Protection and Sustainable Use of the Dinaric Karst Transboundary Aquifer System

NATIONAL REPORT
BOSNIA AND HERZEGOVINA

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CONTENT OF NATIONAL REPORT

WG 1
HYDROGEOLOGY

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1. Introduction

DIKTAS is an acronym of the GEF-UNDP regional project „Protection and Sustainable Use of the Dinaric Karst Transboundary Aquifer System“. This is one of the first-ever attempts to establish sustainable integrated management principles in transboundary karst aquifers at the magnitude of the Dinaric Karst System. The Inception DIKTAS report stated, „At the global level the project aims at focusing the attention of the international community on the huge but vulnerable water resources contained in karst aquifers (porous carbonate rock formations), which are widespread globally, but poorly understood”.
Partner countries within the framework of the DIKTAS project are Albania, Bosnia and Herzegovina, Croatia and Montenegro as GEF-recipient countries, as well as Greece, Italy and Slovenia as non-recipient countries. In addition a number of international organizations and institutions such as the International Association of Hydrogeologists (IAH) Commission for Karst, GWP-Med, French Geological Survey (BRGM), and the Competence Pool Water (Austria) are actively participating in the DIKTAS project as co-financing partners. The project is being implemented by UNDP and executed by the UNESCO‘s International Hydrological Programme (IHP), an intergovernmental scientific cooperative programme in water research, water resources management, education and capacity-building. The UNESCO‘s regional office for science and culture in Europe, located in Venice, as well as the UNESCO Antenna office in Sarajevo are actively supporting the project implementation.
Project preparatory stage had been covered the years 2008 and 2009. Within preparatory stage of the project two working groups (hereinafter called WG) are established to assist in the preparation of the preliminary Transboundary Diagnostic Analyses (hereinafter called TDA): 1)WG 1 Hydrogeology and 2) WG 2 Legal Policy. Most important events during preparatory stage are: Inception workshop in Podgorica (November 2008), Zagreb workshop (March 2009) and Final Validation Workshop (Venice, October 2009). After signing of the Letters of Commitment by competent national authorities and endorse of the Project document (in November 2009) DIKTAS full size project was prepared to take into enforce.
The Full size project duration is 2011-2014. Beside earlier groups, two new groups are established: WG Environment and Socio-Economics and WG Stakeholder Participation to facilitate

1.1. Project tasks and the role of WG

Karst studies have been a part of the UNESCO Science Sector programmes (International Geoscience Programme, IGCP and International Hydrological Programme, IHP) since last three decades. Since 1972 the UNESCO has coordinated and conducted a Global Study of Karst Aquifers and Water Resources and supported an array of international activities in the field of Karst Hydrogeology and Karst Water Resources Management in the region. Through these activities the UNESCO was instrumental in increasing global understanding of karst hydrogeology and water resources challenges.
The proposed project Protection and Sustainable Use of the Dinaric Karst Transboundary Aquifer System, hereinafter called “DIKTAS” Project, as it the above mentioned, is the first ever attempted globally to introduce sustainable integrated management principles in a transboundary karstic freshwater aquifer of the magnitude of the Dinaric Karst System. At the global level the project aims at focusing the attention of the international community on the huge but vulnerable water resources contained in karst aquifers (carbonatic rock formations), which are widespread globally, but poorly understood. The Dinaric Karst Aquifer System, shared by several countries and one of the world’s largest, has been identified as an

ideal opportunity for applying new and integrated management approaches to these unique freshwater resources and ecosystems. At the regional level the project's objectives are to (i) facilitate the equitable and sustainable utilization and management of the transboundary water resources of the Dinaric Karst Aquifer System, and (ii) protect from natural and man-made hazards, including climate change, the unique groundwater dependent ecosystems that characterize the Dinaric Karst region of the Balkan Peninsula (defined in UNDP Project Document).
The DIKTAS project aims at addressing the issue of the sustainable management of karstic groundwater and dependable ecosystems. It focuses on one of the world's largest karstic geological provinces and aquifer systems: the karst region corresponding to the Dinaric mountain range, which runs from Friuli (NE Italy) through Slovenia, Croatia, Bosnia - Herzegovina, Montenegro and Albania.
The task of the Work Group 1 – Hydrogeology within DIKTAS project is to collect, analyse and process data and information necessary for a complete and reliable Transboundary Diagnostic Analysis (TDA). It is necessary to prepare a report about the current status of knowledge on the assessment of the hydrogeological characteristics of the Dinaric Karst aquifers at the national level including compilation of information available,review of existing relevant text and cartographic documentation on geology, structural geology, hydrogeology, geomorphology, hydrochemistry etc.

Briefly, the WG Hydrogeology will:
- based on all relevant data defined (if it is precisely possible) transboundary aquifers (TBA) between parties
- provide characterisation of TBA, including definition of status of present use of the aquifers
- collect data and analyse existing plans and projects and possible interactions regarding transboundary karst aquifers;
- define qualitative status of groundwaters in the transboundary aquifers
- define main pressure regarding quantity
- analyse and prioritize existing threats to groundwater quality in the the Dinaric Karst including contamination from point and disperse sources and land degradation;

The group will develop the first regional GIS hydrogeological base, with all relevant data regarding groundwater, especially in the area of TBA.
The content of this report (and all national hydrogeological reports) is proposed by the advisor of hydrogeological group professor Zoran Stevanović and adopted by the project management.

1.2. General on karst – term, distribution, importance

The term karst, in addition to its geological meaning, is usually used as a synonym for barren rocky terrains (Milanović, 2005). Classical karst terminology recognizes a karstic region as a region consisting mainly of compact and soluble carbonate rocks in which appear distinctive surficial and subterranean features, caused by solutional erosion. The term can also be applied to any region made up of other soluble rocks: anhydrite, gypsum, salt. In a broader sense, the term is utilized to designate every phase of the karstification process in karstifiable rocks.
Karst is a medium which has traditionally been the subject of hydrogeological research, given the abundant water resources that are stored in it. In many cases karst is the product of climatic and hydrological evolution in carbonate areas in recent periods of geological history. Karst contains key information on recent environmental changes. The action of water has generated a great range of karstic features that are part of our natural heritage and some of them form major tourist attractions

(landscapes of natural parks, geosites and show caves, for example). Karst areas often serve as landscapes or as substrates for human activity.

While non-karst geological terrains have been utilized successfully in the construction of large hydro projects including dams and reservoirs and water supply and irrigation projects, karst regions have been considered unsuitable for the development of similar projects. This is due to the complex geological features and unique hydrological characteristics of karst rock formations, consisting mainly of limestone, dolomite, gypsum, and halite. Solubility of these rocks plays a major role in forming the karst terrains with complex geological and hydrogeological characteristics (Milanović, 2005).

However, an increased demand for drinking water, land reclamation, and energy has gradually changed the engineer's attitude toward the use of karst regions. In the past few decades, many water resource projects have been successfully developed in countries with large karst regions, such as Bosnia and Herzegovina, Serbia, Montenegro, Croatia, China, France, Greece, Iran, Italy, Russia, Slovenia, Spain, Turkey, the United States. Nevertheless, the road to those successes has been often paved with failures. For example, many man-made reservoirs in karst regions could not retain water in the quantities necessary for producing expected yields.

Karst is a highly fragile ecosystem and the exploitation of its resources or inappropriate land uses give rise to environmental problems (water pollution, subsidence, flooding, changes in the subterranean environment, etc.).

The first version of the world map of carbonate rocks appeared in Ford & Williams (1989) Karst Geomorphology and Hydrology. A revision was published by Williams & Ford (2006) Zeitschrift für Geomorphologie Suppl-Vol 147, 1-2, and used in Ford & Williams (2007) Karst Hydrogeology and Geomorphology (Wiley). The following figure is map v3.0 revision and it is in greater detail and attempts to differentiate those areas where carbonate rocks are relatively pure and continuous from those where they are abundant but discontinuous or impure. It was prepared by Paul Williams and Yin Ting Fong (figure 1) using a multitude of sources of which the most important are acknowledged in Williams & Ford (2006).

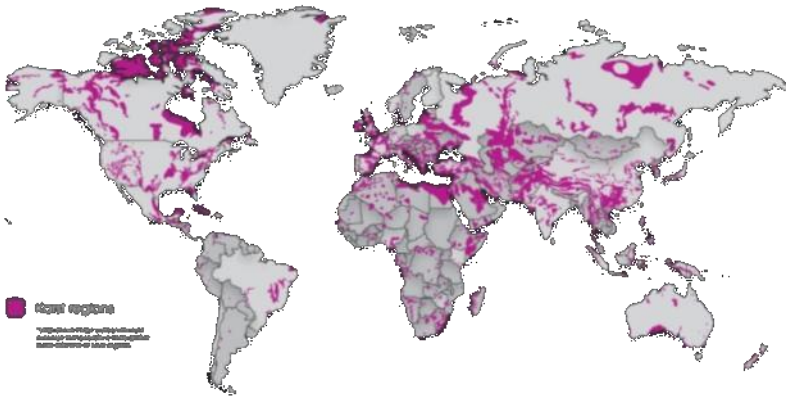


Fig. 1: Karst regions in the world (after Paul Williams and Yin Ting Fong)

Excluded Antartica, Grenland and Island karst regions in the world cover 133448089 km^2 or 13.2%. In Europe the karst areas cover 6125842 or 21.8% of territory (Table 1).

Table 1: *World Carbonate Outcrop Areas (after Paul Williams and Yin Ting Fong)*

Region	Countries Included	Land Area (km^2)	%
World	Exclude Antarctica, Greenland and Iceland	133448089	13,2
Russia Federation plus	Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russia, Turkmenistan, Uzbekistan	20649781	19,3

South America	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Falkland Islands (Malvinas), French Guiana, Guyana, Paraguay, Peru, South Georgia and the South Sandwich Island, Surinam Uruguay, Venezuela	17792882	2,1
Africa	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Congo the Democratic, Cote D'ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Morocco, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Western Sahara, Zambia, Zimbabwe	30001574	10,1
North America (exclude Greenl.)	Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, Canada, Cayman Islands, Costa Rica, Cuba, Dominica, Dominica Republic, El Salvador, Guadeloupe, Guatemala, Haiti, Honduras, Jamaica, Martinique, Mexico, Montserrat, Nicaragua, Panama, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Turks and Caicos Islands, US, Virgin Islands, Virgin Islands (US)	22229293	18,3
East and South East Asia	Brunei Darussalam, Cambodia, China, East Timor, Indonesia (excluding Papua), Japan, Korea (north and south), Lao, Malaysia, Mongolia, Myanmar, Philippines, Singapore, Taiwan, Thailand, Vietnam	15638629	10,8
Middle East and Central Asia	Afghanistan, Bangladesh, Bhutan, Cyprus, India, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Maldives, Nepal, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Sri Lanka, Syria, Tajikistan, Turkey, United Arab Emirates, Uzbekistan, Yemen	11129677	23,0
Europe (exclude Iceland and Russia)	Albania, Andorra, Austria Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Moldova, Monaco, Netherlands, Norway, Poland, Portugal, Romania, San Marino, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, UK, Vatican City, Yugoslavia	6125842	21,8
Australia	American Samoa, Australia, Baker-Howland-Jarvis, Christmas Island, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, Micronesia, New Caledonia, New Zealand, Niue, Norfolk Island, Northern Mariana Islands, Palau, New Guinea (Papua New Guinea plus Papua) , Solomon Islands, Tonga, Tuvalu, Vanuatu, Wallis and Futuna Islands, West Iran, Western Samoa.	9611377	6,2

The Dinaric karst, one of the biggest in Europe, extends from Slovenia via Croatia, Bosnia and Herzegovina, Serbia, Montenegro to Albania.

Outcrops of karstified rocks are registered on the more than 24.000 km^2 of B&H territory. It represents about 45% of the whole territory. Karst terrains in the biggest degree cover the External Dinarides zone which geographically corresponds to the territories of northwestern Bosnia, Western and Eastern Herzegovina.

Other significant karst areas are situated in the east (Romanija Mtn.) and southeast parts of the country (Igman, Jahorina, Lelija, Zelengora, Volujak and Maglić Mts.).
Distribution of the outcrops of kasrtified rocks in the territory of Bosnia and Herzegovina is given in the figure left (Figure 2).

Fig. 2: Most important karst areas in B&H cover about a half of the territory

1.3. Historical review of karst researches

The Dinaric region is a karst holotype. Not only was the term karst born in the area, but Jovan Cvijić also performed most of his work in the Dinaric karst and founded a new scientific discipline - karstology. His publication Das Karstphänomen (1893) established that rock dissolution was the key process and that it created most types of dolines, 'the diagnostic karst landforms'. Germanicised as 'karst'. the Dinaric Kras thus became a type of area for dissolutional landforms and aquifers; the regional name is now applied to modern and paleo-dissolution phenomena worldwide. Cvijić related the complex behaviour of karstic aquifers to the development of solutional conduit networks and linked it to a cycle of landform evolution. He is recognized as "the father of karst geomorphology" (Ford, 2005). Cvijić began postgraduate study of geography at the University of Vienna in 1889 and finished in 1892 with the dissertation "Das Karstphaenomen", tutored by Professor Albrecht Penk. The dissertation was published next year by the Academy of Sciences in Vienna and aroused great interest among geoscientists all around the world. Cvijić was credited with the acceptance of the concept of chemical corrosion as the dominant process in the morphogenesis of sinkholes (in contrast to the generally accepted theory of cave collapse as a major genetic factor). He also classified (descriptive and genetic) caves, karst rivers, and dolines (Stevanović, 2005).
Cvijić stated that "there is no deeper and more thorough karst development than Herzegovina- Montenegro's karst located between the lower Neretva River, Skadar Lake and the Adriatic Sea" (J. Cvijić, 1926).
Following Cvijić's research, a large number of authors from former Yugoslavia, Italy, and Albania contributed to the improvement of the knowledge about the Dinarides in terms of hydrology, geomorphology, geology, hydrogeology and social – humanistic sciences, as well. The list of those authors is very long; some are mentioned in further chapters related to geological history and classification of karst morphological features, while others can be found in the preliminary prepared list of main

references. Work after WW II on the Basic Geological Map of Yugoslavia, on the scale 1:100.000 (with working sheets 1:25.000), also enabled upgrading of the geological information about Dinaric karst.
Important articles on geology of the Dinaride in B&H have been provided by M. Anđelković, S. Behlilović, M. Čanović, S. Čičić, M. Dimitrijević, A. Grubić, M. Herak, V. Jelaska, R. Jovanović, M. Jurić, S. Karamata, M. Mojićević, J. Pamić, S. Pantić, J. Papeš, K. Petković, R. Radoičić, V. Raić, T. Slišković, J. Olujić, L. Vujnović, H. Hrvatović and F. Trubelja.
The most important articles on hydrogeology have been provided by P. Milanović, I. Slišković, N. Miošić, B. Đerković, Đ. Ostojić, M. Komatina etc.
The biggest contribution on the introduction of Eastern Herzegovina karst has been provided by P. Milanović. During the last three decades of the last century this researcher had lead hydrogeological researches within the Trebišnjica and the Neretva river basins with big success. These researches were initiated by the government of the former Republic of B&H and aimed to establish huge hydro-energy systems in the area of Eastern Herzegovina. Various geological researches have been performed during more than 30 years of extensive research activities, in the first order hydrogeological, geotechnical, geophysical, hydro-chemical etc. Based on an enormous experience P. Milanović published some of the most important domestic and international papers in the area of karst hydrogeology like: Karst hydrogeology and methods of explorations (1979), Influence of the karst spring submergence on the karst aquifer regime (1986), Geological engineering in the karst terrains (1999), Karst of Eastern Herzegovina and Dubrovnik littoral (2006) etc. The second most important researcher of karst areas of Bosnia and Herzegovina is I. Slišković. Before 1992 as a team leader of the hydrogeological department of the former Geological Institute of Bosnia and Herzegovina he had been performed numerous hydrogeological researches (especially dye tests) in the area of Western Herzegovina and southwestern Bosnia. Beside Slišković a huge contribution in hydrogeological exploration has been provided by N. Miošić. As the result of regional hydrogeological explorations during the decades, in 1983 a capital paper “Balance of kart-fissure aquifers in the territory of Bosnia and Herzegovina” was published by the former Geological Institute of B&H.
The main hydrogeological project “Basic hydrogeological map” was stopped in 1992, after approximately 10 years of activity. Just a few sheets of this map were finished up to so-called “four phase” (preparation for publishing), but neither a sheet of the map has ever been published. The most important researchers on this project in karst areas, beside the above-mentioned, are L. Jovanović, Z. Brkić, J. Stanković, J. Plavkić, F. Tahirović, S. Glavaš etc.
Between 1992 and 1995 hydrogeological researches had been interrupted by the war events. After 1995 hydrogeological researches have been performed in a very modest manner. Pre-war karst monitoring network was mostly destroyed and new data are restricted on narrow zones, mostly coverage of hydro-energy systems (e.g. groundwater monitoring provide by HES “Trebišnjica” in Eastern Herzegovina).

2. Physiography and climate

The next sub-chapters briefly describe main physiography, land use and climate characteristics of Bosnia and Herzegovina with emphasize on the area of interest for the DIKTAS project.

2.1. Geographic position and boundaries

Bosnia and Herzegovina is located in the western part of the Balkan Peninsula. The territory extends between 42^0 26' and 42^0 15' northern latitude and 15^0 45' i 19^0 41' eastern longitude.
It shares the country border with the following neighbouring countries: the Republic of Croatia (932 km) to the north, west and the south, the Republic of Serbia (302 km) to the east, and the Republic of Montenegro (225 km) to the south-east (Fig. 1.1).
The country is mostly mountainous, encompassing the central Dinaric Alps. The north-eastern parts reach into the Pannonian basin, while in the south the border is the Adriatic Sea. The country has only 20 kilometres of the coastline, around the town Neum in southern Herzegovina.
The name of the country comes from two regions: Bosnia region and Herzegovina region, which have very vaguely defined border between them. Bosnia occupies the northern areas which is roughly four fifths of the entire country, while Herzegovina occupies the rest in the south part of the country.

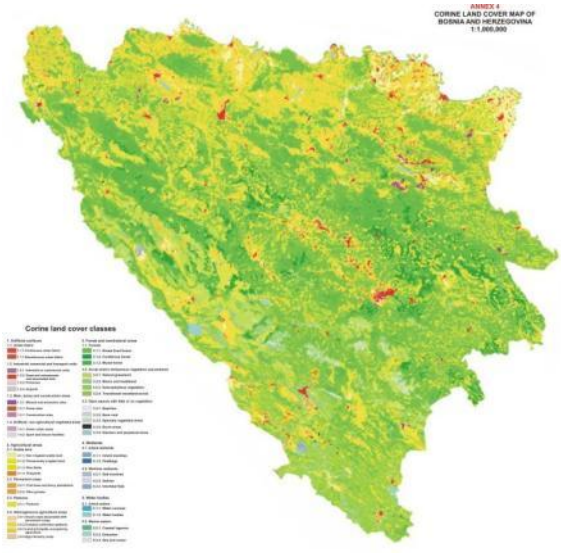
Fig. 3: Geographic position of the Bosnia and Herzegovina

There are the following nationalities in Bosnia and Herzegovina: Bosnians, Serbs, Croats and the members of other nationalities. The official languages are Croatian, Serbian and Bosnian, and two types of writing are in use: Latin and Cyrillic.
The capital city of Bosnia and Herzegovina is Sarajevo. Other considerable towns are: Banja Luka (the administrative centre of the Republic of Srpska), Bihać, Prijedor, Zenica, Tuzla, Bijeljina, Mostar, Trebinje etc.
The country has several levels of political structure under the federal government level. The most important of these levels is the division of the country into two entities: the Republic of Srpska and the Federation of Bosnia and Herzegovina.
The Federation of Bosnia and Herzegovina covers around 51% of the whole area of Bosnia and Herzegovina, while the Republic of Srpska covers around 49%. The entities, based largely on the territories held by two warring sides at the time, were formally established by the Dayton peace agreement in 1995.

The Brcko district in the north of the country was created in 2000 out of land from both entities. It officially belongs to the both, but it is governed by neither, and functions under a decentralized system of local government.
The third level of political subdivision of Bosnia and Herzegovina is manifested in cantons. They are unique to the Federation of Bosnia and Herzegovina entity, which consists of ten of them. All of them have their own cantonal government, which are under the law of the Federation as a whole. Some cantons are ethnically mixed and have special laws implemented to ensure the equality of all constituent nations.
The fourth level of political division in Bosnia and Herzegovina is municipalities. The Federation of Bosnia and Herzegovina is divided into 74 municipalities, and the Republic of Srpska into 63. Municipalities also have their own local government, and are typically based around the most significant city or the place in their territory.

2.2. Vegetation and land cover

Land Cover in Bosnia and Herzegovina has been characterized by 33 out of 44 classes of the CORINE Land Cover nomenclature. The analysis of land cover database shows that more then 61.04% of the surface of Bosnia and Herzegovina is covered by forest and natural vegetation, while about 36.69% is occupied by agriculture. The land classified as artificial areas occupys about 1.48%, while about 0.77% is classified as wetlands or water.
Agriculture areas, natural vegetation and forests cover most part of the north Bosnia. This part of territory, in geological sense, corresponds mostly to the Pannonian basin. It is the most important country region regarding to agriculture production. The central part of the country is dominantly presented by middle and high Bosnian mountains and inter-mountain depressions, in majority covered with forest and pastures. The central part is also a part with intensive mining activities (metallic, non-metallic and energy mineral resources exploitation). The biggest urban areas are situated in the central and the northern part of B&H, in big river vallies. In the central part there are cities like: capitol Sarajevo, Zenica, Tuzla, Doboj and in the north part Banja Luka, Prijedor, Brčko, Bijeljina etc. In two the above-mentioned parts of the country live more than 80% of the total population.



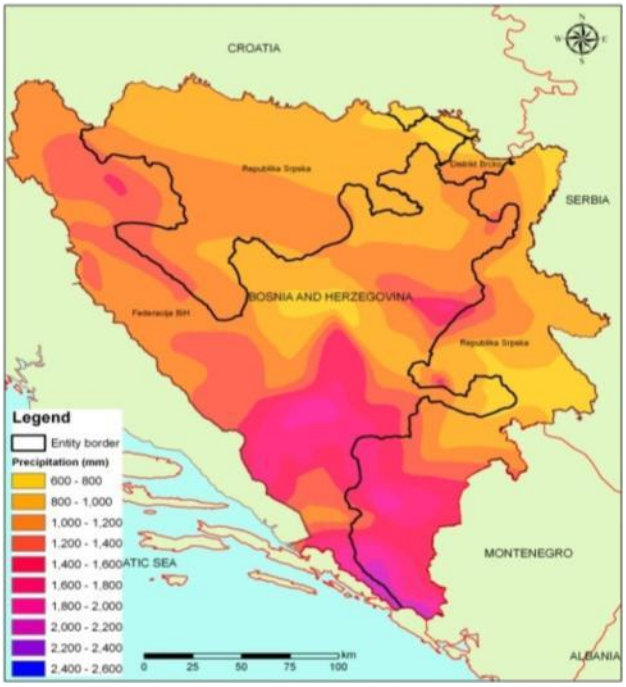
From the central to the southern country part appears transitional zone. It is the zone with sparsely vegetation than in the northern parts, occasionally with occurs of the bare rocks. This kind of the relief (bared rocks) is mostly characteristic for Herzegovina region and in a smaller degree for western Bosnia. The zone of the DIKTAS transboundary karst aquifers mostly comprises Herzegovina and the northwestern part of B&H.

Fig. 4: Corine land cover map of B&H

It is generally sparsely populated area and an area with weak vegetation. Only cultivated areas are karst fields, usually filled with younger (the Tertiary) sediments and with a thicker soil layer than zones out from karst field. Logically, the zones of karst fields are mostly populated and industrialized zones and also with most extensive agricultur production in the karst terrains of B&H.

2.3. Rainfall regime

The country mostly has the continental climate, except its southern part where prevails the Mediterranean climate.
The main characteristics of continental climate are long and cold winter, also short and hot summer (temperature during a year is between -20^{0}C and 40^{0}C) with precipitation between 700 mm on the northern and 1400 mm on the southern part of the belt.
The main features of the Mediterranean climatic belt are summers with high temperatures, in some cases more than 40^{0}C, and mild winters with significant higher temperatures in comparison with the continental belt.



Precipitations generally increase from the north to the south. The highest values are registered in the zone of interest for the DIKTAS project (from Bihać region to Eastern Herzegovina). In the whole area of the north-western Bosnia and Western and Eastern Herzegovina average annual precipitations exceed 1000 mm per year. Precipitations are the main source of the recharge of the karst aquifers and play key role regarding to water balance within the transboundary aquifers.

Fig. 5: Average annual precipitations in B&H, period 1961-1990

In Eastern Herzegovina precipitations are one of the highest in Europe. In Trebinje precipitation station it is measured more than 2200 mm/year. Average annual precipitations are 1780 mm. The main characteristic of precipitations is unequal regime. Spring and autumn months are characterised by huge amount of the rain (spring months with intensive snow melting as well). Occasionally 700 mm of the rain occurs monthly (it is annual values of precipitation in the northern part of B&H, e.g. Bijeljina area). For the example, in the area of Gatačko field 160 mm had been fallen during eight hour in October 13th, 1975. Registered daily maximum of precipitations for Trebinje precipitation stations in the period 1925-1940 is 280 mm.
The values of the average precipitations for the six characteristic climate stations are shown in the following table (two stations in the Mediterranean climate belt, four in the continental belt – two in mountain and two in planes areas).

Table 2: Average annual precipitations for six characteristic climate stations in B&H

Period 1961-1990	Annual precipitation (mm)	River basin	Area in B&H
Bijeljina	760	Drina	North-east
Banja Luka	1026	Vrbas	North

Bihać	1308	Una	North-west
Sarajevo	932	Bosna	Central
Mostar	1515	Neretva	Western Herzegovina
Trebinje	1780	Trebišnjica	Eastern Herzegovina

2.4. Air temperature

Moderate-continental climate (the middle European climate) prevails in the northern country part, with cold winters and hot summers, but in comparison with the Alpine belt, temperature variations between the winter and the summer months are smaller. The warmest part of this belt is situated in the northeast, while values of average temperatures toward the southwestern part of the belt decrease. In the central part of Bosnia and Herzegovina continental-mountain climate of the Alpine type prevails.

Figure 6: Average annual temperatures in B&H, period 1961-1990 (source: Hydro-meteorological institute of the Federation of B&H)

The main characteristics of this climate are very cold winters (absolute temperature minimum is from -24 to -34oC) and hot summers (absolute temperature maximum 30-36^{o}C) with abundance of snow in winter months, especially in high areas. Average temperatures range between 12 and 13 ^{o}C (Figure 6).
In southwestern parts of Bosnia and Herzegovina, caused by vicinity of the Adriatic Sea, average January temperatures are rather higher, from 3 to 5^{o}C. Summer months are rather dry and hot. The absolute temperature maximum is more than 40^{o}C. Average annual temperature is between 13 and 16^{o}C. Occurrence of the snow is very rare.
Table 3: Average annual temperatures for the six characteristic climate stations in B&H

Period 1961-1990	Average annual temperature	River basin	Area in B&H
Bijeljina	10.8	Drina	North-east
Banja Luka	10.5	Vrbas	North

Bihać	10.6	Una	North-west
Sarajevo	9.5	Bosna	Central
Mostar	14.6	Neretva	Western Herzegovina
Trebinje	14.5	Trebišnjica	Eastern Herzegovina

2.5. Other climate elements

Evaporation is shortly considered in the following subchapter, as important element of water balance in the karst regions.

2.5.1. Evaporation in the Dinarides in B&H

Evaporation generally decreases from north to south (visible in map 2.4). Evaporation is between 300-500 mm within the zone of the Inner Dinarides (the middle part of B&H). This values increase in the zone of the External Dinarides (the zone of the interest for the DIKTAS project) up to 720 mm (see table 4). It is aftermath of the rare vegetation and also higher openness of the terrain in the southern parts of the B&H, as the result of the very soluble limestone domination.

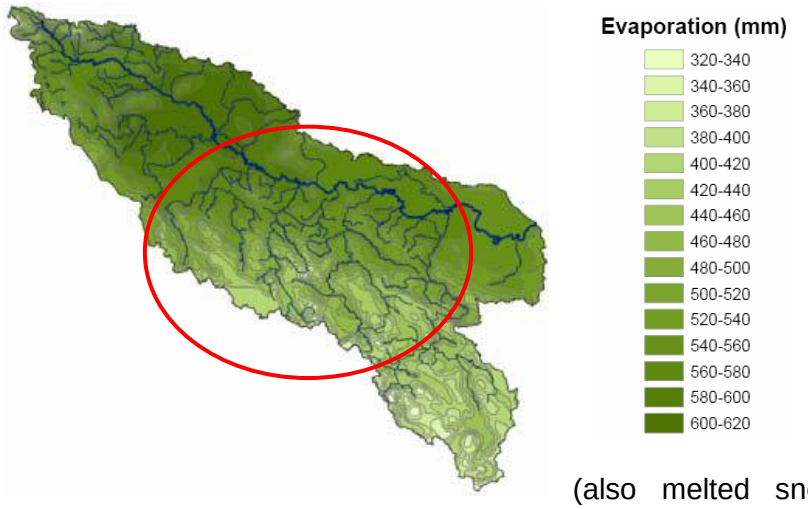


Fig. 7: Mean annual evapotranspiration in the Sava river basin, red circle approximately represent B&H territory (source: UNESCO, 2006)

Low evaporation in the zone of very high precipitation and openness of terrain in the surface allow quick infiltration of the rainfalls (also melted snow) and specific karst regime of waters – with total prevailing of the underground runoff, and very sparsely surface stream network.
Based on the results of the studies about balance of waters in karst-fissure aquifers in the territory of B&H (Slišković et al., 1983) the values of evapotranspiration in the Dinarides karst areas range from 17% (238 mm) for Korčanica spring catchment area to 69% (678 mm) for Tarčevica spring. Most usual values of evapotranspiration for catchment areas of karst springs in the Internal Dinarides are 35-40%. But in the zone of the External Dinarides, in accordance with available data, values of evaotranspirations are significantly lower than above-mentioned within Internal Dinarides zone. For example for Buna and Bunica springs values of this parameter are 30% (528 mm), for Lištica Spring about 23% (504 mm). The lowest value (Table 4) is registered for catchment area of Drežanka spring, something less than 19% (337 mm).

Table 4: Some examples of evapotranspiration values within catchment areas of strong karst springs (based on balance equation)

Spring	Watershed	I*/E**	Evapostranspiration (mm)	Evapostranspiration (%)
Tarčevica	Bosna	I	678	69.3
Vrutok bistrica	Drina	I	288	23.5
Sana	Sana	I	468	35.0
Lučka vrela	Drina	I	278	22.0
Voloder	Una	I	407	34.5
Krupac i Lađanica	Neretva	E	522	23.4
Buna i Bunica	Neretva	E	528	30.0
Tihaljina	Neretva	E	603	33.0
Lištica	Neretva	E	504	22.7
Nezdravica	Neretva	E	722	38.6

*I – the Internal Dinarides
**E – the External Dinarides

3. Hydrology

3.1. Hydrographic network

In hydrographical sense the territory of Bosnia and Herzegovina belongs to the Black sea basin (the Danube river basin) and the Adriatic sea basin. The part of the Danube river basin in B&H is actually a part of the Sava sub-river basin. The Sava river represents the Danube river second largest tributary concerning area and largest tributary concerning average flow.
The Black sea basin takes 75.70% of whole territory of B&H (38,719 km2) and the rest of 24.30% (12,410 km2) belongs to the Adriatic sea basin (Figure 8).
Main tributaries of the Sava river in B&H with area of basin more than 4000 km2 are: the Una river with the Sana, the Vrbas river, the Bosna river and the Drina river. The basins which belong to the Adriatic sea in B&H are: the Cetina river, the Neretva river and the Trebišnica river basins (Figure 9).
In this report especially interesting are: the upper part of the Una river, and whole basins of the Cetina river in B&H, the Neretva and the Trebisnjica river. Proposed and analysed transboundary aquifers are a part of above-mentioned river basins.

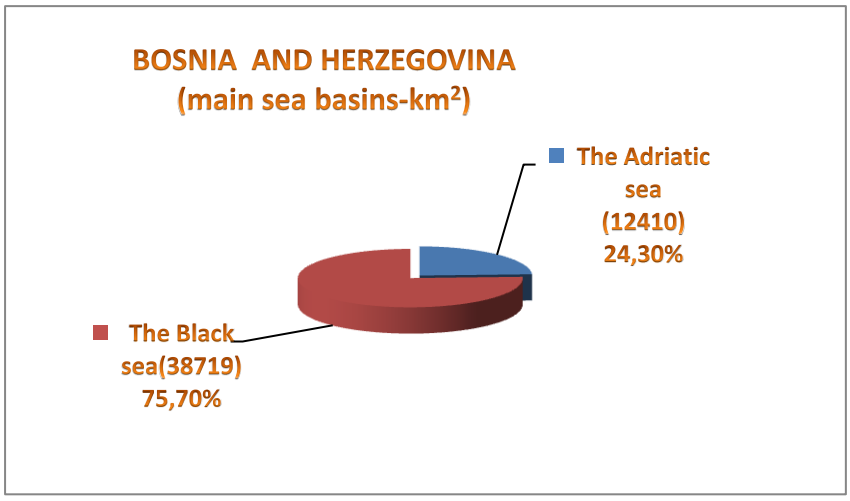


Fig. 8: The main sea basins in B&H with area in km^2

Water resources make one of the most important resources in Bosnia and Herzegovina. Their use through history has caused the development of very complex water systems which represent essential development factor and also very significant environmental factor.
Environmental objectives in accordance with WFD impose the model of sustainable and equitable water management including maintaining, improving and the reasonable use of surface water and groundwater as well as undertaking all available measures for prevention and restriction of water pollution. In accordance with the request of WFD for identification of national river basins with area more than 4,000 km2 in the territory of B&H, the following river basins are defined (Figure 9).
In the area of interest, the most important rivers are: the Una river, the rivers which belong to the Cetina river basin, the Neretva river and the Trebisnjica river (Figure 9).
The Una river belongs to the Black sea basin. It is the left tributary of the Sava river and represents the third largest tributary of this river. It appears in the sole of Suvaja Mt. (420 m a.s.l.). The main left tributaries are the Klokot and the Žirovac. The main right tributaries are the Unac, the Krušnica and the Sana. About 97.5% of the Una river basin belongs to B&H and just about 2.5% (238 km2) belongs to Croatian territory.

Fig. 9: Map of Bosnia and Herzegovina with main river basins (blue coloured basins belong to the Adriatic sea basin, other belong to the Sava river basin – the Black sea basin)

Some springs of the main tributaries of the Una river are very important in consideration of transboundary groundwater aquifers (e.g. main two springs of the Klokot river). For the purpose of this document the most important part is the upper part of the Una basin. In this carbonate part of basin there are some appearances of many significat karst springs as well as the other karst phenomena: swallow holes, strong springs, caves, pits, beautifull waterfalls like in Figure 10 etc. Springs and other phenomena will be in the focus within hydrogeological part of this report.

Fig. 10: Upper part of the Una river with beautifull waterfalls

The area between the Black sea river basin (from the Una basin watershed on the NW) and the basin of the Neretva belongs to the Cetina basin. The basin of the Cetina river belongs to the Adriatic sea basin. The Cetina river basin includes Livanjsko and Duvanjsko fields, Staretine, parts of Glamočko and Kupreško field and Buško mud in the territory of Bosnia and Herzegovina. There are no significant surface streams. In this zone the groundwater runoff dominates. The water from precipitation infiltrates quickly in very porous carbonate mass and flows toward the lower part of terrain in Croatian territory. Rare surface streams like the Jaruga and the Plovuća in Livanjsko field their stream finish sinking in swallow holes at the edge of the mentioned field. This will be explained detaily in the analysis of transboundary flows from B&H to Croatia.

The Neretva basin (without the Trebisnjica) in the territory of B&H comprises about 7,950 km2. It is the longest river and the river with the biggest flow in our karst. Bigger tributaries on the left side are following rivers: the Ljuta, the Rakitnica, the Treštenica, the Neretvica, the Rama, the Doljanka, the Drežanka, the Radobolja, the Jasenica and the Trebižat. On the right side there are following tributaries: the Šistica and the Boščica in the upper part and the Buna, the Bregava and the Krupa in the lower part of the stream through the southern Herzegovina territory. Average altitude of the basin is 795 m. Annual average precipitations are very high – about

1580 mm per year. Whole stream to Čapljina flows through a canyon with the exceptions near Jablanica and Mostar. Between Jablanica and Bijelo field the canyon is deep more than 200 m. The biggest river bed inclination is in Mostar (370 m) (in the middle part of the stream from Jablanica to Mostar 120 m in 40 km). The downstream from Mostar to Žitomislić, the river bed inclination is 1.68%. Beside above mentioned significant surface streams, very important for water regime of the Neretva river are strong karst springs, located close to the river as: Veliki and Mali Praporac, Mlječnik, Crno vrelo (occasionally), Salakovačka vrela, Studenac etc. The basin of the Trebišnjica river is typically karstic, contains intensively karstified carbonated rocks. From the emerge near Bileca to the Grnčarevo flows through a narrow valley in which the biggest accumulation lake is built up in the Dinaric karst and it is one of the biggest in Europe.

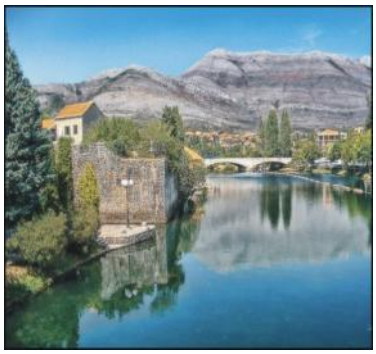


Fig. 11: The Trebišnjica river in Trebinje town

From Grnčarevo, the Trebišnjica diverts its flow to the SW. The upstream and the downstream from Trebinje (Figure 11) some amounts of water infiltrate within the Trebišnjica river bed and appear in Dubrovnik area in Croatia. The Trebisnjica river finishes its stream in the swallow hole Ponikva on the overall western edge of Popovo field.

Lakes: Natural lakes formed in higher mountain areas are mostly of glacier originate. Well-known are Blidnje and Boračko lakes, and also lakes on Treskavica and Zelengora mountains. Beside perennial lakes in karst terrains there are many occasional lakes as in the following fields: Livanjsko, Imotsko-Bekijsko, Duvanjsko and Mostarsko in western Herzegovina and the fields Gatačko, Nevesinjsko, Fatničko and Dabarsko in the eastern Hezegovina. The parts of these fields are flooded four to six months per year.

3.2. Stream-flow regime

In the territory of B&H fall average 1,250 l/m^2 of precipitation. With the area of 51,129 km^2 it gives the volume of 64x109 m^3 per year of precipitation or 2,030 m^3/s. From the territory of B&H (without transitional flows from other countries) runoff 1,155 m^3/s or average 57% of the whole fallen water (Fig. 12).

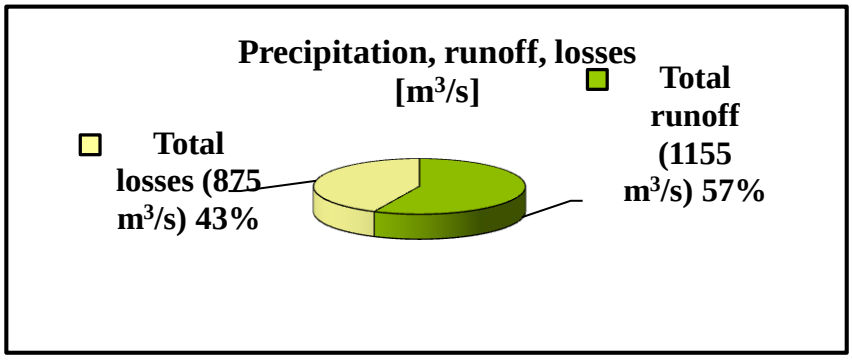


Fig. 12: Average precipitations and runoff in the territory of B&H

From this value (1,115 m^3/s), 722 m^3/s run off toward the Black sea basin and 433 m^3/s toward the Adriatic sea basin (Table 5).

In the following table, some basic information about main rivers, included data about average flow and biological minimum are given.

Table 5: Main sea basins in the territory of B&H with basic data

Basin	Basin area	Lenght of steams more than 10 km	Population (Census from 1991.year)	Average flow	Biological minimum
	[km^2]	[km]		[m^3/s]	[m^3/s]
The Black sea basin	38,719	7,947.7	4,012,266	722	118
The Adriatic sea basin	12,410	1,063.8	515,360	433	58.3
Bosnia and Herzegovina	51,129	9,011.5	4,527,626	1,155	176.3

The main river basins in the area of interest for the DIKTAS project are the following: the Una river, the Cetina river, the Neretva river and the Trebišnjica river basins. The last three belong to the Adriatic sea basin, just the Una river basin belongs to the Black sea basin.

The Una river begin its stream in Croatia. After few kilometres its flow continues in Bosnia and Herzegovina (near Martin Brod) and receives water from right tributary, the Unac river. The flow of the Unac in Martin Brod is similar like the Una river. For this paper the most important part of the Una river is from the source zone to Bihać. The data about the Una river flow regime and flow regime of its tributaries are given in the following table (Table 6). The data are provided from the Water management strategy of the Federation of Bosnia and Herzegovina, draft version 2010.

Table 6: Characterisitc flows on hydrological stations within the Una river basin (source: Water management strategy of the Federation of Bosnia and Herzegovina, draft version 2010)

Hydrological station	River	Qav.ann. (m^3/s)	av.Qmin (m^3/s)	max.Q1/T (m^3/s)		
				20 years	50 years	100 years
Martin Brod - upstr.	Una	23,50	4,97			
Drvar	Unac	7,70	0,50			213
Rmanj Manastir	Unac	29,50	5,60			
Martin Brod – down.	Una	53,50	10,60	492	543	588
Kulen Vakuf	Una	53,60	10,90			
Bihać	Una	90,00	23,40	780	875	933
Klokot	Klokot	14,00	4,40			
Kralje	Una	104,00	27,80			
Bosanska Krupa	Una	116,00	29,50			

The Neretva river begins its stream near Čemerno, in the north of Gatačko polje. The total stream length is about 225 km, about 218 through Bosnia and Herzegovina, the rest in Croatia. Up to Jablaničko lake it is also known as the Upper Neretva. The source zone, in geological sense, is mostly presented by flysch sediments of the Cretaceous age. The first significant amounts of water obtain from strong karst springs which drain southern sides of Lelija and Zelengora Mts (Pridvorica, Grebenac, Krupac). The data about the Neretva river flow regime (Figure 13) and the flow regime of its tributaries are given in Table 7. Data are provided from the Water management strategy of the Federation of Bosnia and Herzegovina, draft version 2010.

These data obviously indicate very low average flow from the Neretva river source zone up to Ulog (cca 30 km from emerge point). The flow is multipled four times in the next 30 km from Ulog (up to Glavatièevo). Enhancement of the flow downstream from Ulog is especially characteristic (gauging station Ljubuša). For about 10 km of the stream, the average flow increases three times.

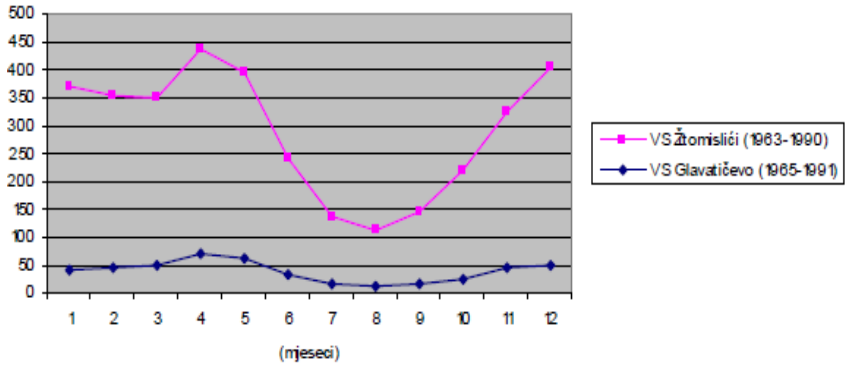


Fig. 13: Annually variation of the average monthly flow of the Neretva river, hydrological stations Žitomislići and Glavatičevo

Long-year measurements on the station Glavatičevo show minimal average annual flow in August less than 9 m^3/s. The Upper Neretva finished stream in Jablanica reservoir. Average natural anual flow of the Neretva river in Mostar is about 180 m^3/sec.

