundwater, if appropriate	Agreed delineation of transboundary groundwaters, and development of monitoring programmes
Notes	In the basin of the Kolpa/Kupa River, within that of the Sava River	Transboundary aquifer under consideration, but not approved

[4] Based on information provided by the Environment Agency of Slovenia and Croatian Waters.

No. 6 Groundwater: Radovica-Metlika/Zumberak[5]		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 (km²)	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 development of monitoring programmes
Notes		Transboundary aquifer under consideration, but not approved

[5] Based on information provided by the Environment Agency of Slovenia and Croatian Waters.

No. 7 Groundwater: Bregana-Obrezje/Sava-Samobor[6]		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 hydro-electric power schemes and associated river regulation on the Sava, transport routes	Agriculture, population, 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 187
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 development of monitoring programmes
Notes	Very small part in Slovenia Within the Sava River Basin	Transboundary aquifer under consideration, but not approved

[6] Based on information provided by the Environment Agency of Slovenia and Croatian Waters.

No. 8 Groundwater: Bizeljsko/Sutla[7]		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 (km²)	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 Pod etrtek impacts on groundwater levels
Groundwater management measures	None	Existing protection zones
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 development of monitoring programmes
Notes	Area uncertain – possibly only part of the Bizeljsko groundwater system is relevant	Transboundary aquifer under consideration, but not approved

[7] Based on information provided by the Environment Agency of Slovenia and Croatian Waters.

No. 9 Groundwater: Ormoz-Sredisce ob Dravi/Drava-Varazdin[8]	**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	None
Groundwater management measures	None	Existing protection zones
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 development of monitoring programmes
Notes	Within the Drava basin, tributary of the Danube	Transboundary aquifer under consideration, but not approved

No. 10 Groundwater: Dolinsko-Ravensko/Mura[9]	**Shared by: Slovenia and Croatia**	
Quaternary alluvial sands and gravel, groundwater hydraulically corresponding to surface water systems of the Mura River and in strong connection; groundwater flow from Slovenia to Croatia and from Croatia to Slovenia? Within the Sava River Basin.	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

[8] Based on information provided by the Environment Agency of Slovenia and Croatian Waters.
[9] Based on information provided by the Environment Agency of Slovenia and Croatian Waters.

No. 11 Groundwater: Mura[10]	Shared by: Hungary and Croatia	
Type 3/4, Quaternary alluvial aquifer of sands and silts, with gravels along the river, generally only 5-10 m thick but up to maximum of 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 (km²)	300	
Water uses and functions	>75% drinking water, <25% each for industry, irrigation and livestock, maintaining baseflow and support of ecosystems	Local water supply
Pressure factors	Agriculture and settlements (fertilisers, pesticides, sewage, traffic), groundwater abstraction	No data
Problems related to groundwater quantity	Local and moderate (at settlements) increased pumping lifts, reduced yields and baseflow, degradation of ecosystems	No data
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	No data
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	-
GWB identification	HU_P.3.1.1	-
Status and what is most needed	Evaluation of the utilisable resource	
Future trends and prospects	Exporting drinking water	-
Notes	(Total groundwater body is 1933 km²)	Transboundary aquifer under consideration, but not approved

[10] Based on information provided by the Geological Institute of Hungary and Croatian Waters.

No. 12 Groundwater: Drava/Drava West[11]		Shared by: Hungary and Croatia
Type 3/4, Quaternary alluvial aquifer of sands and gravels, of average thickness 10 m and maximum 70 m in Hungary, 300 m in Croatia, medium to strong links to surface waters, groundwater flow from Hungary to Croatia, but mainly towards the border river.		Black Sea Basin Border length (km): 31
	Hungary	Croatia
Area (km²)	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 wastewater treatment, integration into river basin management, protection of open pit areas need to introduced	None
Future trends and prospects	Evaluation of the utilisable resource	
GWB identification	HU_P.3.2.2	HR 039
Status and what is most needed	Exporting drinking water	Agreed delineation of transboundary groundwaters, and development of monitoring programmes
Notes	Within the Drava catchment	Transboundary aquifer under consideration, but not approved

[11] Based on information provided by the Geological Institute of Hungary and Croatian Waters.

No. 13 Groundwater: Baranja/Drava East[12]		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
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	Need to establish protection zones
Future trends and prospects	Evaluation of the utilisable resource, status of groundwater quality	
GWB identification	HU_P.3.3.2	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 development of monitoring programmes
Notes	In the Drava catchment, Danube basin	Transboundary aquifer under consideration, but not approved

[12] Based on information provided by the Geological Institute of Hungary and Croatian Waters.

No. 14 Groundwater: South Western Backa/Dunav[13]		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 is about 70% of total water use in the Serbian part.		Black Sea Basin Border length (km):
	Serbia	Croatia
Area (km²)	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, within the Danube basin	According to existing data, no transboundary groundwater is recognised
Future trends and prospects		

[13] Based on information provided by the Directorate for Water and Jaroslav Cerni Institute, Serbia, and Croatian Waters.

