Javno preduzeće
ELEKTROPRIVREDA BOSNE I HERCEGOVINE
d.d. - Sarajevo

Contract no. 162-JP/08 (E-96107)
Investment - technical documentation of preliminary and preparatory activities for construction of HPP Vranduk

HPP VRANDUK

- PRELIMINARY DESIGN -

BOOK 22.
ENVIRONMENTAL IMPACT ASSESSMENT

VOLUME 22.02.
ENVIRONMENTAL IMPACT STUDY

ENERGOINVEST IPSA INSTITUT SARAJEVO PÖYRY

HPP VRANDUK – PRELIMINARY DESIGN
BOOK 22. ENVIRONMENTAL IMPACT ASSESSMENT

CONTENTS OF THE PROJECT DOCUMENTATION

Name:	ENVIRONMENTAL IMPACT STUDY FOR HPP VRANDUK
Client:	JP ELEKTROPRIVREDA BOSNE I HERCEGOVINE 15, Vilsonovo šetalište BiH, 71000 Sarajevo Tel/fax: +387 33 75 17 51
Language:	Bosnian
Contractor:	Centar za ekonomski, tehnološki i okolinski razvoj – CETEOR d.o.o. Put života bb BA, 71000 Sarajevo Tel/fax: +387 33 20 57 25
Head of EIS	Aida Muminović, B.Sc. Eng. in biotechnology
Experts working on preparation of the Environmental Impact Study	Prof.dr. Adem Hamzić Mr.Samir Muhamedagić, B.Sc.Eng. in agriculture Mr.Nusret Drešković, B.Sc.Eng. in geography Doc.dr.Samir Đug, B.Sc.Eng. in biology Orjana Lenasi, B.Sc.Arch.Eng. Amra Šarančić-Logo, B.Sc.Arch.Eng. Jasmina Čomić, B.Sc.Chem.Eng. Andrea Marković, B.Sc.Chem.-Techn.Eng.
Number:	EIS 03/30.03.10 P- 657
Date:	April, 2010.

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INTRODUCTION

STRATEGIC OBJECTIVES FOR CONSTRUCTION OF HPP VRANDUK

Global task is orientation towards sustainable development and reducing greenhouse gas emissions, i.e. the pressures on climate changes. For decades, especially in the European community, the orientation to the use of renewable energy sources is promoted, if their use is the potential for sustainable development, i.e. acceptable economic development from the aspect of the protection of the environment and natural resources. Practice has shown that the use of renewable energy sources in developing the electricity sector can have positive effects on social cohesion and the standard of the local community, including employment, development of small business and recreational sports activities, contributing to safety of electricity supply, etc. At the national and federal level, in accordance with the upcoming commitments for accession to the European Union, it is important to ensure appropriate use of hydropower resources in the production of electricity for the needs of internal and external markets. Bosnia and Herzegovina ratified the Treaty on Establishment of the Energy Community in 2006, where "acquis for renewable energy" are defined. Each Contracting Party undertakes to make a plan for implementation of Directive 2001/77/EC of the European Parliament and the Council on the promotion of electricity produced from renewable sources. The purpose of this Directive is to increase electricity production from renewable sources in the internal electricity market, with the aim of global reducing emissions of CO_2 and the pressures on climate changes.

Combustion of fossil fuels leads to emissions of pollutants into the air, causing air pollution at the global, regional and local level. The project for construction of HPP Vranduk is based on the use of renewable energy sources, which will contribute to reducing CO_2 emissions and pollutants from the energy sector. Therefore, the implementation of this project is in line with the priority commitments of the energy sector, as well as the structure of executive authorities at local and state level in this context.

The use of hydropotential in electricity production in Bosnia and Herzegovina is much less than there are real possibilities. By installed capacity, HPP Vranduk is the project in the category of the CDM (Clean Development Mechanism - CDM) of the Kyoto Protocol, i.e. the UN Framework Convention on Climate Changes. To implement the project, it can be used some favorable financing models, which are provided for developing countries, host countries for implementation of projects of Clean Development Mechanism, and use the certificates obtained as a proof of reducing greenhouse gas emissions (CO_2 equivalent).

Environmental protection strategy of the Federation BiH, in a part related to the air protection, has determined the objective for encouraging the use of renewable energy sources, with measures for the realization of the set objective.

According to the strategic plan and program for energy sector development of the Federation of BiH, HPP Vranduk is one of the planned production capacity in the Federation of BiH.

Directive on the use of renewable energy sources and cogeneration is in preparation (in a draft), which aims are to stimulate greater production and consumption of electricity from renewable energy sources in the internal electricity market, particularly in terms of:

- reducing the impact of using fossil fuels on the environment;
- long-term provision of energy;
- positive effects on social cohesion and approaching to the objectives from Kyoto;
- job creation and entrepreneurship development in the energy industry;
- more efficient use of energy;
- encouraging the implementation and development of new technology and the domestic economy as a whole,

In this sense, local authorities; municipalities and cantons will follow the trends of the European Union and the Federation of BiH.

HYDROPOWER POTENTIALS OF THE FEDERATION OF BOSNIA AND HERZEGOVINA

The construction of hydropower plants is an important segment of development of electric power industry and the economy in general. One of the characteristics of rivers of Bosnia and Herzegovina is a hydropower potential, which has not yet been adequately exploited in the development context.

According to the Strategic plan and program for energy sector development of the Federation of BiH, the total hydropower potential, available for energy use, is 5.555,4 MW and 21.840 GWh. Until now, hydropower capacities dispose of approx. 1.900 MW of installed power and possible approx. 5.000 GWh of production per year, which is bellow 50% of the available potential. The plan envisages the construction of new production capacities, 442,5 MW of the installed power i.e. annual production of 1.281,68 GWh, which would increase the use of available potential to 57,03% in power, i.e. 53,31% in production.

It should be noted that the disposition of hydropower resources is uneven, and that the biggest hydro potential is located in the basins of the Neretva, Vrbas and Drina, which does not correspond to the spatial consumption and energy needs.

Hydropower potential of the Bosna river catchment area is 365,78 MW, and the potential annual production of 1593,6 GWh. Of this amount, hydropower potential of the Bosna river in the Federation of BiH is 171,60 MW, and possible annual production would be 993,6 GWh. For now, the available energy potential of the Bosna river catchment is used only 2,2%.

INSTALLED PRODUCTION CAPACITIES MANAGED BY JP ELEKTROPRIVREDA BIH

According to the installed production capacities, and total production and sale of electricity, the public enterprise JP Elektroprivreda BiH d.d. Sarajevo is the largest electric power company in Bosnia and Herzegovina. In seven cantons of the Federation of BiH, JP Elektroprivreda BiH has more than 675.000 customers. In addition to production facilities, the company also manages the distribution system. Achieved total production for 2008 was 7.295 GWh, with installed production capacity of 1.691 MW.

Table 1. Installed capacities and electricity production in 2008.

Total installed capacity		**1.691 MW**
Thermal power plants	1.164 MW	68,84 **%**
Hydro power plants	507 MW	29,98 **%**
Small hydro power plants	20 MW	1,18 **%**
Total achieved production		**7.295 GWh**
Thermal power plants	5.750 GWh	78,82**%**
Hydro power plants	1.545 GWh	21,18**%**

In the table 1 it can be seen very unfavorable ratio of 31% to 69% in the structure of the installed hydro and thermal capacities of JP Elektroprivreda BiH, as well as the ratio of the produced electricity of 21% in hydro power plants to 79% in thermal power plants. JP Elektroprivreda BiH is interested in implementing the project for construction of new hydropower capacities and increase of participation of hydropower in total electricity production, which is consistent with the principles of sustainable energy development.

JP Elektroprivreda BiH has a duty to accomplish the stability of electric power system, continuity of power supply and quality of electricity supplied to consumers. JP Elektroprivreda BiH is capable personnel, technically and financially to prepare documents for the construction, build and optimize the exploitation of facilities, and distribute the produced electricity to the user.

In accordance with the commitment of JP Elektroprivreda BiH to increase production capacity, and provide safe and reliable electricity supply and the Decision of the Government of the Federation BiH to designate public interest for the construction of power facilities (Official Gazette of FBiH, No. 60/06) and the Decision to designate the public interest and access and construction of priority power facilities in the Federation of BiH (Official Gazette

of FBiH no. 08/10), some activities on the implementation of the Decision are initiated, as well as analysis of possibility of the hydropower use, among other things, of the Bosna river.

SPATIAL-PLANNING BASICS

Since the adoption of the current Spatial Plan 1981-2000 on the territory of Bosnia and Herzegovina there was a change in the political map, economic and social conditions, but the facts on the proven and established qualities and assumptions of development in the area mostly are valid today.

The Spatial plan of the Federation of BiH is not adopted, and the Spatial Plan of BiH is still valid in the territory of this entity. Under the Spatial Plan considering the orientation of development and arrangement of the economy in space, in a special section on the development of energy production is "to build a new hydroelectric power plants along the rivers Neretva, Drina, Vrbas, Trebišnjica, Bosna, Una, Sana, i.e. karst fields, therewith it should expect an accelerated use of available water power and enter into a wider construction of the system of new hydropower plants".

Construction project of HPP Vranduk is, therefore, in accordance with the applicable spatial planning documents of the Federation of BiH and the spatial plan of the Zenica-Doboj Canton (2009. -2029.)

In order to estimate all feasibility aspects of hydropower utilization of the Bosna river, the basis of the hydropower solution of the Bosna river catchment is made in 1967. (Energoinvest Sarajevo), as well as the Study "Prospection of hydropower solution of the Bosna river catchment" in 1994 in the Institute for Water Resources Sarajevo.

IMPORTANCE OF CONSTRUCTION OF HPP VRANDUK

Construction of this facility has multiple significance, in particular the following components could be noted:

- reliable supply of electricity in the Federation of BiH and beyond;
- creation of new jobs: a maximum during construction, and full-time staff during the operation and maintenance of the hydropower plant;
- improved standard of living of local people and reducing poverty;
- reducing emissions of pollutants into the air, compared to combustion of fossil fuels, and contributing to environmental protection, especially important for the global reduction of greenhouse gases (GHG);
- contribute to the socio - economic development of the region and BiH and environmental protection.

Interventions in the area, such as the formation of the accumulation upstream from the dam, will inevitably affect changes of the authentic area. It is significant that such facilities, in most cases, are multifunctional. Primarily they are being built in order to develop and meet the needs of civilization, primarily for the water supply and use of water power for electricity production, and the planned hydro accumulation of HPP Vranduk, in addition to producing electricity, can be used for irrigation, development of small business and recreational activities.

It is significant to use water resources for energy purposes, but "no" without selective approach and thorough assessment of the consequences for the environment. Crucial objective of the environmental impact assessment is to make a choice of the optimal solution in the context of construction, operation and maintenance of the hydropower facility, which should have the attributes of environmental and techno-economically acceptable facility. Likewise, it is necessary to identify and estimate some potential impacts of project implementation of construction of the hydropower plant on quality of ecosystems and the Bosna river catchment area, and the environment in the narrow and broad sense.

BASIS FOR PREPARATION OF THE ENVIRONMENTAL IMPACT STUDY

Basis for preparation of the Environmental Impact Study for HPP Vranduk (hereafter EIS) is the Conclusion on development of the Environmental Impact Study number UPI-05-23-172/09 SN from 09.07.2009., issued by the Federal Ministry of Environment and Tourism on basis of the Preliminary Environmental Impact Assessment, pursuant to the article 58. and 59. of the Law on Environment Protection (Official Gazette of FBiH, no. 33/03, 38/09) and the Article 3. and 4. of the Rulebook on plants and facilities for which the Environmental impact assessment is required and facilities and plants that can be built and operated only if they have an environmental permit (Official Gazette of FBiH, no. 19/04). EIS has been prepared in accordance with the provisions of these regulations and the provisions of Directive 97/11/EC on the environmental impact assessment, amending Directive 85/337/EEC on the impact assessment of certain public and private projects on the environment

The aim of valorisation of potential Project impacts on the environment is identification of some eventual intolerable failures in space, in the context of protection and promotion of cultural-historical and natural values, and the environment in general.

USED DOCUMENTS

As a basis for the Environmental Impact Study for HPP Vranduk the following documentation was available:

- HPP VRANDUK – Preliminary design – Book 07. Buyings and Indemnities (made by Energoinvest IPSA POYRY, Sarajevo, April 2009),
- HPP VRANDUK – Preliminary design – Book 03. Hydrological-meteorological background documentation (made by Energoinvest IPSA POYRY, Sarajevo, May 2009),
- Reservoir of HPP Vranduk-optimization of backwater elevation-Working material, Sarajevo April 2009,
- Design of geological investigation works for the level of the Preliminary design, Sarajevo March 2009,
- Study of seismicity at the location of HPP Vranduk, Sarajevo 2009.,
- Fishing grounds-Sport fishing associations “Lašva“ Zenica, Biological Institute of the University of Sarajevo, 1972,
- Spatial Plan of SRBiH (1981-2001),
- Spatial Plan of Zenica-Doboj Canton 2009-2029,
- LEAP (Local environmental action plan of the Municipality of Zenica), Dvokut pro, Sarajevo 2009,
- Bogut, I., Novoselić, D., Pavličević, J., 2006. Fish Biology I: Fish Morphology, Fish Anatomy and Physiology, Fish systematics, ecology and water protection. University of Osijek, University of Mostar,
- Hamzić, A., 2003: Aquaculture in Bosnia and Herzegovina, Coron`s d.o.o., Sarajevo,
- Kottelat, M,. Freyhof, J., 2007: Handbook of European Freshwater Fishes. Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany,
- Mrakovčić, M,. Brigić., A., Buj, I., Ćaleta, M., Mustafić, P., Zanella, D., 2006: Red Book of fish of Croatia. Ministry of Culture, State Institute for Nature Protection, Croatia,
- Vuković, T., 1963: Fish of Bosnia and Herzegovina – determination key, Institute for textbook publishing, Sarajevo,
- Vuković, T., 1977: Fish of Bosnia and Herzegovina – determination key, IGKRO “Svjetlost” OOUR Institue for textbooks, Sarajevo,
- Vuković & Ivanović, 1971: Freshwater fishes of Yugoslavia, the National Museum of Bosnia and Herzegovina, Sarajevo,
- Law on Freshwater Fisheries of the Federation of Bosnia and Herzegovina (2004).

- Archaeological Lexicon of Bosnia and Herzegovina, Volume 2, Archaeological sites of Region 1-13, Sarajevo 1988., p.206.,
- Comission to Preserve National Monuments, the Decision to designate the Architectural ensemble of the Old Town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, Decision no. 05.2-2-274/04-4 of 25 January 2005, published in the Official Gazette of BiH 16/06“, Explanation – 2. Historical data,
- Comission to Preserve National Monuments, the Decision to designate the Architectural ensemble of the Old Town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, Decision no. 05.2-2-274/04-4 of 25 January 2005, published in the Official Gazette of BiH 16/06“, Explanation – 3. The existing legal protection,
- Comission to Preserve National Monuments, the Decision to designate the Architectural ensemble of the Old Town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, Decision no. 05.2-2-274/04-4 of 25 January 2005, published in the Official Gazette of BiH 16/06“, Disposition, Article 1.,
- Comission to Preserve National Monuments, the Decision to designate the Architectural ensemble of the Old Town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, Decision no. 05.2-2-274/04-4 of 25 January 2005, published in the Official Gazette of BiH 16/06“, Disposition, Article 3.,
- http://www.zemuzej.ba/projekti.html, access on 20.11.2009,
- http://www.mozaik.ba/index.php?id=tbk1, access on 20.11.2009,
- Existing documentation of the Commission to Preserve National Monuments (data on registered, preventive protected, registered cultural property, etc.)
- Insight into the Strategy of Physical Planning of the Federation of Bosnia and Herzegovina,
- Previous Environmental Impact Assessment, JP Elektroprivreda BiH d.d. Sarajevo, CETEOR d.o.o. – Centre for economic, technological and environmental development, May/June 2009,
- Pre-feasibility Study for HPP Vranduk (made by Energoinvest Energoinženjering - HIGRA, Sarajevo, 2002.), which was revised in 2003,
- Review of technical solution of HPP Vranduk made by Energoinvest d.d. Sarajevo, from February 2010.,
- Reports of experts involved in preparation of the Study for domains of: flora and fauna, soil, water, air, climate and existing infrastructure and cultural and historical heritage,
- Orthophotos of the terain – wider area of the planned HPP Vranduk,

- Information on projects aimed at revitalizing the Old Town, the development of potential for its involvement in developmental trends of the region particularly from the aspect of cultural tourism development,
- Written and others (published, unpublished) data on the Architectural ensemble of the Old Town Vranduk,
- Dam photo visualization - the documentation done and submitted by JP Elektroprivreda BiH d.d. Sarajevo,
- Visit of the wider locality of the planned HPP Vranduk.

During preparation of the Environmental Impact Study for HPP Vranduk, we have taken into consideration the Engineer's opinions, as well as suggestions and professional experiences of the Investor (Department of Environmental Management) considering the impacts of hydropower facilities on the environment (action plans and environmental permits for existing hydropower plants).

LEGAL FRAMEWORK

Local and European legislation applicable to the subject project HPP Vranduk with environmental requirements is listed below.

GENERAL

- Law on Environment Protection, Official Gazette of FBiH, no. 33/03, 38/09;
- Book of regulations on the plants and installations for which the environment impact assessment is compulsory and which can be built and put in operation only if they have an environmental permit, Official Gazette of FBiH, no. 19/04;
- Freedom of Access to Information Act for FbiH, Official Gazette of FbiH, no. 32/01;
- Law on expropriation of the Federation of BiH, Official Gazette FBiH, no.70/07;
- Law on spatial planning and land use at the level of Federation of Bosnia and Herzegovina, Official Gazette of FBiH, no.2/06, 72/07, 32/08, 4/10;
- Law on allocation and direction of company revenue realized using hydro-accumulation facilities, Official Gazette of FBiH, no. 44/02 and 57/09;
- Regulations on site arrangement, required documentation at the site and participants in construction works, Official Gazette FBiH, no.48/09; 75/09;
- Aarhus Convention - Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, Aarhus 1998, entered into force (in the process of ratification) - Entry into force: 05.08.1998, Official Gazette of BiH, International Treaties 8/08;
- Decision on declaration of public interest and preparation and construction of priority power facilities in FBiH, Official Gazette FBiH, 08/10;

AIR

- Law on Air Protection, Official Gazette of FBiH, no. 33/03; 4/10;

WASTE

- Law on Waste Management, Official Gazette of FBiH, no. 33/03, 72/09;
- Regulations on waste categories with lists, Official Gazette of FBiH, no. 9/05;
- Regulations on treatment of waste that is not on the list of hazardous waste or whose content is unknown, Official Gazette of F BiH, no.9/05;
- Directive on selective collection, packaging and labeling of waste, Official Gazette FBiH, no.38/06;
- Rulebook on determining allowable quantities of hazardous and dangerous materials into the soil and methods of their investigation, Official Gazette FBiH, no.71/09;

- Rulebook on content of adjustment plan of waste management for existing treatment facilities or disposal of waste and activities that the competent authority undertakes, Official Gazette of FbiH, no. 9/05;

WATER

- Law on Water Protection, Official Gazette, FBiH, no. 70/06;
- Directive on hazardous and harmfull materials in waters, Official Gazette of FBiH, no. 43/07;
- Directive on amendments of the Directive on unique methodology for assessing damages from natural and other disasters, Official Gazette of FBiH, no. 38/06, Official Gazette of FBiH, no. 52/09;
- Directive on an unique methodology for assessing damages from natural and other disasters, Official Gazette FBiH no. 75/04;
- Decision on limits of water areas, Official Gazette of FBiH, no. 37/98;
- Decision on limits of the main catchment areas, Official Gazette of FBiH, no. 41/07;
- Instruction on method, procedure and deadlines for the calculation and payment of special water charges, Official Gazette FBiH, no. 92/07;
- Regulations on types, methods and scope of measurement and testing of used water, discharged waste water and excavated material from watercourses, Official Gazette FBiH, no.92/07; Regulations on conditions to be met by accredited laboratories and the content and manner of issuing the authorization, Official Gazette FBiH, no.54/99;
- Regulation on categorization of water streams, Official Gazette SR BiH No 42/67; 19/86,
- Decree on concessions for water and public water good, Official Gazette FBiH, no. 8/00;
- Rulebook on content, form, conditions and manner of issuance and storage of water management acts, Official Gazette FBiH, no.6/08;
- Regulations on minimum content of the general act of maintenance, use and monitoring of water facilities, Official Gazette FBiH, no.18/07;
- Regulations on calculation, procedure and deadlines for the calculation and payment and control of the settlement of liabilities based on the general water charges and special water charges, Official Gazette FBiH, no.167/07;
- Regulations on the minimum content of general act on the maintenance, use and monitoring of water facilities, Official Gazette FBiH, no. 18/07;
- Directive on Water Classification and coastal sea waters of Yougoslavia within the limits of SR BiH, Official Gazette of SR BiH, no. 19/80;

- Directive 2000/60/EC establishing a framework for Community action in the field of water policy (Water Framework Directive);
- Directive 2008/1/EC concerning integrated pollution prevention and control (IPPC) (Codified version);
- Directive on Surface Water No. 75/440/EEC;
- Fish Life Directive No. 78/658/EEC;

NATURE

- Law on Nature Protection, Official Gazette of FBiH, no. 33/03;
- Law on Forests, Official Gazette of FBiH, no. 20/02;
- Freshwater Fisherie Act of the Federation of BiH, Official Gazette of FBiH, no.64/04;
- Directive on the protection of natural habitats and wild fauna and flora (92/43/EEC);
- Convention on the Protection of the World Cultural and Natural Heritage, Paris, 1972.

  Entry into force: 17.12.1975.;
- Convention on the Establishment of European and Mediterranean Organization for Nature Protection;
- Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), Bern, 1979. (entered into force: 01.06.1982.) – in the process of ratification;

SOIL AND GEOLOGY

- Law on geological investigations of FBiH, Official Gazette of R BiH, no. 3/93, 13/94, 9/10;
- Rulebook on the content of programs, projects and studies of geological investigations, Official Gazette of R BiH, no. 16/93 and 13/94;

CULTURAL AND HISTORICAL HERITAGE

- Act on the implementation of decisions of the Commission to Preserve National Monuments established under Annex 8. of the General Framework Agreement for Peace in Bosnia and Herzegovina, Official Gazette FBiH, no.2/02, 27/02, 6/04 i 51/07;
- Law on spatial planning and land use at the level of Federation of Bosnia and Herzegovina, Official Gazette of FBiH, no. 2/06, 72/07 and 32/08, 9/10;
- Decision of the Commission to Preserve National Monuments to designate the Architectural ensemble of the Old Town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, Official Gazette BiH, no.16/06.

1. DESCRIPTION OF PROPOSED PROJECT

1.1. DESCRIPTION OF PHYSICAL CHARACTERISTICS OF THE ENTIRE PROJECT AND CONDITIONS OF LAND USE DURING CONSTRUCTION AND OPERATION OF THE PLANT AND FACILITIES FORESEEN BY THE PROJECT

1.1.1. LOCATION

Bosna river catchment is the largest single catchment area in Bosnia and Herzegovina, and covers about 20% of the total area of Bosnia and Herzegovina. Future HPP Vranduk will be located in the municipality of Zenica, the location between the town of Zenica and Nemila settlement near the homonymous settlement Vranduk (Figure 1)

Figure 1. Wider area of HPP Vranduk location

The Bosna riverbed, in this section is considerably narrowed, where steep banks make a canyon, and its stream makes a double and very sharp "S" curve. Vranduk settlement is situated at elevations above 310,00 m a.s.l. Map of the wider project area is shown in Appendix 1.

Zenica–Nemila stretch is connected by road and rail communication. Moving from the direction of Zenica, the highway follows the Bosna river on the right side, by the bridge "Bosna V", moves to the left bank, after which near the settlement Hanovi enters the first tunnel „Vranduk" 1.100 m long. After the tunnel, the road leads to the open road route of about 280 m, and then enters the second tunnel 400 m long, and over the bridge "Bosna IV" passes to the right bank of the Bosna river (Figure 2.).

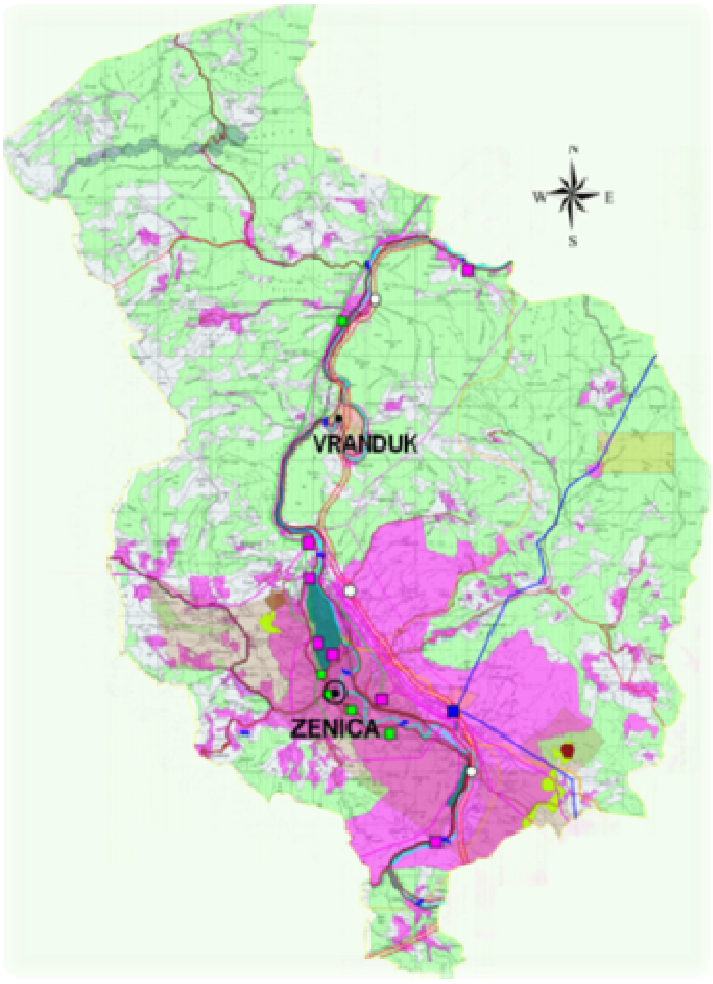


Figure 2. Vranduk location on a topographic map

Double-track railway line goes along the left bank of the Bosna river, and also in settlement Hanovi enters into two parallel railway tunnels Vranduk app.1.500 m long and after leaving the mountain mass continues on the left bank of the Bosna river.

In addition to these essential infrastructure elements, from both sides of the Bosna river, there are local roads that connect settlements (Vranduk, Beharinovac, Hanovi, Ponirak, Lučice, Koprivna, Ljubetovo) on the left and right banks of the Bosna river, with the bridge in

the setttlement of Vranduk, and a new bridge in Nemila settlement. When choosing the best variant of hydropower use of Zenica-Nemila stretch, we have primarily taken into account the altitude of the above mentionned main communications (Figure 3.).

Figure 3. View visualization on location of the future HPP Vranduk dam

1.2. DESCRIPTION OF BASIC CHARACTERISTICS OF THE PRODUCTION PROCESS, THE NATURES AND QUANTITIES OF MATERIALS USED

1.2.1. ENERGY PARAMETERS OF HPP VRANDUK

		MAIN GENERATING SETS	SMALL GENERATING SET	TOTAL HPP VRANDUK
Installed flow	m^3/s	100	14 (18)	
Type and number of turbines		2xKAPLAN(„S“)	1xKAPLAN(„S“)	
Elevation of normal backwate	m a.s.l.	293,50	293,50	
Elevation of tail water (for Q_i)	m.a.s.l.	271,34	284,90	
Maximum gross / net head	m	22,46/20,90	8,45/8,28	
Power	MW	18,24	1,32	19,56
Potential annual production	GWh	86,88	9,50	96,38

1.2.2. GENERAL CONCEPT OF SOLUTION

The general concept of hydropower use of the Bosna river at the stretch Zenica - Nemila is defined on the basis of basic orientations:

- use, in the most effective way, natural features of the Bosna streams at this relatively short, but typical stretch,
- thereby do not affect adversely the main environment values,
- try that existing infrastructure facilities are not affected,

and previous studies, the available backgrounds, realized investigations, boundary conditions and constraints.

Solution with a run-of-river facility is adopted, derivation type, with more or less complex buildings that represent the functional unit, or:

1. The complex of buildings at the location of the dam: dam with four spillway fields located in the central part of the riverbed, gate depot along the left bank, a small hydropower plant along the right bank and fish path between the small hydropower plant and end spillway field
2. Intake structure with equipment and facilities
3. Headrace tunnel with surge shaft;

4. The complex of buildings at the location of the power house: the power house with drainage canals and dug downstream riverbed, the area with pre-turbine gates, the command building, a plateau with transformer and switchgear building;
5. A new road to the Hanovi settlement with a bridge over the railway line, an access road to the weir crest on the left bank and reconstructed existing local roads on the left bank, section Vranduk - Jelina and bridge „Bosna IV“ – Nemila.

The area to be covered by the project extends along the left bank of the Bosna river from the railway station Jelina up to the dam profile located about 150 m downstream from the bridge "Bosna V" on the main road, and then along the left bank downstream from the bridge "Bosna IV" up to the settlement Nemila.

1.2.3. DESCRIPTION OF TECHNICAL SOLUTION OF FACILITIES

The dam is a concrete type, height from the foundations 16 m and length in the weir crest of 110 m, located app. 150 m downstream from the bridge "Bosna V", and it is performed in order to concentrate the head and to provide hydraulic conditions to turn the water in the headrace tunnel. In this way, the accumulation is formed with a maximum depth of 9.0 m just upstream of the dam. This is also the height of segment gates on spillway fields, which means that they are practically part of the dam. Therefore, in the technical literature, such dams are also called movable dams, which means that raising the segment gates, at the time of occurrence of large flows, conditions are provided "as there is no dam"(Figure 4.).

Figure 4. Disposition of the dam, buildings along the dam and intake structure

Part of the dam to evacuate high water is located along the left bank and has four flow fields supplied with segment gates sizes (12x9,20) m, so that the normal operating level at the same time is also the maximum water level in the accumulation. One gate is provided with a spillway flap (9,0x2,0) m. The capacity of flow fields allows the evacuation Q1/1000 = 2043 m^3/s. For inspection of segment gates, it is provided a set of stop logs served by gantry crane from the weir crest. In the extreme gravity dam block on the left bank, a depot of auxiliary gates is foreseen (Figure 5.).

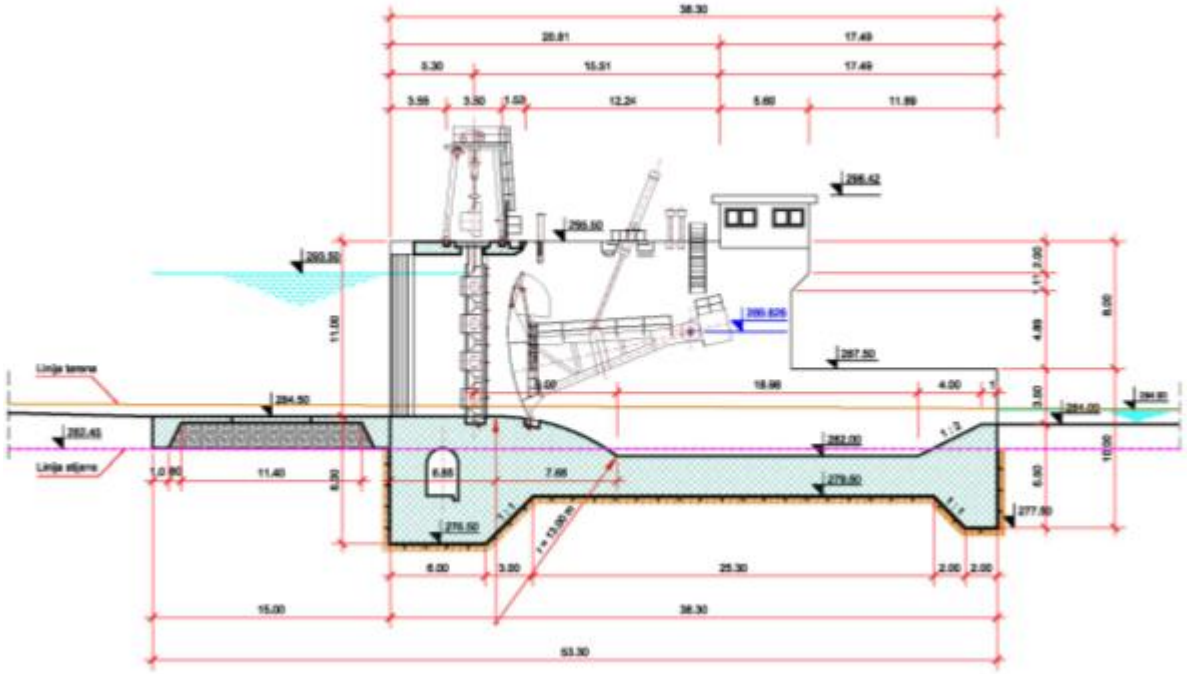


Figure 5. Cross-section through the flow field

Along the right bank in the profile of the dam there is a power house with a small generating set, which effectively forms a part of the dam and allows the leakage and hydropower use of flow of 14 m^3/s (environmentally acceptable flow) i.e. flow of 18 m^3/s during inflows greater than the installed flow of the plant (Figure 6.). A generating set with Kaplan turbine "S" type and horizontal synchronous generator are installed into the power house. Gross head is 9,00 m, and rated power of the turbine is 1300 kW.

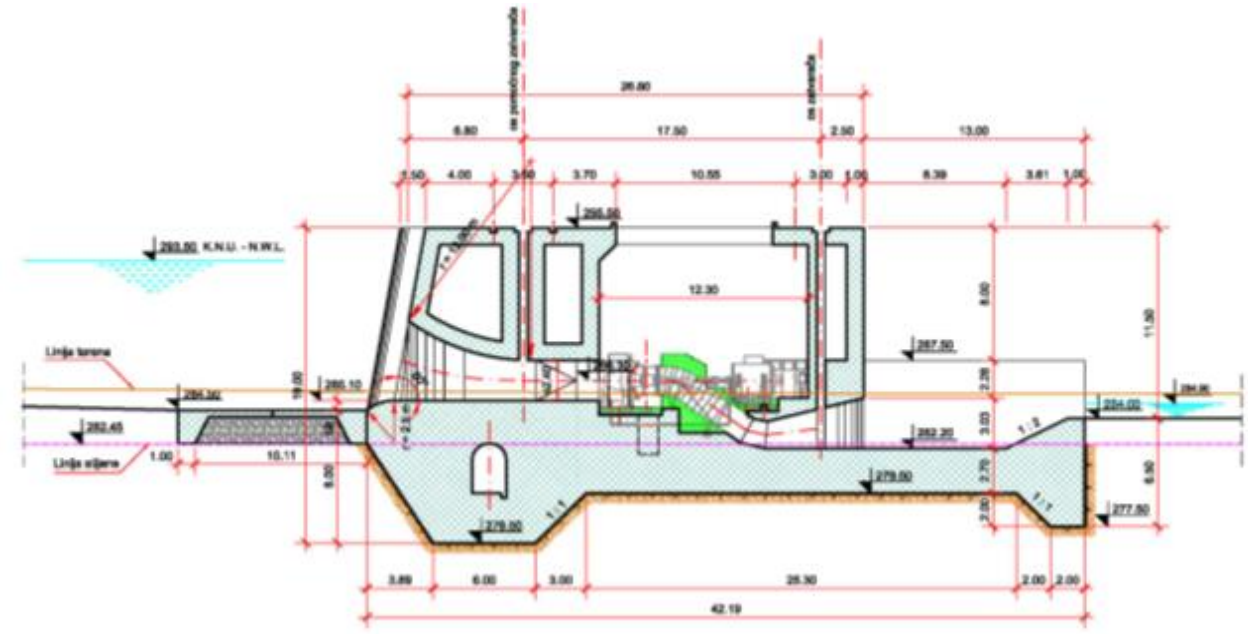


Figure 6. Cross-section through the power house of small hydropower plant

Between the power house with small generating set and extreme spillway field there is a fish path (Figure7.). It is a facility that enables communication of the fish population between downstream channel and the accumulation which is formed by construction of the dam. It presents a series of cascading lined smaller basins with dimensions of 1,20 x 1,00 m. The basins are interconnected by spillway with capacity of about 250 l/s, while the height difference in water levels in two adjacent basins is 20 cm.

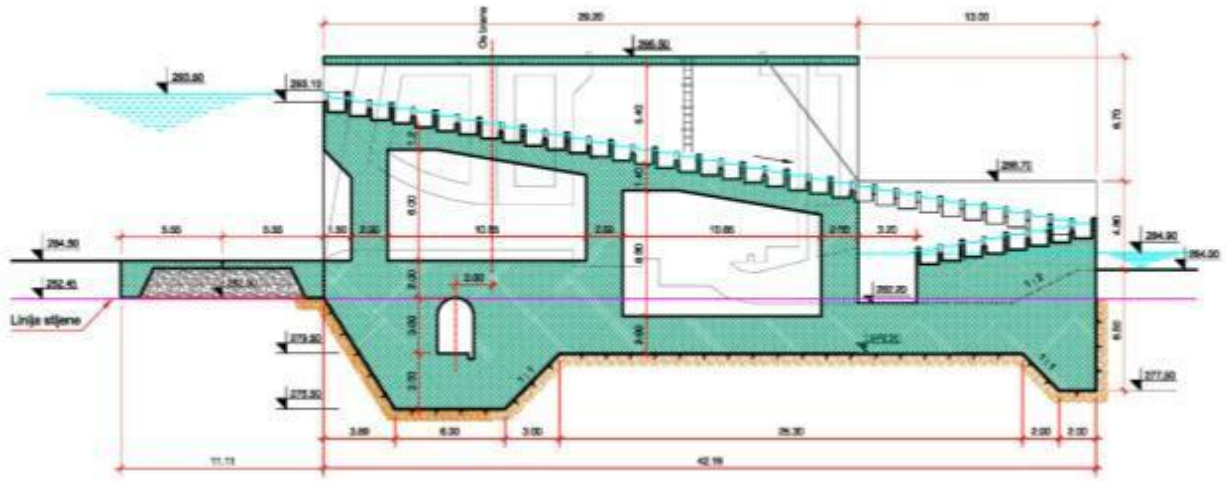


Figure7. Cross-section through the fish path

The hydro accumulation is formed in front of the dam with the elevation of normal (and maximum) backwater of 293, 50 m a.s.l. Total accumulation capacity is 1,62 x 10^6 m^3 , length of 5,8 km and area of 42.56 ha.The accumulation submerges a house and the existing local road along the railway line on the left bank, which connects the surrounding settlements with

Zenica. Therefore, it is anticipated that the grade level of the road rises to a safe elevation under conditions of the accumulation and the appearance of 100-year high water. The existing culverts under the railway line will be reconstructed, and access to settlement Hanovi provided by the construction of new road and bridge over the railway line.

It is important to note that the HPP Vranduk accumulation is only conditionally the accumulation, because it is of small depth (only 9 m), and generally is formed in the riverbed. It has some characteristics of the accumulation only during the period of year, when the inflows of the Bosna river are less than the installed flow of the plant. Then its area is app. 12% higher than the area of the riverbed bottom, while at higher flows and engagements of evacuation organs at the dam it achieves a state similar to natural conditions.

The intake structure is located on the left bank, approximately 35 m upstream from the bridge "Bosna V" and it is designed on the installed flow of 100 m^3/s. (Figure 8). It is equipped with a fine grid, auxiliary and main gate valves. On plateau of the intake structure, at elevation 297,50 m a.s.l., it is envisaged the installation of a combined gantry crane with a cleaning device, and construction of the auxiliary gate depot.

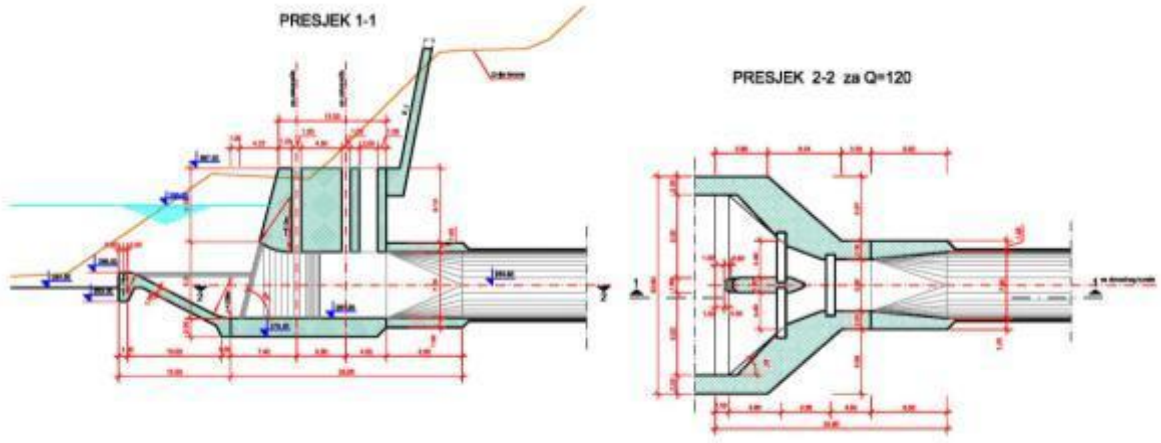


Figure 8. Solution of the intake structure

The headrace tunnel has a length of 1476 m and diameter of 6,60 m. The headrace tunnel route passes between tunnels on the main road Doboj – Zenica and railway tunnels. The minimum distance from the existing tunnels is approx. 100 m

For vibration suppression at the end of the tunnel, a surge shaft was designed with a silencer and an upper non-spillway chamber. At the end of the surge shaft, there are entries in two penstocks, i.e. for each generating set per one pipe with diameter of Φ 3,20 m, length of 13,5 m, and at the distance of 12 m.

The power house is located on the left bank, between the bridge“Bosna IV” and the exit of the railway tunnel. It is to be constructed in a notch, close to the local road.next to the power house, it performs an asssembly plateau at elevation of 281,50 m a.s.l. and command building that will be accessed from the existing local road, and which will be reconstructed. Within the power house, some pre-turbine butterfly gates will be installed for each generating set separately.

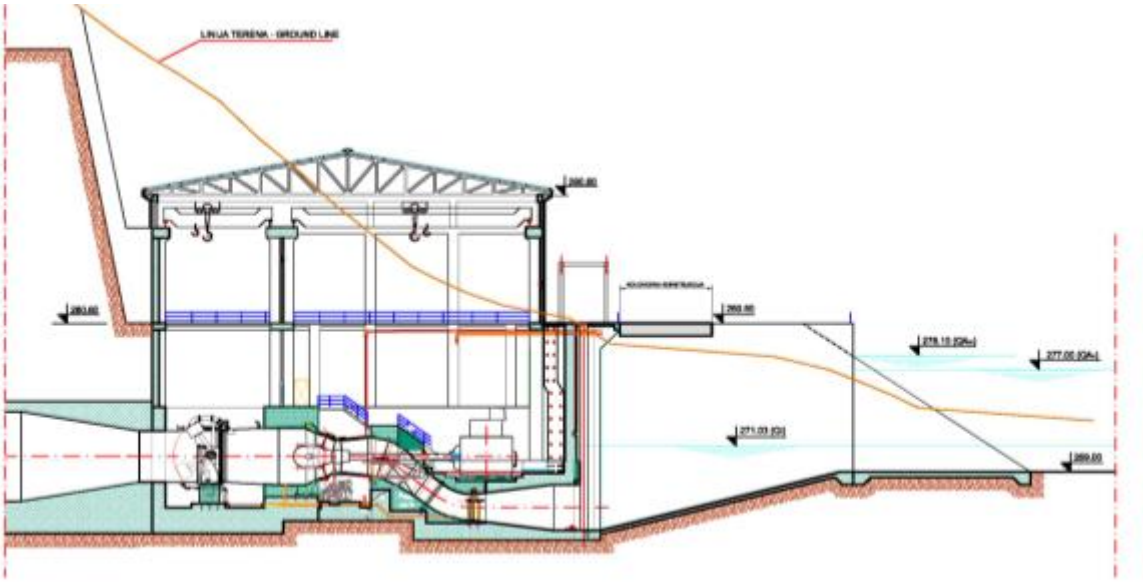


Figure 9. Cross-section through the power house of the main generating sets

According to the maximum net head of Hnmax = 20,9 m with the chosen total installed flow of the power plant of 100 m^3/s, two Kaplan turbines with horizontal axis ("S" type) are selected, directly connected with a synchronous generator (Figure 9.). Installed flow of one turbine is 50 m^3/s with an acceptable technical operational minimum flow of 10 m^3/s. Installed power of both generating units is 18,24 MW and potential annual production is 86,9 GWh.

Digging of the downstream riverbed to increase the head of the plant and improve energy effects is running over a length of 2.500 m, width of the riverbed of 50,0 m with inclination of the bottom of 0.5 ‰. The width is adopted so that it adapts to most natural width of the Bosna riverbed on this stretch. The maximum lowering of the river bottom at the beginning of the deepening is 2,91 m. This increases the head of the plant in the average operation mode for about 3 m, i.e. the energy effect for about $11x10^6$ kWh per year.

1.2.4. CONNECTION TO THE ELECTRIC POWER SYSTEM (EPS) OF BIH

In order to ensure the safe placement of produced electrical energy in the network in all driving situations it was selected a connection to 110 kV network and to the existing 110 kV transmission line Zenica 1 - Zavidovići, which passes near the location of the future plant in the system input-output. The transmission line has been renovated and has sufficient capacity to accept produced energy of the new power plant.

Power of the small generating unit will be, across the transformers 0,4/10(20) kV; 1000kVA and further via the output 35 kV facilities on the dam, placed to the existing distribution network of 35 kV.

Principle scheme of the power plant has been made according to solutions that have proved reliable in operation and represent a standard solution to similar hydropower plants in BiH.

1.2.5. CONSTRUCTION MANAGEMENT

Location of HPP Vranduk is satisfactory in terms of construction management, because the existing road infrastructure allows easy access to all components of the plant. Derivation type of the plant allows to carry out works undisturbed, at the same time on three main buildings: dam, headrace tunnel with surge shaft and power house. Geological conditions are also relatively favorable, and underground works are performed in rocks of medium to low permeability.

There are no borrow pits of aggregate for concrete of the required quality for this type of buildings in the immediate vicinity. Given that it is not very large quantities of aggregates, it was justified to be delivered from the quarries already open, such as quarries in Zavidovići or Misoča in Ilijaš.

Locations of landfills for excess excavation will be determined within the design of construction management, but it is important to note that most of these quantities will be used for cant of the road on the left bank next to the railway.

The buildings that make up the dam are carried out in two phases under the protection of cofferdam, to allow undisturbed flow of water in the river bed. The cofferdams are countrefort concrete structure which are carrying out with combination of concrete diaphragm and structure which is to be concreted in formwork (
Figure 10.). They protect the first phase of the construction pit directing the flow of the river to the other bank, and in the second stage the water is channeled through the previously made flow fields.