Table 7: Characterisitc flows on hydrological stations within the Neretva river basin (source: Water management strategy of the Federation of Bosnia and Herzegovina, draft version 2010)

Hydrological station	River	Qav.ann. (m^3/s)	av.Qmin (m^3/s)	max.Q1/T (m^3/s)		
				20 years	50 years	100 years
Ulog	Neretva	9,02	0,840	118	128	132
Donja Ljuta	Ljuta	2,87	0,328	40,8	51,0	61,4
Glavatičevo	Neretva	38,6	8,90	497	573	628
Konjic	Neretva	58,0		853	880	1064
Konjic	Trešanica	2,15	0,61	$maxQ_{REG}$ = 24,0		
Kralupi	Kraljušnica	2,09	0,273	$maxQ_{REG}$ = 32,2		
Idbar	Baščica	2,13	0,292	$maxQ_{REG}$ = 25,5		
Gorani	Neretvica	4,62	0,600	63	4 80	95,7
Jablanica	Doljanka	4,54	0,330	$maxQ_{REG}$ = 49,8		
Šanica	Šanica	0,90		$maxQ_{REG}$ = 26,8		
Drežnica	Dražanjka	7,48	0,528	137	175	213
Mostar	Neretva	180	50,0	1814	2030	2216
Bačevići	Neretva	201	60,0	1909	2130	2318
Široki Brijeg	Lištica	8,39	0,572	78,0	94,0	114
Ugrovača	Ugrovača	2,13	dry	104	140	184
Uzarići	Lištica	13,3	dry	216	270	322

Dom	Jasenica	10,9	dry	36,8	39,0	40,4
Blagaj	Buna	22,4	4,00			
Malo Polje	Bunica	18,8	2,30			
Buna	Buna	42,2	6,30	333	348	363
Žitomislići	Neretva	253	68*	2046	2250	2433
Čapljina	Neretva	255	-			
Rakitovac	Vrljika	9,01	0,557	$maxQ_{REG}$ = 82,0		
Grude	Grudsko vrelo	2,57	dry			
Peć Mlini-downstr.	Tihaljina	11,1	0,451	$maxQ_{REG}$ = 69,9		
Tihaljina	Tihaljina	16,5	0,66	125	134	141
Poljana vrelo	Klokun	6,54	3,19	24,7	27,1	28,9
Klobuk	Mlade	25,4	4,06	194	210	221
Grabovo vrelo	Grabovo vrelo	2,28	dry	19,2	22,2	24,3
Vitina	Vrioštica	3,21	1,49	10,2	11,0	11,6
Humac	Trebižat	31,4	2,55	201	213	222
Studenci	Studenčica	5,56	1,97	28,3	29,6	30,5
Stolac	Bregava	18,4		54,0	59,0	63,0
Gabela	Neretva	313		2208	2410	2600
Draževo	Krupa	18,0				
Draževo	Neretva	331				

The Cetina river basin (called locally also “Zapadni krš“) covers about 2.876 km^2. There is no stream of the Cetina river in the territory of B&H, just a big part of the river basin belongs to the territory of B&H with dominant transboundary underground runoff.
The river basin is fully situated in the External Dinaride zone with all characteristics of the karst terrains (strong karst springs, sinking rivers, periodical water accumulations in karst fields, sink holes, swallow holes, estavels etc.).
A big part of waters sinks in karst areas (by direct infiltrations or thru swallow holes zones) and quickly drain to strong karst springs in local erosion basis. The river basin of the Cetina river includes southern parts of Glamočko and Kupreško fields, whole Duvanjsko and Livanjsko field.
In Livanjsko field strong deterministic influence occurs by very complex system which collects and transports waters to the HPP Orlovac in Croatia. The part of this system is a big Buško lake (artificial), reservoir Mandak, Drinovac channel (collect waters of the Bistrica, the Sturba and the Žabljaka rivers) and finally the lake Lipa. This lake collects all the above-mentioned water and transports it by a tunnel to the HPP Orlovac. The flow control is provided by numerous hydrological stations in the river basins. In the next table characteristic flows on the stations are shown (also the annually variation of the average monthly flow of the Sturba river).

Table 8: Characterisitc flows on hydrological stations within the Cetina river basin (source: Water management strategy of the Federation of Bosnia and Herzegovina, draft version 2010)

Hydrological station	River	Qav.an. (m^3/s)	av.Qmin (m^3/s)	max.Q1/T (m^3/s)		
				20 years	50 years	100 years
Badanj	Badanj	1,04	dry	17,5	20,3	22,5
Dragnić	Ponor	1,59	dry	-		
Brda	Milač	0,960	0,200	8,90	10,1	11,0
Gornji Malovan	Milač	0,830	0,090	max Qreg. = 11,5		
Šuica	Šuica	2,29	0,110	28,7	38,2	42,9
Mokronoge	Šuica	2,99	dry	47,5	56,5	63,3
Male Brdine	Drina	2,50	dry	-	-	-
Jošanica	Ostrožac	0,210	0,012	7,52	10,2	12,5
Kovači-ponor*	Šuica	dry	dry	190	226	252
Vrelo Sturbe	Sturba	4,48	1,24	max Qreg. = 32,0		
Gornji Žabljak	Žabljak	2,06	0,139	-	-	-
Livno	Bistrica	3,60	0,600	34,8	37,0	38,6
Vrilo	Ričina	8,00	-	-	-	-
Kazanci-ponor	Ševarova Jaruga	1,86	0,002	max Qreg. = 6,63		
Čaprazlije-ponor*	Tovarova Jaruga	2,76	dry	148	185	201

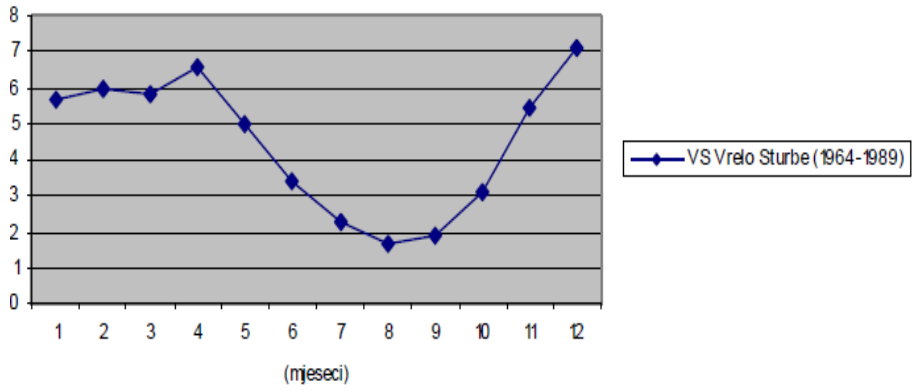


Fig. 14: Annually variation of the average monthly flow of the Sturba river, hydrological stations Sturba spring

The Trebišnjica river basin is typically karst basin. The river is the one of the most famous sinking rivers in Europe. It starts to flow under the name Mušnica. The Mušnica river flows over Gacko karst field and sinks in a wide swallow hole zone, from Srđevići (hydrological station, Table 9) to Šabanov ponor in Small Gatačko field.

River appears on the surface again near Bileća on two strong karst springs under the name Trebišnjica. These springs (Dejanova pećina and Nikšićka vrela) are submerged by the reservoir of Grančarevo dam. After short flow the Trebišnjica reach the reservoir of the next dam – Gorica, a few kilometres from Trebinje town. The downstream flow is under strong impact of the regime of Gorica dam. In natural conditions, during the dry period, the Trebišnjica river totally sinks a few kilometers downstream from Trebinje (locality Dražin Do). In that period thru Trebinje 3 m^3/s are flowed. During the wet period, the flow was formed along the whole river bad. The flow had been reached about 1000 m^3/s (e.g. 2.12.1903. flow reached 1362 m^3/s). The biggest flow of the Trebišnjica river was in the profile downstream from Ravno (after the swallow hole zone Draževo-Strujići). At this point flow exceeded 1400 m^3/s. It was highly exceeded capacities of all swallow holes and Popovo filed was flooded.
After the constructing of the hydropower system Trebišnica, the river bad was covered with concrete and the Trebišnjica today is characterised by permanent flow up to final point of the stream – a regulated swallow hole Ponikva (water from this point is used for the reversible HPP Čapljina)
The data about average flow of the Trebišnjica river are given in the following table.

Table 9: Characterisitc flows on hydrological stations within the Trebišnjica river

Hydrological station	River	Qav.ann. (m^3/s)
Srđevići	Mušnica	8.3
Grančarevo	Trebišnjica	74.2
Gorica	Trebišnjica	85.6

3.3. Controlling streamflow – dams and reservoirs

Bosnia and Herzegovina is a country rich in water, but without appropriate utilization of the energy water potentiality. Just three dams are constructed within the Drina river basin (Višegrad, Bajina Bašta and Mali Zvornik), two on the Vrbas river basin (Jajce and Bočac). The rivers like the Una, the Sana, the Bosna, the Ukrina etc. are totally unused regarding hydroenergy. The Neretva and the Trebišnjica rivers are better utilised. The figure left shows spatial distribution of the constructed dams with reservoirs in B&H (Figure 15). Some of these constructed dams apparently indicate possible benefits in the karst regions. Before all, dams and reservoirs within the Hydroenergy System "Trebišnjica" are situated in the Eastern Herzegovina.

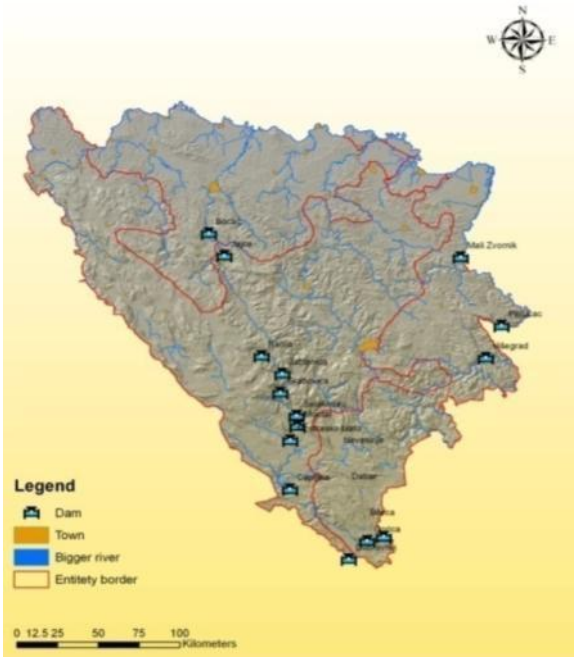


Fig. 15: Constructed dams in the territory of Bosnia and Herzegovina (just southernmost is the HPP Dubrovnik located Croatia)

Table 10: Available hydroenergy objects in the Black sea basin (the Drina and the Vrbas river basins)

No	Name	Average flow	Volume of reservoir		Area of reservoir	Height of dam	Altitude of the highest water	Install power
			total	useful				
		m^3/s	10^6m^3	10^6m^3	ha	m	m a.s.l.	MW
1	Višegrad			101		79.5		315
2	Bajina Bašta			340		90		365
3	Mali Zvornik			89*				92
4	Jajce I	38.2	-	4.20			427	60
5	Jajce II	64.7	2	1.70			328.5	30
6	Bočac	78.4	52.1	42.9	233.45	283	283	110

*-significantly filled with sediment (more than ½ of reservoir)

Table 11: Available hydroenergy objects in the Neretva river basins (source: General operating plan for flood protection of the Sava river and the Neretva river , Water management institute, Sarajevo 1990)

No	Name	Average flow	Volume of reservoir		Area of reservoir	Height of dam	Altitude of the highest water	Function*
			total	useful				
		m^3/s	Hm^3	Hm^3	ha	m	m a.s.l.	
1	Rama	33,10	487,10	466,0	1550,00	110,00	595,00	E, F, I
2	Jablanica	112,30	317,80	288,0	1440,00	85,00	270,00	E, F, I
3	Grabovica	136,20	19,80	5,4	134,00	40,00	159,00	E
4	Salakovac	184,00	68,10	15,6	370,00	69,50	123,00	E
5	Mostar	194,00	10,90	6,40	161,00	44,00	78,00	E
6	Peć - Mlini Vrlika	18,40	-	-	-	-	258,00	E, F
7	Mostarsko Blato Ličtica	15,70		3,60			226,50	E, F

W – water supply
E – Energy purpose
F– Flood protection
I – Irrigation

Table 12: Available hydro-energy objects in the Trebišnjica river basins (source: Official web page of Hydro Energy System Trebišnjica - www.het.ba)

No	Name	Average flow	Volume of reservoir		Height of dam	Altitude of the highest water	Function*	Install power
			total	useful				
		m^3/s	10^6m^3	10^6m^3	m	m a.s.l.		
1	Grančarevo	71	1277	1074	123	400	E, F, I,W	168
2	Gorica	82.9	15.74	9.6	33.5	295	E, F, I	8
3	Dubrovnik	-	-	-		-	E	216
4	Čapljina	-	-	-		-	E	220

An instance of the hydroenergetic system “Trebišnjica” in the best way reflects the wide possibilities of multifunctional utilization of groundwater in karst. By dams and reservoirs formed in the Eastern Herzegovina it is possible to make the adjustment of karst waters regime.
For example, the runoff from the karst fields whose swallow holes capacity is too small for conduction of total amounts of precipitation in the wet period to water accumulation of Grnčarevo dam is provided by hydrotechnical tunnels.
These measures provide wide specter of benefits: flood protection, the conditions for agricultural activities with irrigation measures in karst fields, and provide large amounts of water for energy utilisation.
The improvement of the low water regime of some surface streams by dams and accumulations is also one of the benefits in the karst terrains (e.g. minimal water of the Trebišnjica river).
The creating of Nevesinje artificial reservoir by construction of Pošćenje dam (in the 2nd stage of the HES “Trebišnjica”) will, beside all other things, improve minimal water regime of the Bregava river (controlled realised of accumulated water from the reservoir).
In the following figure, the red circles mark planned objects within project "The Upper Horizons" (include Gatačko, Nevesinjsko and Dabarsko fields with accompanied watersheds).
The blue circles represent constructed objects in hydroenergy system Trebišnjica (Trebinje I, Trebinje II, Čapljina and Dubrovnik I).
Basically, the realisation of the HES (Hydroenergy System) Trebišnjica is planned, in accordance with the concept of multifunction using of water, in two main stages. Both these two stages have two phases. After finishing the system, the whole system will be represented by 7 hydropower plants and 6 water accumulations.
Beside hydroenergy utilisation of water, the aim is to provide an area about 240 km^2 for agricultural production and flood protection of karst fields.
The first stage of building of the HES was finished in 1981. The second stage pertains on utilisation of waters of so-called “The Upper Horizons”.
The building of some dams with water accumulations is planned and using the accumulations would provide time water-adjustment with simultaneously flood protection (the floods happened in the beginning of 2009 indicated once again the urgency of solving the problem).

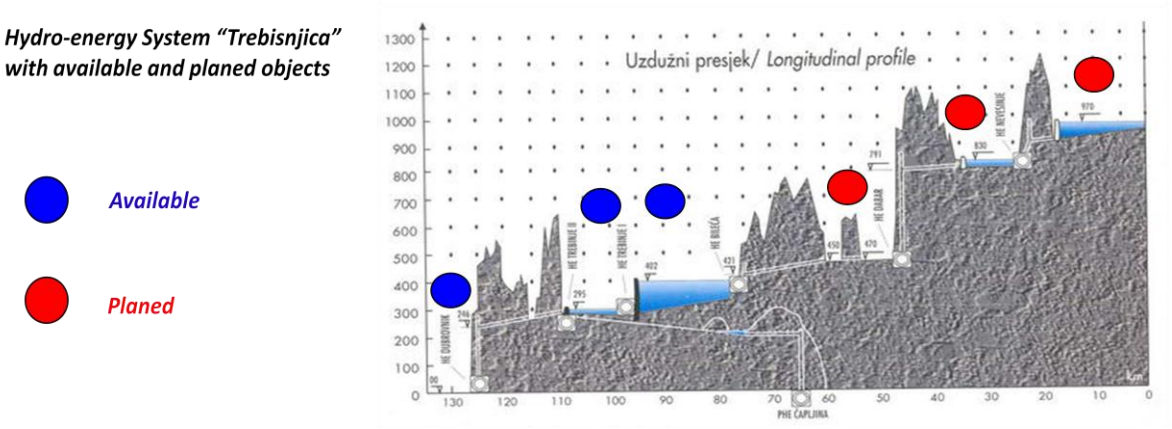
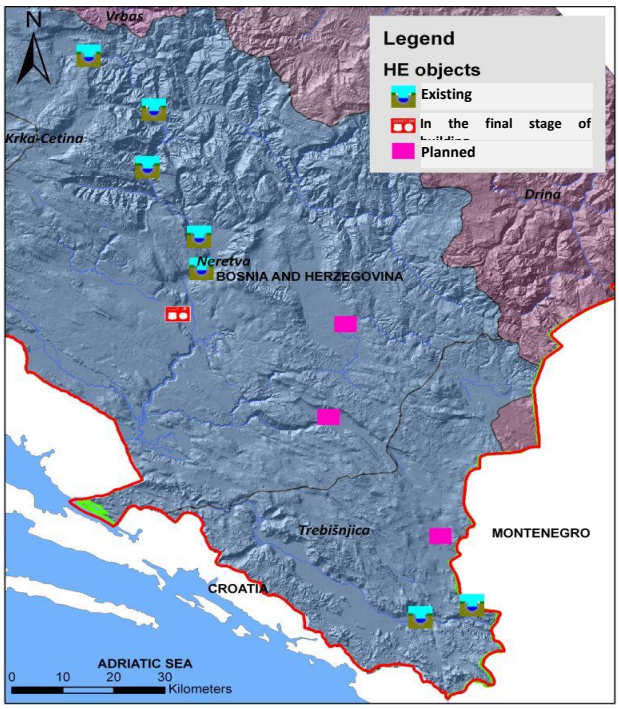


Fig. 16: Available and planned objects within Hydro Power System „Trebišnjica“ (source: Official web page of Hydro Energy System Trebišnjica - www.het.ba)

This water adjustment will be provided by the dams, reservoirs and tunnels between karst fields (Nevesinjsko, Dabarsko, Fatničko) as well as the tunnel and open channel toward Bilećko reservoir. At the moment there are penetrated tunnels Dabar-Fatnica and tunnel and open channel Fatnica-Bileća. These tunnels make a possibility of the drainage of a water sufficiency in the wet period and flood protection of Dabarsko and Fatničko fields. In the same time these waters allow hydro-energy utilisation in available hydro-energy objects.



Aggregate power of both, built up and planned objects of HES Trebišnjica is almost 1100 MW with sum annual productions about 4000 GWh of electric power. The facilities of "Upper horizons" make about 23% of total power and about 30% of total energy production.

Fig. 17: Spatial distribution of hydro-energy facilities: existed, planed and facilities in the final stage of building in eastern and western Herzegovina

There is the current debate about the impact of further objects and water regulation on some big karst springs in the Neretva river basin, in the first order the Buna, the Bunica and the Bregava. The hydrological studies about possible impacts clearly indicate that there is not impact on minimal waters, just on maximal. From the other hand, minimal water of the Bregava will be improved.

The second considerable energy system within project area is HES Neretva. A part of this system is under the jurisdiction of the Energy Corporation of the Federation B&H and the rest of this system is under the jurisdiction of the Energy Corporation of Croatian community Herceg Bosna in B&H. The review of available objects and belonging to appropriate systems within zone of the interest for the project are given in the next table. Spatial distribution of existed, planed and facilities in the final stage

of building in Eastern and Westeern Herzegovina is given in figure 17. The building of the HPP Mostarsko Blato is currently in the final stage and it works within the Energy Corporation of Croatian community Herceg Bosna.

This object is situated in the south-western area of Mostar and in the energy sense it will use natural hypsometric deference 176 m between Mostrasko mud and the Neretva valley. This will provide 172 GWh of electric current more per year (install power 2x30MW). The accumulation of Buško lake was built In 1974. Before 1990, the lake had been the biggest artificial lake in Europe. Waters of Buško lake (south-eastern part of Livanjsko field, B&H) are primary used for hydro-power plant Orlovac (Sinj, Croatia).

4. Geological pattern

4.1. Paleogeography of the Dinaric region

The Dinarides as a mountain system have not been clearly spatially defined yet regarding to surrounding systems. In the framework of the classic but abandoned geosynclinal concept Kober (1911) separated “two branches” within the Alpine-Himalaya belt and the Dinarides, together with the Apennines, the Southern Alps and the Helenides included in “the southern branch” and the Eastern Alps and the Carpatians into “the northern branch”.
The continuation of the Dinarides toward the Alps is not clearly defined. As a matter of fact that the External Dinarides, e.g. the Adriatic-Dinaridic carbonate platform paleogeographically continue in the Southern Alps some geologist their structure boundary anyway put along the Southalpine Front (Carrulli et al., 1991; Placer, 1988).
Recently, in the Alps/Dinaride adjoining area is separated by the transitional zone named the Mid-Trans-Danubian Zone (Fulop et al., 1987), Zagorje-Mid-Trans-Danubian Zone (Pamić and Tomljenović, 1998) or the Sava Zone (Hass et al., 2000). The zone is composed of mixed blocks from both the Alps and the Dinarides and it is the result of the Tertiary (the Oligocene-Miocene) lateral extension tectonics (Kazmer and Kovacs, 1985; Ratschbacher et al., 1991).
The relation between the Dinarides and the Hellenides is clearer. This is shown in the fact that all paleogeographic and structural units of the Internal Dinarides continue south-eastward into the Helenides (under different names) suggesting that they must originate from one and the same oceanic domain, i.e. the Dinaridic-Hellenidic Tethys (Pamić, 2002) or the Vardar Ocean (Decourt, 1972; Stampfli, 2000).
The southwestern boundary between the External Dinarides and the Adriatic Microplate is covered by the Adriatic Sea. The Adriatic-Ionian Zone is positioned between them as a foredeep zone. It does not outcrop along the Adriatic shore but southeastward of Skadar-Peć fault and represents the most external zone of the Hellenides (Figure 18).
The best outcrops of the Palaeozoic and the Mesozoic tectonostratigraphic units of the Dinarides are found in the territory of Bosnia and Herzegovina. Both the Palaeozoic and the Mesozoic tectonostratigraphic units are originated from the Tethys (Suess, 1893). According to the current geodynamic ideas on the evolution of the Alpian-Himalaya belt, the Palaeozoic formations are originated from the Paleothetys i.e., by the convergence of the Lauroasia in the north and Gondwana in the south (Ziegler, 1990; Matte, 1991; Von Raumen and Neubauer, 1993,; von Raumer, 1998 and other). On the other hand, the Alpine tectonostratigraphic units of the Alpine-Himalaya belt, including the Dinarides, are originated from the Neotethys (or simply Tethys) by convergence of Euroasia in the north and the Africa in the south (Dercourt, 1970; Dewey et al., 1973; Dercourt et al., 1993 and other).
The area of Bosnia and Herzegovina is included in the middle parts of the Dinaric Mountain System and it is positioned between Apulia (Adriatic Microplate) in the south and Panonian and South Tisia, respectively. Evolution of the Dinarides is genetically related to the Tethys which existed during the Mesozoic and Early Palaeogene between two supracontinents – Euroasia (its Moesian fragment) in the north and Africa (or its Apulian gragment) in the south.
Main large lithofacies associations of the Dinarides had been originated during the Alpine orogenic cycle. However, there are also large lithological units originated during Varcian orogenic cycle (the Palaeozoic complex of the Una-Sana area, Mid Bosnian Schist Mountains, Southeast Bosnia and North Bosnia) and postorogenic ones originated during the Oligocene-Neocene (marine to fresh water sediments on the south of the South Panonian basin) and Neocene intramountain fresh-water

basins: Sarajevo-Zenica, Tuzla, Ugljevik, Kamengrad, Bugojno, Livno, Gacko, Bihać-Cazin, Drvar, Mesići, Miljevina and smaller others.

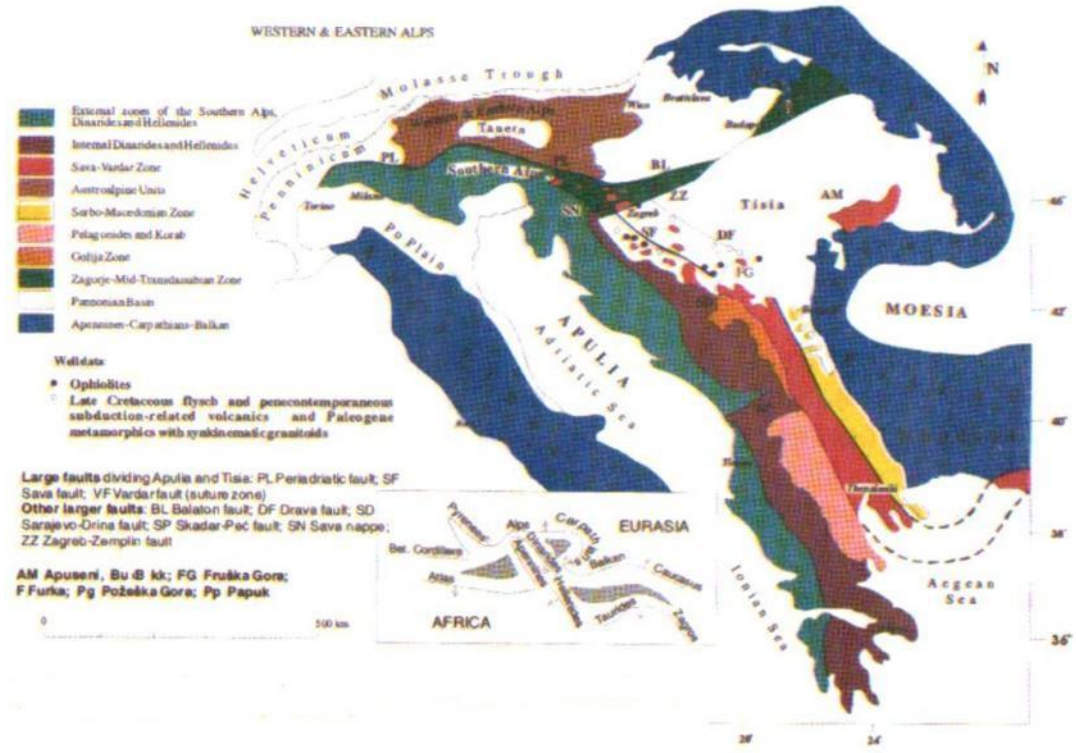


Fig 18. Tectonic scheme of the Alps, Dinarides, Helenide and Pannonian basin; simplified according to Dimitrijević (1999)

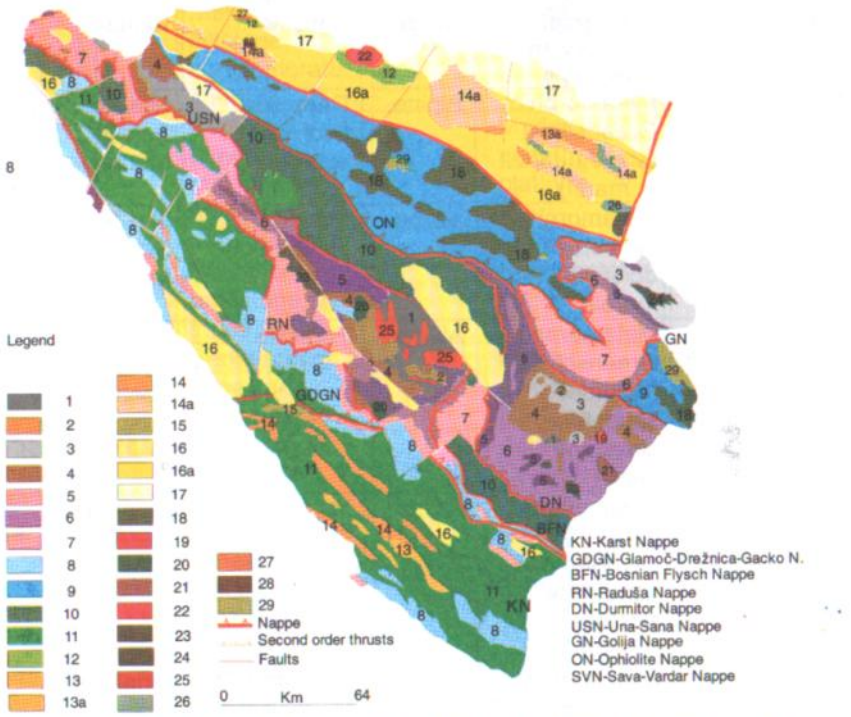
Numerous papers have been published on geotectonic evolution of the Dinaride and they are summarised alsewhere (Herak, 1991). Based on the modern plates tectonic ideas, the Dinarides can be subdivided into several large structural-paleogeographic units as it first proposed by the French geologists (Aubouin et. al., 1970) for the whole Dinaride-Hellenide area.

Despite their complexity, imbricate trust structure, in the Dinarides is preserved distinct zoned patern in the spatial distribution of large tectonostartigraphic units, reflecting their paleogeographic evolution.

Geological map of B&H (after Hrvatović, 2000) is in figure 19.

From the southwest (Apulia) to the northeast (Moesia), the following tectonostratigraphic (paleogeographic) units can be devided (Pamić, 1983):

1. The Dinaric carbonate platform (External Dinarides)
2. Bosnia flysch
3. The Dinaride Ophiolite zone
4. The Sava-Vardar zone



Dinaridic carbonate platform: 7. Late Triassic dolomites, limestonesand marlstone, 8. Jurassic limestones and dolomites, 11. Cretaceous limestones, 13. Paleocene limestones, 14. Eocene limestones and calcareni te,

Flysch bosniaque:
10. Tithonian to Barrlasian siliciclastic flysch (Vranduk group); Late Cretaceous-Lower Paleogene c arbonate flysch(Ugar group)

Dinaridic ophiolite zone: 18. Late Jurassic ophiolitic melange or wildflysch"; 9. Ultramafic massifs; 29. Overstep formations (Pogari formation and platform limestone);

Allochthonous Paleozoic and Triassic formations:Metamorphyc rocks :
1. Silurrian greenchist and epidote-amphibolit e facies ; **Sedimentary rocks:** 2. Devonian limestones and dolomites; 3.Carboniferous siltstones, shales, sandstones, limestones (with turbiditic character); 4. Late Permian siliciclastics, limestones and evaporites; 5. Early Triassic siliciclastics and limestones; 6. Middle Triassic (limestones, chert, tuffite, dolomites); 7. Late Triassic limestones and dolomi tes; **Volcanic rocks :** 25.Paleozoic rhyolite group; 20. Middle Triassic basalt group; **Plutonic rocks** Middle Triassic19. Alkaly-feldspa r syenite, 20. Gabro group, 21. Granodiorite-dior ites group. **Sava-Vardar Zone:** 13a. Paleocene limestones and siliciclastics, 14a. Eocene siliciclastics, 26.Late Cretaceous limestones and siliciklastics; 12. Non-metamorphose d to Greenschist-amphibolite facies Late Cretaceous-Paleogene flysch (Prosara and Motajica), 22. Eocene granite group(Motajica), 24. Andesite i dacite (Srebrenica); 27. Orto and Paragneiss (P rosara and Motajica); 28. Mafic and ultramafic magmatites N-Kozara

Post-orogenic Oligocene, Neogene and Quarternary sediments
15 Oligocene (Promina formation); 16. Miocene intramontain fresh-water sediments, 16a. Miocene South Pannonian Basin 17. Pliocene-Quarternary sediments

Fig. 19: Geological map of Bosnia and Herzegovina (after Hrvatović, 2000)

The units 2 and 4 define the Inner Dinarides. This regular pattern in the distribution of tectonostratigraphic units is disturbed by allochtonous the Palaeozoic-Triassic masses which are trust onto the units of the Inner Dinarides and onto the northeastern margin of the External Dinarides (Figure 19). The correlation charts for the tectonostratigraphic units of the Donarides are visible in Figure 20.

In the many areas the Dinarides are disconformably overlain by postorogenic the Oligocene, the Neocene and the Quaternary sediments.

The Dinarides are characterised by fold, imbricate and trust structures striking NW-SE with distinct southwestern vergences. The above-mentioned Alpine tectonostratigraphic units are trust to each other with the External Dinarides at the base and the Sava-Vardar Zone at the top. As distinguished from the whole Central Dinarides the northernmost parts of the Sava-Vardar zone are characterised with northern vergences which are recognised in the northern parts of the Mts. Majevica, Motajica and Prosara.

In purpose of the topic of this paper (transboundary karst aquifers) the zone of the External Dinarides is in focus of the interest.

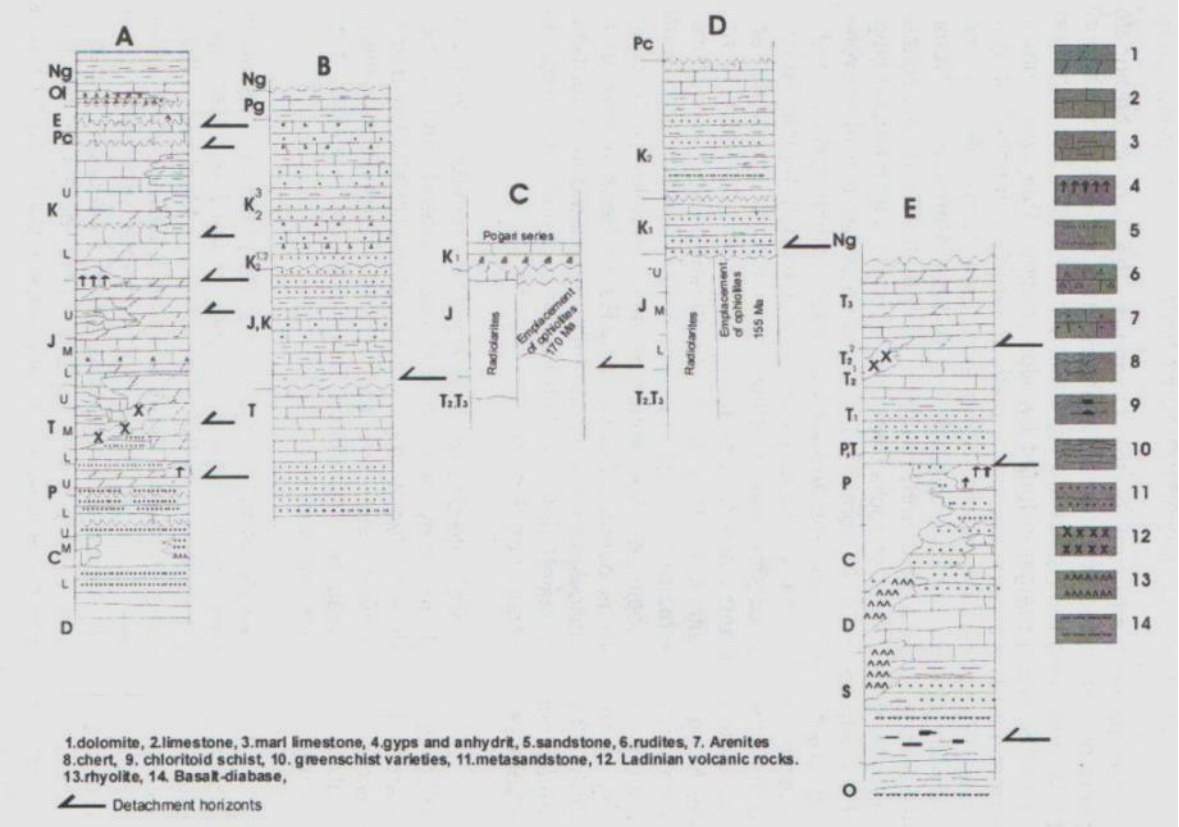


Fig. 20: Correlation charts for the tectonostratigraphic units of the Donarides
A-External Dinarides; B-Bosnian Flysch; C-Dinaride Ophiolitic Zone
D-Sava-Vardar Zone; E-allochtonous Palaeozoic-Triassic formation
(after Hrvatović, 2006)

4.2. The Dinaric Carbonate Platform (the External Dinarides) - litostratigraphic units

The Dinaric carbonate platform mostly consists of:
a) The Upper Palaeozoic sequences composed by the Late Carboniferous-Early Permian clastics and carbonates
b) The Late Permian to the Norian sequences of clastics and platform carbonates and associated synsedimentary igneous rocks deposited during the initial rifting stage of the Alpine cycle. In some areas carbonates are interlayered with chert, shale, pyroclastic and volcanic rocks, accumulated in platform depression, particulary during the Ladinian. The Middle Triassic formations are conformably overlain by the Carnian limestones and associated volcanic and by the Norian limestone and Dolomites. During the Norian the conditions for long-lasting carbonate platform sequence had been finally established
c) The Norian-Lutetian carbonate platform, which begins with the Norian-Lutetian "Hauptdolomit", only in some areas overlies the Carnian Raibls Beds (Pamić et al. 1988).
Stable shallow-marine environments had prevailed during the Jurassic-Cretaceous and lasted until the Lutetian temporarily interrupted by several pelagic intrusions. Platform carbonate deposits, beside their significant thickness (4000 to 8000 m) are characterised by lateral and vertical alternations of different facies, mostly associated with shallow marine environments. Environments are from pretidal through low-

energy shallow subtidal-lagoons, restricted inner platform shallows, high-energy tidal, beach and shoreface.
The following description of stratigraphic units is mostly based on the Monograph on Geology of Bosnia and Herzegovina, part two, the Mesozoic era (S. Čičić, J. Pamić, 1984).

THE MESOZOIC

During the Mesozoic period the territory of Bosnia and Herzegovina had been mostly covered with the sea of the Mediterranean geosynclines. Very thick complex of sediments are deposed as the consequence of this situation. Their thickness can be several thousand of metres (4000-8000). At the end of the Mesozoic and especially in the Tertiary, these rocks had been exposed to strong tectonic movements, which totally disturbed previous conditions. It conditioned the creation of very complex geo-tectonic and geo-morphological structures.
In the Lower Triassic there was a shallow sea in which there had been deposed very deep series of sandstones, siltstone, claystone and limestones. In the lower part of the Middle Triassic (anisian) the sedimentation of deep limestone and dolomites series happened. The changes began at the end of the anisian, especially stressed in the ladinian (the upper part of the middle Triassic). Normal marine sedimentation was interrupted. Geosynclinals area is disturbed with deep longitudinal fractures. These fractures are the ways to strong submarine volcanic activities. These activities had slowly disappeared in the carnian (the lower part of the upper Triassic). The sedimentation of limestone and dolomites with big depth happened in the carnian and especially in the norian and the rhaetian (the middle and the upper part of the upper Triassic).
The development of the Mesozoic in the territory of Bosnia and Herzegovina is given in Fig. 2.1. The one characteristic geological cross-section through the Mesozoic in the External Dinarides zone in Southern Herzegovina is given in figure 21.

TRIASSIC

Lower Triassic (T_1)
The rocks of the lower Triassic in the external Dinarides zone are wide-spread. These rocks cover significant areas in the north-western Bosnia, e.g. between Velika Kladuša and Grahovo, northern from Mostar etc. These sediments often occur in disturbed sides of a big anticline, whose core is built up from the Palaeozoic rocks. In the north-western Bosnia and in Herzegovina their surface spread is limited. They occur mostly in the zones of bigger regional fractures. These rocks do not occur in the part south-eastern from Mostar.

Middle Triassic (T_2)
Various rocks of the middle Triassic have significant dissemination in the External Dinarides. They occur in several separated belts, which represent the zones of higher tectonic disturbance. In the south-eastern part of Herzegovina these rocks are discovered in the areas Trebinje-Lastva and near Mostar. They also occur in the three separated belts: Bihać-Kulen Vakuf-Drvar-Bosansko Grahovo, Bosanski Petrovac-Glamoč-Livno-Duvno and Sanica-Ključ-Mrkonjić Grad in the north-western Bosnia.
To the north from Trebinje, in the river bed and the valley sides of the Trebišnjica river, on micro-location of the dam Trebišnjica I, in the core of Lastvanska anticline dolomites and limestone are discovered. Some authors consider that there is complete development of the Middle Triassic.
Near Mostar this part of the Triassic is not in carbonated form. It is represented by smaller occurrences of granites on the south side of Prenj mountain (Pamić, 1961).

The anisian and the ladinian (the middle Triassic) are presented mostly with carbonated rocks, dolomites and limestone in above-mentioned three separate zones in the north-western Bosnia.

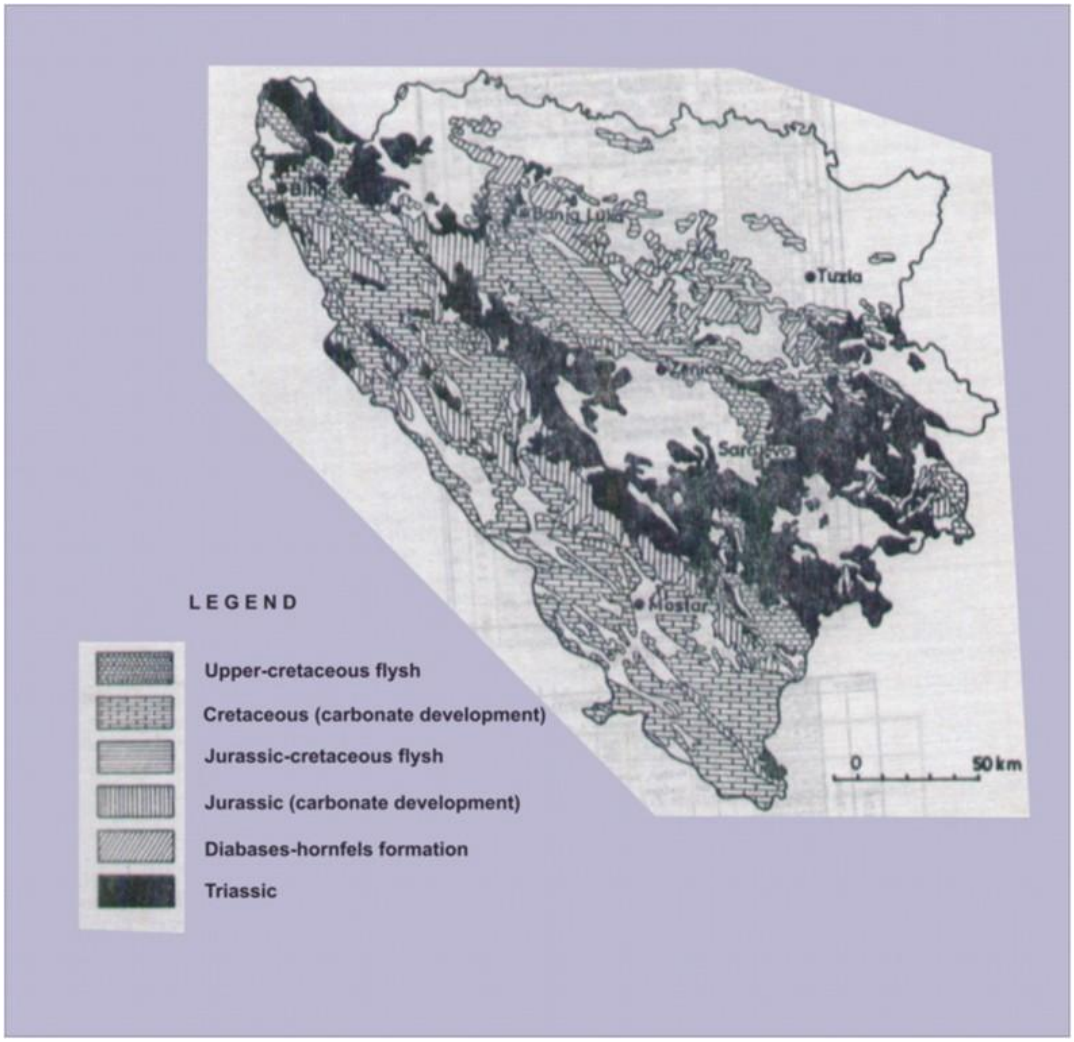


Fig. 21: Development of Mesozoic in the territory of Bosnia and Herzegovina (after Pamić, 1984)

Upper Triassic (T_3)

In the External Dinarides zone, the rocks of this age occur in the eroded top of elongated anticlines. They are always under the very deep Cretaceous and Jurassic limestone and dolomites. In front of a nape near Naum, Herzegovina, the Upper Triassic dolomites are discovered. The similar situation is in the well-known Lastvanska anticline (near Trebinje). The carnian dolomites are separated from the norian-rhaetian dolomites. In the north-western Bosnia, dolomites of the Upper Triassic occur in the following zones: Bihać-Drvar-Grahovo, Bosanski Petrovac-Glamoč-Livno-Drežnica, Sanic-Ključ and also in the north part of Herzegovina in the zone Prozor-Jablanica .

JURASSIC

Lower Jurrasic (J_1)

The sediments of this age are represented by carbonated rocks, which are highly present in the External Dinarides. There is a possiblility to seclude three basic belts

of the Lower Jurassic rocks. The first belt is between Cavtat (Croatia) and Hutovo mud (B&H), the second belt is in Lastva area (Trebinje) and the third belt is from Gatačka Bjelašnica via Velež, Drežnica, Staretina to the Grmeč mountain. This part of the Triassic consists of limestone and dolomites.
Sometimes it is very difficult to find some fossils in the mentioned rocks. In accordance with this fact it is very difficult to divide the lower from the Middle Triassic. This is the reason why rocks which belong to these two ages, in domestic literature often analysed together as the Lower-Middle Jurassic.

Lower-Middle Jurassic ($J_{1,2}$)
It is represented with various limestone and dolomites, often drifting. They usually lie concordant to the Upper Triassic limestone and dolomites. The depth of the lower-middle carbonate rocks in the external zone is usually from 300 to 400 m. In some cases the depth can be smaller or bigger then above-mentioned mostly as the result of tectonic moving.

Middle Jurassic (J_2)
The sediments of this age are secluded as independent complex only in the External Dinarides zone. They occur in the broad area near Dubrovnik (Croatia) and Trebinje (Lastva) and in the zone from Gacko (south-east) via Drvar to Grmeč (north-west). The depth of limestone and dolomites of this age is 150 to 400 m.

Upper Jurassic: (J_3)
The Upper Jurassic sediments occur in the zone of the External Dinarides in many separated zones, mostly as the consequence of tectonic influence in geological history. The zones like Dubrovnik-Hutovo, Lastva-Ljubomir polje, Gatčka bjelašnica-Nevesinjsko polje, Nevesinjska Crna Gora-Prenj-Čvrsnica, Velež-Raška gora-Drežnica, Vran mountain and the Zalomka river are dominantly built up of limestone, rarely of dolomites. Limestone consist of characteristic fossils and thereby defined in many locations with complete development of the Upper Jurassic. The depth of limestone in the External Dinarides is 200 to 800 m.

CRETACEOUS

Carbonate development of the Cretaceous
The Cretaceous carbonate sediments in the territory of Bosnia and Herzegovina covers wide belt, which, in accordance with usually tectonic scheme, belongs to the External Dinarides zone. The same sediments are also located in the Vrbas river canyon, in the transient zone of the Dinarides (to the north from the external zone). In these mentioned areas there are the presence of limestone and dolomite, deep about two thousand meters. Geological column of the Late Cretaceous in South Herzegovina (after Slišković, 1986) is given in figure 22.