No. 15 Groundwater: Srem-West Srem/Sava[14]		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 within each country. Groundwater provides about 70% of total supply in the Serbian part		Black Sea Basin Border length (km):
	Serbia	Croatia
Area (km²)	627	
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 nitrate and pesticides from irrigated agriculture, heavy metals, organics and hydrocarbons from industry, naturally occurring iron and manganese	Naturally-occurring iron
Transboundary impacts	None for quantity or quality	-
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	Possible qualitative risk, no quantitative risk	-
Notes		According to existing data, no transboundary groundwater is recognised

[14] Based on information provided by the Directorate of Water, Serbia, University of Belgrade and Croatian Waters.

No. 16 Groundwater: Posavina I/Sava[15]	Shared by: Bosnia and Herzegovina and Croatia	
Type 4, Quaternary alluvial sands, gravels, clays and marls averaging around 100 m thick in Croatia, 5-10 m in Bosnia and Herzegovina, 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 (km²)	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	Naturally occurring iron at 1-4 mg/l in the upper aquifer (15 to 60 m)	Naturally-occurring iron and manganese
Transboundary impacts	None	No data
Groundwater management measures	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 - BA_SAVA_3	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 Groundwater: Kupa[16]	Shared by: Bosnia and 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 (km²)	…	452
Water uses and functions	No data	Dominantly drinking water
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 development of monitoring programmes
Notes	Possible transboundary aquifer should be considered	Transboundary aquifer under consideration, but not approved

[15] Based on information provided by the Directorate of Waters and Institute of Geological Research, Republic Srpska, Bosnia and Herzegovina and Croatian Waters.
[16] Based on information provided by Croatian Waters.

No. 18 Groundwater: Pleševica/Una[17]	**Shared by: Bosnia and Herzegovina and Croatia**	
Type 5, Thick Palaeolithic, Mesozoic and Cenozoic limestones and dolomites, average thickness 200 m and maximum 500 m, in hydraulic contact with overlying alluvial sediments, strong links with surface waters, flow from Croatia to Bosnia and Herzegovina towards the Una River.		Black Sea Basin Border length (km): 130
	Bosnia and Herzegovina	Croatia
Area (km²)	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	Communities
Problems related to groundwater quantity	Polluted water locally drawn into the aquifer	None
Problems related to groundwater quality	Local but severe nitrogen, heavy metalsand pathogens	-
Transboundary impacts	Yes, for quality only	Sinkholes in Bosnia and Herzegovina with transboundary effects in Croatia
Groundwater management measures	Many used but need improving, others needed or currently planned	Protection zones exist at Klokot, Privilica, Toplica, Ostrovica and need to be established Koreni_ki Izvor, Stipinovac and Mlinac
Future trends and prospects		-
GWB identification	BA_UNA_2	HR 359 and HR 360
Status and what is most needed		Agreed delineation of transboundary groundwaters, and development of monitoring programmes
Notes	Una River is a tributary of the Sava within the Danube basin	Transboundary aquifer under consideration, but not approved.

[17] Based on information provided by the Public Enterprise for the Sava Catchment Area, Bosnia and Herzegovina, and Croatian Waters.

No. 19 Groundwater: Krka[18]		Shared by: Bosnia and Herzegovina and Croatia
Type 5, Cretaceous karstic limestone, strong links to surface water system, groundwater flow from Bosnia and Herzegovina 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
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	-
Transboundary impacts	No data (possibly for quality only)	Sinkholes in Bosnia and Herzegovina 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

[18] Based on information provided by the Public Enterprise for the Sava Catchment Area, Bosnia and Herzegovina, and Croatian Waters.

No. 20 Groundwater: Cetina[19]		Shared by: Bosnia and 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 Bosnia and Herzegovina 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 hydroelectric power, smaller amounts for drinking water, irrigation, industry, mining and livestock, also support of ecosystems and maintaining baseflow and springs	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	-
Transboundary impacts	None for quantity or quality	Sinkholes in Bosnia and Herzegovina 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 Vukovi_a Vrelo
Future trends and prospects		
GWB identification		HR 558
Status and what is most needed	Need to improve protection of upper catchment, vulnerability mapping planned, and improved wastewater treatment needed	Agreed delineation of transboundary groundwaters, and development of monitoring programmes
Notes:		Transboundary aquifer under consideration, but not approved. Includes the Glamo_ko-Kupreško and other Poljes with very large springs Intensive agriculture in the coastal delta region

[19] Based on information provided by the Public Enterprise for the Adriatic Sea Catchment Area of Bosnia and Herzegovina and Croatian Waters.

No. 21 Groundwater: Neretva Right[20]		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 Bosnia and Herzegovina to Croatia		Mediterranean Sea basin Border length (km): ...
	Bosnia and Herzegovina	Croatia
Area (km²)	>1600	862
Water uses and functions	Dominantly drinking water supply and hydroelectric power, 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 Bosnia and Herzegovina 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 Opa_ac 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 and development of monitoring programmes are needed
Notes		Transboundary aquifer under consideration, but not approved

[20] Based on information provided by the Public Enterprise for the Adriatic Sea Catchment Area of Bosnia and Herzegovina and Croatian Waters.