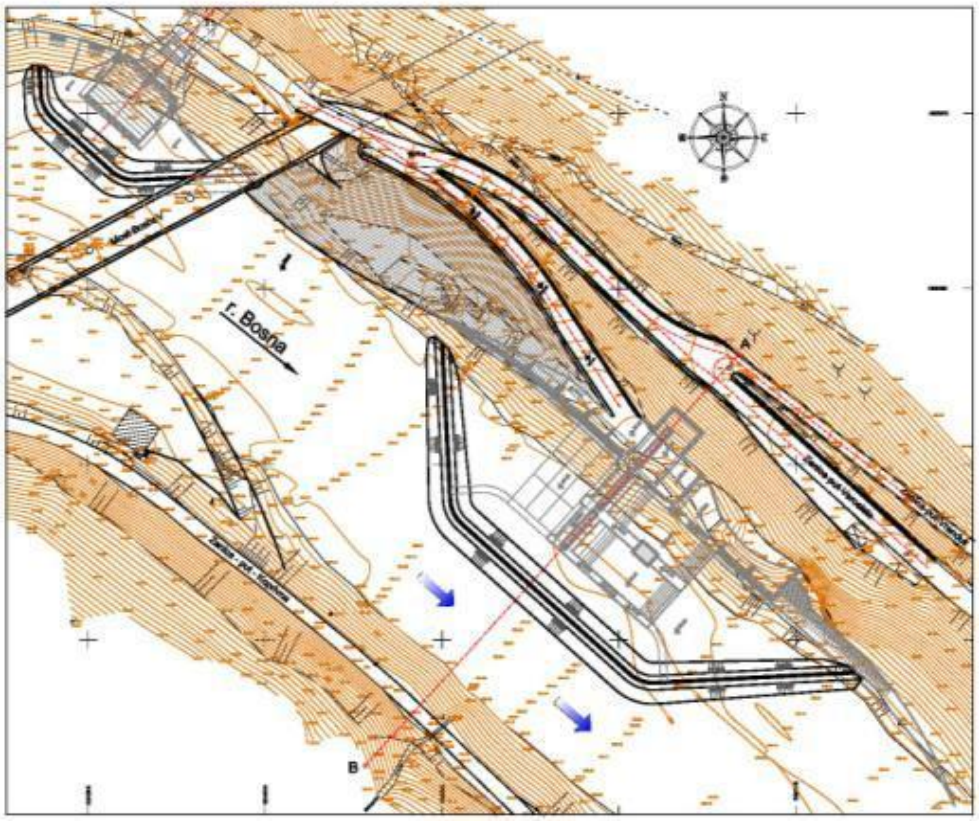


Figure 10. Cofferdam of I Phase

Under the protection of cofferdams of the first phase, two flow fields are realized with the gate depot on the left bank, and temporary concrete walls on which the cofferdams of the second phase are later tied. In the second phase, the facilities along the right bank are performed, i.e. the other two flow fields, fish path and power house of the small generating unit (Figure 6). After completion of civil works, equipment installation and arrangement of the surrounding area is to be made.

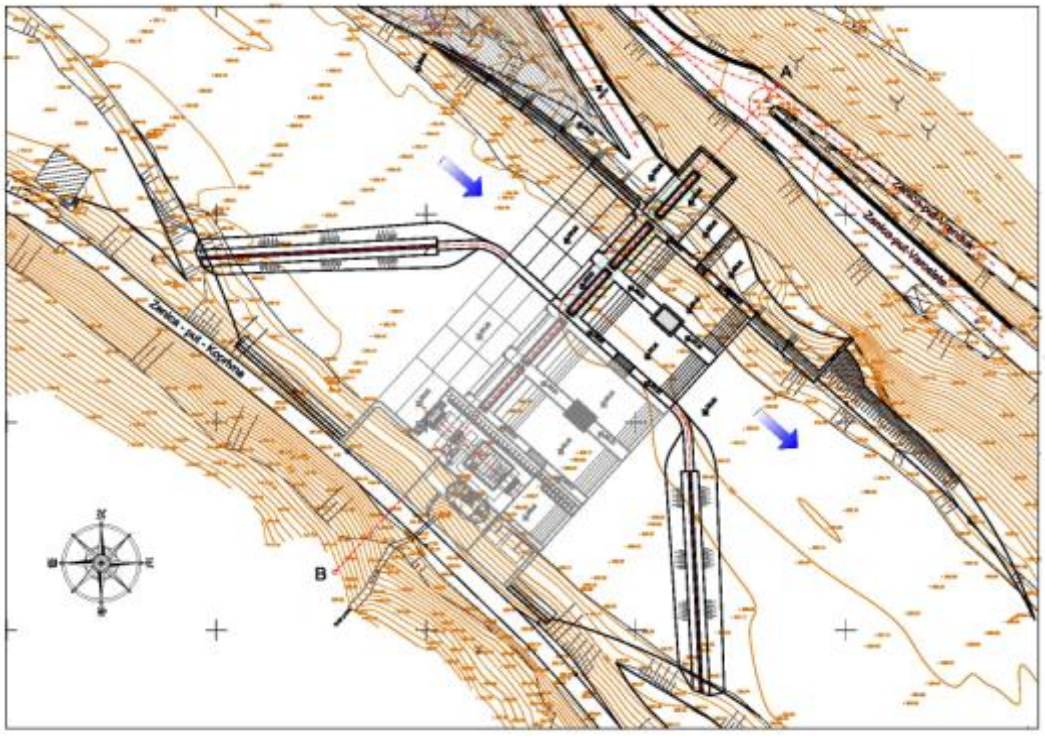


Figure 11. Cofferdam of II Phase

Intake structure is largely above ground facility and can be built independently of the work in the tunnel except the last stage of the coupling. A cofferdam directly in front of the intake structure can not be demolished, and would serve as protection from the entering of bed load in the tunnel.

Headrace tunnel with diameter of 6,60 m and length of 1.460 m is to be realized from two directions using access trenches at the location of the intake structure and surge shaft. Excavation of the tunnel is running by the new Austrian method and by "smooth" blasting. Concreting of tunnel lining is done in two phases using circular sliding formwork.

The surge shaft and penstock are made in principle by the same methods as the headrace tunnel. Excavation of vertical shaft of the surge shaft is carrying out in three phases: a central bore hole, the extension to the shaft 3x3 m and excavation of the remaining section in levels of 3 m.

Power house is carrying out under the protection of cofferdams along the left bank, and the excavation and concreting by methods as for the dam. Deepening of the downstream

riverbed, in a length of 2.500 m is performed parallelly with the execution of works on the power house.

After completion of the major construction works, it shall proceed with the arrangement of space, especially the left bank near the dam area. Specifically, the current state of this river bank is the result of depositing the material from the excavation of tunnels on the main road and a large quantity of municipal and other waste from nearby villages, so that this is a quite unarranged space. In order to found the dam and quay walls on the left bank upstream and downstream, this material must be cut and mostly led to another landfill. The final block of the dam with the gate depot on the left bank will be protected by a retaining structure to ensure stability of the road to the settlement of Vranduk. After finishing of the dam, quay walls, retaining structure and access road to the weir crest, an arrangement of slopes is planned with a layer of stacked stone, i.e. in accordance with the horticulture design.

2. DESCRIPTION OF ENVIRONMENT THAT COULD BE ENDANGERED BY THE PROJECT

Environment that could be affected by the project will be considered at two levels: the narrower and wider area.The narrower area here includes the location itself of the future HPP Vranduk, with all its facilities, and the wider area is the area of the municipality of Zenica.

2.1. POPULATION

Considering that in Bosnia and Herzegovina the last census was in 1991, many relevant data are missing. There are only their approximations, which for obvious reasons is not the same credibility as a source provided by the census.

In 1991, most of the residents of the municipality was concentrated in the town of Zenica, about 66,11%. From a total of 80 settlements, 45 settlements have fewer than 350 inhabitants. The largest settlement after town of Zenica is Gradišće with 2.809 inhabitants. In small settlements, there are more than 10.840 inhabitants, i.e. about 22% of the rural population of Zenica.[1] In 1991, 625 inhabitants lived in Vranduk[2]

Figure 12. Settlement Novi Vranduk

[1] Local environmental action plan for the municipality of Zenica on June, 2009.

[2] Latest data available-Statistical Bulletin No. 234, Central Bureau of Statistics of SR BiH, Sarajevo, December 1993.(After the census was not done, and for Vranduk there are no estimates)

Settlement system of the Municipality of Zenica is characterized by a large number of settlements of different size structure. The urbanization process was not compliant with the process of industrialization, which caused the various activities of the population on the outskirts of the town. This led to a strong commuting population from the municipality of Zenica and other neighboring municipalities.

127.334 people lived in the area of Zenica in 2007., with a population density of 228 inhabitants per km^2. Vranduk settlement with about 50 households is located near the Vranduk fortress. Further, on the right bank of the Bosna river downstream of the dam of the future hydropower plant Vranduk, there is a settlement Novi Vranduk (Figure 12.) with about 20 households. On the left bank of the Bosna river downstream of the dam of the future hydropower plant, there is Varošište settlement with about 40 households and a saw-mill Almy. In these villages there are about 500 inhabitants. Most of the population is employed in the Arcelor Mittal Steel in Zenica and sawmill Almy (two thirds), while the rest are unemployed, children and pensioners. Children attend four-year elementary school located in Novi Vranduk, and after they attend primary school in Nemila. These villages have their own water supply system, but no sewage system, or local ambulance.

Figure 13. Houses close to the Vranduk fortress

2.2. FLORA AND FAUNA

In the area along the Bosna river, the forest communities of willow and poplar are developed, of order *Populetalia albae* Br.-Bl. 31 represented in this area by unity *Salicion albae* Tx. 55 which differentiates in three associations: *Salici-Populetum Slav., Salicetum incanae* Jov. 65, and *Salicetum albae-fragilis* Tx. 55. Community stands of willow and poplar *(Salici-Populetum)* are present on flat terrains. The geological substrate consists of breccias and alluvial deposits, and soil type is fluvisol and illimerised soil. The most abundant species in these communities from the layer of trees, which reaches a height of 20 meters, are White Poplar *(Populus alba)*, White Willow *(Salix alba)*, Black Alder *(Alnus glutinosa)*, The European White Elm *(Ulmus effusa)*, Sycamore Maple *(Acer pseudoplatanus)* and others. In the layer of shrub the most common are spieces Black Elder *(Sambucus nigra)*, Cornel Tree *(Cornus mas)*, Walnut *(Juglans regia)*, The European dewberry *(Rubus ceasius)* and Common Ivy *(Hedera helix)*. Layer of herbaceous plants is very rich in spieces of which are numerous: *Aegopodium podagraria, Pulmonaria officinalis, Glechoma hirsuta, Arum maculatum and Tamus comunis.*

The community stands of riparian forests of Willow and Poplar *Salici-Populetum* made spieces, which have an optimum range in mountain and sub-mountain belt of broadleaf-deciduous forest. In relation to moisture, this type of community consists of spieces adapted to high levels of flooding and groundwater. Concerning the supply of soil by nitrogen, the stands have a high indicator values, which indicates that this community consists of plant species that inhabit the habitats occasionally rich in nutrients. Plant species that make this community belong to the semi-shadow plants and in relation to salinity they are halophobe.

Forest community of the White Willow (*Salicetum albae*) is developed in a narrow river bank zone on the southeastern and flat exposures. The geological substrate consists of alluvial deposits, and soil type is fluvisol. Dominant spieces from the layer of trees are White Poplar *(Populus alba)*, White Willow *(Salix alba)*, The European White Elm *(Ulmus effusa)*, Acacia *(Robinia pseudocacia)* and others. In the layer of shrub dominate Dog Rose *(Rosa canina)*, Black Elder *(Sambucus nigra)* and Crack Willow *(Salix fragilis)*. In the layer of herbaceous plants, which is rich in spieces, the most common are *Aegopodium podagraria, Cirsium arvense, Calyistegia sepium, Galium molugo and Petasites hybridus*. This community consists of plant species that have the optimum range in the sub-mountain belt of broadleaf-deciduous forests.

These species are more or less indifferent and adapted to wet soil. These are semi-shadow plants, and concerning the continentality, they belong to sub- oceanic species with the main area in the central Europe. Index values of this community in relation to salinity suggest that these are halophobe species.

Hygrophilic forest vegetation develops on marsh soils with high level of groundwater, and sometimes surface water, forming a specific zone close to the river banks. In this area, it is differentiating in three vegetation orders: 1) Hygrophilic forest communities of the Alder of order *Alnetalia* Tx., 2) Hygrophilic forest communities of the Willow of order *Populetalia albae* Br.-Bl., and 3) Hygrophilic communities of the Osier of order *Salicetalia purpureae Moor*.

Communities of *Alnetalia* order develop in the vicinity of watercourses on marsh and hydrogenic soils, sometimes on the sandbanks with strong microrelief mainly on leveled terrains. These communities are fragmented character and usually alternate with communities of Order *Populetalia Albae*. Communities of *Alnetalia* Order are in this area represented by unity of the Black Alder *Alnion glutinosae*, i.e. by association *Alnetum glutinosae* where also belong, of trees spieces, a creeper Black Alder *(Alnus glutinosa)*, the European White Elm *(Ulmus effusa)*, the Alder Buckthorn *(Frangula alnus)*, the Bloodtwig Dogwood *(Thelycrania sanguinea)*, the Guelder-rose *(Viburnum opulus)*, and the Hop *(Humulus lupulus)*. Herbaceous species are represented by *Lycopus europaeus, Solanum dulcamara, Scrophularia nodosa, Ficaria verna, Petasites hybridus, Rumex sanguineus, Ranunculus repens, Lysimachia vulgaris*, etc.

Hygrophilic forest communities of willow, which belong to the vegetation order of the White Poplar *Populetalia albae*, are developed on alluvial deposits, on marshy soils. Based on the floristic composition, these stands belong to the association *Salicetum albae fragilis* Tx., which is normally widespread along rivers and creeks in the area of the Dinarides and beyond. Fragments of this community is being developed along the narrow riverbank zone. Edificator role has the White Willow *(Salix alba)* and the Crack Willow *(Salix fragilis)*,and from other spieces of trees and shrubs here are present the European White Elm *(Ulmus laevis)*, the Black Poplar *(Populus nigra)*, the Field Maple *(Acer campestris)*, the European spindle *(Evonymus europae)*, the European Dewberry *(Rubus caesisus)*, the Common Hawthorn *(Crataegus monogyna)*, the European Privet *(Ligustrum vulgare)*, the Common Ivy *(Hedera helix)*, the Old man's beard *(Clematis vitalba)*, the European Hop *(Humulus lupulus)*, the Common dogwood *(Thelycrania sanguinea)*, the Alder Buckthorn *(Frangula alnus)*, the Cranberry Tree *(Viburnum opulus)*, etc. The layer of herbaceous plants are *Glechoma hederacea, Scrophularia nodosa, Geranium robertianum, Brachypodium sylvaticum, Lysimachia nummularia, Lycopus europaeus, Stachys palustris, Roripa sylvestris, Angelica sylvestris, Potentilal reptans*, etc.

In the zone of hygrophilic forests, on nitrified habitats, develops a moist landfill of order *Bidentetalia*, i.e. unity *Menthion pulegii* Lakušić 73. With association *Menthetum pulegii* Lakušić 73., while in the moderately humid and nitrified habitats develops the vegetation of the orders *Onopordetalia* Br.-Bl. et Tx. 43 and *Chenopodietalia* Br.-Bl.

As a result of anthropogenic activities on the secondary vegetation, some fragments of tertiary vegetation occur. The presence of this vegetation indicates the groundwater and can be an indicator of the ecological balance. Tertiary vegetation of the class *Bidentetea tripartiti* was developed on terrains of hygrophilic forests, floodplain depression, along infiltration channels and creeks. The most important species are *Bidens tripartitus, Ranunculus repens, Agrostis stolonifera, Senecio fluviatilis, Mentha longifolia*, etc.

Class *Artemisietea* includes vegetation of dry landfills and in this area it has been developed in smaller areas, mainly outside the narrower and the first protection zone. The main edificator types are *Lappa maior, Artemisia vulgaris, Plantago lanceolata, Vicia sativa*, etc.

Tertiary vegetation of stubble fields and arable crops is covered by vegetation of the class *Stellarietea mediae* and occupies a larger terrain surfaces of ground water from valley to mountain belts. These are larger areas with extensive agricultural production. The most important types are *Papaver rhoeas, Vicia angustifolia, Ranunculus arvensis, Euphorbia falcata*, etc.

Vegetation of endangered habitats of the class *Plantaginetea maioris* includes terrains above the underground water and it is developed along the communication, the economic facilities and in locations that are moderately trodden and with a moderate amount of nitrate. The most important types are *Polygonum aviculare, Taraxacum officinale, Agropyrum repens, Trifolium repens, Trifolium pratense, Bellis perennis, Matricaria discoides, Poa annua*, etc.

On the part of the Zenica-Doboj Canton, including the settlement of Vranduk, some animal species typical for the area of BiH are inhabited, and specific and endangered species of wild animals are not recorded.

2.3. ICHTHYOFAUNA

The Bosna river is one of the largest river in Bosnia and Herzegovina (approximately 270 km) and according to the Ichthiological structure, one of the richest rivers in the region. According to Taler, a famous Austrian ichthyologist at the beginning of last century, the Bosnia is a river rich in fish, in this part of Southeast Europe. Thanks to the wealth of diverse natural food and diversity of ecosystems in the Bosna river, permanently or occasionally, there were about 30 species of fish. The upper flow of this rich streams is the habitat for salmonids, trouts and graylings (trout-graylings region), and some cyprinid species that are typical for this region: The European bullhead, Minnow, Sneep.

The middle section of the river, which is also the largest part, is a typical barbel region. Fish community of this region consists mostly of the sneep and there are also The European chub, the Ide, the Mediterranean and the European river barbel, Gudgeon and some types of small fish (Spirlin, Bleak, etc..). In this water there are also the Common Carp and the Wels Catfish.

The lower course of the Bosna river is pretty slow, although it has rapids, whose bottom is covered with fine gravel and sand. In fishing terms, this water is located at the junction between barbel and cyprinid region. High water levels are typical for spring and autumn period, and during the long rainy period. In the fish habitat there are almost all fish species characteristic for barbel and cyprinid area. There is still dominated by the Sneep, as the basic species of fish, together with the European Chub, the Ide, the Barbel, but going downstream, there are increasingly Carp, Tench, Carp Bream, Zarte, Danube Roach and numerous predators (Wels Catfish, Pike, Danube Bleak and Pike Perch)

Strong industrialization of Bosnia and Herzegovina, particularly the development of heavy industry in the Bosna river valley in the sixties and seventies of last century, have contributed to the pollution of the Bosna river by industrial waste. If we add to this a strong urbanization in the Bosna river valley (Sarajevo, Visoko, Kakanj, Zenica, Maglaj, etc..) and outpouring of wastewater in the Bosna river, without prior purification, led to the fact that in the Bosna river, especially in its middle course in the vicinity of Zenica, the fish stock did not almost exist.

This confirms the results of the analysis of the ichthyofauna in the Bosna River within the Fishing grounds of the Association of Sport Fishing Societies "LAŠVA" - Zenica, made in 1972 by the Institute of Biology, University of Sarajevo. According to Prof Dr Tihomir Vuković "on the part of the Bosna river from Zenica to Žepče at the base of field researches and data of users (Sport Fisherman Association Zenca), there are almost no fish, as a result of waste water of Zenica industry. Conducted representative attempts of fish catching in this part of the Bosna river, show that the fish stocks are almost absolutely devastated as a result of waste water of Zenica industry. Given the unfavorable conditions, this part of the river course should not be treated as a fishing area, because accordingly it will not be included in any measures for the promotion and exploitation of fish stocks."

Data on the quantitative and qualitative structure of the ichthyo-population of the Bosna river, from Zenica to Žepče, at distance of 46 km in 1972 are shown (Table 2. e).

Table 2. Table 2. e

Type	Number		Body measurements	
	pcs	**%**	**Average length (cm)**	Average weight (gr)
European Chub	3	33.3	-	**180,0**
Gudgeon	5	55.6	-	**5,0**
Burbot	**1**	**11.1**	**-**	**100,0**

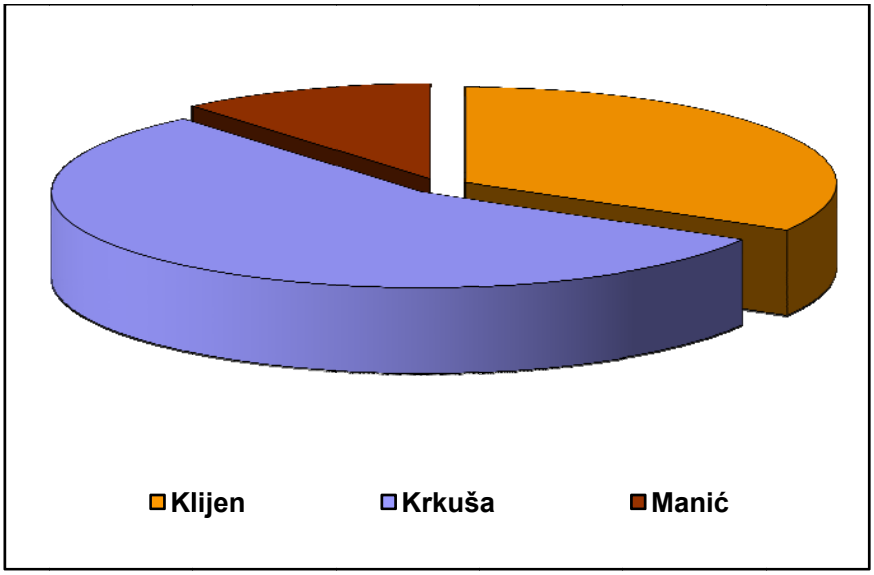


Chart 1. Percentage share of the registred fish spieces

At the beginning of the war and the cessation of Zenica Steel factory, the biggest polluter in the Bosna valley, the Bosna river was quite purified, and in its middle course except indigenous fish species (Sneep, Barbel, Chub) there are some type of fish that previously could not be seen or catched (Danube Roach, Carp, Catfish, Carp Bream, Prussian Carp, Zarte etc).

Based on researches of ichthyo-population in the Sava river catchment, which were conducted during 2006 and 2007, a representative sample in the Bosna river flow downstream from Zenica contains 7 fish species that exclusively belong to the minnow family (*Cyprinidae*):

- Prussian carp - Carassius auratus gibelio (Bloch, 1783)
- European chub - Leuciscus cephalus (Linnaeus, 1758)
- Sneep - Chondrostoma nasus (Linnaeus, 1758)
- Mediterranean barbel – Barbus meridionalis petenyi Heckel, 1847
- Gudgeon - Gobio gobio (Linnaeus, 1758)
- Spirlin - Alburnoides bipunctatus (Bloch, 1782)
- Bleak - Alburnus alburnus (Linnaeus, 1758)
- Common minnow - Phoxinus phoxinus (Linnaeus, 1785).

Data on the quantitative and qualitative structure of the ichthyo-population in the Bosna river downstream from Zenica in 2006 and 2007 are shown in

Table 3 and Chart 2.

Table 3. Qualitative-quantitative structure of ichtyofauna in the Bosna river downstream from Zenica in period of 2006.-2007

Type	Number		Body measurements	
	Pcs	%	Av.length (cm)	**Av.weight (gr)**
Prussian Carp	1	0,8	20,0	**162,0**
Common Nase	3	2,3	35,2	**485,0**
European Chub	36	28,1	18.5	**91,5**
Mediterranean Barbel	33	25,8	15,8	**62,3**
Gudgeon	5	3,9	11,0	**14,0**
Spirlin	20	15,6	11,0	**15,0**
Bleak	8	6,3	15,3	**29,5**
Common Minnow	**22**	**17,2**	**10,5**	**11,0**

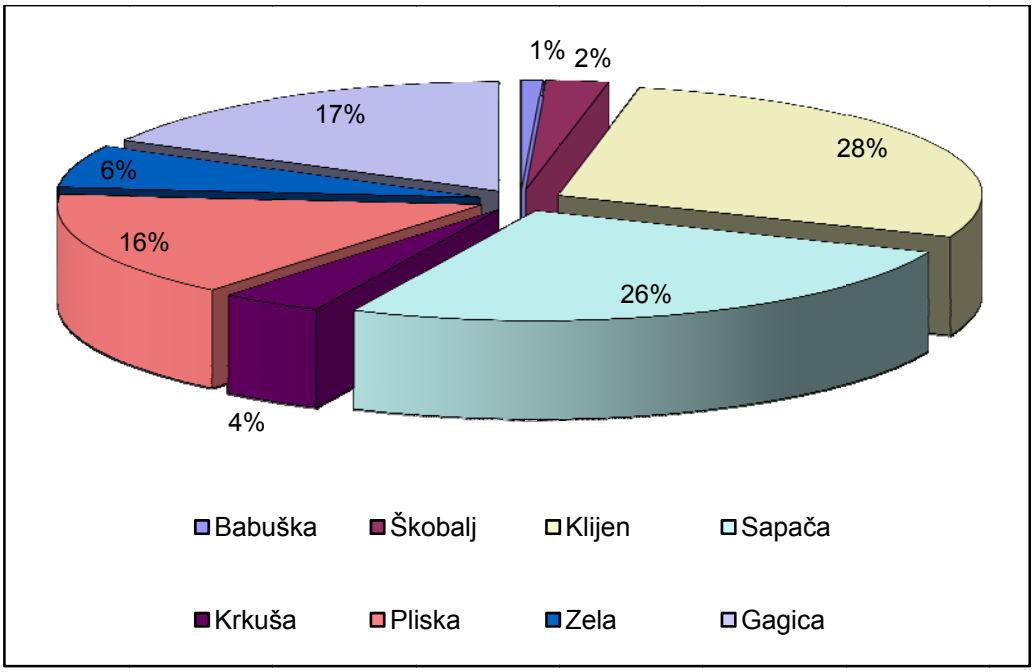


Chart 2. Percentage share of the registered fish

Sampled indicator fish species, indicate that the water quality of the Bosna river downstream from Zenica moves from beta-mezosaprobe to alpha-mezosaprobe type, and the value of the Shannon-Weaverovog index indicates a high degree of diversity of ichthyofauna in this area.

Based on data obtained from the authors of this part of the Study (A. Hamzić; S. Muhamedagić) and the Association of sport fishing "Bistro" Zenica, in the postwar period in the Bosna river area downstream from Zenica, in the wider region of Vranduk, different fish spieces were catched to a greater of lesser extent. Data on capital and extreme catches are largely in the documentation of UGSR "Bistro" Zenica.

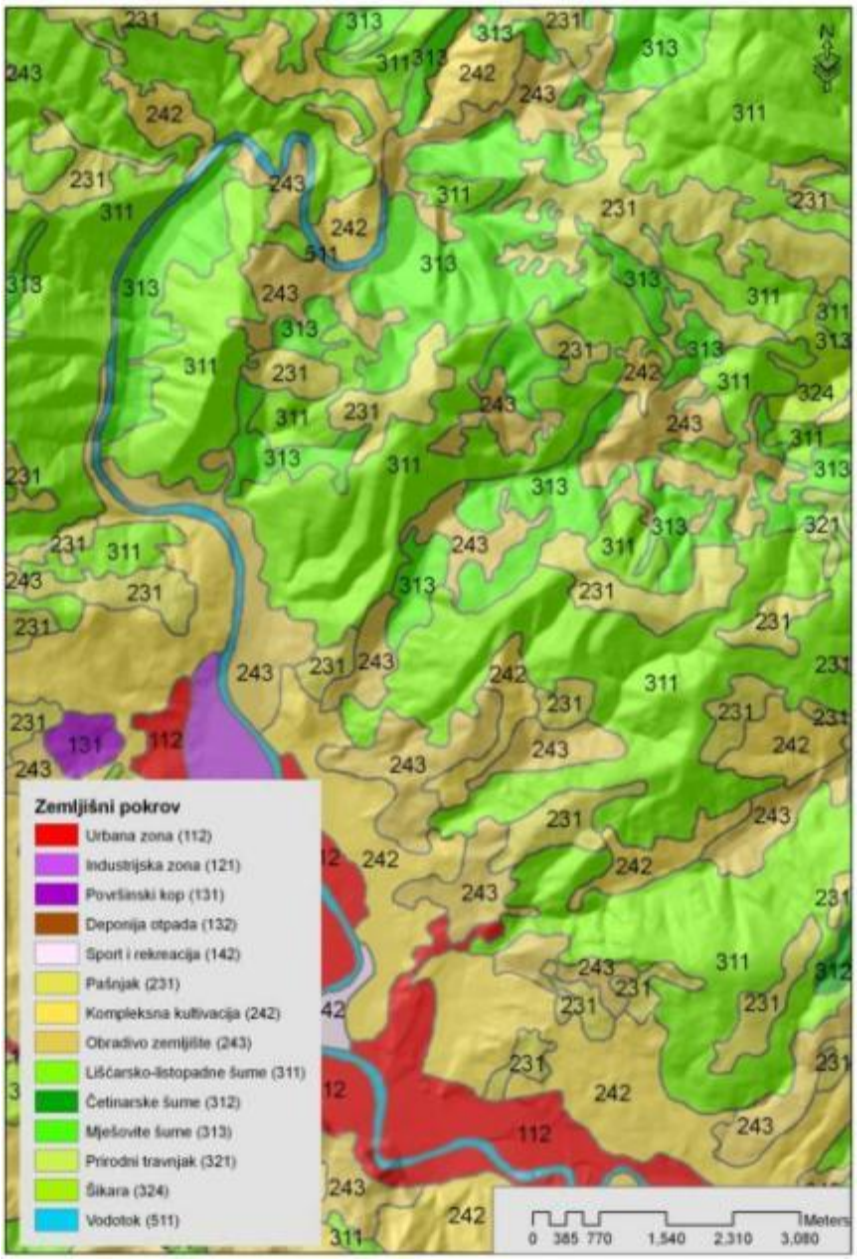
2.4. SOIL

In the area of Zenica municipality there is a large number of landslides. There is a cadastre of landslides, but it requires an adequate upgrade, which would record any new landslides in the cadastre and gain new insight into the situation on the site.

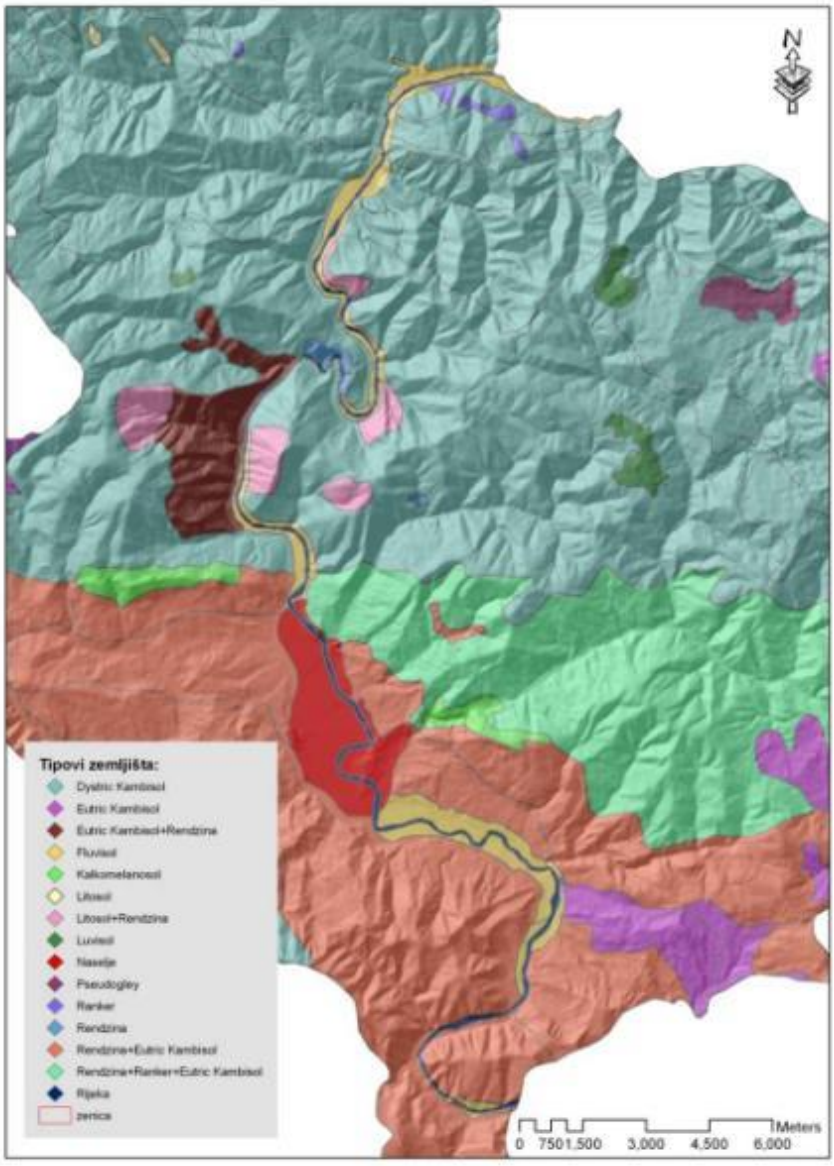
After the war, in the area of Zenica-Doboj Canton, large surface areas remained uncleared by mines and unexploded ordnance, which affects the safety of people and limited land use. However, the area where the facility of HPP Vranduk is to be built, is not at risk of mine fields[3]. Land that the project would include is inshore and unarranged land. In this area, state of lands does not refer to land used for agricultural purposes.

[3] The information was confirmed by letter from the Municipality of Zenica.

Types of soils and land cover in the wider area of the Vranduk canyon are shown on the Map 1. and Map 2. below.



Map 1. Land cover in the wider area of the Vranduk canyon



Map 2. Soil types in the wider area of the Vranduk canyon

SEISMICITY OF THE TERRAIN[4]

According to the seismological map (Association for Seismology, SFRJ Belgrade in 1987) the area of location where HPP Vranduk will be built, belongs to the zone of earthquake intensity of 6°MCS.

According to seismic evaluations, HPP Vranduk, without any significant damage or problems related to safety or stability of the dam, has to withstand earthquakes measuring 6°MCS.

[4] Study of seismicity in the location of HPP Vranduk, Winner Project d.o.o., Sarajevo, 2009.

Definition of seismic hazard is intended to provide the necessary information to determine an acceptable seismic risk, the subject technical - technological system. This system has been integrated into a space defined by a solid coupling of the ground (natural environment) - created system (dam) and social environment posed by users. Base of the facility makes the natural environment, while the artificial facility (dam) and the accompanying engineering buildings that represent its integral part makes the created system.

In the specificity of the dam, it should accept its character and fact that it is located on seismic maps in the zones of varying intensity. Current Seismological map consists of more tracings, which were made for different periods of time, and on them, for the same area, there are different intensities of earthquakes. As the choice of tracing of the seismological map is related to the category of object that is being built at a given location, than the assessment of seismic hazard and acceptable seismic risk represent a complex task. In addition, there are partial hazards and risks of individual buildings, which will be integrated into the general, and thus define the acceptable risk of a complex system of hydrotechnical facility. By innovation of the Rulebook for building construction in seismic areas, in terms of selecting the appropriate seismic map, it was striving to integrate method elements of seismic risk in the the rational designing.

The reason of this approach was that the occurrences of strong earthquakes during the life of building exploitation are rare, and the way of their influence has a great degree of uncertainty. Hence the analysis of structural damage is based on a level of certain acceptable risk, ie the level of reliability of earthquake occurrence. From these reasons, in practice the two concepts are introduced:

1.Design earthquakes for which it is expected that may arise during the life of building exploitation, one or more times. For this earthquake, the level of damage is controled in the design phase and it provides the basic seismic stability of the basic structural system of the building, taking into account the non-linear behavior of the building and allowing its minor structural and nonstructural damages.

2. The maximum earthquake is the earthquake that is expected to happen, with very low probability during the life of building exploitation. Maximum earthquakes define the seismic impacts for the verification of seismic stability of the basic structural system of the building, taking into account the non-linear behavior of the building and allowing more damages to the structural and nonstructural elements, but at the same time the overall stability of the building must not be endangered.

Assessment of seismic hazard, ie the basic level of seismic intensity was done on the basis of current Seismological maps and Seismotectonic map of Bosnia and Herzegovina

Thus, based on available seismotectonic data and data from seismological map, large area of Vranduk (Zenica) belongs to the zones of different seismic intensity

Figure 14. shows the earthquake intensity, whose probability of appearance at least once, during this time period, is 63%, which means that a given period is equal to the return period of earthquakes.

In the Vranduk environment, there are several seismotectonical blocks with a specific mechanism and character of movements. However, based on insight into seismotectonical structure of this space, we can conclude that the wider area of Zenica is induced by earthquakes mainly from the area of Treskavica.

For example, using the formula we get that for the life of building exploitation of t = 50 years and the size of the risk R = 10%, it is necessary to use the seismic map, for the return period of 500 years. On these maps, the basic level of seismicity in the area of Vranduk is 7°MCS.

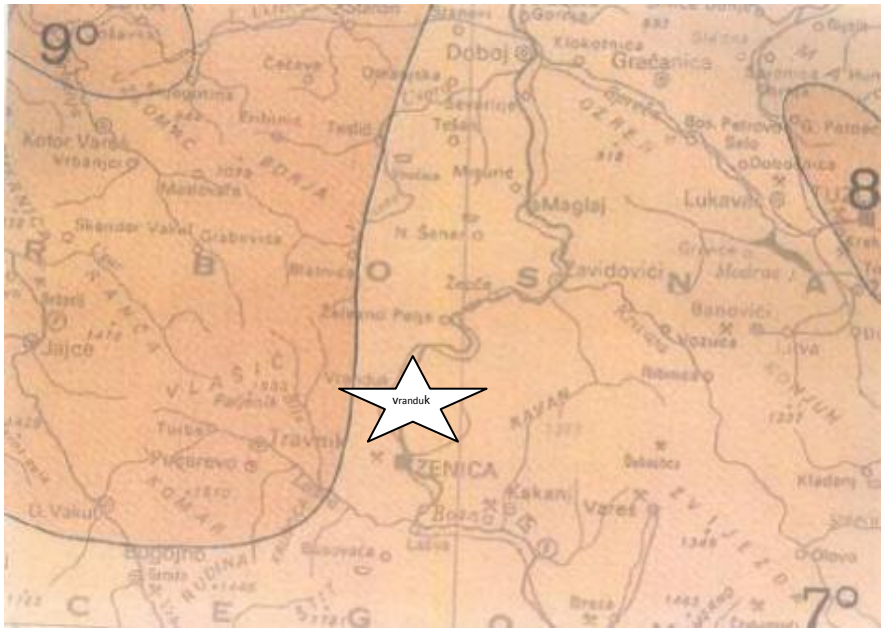


Figure 14. Seismological map for the return period of 500 years

Table 4. The degree of seismic activity for different return periods for large area of Vranduk (Zenica)

Return period, year	Degree of seismicity in ° MCS scale
50	6
100	6/7
200	7
500	7

GEOLOGICAL AND HYDROGEOLOGICAL CHARACTERISTICS

Researched area in the valley of the Bosna River was formed from different lithofacial structures that depending on the structural porosity, water permeability and water drainage have different hydrogeological functions. According to the structure of porosity, two categories of rock masses can be selected:

- Rocks of intergranular porosity
- Rocks of fracture porosity

The intergranular porosity rocks are alluvial, deluvial, proluvial and formations of rock creep, and artificial materials. The above mentioned rock masses are characterized by a wide range of values of water permeability and essentially represent collector rock masses and in some masses, compact outcrop can be formed with the free level of groundwater.

Looking at the complex as a whole, and the highest presence of poorly permeable and practically impermeable rock masses, which are embedded within a permeable rock mass of limestone, we can say that this hydrogeological complex represents in general poorly permeable to impermeable environment.
In this hydrogeological complex, can be formed a sprout of fracture-cracking type of porosity partly and cavernously in the surface parts of the terrain. Sprouts are fed by waters of atmospheric origin, and emptied on a number of sources of low yield, some of which are drying up. Basic geological characteristics of the wider area are in a complex geological-tectonic structure of the terrain.

In essence, the terrain is composed of Jurassic-Cretaceous sediments of flysch called Vranduk series. The composition consists of sandy limestone, marly limestone, calcarenite, sandstone, shales and marls that rotate alternate in the column. The terrain is partly covered by Quaternary sediments, primarily by terrace gravel and alluvial deposits in the riverbed (Appendix 2.). There are also large quantities of artificial sediment deposited during the excavation of the existing traffic tunnels.

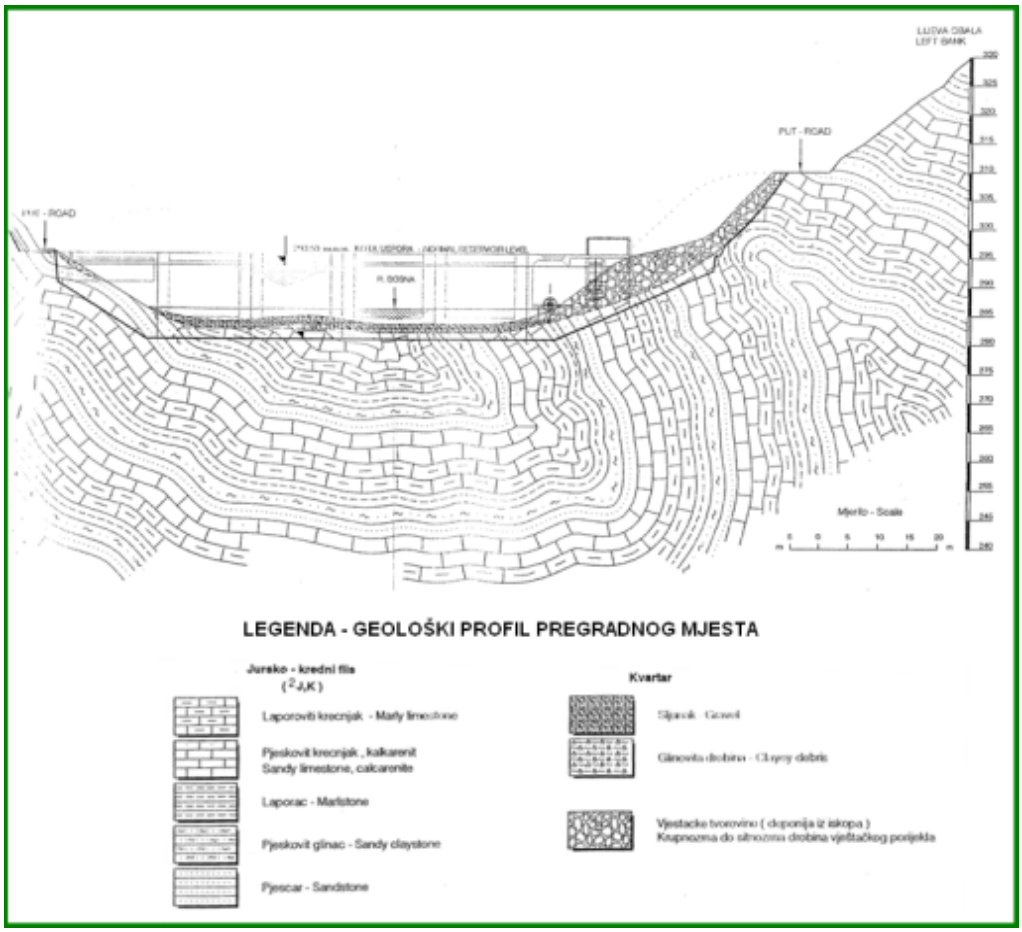


Figure 15. Geological profile of dam section HPP Vranduk (Source: Feasibility pre-study)

In tectonic terms, the terrain belongs completely to a zone of Paleozoic shales and Mesozoic limestone, according to the tectonic scheme Petković K. (1958). Within the zone of Palaeozoic shales and Mesozoic limestone, three facial structural units (M. Živanović, 1967) were selected:

- wrinkle structures of the area Nemila-Travnik,
- area of divergent folding,
- tectonic depressions.

The treated area belongs to the structural facial unit of the wrinkle structure in Nemila-Travnik area and inside, to the separate unit of lower rank "Vranduk-Mehurići belt of scales and laid isoclinal folds"

Vranduk-Mehurići belt of scales and laid isoclinal folds, which belongs to this terrain, is a typical wrinkle belt, where the Jurassic-Cretaceous flysch deposits are strongly pushed toward the southwest, often squeezed and folded into isoclinal folds of usually ten to one hundred meter size.

Axis of wrinkles are mostly stretched in direction of NW-SE. Wrinkles are mostly lying to the southwest. Axial surfaces go down to the northeast. Sometimes due to strong pressure, wrinkles are shifted (with a top of folding plunged toward the northeast). A torsion also occurs locally by spreading of – „whole packages of wrinkles“. The spreading direction of rupture shapes is consistent in direction and spreading of the same shapes in other parts of the Dinarides.

Hydrogeological characteristics of the basic rock formations are in the range of watertight rocks of fracture porosity to water permeable rocks of intergranular porosity in a lesser extent. Generally, the complete massive are poorly permeable rocks.

From Zenica field, the Bosna river enters Vranduk-Nemila canyon. In this section, the Bosna river is flowing as a stream of larger fall, which resulted in intensive cutting, as well as the formation of narrow canyon valley whose bottom the Bosna river is making its way to the north.

The length of the flow, on this stretch, is about 16,5 km. Due to the prevailing spreading of more resistant rocks (diabase - Rožnja series), the valley sides are larger slopes and are deeply dissected by deep valleys which some casual and permanent streams flow into the Bosna river course. They all strongly form sediment. In addition, on sides of the biggest falls, some processes of gravitational movement of the products of wear are also intensive. A special feature of this part of the valley is provided by some restrained meanders.

Downstream from Zenica is provided on both sides, by continuous belt of Jurassic-Cretaceous flysch formations where the valley is narrowed. These geological relations are strongly influenced in recent geomorphological relations. In canyon areas, where some conglomeratic formations prevail, as is the case in one part of the valley in Vranduk-Nemila canyon, some intensive processes of seaming and landslide occur. In Vranduk-Nemila canyon due to the greater range of rocks more resistant to denudation, some large slopes are created, and the valley is a typical canyon. In both narrow valley parts, there are many deep valleys on the sides, where some periodical or continuous streams are flowing. All those in the Bosna river bring enormous quantities of sediment deposited also in the Bosna riverbed.

CONDITIONS FOR FOUNDATION OF FACILITIES

The dam is founded on the rock mass of basic formations, with the expected relatively favorable geotechnical characteristics and poor water permeability in the zones below foundations, which will be increasingly defined by investigations and testing in the next phase of the project.

Headrace tunnel is to be constructed in the massif composed of a complex composition of the rock mass. During excavation, we can expect good behavior of the rock mass around the excavation on the percentage maximum length of the tunnel route. But on the other hand, several short sections of poor characteristics are expected. The inflow of groundwater in the excavation should be expected at the initial and final tunnel section, while in the interior of

massive, higher occurrence of groundwater is not expected. The same applies to the surge shaft.