Lower Cretaceous (K_1)
This Cretaceous is presented in most parts with limestone and rarely in the parts with dolomites and dolomite limestone. Limestone is good stratified, grey and dark-grey coloured. The depth of a stratum is variable. The lower part of these deposits (valangian-hautrivian) in Herzegovina contains limestone and thin splints of dolomites. Dolomites in some locations present the main rocks of this cretaceous part (Velež, Čabulja etc.). The upper part of the Lower Cretaceous (baremian-albian) is built up of good stratified limestone and dolomite limestone with splints of dolomites. The sediments of this stratigraphic member are almost permanently

following sediments of valangian-hautrivian. Very similar situation is also in the south-western part of Bosnia (exactly in the area of Duvno, Livno, Glamoč and Kupres) and in the area of western and south-western Bosnia (Grahovo, Bihać, Drvar, Cazin, Petrovac, Grmeč mountain).

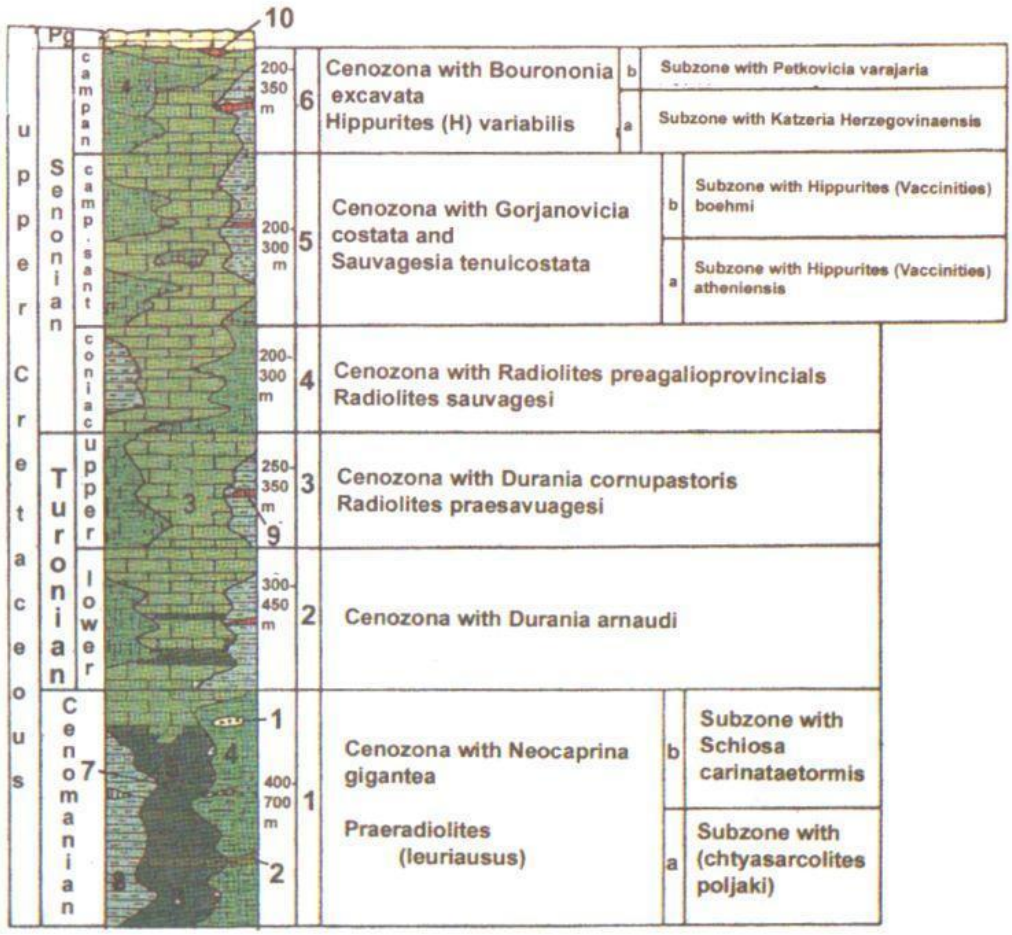


Fig. 22: Geological column of the Late Cretac. in South Herzegovina (after Slišković, 1986)
1-Conglomerates, 2-Breccia, 3-Badded limestones, 4-Massiv limestone, 5-Dolomitian limestone, 6-Dolomites, 7-Marled limestone, 8-Limestone, 9-Cement, 10-Bauxites

Upper Cretaceous (K_2)

The Upper Cretaceous carbonate rocks spread from Montenegro border, through the whole External Dinarides to Bihać and Cazin in the north-western part of Bosnia. They are mostly developed in the area toward country border with Croatia than the area toward central Bosnia.

The Upper Cretaceous sediments cover bigger area in Herzegovina than the Lower Cretaceous carbonates. In western Bosnia the situation is opposite. During the Upper Cretaceous in the External Dinarides belt there have been presented the typical neritian carbonated sedimentation. The result of this sedimentation is deep deposits of limestone in the first order and in very small amounts of dolomite limestone and dolomites.

One characteristic cross-section thru the Mesozoic formations from the Croaian coastal zone to Bileća (eastern Herzegovina, B&H) is given in figure 23.

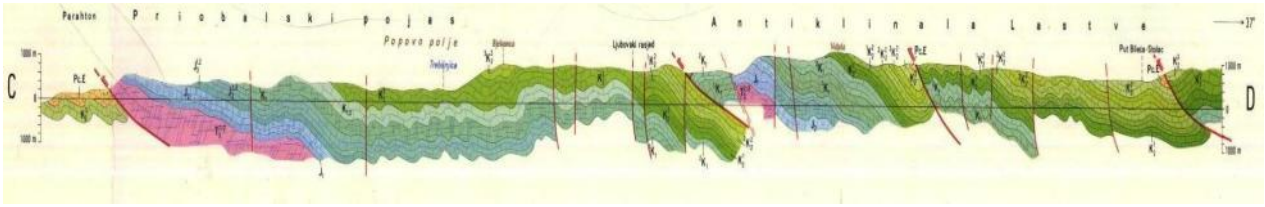


Fig. 23 The geological cross-section through Mesozoic from the coastal zone (Dubrovnik, Croatia) to Bileća (eastern Herzegovina, B&H) (source: Basic Geological Map of SFRY, sheet Trebinje)

TERTIARY

Tertiary rocks within the zone of the External Dinarides belong to the Palaeogene and the Neocene ages.

PALAEOGENE

Palaeocene and Lower Eocene (Pl,E_1)
After short interruption, originated with moving of Laramie phase, in southern Herzegovina started sedimentation of the Palaeocene and the Lower Eocene limestone, in domestic literature named "Liburnian layers". These layers are identified along the line Duvno-Velež mountain-Gatačko field. In every explored cross-section these rocks lay over Senonian limestone under approximately equal slope. The contact of these rocks is presented by clay-bauxite material or by bauxite bearing, sometimes with significant economic values. Liburnian layers create significant areas around Mostar, Stolac, Čapljina and Ljubuški.

Middle and upper Eocene ($E_{2,3}$)
The rocks of this age are divided into two different lithological and stratigraphical packages. The first package contains limestone which have continuous development in the zone of Liburnian limestone. Liburnian layers have lighten colour than the middle limestone. These limestone are significantly widen around Stolac and Mostarsko mud. In this part they have the biggest depth. In other parts of Herzegovina they are considerably thinner and with small surface occurrences. Second package contain sandstones, marls, breccias, conglomerates and breccias limestone. These rocks occur to the north and west from Posušje, near Tribistovo and Lukavičko field (north-western from Stolac).

NEOCENE

Miocene and Pliocene (M,Pl)
In accordance with paleo-geography events in the Neocene subsystems in the territory of Bosnia and Herzegovina, very various genetic types of sediments had become. The lake type is the most important in the zone of the External Dinarides. There are terrestrial-lymnical rocks dominantly with coal (usually basin types mostly belong to the Miocene, rarely to the Pliocene). We could find them in Bihać, Drvar, Livno, Duvno, Glamoč, Mostar and Gacko fields. It is possible to discern older Miocene (M1,2) and younger Miocene (M2,3) complex. Both older and younger are very interesting and very deep. In lithological sense they are presented with sandstones, marls, limestone and clays with layers of coal sometimes with great economic value (the first of all Livanjsko and Gatačko field). The Older Miocene complex occurs in Mostar basin, Livanjsko, Duvanjsko and Glamočko fields with

maximum depth sometimes more than 1,000 m (Livanjsko i Duvanjsko fields). The Younger Miocene rocks occur in Bihać basin, Drvar basin, Grahovsko, Glamočko, Kupreško, Livanjsko, Duvanjsko, Nevesinjsko and Gacko fields and near Posušje. These areas are in range from less than 20 km2 (Grahovsko field) to 270 km2 (Livanjsko field). Maximum depth is registered in Livanjkso field (about 500 m).

QUATERNARY

In the deep karst zone valley, quaternary sediments are mostly developed around the Neretva river and her tributaries. In the basins and near the mouth of the Neretva river these sediments cover bigger areas and have bigger depth. In morphological sense they are presented by alluvium plain and low terraces. Their age is the Holocene. Above alluvium plane and low terraces lay two or three Pleistocene terraces. The gravel of these terraces is connected in conglomerates. There are three visible terraces near Jablanica town. The depths of the terraces complex are about 60 m. The terraces complex appears downstream to Buna. After this zone the terraces swamp under recent alluvium. The terraces are well visible in the Neretva valley downstream from Grabovica, Mostras basin, Bijelo field, between Salakovac and Drežnica etc.
The Neretva tributaries do not have considerable terraces (Buna, Bunica, Bregava, Trebižat etc). Only in the Trebišnjica river bad there are visible conglomerates which lay under recent alluvium sediments.
Quaternary sediments are preserved on the bottom of all kasrtic fields in the external Dinarides zone. Significant areas in Glamočko, Livanjsko, Duvanjsko, Mostarsko, Nevesinjsko, Gatačko, Dabarsko Popovo fields are covered with quaternary sediments. The depth of these sediments is usually from 5 to 10 m, somewhere (like in Buško mud) the maximum is 30 m.

4.3. Tectonic

Apart from small-scale tectonic complications, the tectonostratigraphic units presented by Pamić (1983) were trusted one on top of the other, with the External Dinarides unit and Sava-Vardar zone, corresponding to the lowest and and the highest unit, respectivelly. This large-scale fold-and-trust imbrication of the Dinarides were formed since Late Jurassic up to Eocene collisional deformation phases.
Within the Dinarides the following main large structures can be distinuished (Hrvatović, 2006) (Figure 24):

1) Karst Nappe
2) Glamoč-Drežnica-Gacko Nappe
3) Bosnian flysch Nappe
4) Ophyolite Nappe
5) Raduša Nappe
6) Tectonic block Mid-Bosnian-Schist Mts.
7) The Una-Sana Nappe
8) Golija Nappe
9) Durmitor Nappe
10) The Sava-Vardar Nape

The frontal parts of the trust-nappe structures can be traced along strike for about hundred kilometers. Each of these trust-nappe structure unit is internaly folded, faulted and dissected by second order trust about 50-100 km long, which separate part of one and the same tectonostratigraphic unit.
The karst nappe is the largest trust sheet of the Dinarides comprising the entire Dinaric karst region and is largery composed of the Mesozoic and the Early

Paleogene carbonate platform sequences. Depending on authors and regions, this trust sheet has been reffered under different names. It was trusted southwestward over the Ionian Zone. However, its sole trust is largely concealed (Grandić et al. 1997).

To the northeast the Karst trust sheet is overvide by Glamoč-Drežnica-Gacko and Bosnian Flysch Nappes (figure 24, after Hrvatović, 2006). In the southeasternmost Dinarides, the Karst thrust sheet overlies Budva Zone which continues into the Hellenides as the Cukali Zone (Albania).

The Karst trust sheet can be subdivided into two secondary trust sheets: a) the Adriaticum (Herak, 1986) which correspond to the Autochtonous (Kober, 1952; Petković, 1958) or Gavrovo (Aubouin et al., 1970) and b) Dinaricum which correspond to the High Karst Zone (Kober, 1952; Petković, 1958) or Dalmatia zone (Aubouin et al., 1970). The frontal parts of the Adriaticum extend from Middle Istria in the nortwest and southeastward in the Adriatic sea via Split and is expose in the Budva Zone.

Dinaricum includes several larger second order thrusts, about 50-100 km long each: the Ljubuški-leotar in the middle parts and Fatnica-Grahovo in the southeastern parts of the Dinaricum. The Dinaricum is cut off by Skadar-Peć transversal fault and it does not continue into the Hellenides. On the other hand, the Adriaticum continues southeastward in Albania in form of a very narrow zone.

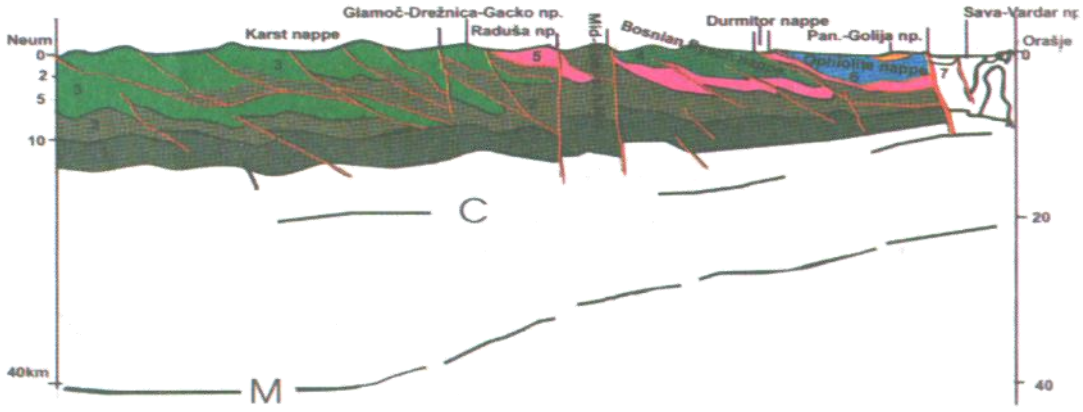


Fig. 24: The schematic geological cross-section of the Dinaides from the Adriatic sea to the Sava river (Hrvatović, 2003)

1. Consolidated uppermost continenetal crust; 2. Paleozoic formations; 3. Dinaric carbonate platform (Triassic-Paleogene); 4. Bosnian flysch (Jurrasic-Cretaceous; Late Cretaceous/Early Paleogene); 5. Alohtone Mesozoic formations (Inner Dinarides); 6. Ophiolite zone; 7. Sava-Vardar zone; C. Conrad boundary; M-Mohorovičić disconitunuity

5. Geomorphology and karstification

5.1. Karstification process

Karstification is an aggregate of geological processes either naturally or artificially in the earth's crust and on its surface due to chemical, physic-chemical, dissolution and erosion under diverse geological and climatic conditions through time. It is expressed through the formation of openings, the destruction and alterations of the structure of the rocks, and through the creation of a particular type of a groundwater circulation and characteristic regime of drainage network and of characteristic regional topography. The degree to which the rocks have been karstified varies greatly from place to place depending on how much the fissure in the rock have been enlarged by the solution action of acidified rain water and the extent to which the underground drainage system has become organised and integrated into efficient conduits for the collection, transport and ultimately discharge of recharge waters. In some karst areas the karstified rocks can be overlain with non-carbonate strata or unconsolidated deposits and this is termed a covered or mantled karst. Old karstic landforms, surface or underground, which have been filled by subsequent deposits, often have no surface expression and do not function hydrogeologically (or has lost its mass transport function). These are called paleokarsts. Paleokarst may be reactivated if environmental conditions change (F. Assaad and F.E. La Moreaux, 2004).
Intensity and deph of karstification process depend on many factors. The most important are (after V. Dragišić, 1998):
- presence of the soluble rocks
- fissuring, permeability and porosity of rocks in which atmosphere and surface water circulate
- geological-structural setting and contemporary climate factors which accelerate or slow-down karstification process
- crust movements which determined acceleration or slow-down karstification process.

Most intensive karstification processes happens in fissures of crust of disintegration and zone of faults. Solution effect of groundwater depends also on content of carbon acid in groundwater. The karstfication process can be simply described by formula:

$$CaCO_3 + H_2O + CO_2 \Leftrightarrow Ca_2^{++}\ 2(HCO3)^-$$

The zone of the External Dinarides is most exposed zone to karstification process in B&H. It is expected if we take into account richness in carbonate rocks, especially limestones, and average values of rainfalls. As consequence of karstification process and other factors (e.g. tectonic) numerous karst features like kasrt fields, dry valleys, lost rivers, estavelles, sink holes, potholes, swallow holes, caves and strong springs are developed. A number of karst features, as result of karstification process, sometimes exceeds 30 features/km^2. P. Milanović (1979) registered more than 500 swallow holes and estavelles in Popovo field. The area of this part of the field is about 68 km2. It means that the dense of karst features is 7.4 per 1 km^2. V. Vlahović in Nikšićka župa (Montenegro) registered 14 karst shapes/1 km^2. Šarin (1981) on aero-photogrametric map to the north from Knin (Croatia) registered more than 100 sink holes per 1 km^2. Here is necessary to emphasise that in the areas only few kilometres distanced from previous there is not found any sink holes.
Karstified rocks are not homogeneous porous media. The porosity is the consequence of litho-tectonic factors and the evolution of the karst process. The process evolution is dictated by the position of the erosion base levels (Figure 25), also responsible for the forming of the directions of circulations of groundwater. As the result of these processes, privileged directions in underground circulations are

formed. Spatial distributions of karstification base in the zone of Bileća accumulation are visible in the figure 25. In the karstified areas there are often visible relicts of dense hydrograph network which is descend deeper or shallower in karst mass through geological history. In accordance with registered data, the effective porosity of carbonate rocks is usually in the range 0.2-4% and somewhere even up to 10% (near submerged spring of the Trebišnjica river). It generally decreases with the depth.

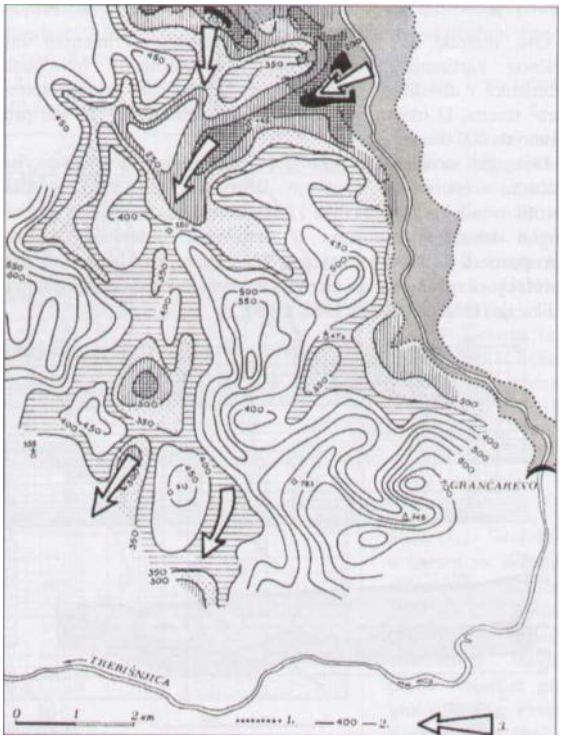


Fig. 25: Base of kasrtification in limestone near Bileća accumulation, 1-contour of accumulation, 2-izolines of base of karstification, 3-possible direction of water losses from accumulation (after D. Anđelković, 1962).

In Eastern Herzegovina, Milanović (1979) processed data about 140 tests of injection of water to boreholes with pressure in the terrains with altitude 200-1000 a.s.l. He defined sum 398 karstified stages. Its number decreased with depth by parabolic dependents: 30 stages to the depth of 10 m, more than 10 stages to 100 m, 2.5 stages to 200 m and 1 stage to the depth of 300 m (Figure 26).

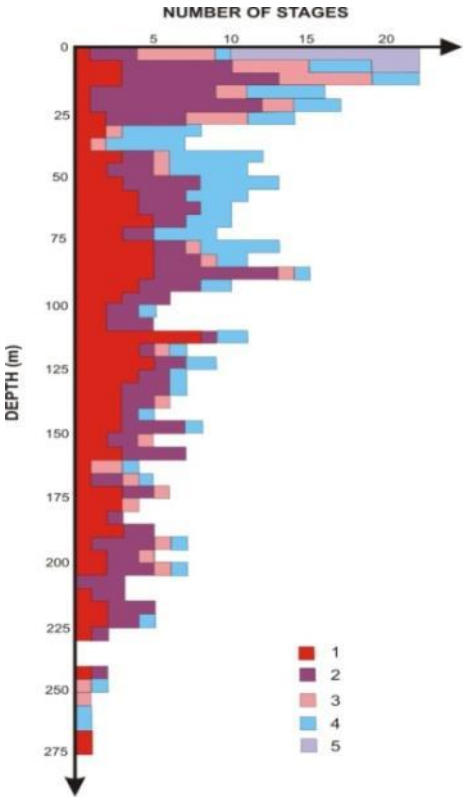


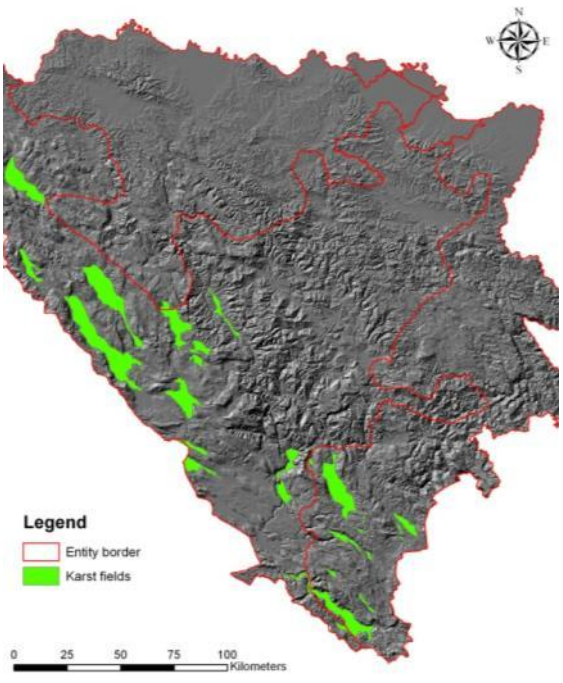
Fig. 26: The diagram of decreasing of permeability in karst with depth, based on measurements of permeability in the boreholes in the east part Herzegovina (after P. Milanović, 1979)
1-empty cavern
2-stage with permeability more than pump capacity
3-stage in which is not achieved pressure of 10 ba
4-stage with permeability more than 30 Lu
5-surface zone (from 0 to 10 meters under surface of terrain) in which permeability is rare measure because karstification is big
Every stage is deep5 m.

5.2. Karstic features

In following sub-chapters basic surface and subsurface karst features are described, generally (in the form of definition) and with emphasize on the features which characterize the External Dinarides of Bosnia and Herzegovina.

5.2.1. Surface karstic features

Surface micro-features - karren runnels, mostly <1 m deep, produced by dissolutional fretting of bare rock (Bögli, 1960), including grykes, cutters and inherited subsoil rundkarren, and ranging in size up to pinnacles 2-30 m high in pinnacle karst (Waltham, 1995);
Surface macro-features - dry valleys, dolines, poljes, cones and towers, all landforms on the kilometre scale that are elements within different types of karst (Ford and Williams, 1989).
Poljes - a large, flat-floored depression within karst limestone, whose long axis develops in parallel with major structural trends (Figure 27) and can become several kilometres (tens of kilometers) long. Numerous poljes in the Dinarides of B&H, different in the area, are created during geological history, particulary in External Dinarides. The larges poljes area: Livanjsko (about 400 km^2), Popovo (68.4 km^2), Nevesinjsko (170 km^2),Glamočko etc. The poljes have the Dinaric orientation (NW-SE), exception is Nevesinjsko polje (rotated during tectonic movements of the blocks, today orientation generally N-S). Generally, altitude of the poljes vary from 1150 (Kupreško polje) to less than 86 m (Gradac polje).
Sinkholes - various surface depressions, 1–1000 m across, that are related to underlying rock cavities (Waltham et al, 2005);



One of the most important and characteristic feature in the Dinaric karst are sinkholes. This type of the features frequently met especially in Western and Eastern Herzegovina. Some sinkholes are occasionally flooded but water retains just in short time period. Sinkoholes are mostly formed in the zone of intersection of two or more faults. It represents the place of concentrated dissolution and most favourable place for karstification process. Thus, the big group of the sinkholes marked the big well-known Zubački fault (extends from the Croatia coastal zone to Trebinje and further to the north).

Fig. 27: Arrangement of the karst poles in the Dinarides of B&H

Sinkholes can be formed as the results of collapse process a cave ceiling and a shallow cave channels as well (e.g. caves Đurkovica and Nova Đurkovica in E. Herzegovina, Milanović, 2006). Beside the karst field, the bottoms of the sinkholes represent rare cultivated areas in karst terrains.
The number of sinkholes per area unit is different from place to place. It is e.g. from 10 up to more than 50/km2 like in the area northern from Bilećko lake (area of Plane

village). These sinkholes are very different in dimensions, from a few meters up to a few hundreds of meters in direction of the longer axis.

Dry valleys - one of the main characteristics of the Dinarides in Bosnia and Herzegovina. These valleys are relicts of the former fluvial drainage system without active stream even in period of the maximum precipitations. In Bosnia and Herzegovina we met this kind of the karst features most frequently in the Eastern Herzegovina. Most well-known dry valleys are: Krstac (from Gatačko polje to Nikšićko polje), valleys between Lukavačko and Nevesinjsko polje, Slato and Nevesinjsko polje, the part of the Bregava river valley from Dabarsko polje to spring Bregava etc.

The one of the most imposing dray valley within the Dinarides in B&H is Vala, between Zavlaka and Slano, sometime probably most important surface drain of the Popovo polje.

5.2.2. Caves and potholes

Caves - cavities typically metres or tens of metres across formed within the rock by its dissolution, and left empty or filled with sediment (Ford and Williams, 1989).The terrains of the Dinarides in Herzegovina region abound in caves. Many caves are registered also in zones of Trebinjska šuma (Đurkovica, Kalađurđevići etc.) and Plane (Golubinka, Tavnica, Golubnjača etc.), in the vallies of the Bregava river and the Tihaljina river, also in other part of Eastern and Western Herzegovina.

Numerous caves in the zone of the External Dinarides are shown in figure 29.

In available references most frequently mentioned and most important cave is Vjetrenica (Milanović, Malez, Basler et al.). It is the most famous speleological feature in the Dinarides, situated at the edge of Popovo field, near to Zavala (Figure 28). The first speleological researches of of the Vjetrenica cave (figure 28) are executed in 1858 (Hilferding). Two main characteristics of cave are: richness in the endemic fauna and strong air-stream (in accordance with that cave carry their name – windy cave). But, regardless strong air-stream, temperature and humidity in the cave are constant: T=11°C, humidity 100%). The results of older and new researches show discrepancy regarding the cave length (6400 m – new data).

Fig. 28: Vjetrenica cave

In the area of Bilećko lake most important cave is Oko, situated about 5 km south from submerged Trebišnjica springs, area Miruša. The cave has been explored in the 1961. It is also submerged by Bilećko lake. In the Western Herzegovina most famous cave is Ravlića cave (municipality Grude). In Grude municipality many caves near to Tihaljna spring are registered.

But caves are not just characteristic of the External Dinarides zone but also the Internal Dinarides. Cave near Sarajevo (Pale municipality) Orlovača (spring of the Mokranjska Miljacka river) is well-known thru the years. But just researches in the last few years are shown that the cave is the longest in the Bosnia and Herzegovina with 6800 m researched chanells. Near Sarajevo, on the road to Tuzla Bijambarska cave is situated (long about 420 m).

The number of karst features sometimes exceeds 30 features per km^2. P. Milanović (1979) registered more than 500 swallow holes and estavelles in Popovo field. The area of this part of the field is about 68 km^2. It means that the dense of karst features is 7.4 per 1 km^2.

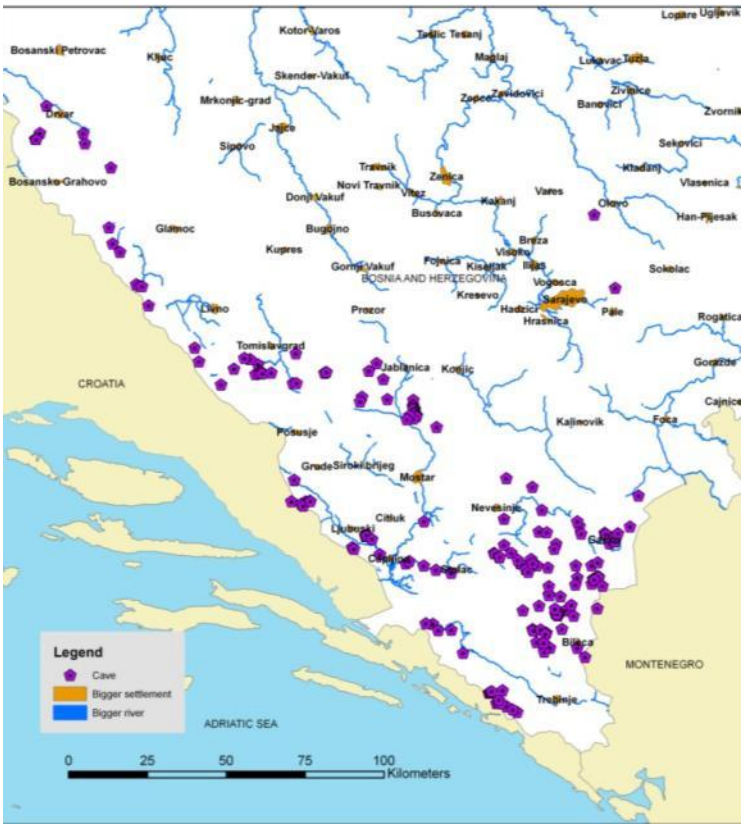


Fig. 29. Numerous caves in the zone of the External Dinarides

Pothole – vertical or steeply inclined shaft in limestone (also pit; shaft). Potholes are very characteristic karst shape in the Dinarides of B&H. Numerous potholes are registered and researched in the area of the DIKTAS project, mostly in Eastern Hercegovina. Some of the well-known potholes are: Bravenik (southern from Trebinje, Zubci area), pothole near Čavaši in Popovo polje and Meginja (both registered by J. Cvijić), Baba Jama near Strujići, Golubinka in Dabarsko polje, Zvonuša and Tumorovača between Dabarsko and Fatničko polje, Baba jama in Fatničko polje, Gradnica in Gradac polje, Golubinka osutheastern from Blagaj near Vranjevići .

The last mentioned occurs on 703 m a.s.l. It is absolutely vertical pothole deep 105 m. Potole Gradnica occurs on 86 m a.s.l. The bottom of pothole is close to sea level. Vertical channel has circle shape 25 m in diameter. The short horizontal channel at the bottom of Gradnica finishes by lake. The registered length of the channel of Meginja pothole is about 285 m.

6. Aquifer systems

In accordance with earlier proposed tectonostratigraphic division of the territory of B&H (M. Aranđelović ,1978) and one new (given in Chapter 4, Hrvatović, 2000) the main hydrogeological regions (Figure 30, Slišković and Miošić) are described within this chapter.

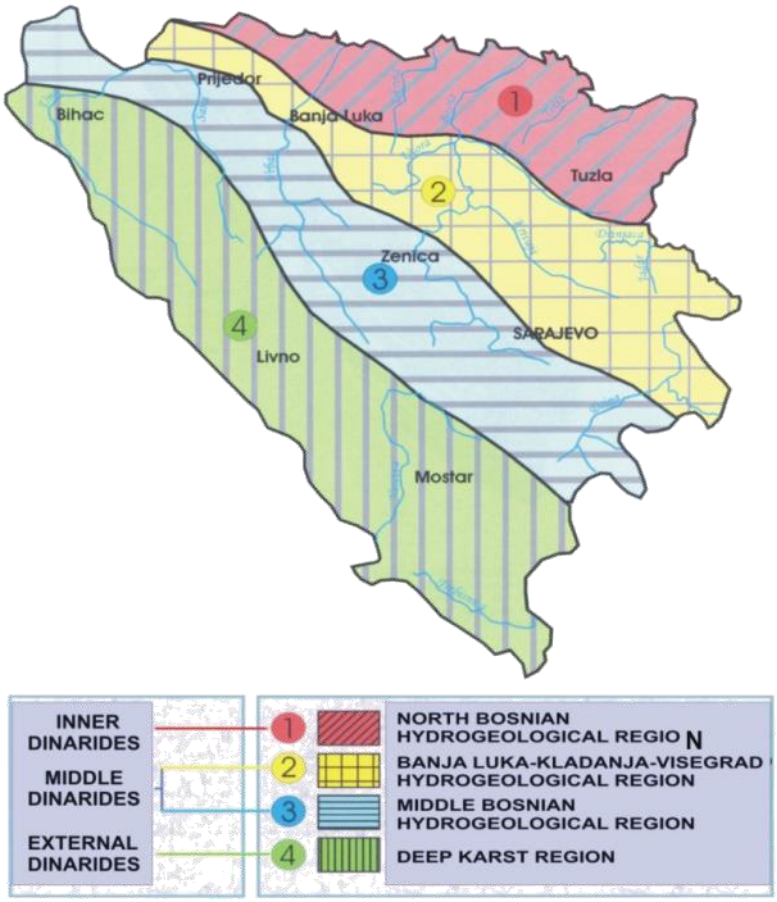


Fig. 30: The basic hydrogeological regions in the territory of Bosnia and Herzegovina (after Slišković and Miošić, 1983)

6.1. Aquifers classification and distribution

Main aquifers are formed within rocks with intergranular and kasrt-fissure porosity. Aquifers with fissure porosity have lesser significance than the first two. Regarding permeability it is possible divide the aquifers as it follow:

1. Aquifers in rocks with integranular porosity with:
a) High permeability
b) Moderate permeability
c) Low permeability
2. Aquifers in rocks with karst-fissure porosity with:
a) High permeability
b) Moderate permeability
3. Aquifers in rocks with fissure porosity with:
a) Moderate permeability

There are also rocks with insignificant porosity treated as impermeable.

The most important aquifers in the North Bosnian hydrogeological region (correspond to the Sava Vardar Zone in geotectonical sense) are situated in alluvium sediments in the lower parts of the main rivers: Semberija (in alluvium sediments of the Drina river), Posavina (in alluvium sediments of the Bosna and the Sava river), Lijevče field (in alluvium sediments of the Vrbas river) and Dubičko field (in alluvium sediments of the Sava). These aquifers belong to group of aquifers with intergranular porosity of high permeability (Figure 31) and present main resources of drinking water in Northern Bosnia. Main characteristic of these aquifers regarding lithology are thick packages of sandy gravels, up to 60 m. Average conductivity coefficient of sandy gravels in Semberija and Lijevča is about $5x10^{-3}$ m/s. In the other smaller aquifers within the Drina, the Sana, the Bosna and the Vrbas triver basins this value slightly decreases, mostly range from $5x10^{-3}$ up to 10^{-4} m/s.

Just smaller fissure aquifers of local importance occur in the Tortonian (M_2^2) limestones (e.g. around Derventa, Prnjavor and Kostajnica).

Other rocks: non-metamorhosed to Greenschist-amphybolite facies of the Late Cretaceous-Paleocene flyschs (Prosara-Motajica Mts.), the Paleocene silicaclastics, the Eocene siliciclastics, the Miocene sediments of south part of the Pannonian Basin, the Eocene granites (Motajica Mt.), orto and para gneisses of Motajica and Prosara Mts. and mafic and ultramafic magmatites of Kozara Mt. (north side) represent impermeable rocks. Exclude smaller reserves of mineral and thermo-mineral waters in these rocks aquifers absent.

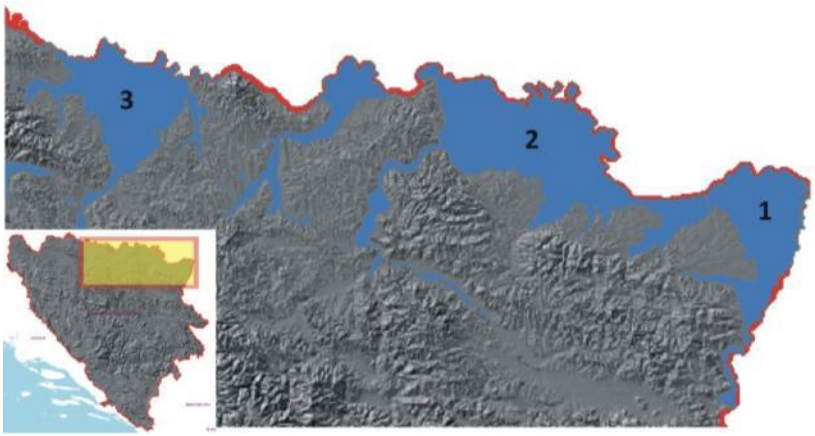


Fig. 31: Locations of Semberija, Posavina and Lijevče polje alluvium aquifers within northern Bosnian hydrogeology region

Within hydrogeological region Banja Luka-Kladanj-Višegrad (mostly correspond to geotectonical unit Ophiolitic zone) impermeable rocks dominate as well. There are: Late Jurrasic ophiolitic melange (or “wildflysh”), ultramafic massifs and overstep formations. Just in area of the Romania Mt. the Triassic allochthonous formation in form of limestones occurs. These rocks (the Middle and the Upper Triassic limestones) present high permeable rocks with karst-fissure porosity. Karst aquifers of Romanija Mt. drain on strong karst springs in the contact zone with impermeable the Jurrasic rocks, somewhere with the Lower Triassic siliciclastics of the Triassic allochthonous formation. Moderate permeable are the Middle Triasic limestones south of Višegrad. Along deep faults numerous mineral and thermomineral springs occurs on the surface from deep aquifers.

The middle Bosnian hydrogeological region (mostly correspond to geotectonical unit Bosnian flysch and the allochthonous Paleosoic and the Triassic formation in figure 19) consists mostly from impermeable rocks like: Carboniferous sandstones and shales, the Late Permian silicaclastics, the Early Triasic silicaclastics, the Tithonian and the Barrisian siliciclastic flysch, the Late Cretaceous and the Lower Paleogene carbonate flysch. There are also mostly the impermeable Miocene intramontain fresh-water sediments (within Sarajevo Zenica basin) and the Pliocene-Quarternary sediments (Prijedor basin). Only significant aquifers of the fresh groundwaters in this hydrogeological region are formed in the high permeable karstified rocks within

Manjača, Čemernica, Golija, Vlašić, Raduša, Vranica, Bjelašnica, Igman, Treskavica, Visočica, Zelengora and Lilija Mts. Moderate permeable are the Upper Triassic limestone between Krupa and Sanski Most and southwest of Banja Luka (Zmijanje area), the Upper Jurrasic limestones between Jajce and Travnik, the Middle-Upper Triassic limestone of Igman, Treskavica, Lelija, Zelengora, Prenj and Crna Gora Mts in eastern part of the region. Similar permeability have the Lower and the Upper Cretaceous limestones of Crna Gora Mt..

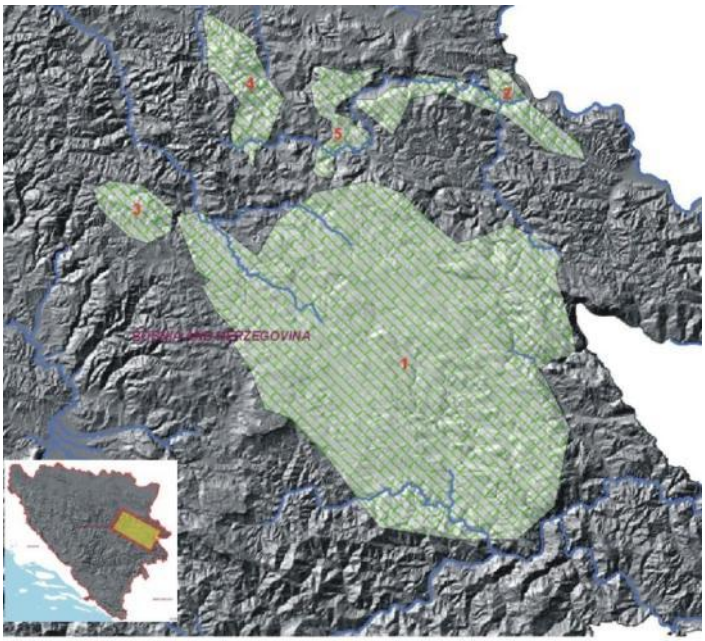


Fig. 32: Significant karst aquifers in the eastern Bosnia within hydrogeological region Banja Luka-Kladanj-Višegrad

The most important zone for this paper, the External Dinarides zone is mostly cover with high permeable limestones of the Jurrasic and the Cretacous age. In smaller degree occurs the Triassic limestones in north-western part of the unit.

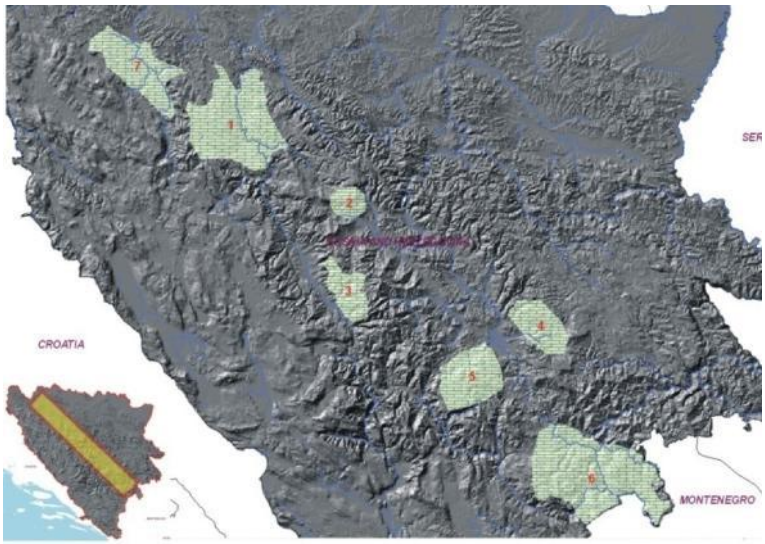


Fig. 33: Significant karst aquifers in the middle Bosnian Region

Moderate permeable are the Lower Jurrasic limestone on southern side of Grmeč Mt., the Middle-Upper Jurrasic limestones of Srnetica Mt., the Upper Jurrasic limestones between Livno and Kupres, the alveolina-nummulites Eocene limestones (E1,2). Moderate permeable are sometime dolomites of the Upper Triassic (T3) e.g. south-eastern from Drvar, around Bosanska Krupa and in the Rama river valley eastern from Prozor. But the Upper Triassic dolomites also can be impermeable.

Fig. 34: The External Dinarides zone present region with most important karst aquifers in B&H

Instance of the Upper Triassic dolomites non-permeability are dolomites of Lastva Anticlyne near Trebinje (its non-permeability is “backbone” of Grnčarevo reservoir and whole HPS Trebišnjica) and on Grmeč Mt. (south from B. Krupa).

The Lower Triassic sandstones, the Upper Cretaceous flysch and the Miocene sediments in the Bihać region represent barrier for groundwater flow and in the contact with the Mesozoic limestones cause drain of aquifers on the strong karst spring (e.g. Klokot I and II). The flysh sediments of the Middle-Upper Eocene age represent also impermeable rocks. These rocks cover significant areas on the left and right side of the Neretva river.