No. 22 Groundwater: Trebisnjica/Neretva Left[21]		Shared by: Bosnia and Herzegovina and Croatia
Type 5, Triassic, Jurassic, Cretaceous layered and massive limestones, with local Eocyne flysch of marls, clays with coals, sandstones, breccias and conglomerates, total average thickness 1000 m and maximum 2500 to 3000 m, groundwater flow from Bosnia and Herzegovina to Croatia, medium to strong links to surface water systems. Groundwater is 100% of total water use in Bosnia and Herzegovina,		Mediterranean Sea Basin Border length (km): 124
	Bosnia and Herzegovina	Croatia
Area (km²)	>2000	242
Water uses and functions	50-75% for hydroelectric power, <25% for drinking water supply and irrigation, 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 and heavy metals from thermal power generation, widely but moderately, some local, moderate pesticides from agriculture	Natural saline intrusion and occasionally microbiologic pollution
Transboundary impacts	Decline of groundwater levels and increased groundwater pollution	Improved connection with sink points in Bosnia and Herzegovina 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 development of monitoring programmes are needed
Notes		Transboundary aquifer under consideration, but not approved Supplies Dubrovnik

[21] Based on information provided by the Public Enterprise for the Adriatic Sea Catchment Area of Bosnia and Herzegovina, the Directorate of Water and Institute of Geological Research, Republic Srpska, Bosnia and Herzegovina, and Croatian Waters.

No. 23 Groundwater: Bileko Lake[22]		Shared by: Bosnia and Herzegovina and Montenegro
Type 5, Triassic, Jurassic and Cretaceous limestones and dolomites up to 3000 m thick, weakly linked to surface waters, groundwater flow from Montenegro to Bosnia and Herzegovina. Groundwater provides 100% of total water usage in Bosnia and Herzegovina		Mediterranean Sea Basin Border length (km): 90
	Bosnia and Herzegovina	Montenegro
Area (km²)	>1000	...
Water uses and functions	>75% for hydroelectric power, small amounts for drinking water and irrigation	No information
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 Groundwater: Dinaric Littoral (west coast)[23]		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 in the Montenegran part		Mediterranean Sea basin Border length (km):
	Montenegro	Croatia
Area (km²)	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

[22] Based on information provided by the Directorate of Water and Institute of Geological Research, Republic Srpska, Bosnia and Herzegovina,- and Croatian Waters.
[23] Based on information provided by the National Committee of the International Association of Hydrogeologists of Serbia and Montenegro and Croatian Waters.

No. 25 Groundwater: Shkodra/Skadar Lake, Dinaric east coast[24]		Shared by: Albania and Montenegro
Type 2, Jurassic, Cretaceous and lesser Palaeogene massive and stratified limestones and dolomites, average thickness of 150 to 500 m and maximum 300 - 1000 m, alluvial fans along the lake up to 80-100 m thick, 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, also maintaining baseflow and support for ecosystems
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	Widespread but 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, local and moderate heavy metals from industry
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		The realization of large planned engineering projects in this area could deeply influence surface and groundwaters.
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	National park and Ramsar site. See also lakes assessment	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)

[24] Based on information provided by the National Committee of the International Association of Hydrogeologists of Serbia and Montenegro and by ITA Consult, Albania.

No. 26 Groundwater: Beli Drim/Drini Bardhe[25]		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, and maintain baseflow	75% for irrigation, <25% each for drinking water and livestock, and 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	No status assessment	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, but do not affect neighbouring Drini Bardhe as they are not in direct hydraulic connection	

[25] Based on information provided by the Directorate of Water and the Jaroslav Cerni Institute, Serbia, and National Committee of the International Association of Hydrogeologists of Serbia and Montenegro, and ITA Consult, Albania.

No. 27 Groundwater: Metohija[26] — 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. In Montenegro, Type 1, Triassic karstic limestones with thickness 300 to 800 m, weak links to surface water systems.
Groundwater is 20% of total water use

Basin…….
Border length (km):

	Serbia	Montenegro
Area (km²)	1000	300-400
Water uses and functions	25-50% for irrigation, <25% each for drinking water, industry and livestock, maintaining baseflow and spring flow	>25% for drinking water, <25% each for irrigation, mining and industry
Pressure factors	Agriculture and local small industries	None
Problems related to groundwater quantity	None mentioned	None reported
Problems related to groundwater quality	Pesticides and industrial organic compounds	None reported
Transboundary impacts	None for quantity or quality	None
Groundwater management measures	Several mentioned as needed	Several mentioned as needed
Future trends and prospects		
Status and what is most needed	No status assessment	
Notes		

No. 28 Groundwater: Pester[27] — Shared by: Serbia and Montenegro

Type 2, Middle Triassic karstic limestones, mean thickness 350 m and 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 (km²)	407	>150
Water uses and functions	>75% for drinking water, <25% each for industry and livestock, support of ecosystems and maintaining baseflow	<25% for drinking water, livestock and mining
Pressure factors	Domestic wastewater	Domestic wastewater
Problems related to groundwater quantity	None reported	None reported
Problems related to groundwater quality	None reported	None reported
Transboundary impacts	None	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	Monitoring of groundwater quantity and quality need to be applied and exchange of data, as well as vulnerability mapping for land use planning
GWB identification	CS_LI3	
Status and what is most needed	No systematic monitoring data for status assessment; good status according to limited data	
Trends and future prospects		
Notes		

[26] Based on information provided by the Directorate of Water, and the Jaroslav Cerni Institute, Serbia, and the National Committee of the International Association of Hydrogeologists of Serbia and Montenegro.
[27] Based on information provided by the Directorate of Water, Serbia and the National Committee of the International Association of Hydrogeologists of Serbia, and Montenegro.