Power house is embedded below the level of the river on the rocks of the basic formations that have relatively favorable characteristics for the funding of facilities, while the deepening of the riverbed downstream of the power house is carrying out in the alluvial gravel, and partly in the rock.

2.5. WATER

It is a known fact that the Bosna river downstream from Zenica was very polluted, even at a time when the plant for wastewater treatment of Sarajevo, as the largest polluter, was in function. Unfavorable factor for water quality is that, according to the census from 1991, 40,2% of BiH population lived in the Bosna river catchment, while from the catchment drains only 14,1% of the total runoff within the boundaries of BiH. In addition, most industry is concentrated in this catchment. According to the Regulation on categorization of water streams (Official Gazette of SR BiH 19/86), the Bosna river downstream of Zenica belonged to the third category (water that can be used for irrigation, and after the usual processing methods, used in industry, except food).

However, based on results of the investigation, the class for the period 1986.-1989 of the Bosna river downstream from Zenica is significantly worse than the fourth class (outside of class)[5]. Lately, they are not officially published the results of testing and determining which class of water belongs to the Bosna river on the stretch where construction of HPP Vranduk is planned.

The issue of water quality of the Bosna river is not relevant for energy use, but it must be taken into account in the planning of any contents of the water use for recreation, as well as the possibility of development of sport fishing or cage culture of fish in the future accumulation.

When it comes to water quality, relevant indicators of impacts of status caused by natural or artificial processes on water quality are saprobity index (a key indicator of impact) and the oxygen content (an indicator of water quality). The average measured oxygen content of the two gauging stations: Raspotočje (upstream of the future dam of HPP Vranduk) and Maglaj (downstream of the future dam of HPP Vranduk) is about 10 mg/l, which corresponds to class 3 of the streams, as well as saprobity index of 2,5. Higher oxygen content in water is caused by higher atmospheric pressure, lower water temperature, higher speed of the Bosna river flow and points to the absence of organic pollution. Figure 16., Figure 17. and

Figure 18. below, show an overview of the mentioned measured parameters of the Bosna river (content of oxygen, phosphate and saprobity index) in the period 1973 to 1991.

[5]Hydrological-meteorological data base, the Consortium Energoinvest, Pöyry and IPSA, Sarajevo, May 2009.

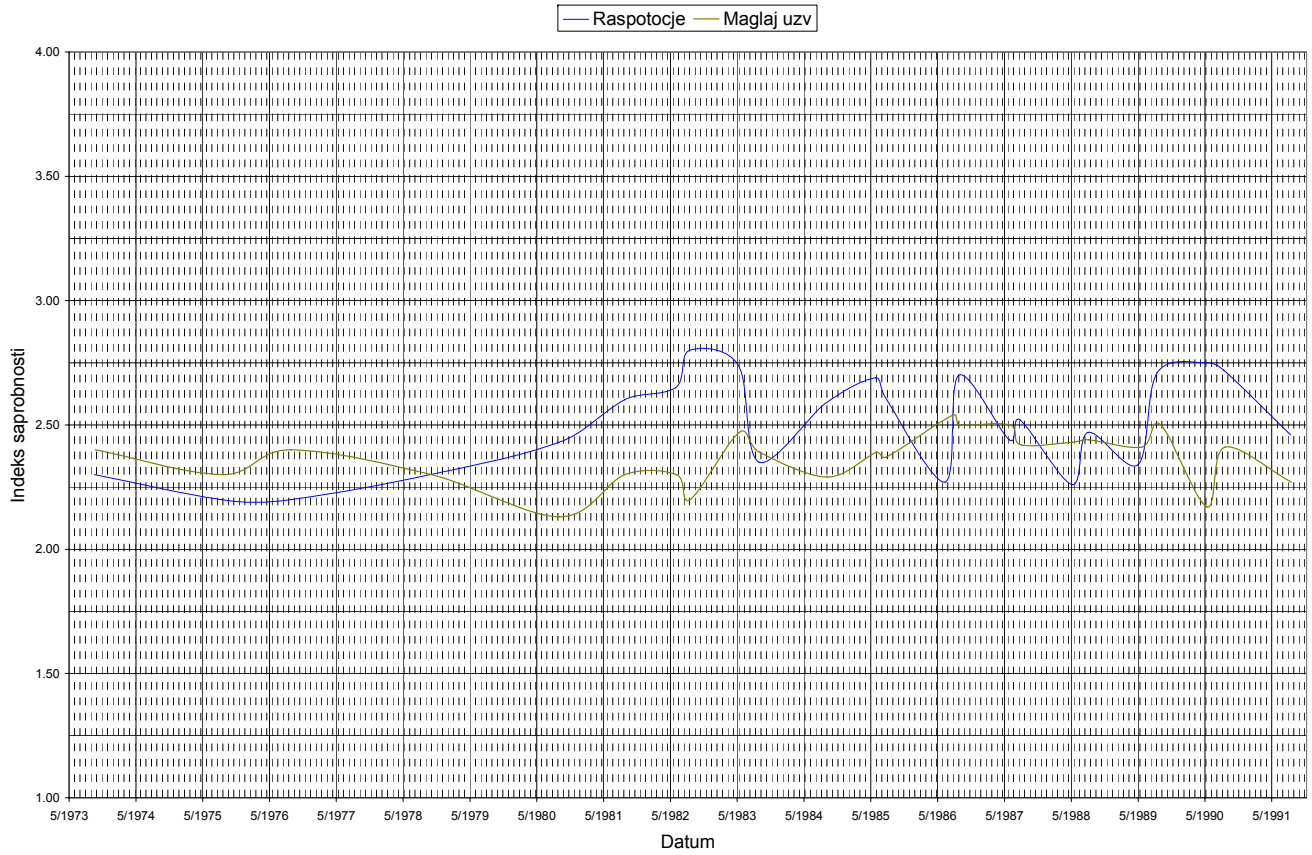


Figure 16. Diagram of measured values of the saprobity index in the gauging stations Raspotočje and Maglaj for the period 1973.-1991.

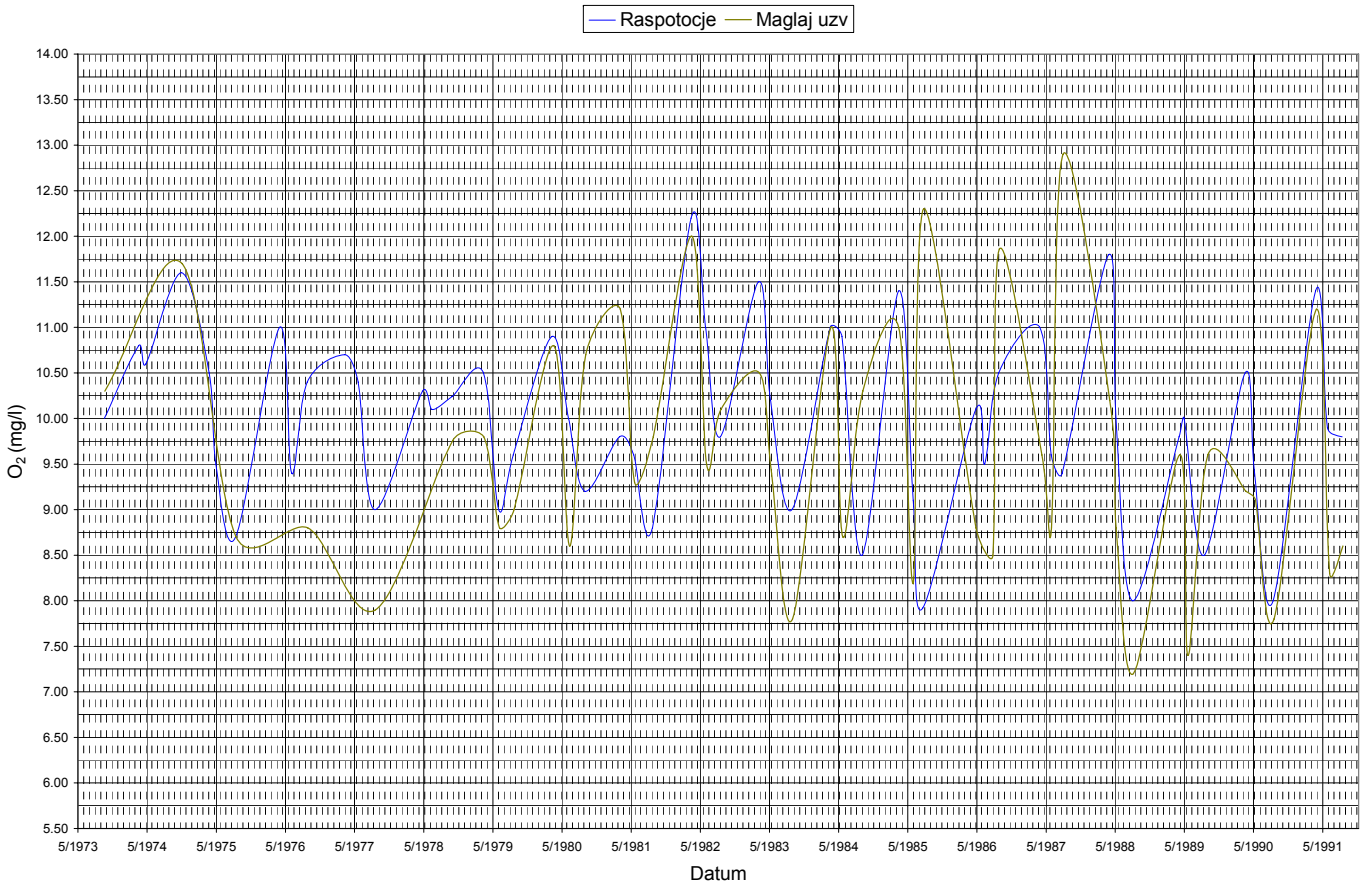


Figure 17. Diagram of the measured oxygen content in the gauging stations Raspotočje and Maglaj for the period 1973.-1991.

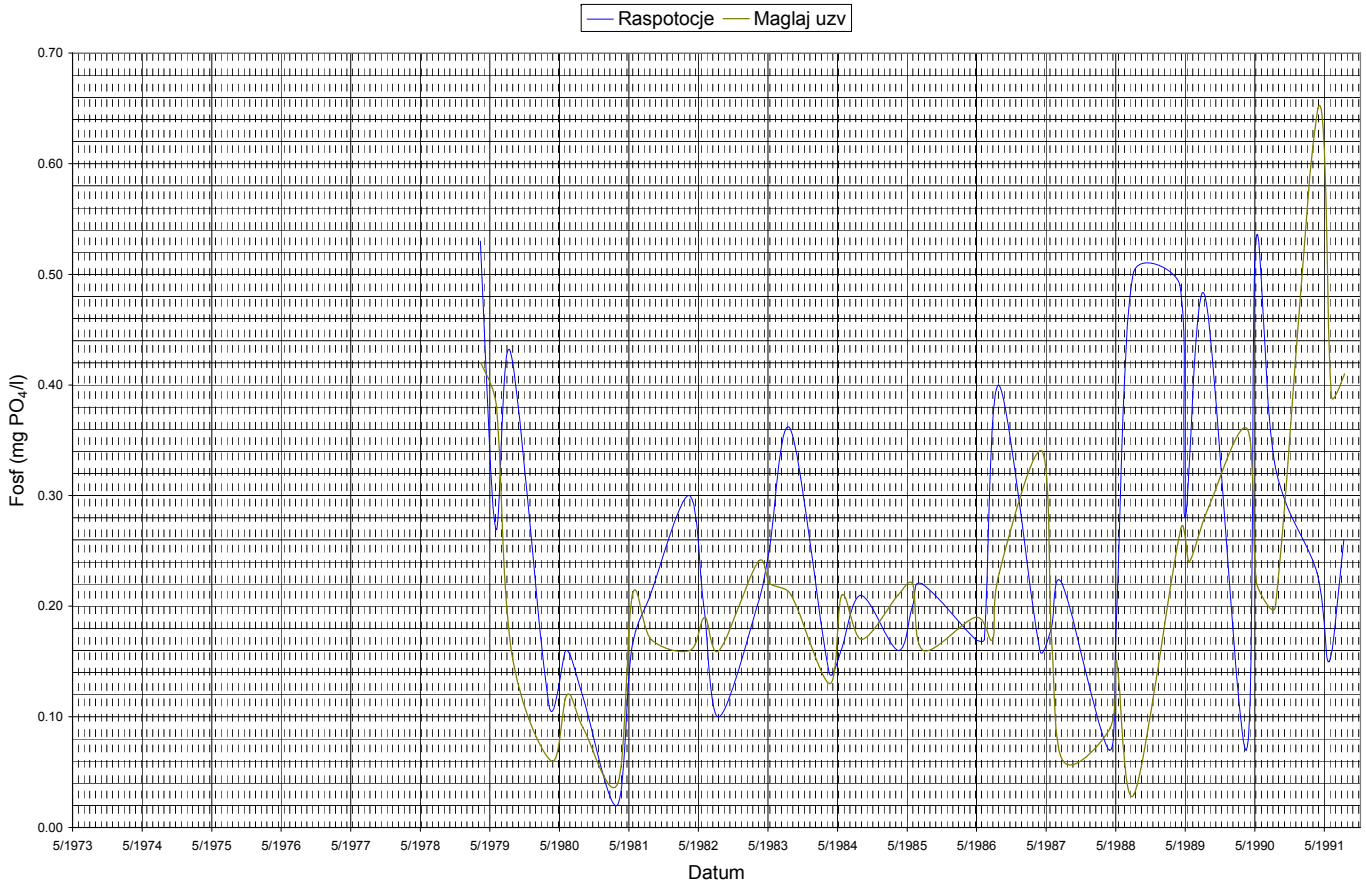


Figure 18. Diagram of the measured phosphate content in the gauging stations Raspotočje and Maglaj for the period 1973.-1991.

CURRENT WATER REGIME ON PROJECT SITE HPP VRANDUK[6]

Location of HPP Vranduk is about 10 km downstream of the gauging station in Zenica, which was established in 1897. There are a registered data on water levels from 1923.

Hydrological analysis for this study included the time series for the period 1955-1991, which can be considered as fully reliable basis for this Project. The difference in the catchment area between the site of HPP Vranduk and GS Zenica is approximately 6%, which is almost negligible difference, and no correction of high water carried on the downstream location. Relevant data on the water regime are presented in Table 5.

Table 5. The relevant data on water regime

Watercourse	Location	Catchment area F (km2)	Mean flow Qsr m3/s	Reg.min. flow Qmin.m3/s	High water QVV (m3/s)			
					Return period (year)			
					10	50	100	1000
Bosna	Zenica	4124	77,50		1010	1329	1463	1913
Bosna	HPP Vranduk	4360	82,00	12,1	1061	1404	1550	2043

Given its proximity to the location, it can be concluded that the meteorological data from GS Zenica (shown in Table 6.) is relevant for the area of HPP Vranduk, i.e.:

Table 6. Meteorological data from GS Zenica

Mean annual temperature	10°C
The coldest months	I and XII
The warmest months	VII and VIII
The average minimum temperature	- 6,0 °C (I) - 3,4 °C (XII)
The average maximum temperature	26,6 °C (VII) i 26,8 °C (VIII)
Average rainfall	822 l/m2

[6] HPP VRANDUK – Preliminary design – Book 03. Hydrological-meteorological data base (by Energoinvest IPSA POYRY, Sarajevo, May 2009.)..

The average intra-annual disposition of flows on section of Vranduk, is given in Table 7.

Table 7. The average intra-annual disposition of flows on section of Vranduk[7]

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
q (m^3/s)	84,86	101,24	116,5	136,34	115,77	72,18	50,32	36,63	37,89	53,83	80,73	98,15	81,33

Duration line

Table 8. Duration line of daily flows

T (%)	Q (m^3/s)	T (%)	Q (m^3/s)	T (%)	Q (m^3/s)	T (%)	Q (m^3/s)
1	346,90	26	103,38	51	59,61	76	33,32
2	272,59	27	99,87	52	58,00	77	32,41
3	248,35	28	97,40	53	57,44	78	31,51
4	224,82	29	95,56	54	56,17	79	30,78
5	208,76	30	93,21	55	54,79	80	29,88
6	196,68	31	91,09	56	53,63	81	29,37
7	186,05	32	88,91	57	52,94	82	28,56
8	175,77	33	86,99	58	51,67	83	27,79
9	169,19	34	85,25	59	50,47	84	27,21
10	162,23	35	83,63	60	49,54	85	26,27
11	156,34	36	80,69	61	48,42	86	25,39
12	151,30	37	79,85	62	47,22	87	24,72
13	145,64	38	77,47	63	46,30	88	24,17
14	142,13	39	76,27	64	44,99	89	23,24
15	137,92	40	75,11	65	43,66	90	22,89
16	134,00	41	73,47	66	42,28	91	22,09
17	129,11	42	72,08	67	41,64	92	21,18
18	126,02	43	70,91	68	40,66	93	20,61
19	122,32	44	69,02	69	39,69	94	19,61
20	118,46	45	67,76	70	38,91	95	18,82
21	116,33	46	66,49	71	38,04	96	17,82
22	113,61	47	65,16	72	36,90	97	16,54
23	111,35	48	63,68	73	35,96	98	15,48
24	108,06	49	62,16	74	35,05	99	13,15
25	105,73	50	61,13	75	33,93	100	11,83

[7] Watercourse: Bosna; Section: intake of HPP Vranduk; Period: 1955.-1991

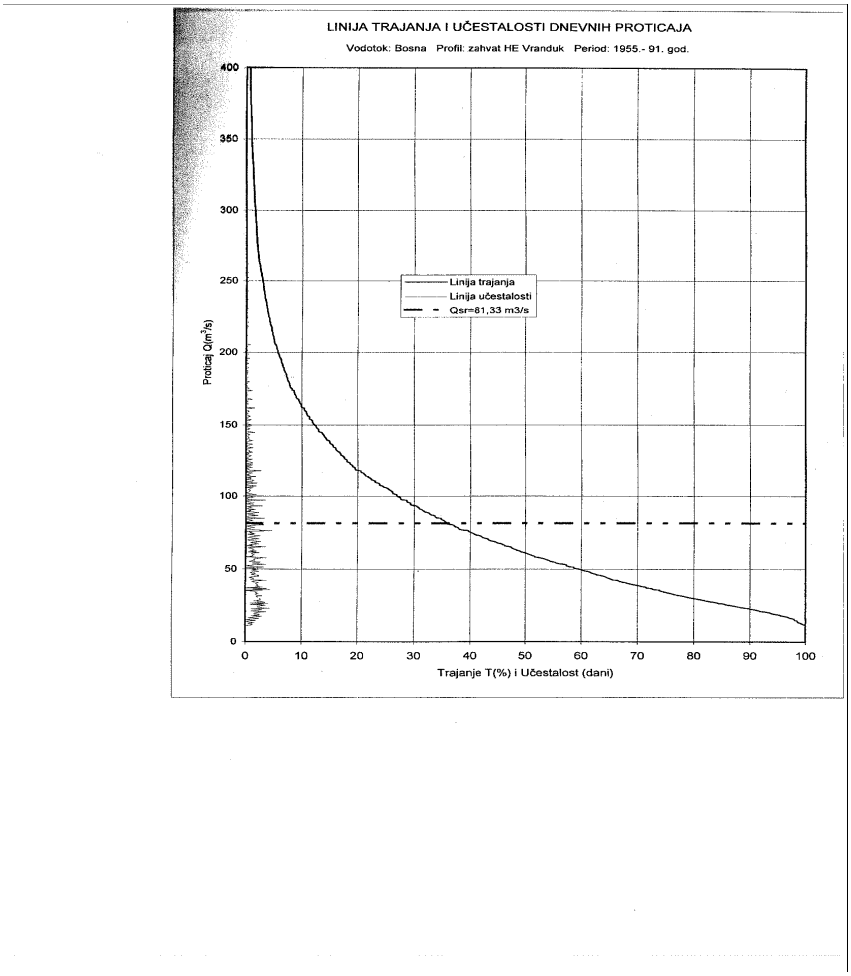


Figure 19. Duration line and frequency of daily flows Watercourse: Bosna; section: intake of HPP Vranduk; Period: 1995.-1991.

LOW WATER

Calculation of low water is made for a minimum annual flows and minimum mean monthly flows.

Minimum annual flows

The minimum annual flows in the treated series were moving in the range of 11,7 to 36,8 m^3/s with an average of 19,5 m^3/s. The coefficient of variation is 0,289, and the coefficient of asymmetry is 0,851. The calculation results for probability of occurrence of the minimum annual flows are given in Table 9.Table 9Table 9. Probability of occurence of the minimum annual flows

Return period (years)	Probability (%)	Q (m^3/s)
1,0001	99,99	50,90
1,0010	99,9	43,73
1,0101	99	36,06
1,0204	98	33,59
1,0420	96	30,99
1,0530	95	30,12
1,1111	90	27,29
1,2500	80	24,25
2	50	18,97
5	20	14,79
10	10	12,97
20	5	11,63
25	4	11,27
50	2	10,31
100	1	9,53
1000	0,1	7,71
10 000	0,01	6,60

MINIMUM MEAN MONTHLY FLOWS

In the calculation of low water, special attention is paid to minimum mean monthly flows for the purpose of defining environmentally acceptable flow.

Minimum mean monthly flows in the treated series were moving in the range of 11,78 to 59,2 m^3/s, with an average of 26,84 m^3/s. The coefficient of variation is 0,370, and the coefficient of asymmetry is 1,058.

The calculation results of probability of the minimum mean monthly flows are given in Table 9.

Minimum mean monthly flows 95% of probability, i.e. 95% of providing on project profile of HPP Vranduk is: 14,0 m^3/s.

Control of the obtained results were analyzed based on regional analysis of low water for the Bosna river catchment. It is formed a dependency of the mean flow - the minimum mean monthly flow with 95% of providing.

The above means that low water 95% of providing ranges from 13,5 to 14 m^3/s. The amount of 14 m^3/s, obtained by calculation, is adopted as an environmentally acceptable design flow in the Preliminary design of HPP Vranduk. Terms of achieving continuous environmentally acceptable flow downstream of the dam in accordance with Article 62 of the Law on water (as well as other requirements for construction of HPP Vranduk) are also defined in the

Decision pn Previous water consent, no UP-I/25-1-40-314-5/09 dated 21.10.2009., issued by „Agencija za vodno područje rijeke Save“ Sarajevo.

HIGH WATER

The probability of occurrence of high water was made on the basis of a series of maximum annual flows of the period from 1926 to 1991, so as the maximums, on GS Zenica, were increased for K = 1,0519. This could be done, since on the stretch GS Zenica - HPP Vranduk there are no major tributaries, which would specifically affect the series of maximums.

Maximum annual flows in the treated series were moving in the range 250-1243 m^3/s with an average of 642,5 m^3/s. The coefficient of variation is 0,366, and the coefficient of asymmetry is 0,681. The calculation results of probability of occurrence of maximum annual flows are given in Table 10.

Maximum annual flows in the project profile HPP Vranduk are obtained from the maximum annual flows of GS Zenica, which were corrected with the ratio of surface area-precipitation of these two profiles (k = 1,0519). Calculation of the probability of occurrence was performed by classical hydrological statistical method and calculation results are provided in Table 10.

Table 10. The probability of occurrence of maximum annual flows

Return period (years)	Probability (%)	Q_W (m^3/s)
2	50	667
5	20	905
10	10	1061
20	5	1211
25	4	1258
50	2	1404
100	1	1550
1000	0,1	2043
10 000	0,01	2567

Flood control for the rank of occurrence 1/100 years has made by the regional analysis. For correspondence, data are used from the water gauging stations from the Bosna river catchment: GS Plandište, GS Reljevo, GS Dobrinja, GS Zenica, GS Zavidovići, GS Maglaj and GS Usora on the Bosna river.

According to data of the Preliminary Design - Book 03 Hydrology-meteorological data base (by Energoinvest, IPSA, PÖYRY, Sarajevo, May 2009.) the obtained data of hydrologic processing of water regime ot the Bosna river in the Vranduk profile are satisfactory both in

terms of the length of the processed sequences and accuracy of the obtained results and can be used for the design of HPP Vranduk on the level of the Preliminary Design. Figure 20. shows a state of banks after withdrawal of the Bosna river.

Figure 20. The current situation on the Bosna river banks in the area of the planned hydro accumulation

2.6. AIR

For more specific location of the future HPP Vranduk, air quality measurements are not made. The only data that are available, are the measurements of air quality carried out in order to develop the LEAP of the Municipality of Zenica. Generally, we can say that the air quality in the area is disturbed due to the work of Zenica steel factory, which greatly contributes to air pollution at a given location.

2.7. EXISTING INFRASTRUCTURE

Electricity Network

To provide a safe placement of electrical power, a connection to the 110 kV grid was chosen, namely to the existing 110 kV transmission line Zenica 1 - Zavidovići that passes near the

location of the future plant in the system input-output. The transmission line has been renovated and has sufficient capacity to accept a new power plant produced energy.

Figure 21. gives an overview of existing and planned electric network, transformer stations and the location of the future HPP Vranduk, while

Figure 22. illustrates a more detailed view of the existing electric lines and roads, as well as the planned HPP Vranduk and the Corridor VC.

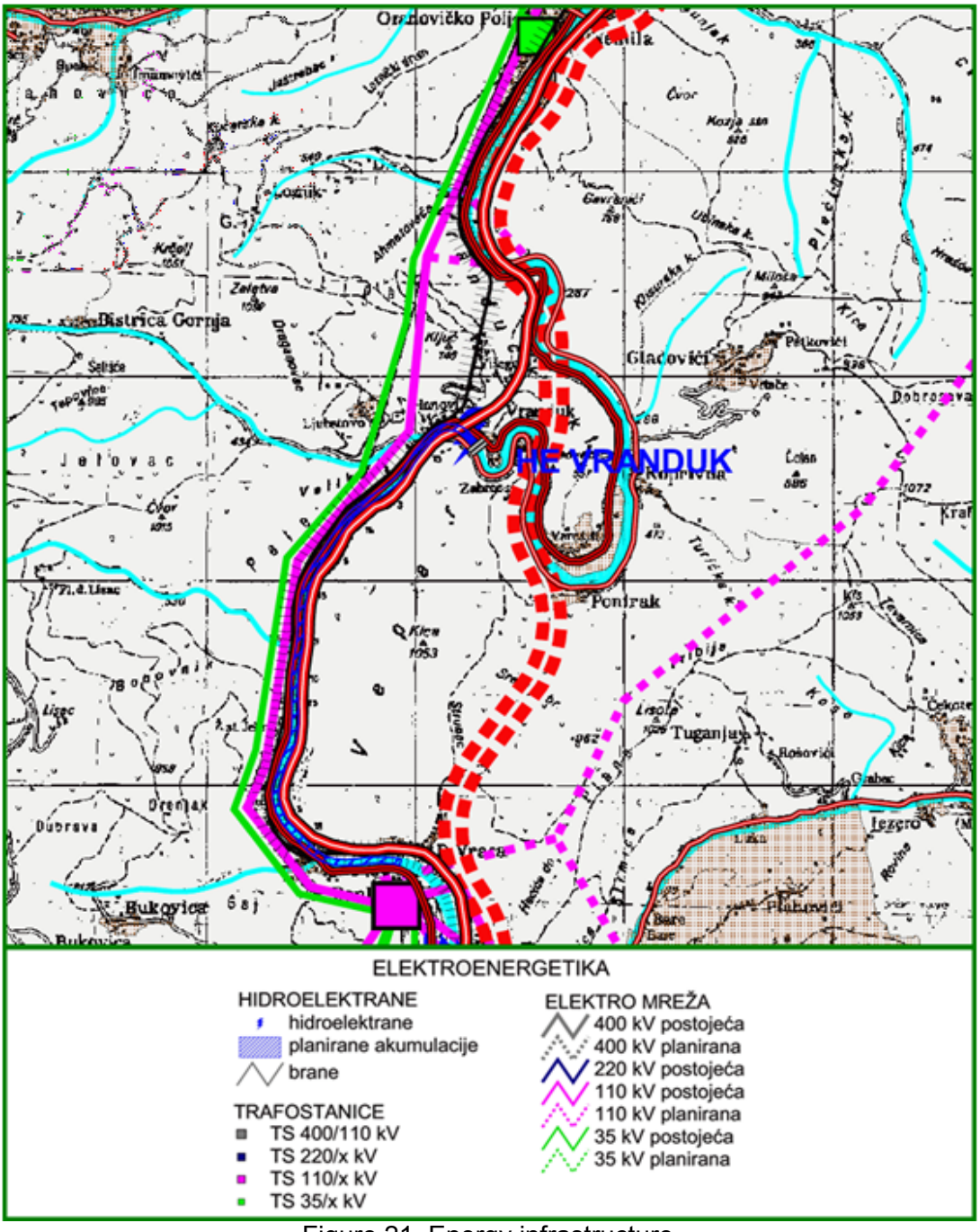


Figure 21. Energy infrastructure

(Source: Spatial Plan of Zenica-Doboj Canton (2009 - 2029.)

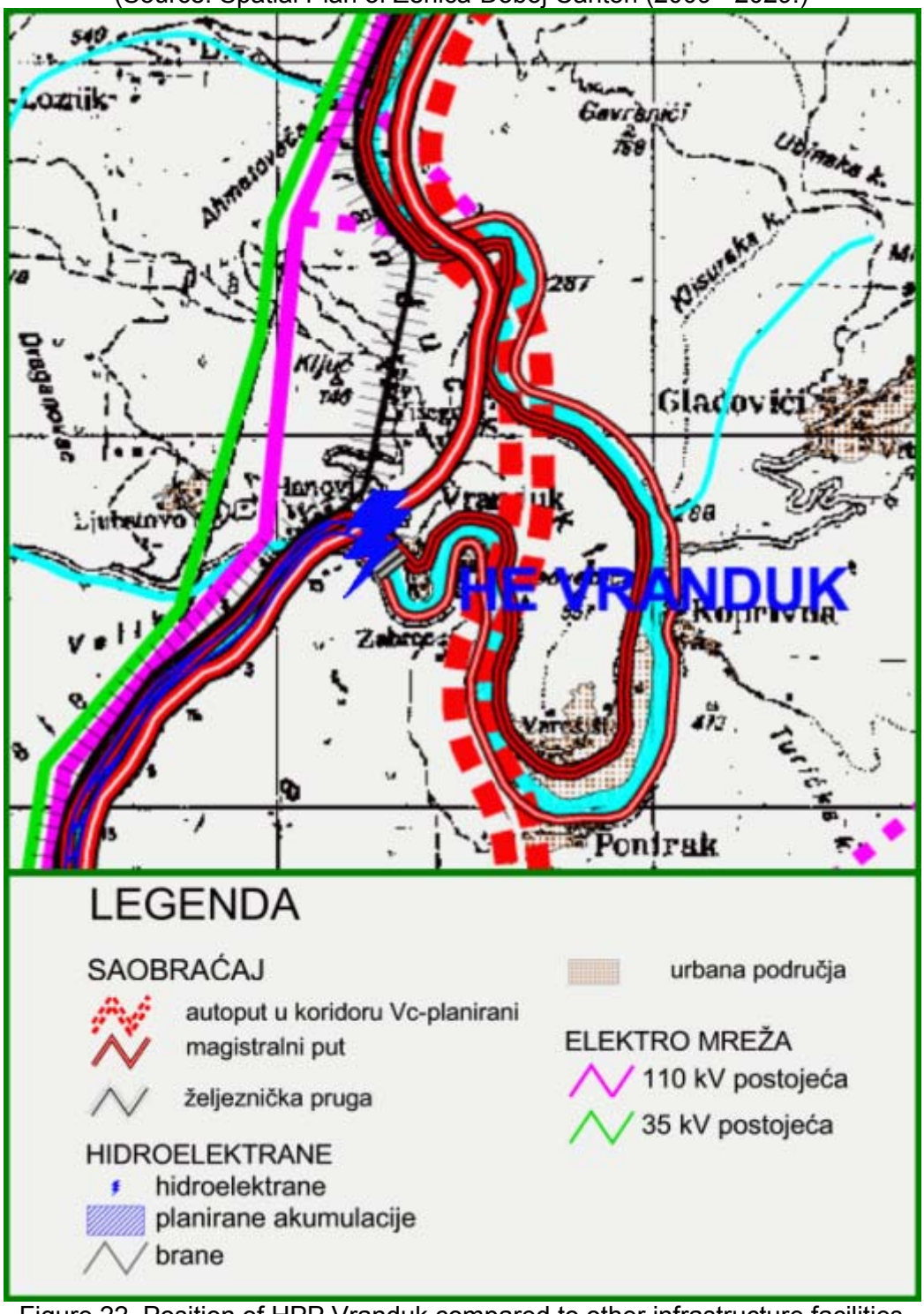


Figure 22. Position of HPP Vranduk compared to other infrastructure facilities
(Source: Spatial Plan Zenica-Doboj Canton (2009 - 2029.)

Telecommunications and postal traffic

The development of communication systems is based on the overall general economic and social development of each country and region. Given the relatively well-developed telecommunications infrastructure in the area of Zenica-Doboj Canton, BH Telecom is also, for the Vranduk area, provided the following (Figure 23.):

- copper cable
- optical cable
- telephone exchange
- broadcasting transmitters

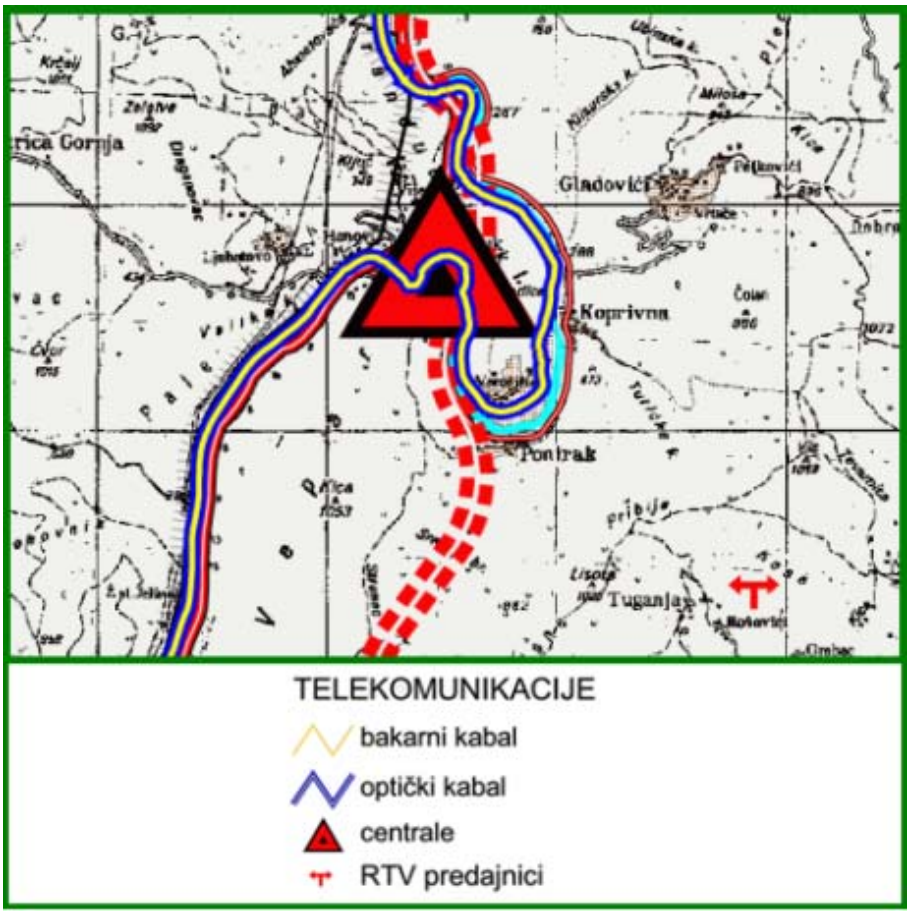


Figure 23. Overview of telecommunication infrastructure in the Vranduk area (Source: Spatial Plan of Zenica-Doboj Canton (2009 - 2029.) – system connection)

Water supply and Sewerage system

It is important to note that in the area of the subject site there is no built infrastructure for urban water supply or sewage system (Figure 24.).

Water supply and sewer infrastructure that is used has been built without official projects and as such is not covered by the Spatial Plan of Zenica - Doboj Canton 2009 - 2029.

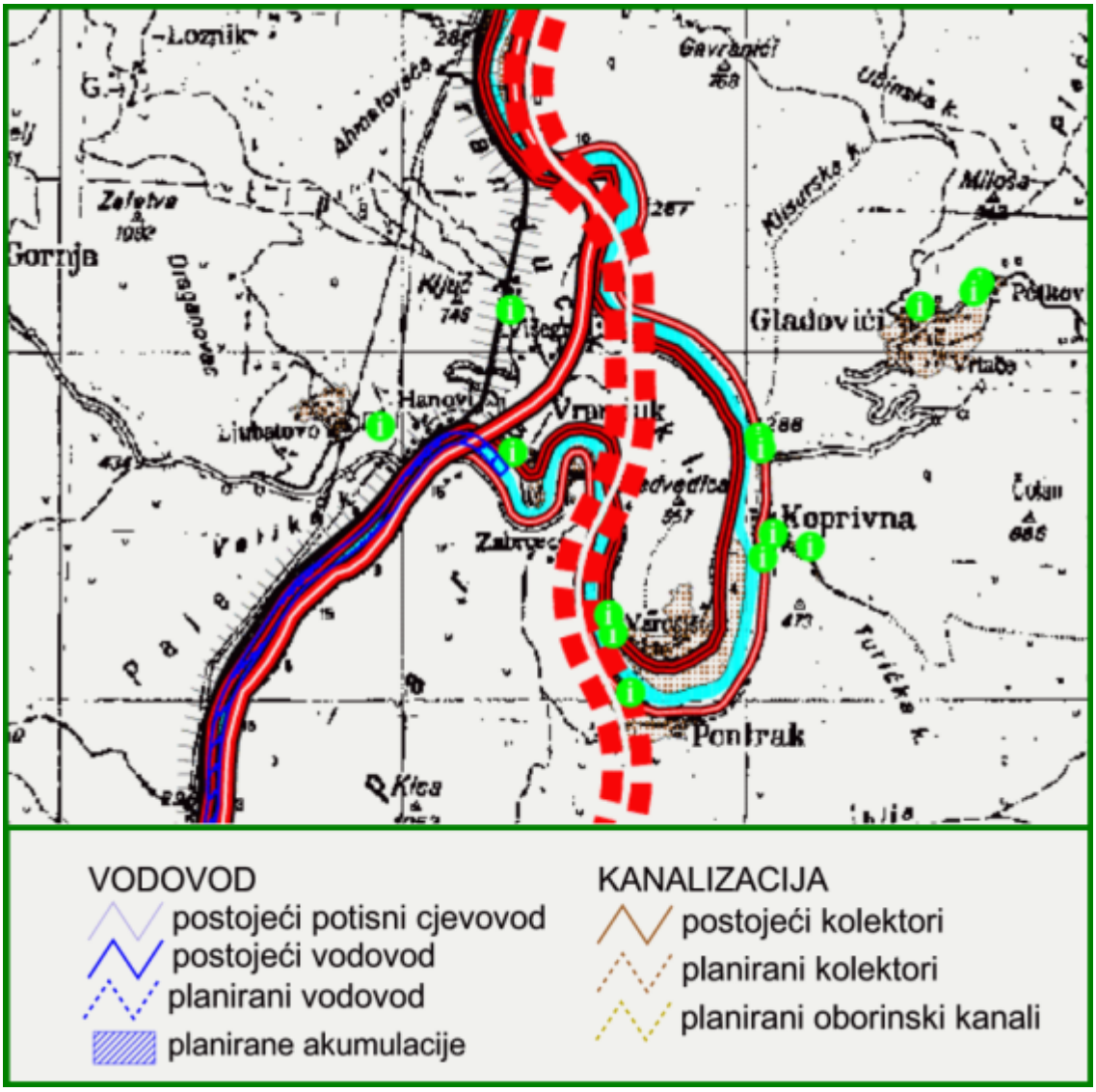


Figure 24. Water supply and sewer infrastructure (Source: Spatial Plan of Zenica-Doboj Canton (2009 - 2029– other infrastructure)

Traffic infrastructure

The stretch Zenica–Nemila is connected to road and railway communication. For external connection of the Canton, the most important road will be the Motorway on the Corridor Vc, which will constitute the backbone of the road infrastructure in Bosnia and Herzegovina. Zenica-Doboj Canton has a central position in this corridor,so that the motorway, railway, gas and oil pipelines will constitute a multimodal transportation corridor where the development of numerous industrial zones, tourist and shopping malls, technology parks, etc. wil be provided.

The current state of the left bank on the general location of the dam profile is unregulated landfill of the excavation from the tunnel on the main road. At the landfill it is visually observed a service road, which was once set aside deposited material, and from the existing local road, it branches off just above the entrance portal of the tunnel on the main road.

Figure 25. shows the projected position of the future motorway in the corridor Vc and the position of the planned dam and accumulation of HPP Vranduk. Power house will be located on the left bank of the Bosna River next to the local road Doboj-Kaonik which is below the level of the main road M17, and thus the future motorway. According to the currently available technical and spatial documentation (Spatial Plan of the Zenica-Doboj Canton) the projects are compatible i.e. there will not be obstacles for the development of both projects. Facility of HPP Vranduk will not directly affect the construction of the motorway.

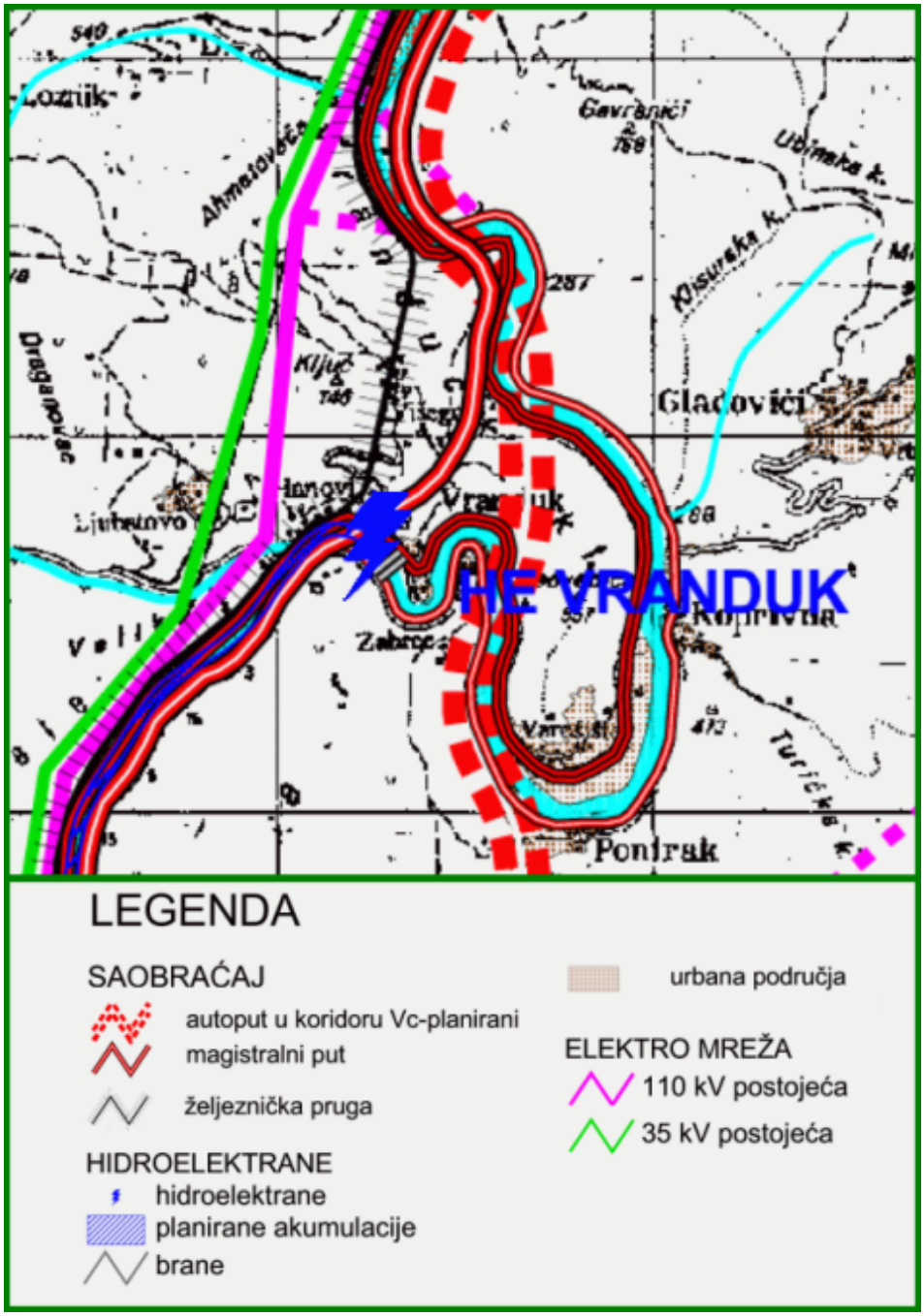


Figure 25. Position of HPP Vranduk compared to other infrastructure facilities (Source: Spatial Plan of Zenica-Doboj Canton (2009 to 2029.) - Energy Infrastructure)

Main road Doboj-Zenica

Moving from the direction of Zenica, the main road follows the Bosna river on the right side, and near the settlement of Hanovi, crosses the Bosna river by the bridge „Bosna V“ .

Road downhill grade is unambiguous and is approximately 0,7%. Elevation of the roadway on the bridge „Bosna V“ is 297,00 m a.s.l. The lowest point of the bridge structure is the support of the bridge girder at elevation of 296,58 m a.s.l.

Immediately after the bridge, the road enters the road tunnel „Vranduk II "at elevation 296,58 m a.s.l. The body length is 1.100 m. After the tunnel "Vranduk II", there is an open route length of 280 m with the end elevations 289,67 i.e. 287,03 m a.s.l. Tunnel „Vranduk I "is the length of 400 m with the exit from the mountain mass at elevation 285,24 m a.s.l. After that, the road again crosses the river by the bridge, "Bosna IV" on the right bank. Elevation of the bridge roadway is 285,00 m a.s.l.

Figure 26. shows the position of the main road, while

Figure 27. illustrates the position of the main road in relation to the Vranduk fortress.