7. Groundwater basins

As it mentioned in the previous chapter the main hydrogeological regions in the territory of B&H are:

1) Northern Bosnia hydrogeological region
2) Hydrogeological region Banja Luka-Kladanj-Višegrad
3) Mid-Bosnian hydrogeological region
4) External Dinarides - deep karst hydrogeological region

In Northern Bosnia hydrogeological region (Figure 30) we do not find considerable occurrences of carbonate rocks on the surface of the terrain when we exclude some appearances of the Tortonian limestones (e.g. Kotorsko-Derventa in northern Bosnia, near Kostajnica in the south-western part of Bosnia and some other smaller areas). The most important aquifers in this region are situated in alluvium sediments in the lower parts of the main surface streams. In this region following significant aquifers are situated: Semberija (1 in figure 30) (in alluvium sediments of the Drina and the Sava river), Posavina (2) (in alluvium sediments of the Bosna and the Sava river), Lijevče field (3) (in alluvium sediments of the Vrbas river) and Dubičko field (in alluvium sediments of the Sava and the Una rivers).
These aquifers (figure 13) present main resources of drinking water in northern Bosnia. Smaller amounts of water in Lijevče field are used for irrigation. The depth of sandy-gravel sediments is from 20 to 60 m. Common characteristics of alluvium aquifers are high permeability.
In the western part of Semberija (1) permeability of gravels is about 5x10-3 m/s and increases to the west up to $1x10^{-2}$ m/s. Vertical drilling wells e.g. in Semberija (drinking water catchments "Grmic" of Bijeljina town; about 100,000 inhabitants) for draw-down less than 1 m gives more than 50 l/s. Roughly estimated exploitation reserves of Semberija aquifer are more than 5 m^3/s. Lijevče field have similar hydraulic characteristics (3). Gravel and sands are deep from 15 to 35 m. Specific yield of wells are between 30 and 100 l/s/m'. Roughly estimated groundwater reserves of this aquifer (3) are about 5m^3/s. The depth of gravels within aquifer Posavina (2) is 20-50 m. Average permeability is in range 10^{-4} m/s. In Dubicko field (to the west of Lijevče field (3) the depth of Sava alluvial sediments is about 40 m.
The Mesozoic rocks lie deep under surface in Semberija and Lijevče field (1 and 3). The Cretaceous limestone in Semberija are drilled on depth more than 1200 m. Exploration boreholes are with artesian pressure and temperature of water above 70°C.
Similar situation is in Lijevče field (3). Some geophysical researches indicate that in Lijevče field (to the north of Banja Luka, the capital city of the Republic of Srpska) the Mesozoic sediments lie more than 1000 m under surface. Occurrences of thermo mineral water on the surface in the surrounding of Banja Luka indicate that these aquifers are also with artesian thermal waters.
Main use of waters from alluvium sediments are for water supply of inhabitants and in smaller degree for industry and irrigation (Lijevče field and Semberija).
Thermo-mineral waters are used for spa.
Considerable areas covered with carbonate rocks in hydrogeological region Banja Luka-Kladanj-Višegrad (the middle Dinarides, number 2 in the figure 30) are located only in its eastern part, in the zone of Romanija and Devetak mountain (1) and in the smaller zones around the Drinjača river (2,4,5 in Fig. 2.6). This region mostly correspond to Ophiolitic zone, compose by impermeable rocks.
Minimum discharge of some springs are: the northern part of aquifer 1 - the Tišča 450 l/s and the Jadar 500 l/s; the middle part of aquifer 1 - the Bereg 350 l/s; the eastern part of aquifer 1 - the Žepa 1,200 l/s; the western part of aquifer 1 - the

Bioštica 240 l/s etc. In the area of Zvijezda mountain (3) in Central Bosnia (near Vareš town) there are smaller aquifers in carbonate rocks. The biggest spring of this carbonate mass is the Očevlja with minimum registered discharge in the three-year period of about 180 l/s. In the area of Ozren-Konjuh massif (4) (central and eastern Bosnia) there are the occurrences of limestone whose main drain is spring "Vukelj" with Qaver=100 l/s and Qmax 790 l/s.
In this region there are very frequent occurrences of thermo-mineral water. These waters are mostly taken through deep drilled wells. The wells have big capacity. For example, in Kakmuz capacity of wells is from 40 to 80 l/s with high concentration of CO_2 (the central part of hydrogeology region, the concession of "SOL group" - Italy) and water temperature about 42°C. Thermo-mineral water occurs around Banja Luka in three zones - Laktaši, Slatina, Šeher. Primary aquifer is not defined yet (supposed that these are in Mesozoic rocks on the depth more than 1000 m). Within one of this zones, in Slatina four drilling pumping wells give about 100 l/s with temperature about 42°C. Similar situation is with waters in spa Teslić and spa Kulaši (also the central part of the region). In the eastern Bosnia, near Višegrad there are artesian thermal water drills. Three wells give aggregate about 70 l/s of thermal water with average temperature 32°C.
The main use of groundwater of karst aquifers is for water supply. Spring Bioštica is used for Sokolac, spring Tišča for Vlasenica, Kraljeva voda for Han Pijesak etc. A part of groundwater of Tišča and Studeni Jadar are used for energy production (two smaller hydro power plants with aggregate power 2 MW). Thermo-mineral waters are used for balneology and tourism.
The middle Bosnian hydrogeological region contains groundwater accumulated in separated carbonated massifs of the following mountains (from north-west to south-east): Manjača, Čemernica, Golija, Vlašić, Raduša, Vranica, Bjelašnica, Igman, Treskavica, Visočica, Zelengora and Lilija. Limestone of Manjača, Čemernica, Golija and Vlašić belong the Vrbas river basin (the Black sea basin). In the south-eastern part of this basin there are the occurrences of Devonian limestone (3 in Fig. 2.7) with several springs whose discharges in the minimum are more than 100 l/s, e.g. Kruščica 350 l/s, Bistrica 300 l/s and Kozica spring with discharge 150 l/s in the minimum.
Adjacent dolomites (near Bugojno town) drain on Okašnica spring with very interesting discharge - two-year the minimum is 280 l/s and the maximum 490 l/s (1979-1980).
North-western from there, among Ključ, Sanica and Sanski Most Mesozoic limestone cover considerable areas (on the left and on the right of the Sana river, 7). The most important springs are Dabar and Zdena. Dabar spring has a big discharge variation of yield – from 1 m^3 to 150 m^3. The minimum of Zdena spring is about 200 l/s.
There are occurrences of thermal waters near Tomina in the valley of the Sana river.
Groundwater in karst mass of the middle part of the Vrbas basin (1) which belong to the middle Bosnian region emerge on two big springs near the right bank of the Vrbas river bad: Krupa with Qaver=1.8 m^3/s and Subunar with Qmin=1.2 m^3/s.
This spring Subunar drains the big karst zone of Podrašničko field. The lost river Ponor sink in the north-eastern part of this field. The Subunar spring is soaked with the reservoir of Bočac dam (the Vrbas river). These two mentioned springs are located on the left side of the Vrbas river. On the right side significant springs are Crno and Trubino springs (sub-basin of the Vrbas river tributary the Ugar river) with aggregate discharge in minimum about 1 m^3/s. The Bosna river basin in this hydrogeological region is very rich with groundwater. Limestone of Igman, Jahorina and Treskavica mountains accumulate big amounts of groundwater.
Groundwater of Bjelašnica-Igman (5) unit discharge on very strong karst springs like Bosna spring in the north-eastern part. These springs are captured for water supply of Sarajevo, the capital city of Bosnia and Herzegovina. The average discharge of these springs is 5.6 m^3/s. Beside Bosnia spring there are many springs with

aggregate discharge about 150 l/s. The south-eastern part of this unit discharge through Ljuta spring near Konjic town with average discharge about 4.4 m^3/s.
Aquifers of karstified mass of Jahorina (4) mountain recharges water of Prača spring (Q_{min} 65 l/s, Qmax 185 l/s), Paljanska Miljacka (Qmin 40 l/s) etc. The accumulations of Trebević discharge through Tilava spring (Qaver 178 l/s), Kovačići (Q_{aver} 78 l/s) etc.
The karst massifs of Vlašić (2) give water for big spring Plava voda near Travnik town. The minimum of this spring is 800 l/s. There are also Bašbunar with Q_{min} 80 l/s, Dokuzi Q_{min} 55 l/s etc. In the Drina water basin (the eastern part of the region) many large karst springs are situated and they drain big Triassic limestone masses of Zelengora, Treskavica and Lelija mountains (6). The most important springs are Lučak spirngs Q_{min} 250 l/s, Todjevac Q_{min} 200 l/s and many springs with the minimum discharge more than 50 l/s.
Significant alluvium aquifers are situated in the valley of the Bosna river, near Sarajevo (Sarajevsko field). These sediments lay directly on limestone. His dept is from 20 to 50 m. Recharging of alluvial aquifer is dominantly from water of karst aquifers of Bjelašnica and Igman. Wells are drilled to 30 m. Specific yield of wells is more than 50 l/s/m'. From this aquifer 600 l/s is capture for water supply of Sarajevo.
The main use of water is for water supply. Thermal water is used for balneology and tourism.
In the External Dinarides - deep karst hydrogeological region there are all significant transboundary aquifers. These are described in details in the following sub-chapter. This region comprise about 50 km wide zone (parallel with the Adriatic sea) and long 350 km from the north-western part of Bosnia (Bihać) to the south-eastern part of Herzegovina (the country border with Croatia and Montenegro). The border of this region to the north is the middle Bosnian hydrogeological region. This region continues to the south across the border with Croatia to the Adriatic sea and to the east it continues in the territory of Montenegro. This is a zone with whole karst development. The main feature is deep and intensive karstification of carbonate rocks – primary limestone. The depth of karstification is various and do not exist typical model of karstification but generally karstification decrease with depth. During the measurements of water permeability within hydro-energy systems Trebišnjica, Neretva, Cetina etc. we have attained vary various results. In some cases permeability is even bigger in the deeper part than in the shallower part of the terrain. Also, it is not rare that we have very different results of water-permeability in two boreholes on small distance (from 5 to 50 m). The same situation is also with drilling wells in the rocks with karst-fissure porosity. The conclusion is that there exists very heterogeneous permeability in horizontal and vertical cross-section and that generally decreases with depth. Previous researches showed that regional permeability is very big ($K=10^{-1}$ cm/s) up to 150-200 m and after this depth rapidly decreases and hardly reaches 10-3 cm/s. Effective porosity, depending on the degree of karstification, is 0.2-4 %. According to G. Castany registered values in the world are from 0.2 to 34%. Currently knowledge confirms suppositions that the circulation of groundwater happens through the system of conductors with numbered reservoirs connected with pipe systems (fissures) of various diameters. One of the main characteristics of karst aquifers in the external Dinarides zone is big fluctuation of water level and sprig discharge depending on rainfall. In the Fig. 35 it is visible that the change of water level is 312 m for 183 days (the example of observation borehole Z-3 in Nevesinjsko field).

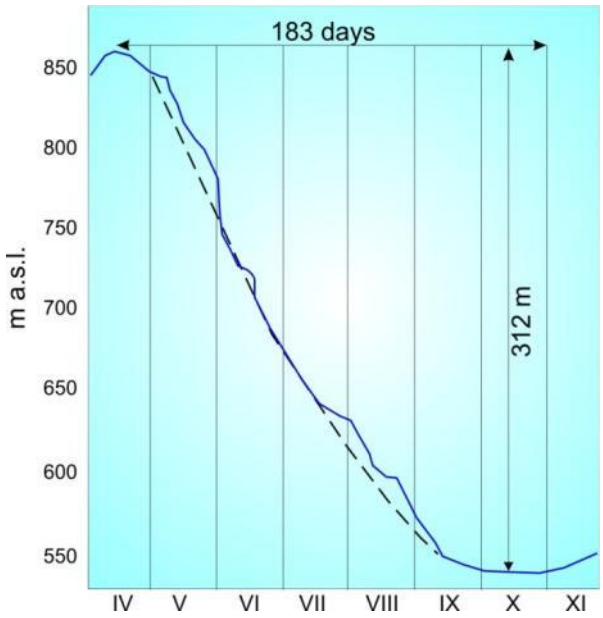


Fig. 35: Enormous high variation of water level in the observation borehole Z-3 in Nevesinjsko field (312 m/183 days)

The main lithological members are limestone. They are permeable and with good transmissibility. Through limestone fissures and other whole spaces are very inhomogeneous arranged. Free water level of karst aquifer is not represented with severe continual surface.

Aquifers have general and local slope. Generally, whole aquifer has slope to the erosion basis which is its drain. Locally, water drainages towards adjacent karst channel of bigger capacity. Precipitation is the dominant way of recharging the aquifers. The way of discharge is though strong karst spring whose minimum yield is often more than 1 m3/s. Wide range of the minimum and the maximum yield of springs is characteristic for most karst springs. For example, the relation among the minimum, average and maximum discharge of Vrioštica spring is 1.25:3.40:16.00 m^3/s, Tihaljina spring 0.75:9.14:27.9 m^3/s etc.

Dolomites in the zone of the external Dinarides have a complex function. If they are in the core of anticline they present impermeable rocks, actually the total underground barrier. In some cases (e.g. between Popovo field and Dubrovnik) dolomites appear like suspended barriers (Figure 36). But they are not just barriers. If they are situated on the side of fold or in the terrain with prevailed fracture tectonic, they can be permeable.

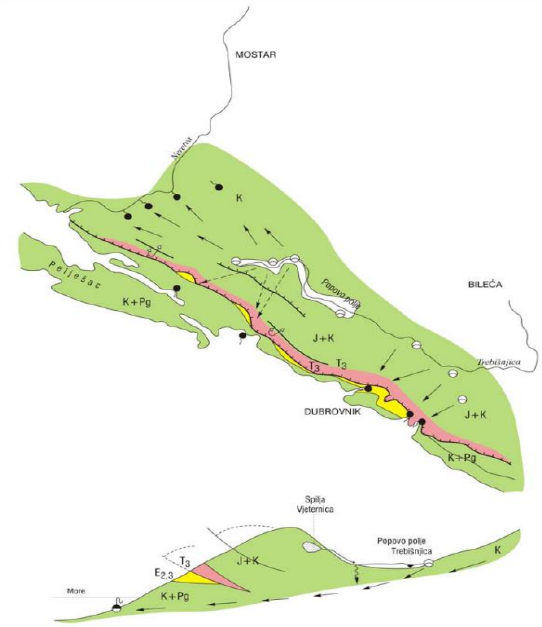


Fig. 36: Triassic dolomites like suspended barrier (after M. Juračić, 2007).

The Tertiary sediments which cover karst fields are impermeable and allow forming of surface streams from strong kartic springs. These rivers sink in swallow holes on the opposite edge of karst field (e.g. Livanjsko field), through swallow holes, in a river bad or both (Trebišnjica).

Generally, in the External Dinarides, the aquifers belong to the Una, the Cetina, the Neretva and the Trebišnjica river basins. Groundwater of the aquifers in the zone of the External Dinarides have a general direction toward the Adriatic sea.

The exceptions are the aquifers which belong to the Una basin and the aquifers toward the zone of the middle Dinarides which flow toward the Vrbas basin (the northern parts of Glamoc and Kupres field).

Most significant aquifers beside those analised as transboundary are given in following paragraph.

In the south, kastic part, of the Vrbas basin most important karst aquifers discharges on left and right spring of the Pliva river (Qmin 8 m^3/s) and spring of the Janj river

(Q_{min} 0.6 m^3/s). This aquifers belong to Black sea basin. Most significant karst aquifers in the Una river and the Sana river belong to Balck sea basin, too. These aquifers discharges on the following springs: springs of the Sana river (Q_{min}:Q_{aver}:Q_{max}=2:8:50 m^3/s), left and right springs of the Ribnik river (Q_{min} 1.3 m^3/s, Q_{aver}=7.5 m^3/s), Krka spring (Q_{min} 0.7 m^3/s), Bastašica spring (Q_{min} 0.1 m^3/s) and Crno vrilo (Qmin 0.2 m^3/s).
Karst aquifers downstream from Jablanica (the Neretva river Basin), exactly kartic massif of Prenj mountain disharges on Crno vrelo (Q=0-20 m^3/s), Mliječnik (Q_{aver} 0.8 m^3/s), Salakovačka springs (Q_{min} 3 m^3/s), Rivač (Q=0-2 m^3/s) etc. Karst aquifers on the left bank of the Neretva river, in Mostar region, discharges on very strong springs Buna and Bunica (Q_{min} 5 m^3/s, catchments area about 1,100 km2), Sabakova springs (Q_{min} 2 m^3/s) and Bregava (Q_{min} 1.1 m^3/s, catchments area about 450 km^2). Springs in Svitavsko-Deransko mud mostly have intremitent character.
In the western Herzegovina most northern karst terrains disharges in the Rama river sources zone - springs Varvara (Q_{min} about 1 m^3/s), Bug (Q_{min} 4 m^3/s), Krupić (Q_{min} 2 m^3/s, N. Miošić,1977). The karst terrains to south discharges in next bigger springs: Doljanka (with $Q_{average}$ 4 m^3/s), Veliki (Q_{min} about 0.4 m^3/s) i Mali Praporac (agregate Q_{min} about 2 m^3/s), Peć Mlini (Q_{min} 2 m^3/s), Crno vrelo/Crno oko (with Q_{min} 1.2 m^3/s) etc. The karst accumulation on the right bank of the Neretva river, in Mostra region, discarges on springs Radobolja, Studenac (Q_{min} 1.2 m^3/s) etc. The spring of the Lištica river have Q_{min} about 5 m^3/s, spring Grude Q_{aver} 3.55 m^3/s, spring Arape near Žitomislić Q_{min} 0.5 m^3/s, Crno oko near Slipići Q_{min} 1 m^3/s etc. Water of karstified limestones in upper of the stream of the Tihaljina river discarges mostly in Klokun spring with Q_{min} 4 m^3/s. In Vitina village the Tihaljina river gain water from Vrioštica spring with Q_{min} 1.5 m^3/s.
The richness of the karst aquifers of the External Dinarides zone with groundawater is clear visible from previously text.
This description of the External Dinarides zone aquifers is general and in the following sub-chapter (2.4.) transboundary aquifers will be described in detail.

7.1. Regional groundwater direction

Genraly, groundwaters in the territory of B&H flow in two directions:

- to the south in the Adriatic sea basin and
- to the north in the Sava river basin (the Black sea basin).

All grounwaters in the Adriatic sea basins (mostly the zone of the External Dinarides, also the zone of the main interest for the DIKTAS project) generaly flow in the north-south direction. From springs which drain karst masses in hinterland, in karst fields there are formed permanent or periodical surface streams on impermeable rocks of the Tertiary age (e.g. Plovuća, Livanjsko polje). In accordance with this, these rivers can sink thru more swallow holes in their river bad or sink concentrate in sallow holes or swallow hole zones (e.g. Mušnica in Gatačko field). Water connection between cascade arranged karst fields is underground. Surface water in the upper horizons disappears and appears again in the lower horizons (fields).
In the western part of Herzegovina waters cascade descent in two directions: toward Cetina river (red elipse) and the Neretva river (violet elipse) (Figure 37).
In the Cetina river basin groundwater flow directions are the following (red elipse in Figure 37):

1. Waters of Kupreško field flow in the northeast-southwest direction to lower Livanjsko field.
2. Waters of Glamočko fields flow in the north-south direction to lower Livanjsko field
3. From Duvanjsko and Livanjsko fields waters flows toward the erosion base - the Cetina river in Croatia, mostly in direction NE-SW.

In the Neretva river basin groundwater flow directions are the following:

1. Waters of Posuško and Imotsko fields flow toward the Trebižat (a tributary of Neretva) river and from Rakitno via Mostarsko mud to the Neretva river basin, mostly in west-east and north-sout directions

In Eastern Herzegovina there are also two main directions (yellow elipse in Figure 37):

1. From Gatačko and Fatničko fields in the north toward Bilećko reservoir in the south. From Trebinje town the Trebišnjica river in natural conditions sinked in numerous swallow holes in the river bad. Waters occur in the coastal zone of Croatia (the biggest spring is Ombla, near Dubrovnik). General directions of groundwater flows were N-S and NE-SW.
2. From Nevesinjsko and Dabarsko fields sinking waters flow toward the Neretva river basin (the Buna, the Bunica, the Bregava) in the east-west direction, and further surficialy flow to the Adriatic sea (the Neretva river).

In the south-western Bosnia – Bihać region, groundwater inflow from Krbavsko polje in Croatia with the general SW-NE and SE-NW directions (green elipse, Figure 37).

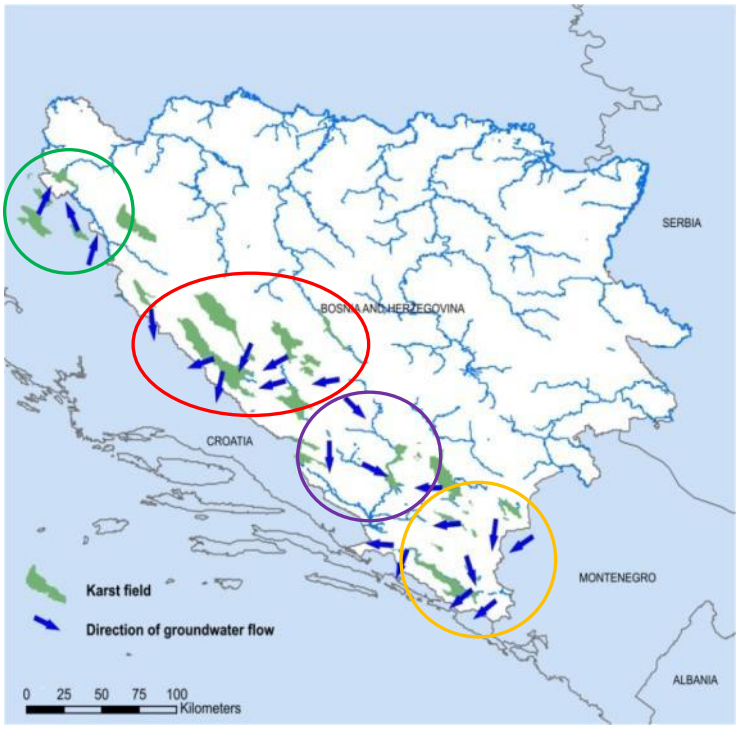


Fig. 37: Directions of groundwater flow in the External Dinarides of B&H

7.2. Tracing tests results

Numerous tracing tests are provided in the Dinarides of Bosnia and Herzegovina. The review of general directions of groundwater flows defined by these tests is available in the figure above.

Almost one hundred tests had been completed within the Trebišnjica and the Neretva river basins. Results of these tests are visible in the following table (Table 13). The tracing test results indicate geoundwater velocities in range 0.33-33.67 cm/s (Milanović, 2006).

Magdalenić (1971) analysed 99 data about fictive velocities in the Cetina river basin. He concluded that 70% of all values were in a range 1-4 cm/s, 20% 5-10 cm/s and 10% have fictive velocity more than 10 cm/s.

Milanović (1976) used these data and other 172 data about fictive velocities of groundwater in the karst of former Yugoslavia (mostly from Eastern Herzegovina). The conclusion was very similar to Magdalenić's case. About 70% of groundwater

flows have the velocities in a range 1-5 cm/s, 19% 5-10 cm/s and 11% more than 10 cm/s.

Based on these facts the most frequent velocities of groundwater flows in the Dinarides of Bosnia and Herzegovina are in a range 2-5 cm/s.

Fictive velocities of a tracer test in the Una river basin are various. This value, e.g. in karst rocks between the swallow hole Prijeboj and the spring Klokot is 3.47 cm/s. In the case of Privilica spring (from the same swallow hole) this value is 0.11 cm/s. In the case of Bare swallow hole fictive velocity of groundwater toward Ostrovica spring is 2.22 cm/s and toward Dobrenica spring 2.61 cm/s.

Table 13: Some results of tracing tests in Trebišnjica and Neretva river basins (Milanović, 2006)

No	Locality, z (a.s.l)	Sinking Q (m^3/s)	Date	Spring where tracer occured z (a.s.l)	Distance (km)	Fictive velocity (cm/s)
1	Biograd – Nevesinje, 799	80	05.01.1963.	Bunica, 37	20	33,67
2	Bobotovo groblje, 970	0,15	26.05.1964.	Piva, 604	16,4	0,54
3	Bravenik- Zubci, 800	0,03	03.12.1971.	Konavoska Ljuta, 90	10	0,53
4	Ponor "C" Fatničko p., 469	Pasamica H=8m	02.04.1964.	Veliki Suhavić, 195, Spring Trebišnjica,325	22.4 17.8	7.15 8.24
5	Dobreljska pećina Gacko, 880	0,075	15.04.1963.	Piva Vrelo, 604	18,1	1,19
6	Geljov most, Mokro polje, 273	0,08	16.08.1956.	Ombla, Dubrovnik, +2.5	16,5	2,08
7	Gradina, Trebinje, 272	0,3	22.09.1959.	Ombla, Dubrovnik, +2.5	18	2,85
8	Ključki Ponor, Cernica, 818		29.11.1961.	V. Trebišnjice, 325 Obod, 476	14 25.6	11.27 12.59
9	Kočela, r. Trebišnjica, 262	≈ 1	28.02.1972.	Ombla, Dubrovnik, +2.5	11,3	1,89
10	Poljice, Mlinica, Popovo polje, 244	0,5	25.02.1952.	Ombla, Dubrovnik, +2.5	18	6,7
11	Provalija, Popovo polje (the first test), 225	Dobri do H=7	20.06.1958.	Doli Slano, Bistrina 0.00 Derane - Londža, +3	16.6 15.6	1.5 1.75
12	Pridvorci, Trebišnjica, 273	0,52	29.07.1956.	Ombla, Dubrovnik, +2.5	16,25	3,2
13	Pridvorci, Trebišnjica, 273	H=1.25	28.03.196?.	Ombla, Dubrov, +2.5 Zavrelje, 100	16.25 12.7	6.45 5.78
14	Slivnica, 410	0,01	03.12.1972.	Zavrelje, Mlini, 100	4,9	1,22
15	Srđevići, Gacko, 940	1	31.08.1958.	Spring Trebišnjica, 325	33,65	1,13
16	Srđevići, Gacko, 940	60	19.10.1964.	Sp.Trebišnjica, 325 Obod, Fatničko p., 476	33.65 19.4	7.53 5.73

7.3. Groundwater bodies

Preliminary characterisation of GW bodies, in accordance with the WFD of the EU, was performed within differnt projects in the territory of Bosnia and Herzegovina. There is no „one-institution“ project regarding GW bodies characterisation.
Characterisation of GW bodies is under the entity jurisdiction. In the territory of the Republic of Srpska three-year project has been started in 2011 and will be finished by 2013. Delineation of GW bodies in the Trebišnjica and the Neretva river basins in the territory of the Republic of Srpska were performed as part of the project Water management plan for the Trebišnica and the Neretva river basins (Elektroprojekt Zagreb and Water management Institute Bijeljina; financed by World Bank). Within the same project groundwater bodies in the Federation of B&H are defined.
In accordance with the analyses given in the mentioned project groundwater bodies with transboundary character between B&H and Croatia are given in the following table.

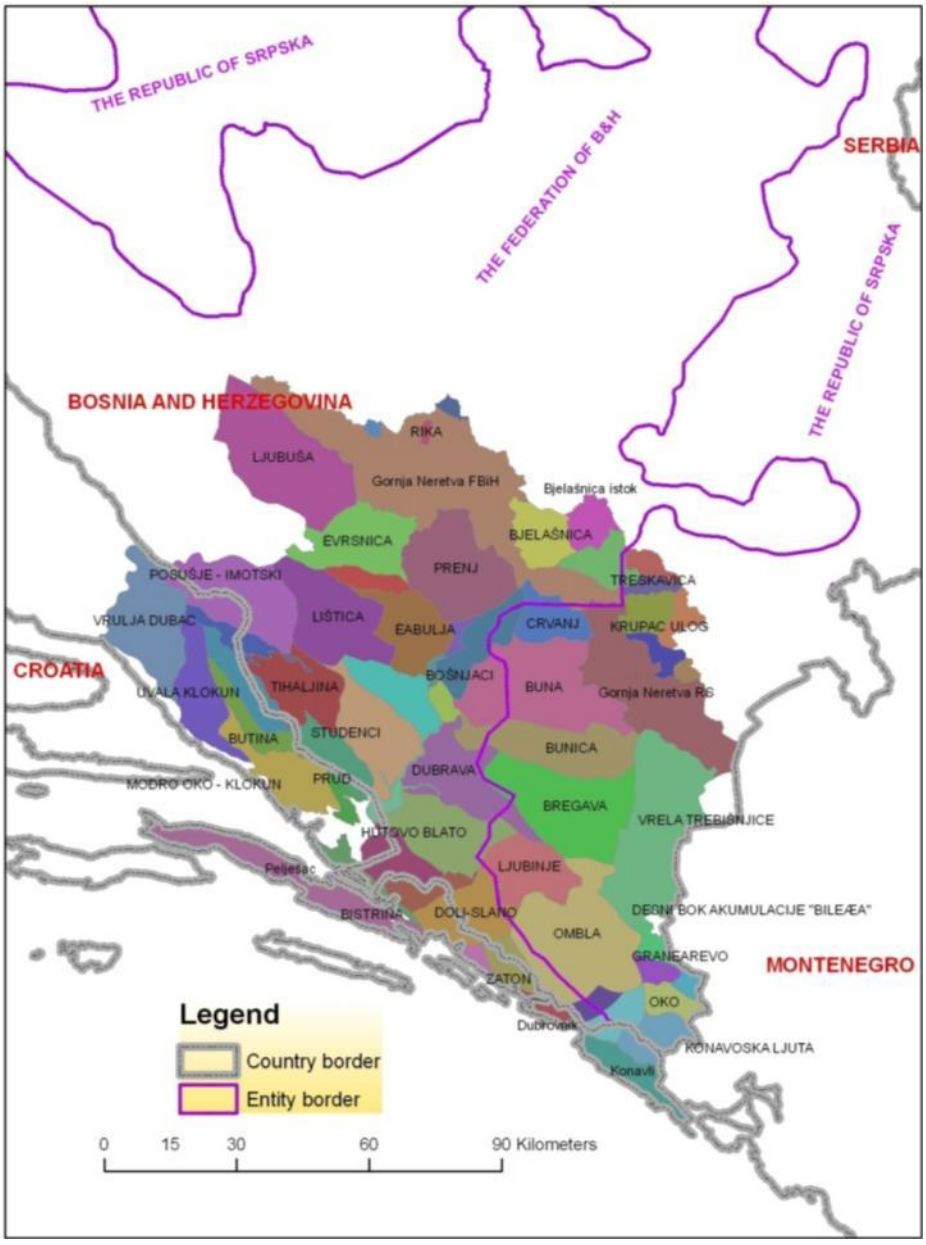


Figure 38: Groundwater bodies in the Trebišnjica and the Neretva river basins in the territory of the B&H and Croatia (Elektroprojekt Zagreb and Water management Institute Bijeljina, 2012)

Table 14: Transboundary GW bodies within the Neretva and the Trebišnjica river basins between B&H and Croatia (Elektroprojekt Zagreb and Water management Institute Bijeljina, 2012)

No	Name	Area (km^2)	River basin
1	Konavska ljuta	138,2	Trebišnjica
2	Zavrelje	54,4	Trebišnjica
3	Ombla	613,2	Trebišnjica
4	Zaton	91,9	Trebišnjica
5	Doli – Slano	243,0	Trebišnjica
6	Bistrina	86,4	Trebišnjica
7	Duboka ljuta	96,0	Trebišnjica
8	Neretva lijeva obala	156,2	Neretva
9	Butina	114,2	Neretva
10	Vrgoračka banja	146,1	Neretva
11	Prud	140,0	Neretva
12	Tihaljina	256,5	Neretva

In the Cetina and Krka river basins characterisation of the GW bodies were performed within the project "Characterisation report for parts of Cetina and Krka river basins in the territory of Federation of Bosnia and Herzegovina (Ćerić et al.,2012), Hydrotechnical Institute Sarajevo.
Most important GW bodies, with transboundary character, are given in the following table.

Table 15: Transboundary GW bodies in B&H in Cetina river basins (Ćerić et al., 2012)

No	Name	Area (km^2)	Type
1	Kupreško polje	54.3	Karst
2	Sturba-Žabljak-Stržanj	413.5	Karst
3	Kablić-Nuglašica	348.8	Karst
4	Cetina left river bank	1071.7	Karst

Just one GW bodies is delineated in the Krka river basin. It is Upper part of the Krka river watershed with area 335.5 km^2 (Ćerić et al.,2012). It mostly correspond to TBA Krka, defined within the DIKTAS project.
Most importnt GW body in the Una river basin is Plješevica with estimated reserves 2.86 m^3/s (Hrvatović, 2008). It mostly correspond with TBA Una, defined within DIKTAS project. The bigest part of this groundwater body is situated in Croatia, smaller in B&H.

8. Karst aquifer characterization

8.1. Aquifer permeability and porosity

The researches showed that regional permeability in the Dinarides is very big (Kf 10-1 cm/s) up to 150-200 m. After this depth it rapidly decreases and hardly reaches 10-3 cm/s.
Porosity of karstified rocks is usually 0.2-4 %. But in the rare cases (zones) exceed even 10% (just up gradient of the spring zone of the Trebišnjica river).
According to G. Castany, the registered world-wide values are from 0.2 to 34 %.
Torbarov analysed recession curve of Trebišnjica and concluded that effective porosity of aquifer is 1.2-1.5%.
Milanović calculated the values of effective porosity for the aquifer of Ombla spring 1.4-3.5%. Vlahović calculated the value of effective porosity 0.79% after analysing fluctuation of groundwater level in 76 observation boreholes in the upper part of the Zeta basin (Montenegro). This value represents the average porosity of a large region. Within the same region, zones with much greater porosity were detected. For example, the porosity of the tectonically disintegrated limestone ridge Budoš-Kunak was found to amount to 6.07%.

8.2. Aquifer recharge

Two main types of aquifer recharge happen in karst terrain: direct infiltration of precipitation and concentrated infiltration and recharge within swallowholes (ponors).
Considerable fracture and porosity of limestone together with high amounts of precipitation caused the occurrences of numerous significant groundwater flows. Precipitations make main resource of recharging (in some parts of Herzegovina its value is about 2000 mm per year).
Rainfall in high degree directly infiltrates in porous karst rocks and flows through complex system of karst channels. A lack of plant cover and surface streams and lakes in many parts of the karst terrains effect on very small amounts of evaporation and transpiration (sometime even less than 25%) and increase the values of infiltration from precipitation. These waters appear on strong karst springs. The occurrence of strong springs is the consequence of contact between permeable (mostly limestone) and impermeable (the Tertiary rocks, sometime dolomites of the middle and the Upper Triassic and clastites of the Lower Triassic age) rocks or is caused by local erosion basis (e.g. deep cut river bed). Ratio between minimum and maximum discharge of stronger karst springs in the external Dinarides karst is usually more than 20.

8.3. Aquifer discharge

Karst springs or emergences are very scattered within karst regions. The majority of important springs are located along the perimeter of the erosion base, that is, at the outer boundary of karst poljes, river valleys, and the seacoast. A common characteristic of these springs, whether permanent or temporary, is the direct dependence of their discharge on precipitation (Figure 39). In general, the capacity and hydrogeological character of karst springs depend on a number of factors such as catchment area, retardation capacity of the aquifer, total effective porosity, geological composition, and other similar factors (Milanović, 2005).
Dominant roles are played by the surface catchment area and relative, active volume of the aquifer.

One of the major characteristics of karst springs is large variation of minimum and maximum capacities (Table 16).
Most large karstic springs have developed in the form of the inverted siphon, so-called Vauclusian springs or siphonal springs. The descending part of siphon for some of them reaches depths as follows:
Most important springs located within the External Dinarides in B&H, with basic data, are given in the following table.

Table 16: Most important springs located within transboundary aquifers with basic data (references 2, 3, 11 and 14)

No	Spring name	River basin (DIKTAS TBA)	Q_{min}	Q_{av}	Q_{max}	Tapped (Y/N)	Remark
1	Klokot	Una	2.3	14	70	Y	
2	Ostrovica	Una	0.789	3.71	12	Y	
3	Privilica	Una	0.03	-	2	Y	
4	Toplica-Klisa	Una	0.06	-	1	Y	
5	Dobrenica	Una	0.23	0.61	5	N	
6	Ilijića vrelo	Una	0.1	-	-	N	
7	Panjak	Una	0.005	-	0.4	N	
8	Bistrica	Una	0.015	-	0.1	N	
9	Žegar	Una	0.006	-	1	Y	
10	Đakulin-Loskun	Una	0.18	-	4.8	N	
11	Crnoć-Nebljusi	Una	1.2	-	-	N	
12	Draga	Una	0.03	-	0.5	N	
13	Donji Tiškovac	Krka	0.02	-	-	N	
14	Duman	Cetina	0.600	3.60	24.13	Y	
15	Žabljak	Cetina	0.140	2.06	4.96	Y	
16	Sturba	Cetina	0.9	4.48	9.50	N	
17	V. Stržanj	Cetina	0	-	-	N	Intermittent, $Q_{av17+18+19}$ = 2.29
18	M. Stržan	Cetina	0	-	-	N	Intermittent
19	Volarica	Cetina	0.11	-	-	N	
20	Ostrožac	Cetina	0.04	0.21		Y	
21	Ričina	Cetina	0	9	>60	N	Intermittent
22	Dejanova pećina*	Trebišnjica (Bilećko lake)	-	-	-	Y	Submerged, $Q_{min22+23}$=2
23	Nikšićka vrela*	Trebišnjica (Bilećko lake)	-	-	-	N	Submerged, $Q_{av\ 22+23+24}$ = 42
24	Čepelica*	Trebišnjica (Bilećko lake)	0	-	-	N	Submerged, $Q_{max\ 22+23+24}$ > 800
25	Oko**	Trebišnjica (Bilećko lake)	0.5	-	40	Y	Submerged

26	Obod	Trebišnjica (Bilećko lake)	0	-	60	N	Intermittent
27	Tihaljin	Neretva	0.650	-	27.5	N	
28	Klokun	Neretva	3,52	-	14.3	N	
29	Vrioštica	Neretva	1.32	-	10.5	N	
30	Bregava	Neretva	0.4	17.5	59.0	T	
31	Buna	Neretva	2.95	23.7	380	N	
32	Bunica	Neretva	0,72	20.2	207	N	

*-Submerged by reservoir for HPP Grančarevo
**- Submerged by reservoir for HPP Gorica

8.4. Springflow and GW regime

Main characteristic of karst springs is a very variable flow regime. Ratio between minimum and maximum discharge of stronger karst springs in the External Dinarides karst is very high.
It is usually more than 20 (Table 16), sometimes excees 40 (Duman spring in the Cetina river basin, 14 in table 16), 80 (spring Oko tapped for Trebinje city water supply, 25 in table 16) and even 100 (the Buna and the Bunica, 31 and 32).
Groundwater levels are generally far below the surface and strongly dependable on rainfall regime. This is visible from the figure below (Figure 39). There have been rapid, significant changes in the water table during extensive rain, in a very short period.
In piezometer boreholes near Bileća (northern of Trebinje) for example, increasing of groundwater level about 100 m has been registered during just about 50 hours.
Enormous high variation of water level were observed in the observation borehole Z-3 in Nevesinjsko field (312 m/183 days, Figure 35). In the same location, in few piesometers on mutual distance 1-3 km measured differences between minimal and maximal froundwater lavel are from 281 up to 312 m. These differences in Nevesinjsko field represent the highest ones measured in the Dinarides.
The values of specific groundwater runoff are various. In karstified limestone between Popovo field and the Adriatic coastal zone (the Trebišnjica river basin) the specific groundwater runoff is 15-35 l/s/km^2.
In the Neretva river basin are calculated following values: catchment area of the Bregava 33.1 l/s/km^2, Jakešnica spring 31 l/s/km^2, Nezdravica-Tihaljina 19.30 l/s/km^2, Buna and Bunica 39 l/s/km^2 etc. (I. Slišković, 1980).
In the Una river basin are calculated following values of specific groundwater runoff: catchment area of Klokot spring 32.14 l/s/km^2, Crno vrelo 9.5 l/s/km^2, Voloder 20.4 l/s/km^2, Vodomut 24.43 l/s/km^2 etc.
According to N. Miošić (1983) specific groundwater runoff in the Cetina basin was 33 l/s/km^2.

8.5. Groundwater quality

The general characteristics of analyzed groundwater indicate that waters in the zone of the External Dinarides belong mostly to HCO3-Ca type. Mineralization is in the range 180-700 mg/l. The temperatures of these waters are usually 8-10 °C and the registered minimum is 6°C in Drežanka spring. There are no considerable changes in natural conditions within macro and micro components in chemical content. The HCO3-Ca type of water is characteristic for limestone aquifers. Waters from dolomites have enhances content of Mg^{2+} ion.

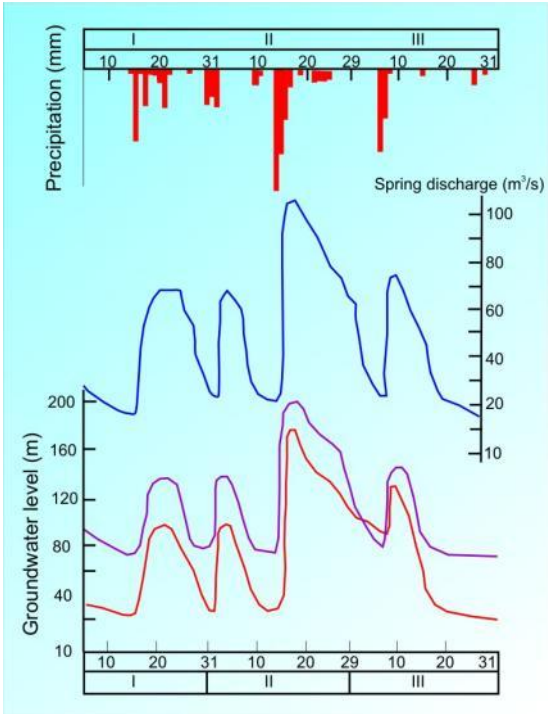


Figure 39: Strong dependence of groundwater level on precipitation:
red poligons-precipitations;
violet and red-groundwater levels in piesometric boreholes;
blue-discharge of Ombla spring
(after Milanović, 1979)

Here is possible to conclude, from numerous analyses, that mineralization is inverse proportional to discharge. For example, springs Vrelo and Vakuf in Studenci village near Čapljina (western Herzegovina) have smaller fluctuation of discharge from August to October. In that period mineralization in Vrelo spring enhances to 690 mg/l and to 580 mg/l in Vakuf spring. During winter and spring (from December to May) discharges of springs considerably enhance. In this period the mineralization of Vrelo spring decreases to 360 mg/l and to 320 mg/l in Vakuf spring.

Waters from limestone aquifers have the dominant content of Ca^{2+} ion and smaller mineralization in the period of faster water-exchange. In the period of lower water levels mineralization is from 300 to 500 mg/l. The mineralization of groundwater in the period of hydrological maximum is 250-370 mg/l.

Waters from dolomites also belong to hydro-carbonate group, mostly to Ca-Mg-HCO_3 type. Mineralization is in the range 200-700 mg/l.

Waters from limestone-dolomites formations mostly have similar characteristics as one from limestone.

The domination of Ca^{2+} ion is especially emphasised in the following areas: the catchment areas of Rama springs; Drežanka, Krupica and Privilica springs in the upper part of the Neretva river basin and Crno oko, Veliki i Mali Praporac and Mliječnica springs in the middle part of the Neretva river basin and also in the area of Mostar basin: Potoci, Radobolja, Studenica, Buna and Bunica springs. The content of the Mg^{2+} ion is much less than Ca^{2+}. This is the consequence of groundwater flowing dominantly through limestone. The content of SO_4^{2-} ion is mostly low. The exceptions regarding low content of the SO_4^{2-} in groundwater are springs in the areas near the Tihaljina river, Kupres and Vrela. Increasing of the content of SO_4^{2-} ion indicates the presence of sandstones of the lower Triassic age and the dolomites of the middle and the upper Triassic age.

Content of Cl- ion is very low, permanently less than 15 mg/l.

Problems concerning chemical parameters of water of the karst aquifers are very rare. The springs mostly satisfy requests in accordance with domestic low regulation. That regulation is harmonized with requests of the World Health Organization and with the EU Directive on drinking water, regarding maximum allowed concentration of components.

Main problems of the qualities of karst waters are turbidity and bacteriology contamination.

The problem of turbidity is especially stressed in spring months, after snow melt and in the period after intensive rains. Turbidity sometimes exceeds 50 NTU (Nephelometric Turbidity Unit). This disabled use of water for this purpose, usually in

the short period of time. Installations for treatment of water turbidity are very rare in Bosnia and Herzegovina.

The second considerable problem is bacteriology contamination. This problem is mostly connected to human activities (inappropriate disposition of waste waters, farms, etc). This problem is usually solved by chlorination of raw water. Sometimes, the presence of bacteria (most frequently faecal) exceeds allowed values after the treatment, too. In some cases the treatment with chlorine give satisfied results but with content of residual chlorine on the border of allowed values.

If we exclude occasional problems with turbidity and bacteriology contamination, in the circumstances of the most intensive recharge of the karst aquifer by precipitation in the higher areas with very limited sources of pollution, the present quality of groundwater in the region is good.

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WG 2
ENVIRONMENT AND SOCIO-ECONOMICS

NATIONAL CONSULTANT: DALIBOR VRHOVAC

TABLE OF CONTENT

BACKGROUND

Diktas project area as part of Dinaric Karst located in South Eastern Europe (Balkan Peninsula), between 13,5°E and 20,96°E longitudes and between 39,93°N and 45,67°N latitude. Dinaric Karst is shared among four (4) Diktas countries (Croatia, Bosnia and Herzegovina, Montenegro and Albania; *Illustration 1*) and five (5) non-Diktas counties (Italy, Slovenia, Serbia, FYR Macedonia and Greece).

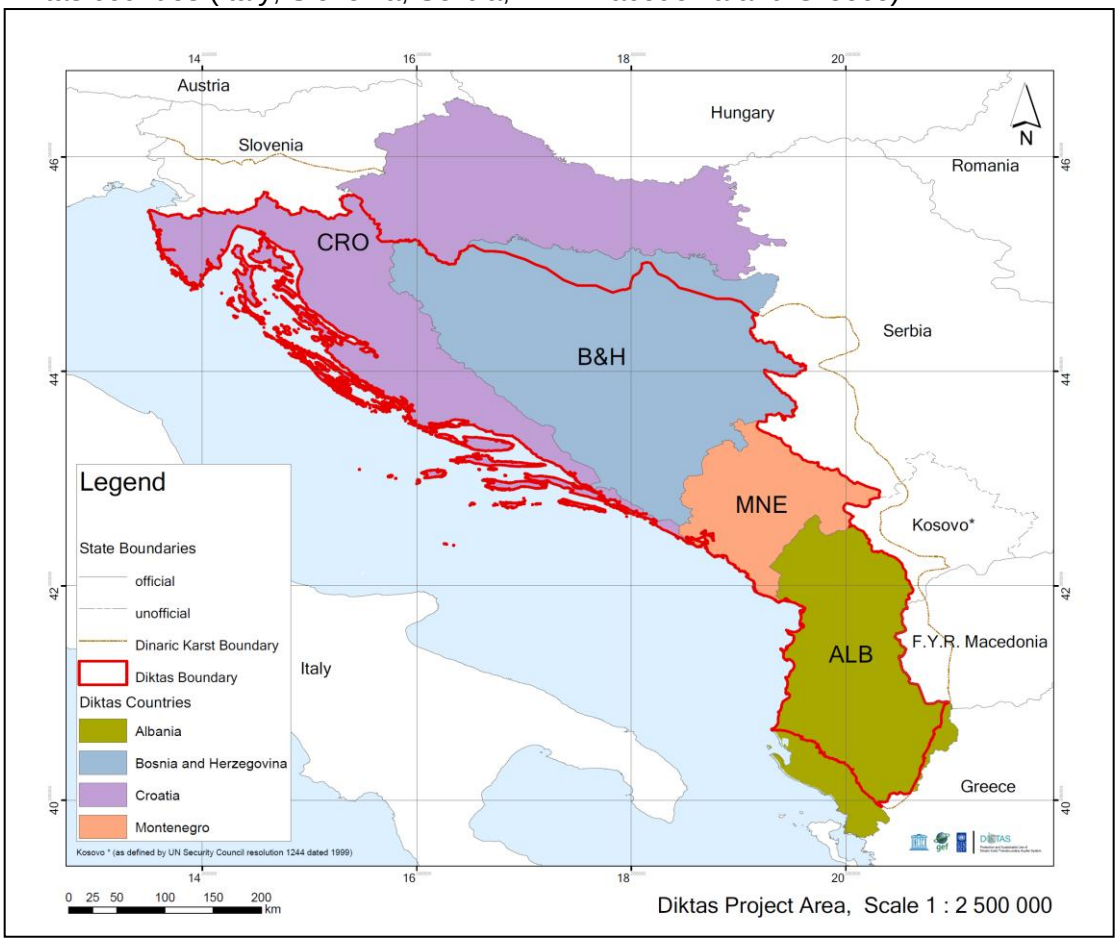


Illustration 1: Diktas project area

ABOUT DIKTAS PROJECT

The project Protection and Sustainable Use of the Dinaric Karst Transboundary Aquifer System (DIKTAS Project), is the first ever attempted globally to introduce sustainable integrated management principles in a transboundary karstic freshwater aquifer of the magnitude of the Dinaric Karst System. Project is financed by the GEF (Global Environmental Facility) and contributions from the beneficiary countries (Croatia, Bosnia and Herzegovina, Montenegro and Albania). Implementing Agency is UNDP and executing agency is UNESCO-IHP. After a preparatory phase (2008-2009) full size project has started with implementation on July 2010 and it is foreseen to be implemented in course of four years.