No. 29 Groundwater: Lim[28]		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 (km²)	600-800	…
Water uses and functions	25-50% for drinking water, <25% each for irrigation, mining and thermal spas, and hydroelectric power at Potpec	<25% for irrigation
Pressure factors	Waste disposal, mining and industry	Waste disposal, agriculture and industry
Problems related to groundwater quantity	None mentioned	None reported
Problems related to groundwater quality	Local but severe nitrogen, heavy metals, pathogens, industrial organics and hydrocarbons from waste disposal, mining and industry	Pollutants from industry
Transboundary impacts	None for quantity, yes for quality due to pollution from Lim River in the upper catchment	
Groundwater management measures	Abstraction management and protection zones used but need to be improved, other measures needed	Abstraction management, protection zones and vulnerability mapping for land use planning need to be applied, together with monitoring of groundwater quantity and quality
Future trends and prospects		
Status and what is most needed	According to limited data, the current status is most probably good, but systematic monitoring of the quantitative and chemical status should be established	
Notes		

[28] Based on information provided by the Directorate of Water, Serbia and the Department of Hydrogeology, University of Belgrade.

No. 30 Groundwater: Tara Massif [29]		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 (km^2)	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 drawing of polluted water into the aquifer
Problems related to groundwater quality	Pathogens	Bacteriological contamination
Transboundary impacts	None for quantity or quality	None for quantity or quality
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	According to limited data, the current status is most probably good	
Notes	Negligible conditions for nomination as a transboundary groundwater	Negligible conditions for nomination as a transboundary groundwater

[29] Based on information provided by the Directorate of Water, Serbia, the Department of Hydrogeology, University of Belgrade, the Directorate of Water and Institute of Geological Research, Republic Srpska, Bosnia and Herzegovina, and the Public Enterprise for the Black Sea Basin.

No. 31 Groundwater: Macva-Semberija[30]		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, total thickness of sequence could be 300 m average and 1000 m maximum, strong links to surface water systems, dominant flow from southwest to northeast towards the Drina River and to the Sava, but see note below. Groundwater is 40-60% of total water use in the Serbian part, and 100% in the Bosnian part		Black Sea basin Border length (km): 87?
	Serbia	Bosnia and Herzegovina
Area (km^2)	967	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 or quality	None
Groundwater management measures	Abstraction control, monitoring of groundwater, protection zones and wastewater treatment need improvement, other management measures need to be introduced or are currently planned	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
GWB identification	CS_DR 1	TBGWB 28 – BA_DR_5
Future trends and prospects		
Status and what is most needed	Possibly at chemical risk, not at quantitative risk	
Notes	Drina River forms the boundary, within the Sava river basin. Information refers to the alluvial aquifer	Component of inflow from Drina River to groundwater is suggested Information refers to the alluvial aquifer

[30] Based on information provided by the Directorate of Water, Serbia, the Department of Hydrogeology, University of Belgrade, and the Directorate of Waters and Institute of Geological Research, Republic Srpska, Bosnia and Herzegovina.

No. 32 Groundwater: Northeast Backa/Danube-Tisza Interfluve[31]		Shared by: Serbia and Hungary
Type 5, Part of North Pannonian basin, Miocene and Eopleistocene alluvial sediments, partly confined, predominantly sands with clayey lenses of average thickness 50-100 m and maximum 125-150 m in Serbia, average 250 m and maximum 700 m in Hungary, medium to strong links to surface waters, groundwater flow from Hungary to Serbia. Groundwater 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 (km²)	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 ecosystems
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 iron	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 used, 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 wastewater treatment and exchange of data need improvement, 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	HU_P.1.15.1, HU_P.15.2, HU_P.1.16.1, HU_P.2.11.1, HU_P.2.11.2
Future trends and prospects	Possibility for use of groundwater from Danube alluvium as substitution for groundwater from deeper aquifers	Evaluation of the utilisable resource
Status and what is most needed	Current status is reported as poor, possible quantitative risk, no quality risk. Need for improved groundwater monitoring. Bilateral cooperation concerning groundwater is in an inception phase	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	Importation of arsenic-free drinking water is reported as planned

[31] Based on information provided by the Directorate of Water and the Jaroslav Cerni Institute, Serbia and the IAH National Committee of Serbia, and Montenegro, and the Geological Institute of Hungary.