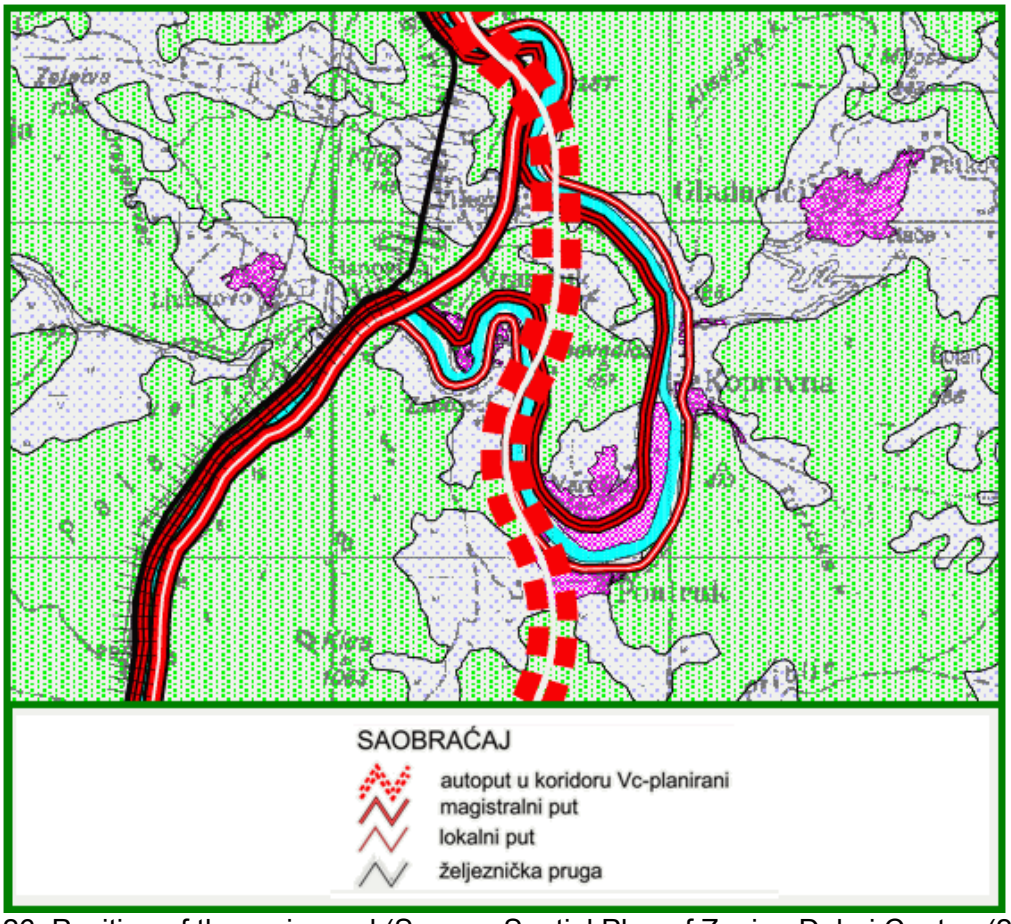


Figure 26. Position of the main road (Source: Spatial Plan of Zenica-Doboj Canton (2009 to 2029.) - Road infrastructure)

Figure 27. Position of the main road in relation to the Vranduk fortress

Double-track railway Šamac-Sarajevo

Double-track railway line goes along the left bank of the Bosna river and also near the settlement of Hanovi, enters into two parallel railway tunnels Vranduk at elevations 295,27 m a.s.l. The length of each tunnel is about 1.500 m. Exit from the tunnel is about 250 m downstream from the road bridge "Bosna IV“. The double- track line continues along the left bank towards Doboj, which is an important railway junction.

Local roads

In addition to these essential infrastructure elements, from both sides of the Bosna river, there are local roads that connect settlements to the left and right banks of the Bosna river.

At the site of crossing the main road over the bridge „Bosna V ", by the right bank of the Bosna river, a branch road continues, approximately 6.850 m in length that passes through the village Novi Vranduk on the right bank, further down the Bosna river through the settlements of Vranduk, Beharinovac, Ponirak, Lučice, Koprivina, and than joins again the main road after its crossing over the bridge „ Bosna IV“. Anyway, this part of the road is going by the route of the abandoned narrow railroad.

The second local road goes along the left bank and continues by Vranduk canyon as the section of the regional road Doboj - Kaonik.

These two current local roads are interconnected with two bridges over the Bosna river: the one between Vranduk settlement on both banks and the second one in the settlement of Nemila.

As part of the Preliminary design of HPP Vranduk, a design of reconstruction of the local road section Ljubetovo-Zenica was done, which is part of the road local communications linking the settlements Zenica-Hanovi-Ljubetovo. On the right side of the local road Ljubetovo-Zenica, there is a double-track railway line Sarajevo-Vrpolje and it is mutually separated by a retaining wall made of reinforced concrete. In Hanovi settlement, through the culvert under the railway line, there is a communication for the Ljubetovo settlement.

2.8. CLIMATE CHARACTERISTICS OF THE AREA

Complete statistical-climate analysis of numerical indicators in the wider area of Vranduk are based on results of continuous measurements performed on the meteorological station Zenica. Although the station began its work earlier, continuous climate series, which is taken into consideration relates to the period 1961 - 2000.

For the purpose of complete and comprehensive analysis of climate data from meteorological station (MS) Zenica, for the main climate elements (temperature and precipitation), the data is also attached from the nearest neighboring meteorological stations which are located in the wider region of Zenica. This working methodology allows the conclusions that are climatic multiple more exact, because they are based on data obtained from a wider area, where the area for construction of the hydro power plant is located.

Solar radiation

Global solar radiation (direct + diffuse) was directly measured only in a few meteorological stations in Bosnia and Herzegovina, i.e. only in Sarajevo, Banja Luka and Mostar. For this reason, the values for the meteorological station in Zenica, were obtained by computation (by method of interpolation in relation to M.S. Bjelave - Sarajevo), based on the following formula:

$$G = G_0 * (a + b) * s/S, \text{ where:}$$

G - global radiation,

G_0 – extraterrestrial radiation,

a and b - constants,

s – real duration of insolation,

S – potential duration of insolation.

Based on the formula we calculated the annual flux of global radiation for M.S. Zenica, and then determined by interpolation for a wider zone around Vranduk, and graphically presented in Chart 3. The average annual sum of global radiation is about 1.129,9 kWh/m^2, while its monthly average – 94,16 kWh/m^2. The average value of annual daily sum is about 3,09 kWh/m^2. The greatest amount of global radiation is present in the summer months, which is primarily a result of the actions of astronomical factors, as well as a small percentage of cloudiness and anticyclonic air distribution during the summer.

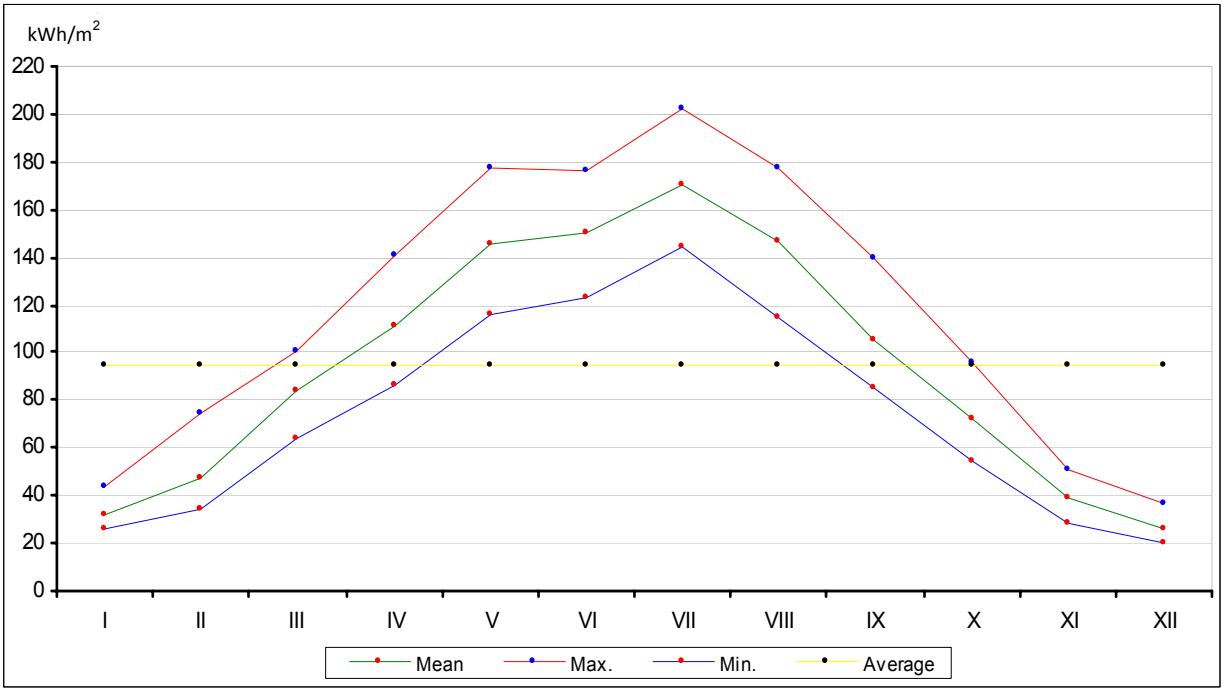


Chart 3. The annual flux of global solar radiation for the wider area of Vranduk (interpolated according to G.S.Zenica – calculating values).

The average sum of the summer period is 156,0 kWh/ m^2. The greatest value of the monthly sums is of July - 170,9 kWh/ m^2, than June - 150,5 kWh/ m^2 and August - 146,7 kWh/ m^2 The average summer daily sum is 5,1 kWh/m^2, and by month: June - 5,0 kWh/ m^2, July - 5,5 kWh/ m^2 and August - 4,7 kWh/ m^2.

Spring (March, April and May) and autumn (September, October and November), in relation to the summer, is characterized by a low-radiation, but between them, there is a difference in the amount of received solar energy.

The average sum of global radiation during the spring months is 113,6 kWh/m^2, respectively, per month, the values of the sums are: March - 84,2 kWh/ m^2, April - 111,3 kWh/ m^2 and May - 145,5 kWh/ m^2. The average values of daily sum of the entire spring period is 3,7 kWh/ m^2,

while its value in some months is: March - 2,7 kWh/ m^2, April – 3,7 kWh/ m^2 and May - 4,7 kWh/m^2.

The average value of the sum of the autumn period is 72,0 kWh/m^2. Maximum amount of radiation is September - 104,7 kWh/ m^2, than October - 72,2 kWh/ m^2 and November - 39,0 kWh/ m^2. Daily average of the autumn amount is 2,4 kWh/ m^2. By months it has the following values: September - 3,5 kWh/m^2, October - 2,3 kWh/ m^2 and November - 1,3 kWh/ m^2.

Winter months have the lowest values of the seasonal average and monthly amounts of the received radiation, during the year. The average sum of all months is 35,0 kWh/m^2 or per months: February - 47,8 kWh/ m^2, January - 31,9 kWh/ m^2 and December - 25,4 kWh/ m^2. The average daily sum of the entire winter period is 1,2 kWh/ m^2 or per months: February - 1,7 kWh/ m^2, January - 1,0 kWh/ m^2 and December - 0,8 kWh/ m^2. Thus low values of radiation are a result of north-hemispheric winter, with the lowest daily altitude of the sun, the minimum duration of the illuminated part of the day, a high percentage of cloudiness, etc.

Local climatic conditions are important for reducing the radiation during the winter, among which the radiation temperature inversions are particularly important. Specifically, the canyon valley of the Bosna river in the wider area around Vranduk, as a consequence of intensive night irradiation and cooling the Earth's surface, is very suitable for formation of the cold air lakes. As a result, in a longer time interval (several days to several weeks) some temperature inversions in the air are formed at the bottom of the valley, reaching to the tops of the surrounding hills. This cold air lakes are suitable for continued retention of radiation fog that sometimes up to 1 / 2 reduce the transparency of the atmosphere and thus the penetration of direct and diffuse solar radiation.

Duration of insolation

The duration of insolation is measured directly at the meteorological station Zenica, so that the data analyzed by interpolation method is adapted for a wider area around Vranduk. Except the use of these measured data, the definition of quantitative indicators on the duration of insolation for a wider zone around Vranduk is also based on monthly and annual flows of cloud, so that the obtained data are fully representative for the studied area.

The results of this analysis are presented in Chart 4.

The annual sum of the actual number of hours of insolation in a wider zone of Vranduk is among the lowest in Bosnia and Herzegovina and amounts to 1480,6 hour (h), which is primarily a result of relief predisposition of the site areas - Međugorje depression. It is surrounded on all sides by distinctive morphostructures, which cause the formation of long shadows in the morning and afternoon as well as increased local cloudiness and fog. In addition, the area of the future hydropower plant is located at the bottom of the river valley, causing, due to the thicker and more dense layer of radiation fogs (especially in winter), the

reduction of values of daily temperature sums. The average of all monthly sums is 123,4 h, while the average daily amount for the whole year has a value that is approximately 4,1 h.

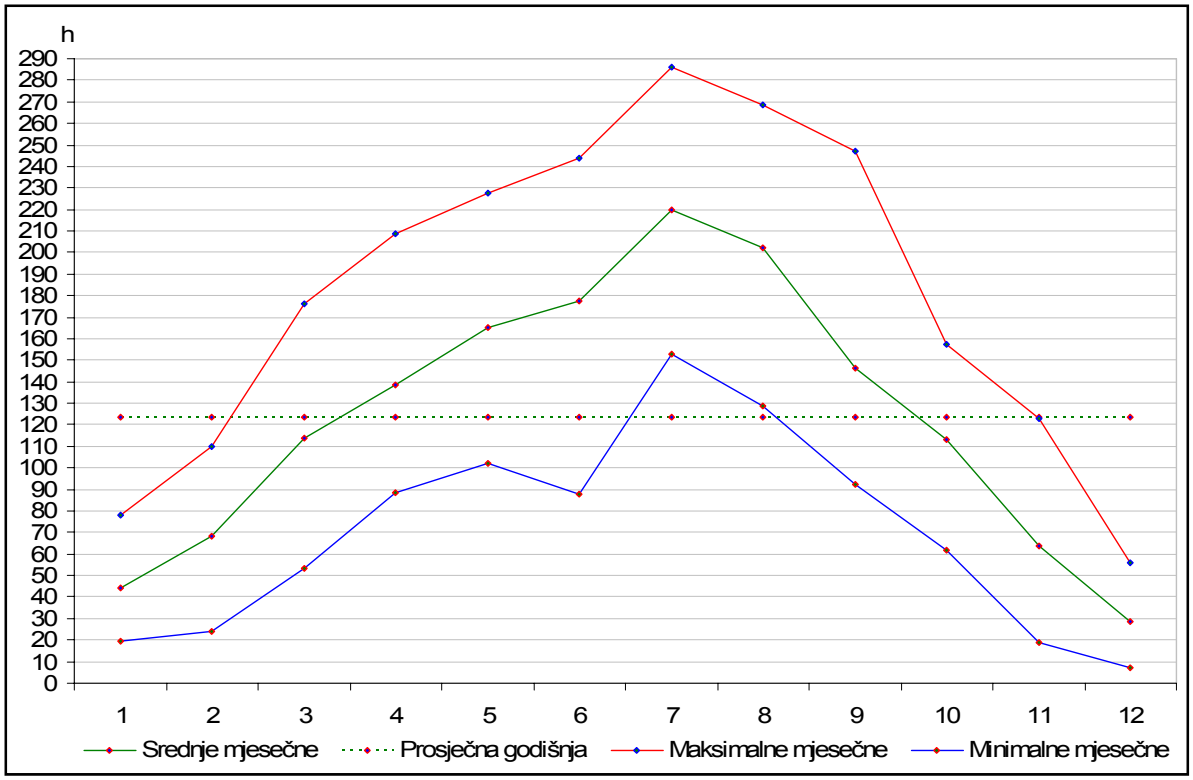


Chart 4. Annual duration flow of insolation for a wider area of Vranduk (interpolated according to M.S.Zenica – calculating values)

The highest values of daily and monthly sums were recorded during the summer period, due to the maximum duration of the illuminated part of the day and at least cloudiness during the year, because the whole territory of Bosnia and Herzegovina at that time is under the influence of Azor anticyclone, which brings good weather. The average of monthly sums of the whole summer period is 199,7 h. The sunniest month is July – 219,6 h, then August – 202,2 h and June – 177,2 h. On the basis of the presented values, it can be concluded that the duration of sunshine at the bottom of the Bosna river valley is characterized by a lower values compared to the values of the contact slope sides, what it can exactly be interpreted by higher average monthly cloudiness of summer months in the valley bottom. The average value of daily amount per months is: June – 5,9 h, July – 7,1 h and August- 6,6 h, respectively for the whole summer – 6,5 h. The valley-canyon character of the wider area of Vranduk has a great impact on values of the summer sums, in terms of their reduction.

Warm air from the ground, from the valley bottom, along the distinctive valley and mountain side, rises up and at a certain height is cooled to a temperature of dew point, wherefore the larger amount of water vapor, which it has (which originates from the previous rainfall and evaporation from vegetation), condenses. This situation causes increased local convective cloudiness, represented mainly by cumulus clouds, which is especially distinctive in some afternoon hours, and sharply reducing the duration of sunshine. This is one of the reasons why the wider region of Zenica belongs to places with the shortest duration of sunshine in Bosnia and Herzegovina. An additional source, which burdens the air, are the colloidal particles produced in an industrial production process in the Zenica steel plant, which are an additional source of condensation nuclei whereby the fogginess and cloudiness of the area further increase.

Autumn period, compared to summer, is characterized by significantly lower values of the monthly sums of sunshine duration. The values of the average monthly sums for each month are as follows: September – 146,1 h, October – 113,2 h and November – 63,7 h, respectively, on an average for the entire autumn, the value of the monthly sum is 107,7 h.

Lower values of the monthly sums of autumn were primarily a result of a shorter duration of the illuminated part of the day (shortening the length of the visible arc of the Sun) and significantly the increased percentage of cloudiness. Daily elevation of the Sun were also lower, so the length of the shadows is much longer, and sunshine duration in space is reduced. Average daily sum of the whole autumn is 3,6 h, or by month: September – 4,9 h, October – 3,7 h and November – 2,2 h.

Spring is characterized by more increased monthly sums of sunshine compared to the autumn. Average of whole spring season is 139,1 h. The values of the sums, for each month are as follows: March – 113,7 h, April – 138,3 h and May -165,4 h. Analogue to the monthly sums, the average daily sums are as follows: March - 3,7 h, April - 4,6 h and May - 5,4 h. Mean daily sum for an average day of the whole spring is 4,9 h.

The lowest values of the insulation are during the winter months of the year. This is also a result, besides the already mentioned astronomical factors (the shortest length of the visible arc of the Sun, a minimum daily elevations of the Sun), of maximum cloudiness during the year. Some local impacts are also attached to the low values, from which the fog is the most important, which, during sunny days, blocks the penetration of solar rays to the bottom of the valley, and thus directly reduces the values of daily sums. The values of the monthly sums for each month are as follows: December - 28,5 h, January - 44,2 h and February - 68,5 h, or, average per month for the entire period - 47,1 h. Based on data, it shows that the minimum duration of sunshine is not in January, which is the coldest month, but in December. This is the result of more frequent winter clarity that, under the influence of winter anti-cyclones, is formed in January. Average daily sums have the following values: December – 1,0 h, January – 1,4 h and February – 2,5 h, while the average for the whole year is 1,6 h. The main reason for this high distinction was already defined by the existence

of thicker and more dense layer of radiation fogs, which in winter, due to lower altitude, characterize the bottom of the Bosna river valley.

In addition to this way of presenting the duration of sunshine (the actual number of hours of sunshine), there is another illustrative way to show flows of this meteorological element, which is especially useful for practical researches, particularly in Agrometeorology. It is relative duration of sunshine (R), which is determined by the following formula:

$$R = S/S_0 * 100 \ (\%), \text{ where:}$$

S – real duration of sunshine,

S_0 – potential duration of sunshine.

The highest relative values were recorded during the two summer months: July – 53,22% and August – 50,65%. These values of results are the consequence, above all, of serenity of the summer, especially during July and August. Certain deviations, as interesting, stand out from the general scheme, which is reflected in the following: and May with 42,07% and September 43,74% have, from the reasons already mentioned (slightly lower cloudiness), a slightly higher relative insolation compared to June – 42,02%.

The minimum values of relative duration of sunshine are in the winter months, due to maximum cloudiness throughout the year, as well as increased cyclogenetic activity over all our country in this part of the year. Here, it certainly should be mentioned the already explained local climatic conditions, some of which, very intense, the winter radiation fogs are the most important. Specifically, the month with very lowest value of duration of relative solar radiation is December with only 11,39%, which also coincides with the general scheme of distribution of the real duration of sunshine.

Air temperature

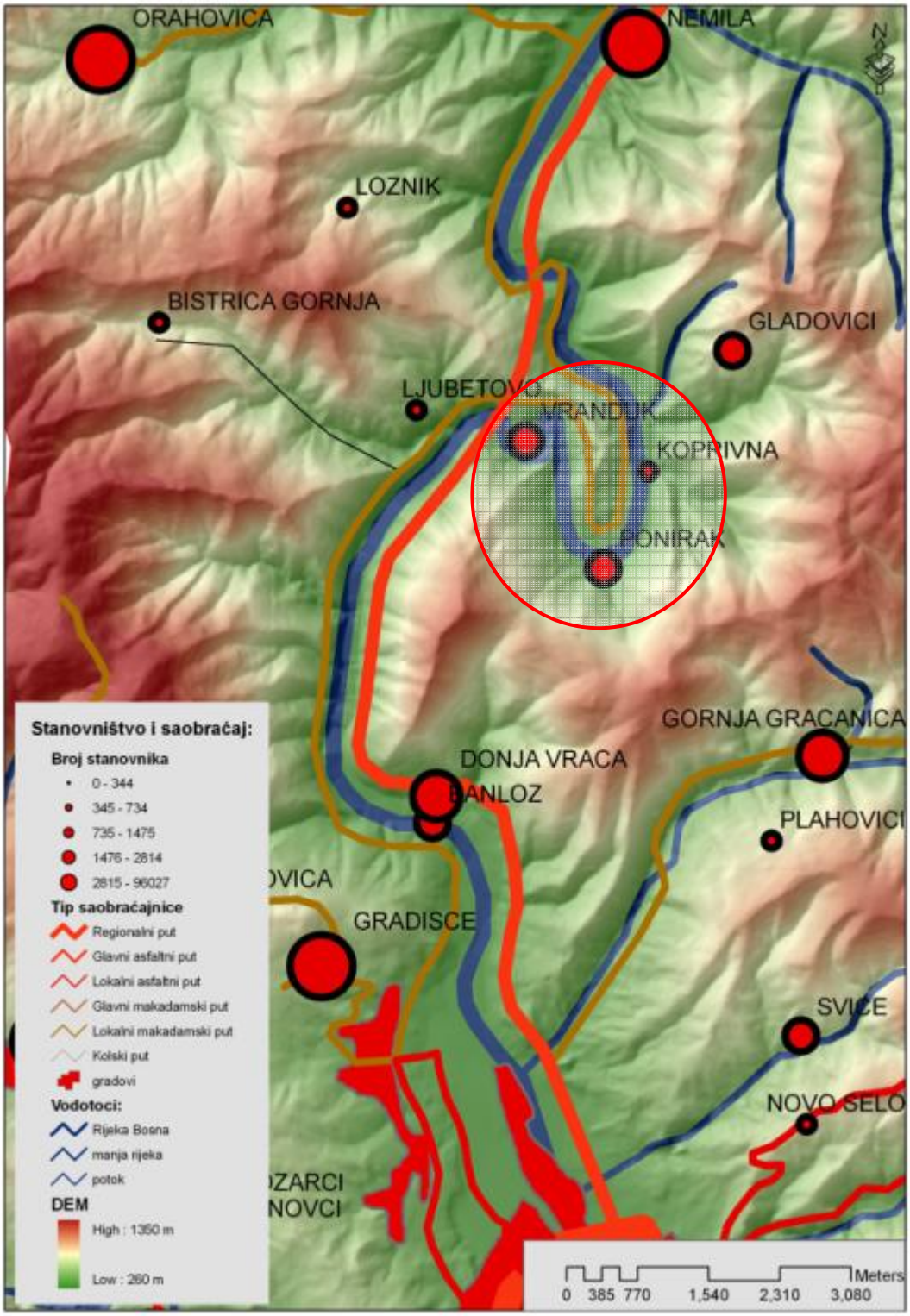
Air temperature is the basic meteorological elements, whose intensity indicates the overall heat balance of a certain space, which is an essential parameter for any type of climatological studies. For the purpose of studying the climate of this Study, it will be analyzed, for the more temperature parameters, mainly the standard statistical values (daily, monthly and annual course presented through the medium, maximum and minimum values, and other similar indicators). These analysis are climatologically exact, because the base weather station in Zenica has a homogeneous and continuous 40-year-old instrumental series of weather measurements.

Air temperature is also one of the meteorological elements, whose detailed monitoring can identify potential modificatory impact of the hydro accumulation on microclimate characteristics of of the environment. For this reason, we will try, at least in part, to consider these problems, through the interpretation of various temperature parameters.

Based on long-term instrumental climate monitoring and the many analysis that are done for the Zenica area, it is possible to define the parameters that directly affect the quantitative values of the daily and annual flux of air temperature in the wider area of Vranduk canyon:

- horizontal and vertical diversity of contact mountain morphostructures in a wider area of Vranduk, distinctive through exposition and inclination of slope sides, the frequency and magnitude of river and stream valleys and ridges between them, morphographic-morphometric characteristics of alluvial valley of the Bosna river, etc. (see map 1.),
- foehn effect of local winds, which raises the air temperature during the flow through the mountain ridges down to lee slope sides,
- changes in the intensity of short wave and long wave radiation due to increased emissions of pollutants and prolonged retention in the air,
- albedo changes due to modifications to the physical (thermal) properties of the substrate, as a result of the construction of new buildings where there were once the fields and woods,
- lower consumption of thermal energy for evaporation of the surface, due to the already mentioned reduced substrates of evaporation, as well as rainfall channel runoff from the town's streets and other infrastructure facilities,
- increased town's local cloudiness and turbidity in air in the wider region of Zenica, which reduce the number of clear days, shortens the duration of sunshine and significantly reduce the value of thermal radiation of the substrate,
- the release of large amounts of heat energy from industrial and power plants, home furnaces and heating plants of the town of Zenica and exhaust systems of a large number of motor vehicles that constantly run in the urban area and the main road route Sarajevo - Zenica - Bosanski Brod,
- relatively quick removal of snow from urban and rural areas,
- existence of significant complex of forest vegetation in mountain slopes, etc.

It should be noted that these are only basic local modifying factors and that it can extract still others beside them, which depends primarily of infrastructure characteristics in the area of Zenica ravine and Vranduk canyon.



Map 3. Morphological characteristics of the wider region of Vranduk, with the narrower impact zone

Annual course of air temperature by months is most illustrative indicator of the thermal characteristics of a given area. This parameter is for the wider area of Vranduk presented in Chart 5. According to the interpolated data (compared to MS Zenica) a mean annual air temperature in the analyzed area is 10,2°C. In the annual course of mean monthly temperatures, there are some distinct variations on the basis of which, it can be made a clear differentiation of the year in the four distinct climatic seasons.

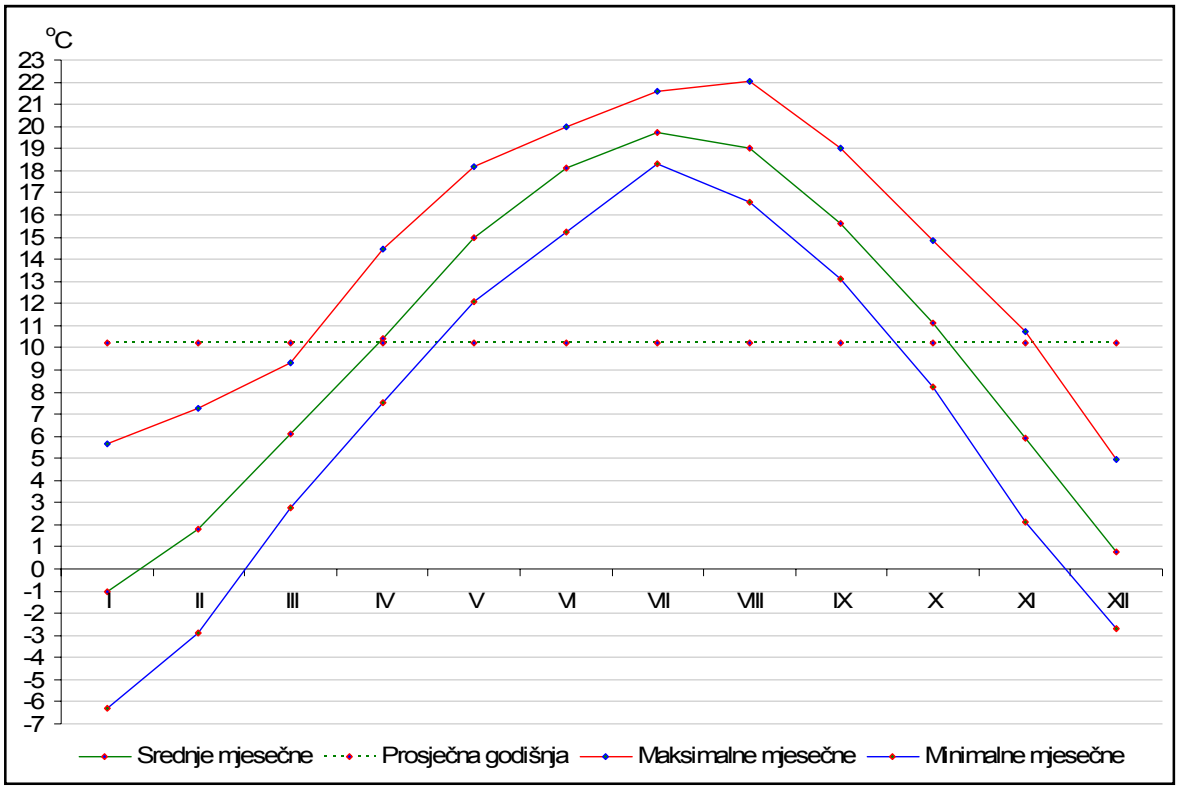


Chart 5. Annual course of air temperature in the wider area of Vranduk (interpolated according to MS Zenica).

The warmest part of the year is summer with mean seasonal temperature of 18,9°C, or by months: June – 18,1°C, July – 19,7°C and August – 19,0°C. The anticyclonic air distribution has the greatest impact on summer air temperatures, over this area during the summer and a small percentage of the monthly cloudiness and relative humidity. Apart from them, a significant impact has also phenomena of some afternoon local cloudiness, as well as local convective precipitation . In addition to these mean values, the mean extremes monthly air temperature are also very illustrative, for practical purposes. Mean maximum summer temperature is 21,2°C, i.e. maximum mean temperature by months during this period is: June – 20,0°C, July – 21,6°C and August – 22,1°C. The mean minimum temperature of summer is 16,7°C, or according to specific mean monthly values: June – 15,2°C, July – 18,3°C and August – 16,6°C. Based on published data, we can determine the value of the average seasonal temperature amplitude, which is 1,8°C. In relation to the values of extreme monthly temperatures, the seasonal temperature amplitude is 4,5°C.

The spring season in comparison to the summer is characterized by a lower average temperature – 10,5°C. Several factors makes direct impact on this value of temperature: the shorter seasonal duration of the illuminated part of the day, lower values of incident angle of the Sun's rays and the local meteorological characteristics, among which the most important are frequent radiation fogs at the bottom of the valley especially during March as well as local convective cloudiness. Mean monthly air temperatures for each month, have the following values: March – 6,1°C, April- 10,4°C and May – 15,0°C. The mean maximum temperature of the spring season is 14,0°C, or in the months: March – 9,3°C, April – 14,5°C and May 18,2°C. The mean seasonal minimum temperature is 7,4°C, or in the months: March – 2,7°C April – 7,5°C and May – 12,1°C. The average seasonal value of temperature amplitude is 8,9°C, which is much more distinctive than in the summer. However, if we take into account that this is a transitional season, which is characterized with intensive positive changes in temperature, the above value is mainly in limits, which for this time of year, were found in temperate latitudes. Seasonal temperature amplitude in relation to extreme monthly temperatures is 6,6°C, which is also an expected value.

Autumn, compared to spring, is characterized by higher average temperature which is 10,9°C, or by month: September – 15,6°C, October – 11,1°C and November – 5,9°C. Higher average of autumn season is primarily interpreted by large number of clear days in relation to the spring, especially compared two hottest months of May and September. The value of the average maximum temperature of the season is 14,9°C, or by month: September – 19,0°C, October – 14,9°C and November – 10,7°C. Minimum monthly temperatures have the following values: September – 13,1°C, October – 8,2°C and November – 2,1°C, while the seasonal value is 7,8°C. The average seasonal temperature amplitude is 9,7°C, which is 0,8°C higher than in the spring. This, even more distinctive value, is interpreted by the differences that arise between the still warm air in September and rapidly cooled air in November due to the transition into the winter period. Amplitude value of extreme months is 7,1°C, which is, from the same reason, 0,5°C higher than in the spring.

The lowest seasonal average in the winter is – 0,5°C, or by month: December – 0,8°C, January - -1,0°C and February – 1,8°C. The values of maximum temperatures by months are: December – 5,6°C, January – 5,0°C and February – 7,3°C, and the average for the whole season is 7,7°C. Seasonal average of minimum temperature is -4,0°C, or by month: December - -2,7°C, January - -6,3°C and February - -2,9°C. The average seasonal temperature amplitude is 2,8°C, which is close to the summer season. Temperature amplitude of extreme months is 11,7°C, which is significantly above other seasonal analogs, and the best illustrates thermal contrasts in space.

Mean maximum monthly temperature values are presented in graph 4. Annual average of maximum temperatures is 16,1°C, but it is extremely uneven. The average of maximum summer temperatures is about 26,0°C, with a peak in July – 26,7°C. Spring average of maximum temperatures ranges in value from about 16,8°C with a maximum in May of 21,7°C. Autumn maximum temperatures have slightly higher average than in the spring, i.e.

17,0°C, while the warmest month of the season is September with 22,9°C. Winter maximum temperatures are the lowest value, so that the seasonal average is about 4,4°C, which is valued at the average of Bosnia and Herzegovina for the mountainous – canyon region.

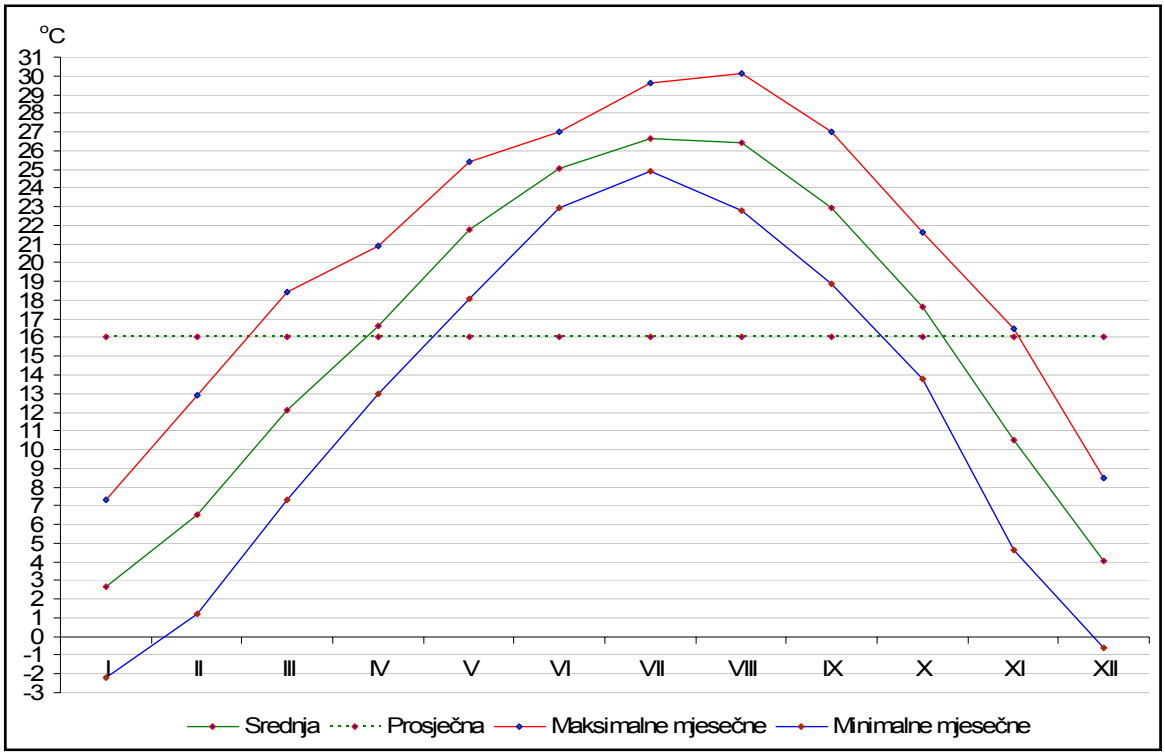


Chart 6. Annual course of mean maximum air temperatures for the wider area of Vranduk (interpolated according to GS Zenica).

Thermal extreme analog are the mean minimum monthly air temperatures (Chart 7.). Annual average of minimum monthly temperatures is 4,7°C. Seasonal variations are also quite distinctive, as is evident from the following indicators:

- mean minimum summer temperature is 12,1°C, with a minimum in June - 11,5°C,
- mean minimum spring temperature is 4,3°C, with a minimum in March - 0,5°C,
- mean minimum autumn temperature is 5,7°C, with a minimum in November - 1,5°C,
- mean minimum winter temperature is -3,2°C, with a minimum in January - 5,0°C,

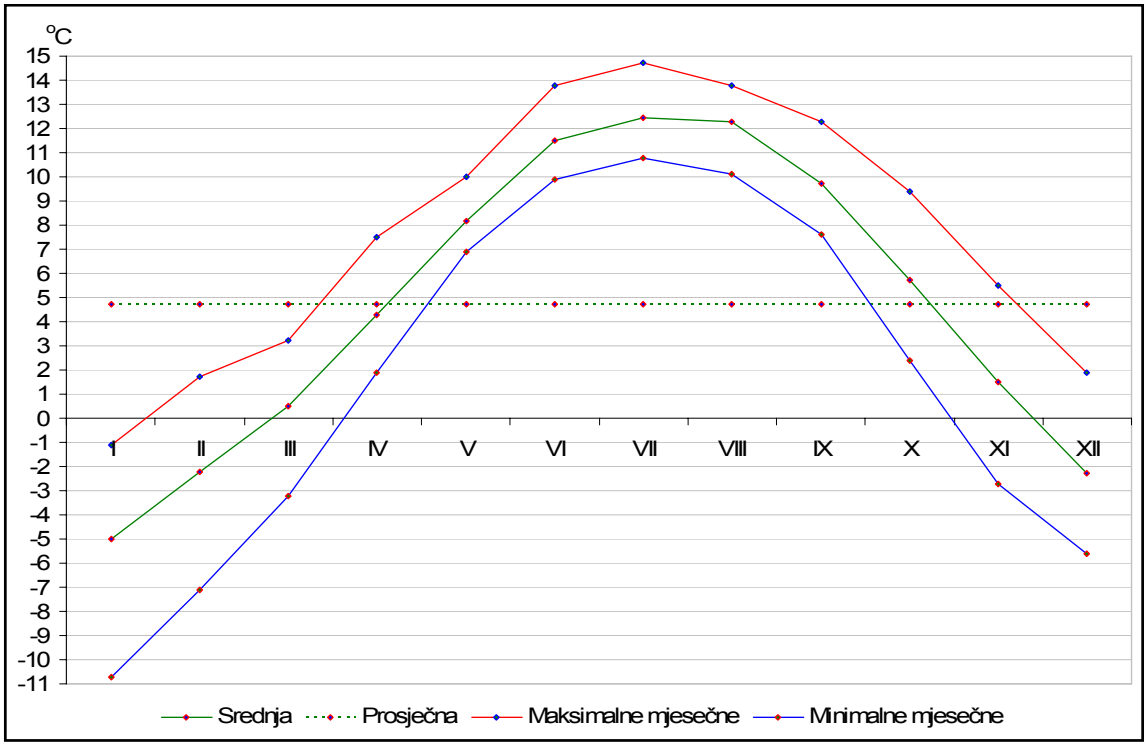


Chart 7. Annual course of mean minimum air temperatures for the wider area Vranduk (interpolated according to G.S.Zenica)

For practical (technical) needs, in terms of thermal characteristics, the mean variability of monthly mean temperatures is often analyzed, which shows the average value of temperature changes in certain months in long period. The results of this analysis for a wider area of Vranduk canyon are presented on Chart 8.

Average annual variability of monthly mean temperatures is 1,51°C, but in the annual course, distinct seasonal fluctuations are observed.

The average seasonal variability of monthly mean temperatures during summer is the lowest, with a value of 1,01°C, or by certain summer months: June – 0,88°C, July – 0,93°C and August - 1,21°C. Such low value is consistent with a small monthly temperature fluctuations during the summer. Average of spring season is higher than in the summer and it is 1,44°C, or by month: March – 1,82°C, April – 1,26°C and May – 1,23°C. Autumn average is close to the spring average, with a value of 1,41°C. The values of certain months are: September – 1,22°C, October – 1,33°C and November – 1,69°C.

If we compare all three seasons, we can see that the lowest values are in the middle of summer and they successively increase towards boundary months to the winter season. The average variability of the winter months is the highest – 2,17°C, or by month: December – 1,85°C, January – 2,05°C and February – 2,61°C.

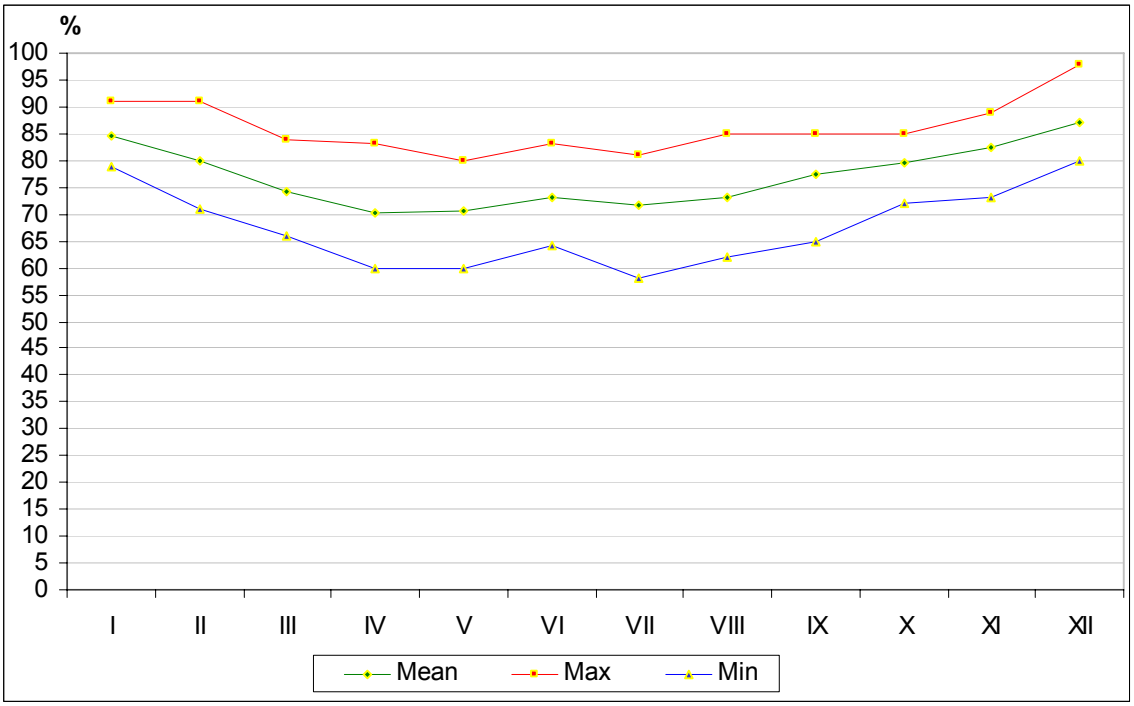


Chart 8. Mean variability of monthly mean temperatures for the wider area of Vranduk (interpolated according to GS Zenica)

According to the observed data, February has the highest temperature fluctuation, which is about three times higher than in June.

Relative air humidity

In the wider area of Vranduk canyon, this meteorological element shows temporal variability (Chart 9.). The general feature is that in comparison with the annual course of mean annual temperature, it has a reverse course. The mean annual relative humidity in the wider area of Vranduk (interpolated according to MS Zenica) is 76,8%.

The summer season has a lower average – 72,7%, or by month: June – 73,0%, July – 71,9% and August – 73,1%. Low values are the result of high summer temperatures and a low percentage of cloudiness.

The spring season has the lowest annual average of 71,6%. This is a consequence of more distinctive instability of the atmosphere, so the intensity of the wind during the entire period is greater, which directly reflects in the reduction of moisture in the air. The values of certain spring months are: March – 74,1%, April – 70,3% and May – 70,5%.

Autumn has a higher average than the annual average – 79,9%, or by month: September – 77,5%, October – 79,6% and November – 82,5%.

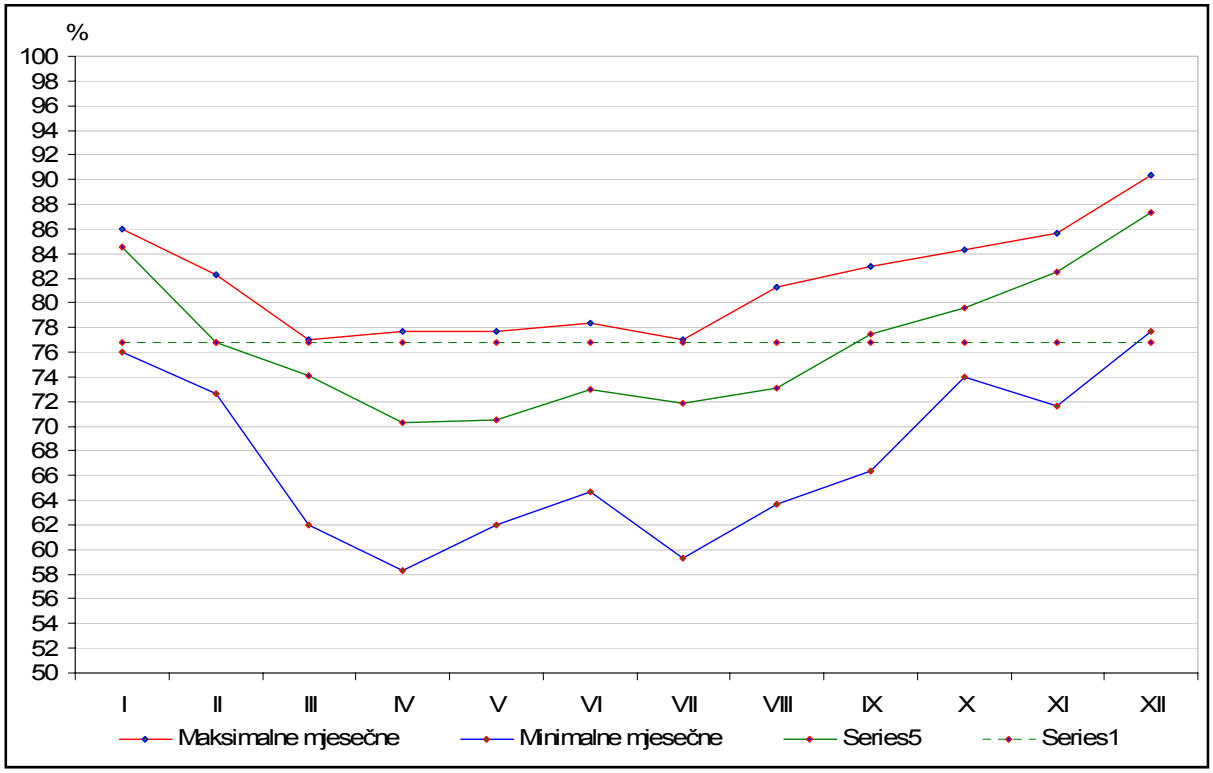


Chart 9. Annual course of relative air humidity for the wider area of Vranduk (interpolated according to GS Zenica)

Winter season is characterized by the highest annual value of relative humidity – 82,9%. This is a consequence of distinctive cloudiness and low temperatures throughout the period. Some months have the following averages: December – 87,3%, January – 84,5% and February - 76,8 %.