The estimated total area of Dinaric karst is 136720,00 km2 (within the above mentioned eleven (11) Dinaric karst countries). The total area of Diktas countries is 149955,00 km2 (separately by countries in Table 1) and total Diktas project area is 110410,00 km2 or 73,6 % of national territories of Diktas counties.

Table 1: Diktas project area

Country	Croatia	Bosnia and Herzegovina	Montenegro	Albania	Sum or average
Total county area (km2)	56610,00	51240,00	13345,00	28760,00	149955,00
Area of county in Diktas project (km2)	27445,00	45375,00	13345,00	24245,00	110410,00
Share of national territory in Diktas project (%)	48,5	88,6	100,0	84,3	73,6

At the global level, the project aims at focusing the attention of the international community on the huge but vulnerable water resources contained in karst aquifers (carbonatic rock formations), which are widespread globally, but poorly understood. The Dinaric Karst Aquifer System, shared by named countries and one of the world's largest, has been identified as an ideal opportunity for applying new and integrated management approaches to these unique freshwater resources and ecosystems.
At the regional level the project's objectives are to (i) facilitate the equitable and sustainable utilization and management of the transboundary water resources of the Dinaric Karst Aquifer System, and (ii) protect from natural and man-made hazards, including climate change, the unique groundwater dependent ecosystems that characterize the Dinaric Karst region of the Balkan Peninsula. These objectives, which aim to contribute to sustainable development of the region, are expected to be achieved through a concerted multi-country effort involving improvement in scientific understanding, the building of political consensus around key reforms and new policies, the enhanced coordination among countries, donors, projects and agencies.

WORKING GROUP FOR ENVIRONMENT AND SOCIO-ECONOMICS

At the beginning of implementation phase of the full-size project, Project Coordination Unit (PCU) has been established in Trebinje, Bosnia and Herzegovina and afterwards four (in each partner country) National Execution Units (NEU) has been established. NEU is comprised of the National focal point and 4 national experts (legal and policy, stakeholder's involvement, hydrogeology and environment and socio-economic aspects).
National Consultants for Environmental and Socio –Economic aspects (NC-ESE) are conducting DIKTAS regional environmental and socio-economical assessment together with other national and international consultants organized in the DIKTAS Working Group Environment and Socio-Economics.
DIKTAS regional environmental and socio-economical assessment will take in consideration both natural conditions as well as anthropogenic impact (such as population and economic activities). The assessment will result in a number of thematic regional maps showing (combination of) various environmental and socio-economic parameters. Data on (point, line, distributed) sources of pollution, population distribution, ecosystems, existing and planned infrastructure and human activities (reservoirs, tunnels, industry, waste disposal facilities, agricultural activities)

and similar, will be collected, processed and presented in the framework of this activity. Both, environmental and socio-economical assessment will have a regional character and will be limited to possible impact on Dinaric karst groundwaters, and in particular to transboundary impact. In order to harmonize collection of data and national reports from NC-ESE Working Group for Environment and Socio-Economics has been established- WG ESE (among 3 others).

First meeting of the WG ESE has been held 31.03.2011 where NC-ESE has agreed joint work plan, methodology and deliverables (updated and agreed in four joint WG meetings that fallowed mentioned initial meeting). This report follows agreed methodology of work.

In general, each NC-ESE is required to gather specific national data necessary for national and regional Environment and Socio-Economic analyses.

Analyses has been done on the data collected on two different scales: national, and on the (more detailed) level of trans-boundary areas of special concern and **presented in this report as part A and B, while data collection has been documented mainly as the Annexes of this Report.**

PART A: ENVIRONMENT AND SOCIO-ECONOMIC OVERVIEW AT THE NATIONAL LEVEL

GENERAL INFORMATION

Bosnia and Herzegovina is located in the western part of the Balkan Peninsula. The territory
extends between 42º 26' and 42º 15' northern latitude and 15º 45' i 19º 41' eastern longitude.
It shares the country border with the following neighbouring countries: the Republic of Croatia
(932 km) to the north, west and the south, the Republic of Serbia (302 km) to the east, and the
Republic of Montenegro (225 km) to the south-east .Capital city is Sarajevo and country area 52.280 sq km.
The country is mostly mountainous, encompassing the central Dinaric Alps. The north-eastern
parts reach into the Pannonian basin, while in the south the border is the Adriatic Sea. The country has only 20 kilometres of the coastline, around the town Neum in southern Herzegovina.The name of the country comes from two regions: Bosnia region and Herzegovina region, which have very vaguely defined border between them. Bosnia occupies the northern areas which is roughly fourfifths of the entire country, while Herzegovina occupies the rest in the south part of the country.

Ilustration 2: Geographic position of the Bosnia and Herzegovina

Bosnia and Herzegovina is administratively divided on the Federation of Bosnia and Herzegovina (51%) and the Republika Srpska (49%). The Federation of Bosnia and

Herzegovina consists 10 Cantons that further consist of the municipalities. Republic of Srpska is administratively divided on regions and further on municipalities. The territory of Brčko, which was under arbitration, did not become a part of Federation of Bosnia and Herzegovina or of Republic of Srpska. In accordance with the decision by the Arbitrary Commission for Brčko, it became a separate district under the authority of Bosnia and Herzegovina.
Bosnia and Herzegovina consists of four large geographic units. Central Bosnia (12.920 sq. km, population of 1.249.000) includes the mountainous area in the central part of Bosnia. This is the most developed part of the country that for a long time was a crossroad of various influences and interests of neighbouring Pannonian, Karst, and Mediterranean regions. "High Karst" of Bosnia and Herzegovina (11.842 sq. km, population of 325.000) consists of the mountainous Karst area of west Bosnia and Herzegovina. This is the part of the country with the smallest population and is the least developed part - only 9% of its territory is cultivable and less then 30% of the entire population lives in the cities of this part. The Mediterranean region, Low Herzegovina (5.399 sq. km, population of 296.000) is situated in the central-coastal region behind a mountain, and is the smallest of the four geographic units of Bosnia and Herzegovina.

ADMINISTRATIVE SETUP

Bosnia and Herzegovina is a compound state, which in line with the General Framework Agreement for Peace in BiH, consists of the Federation of Bosnia and Herzegovina (51% of territory) and the Republic of Srpska (49% of territory). Brcko, which was a subject of disputes and international arbitrage, was proclaimed a district. Thus, Bosnia and Herzegovina has two entities and Brcko District.
Ilustration 3 : Municipalities in Bosnia and Herzegovina

Entities

The Federation of Bosnia and Herzegovina and the Republic of Srpska are entities having their own constitutions, which have to be in conformity with the Constitution of Bosnia and Herzegovina.

Federation of Bosnia and Herzegovina

Federation of Bosnia and Herzegovina, as the entity, consists of ten cantons (which, in administrative terms are further split into communes) as follows: – Una-Sana Canton, Posavina Canton, Tuzla Canton, Zenica-Doboj Canton, Bosnia –Podrinje Canton, Central Bosnia Canton, Herzegovina-Neretva Canton, West Herzegovina Canton, Livno Canton, Sarajevo Canton.There is 74 municipality in this ten cantons. The Parliament of the Federation of BiH has legislative powers and is comprised of the House of Representatives and the House of Peoples. Executive powers are performed by the President of the Federation and two Vice Presidents, as well as the government o
f Federation of B&H. Sarajevo is the capital city.

Republic of Srpska

Republic of Srpska is the entity, which is administratively split into regions (Banja Luka, Doboj, Bijeljina, Pale and Trebinje). Regions are further split into communes.Republic of Srpska cover 63 municipality.
National Assembly of the Republic of Srpska and the Council of Peoples in the Republic of Srpska exercise legislative powers in the RS. Executive powers are excercised by the President and two Vice Presidents of the Republic of Srpska, as well as by the Government of RS.

Brcko District

The territory of Brcko was under arbitrage and was attached neither to the Federation of BiH or to the Republic of Srpska. By decision of the International Arbitrary Commission, close to the end of 2000, Brcko was put under administration of Bosnia and Herzegovina, as the separate district.
District Brcko has its own multi-ethnical government, Assembly, Executive Board, jurisdiction and police forces.

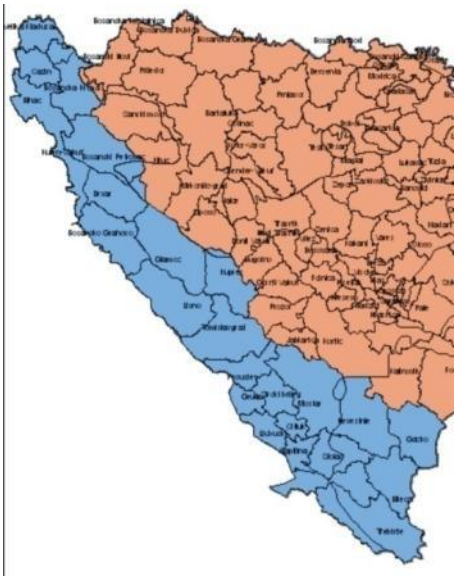
POPULATION

Demographic data for Bosnia and Herzegovina is based on last census 1991. For our project data is available from authorized institutions in charge of demographics in B&H two entity Republican Statistics Institute and Agency for Statistics of B&H level.This three institutions is official and they provide the information about census and make estimates of population in B&H.
Demografical trends and migration are based on estimation and previous censuses. The total area of Bosnia and Herzegovina covers 51,209 km². Under the last census in 1991 there have been 4,377,053 citizens (density 85.5/km^2). The last estimation in 2007 is about 3,980,000 (estimate density 77/km^2). As mention above, there are next nationalities in Bosnia and Herzegovina: Bosnians, Serbs, Croats and the members of other nationalities. In accordance with 1991 census number of 4,377,053 make: 44% Bosnians (in that period declassed as Muslims), 31% Serbs and 17% Croats. About 6% of people in that period declassed as Yugoslavs.
The religious division mostly follows ethnical: 88% of Croats are Catholics, 90% of Bosnians are Muslims and 99% of Serbs are Orthodox.
Data are highly changed in comparison with that period. Many people have been died in the period of ethnic war from 1992 to 1995 (recent research estimates the total number to be less than 110,000 killed civilians and military and about 1.8 million displaced). Some unofficial estimations of American CIA in 2000 year say that national structure of B&H today is: 48% of Bosnians, 37.1% of Serbs, 14.3% Croats and 0.6% members of other nationalities.
Data about demography changes in Bosnia and Herzegovina through history are visible in the Table 2.

Table 2: Population of Bosnia and Herzegovina through history

Population of Bosnia and Herzegovina						
Year of census	*Area km²*	*Population*			*Number of household*	*Citizens per 1 km²*
		Total	*Masculine*	*Female*		
1879	51246	1158440	607789	550651	-	22,6
1885	51246	1336091	705025	631066	226699	26,1
1895	51246	1568092	828190	739902	257493	30,6
1910	51200	1898044	994852	903192	310339	37,1
1921	51200	1890440	966209	924231	-	36,9
1931	51564	2323555	1185040	1138515	398238	45,1
1948	51189	2564308	1236932	1327376	498116	50,1
1953	51221	2847459	1385559	1461900	565212	55,6
1961	51197	3277948	1599665	1678283	706107	64,0
1971	51197	3746111	1834600	1911511	848545	73,2
1981	51197	4124256	2050913	2073343	1030689	80,6
1991	51197	4377033	2183795	2193238	1207098	85,5

In the purpose of necessary analyses for this report, following text is based on demographic characteristics of the external Dinarides zone in the territory of Bosnia and Herzegovina. Here are taken into account following municipalities (from NW to SE): Velika Kladuša, Cazin, Bosanska Krupa, Bihać, Bosanski Petrovac, Drvar, Grahovo, Glamoc, Livno, Kupres, Tomislavgrad, Posusje, Grude, Siroki Brijeg, Mostar, Ljubuški, Čitluk, Čapljina, Stolac, Neum, Nevesinje, Gacko, Bileća, Ljubinje i Trebinje (Ilustration 4). After 1995 year some municipalities have been divided into two parts, in case that the pre-war territory of these municipalities today belong to two entities (e.g. pre-war territory of municipality Trebinje today is divided into Trebinje in the Republic of Srpska and Ravno in the part which belongs to the Federation of B&H). In the Table 3 we can see the number of inhabitants in municipalities, particularly.



Ilustration 4: Analysed Municipalities within zone of External Dinarides (blue colour)

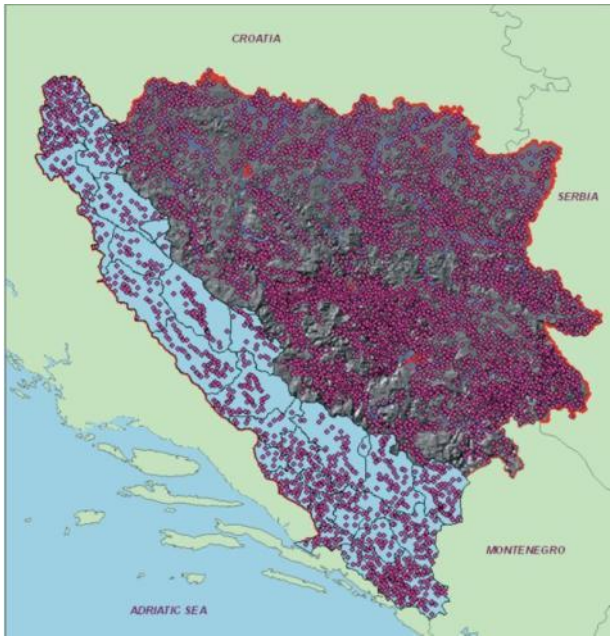
Complete area of analysed municipalities is about 15,940 km^2. If we divide aggregate population 734,526 (Table 3) with this above mention area that will be 46 citizens/km^2. This value is less about 50% in comparison with average value of density of population for the whole territory of B&H (data from 1991).

Table 3: Population in analysed municipalities of Bosnia and Herzegovina whose territories belong to the zone of external Dinarides in accordance with 1991 census with nationality structure

No	*Municipality*	*Sum*	*Muslims*	*Serbs*	*Croats*	*Yugoslavs**	*Other*
1	Bihać	70,732	46,737	12,689	5,580	4,356	1,370
2	Velika Kladuša	52,908	48,305	2,266	740	993	604
3	Cazin	63,409	61,693	778	139	430	369
4	Krupa	58,320	43,104	13,841	139	708	528
5	Bosanski Petrovac	15,621	3,288	11,694	48	366	225
6	Drvar	17,126	33	16,608	33	384	68
7	Kupres	9,618	802	4,864	3813	67	72
8	Bosansko Grahovo	8,311	12	7,888	226	135	50
9	Glamoč	12,593	2,257	9,951	184	118	83
10	Livno	40,600	5,793	3,913	29,324	1125	445
11	Tomislavgrad	30,009	3,148	576	25,976	107	202
12	Posušje	17,134	6	9	16,963	26	130
13	Čitluk	15,083	111	19	14,823	17	113
14	Grude	16,358	4	9	16,210	5	130
15	Široki Brijeg	27,160	9	148	26,864	20	119
16	Čapljina	27,882	7,672	3,753	14,969	1047	441
17	Neum	4,325	190	207	3,792	90	46
18	Ljubuški	28,340	1,592	65	26,127	227	329
19	Stolac	18,681	8,101	3,917	6,188	307	168
20	Mostar	126,628	43,856	23,846	43,037	12,768	3121
21	Bileća	13,284	1,947	10,628	39	222	448
22	Gacko	10,788	3,858	6,661	29	84	156
23	Ljubinje	4,172	332	3,748	39	19	34
24	Nevesinje	14,448	3,313	10,711	210	123	91
25	Trebinje	30,996	5,571	21,349	1,246	1,642	1,188
TOTAL:		734,526	291,734	170,138	236,738	25,386	10,530

*- this category today is pointless

Sparsely populated zone of the external Dinarides is also clearly seen in the next figure (Ilust 5).



In some parts of the terrain of the external Dinarides population is totally absent. Those areas are mostly areas with altitude more than 1,000 m above sea level.
Dense populated areas are around big rivers as the Una river, the Neretva river, the Trebisnjica river etc., and within karst fields. That is logical if we take into account that those zones make most productive parts in carbonates of the external Dinarides zone.

Ilustration 5: Clear distinction in populated density between the zone of the external Dinarides and other parts of the territory of B&H, violet points present populated zones

Number of people per administrative unit is collect for all municipalities based on the data from census 1991, estimation for years 2008. , 2009. , 2010.Data cover whole country on municipality level.This data and Trends for population number per municipalities for this years are provided in Annex II.

SELECTED INFRASTRUCTURE DATA

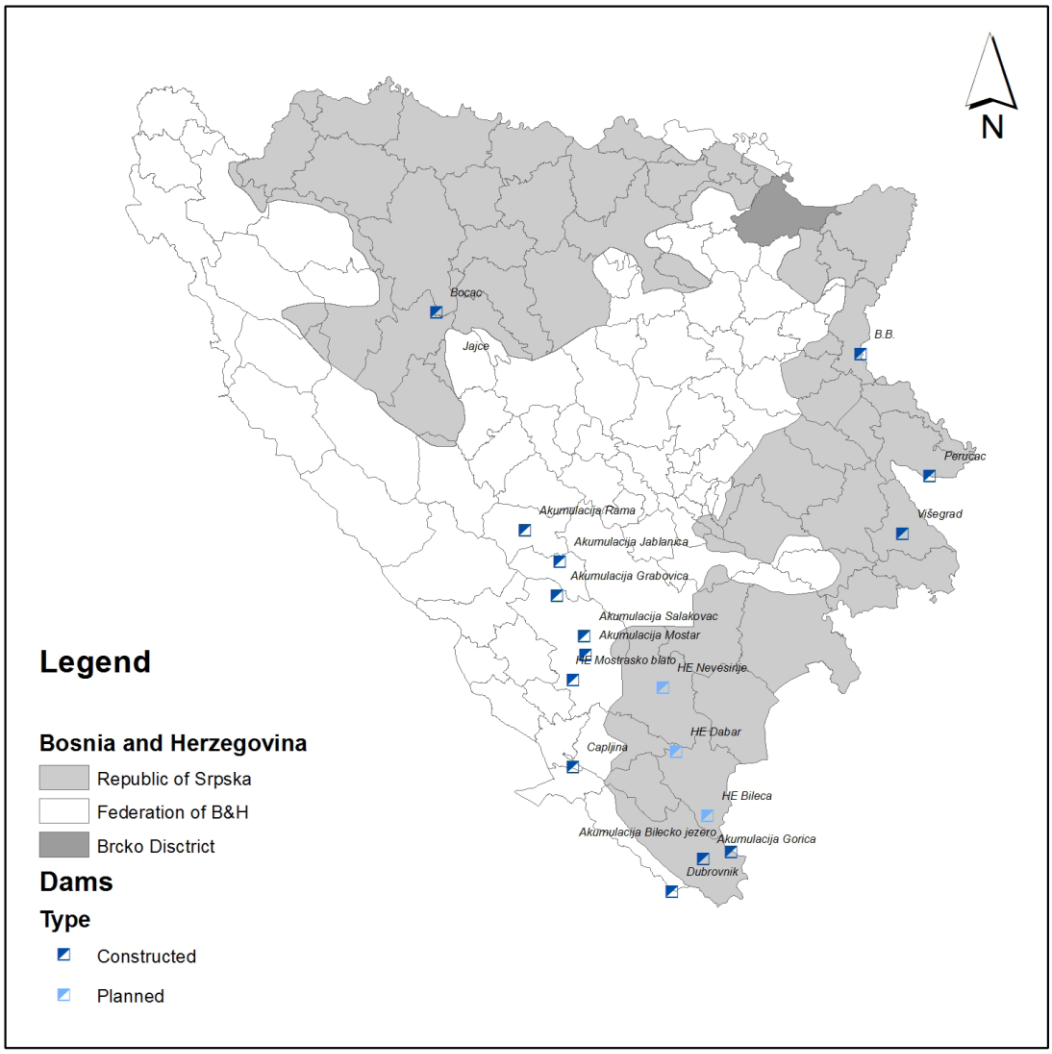
Bosnia and Herzegovina has own categorization of the roads. Shp files already exist and cover two categories : a) main roads and b) secondary roads. During the meeting in Trebinje we already agree for this project is enough.

Ilustration 6: Main and secondary roads in B&H

B&H has a long tradition in water management during the past years built a lot of infrastructure such as dams, canals, defense embankments, pumping stations for flood control system and other facilities. Complete documentation on these types of facilities with all their characteristics is available in the archives for the responsible Agency for water and part of its ongoing business today these institutions must be maintained.

So , for the purpose of the project we collect data about name of dam , place and total storage volume.

Hydropower plants is always sensitive and intrest area. Bosnia and Herzegovina is an area that is very convenient for the construction Hydropower plants.In past them already built a lot, and these data are generally available in the ‘’Electroprivreda’’ and the competent institutions , also in the documentation of relevant Ministries.



Ilustration 7 : Dams B&H

Table 4: Hydropower plants

Name of hydropower plant	Electricity generation (MW)
Trebinje 1	180
Trebinje 2	8
Dubrovnik	216
Čapljina	440
Višegrad	315
Bočac	110
Bogatići	8
Mesići	3
Tišća	2
Vlasenica	0.9
Zvornik	96
Bajina Bašta	360
Jajce I	52
Jajce II	27
Una	6
Jablanica	180
Grabovica	114
Salakovac	210
Mostar	72
Rama	160
Peć Mlini	15

Table 5. : Dams with usefull volume

Name of dam	usefull volume (hm3)
Trebinje 1-Trebišnjica	1100
Dubrovnik-Trebišnjica	9
Čapljina-Trebišnjica	5
Rama	466
Jablanica-Neretva	288
Grabovica-Neretva	5
Salakovac-Neretva	16
Mostar-Neretva	6
Jajce I-Pliva	2
Jajce II-Vrbas	2
Bočac-Vrbas	43
Višegrad-Drina	101
Modrac-Lukavac	86

For our project is very important to mention termopower plant Gacko (capacity 300MW) with large impact on ecology and water in the area of Trebisnjica and Bilecko lake.

TOURISM

Data for number of tourist is available on municipality level and collected from the statistic anual report and documentation from the official statistical institutions.This data cover only municipalities which are relevant for tourism and the unit is ''number of nigths spent'' in municipalities.
Data on tourist arrivals and tourist overnights (by country of residence) are available at national, entity and municipal level. Data are collected on the same methodology

in both entities, i.e. from the monthly reports by business entities, which provide accommodation services to tourists or act as agencies. Reports are made on the basis of registration records in guest book.
Data on expenses and turnover are available only as approximation in relevant ministries in entities
Data for areas of Bosnia and Herzegovina of special interest has been collected for longer time series (2007-2010) in order to document trends. Data sheet with number of nights spent per municipalities for 2010 has been collected and presented in Annex II.

AGRICULTURE

Agricultural issues are considered in Strategy (Development strategy B&H). In above-mentioned document relevant data (agricultural resources, land pattern, production of agricultural products by types, irrigated area etc) are given for 1991, 2001 and 2007 .Steps to be taken in the following four-year period are as follows:
- Conduct inventories of land and establish land or geographic information management systems,
- Resolve the status of high -quality state -owned land
- Decrease dependence on the imports of agricultural products
- Creation of efficient professional and competent administrative institutions, with professional staff,
- Increase capabilities of facing the challenges of the transition period and of accepting and implementing the European and world standards,
- Pass laws and adopt instruments of financial policy to stimulate banks to increase credits for agriculture,
- Adopt an adequate policy of protection of domestic agricultural production and develop instruments for its implementation,
- Increase the rate of usage of natural resources (land, water) and labour force,
- Conduct activities on land development and protection, to prevent losses to arable land
- Increase organised production of medicinal plants,
- Increase production of meat, milk and eggs (since infrastructure already exists)
- Establish a system of land and water pollution monitoring,
- Register and examine pesticides and other protective agents on the level of BiH.

All data are given for the whole country.Now in B&H bought entity have own Strategy of development agriculture for the period till 2020.In this document exist data with regard to agriculture (arable area and used pattern) and they are available at municipal / cantonal, entity and national level yearly. Data on livestock (total and per types) are available and based on expert judgment and estimation of relevant experts from institutions.
Participation of agriculture in GDP of Bosnia and Herzegovina in past ten (10) years is cca 10%.
Arable land in B&H is around 53% of agriculture land, but on entity level trends of using arable land is different.

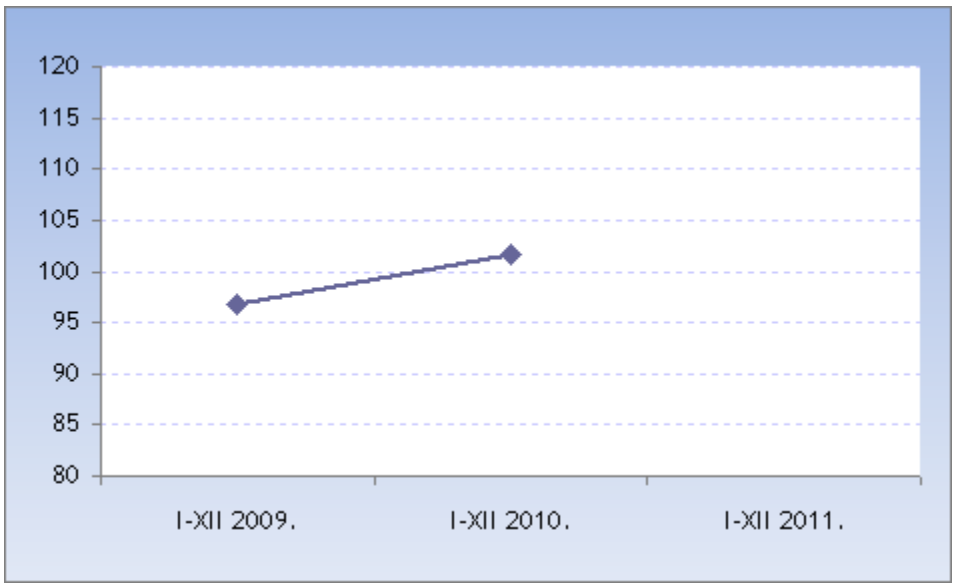
INDUSTRIES

The causes of the present difficult situation of BiH industry is certainly destroyed on the war and the loss of pre-market, but we should not forget the consequences of the earlier ways of development.
In this paper, the middle term strategic document of B^H was assessed that the following industries should be considered strategic, and accordingly encourage the development of: wood processing, food processing ,textile, leather and footwear

industry, metallurgy , tourism ,energy, and information and communication technologies.

On illustration 8, showing that industrial production in Bosnia and Herzegovina, had lower growth in the period 2009-2011 and only in certain areas of industry (mostly energy sector), but the current situation is very different.

According to the Agency for Statistics for February 2012. The evident decline in industrial production in Bosnia and Herzegovina over the previous year. In January-February 2012. The BH decreased physical volume of industrial production of 9.9% compared to the same period last year. This is a continuation of the negative trend from the end of last year when there was a decline in economic activity in Bosnia. The main reason for reduction of industrial production has worsened the situation on export markets, resulting in a significant drop in exports and thus decrease production in manufacturing by 12.3%.



Ilustration 8: Industrial production BiH, by years, indexes y/y

The current principles of development of Bosnia and Herzegovina are based on sustainable valorisation of natural resources in the area of tourism, agriculture, forestry, wood processing and similar in addition to the utilization of modern business and technological methods and introduction of cleaner and new technologies, in order to create the required preconditions for a sustainable development of Bosnia and Herzegovina.

WASTE DISPOSAL, WASTEWATER TREATMENT AND WATER USE

Waste represents one of the main environmental issues in BiH with issues arising mainly due to the inadequate management, lack of infrastructure and social attitude towards waste. The current problem of insufficient waste disposal system capacities has led to considerable quantities of waste being dumped illegally at roadsides, in rivers, abandoned mines, and similar places, posing threats to public health and the environment. No waste incineration facilities are currently operated in Bosnia and Herzegovina. Recyclables separated from the mixed municipal waste amount to less than 5 % of the total municipal waste mass (estimate), while at least 95 % of the collected mixed municipal waste is disposed of mostly on non-sanitary disposal sites.

The responsibility for waste management policy and legislation is shared between entity ministries responsible for the environment and corresponding cantonal ministries in the Federation of Bosnia and Herzegovina (FBiH). The main waste legislation consists of the Law on Waste Management of the Federation of Bosnia and Herzegovina (Official Gazette FBiH 33/2003) and the Law on Waste Management of Republic Sprska (Official Gazette RS 51/2002) which are almost identical. They are harmonized with EU Decision 94/904/EEC and EU Directive 91/689/EEC and cover the management of all kinds of waste following the underlying basic principles of EU environmental policies.
The following table presents waste data from 1999 from the EU Phare, Solid Waste Management Strategy, Technical Report 1, August 1999.

Table 6: Estimated waste generation in Bosnia and Herzegovina 1999

	Waste generation (tonnes/year)					**Waste per capita (tonnes/capita/year)**		
	Population	**Municipal**	Industrial	Hazardous waste*	Total	**Municipal waste**	Industrial	Total
Federation	2,366,373	**1,081,581**	495,360	4,953.6	1,576,937	**0.457**	0.209	0.666
Republic Srpska	1,455,620	**650,266**	353,081	3,530.8	1,003,349	**0.447**	0.243	0.689
Brcko District	80,324	**33,046**	15,191	151.9	48,236	**0.411**	0.189	0.601
Total	3,902,317	**1,764,893**	863,632	8,636.3	2,628,522	**0.452**	0.221	0.674

Note: * Estimated 1 % of industrial waste was considered hazardous.

Recyclables separated from the mixed municipal waste amount to less than 5 % of the total municipal waste mass where 20-25 % of waste paper, 1 % of plastics, and less than 1 % of glass is actually segregated and collected. At least 95 % of the collected mixed municipal waste is thus landfilled, mostly on non-sanitary disposal sites.

Data about sanitary landfills and dumpsites exist in shp file for entity Republic of Srpska and for Federation of B^H is on final phase. List of dumpsites and waste landfills provided in Ilustration 10 of Annex II.

The number and standard of sewerage systems and wastewater treatment plants in B&H is unsatisfactory. Attention to these problems has been predominantly focused in the bigger cities (Sarajevo, Banja Luka, Mostar, Zenica, Bijeljina etc), with inadequate attention being paid to smaller settlements of up to 2,000, and from 2.000-10.000 inhabitants, which comprise 20% of the total population. Settlements with 2,000+ inhabitants typically lack sufficient drinking water treatment and sewerage connections. Those that are connected to the sewerage system, are generally without wastewater treatment facilities meaning untreated effluent is discharged into streams, with serious threats to human health. The Government is fully aware of the present dangerous situation with regards direct discharging of wastewater from smaller urban areas, and calls for a strategy and an activity plan to be developed to reduce the negative impacts.
Water Consumption by Inhabitants and Industry
The biggest cities in the FB&H account for 61% of total water consumption of the entity. Sarajevo consumes 36%, Mostar (10%), Tuzla 9%, and Zenica (6%) . Water consumption by industry in the FB&H is very significant. Part of the industrial water demand is met by drinking water from the water utilities, but the biggest industrial

consumers typically also have their own water supply sources. Today, industrial technologies are working towards reducing consumption of all resources used during production, and introducing water recycling wherever possible, as they are obliged to pay fees for water abstraction and wastewater discharge. The total water quantity used by industry in the FB&H from their own water sources amounts to 59,147,70 x 103m3; a mere 17% of pre-war consumption . In the FB&H, agricultural land covers 1,136,730ha (43.5%), of which 718,400ha is arable. It is predicted the total area in need of irrigation comprises 80,800ha (11.2%) of total arable land, but present estimates suggest only 1,612ha (0.2%) of arable land is irrigated in reality . In the RS, the five biggest cities account for 50% of total water consumption; Banja Luka (25%), Bijeljina (10%), Prijedor (7%), Doboj (4%) and Zvornik (4%) respectively. As in FB&H, a small amount of the industrial water demand (18million m3) is covered by drinking water from water utilities, whilst most is derived from their own sources (150 million m3 per annum). Small quantities of water are used for irrigation.

Wastewater treatment plants and sewerage system and water supply is very important data. Bosnia and Herzegovina through the entity institutions already have a lot of data about numbers, % of connection and needs in this field. Republic of Srpska have a Framework plan for development water sector as a preparatory document for future Strategy and Federation of B&H already have his own Strategy of development water sector.

Data with water production, loses, water use (population and industrial), waste provided in Table of Annex II.

Just for illustration in tables 7 and 8 present the investment costs UWWTP on the size of river basin and agglomeration size.

Table 7 : UWWTP investment cost distribution – Agglomeration size

Size of agglomeration	Number of agglomerations	PE	UWWTP investment costs (mil. Euro)	UWWTP unit investment costs (Euro/ PE)	Percentage of total costs	Percantege of total population
Agglomerations > 100000	5	978,394	165.69	169	37.03%	40.99%
50000 < Agglomerations < 100000	2	130,956	21.09	161	4.71%	5.49%
20000 < Agglomerations < 50000	13	381,832	76.34	200	17.06%	16.00%
10000 < Agglomerations < 20000	30	409,650	100.97	246	22.56%	17.16%
5000 < Agglomerations < 10000	38	269,709	43.41	161	9.70%	11.30%
2000 < Agglomerations < 5000	72	216,275	39.99	185	8.94%	9.06%
Total	160	2,386,816	447.49	187	100.00 %	100.00 %

Table 8: UWWTP investment cost distribution – River basins

	URBAN WASTE WATER	TOTAL SEWERAGE		

	TREATMENT PLANT		(60% connection rate)		
River basin	Total Investment cost	Total annual O&M cost	Total Investment cost	Total annual O&M cost	**PERCENTAGE OF TOTAL COSTS**
	mill EURO	mill EURO	mill EURO	mill EURO	
BOSNA RIVER BASIN	191.160	8.909	62.023	11.603	**42.79%**
CETINA RIVER BASIN	3.846	0.099	1.126	0.142	**0.86%**
DRINA RIVER BASIN	38.140	0.840	18.376	1.367	**8.54%**
KUPA RIVER BASIN	10.374	0.243	4.368	0.375	**2.32%**
NERETVA RIVER BASIN	45.929	1.478	26.180	2.241	**10.28%**
SAVA RIVER BASIN	42.730	1.051	28.563	1.793	**9.57%**
TREBIŠNJICA RIVER BASIN	4.802	0.174	1.178	0.226	**1.07%**
UKRINA RIVER BASIN	7.244	0.121	3.700	0.222	**1.62%**
UNA RIVER BASIN	43.029	1.251	23.392	1.949	**9.63%**
VRBAS RIVER BASIN	59.470	2.445	26.608	3.379	**13.31%**

SURFACE WATER QUALITY

On the basis of the Water law water quality is the responsibility of the Water Agency to engage and give the license authorized and licensed laboratories monitoring the quality of surface waters and in all the parameters that are defined by-law act. This data are published annually.
Collecting of the surface water quality data is of the high importance for future analyses of the possible treats for the underground water systems. In order to be able to compare different national classifications on the regional scale (for the Regional environment and socio-economic analyses) and based on the WG2 agreement classification into 5 categories (inline with EU framework directive) was adopted .

PROTECTED AREAS AND GROUNDWATER DEPENDANT ECOSYSTEMS

Number of protected areas in relation to the degree of biodiversity and other natural values of Bosnia and Herzegovina in general is very small, and it is necessary to prepare and implement an entirely new approach to the management of special-purpose spaces. In doing so, it must be pointed out that the protected areas that are already in the database is not managed according to scientific ecological principles.

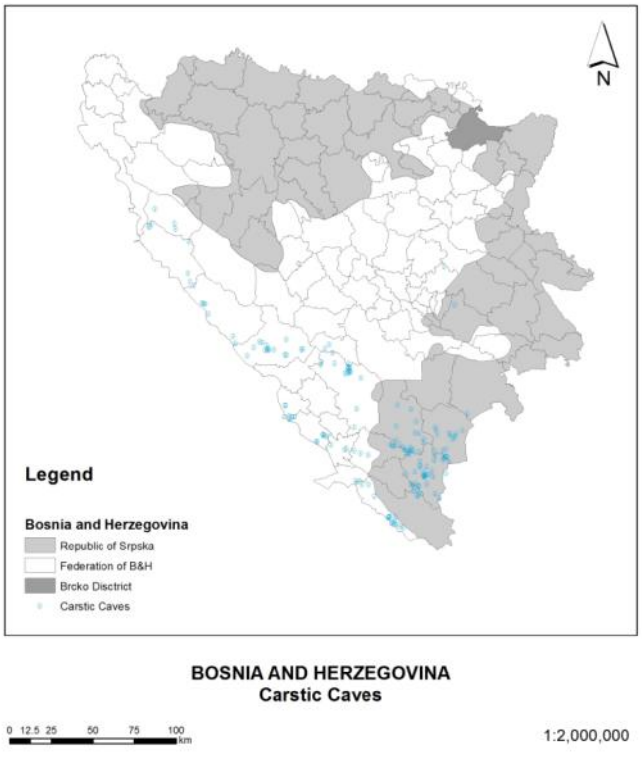
The post-war laws that apply to this area (Law on Nature Protection Federation and RS) is not clearly stated download (retraining) before protected areas, and there were no parallels to the relevant international (IUCN) category. So come on one side to the neglect of certain areas as protected, or protected by declaration previously protected areas. In other words, the majority of previously protected areas (to 1990. G.) practically are not treated as a protected, that their status is not defined. Most of the existing protected areas in BiH is still theoretically regulated by the Law on the Protection of SR BiH natural and cultural heritage in 1985. year

List of protected areas in BiH is provided in Annex II.

Groundwater dependent ecosystems (GDE) are a diverse and important component of biological diversity. The term GDE takes into account ecosystems that use groundwater as part of survival, and can potentially include wetlands, vegetation, mound springs, river base flows, cave ecosystems, playa lakes and saline discharges, springs, mangroves, river pools, billabongs and hanging swamps.
Data about groundwater dependent ecosystem in Bosnia and Herzegovina still missing.

CARSTIC CAVES

Data about karstic caves on their names and locations are available within the Ministry of Ecology and institutions dealing with the protection of nature and natural goods.Exact location (point) with coordinate is mark on the map (Ilustration 9).



Ilustration 9 : Carstic caves B&H

PART B: ENVIRONMENT AND SOCIO-ECONOMIC OVERVIEW AT THE TBA LEVEL

GENERAL INFORMATION

In the first phase of project the working group has needed to collect the general of environmental and socio-economic data and accommodated them in the DIKTAS GIS and database. Currently, we are focusing work on the targeted collection of data for seven Transboundary Aquifers within the project area. The aim is to identify current and potential pressures on water resources, in terms of quantity and quality. This information, along with the data collected by the working group hydrogeology will provide the basis for the identification of issues of transboundary concern.

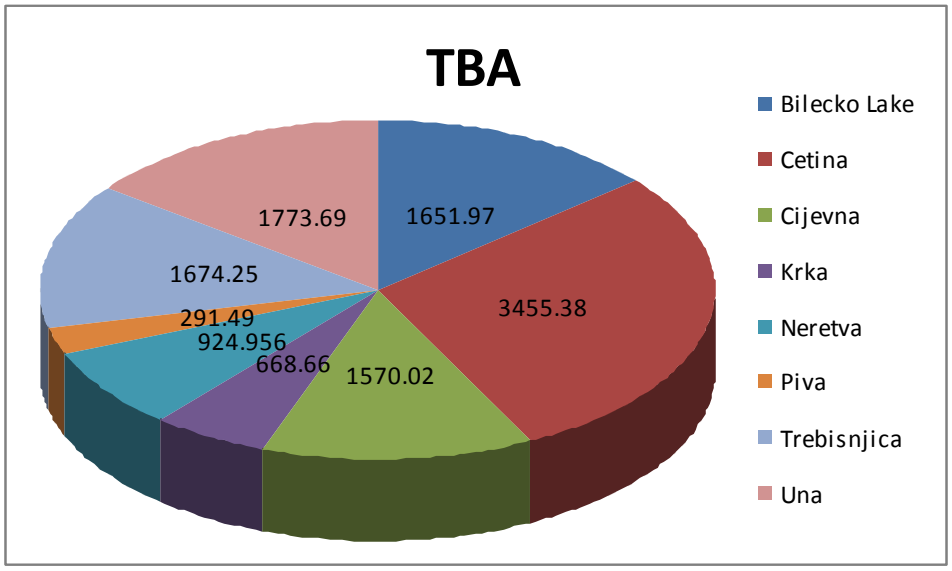


Illustration 10 : Area TBA (km^2)

In this chapter, detailed assessment of each TBA area in Bosnia and Herzegovina is given.

TBA BILECKO LAKE

TBA Bilecko Lake is located in the east Herzegovina in the aera of Municipality of Bileća. Total area of this TBA in Bosnia and Herzegovina is 1060.48 km2 (or surface area 1037.20, area Bilecko lake 21.49 and trebinjsko lake 1.79km^2). The Lake is used for purpose of electric power production as well as for drinking water supply.
Bilecko Lake is artificial lake created by the construction of arc dam (height 123 m) in 1968 on the Trebisnjica River in Bosnia and Herzegovina. Trebinje is main cities and population on TBA area, but dependent on Water Resources from Bilecko lake.

DOMESTIC WATER USE: water needs and pollution potential

Total population of TBA Bilecko Lake is 20192 inhabitants dispersed in area of Municipalities ;
Bileća –urban area : 7568, Gacko (TBA area) : 4584, Trebinje (TBA area) : 7400 and Nevesinje (TBA area) : 640.
According to the 2003 data (CoRINE) 20 % of the TBA Bilecko Lake area in Bosnia and Herzegovina is agricultural land. Pastures covers 10,63% od TBA area while

land principally occupied by agriculture covers 10,71 % of the total TBA area. 20,60 % of the area is classified as forests.
Total domestic water use per day in TBA area has been estimated (based on the number of inhabitants) to the Total 0,033 m3/s.

AGRICULTURE and ANIMAL HUSBANDRY: water needs and pollution potential

Main activity in TBA area Bilecko Lake is agriculture, based on household farming and cattling .
Most of the water is used for small scale irrigation of the household agricultural parcels.
Total domestic water use per day in TBA area can been estimated, as well as total number of animals (cattle, pigs, sheep/goats) and Potential Pollution from agriculture animal husbandry.

INDUSTRY: water needs and pollution potential

There is no big industries in TBA area Bilecko Lake, the biggest impact in this area is from individual fishfarms and termopowerplant Gacko.List of the firms and industries is provided in Annex II of report.
Water needs of small scale industries is need to be calculated: Small industry (along with tourism, hospitals, watering of decorative greenery, etc.) will be included in water demands of the population by increasing percentage of the consumption, e.g. instead 160 l/cap/day to add some 30 l/cap/day (20%) for above purposes.

There is solid waste and wastewater management or treatment in the TBA area. Household wastewater is usually collected in individual septic tanks without any treatment. Garbage is disposed randomly, sometimes in the karstic caves.
In the TBA area Bilecko Lake exist landfills :
Bileća –Ljubišići Volume : 1547.755
Bileća –Pribića Do Volume : 675.746
Gacko – Avatovac : 662.518
Gacko-Berijevo : 239.937

Wastewater treatment plants exist in municipality Bileća and Trebinje.

TBA CETINA

The Cetina river basin (called locally also “Zapadni krš“) covers about 2.455km2. There is no
stream of the Cetina river in the territory of B&H, just a big part of the river basin belongs to the
territory of B&H with dominant transboundary underground runoff.
The river basin is fully situated in the External Dinaride zone with all characteristics of the karst
terrains (strong karst springs, sinking rivers, periodical water accumulations in karst fields, sink
holes, swallow holes, estavels etc.).
A big part of waters sinks in karst areas (by direct infiltrations or thru swallow holes zones) and
quickly drain to strong karst springs in local erosion basis. The river basin of the Cetina river

includes southern parts of Glamočko and Kupreško fields, whole Duvanjsko and Livanjsko field.

DOMESTIC WATER USE: water needs and pollution potential

Total population of TBA Cetina is 55031 inhabitants dispersed in area of Municipalities ;
Livno : 32497, Tomislavgrad (cca 70% inTBA): 19411,Kupres (RS and FBiH): 1043, Bos.Grahovo (TBA area) : 1050 and Glamoč (TBA area) : 1130.
According to the 2003 data (CoRINE) 31% of the TBA Cetina area in Bosnia and Herzegovina is agricultural land. Pastures covers 14,98% od TBA area while land principally occupied by agriculture covers 16,60% of the total TBA area. 25 % of the area is classified as forests.
Total domestic water use per day in TBA area has been estimated (based on the number of inhabitants) to the Total 0,086m3/s.

