

STUDY ON ENVIRONMENTAL IMPACT ASSESSMENT

INVESTOR: BERANE MUNICIPALITY

**BUILDING: WASTE WATER TREATMENT PLANT
(WWTP)**

LOCATION: BERANE

STUDY NO: 100

LARS FIRE Ltd

Karadorđeva 5
Montenegro – 81000 Podgorica

phone/fax: +382 20 238 986

mob. phone: +382 67 620 190

+382 69 456 480

e-mail: kosticr@t-com.me
larsfire@t-com.me

Registration number: 5-0282933-009

Code of activity: 7112

VAT: 30/31-05046-3

TIN: 02454963

account: CKB 510-11299-93

Mart 2012

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THE WASTE WATER TREATMENT PLANT
(WWTP)**

Location: Berane

Podgorica, November 2012

CONTENTS

I GENERAL DOCUMENTATION

Data on the Project Proponent and the Project
 Decision on Extended Registration of the Legal Entity In the Central Registry
 Of the Commercial Court in Podgorica
 Legal Entity License for Designs undertake
 Decision on forming of Multidisciplinary Team
 Multidisciplinary Team Licenses and Authorizations
 Terms of Reference
 Statement of the Multidisciplinary Team

II TEXTUAL DOCUMENTATION

2. DESCRIPTION OF THE LOCATION	12
2.1. Basic data	12
2.2. Characteristics of the Terrain	16
2.3. Information About the Water Supply Sources and Hydrological characteristics	22
2.4. Climate Characteristics	24
2.5. Flora and Fauna	26
2.6. Landscape Characteristics	31
2.7. Protected Cultural Heritage Review	32
2.8. Population Density	32
2.9. Existing Properties and the Infrastructure	33
3. DESCRIPTION OF THE PROJECT	35
3.1. Basic parameters	35
3.2. Description of the Previous Preparatory Works	36
3.2.1. Description of the Road Route	36
3.2.2. Preparatory Works for Facility Construction	37
3.3. Detailed Description of the Design	39
3.3.1. Wastewater Treatment	39
3.3.2. Sludge Treatment and Disposal	44
3.3.3. Administration Building	50
3.3.4. Supporting infrastructure	52
3.4. Types, Volumes and Characteristics of the Matters used for Technological Process	54
3.5. Types and Volumes of Discharged Gases, Water and Solid Urban Waste	54
4. ANALYSIS OF THE REVIEWED ALTERNATIVES	56
5. DESCRIPTION OF THE ENVIRONMENTAL SEGMENTS	64
5.1. Concentration and Density of Population	64
5.2. Flora and Fauna	64
5.3. Soil Quality	64
5.4. Water Quality	66
5.5. Air Quality	72
5.6. Landscape and Topography	74
5.7. Climate Characteristics	74
5.8. Infrastructure on the Site and Its Surroundings	74
5.9. Cultural Heritage and Protected Natural Assets	74
5.10. Mutual Relations Between the Above Mentioned Factors	74
6. DESCRIPTION OF POSSIBLE SIGNIFICANT IMPACTS	75
6.1. Air Quality	80
6.2. Water Quality	82
6.3. Soil Quality	85
6.4. Local inhabitants	86
6.5. Impact on the Ecosystem and Geology	88
6.6. Impact on Designation and Use of the Land	89

6.7. Impact on the Communal Infrastructure	89
6.8. Impact on Protected Cultural Heritage, Natural Assets and Their Surroundings	90
6.9. Impact on the Landscape Characteristics	90
6.10. Accident situations	90
7. MEASURES FOR PREVENTION, REDUCTION OR REMOVAL OF HARMFUL EFFECTS	92
7.1. Protection Measures Anticipated by the Designs	92
7.2. Anticipated Measures for Facility Construction	93
7.3. Safety Measures During Facility Exploitation	94
7.4. Fire Protection Measures	96
8. MONITORING OF THE ENVIRONMENTAL STATE	98
9. INFORMATION SUMMARY	100
10. INFORMATION ON POSSIBLE DIFFICULTIES	108
III GRAPHIC DOCUMENTATION	

I GENERAL DOCUMENTATION

1. GENERAL INFORMATION

Project proponent data:

Project proponent: **BERANE MUNICIPALITY**

Person for contact: Rita Barjaktarević

Mob phone: 068 895 809

Project Title:

WASTE WATER TREATMENT PLANT
(WWTP)

Location: Berane

Podgorica, November 2012

**TERMS OF REFERENCE
ENVIRONMENTAL IMPACT ASSESSMENT OF THE INTERVENTION**

INVESTOR: BERANE MUNICIPALITY

BUILDING: WASTE WATER TREATMENT PLANT (WWTP)

LOCATION: BERANE

**PROJECT TYPE: STUDY ON THE ENVIRONMENTAL IMPACT
ASSESSMENT**

Study on the environmental impact assessment of the intervention, is to be done in accordance with current legislation, regulations, standards, urban and technical requirements and other technical documentation, and it is referred to the environmental impact assessment of the Waste Water Treatment Plant in Berane.

Study is to be done in accordance with Rulebook on Contents of the EIA Study, (Official Gazette of Montenegro No 15/07), in accordance with the Decision of the Agency for Environmental Protection 02-UPI-1529/6, 19 November 2012.

I N V E S T O R

According to Article 19. Of the Law on Environmental Impact Assessment (Official Gazette of Montenegro No 80/05), I issue the following:

D E C I S I O N
On forming a multidisciplinary team for drawing up

The Study on Environmental impact assessment of the Waste Water Treatment Plant in Berane, I define a team composed of:

PhD Dragoljub Blečić, BScMetE,
Doc Dr Radinko Kostić, BScMetE,
PhD Goran Sekulić, BScCE
Dr Snežana Dragičević, BScBio,
Ivan Cuković, BScME.

E x p l a n a t i o n:

Since the aforementioned comply with the valid legal regulation it is decided as in the enacting terms of this Decision.

Podgorica

Executive director

20 October 2012

Doc Dr Radinko Kostić, BScMetE

STATEMENT OF THE MULTIDISCIPLINARY TEAM

Drawing up:

THE STUDY ON THE ENVIRONMENTAL IMPACT ASSESSMENT OF THE WASTE WATER TREATMENT PLANT IN BERANE

the following has been used:

1.1 LEGAL REGULATIONS

- ◆ Law on Spatial Planning and Construction (Official Gazette of Montenegro No 51/08) and amendments to the Law on Spatial Planning and Construction (Official Gazette of Montenegro No 40/10, 34/11, 40/11 and 47/11).
- ◆ Law on Environment (Official Gazette of Montenegro No 48/08) and amendments to the Law on Environment (Official Gazette of Montenegro No 40/10 and 40/11)
- ◆ Law on Environmental Impact Assessment (Official Gazette of Montenegro No 80/05) and amendments to the Law on Environmental Impact Assessment (Official Gazette of Montenegro No 40/10, 73/10 and 40/11)
- ◆ Law on Strategic Assessment of the Environmental Impact (Official Gazette of Montenegro No 80/05) and (Official Gazette of Montenegro No 70/10 and 40/11).
- ◆ Law on Nature Protection (Official Gazette of Montenegro No 51/08) and amendments to the Law on Nature Protection (Official Gazette of Montenegro No 21/09 and 40/11).
- ◆ Law on Protection of Cultural Property (Official Gazette of Montenegro No 49/10).
- ◆ Water Law (Official Gazette of Montenegro No 27/07 and 22/11) and amendments to the Water Law (Official Gazette of Montenegro No 22/11, 32/11 and 47/11).
- ◆ Law on Air Protection (Official Gazette of Montenegro No 25/10) and amendments to the Law on Air Protection (Official Gazette of Montenegro No 40/11).
- ◆ Law on Waste Management (Official Gazette of Montenegro No 64/11).
- ◆ Law on Integrated Pollution Prevention and Control (Official Gazette of Montenegro No 80/05) and amendments to the Law on Integrated Pollution Prevention and Control (Official Gazette of Montenegro No 54/09 and 40/11)
- ◆ Law on Public Utilities (Official Gazette of Montenegro No 12/95).
- ◆ Law on Protection and Rescue (Official Gazette of Montenegro No 13/07, 05/08, 86/09) and Law on Amendments to the Protection and Rescue (Official Gazette of Montenegro No 31/11).
- ◆ Rulebook on Contents of the EIA Study (Official Gazette of Montenegro No 14/07).
- ◆ Rulebook on Limit Values of Environmental Noise, Methods of Identifying the Indicators and Acoustic Zones, and Methods of Assessing Adverse Effects of Noise (Official Gazette of Montenegro No 60/11).
- ◆ Rulebook on Methods and Terms of Air Quality Monitoring (Official Gazette of Montenegro No 21/11).
- ◆ Rulebook on Emission of the Pollutants into the Air (Official Gazette of Montenegro No 25/01)
- ◆ Decree on Limit Values of the Air Pollutants Emission from the Stationary Sources (Official Gazette of Montenegro No 10/11).
- ◆ Decree on Determining the Types of Pollutants, and Other Air Quality Standards (Official Gazette of Montenegro No 25/12).
- ◆ Decree on Determining the Types of Pollutants, Limit Values and Other Air Quality Standards (Official Gazette of Montenegro No 45/08).
- ◆ Rulebook on Quality and Sanitary Technical Requirements for Wastewater Discharge to the Recipient and Public Sewage System, Method and Procedure for Wastewater Quality Inspection, Minimum Number of Inspections, and the Content of Reports on Wastewater Quality (Official Gazette of Montenegro No 45/08), Rulebook Amending the Rulebook

(Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12).

- ◆ Rulebook on More Detailed Characteristics of the Location, Conditions for Construction, Sanitary Technical Requirements, Way of Working and Shutting Down The Landfills, Education, Landfill Manager Qualifications, Types of Waste, and Requirements for Taking the Waste on the Landfill (Official Gazette of Montenegro No 84/09).
- ◆ Decree on Classification and Categorization of Surface and Ground Water (Official Gazette of Montenegro No 02/07).
- ◆ Decree on Method for Categorization and Categories of Water Facilities and Their Giving in to Administration and Maintenance (Official Gazette of Montenegro No 15/08)
- ◆ Rulebook on Waste Classification, and Procedures for Its Processing and Taking Away (Official Gazette of Montenegro No 68/09 and 86/09).
- ◆ Rulebook on More Detailed Requirements That Sewage Sludge Should Comply With, its volume, frequency and methods of analysis for permitted purposes and requirements which soil, planned for that use, should comply with (Official Gazette of Montenegro No 89/09).
- ◆ Rulebook on requirements, which waste treatment or disposal plant, should comply in respect of equipment and personnel, and content of detailed description of working process (Official Gazette of Montenegro No 75/10).

European Regulation

- ◆ Directive on Environmental Impact Assessment 91/271/EEC.
- ◆ Council Directive 2003/4/EC on public access to the information about environment, which repeals Council Directive 90/313/EEC (OJ L41, 14 February 2003)
- ◆ European Council Directive on the cities waste water treatment 91/271/EEC, which was amended by European Commission Directive 98/15/EC.
- ◆ Directive on Bathing Water 2006/7/EC.
- ◆ Directive on Sewage Sludge (86/278/EEC).
- ◆ Framework Directive on Waste 75/442/EEC.
- ◆ Directive on Hazardous Waste 91/689/EEC.
- ◆ Directive on Waste Incineration 2000/76/EC.
- ◆ Directive on Landfills 99/31/EC.
- ◆ Waste Export CR No 259/93, CR 1420/1999, CR 1547/1999 under the aegis CR.

1.2 AVAILABLE DOCUMENTATION

- ◆ Study on development of water supply and sewage systems in Berane (WYG International, 2010) and Preliminary Design of WWTP.

The above mentioned Acts define Investor's obligations in order to implement necessary preventive measures in terms of the environmental impact assessment.

Multidisciplinary team,

PhD Dragoljub Blečić, BScMetE

Doc Dr Radinko Kostić, BScMetE

PhD Goran Sekulić, BScCE

Dr Snežana Dragičević, BScBio

Ivan Ćuković, BScME

II TEXTUAL DOCUMENTATION

2. DESCRIPTION OF THE LOCATION

2.1. Basic Data

Municipality of Berane occupies an area of 717 km², i.e. 5,2% of total area of Montenegro (13.812 km²). It is located in the north of Montenegro, in the area called Gornje Polimlje, between the peaks of mountains Bjelasica in the west, Cmiljevica in the east, Tivran Ravine in the north, Sutjeska and Previja in the south. Arable land is 22% of total area, forests 37%, and other land is 41%.

Headquarters of the municipality is in town Berane, located at an average altitude of 670m above sea level.

The location proposed for construction of Waste Water Treatment Plant (WWTP) is in the northern part of Berane, in the unpopulated part of Donji Talum, on the left bank of the River Lim, and covers around 2,5ha of currently unused land. It is approximately 1.800m far from Berane downtown, and approximately 150m from Berane - Bijelo Polje highway.

According to Urban and Technical Requirements (Graphical Documentation, Appendix I) issued by the competent state authority, construction of WWTP in Berane is planned to be on urban parcel UP1 of 25.880 m² square surface, and the parcel is composed of cadastral parcel No 76 and parts of the following cadastral parcels No: 24, 31, 34, 35, 38, 73, 74 and 75.

The facility occupies 4.122 m² of total surface, 4.594 m² handling surface, and 17.164 m² protective greenery. Construction index is 0,16.

Geographic position of the site is shown on Figure 1, and geodetic survey is given in Graphical Documentation (Appendix II).

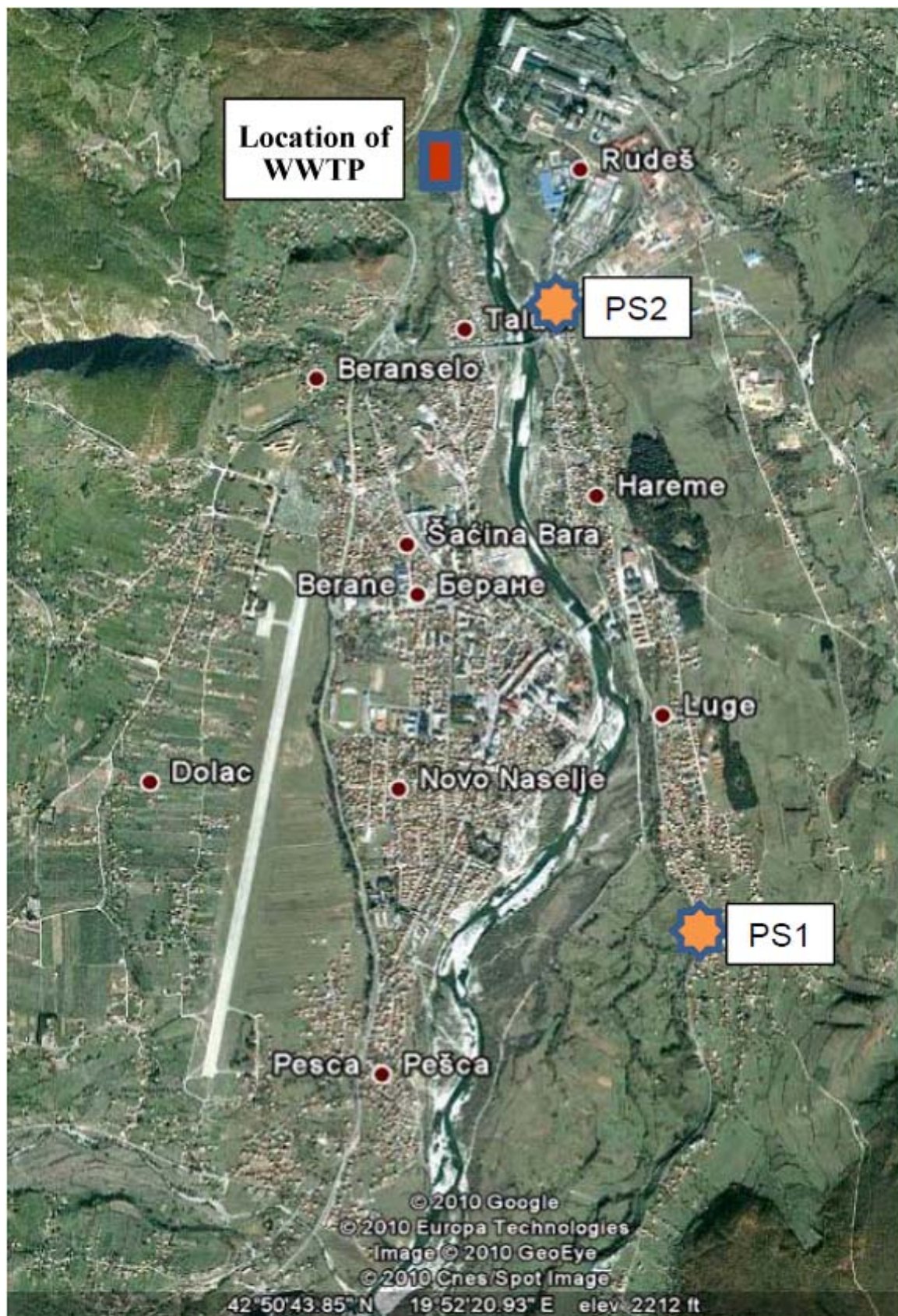


Figure 1. Geographic position of the site for WWTP

Layout of the location and its close surrounding planned for construction of WWTP is shown in Figure 2.



Figure 2. Location of WWTP and its surrounding

In the morphological sense, the location belongs to a flat flood-prone part of Lim riverside, so before WWTP construction it is necessary to raise the terrain on the location, and during the procedure undertaken stabilize and clean the part of the course of Lim River.

Terrain on the location is relatively flat, and it is a grassy surface with a certain number of plant species (Figures 3 and 4.). There are no landslides or other potential limitations to use the site for building up WWTP. The site is not on the protected area, and there are no natural and cultural assets on the very place. Examining the available documentation it was found that the site had no visible remains of material and cultural assets that would indicate possible archaeological field.

Makva stream (Figure 5) flows through a part of the subject area, and its function is to collect surface water from the surrounding area. During the procedure undertaken, part of the stream needs to be cleaned and stabilized in order to make the space free from potential impact of storm water.

The site elevation allows gravity flow of wastewater from the entire area of the town and settlements along the left bank of the River Lim, but wastewater from settlements on the right bank will have to be pumped across the river into the main collector. The location is outside of any sanitary protection zones and is in close vicinity of Lim, which in this area is not used for fishing or recreation by local residents.



Figure 3. *Layout of the WWTP site (view from the north)*



Figure 4. *Layout of the WWTP site (view from the east)*



Figure 5. *Makvas streambed*

It is possible to access the site by local road running through the settlement Donji Talum, but its technical and exploitation characteristics do not correspond to the future needs of the location. So, for needs of construction and operation of WWTP it is going to be constructed a separate access road that will pass through the unpopulated part to the location.

2.2. Characteristics of the Terrain

- **Pedological characteristics,** Area of Berane is characterized by different types of soil, with different physical and chemical features. The most important factors which influenced the creation of soil are the following: bedrock, relief, climate, hydrography, vegetation and man.

Soil map of Montenegro SFRY 1 : 50000 sheet "Peć 1" (Agricultural Institute of Titograd, 1985) and monograph "Soils of Montenegro" (Fustic B., Podgorica, 2004) were used as basis for exploring the pedological characteristics of the observed terrain and its surroundings.

Predominant types of soil in Berane are district and eutheric brown soils, which are on western, northern and eastern sides of Berane, while along the Lim River alluvial diluvial soils are found as shown in the Figure 6.

Brown acid soil (district cambisol) – according to its spreading (394,825 ha), is on the second place in Montenegro, after limestone and dolomite fertile soil.

It is mostly widespread in the northeastern part of Montenegro, where silica rocks are found in the base (eruptive, various slates, cherks, flysch and the like), and their decomposition creates a lot of waste material with a little clay and sandier fraction. Silica rocks contain little base cations so cleansing of the bases and accumulation of humus affect surface features. Brown acid soil was formed in various relief conditions, altitudes (from 400 or 500 above the sea level to mountain massifs) and climate (precipitation of 700 – 2500mm and average annual temperatures up 8 °C).

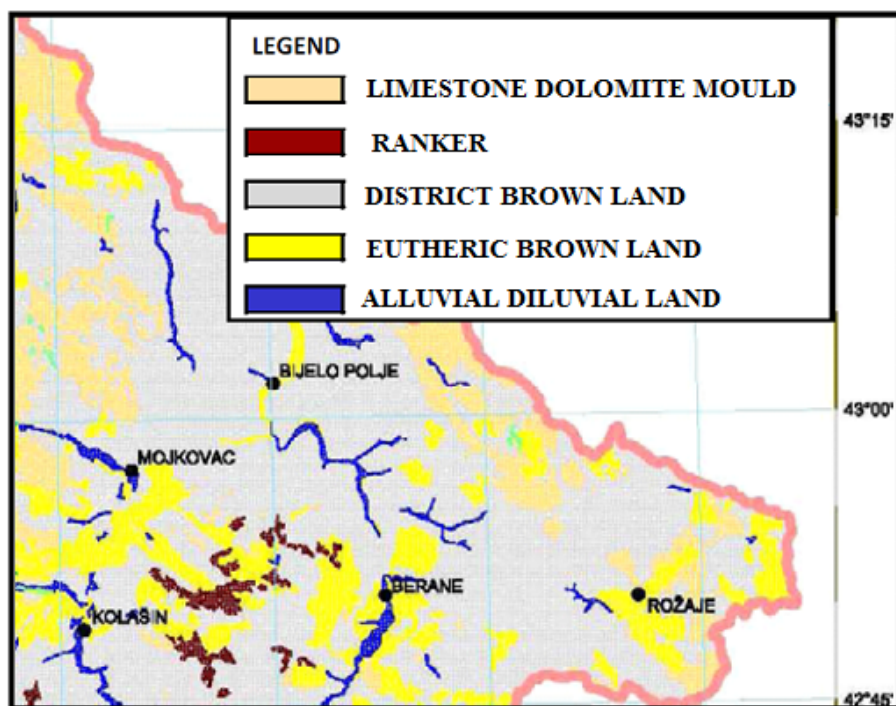


Figure 6. Extract from the pedological map of Montenegro

Depending on the substratum, the granulometric composition, structure, profile and morphology of brown acid soil varies, and in that respect, it has different physical, chemical and biological properties. More intensive dissipation of base and decomposition of primary minerals characterize more or less all subtypes, as well as releasing of oxides and hydroxides of which red oxides are the main agent of browning the soil. The process of browning is followed by the processes of synthesis of secondary minerals and creation of clay (argilogenesis), which are features of cambisols majority. In further development, depending on topographic, climate, and other conditions, the processes of clay cleaning, reduction of iron may appear which deteriorates the features and characteristics of this soil.

Brown acid soil, by its nature, is predetermined for natural vegetation, i.e. deciduous and coniferous trees and natural lawns. Deforestation has being done for a long time in order to obtain cultivated land. Pastures are above the upper border of the woods. Ecological and production value of district cambisol varies depending on the depth, its acidity, mechanical composition, content of nutrients, etc. The erosion weakens the land due to washing away small particles and nutrients. It is particularly seen on fields and pastures at higher slopes and in sparse and devastated woods near settlements and on steep terrain.

Brown eutric soil (Eutric Cambisol) – covers 118,275ha in lower rainy parts of river valleys, some ravines, karstic fields and terraces. The soil is formed on various bases, most frequently on the lake sediments, and it has similar or the same composition as district cambisol, but it has weak and neutral acid reactions since it is formed on substrates that are more alkaline. The presence of CaCO_3 in the foundation and soil influences the physical and chemical features, so there are no adverse features or there are few when compared to district cambisol.

Brown eutric soil is mostly found in the flat terrain, so it has somewhat greater depth (60-120cm), except in the marlstone base at neogenic hilly terrain and extremely gravelly quaternary sediments.

The ecological and production value of brown eutric soil varies depending on several factors.

On the very site, as well as in its close surrounding alluvial soils – fluvisol could be found. Those are young soils made of alluvial deposits, and near the river, willow and poplar communities are present on them.

The land in the wider area of the site could be used for agriculture, and construction of infrastructural and housing facilities.

- **Geomorphologic characteristics,** Dominant orographic unit in this area is composed of Lim canyon and hilly and mountainous terrains on its west and east sides. Lim Basin has mountainous characteristics within the municipality of Berane, and it is distinguished by a well-developed drainage network which has a great number of permanent and intermittent streams with deep canyons indicating significant river erosion. Additionally, in this area many parts of the terrain are made of clastic and flysh-like clay-sandy-marly sediments with frequent occurrences of accelerated erosion, gully making, cutting and sliding.

Decisive factors for catchment area relief forming are erosion (fluvial, karst and glacial erosion), petrographic composition and tectonics. There are lot of morphologic shapes, such as alluvial plains, terraces, slopes, ravines, canyon parts of the valleys, bluffs and

mountain peaks. The terrain gradually, and sometimes abruptly rises from water flow beds to the heights where becomes surface.

The main geomorphological structure was formed by tectonic movements, when Skadar-Berane cleavage of meridian direction was formed, and young ranges of mountains rose on the east and west of the cleavage. Tectonic forces were present for a very long time, and all the volcanic (igneous) and metamorphic rocks were created during those long processes, while forming of sediment rock masses occurred before and after. The main geomorphological classification is into two units – Bjelasica and Komovi.

As already been mentioned, in the morphological sense the location belongs to a flat alluvial part of Lim riverside.

- **Geological characteristics,** Geological composition of the Berane valley was formed of Palaeozoic slates, Triassic limestone cherts, and neogenic sediments (Figure 7).



LEGEND

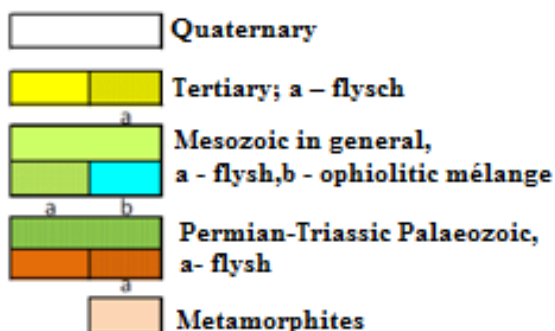


Figure 7. Geological map of North Montenegro

Bjelasica massif is composed of Palaeozoic slates (sandstones, argilosit, phyllite). While Cmiljevica opposite is mostly of Triassic limestone on a base of verfenic slates and cherts. Similar geological composition is present in the Tivran gorge, whose slopes are formed of medium Triassic slates. On the right bank of the river Lim, the hills of

Jasikovac, a large part of Budimlje, and the majority of Police have neogenic sediments that spread deep up to lacustrine deposits in Laguma and south to Ržanica. On the left bank of the river Lim, and partly on the right as well, lacustrine sediments are covered by thin or thick layers (10 to 40m) of fluvial - glacial deposits (boulders, gravel and sand) of various petrographical composition.

The oldest discovered sediments are lower Triassic (T1) quartz-mica sandstones and shales, and then Anisian (T21) layered and massive limestones and dolomites. The terrain north of Berane i.e. Tivran Massive is in great part made of these sediments. Ladin (T22) layered limestones with interlayers and cherts are over the Anisian ones, and they also could be found in the area of Tivran.

Jurassic sediments begin with Upper Jurassic limestones (J31+2). Those are layered limestones with cherts, marly at places. They are minimally exposed on the edge of the valley, in its northwestern part. A large area in the central and especially eastern part is built of diabase-chert sediments of Upper Jurassic (J33) formation. They consist of sandstones, cherts, marls, shales and marly limestone, and most common members are quartz sandstones. Usually they are solid and compact, of gray and dark gray colour. Mica and quartz sandstones are alike by their composition, and have schistose texture. After sandstones, cherts are the most abundant. They are hard and brittle sediments, usually of gray and gray-green colour. They are very common in the village Kaldura, as well as on the lake basin rim from Budimlje toward Lim. Volcanic rocks represented by spilite (ββabJ3) are also of Jurassic age. In the east of Budimlje they could be found in greater mass, while in in very small degree they appear on northwestern edge of Berane valley.

Oligo-Miocene lacustrine sediments (Ol, M) are present in the central and northern part of the valley. Terrain made of this sediments is in its greatest part completely covered. According to lithological composition those sediments are very heterogeneous. They are comprised of marl, clay, sand, sandstone, and less gravel and conglomerates. Marls are dominant. They are pale yellow, greenish to gray. They appear in 15-30 cm thick layers. Deep drilling found the might (hardness) of these lithologic members up to 250m. Sand stones are more common in the upper parts and the series ends with them. Shales are also common, occurring in the form of differently thick layers at various depths.

From Quaternary sediments the following are present: alluvial(al), diluvial (d), terraced (t), and lacustrine (j). Alluvion of the River Lim is built of sand and gravel. Diluvial debris is deposited below steep hillside of Jejevica, north of Budimlje. It is mostly made of big limestone debris. Glacie-fluvial terraces of the River Lim are particularly well preserved. They are composed of loosely-bound conglomerates, sand, gravel, clay, well-rounded pieces of carbonate and rarely igneous rocks. Thickness of Glacie-fluvial terraced sediments is different and ranges from 5 to 30m. Lacustrine sediments of glacial origin, are located on Tivran summits. They are usually quartz sand, gravel and pieces of rocks.