No. 33 Aquifer: North and South Banat[32]		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 in a deep tectonic depression, forming a confined aquifer sequence with weak links to surface water systems, groundwater flow from Romania to Serbia, with Quaternary lacustrine and alluvial sediments above. Groundwater is up to 90% of total water use in the Serbian part, with all drinking water supply from groundwater		Black Sea Basin Border length (km): 225
	Romania	Serbia
Area (km²)	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, also support of ecosystems
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, a wide range of 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	Good status, 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 (North part)
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. Very important aquifer – provides 100% of drinking water supplies in Vojvodina

[32] Based on information provided by the Directorate of Water, the Jaroslav Cerni Institute and the Department of Hydrogeology, University of Belgrade, Serbia, and the National Institute of Hydrology and Water Management of Romania.

No. 34 Aquifer: Stara Planina/Salasha Montana[33]		Shared by: Serbia and Bulgaria
Type 2, Triassic and Cretaceous karstic limestones with some overlying Quaternary alluvium, average thickness 100 – 200 m and maximum 400 m, medium links to surface water systems, groundwater flow from north east to south west, from Bulgaria to Serbia Groundwater is about 50% of total water use		Black Sea Basin Border length (km):
	Serbia	Bulgaria
Area (km^2)	785	87? + 203? + 28?
Water uses and functions	25-50% drinking water, <25% each for irrigation, industry, thermal spa and livestock, also supports ecosystems	-
Pressure factors	Waste disposal and industry, agriculture	-
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 and farming, 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	? + CS_NI4	BG063, BG082 and BG131
Trends and future prospects		
Status and what is most needed	According to limited data the current status is most probably good, there is need for quantity and quality monitoring	-
Notes	Includes the Vidlic/Nishava and Tran	The Salasha Montana and Nishava karst basins are part of the West Balkan Nature Park which may become an agreed transboundary park

[33] Based on information provided by the Directorate of Water, Serbia, and the Department of Hydrogeology, University of Belgrade.

No. 35 Groundwater: Korab/Bistra - Stogovo[34]		Shared by: Albania and The former Yugoslav Republic of Macedonia
Type 1 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, mean aquifer thickness from 500 to 700 m, maximum more than 2000 m, weak links to surface waters, groundwater flow occurs in both directions, but more from The former Yugoslav Republic of Macedonia to Albania Groundwater provides >90% of total supply in Albania and The former Yugoslav Republic of Macedonia		Mediterranean Sea basin Border length (km): 25
	Albania	The former Yugoslav Republic of Macedonia
Area (km²)	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	Local and moderate degradation of ecosystems and drawing of polluted water into the aquifer	Local reduction of discharge from springs
Problems related to groundwater quality	Local and moderate 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 of 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 The former Yugoslav Republic of Macedonia is needed. There are large fresh water karst springs issuing at high elevations	

[34] Based on information provided by ITA Consult, Albania, and the Ministry of Environment and Physical Planning, The former Yugoslav Republic of Macedonia.

No. 36 Aquifer: Jablanica/Golobordo[35]	**Shared by: Albania and The former Yugoslav Republic of Macedonia**	
Type 2, Triassic and Jurassic 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	The former Yugoslav Republic of Macedonia
Area (km²)	250	...
Water uses and functions	25-50% for irrigation, <25% each for drinking water and industry, also for maintaining baseflow and springs	Drinking water supply, thermal water and industry, also hydroelectric power
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, sanitation and sewer leakage	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, wastewater treatment and exchange of data 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 electricity by hydroelectric power 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	

[35] Based on information provided by ITA Consult, Albania, and the Ministry of Environment and Physical Planning, The former Yugoslav Republic of Macedonia.

No. 37 Groundwater: Mourgana Mountain/Mali Gjere[36]		Shared by: Greece and Albania
Type 1 or 2, karstic aquifer developed in Triassic, Jurassic and Cretaceous limestones in large anticlines with flysch in synclines. Average thickness about 100 m and maximum about 150 m. Thickness of alluvium of 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 70% of total water use		Mediterranean Sea Basin Border length (km): 20
	Greece	Albania
Area (km^2)	90	440
Water uses and functions	50-75% for irrigation, 25-50% for drinking water supply, <25% for livestock, also support of ecosystems and maintaining baseflow and springs	Provides 100% of drinking water supply and spa use, and >75% for irrigation, industry and livestock
Pressure factors	Low population in mountain area, minimal pressures due to agriculture	Minor from waste disposal and sewer leakage
Problems related to groundwater quantity	Local and moderate from increased pumping lifts	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 monitoring needs to be improved, a range of other management measures are needed or planned, according to the requirements of the Water Framework Directive	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	Implementation of the WFD is in progress	Increased use of groundwater in alluvial deposits and export of karst water to Italy
Status and what is most needed	Groundwater management in the framework of IWRM is 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.

[36] Based on information provided by the Institute of Geology and Mineral Exploration and the Central Water Agency, Greece, and ITA Consult, Albania.