AGRICULTURE and ANIMAL HUSBANDRY: water needs and pollution potential

Main activity in TBA area Cetina is agriculture, based on household farming and cattling .
Most of the water is used for small scale irrigation of the household agricultural parcels.
Total domestic water use per day in TBA area can been estimated, as well as total number of animals (cattle, pigs, sheep/goats) and Potential Pollution from agriculture animal husbandry.

INDUSTRY: water needs and pollution potential

Total EBS for CETINA based on information on Water Agency for Adriatic sea Mostar is 16.852 EBS.There is no big industries in TBA area Cetina, the biggest impact in this area is from public sewerage system and small industries company.List of the firms and industries is provided in Annex II of report.
Water needs of small scale industries is need to be calculated: Small industry (along with tourism, hospitals, watering of decorative greenery, etc.) will be included in water demands of the population by increasing percentage of the consumption, e.g. instead 160 l/cap/day to add some 30 l/cap/day (20%) for above purposes.

There is solid waste and wastewater management or treatment in the TBA area. Household wastewater is usually collected in individual septic tanks without any treatment. Garbage is disposed randomly, sometimes in the field.

TBA KRKA

TBA Krka is located in the aera of Municipality Bihač and Bos.Grahovo. Total area of this TBA in Bosnia and Herzegovina is 169.28 km2 .

DOMESTIC WATER USE: water needs and pollution potential

Total population of TBA Krka is 3889 inhabitants dispersed in area of Municipalities ;
Bihac–TBA area : 1391 and Bos.Grahovo (TBA area) : 2498.
According to the 2003 data (CoRINE) 10 % of the TBA Krka area in Bosnia and Herzegovina is agricultural land and 50% of the area is classified as forests.
Total domestic water use per day in TBA area has been estimated (based on the number of inhabitants and level of agriculture) to the Total 0,064 m3/s.

AGRICULTURE and ANIMAL HUSBANDRY: water needs and pollution potential

Main activity in TBA area Bilecko Lake is agriculture, based on household farming and cattling .
Most of the water is used for small scale irrigation of the household agricultural parcels.
Total domestic water use per day in TBA area can been estimated, as well as total number of animals (cattle, pigs, sheep/goats) and Potential Pollution from agriculture animal husbandry.

INDUSTRY: water needs and pollution potential

There is no big industries in TBA area Krka, the biggest impact in this area is from individual farms and small industries in area of municipality Bihac.
Water needs of small scale industries is need to be calculated: Small industry (along with tourism, hospitals, watering of decorative greenery, etc.) will be included in water demands of the population by increasing percentage of the consumption, e.g. instead 160 l/cap/day to add some 30 l/cap/day (20%) for above purposes.

There is solid waste and wastewater management or treatment in the TBA area. Household wastewater is usually collected in individual septic tanks without any treatment. Garbage is disposed randomly, sometimes in the karstic caves.

Wastewater treatment plants exist in municipality Bihac.

TBA NERETVA

The Neretva river begins its stream near Čemerno, in the north of Gatačko polje. The total stream length is about 225 km, about 218 through Bosnia and Herzegovina, the rest in Croatia. Up to Jablaničko lake it is also known as the Upper Neretva. The source zone, in geological sense, is mostly presented by flysch sediments of the Cretaceous age.

DOMESTIC WATER USE: water needs and pollution potential

Total population of TBA Neretva is 27323 inhabitants dispersed in area of Municipalities ;
Posušje(settlements in area TBA):4626, Grude(settlements in area TBA): 3762,Ljubuški (settlements in area TBA) : 17854 and Čapljina (settlements in area TBA) : 1081
According to the 2003 data (CoRINE) 40 % of the TBA Neretva area in Bosnia and Herzegovina is agricultural land. Pastures covers 0,92% od TBA area while land principally occupied by agriculture covers 31,57 % of the total TBA area. 13.93 % of the area is classified as forests.
Total domestic water use per day in TBA area has been estimated (based on the number of inhabitants) to the Total 0,042 m3/s.

Total area of this TBA in Bosnia and Herzegovina is 376.94 km2 .

AGRICULTURE and ANIMAL HUSBANDRY: water needs and pollution potential

Main activity in TBA area Neretva is agriculture, based on household farming , fishfarming and small industries or privreda companies .
Most of the water is used for small scale irrigation of the household agricultural parcels.
Total domestic water use per day in TBA area can been estimated, as well as total number of animals (cattle, pigs, sheep/goats) and Potential Pollution from agriculture animal husbandry.

INDUSTRY: water needs and pollution potential

There is no big industries in TBA area Neretva, the biggest impact in this area is from individual fishfarms and small industries.List of the firms and industries is provided in Annex II of report.
Water needs of small scale industries is need to be calculated: Small industry (along with tourism, hospitals, watering of decorative greenery, etc.) will be included in water demands of the population by increasing percentage of the consumption, e.g. instead 160 l/cap/day to add some 30 l/cap/day (20%) for above purposes.

There is solid waste and wastewater management or treatment in the TBA area. Household wastewater is usually collected in individual septic tanks without any treatment.

TBA PIVA

TBA Piva in Bosnia and Herzegovina cover only few settlements (significant Samobor with 172 Inhabitant). Total area of this TBA in Bosnia and Herzegovina is 85.75 km2 .

DOMESTIC WATER USE: water needs and pollution potential

Total population of TBA Piva is 172 inhabitants dispersed in area of settlement Samobor.
According to the 2003 data (CoRINE) 41 % of the TBA Piva area in Bosnia and Herzegovina is agricultural landand 10 % of the area is classified as forests.
Total domestic water use per day in TBA area has been estimated (based on the number of inhabitants) to the Total 0,00024 m3/s.

AGRICULTURE and ANIMAL HUSBANDRY: water needs and pollution potential

Main activity in TBA area Piva is agriculture, based on household farming and cattling .
Most of the water is used for small scale irrigation of the household agricultural parcels.
Total domestic water use per day in TBA area can been estimated, as well as total number of animals (cattle, pigs, sheep/goats) and Potential Pollution from agriculture animal husbandry.

INDUSTRY: water needs and pollution potential

There is no industries in TBA area Piva. The biggest impact in this area is from individual farms

There is no solid waste and wastewater management or treatment in the TBA area. Household wastewater is usually collected in individual septic tanks without any treatment.

TBA TREBISNJICA

The Trebišnjica river basin is typically karst basin. The river is the one of the most famous sinking
rivers in Europe.

Total area of this TBA in Bosnia and Herzegovina is 1334.23km2 .

DOMESTIC WATER USE: water needs and pollution potential

Total population of TBA Trebisnjica is 30625 inhabitants dispersed in area of Municipalities ;
Trebinje (75% TBA AREA): 23247, Neum : 1842, Ljubinje (75%TBA AREA): 4136 and Ravno : 1400.
According to the 2003 data (CoRINE) 15 % of the TBA Trebisnjica area in Bosnia and Herzegovina is agricultural land and 8,65 % of the area is classified as forests.
Total domestic water use per day in TBA area has been estimated (based on the number of inhabitants) to the Total 0,046 m3/s.

AGRICULTURE and ANIMAL HUSBANDRY: water needs and pollution potential

Main activity in TBA area Trebisnjica is producing energy, agriculture, farming and cattling .
Most of the water is used for small scale irrigation of the household agricultural parcels.
Total domestic water use per day in TBA area can been estimated, as well as total number of animals (cattle, pigs, sheep/goats) and Potential Pollution from agriculture animal husbandry.

INDUSTRY: water needs and pollution potential

There is no big industries in TBA area Trebisnjica, the biggest impact in this area is from individual fishfarms and small meat industries.List of the firms and industries is provided in Annex II of report.
Water needs of small scale industries is need to be calculated: Small industry (along with tourism, hospitals, watering of decorative greenery, etc.) will be included in water demands of the population by increasing percentage of the consumption, e.g. instead 160 l/cap/day to add some 30 l/cap/day (20%) for above purposes.

There is solid waste and wastewater management or treatment in the TBA area. Household wastewater is usually collected in individual septic tanks without any treatment. Garbage is disposed randomly, sometimes in the karstic caves.
In the TBA area Bilecko Lake exist landfills :
Trebinje – Tvrdoš Volume 53.024
Trebinje-Orovac Volume 173.220

Wastewater treatment plants exist in municipality Bileća and Trebinje.

TBA UNA

The Una river begin its stream in Croatia. After few kilometres its flow continues in Bosnia and
Herzegovina (near Martin Brod) and receives water from right tributary, the Unac river. The flow of the Unac in Martin Brod is similar like the Una river. For this paper the most imp
Una river is from the source zone to Bihać.
TBA Una is located in the aera of Municipality of Bihac. Total area of this TBA in Bosnia and Herzegovina is 188.93 km2 .

DOMESTIC WATER USE: water needs and pollution potential

Total population of TBA Una is4426 inhabitants dispersed in area of settlments ;
Izačić: 1,570, Kulen Vakuf: 812, Međudražje: 735 and Kamenica : 1309.
According to the 2003 data (CoRINE) 30 % of the TBA Una area in Bosnia and Herzegovina is agricultural land. Pastures covers20,29% od TBA area while land principally occupied by agriculture covers 9,71 % of the total TBA area. 54,13 % of the area is classified as forests.
Total domestic water use per day in TBA area has been estimated (based on the number of inhabitants and level of agriculture) to the Total 0,0067 m3/s.

AGRICULTURE and ANIMAL HUSBANDRY: water needs and pollution potential

Main activity in TBA area Una is agriculture, based on household farming .
Most of the water is used for small scale irrigation of the household agricultural parcels.
Total domestic water use per day in TBA area can been estimated, as well as total number of animals (cattle, pigs, sheep/goats) and Potential Pollution from agriculture animal husbandry.

INDUSTRY: water needs and pollution potential

There is no big industries in TBA area Una, the biggest impact in this area is from individual fishfarms and small industries company.
Water needs of small scale industries is need to be calculated: Small industry (along with tourism, hospitals, watering of decorative greenery, etc.) will be included in water demands of the population by increasing percentage of the consumption, e.g. instead 160 l/cap/day to add some 30 l/cap/day (20%) for above purposes.
There is solid waste and wastewater management or treatment in the TBA area.
Household wastewater is usually collected in individual septic tanks without any treatment.

Wastewater treatment plants exist in municipality Bihac.

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ANNEX I : DEFINITION OF DATA REQUIRED (WITHIN THE BOUNDARIES OF THE DINARIC KARST AS DEFINED BY THE HYDROGEOLOGY GROUP) FOR EACH COUNTRY

Demographic data
- Number of people per administrative unit (to the lowest level possible)
- Demographical trends
- Migration
- Number of tourists/visitors (for hot spots only)

Land Use and sources of income
- Land use (shp file)
- Sources of income per sector (agriculture, fishery, industry, tourism…)
- Agricultural data (crops being grown, fertilizers, pesticides…)

Infrastructure and potential sources of pollution
- Roads
- Wastewater treatment plants
- Sanitary landfills/dumpsites
- Industries (specify potential pollutants)
- Mining sites (specify potential pollutants)
- Military sites

Protected areas
- All types (national parks, biosphere reserves, nature parks, etc – shp file)
- List of species (including endemic species, endangered species)
- Groundwater dependant ecosystems
- Karstic caves

ANNEX II: DATA SHEETS COLLECTED FOR DIKTAS GIS – BOSNIA AND HERZEGOVINA

Excel format of this data is attached on http://igrac.nitg.tno.nl/bscw/bscw.cgi/118812

WG 3

LEGAL AND INSTITUTIONAL FRAMEWORK AND POLICY

NATIONAL CONSULTANT: SELMA ČENGIĆ

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1.1.1. B&H's Governmental Structure

The Constitution of Bosnia and Herzegovina (BiH) is an integral part of the Dayton Peace agreement, which has created a very specific State comprising of two Entities, the Federation of Bosnia and Herzegovina (FB&H) and the Republic of Srpska (RS) and Brcko District (BD). The State of BiH is the central authority, but has only limited and specific powers, whereas the two Entities and the Brcko District are politically, administratively and legally largely autonomous. Accordingly, environment and water sector are under responsibility of both B&H entities, and of Brčko District, and only some responsibilities belong to state of B&H.
However, by passing the Law on Ministries and other bodies of administrations of Bosnia and Herzegovina (Official Gazette of B&H, No. 5/03), the State Ministry of Foreign Trade and Economic Relations (MoFTER), receives the authority to deal with the issues of environmental protection and natural resources at the state level. This Ministry is also responsible for implementation of international treaties in environmental field.
Law on Council of Ministries B&H (Official Gazette of B&H, No 30/03, 81/06, 76/07 and 81/07) prescribes conditions for establishment of the administration at the state level, in accordance with the B&H Constitution.
On the level of the entities, ministries are established in accordance with Law on Ministries of F B&H and other bodies of Federal administration (Official Gazette of F B&H, No 19/03, 38/05, 2/06, 8/06 and 61/06) and Law on Ministries of RS **(**Official Gazette of RS, No 70/02, 33/04, 118/05 and 33/06). Both of entities have established 16 ministries.
The primary responsibility for water resources belongs to Federal Ministry for Water, Agriculture and Forestry in F B&H and Ministry for Water, Agriculture and Ecology in RS. Federal Ministry for Environment and Tourism in FB&H, and Ministry for Urban Planning, Civil Constructing and Ecology in RS have responsibilities for different environmental issues, including some aspects of water, such as protection of water resources, trough EIA procedures, issuing integral environmental permits etc.

1.1.2. Relevant Institutions in Federation of B&H (entity Level)

- **Federal Ministry of Agriculture, Water Management and Forestry**

In Federation of Bosnia and Herzegovina the principal role for the water sector is assigned to Federal Ministry of Agriculture, Water Management and Forestry, which is responsible for and water policy development, issuing agreements, setting of standards and regulations; and the maintaining of compliance with Laws and regulations through licensing and inspections.
Federal Ministry of Agriculture, Water Management and Forestry perform administrative and professional tasks related to:

- water management plans;
- water abstraction and usage of water;
- ensuring water for water supply needs of the population and industry;

- inspection in the field of agriculture, water management and forestry and other tasks identified by the Law on Federal Ministries and other bodies of the federal government.

- **Federal Ministry of Environment and Tourism**

According to the Law on Federal Ministries and other bodies of Federal administration (Official Gazette of F B&H, No. 19/03, 38/05, 2/06, 8/06 and 61/06), Federal Ministry of Environment and Tourism performs administrative, professional and other tasks from jurisdiction of F B&H, which relates to:

- ecological protection of the air, water and soil;
- development of the environmental protection strategy and policy;
- air, water and soil quality standards;
- ecological monitoring and control of air, water and soil;
- development of tourism policy and strategy;
- follow up on touristic trends at domestic and foreign market;
- mapping the long-term development of tourism in the framework of an integrated economic system and other tasks stipulated by law.

- **Federal Ministry of Energy, Mining and Industry**

According to the Law on Federal Ministries and other bodies of Federal administration (Official Gazette of F B&H, No. 19/03, 38/05, 2/06, 8/06 and 61/06), Ministry of Energy Mining and industry performs administrative and professional tasks under jurisdiction of Federation and related to: energy, mining and industry, geological researches and industry, creation of energetic policy and geological researches, inspection monitoring over exploitation of mineral raw materials and other tasks determined by relevant Law.

- **Federal Ministry of Health**

The main water-related functions and tasks of this ministry are:

- safeguarding of the quality of potable water by co-ordination of expertise for development of relevant legislation, regulations and standards;
- organizing water quality monitoring.

- **Federal Agency for ”Watershed Area of the Sava river Basin” (located in Sarajevo town) and Agency for ”Watershed Area of Adriatic Sea Basin” (located in Mostar town)**

Water Agencies were established under the FB&H Law on Water («Official Gazette of FB&H», No. 70/06), adopted on 20. 11. 2006. year, in order to implement the water management tasks, which were put under their jurisdiction by this Law and regulations.

Their main Agencies’ responsibilities are as following:

- preparation of analysis of the characteristics of water areas;
- preparing of an overview of the influence of human activities on the condition of surface and underground water;
- preparation of economic analysis of water usage;
- establishing a register of protected areas (under Article 65. of above mentioned Law on Water), as well as areas with special protection determined by the decision of the federal government;
- establishing an register of water bodies, that are used or planned to be used for water abstraction for human consumption;
- organization of classification of ecological, chemical and quantitative water status;
- preparation of water monitoring program and organization relevant activities;
- preparation of water management plans and programs of measures.

- **Federal hydro-meteorological institute**

Federal hydro-meteorological Institute performs expert and other activities that are under the jurisdiction of Federation B&H, according to the Law on Ministries of F B&H and other bodies of Federal administration (Official Gazette of F B&H, No. 19/03, 38/05, 2/06, 8/06 and 61/06)

Basic programs' activities related to water are:

- development and undertaking of meteorological, air-meteorological, hydrological and seismic and environment quality activities; researching the atmosphere, water resources, the quality of the environment (air, water and soil) and seismic processes;
- collecting, processing and publishing data from the activity filed that is of interest for Federation as well as performance of other tasks in the fiels of meteorology, air-meteorology, hydrology, life environment quality and seismology.

According to Law on Water («Official Gazette of FB&H», No. 70/06), Federal meteorological Institute is responsible to establish a system for monitoring and prognosis of meteorological emergencies and deliver such prognosis regularly to water information system (WIS).

- **Federal geological Institute**

Federal geological Institute is established according to the Law on Ministries of F B&H and other bodies of Federal administration (Official Gazette of F B&H, No. 19/03, 38/05, 2/06, 8/06 and 61/06).

Basic programs' activities related to water are:

- participation in preparation of laws and bylaws from the field of hydro-geological researches;
- research of groundwater (drinking, mineral, thermo-mineral and thermal);
- participation in preparation of the proposals, for Federal Government, of hydro-geological maps for development of the water-supply;
- performing of hydro-geological researches in the field of drinking, thermal, thermo-mineral and mineral groundwater;
- performing hydro-geological research in the field of geothermal energy, scientific-expert education of the employees in the sector;
- improvement and introduction of contemporary methods in the field of hydro-geological research;
- preparation of the studies on amounts and quality of all groundwater;
- establishing of cooperation with other federal bodies which deals with water supply problems and ground waters protection;
- preparation of studies on water protection and providing a propositions for storage of dangerous and toxic materials in underground;
- preparation of the drafts of mid-term and annual working programs.

- **Public Health Institute F B&H**

Public Health Institute of F B&H is the public health institution performing the public health activities at the territory of F B&H (Law on Health Care – «Official Gazette of FB&H», No. 29/97).

It was established by the Parliament F B&H, as the institution of key importance for performing the secondary and tertiary public health services.

Description of work (relating to environment):

- monitoring of environmental and health risk factors;
- compiling of all Cantonal' health institutions activities;
- providing technical assistance in health and other legislation creation;
- investigations, analysis and assessment of environmental impact;
- planning and undertaking measures for health protection against harmful impact of environmental pollution;
- planning and caring out measures for maintaining and improving health of the population;

- co-operation with relevant international organizations.

- **Environmental Fund**

Law on Fund for Environmental Protection ("Official Gazette of FB&H", No. 33/03), establishes the Fund for Environmental protection of F B&H, defines organization, management and operation of the Fund, defines property and business functions of the Fund, defines purpose and usage of Funds' resources, and regulates other issues related to raising and management of the Funds' resources. In F B&H, Fund is still not in full operation.

1.1.3. Relevant Institutions in Federation of B&H at Cantonal level

Each of 10 Cantons in F B&H has established Ministries specifically for waters, or has put water issues to be treated under some another Ministry (ministry for economy, environment e.t.c.). Relevant cantonal ministries which treat water issues are listed in Annex 1.
The main functions and tasks related to water assigned to the Cantons include licensing and allocation of water resources under their competence (drainage, irrigation, water supply, waterways for navigation, hydropower, and water protection). Cantons, either independently or in coordination with federal bodies, are competent for identifying the policy of environment protection and utilization of natural resources. Each canton adopted its own relevant Laws. (Law on Cantonal Government; Law on Cantonal Administration; Law on Cantonal Ministries and Other Administrative Bodies; Law on Local Self-governance; Water Law; Law on Environment; Law on Air; Law on Nature Protection; Law on Waste Management; Law on Spatial Planning; Law on Concessions; Law on Agricultural Land; Law on Forests)

1.1.4. Relevant Institutions in Federation of B&H at Municipal or Cantonal level

- **Water Supply Companies**

According to the Law on public companies ("Official Gazette of FB&H", No. 8/05) Water Supply Companies perform certain activities in water management sector at local level, such as:

- production and distribution of water;
- waste water treatment and drainage;
- sanitary-technical activities and water quality control;
- management of public water supply and sewage;
-

1.1.5 Relevant Institutions in Republic of Srpska (entity level)

- **Ministry of Agriculture, Water Management and Forestry RS**

According to the RS Law on Ministries (Official Gazette RS No. 70/02, 33/04, 118/05 and 33/06), the Ministry conduct administrative and other professional work related to:

- protection and usage of agricultural land, protection of agricultural plants and products from diseases, pests and weeds;
- seed protection and trading, trading of nursery plants, production and improvement of cattle breeding;
- control of animal food and water;
- integral management over ambient waters;
- organizing water protection plans; protection against negative water impact;
- providing conditions for issuing permissions for water intake and usage;

- conducting and organizing water quality control;
- taking measures for providing water for water supply needs of population and industry;
- ensuring water supply for population and industry;
- ensuring hydro-melioration;
- inspection/monitoring done in the agriculture and veterinary medicine domain;

- **Ministry of Physical Planning, Civil Engineering and Ecology**

This Ministry, according to the Law on Ministries (Official Gazette RS No. 70/02, 33/04, 118/05 and 33/06) conducts administrative and other professional activities related to:

- integral planning and spatial planning and management;
- preparation and implementation of RS spatial plan; reviewing, administrative supervision and providing approval to: spatial plans for cities, municipalities, and special areas and the urban plans as well;
- revision of spatial-planning documentation, developing programs and investment-technical documentation specially important for RS;
- urban planning and construction;
- overall protection of the quality of the environment and its improvement through research, planning management and protection measures;
- protecting assets of general interest, natural resources, natural and cultural heritage;
- inspection supervision in the field of urban planning, civil engineering, utilities and environment protection.

- **Ministry for Economy, Energy and Development**

This Ministry within its activities directs all issues related to the filed of energetic and mining industry, controls application of relevant Laws, rules and regulations. Ministry has competence for approval of project documentation with environment protection measures and regulations, relevant for energetic and mining industry.
Ministry for Economy, Energy and Development performs administrative and other professional activities I the field of activities of energy and mining, and some of them relate to:

- geological surveying of natural mineral raw materials – metals, non-metals, nuclear raw materials and underground waters (thermal, thermal-mineral and drinking water) and their exploitation;
- collection and primary processing of industrial waste;
- making annual energetic balances;
- making annual and medium-term geological surveys programs;
- verification of mineral resources and keeping their cadastre, keeping cadastre of survey and exploration rights and other concessions' cadastre.

- **Ministry of Health and Social Protection**

According to the Law on Ministries of RS (Official Gazette No. 70/02, 30/04, 118/05, 33/06), the Ministry of Health and Social Protection carries out administrative activities and other professional tasks related to:

- protection and improvement of citizens' health and monitoring of health conditions and health needs of citizens;
- inspection supervision in sanitary field;
- providing information through the media and other public means and performs other tasks in accordance with relevant Law and other regulations of the RS and B&H.

- **Republic Directorate for Water of RS**

Ministry of Agriculture, Forestry and Water management has established Directorate for Water, which is currently, according to the new water Law from 2006. year, in process of transformation into two RS Water Agencies – one for Sava river basin (location in Bijeljina town) and one for Adriatic basin (location in Trebinje town). The RS Water Agencies will have the same responsibilities as Federal Water Agencies.

- **Republic Hydro-meteorological Institute**

According to the Article 30 of the Law on Ministries of RS (Official Gazette No. 70/02, 30/04, 118/05, 33/06), Republic Hydro-meteorological Institute performs professional and other tasks related to:

- development and undertaking of hydrological, meteorological and seismological activities;
- research of the atmosphere, water resources, air and water quality and seismological processes;
- collecting, processing and publishing hydro-meteorological and seismological data of interest for RS and performing other tasks in the field of hydrology, meteorology and seismology.

- **Republican Institute for Geological Researches**

According to the Article 31 of the Law on Ministries of RS (Official Gazette No. 70/02, 30/04, 118/05, 33/06), Republic Institute for Geological researches performs professional and other tasks related to:

- geological research of natural mineral raw material – metallic, non-metallic and nuclear, groundwater (thermal, thermo-mineral and drinking water) and their exploitation;
- development of geological balances;
- development of annual and medium-term programs of geological research;
- verification of mineral raw material and keeping their cadastre, keeping the cadastre of research and exploitation rights and cadastres given by concession.

- **Agency for Recognizing and Improving the Quality of Health Protection in RS**

According to the Law on Ministries of RS (Official Gazette No. 70/02, 30/04, 118/05, 33/06), the Agency carries out professional and other activities related to:

- promotion of the position and role of accreditation within the system of health protection quality improvement;
- proposing measures and standards for improvement of the quality of health protection.

- **Environmental Fund**

Law on Environmental Protection Fund (Official Gazette of RS, No. 51/02) determines establishment of an Environmental Protection Fund, sets up scope of work, organization, administering and managing the Fund, purposes and use of financial resources of the Fund.

1.1.6. Relevant Institutions in RS at Municipal level

- **Water Supply Companies**

According to the Law on Water Supply Companies (“Official Gazette of FB&H”, No. 75/04) perform certain activities in water management sector at local level, such as.

- production and distribution of water;
- waste water treatment and drainage;
- sanitary-technical activities and water quality control;
- management of public water supply and sewage;

1.1.7. Relevant Inter – Entity Bodies

Existing Inter entity bodies in B&H (for environment and water related issues) are established in order to facilitate entities' coordination on relevant issues but they have no executive power.

- **Inter – entity Environmental body**

Inter – entity environmental body has eight members, four appointed by Federal Government and four by Government of RS
Inter – entity environmental body is authorized for all environmental issues where harmonized approach of the entities is needed, and some of them are:

- Coordinating the implementation and enactment of laws and other regulations;
- Providing recommendations for the establishment of harmonized standards of the quality of environment at the entity level;
- Development of guidelines for the coordination and cooperation related to transboundary protected areas;
- Coordinates preparation of the Integral Environmental Protection Strategy at the entity level.

➢ **Inter-entity Advisory Commission for the Coordination of Water Management**

The Inter-entity Advisory Commission for the Coordination of Water Management is responsible for cooperation on all water management issues among the relevant ministries of both entities. Its goal is to prevent potential disputes in water management. The Commission includes both government officials and private citizens from the two entities, as well as representatives from the donor community and the Office of the High Representative. Its responsibilities include:

- International waterways;
- International water-management projects;
- Cooperation with neighbouring countries;
- Harmonization of regulations in water management;
- Harmonization of water-quality issues and monitoring of water quality;
- Water resources protection through control of solid waste disposal;
- Oversight of laboratories that monitor water quality;
- Water facilities that straddle the border between both entities;
- Collection and exchange of information (inter-entity and international); and
- Harmonization of emergency response plans.

1.1.8. Relevant Government departments in Brčko District

The Government of Brcko District is divided into 10 departments and three of them are relevant for water:

- **Department for Agriculture, Forestry and Water Management**

Department for Agriculture, Forestry and Water Management performs professional, administrative and other duties of the Government related to:

- implementation of Laws and regulations of competent bodies and institutions of BiH and BD in domain of agriculture, forestry and water management, under the supervision and according to instructions of the Mayor of BD;
- Protection and effective utilization of forest and agricultural fund;
- Agro-industry,
- Veterinary and public veterinary services;
- Protection of forests,

- Proposing policies of capital development and pricing policy in the field of agriculture and forestry;
- Market interventions and reserves in the field of agriculture
- Rural development,
- Regulations, management and monitoring of activities related to:

- Water systems;
- Utilization of water,
- Hydro-melioration;
- Protection from water,
- Management, maintenance, development, planning and research in the water sector;
- Financing of water management installations.

▪ **Department for Public Affairs**

This Department is responsible for the following activities related to environment and water:

- Implementation of Laws and regulations of authorized bodies and institutions of B&H and District Brčko, from the filed of communal activities, and under the jurisdiction and guidelines of the Mayor.
- Environmental protection and supervision of implementation of ecological standards;

▪ **Department for Communal Affairs**

This Department is authorized for development and maintenance of efficient water supply system, as well as for implementation of the laws and regulations of authorized bodies and B&H institutions and Brčko District for the field of communal activities, under the supervision and instructions of the Mayor.

1.1.9. Communal Utility of Brcko District

According to the Law on communal activities (Official Gazette No. 30/04), authorized departments of Government of Brcko District and all legal and physical persons, to which the Mayor consign the provision for communal services, can provide such services in accordance with the regulations of this Law. Communal Utility of Brcko District performs activities related to water at local level, such as:

- production and distribution of water;
- waste water treatment and drainage;
- sanitary-technical activities and water quality control;
- management of public water supply and sewage;

1.2. Overview on legal and regulatory frameworks for water

1.2.1. General remarks

This Chapter present the key laws and regulations dealing with water, but focusing mostly on ground waters. Full list of legislation and regulation relevant for water is included in the Annex 2. of this report, including also legislation on agriculture, environment, nature and waste.

Several Laws, including Law on geological research (1993), Law on mining (1994), Law on unique procedure for determination, evidencing and collecting data on reserves of mineral raw material and groundwater and on balance of those reserves (1994), were adopted in early nineties, as a state (B&H) Laws. However, these laws are still in force in FB&H, while RS has adopted its own Laws in the recent period.

1.2.2. Relevant legislation and regulation in Federation of B&H

- **Water Law («Official Gazette of FB&H», No. 70/06) (20.11. 2006)**

This Law prescribes measures for water management, protection, and usage, establishment of the water information system and issuing of water acts. This law treats all categories of water, including ground waters.
According to article 4 of this Law, groundwater are: "all waters under the ground surface in saturated zone and which are in the direct contact with surface and ground soil layers".
Article 49 of the Law defines that usage of water from the source and groundwater, for other purposes besides general, can be approved only if water research activities are previously performed.
Article 53. point 2, of this Law stipulates that it is forbidden to discharge the wastewater into a natural lake, pond, swamps and other natural water reservoirs, which have permanent or temporary inflow or outflow into / out of surface water or groundwater, as well as into water reservoirs, which were developed from removing or exploitation of mineral raw materials or other similar procedures, and which are in contact with a ground water.
Article 53. point 3, of this Law stipulates that it is forbidden to use water in a way that could endanger ecological and chemical status of natural lakes, fishponds, swamps and other natural water accumulations, which have permanent or temporary inflow or outflow of surface water or groundwater.
Article 53. point 4, of this Law stipulates that waste water discharge directly into groundwater is prohibited.
Article 53. point 5, of this Law, stipulates that indirect waste water discharge into groundwater is limited in the manner and under conditions, which determines the Law and by-laws arising from article 55, point 1., of this Law.
Article 55, of this Law stipulates that Federal Government is obliged to issue a regulation on limiting values of polluting substances in waste waters, and on other requests which concern discharge of a waste waters in surface waters and indirect discharge of waste waters in groundwater, as well as regulation on priority substances, on the proposal of the federal minister responsible for environment.

- **Relevant water sub-laws – decisions and regulations**
- Regulation on limited value of dangerous and harmful substances (Official Gazette of FBH, No. 50/07), defines the limited value of dangerous and harmful substances for technological waste water prior its discharge in sewerage system or other recipient, conditions for water waste discharge, as well as way of the quality control of technological waste water.
- Decree on dangerous and harmful substances (Official Gazette of FBH, No. 43/07) defines the substances and their allowed concentration in different water classes of surface water.
- Regulation on methods of calculation, procedures and deadlines for payment and on control of execution of obligations according to general and special water fees («Official Gazette F B&H F B&H», No. 92/07)"
- Decision on the borders of the water areas («Official Gazette F BiH F BiH», No. 37/98)
- Decision on the borders of the main river basin areas («Official Gazette F BiH F BiH», No. 37/98)
- Decision on the special water fees («Official Gazette F BiH F BiH», No. 46/98, 25/00, 7/02, 6/03)
- Regulation on the types, method and scope of measuring and testing the utilized water, discharged waste water and extracted material from the water («Official Gazette F BiH F BiH», No. 48/98; 36/00; correction 35/01; 20/03)

- Regulation on the conditions to be necessarily met by the authorized labs and contents and way of issuing the authorization («Official Gazette F BiH», No. 54/99)
- Regulation on the concessions on waters and public water good («Official Gazette F BiH», No. 8/00)
- Regulation on the plans for flood defense («Official Gazette F BiH», No. 3/02)
- Regulation on the minimal contents of the General Act on maintenance, utilization and observing the water management objectstructures («Official Gazette F BiH», No. 49/01)
- Regulation on the contents, scope, conditions and methods of issuing and saving the water management acts («Official Gazette F BiH», No. 22/02; correction 31/02)
- Regulation on the conditions for determining the zones of the sanitary protection and protection measures for the sources used or planned to be used for public water supply («Official Gazette F BiH», 2012)
- Decision on the main operative plan for flood defense in 2003 («Official Gazette F BiH», No. 20/03)

- **Law on geological research («Official Gazette of B&H», No. 3/93)**

This law determines basic geologic activities including discovering and determination of the mineral raw material, groundwater and geothermal energy, as well as the rational use of those resources. The basic geological activity includes: general geological, geomorphologic, geo-chemical, hydro-geological and geo-thermal researches, preparation of the geological maps, research of mineral raw material and other geological activities.

According to the article 6 of the Law, geological investigation are performed on site where it is determined existence or a possibility for existence of the mineral raw material and groundwater, with the purpose of determination of the position, characteristics, amount and reserves of those resources, with the evaluation of the possibility for their exploitation. Under geological investigation are also considered geologic researches performed during the exploitation of all mineral raw material, of groundwater intakes, as well as during renewal of groundwater reserves and their protection during construction of structures.

According to the article 11 of this Law, geological map are being prepared with the purpose of understanding of general geological composition and structure of certain site, trough the positioning of mineral raw material and groundwater. Preparation of the geological maps includes general geologic maps, geo-morphological, hydro-geological and other maps which presents different geological characteristics.

- **Law on mining («Official Gazette of B&H», No.24/93, 13/94)**

According to articles 4 and 5 of this Law, mineral and thermal waters, as well as gases which appear with waters are considered as industrial mineral raw material.

Article 71 stipulates that minister of work and social policy, in agreement with minister of energetic, mining and industry and ministry of agriculture, water management and forestry can determine the wider protection zones of healing springs of mineral and thermal waters, where mining works could be performed only if protective measures of the healing springs are undertaken.

According to article 75, if the works in the pits and surface diggings or in its parts must be terminated due to not expected obstacles such as waters, the Ministry of energetic, mining and industry of B&H must be informed within 24 hours after suspension of the works.

Article 91 stipulates that for mine pits with the high water inflow and complex tectonic, minister of energetic, mining and industry can prescribe elaboration of hydro-geological plans.

- **Law on unique procedure for determination, evidencing and collecting data on reserves of mineral raw material and groundwaters and on balance of those reserves («Official Gazette of B&H», No. 8/93, 13/94)**

According to this Law, groundwater, which are being determined, evidenced and for which data are collected on reserves and balance is prepared, include drinking, mineral and thermal waters. All companies that are authorized for research of mineral raw material and groundwater and for their exploitation are obliged to determine, evidence and deliver data on mineral raw material and ground waters reserves to the Ministry of energetic, mining and industry of B&H. Ministry will , based on that, prepare and adopt "Balance on mineral raw material and groundwater of B&H, with analyze of natural indicators".
Relevant sub – law is „Rulebook on methods and procedure of determination and certification of the mineral raw material reserves and ground waters" («Official Gazette of B&H», No. 24/90).

1.2.3. Relevant legislation and regulations in Republic of Srpska

- **Water Law («Official Gazette of RS», No. 50 /06, - adopted on 11.05. 2006**

This law prescribes measures for water management, protection, usage, establishment of the water information system and issuing of water acts. This law treats all categories of water including ground waters.
According to article 4 of this Law, ground waters are: "all waters under the ground surface in saturated zone and which are in the direct contact with surface and ground soil layers".
Article 50 of this Law defines that usage of water from the source and groundwater, in other purposes besides general, can be approved only if water research activities are previously performed.
Article 57, point 2., of this Law stipulates that it is forbidden to discharge the wastewater into a natural lake, pond, swamps and other natural water reservoirs, which have permanent or temporary inflow or outflow into / out surface water or groundwater, as well as into water reservoirs, which were developed from removing or exploitation of mineral raw materials or other similar procedures.
Article 57. point 3, of this Law stipulates that it is forbidden to use water in a way that could endanger their ecological and chemical status of natural lakes, fishponds, swamps and other natural water accumulations, which have permanent or temporary inflow or outflow into / out surface water or groundwater.
Article 57. point 4, of this Law stipulates that waste water discharge directly into groundwater is prohibited.
Article 57. point 5, of this Law stipulates that indirect waste water discharge into groundwater is limited in the manner and under conditions, which determines the Law and by-laws arising from this Law.
Article 67 of this Law stipulates that the Ministry of Agriculture, Water management and Forestry of RS, in accordance with the provisions of this Act, shall issue regulations on the limiting values of pollutant substances in waste water, and on other requirements related to waste water discharge in surface water, soil, public sewage system, as well as for other dangerous substances whose discharge is prohibited into water, soil that belongs to water good, forest and agricultural land. Before preparation of these regulations, the Ministry will ensure its compliance with the regulation of another entity, through consultation at their adoption.

- **Relevant water sub-laws – decisions and regulations**

Conditions of waste water discharge and limited values of dangerous and harmful substances which may be discharged into surface water and in sewerage systems, are set by the folowing two sub-laws:

- Regulation on the conditions of discharge waste waters into the public sewage system («Official Gazette RS», No. 44/01)
- Regulation on the conditions of discharge of waste waters into the surface water («Official Gazette RS», No. 44/01). According to this Rulebook, biological treatment is obliged before waste water is discharge in water streams.
- Regulation on water classification and categorization of the watershed areas («Official Gazette RS», No. 42/01), establishes criteria for classification and makes classification of quality of surface and ground waters, as well as categorization of water courses.
- Decision on the borders of the water areas in RS («Official Gazette RS», No. 9/00; 46/02)
- Decision on the water fees («Official Gazette RS», No. 19/98; 29/98; 4/99; 6/00; 55/01; 49/02)
- Guideline on the methods, procedures and deadlines to calculate and pay the general and special water fees («Official Gazette RS», No. 19/98; 27/01)
- Regulation on the treatment and discharge of waste waters for the cities and districts where there is no public sewage system («Official Gazette RS», No. 68/01)
- Regulation on the method of maintaining the river beds and river soil («Official Gazette RS», No. 34/01)
- Regulation on potable water safety («Official Gazette RS», No. 40/03)
- Regulation on the protection measures, method of determining the sanitary protection zones, areas where water sources and water management structures exist, and areas where water is used by humans («Official Gazette RS», No. 7/03)
- Regulation on the method of determining the pollution level of the waste waters to serve as the basis for water fees («Official Gazette RS», No. 44/01)
- Regulation on the conditions to be necessarily met by the authorized labs as legal entities or within the legal entities performing the tasting of the quality of land, underground and waste waters («Official Gazette RS», No. 44/01)

- **Law on mining («Official Gazette RS», No. 107/05)**

According to article 3 of this Law, mineral and thermal waters, as well as gases which appear with waters are considered as industrial mineral raw.
According to article 52, if the works in the pits and surface diggings or its parts must be terminated due to not expected obstacles such as water inflow, drainage or change of a water regime, the inspection must be informed immediately, or latest within 24 hours.
Article 69 stipulates that company which performs works must obtain hydro-geological and tectonic plans for mine pits with the high water inflow and complex tectonic.

- **Law on geological research («Official Gazette RS», No.51/04)**

This Law determines basic geologic activities including discovering and determination of the mineral raw, groundwater and geothermal energy, as well as the rational use of those resources.
Article 4 of this Law defines the mineral raw material, and according to it, all ground waters (drinking, industrial, mineral, thermal and thermo-mineral), are considered as mineral raw material.
According to the article 11 of the Law, geological researches can not be performed on the site with settlement, public roads, water management facilities, cultural monuments, natural parks, sources of a mineral, thermal and other water as well as on the area which is proclaimed as protected (national parks, forests, mineral springs). Only in case when the researches are of a general interest, they can be performed on these sites, but in the way prescribed by a Government of the Republic of Srpska.

According to the Article 11 of this Law, geological map are being prepared with the purpose of discovering general geological composition and structure of certain site, trough the position and concentration of mineral raw materials and groundwater. Preparation of the geological maps includes general geologic maps, geo-morphological, hydro-geological and other maps which presents different geological characteristics.

1.2.4. Relevant legislation and regulation in District Brcko

- **Law on Water Protection (Official Gazette of DB, No. 25/04 1/05)**

According to this law under waters are considered all waters, natural and artificial, surface and groundwater.

The Law is mostly treating water protection, but it consists several provisions on water permitting relevant for water abstraction/ usage : .

Article 43. stipulates that " Water protection authorization is to be issued in cases of direct usage of water for:

1. Water supply for drinking purposes from individual sources or public water supply systems
2. Technological processes
3. Swimming and Bathing
4. Heating energy production
5. Irrigation of agricultural lend
6. Production of enerhy in hydro – power plants
7.Water facilities for flower production
8. Fisheries and other aquatic organisms rising
9. Port construction (river port)
10. Waste water discharges and hot water discharge
11. all other water pollution loads

Article 43. stipulates that a Mayor of Brčko District defines the list of direct water usage activities for which water authorization is not required.

Article 18 of this Law stipulates that water protection and protection of water ecosystems includes: classification of surface and groundwater, prohibitions and restrictions related to water loads, special prohibitions and restrictions in protected areas, control and collection of data related to water protection and other measures determined by this Law.

The Mayor of Brcko District determines limiting values for chemical, physically-chemical and biological parameters for bathing waters, drinking, and for mineral, thermal and thermo-mineral waters, according to the article 22, of this Law.

Article 23, point 2., of this Law stipulates that direct discharge of waste waters in to the ground water is forbidden.

Article 23, point 3., stipulates that direct discharge of waste waters, emission of heat into groundwater and absorption of heat from groundwater, can be performed only in the way and under conditions prescribes by this Law.

Article 23, point 4., of this Law stipulates that it is forbidden to discharge waste waters in to the natural lakes, fishponds, and natural water accumulations with permanent and periodical inflow and outflow in / out surface water and groundwater, as well as discharge into water accumulations during the extraction and use of the raw minerals and other similar cases of water use.

Article 23, point 5., of this Law stipulates that it is forbidden to use water which degrades chemical and ecologic state of waters in natural lakes, fishponds and other natural water accumulations with permanent and periodical inflow and outflow into / out surface water and groundwater.

Article 34 of this Law stipulates that authorized agency for watershed area determines protected areas with purpose of protection of water flows or parts of a water flows, and protection of groundwater flow towards the watershed areas, in

order to be usable for drinking water, for bottling of natural water and for usage of mineral, thermal and thermo-mineral water for production of drinks.
Article 35 of this Law stipulates that if the water source is discovered, and which has importance for water supply, or is a source of mineral, thermal, or thermo-mineral or groundwater for production of drinks, the Mayor can bring a decision on proclamation of a protection of the zone where the source is located, on the proposition of an authorized agency for watershed area.

1.2.5. Socio economic insentives and obstacles to effective groundwater managment

Water Sector Financing
Funds for performing water management tasks, defined by water entities' Laws (FB&H and RS) are ensured through "general" and "special" water fees in F B&H, and through "special" water fees in RS:

- **General water management fees**

paid by all employees in the amount of 0,5% of their net salary (this fee exist only in FB&H);

- **Special water fees:**

1. Water abstraction fees for usage of surface and groundwater include:
- water abstraction for public water supply, paid by water supply companies, and then passed to the final consumers for payment (KM/m^3);
- water abstraction for producing bottled water and mineral water (KM/m^3);
- water abstraction for irrigation (KM/m^3);
- water abstraction for utilization of water for fish farming (KM/m^3);
- water abstraction for industrial processes, including thermo power plants(KM/m^3);
- water abstraction for other purposes (KM/m^3).
2. Special water fee for production of electricity by using hydro energy (kWh/m^3);
3.Water protection fees:
- fee paid by owners of transport vehicles using oil and oil products;
- fee for wastewater discharge based on PE;
- fee for fish farming, paid in KM/kg of produces fish;
- fee for using fertilizes and chemicals for crop protection;
4. Charges/fees for sand and gravel abstraction (KM/m^3 of sand/gravel)
5. Charges/fees for protection from waters (flood protection), paid by:
- owners of agricultural, forest or construction land protected by water protection objects (KM/ha);
- owners of residential, business and other facilities protected by water protection objects (KM/m^2).

In FB&H, these charges/fees are distributed among the following institutions:
- 40% to the relevant Water Agency;
- 45% to the Cantonal budgets; and
- 15% to the Environment Protection Fund.

In RS, distribution of charges/fees, except for first three charges from item 3. is performed as following:
- 70% for the special water purposes account;
- 30% for local authorities budgets

First three charges from item 3. are distributed as follows:
- 55% for the special water purposes account;
- 15% for special purpose of environment protection in RS;
- 30% for local authorities budgets.