Diverse geological composition offers good conditions for occurrence of various minerals: coal, clay marl, decorative stone, lead and zinc. Coal deposits are located mostly in Budimje, Petnjik, Zagorje and Berane. The territory of Berane municipality is affected by significant erosion, often resulting in landslides. In places where the soil layer is shallow on the limestone and dolomite bedrock, and where the forest cover disappears, frequent phenomena of rapid rain wash of the soil, formation of ravines, sliding and tearing of the land occurs. Landslides occur particularly often on the mountainous slopes

and in the hilly areas. There is a constant problem of serious landslides on one section between the Merica spring source and the Banjevac break pressure tank (over a distance of ca 100m). The geological configuration and strong winds makes forestation difficult.

Tectonics

According to reviewed tectonic map from the newspaper OGK Ivangrad, Berane belongs to Lim tectonic unit. Berane valley is indigenously seismic and tectonically active area. It is traversed by continuous cleavages and lowered in the rocks that build up its rim.

The main cleavages are along the edge of the valley. Lim riverbed is connected to the cleavage along the valley bottom. Morpho-tectonically, Berane Valley leans on Bjelasica Massif toward west. Analysing topographic and geologic maps, it is concluded that there is a distinct shift of the valley towards Bjelasica in places where steep limestone elevations are leaned on mild slopes (made of Paleozoic rocks).

There is a striking vertical slope Osoje on the valley's right side, along which the plateau Krceva descends steeply into the valley. This cleavage is supervised in the highest part of the village Zagorje, by a transverse short cleavage which separates the two limestone terrains of settlements Bukovica and Glavice. Long cleavage along which Lim partly flows, extends along the entire length of the valley, in the southwest – northeast direction, from the River Marsenic to Budimlje. Lim riverbed is in the cleavage that follows the mentioned one from the very town.

Cleavage structure of Berane area indicates general moving and tectonic strain of Dinara Mountains towards northeast. Berane valley is *isolated seismic zone* at the contact of tectonic and morpho-structural units, and possible earthquakes can reach 8 degrees of MCS scale. Despite being marked as hazardous, the Valley of Berane within Zone of Lim shows stability during decades.

- **Hydrogeological characteristics,** Hydrogeology of Berane is characterized by different hydrogeological units with the prevailing impermeable complex of diabase-chert formations and oligo-Miocene sediments.

Permeable rocks contain highly karstified Anisian limestones and dolomites of Tivran, as well as cracked cavernous and porous rocks. Water sinks through these rocks into deeper layers, and finally appears in the form of spring, forming an unconfined aquifers.

Impermeable rocks include Ladin and Jurassic layered limestones and cherts with unconfined aquifer that has free water level. The aquifer is emptied into wells at lower altitudes.

The other permeable and impermeable rocks are Quaternary sediments, especially alluvial and fluvio-glacial, terraced sediments. Within them confined aquifer was formed which has free water level. Significant amounts of ground water are accumulated in those sediments, and water level is hydraulically connected to the level of Lim.

Diabase-chert formations contain heterogeneous complex of various lithological formations with different hydrogeological characteristics. Generally speaking, this is very or completely impermeable complex, with fracture porosity, and without clearly identified aquifers. Unconfined aquifers are rarely found, but they could be mainly found in the areas that suffer a greater degree of decay, so their capacity and coverage are limited.

Oligo-Miocene sediments are virtually impermeable, acting as a barrier to the penetration of ground water. Low fracture porosity can exist on the surface, besides capillary and sub-capillary porosity in deeper layers. These sediments contain aquifers.

Pollution monitoring for local ground water has not been carried out, but it is expected to be significant in urbanized parts of the municipality. Pollutants from a number of uncontrolled landfills and from municipal landfill which is not currently regulated in an appropriate manner, leach into groundwater and pollute both confined and unconfined aquifers. Additionally, the river Lim serves as a waste water collector for the settlements it flows through and often as a solid waste dumping place, which contaminates the river within the urban parts of the municipality. There is believed to be a high risk of pollution of aquifers through the process of infiltration of the river to ground waters.

- **Engineering geological characteristics**, All the rocks involved in the structure of the observed terrain may be classified as:

- Unbound rocks,
- Unbound and half bound rocks, and
- Bound rocks.

Unbound rocks are: terraced glaciofluvial sediments represented by sandy gravel, here and there lightly clayed with layers of loosely bound conglomerates.

Lacustrine, oligo-Miocene sediments are also heterogeneous complexes with frequent shifts of certain lithologic members in the sediment column. Marls are dominant, and they occur as layers. Clay occurs in the form of layers and interlayers at different depths.

Terraced sediments belong to a group of unbound and half bound, fossilized and poorly fossilized sediments. They appear as fine-grained and coarse-grained. Cement sands and gravels in the form of conglomerates are loosely-bound and poorly fossilized. They have carbonate or clay binder. It is a heterogeneous and unsorted complexes. The size varies from fine sand to pebbles of 50cm diameter.

Their capacity is up to 200 kN/m^2 . Cubical weight for sand and gravel ranges from 20,5 to 22 kN/m^3 , while for clay is from 17,5 to 20 kN/m^3 . According to GN₂₀₀ categorization they are in I and II category.

Bound rocks are: limestone, dolomitic limestone, and dolomites of Paleozoic age, limestones with cherts, as well as volcanic rocks keratophyre and quartzkeratophyre, Cretaceous Triassic age. They occur as layered or massive, mostly contracted and karstified. Sediments of diabase-chert formation are over them. It is a heterogeneous complex of different lithological members. Quartz and mica sandstones or cherts are dominant.

Alluvial sediments such as gravel, sand and clay are present in the area of the location. Gravel and sand with a somewhat lower share of clay are dominant. Clay in these appearance intervals gives to a soil a degree of moisture, and when the soil is wet it has a plasticity and low cohesion. Gravel has different grain size.

Their capacity is up to 120 kN/m^3 , cubical weight from 19-21 kN/m^3 , and according to GN₂₀₀ categorization they are in II and III category.

- **Seismic characteristics**, from the micro-seismic point of view, Bane municipality is within the area of high seismic activity, what is characteristic for the whole territory of Montenegro.

Figure 8. shows the map of seismic regionalization of Montenegro (B.Glavatović etc. Titograd,1982) with zones of maximum expected earthquake intensity, expressed in the **MCS** scale. The earthquakes will occur in the next 100 years, with the probability of 63%.

According to the map, the location has VIII degree of the **MCS** scale, so the construction

and exploitation of the facility have to be in accordance with the current regulations and principles for anti-seismic designing and constructing, all according to the Law on Spatial Planning and Construction (Official Gazette of Montenegro No 51/08) and amendments to the Law on Spatial Planning and Construction (Official Gazette of Montenegro No 40/10, 34/11, 40/11 and 47/11).



Figure 8. Map of seismic regionalization of Montenegro

2.3. Information About the Water Supply Sources and Hydrological characteristics

The hydrological system of Berane encompasses numerous watercourses, glacial lakes, wells, springs and aquifers which classify this area as one of the hydrologically richest parts of Montenegro. The river Lim along with its tributaries is the main feature of this hydrographic network. The main tributaries of Lim river in the Berane valley include: Piševska, Šekularska, Dapsićka, Kaludarska, Trebačka, Trepčanska i Lješnička rijeka, Zlorečica, Kraštica, Bistrica and Ljuboviđa.

Other components of the hydrographic network of Berane valley include numerous springs of high quality mountain water. Among them are Zagradska and Monastery springs which are considered as tourist attractions, and glacial lakes of Bjelasica (Biogradsko Lake, Pešića Lake, Great Ursulovačko Lake, Little Ursulovačko Lake, Great Šiško Lake and Little Šiško Lake), which all belong to the municipality of Berane with the exception of Biogradsko Lake.

Berane has a reliable gravity supply of good quality water from the Merica Spring, and it is captured at an elevation of 960,5m as it discharges from a cliff just above the adjacent stream. The Merica Spring overflows at the intake structure continuously through the year. A pipeline takes water from the intake chamber and conveys it through a ravine under gravity to a break pressure tank at an elevation of 774 m, just above the town. The flow in the pipeline was measured at 174 l/s in 2008 using a temporary flow meter. Excess water from the spring overspills the intake chamber into the stream.

The raw water pipeline has no controls but is equipped with air-release and washout valves. The upper pipeline section with 400mm diameter is 590m long and comparatively flat. As the natural slope increases the diameter reduces to 350mm for a length of 550m

and then to 300mm for another 1920m. At 340m before the air valve, installed at a final point of inflection, the pipeline splits into two parallel pipelines each of diameter LG 300mm and PVC DN 315. After the air valve, diameter of the pipeline is reduced to 250mm in the slope length of 2.250m, to the break pressure tank. This section was recently damaged by a landslide and a section 285mm PVC pipe has been laid in parallel to the existing 250mm pipe. The PVC pipe is throttled at the baffled Break Pressure Tank to provide contact time for the chlorine. Three independent outlet pipes from the break pressure tank supply the town by gravity.

There are no controls on the gravity supplies so any excess over the demand overflows at the break pressure tank and the service reservoirs.

During the summer when water consumption is high, other source in Djurdjevi Stupovi is used. Here water is also chlorinated and pumped into the network through PS Berane.

The source is also a karstic spring, emerging from beneath the monastery Djurdjevi Stupovi. It is at a lower elevation than Merica Vrelo and therefore cannot supply all parts of the town by gravity. Dynamic modelling of the supply and distribution systems using EPANET indicates that the need for pumping from this source in the summer is due to insufficient service reservoir capacity rather than inadequate supply from Merica Vrelo.

Total length of the distribution network (primary and secondary) is approximately 160km, and is used by a little over 70% of the total population of Berane. The network is constructed from cast-iron, galvanised, asbestos-cement, polyethylene and PVC pipes.

Total number of registered consumers is 7.764 out of which 5.549 in private houses, 1.517 in apartment blocks and 698 legal entities. Consumption is recorded and read from almost 4,300 water metres.

In the Banjevac break pressure tank water is chlorinated continuously, the residual chlorine is tested every two hours. Water from the monastery spring is tested in the same way when it is used as an additional source for the needs of the city water supply system. Berane ViK has provided results from its routine testing of water quality at its sources. These show that the water from each of its sources has good physical and chemical properties according to Regulation on the hygienic water quality. The turbidity of the main source increases above the limit of 1 NTU for short periods after heavy rain and there are isolated cases of faecal contamination of the raw water. The results in October 2009, when e-coli were found in both raw and treated water samples, suggest that the chlorination at the break pressure tank, where chlorine cylinders must be changed manually, may not always be effective at eliminating contamination of the raw water.

The most serious environmental problem in the Municipality is related to the potential for surface and ground water contamination. Raw sewage and industrial wastes contaminate most surface water sources. Not all of the operating industries provide wastewater treatment, and un-treated effluent discharges straight to the Lim river and numerous streams.

The percentage of population served within the Municipality is 70% but the percentage served within the main supply area is near 100%. However, it is expected that there will be a modest extension of the system and that 76% of the Municipality will be connected to the ViK system by 2035.

Although Berane has a fundamentally sound water supply system the following problems require attention and investment:

- Measurements show there to be a high level of unmetered consumption that leads to an unrestrained peak in summer consumption,
- Distribution system lacks the pressure and flow monitoring needed to identify areas with high leakage and unmetered use,
- Supply system lacks the instrumentation and controls it needs to adjust chlorine dosing to match demand,
- Service reservoir capacity is insufficient to satisfy daily peaks in demand when the source and transmission pipeline are running at full capacity, and
- The principal source has seasonal turbidity problems that require additional treatment.

2.4. Climate Characteristics

Climate characteristics and meteorological parameters are the important factor in defining the environmental state and the assessment of potential impacts, which are generated by new facilities construction. They are usually defined through the spatial and weather variations, drifts, temperature, and humidity.

Berane climate characteristics are mostly conditioned by Canyon of Lim and proximity of the mountains that surround it from the east and west. Map of climate zones in Montenegro 1 : 300 000 is shown in Figure 9.

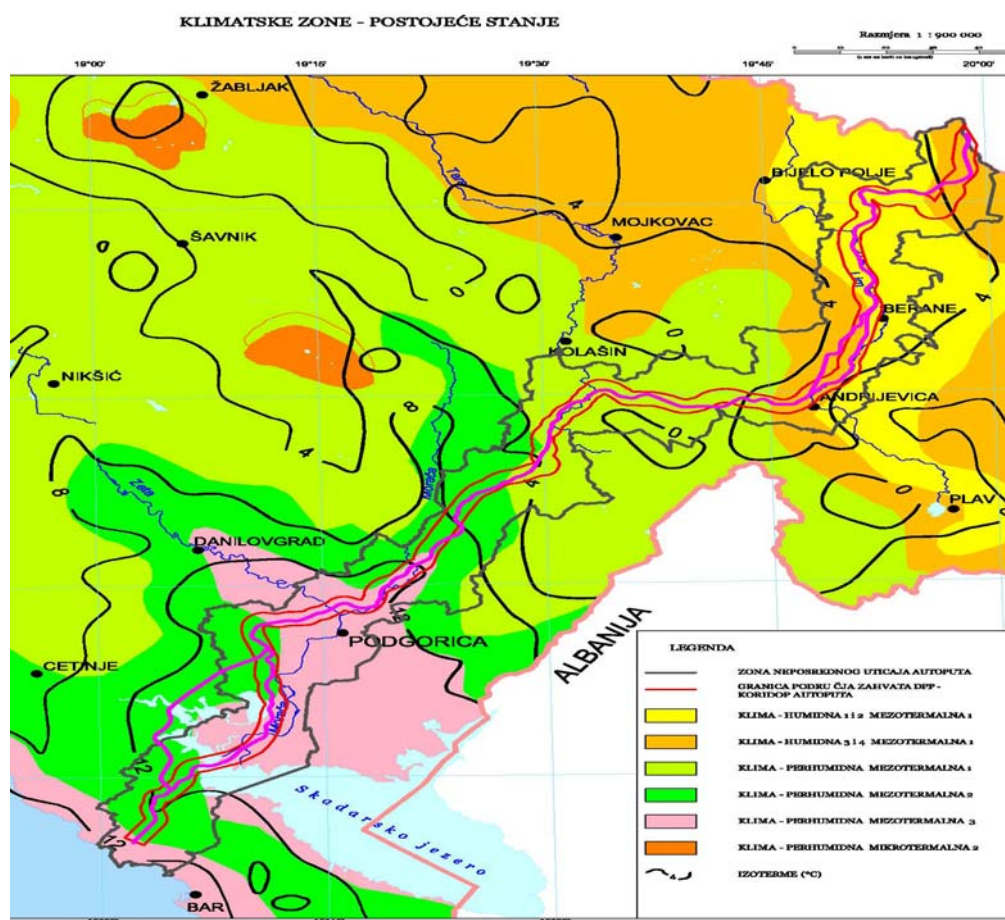


Figure 9. Climate zones in Montenegro

The climate of Berane area varies between continental sub - alpine climate in mountainous areas and moderate continental climate in Lim River valley. Sub-Alpine

climate can be characterized by the long cold and wet winters with large amounts of snowfall, relatively short and fresh summers, and less defined changes in seasons. Moderate continental climate is on the other hand characterized by seasons of disproportionate lengths, moderate cold winters, long and warm summers.

Due to the physical phenomena of temperature inversion, when colder air from the surrounding hills is getting down the valley forming a core of cold air, cold periods are slightly longer than in geographically similar areas. Also, increased humidity, and frequent fog, because of the presence of natural watercourses, makes the atmosphere saturated with humidity.

In order to evaluate the climatic and meteorological conditions in the considered area, available data of Hydrometeorological Institute of Montenegro were used. The data were collected from the meteorological station in Berane. Average perennial air temperature at this meteorological station is 9,1 °C. July is the warmest month in the year, with perennial average 18,9 °C, and the coldest is January with temperature -1,5 °C. Perennial average for mean maximum temperature is 15,2 °C, and the highest mean maximum temperature is in August 26,0 °C. Perennial average for mean minimum temperature is 3 °C. January also has the lowest mean minimum air temperature - 6,0 °C.

Average number of tropical days with air temperature > 30 °C for several years is 5,6, but in terms of months, on average August has the highest number of tropical days, 6. The most tropical days 25, were recorded in Jun. Average number of days with frost for several years, with the minimum air temperature < 0.0 °C, is 116. On average, January has the largest number of frosty days (26 days), then December (23 days), and February (22 days). It was also registered that during several years January and December each, had 31 frosty days.

Data about cloudiness, expressed in tenths of sky coverage, indicate the average perennial cloudiness in the observed area of 6,2. Perennial average of clear days in the year, with mean daily cloudiness < 2/10, is 42 days, and on average, August has the highest number of clear days, 8. Perennial average of gloomy days, with mean daily cloudiness < 8/10, is 130 days. On average, December and January are the gloomiest months with 18 and 17 gloomy days.

Precipitation regime is characterized by high variability in time and space. In this region, 45% of precipitation occurs in the growing season. The most precipitation occurs during the period October – December, when on average 32% of annual precipitation is released, while the least precipitation occurs during the period July – September with 20% of annual precipitation. In the wider region, maximum daily amounts of precipitation during hundred years time ranged from 110 mm (Berane) to 193 mm (Plav).

The average number of days per year with precipitation amount > 0.1 lit/m² is 141, with precipitation amount > 1.0 lit/m² is 104, and with precipitation amount > 10.0 lit/m² is 31. On average, December has the maximum number of days with precipitation 11, while August, September and October have the minimum number of days with precipitation 7.

Figure 10 shows the following:

- average maximum temperatures,
- average minimum temperatures,
- number of clear days
- average number of days with precipitation and

- average amount of precipitation.
per months during one-year period.

The maximum thickness of snow cover is 108cm, while January is recorded as the month with the highest average snow cover of 26,5 cm. The average number of days per year with snow cover > 30 cm is 6,2, while February has the maximum number of days with this snow cover thickness (28 days). The average number of days with snow cover > 50 cm is only 2,5 days, but in February this value is 18 days.

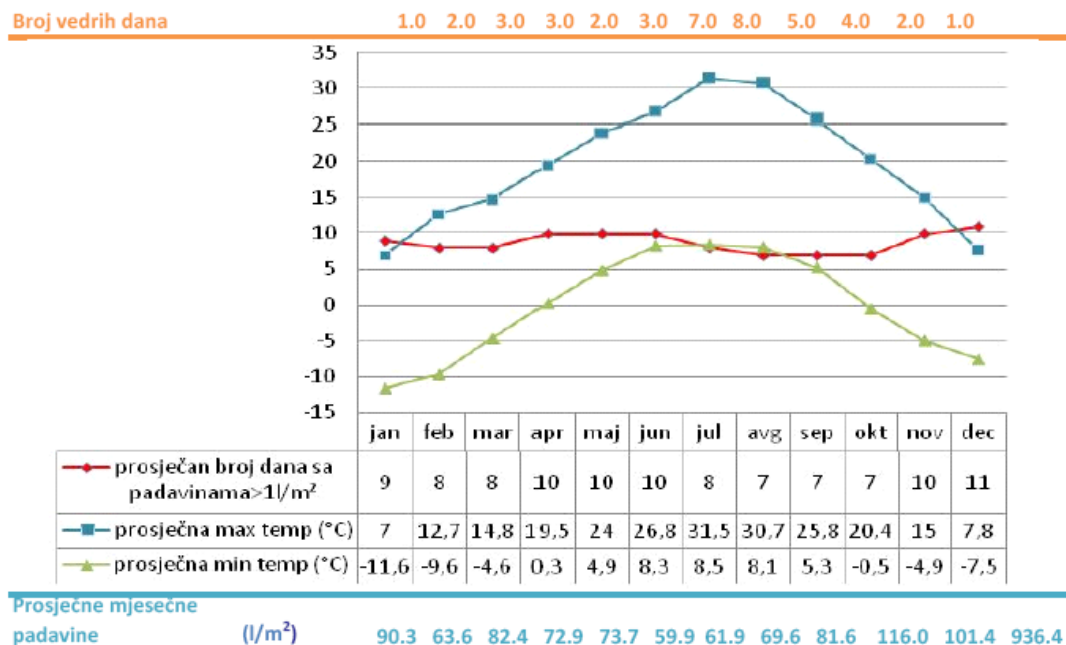


Figure 10. Berane Climate Characteristics

Wind occurrence on the observed area is analyzed on the basis of data on maximum and mean wind speeds, as well as on the data about its frequency in 8 characteristic directions. Harmonized results of the analysis, presented in the so-called Wind Rose, indicate significant presence of silence (41%) in this area. That should be taken with reserve because the data on wind were obtained from three term measurements on daily basis, so it was possible that these measurements did not registered winds that blew in-between. According to directions, northerly wind is most common (14%), then north – easterly wind (12 %) and southerly wind (9 %). Mean wind speed ranges from 1.6 m/s to 3.3 m/s, and maximum wind speed per directions ranges from 5.0 m/s (east-northeast) to 18.0 m/s (south-southwest).

2.5. Flora and Fauna

Flora

The area of Berane with its close surroundings (valley) has moderately continental climate which becomes a cold mountainous climate with the increase in altitude. Snow and frosts are common.

According to this temperature regime, plants that grow in this region have short growing season. Urban part of Berane municipality is at about 700 meters above sea level, and remote villages (and pastures i.e. cattle-men huts) belong to hilly and mountainous areas which are spread above 1000 meters above sea level. There are different geologic

structures in this expanse, which together with other natural factors have caused the development of various plant and animal species.

Reviewing the available literature, it was determined that in the area of Berane municipality, detailed floristic and faunistic researches have not been done. Data in this section of the Study are based on the fieldwork (subject location) and individual reports on wider area that contact and protected zone NP Biogradska gora belongs to.

Observing the flat part of Lim valley all to the mountain area, shift of many vegetation zones can be noticed. Horizontal layout of the zones is circular and divided by the River Lim and its tributaries. Appearance and layout of the vegetation zones are conditioned by the habitat and community of the plants living there. Within each zone there is a large number of ecosystems, habitats, plant communities.

General image of vegetation in Lim Basin is given in the Paper "Prodromus biljnih zajednica Crne Gore" (Blečić and Lakušić, 1976). According to this authors, in the vertical profile of the Basin it is possible to distinguish several climatogenic vegetation zones, such as:

- Vegetation of broadleaf deciduous forests in the sub-Mediterranean, hilly, mountainous and sub-mountainous zones (QUERCO-FAGETEA Br.-Bl. et Vlieger 1937.),
- Vegetation of wet and acid oak-beech forests (QUERCETEA ROBORI-PETRAEAE Br.-Bl. et Tx. 1943.),
- Vegetation of riparian coppices, and willow and poplar forests (SALICETALIA PURPUREAE Moor 1958). Between Zaton and Andrijevića there is a community of willow and heather with endemic tertiary-relict species *Myricaria ernesti mayeri* Lakušić.
- Vegetation of dark coniferous forests (VACCINIO-PICEETEA Br.-Bl. 39.),
- Vegetation of fallow (deforested) land, and land where the fire was, in the hilly, mountainous and sub-mountainous zones (EPILOBIETEA ANGUSTIFOLII Tx et Prsg. 50.),
- Hygrophilous forests of black alder and coppices of swamp willow (ALNETEA GLUTINOSAE Br.-Bl. et Tx. 1943.),
- Vegetation of mountain swards on acid soils (CARICETEA CURVULAE Br.-Bl. 48.),
- Vegetation of mountain swards on limestones (ELYNO-SESLERIETEA Br.-Bl. 48.),
- Vegetation around glaciers (SALICETEA HERBACEAE Br.-Bl. 47.),
- Vegetation of mesophilic meadows (ARRHENATHERETEA Br.-Bl. 1947.),
- Vegetation of xerophilous meadows in continental areas (FESTUCO-BROMETEA Br.-Bl. Et Tx. 43.), i dr.

From the general picture of vegetation of the location wider area, it can be seen that many plant communities grow here. Those communities are composed of a large number of species, some of which are rare and endemic, such as Mayer's false tamarisk (*Myricaria ernesti mayeri*). When this picture is simplified and in its greater part translated from the professional to the "economic aspect", then it can be said that going from Lim Riverside toward mountain peaks, shifts of the following zones appear:

- riparian forests and coppices composed of alder (*Alnus* sp.), poplar (*Populus* sp.), willow (*Salix* sp.) etc., that do not have a significant economic value;

- forests of various broadleaves where oak is dominant (*Quercus* sp., i.e. Hungarian Oak, English Oak and *cerris*), but hornbeam (*Ostrya carpinifolia*, *Carpinus betulus*), ash (*Fraxinus* sp.), maple (*Acer* sp.) etc. are also present; these forests are much degraded;
- Mesophilic, mountain meadows which are partly converted into arable land (near the houses), and partly are mowed and used for cattle grazing; many medicinal (and other) herbaceous plants grow on them, as well as fungi that are economically significant;
- Beech forests (*Fagus sylvatica*) that used to be widespread in this area, but now they are much degraded; besides beech these forests contain other deciduous trees (hornbeam, maple, birch,...);
- Mixed, deciduous-coniferous forest whose edificators are beech (*Fagus sylvatica*), fir (*Abies alba*) and spruce (*Picea abies*); they are very significant for the development of forestry and wood industry;
- Coniferous forests with dominant fir (*Abies alba*) and spruce trees (*Picea abies*), are also important in wood industry; in higher limestone areas dwarf pine (*Pinus mugo*) occurs, which has no economic importance;
- Mountain pastures, which are substantially present on all mountains of this area; they are significant for the development of summer cattle breeding and winter tourism especially on Bjelasica and Cmiljevica.

Having visited the subject location, it has not been found that species protected by Montenegrin Law ("Official Gazette, No76/2006") grow there.

The subject location is fringed with riparian vegetation consisting of a thick herbaceous and woody plants, mainly willow (*Salix* sp.), alder (*Alnus* sp.), heather (*Myricaria* sp.), poplar (*Populus* sp.), hornbeam (*Carpinus betulus*), maple (*Acer* sp.), *Rhamnus fallax*, as well as individual acacia (*Robinia pseudoacacia*) and mulberry trees (*Morus alba*), then lily *Clematis vitalba*, wild rose (*Rosa canina*), blackberries (*Rubus fruticosus*), hawthorn (*Crataegus monogyna*) etc. In the level of herbaceous plants, closer to water there are horsetail (*Equisetum* sp.), *Telekia speciosa*, *Petasites* sp., mint (*Mentha* sp.), sedge (*Carex* sp.), *Polygonum lapathifolium* (Figure 11.) etc. Farther away from the riverside, numerous species of grass grow, such as: (*Poa* sp., *Festuca* sp., ...), dandelion (*Taraxacum officinale*), yarrow (*Achillea* sp.), clover (*Trifolium* sp.), plantain (*Plantago* sp.), geranium (*Geranium* sp.), *Dipsacus* sp. (Figure 12.), mullein (*Verbascum* sp.), *Erodium cicutarium*, nettle (*Urtica dioica*), buttercup (*Ranunculus* sp.), shepherd's-purse (*Capsella bursa-pastoris*), coltsfoot (*Tussilago farfara*) (Figure 13.), and mosses *Bryum argenteum*, *Bryum capillare* etc. Apart from acacia, *Aster novi-belgii* has been recorded of the adventive species (Figure 14).



Figure 11. *Polygonum lapathifolium*, common species at subject location.



Figure 12. *Dipsacus* sp., also common species at subject location.



Figure 13. Podbel, *Tusillago farfara*



Figure 14. *Aster novi-belgii*, invazivna vrsta.

Fauna

Since faunistic researches have not been done on the subject area and its surrounding, data given in this section of the Study are based on the literature data of wider area (Lima Basin, area of Bjelasica mountain).

For the subject area (its narrow and wide environment) it could be said that is inhabited by numerous and various animal species. Mammals, birds, reptiles, amphibians, numerous invertebrates, live here.

Forests are an important habitats for puny and beefy mammals and birds. Some of them are scarce, and rarely could be seen, such as bear (*Ursus arctoa*). Wolf (*Canis lupus*), fox (*Vulpes vulpes*), deer (*Cervus elaphus*), doe (*Capreolus capreolus*), boar (*Sus scrofa*) live here, as well as puny mammals such as: rabbit (*Lepus europaeus*), badger (*Meles meles*), marten (*Martes* sp.), squirrel (*Sciuris vulgaris*), dormouse (*Glis glis*), bat (Chiroptera, genus *Myotis* – all protected by law), hedgehog (*Erinaceus europaeus*), mole (*Talpa* sp.), shrew (*Sorex* sp., *Crocidura* sp., *Neomys fodiens* - water shrew), house mouse (*Mus musculus*), wood mouse (*Apodemus flavicollis*), vole (*Microtus* sp.), ... Tawny owl (*Strix aluco*), long-eared owl (*Asio otus*), buzzard (*Buteo buteo*), woodpecker (*Dendrocopos* sp.), spotted nutcracker (*Nucifraga caryocatactes*), ring ouzel (*Turdus torquatus*), kestrel

(*Falco tinnuculus*), chaffinch (*Fringilla coelebs*), raven (*Corvus corax*), jackdaw (*Corvus monedula*), siskin (*Carduelis carduelis*), cuckoo (*Cuculus canorus*), thrush (*Turdus merula*), great tit (*Parus major*), yellowhammer (*Emberiza citrinella*),... are the birds that live or fly over these areas (all of them are protected by law).