No. 38 Groundwater: Nemechka/Vjosa-Pogoni[37]		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 (Albania), 100 to 150 m (Greece), 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 about 70% of total water use in the Greek part and up to 90% in the Albania part		Mediterranean Sea Basin Border length (km): 37
	Greece	Albania
Area (km^2)	370	550
Water uses and functions	25-50% irrigation, <25% each for drinking water supply and livestock, maintaining baseflow and springs and supporting 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, mainly from agriculture	Minor waste disposal and sewer leakage
Problems related to groundwater quantity	Local and moderate increases of pumping lifts	Local and moderate degradation of ecosystems
Problems related to groundwater quality	Sulphate concentrations of 300-800 mg/l in many of the springs	Local and moderate pathogens from waste disposal and sewer leakage
Transboundary impacts	None for quantity or quality	None for quantity or quality
Groundwater management measures	Existing awareness raising and monitoring need improvement, other measures need to be applied or are planned according to WFD requirements	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	Implementation of the WFD in progress	
Status and what is most needed	Groundwater management in the framework of IWRM is 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

[37] Based on information provided by the Institute of Geology and Mineral Exploration and the Central Water Agency, Greece, and ITA Consult, Albania.

No. 39 Aquifer: Prespes and Ohrid Lakes[38] [39]			Shared by: Albania, The former Yugoslav Republic of Macedonia and Greece
Type 5, Mainly Triassic and Jurassic and up to Middle Eocoene massive limestones and lesser dolomites, mean thickness 200 m in the Greek part and 400 m in the Albanian, and up to a maximum of 330 m (Greece) and 550 m (Albania), including Galicica mountain between the lakes, medium to strong links to surface water systems, groundwater flow dominantly from the basin of Small Prespa Lake to that of 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 in the Albanian part and less than 25% in the Greek part			Mediterranean Sea Basin Border length (km): 40 (GR/AL), 20 (GR/MK)
	Albania	The Former Yugoslav Republic of Macedonia	Greece
Area (km^2)	350	…	110
Water uses and functions	25-50% for irrigation and <25% each for drinking water, livestock and industry, also support for baseflow and ecosystems	Drinking water, industry and ecosystems	<25% for water supply and also support of ecosystems and maintaining baseflow and springs
Pressure factors	Minor sanitation and sewer leakage and sewage effluent from Pogradec	Minor sanitation	Tourism but not a major pressure yet
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	Local and moderate degradation of ecosystems
Problems related to groundwater quality	Local and moderate nitrogen and pathogens from sanitation and sewer leakage in both groundwater and lakes, but the trend is increasing. Local pesticides from agriculture	None mentioned	None significant
Transboundary impacts	A slight increase in the phosphorus in Lake Ohrid	None mentioned	None
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	Monitoring of groundwater status is used, other management measures are planned or need to be improved according to the requirements of the WFD
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		Increasing groundwater use by the 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		Not at risk
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- The former Yugoslav Republic of Macedonia border at the edge of Lake Ohrid	Lake Ohrid has been a World Natural Heritage Site since 1980	Groundwater management in the framework of IWRM is very important in relation, inter alia, to the protection of the ecosytems supported by Prespa Lake which is a Natura 2000 site

[38] Based on information provided by ITA Consult, Albania, the Institute of Geology and Mineral Exploration and Central Water Agency, Greece, and the Ministry of Environment and Physical Planning, The former Yugoslav Republic of Macedonia.
[39] See also lakes assessment in Part II, Section II, Chapter 6.

No. 40 Groundwater: Pelagonia - Florina/Bitolsko[40]		Shared by: Greece and The former Yugoslav Republic of Macedonia
Type 5, Quaternary and Neogene unconfined shallow alluvial sands and gravels with some clay and silt and cobbles, with confined Pliocene gravel and sand aquifer, total thickness average 60 m and up to 100-300 m overlying Palaeozoic and Mesozoic schists, medium links to surface waters, groundwater flow from Greece to The former Yugoslav Republic of Macedonia. Groundwater is more than 50% of total use		Mediterranean Sea Basin Border length (km): 45?
	Greece	The former Yugoslav Republic of Macedonia
Area (km^2)	180	...
Water uses and functions	25-50% for irrigation, <25% each for drinking water supply, industry and livestock, also support of ecosystems	Drinking water supply, support of ecosystems and agriculture and maintaining baseflow and springs
Pressure factors	Agriculture	Groundwater abstraction
Problems related to groundwater quantity	Local and moderate reduction of borehole yields and drawing of polluted water into the aquifer	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 ,monitoring, vulnerability mapping for land use planning and wastewater treatment need to be improved, a range of other measures are mentioned as needed or currently planned according to WFD requirements	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	Implementation of the WFD is in progress	
Status and what is most needed	Groundwater management in the framework of IWRM is neeeded	
Notes		

[40] Based on information provided by the Institute of Geology and Mineral Exploration and the Central Water Agency, Greece, and the Ministry of Environment and Physical Planning, The former Yugoslav Republic of Macedonia.