Cloudiness

Mean annual cloudiness in a wider area (according to interpolated data for MS Zenica) is 6,2/10, which practically means that the cloudy weather is here more often characteristic of weather conditions during the year (Chart 10.). In the annual course, we can find also a distinct seasonal fluctuations, therefore, the need for seasonal analysis is imposed.

The lowest seasonal average is summer - 5,0/10, or by individual summer months: June - 5,4/10, July - 4,7/10 and August – 5,0/10. This is certainly a consequence of the direct impact of anticyclonic distribution in weather conditions over this space and the reduced air humidity

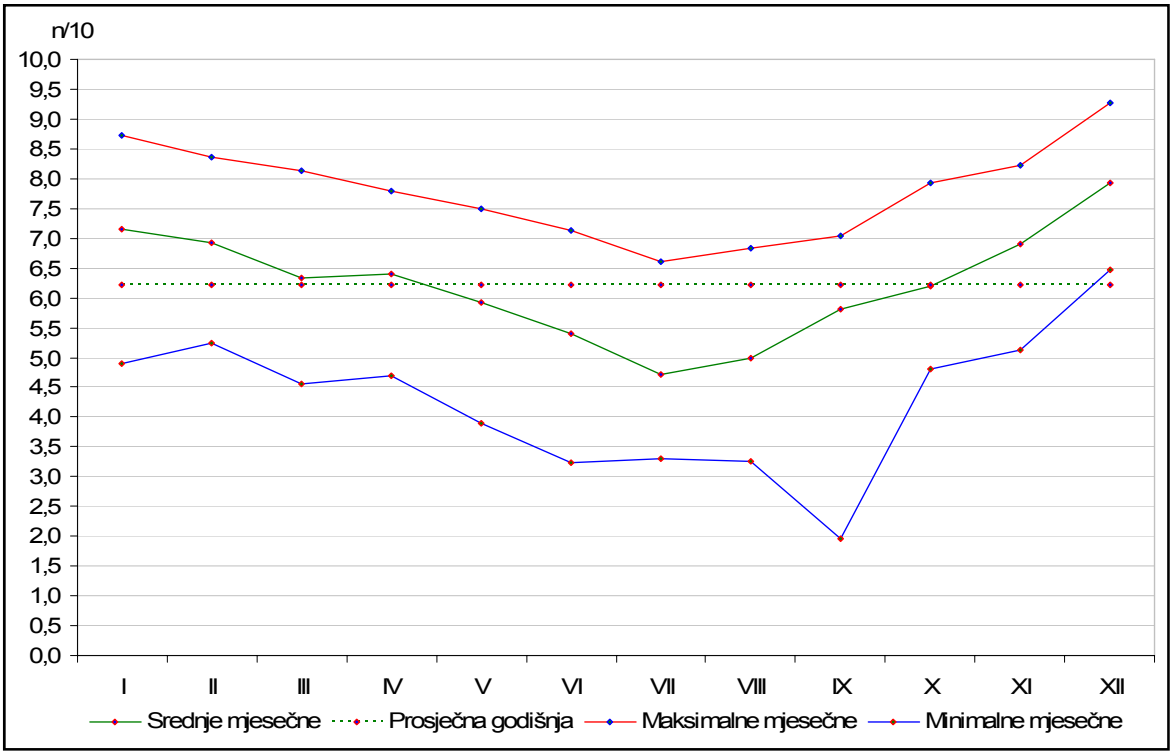


Chart 10. The annual course of Cloudiness for the wider area of Vranduk (interpolated according to GS Zenica).

Spring is characterized by higher values of cloudiness, as compared to summer, due to stronger cyclone impacts in weather conditions. Average of the whole season is 6,2/10, which is about 1,2 more than in the summer. Some spring months have the following values: March – 6,3/10, April - 6,4/10 and May – 6,0/10.

Autumn average is slightly higher than the spring and was 6,3/10, which can be explained by a marked increase in cloudiness during the transitional month in the winter season – November. Specifically, some of the autumn months have the following values: September – 5,8/10 October - 6,2/10 and November 6,9/10.

Winter season is characterized by the highest seasonal average and the individual monthly values, as a consequence of the dominant influence of cyclone air distribution, which results in the formation of gloomy and cloudy weather. Seasonal average is significantly above the annual average – 7,3/10, while some winter months have the following values: December - 7,9/10, January - 7,1/10 and February – 6,9/10. The attached data suggest that the most cloudy month is - December of 3,3 tenth more cloudy than the clearest month - August.

Precipitation

This is also the basic climatic element, whose value directly determines the basic hydrothermal characteristics of the area. Annual course of pluviometric regime for the wider area of Vranduk is presented in Chart 11. The average annual sum of precipitation amount in the wider area of Vranduk is about 798,0 mm, while the average monthly sum is 66,5 mm. However, in the annual course of pluviometric regime, monthly and seasonal fluctuations were significantly distinct.

Average sum of precipitation amount during the summer season is 72,3 mm, which is about 5,8 mm higher than the annual average and indicating the characteristic pluviometric type of regime. The above value is much higher than the regime of air temperature and cloudiness, and it is the result of high value of the June sum, which is 79,4 mm, because this is the month that belongs to the period of main precipitation maximum. The July average of sum is the lowest - 67,4 mm, and the August average is slightly higher- 70,1 mm.

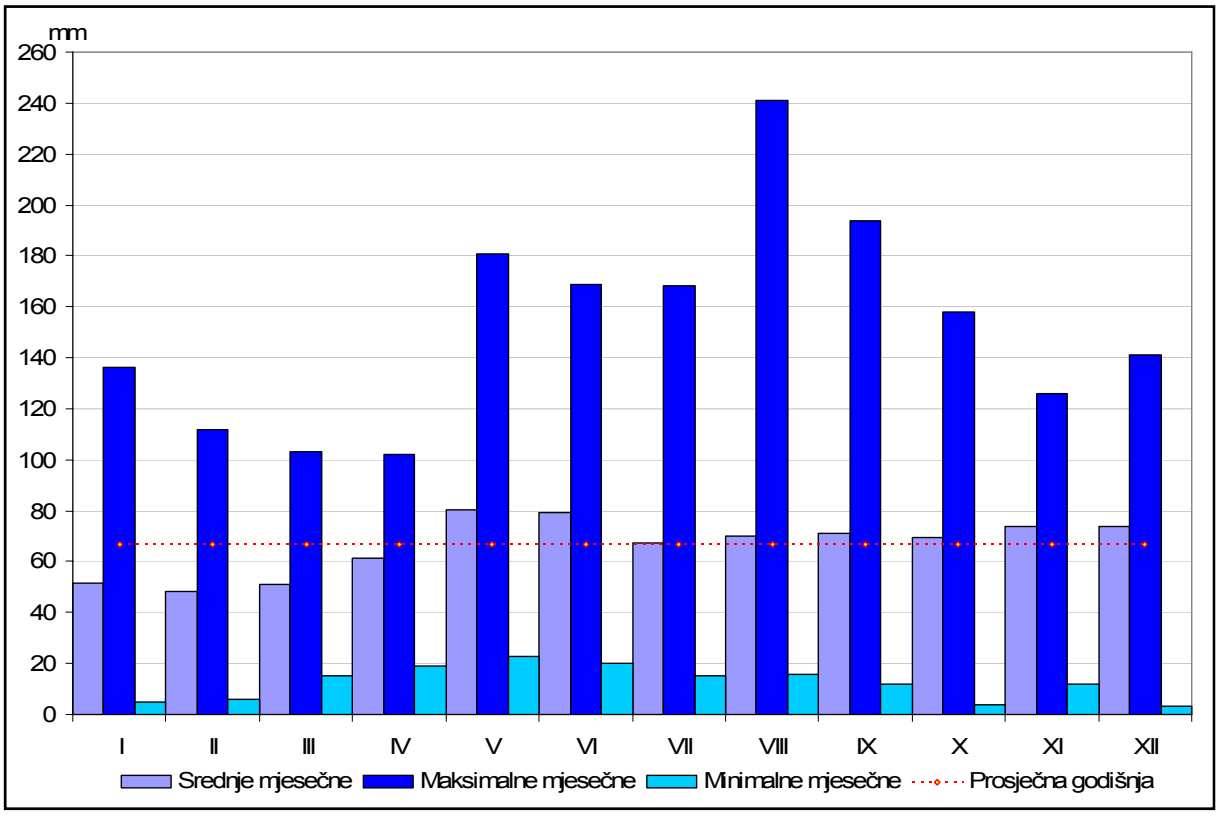


Chart 11. Annual course of precipitation amount for the wider area of Vranduk (interpolated according to G.S.Zenica)

The spring season has, compared to summer, lower average – 64,3 mm, which is due to the presence of modified Posavina variant type of pluviometric regime in the transitional area from the mountain-canyon to the Posavina zone of the wider area of Vranduk. In other words, low seasonal average is a consequence of belonging of March and April to the drier between

precipitation period, which is timely allocated to the second half of winter and to the first half of spring. For some months, precipitation sums have the following values: March – 51,2 mm, April – 61,3 mm and May – 80,3 mm – the rainiest month in the wider area of Vranduk.

Autumn is the season that can be described as "richer" in precipitation, with an average of 71,3 mm. This is a consequence of belonging of almost the entire season to the second precipitation maximum, which occurs during the second half of the autumn and early winter. The values of certain monthly sums are: September – 70,8 mm, October – 69,3 mm and November – 73,8 mm.

Winter period has an average of 58,1 mm, which is well below the annual average and points to the fact that the main precipitation minimum is located in January and February. Average monthly sums have the following values: December – 74,1 mm, January - 51,7 mm and February – 48,5 mm - the coldest month in the wider area of Vranduk. The main characteristic of winter precipitations is that they are in the prevailing form of snow in the Bosna river catchment, which has a special importance in the regime of water supply of the main watercourses.

In order to better illustrate the spatial and temporal variation of this parameter during the year, it is necessary first to determine the wider area of Vranduk in relation to type and variant of pluviometric regime, which characterizes it. In Bosnia and Herzegovina, the spatial distribution of pluviometric coefficient q is presented by isocontinental with a value of 5%, which allows a detailed representation of all existing pluviometric types and their transitions. isocontinental with the value q = 50% is the boundary value, on the basis of which the pluviometric type is determined. In Bosnia and Herzegovina, it has a predominant direction of NW - SE, extending by mainly dominated morphostructures of external Bosnian Dinarides. All areas, which are spread across the north of this line, have prevailed continental pluviometric type, while those, south of it, have Mediterranean pluviometric type. The above methodology was applied for the wider area of Vranduk, though from the above general conclusions can be already drawn. Specific information on the type of pluviometric regime were adopted on the basis of the annual course of precipitation height, which for a wider analyzed area was obtained by interpolation according to data from M.S. Zenica (Chart 11.).

According to the present methodology and data from the Chart 11. it can be concluded that the overall wider area of Vranduk canyon belongs to continental pluviometric type. However, in Bosnia and Herzegovina (even in the Vranduk) there developed a real continental pluviometric type regimes, because there is great diversity in the annual amount of precipitation trends in specific areas of Bosnia-Herzegovina, caused significant natural, especially the relief variety. However, in Bosnia and Herzegovina (even in the Vranduk area) there is no a real developed continental pluviometric type of regime, because there is a great diversity in the annual courses of precipitation height in specific areas of Bosnia-Herzegovina, caused by significant natural, first of all relief differences. Therefore, in Bosnia and Herzegovina, we can meet its specific variants, depending on the time position of the main maximum and the main minimum precipitation.

Specifically, within the continental pluviometric type, two groups of subtypes can be distinguished: I group with four and II group with three variants. According to the observed data, the wider area of Vranduk belongs to the second group with the first variant - II K-1, whose main characteristic is that the main maximum of rainfall is positioned in the period May - June, and the main minimum in the period January - February. This can be practically seen from the following values:

- maximum precipitation V month - 80,3 mm,
- minimum precipitation II month - 48,5 mm,

In the literature, the above variant is often referred to as modified Posavina variant of the pluviometric regime. This type has been developed in areas where contact is achieved between the moderate humid and steppe climate. Dry and sunny weather during most of the summer is a consequence of anticyclonic activity which is present in the whole of Central Europe. This type is also very suitable for seeding of crops and development in general of plant life for this area because there is a large amount of precipitation at a time when it is needed for the development of cultures. Reduced rainfall during August and September is for the same aspect very convenient, because this is the period of fruit ripening, so these areas is also the most advantageous for agricultural production.

One of the most representative indicators of the quantitative and temporal variation of rainfall is relative fluctuation of rainfall. Its value for the entire continental pluviometric type in Bosnia and Herzegovina ranges from 4,2 to 6,8%. The values of the relative fluctuation in the wider area of Vranduk are ranging in values from about 5,9%. These values show that rainfall in the analyzed area is quite evenly distributed monthly. Such accuracy is primarily caused by relatively stable cyclonic activity during the winter months of the year, while during the summer, local climatic conditions (first of all any relief predisposition) cause the formation of local rainfall and thus significantly contribute to increasing the total amount of summer rainfall.

On the basis of the expressed views, it could be concluded that the observed area is characterized by mostly stable and equal precipitation. Temporal and quantitative deviations from the presented values are however very common, on this basis we can say that the interannual variations are quite significant. Specifically, it often happens that the amount of rainfall for each month is several times higher or lower than average. Based on these data, conclusions can be drawn about the potential too dry or too wet periods. The general conclusion is that in some years can appear completely the reversed situation in relation to the averages presented above so that both droughts and floods can occur in all months. However, a month, with the most likely occurrence of drought is October, during which it often happens that there is a very small amount of rainfall. Opposite to drought, monthly periods with the highest rainfall can reach extremely high values exceeding 240 mm and over, and usually appear in late spring and early autumn.

Wind

The main characteristic of wind air circulation is its morphological dependence. More specifically, spatial-temporal dynamics of wind circulation is directly limited by the size and shape of dominant morphostructural forms in the wider region of Vranduk canyon. First of all, these are the dominant positive morphostructures: Vepar (1.053 m), Pokik (1.115 m), Zeletva (1.092 m) and Jelina (1.331 m). Dominant negative morphostructure is the valley of the Bosna river, which notched between these mountains, so it has a structure of wedged meander in the zone of Vranduk canyon. According to the morphostructural composition of the site it may determine that the dominant type of regional circulation is the northern direction. More specifically, the dominant regional wind is north wind whose roots are located in the polar zone of the Arctic circle, and who, especially during the winter months of the year, along the Bosna river valley reaches the area of Zenica ravine as a very cold and strong wind which causes sudden and intensive lowering of air temperature. The same wind also operates during the warmer months of the year but is much weaker intensity and frequency.

The local air circulation is represented by winds with the so-called daily alterations i.e. anabatic and catabatic wind. Anabatic wind effect during the illuminated part of the day and blows up slope sides while catabatic wind is present during the night and have the opposite direction of blowing. The dominant blow direction of these winds are directly provided by local morphology, primarily the orientation and inclination of slope sides, and on that basis, it can indirectly conclude on their intensity in different parts of Vranduk canyon. In fact, along the steep slope sides, the intensity of these currents increases and vice versa, and the predominant exposure of contact slopes defines its direction of blowing. Generally, it can be emphasized that the main characteristic of this type of air circulation in the area of Vranduk canyon is weaker intensity and duration of action.

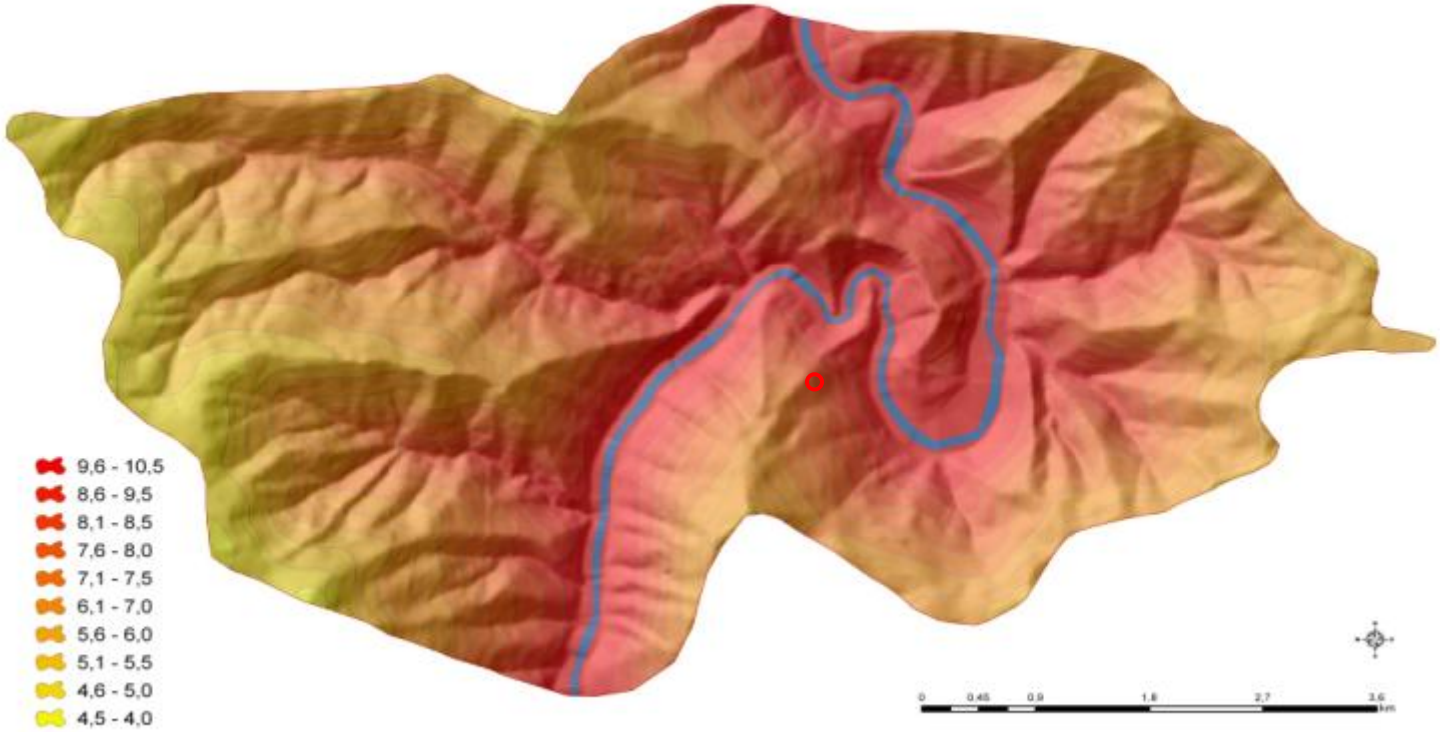
Climate type

The wider area of the Bosna river valley in the zone of Vranduk canyon has very specific climatic characteristics. This is a consequence of its specific valley-ravine topographic position, where local climatic factors are of great importance in shaping the basic climatic characteristics of the space.

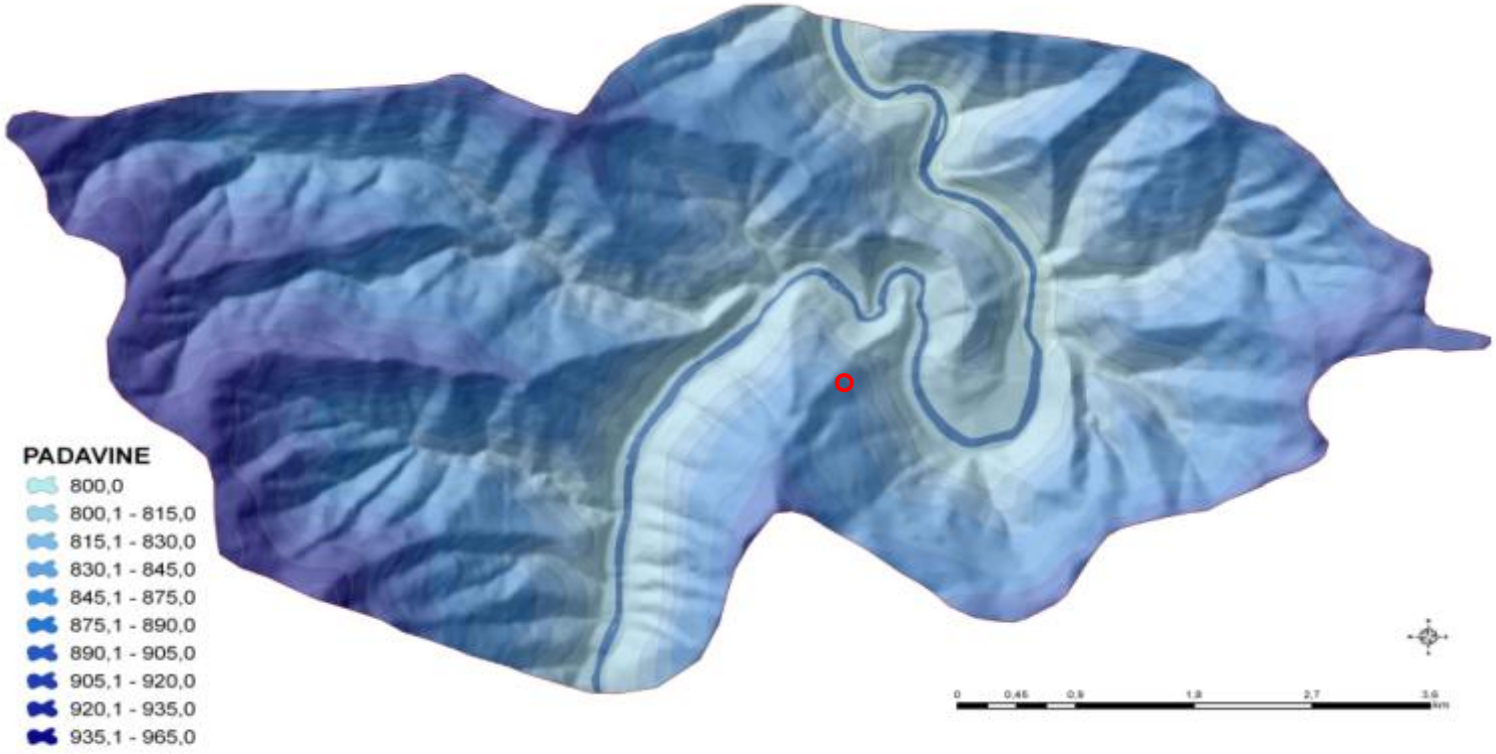
For the purposes of technical expert assessment of climate impacts, the general climatic characteristics of the studied area, it is necessary to process it using Köppen's climate classification, which is based on Pluvia-thermal analysis of climatic parameters. More specifically, some climatic features of the wider area of the Bosna river valley in the zone of Vranduk canyon have the characteristics of Cfbx "climate type. The warmest month is July, with average monthly temperature, which ranges in the northern parts of the Vranduk canyon from about 19,5°C to about 20,0°C in the northern parts of Zenica ravine (interpolated

values). Warmer part of the year was presented with 7 months with a mean monthly temperature ≥ 10°C. The coldest month is January with a mean temperature of -0,8°C in Zenica ravine up to about -1,2°C in the narrower part of Vranduk canyon. Colder season is presented with 5 months with a mean monthly temperature <10°C. Temperature amplitudes in their size fit into the spatial distribution of Isotalantoses for wider area of mountainous-ravine zone - from 20,5°C to 21,0°C. In addition to the horizontal, the thermal conditions also change in altitude direction. More specifically, the value of the vertical thermal gradient at the level of the annual average is about 0,5°C, so that in the zones of highest mountain peaks the mean annual temperature decreases to values of about 4,5°C (Map 4.). During the summer period, the value of the gradient is a little above the annual (about 0,7°C) so that the highest hypsometric levels in the wider area of Vranduk canyon have a mean summer temperature approximately 15°C. Winter gradient is lower - about 0,35°C and the seasonal average of winter in the mountain peaks ranges approximately -3,0°C.

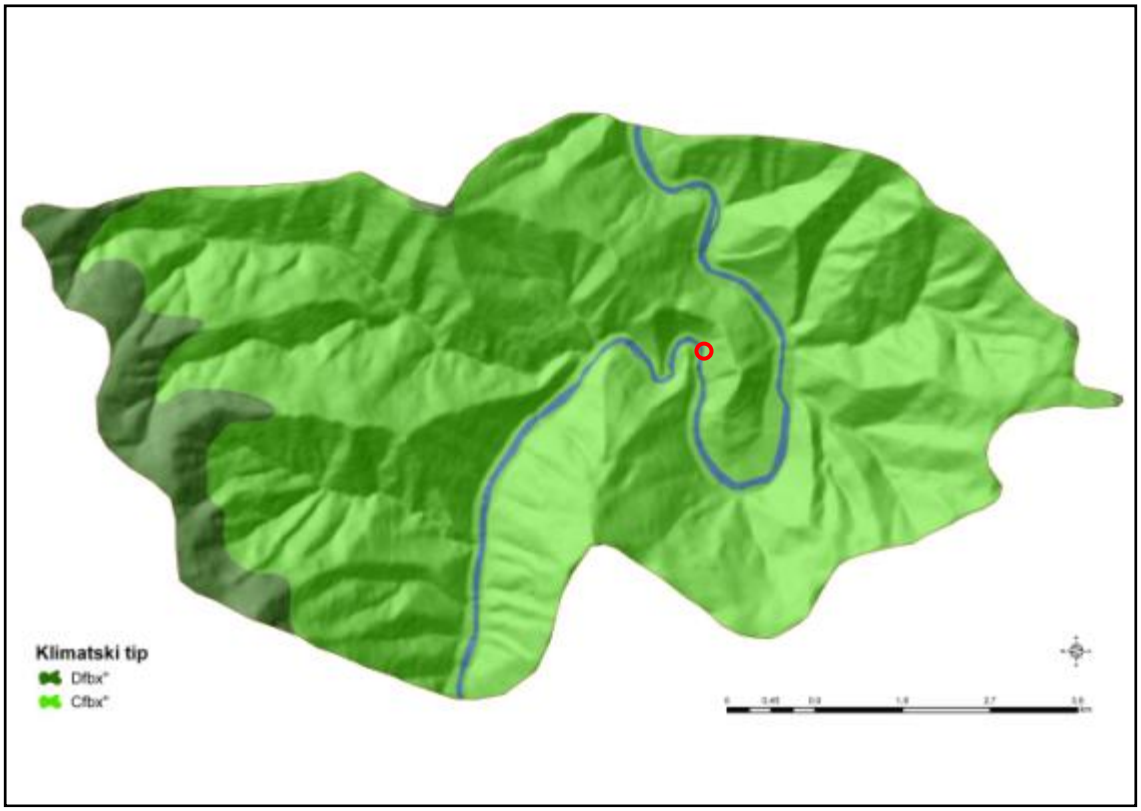
Precipitation indicators are also characterized by some degree of spatial variation, although in comparison with the thermal area it is still lower. On average, in the wider area of Zenica ravine during the year, it rains approximately 790 mm up to app. 800 mm in canyon part of the Bosna river valley in the north. The rainiest month in the whole area is May with values of about 80 mm in Zenica valley to about 82 mm in the zone of the canyon valley of the Bosna river in the north. February is the month with precipitation minimum of about 48 mm in the ravine part up to about 50 mm in the north area. The height of rainfall increases towards higher altitudes so that, in the zone of mountain peaks, the values are about 950 mm, therewith the summer precipitations have higher pluviometric gradient in relation to winter. The above mentioned annual course of precipitation mostly fits in precipitation regime of Cfbx "climate. The main precipitation maximum is May-June - with approximately 79,9 mm, i.e. the second maximum is November - December with 74,0-mm of rainfall (Map 5.). From the above data, we can conclude that late spring - early summer precipitation maximum is "richer" in rainfall than late autumn-early winter period. The main minimum of precipitation occurs during the period February - March (late winter-early spring) with an average of 49,9 mm, while the secondary minimum occurs in mid-autumn, in October with about 70 mm. The largest part of the precipitation takes place in the form of rain, which reflects directly on the parameters of the river regime. Solid rainfall takes place on average during the period December - February, causing the formation of a quite intense snow cover. This type of precipitation water in the river regime is present during the spring months, as an element of level retention.



Map 4. Spatial distribution of Mean annual air temperature in a wider area of Vranduk canyon



Map 5. Spatial distribution of Mean annual height of precipitation in a wider area of Vranduk canyon



Map 6. The main climate types (according to W. Koopen) in a wider area of Vranduk canyon

Recognizing hydrothermal indicators presented, it can be concluded that the wider area of Vranduk canyon up to approximately 1.000 m a.s.l. has the characteristics of a moderately warm and humid climate, with cool summers or Cfb climate subtype with precipitation variant x ", ie Cfbx. Areas with altitude up to 1.400 m have elements of Dfbx "climate subtype or boreal (forest - snowy) climate with cool summers, during which two to three months have a negative mean monthly temperature.

2.9. DESCRIPTION OF THE CULTURAL AND HISTORICAL HERITAGE

In the area of Vranduk canyon, two sites of cultural-historical heritage have been identified, Vranduk - Varošište (medieval church of the Franciscan monastery) and Vranduk[8]. The sites are related geographically, as well as by the period of formation and the development through history. Specifically, the site Vranduk is primarily a defensive fortification, but also the backbone of the development of settlements, which, due to the geographical characteristics of the place where the Vranduk is built, develop on the left side of the Bosna river. At the site known as Varošište, remains of the church are located, built in the late Middle Ages, which is situated on the Bosna river terrace.

Locality Vranduk is one of the most important sites of the medieval Bosnian state. Located on top of steep and rugged cliffs, the old town Vranduk is always considered as a guard of the entrance to Central Bosnia, but also the core of the development of a picturesque village which was eventually created around it. Vranduk is located on a very important strategic road, which, by the Bosna valley from Visoko led to the Sava river. In addition to military-strategic reasons, this road, particularly in the Middle Ages, and in later periods, was of interest to traders. There has always been a barrier to the passage from the middle to the river basin of the upper flow of the Bosna river.

The settlement is characterized by a specific relation between suburbs and the fort, giving a special value to the overall picture of Vranduk. The spatial organization of Vranduk with the fort in the center and two separate residential units (Donja Mahala and Prigrad with Zavtez) reminds of one of prehistoric settlement, fort type. [9]

Old Town in Vranduk belongs to the type of mountain fortresses. By area, which occupies, it is a small fort erected at strategic, easily defensible hill with difficult access. The fort is well adapted to the relief, which has the effect of substantially reducing the thickness of the walls of the ramparts, while the construction of the tower is reduced to a minimum.

Disposition of defense facilities and the size of the Old Town Vranduk are conditioned by the nature of the terrain. The town is built on natural and artificially flattened stone rocky plateau, on whose slopes, the outer walls of the fort are built. Above the valley of the Bosna river, it rises about 25 m.

Old Town Vranduk is a single whole with the landscape within which it is built. The natural position of the town, with canyon and sharp curves of the river, emphasizes its defensive importance and contributes to values of the Old Town.

[8] Archaeological Lexicon of Bosnia and Herzegovina, Volume 2, Archaeological sites of Region 1-13, Sarajevo 1988., Pp. 206.

[9] Description based on data from the Decision of the Commission to Preserve National Monuments to designate the architectural ensemble of the old town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, the number of 05.2-2-274/04-4 from 25th of January 2005, published in „Official Gazette BiH 16/06“.

Figure 28. Current status (November 2009.) - View at the Old Town

Figure 29 View at the designed dam and the Old Town Vranduk – visualization in space made by Elektroprivreda BiH (without presenting the access road and the way for public communication)

Figure 30. Current state (November 2009) – view from the Old Town Vranduk towards the bridge on M17

HISTORICAL DATA

„*(...)*Vranduk was situated in the medieval parish Brod, one of the seven parishes of medieval Bosnia, which, as a country, appears in historical documents in the middle of the tenth century. In the period from XIV century to 1463, Vranduk is ruled by a ban, and then it began the royal town, which belonged to the Crown lands. At that time, it was the only fortified town in the parish Brod.

In historical books, the military function of the fort is stressed, especially the increased concern of the Bosnian kings in the fifteenth century for its important strategic position. *(...)*

Archaeological and toponomastic traces in Vranduk show that this place has undergone a full development, just like most developed centers of the fifteenth century in Bosnia. Apart from relatively small fort in the vicinity of Vranduk developed a system of defensive structures and within these walls, a small settlement *"sotto Vranduch".* Its location directly on the slopes below the town shows the need to protect the town-fortress. Here, the king Tomaš had built the Church st. Tomo, his protector, and, at his request, because of it he got some special privilegies by the Pope from Rome. Along the fort, there is no arable land, so the larger trading-craft settlement outside the walls has been formed in the village Varošišće, approximately 2,5 km away from the fort in Vranduk. The Franciscans founded a monastery there and built the Church of St.Mary according to the documents from 1449., 1461. and 1462.*(...)*

(...) Town Vranduk was occupied by the Ottomans in 1463. *(...)*

(...) According to the Defter from 1468./1469., Vranduk was the northernmost fortress in the Ottoman government on the Bosna river. *The fortress Vranduk with garrison and town „Podgrađe"* was in the vilâyet *Crown lands*, a territorial unit of Bosnian Sandzak. It is not mentioned in the lists from 1485 and 1489, then reappeared in the list in 1516 as a fortress and center of Vranduk Nahiye.

From 1516 until the end of XVI century, Vranduk Nahiye had a garrison. Later, it loses on strategic importance as the headquarters of this administrative unit, and remains as a fortress in Zenica Nahiye.

In his campaign to Bosnia in 1697, Prince Eugene of Savoy , noting the weight of conquest of Vranduk, decided to bypass the town.

In the XVIII Century, 28 Captaincies were founded in the Bosnian Sandzak. Between 1699 (Karlovac Peace) and 1718 (Požarevac Peace), after 1715, *Vranduk Captaincy* was also established with its headquarters in Vranduk. It was not until 1773, the headquarters of the captaincy was transferred to Derventa. During the XVIII Century, Vranduk belonged to the Kadiluk Bosna Brod or Travnik in Zenica Nahiye with Vranduk. As can be seen from the preserved documents, Vranduk served in the eighteenth and first years of the nineteenth century as a prison for political culprits, and mostly educated people.

In 1878, Austrian troops occupied the town without a fight. Until 1890, a small Austrian garrison was in it. Since then, the fort was left empty and cease to exist as a military-strategic position."[10]

Locality of Vranduk, because of its value, was legally protected as a site of national interest at the very beginning of legal protection of heritage in Bosnia and Herzegovina. Conservation works were carried out on the town even before its formal protection, in 1914.

"The decision of the National Institute for the Protection of Cultural Monuments of NR BiH, Sarajevo, no. 1304/50, dated on 9th of October 1950, the facility was placed under state protection, and by Ruling of the Institute for the Protection of Cultural Monuments of NR BiH, Sarajevo, no. 02-788-3, dated on 18th of April 1962, the building Old Town Vranduk, NOO Zenica, state ownership, no. of cadastral plot 191/47 and 191/48, was placed under state protection and is registered in the Register of Immovable Monuments of Culture. This decision became final on October 24, 1962."[11]

By the Decision on registration in 1968 by the Institute for the Protection of Cultural Monuments of NR BiH in Sarajevo, the medieval church in Varošište is registered as a monument of culture.[12]

By the Spatial plan of Bosnia and Herzegovina in 1980, this well was recorded and classified in the II (second) category as the cultural and historical well.

[10] Commission to Preserve National Monuments, Decision to designate the Architectural Ensemble of the Old Town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, the number of 05.2-2-274/04-4 of 25th of January 2005, published in „Official Gazette BiH 16/06", part of the Explanation – 2. Historical data

[11] Commission to Preserve National Monuments, Decision to designate the Architectural Ensemble of the Old Town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, the number of 05.2-2-274/04-4 of 25th of January 2005, published in „Official Gazette BiH 16/06", Explanation – 3. The existing legal protection.

[12] Data obtained from the Federal Ministry of Culture and Sport - Department of Protection of Monuments

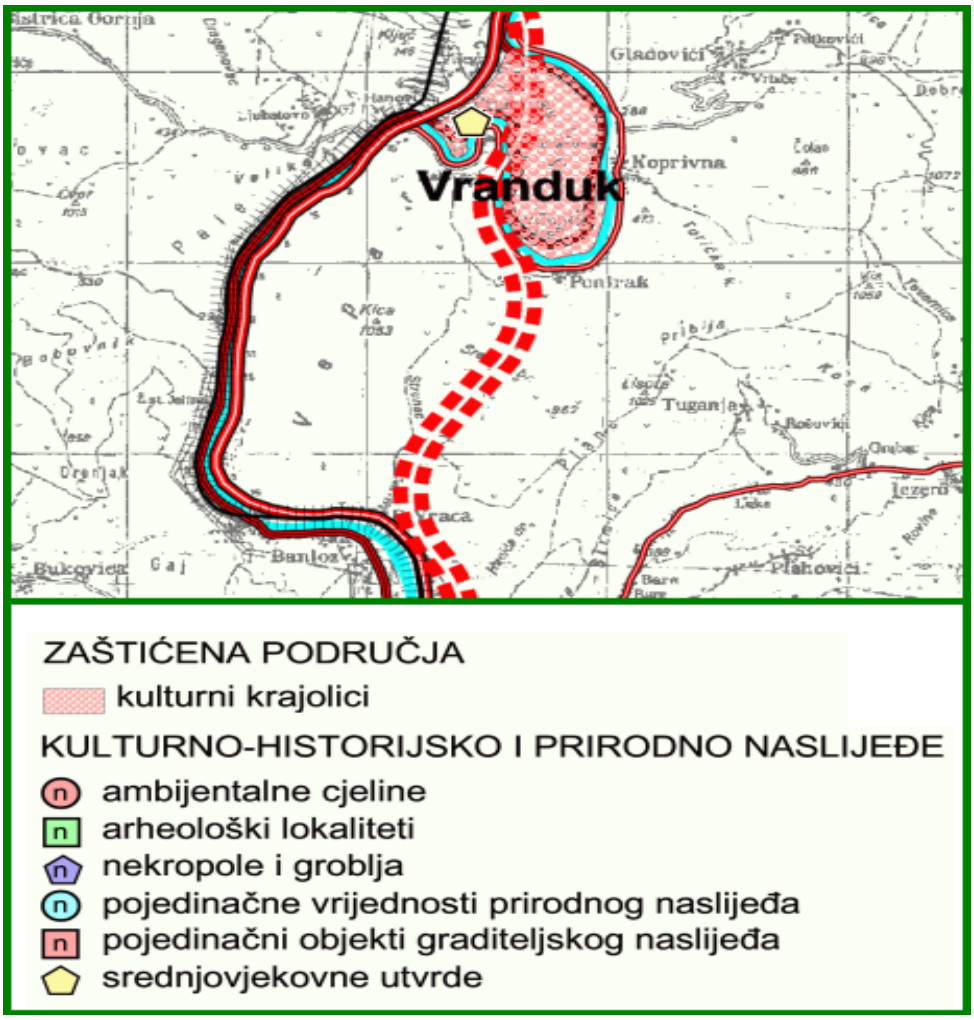


Figure 31. Cultural-historical and natural heritage (Source: Spatial plan of Zenica-Doboj Canton (2009 - 2029.) – Protected areas)

The well, under the name of Medieval town and fortress Vranduk and numbered 772, was on the Provisional list of the Commission to Preserve National Monuments of Bosnia and Herzegovina."[13]. According to the Spatial Plan of Zenica-Doboj Canton 2009-2029 Vranduk area is classified as a cultural landscape. The Spatial Plan states that construction of HPP Vranduk, under the adopted version, would not reduce the aesthetic values of this cultural landscape. The planned construction of hydro power plant, i.e. its location was charted in the adopted Spatial Plan of Zenica-Doboj Canton.

[13] Commission to Preserve National Monuments, Decision to designate the Architectural Ensemble of the Old Town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, the number of 05.2-2-274/04-4 of 25th of January 2005, published in „Official Gazette BiH 16/06", Explanation – 3. The existing legal protection

2.10. CURRENT STATUS OF THE SITE - OLD TOWN VRANDUK

Old Town Vranduk is now in relatively good structural condition.

In the town, some conservation and restoration works were continuously carried out several times by the Institute for Protection of Monuments of Bosnia and Herzegovina and the Museum of Zenica. In the period from 1999 to 2002, some conservation and restoration works were carried out in the Old Town Vranduk and eliminated risks to which the fortress was exposed. Monitoring of the repaired damage on the east side of the outer walls (cracks) is continued.

Besides nonmaintenance of existing old buildings in the village and its immediate surroundings, which are subjected to rapid deterioration, in this area the problem of building new housing is also evident, which by its look does not correspond to the existing environment. Also, the location downstream from the dam of the future HPP Vranduk is unarranged, and during high rainfall it leads to flooding of surrounding land. On the banks of the Bosna river, there is the waste that goes down in the riverbed.

The fortress building Vranduk is actively involved in the realization of cultural events in Zenica, and in Bosnia and Herzegovina (Days of European Heritage, Days of cherry (ašlama), cultural events within the fair ZEPS, plays ...). Now, in the building of big tower, there is a permanent exhibition, in accordance with the thematic - expository plan of the curator of the Museum of the City of Zenica, which presents the life in the town during its history.

Old Town Vranduk is actively involved in several projects aimed at revitalizing the Old Town and involvement in cultural tourism. Projects are initiated and implemented by local communities and financed by local and foreign donors (Figure 32.).

Figure 32. Vranduk Fortress - Tourist destination

In cooperation with the Foundation "Mozaik" from Sarajevo, in 2005, the project of "Revitalization of the Old Town Vranduk" was made and immediately thereafter, the project " Preservation of traditional crafts and handicrafts of the local community Vranduk".[14]

Among the major projects currently being implemented at the site Vranduk, from the standpoint of the development of cultural tourism in the narrower and wider region, is a project called "Bosnian Kingdom Trail", which is implemented by Foundation "Mozaik", and largely funded by the European Union. Partner on this project, among others, is the museum of the city of Zenica.

The project covers 10 communities / medieval towns of interrelated cultural and historical heritage, and events from the period of medieval Bosnia. Selected communities are: Bobovac (Vareš), Čajangrad (Visoko), Jajce, Kraljeva Sutjeska (Kakanj), Kozovgrad (Fojnica), Maglaj, Prusac (Donji Vakuf), Tešanj, Travnik, Vranduk (Zenica). Mozaik Foundation in collaboration with 10 selected communities works on development of a unique branded tourist product in the context of cultural tourism. The development of the

[14] http://www.zemuzej.ba/projekti.html, access on 20.11.2009.

tourism product is based on a common theme of medieval Bosnian kingdom. The project is aimed at improving infrastructure, content and quality of the entire tourist supply and a strong promotion of the common brand of 10 listed sites.

The project objective is that through the theme of the medieval Bosnian state to improve the competitiveness of Bosnia and Herzegovina in the field of cultural tourism and tourist interest. Project budget is € 550.000, of which the European Commission supports the program in the amount of € 300.000

Planned activities:

1. Improving the attractiveness of tourist destinations
2. Increase quality of tourist services in locations
3. Creating and selling tourism products - bringing tourists.

Within this project at the site Vranduk (Zenica) following specific activities have been implemented:

3. Setting up tourist signs (setting seven signposts)
4. Arrangement of the fortress with the supporting infrastructure and content enrichment
5. Marking the Fatih Sultan (Imperial) Mosque and the Vranduk fortress (setting two signboards
6. Workshops/training of traditional weaving.[15]

Through these projects, it seeks to preserve a very important national monument of Bosnia and Herzegovina, but above all, maintain the existing environmental values and attributes with appropriate measures: preserving the environment and its diversity, the preservation or re-introduction of traditional activities that have been shown to have the function of sustainability, as well as help local community development, sustainable use of heritage in the cultural tourism.

2.11. PROTECTIVE MEASURES OF THE OLD TOWN VRANDUK

Commission to Preserve National Monuments of Bosnia and Herzegovina declared the Architectural ensemble of the Old town Vranduk in Vranduk, as a national monument of Bosnia and Herzegovina, at its 18th session, held on 25-31 January 2005. (Decision No. 05.2-2-274/04-4, published in „Official Gazette BiH 16/06"). By the aforementioned decision of the Commission, it was found that the "National Monument consists of: the old town walls, with facilities of large and small tower, the mosque and the movable archaeological material, excavated at the site which is kept at the Museum of the City of Zenica. National Monument is located on a site designated as the cadastral plot no. 84, 85 and 123 (new

[15] http://www.mozaik.ba/index.php?id=tbk1, access on 20.11.2009.

survey), which corresponds to the cadastral plot no. 191/47 and 191/48 (old survey), registered in the Land Registry folio number 468, k.o. Vranduk, Municipality of Zenica, Federation of Bosnia and Herzegovina, Bosnia and Herzegovina“[16].

Figure 33. A graphic representation of the protection zones, the Commission to Preserve National Monuments of BiH

[16] Commission to Preserve National Monuments, Decision to designate the Architectural ensemble of the Old town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, the number 05.2-2-274/04-4 from 25th of January 2005, published in „Official Gazette of BiH 16/06“, a part of Disposition, article 1.