On the subject area, when reptiles are concerned, mostly lizards could be expected (for example *Podarcis muralis*, known as wall lizard, that lives under rocks and in places without dense vegetation, and that has numerous populations; green lizard, *Lacerta viridis*, numerous population) and snakes (horned viper, *Vipera ammodytes*; adder, *Vipera berus*; then *Zamenis longissima* and dice snake, *Natrix tessellate* that has small population). Amphibians generally prefer moist or aquatic habitats. Frog genus *Rana* or *Bombina scabra* could be found here. Their habitats are small puddles next to the water flow, although they have small population. All above mentioned species are protected by law.

Ichthyofauna of some water stream (composition of fish population, prevalence of certain species), depends on complex of factors, both natural and anthropogenic. It is primarily thought of the following: impact of waste water on populated areas, the extraction of gravel from the river bed, and the intensity of fishing on one side, and measures taken to promote and protect fish habitats on the other side. The following fish species live in Lim Basin (Information on environmental state in 2011, Agency for Protection of Montenegrin Environment):

- Rainbow trout (*Oncorhynchus mykiss*), the invasive sort that could be found in all habitats, except whirlpools. It has reached Lim (and its tributaries) by restocking of unautochthonous material, and fortunately it is the sort that by nature does not spawn in the rivers, so the population has not been established. This improper restocking could endanger the river by bringing in it a sort that freely spawns in wilderness, so it could establish the population what brings it in competition with autochthonous brown trout.
- Huchen trout (*Hucho hucho*), lives mainly in whirlpools below the rocks, except when it goes for food in overflows or quiet parts of the river. It is protected by law in Montenegro.
- Grayling (*Thymallus thymallus*), lives in whirlpools and in the centre of quiet parts of the river.
- Nase (*Chondrostoma nasus*) could be found in deeper and quiet parts of the river, and smaller specimens along the riverside and riverside rocks.
- Barbel (*Barbus* sp.) is widespread in this basin. Specimens could be found in all parts of the river, and bigger specimens in the middle of quiet parts of the river and whirlpools.
- Balkan Loach (*Cobitis elongata*), lives in all parts of Lim and lower parts of its tributaries, as well as in places with muddy substrate.
- Weather Loach (*Sabanejewia* sp.), is found in Lim beneath Berane as well as in Vinička Rijeka. Like Balkan Loach, it lives in all places with muddy substrate.
- Brown trout (*Salmo trutta*), lives in Lim and its tributaries.

Many invertebrates species live in the subject area and its narrow and wide environment, but insects are dominant (representatives: Plecoptera, Trichoptera, Ephemeroptera, Diptera etc.). According to the literature and habitat features, we could expect that species found on the list of protected taxa live here. Some of them are butterflies *Papilio*

machaon and *Parnassius apollo*, stag beetle (*Lucanus cervus*), rhinoceros (*Oryctes nasicornis*), great capricorn beetle (*Cerambyx cerdo*), as well as leech *Dina lineata*, widely spread in the River Lim and its tributaries, etc. (Information on environmental state in 2011, Agency for Protection of Montenegrin Environment).

Protected Areas in the Municipality of Berane

Berane Municipality has two areas which are protected by national legislation. Those are: NP Biogradska gora and community of dwarf pines on Bjelasica which has the status of a Monument of Nature.

Bjelasica and NP “Biogradska gora” with their geographical position, geological structure, relief, climate, hydrography, diverse wildlife, are the unique biogeographical and ecological unit. Numerous endemic species and specific habitats are characteristic for the area. This is why the area is recognized as the IPA and IBA (important habitat for plants and birds), and potentially IFA (important habitat for fungi). Monkshood (*Aconitum toxicum*), docks (*Rumex balcanicus*), (*Pancicia serbica*), spotted orchid (*Dactylorhiza cordigera* subsp. *bosniaca*), (*Alchemilla velebitica*), (*Potentilla montenegrina*), (*Asperula doerflerii*),...- are endemic in this region. Over 700 species of mushrooms grow here, there are around 150 species of birds, 13 species of amphibians, 26 species of reptiles, 99 species of moths, 27 species of slugs, etc. There are 11 habitats on Biogradska gora, of all found in Appendix of First Bern Convention.

2.6. Landscape Characteristics

Every major landscape consists of four basic components: relief, vegetation, water, and all objects created by man. Diverse landscape is increasingly treated as a treasure and valuable possession of a country. The Spatial Plan of Montenegro until 2020, states 10 landscape types and 21 landscape units which are identified on the basis of biogeographical and ecological analyzes of space in Montenegro. Polimlje is a landscape unit which represents combination of exceptional natural values and local tradition through the use of space. This one, like the other landscape units was developed as reflection of cultural, historical and socio-economic circumstances of the region.

Polimlje landscape unit covers Lim Valley, from the lake of Plav to the entrance of Kumaracka gorge. Basic structural elements of landscape are following: Lim Valley, gorges, and expansions in the form of valleys along the river course.

Lim Valley has composite character and striking morphology, in which bigger and smaller valleys (such as: Plavska, Murinjska, Andrijevačka, Beranska, Zatonska, Bjelopolska) alternate with gorges (such as: Sutjeska, Tifran).

The gorge of Berane is the biggest expansion in the Valley of Lim. Impressive Tifran gorge was formed to the north of Berane. Downstream, Lim flows into the Valley of Bijelo Polje. Relatively low hills and plateaus rise along the rims of the valleys. The terrain is intersected by numerous narrow, relatively deep valleys of little rivers and streams which make up a dense valleys network.

Landscape is complemented by inundated forests and coppices. Those are mainly coppices of willows, poplars, alders spread in the form of narrow strip along the watercourses. The ones with myricaria are particularly interesting because it makes the appearance of the area typical, especially in the flowering season. Inundated coppices

should be protected from further degradation because of their function in ambiance and reclamation.

This picturesque and dynamic landscape is cultivated, and it has predominant rural character. Due to urbanization, landscape in the area of Berane has changed a lot, and it has the character of the built landscape.

2.7. Review of Protected Cultural Heritage

On the territory of Berane Municipality there is a great number of cultural and historical monuments dating back from the Middle Ages all to the present time.

The Museum of Polimlje in Berane has so far registered around 150 cultural monuments and archaeological sites in the area of Polimlje, and there are 4 cultural monuments protected by national legislation in Berane:

- "Beran krš" in the village Beranselo (Neocene),
- Monastery Djurdjevi Stupovi in Berane (XIII century),
- Monastery Sudikova in Tifran Gorge (XIV century) and
- Monastery Celijski in Kaludra (XIV century).

The most significant and the oldest preserved cultural monument is Monastery Djurdjevi Stupovi that was built up in 1212 by prefect Prvoslav. Together with St George Church, it was the spiritual and cultural centre in time of Nemanjic Dynasty, and later on. Besides Monastery Djurdjevi Stupovi, a great cultural and historical value has restored Monastery "Šudikova". It was a famous shrine and cultural centre.

Remains of buildings from the Roman period are near the town, i.e. two kilometers from the town centre is "Roman castrum". In memory of the victims from liberation Balkan Wars, as well as from the First and Second World Wars, several memorials were built on the territory of the Municipality, but the most famous is "Spomenik slobode" ("Monument of Freedom") on the hill Jasikovac, a kilometer far from the town centre. Of the written cultural heritage in Berane, best known to a science is "Moračka krmčija" written by Bishop Teofil in 1252.

In the part of the zone where the location anticipated for facility construction is, as well as in its surrounding, there are neither facilities nor assets from cultural heritage that is protected by law.

2.8. Population Density

According to censuses that were carried out between 1948 and 2011 (Statistic Yearbook of Montenegro 2011) population in Berane ranged among numbers as shown in table 1.

Table 1. Population, households and square area of Berane municipality

Number of inhabitants								Square area km ²
1948	1953	1961	1971	1981	1991	2003	2011	
27.655	30.376	34.280	40.085	42.285	38.953	35.068	33.970	717
Number of households								
5.514	5.890	6.960	8.223	8.720	9.458	9.823	9.991	

From the above data in Table 1. it can be seen that there was an increase in Berane population from 1948 to 1981, and from 1991 it began to fall down, while the number of households grew steadily but slightly in a given period. However, there was also a decline in number of members per household from 1991 and in 2011 it was 3,40 members.

According to census from 2011, population density in Berane Municipality was 49,05 inhabitants per 1 km². Biggest population is in the very town and its close surroundings. Settlements in the Valley of Lim have around 14.000 inhabitants, and it is the space which together with the town makes the area of potential development in Berane.

It should be noted that the definition of permanent population differs between the censuses of 2003 and 2011, and previous censuses. In the previous censuses, beside in-country population, Montenegrin citizens at temporary work abroad, as well as their family members living with them abroad were counted as permanent inhabitants.

This methodology change has caused smaller number of inhabitants in the municipality according to two last censuses, because citizens working abroad longer than a year have not been counted.

However, many non-resident Montenegrin citizens are coming back in the summer, which is also characteristic for Berane, so the number of inhabitants in Berane increases in the summer for about 5.000, which is very important for designing of WWTP.

Gender structure of the population according to Census from 2011, shown in Table 2.

Table 2. *Gender and age structure of the population in Berane municipality*

Place	Total population	Male	Female
Berane	33.970	17.087	16.883

Structure of working population in some economy branches based on statistic data from the Census 2003, shown in Table 3 (Statistic Yearbook of Montenegro 2011).

Table 3. *Working population per economy branches in Berane municipality*

Year	Economy branches						
	Agriculture, hunting, forestry,	Manufacturing	Transport, storage, communication	Public administration and social security	Education	Health and social work	Financial Intermediation
2003	778	1089	513	1030	883	624	513

From the above data in the table, it can be seen that most of the population worked in manufacturing, public administration and education.

Close surrounding of the location, at 100m distance, is unpopulated, while wider surrounding, on the south and west sides of the location (settlements Donji Tulum i Banjevac) has relatively high population density.

2.9. Existing Properties and the Infrastructure

Berane – Ribarevina highway is on the west side of the location, 150 to 200m distanced, and the settlement Beranselo with a high number of individual residential objects follows. The individual residential objects are 200 to 300m distanced from the location. The settlement Donji Tulum is on the location south side, whose first objects are 100m far from the location. The River Lim is on the east side of the location, 50 to 100m distanced, and on its right bank is paper factory "Nova Beranka", around 500m far from the location, while Tivran Gorge is in the north.

It is possible to access the site by local road running through the settlement Donji Talum, but its technical and exploitation characteristics do not correspond to the future needs of the location, because it is a narrow street with houses very close to the edge of the road. Large vehicles would not be able to use this road and broadening of the road would be difficult as there is very limited space available.

To avoid the above issues, for needs of construction and operation of WWTP it is proposed to construct a separate access road that would pass through the unpopulated part to the location.

Other infrastructure facilities in the location surrounding are water and electricity supply networks, telephone networks, so the location can be connected to the necessary infrastructure.

3. DESCRIPTION OF THE PROJECT

3.1. Basic parameters

The existing sewerage system in Berane was made on both sides of the River Lim, and waste water from the system, without previous treatment, were discharged through three outlets into the river. From the total number of population around 40% are connected to the sewerage network, i.e. around 85 % of urban area.

Construction of waste water treatment plant and sewage system was planned for Berane according to the concept of the Strategic Master Plan for sewage system and waste water in the central and northern regions of Montenegro (adopted by Montenegrin Government in 2005). The concept defines the issue of waste water management by 2025, in accordance with the European Union Directive (271/91 EEC).

The main objective of WWTP construction is to reduce pollution in Berane and in Lim river, caused by the lack of a complete wastewater collection system, and particularly by the lack of wastewater treatment. The biggest problem is certainly the discharge of untreated waste water into Lim, that is both, significant river pollution (especially when the water level is low), and treat to water sources downstream from the town. There are also a number of septic tanks in certain parts of the town, discharging effluent to the ground and sometimes to open streams.

The Design for Wastewater Treatment Plant was based on 27.000 population equivalent, and 22.500 people from household category. The connected population at present is around 12.000, and the rate at which this increase will depend largely on the development of the wastewater collection system. For the Minimum Project, the population connected is projected to reach 14.050 in 2015, and growth beyond this depends on extension of the collection system. For the Base Project, the population connected is projected to reach 16.210 in 2015, and growth beyond this again depends on extension of the collection system. In the case of the Maximum Project the population connected is projected to reach 19.450 in 2015, and 22.500 by 2035. Unless the Maximum Project is implemented initially, it is clear that the implementation of the WWTP should be phased to avoid providing excessive overcapacity, particularly if the wastewater flows and loads received at the treatment plant do not increase as fast as assumed.

Designs have therefore also been prepared for a Minimum WWTP which is designed for a population equivalent of 17.750 (14.050 connected population) and a Phase 1 for the WWTP (Base Project) which is designed for a population equivalent of 20.000 (16.210 connected population). The storm tank that is included in the full design has been omitted from the Minimum and Phase 1 designs. To further reduce the initial cost of the Minimum WWTP the process parameters have been amended so that Nitrogen and Phosphorus removal is reduced. Both the Phase 1 and the full WWTPs include Nitrogen and Phosphorus removal to the level required by Montenegrin and EC regulations.

Concept of the solution and organization of Waste Water Treatment Plant complex, are based on the implementation of technical, technological and organizational measures for providing environmental and health protection, with rational space use and investments, and in the same time respecting current regulations and technical norms, as well as basic principles of Strategy for sustainable development.

3.2. Description of the Previous Preparatory Works

Before the project realization, certain preparatory works need to be done. After the location is thoroughly identified, it is necessary to fence it, that is, mark the place of construction for each segment, actually, each square area occupied by buildings.

Square area to be engaged in the implementation of the project is around 10.000 m², and square area to be occupied by WWTP is around 4.122 m².

3.2.1. Description of the Road Route

Existing access to the WWTP site, through the Donji Talum settlement, is not appropriate, because it is a narrow street with housing very near the kerb of the road. Large vehicles would not be able to use this road and broadening of the road would be difficult as there is very limited space available. There is no pavement for pedestrians, so they use the road. Large number of pedestrians consists of children and elderly. This would pose risk of injuries during construction of the collector and during construction and operation of the WWTP.

To avoid the above issues, for needs of construction and operation of WWTP it is proposed to construct a separate access road that would be the extension of Obalska street which is primary traffic artery. The road would run through a meadow, and would go up by the slope toward the main road. Passing under the main road it is connected to the roundabout which is going to be constructed from the west side of the main road, and which will enable in the same time the connection between the city roads in the region, and connection with main road M – 2 (Berane-Ribarevina) (Figure 15). The access road is around 300m long.



Figure 15. The main collector and access road to WWTP

The extension of Obalska Street is designed with cross-section that is composed of roadway 7,0m wide, and both sides sidewalk 2,0m wide. The entrance of the WWTP location is planned as two-way road with roadway width 6,0 m, and rounding radius that allows turning of heavy goods vehicles. From the highway to the location the road passes through inhabited area, close to it are just two individual houses and they would not suffer significant adverse effects (noise, odours) because of low traffic frequency.

Construction parts for this kind of road are made of:

- Asphalt-concrete layer 5 cm,
- Bituminous supporting layer..... 10 cm
- Buffer layer 35 – 50 cm.

At the point where the road passes over filled area, segmental concrete channels are planned. The channels collect and carry away water from the terrain slopes, to road drains and further till the recipient.

3.2.2. Preparatory Works for Facility Construction

Before the construction starts, building site has to be secured against unauthorized access and passing persons other than employees engaged on project realization, surveillance workers, inspection workers, and Investor representatives. The building site has to be fenced because of unauthorized access.

Preliminary work includes a range of activities required for all tasks completion. Plan of organization anticipates continuous construction. All anticipated preparatory works are adjusted to continuous tasks performance.

Before the work starts and during setting up of the building site, it is necessary to provide temporary objects, as well as all infrastructures necessary for tasks performance.

The contractor is required to arrange setting up of the building site, so that its temporary buildings, machinery, equipment, etc do not affect the third party.

After the work completion, the contractor shall remove all temporary objects set for construction, and restore all the terrain, or restore it like it has been shown in tender documentation.

Loading area used for loading and unloading of construction material, should be provided. Traffic speed on the road toward the facility shall be limited to 10 km/h, and if required it could be lower.

According to the type of work being done on the building site, all the construction machinery and work means should be set on the safe – appropriate place. To use the work means, it is necessary to obtain, from the authorities, the appropriate documentation on implementation of safety measures and regulations. Only professionally trained person, who complies with the certain technical and medical requirements, on which the record has to be kept, can use and maintain the work means. All the construction machinery and vehicles have to be equipped with fire extinguishers.

According to the construction type and techniques, electric power and lighting are necessary on the building site. Each machine has to be equipped with a switch for its starting or shutting down, and electric cables shall be protected from mechanical loads. All electric devices shall be protected against overvoltage contact by one of the safety measures (protective earthing, neutralization, breakers, etc), and before starting the device, the protecting control shall be done. All elements of electric power distribution shall be installed in appropriate distribution cubicle, which is set outside the communications, on a firm surface, and it is secured against knocking over, and always

locked. Cables and free leads have to be set in a way that they are not passed over, or do not hinder the passage or access, but in case when this can not be avoided, they are enclosed into a solid mechanical protection or lifted to a certain height.

Building site has to be supplied with water, according to current regulations, and telephone connections.

In order to create working conditions for technical and other staff, offices are built on the building site. The offices are usually of the container type.

Building site organization scheme closely defines spatial assumptions for performing the preparatory work.

Preparatory works primarily include earthwork on foundation digging, filling activities, delivery of construction material, as well as concrete and reinforced concrete works.

- **Earthwork** includes foundation digging, and it is going to be performed by mechanical means, in accordance with technical description, and priced bill of quantities. Excavated soil, in one its part, shall be used for flattening of the terrain, and the rest is going to be transported to the location intended for that purpose.

In order to prevent soil collapse, foundation dig should be secured during digging up by propping it up, if the need for that arises.

If historic or prehistoric monuments or unexploded mines are found during digging up, the contractor shall immediately inform the Investor and authorities. Unexploded mines have to be deactivated, taken away from the construction zone, and destroyed by qualified persons.

- **Filling activities** are intended for raising the location height, since the existing terrain level is flood prone. Filling activities include groundwork, spilling and spreading the material over the location, possible wetting and compressing of the material in the embankment to the dimensions given in the Design. Filling of the material is done in 30cm thick layers, and each layer is compressed to required density. Light vibrating machinery is used for compressing. Filling material should be free from splinters, roots, grass, and other organic items.

Together with the location arrangement and filling activities until the required elevation is achieved, cleaning and stabilization shall be done in the parts of Lim and Makva courses within the subject area.

- **Transport of the construction material** will be in accordance with its delivery program, within fixed time lines and quantities.

- Gravel (granular and natural),
- reinforcement,
- timber (planks, baulks),
- concrete
- steel structure (columns and sections).

Carry out construction material delivery in a way to avoid further pollution of the environment, actually lower the pollution to the minimum.

Performing of construction works does not pollute the environment, but in case of noise, vibrations, work in the night lighting, dust, occurrence of groundwater or other side effects, that could endanger surrounding area and population, certain measures for their elimination or limitation are taken.

- **Concrete and reinforced concrete works** are done in accordance with current regulations. Portland cement, which complies with SRPS B6.1011/1975 standard, will be used for all concrete and reinforced concrete works.

Concrete transport has to be done in accordance with the current regulations. Quality control of concrete and its components is done in the place of its preparation, installation,

and in the very construction where the concrete is already installed.

For reinforced concrete constructions, the Design anticipates the use of normal round profile concrete reinforcing steel, reinforcement networks, and corrugated steel.

Cold rolled steel bars, twisted bars, hardly drawn steel wire and high-toned mesh reinforcement are in accordance with the requirements SRPS C.KG.020, SRPS C.KG.120 and SRPS U.M1.091.

Recapitulation of earthwork:

- Excavated material..... around 8.200 m³
- Filled material..... around 25.000 m³,

Building site organization scheme closely defines workers and machinery necessary for realization of the building, as well as execution schedule for all stages of realization, such as: preparation, construction and starting of the facility.

3.3. Detailed Description of the Design

3.3.1. Wastewater Treatment

Feasibility Study for Water and Wastewater Development Project in Berane (WYG International, 2010), reviews the possibilities for secondary treatment of wastewater such as:

- Lagoon or constructed wetland
- Attached and suspended growth.

Attached and suspended growth system with a process using Suspended growth – Sequential Biological Reactor (SBR) within it, was chosen as better solution for Berane. Advantages of Sequential Biological Reactor are: occupation of small space, settlement tanks and sludge recycle are not necessary, and disadvantages are: high automation requirement, relatively complex control and drainage systems.

The Phase 1 design includes 75% capacity of the SBR tanks planned for 2035 but, as mentioned above, excludes the storm tank.

Starting with the conditions of the site, the amount of waste water to be treated in WWTP, and complying with the current regulations and laws for this kind of objects, content of the complex and object spatial arrangement are defined and shown on Figure 16. Layout is given in Graphical Documentation (Appendix).

• **Unit with the screen** is the first working unit that participates in the process of wastewater treatment after its pumping, and it serves for removal of sewage coarse waste, such as: rags, wickers, tampons, cans, fruits, etc., which are brought to the WWTP by inflow of wastewater.

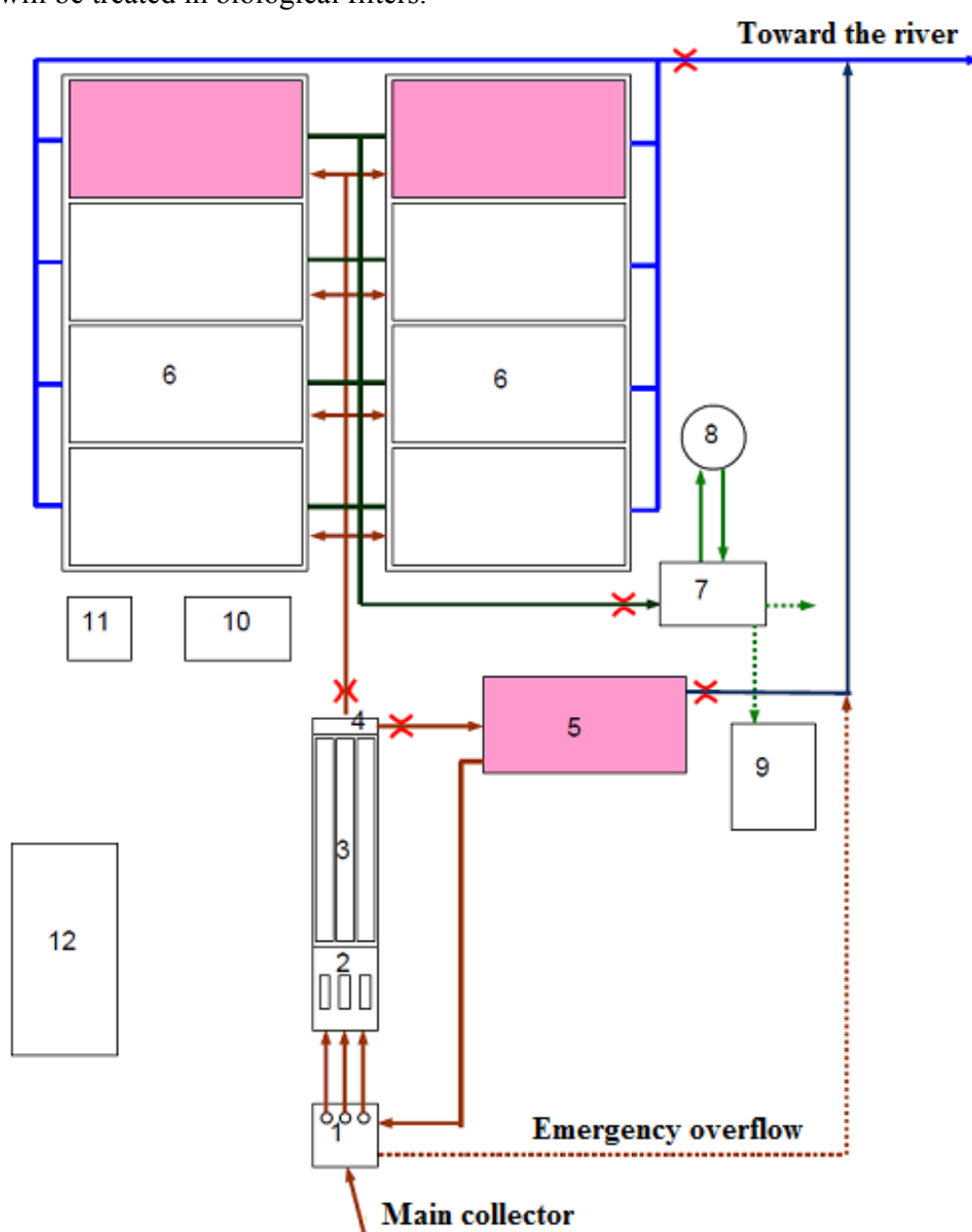
The screen protects the pump, valves, pipeline and other Plant accessories from damage or blockage caused by coarse material, and also lowers the possibility that blockage interferes work of following units for biological treatment.

The screen will be made of stainless steel, and it will be closed from all four sides. Unimpeded access to all mechanical parts will be provided for maintenance. The screen work is automated and connected to up thrust of wastewater, which passes through the screen. In case of the screen breakdown or its work failure, ancillary roundabout channels with coarse screen to be cleaned manually, are placed parallelly.

Part of the treatment plant with the screen will be also equipped with a press for compressing separated material, and with devices for transport of the material to the

containers. Waste material will be transported regularly to public sanitary landfill intended for final disposal.

Units with the screen will be covered in order to prevent odours spreading. Air from these units will be treated in biological filters.



1	Inlet pump station	9	Dewatered sludge storage
2	Fine screens	10	Air blower house
3	Grit and grease removal	11	Electricity substation
4	Overflow chamber	12	Office and laboratory
5	Storm tank		Phase 1 structures
6	SBR tanks		Phase 2 structures
7	Sludge thickening/dewatering	X	Flowmeters
8	Sludge buffer storage tank		

Figure 16. Layout of WWTP

- **Sand and grease removal**, extraction of the gravel will be performed in two aerated sand traps. Long aerated sand traps have been chosen, with movable bridges and aeration system using large bubbles. The system reaches constant speed of horizontal flow < 0.2 m/s, and the retention time of > 5 min in rainy weather. It allows separation of bigger minerals such as sand and gravel, and retention of organic suspended substances into wastewater, in order to obtain well-washed sand.

Grease collectors, which are integral part of the movable bridges, collect floating oil and fat from the upper part, which is usually at the end of the chamber for extracting of gravel and grease, and from there, they could be collected with sucking trucks. Deposited material from the bottom of aerated sand trap is brought to the channel by pumps, and through channel, it comes down to the sand classifier.

Sand and gravel are washed in this unit, in order to reduce the content of organic substances, because sand, which is not well washed and contains organic materials, can spread odours, which attract insects. Water excess left from sand washing is returned into the process. Rejected material will be transported regularly to public sanitary landfill intended for final disposal. Wastewater from sand trap will flow away into a separation chamber and further into a retention tank.

With the aim to prevent the spreading of the unpleasant smells, parts of the plant, unit with a screen and sand trap together with a grease trap shall be enclosed in an object built up and covered with a solid material chosen by the designer. Air from these units will be collected and treated in the devices for biological treatment.

- **The SBR process** is a very flexible process that is capable of producing high quality treated effluent. The small land requirement for the process is a particular advantage for Berane where the available land for the treatment plant is very limited. Although the SBR process is somewhat more complex to maintain than some processes due to the extensive automated control systems, it is not considered that this should present any great problem to ViK given the proper training from the supplier.

Waste water from the mechanical treatment (coarse and fine screen, grit and grease removal) gravitationally enters in the contact tank and alternately flows away through pipelines into Sequential Biological tanks (SBR reactors). According to Study of Justifiability, 4 is total number of these tanks in the first phase, and later on 2 more are planned to be built, in the second phase. Contact tank is equipped with a mixer, and recirculated waste water with sludge is injected in it. Purpose of the contact tank is to increase biological removal of phosphorus. For additional phosphorus removal, coagulant solution is dosed into the contact tank.

SBR technology with activated sludge is based on the principle "fill and empty". Proceedings of aeration (nitrification), denitrification, and settlement are performed one after another in the same tank.

Steps of a typical SBR proceeding for waste water treatment include filling of the tank with waste water, aeration of waste water, in order to organic matters turn themselves into growth (biomass), and after that follows a period of rest for settle, and at the end discharge of settled effluent. Further steps could be added in order to ensure anoxic and anaerobic conditions necessary for removal of nutrients. After discharge, period of rest is enabled in order to obtain flexibility and safety since inflow has to be redirected into empty tank while aeration, settling, and discharge are performed in the other tanks. A key element of SBR process is keeping a most of the settled sludge for next cycle in the tank,

thus avoiding the need for pump for sludge recirculation which is the case with conventional aeration schemes.

Typical characteristics of the SBR process are given in the Table 4., and its scheme in Figure 17.