No. 41 Groundwater: Gevgelija/Vardar[41]		Shared by: The former Yugoslav Republic of Macedonia and Greece
Type 3 or 5, Quaternary alluvial sediments, sands with gravel, partly clayey and silty with cobbles of bedrock - diabases, biotite gneisses and schists. Average thickness of 10-30 m and maximum 60-100 m. Very shallow water table. Medium to strong link with surface water systems, groundwater flow from The former Yugoslav Republic of Macedonia to Greece and from W to E in the Greek part.		Mediterranean Sea Basin Border length (km):
	The former Yugoslav Republic of Macedonia	Greece
Area (km²)	...	8
Water uses and functions	Maintaining baseflow and springs and support of ecosystems	>75% of abstraction is for irrigation, <25% each for drinking water supply and livestock, also support of ecosystems
Pressure factors	Abstraction of groundwater, agriculture	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	None
Problems related to groundwater quality	Salinization of natural origins and Nitrogen, pesticides, heavy metals, pathogens, industrial organics and hydrocarbons	None
Transboundary impacts	Observed both decline of groundwater levels and increased groundwater pollution	None for quantity or quality
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	Existing abstraction controls and monitoring need to be improved, other measures are needed or currently planned according to the requirements of the WFD
Status and what is needed		Not at risk Groundwater management in the framework of IWRM
Trends and future prospects		Implementation of the WFD is in progress
Notes		Within the Vardar River catchment

[41] Based on information provided by the Ministry of Environment and Physical Planning, The former Yugoslav Republic of Macedonia, and the Institute of Geology and Mineral Exploration and the Central Water Agency, Greece.

No. 42 Groundwater: Dojran Lake[42, 43]		Shared by: Greece and The former Yugoslav Republic of Macedonia
Type 3, Quaternary and Upper Eocene alluvial aquifer, lake deposits and terraces of silts, clays, sands and gravels, average thickness 150 m and up to 250 m, overlying metamorphic rocks, sedimentary sequences and carbonate formations - Precambrian, older Paleozoic and Green Metamorphic Complex. Unconfined, with strong links with surface water systems, groundwater flow is from north to south in the Nikolic area of The former Yugoslav Republic of Macedonia, north east to south west on the Greek side and generally towards the lake. The catchment of the Lake covers a total of 270 -280 km^2 Groundwater is 90% of total water use in the Greek part		Mediterranean Sea basin Border length (km)
	Greece	The former Yugoslav Republic of Macedonia
Area (km^2)	120	92
Water uses and functions	>75% for irrigation, <25% for drinking water supply and livestock, maintaining baseflow and springs and support of ecosystems	Irrigation and water supply
Pressure factors	Groundwater abstraction for irrigation	Groundwater abstraction
Problems related to groundwater quantity	Local and moderate reduction in 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	Low concentrations of heavy metals, but see comments on pollution in the lakes assessment	None
Transboundary impacts	Not for quantity or quality	For quantity only
Groundwater management measures	Existing data exchange, good agricultural practices and public awareness need to be improved, other management measures are needed or currently planned according to the requirements of the WFD	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	Groundwater management in the framework of IWRM is very important for protection of the available resources	
Trends and future prospects	Implementation of the WFD is in progress	
Notes	Groundwater abstraction exceeds mean annual recharge, decrease in precipitation and reduction of surface water inflows have also contributed to the decline in lake levels and area	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

[42] Based on information provided by the Ministry of Environment and Physical Planning, The former Yugoslav Republic of Macedonia, and the Institute of Geology and Mineral Exploration and the Central Water Agency, Greece.
[43] See also lakes assessment in Part 2, Section II, Chapter 6.

No. 43 Aquifer: Sandansky - Petrich[44]			Shared by: Bulgaria, Greece and The former Yugoslav Republic of Macedonia
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 groundwater 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 The former Yugoslav Republic of Macedonia to Bulgaria and Greece			Mediterranean Sea Basin Border length (km): BG/GR - 18, BG/MK - 5
	Bulgaria	Greece	The former Yugoslav Republic of Macedonia
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			
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			
Trends and future prospects			
Notes	Alluvium of Struma River and tributaries		

[44] Based on information from the Ministry of Environment and Physical Planning, The former Yugoslav Republic of Macedonia and the 2004 INWEB report.

No. 44 Groundwater: Orvilos-Agistros/Gotze Delchev [45]		Shared by: Greece and Bulgaria
Type 1 Karstic marble aquifer formed in the Proterozoic crystalline schist of the Rhodopi with thick marbles overlying gneiss, some Pleistocene alluvial sediments at the edges. Dominant groundwater flow from east to west (in Greece)		Mediterranean Sea Basin Border length (km): 22
	Greece	Bulgaria
Area (km²)	96	202
Water uses and functions	<25% for each of irrigation, drinking water supply, industry, mining, thermal spa, livestock, fish production, hydropower, also maintaining baseflow and support of ecosystems	
Pressure factors	Minimal pressures from groundwater abstraction	
Problems related to groundwater quantity	None	
Problems related to groundwater quality	None	
Transboundary impacts	None	
Groundwater management measures	Monitoring of groundwater status is already used, a range of other management measures are planned or need to be improved according to WFD requirements	
GWB identification		
Status and what is needed	Not at risk Further collaboration between the two countries to protect groundwater and surface water resources in a basin-wide way	
Trends and future prospects		
Notes		Within the Mesta and Struma river catchments. Large springs (eg Petrovo)

[45] Based on information provided by the Institute of Geology and Mineral Exploration and the Central Water Agency, Greece.