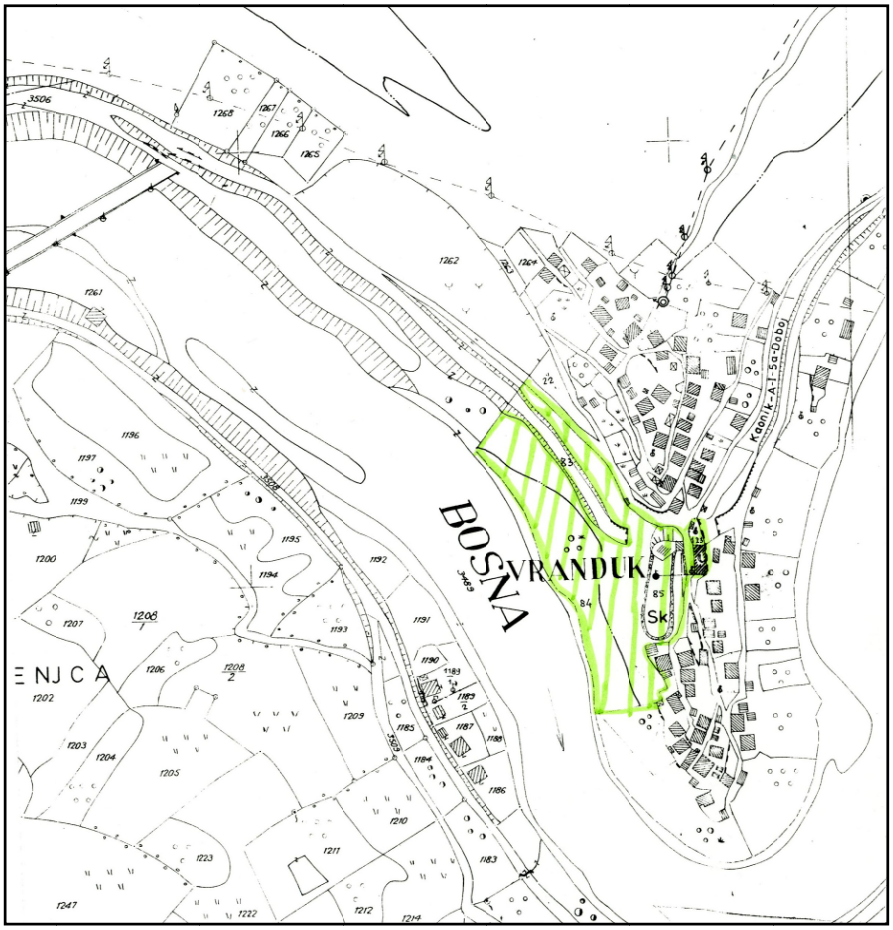


Figure 34. Cadastral plots of the zone I (Source: Municipality of Zenica)

This Decision of the Commission, among other things, defines measures for protection of the national monument, the institution responsible for implementing and overseeing the implementation of conservation measures, and abrogates all spatial planning documents that are in conflict with the provisions of Commission Decision

It is obvious that the above situation in Figure 33. and Figure 34. show different cover in I and II zone of protection of national cultural monuments. It is important to draw a real cadastral plot to which it refers, primarily I Protection Zone, and it should conform to data from the Commission and retrieved data from the Municipality of Zenica.

In preparation of the Environment Impact Study, the original cadastral data are taken from the Municipality of Zenica, the provisions of the Decision on the protection of "Architectural ensemble of the Old town Vranduk" and the expert opinion of professionals committed to cultural and historical heritage, and it is estimated that the dam building will be in cohabitation with the II zone of protection of national cultural monuments.

In order of permanent protection of national monuments, two zones of protection are defined: „I. Zone of protection includes the area of national monument, where the following protective measures are implemented:

- Only research and conservation and restoration works are permitted, including those designed to present the monument, with the approval of the Federal Ministry in charge of urban planning and supervision, the heritage protection authority of the Federation of Bosnia and Herzegovina,
- the monument will be open and accessible to the public and can be used for educational and cultural purposes,
- waste disposal is not allowed
- Protection Zone II covers an area of the architectural ensemble of Vranduk settlement, or the area defined by boundary:
    - the southern, eastern and western sides, Bosna mid-river [17];
    - from the north side, the tunnel route of the road M-17.

In this zone, the following protection measures are implemented:

1. Analysis of the current state of the architectural ensemble of Vranduk settlement, which includes:
    - chronological overview and stylistic evaluation of existing residential buildings,
    - review of storeys of existing facilities,
    - application of materials,
    - state of damage and preservation,
    - analysis of street's façade view - a detailed survey of the current situation, processing and identifying their stratification,
    - analysis of open spaces
2. Based on an analysis of the current situation, develop a restoration project of the historical ambiance of the architectural ensemble Vranduk, with the following measures:
    - maintaining, rehabilitation, conservation and presentation of existing architectural buildings and urban elements that have environmental values,

[17] According to the limits defined by the Decision of the Commission, the northeastern half of the planned dam together with the access road and half of the planned public communication, are located in the area of Protection Zone II.

- restoration and reconstruction of buildings, shapes and spaces that will enhance the environmental significance of the settlement,
- it will be required to preserve or restore the original appearance of facilities (horizontal and vertical dimensions, proportions, number, size and arrangement of openings, architectural details and color of the walls, openings, facade treatment),
- all methods used and the degree of intervention must be recorded,
- cleaning and removal of the heightened parts of facilities or facilities that are not in accordance with the ambience; to make modifications to certain elements on the buildings that have been incurred as a result of subsequent interventions (replacement of saddleback roof with a hipped roof, remove the balconies, loggias and large glass surfaces),
- any construction, construction-craft and craft project cannot be granted for performance or carried out without the approval of the competent ministry and expert supervision of the authorized protection services,
- introducing some new purposes of the facilities is prohibited, which deviate from the traditional functions, purposes that would affect the change in character and elements, which characterize the given ambiance and the purposes, which pollute the environment,

3. Application of materials and forms to the facilities:
   - in the conservation and restoration works, use the original materials (stone, travertine and schist), traditional binders (hydraulic lime mortar, lime mortar) and traditional methods of construction, to the fullest extent possible,
   - external surface treatment - lime mortar plastering with lime whitewash,
   - use of wood: pine, fir, spruce, chestnut, beech and oak,
   - type and pitch of the roof must match the original condition of the buildings: only hipped roofs, wooden roof structure with the pitch of 30 to 60 degrees,
   - develop a design of conservation and rehabilitation of lanes with retaining walls in dry stone masonry".

2.12. LANDSCAPE

The structure and morphology of the terrain that caused the very construction of the fortress, as a central and powerful element of a given area, further emphasizes its importance. Also, the site of the Old Town Vranduk is a potential in development trends of the region, particularly with regard to the development of cultural tourism. The organization and concentration of the built structures provide a recognizable picture of the development of medieval cities and their suburbs preserved in its appearance to the present day. Accessibility is poor, as well as spatial "dominance" of the Old Town over the surrounding

terrain, together with the Bosna river, whose riverbed is considerably narrowed in this part, with steep banks making the canyon, while the flow makes a double and very sharp "S" curve.

Spatial agglomeration has the characteristics of the cultural landscape, one of the most important in the Zenica-Doboj region, but also in Bosnia and Herzegovina.

Houses that are located near the Vranduk fort and their environment are in very poor condition.

Figure 35. Houses near the Vranduk fort

Figure 36. The current state of the hillside on which the left block of the dam is planned to build

Figure 37. The current state of the hillside on which the left block of the dam is planned to build

Location downstream from the dam of the future HPP Vranduk is pretty uncared for and loaded with various types of waste (Figure 37.). During high rainfall, it leads to flooding of surrounding land. Bosna river banks are unarranged and encumbered with accumulated waste, which goes down and encumbers the surrounding land and riverbed. The existing bridge on the main road M17 (Figure 38) clearly has an impact on the cultural landscape/natural environment and views in the area.

Figure 38. View on the monument from the existing bridge on the main road M17

Figure 39. View from the Old Town Vranduk, downstream from the dam

2.13. SPECIFIC ELEMENTS DETERMINED BY PREVIOUS ENVIRONMENTAL IMPACT ASSESSMENT

During the implementation of procedures for environmental impact assessment, in the phase of previous impact assessment, the consultant has not received written comments on the document entitled "Previous Environmental Impact Assessment of HPP Vranduk", by relevant institutions, citizens, interested public, local communities, nor of the Federal Ministry of Environment and Tourism.

In the process of environmental impact assessments of HPP Vranduk, constant communication was maintained with the engineer of the Preliminary Design and the investor.

3. DESCRIPTION OF POSSIBLE SIGNIFICANT IMPACTS OF THE PROJECT ON THE ENVIRONMENT

3.1. IMPACTS OF HPP VRANDUK DURING CONSTRUCTION

3.1.1. IMPACT ON POPULATION

Given the relatively small population in the area of the planned dam and accumulation, the negative impacts in terms of necessary resettlement of the population are minimal. Only one house is foreseen for demolition i.e. relocation of one household.

Possible negative impacts that will result from increased concentrations of dust and the increased intensity of traffic and noise levels are temporary, and with implemented mitigation measures they can be considered acceptable. It should be noted that the locations, where construction works will be carried out, are far enough from the first inhabited houses, approximately 250 m, which means that the above impacts on the population should be mitigated.

Positive impacts on the population are numerous and relate to the increase of economic activities, which follow the construction of such facilities. It creates conditions for employment of a large number of population, i.e. employment of local construction firms and local residents during construction of hydropower facilities.

It shall proceed with the reconstruction of approximately 1.200 m of the local road and build about 500 m of the new local road.

Fair compensation for damages will be provided to the local community and compromise of the interests of local community and investor will be achieved, which implies creating conditions for the multipurpose use of water resources of the Bosna River. Apart from the concession fees, obligations will be also determined in the Investment Program for the local community after the Project support, which should be "friendly" to the population and the environment.

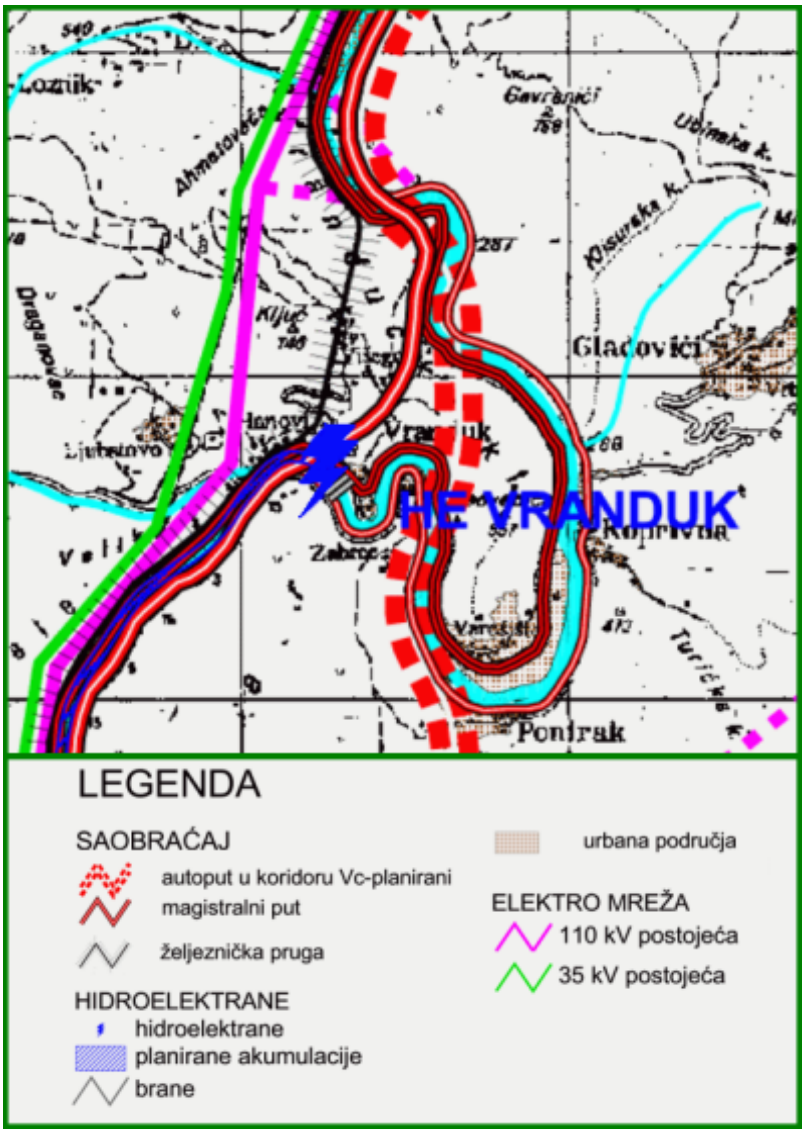


Figure 40. Position of HPP Vranduk compared to other infrastructure facilities (Source: Spatial Plan of Zenica-Doboj Canton (2009 - 2029.) - Energy Infrastructure)

3.1.2. IMPACT ON CLIMATE

Based on data on the general climatic and morphological characteristics of the narrower and wider area of Vranduk canyon, it may be concluded that it is climate specific area within which all possible changes in the surrounding natural environment can have its own reflection. This is a consequence of the relative "morphological closure" of the area where the local air circulation and other meteorological conditions are directly conditioned by local natural ambient section, so that even minor changes reflect in their current situation and the spatial-temporal dynamics. For these reasons we can not say that there will be significant changes from the microclimate aspects, and which may result from changes in natural ambient conditions. In one of the most important processes that are also the most frequent

causes of microclimate conditions, Technogenic - construction activities are included, among which is certainly involved the formation of artificial accumulations.

In the most important impacts of construction activities that may have less modifying impact on micrometeorological conditions of the wider area, can be classified:

- dust that will arise during civil works in the construction of foundations of the movable dam in the rock base and sidewalls of the riverbed, civil earthworks to build the necessary supporting facilities, civil earthworks to build access roads, etc.
- preparatory technical works, which can result in harvesting small-scale woody vegetation.

These impacts, which depend on the size of the project in the area, mainly civil works, can potentially be a temporary impact on the natural ambient condition, in a narrower area of Vranduk canyon. First of all, the increased amount of dust in the ground layers of air during the construction may occasionally cause dust and impact on the local atmosphere and thus to some extent reduce the flow of solar radiation.

3.1.3. IMPACT ON AIR QUALITY

During the construction of facilities of HPP Vranduk, the impact on air will be caused by raising of dust, and emissions of exhaust gases from machines that will be used:

- during the construction of access roads;
- on the location during the activity on the site and along access roads;
- during the supply of construction materials and disposal of waste material; and
- during operation of the borrow pit of materials for civil works (construction of tunnels and dam). This impact is temporary, and it can be concluded that it would not be significant, because the material will be transported from the borrow pit of materials that is not located in the narrower location of the planned facility.

3.1.4. IMPACT ON WATER

Construction of the facility HPP Vranduk, may temporarily cause the water turbidity due to excavation works in the riverbed, as well as on the banks, then during the backfilling and placing materials. Also, during the construction phase it can lead to erosion of various materials used on the site. It will temporarily come to hydromorphological changes in the natural water regime.

3.1.5. IMPACT ON SOIL

During construction, the area will be occupied with supporting facilities, temporary places for the disposal of construction materials, construction of infrastructure and site.

Estimation of the total area of land that can be purchased in the area of cadastral municipalities Vranduk, Nemila, Banlozi and Donja Gračanica for the construction of HPP Vranduk is 84. 434 m^2. The fact is that, after the formation of the accumulation, it will result in raising the water level, for three houses in the settlement of Hanovi it will be taken appropriate technical and construction measures for the protection and safety of these facilities, and undertaking these measures there will be no threat to them. During the project implementation, there will be a submersion of one house.

Table 11. Data on agricultural and forest land of cadastral municipalities Vranduk, Nemila, Banlozi and Donja Gračanica

Culture	Canton	Municipality of Zenica	Subject cadastral municipalities[18]	The surface area to be purchased
Forest	214.891 ha	30.784 ha	65,511 ha	0,027 ha
Agricultural land	72.456 ha	16.700 ha	1,48 ha	1,037 ha

Percentage of agricultural and forest land, which will be purchased for the construction of HPP Vranduk is 1,6% compared to the surface area of cadastral municipalities (Vranduk, Nemila, Banlozi and Donja Gračanica), and 0,002% in relation to forest and agricultural land of the Municipality of Zenica.

The planned accumulation of HPP Vranduk will submerge 5,3 ha of land. Since it is a land that is not used for agricultural or any other purpose, it is considered that this impact is negligible.

The Main Project should determine the flood line on the stretch downstream from the dam of HPP Vranduk in case of emergency emptying the accumulation, or possibly wrong and illegal manipulation of facilities.

If the managing of waste collection and disposal could not be possible at locations near the site, it could cause an overload of the land.

3.1.6. IMPACT ON WASTE GENERATION

During the digging of tunnels and site preparation for future hydro-accumulation, as well as other civil works, it will lead to the accumulation of excavated material. Construction waste includes earth materials, stone, gravel, vegetation and etc. It is necessary to continuously

[18] Overview of areas and cadastral income for 2008.(Administration for Geodetic and Real Property Affairs)-Cadastral municipalities: Vranduk, Nemila, Banlozi and Donja Gračanica

collect it, if possible use for civil works, and the remaining unused material are to be removed from the construction site area, as well as the location for the temporary deposit

Given that the level of the local road will have to raise to the level of the railway line near the village of Hanovi, most of the excavated material will be used as an embankment for the new local road. Regarding the cuts, which are made for the foundations of the dam, the material will be used for arrangement of the banks upon completion of civil works. Unused portion of construction waste will be necessary to transport to the specified and approved landfill.

At the stage of preparatory works on the locations of facilities and access roads, by cutting of vegetation, biomass will be generated, which should be exploited-used as a useful fuel, as well as for processing into compost.

Within the Main Project, it should determine the total amount of waste from civil works and develop a Waste Management Plan.

It is estimated that it will incur very small amounts of hazardous waste. In the context of the disposal of these wastes (paints, oils, oily materials, etc.) the contractor must comply with the Waste Management Plan - hazardous waste. Delivery of waste, i.e. undertaking this kind of waste should be carried out by the companies authorized for collection and final disposal of hazardous waste.

Waste from the category of municipal waste will also be created (key number 20 00 00) which includes packaging and waste from activities of workers on site.

In accordance with the Decree on site organization, compulsory documentation on site and participants in construction works (Official Gazette FBiH, no. 48/09; 75/09) the Waste management plan is a mandatory document, whose implementation will have to continuously monitor.

3.1.7. IMPACT ON FLORA AND FAUNA

Construction of hydro power plant-hydro accumulation with a dam, is leading to changes in the structure of the ecosystem of the Bosna river. Disruption of a single link in the food chain can cause certain damages to the entire ecosystem. Therefore, it is necessary to carefully consider all issues related to wildlife in the planning stage.

The most significant effects on the environment during the construction phase are manifested during the formation of small hydro accumulation and changes of the Bosna river flow regime, which is reflected in aquatic and semiaquatic flora and fauna. Living world is changing, both in the accumulation, and downstream from it. During the works, filling the accumulation will result in irreversible loss of terrestrial habitat, while increasing border zone between terrestrial and aquatic environment. This change in the watercourse will cause less quantitative and qualitative changes in the flora and fauna. Water surface in relation to the current situation will be only 12% extended. Decomposition of submerged vegetation and soil is possible, if the same are not removed prior to filling the hydro accumulation.

3.1.8. IMPACT ON ICHTHYOFAUNA

Any partitioning of the riverbed and the river changes, especially the construction of hydropower plant, will inevitably lead to distortions and changes in the ecosystem. Ecological niches are changing, as animal and plant life reacts to a greater or lesser extent, and of which even ichthyo populations are not immune.

Site preparation, civil works within the river bed, dam building and construction of bank fortifications, will disturb the ecological balance of streams and affect the ichthyofauna, especially in the downstream part of the river, nearby.

During construction of the hydro power plant, habitat of indigenous species will be broken. In the immediate vicinity of the construction site, the river surface will be completely altered or destroyed. Besides the ambient effects, habitat destruction has resulted in the destruction of flora and fauna of the bottom i.e. interruption of the food chain for a certain period of time.

Daily and seasonal fish migration will be disrupted from early works, which should especially be taken into account in the stage of preparing the site.

Fish migration (daily and especially seasonal) from the lower flow to the upper river, would be interrupted by construction of the dam. During spawning, many fish species migrate to the water source or smaller tributaries to spawn in them and laid eggs. Therefore, inevitably there will be a disruption of natural balance

To avoid these possible effects on the ichthyofauna, it is proposed to ensure migratory routes and construction of fish path.

Turbidity of water that will be created during earthworks and heavy machinery moving through the river bed will adversely affect plant and animal life downstream from the site.

Different waste, which can occur during the construction of buildings, should not have a major impact on the ichthyofauna, if it manages properly with it. During the execution of planned civil works and deepening the riverbed below the power house, it can get to the accumulation of certain amounts of gravel, stone and floodplain deposits, which must be removed from the riverbed and directed on the utilization or final disposal in an adequate location.

3.1.9. IMPACT ON CULTURAL AND HISTORICAL HERITAGE AND LANDSCAPE[19]

Based on available literature and available documents (especially those relating to the protection of the Architectural ensemble of the Old Town Vranduk), it can be concluded that the location of HPP Vranduk foreseen by the Preliminary design, in its part (half of the dam, access road and major part of an eventual road for public communication over the dam) is located in the second zone of protection of national monuments, i.e. in the Architectural ensemble of the Old Town Vranduk (zone established by the Decision of the Commission to Preserve National Monuments, number 05.2-2-274/04-4 of 25 January 2005., published in the Official Gazette of BiH 16/16"). Given these facts, the approval for construction of HPP Vranduk, a part which is located in the Protection Zone II of national monuments under the Law on the implementation of decisions of the Commission to Preserve National Monuments, established pursuant to Annex 8. of the General Framework Agreement for Peace in Bosnia and Herzegovina (Official Gazette FBiH, no. 2/02, 27/02, 6/04 and 51/07) and the Commission Decision, is issued by the Federal Ministry of Physical Planning with the prior provision of expert opinion of the competent institutions for Protection of Cultural and Historical Heritage.

Construction of HPP Vranduk at the proposed location will affect the physical structures of the spatial system of the cultural landscape (built structures and natural environment of the wider area) around the Old Town Vranduk which is reflected in the image, structure and shape of the entire area.

Impacts of construction of the planned facility on the cultural and historical heritage can be divided into direct and indirect. Direct impact is considered to be any physical transformation of the site area / facilities provided within the affected zones (an area of 500 m concentrically formed around the Old Town and the suburbs was found as a boundary area of impacts on individual cultural and historic buildings and recorded archaeological sites). The indirect impact represents the integrity impairment of the associated surrounding area of the cultural heritage (the space within the 1.000 m along the Bosna river was established as the boundary area of impacts on cultural property with physical characteristics - cultural landscapes), with special emphasis on climate components, the topography of the terrain, etc.

This kind of impact specifically relates to the whole space, but also the individual sites that the construction of the planned structure will affect visually, functionally and content.

[19] Aspects of the cultural and historical heritage and landscape, in the framework of this Study, are treated as an inseparable whole and in this sense the impact assessment is also made. The reason for this mode of observation is the fact that the space of the Architectural ensemble Vranduk is a unique agglomerate with the surrounding environment, which the Spatial Plan of Zenica-Doboj Canton 2009-2029 define also as a cultural landscape (cultural landscape as a separate segment of the immovable cultural heritage, is one of the primary and the most complex elements of space, the joint work of nature and man created by their interactions over time).

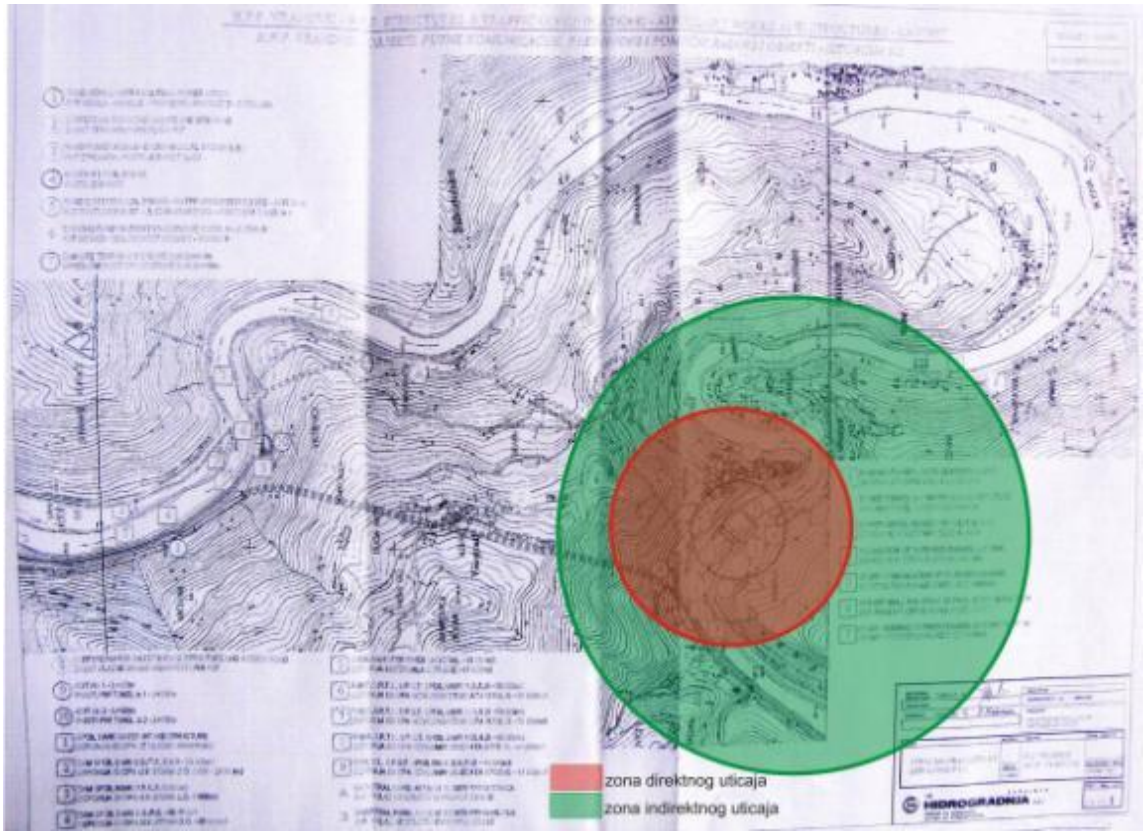


Figure 41. Map of the designated zone of direct and indirect impacts

In the event that the planned plant causes possible change of groundwater flows that could affect the architectral ensamble Vranduk, it is necessary to give special consideration to this aspect after the research and analysis in accordance with the Decision on the previous water permit.

Taking into account the existing landscape and specificity of Vranduk canyon, it can be concluded that the construction activities during the construction of dam with four spillways, access road and the proposed road for public communication over the dam significantly affect the natural environment where Vranduk Old Town is located, given that there will be some changes in terms of its spatial perception (visual and audio).

The main construction activities that will have an impact on the change of natural environment can be classified as follows:

- Temporary changes in watercourse of the Bosna river (river diversion) that will occur as a result of technology of dam construction (creating cofferdams);
- Dust, which will occur during the civil works, possible cement dust, which will occur during the production of concrete (if it provides the placement of concrete fabrication plant within the zone of direct or indirect impact) and products of combustion of oil and petroleum products and other gases and soot, which will be the products of using the construction machinery;

- changes in the landscape under the influence of construction works (foundation of the dam and quay walls on the left bank upstream and downstream, notching of existing deposit material, construction of retaining structure, which is performed in order to stabilize the road for Vranduk settlement) and cutting woody vegetation and shrubs.

These products of the construction activities will undoubtedly lead to modifications of the environment in which the Old town Vranduk is situated. The changes will be reflected in physical changes, i.e. in modification of the environment as a result of the construction of new structures and fitting them into the space (construction of slopes, cutting of vegetation, construction of access road, etc.). It is possible that a temporary increase in dust and other pollutants in the air affect the temporary increase in deposition of these, on the structures of the Old Town.

During construction activities, the noise will inevitably increase, which could possibly decrease the number of tourists in the Old Town Vranduk during this period.

There will be a modification of space in terms of visual effects.

The proposed construction of roads for public communication over the dam, will significantly affect the natural environment and visual effects of the new facility - the dam, near the Architectural ensemble of the Old town Vranduk.

If any archaeological sites might discover during construction, which have so far not known, it is necessary to stop all work and notify the relevant services for the protection of cultural monuments.

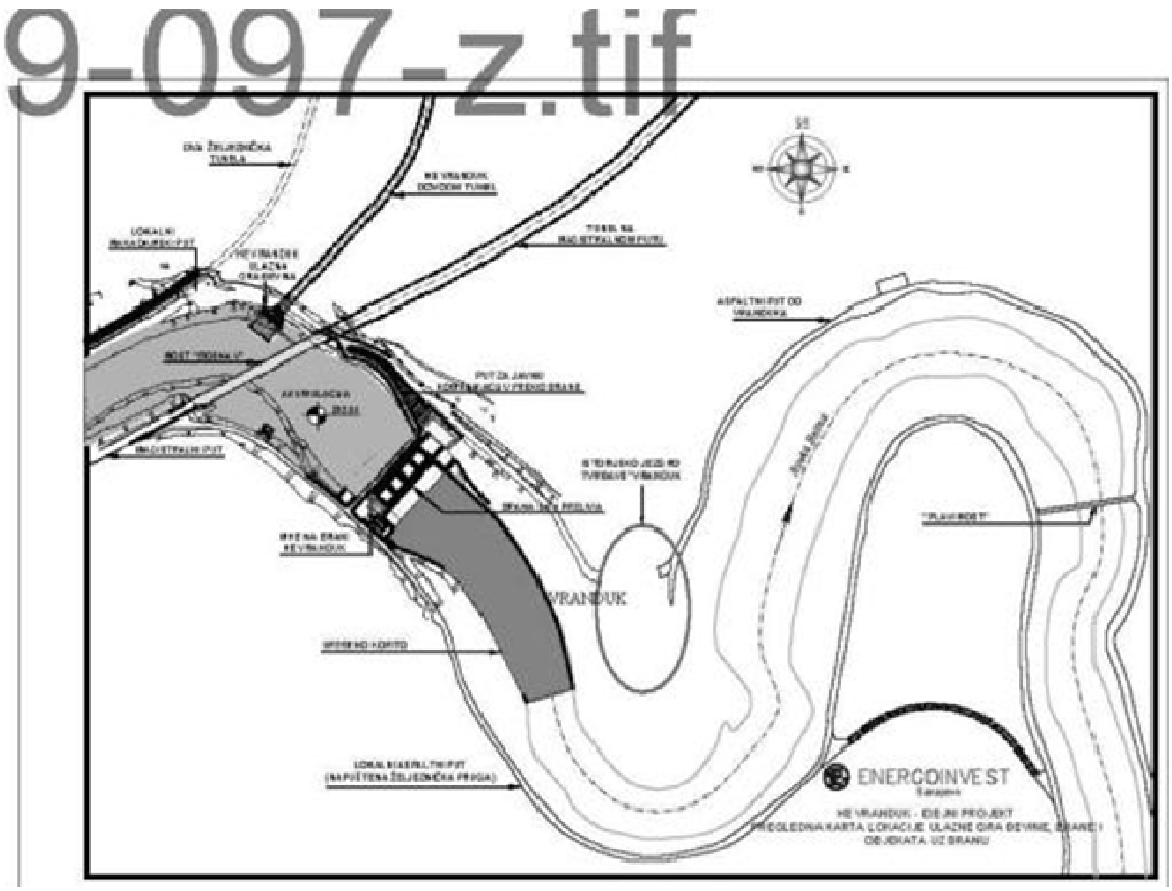


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Figure 42. View of the main elements of HPP Vranduk located near the Old town Vranduk : concrete dam, intake structure, headrace tunnel, way for public communication over the dam

During preparation of Environmental Impact Study for HPP Vranduk, the Preliminary Design, in part related to the dam, has been extended with the construction of the way for public communication over the dam, which, besides being an extension of the access road planned by the design, presents also a visual extension of the dam, because it is directly adjacent to it. Although the construction of the way for public communication has not been definitively confirmed, given the impact that it has in the environment, it is discussed in this part of the Study.

The way for public communication is planned to carry out next to the dam, the upstream side in the same altitude level with the access road and the upper dam elevation. Given the requirements for operation and control of dam safety, the way for public communication is physically separated from the dam (creating the console and separation with a fence). The way width is approximately 7 m. In order to connect the way for public communication with

the local road on the left bank, and due to height differences of each other, the construction of a retaining wall is planned with height of 15 m. [20]

Given the planned spatial disposition and location of facilities, as well as the position of the identified sites of cultural and historical heritage, it is concluded that, from the point of the protection of cultural and historical heritage, the most significant impact will have the dam building, access road and way for public communication over the dam, located in the proximity of the Old Town Vranduk (at a distance of approx. 400 m upstream).

3.1.10. IMPACT ON NOISE

On the site, due to the anticipated activities, the noise will arise from the transport means (trucks), machinery (loader, bulldozer, excavator, etc.). Occasional sources of noise (low-intensity - varies throughout the day) will occur during the operation of machinery on the site, and the loading and removal/ transport of materials required for civil works.

Since it is a heavy traffic and frequent area (proximity to the main road M-17 and railroad track) the impact on noise that will arise from machinery, from construction site of HPP Vranduk, will be negligible.

3.1.11. IMPACT ON EXISTING INFRASTRUCTURE

During construction of the facility HPP Vranduk and access road on the left bank, the impact on traffic is expected, in terms of the reorganization of traffic on local roads by diverting from the existing to other alternative roads, as well as to a possible temporary stopping the traffic on some shorter sections, particularly at the local road for settlements Hanove and Ljubetovo.

Construction of the dam HPP Vranduk is planned in two phases, so that under the protection of cofferdams in the first stage, two flow fields are performed along the left bank. The only possibility of access to the building pit of the first phase is from the local road on the left bank, and using the existing service road through the landfill. Given that this road has the function of berms and thus contributes to the stability of the "body" of the landfill, after the completion of the dam in accordance with the design, it remains physically, but has no practical function.

The variant with a bridge over the dam, i.e. with a public road through the weir crest, the road on the left bank would have also the same function. However, according to Impact Assessment, in the final solution of HPP Vranduk, the public communication through the dam should be excluded, and access to the site provided from the local road on the right bank.

[20] Detailed data on the designed way for public communication are not possible since the way was not provided during the Pre-Feasibility Study of HPP Vranduk, Sarajevo 2002. Collaborators on the study were informed verbally about the planned route, the aspect of protection of cultural and historical heritage, by the representative of investor and design engineer.

From the right side of the existing local road Ljubetovo-Zenica there is a double track line Sarajevo-Vrpolje and they are mutually separated by reinforced concrete supporting wall. Through the culvert under the railway there is a communication for Hanovi settlement. Due to the formation of the accumulation of the planned HPP Vranduk upstream of the dam profile there would be a submersion of part of this road, so it was done the preliminary design of its reconstruction. The axis of the considered section is in the fullest possible extent retained, and the reconstruction is most related to uplifting of the road grade line in order to ensure safety communications over the elevation of water level, which is formed in the accumulation on the occurrence of the century-old water Q1/100. Since it is intended to uplift the road grade line, in order to ensure also the safety of rail and road traffic, it is intended to raise the elevation of the crown of the existing retaining walls to the elevation GIS, i.e. setting up a single fence on the road shoulder along the railway line. The existing underpass (culvert) for Hanovi and other villages at higher elevations due to water level, which is formed in the accumulation on the occurrence of the century-old water Q1/100, closes, so that the construction of the local road for the above settlement is provided from the other side of the railway. Further, the local road is connected to the existing road Ljubetovo-Zenica, over the overpass above the entrance i.e. exit portals of the railway tunnels (whose normal cross section near traffic lanes includes unilaterally a footpath width of 1.00 m)

To facilitate implementation of HPP Vranduk according to the design and obtain the access to the plant facilities, construction of the following tranffic infrastructure is foreseen:

- construction of the access road: to the weir crest on the left bank at the length of app. 100 m, which is connected to the existing road towards Vranduk settlement,
- construction of the access road up to surge shaft on the left bank in the wider area of the power house location,
- construction of the new road to Hanovi settlement with length of app. 600 m, with a bridge over the railway line, 24 m of range,
- reconstruction of the existing local road Vranduk – Zenica at length of 4,3 km,
- reconstruction of the existing local road from the bridge „Bosna IV“ - Nemila at length of app. 1 km, from which the access to the power house is provided.

3.2. IDENTIFICATION OF IMPACTS DURING EXPLOITATION

3.2.1. IMPACT ON POPULATION

Implementation of the agreed project documentation with environmental protection measures, will ensure that the impacts of built structures of the hydropower plant are eligible for the local community. In the framework of realization of the Improvement Program of outer space, a cohabitation of the new facility with the environment will be provided in the vicinity of built facilities.

Due to the loss of the authentic condition and loads of space, this project is accompanied by various indemnifications to society and local communities, as well as fees for the use of energy resources, pursuant to the applicable legislation in the Federation of BiH and namely:

- employment opportunities, during the construction, of several hundred people, and during the facility operation, of permanent 20 people, as well as creating favorable conditions for faster economic development,
- Programs to improve the local area within the agreed obligations, which includes continuous collection and disposal of waste that causes the Bosna river on a built floating barrier and a grid at the intake structure,
- profit of local community non-recurring and annual at pr. revenue from income tax in the cantonal/municipal budget. Especially significant are the benefits of concessions and other benefits that are already regulated by rules of the Federation of BiH.

Potential income in this context, by the estimate would be as follows:

Concession compensation

Criteria and methodology for calculating the non-recurring and current concession compensations are determined by the provisions set forth in the Rules of establishing compensations for concessions (Official Gazette of FBiH, no. 67/06). The amount of non-recurring compensation in a procedure for granting concessions, can not be less than 1,5% of total investment.

- According to the preliminary financial budget of investment for HPP Vranduk, it would amount to at least 2,25 million KM. Also, the amount of current concession compensation may not be less than 1,5% of the amount set by the projected annual revenue. In the case of implementation of the planned project HPP Vranduk, current concession compensation would be approximately 140.000 KM annually.

According to the draft Law on Amendments to the Law on Concessions of the Federation of BiH, in May 2009, it proposes the allocation of concession compensations as follows:

- 60% municipality/municipalities
- 10% canton/cantons,

- 30% Federation of BiH

- According to this principle, a non-recurring compensation of at least 1,35 million KM would be Zenica municipality on whose territory is located the subject of concession i.e. in Zenica-Doboj Canton least 225.000 KM.
- The current concession compensation, in this context, belongs to the Zenica municipality in which the area will be HPP Vranduk, minimum 86.000 KM per year, i.e. Zenica-Doboj canton 14.000 KM per year.

Compensation for using hydro-accumulation facilities

By the Law on allocation and direction of the revenue part of the company generated using hydro-accumulation facilities (Official Gazette of FBiH, no. 44/02 and 57/09) it was determined the amount and method of allocation and direction of revenue part of the company generated using hydro-accumulation facilities constructed in the flooded areas in order to produce the electricity. This compensation currently amounts to 0,01KM per kWh of the produced electricity. The compensation is to be paid in the budget of the municipality or the city, on whose territory the hydro-accumulation facility is built. According to available data, we can estimate, that the compensation for the planned HPP Vranduk, would be approximately 964.000 KM per year.

Special water fees for electricity production

According to provisions of the Law on water (Official Gazette of FBiH, no. 70/06) the special water fees are to be paid for water use for electricity generation, obtained using the hydro power. This fee is calculated on the basis of generated electricity expressed in kWh. Water fees are distributed as follows:

- the competent agency 40%
- the budget of Canton 45 %
- Environmental Protection Fund 15%

According to the Decision on amount of special water fees (Official Gazette of FBiH, no. 46/07), the amount of special water fees for water use for electricity generation, is 0,001 KM per kWh of energy produced. In this context, approximately 43.000 km a year would be directed to the budget of Zenica - Doboj Canton, for the use of water for the planned HPP Vranduk. Summary of minimum fees under the applicable laws is given in Table 12.

Table 12. Minimum fees under the applicable laws

Fees	Municipality KM	Canton KM	Federation of BiH KM
Non-recurring concession	1.35 mil	225.000	675.000
Annual fees	1.05 mil	58.000	43. 000

3.2.2. IMPACT ON CLIMATE AND AIR

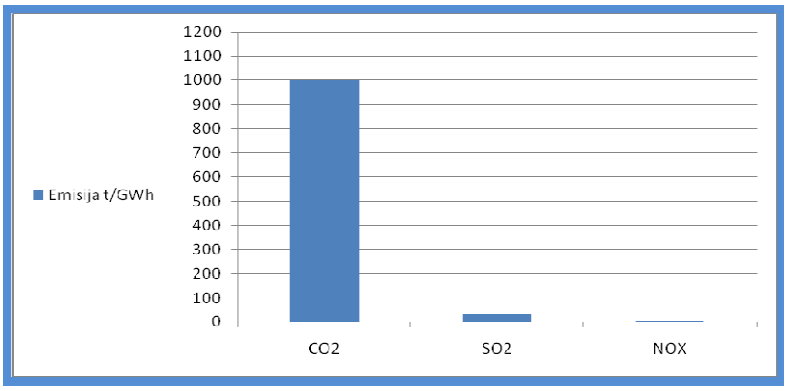
Total surface area of water in the accumulation will be only 1,6 million m^3, which is, for only 12%, the increase of water mass in relation to the existing amount of water. On this basis, it can be concluded that the speed of flow is only slightly reduced from time to time in the hydro-accumulation basin in Vranduk canyon. Therefore, we do not expect the occurrence of intense evaporation during the warmer months of the year.

On the other hand, in more intensive processes of evaporation, the so-called latent heat is also more intense used, which causes a mild decrease in air temperature in the vicinity of the hydro-accumulation, i.e. quickly reaching the temperature of the dewy point. It is important to emphasize that, in the area of closer accumulation environment, during the summer it is not expected to significantly intensify radiation and advection fogs, as well as a mild increase in the frequency and amount of local rainfall.

Colder part of the year, for similar reasons, will not be characterized by a significant increase in the number of days with fog and precipitation, but in a wider area of Vranduk canyon, in winter weather conditions, cloudy and precipitation weather can be occasionally developed.

Given that it is about the increase of water mass for only 12%, it can be concluded that there will not be an increase in humidity in the wider area of the hydro accumulation in Vranduk canyon, and the local climate will not be formed, which would increase the air humidity, intensity and frequency of radiation and advection fogs, lower air temperature.

Since HPP Vranduk is the project from the scope of the clean development mechanism (CDM) of the Kyoto Protocol, and that is based on the use of renewable energy sources, it indirectly impacts on reducing CO2 emissions and pollutants that are emitted into the air from thermal power plants. Below is an overview of the annual emissions of CO2, SO2 and NOx per GWh of electricity generated, for example in TPP Kakanj (Table 13).



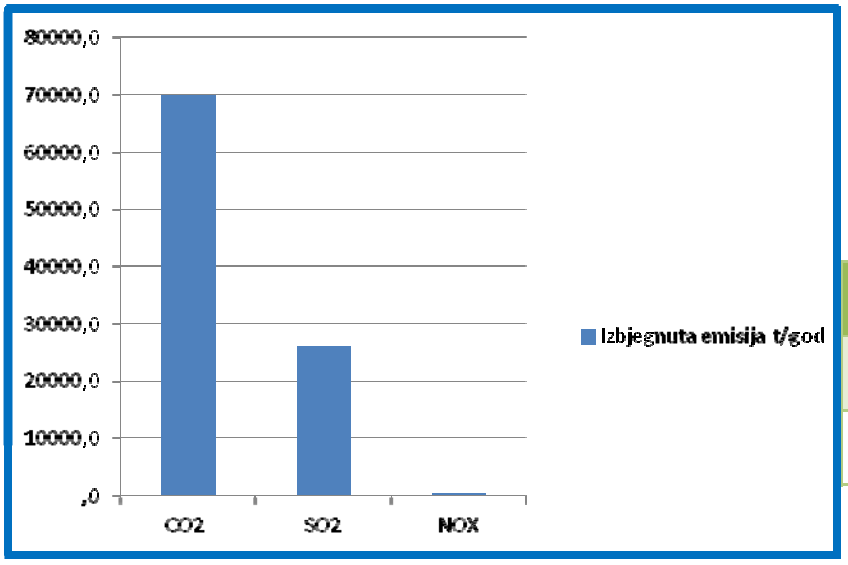
Pollutant, (t/GWh)		
CO_2	SO_2	NO_X
1.000	35	4

Annual emission per GWh

Table 13. Pollutant emissions per GWh of electricity generated in TPP Kakanj

In the case of electricity production in the planned hydro power plant Vranduk, installed power of 19,56 MW, with a possible annual production of 96,38 GWh, it is possible to estimate the amount of eliminated emission of pollutants into the air.

Table 14. shows the amount of emissions that will not be in the case of electricity production in HPP Vranduk



Pollutant, (t/year)		
CO_2	SO_2	NO_X
70.000	26.000	375

Table 14. Eliminated emission of pollutants into the air

3.2.3. IMPACT ON WATER

The total volume of the future hydro accumulation is $1{,}62 \times 10^6$ m^3, length of the accumulation is 5,8 km, and surface areas approximately 42 ha. Comparing the flow width, the accumulation is very small and can be considered as an expanded water stream of the Bosna river. The water slows down in a part of the accumulation, and by settling down it leads to alteration of the natural flow regime. Water quality downstream will be changed due to turbidity and concentration of dissolved oxygen, which is not considered as a harmful impact, but suitable for the development of some aquatic organisms in relation to the current status of water quality, HPP Vranduk and accumulation, will have no impact on water quality. Waste of local communities located upstream of HPP Vranduk, although it is not an obligation established by regulations for HPP Vranduk, because of safety of the plant and in order to maintain cleanliness and visual effects of the hydro accumulation, it will be collected in the zone of the accumulation on a grid and floating barrier. It shall be routinely collected and disposed of at the nearest waste landfill. This waste of different composition has an indirect impact on the quality of the Bosna river.

The morphology of the river bottom and banks of the Bosna river, will also be exposed to changes in water level and rate of sedimentation. The river carries a certain amount of sediment. After formation of the dam, most of the sediment will stay in the zone of accumulation. Deposition of sediment at the bottom of the accumulation will contribute to the purification of water from suspended particles.

Upstream oscillations are not expected. According to the Decision on the previous water permit, it will ensure that the downstream fluctuations are minimal.

3.2.4. IMPACT ON SOIL

Impact during the operation of HPP Vranduk on soil is not expected. To achieve the positive effect of cohabitation of new buildings with the natural landscape, it is important to regularly maintain recultivated surfaces according to Landscaping design of the built facilities.

3.2.5. IMPACT ON WASTE GENERATION

During the operation of HPP Vranduk, larger quantities of waste will be created in the overhaul period. Taking into account the fact that the repairs will be made rarely i.e. in accordance with the needs, we can say that the continuous creation of waste is in small quantities. Therefore, the collection, storage and transportation of waste will not be a problem. Accordance with the fact that the facility have a Waste Management Plan, which will include the collection, storage and transportation of waste, negative environmental impacts are not expected.

Figure 43. shows one example of waste, which usually accumulates along the dam

Figure 43. An example of waste accumulating in front of the dam

3.2.6. EXTERNAL IMPACTS ON FACILITIES OF HPP VRANDUK

Positive effects of the dam existence at this location will manifest in the reduction of floating waste down the Bosna river. Floating waste generated by local communities upstream, which causes the Bosna river, will accumulate on the grid and floating barrier, and will be disposed of so that it is transported by authorized companies. It should be noted that disposal of this waste is not a legal requirement for HPP Vranduk, but will be regularly implemented, as a compensation to the community and in order of safety of facilities, cleanliness, and visual effects of the hydro accumulation.

3.2.7. IMPACT ON FLORA AND FAUNA

Impacts during operation can be grouped into direct and indirect. Each of these changes have an impact on communities near the river banks.

The formation of the accumulation causes some changes of natural conditions and reduction of flooding zone. Many aquatic and terrestrial species can not adapt to these changes in flow regime and water level. Therefore, ecosystems are subjected to change of biodiversity i.e. reduction, because a small number of species can maintain high density in these areas.