Table 4. *Characteristics of the SBR process*

Steps in the process	Purpose	Operation -Aeration	Maximum volume (%)	Cycle time (%)
charging	Substrate adding	Air incl / excl	25 - 100	25
reaction	Biological decomposition	air – mixing	100	35
settling	clarification	Air excluded	100	20
discharging	dewatering	Air excluded	35 -100	15
quiescence	sludge	Air incl / excl	25 - 35	5

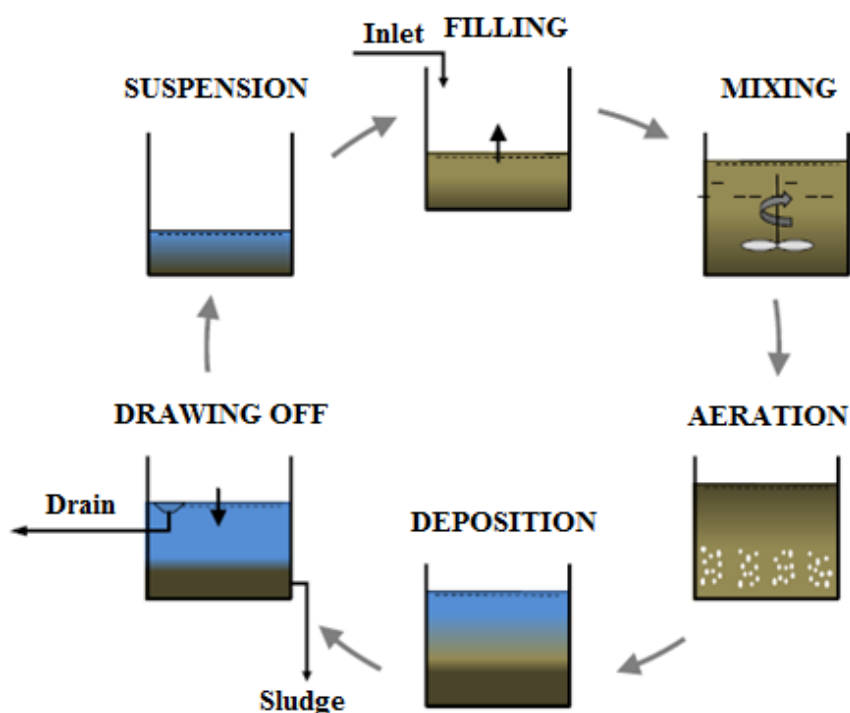


Figure17. *Cycle of SBR process*

In SBR tanks, waste water is treated by microorganisms, contained in activated sludge. In the presence of air, microorganisms remove the organic load. In the SBR tanks, nitrification and denitrification are also performed, and they are required for biological removal of nitrogen compounds. In the process of nitrification, due to air pumped in, oxidation of nitrogen from ammonia occurs, and ammonia is converted into a nitrate.

In the process of denitrification, with the absence of air, nitrate is reduced to gaseous nitrogen, by organic compounds which are present in waste water.

Air for waste water aeration is provided by a special thrust pipeline and through electric valves the air is routed to the individual tanks. Control of the electric valves is done through automation.

The initial operation cycle of sequential tanks is anticipated, and during the process it is easily changed and adjusted to a variable load which can occur in the plant.

Operation cycle of each sequential tank is roughly composed of the following phases: charging, settling and discharging. In the discharging phase, treated water is collected from the surface, and excess sludge is stored. Cycle of each SBR tank lasts around 4 hours. SBR tanks work in intervals – while one reactor is being charged with a new amount of waste water, the rest are aerated, settled or discharged. Reactors operation is optimized in a way that incoming waste water are always accepted in one of the tanks at any time. Daily, each of the reactors undergoes a total of six full cycles. In the second phase two more equal SBR reactors shall be constructed, and they shall have equal volumes and operation cycles.

For the purpose of aeration (air insertion), at the bottom of the SBR reactor, membrane diffusers are installed, and by fine, bubble jet they insert air together with the oxygen in waste water. Insertion of air into aeration tank is regulated via an oxygen probe. Depending on the oxygen amount dissolved in water, oxygen probe through automation affects the regulation and operation of blowers.

SBR tanks are equipped with submersible mixers, which provide mixing of waste water with sludge, and denitrification. For the purpose of mixing and in order to prevent settling of activated sludge, two mixers are installed in SBR tank.

Overflow from the device is provided with electric overflow grooves which are placed in overflow manhole. Overflow is regulated by electric motor which is controlled by automation and gauge of waste water level in the SBR tank.

For the calculation of SBR tank 18 days old sludge is adopted, because that period allows nitrification and denitrification of waste water. 4 mg/l is adopted concentration of sludge in SBR tanks.

Treated waste water gravitationally flows out from SBR reactor through a measuring channel. Following equipment is installed in the measuring channel: magnetic flow meter, object for by-passing of the effluent, and automatic sampling station with a section for cooling where the samples will be stored. An ultrasound probe measures water level in Ventur channel, and calculates it automatically in waste water flow rate. In the measuring channel an automatic sampler for submersible pumps used for technical water, is installed.

The submersible pump for technical water pumps treated waste water through an automatic filter, and further to a tank for technical water. The automatic filter removes possible mechanical impurities, and has a built-in system for automatic washing of the filter network. The system is turned on when differential pressure rises on the filter. The tank for technical water has 10 m³ volume. Technical water from the tank is transported through a hydraulic accumulator to a system for division of technical water. Technical water is used on the coarse and fine screens, for flocculant preparation, and for washing of centrifuge.

The hydraulic accumulator is automatically turned on when the pressure falls in the system. UV disinfection is installed on the thrust pipeline. UV disinfection has installed lamps for emitting UV light, which destroys microorganisms.

The Montenegrin Regulation on quality and sanitary technical requirements for wastewater discharge to the recipient and public sewer system, method and procedure for wastewater quality inspection, minimum number of inspections, and the content of reports on determined wastewater quality (Official Gazette of Montenegro No 45/08), and Rulebook amending the Rulebook (Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12), requires

secondary (biological) treatment of the wastewater until the following standards for discharge into a surface water recipient of second category are obtained:

- Biochemical Oxygen Demand (BOD5)* 40 mg O₂/l,
- Chemical Oxygen Demand* 125 mg O₂/l,
- Suspended Solids* 60 mg/l,
- Total Nitrogen 15 mg N/l,
- Total Phosphorus 2 mgP/l
- Total coliform bacteria 10.000 TC/100 ml and
- Fecal coliform bacteria 5.000 FC/100 ml.

*(These standards have to be met on a 95% basis)

These standards are similar to the EC Urban Wastewater Treatment Directive (91/271/EEC) standards for a p.e. of 10,000 to 100,000 discharging to a sensitive area. The standards for this situation are:

- Biochemical Oxygen Demand (BOD5)* 25 mg O₂/l,
- Chemical Oxygen Demand* 125 mg O₂/l,
- Suspended Solids* 35 mg/l,
- Total Nitrogen 10 mgN/l and
- Total Phosphorus 1 mgP/l.

*(These standards have to be met on a 95% basis)

In order to meet the total N and P standards, a high quality effluent would be required, should achieve BOD5 below 15 mg/l and suspended solids standards below 20 mg/l respectively.

Within the plant, dispensing station for additives is installed, and they are going to be added to wastewater in the bioreactor, in order to improve sludge deposition and reduce sludge volume index. Chemical additives are stored in polyethylene tanks, and they are added to the wastewater by dosing pumps.

Inner mains and reinforcements between each treatment unit (wastewater, sewage waste, sludge are treated), all main connections between each system for disposal (drainage water, sludge liquid are disposed), and inner pipeline are made of polyethylene.

Effluent from the WWTP passes through the measuring station containing a magnetic flow meter, (of immersing kind) and automatic sampling station.

After all above mentioned phases treated wastewater goes into a pipeline for the evacuation of the effluent, on the east side of the plant, and from there into Lim by free fall..

3.3.2. Treatment and Disposal of the Sludge

Sludge is product obtained from the process of wastewater treatment, which should be treated properly, and later disposed safely. From the experience, around 70-80% of organic carbon turns into dry, solid material during biological treatment in the plants. The obtained deposition – sludge is one of the toxic pollutants, environmentally harmful, and of very unpleasant smell. It absorbs and keeps in itself pathogenic organisms and toxic substances. The amount of sludge separated in the plant, depends primarily on quality of treated water, and on treatment technology itself. If the process is more complete, the amounts of sludge are larger. According to so far experiences, the amount of separated sludge ranges from 40 to 60g of dry content per equivalent inhabitant per day.

Sludge Treatment

Several very different methods of sludge treatment have been developed and demonstrated. They could be mutually combined in different ways, depending on the size of the device, and the way of further sludge usage. The aim is the same for all methods. Reduction of sludge volume, or removing as much water from the sludge as possible. To achieve that, the following processes are used: dewatering, sludge thickening and drying, sludge stabilization, sludge usage for economy purposes, sludge disposal and incineration.

Figures 18. and 19. show schemes of raw sludge treatment depending on whether it is used in agriculture after the treatment, or disposed on a landfill.

Sludge thickening is performed by gravity, deposition, or resurfacing in special deposition/settlement tanks where it stays for a day or day and a half. Gravitational thickeners can be static or dynamic, with all pertaining equipment and elements for collecting the sludge. Resurfacing is used for low-density sludge, and the process is facilitated by pumping of air.

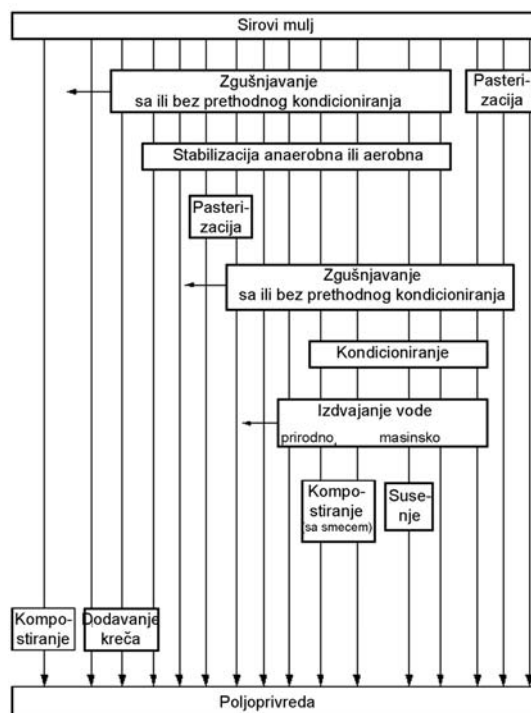


Figure 18. Stages in sludge processing – final use in agriculture

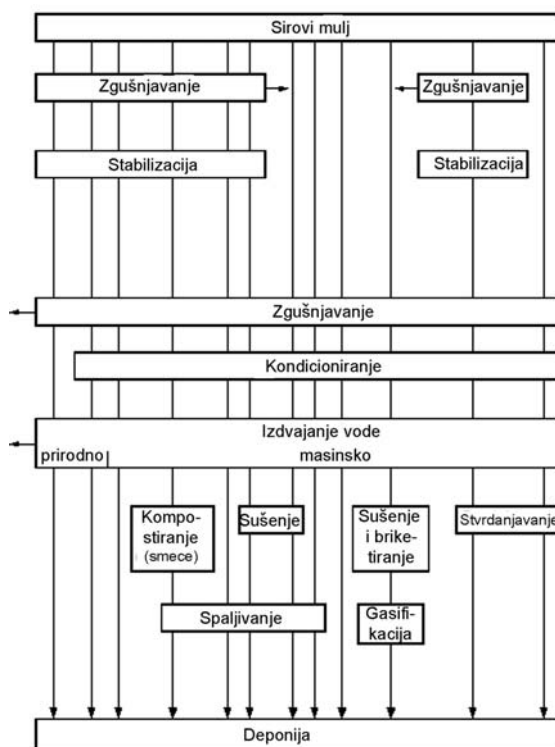


Figure 19. Stages in sludge processing – final disposal in landfill

Basic process in the whole sludge treatment is its stabilization. The stabilization prevents further sludge decomposition, and achieves better dewatering which provides its volume decrease. Biological sludge stabilization is most common in conventional devices for used-water treatment, but also chemical and thermal sludge stabilizations are used. Biological stabilization can be aerobic (simultaneously or independently of biological treatment process) and anaerobic (digestion, rotting). Chemical stabilization is done by adding lime or chlorine.

After thickening and stabilization, the sludge still contains a lot of water, and is not suitable for further processing. Therefore, sludge dewatering is done, whether naturally by disposing sludge on open fields where water evaporates, or artificially, on mechanical sieve using pressure or vacuum, or even on centrifuge for sludge.

After the conducted procedures, and before its final disposal, the sludge is treated thermally. Today, there is a number of combinations for thermal treatment of sludge, with wide variety of devices. Thus, there are furnaces with multiple hearths, so-called, wet incineration with variations, the process of pyrolysis at high temperatures (up to 1600 °C). Thermal sludge treatment is a particular field that is often related to incineration of urban solid waste.

Composting of sludge actually is aerobic decomposition of sludge performed by microorganisms. Its final product is compost, similar in characteristics to humus, and as such, it can be used in agriculture. Composting is usually performed in the open space, by mixing of sludge and municipal solid waste, which previously have to be inert substances free.

Disposing of sludge in the soil which has been previously prepared in a way that special filter layer (drainage and substrate) was made and sown with plants (commonly reed), has been a new method for final removal of sludge from the Plant, emphasized as effective.

This method is called "wet fields". Filter layer and sludge are habitats for plants and microorganisms that live in special symbiosis, allowing the decomposition and mineralization of sludge loaded there. Disposing of all kinds of sludge from classic devices for used-water treatment, can be done on these fields, as well as dewatering of sludge from septic tanks, lagoons, industrial waste water etc.

Compounds of nitrogen, phosphorus, heavy metals, and other toxic substances are removed effectively on these fields (70- 90 %). They also reduce the number of fecal and other bacteria (90-99 %). Electricity and mechanical equipment are generally not necessary for this system to operate. Operation and maintenance are simple, without much cost. With the increase in population, "wet fields" are simply expanded.

It should be emphasized that careful acting is necessary with the sludge usage and disposal, because there is a real danger of its harmful effect on the environment and human health. Consequences of improper use and disposal of sludge are listed below:

- pollution (eg. by heavy metals),
- human and animal infection with parasites,
- pollution of water resources and groundwater
- odour near the area of sludge application etc.

It takes work to improve the quality of sludge generated in WWTPs. The quality is enhanced by more efficient control of wastewater, and especially by control of pollution in industrial wastewater, if even that water gets into the Plant.

Sludge treatment method depends on its use or disposal. According to the Law on Waste Management (Official Gazette of Montenegro No 64/11) sludge can be used in:

- Agriculture
- Green areas and parks
- Land reclamation
- Landfills as the final coating layer and
- Making a specially purposed land, according to waste management plans and regulations on spatial planning.

Sludge may be used for these purposes provided that the following procedures are carried out: stabilization, proper preparation, application of biological, chemical, thermal, and other processes for reduction of sludge susceptibility to mineralization, and for elimination of danger to human health or the environment.

According to the Law on Waste Management, temporary disposal of sludge on the future landfill in Berane, in a form of a final coating layer, is suggested as most favourable solution for WWTP in Berane. If construction of WWTP completes before the construction of landfill, the use of sludge for land reclamation, primarily in forests, is suggested as an alternative solution.

Having in mind the above mentioned, the sludge generated in the wastewater treatment process will be subjected to retention and mechanical dehydration.

In order to obtain maximum flexibility in choosing sludge disposal methods applicable in Montenegro, and to select most economical way of disposal, lime stabilization is suggested within the process of sludge treatment. Lime is added to the dehydrated sludge before the disposal.

Sludge retention will be performed in the chambers for retention. The chamber is going to be designed in a way that it can receive sludge excess generated during 3 days of

treatment. It will be equipped with the driver for sludge homogenization, and with height adjustable devices for discharge of sludge liquid. It is necessary to predict even overflow. Sludge liquid will be transported into the separation chamber in front of retention pool. Thickened sludge excess is pumped out onto two parallel band filter presses for mechanical dehydration. Water extracted by sludge dewatering is returned into the treatment process. Line for bringing the sludge up to the filter presses will involve points for polymer injection. It will be also equipped with a stirrer, which will ensure well mixing of polymer with sludge, before it reaches the filter press. Polymer solution will be transported to the dosing unit, by dosing pumps. Dosing unit consists of the reservoir, which is divided into tank for mixing flocculants, and tank for flocculation.

Tank for mixing flocculants receives powder polymer. Sprayed water is added till certain level is reached in the tank for mixing flocculants. When the liquid is ready, it is transferred into the tank for flocculation, from where it is in certain amounts added to the process. Dehydrated sludge is discharged onto conveyor belt that transfers it into the pool for sludge disposal. Storage in containers in the facility for dehydration is planned for dehydrated sludge, in order to prevent odour spreading.

The amount of lime added is enough to increase pH to more than 12, and to preserve that value for at least 2h. Final sludge stabilization is subsequent addition of either lump lime or hydralime, and it is applied after the last sludge dewatering. Lump lime is more suitable than hydralime, because the reaction between lump lime and water is more exothermic, and it can raise the temperature above 50 °, which is enough to prevent further development of worm larvae, and it additionally reduces sludge moisture. Providing adequate mixing process is crucial for the system of subsequent lime addition, because appearance of pockets of impure material should be avoided. This system usually consists of mechanism for adding lump lime, conveyor belt with dewatered sludge, and mixer for sludge and lime. Good mixing is particularly important, in order to enable contact of lime with all little sludge particles. When the sludge and lime are well mixed, mixture gets grainy texture. This allows its long-term storage, and easier spreading over the soil, using conventional machines for fertilization.

Subsequent lime addition proved itself as useful for removal of pathogenic organisms, worm larvae, and odours. Besides, it increases the amount of solids in sludge which is now much easier to operate with, due to its granular structure, rather than when it has not been treated with lime. In cases where it is necessary to find an interim solution for final sludge processing, and final disposal has been searched for, the introduction of subsequent lime addition can prove to be beneficial approach. In cases of processing with lime, the treated sludge has to be stored for a certain period. The appropriate area where necessary storage can be done needs to be identified. Lime processing systems are often available as units that are used for the implementation of interim solution.

Advantages of lime adding are:

- Stabilizes sludge with negligible risk of re-development of the pathogen,
- Easy to perform, and can serve as mobile plant,
- Relatively low investment costs,
- Small area required for the plant,
- Granular texture allows easy storage and spreading over agricultural assets,
- Allows the bioavailability of nutrients,

while disadvantages are:

- Low nutrient concentration
- Increase in mass due to the addition of lime, and chemical compounding can lead to higher transport costs and higher final disposal costs.

With the aim to prevent the spreading of the unpleasant smells, parts of the plant, the retention tank and room for sludge dehydration shall also be enclosed in an object built up and covered with a solid material chosen by the designer. Air from these units will also be collected and treated in the devices for biological treatment.

Usage and Disposal of Sludge

The recommended sludge treatment will produce a stabilised sludge with a typical dry solids content of 40%. The other plants evaluated include mechanical dewatering of sludge to produce a 'solid' sludge with a dry solids content of 20 up to 30%. At full design capacity and assuming 20% dry solids content, the proposed SBR treatment plant should produce about 7 tonne of dried sludge. These quantities can be reduced in proportion to the population served, depending on when the whole collector scheme is provided and the rate at which new connections are made to the collector system.

The options normally considered for use, disposal or removal of sludge is:

- Agriculture and forestry/silviculture,
- Land reclamation or restoration,
- Composting,
- Thermal or solar drying,
- Landfill disposal,
- Incineration,
- Energy recovery
- Alternative technologies.

Each of these options has its advantages and disadvantages and there are environmental risks associated with all of them. Due to volumes of the dewatered sludge from Berane, methods such as incineration, energy recovery and gasification are not viable options at the moment. However, the potential of the viable options needs to be considered in the context of providing secure and cost-effective short-term and long-term outlets for the sludge from the WWTP.

On the other hand, ways of final sludge disposal can be divided into short, medium and long-term solutions for disposal of the sludge from wastewater treatment, depending on available conditions.

As already been mentioned, temporary disposal of sludge on the future landfill in Berane, in a form of a final coating layer, is suggested as most favourable solution for WWTP in Berane, but if construction of WWTP completes before the construction of landfill, the use of sludge for land reclamation, primarily in forests, is suggested as an alternative solution, which is going to be discussed furthermore, while other methods of sludge use and disposal are going to be discussed in the alternatives.

a) Disposal on Landfills

The attitudes and practices in European countries regarding disposal of sludge in landfill are in stark contrast. The report "Disposal and recycling routes for sewage sludge" prepared for the EC by SEDE and ARTHUR ANDERSON in 2001/2002 found that: The disposal of sludge in landfills is considered by most stakeholders to have the disadvantage of wasting the fertilising value of sludge. In addition, in several countries,

disposal to landfill has become very costly, and in certain cases, it has become difficult to create new landfills due to strong resistance on behalf of the local inhabitants (Ireland, Denmark, France, etc.)...

However, the disposal of sludge in landfills is still an important disposal route for sludge (and concerns about 25% of the sludge produced in the EU). In some cases, it is the only possibility, and one of the major advantages of this disposal route is that it presents very limited risks for health and the environment.

It should be noticed that in most EU countries, disposal to landfill of sludge should progressively be reduced, in application of the Directive on the landfill of waste (1999/31/EEC) which recommends reducing the quantities of biodegradable waste going to landfills, and prohibits the land filling of both liquid wastes and untreated wastes. Indeed the SEDE/ARTHUR ANDERSEN report notes that in Sweden, from 2005 onwards, no organic waste (including sludge) will be accepted in landfills, by application of waste regulations. Germany also effectively prohibited sludge disposal to landfill from 2005. These elements explain the widely shared perception of a future decline of disposal to landfill as an option for sludge. Nevertheless, since there are no conditions for use of sludge in agriculture in Berane, the landfill disposal, in a form of a final coating layer can be viable option for sludge disposal, at least in the short term.

There are two possibilities in terms of sludge land filling: mono-deposits, where only sludge is disposed of, and mixed-deposits (most commonly observed), when the landfill is also used for municipal wastes. Considering the karst features of Berane region, it would be important to ensure that future landfill used for temporary sludge disposal is properly engineered and lined.

b) Land Reclamation or Restoration

However, as already been mentioned, if construction of WWTP completes before the construction of the landfill, the use of dewatered sludge for land reclamation or restoration, primarily in forests, can be an alternative option, certainly with proper controls.

3.3.3. Administration Building

Construction of the Administration Building is planned to be on the west side of the WWTP. It was planned to be single-storey stone building with a double – pitch roof.

Figure 20 shows standard design for Administration Building.

Foundations are monolithic AB lanes. In places where foundation lanes overlap with the channels of foundation slab (technological channels), foundation lane fits into foundation structure.

Exterior walls are made of perforated bricks, thermally protected by styro-therm facade (on free surfaces), while interior walls have different thickness, depending on the position, and they are made of perforated bricks, too.

The walls in the laboratory, bathroom and toilets will be covered with ceramic tiles in the effective height.

Roof construction is designed as queen-post roof truss, built of fir lumber. The roof is going to be made of galvanized, plastic coated sheet metal, which is moulded as a tile. All openings in the building will be closed by locksmith elements.

The Administration building for the plant management has following premises:

- Control centre,

- Laboratory,
- Shared rooms (living room, bathroom and toilets)
- Workshop and warehouses.

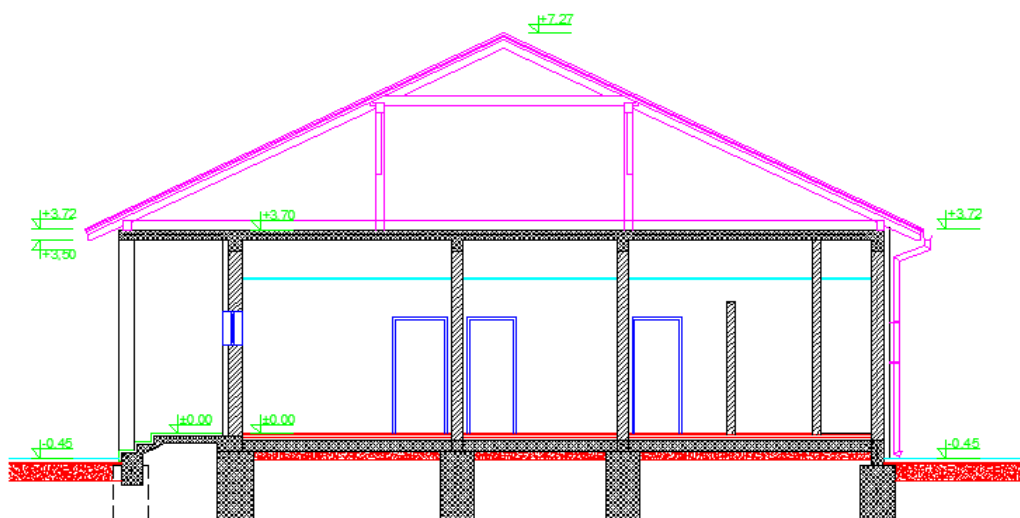
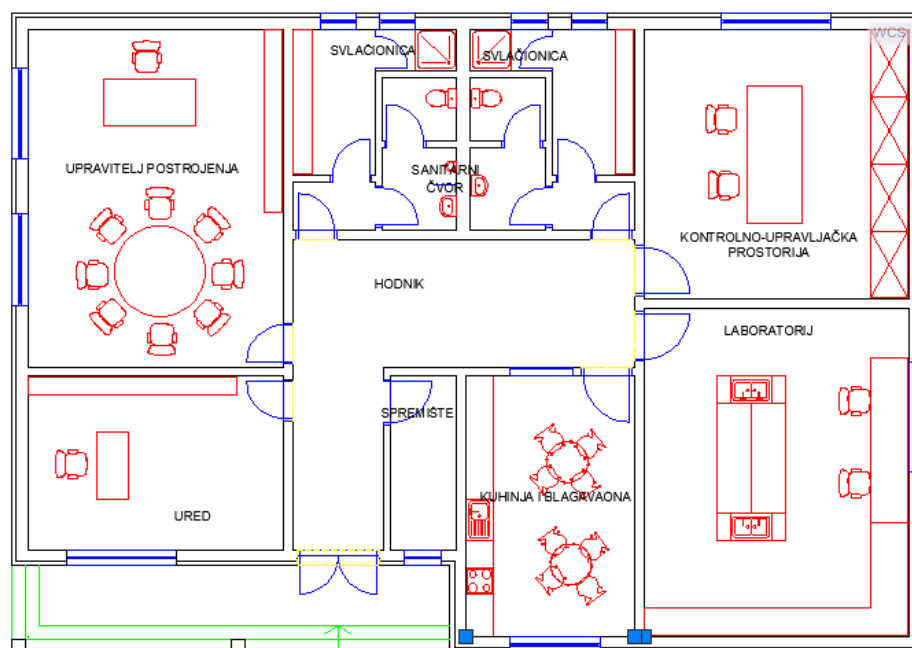


Figure 20. The basis and section of Administration building type solution

WWTP Control centre will be equipped both with a mosaic monitor that will provide simultaneous insight into all aspects of work process, and central system for recording operating data.

Extensive systems for automation, control and measurement will be provided. The system will include measuring of wastewater coming to WWTP, effluent and sludge flow. Devices for treatment will also include measuring of dissolved oxygen for the automatic control of the compressor, as well as redox measuring (reducing-oxidizing measurement) in order to facilitate control of anaerobic zones. RBC, pumps, dosing devices etc, will be controlled either by local logic controllers which can be programmed (PLCs), or/and by central control room.

The laboratory will contain all the equipment necessary for internal control of treatment process.

Shared rooms are necessary for providing adequate working conditions.

Workers at the plant will perform all the work in the workshop and they will use material supplies sufficient to enable proper operation, maintenance and construction work round the plant.

Certain number of parking spaces is going to be built around the Administration building, while free area on the location is going to be cultivated according to the design on spatial planning. It involves planting of the herbs characteristic for the observed area, as well as planting tree lines around the WWTP, in order to establish a connection as natural as possible to the surrounding environment defined as indigenous vegetation.

WWTP facility will be fenced by 2,2m high fence, in order to prevent unauthorized access. The fence will consist of concrete base with pillars on which splicing wire is stretched. Location entrance and exit will be on one controlled place.

3.4.4. Supporting Infrastructure

Electricity Supply of the Facility

Electricity supply of the facility is planned to be from the transformer station, which is going to be built up for the facility necessities. The transformer station will be built up in accordance with requirements and standards for this type of objects, issued by the appropriate Power Company.

External electricity supply includes building up of 10 / 0.4 kV transformer station, with up to 630 kW power. Transformer station will be supplied from a nearby transmission line through 10kV underground cable, which is laid at 0,8 to 1m depth, in 40cm wide trench. Transformer with distribution boards is going to be designed in accordance with assessed needs, consumption. Layout of the equipment and position of the transformer will provide rational use of space and easy handling.

In case of blackout, diesel generator will provide the electricity for the facility. Capacity of the generator is sufficient for the basic needs, first of all pump station operation and lighting. Devices for electricity supply, as well as supporting generator will be installed in a separate building on the facility location.