No. 45 Groundwater: Orestiada/Svilengrad-Stambolo Edirne[46]		Shared by: Greece, Bulgaria and Turkey
Type 3, Pliocene and Pleistocene lake and river alluvial sands, clayey sands, gravels, sandy clays and clays of mean thickness 120 m and maximum 170 m, overlying the metamorphic rocks of the Rhodopi Massif. Dominant groundwater flow is from Greece towards Turkey and Bulgaria. Strong links with surface water systems, with recharge from and discharge towards the rivers Ardas and Evros. Groundwater is 25% of total use		Mediterranean Sea Basin Border length (km):
	Greece	Bulgaria
Area (km^2)	450	665
Water uses and functions	>75% for irrigation and <25% for drinking water supply, also support of ecosystems	Drinking water supply, irrigation and industry
Pressure factors	Agriculture	
Problems related to groundwater quantity	Moderate problems due to abstraction for irrigation	
Problems related to groundwater quality	Recharge of the groundwater from the irrigation network of the Kiprinos Dam on the Ardas River increases the danger of pollution from 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, a range of other measures need to be applied or are planned according to WFD requirements	
Status and what is needed		
Trends and future prospects	Collaboration of the three countries to protect groundwater and surface water resources in a basin-wide way	
Notes	Alluvial sediments of Maritza River Although groundwater abstraction is reported to greatly exceed recharge, the problems mentioned were not severe	

[46] Based on information provided by the Institute of Geology and Mineral Exploration and the Central Water Agency, Greece.

No. 46 Aquifer: Topolovgrad Massif [47]		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 (km²)	249	
Water uses and functions	25 – 50% Drinking water supply, < 25% each for irrigation and livestock, maintaining baseflow and springs and support of ecosystems	
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 and exchange of data between countries	
GWB identification		
Status and what is needed		
Trends and future prospects		
Notes	Tundzha River in the catchment of the Meric River	

[47] Based on information provided by the Basin Directorate for the Black Sea Region, Bulgaria.

No. 47 Groundwater: Pleistocene Mure/Maros alluvial fan[48]		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), and 45%, 35% and 20% respectively 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 four 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.2.13.1 and HU_P.2.13.2
Status and what is needed	Good status. 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

[48] Based on information provided by the National Institute of Hydrology and Water Management, Romania, and the Geological Institute of Hungary, supplemented by the Danube Basin Analysis (WFD Roof Report 2004).

No. 48 Aquifer: Pleistocene Some/Szamos alluvial fan[49]		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 (km²)	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 and industry	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	RO_SO01 and RO_SO13	HU_P.2.1.2
Status and what is needed	Good status. 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

[49] Based on information provided by the National Institute of Hydrology and Water Management, Romania, and the Geological Institute of Hungary, supplemented by the Danube Basin Analysis (WFD Roof Report 2004).

No. 49 Aquifer: Middle Sarmantian Pontian[50]		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 (km²)	11,964	9,662
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 identification	RO_PR05	
Status and what is needed	Good status	
Trends and future prospects		
Notes	Within the Prut and Siret river basins	

[50] Based on information provided by the National Institute of Hydrology and Water Management, Romania.

No. 50 Aquifer: Neogene-Sarmatian[51]		Shared by: Bulgaria and Romania
Type 1 or Type 4 Neogene – Sarmatian oolitic and organogenic limestones in Romania, limestones, marls and sands in Bulgaria, with some sands and clays, average thickness 80 m (Bulgaria) and 75 m (Romania) and up to 250 m or 150 m respectively, weak to medium links with surface water systems, largely unconfined groundwater, dominant groundwater flow from W-SW (Bulgaria) to E-NE (Romania) Groundwater is approximately 30% of total water use in the Bulgarian part		Black Sea Basin Border length (km): 90
	Bulgaria	Romania
Area (km²)	4,450	2,178
Water uses and functions	25 – 50% for drinking water, < 25% each for irrigation, industry and live-stock, 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 agriculture	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	BG_BSGW01	RO_DL04
Status and what is needed	Possibly at risk for quality, not for quantity Improved monitoring needed	Good status, not at risk for quantity or for quality Improved monitoring needed
Notes		
Trends and future prospects		

[51] Based on information provided by the Black Sea and Danube Basin Directorates of Bulgaria and the National Institute of Hydrology and Water Management, Romania, supplemented by the Danube Basin Analysis (WFD Roof Report 2004).

No. 51 Groundwater: Upper Jurassic – Lower Cretaceous[52]		Shared by: Bulgaria and Romania
Type 4, Upper Jurassic –Lower Cretaceous karstic limestones, dolomites and dolomitic limestones, mean thickness 500 m and maximum 1000 m in Bulgaria mean 350 m and maximum 800 m in Romania, weak links with surface water systems, largely confined by overlying marls and clays, groundwater flow from NW (Bulgaria) to SE (Romania) Groundwater is about 40% of total water use in the Bulgarian part		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	None
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	RO_DL06
Status and what is needed	Not at risk for quantity or quality based on available data Improved monitoring is needed	Good status, not at risk for quantity or quality according to available data Improved monitoring is needed
Trends and future prospects		
Notes	Connected to Srebarna Lake	Connected to Sintghiol Lake

[52] Based on information provided by the Black Sea and Danube Basin Directorates of Bulgaria and the National Institute of Hydrology and Water Management, Romania, supplemented by the Danube Basin Analysis (WFD Roof Report 2004).