The base amount of the special water fees is determined by entity governments based on the proposal of the entity ministries responsible for water, and ministries for environment, with the previous agreement with entity ministries responsible for finances.
Some of established charges and fees contribute to a certain extent to internalization of environmental and resource costs.
Revenues collected from water management fees are earmarked for the investments in the water sector, such as: financing of construction and maintenance of some water facilities, elaboration of water management plans and other activities related to water management, in accordance with the annual plan and program of the relevant ministries responsible for water.
Water companies make plans on annual bases , in coordination with the local level authorities, on the needs for investments in water and wastewater services. These plans are then submitted to the Water Agencies, which forward them to the entity authorities, which make the final decision of the investments. There are no long-term plans on improvements and investments in the water and wastewater.

Water prising and costing

- **Main water users in B&H**

The main water users in B&H are households, industry and agriculture. Apart from that, water resources are also used, and are planned to be used more as a hydro-power potential. Water supply systems in B&H (for households, industry and agriculture) relay mostly on underground waters (more than 85%), so only rare systems use surface waters for water supply.

- Domestic Water Supply

Central Municipal Water Supply Systems in B&H are managed by more than 120 Water Utilities in B&H, which are usually organized as Public companies, owned by Municipalities, or Cantons (F B&H, Sarajevo Water Utility), or Cities (Mostar and Banjaluka, F B&H and RS respectively).

According to National Environment Action Plan for B&H (NEAP), Central Municipal Water Supply Systems, managed by Municipal Water Supply Utilities cover 56% of population in FBH and 48% of RS. Population which is not covered by Central Municipal Water Supply System relay on their own – local community water supply systems or on individual wells.

- Irrigation

Bosnia and Herzegovina was even before the war country with much less irrigated surfaces then world average. According to Federal Strategy of Agriculture for 2006-2010, B&H irrigate only about 8000 ha of surface, i.e. about 0.5 % of cultivable lend, or 0.8% of arable lend.
However, due to the past war (1992 – 1995), some of irrigation systems were destroyed and out of usage, but some were reconstructed again, after the war. Irrigation is now mostly present in the southern, Mediterranean part of B&H, as well as in northern part of B&H (close to Sava river), but also in some other parts of the country.
The irrigation systems and water usage are managed by agriculture enterprises, associations and individual farmers.
Currently, exact technical data on irrigation facilities does not exists, so as data on quantities of water used for irrigation (not systematically collected), or data on modes of irrigation.

- Industry

According to NEAP, industries in BiH mostly use water from its own sources, but also from the public water supply system. It is assumed that industrial production in Bosnia and Herzegovina is to a large extent smaller than at the beginning of 1990s (about 35% of the pre-war capacities). Due to this fact, the water consumption in the industrial sector has been reduced, which also contributes to reduction in terms of pollution.

- Hydro Power systems in B&H

Currently, in B&H's power sector there are three major producers and distributors of electricity, public companies – Elektroprivredas (EPs): Elektroprivreda B&H (EP B&H), Elektroprivreda Hrvatske Zajednice Herceg-Bosne (EP HZHB) and Elektroprivreda of the Republic of Srpska (EP RS). Each EP has its own generation and distribution facilities and is in charge of generation, distribution and supply on its territory.

The existing hydro power plants in B&H are in charge of those three public enterprises, and their total Hydro power Plant (HPP) Power House output is 1990.7 MW, while total expected annual production is 5809.9 GWh.

Behind 26 dams (5 rock- and earth-filled dams, 20 concrete dams and one constructed from blocks), are the reservoirs with total storage capacity of 3,85 km^3, or approximately 10 % of total runoff volume in B&H (38 km^3).

With its hydro energy potential, B&H is at eleventh position in Europe (without the European part of Russia, behind Norway, Sweden, France, Italy, Austria, Island, Spain, Switzerland, Serbia and Montenegro), and in front of Germany, Portugal, Finland and Ukraine, which have similar potential. A large part of other European countries has much smaller potential than B&H.

Usable hydro potential is estimated to 22 TWh per year, and the potential used today is approximately 40%.

Unused potential for small-scale hydro power plants is approximately 2.500 GWh per year. Studies from the period 2000-2002, identified approximately 140 small-scale plants from 1 to 5 MW.

According to the existing plans of Power Companies (Elektroprivredas) in B&H, EP B&H plans to construct 8 new big HPPs and several new small-scale HPPs, EP HZHB plans to construct or extend 8 new big HPPs and several new small-scale HPPs and EP RS plans to construct 10 new big HPPs and several new small-scale HPPs. Taking into consideration all planned HPPs (including EPB&H, EPHZHB and EPRS), the total planed (HPP) Power House output is expected to be 1865 MW and total expected annual production is 5072 GWh.

In addition to public Power Companies (Elektroprivredas), new projects will be managed by several other, private companies from both entities, as well as foreign concessionaires.

- **Water costs and pricing**

As water supply is under responsibility of Water Supply Companies, water supply pricing policy is under the jurisdiction of local authorities (Municipalities, Cantons or towns). There are no decisions or policies on a higher level (national or entity's) which determine a unique water price for all. Water supply companies propose the prices, but the final decision is made by the Municipal Councils.

Water prices usually slightly differ from one municipality to another, as they are set independently in each municipality.

Current water prices for water supply range from 0.4 – 1.10 KM/m^3 (1 Euro = 1,9558 KM) for households, and 1.0– 3.50 KM/m^3 for industry.

For the agricultural sector the prices are sometimes equal to those for households, and in other cases they are equal to those for industry.

Furthermore, water supply prices for industrial sector are usually much higher compared to prices for households in the same Water supply Company. It is a kind of cross-subsidies between different consumer categories.

Generally, in all Water Companies, the price structure consists of the following elements:

- price of water (KM/m^3),
- VAT on water price,
- price of sewage (KM/m^3 of water used),
- VAT on sewage price,
- Internalised resource costs through a "water abstraction fee",
- Internalized environmental costs through a "water protection fee".

Cost recovery

Generally, the revenues collected from water and wastewater tariffs are covering only the part of the operation and maintenance costs (O&M) of water companies, without leaving the assets for necessary improvements and investments.

As stated, in many Water Supply Companies revenue collection is not sufficient to cover annual expenses of the system (O&M), even if rate collection is 100%. It is due to the fact that, mostly, current system of establishing water tariffs is not based on cost - recovery principles, i.e. the rates are not economic than social. Political ambient is such that Municipal Councils very often does not allow increasing of tariff rates when required by Water Supply Companies. So, cost recovery is one of major problem for Water Supply Companies, generating serious problems for investments financing and generally, their sustainability.

Water Permits

According to the new entities Water Laws (2006. year), water permits are issued by entities' Water Agencies through three steps: Water regulatory pre-authorization, Water regulatory authorization and final Water regulatory permit.

Water regulatory pre-authorization are used for defining if the conditions exists for usage of water, as well as for defining of conditions which must be met by documentation for construction of new or for reconstruction of existing structures, for changes of technology and other works that are not regarded as construction, and that can permanently, occasionally or temporarily affect the changes of water regime.

Water regulatory authorization defines that the documentation attached with the application for issuance of water regulatory authorization is in accordance with the enacted water regulatory pre-authorization, with regulations on waters and plan documents.

Water regulatory permit defines the purpose, the way and conditions for water utilization, water regime of the structures and facilities, way and conditions of discharge of waste waters, as well as the gasses into the atmosphere, the way and conditions of disposal of the solid and liquid wastes and other conditions. Water regulatory permit defines that conditions defined by water authorization are met. It is valid for limited time, with maximum validity of 15 years.

The following activities are, regardless of their impacts, subject to a water authorization and permit:

1. abstraction of waters (for industry and energetic purposes, domestic water supply, agriculture, tourist services and services which uses the water in their technological processes);
2. discharge of wastewater into surface water;
3. indirect discharge of water into ground waters;
4. artificial recharge of groundwater;
5. extraction of material from watercourse;
6. construction of facilities to utilize hydro-power;
7. permanent transformation of land area into water area;

8. construction of flood protection facilities;
9. construction of roads including forest roads;
10. construction of bridge or other structures over or in a navigable watercourse;
11. construction of lend fields;
12. initiation of concessions procedures related to waters
13. transport of hazardous materials and their products which end up in water upon its usage
14. water courses regulation

Water regulatory authorization and permits are to be issued also for the activities which can:

1. temporarily or permanently degrade the quality of waters, or impede the improvement of their existing quality;
2. harmfully impact aquatic or semi-aquatic ecosystems;
3. increase the risk of flooding or erosion; or
4. significantly reduce the quantity of waters, change the morphology of a watercourse; alter the depth, water level or flow in a watercourse, impede the recreational use of surface waters.

According to the Water Law of FBiH Art no. 110 Water act are not needed for water usage which does not exceed the ammount of general water usage as : water intake from special devices and wtarestreams and lakes for basic needs of one ousehold, groung water intake (well on private property) or water from the source on private property which is used for basic needs of one household, collection and usage of streamewaters for basic purposes of one household collected at own private property and recreation on waters.

Economic instruments and incentives

- **Abstarction fees** prescribed by new Water Laws (2006. year) are elaborated in the above Chapter

- **Subsidies:**

Local comunities' authorities (Municipalities) have interest to subsidize Water Supply Companies, since Water Supply companies' infrastructure is mostly owned by Municipalities, which is in charge for adoption and implementation of the program of investment into water works and equipment.

Since such infrastructure is of interest for the entities and cantons as well, a certain part of the financial resources for construction is secured at that level too. Also, Water Supply Companies receive some financial resources from the local (Municipal) authorities for investments and reconstruction works.

Municipal Authorities throuhgt their Water Supply Companies, in some cases, provide subsidiseng of some consumer categories such as low income population or retired people.

Agreculture policies does not envisage water subsidiseng.

- **Agrochemical pollution – reduction measures:**

The Law on Agricultural Land of F B&H (1998. year) defines management and protection of agriculture lend. The Law forbids discharge and disposal of dangerous and harmful materials in agricultural land which can have negative effect on agriculture lend productivity, as well as irregular application of mineral and organic manure.

Federal Ministry for Agriculture released the sub-law on hazardous materials which are not allowed to be discharged into water, but this sub law is planed to be replaced with new one, harmonized with new federal Water Law (2006. year).

The another sub-law regulates maximal level of dangerous and hazardous material that can be found in the land/soil. This sub - law provides methods for examination of usage of sewerage sludge from waste water treatment plants, as well as organic and mineral manure, pesticides and herbicides.
The Law on Agricultural Land of RS (2007. year) defines the responsibilities of Ministry of Agriculture, Forestry and Water Management of RS, as well of Municipalities and Towns, in terms of agriculture land protection. These responsibilities must be in accordance with the main planning documents for land protection and usage of agricultural land. These documents defines on local level, inter alia, the areas that should be irrigated, possibilities of re-ionisation, define surfaces suitable for healthy food production, sets the level of agricultural land erosion, etc.
The Law forbids discharge and disposal of dangerous and harmful materials in agricultural land and in irrigation channels.
The Law also forbids irregular application of mineral and organic manure which will cause existence of dangerous and harmful materials in agricultural land, ground water and rivers.
Ministry for Agriculture in cooperation with Ministry for Health regulates the obligation to define the maximal level of dangerous and hazardous material that can be found in the land/soil and water for irrigation. Disposal of liquid manure, waste water, sewage sludge etc to agricultural land is not defined.

1.3. Known gaps in the policy and legal framework

Water sector reforms in B&H, which started in late nineties and is currently still in process, supported mainly by EC programs, has lead to elaboration of new water legislation, based on the EU Water Framework Directive, as well as to reforming of some water sector institutions and introduction of water management at a river basin level.
Consequently, the two entities' Water Laws harmonized between each other, as well in line with Water Framework Directive, have been adopted in both entities in 2006. year, and started to be implemented in 2007. year. The Laws prescribed establishment of adequate institutional organizations (Entities' Water Agencies) and sustainable system of funding of the water management sector. Within the water sector reform water quality/ quantity monitoring projects at the river basin level were also implemented, putting more focus on surface water quality, rather than groundwater.
However, the new water Laws present a framework Laws which should be future elaborated through specific laws and by –laws.
The major gap in water legal framework presented non-existence of relevant by-laws. In the period after the adoption of Water Laws, it was estimated that about 50 by-laws for each entity are required to be elaborated. During the last period quite number of sub –laws were elaborated.
Consequently, there is no any specific legislation or regulation relevant for groundwater. Limiting values for certain substances for surface water were established through by-laws in both entities, but for groundwater not yet. The issue of monitoring ground water quality and quantity is completely lacking. Monitoring of groundwater quality has never been very well established in B&H, so there is no clear understanding on impact to groundwater environment. Monitoring equipment in B&H is almost completely destroyed during the war activities, so the current activities on water quality monitoring are brought to minimum. As a consequence, the only available information are those on quality of effluent, and some earlier quality analyses of surface waters.

According to the Water Laws, Entity Ministries were responsible for preparation of entity Strategies for Water Management until 2009. year. , for the period of 12 years. General objectives of the Strategies are the following:

- reducing pollution, prevention of degradation and achievement of good water status,
- improving sustainable water use,
- ensuring equitable access to water,
- fostering social and economic growth,
- ecosystem protection,
- reducing the risk from floods and other negative effects of water,
- ensuring public participation in decision making related to water,
- preventing and solving conflicts related to water protection and water use,
- fulfilment of responsibilities from international contracts which are binding for B&H.

The indirect objectives of the Strategy, through creating a policy of water sector development, are:

- providing sufficient drinking water quantities for the population, and increasing the percentage of population connected to public water supply systems;
- providing sufficient water quantities for development of other economic activities in accordance with real possibilities and development plans of specific sectors;
- increase of safety level from the negative effects of water on people and property;
- improvement of water quality with a long-term objective – achieving and preserving good status of waters.

Article 24. of Water Law of FBiH ("Official Gazette" of FBIH No. 70/06) defines the preparation and adoption of Water Management Strategy. Federal Strategy was prepared as the draft in 2010 for period 2010-2022 and is adopted by Government of FBiH as well as the Parliament of Federation of Bosnia and Herzegovina at the end of 2011. RS has elaborated the "Framework Plan for Development of Water Management" in 2006. year, which actually represents the the base for Strategy for Water Management in RS Which wil include integrated water management principles.

Further more, according to the Water Laws, Water Agencies are obliged to prepare Water Management Plans for river basins, specifically for Sava river basin and Adriatic Sea basin, until 2012. These Plans should be revised and updated every 6 years.

Currently, river basin management Plans are in process of elaboration for: Rivers Krka and Cetina and Rivers Neretva and Trebišmjica. Howevever, FB&H Water managment Strategy sets more flexible deadline for elaboration of river basin Managment plans – 2015, including program of measures.

Inter – sectoral coordination during preparation of legislation is also weak point in B&H. As a consequence, water issues are not sufficiently or not at all addressed within other legislation.

Environment legislation to some degree addresses a need for protection of water through requiring water permits in the process of issuing integrated environmental permits. Prevention of pollution is regulated by the Environmental law trough procedure of environmental impact assessment and integrated environmental permit, but B&H has no national BAT documents. Entity Laws on Environmental Protection include requirements of IPPC Directive, the Seveso II Directive, the Landfill Directive, the Environmental Impact Assessment Directive etc.

Agriculture and/or Land legislation is only focused on the protection of agricultural land.

1.4. State of Law enforcement

Enforcement of measures for the water quality insurance is applied according to the new Water Laws, as well as through the application of different water related by – laws such as:

By-laws relevant for general and special water fees which enforce payment of special water protection fees as following:

- fee paid by owners of transport vehicles using oil and oil products;
- fee for wastewater discharge based on population equivalent (PE); Competent bodies are monitoring effluent quality, e.g. they are determining the pollution load based on the population equivalent number (PE). It is the unit of measure used to compare the organic load of wastewaters generated by generic not necessary household sources. Population equivalent refers to the amount of oxygen-demanding substances whose oxygen consumption during biodegradation equals the average oxygen demand of the waste water produced by one person. For practical calculations, it is defined that one unit equals 60 grams of BOD5 per day. Since it includes other sources of wastewater, population equivalent doesn't necessarily reflect the actual population of a community (or Agglomeration).
- fee for fish farming, paid in KM/kg of produces fish;
- fee for using fertilizes and chemicals for crop protection;

By-laws relevant for water quality laboratories performance

These Rulebooks defines conditions to be necessarily met by the authorised labs for the tasting of the quality of land, ground water and waste water, technical conditions (space and equipments), human resources, good lab practices and management which fulfil international standards requirements and users needs.

By-laws relevant for classification of waters and categorization of water courses

This decree regulates class of water according to quality which supports ecological function of given types of aquatic systems, as well as use of water for current and planned needs, and refers to all surface waters (rivers, lakes, artificial and heavily modified water courses) and ground waters.

By – laws relevant for defining of water protection zones of drinking water sources

These by –laws define methods for establishment of water protection zones, protection regimes and protection measures which are to be implemented in those zones.

Law on Environment Protection contributes to the enforcement measures for water protection by incorporating water permits into integrated environmental permit.

The scope of the Environmental Law cover all environmental media (air, water, soil, flora and fauna, landscape, built environment). Installation may be built and operated only if they have environmental permit issued in accordance with provisions of this law. This permit provides high level of integrated environmental protection through protection of air, water and soil - all forms of activities which utilize, load, or pose hazard to, or pollute the environment, or have an impact on the environment (such as noise, vibration radiation - with the exception of nuclear radiation, waste, etc.).

1.5. On-going and planned activities to improve/update the current legal and regulatory framework

Primary water and environment legislation in B&H is fairly modern and to a considerable extent harmonised with the EU acquis.

The main issue of water sector in this moment is secondary, i.e. implementing legislation, which was during last years lagging far behind needs and plans. Both entities' water Ministries are currently working on elaboration of secondary water legislation. See Annex 2.

Water management Strategy of Federation of B&H was adopted at the end of 2011 and is in the adoption phase. RS adopted the base for water management strategy in September 2006, entitled as Framework plan for development of Water management in RS. Furthure step would be the elaboration of RS Water management strategy including integrated water management principle,

Project "Suport to B&H Water Policy ", funded by the EC has recently been completed. Its implementation presented the important step toward transposing EU water related acquis into B&H legislation, toward development of secondary legislation In both FB&H and RS Entities.(regulation on wastewater discharge, regulation on water laboratories, regulation on water characterisation, regulation on RBM Plans as well as understanding of economic analysis as required by WFD.

Apart from secondary legislation and policy development in B&H, of the biggest significance is organizing, reconstructing and modernizing the existing, or improving inadequate monitoring of water quantity and quality.

According to the new Water Laws, future Water management Plans for two River Basin Districts will include map of monitoring network and overview of results of monitoring program including following:

- Status of the surface waters (ecological and chemical)
- Status of the groundwaters (chemical and quantitative)
- Status of the protected areas

Taking this requirements into account and based on the recommendations, as well as equipment and capacity building activities, provided through the EC Project "Water quality monitoring at the river basin level", Water Agencies as well as Hydro-meteorological Institutes are gradually improving water quality and quantity monitoring system is in both B&H's entities.

1.6. Link to implementation of EU Water Framework Directive

B&H's strategic goal is joining the European Union. Therefore, a variety of activities are taking place in order to prepare the accession, including the signing of the Stabilization and Association Agreement with the EU, which occurred in June 2008.
Although it is not a member of European Union and so, has no formal obligations to implement the EU regulations, B&H, with its both entities, express the will to implement EU Water Framework Directive (WFD).
The intention to implement the WFD is expressed by signature of Memorandum on Understanding within national CARDS project "Institutional Strengthening of Water Sector in B&H", signed between the Delegation of European Commission in Sarajevo and Council of Ministers of B&H, and Entity Governments, with the goal to: "harmonize, finalize and approve the reform of water sector in Bosnia and Herzegovina, based on principles and goals of EU Water Framework Directive (2000/60/EC)".
Within this project, new Water Laws for both entities were elaborated, incorporating basic principles of Water Framework Directive.
Entity Water Laws are to great extend harmonized with each other, but there are some slight differences. Therefore, WFD transposition into these laws is not completely the same. Transposition of WFD into Water Law in Federation, according to the Progress Monitoring Report related to transposition of EU acquis, prepared for period 2009-2010, by Regional Environmental Center (REC) is 90%. Based on this report, it can be concluded that the requirement regarding the transposition and harmonization with WFD is almost fulfilled.

In Republic Srpska, Transposition of WFD into Water Law of this entity is 100%,
Since the WFD requires the implementation of the other water relevant EU-Directives, it is important that these are also found in entities' Water Laws and other regulations. Some of the most relevant Directives for B&H, transposed in some degree in B&H legislation are discussed below:

According to the above mentioned REC Report, the transposition of the "Urban Waste Water Directive" (UWWD, 91/271/EEC) into the Water Laws in B&H is still at an early stage. Transposition of UWWD into Federal Water Law and other regulations, according to the above source, is 35%. Even tough there is san evident progress in comparison with the Progress Monitoring Report from 2007, prepared by a Danish consultant company "COWI", when level of transposition of this Directiive was only 8%. However, major steps are foreseen to take place until 2012. year, Transposition of UWWD into RS Water Law and other regulation is 41%. The expected date of the complete transposition is 2012 in Federation, and 2015 in RS.

The Drinking Water Directive (DWD, 98/83/EC) is transposed into Federal Water Law and a few other regulations to 58% and the transposition is expected to fully occur in 2012 year,. The transposition in RS Water Law and regulations is 87%. Transposition of the remaining provisions is foreseen by the end of 2012.

The transposition of the Nitrates Directive (91/676/EEC) in FB&H has not yet been initialized. The definition of groundwater has been transposed in the Federal Water Law, which makes 11% of the transposition. For the remaining definitions and majority of provisions, transposition is foreseen through two Ministerial Orders, one of which is planned to be adopted until 2012, Full implementation of the Directive into FB&H laws and regulations is foreseen for 2018. Transposition of Directive in RS, through the application of the new Water Law and supplementing regulations,is 22%. The remaining items are expected to be transposed through a Ministerial Order by the end of 2012. The full implementation is scheduled for 2021.
However there is still work to be done on transposition of EU legislation, particularly by elaboration of missing sub-laws.

2 INTERNATIONAL COOPERATION (BILATERAL, REGIONAL, INTERNATIONAL)

2.1. Existing bilateral and regional agreements

Bosnia and Herzegovina has signed several bilateral agreements relevant for water with Republic of Croatia, as following:

1. "Agreement on setting up of the water management relations between Bosnia and Herzegovina and Croatia"
This agreement was signed in 1996. year in Dubrovnik, Croatia.
Agreement relates to the water management activities at the water streams which present the mutual state border between Croatia and Bosnia and Herzegovina, or at the water streams which are cut with state borders. Agreement is also relevant for all areas of interest for improvement of water management of Contracted Parties (B&H ands R Croatia).
According to this agreement, the Commission was formed for the implementation of this Contract (3+3 members). Until now, members of Commission from B&H side are only from Federation of B&H.

2. "Agreement between Croatian Government and Council of Ministers from B&H on common financing of maintenance and operation of regional sewerage system "Komarna- Neum- Mljetski Kanal"

This Agreement was signed in Sarajevo, 2004. year.

Agreement relates to the regional sewerage system which cover B&H and Croatian coastal settlements. Regional sewerage system was constructed during a period when Croatia and Bosnia were within the same state, and the share of financing was 30% from Croatian side and 70 % from B&H side.

3. Contract between World Bank, and Government of Croatia, FB&H and RS, as well as Memorandum of understanding between B&H and Croatia.

Contract was signed in Zagreb and Sarajevo 2008. year.

It relates to the WB grant for the B&H's and Croatia's common Project " Managing of Neretva and Trebišnjica rivers". Total grant was 8 mil. US $, out of what 6 mil. US $ is dedicated for B&H, and 2 mil. US $ for Croatia.

Project should cover issues of water allocation, preservation of ecosystems and biodiversity, as well as reduction of pollution from sewerage systems in B&H's and Croatia's settlements and industries.

4. „Framework Agreement on Sava river basin (FASRB), " between Slovenia, Croatia, Serbia and Bosnia and Herzegovina.

Agreement was signed in December 2002, at Kranjska Gora (Slovenia). Consequently, the Interim Sava Commission was formed to prepare all steps necessary for the establishment of the permanent Commission upon entry of the FASRB into force.

Upon all Parties ratified the FASRB, it entered into force on December 29, 2004.

The First Constitutional Session of the Sava Commission was held on June 27, 2005.

The permanent Secretariat of the Sava Commission, located in Zagreb, started to work on January 09, 2006.

The Agreement, as well as Sava Commission activities, relate to the utilizing, protecting and controlling Sava River Basin water resources, in a manner that would enable better life conditions and raising the standard of population in the region, and to finding appropriate institutional frame in order to enhance the cooperation.

2.2. Perceived transboundary issues of concern

Most of B&H's major river basins are internationally shared what require strong attention to be paid to international water laws, arrangements, programs and projects.

The most interesting in international terms, out of alluviums aquifers are the catchments of Sava, Una and Drina rivers (northern and western part of B&H, bordering with Croatia and Serbia), while among carstic aquifers, the most important are catchments of Cetina river and Neretva and Trebišnjica rivers (southern and western part of B&H, bordering with Croatia and Monte Negro).

However, international groundwater considerations were in B&H, and still are, the second priority, after surface waters. Shared groundwater aquifers are generally neglected comparing to surface water in trans-boundary river basins.

Such situation resulted in very weak activities regarding ground trans-boundary arrangements, programs and projects.

2.3 Completed, on-going and planned international, bilateral or multilateral activities

Bosnia and Herzegovina is a member or contractor of the following conventions and agreements related to transboundary water: .

- **Danube River Protection Convention (1994).**

Since 1996 B&H is actively involved in the work of expert teams of the Danube River Protection Convention (representatives in the ICPDR and the expert groups AEW, MLIM, EMIS, ECO etc.). B&H ratified this Convention in January of 2005 (Official Gazette BiH 1/05).

- **Convention of Mediterranean Sea pollution protection, Barcelona from 16.02.1976.** (Took effect on: 12.02. 1978.; Official Gazette SFRJ-International Agreements, No. 12/77, Official Gazette BiH, No 26/98) and its Protocols:

1. Protocol for the protection of the Mediterranean Sea against pollution from land-based sources and activities – LBS Protocol, Atina, from 17.05.1980. (Took effect on: 17.06.1983.). Revised in Syracuse (Italy) 1996. (Official Gazette RBiH No 13/94, Official Gazette SFRJ IA No. 1/90).
2. Protocol concerning specially protected areas in the Mediterranean sea, Monaco, from 1996. (old name: Protocol on specially protected areas of Mediterranean Sea, Geneva 1982.) (Took effect on: 23.3.1986.) (Official Gazette RBiH No. 13/94 Official Gazette SFRJ IA No. 9/85)
3. Protocol for the prevention and elimination of pollution in the Mediterranean Sea by dumping from ships and aircraft, Barcelona from 16.02.1976. (Took effect on: 12.02.1978.)
4. Protocol concerning cooperation in combating pollution of the Mediterranean Sea by oil and other hazardous substances in accidental cases, Barcelona, from 16.02.1976. (Took effect on: 12.02.1978)

Since 1998, B&H is actively involved in the work of Mediterranean Action Plan, located in Athens, and its Regional Centres.

- **International convention on oil pollution prevention of sea, London, from 12.05. 1954. (Took effect on: 26.07.1958.) (Official Gazette RBiH No. 13/94, Official Gazette SFRJ IA No.60/73, 53/74)**
- **International convention on protection from ship pollution , London, from 02.11.1973. (Took effect on: 02.10.1983.) (Official Gazette RBiH No. 13/94, Official Gazette SFRJ IA No.2/85)**

B&H is in phase of preparation for ratification of **Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Helsinki, 1992. , and Convention on the Transboundary Effects of Industrial Accidents, Helsinki, 1992.**

2.4. Main achievements and obstacles and lessons learned

Bosnia and Herzegovina, as a relatively new post-war democracy is in the process of intensive transformations in terms of arrangements and regulations of water management on both, national and international level. Those transformations are mostly focused on legislation, capacity building and institutional strengthening, moving from pre-war Yugoslav legislation towards arrangements in line with international and particularly European Union guidelines. Some on-going processes in B&H such as ratifications of international agreements, implementation of cross-bordering projects and involvement in regional environment programs, described in Chapter s 2.2. and 2.3., are likely to result in sound international arrangements in the future. Anyway , it is quite slow process in B&H caused by complex administrative structure, as well as low human capacities.

International cooperation in B&H reflects the deficiencies of the national internal administration. The distribution of competencies regarding international cooperation in B&H is extremely complicated granting the right to international initiatives even to Cantons. This results in considerable delays in coordination and difficulties in entering international agreements. Conflicts of opinion and/or unproductive legal debates prevented the clarification of B&H's status versus a number of international conventions/agreements.

Regarding human resources four phenomena become apparent. First, the very low number of genuine specialists in any of the environmental fields (waste, air-emissions, noise, nuclear radiation, etc.) Second, the low number of environmentalists compared with the number of chiefs. Third, the frequency of multi-functional occupation of environmentalists. Fourth, the significant gap between the number of posts established and the number of posts actually filled.

A strategy for international cooperation and implementation of commitments is yet to be formulated. The underlying defect is inability of the administration to oversee and manage Multilateral Environmental agreements. Good management would require a national strategy for international environmental cooperation, setting of priorities in view of the obligations, the estimation of the expected costs of implementation through the years, a cost-benefit analysis prior entering the international obligation, clarification of internal institutional responsibilities, and due reporting to the decision-making and supervisory state and entity bodies.
Despite strengthening of the state level (Ministry of Foreign Trade and Economic Relations – MOFTER), the weakness of national coordination and the elaboration of national concepts remains a visible problem.
EC Project "Functional Review of the Environmental Sector in Bosnia and Herzegovina" elaborated by the consultant "Agreconsulting" (2005. year), provided recommendations for strengthening environment sector in B&H. The first reform measure was "transformation of the present MoFTER's Department for Environmental Protection into a new "Sector for Environmental Protection". It is proposed that the new sector consist of three departments, out of which one would be dedicated for international agreements:

- Department for EU accession and international agreements with the following tasks:
  - preparation and negotiation of international conventions and agreements in the environmental field;
  - assessment of the requirements and costs of implementation of international obligations;
  - monitoring of the implementation of agreements and conventions,
  - elaboration and upkeeping of a national strategy for international environmental cooperation;
  - designation and coordination of focal points for international cooperation;
  - coordination of due national reporting to all international fora;
  - preparation of documents and data for the various EU negotiations;
  - coordination of the approximation to the EU acquis of environmental law and
  - policies, natural resource management and pollution control;

3. QUESTIONNAIRE ON IMPLEMENTATION OF THE GROUNDWATER MANAGEMENT ISSUES INTO NATIONAL (B&H) LEGAL AND POLICY FRAMEWORK

1. Is the national strategy for water management defined? Does it include groundwater?

F B&H[1] - Article 24. of Water Law of FBiH ("Official Gazette" of FBIH No. 70/06) prescribes that water management policy is defined by Water Management Strategy. According to the Water Law, first Water Management Strategy was supposed to be adopted in 2009. However, Water Management Strategy was prepared later on (in 2010) for the period 2010-2022 and adopted at the end of

[1] *B&H consist of two governmental entities – Federation of B&H (FB&H) and Republic of Srpska (RS)*

2011 by Government of FBiH . According to the Water Law, Water Management Strategy of FB&H is a part of the Federal Environmental Protection Strategy.
It represents planning document which sets out the vision, goals and measures of FB&H policy in water management, including groundwater management. Water management Strategy defines different strategic and operational goals in respect to different fields in water management (legal, economic, institutional, water usage, water protection and protection of water).
RS[1] - According to RS Water Law (Article 25), it is foreseen that Strategy of integrated water management will be elaborated. RS has elaborated the "Framework Plan for Development of Water Management" in 2006. year, which actually represents base for RS Water Management Strategy, in the framework of integrated water management policy. Framework Plan provides strategic directions for development of water management in RS and defines criteria, conditions and limitations for development of water management

If, yes, please specify the goals and requirements regarding groundwater
a. If yes, does it include goals for transboundary waters, particularly groundwater?
FB&H Strategy - The main requirements regarding ground water were elaborated within following:

Water usage strategic goal **- a) increasing of population coverage with public water supply systems (from 60 % to 80%) - 85 % of drinking water comes from groundwater. Operational goal - Rational water usage, protection and preservation of water resources planned for water supply of population. Measures*:* continual investigation works of present and potential water resources of drinking water, particularly focusing on underground water (inter-granular and karst aquifers).**

Water protection strategic goal **– a) achievement and maintenance of good quality of surface and ground waters due to protection of flora, fauna and users (population, economy)**
Operational goal – Elaboration of Water Management Plans for watershed areas of river Sava and Adriatic sea; Measures: Elaboration of methodology for determination of water body types and for characterisation of surface and ground water bodies; Defining of parameters of quantitative and chemical quality for classification of state of ground water bodies; Establishment of supervision system of surface and ground water quality derived from Monitoring program; Elaboration of river basin management Plans.
According to FB&H Strategy deadline for elaboration of first River Basin Management Plans is 2012.year, Operational goal - Decreasing of pollution load from urban and industrial waste water systems; Measures: Increasing of population coverage with public waste water system (from 33 % to 45%) and construction of WWTP; Operational goal - Decreasing of harmful and tocsic substances from industrial facilities through application of polluter pay principle; Measures: Set –up of polluters register; Continual monitoring of effluent by polluters; Operational goal - Decreasing of pollution of surface and ground waters from dumping sites; Measures: Removal of dumping sites; Construction of environmentally sound landfilds; Operational goal - Decreasing of pollution from agriculture, forest and traffic activities; Operational goal - Establishment of protected areas according to FB&H Water Law (and WFD) - Establishment and proclamation of:
areas for potable water abstraction - sanitary zones protection, protected areas for economically significant aquatic species, protected areas important for sport and recreation, areas sensitive to eutrophication and nutrients and

relevant monitoring program, protected areas for habitats of aquatic and semi – aquatic species as well as establishment of data base on water bodies status (surface and ground waters).

RS Framework Plan - The main directions regarding ground water were elaborated within following:
-Increasing of population coverage with public water supply systems by intensive use of ground water sources (particularly inter granular aquifers but also karstic aquifers). This requires securing of water quality by water treatment and water source protection measures as well as guiding the economic development in a way that these sources stay permanently preserved as recourses for drinking water.
-Increasing of population coverage with public waste water system and construction of WWTP for settlements over 5000 population, as well as for smaller settlements, if it is necessary according to criteria for priorities selection (public health, drinking water sources protection, water protection and water courses protection).

b. If yes, does the Water Management Strategy comply with the requirements set in EU Water Framework Directive and of the Groundwater Directive?
According to the Progress Monitoring Report prepared by Regional Environmental Center (REC) for period 2009-2010, transposition of WFD into Water Law of FB&H is 90 % and in RS 100%. Ground Water directive was not considered as it was adopted after entities' Water Laws.
Nevertheless, the real scope and quality of transposition of EU legislation into B&H legislation will be estimated during the implementation of Stabilisation and accession Agreement, prior to what it would be necessary to enact quite amount of new sub – laws.

FB&H Water management Strategy concentrates on fully transposition of EU legislation, mainly through the sub-laws, for which deadline were defined within FB&H Water Law. Strategy sets more flexible time frame, in accordance to the requirements of Stabilisation and accession Agreement (signed in 2008) which provide deadline of 6 years for full transposition.
***FB&H Strategy sets the Legal Strategic goal* - Water sector reform which comply with EU requirements in water sector and Operational goal relevant for ground water - Full transposition of Directive 80/68/EEC in 2012; Full transposition of WFD in 2012;**

RS Framework Plan stipulates that the key legal documents which should be considered while elaborating RS water legislation, within the process of harmonisation with EU water legislation, are the following Directives: ground water protection directive, surface water protection directive, fishing water quality directive, bathing water quality directive, urban waste water treatment directive, nitrate directive e.t.c.

c. Is it fully or partly harmonized with other sectoral related strategies (agriculture, environment, tourism …)
FB&H Water Management Strategy represents a part of Environment protection Strategy. Water Management Strategy recognised lack of inter-sectoral cooperation (agriculture, protected areas, energy, physical Planning). Thus, Water management Strategy initiate inter-sectoral cooperation and sets institutional operational goal: Intensification of inter-sectoral cooperation (planning processes within different sectors to be based on inter-sectoral coordination) and introduction of IWRM principles in other sectors.

The goals of RS Framework Plan are that Plan serves as base for: elaboration of Development Strategy of RS, defining physical requirements for water infrastructure (Physical Plan of RS was not elaborated), elaboration of planning documentation of other sectors and to define interrelations of all water plans with requirements of physical planning and environmental protection.

d. If not, can you identify any long-term planning document which sets out the vision, mission, goals and tasks of state policy in water management, particularly groundwater management?

2. To what extent was performed transposition of European water directives, particularly the Water Framework Directive, new Groundwater Directive and Nitrate Directive into national legislation? What is the state of the implementation of these directives?

According to the Progress Monitoring Report prepared by Regional Environmental Center (REC) for period 2009-2010, transposition of WFD into Water Law of FB&H is 90 % and in RS 100%. Transposition of the Nitrate Directive is still at an early stage - only the definition of groundwater is provided in the Water Law of FB&H which makes 11% of compliance, and transposition of this Directive in RS is relatively advanced, through the implementation of the new Water Law and supplementing regulations, and it is 22%.Since the transposition of the requirements of the Ground Water Directive was not analyzed in the above mentioned report, there are no reliable data on level of compliance of entity Water Laws with this Directive.

However, according to the FB&H Water management Strategy, there is still lot of job to be done, particularly related to the adoption of numerous sub.-laws. It sets deadline for full transposition of WFD and ground water directive in 2012, as well as for Nitrate Directive in 2009 .

3. Can you explain how the "user/polluter pays principle" and the principle of recovery of the costs is promoted in the legislative framework of your country?

The Environmental Protection Law of FB&H ("Official Gazette of FB&H" No. 33/03) defines in article 11. User/Polluter pays principle, and Environmental Protection Law of RS ("Official Gazette of RS" No. 53/02, 109/05) also in article 11. defines User/Polluter pays principle. In these articles is precisely defined that polluter pays the costs for control and prevention of pollution regardless of the fact if the costs are the result of the imposed obligation for polluting emissions or certain economic mechanisms, or obligation arises from the regulations relevant for pollution reduction in environment. These articles further on define that user of the environment is responsible for all activities that might impact the environment. Article. 109 of Environmental Protection Law of FB&H and article. 119 of Environmental Protection Law of RS defines that in case that operator performs the activity that can harm environment, the operator is responsible to reimburse the costs for damage assessment and recovery costs.

FB&H Water management Strategy supports application of cost –recovery principle in accordance to economic analysis (Appendix III of WFD) and polluter –pay principle. It sets economic operational goal: Sustainable financing in water management and full cost recovery from users or from other sources. However, principle of cost recovery is not fully implemented nor in B&H regulations nor in water management practice as well. Application of the charges for the use and protection of water, in the way defined by the *Water Law*, is necessary to expand, taking into account the environmental and

resources costs, which are not properly defined. Specifically, the economic value of groundwater is not clearly defined, especially in terms of defining and evaluating the different functions of a (ground)water environment.

RS Framework Plan sets guidelines for implementation of IWRM, including economic pre-requests i.e. policy of real prices which considers cost – recovery and pollution-pay principle.

4. Can you specify any legal or policy document containing provisions on integration of environmental and resource costs into the development of pricing policies?

There is no legal or policy document containing provisions on integration of environmental and resource costs into the development of pricing policies in FB&H or RS.

5. Has your country implemented the approach for defining (qualitative and quantitative) status of groundwater bodies, according to the WFD and GWD? Does it include:

a. some specific provisions on karstic areas?

There are no specific provisions on karstic areas

b. Provisions on the methodology for defining threshold values and/or groundwater quality standards, according to the GWD?

Water Laws of FB&H and RS contain provisions related to classification of the status of the groundwater bodies, according to the WFD, by monitoring of parameters for classification of the quantitative status and chemical status of ground waters.

The following sub-laws relevant for ground waters are still to be prepared according to the Water Laws:

-The methodology for determining the types of water bodies for surface water and characteristics of water bodies for surface waters and ground waters.

-Parameters of the quantitative and chemical quality for the classification of status of the water bodies of groundwater.

6. What is the status of development of the national river basin management plans?

Article 25 of the Water Law of FB&H and Article 26 of Water Law of RS prescribe the obligation of development of river basin management plans for defined watershed areas . Relevant Water Laws contain a detailed contest and procedure of adoption of water management plans. Deadline for preparation of the first river basin management plans in FB&H and in RS is 2012.

Howevever, FB&H Water managment Strategy sets more flexible deadline for elaboration of river basin Managment plans - 2015 including program of measures

Currently, river basin management Plans are in process of elaboration for: Rivers Krka and Cetina and Rivers Neretva and Trebišmjica.

7. Is the program of measures that will be applied within the river basin management plans already defined? If not, can you identify any legal or policy document in which such program of measures exists?

Water Laws of the FB&H and RS define that program of measures contains basic measures which are necessary in order to achieve objectives related to water protection, water management , water regulation, protection from

negative impact of the waters as well as to water usage. Supplement measures are to be defined as well if necessary for good water status.
Water laws prescribes obligation of elaboration of program of measures and lists (very generally) basic and supplementary measures, that should be applied within the river basin management plans in accordance with WFD.

8. If existing, how the program of measures relates to the WFD requirements, specifically to the need for defining the basic and supplementary measures?
Program of measures still does not exists.
a. Can you specify the most important measures which are or are planned to be implemented for groundwater protection?
b. Can you specify whether and how the measures necessary to prevent or limit (direct or indirect) input of pollutants into groundwater are implemented?
c. Does the program of measures contains the obligation of controlling and reducing water pollution from point and diffuse sources of pollution?

9. Do you think that the existing system of protection of the well fields and springs is good in your country, or it requires some changes?
According to the F B&H Water Management Strategy, the existing system of protection of the well fields and springs is not satisfactory. For number of water sources Decision on water source protection has not jet been adopted, and only for some of them protection measures are in place.
Similar situation is in RS as well.

a. Can you specify the legal base for the existing practice of groundwater protection in the karstic areas?
In FB&H, the Regulation on conditions for determining the sanitary protection zones and protective measures for water sources that are used or planned to be used for drinking („Official Gazette of FBiH" No. 51/02), defines the protection of ground water sources in karstic areas. This regulation was adopted on the basis of the Water Law of FB&H from 1998, and will stay in force until adoption of the new Regulation on the basis of the Water Law from 2006. This regulation prescrices very strict measures for protection of groundwater sources in the karstic areas.

In RS, Regulation on the protection measures and method of determining the sanitary protection zones as well as on areas where exist water sources, water management facilities and water for human utilization defines the above issues. («Official Gazette RS», No. 7/03).

b. Is the requirement for implementation of any kind of remedial measures in the zones of sanitary protection legally defined (e.g. implementation of BAT, removal of illegal facilities etc.)
Yes, regulations mentioned in question 9, point a., legally define the remedial measures in sanitary protection zones.

c. If yes, does it include also the remediation measures of contaminated soil and groundwater?
Yes, prescribed measures are described in details for each water protection zone (I, II and III). They are very strict and include measures of contaminated soil and groundwater. For e.g., in protection zone I, all activities which are not related to the normal functioning of the water facility are forbidden, and activities performed with the purpose of maintaining and enabling normal functioning of the water facility must not have harming effect on environment. Construction of industrial and other facilities is also forbidden in the protection

zone II, and protective measures in the protection zone III are more flexible regarding construction, but still strict enough to prevent contamination of soil and groundwater.

10. Are there any differences in the approach for groundwater protection in different types of aquifers? If yes, define main differences, related to:

a. the methodology of delineation of sanitary protection zones,

Methodology of delineation of sanitary protection zones is described in regulations mentioned in question 9, point a.
Regulation prescribes that the sanitary protection zones are determined depending on the type of aquifer, separately for aquifers with intergranular porosity and separately for karst aquifers.
For aquifers with intergranular porosity three zones of sanitary protection are prescribed I, II and III: zone of strict protection regime, zone of limited protection regime and zone of smooth protection regime, respectively.
For karst aquifers four *zones (Ia, Ib, II, and III)* are prescribed: zone of strictest protection regime – water source zone, zone of strict protection regime, zone of limited protection regime and zone of smooth protection regime, respectively.

Generally, methodology of delineation of sanitary protection zones is based for both intergranular and carst aquifers on groundwater velocity and time of travel to particular source.
For intergranular aquifers: border of I zone is defined on the base of 50day of water travel to the source, border of II zone is defined on the base of 180day of water travel to the source, borders of III zone are defined from the outside border of II zone up to the border of hydro-geological watershed area.

For kars aquifers: border of Ia zone is defined on the base of 24h of water travel to the source (or at least 50 m from the karst source), border of Ib zone is defined on the base of 48h of water travel to the source (or at least 50 m from the karst source), border of II zone is defined on the base of 4 day of water travel to the source, borders of III zone are defined from the outside border of II zone up to the border of hydro-geological watershed area.

b. the types of hydrogeological investigation needed for delineation of sanitary protection zones

Regulations mentioned under question 9., point a., prescribe that sanitary protection zones are defined depending on local conditions, determined by investigation works and expert study prepared by registered institution for such type of works. For the purpose of establishment of sanitary protection zones and protective measures B&H regulation doesn't contain further explanation on the types of hydrogeological investigation needed for delineation of sanitary protection zones in either type of aquifers.

c. the measures applied in different types of aquifers.

The measures applied depend on the types of aquifers. According to the Regulation, protection measures generally include: regular monitoring of water quality in water source catchment areas, construction and reconstruction of waste water and water supply systems,, wastewater treatment, forests recovering etc.

11. Is groundwater in the karstic area specifically treated in the national legislation?

Only in the context of sanitary zones protection (Point 9 and 10)

12. Are the areas intended for the abstraction of water for human use specified in the regulations or strategic documents? How they are treated:

a. as whole groundwater bodies, according to the criteria set in the WFD, or

b. as a sanitary protection zones around the well fields and springs?