Within WWTP facility 1kV cables are going to be laid and they will provide electricity supply for certain objects. Laying of cables will be performed in accordance with current regulations for this type of work.

Earthing of all metal masses will be done, as well as facility protection against lightning. Electricity supply of the Administration building will be also from the transformer station, through the distribution cubicle. Following installations are anticipated in the facility: general consumption and lighting, earthing and lightning rod, telecommunications and fire alarm.

Outdoor lighting will be set around WWTP, and connected to the distribution cubicle.

In accordance with the purpose of the premises and needs of the users, proper installation will be set.

Facility earthing will be performed with galvanized steel strip.

Installation for fire alarm will be considered in detail in the Study on fire protection.

Water Supply

Facility will be connected to the town water supply network with pipes of proper diameter, and in accordance with requirements of PE "Water Supply and Sewage System" Berane.

Before coming into operation, the entire water supply network has to be flushed and disinfected, in accordance with current law regulations.

For the purposes of fire fighting, special water supply network is anticipated, according to the Study on fire fighting.

A system for water supply of all parts of the plant will be constructed, and it will consist of hard plastic pipes, sufficiently long, of appropriate diameter, and with a nozzle and a cap. Hoses with taps will be connected on the places that are provided near each work unit.

It is planned that the Administration Building sewer system is connected to the WWTP. The network will be made of durable and strong material, which is resistant to corrosion or protected against the same from inside and outside. After completing the installation work on sewer system, testing is carried out to see whether the system is passable and water keeping.

A special system is planned for draining water, which has been left after washing the handling areas and the parking, because that water can be loaded with soil, sand or light liquids from the trucks. Water collected from these surfaces by a specific network, will also be discharged into WWTP and leaked through the aerated sand trap and separator for oil and grease, where the water is treated, or soil and sand from it are deposited, and light liquids (fuel and oil) are separated.

For collecting storm water from the roof of the Administration Building, verticals with drains and revisions over the sidewalk are planned.

Labour

Number and structure of employees in the WWTP, after the implementation of the first phase, are planned, both based on DWA M 271 standards, and experience of a designer of a plant with approximate capacity. The number and the structure are shown in Table 5.

Plant management requires special skills, because the process is complex and delicate. Anticipated labour will do the work within the Administration Building around the plant, and they will use workshop, warehouse and maintenance facilities.

Table 5. *Number and structure of the staff for monitoring and maintenance of WWTP*

No	Job Title	Number of executors	Education level
1.	Manager	1	College degree
2.	Administrator	1	High school degree
3.	Laboratory technician	2	High school degree
4.	Operator	4	Secondary school degree
5.	Co-workers	2	No degree
6.	Security Service	2	High school degree

Proper management of WWTP requires skills, which have not been developed in Montenegro yet, actually, labour particularly operators and laboratory technicians have to

go through appropriate training in order to acquire basic knowledge about control of the process and operations, which take part in the treatments of wastewater and sludge, as well as basic knowledge for monitoring effluent quality. Continuous training of the staff should last until more working experience is gained, and until working unit is capable to lead the system and manage the plant without outside help.

3.4. Types, Volumes and Characteristics of the Matters used for Technological Process

Significant amounts of natural resources and energy will not being used permanently for the operation of the WWTP.

Bearing in mind facility purpose, and during the operation of the same, electricity will be used primarily for the operation of various devices, and consumption of electricity will depend only on the capacity of the plant. The amount of other materials used in technological process is negligible.

3.5. Types and Volumes of Discharged Gases, Water and Solid Urban Waste

- **The emission of gases** on the location may occur because of mechanization work, during the preparatory work such as: soil digging, taking away the excavated soil, bringing the material for filling the location, and bringing construction material. Since it is a large object, the amount of gases is not negligible. However, since the work is performed in an uninhabited area, and in the limited period of time, or the work is temporary, it will not significantly affect the environment pollution.

During the facility exploitation, separation of the gases is negligible, while odours occurrence is possible, depending on weather conditions and plant operation.

- **Discharge into watercourses**, during the facility construction, there is no discharging of waste into the water streams, while during the facility exploitation, treated waste water is being discharged into river Lim.

The amount of discharged water depends on WWTP capacity, or on the number of connections to the sewage network, and the number is going to increase steadily, while the quality of treated water is going to be controlled, noting that it has to comply with the requirements set by valid national and European legal regulation concerning the content of harmful substances.

- **Disposing onto soil**, because of the construction, significant amount of excavated material appears, and in one its part it is going to be used for filling, but the excess is going to be transported to the location determined for that purpose.

- **Noise** occurs at the building site during the construction of the facility, due to the machinery, transportation equipment, and other tools, and it is not negligible, but it is temporary and most intense on the very location.

According to the type of proposed WWTP, it is considered that the noise made during the facility exploitation (pumps and compressors) will not pose a significant problem, since they will be enclosed.

- **Vibration** during the facility construction and exploitation, will not be significant, because the facility is made of modern construction material.

- **Heat and radiation**, will not be present during the construction and exploitation of the facility.

- **Waste**, during the exploitation of the object in WWTP in Berane, besides the main product, dehydrated sludge, which is going to be disposed in the town landfill or used for land reclamation, the following wastes are produced:

- waste from the screen
- waste from screening (sand) and
- waste from degreasing (grease and oil).

Originated waste will be selectively classified into categories, and mixing of hazardous and non-hazardous waste is not allowed. Collecting and storing of waste will be organized within the space around the plant.

Coarse sewage waste, such as: packaging, rags, branches, leaves, etc., is separated on the coarse and fine screens, transported through a grid press, and stored into a special container from where it is transported to a landfill by an authorized utility company.

After leakage of waste water through the aerated sand trap and oil and grease separator, sand and waste oil and grease are produced. The sand will be transported to the landfill, while oil and grease marked as hazardous waste will be stored separately.

In addition, during the facility operation, small amounts of urban waste can appear, due to the presence of people at the location. This kind of waste will be disposed into the containers, which are emptied, and Utility Company in charge transports the waste to the specified place - landfill.

• **Treatment of waste materials**, of waste materials that will be produced during the operation of the object, in respect of their treatment i.e. disposal, besides the sludge, oil and grease separated in WWTP, are the significant ones, since they are marked as hazardous waste.

Waste Oil and Grease

Since this is about hazardous waste, system for collection and treatment of hazardous waste is only partially established in Montenegro. However, laws and regulations control the method for handling this kind of waste. Law on Waste Management (Official Gazette of Montenegro No 64/11) in Article 10 stipulates that sludge producer is required to apply the following: technological process, raw and other materials, organize services in a way to produce the least or none waste.

According to Article 4 of Rulebook on criteria for choosing the location, method and procedure for disposal of waste materials (Official Gazette of Montenegro No 56/00), hazardous waste should be collected into at least 100 l barrels with a cover, made of material that will ensure their impermeability, corrosion stability, and mechanical resistance. According to Article 6 of the Rulebook, the legal or physical entity who creates a hazardous waste, determines temporary landfill for disposal of hazardous waste.

According to Article 52 of Law on Waste Management (Official Gazette of Montenegro No 64/11), owner of hazardous waste shall entrust destroying of the same to a commercial company or entrepreneur who complies with the requirements determined by special regulation. The owner of hazardous waste, before handing it to a distributor or collector, has to keep the same separated from other waste, and cannot hand it as mixed urban waste.

Means of transportation and equipment, used for collecting or transporting hazardous waste, have to prevent spilling or leaking of the waste, i.e. have to comply with the requirements set by the mentioned Law.

4. ANALYSIS OF THE REVIEWED ALTERNATIVES

According to the Feasibility Study for Water and Wastewater Development Project in Berane (2010), created under the auspices of the EU which finances Infrastructure Project of the Western Balkans, for which WYG International has been appointed as Consultant, competent local authority together with the consent of engaged professional team, among alternatives in terms of the location, waste water treatment process, sludge processing and storage, has chosen most favourable solutions, and started the elaboration of the project in accordance with the received urban and technical requirements issued by the competent state authority responsible for drafting of technical documentation and construction of WWTP in Berane.

Location

From the aspect of location choice, only the location for WWTP in Donji Talum complied with the requirements. This location was identified in previous wastewater studies and the Sewerage and Wastewater Strategic Master Plan (Central and Northern Region) Montenegro, December 2004.

The reasons behind this decision were as follows:

- Topography of Berane – available flat and non urbanized land stretches from the south of the site to the north. However to the north of the site the River Lim enters a gorge and there is no suitable site available and
- Urban development of Berane – to the south of the site all the low lying areas sufficient in size to host a treatment plant have been already developed.

The site of the proposed WWTP can be seen from the:

- Berane – Bijelo Polje road bypassing the site from north, west and south,
- Rudeš Tilery and Beranes industrial area located 500m east of the site,
- From the RAE residential properties in Donji Talum located ca 80 - 100m south of the site and
- From the residential properties in Banjevac settlement located around 300 m west of the site.

Waste Water treatment

Apart from Sequential Biological Reactor (SBR) (Chapter 3.3.1.) which belongs to the processes of suspended and attached growth, and which has been chosen for waste water treatment in Berane, the above mentioned Study considers other possible solutions/alternatives used for secondary treatment of urban waste water, such as:

- Lagoon or constructed wetland
- Suspended and attached growth.

Brief description of feasible treatment processes is given below:

1. Lagoons and constructed wetlands

They are a low cost natural system that requires a large area of land, particularly in cold regions. Land requirements either can be reduced by including an anaerobic pond or aerated lagoon first stage. However, the land requirements are still too large to be considered for Berane.

Process Description: Microorganisms suspended in effluent. Aeration provided by surface aerator. Natural low intensity process used.

Benefits:	Stable and resistant to shock load. Low operating expenditure. Low volume stabilized sludge.
Constraints:	Large land area required. Cannot achieve desired effluent quality without effluent "polishing".

For these reasons it is not suitable for WWTP in Berane.

2. Attached and suspended growth systems

There are several solutions that can be used for WWTP in Berane, and their characteristics, benefits and constraints are following:

a) Suspended Growth - Biological Filter

Process Description: Microorganisms suspended to natural or plastic media with natural ventilation. Primary and secondary settlement required.

Benefits: Stable and resistant to shock load, and low operating expenditures.

Constraints: Low treatment efficiency in cold weather. Unstable sludge produced. Potential for odour and insect problems. Not recommended for WWTP in Berane

b) Suspended Growth - Conventional Activated Sludge

Process Description: Microorganisms suspended in liquor. Aeration provided by diffusers/ surface aerators. Primary and secondary settlement required.

Benefits: Well-understood process widely used for larger WWTPs, but not so much for small WWTPs. Average energy consumption. Can be difficult to operate with.

Constraints: Susceptible to shock load and high flows. Unstable surplus sludge requiring additional processing.

Suitable for this size of WWTP. Additional sludge treatment using anaerobic and aerobic digestion can be considered.

c) Suspended Growth - Extended Aeration

Process Description: Microorganisms suspended in liquor. Aeration provided by diffusers/ surface aerators. Secondary settlement required.

Benefits: Primary settlement not necessary. Stable and resistant to shock load/ flows. Low volume of stabilized sludge produced. Simple operation and maintenance.

Constraints: High-energy consumption. Relatively large land area required.

Unlike the aforementioned processes, Sequential Biological Reactor (SBR) with extended aeration has the lowest construction costs. However, the operating costs of this option are not the lowest due to higher power costs compared to options with anaerobic sludge digestion and power generation from bio-gas. Nevertheless, average costs (an indication of the entire operation life) of this option are still the lowest illustrating that the extra cost and complexity of anaerobic sludge digestion are not justified at this size of treatment plant.

The SBR process is a very flexible process that is capable of producing high quality treated effluent. The small land requirement for the process is a particular advantage for Berane where the available land for the treatment plant is very limited. Although the SBR process is somewhat more complex to maintain than some processes due to the extensive automated control systems, it is not considered that this should present any great problem to ViK given the proper training from the supplier.

Sludge Treatment and Disposal

In addition to the proposed solutions for sludge (on landfills as the final coating layer, and for land reclamation) from WWTP in Berane, Feasibility Study considers other possible solutions/ alternatives used for sludge treatment and disposal, such as:

a) Agriculture and forestry/silviculture

The reed bed treatment of sludge, produces a soil like sludge that will be stable and which, in some cases, can be disposed of to land without further treatment. The use of sewage sludge in agriculture needs the establishment of thorough controls for the application of the sludge, and also education of farmers and other end users. Sludges can contain substances from industrial processes whose waste stream enters the sewer system. However, wastewater companies and authorities must exercise control on such trade effluents to ensure, amongst other things, that the sludge still meets the standard necessary for use on land. These controls would be of particular importance in Montenegro, according to the karstic nature of the region.

Sewage sludge is recognised as an excellent soil conditioner and a useful fertiliser. There is a positive environmental benefit from recycling sludge to agricultural land or forestry, to make use of the organic matter and plant nutrients that are in sewage sludge. However, the issue of use of sewage sludge in agriculture and forestry has become contentious in much of Europe, and there is little or no consensus on what standards and controls should be applied. The existing EC legislation on this subject is included in Directive 86/278/EEC on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture.

The Directive contains regulations to prevent harmful effects on soil, vegetation, animals and people, while encouraging the correct use of the sludge. However, the provisions of the Directive are regarded as inadequate in some European countries but, despite debate over several years there has been no agreement on an updated Directive.

It is considered that it will be in the general interests of Montenegro to try to ensure that the option of disposal of sewage sludge in agriculture and forestry remains open. In this context, it is encouraging that transposition of Directive 86/278/EEC into Montenegrin legislation has already been completed.

b) Composting

Composting of sewage sludge together with organic solid waste is an attractive option that is worth of consideration. Composting with organic material increases the nutrient value and, most importantly, produces a material that is widely accepted by users (if the solid waste is properly screened to eliminate, for example, plastics, glass and metallic wastes). Composting can be achieved in simple windrows if suitable sites are available or in more compact specially constructed composting cells with forced ventilation. Equipment and construction requirements for windrow composting are modest, but

relatively large sites, distant from the development are needed. Composting cells have much greater construction and equipment requirements but can be located nearer to development as they are normally covered.

c) Thermal or solar drying of sludge

Thermal drying of sludge using direct or indirect heating can produce sludge of more than 90% dry solids content that can be used in agriculture or as a fuel. However, the equipment is expensive and the energy requirements are very high and therefore thermal drying is not a viable option for Berane at the present time.

The solar drying process is an alternative to thermal drying method, which is based on the use of solar energy. The principle involves evaporating the sludge water by the means of solar heat enhanced and stored by a glasshouse or tunnel with translucent cover. Evaporation is helped by a mechanical mixing system which increases the exchange surface between sludge and warm air and the saturated air is evacuated by the means of an effectively regulated ventilation system. Mixing induces aerobic fermentation (composting-like process) which raises the sludge temperature and can thus pasteurize the sludge.

Mechanically dewatered sludge is placed as a quite thin layer (typically 10 to 50 cm) on the floor of the glasshouse and regularly mixed by a mechanical turner. The drying can be undertaken continuously or batch processed. In the later case, the insulated glasshouse is hermetically closed during the drying process in order to accurately regulate the airflow through ceiling circulation fans, exhaust fans and flaps according to local meteorological conditions and the state of sludge.

Solar drying has the same advantages as thermal drying, i.e.: volume reduction, pasteurization, stabilization, odour abatement, increase of the calorific value of sludge, final product likely to be accepted by farmers but, in addition, it presents a far better environmental balance.

The energy consumption per ton of evaporated water for solar drying is only 20 to 80 kWh of electrical energy against, for thermal drying, 70 to 120 kWh electrical energy. In addition, the technology used is simple and reliable, and there is no risk of fire or explosion as possible with thermal drying technology.

Solar drying requires large surfaces of glasshouses, and the rate of 1 m² per tonne of dewatered sludge per year is commonly accepted for the climate of Berane. This would equate to some 2.500 m² of glasshouses. The investment cost of solar drying system is quite high at about 300 €/m², but the operating cost is low at 30-50 €/t.

The area required for glasshouses is not available at the WWTP site and the additional cost of transporting dewatered sludge to another site would make this treatment method less attractive. Therefore it cannot be recommended for Berane at present but it could be worthy of consideration in the future if sludge disposal proves to be a major problem.

d) Incineration

Incineration of sludge is mostly used in countries with low rate of arable land where the sludge could be spread out. This method is also commonly used in large urban areas where transportation costs make other solutions unappealing.

Incineration process is carried out within enclosed building at high temperatures, where the sludge is turned into ash with volume less than 20% of the original sludge volume.

Incineration system consists mainly of the burner and air pollution-controlling device. Several furnaces systems and reactors with direct feeding are commonly used types of

burners.

Multiple hearth furnace systems (MHF) consist of series of vertically oriented chambers (furnaces). The air is introduced from the bottom, and the sludge from the top of the furnace. The sludge in each chamber is pushed to the outlet from where it falls into series of furnaces. Combustion is largely done in the central part of the furnace, while the ash is cooled in the lower part. Machines remove the ash from the furnace, and after that, it is disposed on the landfills.

Reactors with direct feeding (fluidized bed reactor) (FBR) are considered as the cleanest technology of incineration, and they are the least expensive for use in large plants. The system involves a layer of sand to which air under pressure is constantly introduced. The air flares up the fire, leading to more intense and more complete combustion, and thus to the production of ash smaller than with previous proceedings. In addition to that, these reactors are simpler in respect of mechanics than the previous, easier to operate with, and the ash from these burners is very fine.

This technology is considered to be more appropriate for the incineration of sewage sludge, because it allows uniform combustion with lower production of toxic substances, such as dioxins and furans.

Common to both systems is usage of extra fuel (such as oil or natural gas) at the beginning and during the incineration.

When it comes to combustion, it is particularly important to define limit value for maximum allowed amount of heavy metals. In order to reduce negative environmental impacts to the lowest level, it is of great importance to provide functional surveillance system and quality assurance, or it is necessary to regulate issues regarding sampling (volume, frequency, etc.), sample preparation, analysis instructions, keeping limit values, data recording, and reporting.

In accordance with EU regulations, the ash, which remains after sludge incineration, is classified as dangerous substance, and therefore has to be disposed of. If it is disposed on a landfill, it has to be addressed to a separate facility for disposing industrial waste. The alternative solution is to use ash as raw material for other products, such as construction material, or as a material for road filling. A set of laws governing the classification of the ash from sludge incineration process in Montenegro is to be adopted.

e) Renewable Energy

Dewatered sludge can be used in production of energy, as a substitute for fuel. Combustion of sewage sludge combined with solid waste in the incineration plants, or combined with conventional fuel in the industrial burners. There are several methods of industrial sludge combustion and exploitation of released energy, such as: in cement plants, thermal power plants, wood and paper industry, as well as for production of sawdust and cardboard.

Lacking the other environmentally friendly techniques, combustion may be applicable solution, provided that necessary infrastructure is available.

f) Alternative technologies

The threat that the agricultural route for beneficial recycling may not continue to be available has led to a number of companies seeking alternative uses. These include ideas such as the use of sludge in lightweight aggregates manufacture. It is anticipated that other uses will be developed in coming years. However, it is unlikely that, in the short term, these uses will be applicable to Berane.

Each of these options has individual advantages and disadvantages and there are environmental risks associated with all of them. The volumes of the dewatered sludge from Berane may advanced treatment/disposal methods such as incineration, energy recovery and gasification are not thought to be viable options at present. However, the potential of the viable options needs be considered in the context of providing secure and cost-effective short-term and long-term outlets for the sludge from the treatment plant.

For these reasons, it was decided to draft the design documentation for WWTP construction, and the adopted solution was considered within the Study.

- **Location,** Construction of the WWTP at the aforementioned location is conditioned by the fact that the same has been planned to be on the area suitable for carrying out this type of activity. All the works planned for construction of the facility are subjected to the treatment of waste water, which will result in better quality of water in Lim, and less polluted environment.

Narrow area around the location is uninhabited, which is an essential precondition for the performance of specified activities. The location is connected to the regional road by local roads. Facility position within the location is optimal, and meets the purpose, so in terms of environmental protection, together with planned equipment it complies with the norms and standards.

- **Production processes or technology,** WWTP construction was planned based on technology used in the construction of such facilities.

Attached and suspended growth system with a process using Suspended growth – Sequential Biological Reactor (SBR) within it, was chosen as better solution for Berane. Advantages of Sequential Biological Reactor are: occupation of small space, settlement tanks and sludge recycle are not necessary, and disadvantages are: high automation requirement, relatively complex control and drainage systems.

- **Working method during the construction and operation of the object** is in full compliance with requirements stipulated by general law regulation, but on the other hand, it is adjusted to the specific features of the observed object.

Construction work will be carried out in accordance with international standards ISO, EN or DIN, collectively referred to as IS. Appropriate codes, practices and standards, commonly used in waste water treatment plants in foreign countries, which are adjusted to local conditions, shall be used as an alternative that can be approved in writing by Construction Manager.

In any other section of the Contract where standards are not defined, the above mentioned EN or DIN standards shall be applied. Also, if there is a conflict between the general specifications and the relevant DIN standards, preference shall be given to general specifications.

Finally, materials that shall be used for the construction of the plant and works performed, as minimum requirement should meet the proposed standards and regulations. If producers offer materials which are in accordance with other standards, those standards have to be equivalent to or beyond those given in the specifications, and at the request of Construction Manager description of the differences between the standards in general should be submitted.

Working method during the WWTP exploitation shall be in accordance with standards relevant for this kind of objects, with a special emphasis on efficiency, flexibility and proper management of the process.

During the exploitation of the object with the aim to provide its optimal operation, and protection of both human health and environment against possible harmful effect of this procedure taken, measures for prevention or elimination of possible negative impacts shall be taken.

Permanent control of working parameters in the process of water treatment shall be provided, and the main objective of the control will be testing of the plant operation when different quality of raw waste water is applied. Testing is either in terms of plant efficiency and provision of the minimum operational costs. In that sense, program of control operation will be installed, and besides the plant operation it will cover a wide range of measurable and comparable effects on the environment.

- **Location plans and project drafts,** The choice of location was made on the basis of General and Spatial Urban Plan for Berane, made in 1996.

On the same location, due to lack of space sludge treatment is not foreseen by GUP.

Following project documentation was available: terms of reference, Feasibility Study for Water and Wastewater Development Project in Berane (WYG International, 2010), general designs for WWTP where waste water treatment was elaborated, as well as Strategic assessment of Berane Spatial and Urban Plan impact on the environment in 2012, and Waste Management Plan for Berane municipality 20010-2014.

- **Types and selection of materials for project construction,** Basic materials for facility construction are following:

- Differently granulated gravel,
- Steel construction S235JR (Č.0361),
- Concrete, brand MB30
- YTONG building block, etc.

All the WWTP equipment will be bought from the manufacturers well known around the world. Inner leads and reinforcement between each treatment unit (waste water, sewage waste, sludge), all lead connections between each system for disposal (drainage water, sludge liquid), and internal pipe network will be made of polyethylene.

- **Timetable for the execution and termination of the project,** The project will be realized in phases, considering the present elements, or the realization of some segments will influence further execution of another, although certain elements could be executed simultaneously, what refers to the construction of the facility and Administration building.

Time-specific review of certain construction phases will be given in the Dynamic plan of the facility construction.

- **Date of construction commencement and completion,** WWTP construction will start when all the necessary documentation is provided, which is estimated to be at the beginning of 2014, and work completion at the end of 2016.

- **Location and object size,** The facility occupies 4.122 m² of total UP1 cadastral parcel surface which is 25.880 m², handling surface is 4.594 m², and protective greenery 17.164 m², i.e. construction index is 0,16.

- **Scope of the work,** Work conditions and ways of realization will determine its scope, which is defined in the Study on building site organization.

- **Training,** everyone needs training for the following activities: designing, application, construction, control of functioning, and quality control of the realized project. The fact is that specialization courses are needed for designing and implementation of modern solutions for protection measures. Designers themselves should be the first link in the chain of training. Later, if necessary, the designed solution is to be explained more precisely to the contractor. This is, of course, referred to the Main Project, or the Project of technical measures for environmental protection.

- **Monitoring,** During the facility construction, all the measures designed to reduce environmental impact of the construction activities, are to be monitored and enforced by the authorized organization.

After the construction starts, it is necessary to examine whether the building site influences the environment, and thus the efficiency of the measures taken is assessed. Of course, the test has to be done during the machinery operation. The number and location of measuring points can be determined only after the final organization of the building site is known.

Environmental state monitoring also should be done during the facility exploitation, for those segments that are according to the analysis, affected by the facility operation.

- **Emergency,** In case of some accidents, the main goal is to save human lives. Workers on the construction of the object are the most endangered group. Adequate equipment and adherence to the Safety Rulebook are mandatory for each contractor.

5. DESCRIPTION OF THE ENVIRONMENTAL SEGMENTS

Since the Chapter 2 describes the location and its environment, this Chapter describes environmental segments that in certain way could be affected by the project, but are not considered in the above-mentioned Chapter.

Available data on current state of the environment in the immediate vicinity of the facility and its wider surrounding, were used for the analysis. The data were primarily related to the concentration of population and population density, soil water and air quality, and quality of all factors mutual relations.

5.1. Concentration and Density of Population

This was described in Chapter 2.8. Since this is about the facility for waste water treatment in the projected period until 2035, in this chapter will be given the projection of both population density and concentration in Berane and suburbia's which is going to be included in the project for the above mentioned period, because building capacity depends on the number of households which is going to be connected to the sewerage network.

Projection includes three scenarios, and the medium growth scenario is considered to be the most realistic with no growth in the Municipality overall, 0.25% p.a. growth in the urban area and a slightly higher growth of 0.30% p.a. in the remainder of the conurbation. Table 6. shows the population projections for the Municipality, urban area and suburbia's from 2015 to 2035.

Table 6. *Population projection data for Berane from 2015 to 2035*

Area	2008	2010	2015	2020	2025	2030	2035
Municipality population	34832	34833	34833	34833	34833	34833	34833
Urban population (census defn.)	11776	11805	11954	12104	12256	12410	12566
Rural population (census defn.)	23056	23028	22879	22729	22577	22423	22267
Main water system population	21313	21420	21743	22071	22404	22742	23085
Dapsici-Polica system population	3523	3511	3476	3441	3407	3373	3340
Total service areas population	24312	24409	24702	25001	25305	25614	25928
Outside service areas population	10520	10424	10131	9832	9528	9219	8905

5.2. Flora and fauna

This was described in Chapter 2.5. It was concluded that there were no rare, endemic, and endangered plant and animal species on the location and its close surrounding.

5.3. Soil Quality

As already been mentioned in Chapter 2.2., predominant type of soil in Berane and its surroundings is euteric brown soil and district brow soil, while at its lowest parts, along the Lim River, alluvial deluvial soils are found.

Many factors influence soil quality, but the climate is most important. Warm climate stimulates browning and reding of soil, which lead to the appearance of red (terra rossa) and brown soil. Cold climate is on 500 asl, so black soil (chernozem) and brown soil is found there. Those kinds of soil are characteristic for their higher content of humus, which is accumulated due to both, slower decomposition, and mineralization of organic matter, and lower biological activity.

Vegetation is an important factor in the protection and preservation of soil against the erosion, but it also affects some soil features, which is especially noticed in the soils

under natural vegetation cover, for their humus content, which is higher than in the agricultural soil, and for the differences in soil reaction.

Land use often leads to an imbalance of certain soil ingredients, which inevitably leads to its weakening. Soil should be observed as multifunctional system, rather than a set of physical and chemical properties. Besides being the source of food and water, the soil is also source of biodiversity and the environment for human beings. Therefore, soil monitoring is one of the measures for its protection, which is a precondition for both, preservation of life quality, and survival of wildlife.

Certain concentrations of heavy metals occur naturally in the soil, originating from the source rocks, or from the substratum on which the soil has been formed. In the surface horizons of the soil, heavy metals which are not of geochemical, but anthropogenic origin could be found, i.e., they are found in the soil due to various human activities (such as: industry, combustion of fossil fuels, use of agro-chemicals, atmospheric deposition,...).

Besides these inorganic pollutants, many organic pollutants often could be found in the soil. Due to its low biodegradability, they are called persistent (persistent organic pollutants, so called POPs), and some of them are polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticide and their metabolites remains.

In order to determine soil quality, or presence of hazardous and harmful substances in the soil, sampling and analysis were performed during 2011. The soil was taken from the vicinity of 10 urban areas in Montenegro, including Berane (Information about environmental state in Montenegro for 2011, Agency for Montenegro environment protection 2012).

These samples were analysed for possible presence of inorganic substances (cadmium, lead, mercury, arsenic, chromium, nickel, fluorine, copper, molybdenum, boron, zinc and cobalt), and organic substances (polycyclic aromatic hydrocarbons, polychlorinated biphenyls, PCB congeners, organotin compounds, triazines, dithiocarbamates, carbamates, and chlorinated pesticides). Samples taken from the soil near transformer stations were analysed for possible content of PCB, and even dioxins and furans in certain locations. The results were compared with maximum permitted concentrations (hereinafter referred to as MPC) which are standardized by both, Rulebook on permitted amounts of hazardous and harmful substances in the soil, and methods for their testing (Official Gazette of Montenegro No 18/97).