If the accumulation zone, before the formation, has not been cleared of vegetation, organisms that decompose organic matter (decomposers) cause an increase in nutrients in the water for a very short time. Accordingly, the BOD (biological oxygen demand) in water rises and it comes to increasing concentrations of phytoplankton and the formation of green cover on the surface. It also comes to the development of macrophytes on the water surface, which may have consequences for wildlife in the accumulation, which is not also good for technical equipment. Area, which will be covered by the accumulation of HPP Vranduk, is small and will amount to 42 ha and due to the accumulation formation of 1.6

mil.m^3 there will be no significant loss of habitats of terrestrial flora and fauna. Since the construction of fish path is planned, there will be no interruption of natural migration routes for aquatic organisms. Also, there would not be significant impacts to the migratory paths of semi-aquatic and terrestrial animals.

According to the design solution of the accumulation, water temperature and distribution of dissolved oxygen in water will not be changed in a vertical column, which will not cause a qualitative and quantitative changes in aquatic flora and fauna.

3.2.8. IMPACT ON ICHTHYOFAUNA

Construction of the dam building will change the ecosystem. The creation of accumulation will transform the natural water flow in lake ecosystem type, where there will be minor or major changes in hydrological and ecological characteristics.

Upon completion of the hydropower plant and filling of the accumulation Vranduk, ecosystem will be significantly altered, which will have an impact on wildlife, primarily on fish. Therefore, the impact of hydropower plant during its operation must be separately considered on the part of the river bed upstream of the hydropower plant (accumulation) and part of the river bed downstream of the hydropower plant.

Fish migration from the lower to the upper river will be available by the fish path, which will be built within the dam.

River bottom, and the whole bank for a length of several hundred meters below the hydropower plant will be disrupted, which will affect the development of phyto and zoobenthos and lead to a disruption in the food chain of ichthyo population.

River water flow will slow down or stop, the depth of the water column will increase to a maximum of 9 m, which should not lead to a significant increase in water temperature. Sediments, arriving with the water course will settle in this region, and decompose and can affect the quality. Lower aquatic organisms that were typical for streams in this part of the watercourse will cede its place organisms that inhabit stagnant and slow flowing water. This will to some extent influence the formation of a new ichthyo population with some new species which corresponds to such habitat and diet typical for this habitat. The change ichthyo population is likely to be anthropological influence, and will lead to the introduction of new species in the accumulation of the fishermen, a process that happens in practice. Probably, there will be anthropological impacts on change of ichthyo population i.e. that will lead to the bringing of new species in the accumulation by fishermen, a process that happens in practice.

3.2.9. IMPACT ON CULTURAL AND HISTORICAL HERITAGE AND LANDSCAPE

The most direct impact of HPP during operation, is reflected in the changing cultural landscape/natural environment, characteristics and perception of Vranduk canyon. This impact can be considered as a degradation in the area, since this will lead to changes in the perception of the Old Town and its setting, as well as the overall perception of the cultural landscape/natural environment and its impact on visualization in the Old Town and from the Old Town in the surrounding neighborhood. Built dam structures contribute to the above effect: dam height of 16 m and length of 110 m[21] in the weir crest and the architectural design conditioned by operation technology and the proposed route for public communication through the dam. Additional increase of spatial dimensions of the dam includes also the construction of the retaining wall, expansion of existing road, construction of fences, etc., which will have an additional negative visual impact in the area. In the night time due to requirements for lighting of the dam and eventually the built way for public communication via the same, it will significantly impair the recognition and viewpoint of the entire area.

Construction of the proposed route for public communication through the dam, would enable the increased frequency of motor traffic to the Old Town on the upstream side of the existing access road, which would directly impact on the increase in noise and pollution, i.e. the scope of intervention in the area. If the access road on the left bank, which it plans to use during the construction of the dam, retains also during operation, it would have an additional visual effect of the load in the space. Besides the foregoing, the additional visual impact, especially in terms of changing vistas of the Old Town, will also have the formed accumulation.

Figure 44. Spatial representation of the bridge on the main road M17 and the designed dam – view from the Old Town Vranduk, visualization in the space made by Elektroprivreda BiH (without presentation of the access road and the way for public ccommunication)

Figure 45. View on the designed dam and The Old Town Vranduk – visualization in space made by Elektroprivreda BiH

(without presentation of the access road and the way for public ccommunication)

Figure 46. View on the Old Town Vranduk with the settlement, the Bosna river, the bridge on the main road M17 and the designed dam, visualization in space made by Elektroprivreda BiH

3.2.10. IMPACT ON LANDSCAPE

In the Bosna riverbed, downstream from the power house of the future HPP Vranduk, if necessary, a bank revetment will be made, which could change the aspect of the river bed and thus prevent the previous flooding of plots, but also change the natural aspect of the riverbed. Also, on the other hand, there will be elimination of waste from these sites, so the aspect of the present negative visual impact, will be eliminated.

3.2.11. IMPACT OF NOISE EMISSION AND VIBRATION

Source of noise and vibration during operation of HPP Vranduk is the turbine, which will be located inside the power house. Equipment in the power house is to be modern and meet the technical standards and requirements of local and EU legislation on the level of external noise. More significant levels of noise from this source are not expected, especially considering the fact that at the location there are significant sources of traffic noise on the main M17 road and rail traffic. Nearby the power house, there are no settlements, and the first house from the power house is located approximately 1,5 to 2 km, so there will not be noise impacts on residents.

3.2.12. IMPACT ON EXISTING INFRASTRUCTURE

More significant impacts on the existing infrastructure are not expected.

3.3. DESCRIPTION OF METHODS THAT THE AUTHOR OF THE STUDY (PROPONENT) PREDICTED FOR ENVIRONMENTAL IMPACT ASSESSMENT

Environmental Impact Study of HPP Vranduk was made on the basis of the Conclusion on the development of the Environmental Impact Study number UPI-05-23-209/09 FM dated 09.07.2009 issued by the Federal Ministry of Environment and Tourism. The content of the study is conformed with the above decision.

During development of the Environmental Impact Study, an analysis has been made:

- in terms of building the HPP (site organization, the location of machines, effects of machines operation, manipulation with construction materials, borrow pits and disposal sites, etc.),
- in terms of traffic (to prevent effects of noise, polluted air and water) and
- in terms of management and maintenance of HPP (impact monitoring)

Environmental Impact Study was done parallelly with:

- experts to ensure the quality of water, air and soil, biodiversity, cultural heritage, landscape, etc.
- design engineers (including geologists, seismologists, hydrologists).

During the Study preparation, a regular contact was maintained with the Engineer of the Preliminary Design HPP Vranduk and the client. During preparation of the Environmental Impact Study HPP Vranduk, the Engineer's opinions are taken into account, as well as suggestions and professional experience of the Investor (Department of Environmental Management) about the impacts of hydropower facilities on the environment (action plans and environmental permits for existing hydro power plants).

The methodological approach to the Environmental Impact Study is based on an analysis of available documentation, researches of relevant information, legislation, planning and project documentation, as well as field observations and focus on the characteristics of the location.

Considerations, analysis and assessment are dedicated to the current situation in order to identify possible environmental impact assessment of potential risks. From basic identified potential impacts, some impacts are analyzed in detail, which are important in specific spatial conditions to fit HPP Vranduk. On the basis of impact assessment, their classification was performed by importance, and some measures were proposed for prevention, mitigation and protection of the environment and landscape values. Also, based on the valorisation of impacts, a system to monitor impacts on the environment is also suggested.

Generally used methods are the methods of comparison, calculations, modeling for the individual environmental components.

3.4. EVALUATION OF RESULTS OF THE PROJECT IMPACT ASSESSMENT ON ENVIRONMENT

Evaluation and Project Impact Assessment, according to the possible emergence and persistence, will be done in two stages and classified in:

- impacts during construction of hydropower plant components and
- impacts during operation of the hydropower plant Vranduk.

Evaluation is based on available data on the current state of the environment, technical information and suggestions in the Preliminary design and multidisciplinary assessment of all environmental and developmental effects of the underlying project, taking into account the regulations and conditions, and sectorial interests in a focused area. The primary consideration was the possibility of cohabitation of the Project with the second zone of protection of National cultural monument "Architectural ensemble of the Old Town Vranduk", i.e. not to destroy the basic values and cultural heritage. Also, it has been considered the natural characteristics and values of the Bosna river ecosystem and acceptability of the project compared to the same. After evaluating the consequences for local environment, some advantages, positive effects and the overall justification for Project implementation were considered.

Changing the traditional landscape certainly has effects on the quality of life and local people often emotionally survives changes in the natural environment, even if the new hydropower capacity with a hydro accumulation does not make a significant damage in the area. With modern techniques and technology, with mitigation measures of negative impacts on environment, cultural and environmental values, it is possible to bring the Project to the environmental acceptability and adaptation of the population and the "nature" into the new equivalent and multi-functional condition. Changes in the aesthetic and visual sense can be compensated with the improvement of the area and more dominant presentation of the architectural ensamble of the Old Town Vranduk, according to the approved Planning Design, equitable indemnification of the population that will be directly affected by the Project, and balancing the general-social benefits and damage.

3.5. CLASSIFICATION OF THE ESTIMATED POTENTIAL IMPACTS / EFFECTS OF THE PLANNED HPP VRANDUK BY THE IMPORTANCE

After the identification of possible environmental impacts, primarily on the lower part of the Bosna river catchment, it has been estimated the negative and positive impacts of the Project, and proposed the environmental protection measures. It has been also assessed the socio - economic and environmental justification for the planned construction of the hydropower facility.

3.6. POTENTIAL NEGATIVE IMPACTS / EFFECTS ON THE ENVIRONMENT

Possible estimated negative impacts / effects of the construction of HPP Vranduk are:

- transforming the stream ecosystem in the ecosystem of lake type, at length of 5,8 km,
- changes in the landscape/natural environment in the second zone of protection of national cultural monument "Architectural ensemble of the Old Town Vranduk",
- characteristics and perceptions of Vranduk canyon, views from the "Architectural ensemble of the Old Town Vranduk",
- relocation of a household - 1 house is to be demolished,
- loss of land areas- the total land area, which will be redeemed, is 84. 434 m^2,
- loss of indigenous habitats of flora and fauna in the zone of accumulation and colonization of new species,
- disturbance of ecological balance, the number of species and the natural migration routes for aquatic and semiaquatic organisms, on the part of the Bosna river catchment, where the dam and accumulation of HPP Vranduk are situated,
- disturbance of self-cleaning mechanism – the self-cleaning will be disrupted in the accumulation area, while it will increase in the downstream part,
- there will be minimal fluctuations downstream of the hydropower plant,
- impact on quality of air, water and land during construction of facilities, which is temporary,
- changes in the natural riverbed below, with the planned deepening at the length of max 2,5 km by conic from the power house, where the initial depth is 2,91 m,
- the possible occurrence of erosion processes, which, before the commencement of the works can not assess with certainty,
- regulation of sediments and deposition of sediments in the zone of accumulation,
- relocation of the local road and creating a new road with a length of 600 m,
- reconstruction of the local roads, total app. 5,3 km
- flow in this part of the river will be regulated by environmentally acceptable flow, which will guarantee the maintenance of ecological balance of the downstream part of the Bosna river.

3.7. POSITIVE IMPACTS /EFFECTS ON THE ENVIRONMENT

In addition to development - economic significance, the construction of HPP Vranduk will follow the typical potential positive impacts / effects:

- production of hydro - energy, i.e. "green energy" in the territory of Zenica - Doboj Canton, and the reduction of pollutants in the electrical power production,
- construction of facilities within the clean development mechanism - "Green kWh“, i.e. contribution to reducing greenhouse gas emissions, approximately 70.000 t of CO_2/year,

- physical integrity and security of facilities in the protection zone I "Architectural ensemble of the Old Town Vranduk" will be preserved
- implementation of the Planning Programme and additional presentations of the National Monument,
- cohabitation of the new building with landscape characteristics of the protection zone II "Architectural ensemble of the Old Town Vranduk",
- hydro accumulation are formed in the riverbed, with expansion of 12% only,
- construction of a fish path, which will alleviate the disruption of ecological balance and ensure the migration of aquatic and semi aquatic organisms,
- fair compensation for the submersion of material goods, removal of only one family, i.e. demolition of 1 house,
- submersion of only 0,20 ha of arable land,
- collecting and cleaning of the Bosna river of floating waste, which will accumulate in front of the dam and intake grilles. The Bosna river is evident loaded with waste that people throw along the entire river catchment,
- the possibility of water supply for irrigation in the region,
- the chosen location of the plant is good for the organization of civil works, transport and installation of equipment,
- tourism development and more aspects of recreation and sports activities in the area of the planned hydro accumulation, eg, recreational sailing, fishing, etc.,
- minimal changes in microclimatic conditions, may be suitable for the development of some plant and animal communities,
- local economic significance and the establishment of small business activities,
- employment of local people – in the period of construction of similar facilities, practice shows that the number of people engaged is moving up to several hundred. Planned civil works would indicate the significant increase of employment, if some domicile companies and labor would be preferred,
- increased value of property in the vicinity of the hydro accumulation,
- in addition, some other measures to compensate the society for the loss of authentic conditions in that part of the Bosna river catchment,
- programs to improve the areas affected by the Project - Investments in consultation with local community.

After evaluating the positive and negative effects, i.e. real losses and benefits of the Project, taking into account the indicators of listed fees and compensations to the local community which the project implementation provides, according to applicable regulations of the Federation of BiH, it can be concluded that the planned projects in the Bosna river catchment is environmentally acceptable and socially justified.

With the application of protection measures and realization of the Project to improve the condition and presentation of the national cultural and historical monument "Architectural ensemble of the Old Town Vranduk", it should accept cohabitation of a new building with a cultural landscape.

Objective measures to protect the values of material goods are essential to assess the project as a techno-economically and environmentally justified, because during the construction works and during operation of the planned power facility, the sustainable development principles will be met and the project will have attributes of the friendly development project.

4. DESCRIPTION OF MEASURES TO MITIGATE THE NEGATIVE EFFECTS ON THE ENVIRONMENT

4.1. MITIGATION MEASURES DURING CONSTRUCTION PERIOD

4.1.1. POPULATION

For all construction machinery and vehicles used in the construction of hydro power plant, be sure to install sound protection/insulation of the engine and other components that produce or contribute to the development of noise. Also, the exhaust pipes of all machinery and vehicles with diesel engines should have filters for the separation of soot. By regular (periodic planned) and emergency technical inspection of machinery and vehicles it should ensure maximum safety and functionality of the system of motor fuel combustion. It is necessary to use a fuel of guaranteed standard quality. Dust, which is a regular companion on temporary construction site roads, to prevent by occasional wetting-spraying pavement and operational areas.

In the case of blasting for excavations in the rock massif, to select the type of explosive that has the least adverse impacts to the environment; apply the techniques of mili-second activation of mine charge with action-oriented explosion, in order to reduce the effect of superposition of dynamic impacts (vibration, seismic), noise and dust emissions. Alternatively use the technique of excavation using hydraulic hammers or mechanical excavation by milling, 'moles' and the like.

It is necessary to build a "deviation" of the existing or build new traffic infrastructure that meets the needs and habits of the local population. It should set an adequate signalization for the site zone and prevent the population, during the execution of works, for their own purposes, enters and uses the site zone, because it is a danger to residents and contractors.

Zones of construction site and access roads should be promptly marked with: traffic signs, fences and straps, warning boards, light signals, if necessary, install a service of traffic control (alternating by-passing of traffic flow by directions). This should be in accordance with the Regulation on the site organization, compulsory documentation on site and participants in construction works.

Within the Study on land acquisition to determine the real facts and investment program for fair compensation. Before performing works, within the Projects of Construction Management, to plan the construction, maintenance of alternative crossings/passages for the local population.

The workers' village is to be described through the design of site organization.

4.1.2. AIR - CLIMATE

Based on the presented indicators of climatic and other characteristics of the wider area of Vranduk canyon, basic measures can be proposed for mitigation and prevention of potentially negative impacts of civil works during the construction of facilities HPP Vranduk:

- mitigation of dust emissions can be substantially achieved by using modern construction techniques,
- dust, which is a regular companion on temporary construction site roads, is necessary to prevent by occasional wetting-spraying pavement and operational areas,
- suppress the spread of dust outside the access roads and on the roads to be used by construction machinery with periodic wetting and spraying pavement surfaces. If necessary, before exit of the mechanization to the main road, depending on the dirtiness of wheels, to make cleaning them,
- wherever possible avoid the use of explosives during the construction of dam foundations, construction of headrace tunnel and deepening the river bed downstream from the power house and the grout curtain of the dam, auxiliary tunnels and part of the riverbed at the expense of application of modern construction equipment which produces much less dust, noise and waste rock material,
- in case of blasting, it should select the type of explosives and methods (eg. split method) that have the least adverse impacts on air quality,
- provision of spraying pump and splashing with water the site area, especially during the dry season of work in the area of earth excavation,
- carry out the production of concrete in the area outside the hydropower plant site, especially the location of the dam, which is near the Architectural ensemble of the Old Town Vranduk,
- carry out civil works in site zone and avoid the devastation of the environment, vegetation and soil outside the zone,
- it is necessary that all the machinery involved in construction is correct, with the declared emissions of pollutants and modern engines, by which the impact of exhaust gases will be reduced to a minimum. It is necessary that the supervisory authority at the site regularly controls the above.

4.1.3. WATER – ECOSYSTEM OF THE BOSNA RIVER

Within the Construction Management Plan, it is important to prevent backfilling of the riverbed with any waste material, and ensure waste management in accordance with the Waste Management Plan during construction. All wastewater from the site to collect and manage in accordance with the Construction Management Plan.

In all phases of construction works, to ensure a continuous water flow by the Bosna river, and migration of aquatic organisms. Also, during construction works, it is necessary to take the following measures:

- if the process of blasting is undertaken, the same can not disturb the groundwater,
- avoid temporary disposal of waste materials in the riverbed and along the banks of watercourse,
- to protect areas sensitive to erosion by means of stabilization that will prevent erosion and backfilling of the riverbed,
- prior to filling the hydro accumulation, it is necessary to completely clean the riverbed from the existing vegetation and up to the spatial coverage on the banks with the maximum elevation of backwater,
- at the end of construction works on dam, i.e. after destruction of the cofferdam, all remains of building materials are to be cleaned up to the bottom of the riverbed,
- in the case of accidental outpouring of oil and fuel from construction machinery, the performer of civil works is obliged to take measures to prevent the spread of such materials in the watercourse, i.e. to comply with the Operational Plan for the emergency pollution in waters and water bank land;
- take other measures as specified within the Decision on prior water permit.

4.1.4. PROTECTION OF STRUCTURES AGAINST EXTERNAL INFLUENCES

Accordance with the fact that the Bosna river is burdened by municipal and other waste, it is necessary to install a floating barrier at which the waste would be accumulated, and which causes the river. It is therefore necessary to set the grid in front of intake.

4.1.5. SOIL – WASTE

In accordance with the Regulation on site organization, in the mandatory documentation at the site and to the participants in construction works, it should be defined:

- organization of the landfill for construction waste (according to the type of material),
- storage of hazardous and noxious substances, in accordance with the regulations that govern it,

- Waste, which can be recycled and reused should be collected, and the only waste that cannot be used in the above manner shall be disposed at an appropriate landfill. Collecting and taking waste to its final disposal should be submitted to the authorized organization. Give wood material to the inhabitants for use as fuel and the excess biomass can be directed to composting. Waste that is not recycled must take to the appropriate landfill.
- If there is any spilling of oil or fuel from the working machines to the ground, with oily soil as hazardous waste should be treated in accordance with the regulations governing this domain and the Operational Plan for mergency pollution in waters and river bank soil (in this case, the contaminated soil will be disposed of as a waste under a code in the Rulebook 17 05 05* - earth excavated by dredger that contains hazardous substances),
- upon completion of civil works, all construction sites should be cleaned and rehabilitated to environmentally and spatially acceptable levels.

Attached to this Environmental Impact Study, there is a framework Waste Management Plan (Attachment 3) during construction and during operation period of HPP Vranduk. This Plan should be updated after the commencement and during construction pursuant to an objective indicators of the possible and the generated waste. Records and periodic reports on waste management should be taken during the works.

Waste Management Plan during the operation of HPP Vranduk will be a required document of the general act on maintenance, use and monitoring of water facilities and Environmental Management Plan, which will be regularly updated. Annual report on waste management, i.e. report on environmental protection should be regularly made.

To manage waste generated in the future HPP Vranduk, pursuant to statutory obligation, a responsible person will be appointed.

4.1.6. FLORA AND FAUNA

During the construction of the hydropower plant, it is necessary to remove existing vegetation from the site of facilities. Prior to the formation and filling of the accumulation, it shall be cleared of vegetation, because it is essential to avoid decay and loss of oxygen in the future accumulation.

4.1.7. ICHTHYOFAUNA

During and at completion of construction of the hydropower plant by proper management on the site, detrimental impact on the ichthyofauna can be greatly reduced. In particular it should take the following:

- The location of facilities for the stay of personnel and facilities to place construction equipment and temporary disposal of waste and waste water should be a maximum away from the riverbed and should prevent to get at the river,

- To prevent water turbidity, it is necessary that the use and movement of construction machinery and tools by the river bed is only in an emergency,
- Before the construction of facilities for HPP in order to reduce damage to fish stocks, it is necessary to catch fish in a length of 1 km downstream from the site and the entire population is to be evenly distributed at various locations upstream from the site. Fishing is to be carried out by fishnets and generator,
- According to the Project that includes the construction of fish path, during the dam construction to ensure the smooth propagation of fish, protection of fish stocks and fish migration,
- On the water intake it should install devices to prevent fish entering the tunnel (adequate grid)[21],
- In the event of damage to fish stocks, it should make the Program of rehabilitation and equitable compensation to the user of fishing rights over fishing areas, according to the damage compensation price list in fisheries.

4.1.8. CULTURAL AND HISTORICAL HERITAGE AND LANDSCAPE

It is necessary to take measures to protect cultural and historic heritage and archaeological sites, or any new findings, which implies:

- Stop all works and notify the appropriate authorities for the protection of heritage, if, during operations, any archaeological sites or artifacts were found, which until now are not known or explored,
- In case of discovery of archaeological finds, it is necessary that the appropriate authorities for protection of cultural and historical heritage manage or under its supervision, implement the process of research and documenting the site. Depending on the nature of findings, opportunities and methods for its protection and preservation will be determined by applying the following measures:
    - conservation of findings by re-backfilling,
    - transfer of findings,
    - relocation of a part of the findings with the conservation of the remaining part of the site by re-filling,
- Using quality site organization, with the systematic waste disposal, using modern construction technology and machinery, with preventative measures and good construction practices can mitigate the overall negative impacts on cultural and historical heritage and the landscape during the construction of facilities,

[21] Freshwater Fisheries Act of FBiH (Official Gazette of FBiH, 64/04)

- Already in the Preliminary design, it should take into account the possibility of construction of related content of HPP Vranduk, which includes: access roads, the proposed route for public communication through the dam, any parking, etc.
- Also, it is necessary to take care of visual communication (signposting and information signs) and the illumination of dams and roads, to ensure proper presentation of heritage, visual alignment of structures with the surrounding cultural landscape,
- If possible, it should avoid the construction of communication over the dam, which will contribute to mitigating the negative visual effects and reducing the traffic load in the area of Architectural ensemble Vranduk
- During the construction and use of the access road (road on the left bank of the river is necessary for the construction of the dam) strictly take into account to avoid irreversible changes to the existing slope (changes in inclination, an extension that would later be impossible to completely repair, etc) and damages to the existing road for the settlement.
- During development of the Landscape Design, it should pay special attention to the proper presentation of the heritage, visual alignment of newly built structures with the surrounding cultural landscape, as well as ensuring safety belts-plantations or protective structures which will be reduced vibration of the soil and possible changes in groundwater flow, which indirectly have an impact on the monument.
- Reduction of negative impacts of HPP Vranduk plant construction on heritage should be provided in accordance with the Landscape Design. It should be noted that the Landscape Design of outer space must be an integral part of the Main Design of HPP Vranduk.

Reccomendation for development of the Landscape Design for HPP Vranduk:

- Measures to protect landscape (reconstruction, rehabilitation, restoration, etc.) should be chosen in a way that will not undermine the basic character of the cultural and historical heritage and the associated landscape, and they should be in details elaborated in the framework of the Landscape Design. Having in mind that the direct impacts and results of building such a plant, in a given area, are substantial and irreversible, it is recommended that, after the construction of the dam, the access road on the left bank, used during the construction of the dam, should try to repair completely i.e. adjust the space as much as possible to the surrounding environment.
- The visual treatment of the built structures through the possible change of materialization and the possibility of greening the retaining wall space, access sequences of the facilities, color treatment of built structures and similar are measures to mitigate negative effects, but not complete reduction in this context. When selecting the approach to final materialization of visible dam structures, it is

necessary to strictly take into account the use of colors and elements in a given area, and try to bring the entire area treated by construction to a state similar to the natural ambient condition.

- It is recommended the greening of the dam structures as much as possible and how the functionality of the facility allows (the supporting structures, parts of the dam along the river bank)
- The dominant use of stone lining is not recommended on structures along the river bank or those inclined slopes. In nature, these coverings are covered with vegetation or no vegetation or with less visible stone parts of the micro locations
- Given that the dam is a contemporary intervention in the area, for finishing the dam, it is recommended to leave a visible concrete because the stone flooring, as the dominant final materialization, is not a material that is prevalent in natural surroundings, and thus could degrade the structure of the Old Town
- For the materialization of fences on the dam, it is recommended to use transparent materials, to lessen the negative visual impact, and as much as possible, enable the views on the Old Town.

It is recommended that the investor, while preparing the necessary project documentation for building permits for the preparatory works, in accordance with Article 47. and 48. Paragraph 6 of the Law on spatial planning and land use of the Federation of BiH (Official Gazette of FBiH no. 2/06) engages a design office certified by the Federal Ministry of Spatial Planning for work on buildings and heritage sites, which will make the documentation - Study on the heritage protection[22]. When creating documents - Study, the current state of the Old Town will be taken into account, all the possible physical impacts on it (possible movement of groundwater, stability of the massif on which the Old Town is located, etc.) as well as planned facilities (access road, a way for public communication, a dam) and the possibility of their placement on the scheduled location. In this way, it will be possible to give detailed and specific recommendations for the architectural design of HPP Vranduk, as its aim to better fit into the existing environment of the National Monument.

[22] Due to the absence or unavailability of required data in the preparation of the Study part relating to the heritage such as: the results of previous studies on soil stability (whether works on the construction of HPP influence on the stability of massive on which the Old Town was built) and information on the existence and movement of groundwater, which will be done after obtaining a zoning approval, pursuant to Article 62. Of the Law on spatial planning and land use of the Federation of BiH (Official Gazette of FBiH no. 2/06), it should draw up (whether they will affect the Old Town, its environment), documents - Study on the protection of heritage. For this, it should hire a company certified for that type of work and approved by competent authorities for the protection of heritage. Study, depending on the location of the HPP Vranduk in the zone II of the National Monument, is a binding document for the issuance of building permits for the preparatory works. The Study would eventually propose to and require from the designers a correction of certain parts of the roads, give detailed instructions for making retaining walls, fences, fitting of parking spaces and fencing of HPP into the environment, etc, or make specific and detailed measures (plans with a timeframe) for: monitoring the Old Town, the presence of conservators and archaeologists during construction works and during the operation of HPP plant.

4.1.9. NOISE AND VIBRATIONS

- In case of the blasting process for excavation in rock massifs, hire a competent company that will guarantee safety for the cultural and historical heritage, acceptable noise and vibration for residents, as well as acceptable noise for wildlife and the environment in general
- If possible, use excavation technique using hydraulic hammers or mechanical excavation by milling, "moles" and the like,
- Machinery that will be used for construction, and equipment that will be installed in buildings of HPP Vranduk should be in accordance with the technical standards for protection against noise and vibration.

4.1.10. INFRASTRUCTURE

- In areas of collision with existing roads of higher level: main roads and railway tracks (double track line, electrified), perform the necessary temporary protective structures that will separate the roads from the construction work zones;
- Implement all the required traffic signalization and if necessary to ensure traffic police patrols;
- Finding an alternative route or by road construction it is necessary to enable a seamless communication to the inhabitants of surrounding villages;
- If there is a collision with existing installations of electricity (power lines) in the previous works to displace lines; i.e. by technical measures to separate / protect / isolate the lines. Take these measures in accordance with the sector approvals.

4.2. MITIGATION MEASURES DURING OPERATION PERIOD

4.2.1. POPULATION

Taking into account that the impacts during operation of HPP Vranduk are positive on population, mitigation measures are not required to take.

4.2.2. CLIMATE

Concerning the above meteorological impacts that the hydro accumulation achieves during the phase of its operation, taking into account the fact that it is a power plant of run-of-river type and with increasing the surface area of water mass for only 12% (42ha) in relation to the current state (36,7 ha), we can conclude that there are no significant impacts that may arise during the exploitation of the hydro accumulation.

However, it would be particularly important that some significant technogenic changes in the environment are not made during the period of exploitation. It would be appropriate to bring the entire proximate area around the hydro accumulation in the state as similar ambient condition before the construction of the hydro accumulation, which its potential negative impacts would be reduced to a minimum.

4.2.3. WATER – BOSNA RIVER

- It should engage a competent firm that will collect, if necessary, transport waste and properly dispose of it, and all in order to reduce accumulation of waste in front of the floating barrier and the grille on water intake in the hydro accumulation,
- In accordance with the Regulations on the minimum content of general act on the maintenance, use and monitoring of water facilities (Official Gazette of FBiH, no. 18/07) make a general act, which is the basis for the Water permit. The realization of water protection measures and Operational plan for emergency pollution in waters and river bank soil regularly to implement and update.
- Potential and other measures to protect water and ecosystem of the Bosna river are to be carried out in accordance with the Water permit for HPP Vranduk.

4.2.4. FLORA AND FAUNA

- Mitigation of negative effects that may arise as a result of sedimentation in the accumulation, and a possible reduction in the capacity of storing water, includes the maintenance of the newly created ecological balance of the hydro accumulations. If there is a higher phytoplankton and zooplankton to take measures to remove them.
- Measures to mitigate the proliferation of aquatic weed species in the accumulation area should be used because they may pose a significant problem. The measures include the removal of woody vegetation from the accumulation and river bank area, which will contribute to the reduction of nutrients.

4.2.5. ICHTHYOFAUNA

- Built-in devices to prevent entry of fish on the water intake should be regularly maintained.
- Regularly maintain and clean the fish passage routes.
- In case of incidents related to HPP Vranduk, rehabilitation measures should be taken and the damages caused to fish stocks should be evaluated, to make a Program of rehabilitation and equitable compensation to the user of the fishing rights over fishing areas.

4.2.6. CULTURAL AND HISTORICAL HERITAGE AND LANDSCAPE

Measures to mitigate effects during operation of the plant are as follows:

- establish the necessary (minimum) lighting of the access road, possibly built-in way for public communication, dam and other facilities of HPP Vranduk;
- ensuring adequate presentation of the several sites of the Old Town or the entire cultural landscape, which until now has not been done or has not been provided by existing development projects.

The investor, as a compensation to the community, during operation and in a manner determined by the institutions responsible for implementing the Decision of the Commission to Preserve National Monuments BiH, could participate in the efforts to protect the Architectural ensemble of Vranduk identified in the Decision of the Commission to designate the Architectural ensemble Vranduk as a national monument, No. 05.2-2-274/04-4 dated 25 January 2005, published in „Official Gazette of BiH 16/06".

Accordingly, during the operation of the plant, it should provide project development and implementation of the Design of illumination and Design of routine maintenance of the Old Town Vranduk. Design of routine maintenance of the Old Town Vranduk should be made by an authorized design engineer. The design, among other things, should include regular cleaning of the town's structures from sediments of contaminated air particles, and regular monitoring and timely remediation of any cracks in the structures of the town and/or modification of the connective or structural elements (the period when it should perform regular cleaning and monitoring will be defined by the design). Both of these designs must be approved by the competent institutions for heritage protection. All works can also be performed under regular supervision of the institutions responsible for heritage protection.

5. DRAFT OF BASIC ALTERNATIVES

Conceptual solution that was discussed and selected, is the best alternative from the techno-economic and environmental aspects. With HPP Vranduk project, it departed from the variants that had a significant negative impact on the environment. In the process of design, attention was paid to avoid large failures for the population living space, the quality of the Bosna river ecosystem and the entire environment. The cohabitation of project implementation and characteristic values of the space were taken into account. Special attention is devoted to protecting the integrity and safety of the protection zone I of the Architectural ensemble Vranduk.

Bosna river catchment since 1967 has been studied in terms of hydropower use in the "Basic hydropower solutions of the Bosna river catchment" (Energoinvest, Sarajevo, 1967).

During the war 1992-1995, a study was made titled „Prospecting of hydropower solution of the Bosna river catchment“ (Zavod za vodoprivredu, Sarajevo, 1994.) For the main course of the Bosna river, a total of 36 steps is planned with a total annual electricity production of 2263 GWh. HPP Vranduk is a hydropower plant of importance for the power system of BiH.

In 2001, a study was made titled „HPP Vranduk – Background documentation for development of concession study“. The main objective was to consider alternative solutions of hydropower use of the stretch Zenica-Nemila. Three variants were analyzed and with one or two steps, i.e. one derivation plant. After comparing all the relevant parameters for further elaboration, it is proposed a derivation plant that was the best solution for the utilization of hydro potential on this stretch of the Bosna river.

During the project elaboration, several alternatives have been discussed after which it has been selected a technically and economically justified and environmentally acceptable solution. We reviewed the following alternatives:

- without project
- an alternative solution - Variant S, HPP 1 and HPP 2 (site for construction of hydropower facilities and formation of accumulations)
- an alternative for construction of the Variant V – HPP 4 (site for construction of hydropower facility and formation of the accumulation)
- an alernative solution - Variant D – HPP 3 (site for construction of hydropower facility and formation of the accumulation with specified location for dam construction and formation of smaller accumulation and locations for construction of derivation tunnel and power house

5.1. ALTERNATIVE NO PROJECT

If we evaluate the positive effects of the Project implementation, the alternative "no project" would be less justified in terms of sustainable energy sector development and overall development of the Federation of Bosnia and Herzegovina. There would be no intervention in the space and the environment would remain unchanged, but the orientation towards the use of renewable energy sources available in BiH would not happen.

5.2. ALTERNATIVE SOLUTION – VARIANT S - HPP 1 AND HPP 2

According to the variant HPP 1 (moveable dam) at the location downstream from the bridge Bosna 4 on the M 17 road with backwater elevation at 282 m a.s.l. and HPP 2 (moveable dam) at the location upstream from the bridge Bosna 5 with backwater elevation at 293,5 m a.s.l., as well as the formation of the accumulation in the context of environmental impact and techno-economical justifiability is analysed in Table 15.

5.3. ALTERNATIVE SOLUTION – VARIANT V – HPP 4

An alternative solution - Variant V HPP 4 with movable dam at the location upstream from the bridge Bosna 4 and with the backwater elevation 292 m a.s.l. and the formation of the accumulation is analyzed in Table 15 in terms of environmental protection and energy use and potential external costs - compensation costs

5.4. ALTERNATIVE SOLUTION - VARIANT D

An alternative solution - Variant D (derivation plant) – a dam at the location upstream from the bridge Bosna 5, power house at the location downstream from the bridge Bosna 4 on the road M 17 with backwater elevation 293,5 m a.s.l. , as well as the formation of the smaller accumulation is selected as a design solution and also environmental impacts and techno-economical justifiability are analyzed and compared with other alternative solutions in Table 15. (Appendix 4.)

Table 15. Comparison of considered alternatives [23]

Impact on:	Alternative „no project“	Alternative solution - Variant S	Alternative solution – Variant V	Alternative solution – Variant D
Submersion of surfaces by accumulation basins at elevation of normal backwater	No changes	54,46 ha + 38,05 ha	92,97 ha	42.56 ha
Permanent inundation of arable land	No changes	2,77 ha	30,70 ha	0,20 ha
Long-term changes in the ecosystem of the Bosna river	No changes	Evident changes	Formation of larger accumulation and major changes	Formation of small accumulation with evident and environmentally friendly changes
The loss of flora	No changes	2,77 ha of trees, shrubs and grass will be destroyed	Approximately 30,70 ha of trees, shrubs and grass will be destroyed	Approximately 0,20 ha of trees, shrubs and grass will be destroyed

[23] The data in Table 15 are taken from the Pre-Feasibility Study for the HPP Vranduk - Energoinvest Energoinženjering-Higra, Sarajevo, 2002. and amended on the basis of Previous environmental impact assessment for HPP Vranduk and identified impacts in the Environmental Impact Study

Impact on:	Alternative „no project“	Alternative solution - Variant S	Alternative solution – Variant V	Alternative solution – Variant D
Fauna	No changes	Possible loss of habitats of fauna that inhabits the land that will be submerged	Possible loss of habitats of fauna that inhabits the land that will be submerged	Possible loss of habitats of fauna that inhabits the land that will be submerged
Ichthyofauna	No changes	Significant migration of indigenous fish species from the hydro accumulation and potential colonization of new fish species	Significant migration of indigenous fish species from the hydro accumulation and potential colonization of new fish species	Migration of indigenous fish species from the hydro accumulation and potential colonization of new fish species
Cultural and historical heritage	No changes	Some microclimatic changes are not expected, and also more significant impact of pollutants on the Architectural ensamble Vranduk, Identified visual impact from and on the building of the Old Town	Because microclimate changes, possible concentration of pollutants on the outside walls of the Architectural ensemble of Vranduk and changes of visual effects from and on the building of the Old Town of Vranduk (I zone of the Architectural ensemble Vranduk)	Some microclimatic changes are not expected, and also more significant impact of pollutants on the Architectural ensamble Vranduk. Identified visual impact from and on the building of the Old Town

Impact on:	Alternative „no project“	Alternative solution - Variant S	Alternative solution – Variant V	Alternative solution – Variant D
Removal	No changes	1 household would be dislocated	Approximately 125 households, 15 cottages, 136 stables, sheds and garages, 2 public buildings (mosque school), 6 business premises and 1 cemetery with 330 graves would be relocated.	1 household would be dislocated
New roads	No changes	New local road	Necessary relocation of local roads	New local roads
Electricity production [kWh]	No changes	93 819 600	116 570 000	103 160 607
Recreational opportunities	No changes	Opportunities for fishing, kayaking	Opportunities for fishing, kayaking	New recreational areas will be created for fishing, boating and possible swimming
Changes in hydrological regime - flow	No changes	Slowing the flow and permanently increase the level in the accumulation	Slowing the flow and significantly increase the level of the accumulation. Significant oscillations in the downstream course	Slowing the flow and permanently increase the level in the accumulation of 12%. The prescribed environmental minimum flow and minimum

Impact on:	Alternative „no project“	Alternative solution - Variant S	Alternative solution – Variant V	Alternative solution – Variant D
				oscillations downstream
Microclimatic changes	No changes	There is a possibility of changes in microclimate	There is a possibility of significant changes	Microclimatic changes minor
Employment	No employment	Employment of local labor during construction and operation of the facility HPP Vranduk with the appropriate development of services.	Employment of local labor during construction and operation of the facility HPP Vranduk with the appropriate development of services.	Employment of local labor during construction and operation of the facility HPP Vranduk with the appropriate development of services.

5.5. ANALYSIS OF PROPOSED ALTERNATIVE SOLUTION

Comparison of different alternatives has shown that the best alternative solution is D - HPP 3, the dam at the site upstream from the bridge Bosna 5, the power house at the location downstream from the bridge Bosna 4 on the road M 17, construction of a derivation tunnel and formation of smaller hydro accumulation. By choosing this alternative solution an insignificant area of arable land will be submerged and a smaller loss of flora and fauna will be caused, as we can see in Table 16.

From the aspect of resettlement and destruction of housings, the proposed variant is also the most favorable option, because one household is to be dislocated only.With the construction of the dam according to the alternative solution D, a small hydro accumulation is formed in relation to other variants.

Access to all facilities in the considered alternative solution is possible with the existing asphalt road communications, with minimal investment in highways.

The selected solution with the derivation type of the plant HPP Vranduk was elaborated in the Preliminary Design. Based on the selected alternative solution D - derivation facility, additional variants were examined.

Specifically, in order to find a technical solution that will be the most advantageous in terms of economy, rationality and integration into the space, it has been considered more alternative solutions of some facilities and composition of these facilities in a functional unit. In this respect we should emphasize the following:

- The concept of technical solution of the HPP Vranduk dam is such that it presents a low barrier, with a maximum depth of the accumulation of 9 m. In terms of natural migration regime of fish stocks along the river, the dam nevertheless represents a barrier that separates the river on the upstream and downstream part. This problem can be solved in two ways:
    - Construction of the facility that enables communication of the fish between tail water and the accumulation (fish path),
    - Compensations for damage caused to fish stocks during the construction and provision of continuous annual stocking of the Bosna river

  During development of the Preliminary Design and Environmental Impact Study, it has been discussed the above solutions to ensure the natural balance of fish stocks and concluded that it is safer and more acceptable solution to construct a fish path. Such decision is influenced by a similar design solution to some of the projects adopted for construction of hydropower plants on the lower Bosna river catchment.
- HPP Vranduk dam is located near the homonymous village and the national monuments of the Architectural ensemble of the Old Town Vranduk. The initiative to build a public road over the dam is given by the local community representatives. Within the project, this variant was considered, although this was not foreseen in the terms of reference. Analysis showed that this solution is possible, but significantly increases the investment. After making the Previous Environmental Impact Assessment and the draft of Environmental Impact Study, especially impact assessment and measures to protect

cultural and historical heritage, it was concluded that the solution with the public road over the weir crest is not acceptable, because it substantially burdens the whole ambience, further affect the views, traffic load of the architectural heritage.

- Within the dam, a small hydropower plant is also planned, which will use the hydropower potential in an environmentally acceptable discharge flow. In terms of the optimal location of that hydropower plant, two options were considered:
    - variant of location along the left bank, which is more favorable from the point of connection to the power grid,
    - the location along the right bank which is more acceptable in terms of impact mitigation on the cultural and historical heritage.

  Although the solution was provided locating the mini hydropower plant along the left bank of the river, after the consideration of the draft of Environmental Impact Study HPP Vranduk, the project has been changed and a variant of small hydropower plant has been adopted with the location along the right bank, and in order to implement measures to protect the national monument of the Architectural ensemble Vranduk.

6. INDICATION OF DIFFICULTIES

Professional team engaged in preparation of the Environmental Impact Study for HPP Vranduk during its work had some difficulties. The biggest difficulty was simultaneously preparation of the Preliminary Design and Environmental Impact Study. Therefore, data were successively delivered by the design engineer, who has had problems with obtaining data that are supposed to be the result of investigation works. Some of these data would be also important for the preparation of this Study, for example, data on groundwater, the renewed indicators of water quality and aquatic organisms of the Bosna River etc. A significant problem for making a conclusion on the environmental acceptability of the considered Project was a fitting of the same to the second zone of protection of national cultural-historical monuments "The architectural ensemble of the Old town Vranduk". Commission for Cultural and historical heritage of Bosnia and Herzegovina established by the Decision the activities permitted in this zone, and the fact is that the half dam of HPP Vranduk is located in the coverage of the II zone of protection.

It is important to emphasize that, for the subject site, there are several laws and other regulations of Bosnia and Herzegovina and the Federation of BiH which are not harmonized. Until now, a compromise solution is not found for the approval of building HPP Vranduk on the focused stretch of the Bosna river. This confirms the fact that the facility HPP Vranduk is planned within the spatial plan of the Zenica-Doboj Canton, and that, in accordance to the provisions of the Law on water, a Previous water approval is issued for construction of the facility within the public water resources. This hydropower capacity is one of the priority development projects of electric power system in accordance with the decisions of the Government of the Federation of BiH, and that is by its characteristics in the frame of the Clean Development Mechanism - CDM of the Kyoto Protocol etc.

Also, project implementation HPP Vranduk is also included in the Study of area vulnerability of the Zenica-Doboj Canton, as well as in the Study of cultural and historical heritage of the Zenica-Doboj Canton.

7. MONITORING SYSTEM

7.1. WATER MONITORING

Monitoring of water of the Bosna river should be established and enforced in accordance with the Prior water approval, i.e. Water permit in the future. In accordance with the provisions of the Law on water, the water monitoring should include:

- monitoring surface water regime and impact on ground water, according to the established backwater elevation 293,50 m a.s.l. (piezometers on the dam profile). Monitoring of the groundwater regime is also important for the safety of the area of national monument, "The architectural ensemble of the Old town Vranduk",
- monitoring continuous releasing of the environmentally acceptable flow downstream from the dam, to avoid a drying of the Bosna river bed, on the stretch from the dam to the power house,
- control of oscillations downstream of the dam as established by the project, and the protection of flora and fauna in the Bosna river,
- monitoring the volume of sediment in the accumulation,
- monitoring changes in the rate of erosion in the catchment area in the accumulation downstream from the power house.

During the construction works and operation of hydropower plant (with gauges) to monitor the water level, the registration of the flow at the entrance and exit of the accumulation.

It is necessary to regularly monitor and control the accumulation of waste in the accumulation zone, on the grid of the intake structure and the floating barrier.

In the emergency – incident situations, in the contents of the General Act - Plan for maintenance and use of facilities HPP Vranduk, it must be also established the security measures and alert notification system in case of a possible threat to areas downstream of HPP Vranduk, which includes monitoring of quality of water, river bank soils and the like.

The above monitoring should be harmonized with any special requests of „the Agency for Water Area of Sava River Basin" Sarajevo and the Hydrometeorological Institute of the Federation of BiH.

7.2. CULTURAL AND HISTORICAL HERITAGE AND LANDSCAPE

Monitoring system of impacts during construction and operation of HPP Vranduk on the national monument "The architectural ensemble of the Old town Vranduk" should be conducted in accordance with applicable legislation from the subject domain: Act on the implementation of decisions of the Commission to Preserve National Monuments, established pursuant to Annex 8 of the General Framework Agreement for Peace in Bosnia and Herzegovina (Official Gazette FBiH, no. 2/02, 27/02, 6/04 and 51/07); Law on spatial planning and land use at the Federation of Bosnia and Herzegovina (Official Gazette of FBiH ", no. 2/06, 72/07 and 32/08), Law on Environmental Protection (Official Gazette of FBiH ", no. 33/03); and the Decision of the Commission to Preserve National Monuments to designate the Architectural ensemble of the Old town Vranduk in Vranduk as a national monument of Bosnia and Herzegovina, number 05.2-2-274/04-4 dated on 25th of January 2005., published in „Official Gazette of BiH 16/06“. Monitoring under the jurisdiction, will be done by competent and authorized institutions for the protection of cultural and historical heritage.

7.2.1. MONITORING SYSTEM DURING CONSTRUCTION

Monitoring during the construction phase covers the period from planning and site preparation to completion of construction of facilities. Monitoring includes the observation of impacts in the phase of site and material preparation, delivery of materials and hiring of machinery and the construction itself (influence of work and servicing of machinery, etc.).

Before the construction works, it is essential that representatives of relevant institutions for the protection of heritage make a record (or complement of the existing record) of the Vranduk Old Town, with an emphasis on the recording of existing damage to the Town's structure. It is also necessary to make identification of the terrain - hills through which the headrace tunnel breaks through, in order to identify potential archaeological sites.

It takes the regular presence of an archaeologist during the earthworks.