Classification of protected areas specified in the relevant Water Laws of FB&H and RS is in accordance to WFD (5 types of protected areas one of which is protected area for abstraction of potable water for human use). Protected area for abstraction of potable water is defined as area in which is located water source which, according to its capacity and quality, might be used or is already used for public water supply. The Laws define that these sources must be protected from pollution and other negative impacts on health characteristic for potable water and on capacity of the source. On this protected area, water source protection is performed by defining the sanitary protection zones (sizes, borders, regimes etc in accordance to Regulation mentioned in point 9a).

Relevant by-laws (regulations mentioned in point 9a) treat those protected areas as a sanitary protection zones, but the zones "technically" cover the whole catchment area of the source (surface and underground catchment area).

13. Can you identify any other types of groundwater protected areas in your country, which are legally defined (other than the "Drinking water protected areas" (DWPA) or sanitary protection zones, which are specified in the WFD)? In Croatia we have designated the area with strategic groundwater reserves, which are intended for the current or future abstraction of water for human use.

According to the Article 69. of Water Law, beside the protected area for abstraction of potable water, Water Agency can determine protected areas with inland water reserves regardless of their future usage. These areas are determined in accordance to defined reserves of inland waters which are classified in to highest rang, taking into account their chemical, physical-chemical and microbiological characteristics. On the proposal of Water Agency, regulation could be adopted for restriction of occupation of space and limitation of activities which could endanger qualitative or quantitative characteristic of inland waters.

According to the Article 70. of Water Law (temporary protection), for the water source which could be significant for future water supply, usage of mineral, thermomineral or other ground water source, Water Agency propose adoption of regulation on temporary protection of the area in which the source is located. Regulation define borders of protected areas, temporary water protection regime, financing modele of protection, maintenance of the area and supervision of regime implementstion. This regulation is implemented until the adoption of Decision of water sorce protection

14. In what way is defined (within legislative framework) the need for inclusion of sanitary protection zones and other protected areas in the spatial planning documents?

FB&H Law on spatial planning and lend use ("Official Gazette of FB&H" No. 2/06, 72/07, 32/08, 4/10, 13/10, 45 /10) defines that Spatial plan of FB&H determines particularly basic principles of spatial planning, protection, usage and land use as well as the areas of importance for Federation B&H. Further on, this Law prescribes that the performer of the planning document shall

prepare a document in accordance with the Law, the Decree on unique methodology for the development of physical planning documents, regulations issued there under, the decision on preparation of documents and other regulations and information relevant to the area for which the document is prepared. Accordingly, this defines the need for inclusion of sanitary protection zones and other protected areas in the spatial planning documents. Mentioned Law also contains provisions related to establishment of infomration system with relevant data and information for all territory of FB&H, including data on natural resources with its qualitative and quantitative characteristics.

The Law on Construction and spatial planning if RS ("Official gazette of RS" No. 55/10) in the simmilar way defines the need for inclusion of sanitary protection zones and other protected areas in the spatial planning documents.

15. Can you identify the legal base (e.g. law or rulebook) for establishment of groundwater monitoring?

a. If yes, does it include clear criteria related to:
   i. Conceptual model of groundwater system
   ii. Representativeness of the monitoring places
   iii. Selection of parameters
   iv. Integrated monitoring requirements (e.g. in the case of proved hydraulic connection between surface waters and groundwater)
   v. Frequency of sampling etc.

Relevant articles of Water Law of FB&H and RS contain provisions which define that authorized Water agencies are obliged to organize groundwater monitoring.

FB&H Water management Strategy set *water protection* *operational goal* – Elaboration of river basin management Plans and related measure - establishment of supervision system for surface and groundwater quality which will be derived from Monitoring Program (until 2014 year) - according to the Annex 5 of WFD Development of surface and ground water monitoring program - monitoring of chemical status of ground waters .

RS Framework Plan stipulates necessity of providing adequate gauge stations for water quality and quantity monitoring.

16. Does your national legislation include provisions regulating GW abstraction (quantity) such as permits systems, control on wells, and control on well drillers? Specify.

Water Law of FB&H and RS contain provisions which generally define the abstraction of water trough the permits system.
Abstraction of water from the wells and ground waters, except for general use (use which does not consider any specific facility for abstraction, use on private property which consider basic water needs of one household, recreation use …), can be approved only after performance of the water investigating works. All legal and private subjects which abstract raw water, except for general use, are obliged to register the amounts of extracted water and to deliver those data to the authorized Water agency as well as to obtain water permit.

4. NATIONAL (B&H) SWOT ANALYSE

Strengths

Good availability of water resources (intergranular and karst aquifers) v.s. water demands for human and economy activities

Potential for economic development (hydro-energy, agriculture…and recreation activities

Skilled experts for technical aspects of water management

Water sector reform according to EU principles and legislation accepted and underway

Transposition of EU legislation under way (elaboration of sub-laws)

Water Laws of FB&H and RS contain provisions related to classification of the status of the groundwater bodies

Elaborated Water management Strategy in compliance to EU principles

Established institutional set-up for managing water at river basin level

Weaknesses

Low level of water supply coverage and services

Low level of waste water coverage and services and WWTPs

Low level of implementation of water sources protection measures within sanitary protection zones

Lack /missing of water quantity and quality monitoring, particularly ground water

Slow progress in water sector reforms due to: -complex institutional set-up (two governmental entities and 10 cantonal entities in FB&H)
-lack of human capacities in administration (water lawyers, environmental engineers, water economists…)
-Inter-entity cooperation related to elaboration and implementation of river basin management plans and relevant sub-laws is optional

Slow progress in transposition of EU legislation, particularly in preparing sub – laws (ground water Directive not yet transposed, sub-laws relevant for ground waters are still to be prepared)

Slow progress in preparing river basin management plans with program of measures
(not any river basin management plan completed)

Principle of cost recovery only partially implemented in water management practice

Opportunities

Inclusion of B&H into EU integrations

Technical and financial support to water sector reforms by international community, particularly EU funds

Promotion of investment in the field of wastewater collection and treatment for large and small agglomerations as well as for drinking water supply systems

Improving program of groundwater monitoring taking into consideration the requirements of EU directives

Criteria for determining good chemical and quantitative status need to be properly defined in river basin management plans

Initiation of institutional effort for support of better communication between decision-makers and legislators and water scientists and experts working on national or international scientific or professional (ground)water projects

Threats

Lack of human resources and financial means for fulfilling policy requirements

Sustainable financing in water management

Impact of climate change on (ground)water resources is not adequately considered in national regulations and policies

WG 4
STAKEHOLDERS PARTICIPATION

NATIONAL CONSULTANT: ALMA IMAMOVIĆ

TABLE OF CONTENT

IV COMMUNICATION, DISSEMINATION AND REPLICATION ACTIVITIES

5. STAKEHOLDER ANALYSIS

The steps for preparing the Stakeholders Analysis are presented below; a number of coordination meetings between the GWP-Med team and the National Experts were used for the preparation and implementation of the respective actions..

(i). Identification of stakeholders at the transboundary level and preliminary analysis of their characteristics.

(ii). On-line survey for information collection.

(iii). National Consultation Meetings with selected stakeholders in order to: (a) elaborate on initial information acquired regarding stakeholder identification and analysis, and; (b) to acquire new information regarding the significant issues related to the karst aquifers' management to be fed in the preparation of Transboundary Diagnostic Analysis.

(iv). Processing and analysis of National Consultation Meetings results.

(v). Semi-structured Interviews with selected stakeholders.

- Preparation of questionnaires / interview script;
- Selection of the stakeholders to be interviewed;
- Interview of selected stakeholders);

(vi). Preparation of the stakeholder analysis report using the results of the on-line surveys, the National Consultation Meetings and the selected stakeholder Interviews

Characteristics of the stakeholders

The categorization of the important stakeholders at transboundary level in accordance to their characteristics (interest, influence, importance and attitude) is given under (b. Workshops).

Stakeholders are grouped in four tables for each Project country, in accordance to their characteristics - these tables constitute the transcription of the "Influence – Interest" Stakeholders' Grid produced by the participants of the National Consultation Meetings (see Part A, section 1.1.2, point (iv)):

i. High Interest / High Influence
ii. High Interest / Low Influence
iii. Low Interest / High Influence
iv. Low Interest / Low Influence

Furthermore, the level of importance and the attitude of each important stakeholder, as this is perceived by the participants of the National Consultation Meetings, is indicated in each of the aforementioned tables.

5.1. Bosnia and Herzegovina On-line Survey Results

Seventeen (17) stakeholders participated in the survey; a little more than half answered most or all of the questions. The majority of the respondents (16) are involved in Projects relevant to water management. Tourism Agencies/Boards are best represented in the survey.

Table: On-line survey participants

Nature of Organisation	
Ministry or other high level governmental authority	0
Entity / Regional or Local Government body/Authority (entity, region, county, municipality etc.)	4

Protected Area Authority	0
River Basin District Agency	1
State Organisation	0
State owned utility	2
Research institute	1
Land and Water Use Associations / Cooperatives (Farmers'/Livestock Breeding/Fishermen/Water Boards)	3
Public Enterprise (Forest and Water Management)	1
Private sector (land owners, navigation, industry) including Chambers	0
Tourism Agency/Board	5
NGO	0
Civil society	0
Local community	0
International and Regional Institution or Organisation	0
Donor country and development agency	0
International Commission/Committee/Organisation	0
Media	0
Religious Institution	0

All of the respondents that answered the relevant questions stated that they wish to get involved in the management of groundwater in the Dinaric Karst Area and would like to be kept informed about the DIKTAS project. E-mail communication, either bulk or personalised e-mails, provided on a monthly basis, and monthly internet updates in the DIKTAS website are the most preferred means of receiving information. According to most of the responses, publications should be prepared and disseminated on outstanding occasions; the same is indicated for information meetings.

Furthermore, all of those responding to the relevant question, wish to contribute information to the Project team and to be consulted and/or contribute to the project implementation. The respondents would be doing this equally through participating in meetings and through the internet, while responding in on-line surveys also seems to be suitable for them. Travelling to the capital or the nearest big city in order to participate in consultation activities is acceptable by the respondents, while one stakeholder is willing to travel anywhere within the project area.

Most of the respondents indicated **Expertise and Information**, followed by **Human Resources**, and to a lesser degree **Political Power/Lobbying** as resources that they have available; the option of Financial Resources was not indicated by anyone.

Table: Preferred means of information and frequency

Would you prefer to be informed by... (choose all that apply)						
Answer Options	every month	every 3 months	every 4 months	on outstanding occasions	never	**Responses**
Information provided on DIKTAS website	7	1	0	0	0	**8**
Bulk e-mails	5	2	0	1	0	**8**
Newsletter	1	1	1	2	0	**5**
Publications (brochures, leaflets)	1	0	0	3	0	**4**
Personalised e-mails	4	2	1	1	0	**8**
Information meetings (conferences, workshops, lectures)	2	1	2	3	0	**8**

Figure Willingness to travel

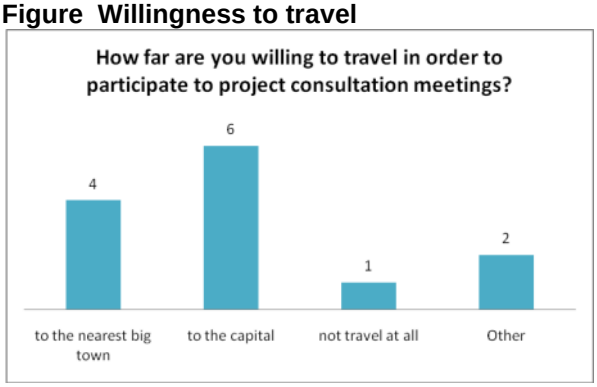


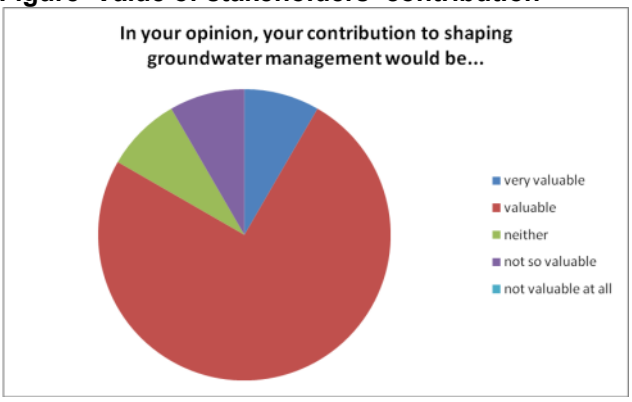
Table Preferred means of consultation

Would you like to be consulted by ... (choose all that apply)	
Answer Options	**Responses**
participating in consultation meetings	10
providing feedback in electronic or other form	10
participating in on-line surveys	7
Other	1

Figure Stakeholders' available resources

Most respondents consider their contribution to a project like DIKTAS as valuable and attribute this value to the experience they have to offer and their professional position and responsibilities. Results show an important pool of knowledge potentially available for the purposes of karst water-management improvement.

Figure Value of stakeholders' contribution



5.2. **Sarajevo** National Consultation Meeting **Results**
Stakeholders Map and Evaluation

Participants to the National Consultation Meeting evaluated a large number of stakeholders, removed a small number considered irrelevant to the subject of karst aquifers management, and identified additional thirteen (13) stakeholders as being important at the transboundary level; the resulting list includes hundred-twenty-seven (127) stakeholders. These are presented in the tables 19, 20, 21 and 22 below. The large number of stakeholders is attributed to the extent of the project area and the institutional setting in the country.

The participants evaluated stakeholders representing most water users as of high interest; these included the municipalities overlapping the karst aquifers, farmers associations, central and entity management authorities, the ecosystem as represented by the Nature Parks and some NGOs, and the hydropower industry. However, the tourism sector was assumed to have low interests and influence on the matter of groundwater resources. The private sector is underrepresented. It is also noted that according to NCM participants the vast majority of the stakeholders are presumed to have a positive attitude towards the DIKTAS, its goals and objectives, and high importance to the success of the project.

Category 1 – High interest/ high influence

A little more than a third of the stakeholders (47 stakeholders) that were identified as important at the transboundary level were categorized as of high interest/ high influence. Most of these stakeholders are perceived to be of high importance. The participants estimated five (5) stakeholders as having a neutral attitude towards the project and had no inclination for one other, who happens to be the stakeholder attributed with low importance. No probable opponents were identified. A large number of ministries from both entities and most of the municipalities are included in this category, and attributed high importance. Other stakeholders include water agencies and research institutes, but also hydropower production utilities, and the Farmers' Association for Republika Srpska.

Category 1 requires the highest attention of the project, since these are stakeholders with high interests, and therefore high motivation, and high influence or means to promote or hinder the objectives and the implementation of the project. They should be consulted and engaged in the project participation process. Efforts should be put in order to inform and gain the support of two stakeholders who are of high importance and neutral attitude.

Table Category 1 – High interest/ high influence[2]

Bosnia and Herzegovina – Stakeholders	Importance	Attitude
Delegation EU in BiH	HIGH	SUPPORTER
European Bank for Reconstruction and Development (EBRD)	HIGH	SUPPORTER
Council of Europe Development Bank CEB	HIGH	SUPPORTER
Commission for transboundary Water Management between BiH and Croatia	HIGH	SUPPORTER
Ministry of Foreign Trade and Economic Relations – BiH	HIGH	SUPPORTER
FBiH: Ministry of Agriculture, Water Management and Forestry	HIGH	SUPPORTER
FBiH: Ministry of the Environment and Tourism	HIGH	SUPPORTER
FBiH: Ministry of Physical Planning	HIGH	SUPPORTER
FBiH: Ministry of Energy, Mining and Industry	HIGH	SUPPORTER
RS: Ministry of Agriculture, Forestry and Water Management	HIGH	SUPPORTER

[2] BiH: Bosnia and Herzegovina, FBiH: Federation of Bosnia and Herzegovina, RS: Republika Srpska

RS: Ministry of Industry, Energy and Mining	HIGH	SUPPORTER
Environmental inter-entity governing body	HIGH	SUPPORTER
Hercegovina-Neretva Canton	HIGH	SUPPORTER
Cantonal Ministry of Construction and Urban Planning, Hercegovina-Neretva Canton	HIGH	SUPPORTER
Una-Sana Canton	HIGH	SUPPORTER
Municipality Trebinje	HIGH	SUPPORTER
Municipality Bileće	HIGH	SUPPORTER
Municipality Gacko	HIGH	SUPPORTER
Municipality Nevesinje	HIGH	SUPPORTER
Municipality Berkovići	HIGH	SUPPORTER
Municipality Grude	HIGH	SUPPORTER
Municipality Široki Brijeg	HIGH	SUPPORTER
Municipality Posušje	HIGH	SUPPORTER
Municipality Tomislavgrad	HIGH	SUPPORTER
Municipality Bihać	HIGH	SUPPORTER
FBiH: Water Agency for Adriatic Sea Watershed	HIGH	SUPPORTER
FBiH: Water Agency for Watershed of the Sava River	HIGH	SUPPORTER
RS: Water Agency for Trebišnjica River District	HIGH	SUPPORTER
HET Trebinje	HIGH	SUPPORTER
Federal Institute for Agriculture Sarajevo	HIGH	SUPPORTER
Federal hi Zavod Agro Geologija	HIGH	SUPPORTER
Youth environmental organisation "Juznjacko plavo nebo"	HIGH	NEUTRAL
Municipality Jablanica	HIGH	NEUTRAL
RS: Ministry of Physical Planning, Civil Engineering and Ecology	MEDIUM	SUPPORTER
Cantonal Ministry of Trade, Tourism and Environment, Hercegovina-Neretva Canton	MEDIUM	SUPPORTER
Municipality Konjic	MEDIUM	SUPPORTER
P.E. Elektroprivreda HZ HB (PE Elektroprivreda Hrvatske Zajednice Herceg-Bosne)	MEDIUM	SUPPORTER
Agricultural Institute of Republika Srpska	MEDIUM	SUPPORTER
Institute for Geology Sarajevo	MEDIUM	SUPPORTER
Water Institute Bijeljina	MEDIUM	SUPPORTER
Farmers Association RS	MEDIUM	SUPPORTER
The Association of Cities and Municipalities of the FBiH	MEDIUM	SUPPORTER
City of Mostar	MEDIUM	NEUTRAL
Municipality Čitluk	MEDIUM	NEUTRAL
Municipality Ljubuški	MEDIUM	NEUTRAL
Association of Forestry Engineers and Technicians RS or Forestry of RS	LOW	SUPPORTER
Municipality Bosanska Krupa	LOW	

Category 2– High interest/ low influence

Thirty-five (35) stakeholders were placed under this category by the NCM participants. Thirty (30) stakeholders are estimated to be of high importance, three (3) of medium and one (1) of low importance. The vast majority is estimated to be supportive (33) while only one is estimated to be neutral towards the project

objectives and activities. Once more the stakeholder of neutral disposition is the one of low importance to the project.

Given its high interest and the high rate of positive attitude and importance, this group should be consulted and in cases engaged to the project; they could form a positive driving force. The category includes a fair amount of international funding organisations, research institutions, users associations and nature parks; these, could prove valuable in the development and the implementation of project activities as well as later on in the sustainability of the outcomes of the Project.

Table 1 Category 2 – High interest/ low influence[3]

Bosnia and Herzegovina – Stakeholders	Importance	Attitude
UNESCO	HIGH	SUPPORTER
GEF	HIGH	SUPPORTER
Swedish International Cooperation Agency (SIDA)	HIGH	SUPPORTER
United States Agency for International Development (USAID)	HIGH	SUPPORTER
Cantonal Ministry of Agriculture, Forestry and Water Management	HIGH	SUPPORTER
Municipality Ravno	HIGH	SUPPORTER
Municipality Čapljina	HIGH	SUPPORTER
Municipality Bosanski Petrovac	HIGH	SUPPORTER
FBiH: P.E. Hutovo Blato - Nature Park	HIGH	SUPPORTER
FBiH: P.E. Blidinje - Nature Park	HIGH	SUPPORTER
FBiH: P.E. Vjetrenica -Popovo poljo, Ravno - Protected nature monument	HIGH	SUPPORTER
FBiH: Hydrometeorological Institute	HIGH	SUPPORTER
RS: Hydrometeorological Institute	HIGH	SUPPORTER
FBiH: Federal Agromediterranean Institute Mostar	HIGH	SUPPORTER
FBiH: Federal Institute for Geology	HIGH	SUPPORTER
Centre for Ecology and Natural Resources Sarajevo	HIGH	SUPPORTER
Geological Survey of RS	HIGH	SUPPORTER
Water Management Institute of FBiH	HIGH	SUPPORTER
Water Management Institute of RS	HIGH	SUPPORTER
Ichthyology and Fishery Centre, Faculty of Science University of Sarajevo	HIGH	SUPPORTER
Institut za Sumarstvo	HIGH	SUPPORTER
Biospeleological Society of BiH	HIGH	SUPPORTER
FBiH: Association of utility companies in FBiH	HIGH	SUPPORTER
Sports Fishing Association of BiH	HIGH	SUPPORTER
P.E. “BH Šume“	HIGH	SUPPORTER
P.E: ”Hercegbosanske Šume“	HIGH	SUPPORTER
Environmental protection association “Zeleni-Neretva“	HIGH	SUPPORTER
Centre for development Herzegovina	HIGH	SUPPORTER
Ekomreža BiH	HIGH	SUPPORTER
Ecological organization “Lijepa Naša Neretva"	HIGH	SUPPORTER
Municipality Velika Kladuša	MEDIUM	SUPPORTER
Farmers Association BiH	MEDIUM	SUPPORTER
Union of Agricultural Association of West Herzegovina	MEDIUM	SUPPORTER

[3] BiH: Bosnia and Herzegovina, FBiH: Federation of Bosnia and Herzegovina, RS: Republika Srpska

Municipality Cazin	LOW	NEUTRAL
WWF Mediterranean Programme		

Category 3 – Low interest/ high influence

The third category contains fewer stakeholders (18) than the other three. A little more than half of these stakeholders (11) are attributed with a high level of importance, four (4) with medium and two (2) with low. With regard to one of the stakeholders, (PE Elektroprivreda RS-Trebinje) the participants of the workshop could not make a definite estimation of its importance or of its attitude towards the project aims and activities. Local authorities at Canton level are included here, along with development organisations. All of the stakeholders in this category are thought to be supportive to the Project, and given their high influence this category should be treated with caution and kept well informed of the positive input of the Project to karst aquifers management in order to maintain their favourable attitude. The project should take under consideration the needs and the concerns of these stakeholders and aim to engage them on issues of their specific interest.

Table Category 3 – Low interest/ high influence[4]

Bosnia and Herzegovina – Stakeholders	Importance	Attitude
Cantonal Ministry of Economy	HIGH	SUPPORTER
Western Hercegovna Canton	HIGH	SUPPORTER
Cantonal Ministry of Economy, Western Hercegovna Canton	HIGH	SUPPORTER
Cantonal Ministry of planning construction and environmental protection, Western Hercegovna Canton	HIGH	SUPPORTER
Una-Sana Canton	HIGH	SUPPORTER
Cantonal Ministry of Civil Engineering Physical Planning and Environmental protection, Una-Sana Canton	HIGH	SUPPORTER
Cantonal Ministry of Agriculture, Water Management and Forestry, Una-Sana Canton	HIGH	SUPPORTER
Western Bosnian (Herceg-Bosana; Livno) Canton	HIGH	SUPPORTER
Municipality Neum	HIGH	SUPPORTER
Municipality Livno	HIGH	SUPPORTER
Association of municipalities and towns of Republic of Srpska	HIGH	SUPPORTER
United Nations Development Programme (UNDP)	MEDIUM	SUPPORTER
Hydro-Engineering Institute, Sarajevo	MEDIUM	SUPPORTER
Association for Hunting BiH	MEDIUM	SUPPORTER
Kreditanstalt für Wiederaufbau, KfW - Reconstruction Credit Institute	MEDIUM	SUPPORTER
German Technical Cooperation – GiZ	LOW	SUPPORTER
Netherlands Development Organization - SNV	LOW	SUPPORTER
PE Elektroprivreda RS-Trebinje		

Category 4 – Low interest/ low influence

The fourth Category 4 includes twenty-seven (27) stakeholders. Little more than half (14) are estimated to be of high importance. As in the other categories, support is high; there are only two neutral stakeholders included here. The Chambers of Commerce (for RS) and Economy (for FBiH), are placed in this category by the NCM participants indicating the perception of the participants for the private sector as having low interest and low influence in water management issues. With regard to stakeholders in the tourism sector, the participants of the workshop could not make a

[4] BiH: Bosnia and Herzegovina, FBiH: Federation of Bosnia and Herzegovina, RS: Republika Srpska

definite estimation of their attitude towards the project aims and activities. Since tourism is proposed as a development option for the area, the project should aim to engage with them and gain their support. All stakeholders in this category should be kept informed about developments in karst aquifers' management and the project activities.

Table Category 4 – Low interest/ low influence[5]

Bosnia and Herzegovina – Stakeholders	Importance	Attitude
World Bank	HIGH	SUPPORTER
Municipality Ljubinje	HIGH	SUPPORTER
Municipality Stolac	HIGH	SUPPORTER
Municipality Kupres	HIGH	SUPPORTER
Municipality Bosansko Grahovo	HIGH	SUPPORTER
P.E: "Šume RS"	HIGH	SUPPORTER
University of Banja Luka	HIGH	SUPPORTER
Faculty of Forestry, Sarajevo	HIGH	SUPPORTER
Regional Environmental Centre BiH- Sarajevo	HIGH	SUPPORTER
Association of Nature Admiers «Močvara» Čapljina	HIGH	SUPPORTER
EKO Neretva	HIGH	SUPPORTER
European Investment Bank (EIB)	HIGH	
University of Sarajevo	MEDIUM/HIGH	SUPPORTER
Faculty of Science, Sarajevo	MEDIUM/HIGH	SUPPORTER
The Mediterranean Commission on Sustainable Development (Barcelona Convention)	MEDIUM	SUPPORTER
Institute for Agricultural Economic and Food Industry, Sarajevo	MEDIUM	SUPPORTER
FBiH: Chamber of Economy	MEDIUM	SUPPORTER
RS: Chamber of Commerce	MEDIUM	SUPPORTER
Wine Route of Herzegovina	MEDIUM	SUPPORTER
Environmental association "Bura" Mostar	MEDIUM	SUPPORTER
Municipality Bužim	MEDIUM	NEUTRAL
RS: Association "Water supply and sanitation companies in RS"	MEDIUM	NEUTRAL
Tourist Board of Hercegovna-Neretva cantonzajednica HNK/Ž	MEDIUM	
Tourist Board of Una-Sana Canton	MEDIUM	
Tourist organisation of RS	MEDIUM	
Association of Forestry Engineers and Technicians FBiH	LOW	SUPPORTER
BiH: Foreign Trade Chamber	LOW	SUPPORTER

5.3. Results from interviews

The following organizations and institutions were interviewed in Bosnia and Herzegovina between 24 of April and 18 of June 2012:

Table List of Key Stakeholders interviewed

Stakeholders Interviewed	
1	Ministry of Foreign Trade and Economic Relations BiH
2	FBiH: Ministry of Agriculture, Water Management and Forestry
3	FBiH: Ministry of the Environment and Tourism

[5] BiH: Bosnia and Herzegovina, FBiH: Federation of Bosnia and Herzegovina, RS: Republika Srpska

4	RS: Ministry of Agriculture, Forestry and Water Management
5	Western Hercegovina Canton
6	Una-Sana Canton
7	Trebinje Municipality
8	Water utility company Bileće
9	FBiH: Water Agency for Adriatic Sea Watershed
10	FBiH: Water Agency for Watershed of the Sava River
11	RS: Water Agency for Trebišnjica River District
12	Federal Institute for Agriculture Sarajevo
13	FBiH: P.E. Hutovo Blato - Nature Park
14	PE Elektroprivreda BiH Sarajevo
15	P.E. Elektroprivreda HZ HB (PE Elektroprivreda Hrvatske Zajednice Herceg-Bosne)
16	PE Elektroprivreda RS-Trebinje- HET Trebinje
17	WWF Mediterranean Programme
18	NGO VRELO
19	Lijepa naša Čapljina
20	Chamber of Commerce RS, Regional office in Trebinje
21	Institute for geology FBiH

5.3.1 Level of knowledge

Almost all the responders interviewed are familiar with the WFD's objectives. Half of the respondents feel they are not sufficiently informed about issues related to groundwater management. Only four out of the 21 interviewees are not aware of the DIKTAS project and all wish to be kept informed about the project. This is very encouraging and indicative of the interest for the Project and for karst aquifers management.

The most commonly stated sources of information regarding water-management issues are the Water Agencies of the country and more in particular the Water Agency for Sava River Watershed in Sarajevo and the Water Agency for the Adriatic Sea Watershed in Mostar. The next most common source of information according to the respondents are the various projects in the area, including the DIKTAS and the GEF Project "Neretva Trebišnjica water management project"; equal in popularity are the Internet, European and national legislation, and various official documents.

The interviewees prefer information to be provided mostly through personalised e-mails on a monthly basis or on outstanding occasions and through brochures mostly on outstanding occasions as well. A well maintained website is greatly appreciated, while face to face communication in the form of workshops, and information meetings occasionally or every six months are also preferred. Furthermore, hard copy newsletters seem to be more popular than electronic newsletters among the interviewees. Regarding the content of information all related options provided to the stakeholders are almost equally popular (see Table 24).

Table Content of Information

What would you like to be informed about?	
Information Content	**Responses**
News about the DIKTAS project	17
Karst aquifer management issues	16
Water management policy issues	17

Water management practical issues	18
Best practices and guidelines	17
How to participate in the DIKTAS activities	12

5.3.2. Desired Capacity and willingness of the Stakeholder to contribute, and desired level of participation to the DIKTAS Project

All interviewees are strongly (10) or somewhat (10) supportive[6] to the improvement of the management of Transboundary Karst Aquifers through enhanced cooperation (one stakeholder has not given a reply but is considered to be supportive as they are involved in the project). The resources which are available and can be easily mobilized by most of the respondents towards this goal are **Human Resources** and **Expertise and Information**. Financial resources and political power/lobbying are on the other edge of the spectrum: the least available kind of resources and those not easily mobilised. The stakeholders interviewed appear to be a good pool of expertise and a fair pool of human resources.

Table Resources available to stakeholders and ability to mobilise them

Which resources are available to your organization/institution/authority and how easily can these be mobilized to influence decisions related to the management of the Transboundary Karst Aquifers?								
Resource	**Not easily**	**Easily**	**Very easily**	**A**	**B**	**C**	**D**	**E**
Financial resources	9	2	0	10	2	2	0	0
Expertise / Information	6	10	0	2	1	9	3	1
Political power / Lobbying	9	4	0	6	3	2	2	0
Human resources	4	13	2	1	9	4	4	0
Other (please specify)		2		1	0	0	1	0

(A) VERY LITTLE, (B) LITTLE, (C) SOME, (D) ENOUGH, (E) A LOT

5.3.3 Expectations from participating in the DIKTAS implementation

The vast majority of the respondents wish to participate in the DIKTAS project implementation. The interviewees were asked to indicate the most preferred form of participation in the DIKTAS activities (see Table 26). Being **consulted on the TDA/SAP preparation process** is by far the most preferred form of participation followed by **being involved in and contributing to the project activities**.

Table Preferred form of participation in the DIKTAS' activities

What is the preferred form of participation in the DIKTAS' activities?	**Responses**
Contribute information related to my domain/business to be used through DIKTAS for the sustainable management of the transboundary karst aquifers	5
Consulted on the preparation of the document that analyse the aquifers systems state / on the transboundary problems and issues. **Consulted** regarding the identification of policy, legal and institutional reforms and investments needed to address the problems?	11
Involved in and contribute in the implementation of the project activities	6

With regard to the stakeholders participation in the management of the transboundary karst aquifers, advanced forms of participation were preferred: most responses (11) refer to **consultation on proposed decisions and measures**, followed in descending preference by **involvement in the decision making**,

[6] The stakeholders were asked to choose among the following options: strongly support it, somewhat support it, do not support nor oppose it, somewhat oppose it, strongly oppose it.

information about the decisions and measures and lastly involvement into the implementation of the decision. However, their participation in the decision making process could lead to their involvement and commitment in the implementation of decisions, if they feel ownership of the process and its products (decisions).

Most respondents list **Economic cost** followed by **Work load** as the main constraints keeping them from participating in the management of the transboundary karst aquifers, while **Lack of training/education** seems to be a considerable constrain as well.

Table Preferred form of participation in transboundary karst aquifers management

What is the preferred form of participation in the management of the transboundary karst aquifers?	**Responses**	International/ transboundary	National	Regional	Local
Informed about decisions and measures	7	4	4	6	3
Consulted on proposed decisions and measures	13	7	7	10	5
Involved into decision making	8	6	7	7	4
Involved into implementation of decisions	6	5	5	5	4

Table 2 Constraints to participation in the management of the transboundary Karst Aquifers

What constraints exist, that would hinder your participation in the management of the transboundary Karst Aquifers?	**Responses**
Economic cost (fees/taxes implied by measures, travel, equipment etc)	11
Work load (limited human resources)	9
Working with other stakeholders	3
Access to information	2
Lack of training/ education	5

Financial support is considered very important or important for stakeholders to overcome constraints and to participate meaningfully in the management of the transboundary aquifers. Furthermore, **Training/Education** and/or more **Human Resources** and **Opportunities for information exchange** are also valued as important or quite important as means of support for participation. This gives an additional value to the efforts of DIKTAS to engage with stakeholders and other relative initiatives.

Table 3 Support to participation in the management of the transboundary Karst Aquifers

What kind of support would you need to overcome these constraints and participate/ be involved?	Not Important	A bit important	Quite important	Important	Very important
Financial support	0	2	2	5	5
Training/Education and/or more human resources	0	0	6	5	2
Opportunities for information exchange with other stakeholders (e.g. conferences, meetings)	0	2	6	5	1
Legal advice	1	0	5	3	0
Access to information	0	0	5	5	0

5.3.4. Expectations and aspirations for the future of the transboundary Karst Aquifers management

Most interviewees wish to see the areas, where the transboundary Dinaric karst aquifers extend, developed according to the principles of sustainable development. Sustainable agriculture with organic production and cultivation of alternative crops such as medicinal plants is cited mostly. Sustainable tourism is also an activity stakeholders envisage for the development of the area. Furthermore, one stakeholder comments on the importance of public participation in the decision making procedure, which would ensure equality and sustainable economic development.

Table 4 Economic activities envisaged

Economic activities	
Sustainable Tourism	9
Sustainable Agriculture (organic production, medicinal plants)	10
Energy production - Hydropower	7
Animal husbandry	2
Food production industry	1
All economic activities according to sustainable development	3

The majority of stakeholders hope to see water management of the shared resources improving, through the cooperation, communication and networking between states and organisations, at transboundary through to local level. They support the preparation of management plans and the alignment of legislation and management of the resources to the basic objectives of the EU Water Framework Directive. They expect adequate protection of the natural wealth of the area, and the updating and modernisation of infrastructure.
Stakeholders are willing to contribute towards the improvements through cooperation and information exchange and proposals for solutions. Many are willing to contribute expertise and scientific knowledge to the project and other similar initiatives. A number of stakeholders commit to the development and implementation of legislation.
They view DIKTAS as an opportunity for the cooperation of the different actors and stakeholders at transboundary level and they appear very positive towards the idea of developing a common shared vision and the harmonization of karst aquifers management frameworks among the countries. They expect the promotion of sustainable management proposals, practices and mechanisms. Finally, the updating of methods in research use and protection of the resources as well as the production of more and reliable scientific knowledge on the resource are additional outcomes they expect to result from the implementation of the project.

5.4. Conclusions for Bosnia and Herzegovina

The identified stakeholders include a very wide range of actors, from primary users (farmers associations, municipalities, hydropower), to secondary stakeholders of various influence and importance to the project development. Ministries relevant to management of the recourse, research institutes, and most primary users (farmers associations, hydropower and municipalities) are characterised as having high interests and varying influence. The project should engage these into meaningful participation. Efforts should also be targeted towards the tourism sector, which is characterised by National Consultation Meeting participants as having low interests and low influence, but are however interested to contribute information and to participate in the consultation process according to the on-line survey. They also

constitute representatives of one of the proposed development options for the transboundary area and their current and potential impact on the water resources should be taken under consideration. Hydropower is also a sector which would require special attention, since it is one of the most important industries of the country, and is identified as one of the main pressures on the resource. The project should try to identify additional stakeholders from the private sector.
The interviewed key stakeholders are well aware of the DIKTAS project, an indicator of the interest into groundwater management in the country. They are all interested in the developments and achievements of the project and are supportive towards the project's and other initiatives' efforts for the enhancement of karst aquifers management. They wish to participate to the project implementation, and are very interested to engage in the decision making process and propose solutions. This could lead to their involvement in the implementation of the decisions made, once they feel ownership of the process and its products.
Furthermore, interviewed stakeholders are willing to a large degree to mobilise human resources and expertise in order to participate in karst aquifers management, and the project should aim to tap in this pool of resources by alleviating constrains to participation and providing support to the best of its ability. The most sought out support includes training and education support, financial support, opportunities for exchange of and access to information, as well as advice relating to legal and regulatory issues.
According to the stakeholders, the DIKTAS should aspire to facilitate communication and cooperation between aquifer sharing states and, to offer the opportunity for networking and knowledge and information exchange between initiatives and stakeholders in many different levels, transboundary, national, regional and local. It should also foster cooperation with other relative initiatives or projects in the area, since these are operating as efficient channels of information. The project should employ a combination of electronic and more conventional means in this regard, such as a well maintained website, bulk and, especially in the case of key stakeholders, personalised e-mails, but also hard copy newsletters and occasional or six-monthly meetings in order to pursue good communication with all stakeholders.

5.5. Perceived Significant Issues in Bosnia and Herzegovina

In Bosnia and Herzegovina the main issue identified is groundwater and surface waters affected by toxic substances, organic and bacteriological pollution. The most important causes indicated are unsustainable/insufficient municipal waste water management, followed by unsustainable/insufficient municipal solid waste management and unsustainable agricultural practices.
The identified decline of groundwater levels is attributed mainly to the production of hydropower.
The availability of data and scientific knowledge and the cooperation of all stakeholders for the enhanced management of the resource are issues also highlighted.
Raising of awareness of all stakeholders at all levels is considered as an important factor for addressing many of the issues affecting the shared groundwater resources
.

5.5.1. Issues

a) Pollution
Stakeholders have attributed pollution to the following sources; these are listed in terms of perceived significance.
Waste water pollution

Pollution due to unsustainable/insufficient waste water management is an issue rated as a top priority by the interviewed stakeholders; it is indicated to cause bacteriological and organic pollution and to affect equally both surface and underground waters. It is the second most familiar pressure for those answered the on-line survey. Mostly urban areas -households are recognised as the main users exerting pressure to karst aquifers- and to a less extent industries are mentioned as sources.

Pollution from solid waste

Most interviewed stakeholders indicate unsustainable/insufficient municipal solid waste management and more in particular landfills, as the source of groundwater pollution by toxic substances. The failure of landfills to meet basic sanitary and technological conditions is pointed out, resulting to infiltration of toxic substances to groundwater. Unsustainable waste management comes third as the most familiar pressure according to the on-line survey respondents and solid waste management is prioritised on top of the list of the NCM Pollution cluster of issues.

Pollution due to unsustainable Agriculture

Unsustainable agricultural practices, and most noticeably livestock waste management and use of agrochemicals, are indicated as the major contributors to nitrate and phosphate pollution. It is rated as the second most important issue within the Pollution cluster by NCM participants and is credited to low implementation of good agricultural practices.

b) Groundwater over-abstraction

Over-abstraction, leading to decline of groundwater levels, is the third most frequently quoted issue during the interviews with stakeholders[7]. This issue has been related to the use of the resource for the production of energy.

c) Hydro-technical infrastructure

Construction and operation of dams for electricity production, is one of the issues mentioned in conjunction with the issue of groundwater over-abstraction. Hydropower production is thought of as the second most important user in terms of pressure exerted on groundwater resources, affecting water dependent ecosystems as well as disturbing the water flow regime.

An improvement related to this issue is proposed by stakeholders: “Clearly define responsibilities and mechanisms for the control of hydro-power production facilities in accordance with adopted and implemented plans”. Diverting part of the water used for hydropower towards places where it appears to be a deficit it is thought to provide a solution for water scarcity.

d) Loss of biodiversity in surface waters and water-related ecosystems

This is an issue concerning stakeholders, who mention the value and the remarkable wealth of biodiversity in the water dependent ecosystems of the country and especially the transboundary areas of interest, and see it threatened by a number of issues, such as pollution, reduction of water flows, lack of protective measures, lack of awareness and others.

5.5.2. Other Significant Issues

A range of issues that are currently missing or are subject to improvement have been indicated by the stakeholders as means to achieve enhanced water management. Integrated water resources of surface water and groundwater resources is thought to be necessary by many.

a) Data and scientific knowledge / Research and application

Lack of reliable data regarding the characteristics of karst aquifers as well as its uses is the second most mentioned issue in the interviews with stakeholders and quoted

[7] One interviewee commended “4 million cubic meters of water has been taken from the groundwater aquifers and this water should be return to the ground”.

as a cause leading to decisions that are harmful to biodiversity and ecosystems. Stakeholders have referred to systematic monitoring and further research regarding the quality, quantity and protection of the resource as necessary for the proposal and implementation of appropriate protection measures.

b) Cross-border communication and cooperation

The need for bilateral agreements and management of the resources based on a common platform as well as transboundary management plans are indicated by the stakeholders, among others, as means for the protection of resource. Some stakeholders proposed in particular the adoption of a joint water resources management plan for the basins of Neretva and Trebšnjice, and Bileća Lake.

c) Legislation

The setting of rules through appropriate legislation was viewed by the participants in the NCM as necessary to address a series of issues of concern. These include the allocation of: groundwater resources among users at national and transboundary levels; responsibilities among Bilateral Commissions, Ministries, Agencies regarding the identification of the transboundary issues (hot-spots); responsibilities among the countries sharing the resource including with regard to the collection and exchange of information and data.

Furthermore, the need for improvements in the existing legislation and the adoption and implementation of the European Water Framework Directive (EU WFD) is mentioned.

Stakeholders point out that it should be made sure that national legislation, strategic documents and priorities are taken into consideration by the project regarding, among others, the preparation of suggestions related to investments and the mechanism that will govern their implementation.

d) Awareness

Lack of awareness among stakeholders including the institutions and authorities is raised as an issue of concern. Interviewed stakeholders point out the need to continually educate the public and different productive sectors, and to inform and involve them into the decision making process. One stakeholder also proposes the introduction of optional environmental education subjects as early as elementary school.

5.5.3. Hot Spots

Several issues have been indicated by stakeholders to manifest in a number of areas:

1. The management of the **Bileća Lake** is insufficient.
2. Attention should be paid with regards to the quality, quantity, use and protection of the:

- (catchment areas) sources **of Klokot, Privilica, Toplica, Ostrovica** and several other smaller sources, which are used by the **Bihać Municipality** for drinking water supply.
- **Plitvice Lakes** and **Udbina** in Croatia.

3. In **Hutovo Blato** and Delta of the Neretva River, Elektropriveda do not respect the “biological minimum flow of 8m^3.
4. Salt water upcoming has been observed in **Dračevo** in **Čapljina** Municipality.
5. There are flooding incidents in **Mostar** and **Popov Polje**.
6. The “upper horizon” project can significantly disturb the water regime in the area affecting, both surface and underground water.
7. Lack of water resources have resulted in the complete destruction of agricultural production in **Popov Polje**.
8. Point and diffuse sources of pollution exert pressure on the groundwater resources in the **Una River Basin**.

5.6. Perceived Significant Issues in transboundary areas of interest

Bosnia and Herzegovina and Montenegro

- The management of **Bileća/ Bilećko Lake** is mentioned by stakeholders from both countries. Interviewees from both countries indicated that water supply and water use issues affect the lake.
- Stakeholders from both countries agree on the impact of water use to the resources of the aquifers in **Trebisnjica** and the depending ecosystems. Stakeholders from Bosnia and Herzegovina point towards the use of the resource for hydropower production as the main pressure. The concentration of industrial polluters in the area is also pointed out by stakeholders interviewed in Montenegro.

Bosnia and Herzegovina and Croatia

- According to stakeholders from Bosnia and Herzegovina, attention should be given to the quality, quantity, use and protection of the sources of transboundary karst groundwater for the source and catchment area of **Klokot Privilica**, which is located in the **Municipality of Bihac** in Bosnia, for **Plitvice Lakes** and **Udbina** in Croatia and for the sources **Ostrovica and Toplica** which are also used for drinking water. Additionally, it is reported by Croatian interviewees that settlements near the **Korenica** and **Plitvice** Lakes need to be connected with wastewater treatment plants through an improved connection network.
- Another point of attention cited by both sides is **Popov Polje**. Stakeholders from Bosnia and Herzegovina mention floods and scarcity of water resources, in such a degree that one stakeholder commented that agriculture production in Popov Polje was completely destroyed due to lack of water resources. Stakeholders from Croatia report pollution originating from Popov Polje reaching the area of Dubrovnik.
- The third point of great concern reported from both countries refers to the transboundary basin of the **Neretva and Trebišnjica**, where, according to stakeholders from Bosnia and Herzegovina, there is a need for River Basin Management Plans. The major issue reported in both countries is the reduction of groundwater flows. According to stakeholders from Bosnia and Herzegovina, the use of the resource for the production of electricity is creating the problem, while stakeholders from Croatia cite that the reduction of groundwater flows is evident downstream having negative impacts on ecosystems, such as **Malostonski zaljev** and **Malo more – uvala Bistrina**, or areas where the groundwater is returning to the natural state (springs, wetlands, etc.). Furthermore, salt water is reported by stakeholders in Bosnia and Herzegovina to be intruding through the aquifers of the **Neretva River** to the **Dračevo** in **Čapljina Municipality.**