Chemical analysis of the soil from the location vicinity has not been done. However, in order to estimate the quality of soil on the location and its surrounding, chemical analysis made in 2011 for four locations in Berane were used, and the locations are:

- Industrial zone 1,
- Industrial zone 2 ,
- Transformer station 1
- Transformer station 2

Figure 21 shows the content of arsenic in the samples of soil taken from the Industrial zones 1 and 2, in 2009, 2010 and 2011, and Figure 22 shows the ratio of recorded concentrations of congeners 138 and 149 in the samples of soil taken near the Transformer station 1 and 2, also in 2009, 2010 and 2011.

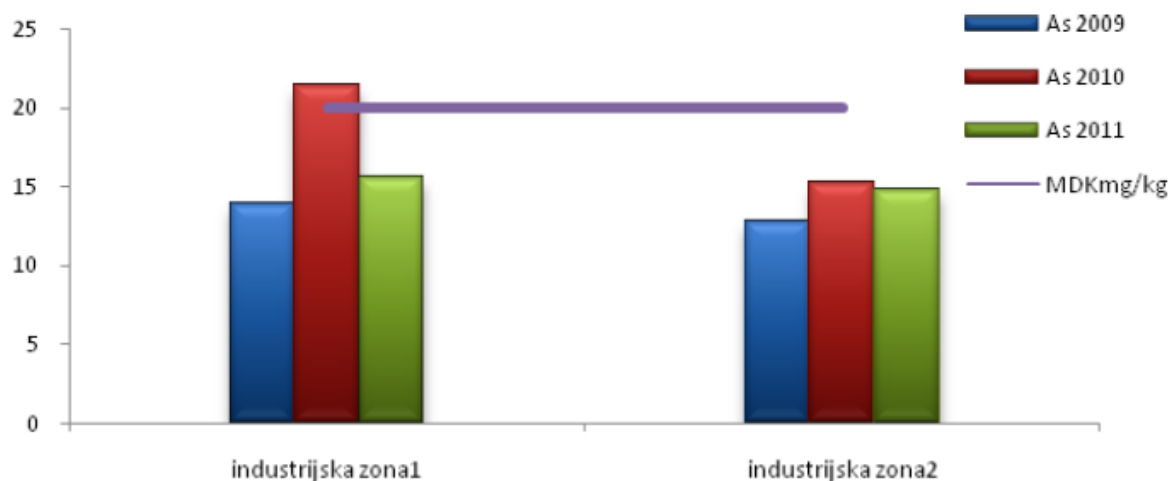


Figure 21. Ratio of registered arsenic concentrations (As)

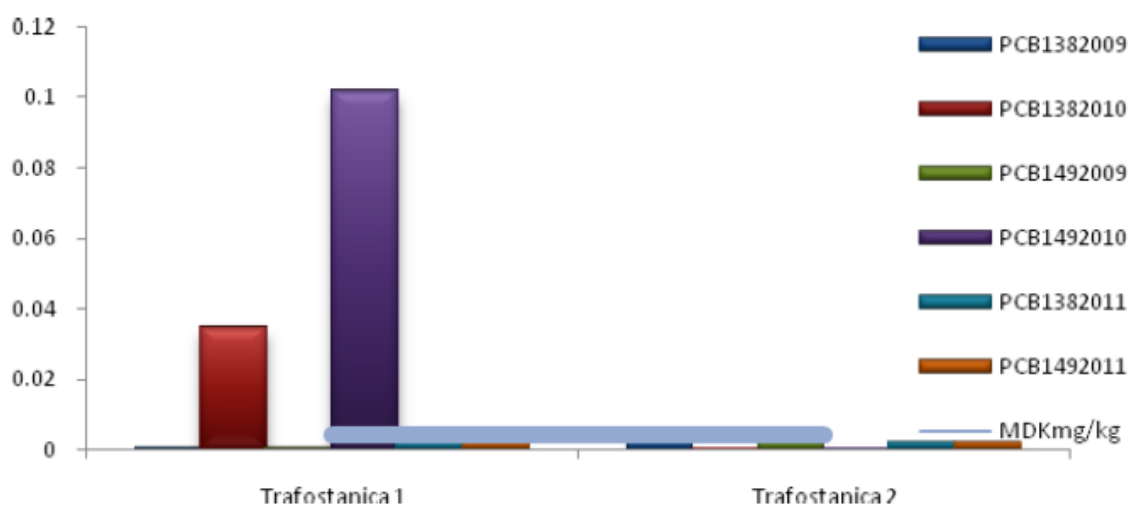


Figure 22. Ratio of registered congeners concentrations 138 and 149.

Test results of soil contamination in Berane in 2011 indicate that in the samples of agricultural soil on the locations in the Industrial zone, fluorine concentration deviates from the norm prescribed by the Rulebook, while the content of other inorganic and organic pollutants is below MPC standardized by the Rulebook.

According to the soil quality results, it could be assumed that the soil on the location and its immediate surrounding has satisfactory quality, in terms of toxicants content, because there are no industrial facilities nearby.

Geomorphologic, geological and hydrogeological characteristic are given in Chapter 2.2.

5.4. Water Quality

Water Law (Official Gazette of Montenegro No 27/07), Article 75 and Article 76 are legal basis for the protection of surface and ground water in Montenegro, which defines the categorization and classification of surface and ground water. Our legislation and Decree on classification and categorization of surface and ground water (Official Gazette of Montenegro No 2/07) did the classification and categorization of surface and ground water on the land and coastal area in Montenegro.

According to the purpose, water is classified as:

Waters that can be used for drinking and food industry based on limit values of 50 parameters, and can be assigned to one of the four classes:

- Class A – water suitable for drinking in its natural form (with possible disinfection).
- Class A1 – water that can be used for drinking after simple physical treatment and disinfection.
- Class A2 – water that can be used for drinking only after appropriate treatment (coagulation, filtration and disinfection).
- Class A3 – water that can only be used for drinking after an intensive physical, chemical and biological treatment with extended disinfection and chlorination, i.e. coagulation, flocculation, decantation, filtration, active coal absorption and ozone/ chlorine disinfection.

Limit values for a selected number of a total of parameters pertinent to different water classes is provided in the Table 7.

Waters that can be used for fishing and shell production, based on 10 parameters are classified into three categories:

- Class S – waters that can be used for salmonid fish farms.
- Class Š – waters suitable for shells.
- Class C- waters suitable for cyprinid fish farms.

Bathing waters are assigned to one of the two possible classes:

- Class K1 – excellent.
- Class K2 – satisfactory.

In order to determine whether surface and ground water on the land and costal sea water, are within the class, monitoring of qualitative and quantitative water parameters is carried out, by the administrative authority responsible for hydrometeorological affairs (Hydrometeorological Institute of Montenegro), according to annual program of systematic examination of surface and ground water quantity and quality.

According to the document 'Information about the environmental state in Montenegro in 2011', made by Agency for Environmental Protection of Montenegro, surface water network covered 13 streams with 36 measuring profiles, including Lim.

The following parameters were analysed:

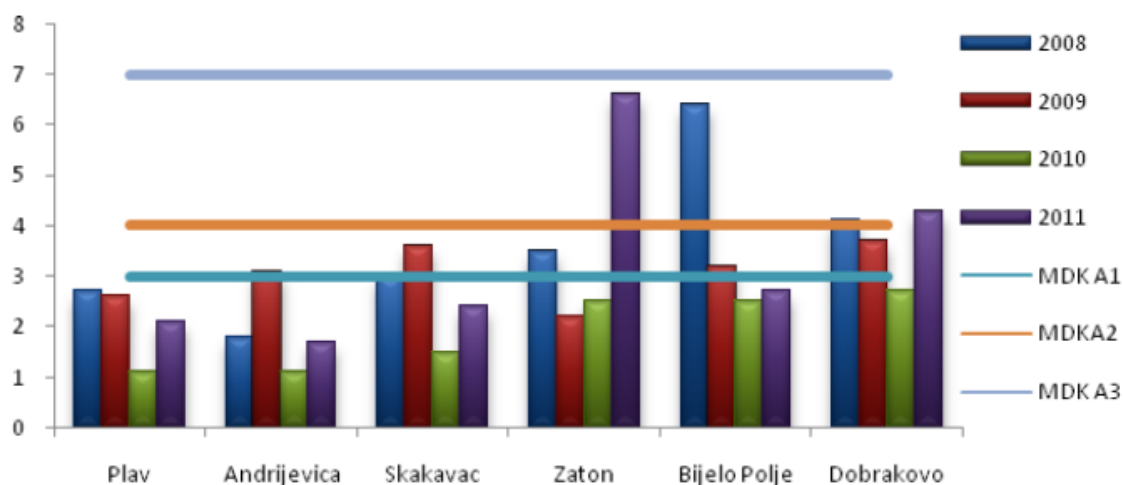
Table 7. Limit values for some of the key parameters defining water quality classes A – A3

	Parameters	Units	A	A1	A2	A3
1	pH		6.80-8.30	6.80-8.50	6.50-8.50	5.50-9.00
2	Colour (after simple filtration)	mg/l Pt scale	5	5	10	20
3	Turbidity	NTU	1	5	5	10
4	Total suspended matter	mg/l	0	<10	20	50
5	Temperature	°C	8-12	9-12	30	30
6	Conductivity	µs/cm at 20°C	300	400	600	1000
7	Nitrates	mg/l	10	20	25	50
8	Nitrites	mg/l	< DL*	0.003	0.005	0.02
9	Cadmium	mg/l	0.000	0.001	0.005	0.005
10	Lead	mg/l	0.001	0.010	0.05	0.05
11	Selenium	mg/l	0.001	0.001	0.010	0.010
12	Mercury	mg/l	< DL*	< DL*	0.0005	0.001
13	Cyanides	mg/l	< DL*	0.001	0.005	0.005
14	Sulphates	mg/l	20	20	50	200
15	Chlorides	mg/l	10	20	40	200
16	Total mineral oils	mg/l	< DL*	0.01	0.05	0.5
17	PAHs	mg/l	< DL*	0.0002	0.0002	0.001
18	Total pesticides	mg/l	< DL*	< DL*	0.001	0.0025
19	COD	mg/l O ₂	1	2	4	8
20	Oxidisability	mg KMnO ₄ /l	5	5	8	8
21	BOD ₅	mg/l O ₂	2	3	4	7
22	Total organic carbon	mg/l	1	1	2	2,5
23	Total coliform bacteria 37°C	/1ml	10	10	500	5000
24	Faecal coliform bacteria	/100ml	10	20	2000	20000

* DL – detection limit

BOD5- biochemical oxygen demand

Biochemical oxygen demand is the amount of oxygen required for biological oxidation of present, biodegradable water constituents. This parameter defines the assessment of water pollution, and the efficiency of waste water treatment process, and its values for different sections of Lim in the period from 2008 to 2011, are shown in Figure 23.

**Figure 23.** BOD5 in Lim expressed in mg/l

Phosphate content

They can appear in nature due to pollution from organic pesticides containing phosphates, but even precipitation can cause different amounts of phosphate in the recipient by washing away agricultural lands. Phosphates stimulate the growth of plankton and aquatic plants that serve as fish food. This growth may lead to an increase in the number of fish, and improve the general state of the water, but excessive amount of phosphates in water streams causes uncontrolled proliferation of algae and aquatic plants, which increases oxygen consumption and leads to its deficit. Phosphates are not toxic, unless they appear in very high concentrations.

Phosphates content in different sections of Lim in the period from 2008 to 2011, are shown in Figure 24.

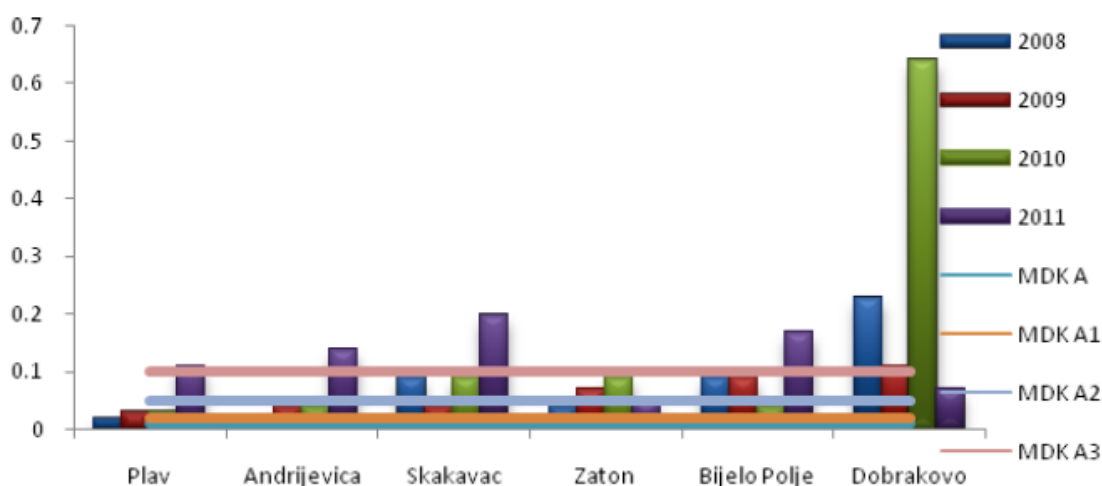


Figure 24. Phosphateu in Lim expressed in mg/l

Nitrate content

Compounds containing nitrogen, in waterstreams act as nutrients, cause lack of oxygen, and thereby influence the extinction of wildlife. Municipal and industrial waste water, septic tanks, the use of nitrogen fertilizers in agriculture, and animal waste are the main sources of pollution by nitrogen compounds. Water bacteria very quickly transform nitrates into nitrites.

Nitrate content in different sections of Lim in the period from 2008 to 2011, are shown in Figure 25.

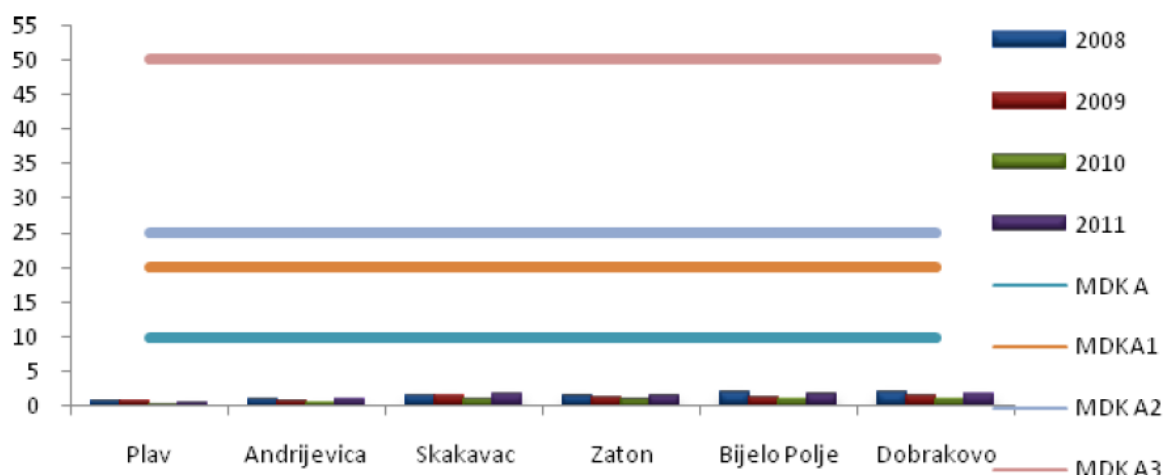


Figure 25. Nitrate in Lim expressed in mg/l

Measured values show that the nitrate content is within permitted limits.

From the aspect of Lim water quality, upstream of Berane it was designated as A1 class, and downstream as A2 class. Water was mostly loaded by phosphates, with its "out of class" concentration along the entire course, except near Zaton and Dobrakovo. Significant anthropogenic pressure along the entire course show nitrites, with their "out of class" concentration downstream of Zaton, and outside the prescribed class near Plav and Skakavac. Microbiological parameters are significantly increased, and downstream of Bijelo Polje they are designated as A3 class, i.e. "out of class" for fish farm and bathing.

Water Quality Index indicator was developed in the Agency for Environmental Protection, and it was intended for public reporting. The indicator is based on Water Quality Index method, according to which ten physico-chemical and microbiological quality parameters (oxygen saturation, BOD5, ammonium ion, pH, total oxides of nitrogen, orthophosphate, suspended solids, temperature, electrical conductivity, and coliform bacteria), aggregate into a composite indicator of surface water quality. Share of each of the ten parameters, does not have the same relative importance for the overall water quality, so each of them has its own weight (w_i) and ranking according to contribution in compromising quality. Summing the results ($q_i \times w_i$) index 100 is obtained as the ideal sum of all parameters quality shares. Numbers and types of parameters, as well as their weight coefficients could be modified according to local conditions and needs.

Adopted values for descriptive quality indicator are following WQI = 0-38 very bad, WQI = 39-71 bad, WQI = 72-83 good, WQI = 84-89 very good and WQI = 90-100 excellent.

Surface water quality indicators, along with compatibility of the existing classification of surface water according to their purpose and purity degree, are classified into the following categories:

Excellent – water that in its natural state along with filtration and disinfection, can be used for settlement supply and food industry, and surface water that can be used even for salmonid fish farms,

Very good and good – water, in its natural state, can be used for bathing, recreation, water sports, cyprinid fish farms, or, treated with modern methods, can be used for drinking water supply and in food industry,

Bad – water that can be used for irrigation, and after been treated with modern methods it can be used even in industry, except in food industry,
 Very bad – water which is, due to its quality, harmful for the environment, and it can be used only after been treated with special methods.

Figure 26 shows Water quality index (WQI) per basins. According to this indicator, Lim water quality is good (WQI = 76).

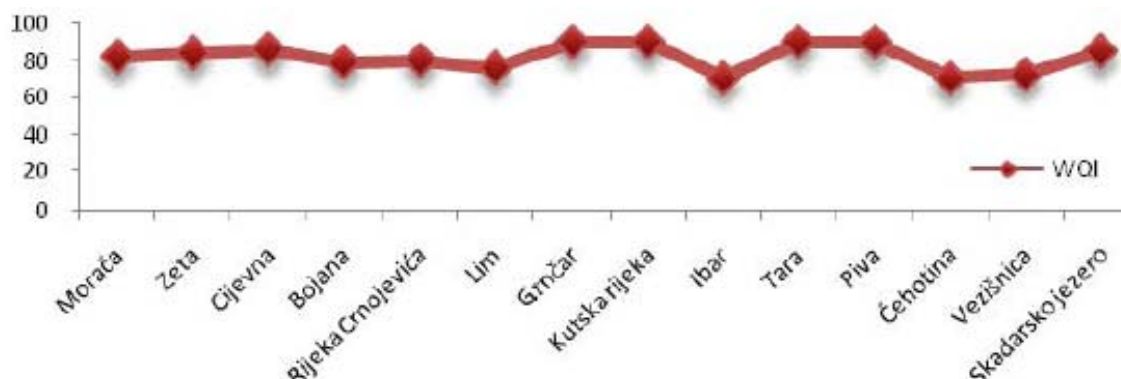


Figure 26. Water quality index (WQI) per basins

There is little information about ground water quality for the area of Berane. Testing is mainly related to water sources used for public water supply. Endangerment of ground water in the surveyed area is mostly related to the way of its capturing (compliance with sanitary and technical standards), and to possible infiltration of pollutants to the aquifer, which depends on structure of the rock mass. Generally, the most significant sources of ground water pollution are: wastewater from households nearby the source, landfill waste and manure, products of agricultural activities, as well as storm water contaminated by hazardous substances from agricultural areas.

Since majority of ground waters have karstic characteristic, their quality greatly depends on surface waters quality, considering their overlapping and weaker ability of karst ground water to purify itself.

When it comes to the quality of drinking water, according to 'Information about the environmental state in Montenegro in 2011', on the territory of Montenegro, a total of 14.503 samples from cities' water supply systems and other public water supply facilities were analyzed. Of this number, for 7.452 samples microbiological analysis was carried out, and for 7.031 physico-chemical testing was performed.

The results of physico-chemical and microbiological testing of chlorinated drinking water for all municipalities in Montenegro are shown in Figures 27 and 28.

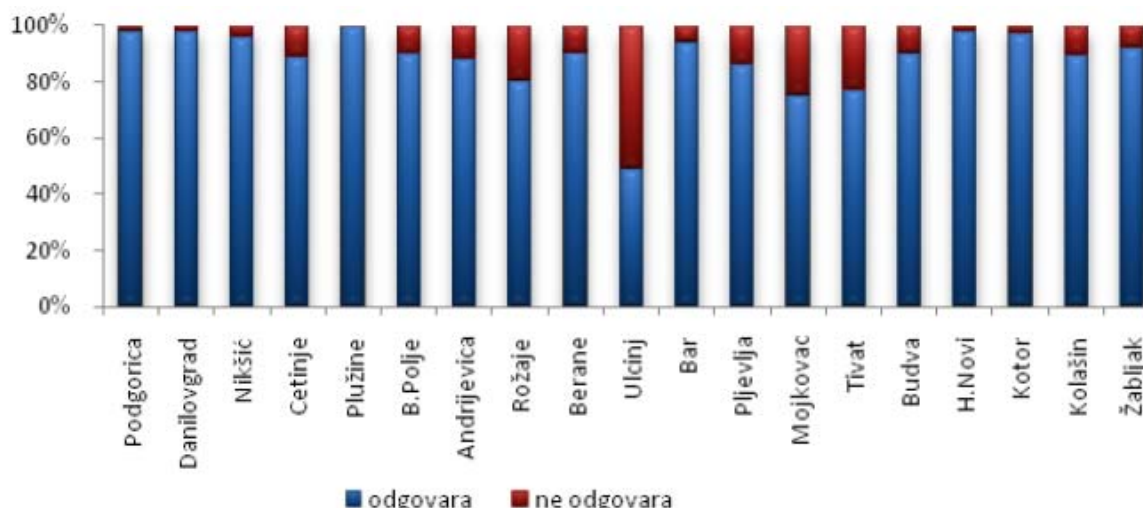


Figure 27.. The results of physico-chemical testing of chlorinated drinking water

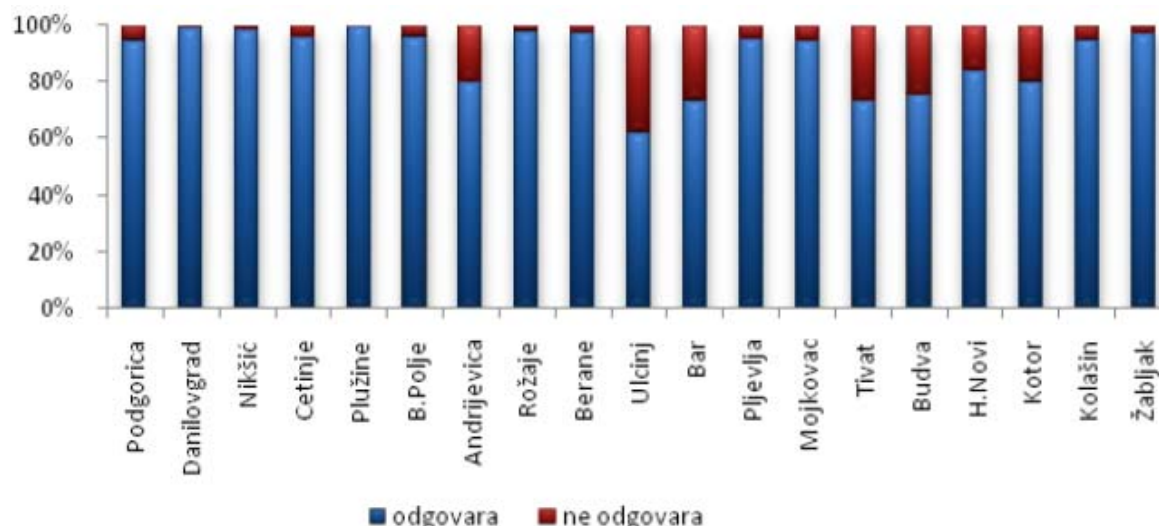


Figure 28. The results of microbiological testing of chlorinated drinking water

Based on these results, it can be concluded that the quality of chlorinated water from water supply systems in Berane meets the drinking water requirements without additional treatment, noting that adequate chlorination manages to provide bacteriologically safe drinking water.

5.5. Air Quality

Adoption of the Rulebook on Methods and Terms of Air Quality Monitoring (Official Gazette of Montenegro No 21/11) prescribes the methods for air quality monitoring and data collecting, as well as referent measuring methods, criteria for achieving data quality, data quality assurance and their validation.

In accordance with the Decree on the establishment of network for air quality monitoring (Official Gazette of Montenegro No 44/10 and 13/11), Montenegro territory is divided into three zones (Table 1) which are determined by a preliminary air quality assessment, in relation to the evaluation of pollutant limits, based on the available data on concentrations of pollutants, and modelling the existing data. Borders of air quality zones match up the external administrative borders of the municipalities, which are part of that zones (Table 8.).

Table 8 . Air quality zones

Air quality zone	Municipalities within the zone
Zone of maintained air quality	Andrijevica, Budva, Danilovgrad, Herceg Novi, Kolašin, Kotor, Mojkovac, Plav, Plužine, Rožaje, Šavnik, Tivat, Ulcinj i Žabljak
Northern zone - necessary to improve air quality	Berane, Bijelo Polje i Pljevlja
Southern zone – necessary to improve air quality	Bar, Cetinje, Nikšić i Podgorica

From the above table it can be seen that the Municipality of Berane belongs to a zone which needs to improve air quality.

In northern zone where Berane belongs, and where in accordance with Decree on the establishment of network for air quality monitoring it is necessary to improve air quality, the greatest impact on poor air quality has dust with particles of radius below 10 μ m (PM10). The main causes of air pollution in Berane are transport and heating, ie. emissions from the combustion of various fuels, while industry contribution to air pollution is minor in recent years, because small number of plants is working.

Air quality on the location has not been monitored. However, according to 'Information about the environmental state in Montenegro in 2011', made by Agency for Environmental Protection of Montenegro, basic network (called semi automatic stations) of air quality monitoring, carried out by HMI during 2011, covered 17 stations including the station in Berane where the content of following elements was monitored: sulphur dioxide, total oxides of nitrogen, ozone, smoke and soot, particulate matter, sediment, heavy metals, polycyclic aromatic hydrocarbons, as well as the quality of precipitation. 298 samples were realized on the station, thus fulfilling the statistical requirement for validity of the relevant parameters.

Sulphur dioxide content was generally very low, even annual mean values were below the detection limit. Content of nitrogen oxides was also below the prescribed norms.

Relatively low values for smoke were measured. Maximum of these particles was recorded during winter, suggesting an additional emission from heating.

Program of systematic precipitation quality testing, was realized through the network of 15 stations for general chemism, and 5 stations including the one in Berane, for total sediment particles. Percentage of sampling realization was satisfactory for all locations. The average value of precipitation electrical conductivity ranged between 50-60 μ S/cm, and the lowest average mineralization of precipitation was recorded in Berane (14 μ S/cm). Mean annual pH ranged between 6-7, and little above 7 was in Berane, while occurrence of acid rain was less than in 2010, and in Berane was not even recorded. According to pollutant content, the quality of precipitation was satisfactory.

Data show that the air quality in Berane evaluation based on the content of basic and specific pollutants, is satisfactory. It could be expected that the air on the location and its close surrounding is also of good quality, because favourable circumstance is that there is no source of air pollution in that area.

5.6. Landscape and Topography

Landscape and topography are described in Chapter 2.6. Knowing the facility size, as well as the area where it is constructed, it can be concluded that the facility will not affect the landscape and topography around the terrain in great scale.

5.7. Climate Characteristics

Climate Characteristics are described in Chapter 2.4. Knowing the facility type and size, the same will not affect climate characteristics of the area.

5.8. Infrastructure on the Site and Its Surroundings

Infrastructure on the site and its surroundings is described in Chapter 2.9. Knowing the facility size, its construction will increase the degree of what has already been built, both on the location and in the environment.

5.9. Cultural Heritage and Protected Natural Assets

As already been mentioned in Chapter 2.7., there are no cultural heritage and protected natural assets on the location and its close surrounding, so it cannot be spoken about the effect of the facility construction and exploitation on them.

5.10. Mutual Relations Between the Above Mentioned Factors

Reviewing different elements of the environment on one hand, and newly designed facility on the other, following conclusions could be made:

- There are no existing pollution sources on the wider area of the location, but the facility, during its construction, could be a particular source of effects on certain segments of the environment.
- Facility construction will violate the beauty of the canyon in certain degree, but current image of the area will not be significantly changed, due to the facility height.
- Additional negative impacts on the environment will not occur during the facility exploitation, except some accident situations, which are unlikely.
- Additional effect on air quality during the construction and exploitation is negligible.
- Since objects of the cultural heritage are placed far from the location, the effect on them, during construction and exploitation, is not expected.
- There will not be significant additional effects on the soil and groundwater, since the waste water has to meet the requirements given by current legislation, before being discharged into the river.

6. DESCRIPTION OF POSSIBLE SIGNIFICANT IMPACTS ON THE ENVIRONMENT

Construction and exploitation of Waste Water Treatment Plant (WWTP) in Berane could represent a kind of environmental pollution source. All effects are manifested through two types of impacts, which could be temporary or permanent.