Regular and continuous conservation monitoring of the state of the Old Town (any changes to existing cracks, the formation of new cracks, the increased deposition of dust and soot, the changes in the structure of materials and fixings, etc.), by the competent services of protection of cultural and historical heritage.

In the phase of plant construction, this monitoring will include the observation of state and changes that are reflected through:

- occurrence of any cracks or expansion of existing structures in the Old Town Vranduk,
- changes in rapidity and amount of sedimentation of soot and dust particles, and changes in binding elements of structures in the Old town Vranduk,
- changes (crackings, shiftings, dissipation of soil and similar) in any identified archeological heritage at site,

- erosion due to removal of vegetation and soil cuts,
- construction of facilities for the site needs (parking lots, storehouse and storage areas, etc.),
- creating the landfill for the disposal of the removed layer of fertile soil,
- providing the borrow pits of materials for backfilling and similar, which must be outside the construction area of HPP Vranduk

7.2.2. MONITORING SYSTEM DURING OPERATION

In addition to the obligatory monitoring of impacts of HPP Vranduk on buildings of a national monument "The architectural ensemble of the Old town Vranduk", it would be useful to monitor also changes of socio-economic indicators, which relate to a broader area of Vranduk. It would observe the change in population, urban development, implementation of development-self-sustainable projects, development of cultural tourism, etc. This would be done by the competent institutions, and the user of HPP Vranduk would possibly be involved in these activities, according to objective and economic opportunities.

7.3. FLORA AND FAUNA

Decomposition of organic material leads to the nutrient enrichment of the accumulation, which stimulates the growth and development of aquatic plants (algae and macrophytes) and leads to undesired balance disturbance of organisms present in water, and water quality. To prevent this, it is necessary to continuously monitor:

- water quality at the discharge from the accumulation and at different points on the Bosna River (pH, temperature, electrical conductivity, turbidity, dissolved oxygen, suspended particles, phosphates, nitrates),
- elements of biodiversity (phytobentos and phytoplankton, zoobenthos, ichthyofauna, macrophytes), and occasionally, if necessary, if the changes are observed.

7.4. ICHTHYOFAUNA

Before starting the construction of dam, it is necessary to make a study of the zero state of flora and fauna of the Bosna river, at the micro-location of Vranduk. These studies are needed to better perceive the future consequences of dam impacts on wildlife of the Bosna river.

As part of the Fishermen basis for the fishing area where HPP Vranduk is to be located (which is to be made most every 10 years), it is desirable to do a segment of the impact assessment of the hydropower plant on ichthyofauna and other aquatic organisms.

It is necessary to perform a visual control of the waste accumulation, which caused the Bosna River on the fish path and perform routine maintenance of its passage.

8. MEASURES IN EMERGENCY SITUATIONS

Measures for dealing with emergency situations are defined in the Plan to prevent accidents threatening the environment for HPP Vranduk, within which will be given steps and procedures governed by the Regulations on the procedures and measures in case of an incident in waters and water bank soil (Official Gazette of FBiH, No.71/09) (Appendix). Procedures and measures in case of an emergency will be also a segment of the General Act on the maintenance, use and monitoring of water management facility. The General Act is the basis for obtaining a Water Permit and will be made in accordance with the Regulations on the minimum content of general act on the maintenance, use and monitoring of water facilities (Official Gazette of FBiH, no. 18/07).

9. NON-TECHNICAL SUMMARY

9.1. THE STRATEGIC AIMS OF BUILDING HPP VRANDUK

Global task is orientation towards sustainable development and reducing greenhouse gas emissions i.e. pressures on climate change. For decades, especially in the European Union is promoting the orientation towards the usage of renewable energy sources, if their use is a potential for sustainable development, i.e. acceptable economic development in terms of environmental protection and natural resources. Practice has shown that the use of renewable energy sources in developing the electricity sector can have a positive effect on social cohesion and the standard of the local community, including employment, development of small business and recreational sporting activities, contributing to security of electricity supply, etc. At the national and federal level, according to upcoming obligations for accession to the European Union, it is important to ensure appropriate use of hydropower resources in the production of electricity for the needs of internal and external markets. Bosnia and Herzegovina has ratified the Treaty of establishing the Energy Community in 2006., where are established "acquis for renewable energy sources." Each Contracting Party undertakes to make a plan for implementation of Directive 2001/77/EC of the European Parliament and the Council on the promotion of electricity produced from renewable sources. The purpose of this Directive is to increase electricity production from renewable sources in the internal electricity market, with the aim of global reducing CO_2 emissions and pressures on climate change.

Combustion of fossil fuels leads to emissions of pollutants into the air, causing air pollution at the global, regional and local level. The project of construction of HPP Vranduk is based on the use of renewable energy sources, which will contribute to reducing CO_2 emissions and pollutants from the energy sector. Therefore, the implementation of this project is in line with the priority obligations of the energy sector, as well as the structure of executive authorities at local and state level in this context.

The use of hydro potential in production of electric power in Bosnia and Herzegovina is much lower than there are real possibilities. HPP Vranduk by an installed capacity is the project in the category of clean development mechanism (Clean Development Mechanism - CDM) of the Kyoto Protocol, ie the UN Framework Convention on Climate Change. To implement this project can be used favorable financing models, which are designed for developing countries, host countries for implementation of the clean development mechanism projects, and use the certificates obtained as a certificate of reducing greenhouse gas emissions (equivalent CO_2).

Environmental Strategy of the Federation of BiH, in a part related to the protection of air, was determined an objective to encourage the use of renewable energy sources, with measures for the realization of set objective.

According to the strategic plan and program to develop the energy sector of the Federation of BiH, HPP Vranduk is one of the planned production capacity in the Federation of BiH.

Directive on the use of renewable energy sources and cogeneration is in preparation (in a draft form), which aims to stimulate greater production and consumption of electricity from renewable energy sources in the internal electricity market, particularly in terms of:

- reducing the impact of the use of fossil fuels on the environment,
- long-term provision of energy,
- positive effects on social cohesion and approaching to the Kyoto aims,
- job creation and entrepreneurship development in energy,
- more efficient use of energy,
- encouraging the implementation and development of new technology and the domestic economy as a whole

9.2. HYDROPOWER POTENTIALS OF THE FEDERATION OF BOSNIA AND HERZEGOVINA

The construction of hydropower plants is an important segment of development of electricity industry and the economy in general. One of the characteristics of rivers of Bosnia and Herzegovina is hydropower potential, which has not yet been adequately exploited in the development context.

In accordance with the commitment of JP Elektroprivreda BiH to increase productive hydropower capacities, and providing safe and reliable electricity supply and the Decision of the Government of the Federation of BiH declaring the public interest for the construction of power facilities (Official Gazette of FBiH, No. 60/06) and the Decision to designate the public interest and access and construction of the priority power facilities in the Federation of BiH (Official Gazette of FBiH No. 08/10), were initiated activities on implementation of the Decision and analysis of the possible hydropower exploitation, among other things, of the Bosna River.

Hydropower potential of the Bosna river catchment is 365,78 MW, and the potential annual production is 1593,6 GWh. Thereof, the hydropower potential of the Bosna river in the Federation of BiH is 171,60 MW, i.e. the potential annual production amounts to 993,6 GWh. For now, of the available energy potential of the Bosna river catchment it uses only 2.2%.

9.3. SPATIAL PLANNING BASICS

Since the adoption of the current Spatial Plan 1981-2000 on the territory of Bosnia and Herzegovina there was a change in the political map, economic and social conditions, but the facts on the proven and established qualities and assumptions of development in the area largely are valid today.

The Spatial plan of the Federation of BiH is not adopted, and the Spatial Plan of BiH is still valid in the territory of this entity. Under the Spatial Plan considering the orientation of

development and arrangement of the economy in space, in a special section on the development of energy production is "to build a new hydroelectric power plants along the rivers Neretva, Drina, Vrbas, Trebišnjica, Bosna, Una, Sana, i.e. karst fields, therewith it should expect an accelerated use of available water power and enter into a wider construction of the system of new hydropower plants".

Construction project of HPP Vranduk is, therefore, in accordance with the applicable spatial planning documents of the Federation of BiH and the spatial plan of the Zenica-Doboj Canton (2009. -2029.).

Interventions in the area, such as the formation of the accumulation upstream from the dam, will inevitably affect changes of the authentic area. It is significant that such facilities, in most cases, are multifunctional. Primarily they are being built in order to develop and meet the needs of civilization, primarily for the water supply and use of water power for electricity production, and the planned hydro accumulation of HPP Vranduk, in addition to producing electricity, can be used for irrigation, development of small business and recreational activities.

It is significant to use water resources for energy purposes, but "no" without selective approach and thorough assessment of the consequences for the environment. Crucial objective of the environmental impact assessment is to make a choice of the optimal solution in the context of construction, operation and maintenance of the hydropower facility, which should have the attributes of environmental and techno-economically acceptable facility. Likewise, it is necessary to identify and estimate some potential impacts of project implementation of construction of the hydropower plant on quality of ecosystems and the Bosna river catchment area, and the environment in the narrow and broad sens.

9.4. BASIS FOR PREPARATION OF THE ENVIRONMENTAL IMPACT STUDY

Basis for preparation of the Environmental Impact Study of HPP Vranduk (hereafter EIS) is the Conclusion on development of the Environmental Impact Study number UPI-05-23-172/09 from 09.07.2009., issued by the Federal Ministry of Environment and Tourism on basis of the Preliminary Environmental Impact Assessment, pursuant to the article 58. and 59. of the Law on Environment Protection (Official Gazette of FBiH, no. 33/03, 38/09) and the Article 3. and 4. of the Rulebook on plants and facilities for which the Environmental impact assessment is required and facilities and plants that can be built and operated only if they have an environmental permit (Official Gazette of FBiH, no. 19/04). EIS has been prepared in accordance with the provisions of these regulations and the provisions of Directive 97/11/EC on the environmental impact assessment, amending Directive 85/337/EEC on the impact assessment of certain public and private projects on the environment.

The aim of valorisation of potential Project impacts on the environment is identification of some eventual intolerable failures in space, in the context of protection and promotion of cultural-historical and natural values, and the environment in general.

Project Description

Future HPP Vranduk will be located in the municipality of Zenica, at the location between the city of Zenica and Nemila settlement near the homonymous settlement of Vranduk. The area to be covered by the project extends along the left bank of the Bosna river from the Jelina train station up to the dam profile located about 150 m downstream from the Bosna V bridge on the main road, and then the left bank downstream from the Bosna IV bridge up to the Nemila settlement. Location of HPP Vranduk is good from the aspect of construction organization because the existing road infrastructure allows easy access to all components of the plant. Derivation type of the plant allows that works, without disturbances are carried out on three main buildings: dam, headrace tunnel with a surge shaft and on the power house. Geological conditions are also relatively favourable, and underground works are performed in rocks of medium to low water permeability

Energy parameters of HPP Vranduk

		MAIN GENERATING UNITS	SMALL GENERATING UNIT	TOTAL HPP VRANDUK
Installed flow	m^3/s	100	14 (18)	
Type and number of turbines		2xKAPLAN(„S“)	1xKAPLAN(„S“)	
Elevation of normal backwater	m a.s.l	293,50	293,50	
Elevation of tail water (for Q_i)	m a.s.l	271,34	284,90	
Maximum gross / net head	m	22,46/20,90	8,45/8,28	
Power	MW	18,24	1,32	19,56
Possible annual production	GWh	86,88	9,50	96,38

The general concept of solution

The general concept of hydropower use of the Bosna river at the stretch Zenica - Nemila is defined on the basis of basic orientations:

- use, in the most effective way, natural features of the Bosna streams at this relatively short, but typical stretch
- thereby do not affect adversely the main environment values,
- try that existing infrastructure facilities are not affected,

and previous studies, the available backgrounds, realized investigations, boundary conditions and constraints.

Solution with a run-of-river facility is adopted, derivation type, with more or less complex buildings that represent the functional unit, or:

6. The complex of buildings at the location of the dam: dam with four spillway fields located in the central part of the riverbed, gate depot along the left bank, a small hydropower plant along the right bank and fish path between the small hydropower plant and end spillway field;
7. Intake structure with equipment and facilities;
8. Headrace tunnel with surge shaft;
9. The complex of buildings at the location of the power house: the power house with drainage canals and dug downstream riverbed, the area with pre-turbine gates, the command building, a plateau with transformer and switchgear building;
10. A new road to the Hanovi settlement with a bridge over the railway line, an access road to the weir crest on the left bank and reconstructed existing local roads on the left bank, section Vranduk - Jelina and bridge Bosna IV – Nemila.

9.5. DESCRIPTION OF THE TECHNICAL SOLUTION OF FACILITIES

The dam is a concrete type, height from the foundations 16 m and length in the weir crest of 110 m, located app. 150 m downstream from the bridge "Bosna V". **The hydro accumulation** is formed upstream of the dam with the elevation of normal (and maximum) backwater of 293, 50 m a.s.l. Total storage capacity is 1,62 x 10^6 m^3 , length of 5,8 km and area of 42,56 ha. It is important to note that the storage of HPP Vranduk is conditionally the storage, because the parameters and a depth up to 9 m, and generally is formed in the riverbed. It has the characteristics of the storage only during the period, when the inflows of the Bosna River are less than the installed flow of the plant. Then its area is app. 12% higher than the area of the riverbed bottom, while at higher flows and engagements of evacuation organs at the dam it achieves a state similar to natural conditions. **The intake structure** is located on the left bank, approximately 35 m upstream from the bridge "Bosna V" and it is designed on the installed flow of100 m^3/s. **The headrace tunnel** has a length of 1.476 m and diameter of 6,60m. The headrace tunnel route passes between tunnels on the main road Doboj – Zenica and railway tunnels. The minimum distance from the existing tunnels is approx. 100 m. **The power house** is located on the left bank, between the bridge after the exit of the railway tunnel. It is to be constructed in a notch, close to the local road.

Digging the downstream riverbed, in order to increase the gradient of the plant and improve energy effects, is running over a length of 2500 m wide of the riverbed of 50,0 m, with the bottom gradient of 0.5 ‰. The adopted width adjusts the natural width of the Bosna riverbed, on this stretch. Cone lowering of the river bottom at the beginning of deepening is maximum 2,91 m.

9.6. CONNECTION TO THE ELECTRIC POWER SYSTEM (EPS) OF BIH

In order to ensure the safe placement of produced electrical energy in the network in all driving situations it was selected a connection to 110 kV network and to the existing 110 kV transmission line Zenica 1 - Zavidovići, which passes near the location of the future plant in

the system input-output. The transmission line has been renovated and has sufficient capacity to accept produced energy of the new power plant.

9.7. IMPACTS OF HPP VRANDUK ON ENVIRONMENTAL QUALITY

9.7.1. IMPACTS DURING CONSTRUCTION PERIOD

9.7.1.1. Impact on population

Taking into account the relatively low number of inhabitants in the area of the planned dam and storage, the negative impacts in terms of necessary removal of the population are minimal. Only one house is predicted for demolition i.e. relocation of one household.

Positive impacts on the population are numerous and relate to the increase of economic activities, which follow the construction of such facilities. It creates conditions for employment of a large number of population i.e. employment of some local construction firms and local residents, during the construction of hydropower facilities.

The local community will ensure a fair compensation for some occurred damages and it will be achieved a compromise of interests between the local community and the investors, which implies creating conditions for the multipurpose use of water resources of the Bosna river. In addition to concession fees, duties will be determined in the Investment Program for the local community after the Project support, which should be "friendly" to the population and the environment.

9.7.1.2. Impact on climate

Based on data on the general climatic and morphological characteristics of the narrower and wider area of the Vranduk gorge, it was noted that there will not be significant changes from the microclimate aspects. The most important impacts depending on the size of the project in the area, mainly construction works, can potentially be a temporary impact on the natural ambient condition in a narrower area of the Vranduk canyon.

9.7.1.3. Impact on air quality

During the construction of facilities HPP Vranduk, the air will be affected due to increase of dust, as well as the release of exhaust gases from machines that will be used.

9.7.1.4. Impact on water

During construction of HPP Vranduk it can temporarily occur water turbidity due to excavation works in the riverbed, then during the filling and installation of building materials. Also, during the construction phase can occur leaching of various materials used on the site. It will temporarily come to hydromorphological changes in the natural water regime.

9.7.1.5. Impact on soil

During construction a certain area will be occupied with some auxiliary facilities, construction of site and infrastructure, some temporary places to store construction materials.

9.7.1.6. Impact on waste generation

During the digging of tunnels and site preparation for future hydro accumulation as well as other construction works it will lead to the accumulation of excavated material. Construction waste materials include earth material, stone, gravel, biomass etc. It is to be continuously collected and removed from the construction site area and directed for use, and the rest of the unused construction debris finally disposed to an established landfill.

Given that it will have to raise the level of the local road up to the level of the railway line near the Hanovi settlement, the major part of the excavated material will be used as an embankment for a new local road.

9.7.1.7. Impact on flora and fauna

Construction of hydropower plant – hydro accumulation with a dam leads to changes in the structure of the Bosna river ecosystem. The most significant effects on the environment during the construction phase are manifested during filling a small accumulation, which is reflected in aquatic and semiaquatic flora and fauna. Filling the storage will result in irreversible loss of terrestrial habitat, with simultaneous increasing of border zone between terrestrial and aquatic environment. Water area in relation to the current situation will be only 12% extended. It is possible that there will be eventual degradation of the submerged vegetation and soil, if they are not removed prior to filling the hydro storage.

9.7.1.8. Impact on ichthyofauna

Any partitioning of the riverbed and changes of the stream, especially the construction of hydropower plants, will inevitably lead to distortions and changes in the ecosystem.

Site preparation, construction works within the river bed, dam building and construction of coastal fortifications, will disturb ecological balance of the stream and affect the ichthyofauna, especially in the vicinity of facilities.

During construction of the hydropower plant, a habitat of indigenous fish species will be disrupted. In the immediate vicinity of the construction site, a river surface will be completely altered or destroyed. In addition to ambient effects, habitat changes have resulted in the destruction of flora and fauna, or interruption of the food chain for a certain period of time.

To avoid possible consequences on the natural balance of the ichthyofauna, it is proposed to ensure migratory routes and construction of a fish path.

9.7.1.9. Impact on cultural and historical heritage and landscape

Construction of HPP Vranduk at the proposed location will affect the physical structures of the space of the other protection zone of the Old Town Vranduk i.e. cultural landscape around the Old Town Vranduk which is reflected in the images, structures and shape of the entire area.

Impacts of construction of the planned facility on the cultural and historical heritage can be divided into direct and indirect impacts. Direct impact is considered to be any physical transformation of the site space / facilities within the anticipated impact zones. Direct impact on facilities in the protection zone I has not been determined. Indirect impact represents the violation of integrity of respective surrounding area of cultural heritage, which was established during consideration of impacts of the dam and hydro storage HPP Vranduk on the architectural ensemble of the Old Town Vranduk.

During construction works, noise will inevitably increase, which may decrease the number of tourists in the Old Town Vranduk during this period. There will be a modification of space in terms of visual effect.

In the preliminary design it is planned to construct, next to the dam, a road for public communication from the upstream side in the same height level with the access road and dam top elevation. The planned width of the road was about 7 m. Due to the connection with the local road on the left bank, it was intended to build the retaining wall height of 15 m.

Given that from the aspect of protection of cultural and historical heritage it is estimated that a major impact will have the dam, access road and road for public communication next to the dam and hydro storage. It is therefore proposed that the additional load of the space and visual effects should be reduced by giving up of road construction for public communication. The Design Engineer and the Investor supported the proposal and the expert opinion of staff that have made the Impact Assessment of HPP Vranduk on the cultural and historical heritage.

9.7.1.10. Impact on noise level

The impact that will be caused by the noise in the operation of machinery from the site HPP Vranduk will be acceptable. It is important to emphasize that the first residential buildings are about 250m and the area is already exposed to noise from the frequent traffic of M17 highway and the railway line.

9.7.1.11. Impact on existing infrastructure

During construction of the facility HPP Vranduk and access road on the left bank, it is expected to impact on traffic. The reason is the reorganization of traffic on local roads, diverting the current to the other alternative routes, and it will come up to the occasional short-term traffic stopping on some shorter sections, especially on a local road to the settlements Hanove and Ljubetovo. It will start the reconstruction of about 1200 m of the local road and build about 500 m of the new local road.

9.7.2. IMPACTS DURING OPERATION PERIOD

9.7.2.1. Impact on population

Implementation of the agreed project documentation with environmental protection measures, will ensure that the impacts of built structures of the hydropower plant will be acceptable for the local community.

In the realization of the Improvement Program of outdoor space next to buildings constructed on the dam section, the cohabitation of a new building with the environment will be ensured.

Due to the loss of the authentic condition and loads of the area, the realization of this project is accompanied by various compensations to the society and local community, as well as indemnities for the use of energy resources, pursuant to the applicable legislation in the Federation of BiH, minimum indemnities, under current laws, would amount to:

Indemnities	Municipality (KM)	Canton (KM)	Federation of BiH (KM)
One-off concessions	1,35 mil.	225.000	675.000
Annual indemnities	1,05 mil.	58.000	43. 000

9.7.2.2. Impact on climate and air

Given that it is about the increase of water mass for only 12%, it can be concluded that there will not be an increase in humidity in the wider area of the storage in the Vranduk gorge, and a local climate with increased air humidity, intensity and frequency of radiation and advection fogs and low air temperature will not be formed.

Since the HPP Vranduk is a project from the scope of the Clean Development Mechanism (CDM) of the Kyoto Protocol, and that is based on the use of renewable energy sources, indirectly impact on reducing CO_2 emissions and pollutants that are emitted into the air from the thermal power sector.

9.7.2.3. Impact on water

Construction of the accumulation itself of HPP Vranduk will not lead to additional distortions of flow regime and not expect the impact of oscillations upstream. The project will, in accordance with the Decision of the previous water permit, ensure that the downstream oscillations are minimal. Water quality downstream will be altered due to changes, turbidity and dissolved oxygen concentration, which is not considered a harmful impact, because it helps the development of some organisms. Bearing in mind the current situation regarding

water quality or characteristic parameters of HPP Vranduk and storage, negative impact on water quality is not expected.

9.7.2.4. Impact on soil

The impact during the operation of HPP Vranduk on soil is not expected. To achieve the positive effect of cohabitation of new buildings with the natural landscape, it is important to regularly maintain recultivated surfaces according to the Project of external organization of built facilities.

9.7.2.5. Impact on waste generation

During operation of HPP Vranduk, larger quantities of waste will be created in the overhaul period. Collection, storage and transportation will not present more significant problems and impacts on the environment, because the facility have a Waste Management Plan.

External impacts on facilities of HPP Vranduk

Floating waste generated by local communities upstream, and which causes the Bosna river, will be accumulated on the grid and floating dam. The accumulated waste will be disposed by an authorized organization. It should be noted that disposal of this waste is not a legal obligation for HPP Vranduk, but it will be regularly implemented to compensate the community and with the aim of security of facilities, cleanliness, and visual effects of the hydro storage.

9.7.2.6. Impact on flora and fauna

Formation of the accumulation changes natural conditions and reduces the flooding zone. Many aquatic and semiaquatic species can not adapt to these changes in flow regime and water level. Because of that the ecosystems are subject to change of biodiversity i.e. reduction, because a small number of species can maintain high densities in these areas.

According to the design solution of the storage, water temperature and distribution of dissolved oxygen in water will not be changed in a vertical column, which will not cause the consequences and both qualitative and quantitative changes of aquatic and semiaquatic flora and fauna.

9.7.2.7. Impact on ichthyofauna

Construction of the dam structure will change the ecosystem. Formation of accumulation will transform a natural stream to the ecosystem of lake type, where there will be minor or major changes in hydrological and ecological characteristics.

Migration of fish and other aquatic organisms from the lower to the upper river, will be enabled by building fish path under the dam.

9.7.2.8. Impact on cultural and historical heritage and landscape

The most significant direct impact of HPP during operation is reflected in the changing cultural landscape / natural environment, characteristics and perceptions of the Vranduk canyion. It can be assumed that the impact will cause a permanent change in the area, as well as in the overall perception of the cultural landscape / natural environment and its impact on the visualization of the Old Town and from the Old Town on the surrounding neighborhood.

9.7.2.9. Emission of noise and vibrations

Source of noise and vibration during operation of HPP Vranduk is the turbine, which will be located inside the power house. Equipment in the power house must be modern and meet the technical standards and requirements of local and EU legislation which sets the level of external noise. Significantly higher levels of noise from this source are not expected, especially considering the fact that at the location there are significant sources of traffic noise on the main road M-17 and rail traffic. Nearby the power house, there are no settlements, and the first house from the power house byis located approximately 1,5 to 2 km, so there will not be noise impacts on residents.

9.7.2.10. Classification of the estimated potential impacts / effects of the planned HPP

9.7.2.11. Vranduk by importance

After the identification of possible environmental impacts, primarily on the minor part of the Bosna river catchment, some negative and positive impacts of the Project are estimated and environmental protection measures are proposed. Socio - economic and environmental justification for the planned construction of the hydropower facility has been evaluated.

NEGATIVE IMPACTS /EFFECTS ON ENVIRONMENT	POSITIVE IMPACTS /EFFECTS ON ENVIRONMENT
Possible estimated negative impacts / effects of the construction of the HPP Vranduk are : • transformation of the ecosystem of stream to the ecosystem of lake type, a length of 5,8 km , • changes in the landscape / natural	In addition to development - economic significance, and possible typical positive impacts / effects will follow the construction of HPP Vranduk : • production of hydro – energy, i.e. „green energy“ in the territory of Zenica – Doboj Canton, as well as reducing pollutant emissions in electricity production, • construction of facilities within the clean development

environment in the II zone of protection of national cultural monuments "Architectural ensemble of the Vranduk Old Town,

- characteristics and perceptions of the Vranduk canyon, views from “Architectural ensemble of the Vranduk Old Town”,
- relocation of a household - 1 house to be demolished
- loss of land area - the total land area to be bought off is 84. 434 m^2,
- loss of indigenous habitats of flora and fauna in the zone of the storage and colonization of new species,
- disruption of ecological balance, the number of species and the natural migration routes for aquatic and semiaquatic organisms, on the part of the Bosna river catchment where the dam and hydro storage of HPP Vranduk are situated,
- disruption of the self-cleaning mechanism – the self-cleaning mechanism will be disrupted in the hydro storage area, while it will be increased in the downstream part,
- there will be minimal oscillations downstream of the hydropower plant ,
- impact on quality of air, water and soil during construction of facilities, which is temporary,
- changes in the natural riverbed below, with the planned deepening of the maximum length of 2,5 km conic from the power house, where is the initial depth of 2,91 m,
- regulation of sediments and deposition of sediments in the storage zone,
- eventual occurrence of erosive processes, which beforehand with certainty can not be assessed,
- relocation of the local road and making a new road in a length of 600 m,

mechanism - "Green kWh”, or contribution to reducing greenhouse gas emissions, approximately 70.000 t CO2/year,

- physical integrity and safety of facilities in the I protection zone "Architectural ensemble of the Vranduk Old Town" will be preserved
- implementation of the Planning Programme and additional presentations of the National Monuments
- cohabitation of the new building with landscape characteristics of the II protection zone of "Architectural ensemble of the Vranduk Old Town",
- the hydro accumulation is formed in the riverbed, with expansion of only 12%,
- construction of a fish path, which will mitigate the disruption of ecological balance and ensure the migration of aquatic and semiaquatic organisms,
- fair compensations for the submersion of material goods, removal of only one family, or demolition of 1 house ,
- submersion of only 0,20 ha arable lands,
- collection and cleaning of the Bosna river from floating waste, which will be accumulated in front of the dam and water intake grilles. It is evident that the Bosna river is burdened with the waste that people throw around the entire basin,
- the possibility of water supply for irrigation in the region ,
- chosen location of the plant is good for the organization of construction works, transport and installation of equipment ,
- tourism development and several forms of recreation and sports activities in the area of the planned hydro storage, eg, recreational sailing, fishing, etc.,
- minimal changes in microclimatic conditions, may be suitable for the development of some plant and animal communities,
- local economic importance and the establishment of small business activities,
- employment of local people, if some domicile firms and labor would be preffered ,
- increased value of property in the immediate vicinity of the hydro accumulation,

• reconstruction of local roads, total app. 5,3 km • flow in this part of the river will be regulated by environmentally acceptable flow, which will guarantee the maintenance of ecological balance of the downstream part of the Bosna river	• in addition to the above, some other measures to compensate the community because of losse of the authentic condition at this part of the Bosna river catchment, • programs to improve the area affected by the Project - Investments in consultation with local community.

9.8. DESCRIPTION OF MEASURES FOR MITIGATION OF NEGATIVE EFFECTS ON ENVIRONMENT

9.8.1. Mitigation measures during construction

9.8.1.1. Population

For all construction machinery and vehicles used in construction of the hydropower plant, there should be a sound protection / isolation of the engine and other components, which produce or contribute to the development of noise. In the case of use of blasting for excavations in rock massifs, select the type of explosive that has the least harmful impacts on environment.

Within the Study on land acquisition to determine the real facts and investment program for fair compensation. Before performing works, within the Projects of construction organization to plan the construction, maintenance of alternative crossings / passages for the local population.

9.8.1.2. Air - Climate

Basic measures to mitigate and potentially prevent negative impacts of construction works during construction of the HPP Vranduk facilities are relating to mitigation of dust emissions using modern construction techniques and devices to control emissions from fuel combustion, the performance of construction works in the site zone and avoid the devastation of the environment, vegetation and soil, outside that zone. Avoiding, wherever possible, the use of explosives. It should be noted that the production of concrete will be done in the area out of the site location of the hydropower plant, especially the location of the dam which is near the Architectural ensemble of the Vranduk Old Town.

9.8.1.3. Water – Ecosystem of the Bosna river

At all stages of works to ensure a continuous water flow by the Bosna river, and migration of aquatic and semiaquatic organisms. Also, during the construction works, it is necessary to take measures concerning the possible blasting, temporary disposal of waste, and after

destruction of the cofferdam, all remnants of construction materials to be cleaned up to the bottom of the river bed and etc.

Within the Programme of Site Organization it is important to prevent spreading the riverbed with any waste material, and ensure waste management in accordance with the Plan of waste management during construction. Collect and manage all wastewater from the site in accordance with the Programme of Site Organization.

Also, take other measures as specified in the Resolution on the previous water permit.

9.8.1.4. Protection of structures against external impacts

In accordance with the fact that the Bosna River is loaded with municipal and other waste, it is necessary to install a floating barrier which would collect the waste accumulated by river flow. It is therefore necessary to set a grille in front of the water intake.

9.8.1.5. Soil – Waste

Within the Environmental Impact Study it has been made a general Waste management plan during construction and during operation of HPP Vranduk. The Plan should be updated after the start and during construction in accordance with some objective indicators of the possible and the generated waste. During works, records and periodic reports on waste management should be taken.

9.8.1.6. Flora i fauna

9.8.1.7. Flora and fauna

During construction of the HPP Vranduk, It is necessary to remove existing vegetation from the site of the facilities. Prior to the formation and filling of the accumulation, cleaning of vegetation should be made, because it is essential to avoid decay and loss of oxygen in the future accumulation.

9.8.1.8. Ichthyofauna

Proper management of the site can greatly reduce harmful impact on the ichthyofauna during construction and at its completion. Basic measures will be as follows:

- maximum remove the site facilities from the riverbed,
- depots of construction material and waste,
- prevent the same to reach into the river.

Before construction of the HPP facilities in order to reduce damage to fish stocks it is necessary to catch fish in a length of 1 km downstream from the site and to place evenly the entire population at various locations upstream from the site. Build a fish path and ensure the protection of fish stocks and fish migration. Install some devices on the water intake to prevent fish entering the tunnel (adequate grid), and in case of damage to fish stocks it

should make the Program of rehabilitation and equitable compensation to the user of fishing rights.

9.8.1.9. Cultural and historical heritage and landscape

It is necessary to take measures to protect cultural and historic heritage and archaeological sites, or any new findings, which implies:

- Compulsory termination of all works and information of the authorized services for the protection of heritage, if any archaeological sites or artifacts are found during the execution of works, which have not known or explored;
- In case of discovery of archaeological finds it is necessary that the competent services for protection of cultural-historical heritage manages or under its supervision, carries out the process of researches and documentation of the site. Depending on the nature of findings, possibilities and methods for its protection and preservation will be determined by applying the following measures:
    - conservation of the findings by re-backfilling,
    - relocation of findings,
    - relocation of a part of findings with conservation of the remaining part of the site by re-backfilling.
- Applying a quality site organization, with the systematic waste disposal, using modern construction technology and machinery, with preventative measures and good construction practices, the overall negative impacts on cultural and historical heritage and the landscape can be mitigated during construction of the facilities
- Already in the Preliminary design it should take into account the possibilities of construction of related structures of HPP Vranduk, which includes: access roads, the proposed road for public communication over the dam, any parking, etc,.
- Also, it is necessary to take into account the visual communications (signposting and information signs) and the illumination of the dam and roads, to ensure proper presentation of heritage, visual compatibility of structures with surrounding cultural landscape.
- If possible to avoid the construction of communication over the dam, this will contribute to mitigation of negative visual effects and reducing the traffic load over the area of the Architectural ensemble of the Vranduk Old Town.
- During the construction and use of the access road (road on the left bank of the river is necessary for the construction of the dam) it should strictly take into account to avoid irreversible changes to the existing slope (inclination changes, an extension that would later be impossible to completely repair, etc) and damages to the existing road for the settlement.

- During preparation of the Landscape design it should pay special attention to the proper presentation of the heritage, visual conformity of newly built structures with the surrounding cultural landscape, as well as ensuring safety belt - plantations or protective structures by which vibrations of the soil will be reduced and possible changes in groundwater flows, which may indirectly have an impact on the monument.
- Reducing the negative impact of construction of HPP Vranduk on heritage should be provided in accordance with the Landscape design. It should be noted that the Landscape design of outer space must be an integral part of the Main design of HPP Vranduk.

Recommendations for preparation of the Landscape design of HPP Vranduk area:

- Measures to protect landscapes (reconstruction, rehabilitation, restoration, etc.) should be chosen in a way that will not undermine the basic character of the cultural and historical heritage and the associated landscape, and they should be elaborated in details within the Landscape design. Having in mind that the direct impacts and results of building such a plant in a given area are significant and irreversible, it is recommended that after the construction of the dam, the access road on the left bank used during the construction of the dam, tries to fully repair i.e. adjust the space as much as possible to the surrounding environment.
- Visual treatment of the built structures through the possible change of materialization and the possibility of greening the area of retaining wall, access sequences to the facilities, colourful treatment of built structures and similar are measures to mitigate negative effects, but not complete reduction in this context. When selecting the approach to the final materialization of visible dam structures, it is necessary to strictly take into account the use of colors and elements in a given area, and try to bring the entire area treated by construction to a state similar to the natural ambient condition
- Greening of the dam structures is recommended if it provides the functionality of the facility (support structures, parts of the dam along the bank);
- A dominant use of stone lining is not recommended for the structures along the bank or those lying on the slopes, since they are, in nature, covered with vegetation, with or without a small quantity, of the visible stone parts of the micro locations of the dam;
- To finish the dam, it is recommended to leave a visible concrete, due to the dam represents a contemporary intervention in the area, and the stone lining, as a dominant final materialization, is not the material that predominates in a natural ambient, and it could degrade the structure of the Old Town;

- For the materialization of fences on the dam it is recommended to use some transparent materials, to mitigate the negative visual impact, and as much as possible, enable the views to the Old Town.

It is recommended that the investor when making the necessary project documentation for building permits for the preparatory work, in accordance with Article 47 and 48, paragraph 6 of the Law on spatial planning and land use of the Federation of BiH (Official Gazette of FBiH no. 2 / 06) engages an engineering company certified by the Federal Ministry for Physical Planning to work on buildings and heritage sites, which will make the documentation - Study on the protection of heritage. When creating documents – Study, it will be taken into account the current state of the Old Town, all the possible physical impacts on it (possible movement of groundwater, the stability of the massif which the Old Town is located on, etc.) as well as planned facilities (access road, a possible road for public communication, dam) and the possibility of their placement on the predicted location. This will be possible to give detailed and specific recommendations for the architectural design of HPP Vranduk, with the aim of its better integration into the existing environment of the National Monuments.

9.8.1.10. Noise and vibrations

In the case of the blasting process for excavations in rock massif, it should engage an authorized organization that will provide protection for the cultural-historical heritage, acceptable noise and vibrations for residents, wildlife and the environment in general. If possible, use excavation technique using hydraulic hammers or mechanical excavation with milling machines, "moles" and the like. Machinery to be used for construction and equipment that will be installed in facilities of HPP Vranduk should be in accordance with the technical standards for protection against noise and vibrations.

9.8.1.11. Infrastructure

In places of collision with the existing roads of higher rank: main roads and railroad to perform the necessary temporary protective structures that will separate the roads from the zone of works; apply all the required traffic signalization and if necessary to ensure traffic police patrols. Finding an alternative route or road construction, it is necessary to provide a unobstructed communication to the residents of surrounding settlements. If there is a collision with the existing installations of electricity (power lines) in the previous works to displace lines; or by technical measures it should separate / protect / isolate the lines. These measures taken in accordance with the sector permits.

9.8.2. MITIGATION MEASURES DURING OPERATION PERIOD

9.8.2.1. Population

Taking into account that the impacts during operation of HPP Vranduk are positive on population, it is not necessary to take measures to mitigate impacts.

9.8.2.2. Climate

Concerning the meteorological impacts that the accumulation provides during the phases of its operation, taking into account the fact that it is a power plant of run-of-river type and with increasing the area of water mass for only 12% (42ha) in relation to the current state (36.7 ha), it can be concluded that there are no significant impacts that may arise during the exploitation of the accumulation.

However, it would be particularly significant that, in the period of exploitation, some significant technogenic changes are not made in the environment. It would be suitable to bring the entire direct area around the hydro accumulation in the state with similar ambient conditions as before construction of the accumulation, which would reduce its potential negative impacts to a minimum.

9.8.2.3. Water - The Bosna river

In order to reduce the accumulation of waste in front of the floating dam and the grille on the water intake in the hydro accumulation, it should engage an authorized firm that will collect the same, if necessary, transported and properly disposed of it. In accordance with the Regulations on the minimum content of general act on the maintenance, use and monitoring of water facilities it should make the general act, which is the basis for Water Licence. The realization of water protection measures and Operational Plan for exceptional pollution in waters and bank water soil regularly to implement and update. Some potential and other measures to protect water and ecosystem of the Bosna River should be carried out in accordance with the Water Licence for HPP Vranduk.

9.8.2.4. Flora and fauna

Mitigation of negative effects that may arise as a result of sedimentation in the accumulation, and a possible reduction in the capacity of water storing, is including the maintenance of newly created environmental balance of the hydro storage. If there is an increased phytoplankton and zooplankton to take measures to remove it. Measures to mitigate the proliferation of aquatic weed species in the storage area should be applied, because they can pose a significant problem. The measures include the removal of woody vegetation from the storage and bank area, which will contribute to the reduction of nutrients.

9.8.2.5. Ichthyofauna

Built-in devices to prevent entry of fish on the water intake, are to be regularly maintained. Regularly maintain the fish path being passable and clean. In the case of emergency situations related to HPP Vranduk, measures should be taken to evaluate and repair the damage caused to fish stocks.

9.8.2.6. Cultural and historical heritage and landscape

Measures to mitigate effects during operation of the plant include:

- establish the necessary (minimum) lighting of the access road, possibly built road for public communication, the dam and other facilities of HPP Vranduk;
- ensuring some adequate presentations of the individual site of the Old Town or the entire cultural landscape, which, until now, has not been done or has not been provided by existing development projects.

The investor, as compensation to the community, could during operation period, and in a manner determined by the institutions responsible for implementing the Decisions of the Commission for Preservation of National Monuments, participate in the effort to protect the Architectural ensemble of Vranduk established by the Decision of the Commission to designate the Architectural ensemble Vranduk as a national monument, No. 05/02-2-274/04-4 of 25 of January 2005., published in the „Official Gazette of BiH 16/06".

Accordingly, during the operation of the plant it should foresee the development and implementation of the Illumination Design and the Design of regular maintenance of the Vranduk Old Town. The design of regular maintenance of the Old Town Vranduk should be made by an authorized design engineer. The design, among other things, should include regular cleaning of the town structures from sediments of contaminated air particles, and regular monitoring and timely repair of any cracks in the town structures and/or replacement of the connective or structural elements (the period in which it is necessary to perform regular cleaning and monitoring will be defined by the design). Both of these designs must be approved by the competent institutions for heritage protection. All works can also be performed under regular supervision of the institutions responsible for heritage protection.

9.9. MONITORING SYSTEM

9.9.1. Water monitoring

Water monitoring of The Bosna river should be established and enforced in accordance with Prior Water Approval, or Water Licence in the future. In accordance with the provisions of the Law on waters, the water monitoring should include:

- monitoring of surface regimes and impacts on groundwater, according to the established backwater elevation 293,50 m a.s.l. (piezometers on the dam profile). Monitoring of the groundwater regime is also important for the safety of the area of the national monument - "the Architectural ensemble of the Vranduk Old Town",
- monitoring of continuous discharge of environmentally acceptable flow downstream from the dam, to avoid drying up of the Bosna river bed, on the stretch from the dam to the power house
- control of oscillations defined by the design downstream from the dam, and the protection of flora and fauna in the Bosna river,
- monitoring the volume of sediment in the storage,
- monitoring of changes in the rate of erosion in the catchment, in the storage area downstream from the power house.

During the construction works and operation of the hydropower plant (with gauges) to monitor the water level, the registration of the flows at the entrance and exit of the hydrostorage.

It is also necessary to regularly control the accumulation of waste in the storage zone, on the grid of the intake structure and floating dam.

In some emergency – incident situations in the contents of the General Act - Plan for maintenance and use of HPP Vranduk facilities, it is also required to determine the protection measures, the notification and alert system in case of a possible threat of the areas downstream of HPP Vranduk, which also includes monitoring of water quality, bank soil, etc.

These monitoring should agree with any special requests of the public enterprise „Agency for the water area of the Sava River Basin "of Sarajevo and the Hydrometeorological Institute of the Federation of BiH.

9.9.2. Cultural and historical heritage and landscape

The monitoring system of impacts during construction and operation of HPP Vranduk on the national monument, "The architectural ensemble of the Vranduk Old Town" should be carried out in accordance with applicable legislation from the respective areas: the Law on implementation of the decisions of the Commission for Preservatinon of National Monuments, established pursuant to Annex 8 of the General Framework Agreement for Peace in Bosnia and Herzegovina (Official Gazette of FBiH, no. 2/02, 27/02, 6/04 and 51/07); Law on spatial planning and land use at the Federation of Bosnia and Herzegovina (Official Gazette of the Federation BiH, no. 2/06, 72/07 and 32/08), the Law on Environmental Protection (Official Gazette of the Federation of BiH, no. 33/03); and the Decision of the Commission for Preservation of National Monuments to designate the Architectural ensemble of the Vranduk Old Town in Vranduk as a national monument of Bosnia and Herzegovina, the number of 05.2-2-274/04-4 of 25 of January 2005 published in the Official Gazette of BiH 16/06. Monitoring under the jurisdiction, will be done by competent and authorized institutions for the protection of cultural and historical heritage.

9.9.3. Monitoring system during construction

Monitoring during the construction phase covers the period from planning and site preparation to completion of construction of facilities. Monitoring includes monitoring of the impacts during preparation of site, materials, delivery of materials and hiring of machinery and the construction itself (impacts of work and servicing of machinery, etc.).

Before construction works it is necessary that representatives of relevant institutions for the protection of heritage made recording (or completion of the existing record) of the Vranduk Old Town, with an emphasis on the recording of existing damages to the Town structure. It is also necessary to make recognition of site - hills through which the headrace tunnel will pass, and in order to identify potential archaeological findings.

It takes the regular presence of an archaeologist during earthworks.

Regular and continuous conservation monitoring of state of the Old Town (any changes on existing cracks, formation of new cracks, the increased deposition of dust and soot particles, the changes in the structure of materials and fixings, etc.), by the competent services for protection of cultural and historical heritage.

In the phase of the plant construction, this supervision will include monitoring of state and changes that are reflected through:

- the occurrence of any cracks or expansion of the existing cracks in structures of the Old Town Vranduk,
- changes in rapidity and amount of sedimentation of soot and dust particles, and changes in the connective elements of the structures of the Old Town Vranduk,
- changes (cracking, moving, crumbling of earth, etc.) on possibly recognized archaeological heritage at the site,

- erosion due to removal of vegetation and soil cuts,
- construction of facilities for the site (parking lots, warehouse and storage areas, etc.)
- raising the depot for the disposal of the removed layer of fertile soil,
- providing a borrow area of material for backfilling and similar, which must be outside the construction zone of HPP Vranduk

9.9.4. Monitoring system during operation

In addition to the mandatory monitoring of impacts of HPP Vranduk on buildings of national monument, "The architectural ensemble of the Vranduk Old Town" it would be also needed to monitor some changes of the socio-economic indicators, which relate to a broader area of Vranduk. It would be supervised the change in population, urban development, implementation of development-self sustainable projects, development of cultural tourism, etc. It would be carried out by relevant institutions, and the user HPP Vranduk would possibly be involved in these activities, according to objective and economic opportunities.

9.9.5. Flora and fauna

Decomposition of organic material leads to the nutrient enrichment of the storage, which stimulates the growth and development of aquatic plants (algae and macrophytes) and leads to undesirable imbalance of organisms present in water, and water quality. In order to prevent this, it is necessary to continuously monitor: water quality at the discharge from the storage and at different points on the Bosna River (pH, temperature, electrical conductivity, turbidity, dissolved oxygen, suspended particles, phosphates, nitrates), as well as elements of biodiversity (phytobentos and phytoplankton, zoobenthos, ihtuiofauna, macrophytes), and occasionally and if necessary if the changes are observed.

9.9.6. Ichthyofauna

Before starting the construction of the dam it is necessary to made a study of the zero state of flora and fauna in the Bosna river, on the micro-location of Vranduk. These studies are needed to better anticipate the future consequences of dam impacts on wildlife of the Bosna River.

As part of the Fishermen basis for a fishing area, where HPP Vranduk will be located (which is to be made most every 10 years), it is desirable to do a segment of the impact assessment of the hydropower plant on ichthyofauna and other aquatic organisms.

It is necessary to perform a visual control of the waste accumulation, which is caused by the Bosna river to the fish path and perform routine maintenance of its passage.

After evaluating the positive and negative effects, or real losses and benefits of the Project, taking into account the indicators of listed fees and compensations to the local community, which the implementation of the project provides, according to the applicable regulations of the Federation of BiH, it can be concluded that the planned

projects in the Bosna river catchment is environmentally acceptable and socially justified.

With the application of measures for the protection and realization of the Project to improve the condition and presentation of the national cultural and historical monument "The architectural ensemble of the Vranduk Old Town", it should accept cohabitation of a new building with a cultural landscape.

Objective measures for protection of the values of material goods are essential to assess the project as a techno-economically and environmentally justified, because during the construction works and during operation of the planned power facility the principles of sustainable development will meet, and the project will have attributes of friendly development project.