In the first group are those effects, which appear as a result of construction, and by nature they are mostly temporary. They result from people presence, construction machinery, application of different technologies, and work organization. Negative effects on certain segments of the environment occur because of excavation and filling certain amounts of material, transport, installation of building materials, and permanent removal of soil cover.

Negative effects during the exploitation phase may occur in case of inadequate project management, while the accident cases are considered to be adverse events occurring during the project exploitation, either because of disasters or because of major force.

Project impact on certain segments of the environment, depends entirely on the quality of treated water coming out of WWTP, as well as on the characteristic of the sludge and method of its disposal.

For these reasons, before the analysis of possible project impact on certain segments of the environment, basic national and European legislation defining ie. specifying requirements to be met by effluent when it comes to its discharge into the recipient, as well as the requirements for sludge disposal, are going to be specified.

Waste Water

According to Article 80-85 of **Water Law** (Official Gazette of Montenegro No 27/07 and 22/11) and amendments to the Water Law (Official Gazette of Montenegro No 22/11, 32/11 and 47/11), a commercial company, other legal entity or entrepreneur who discharge waste water into the recipient shall treat the water before its discharge into the recipient, while using devices intended for that purpose, and thereby satisfying the effluent criteria prescribed by Rulebook on quality and sanitary technical requirements for wastewater discharge to the recipient and public sewage system, method and procedure for wastewater quality inspection, minimum number of inspections, and the content of reports on wastewater quality (Official Gazette of Montenegro No 45/08), Rulebook Amending the Rulebook (Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12).

Besides the above mentioned, local governments are required to invest in the equipment for purification of waste water annually, in order to reduce pollution with waste water as much as possible. Water facilities for collection, treatment, disposal, and discharge of wastewater from households, are in the possession and in the area of responsibility of local governments. The right to manage these facilities may be allocated to other companies or entities, if they are technically equipped and officially registered in the Central Registry as authorized for performing activities related to water protection against pollution. Facilities for waste water treatment should be equipped with devices for measuring waste water quality, and it is necessary to keep daily records about these facilities operation.

Law on Integrated Pollution Prevention and Control (Official Gazette of Montenegro No 80/05) and amendments to the Law on Integrated Pollution Prevention and Control (Official Gazette of Montenegro 40/11), regulates the conditions and procedures for issuing integrated permit for facilities and activities that can have a negative impact on human health, environment or properties, and also describes the types of activities and facilities, surveillance and other issues important for prevention and control of environmental pollution.

Decree on Classification and Categorization of Surface and Ground Water (Official Gazette of Montenegro No 02/07), governing the classification and categorization of surface and ground water in the land and coastal part of Montenegro, states the difference between the water that can be used for drinking, water for fishing and shell production, and bathing water. The Decree also prescribes limit values of quality indicators for water classification, as well as requirements for water sampling and water analyzing. However, the Montenegrin state laws do not distinguish sensitive and less sensitive recipients for waste water discharge. Water classification by application is presented in section 5.4.

Rulebook on quality and sanitary technical requirements for wastewater discharge to the recipient and public sewage system, method and procedure for wastewater quality inspection, minimum number of inspections, and the content of reports on wastewater quality (Official Gazette of Montenegro No 45/08), Rulebook Amending the Rulebook (Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12), prescribes waste water quality, sanitary and technical requirements for wastewater discharge into the public sewage system and natural recipient.

European Council Directive on the cities waste water treatment (91/271/EEC) concerns the collection, treatment and discharge of urban waste water, and its aim is to protect the environment from the adverse effects of above-mentioned discharges.

European Commission Directive (98/15/EC) which regulates the following amends the Directive:

- Collection, treatment and discharge of waste water from urban cores
- Treatment of biodegradable waste water from certain industrial sectors, and their discharge.

The purpose of the Directive is to protect the environment from the adverse effects of such discharges. Member States shall provide collection and treatment of waste water from cities, in accordance with certain standards and requirements, before their release. As to the treatment requirement, secondary treatment (i.e. biological) is implied, together with the tertiary treatment for additional nutrient removal in sensitive areas. Deadlines for the Directive implementation vary depending on the size of the centres and characteristics of the receiver.

According to Article 4 of Directive 91/271/EEC, waste water from cities, reaching the collector systems of Member States, since 1991 have to be purified by secondary (biological) treatment or some other equally effective treatment, before their discharge. By "secondary treatment" is considered the treatment of waste water from cities, which uses the process that generally involves biological treatment with secondary settlement, or some other process, which meets the requirements set out in the Table 1 of Annex I (of Directive), and those processes are:

- Waste water from the system of collectors for agglomerations with more than 15.000 ES ending with 31 December 2000
- Waste water from the system of collectors for agglomerations between 10.000 and 15.000 ES ending with 31 December 2005
- Waste water from the system of collectors for agglomerations between 2.000 and 10.000 ES, discharged into freshwater systems and confluences ending with 31 December 2005.

According to Directive 91/271/EEC, Article 7, waste water from cities coming into collector systems will be subjected to an appropriate treatment process as Article 2 defines, i.e. they will be subjected to any treatment and/or carried away by the system, which after discharging allows the receiver to meet relevant quality criteria and relevant provisions of this Directive and of the other Community Directives:

- Waste water from the system of collectors for agglomerations with less than 2.000 ES discharged into freshwater systems and confluences ending with 31 December 2005.
- Waste water from the system of collectors for agglomerations with less than 10.000 ES discharged into coastal water ending with 31 December 2005.

Sewage Sludge

Montenegrin legislation defines sewage sludge as the one produced in waste water treatment plants, or as a product of treatment process. When considering its disposal, the following Montenegrin regulations and documents should be kept in mind:

Law on Waste Management (*Official Gazette of Montenegro No 64/11*), which created the legal basis for the transfer of EU legal system into the national law. Besides determining the sludge as a special type of municipal waste, the law defines even the principles for its management in respect of the following: sludge producer obligations, permitted applications of sewage sludge, prohibited uses of sewage sludge, as well as the conditions under which it can be disposed of, incinerated or transported across the state borders. Law on Waste Management was harmonized with Directive 86/278/EEC.

As for the permitted use of sewage sludge, it can be used for land reclamation, land-use change in accordance with current urban plan, production of plants for composting, as well as for the cultivation of plants that are not used for food, and for production of animal feed. Sludge producer obligation is to perform the necessary analysis in order to determine limit values of sludge that can be used on different types of soil, and thus he provides the necessary information for a sludge user.

The legislature has clearly stated that only the sludge that has previously gone through the process of stabilization and necessary biological, chemical, thermal, and other preparation for reduction of its infectiousness and health hazard can be used for the above-mentioned purposes.

Strategic Master Plan for Waste Management at the national level in 2004, includes the following: the state projections on sludge production, plan for sewage sludge management, as well as the requirements for its implementation. According to this document, which has been prepared in accordance with EU Constitution and Directives, the leading strategy for ridding the country of the waste and sewage sludge, is prevention in the first place, then reduction, processing (recycling and reuse), and disposal as the last solution. Along with the preclusion of waste water production, a significant reduction of

sludge amount can be achieved through the implementation of a system for processing sewage sludge by aeration, as well as through the optimization of existing waste water treatment plants. Recycling and reuse of sludge largely depend on the sludge quality, which is variable due to different treatment and processing.

Consequently, an approximate classification of processed sludge could be made:

- Quality A+: the sludge subjected to drying, can be used in agriculture.
- Quality A: the sludge subjected to composting, can be used in agriculture,
- Quality B: the sludge subjected to composting, can be used in agriculture and in parks or on green spaces.
- Quality C: the sludge subjected to drying, can be incinerated and/or used for reclamation of landfills or mining areas.
- Low C quality: the sludge subjected to drying, can be used for reclamation of landfills or mining areas.

Disposal of sewage sludge on municipal landfills as the last option should be exercised in accordance with the current legal framework, some parts of which are planned to be replaced with new drafts of regulations by the end of 2012, in order to introduce EU standards into this part of state legal system. For now in Montenegro, only sanitary landfill "Livade" functions in accordance with the strict EU standards and at the moment accepts waste from Podgorica, Danilovgrad, Budva, Tivat and Kotor. The landfill is equipped with devices for collecting biogas, while the construction of the facility for recycling the unselected waste is now in progress. However, landfill Livade has neither facilities for composting nor processing the sludge and waste water from the landfill. Strategic Master Plan for Waste Management anticipates the construction of six more regional sanitary landfills, which are going to meet the standards of the Decree on EU Landfills, and it is also going to be in accordance with the other requirements set by the landfill locations themselves.

Law on Transport of Hazardous Substances (Official Gazette of Montenegro No 05/08), closely defines circumstances and activities related to the transport of hazardous substances.

In addition to above-mentioned documents, a number of regulations defining more precisely the topic were adopted, such as:

- Rulebook on more detailed characteristics of the location, conditions for construction, sanitary technical requirements, way of working and shutting down the landfills, education, landfill manager qualifications, types of waste, and requirements for taking the waste on the landfill (Official Gazette of Montenegro No 84/09).
- Rulebook on waste classification, and procedures for its processing and taking away (Official Gazette of Montenegro No 68/09 and 86/09).
- Rulebook on more detailed requirements that sewage sludge should comply with, its volume, frequency and methods of analysis for permitted purposes and requirements which soil, planned for that use, should comply with (Official Gazette of Montenegro No 89/09)
- Rulebook on requirements, which waste treatment or disposal plant, should comply in respect of equipment and personnel, and content of detailed description of working process (Official Gazette of Montenegro No 75/10).

In considering the transport of hazardous waste across the border, it is important to note

that Montenegro has signed the Basel Convention on the control of transboundary movement and disposal of hazardous waste, and its basic principles are incorporated into Law on Waste Management.

EU regulation concerning the final sludge disposal, covers several Directives, and the most important is **Directive on Sewage Sludge** (Council Directive 86/278/EEC, as amended by Directive 91/692/EEC: OJL 181, 04.07.86 on environmental protection, particularly protection of the land when sewage sludge is used in agriculture) (Annex II to Directive on Sewage Sludge). The main objectives of this Directive are to regulate the use of sewage sludge in agriculture, in order to prevent harmful effects on soil, vegetation, animals and man, and to stimulate proper use of sewage sludge. The Directive requires from Member States to adhere maximum permitted values of heavy metals, when it comes to either sewage sludge or land on which it is applied. This Directive also requires pre-treatment of sludge, and limits its use in certain types of soil (see Annex 1 of this report). The Directive sets limit values for concentration of heavy metals in soil (Annex I A of Directive on Sewage Sludge), in sludge, (Annex I B of the Directive), and limit values for maximum annual quantities of heavy metals that can be incorporated into the soil (Annex I C of the Directive).

Besides the Directive there are many other regulations discussing the above-mentioned field, such as:

- Directive on Environmental Impact Assessment 91/271/EEC.
- Council Directive 2003/4/EC on public access to the information about environment, which repeals Council Directive 90/313/EEC (OJ L41, 14.2.2003).
- Framework Directive on Waste 75/442/EEC.
- Directive on Hazardous Waste 91/689/EEC.
- Directive on Waste Incineration 2000/76/EC.
- Directive on Landfills 99/31/EC.
- Waste Export CR No 259/93, CR 1420/1999, CR 1547/1999 under the aegis CR.

Directive on Sewage Sludge demands from the EU Member States to meet the following legal requirements:

- Safe use of sewage sludge in agriculture in accordance with the regulations and requirements of the Directive in respect of pre-treatment of sludge (Articles 3 and 6), nutritional needs of plants (Article 8), soil quality (Article 8), protection of surface and ground water (Article 8), and compliance with the limit values for concentrations of heavy metals in soil (Article 5).
- Prohibition on the use of sewage sludge in some soil categories in certain periods prior to harvest (Article 7), and in those places where the concentration of heavy metals in soil exceeds defined limit values (Article 5 and Annex I A of this Directive).

Directive on Sewage Sludge demands from the EU Member States to meet the following obligations of monitoring:

- Analysis of sewage sludge and land where it is used, in order to ensure that the concentration of heavy metals in the sludge and in the land does not exceed defined limit values (Article 9 and Annexes II A, B and C of Directive on Sewage Sludge).

Directive on Sewage Sludge demands from the EU Member States to meet the following obligations of data recording and reporting:

- Precise record keeping and its availability to the government authority responsible for the environment protection, with regard to the following:
 - Amount, composition, use, treatment and results of sewage sludge analysis,
 - Names and addresses of sewage sludge users
 - Places where sewage sludge will be used (Article 10).
- Requirement from the sewage sludge producer to provide the users with specific information about the sludge composition (Article 6 and 11 and Annex II A of the Directive).
- Reporting to the Commission regarding:
 - The use of sewage sludge in agriculture (Article 17 and Commission Directive 91/692/EEC),
 - The measures taken in order to meet the requirements of the Directive, including the circumstances in which stricter criteria than required are adopted (Article 16)
 - The introduction of EU regulations into national legal system, together with the contents of the main provisions of adopted national law in the field covered by the Directive (Article 16).

Based on the above presented data, impact of treated waste water and sludge on the environment could be estimated.

It should be noted that the construction of Water Treatment Plant would positively affect the environment, because it will include the construction of new sewerage system, together with the network of main collectors, which will eliminate the use of septic tanks. On the other hand, elimination of untreated discharges, which is going to be achieved by construction of WWTP, will have significant positive effects, especially on reduction of Lim water pollution.

6.1. Air Quality

• *During the work execution*

Air quality is affected during the work execution, due to machinery presence, application of various technologies, and organization of work on the facility.

During the construction air quality could be affected due to the following:

- Emissions from vehicles and machinery engaged in the facility construction,
- Particulate matter (dust) arisen from the excavation and filling activities,
- Transport of excavated and filling material.

Quantification of these effects will depend primarily on the work dynamic, ie. the number of trucks and machinery that will be engaged in the facility construction.

During the project realization, a number of construction machinery (machine for excavation of material, loaders and trucks) will be engaged. These machines use oil derivatives - euro-diesel or diesel Eco, as fuel. An average fuel consumption of loaded machine is around $q = 0.2 \text{ kg/KWh}$. The machines have to be equipped with catalytic converters and filters for treatment of exhaust particles.

Based on the presented parameters, engine performances, and various literature findings (S. Joksimovic Tjapkin: "Procesi sagorijevanja", TMF Beograd, C.Stan: "Direkteinspritzsysteme fuer Otto-und Dieselmotoren", Springer-Verlag Berlin, H. Maass, H. Klier: "Kraefte, Momente und deren Ausgleich in der Verbrennungskraftmaschine", Springer-

Verlag Wien New York), volume of pollutants generated during the operation of machinery in a certain number of hours (6,5 h/day was taken as an example) is shown in Table 9. The calculation was done for a machine, a loader and a truck.

Table 9. *Volume of pollutants generated during the operation of machinery*

Type of Equipment	Horse power Kw	Volume of exhaust gas, m ³ /s	Total emissions m ³ /s				
			CO ₂	CO	NO _x	SO ₂	Aldehydes
machine for excavation of material	221	0.154	0.0154	0.0017	0.00015	0.000019	0.0000002
Loader	184	0.128	0.0128	0.00143	0.000128	0.000018	0.0000002
Truck	239	0.184	0.0184	0.002	0.000188	0.000019	0.0000002

Limit values of emissions, according to Decree on determining the types of pollutants, limit values and other air quality standards (Official Gazette of Montenegro No 45/08) are given in Tables 10 and 11.

Table 10. *Emission limit values for inorganic substances*

Pollutant	Concentration mg/m ³	
	C _{sr}	C _{max}
Sulfur dioxide	50	350
soot	50	150
Suspended particles	70	200
Nitrogen dioxide	60	150
Ground –level ozone	80	150
Carbon monoxide	3	10

Table 11. *Emission limit values for total sediment substances*

Pollutant	Unit of measure	Sampling time	Populated areas
Total sediment substances	mg/m ² /dan	1 month	450
		1 year	200

Limit values for dust in the air, according to the instruction of World Health Organization, are shown in Table 12.

Table 12. *Limit values for dust as a pollutant according to the instruction of World Health Organization*

Dust:	
Annual mean value for Class I	40-60 µg/m ³
98 percentile for Class I	100-150 µg/m ³
Annual mean value for Class II	60-90 µg/m ³
98 percentile for Class II	150-230 µg/m ³

Since the calculated amounts of pollutants are shown in the units of flow, and limit values of emission in the units of concentration, they cannot be compared.

However, since the emitted mass flow of each gas component (Table 9) does not exceed the limit mass flow prescribed in the Rulebook on emission of the pollutants into the air (Official Gazette of Montenegro No 25/01) (Article 14), then according to Article 13 of the same Rulebook, it is not necessary to do the measurements, ie. the emission is lower

than the permitted one. In case of lot of mechanization, a mitigating factor is that not all the machinery will be operative in the same time, on the same place.

The results clearly show that the extracted amounts of pollutants cannot cause a significant negative impact on air quality in this area, so in this respect there is no need to do the particular monitoring of environmental state during the facility construction. However, in order to minimize negative impacts of dust during the dry season and in time of wind, wetting of the excavations is necessary.

During the exploitation

During the facility exploitation, air pollution may appear due to the substances, which are released or evaporate from waste water, or due to emission of droplets from the aeration tanks. Odour intensity depends on the amount of discharged matters, air and water temperature, as well as on the wind strength and direction.

Having in mind that the facility will have electricity supply, i.e. there will not be any kind of fuel combustion, and thereby no air pollution.

It is possible that odour impacts from the WWTP will be detected, depending on weather conditions and plant operation, especially when bearing in mind that the nearest town is about 80m south of the location, and that north wind is most common. Having in mind that screen unit and sand trap with grease trap, retention tank and building for sludge dehydration will be covered, and the air from these units will be treated biologically, potential odour impact will be greatly reduced.

The construction of access road, which will be used during WWTP construction and operation, and which passes through uninhabited area, would help in avoiding adverse noise and odour impacts from cisterns bringing septage to the site and tankers removing sludge from the site.

Based on the above mentioned, it can be concluded that construction and operation of the object will not affect weather and climate parameters, and considering the place of the location, the cross-border impact is out of discussion.

6.2. Water Quality

During the work execution

During the construction work, Lim water quality could be endangered by uncontrolled leakage and discharge of oil, grease and fuel from used machinery. However, the use of technically correct machinery for the excavation and filling, and its regular daily and periodic review, make the occurrence of this accident slightly possible.

If construction landfills are not protected correctly, they could also be a potential source of pollution, especially during intense rainfall, and due to water from the access roads and machinery parking.

Probability of these temporary phenomena cannot be precisely assessed, but there is a certain risk of their occurrence, and it can be minimised by adequate organization of the building site.

During the exploitation

Sanitary and technical requirements for wastewater discharge into the recipient, define that the quality of discharged waste water must not cause deterioration in quality of the recipient, as stipulated by Rulebook (Official Gazette of Montenegro No 45/08), Rulebook Amending the Rulebook (Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12).

Table 13 shows the maximum allowed concentration in waste water for discharge into water bodies, based on which the quality of treated water could be monitored.

Table 13. *maximum allowed concentration of hazardous and harmful matters in waste water, which can be discharged into surface waters*

Ordinal No	Parameter	Units	Maximum allowed concentration (MAC)
1	pH		6,5-8,5
2	Temperature	°C	30
3	Δt, no more than	°C	2
4	colour	mg/l Pt skale	5
5	Odour		without
6	Depositing matters	ml/lh	0,5
7	Total suspended matter	mg/l	35
8	BOD5	mgO2/l	25
9	COD	mgO2/l	125
10	Total organic carbon (TOC)	mgC/l	15
11	Aluminium	mg/l	3,0
12	Arsenic	mg/l	0,1
13	Copper	mg/l	0,5
14	Barium	mg/l	3,0
15	Pine	mg/l	2,0
16	Zinc	mg/l	1,0
17	Cobalt	mg/l	1,0
18	Tin	mg/l	0,75
19	Cadmium	mg/l	0,01
20	Mercury	mg/l	0,005
21	Total chromium	mg/l	1,25
22	Chromium 6+	mg/l	0,1
23	Manganese	mg/l	2,5
24	Nickel	mg/l	1,25
25	Lead	mg/l	0,5
26	Selenium	mg/l	0,03
27	Silver	mg/l	0,15
28	Iron	mg/l	2,0
29	Vanadium	mg/l	0,05
30	Total phenols	mg/l	0,1
31	Fluorides	mg/l	2,0
32	Sulphites	mg/l	2,0
33	Sulphides	mg/l	0,25
34	Sulphates	mg/l	20
35	Active chlorine	mg/l	0,05
36	Mineral oil	mg/l	2,0
37	Total oil and grease	mg/l	10
38	Aldehydes	mg/l	1,0
39	Alcohols	mg/l	1,0

40	Total aromatic hydrocarbons	mg/l	0,05
41	Total nitrated hydrocarbons	mg/l	0,025
42	Total halogenated hydrocarbons	mg/l	0,25
43	Total organophosphorus pesticides	mg/l	0,025
44	Total organochlorine pesticides	mg/l	0,025
45	Total surfactants	mg/l	4,0
46	Total detergents	mg/l	0,5
47	Radioactivity	Bq/l	0,5

Requirements of EU legal regulations (Directive 91/271/EEC on Urban Wastewater Treatment and Directive 98/15/EEC amending Directive 91/271/EEC) and Montenegrin regulations (Water Law and Rulebook) on waste water treatment and their disposal into natural recipients for main pollutants are shown in Table 14.

Table 14. Effluent standards set by EU and Montenegrin legislation

Parameters	EU requirements		Montenegrin requirements	
	Minimum % of reduction	Maximum allowed concentrations	Minimum % of reduction	
	<i>All receiving waters</i>		<i>I category waters</i>	<i>All receiving</i>
BOD ₅	25 mg/l O ₂	70 - 90 40 under Article 4 (2)	25 mg/l O ₂	40 mg/l O ₂
COD	125 mo/l O ₂	75	90 mg/l O ₂	125 mg/l O ₂
Total suspended solids	35 mg/l *	90*	30 mg/l	60 mg/l
	35 under Article 4 (2) (more than 10.000 ES)	90 under Article 4 (2) (more than 10.000 ES)		
	60 under Article 4 (2) (2,000-10,000 ES)	70 under Article 4 (2) (2,000-10.000 ES)		
	<i>Sensitive areas</i>			
Total P	2 mg/l (10,000- 100,000 ES) 1 mg/l (more than 100,000	80	1 mg/l	2 mg/l
Total nitrogen	15 mg/l (10,000 - 100,000 ES) 10 mg/l (more than 100,000 ES)	70 - 80	10 mg/l	15 mg/l

As shown in Table 14. EU requirements for effluent load depend on identification of recipient as sensitive or less sensitive. In accordance with Article 5 of Directive 91/271/EEC, Member States were asked to specify sensitive area by 31 December 1993.

In comparison with the EU, Montenegrin legislation (Water Law and Rulebook) does not include standards expressed as percentage reduction of pollution load, does not differentiate between effluent standards depending on the size of WWTP, nor does it make

distinction between sensitive and other waters (but refers to national categorisation of waters). Finally, Montenegrin legislation does not include a time bound plan for provision of urban wastewater treatment and refers to all wastewaters. Sampling frequency is determined based on the point of discharge and dissolving coefficient, i.e. based on the total quantity of wastewater.

Project of WWTP in Berane is based on 27.000 ES, i.e. effluent from Berane WWTP should meet the regulations shown in Table 14 for category of 10.000 – 100.000 ES.

In order to meet the requirements given in Table 13, WWTP should be designed in accordance with Rulebook (Official Gazette of Montenegro No 45/08), Rulebook Amending the Rulebook (Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12) and EU Directive EU 91/271/EEC, i.e. technology used for waste water treatment (WWTP) in Berane should provide the above requirements.

However, to make the security complete, in the building reception phase it is necessary to examine the quality of treated waste water at the outlet of WWTP, and the obtained values compare with those stated above, and then accordingly make a decision on putting the Plant in operation.

Therefore, outlet from WWTP should release purified water, which meets the standards. Considering this object, there is no possibility of influencing transboundary water pollution.

6.3. Soil Quality

During the construction

During the construction of WWTP the greatest impact on soil is actually the loss of free surface, which is going to be occupied by the building.

Having in mind that the location is on flat terrain, construction of the facility will not cause significant changes of local topography, erosion, landslides, etc.

Contamination of soil may occur due to both, disposal of construction material and excess of excavated material on the soil, which has not been, determined a prepared for that purpose, and uncontrolled leakage of grease and fuel from the machinery and transport equipment (specified in section 6.2.). These impacts are temporary, i.e. last until the facility is constructed.

Summarizing these effects, it is estimated that work on ground preparation for the construction of WWTP, besides its occupying necessary surface will not significantly affect soil quality.

During the exploitation

Impact of the facility on land use and natural treasures in the area, excluding the land occupied by the object, will not be significant.

In the exploitation of the Waste Water Treatment Plant there will not be deposition of chemical or other matters that could affect the soil, since the Investor is obliged to act in accordance with the solutions and suggestions given in the technical documentation (description of work process).

However, the improper disposal of waste can have negative impact on the quality of the environment, especially land and water.

Potential negative environmental impacts may occur due to improper disposal of waste, which is generated during the exploitation of the facility, and those are:

- Screenings and contraries from the screens,
- Grit, sand and grease from the traps
- Stabilised and dewatered sewage sludge.

The waste from the screen need to be disposed of to landfill, while the waste mentioned in the second items, mostly oil, grease, pathogens, and other potentially harmful contaminants, have to be disposed on a sanitary landfill.

Sludge disposal is different kind of problem since its disposal on landfills can not be considered as sustainable solution, so for these reasons its use for other purposes is discussed in the alternatives.

During the facility exploitation, temporary disposal of utility waste, until it is transported to the town landfill by utility vehicle, will be provided in the containers, so there will be no significant impact on the environment arising there from.

In the area of construction, fields of mineral materials are not recorded, so it can not be spoken about their blockage.

6.4. Local inhabitants

Bearing in mind the purpose of the object, its construction and operation shall not cause a change in the number and structure of the population in this area which is already poorly populated because, during the operation of the object, only a handful of persons shall be employed, while during its construction the workers shall be present until the finalization of planned works. The number of employees that will execute these works (that are of temporary character) shall not change the number or the structure of the population which further on could negatively affect the quality of the environment.

During the course of the construction of the plant, visual effect shall not be most favourable; however, the same shall not be visible to a great number of people considering the population density in this area. Naturally, these effects are of temporary character.

Concentration of pollutants emitted during the construction of the object are presented in section 6.1, where it is also indicated that their impact on the environment of the location itself and around it is not high, and is of temporary character.

Noise

Noise appears on the construction site during the construction of the object (especially in the phase of foundations digging and location filling), as a result of the operation of the construction machinery, means of transportation and other tools. During the operation of the construction mechanization for the purpose of digging and filling, noise of significant intensity is emitted, and according to the information provided by the manufacturer of this mechanization, a maximum level of noise during operation, i.e. maximum load, can reach the values indicated in Table 15. The calculation was done for a machine, a loader and a truck.

Table 15. *Noise levels emitted by the construction mechanization that will be operating on the construction site*

Type of equipment	Noise level dB(A)
Machinery for the excavation of the material	99
Loader	92
Truck	90
Total noise level	100,22

Considering the fact that this is the case of multiple noise sources, it is necessary to calculate the total noise level using the following formula:

$$Lr = 10 \cdot \log \sum_j 10^{0.1Lrj}; dB(A)$$

where:

- Lr: is the total noise level.

Acceptable noise level during the night is calculated using the formula bellow:

$$P_x = P_0 \cdot e^{-RX}; dB(A)$$

Where:

- P₀: is noise level at noise source,
- P_x: is noise level reaching distance "X" and
- R: is air absorption coefficient.

The results of the calculation are shown in Table 15, in the event of maximum short-term noise "pollution" under the condition that all machines are put into operation and are operating close to each other, which is a rare case when it comes to the construction of a plant like this one. On the other hand, this situation appears in specific time intervals and is of temporary character and here it is noted that according to the Rulebook on Limit Values of Environmental Noise, Methods of Identifying the Indicators and Acoustic Zones, and Methods of Assessing Adverse Effects of Noise (Official Gazette of Montenegro No 60/11), allowed noise level ranges between 60 for the noise during the day, and 60 during the night and 50 dB(A) during the nights for the industrial zone which borders with road traffic, which most closely corresponds to the location of the object. The results indicate that during the construction phase there will be occasional increases of noise levels in the surrounding area which will exceed allowed values. In case of lot of mechanization, a mitigating factor is that not all the machinery will be operative in the same time, on the same place. However, favourable circumstance is that the narrow area around the location is unpopulated, and hence it should be expected that the noise level around the first individual residential objects be much lower. On the other hand, the works shall be executed only during the day.

All other construction works, considering the execution technology, cannot generate 50% of the noise level in regards to rough construction works (excavation, loading of excavated material and its transportation).

During the exploitation, mHE noise appears as a result of the operation of the pumps and compressors, and according to the prospect provided by the manufacturer, it equals 85 dBA at one meter distance from the source.

Bearing in mind that the equipment is kept in a soundproof closed object, and that the narrow area around the plant is unpopulated, than the noise level around the first residential objects located at over 80 m distance shall be lower than the allowed values.

Vibrations

During the implementation of the project on the location vibrations will occur as a result of the operation of construction machinery and the movement of the trucks. These vibrations shall be present until the finalization of the works on the location, but without significant impact on the environment due to the position of the location.

During the phase of the exploitation of the object, the vibrations shall not be significant, bearing in mind that the plant shall be built using modern construction materials.

During the construction and the exploitation, high amounts of heat that could threaten the environment around the location will not be emitted, and there will be no radiation during the construction and operation phase.

6.5. Impact on the Ecosystem and Geology

During the execution of the project all soil covers shall be removed, as well as all plant species on it. As far as the animal species are concerned, certain species, primarily reptiles, shall abandon the location; and on the other hand, it is possible to increase the population of some types of insects, primarily mosquitoes and flies. In the ecological sense, the location does not represent a highly significant area for the animal species, especially if taking into consideration the environment and the organisms that could be found there. Namely, all listed species are mobile and use much wider living space than this one, and hence it is to be expected that the species already living there will move and find new adequate habitats.

Disposal of excavated land can have negative impact on the living beings inhabiting the area where the works are executed (as well as the areas in direct vicinity). Therefore, this phase of works must be performed in a way to avoid massive consequence on the wildlife, i.e. it must not be of large dimensions and must be limited to a narrow strip on the location itself. A positive side of this construction phase is that it is of a temporary character.

Works to be performed during the construction of the object entail increased presence of the people and construction mechanization, and consequently an increased noise level. Animals living around this area shall temporarily abandon their inhabitants and migrate further away (this especially and to a largest extent refers to the wildlife living in the zone of direct impact of the planned project). This negative impact is of temporary character and refers to the time during which the object shall be constructed.

During site visit it was stated that there, as well as in the direct vicinity of the site, there is no rare, sparse, endemic or endangered plant or animal species ("Off. Gazette of Montenegro", no. 76/2006), i.e. the impact of the construction and exploitation of the object on the flora and fauna in the surrounding area of the location shall not be significant.

During the construction of the plant no damage shall be caused to the geological, paleontological or geomorphologic features of the location because the location of the object does not cover mineral deposits, paleontological or mineralogical phenomena that are or ought to be protected.

During the exploitation of the object there is no impact on the geology.

The impact of the treated waters on the Lim River and its flora and fauna shall not have a pronounced effect provided that the standards foreseen by the Rulebook on quality and sanitary technical requirements for wastewater discharge to the recipient and public sewage system, method and procedure for wastewater quality inspection, minimum number of inspections, and the content of reports on wastewater quality (Official Gazette of Montenegro No 45/08), Rulebook Amending the Rulebook (Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12).

However, a positive side of the planned project should also be taken into consideration, considering the fact that, for many years, all untreated waste waters from Berane, are being discharged into the River Lim. Because, when large quantities of nutrients (mostly nitrogen and phosphorous compounds, detergents) are introduced into the water ecosystem, this results in the increase of the concentration of organic substances and the reduction of oxygen which negatively affects the water ecosystem. With the construction of the WWTP, these phenomena shall disappear.

6.6. Impact on Designation and Use of the Land

Well known is the fact that the areas on which the object is going to be constructed are permanently lost and cannot be returned to the original purpose. Apart from them, there are areas that shall be used in the phase of construction.

Space planned for the realization of the object belongs to the unpopulated and unconstructed area, which earlier has not been used for any purpose, and by the decision of the state authorities, urban and technical requirements for carrying out these activities have been issued to the investor, so therefore the site has not been intended for any other purpose.

The land which is going to be occupied is not of agricultural character, so it cannot be spoken about the negative effect of the object on agricultural land.

6.7. Impact on the Communal Infrastructure

Proposed design solution shall not affect the existing utility infrastructure in the wider surrounding area of the location, i.e. it will not have any impact on the traffic and power and water supply.

Taking into consideration the fact that the traffic on the road which is going to be constructed for the needs of WWTP shall not be heavy and that the road does not go through the populated area, hence there will be no traffic congestion.

The connection of the facility to the power supply network shall be performed in accordance with the requirements prescribed by the competent Power Company.

Water supply of the subject plant shall be secured by the connection to the city water supply network in accordance with the requirements of the public utility company Vodovod i kanalizacija Berane.

It is foreseen that the treated waste waters be discharged through the outlet into Lim, while waste waters from the parking and manoeuvring areas surrounding the area shall be discharged into the separator for treatment.

Dehydrated sludge shall be transported to the landfill, while the solid waste shall be disposed of into the containers, and the utility company shall transport it from that point to the chosen landfill.

This type of solution for waste waters and solid waste shall have no negative impact on the utility infrastructure.

6.8. Impact on Protected Cultural Heritage, Natural Assets and Their Surroundings

There are no cultural heritage and protected natural assets on the location and its close surrounding, so it cannot be spoken about the effect of the facility construction and exploitation on them.

6.9. Impact on the Landscape Characteristics

Project realization and functioning will result in certain effect on the landscape characteristics of the zone that contains the location of the planned project. The Plant will harm visual appearance, but having in mind the height of the building visual impact will not be disrupted.

6.10. Accident situations

The greatest negative impact, during construction and exploitation of the project, on some segments of the environment (air, water and land) may occur in the event of an accident, and above all, oil and fuel leakages from the machinery and vehicles, plant damage, fire, and due to major force – an earthquake.

Oil and fuel leakage risk

This accidental situation has an impact on the land, and may result from spilling fuel and oil from machinery and motor vehicles, especially during construction.

During the construction phase in the event of spilling the fuel or oil from the machinery, chemically hazardous substances (hydrocarbons, organic and inorganic carbon, nitrogen compounds, etc.) could get into the surface soil layer.

In case of this accident, work should stop and contaminated part of the soil should be removed, stored in sealed barrels in protected part of the location, according to the Law on Waste Management (Official Gazette of Montenegro No 64/11).

The scope of the consequences in case of such accidents significantly depends on the specific characteristic of the location, primarily on soil sorption and coefficient of filtration.

However, possibility of this kind of accident can be minimized as far as the appropriate organizational and technical measures are applied during the construction of the building, which means that for all work means it is necessary to obtain proper documentation on the implementation of measures and regulations, together with regular maintenance of machinery (construction machinery and vehicles) in good condition, with the aim of maximizing the possibilities for elimination of fuel and oil leakage during operation.

In case of accidents during the object exploitation, such as oil and fuel leaking from motor vehicles in the parking areas and manipulative surfaces, negative impact on land and water will not be expressed, because in washing of these surfaces waste water is

drained through the separator for its treatment of light liquids and then discharged into street sewage.

Plant damage risk

Due to the cessation of plant operation or of some its parts because of various malfunctions, block out, fire, and the like, uncontrolled overflow of waste water may occur, which could have a negative impact on the surrounding land, particularly on Lim water quality.

In case of failure, which may occur due to irregular maintenance of the plant, urgent intervention is required in order to eliminate it. To avoid this there have to be regular control of the plant.

However, short delays at WWTP which are sometimes possible, will not lead to a greater negative impact on the environment.

Fire occurrence

The fire as elemental phenomena happens by accident, can practically occur in any part of the subject facility, and its scale, duration and effect cannot be pre-defined and predictable.

A fire in the facility may occur due to the following:

- Use of open flames (smoking, etc.)
- Malfunction or overloading of electrical equipment and installations,
- Use of hot plates, heaters and other heating body with red-hot surfaces,
- Non compliance with necessary preventive measures when using devices for welding and soldering,
- Keeping and accommodation of materials prone to spontaneous combustion, and their deliberate posting and the like.

Fire in the facility depending on its scale primarily can threaten safety of people, damage property and adversely affect the environment, and above all the quality of air, water and land.

However, having in mind that the facility is constructed of materials that are not easily flammable, and that processes going on inside do not use highly flammable and hazardous substances, so the probability of fire is minimal. On the other hand fire fighting system will be installed in the building.

Earthquake

A large negative impact on the stability of the building, and environment, especially water and land may have a strong earthquake, whose appearance, power, and possible consequences cannot be predicted.

The location has VIII degree of the **MCS** scale, so the construction and exploitation of the facility have to be in accordance with the current regulations and principles for anti-seismic designing and constructing, all according to Article 4 of the Law on Spatial Planning and Construction (Official Gazette of Montenegro No 51/08) and amendments to the Law on Spatial Planning and Construction (Official Gazette of Montenegro No 40/10, 34/11, 40/11 and 47/11).

7. MEASURES FOR PREVENTION, REDUCTION OR REMOVAL OF HARMFUL EFFECTS

The main goal of the construction of the WWTP is to reduce the pollution of Berane and the Lim River caused by the lack of a complete waste water collection system, and especially the non-existence of their treatment. Due to its specificity, this type of activity can, in certain cases, have negative impact on the environment, unless during the implementation and the functioning of the project adequate preventive measures are taken.

Based on the analysis of all characteristics of the existing location of planned project, it is indicative that basic preconditions for the minimization of negative impacts on the environment were created.

For certain impacts on the environment that are possible to expect and those which were identified with the analysis, it is necessary to take adequate preventive measures of protection in order to bring the reliability level of the whole system to an even higher level.

Impacts can be temporary or permanent. Temporary impacts are mostly related to the construction of the object and they mostly manifest themselves in a form of noise level and air pollutant emissions from means of transportation and mechanization employed on the construction site. Permanent impact during the construction of the object is related to the destruction of the land surface occupied by the object.

Impacts related to the exploitation of the object are not too evident, except in the event of accidents. Prevention, reduction and elimination of harmful impacts is going to be taken into consideration through the measures of protection foreseen by the technical documentation, measures of protection foreseen during the construction of the object, measures of protection during the exploitation of the object and measures of protection in the event of an accident.

7.1. Protection Measures Anticipated by the Designs

Waste water treatment plant (WWTP) in Berane must be planned, designed and constructed in a way that it:

- provides efficient treatment and disposal of waste water from the WWTP and
- has no negative impact on the ecological status of the Lim River and its environment.

General measures of protection include all activities prescribed by the development plans and legal regulation and are in accordance with the general global strategy referring to the preservation and enhancement of the environment.

In that context, it is necessary to:

- Adhere to all the guidelines identified in accordance with the general development principles of Montenegro, and concretized through the development plans, i.e. strategies.
- Respect all regulations (national and European) relating to intensity value of specific factors such as primarily water pollution, noise, air pollution etc. Measures of protection should bring the level of acceptable intensity within the framework of a specific investment project.
- Regularly monitor environmental status by organizing units for specific parameter monitoring on site.

- Elaborate plans for object maintenance during the year.
- Elaborate plans for the maintenance of planned elements referring to the environmental protection.

Administrative measures include all those activities to be undertaken so as to prevent some future phenomena that could jeopardize desirable expectation and legal norms. These measures include the following:

- Sanction potential individual construction in direct vicinity of the object during the elaboration of the technical documentation before the initiation of construction works.
- Provide professional supervision during the execution of the works so as to ensure control of the implementation of prescribed measures of protection during all phases.
- Provide instruments as part of contractual documentation that is to be formed by the Investor and the Subcontractor that refers to the essentiality to respect and implement measures of protection.

7.2. Anticipated Measures for Facility Construction

Environmental protection measures during the construction of the object include all measures that are necessary to be taken in order to bring quantitative negative impacts to an acceptable level, as well as taking of measures so as to reduce certain impacts to a minimum level.

Measures of protection include the following:

- Before starting the works, the construction site should be fenced, i.e. secured from unauthorized accesses and trespassing of all persons except workers hired to perform the works, workers who perform supervision, workers who perform inspection supervision and representatives of the Investors.
- The Subcontractor is obliged to set up the construction site in a way that the temporary objects, plants etc. have no negative impact on the third party.
- The Subcontractor is obliged to elaborate a separate Study on Construction Site Set-Up with precisely defined places for the storage and disposal of the equipment and material to be used during the execution of the works, as well as personnel and traffic safety.
- All construction and other material that could contaminate the environment should be stored in closed objects with hydro-isolated floors that could be cleaned.
- During the execution of the works maintain the mechanization, construction machinery and means of transportation in good working condition with the aim to reduce noise pollution to a maximum level, as well as eliminate possible leakages of oil, derivatives and lubricant oil.
- All construction machinery and means of transportation must be equipped with fire extinguishers.
- Traffic speed toward the object should be limited to 10 km/h, or even less if necessary.
- Vehicles that will be used for the transportation of the excavated material should be regularly washed in order to maintain the roads clean.
- The Subcontractor is obliged to make a right selection of construction machinery with noise emission and vibrations into the environment during operation not exceeding acceptable values which are 60 dB (A) for the noise during the day, and

60 dB(A) during the night and 50 dB(A) during the nights for the industrial zone which borders with road traffic, which most closely corresponds to the location of the object.

- If during the execution of the works discovered is a natural good for which it is assumed to have the characteristics of the natural monument, of geological-paleontological or mineralogical and petro-graphic origin, informs the Institute for Protection of Monuments of Montenegro and take all measures to secure that natural good until the arrival of authorized person.
- Material from the excavation of the foundations of the object should be transported to the location determined by the competent organ of the local self-government, unless there is an already registered landfill for that purpose.
- Within the preparatory works, location arrangement and filling activities until the required elevation is achieved, cleaning and stabilization should be done in the parts of the River Lim and Makva stream, within the subject area.
- Following the installation of the equipment it is mandatory to perform functional testing of the whole system in the presence of an authorized representative of the competent state organ.
- On the construction site of the object it is necessary to build toilets in a form of standard PVC hygienic toilets and locate them at points sufficiently distanced from other objects.
- Provide a sufficient number of portable containers for the collection of solid utility waste from the construction site and provide disposal and deposition of collected utility waste in agreement with the competent town utility service.
- Recover the area around the object once the works are completed, i.e. remove objects and materials which were used for the needs of the construction by transporting them to a chosen landfill.
- Cultivate free surfaces on the location around the object in accordance with the spatial planning project, which entails planting of plants that are characteristic of the project area, as well as planting of tree line around the WWTP.
- In the event of stopping the works due to whatever reason, it is necessary to secure the construction site until the continuation of the works.

7.3. Safety Measures During Facility Exploitation

In Chapter 6 listed were potential impacts of the object on the environment. In order to minimize the same, it is necessary to adhere to the following measures:

- At the WWTP outflow (inlet and outlet) it is necessary to perform permanent control of treated waste water which is discharged into the river through the outlet in accordance with the Rulebook on quality and sanitary technical requirements for wastewater discharge to the recipient and public sewage system, method and procedure for wastewater quality inspection, minimum number of inspections, and the content of reports on wastewater quality (Official Gazette of Montenegro No 45/08), Rulebook Amending the Rulebook (Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12).

It is required to submit obtained data to the state organ competent for the water management affairs (Decree on Method for Categorization and Categories of Water Facilities and Their Giving in to Administration and Maintenance (Official Gazette of Montenegro No 15/08).

Regulations referring to the manner and procedure for waste water quality testing, minimum number of tests and the content of reports on identified quality of waste waters are adopted by the Ministry, with prior opinion given by the Ministry competent for the environmental affairs and the Ministry competent for health-related affairs.

- With the aim to prevent the spreading of the unpleasant smells, all parts of the plant (screen unit, sand trap with grease trap, retention tank and building for sludge dehydration) emitting unpleasant smells have to be covered together with necessary ventilation and air purification.
- Sewage waste separated on the coarse and fine screens should be stored into a special container, from where it is transported to a landfill by an authorized utility company.
- Sand, waste oil and grease originated after leakage of waste water through the aerated sand trap and oil and grease separator, should be stored separately. The sand shall be transported to the landfill, while oil and grease marked as hazardous waste shall be stored separately.

According to Article 4 of Rulebook on criteria for choosing the locations, method and procedure for disposal of waste materials (Official Gazette of Montenegro No 56/00), hazardous waste should be collected into at least 100 l barrels with a cover (at least two), made of material that will ensure their impermeability, corrosion stability, and mechanical resistance. According to Article 6 of the Rulebook, the legal or physical entity who creates a hazardous waste, determines temporary landfill for disposal of hazardous waste in the area protected from precipitation.

- According to Article 52 of Law on Waste Management (Official Gazette of Montenegro No 64/11), the owner of hazardous waste shall entrust destroying of the same to a commercial company or entrepreneur who complies with the requirements determined by special regulation.

Means of transportation and equipment, used for collecting or transporting hazardous waste, have to prevent spilling or leaking of the waste, i.e. have to comply with the requirements set by the mentioned Law.

- Perform a regular quality control of dehydrated sludge before its final disposal (to the landfill or used it for land reclamation i.e. make a specially purposed land), according to Rulebook on more detailed requirements that sewage sludge should comply with, its volume, frequency and methods of analysis for permitted purposes and requirements which soil, planned for that use, should comply with (Official Gazette of Montenegro No 89/09).
- All devices (pump station, compressor station, backup generator and alike) must be secured in a way that the level of noise pollution nearby does not exceed values prescribed by the law.
- All chemicals necessary for the operation of the plant must be adequately and safely stored.
- Maintain the quality of the treated waste waters at the outlets from the light liquid and oil separator and mechanical filter according to the Rulebook on quality and sanitary technical requirements for wastewater discharge to the recipient and public sewage system, method and procedure for wastewater quality inspection, minimum number of inspections, and the content of reports on wastewater quality (Official Gazette of Montenegro No 45/08), Rulebook Amending the Rulebook (Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12).

- Regularly maintain access roads and other infrastructure facilities.
- Regular maintenance of plants and grassy surfaces that will be laid down in accordance with the spatial planning project.
- Regular utility maintenance and cleaning of objects and plateaus with the purpose to reduce potential pollution.
- Perform regular space disinfection and deratization by authorized institutions.
- Provide a sufficient number of trash cans and utility waste containers and secure collection and disposal of waste in coordination with a competent town utility service.
- Potential expansion of activities on the location cannot be performed before adequate analyses prove that such changes shall not have negative impact on the environment.
- According to the Law on Waters, a commercial company, other legal entity or entrepreneur who has waste water treatment systems and measurement devices should maintain the same in good working order i.e. secure their regular operation and keep an operations logbook.
- It is necessary to ensure that all objects are protected from flooding at the maximum flood flow of the river.
- Continuous supervision of operation, accuracy and efficiency of the Waste Water Treatment Plant performed by the water inspector, all in accordance with the Law on Waters.

7.4. Measures of Protection in the Event of an Accident

Fire protection measures

In the design documentation for the construction of the object, projected is a series of measures in the field of fire protection. These measures have serious impact on the increase of the general safety level of material goods in the object, i.e. the degree of fire resistance of the object shall be determined in accordance with the standards and shall be indicated in the Fire Safety Study.

In order to obtain fire safety it is necessary to do the following:

- All materials used for the construction of the plant and the accompanying objects must be calibrated by competent institutions in accordance with the applicable Law on Spatial Planning and Construction of Objects and fire safety regulations.
- Adequate selection of equipment and elements of electric installations should by all means be in accordance with the Project, i.e. it should provide be secured that the installations are not the cause of the fire or accidents at work during the execution of the works, exploitation and maintenance.
- In order to extinguish the fire it is necessary to provide a sufficient number of portable fire extinguishers which ought to be placed at accessible points, noting that the instructions be given as part of the Operation Manual provided by the manufacturer.
- The Investor is obliged to keep the fire fighting equipment in good working condition.
- Access roads should enable easy access to the object to all fire fighting units.

The Investor is obliged to elaborate a Protection and Rescue Plan which, among other things, includes training mode as well as actions of the employees in case of an accident. Everyone working in this plant must be familiar with all the aforementioned acts, their

rights and responsibilities.

Emergency Response Plan in the Event of an Accident must include the following:

- how to identify and recognize an accident,
- duties and responsibilities in the event of an accident,
- name, family name and the position of the head of a shift,
- method and procedure for notifying the employees and the Investor about the accident,
- procedure and roads for evacuation of employees to the safety distance,
- manner and way of transmitting information about the accident among responsible competent state intervention departments (Ministry of Internal Affairs, Emergency, Fire Dept. etc).

Measurements for protection from fuel and oil leak

Environmental protection measures in the event of an accident – spilling of fuels and oils during the construction and exploitation of the object also cover all measures that are necessary to be taken in order to prevent an accident, as well as taking of measures with the aim to mitigate the impacts of the accident.

Measures of protection include the following:

- The Subcontractor is obliged to make an adequate selection of construction machinery in the context of their quality – working condition.
- For all employed means of work gather necessary documentation on application of measures and requirements for technical condition of vehicles.
- During the execution of the works maintain the mechanization (construction machines and vehicles) in good working condition with the aim to eliminate potential leakages of oil, derivatives and machine oils during operation.
- In case there is some oil spilling from machinery during the construction of the object, it is necessary to remove the contaminated soil, storage it into the barrels in the protected area of the location, all in accordance with the Law on Waste Management ("Off. Gazette of Montenegro" No 64/11), and replace it with a new layer.

8. MONITORING OF THE ENVIRONMENTAL CONDITION

Even though present condition of the environment on the location and its wider surrounding area has been partly presented in Chapter 2, and partly in Chapter 5, before the construction of the object, the Investor is obliged to investigate the quality of the environment (segments for which there is no exact data relating to the location) through the competent institution, all with the aim to establish “baseline condition” of the site, i.e. obtain a full picture of the condition of the environment on the location and its surrounding area.

In that context it is necessary to do the following:

- Conduct naturalistic research of the Lim River, and its part that is going to be exposed to direct impact with the aim to identify all impacts (both positive and negative) of the construction and exploitation of objects on the flora and fauna of the river.
- Perform physical and chemical and microbiological analysis of water samples from the Lim River (upstream and downstream from the point of future outlet) in order to identify the impact of the object during the construction on the quality of its water.
- Perform air quality analysis and measure noise level on the location.

Since after having performed the analysis of the impact of the construction of the object on the environment and application of adequate measures of protection, it was concluded that during the construction of the object certain temporary impacts on air quality can be expected, as well as increase of noise pollution level, hence it is recommended to occasionally monitor them – measurements in the event of increased dusting and operation of a larger number of machines at the same time.

Even though the values of calculated concentration of released pollutants in the air during the construction of the object are lower than the threshold limits values, it is mandatory to perform air quality control measurement at the beginning of the construction of the object in order to check the values obtained based on the model.

Perform measurements at the place of the location of the object.

The monitoring is performed by an authorized organization certified in accordance with the MEST ISO 17025 standard.

As part of noise level monitoring, also perform measurements during the construction of the object. If the need arises for the reduction of the noise level, it is necessary to reduce the number of construction machines working at the same time.

Noise level monitoring is performed by authorized organization certified in accordance with the MEST ISO 17020 standard.

In addition to the aforementioned, in the construction phase of the object it is necessary to visually control the following:

- once in fifteen days control the level of dust on the construction site, and even more frequently during the dry periods when the winds are blowing,
- once in fifteen days control the site cleaning and disposal of excavated material.

Also, through the analysis of the impact of the exploitation of the object on the environment with the application of adequate measures of protection, it was concluded

that significant impacts on the air and land quality and generated noise level are not to be expected, and hence due to that reason it is not recommended to separately monitor segments of environment, excluding the quantity and quality of treated waste waters on the outflow of the WWTP, as well as the status of flora and fauna of the Lim River at the water discharge point from the outflow, as well as legal obligations in the event of an accident, which have been reduced to a minimum with the adherence to the regulations and measures.

In that context commercial company, other legal entity or entrepreneur who discharge waste water into the recipient shall provide measurement of the flow of treated waste waters discharged into the Lim River, in accordance with Article 84 of the Law on Waters ("Off. Gazette of Montenegro", no. 27/07 and 22/11) and Amendments to the Law on Waters ("Off. Gazette of Montenegro", no. 22/11, 32/11 and 47/11), as well as control of the quality of waste waters at the outflow of the WWTP by taking regular samples, all in accordance with Article 27 of the Rulebook on quality and sanitary technical requirements for wastewater discharge to the recipient and public sewage system, method and procedure for wastewater quality inspection, minimum number of inspections, and the content of reports on wastewater quality (Official Gazette of Montenegro No 45/08), Rulebook Amending the Rulebook (Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12).

In accordance with the Rulebook, treated waste water discharged into Lim has to comply with the following standards:

- Biochemical Oxygen Demand (BOD5)* 25 mg O₂/l,
- Chemical Oxygen Demand* 125 mg O₂/l,
- Suspended Solids* 60 mg/l,
- Total Nitrogen 15 mg N/l
- Total Phosphorus 2 mgP/l
- Total coliform bacteria 10.000 TC/100 ml and
- Fecal coliform bacteria 5.000 FC/100 ml.

*(These standards have to be met on a 95% basis)

Perform regular control of the quality of dehydrated sludge prior to its disposal to the landfill according to the Rulebook on More Detailed Requirements That Sewage Sludge Should Comply With, its volume, frequency and methods of analysis for permitted purposes and requirements which soil, planned for that use, should comply with (Official Gazette of Montenegro No 89/09).

During the exploitation of the object, the ecosystem of Lim should be monitored once a year. After the first year of monitoring, depending on the results, adjust the frequency of monitoring.

Investigations and monitoring are performed by authorized certified organizations, and they submit the reports on investigations to the state organ responsible for the environmental protection, all in accordance with Article 35 of the Law on Environment in (Off. Gazette of Montenegro" no. 48/08) and Amendments of the Law on Environment ("Off. Gazette of Montenegro" no. 40/10 and 40/11).

It is mandatory to inform the public about all the measurement results in a transparent way.

9. INFORMATION SUMMARY

The location proposed for construction of Waste Water Treatment Plant (WWTP) is in the northern part of Berane, in the unpopulated part of Donji Talum, on the left bank of the River Lim, and covers around 2,5ha of currently unused land. It is approximately 1.800m far from Berane downtown, and approximately 150m from Berane Bijelo Polje highway.

According to Urban and Technical Requirements issued by the competent state authority, construction of WWTP in Berane is planned to be on urban parcel UP1 of 25.880 m² square surface, and the parcel is composed of cadastral parcel No 76 and parts of the following cadastral parcels No: 24, 31, 34, 35, 38, 73, 74 and 75.

The facility occupies 4.122 m² of total surface, 4.594 m² for handling surface, and 17.164 m² for protective greenery. Construction index is 0,16.

In the morphological sense, the location belongs to a flat flood-prone part of Lim riverside, so before WWTP construction it is necessary to raise the terrain on the location, and regulate the part of the course of Lim River. Makva stream flows through a part of the subject area, and its function is to collect surface water from the surrounding area. The stream also needs to be cleaned and regulated in order to make the space free from potential impact of storm water.

Terrain on the location is relatively flat, and it is a grassy surface with a certain number of plant species. There are no landslides or other potential limitations to use the site for building up WWTP. The site is not on the protected area, and there are no natural and cultural assets on the very place. Examining the available documentation it was found that the site had no visible remains of material and cultural assets that would indicate possible archaeological field.

The location allows gravity flow of wastewater from the entire area of the city and settlements along the left bank of the river Lim, but wastewater from settlements on the right bank will have to be pumped across the river into the main collector. The location is outside of any sanitary protection zones and is in close vicinity of the Lim, which in this area is not used for fishing or recreation by local residents.

Berane – Ribarevina highway passes from the west side of the location, it is 150 to 200m distanced, and the settlement Beranselo with a high number of individual residential objects follows, while the settlement Donji Tulum is on the location south side. The River Lim is on the east side of the location, and on its right bank is paper factory "Nova Beranka", while Tivran Gorge is in the north.

It is possible to access the site by local road running through the settlement Donji Talum, but its technical and exploitation characteristics do not correspond to the future needs of the location, because it is a narrow street with houses very close to the edge of the road.

To avoid the above issues, for needs of construction and operation of WWTP it is proposed to construct a separate access road that would pass through the unpopulated part to the location.

Other infrastructure facilities in the location surrounding are water, electricity and telephone networks, so the location can be connected to the necessary infrastructure.

The main objective of WWTP construction is to reduce pollution in Kolasin and in Tara River, caused by the lack of a complete wastewater collection system, and particularly by the lack of wastewater treatment. A major problem is the discharge of untreated

wastewater to the Lim river which, apart from causing notable pollution (particularly when the river flow is low), also poses a threat to downstream rivers and water resources. There are also a number of septic tanks in parts of the city discharging effluent to the ground and sometimes to open streams.

The Design for Wastewater Treatment Plant was based on 27.000 population equivalent, and 22.500 people from household category. The connected population at present is around 12.000, and the rate at which this increase will depend largely on the development of the wastewater collection system. For the Minimum Project, the population connected is projected to reach 14.050 in 2015, and growth beyond this depends on extension of the collection system. For the Base Project, the population connected is projected to reach 16.210 in 2015, and growth beyond this again depends on extension of the collection system. In the case of the Maximum Project population connected is projected to reach 19.450 in 2015, and 22.500 by 2035. Unless the Maximum Project is implemented initially, it is clear that the implementation of the WWTP should be phased to avoid providing excessive overcapacity, particularly if the wastewater flows and loads received at the treatment plant do not increase as fast as assumed.

Designs have therefore also been prepared for a Minimum WWTP which is designed for a population equivalent of 17.750 (14.050 connected population) and a Phase 1 for the WWTP (Base Project) which is designed for a population equivalent of 20.000 (16.210 connected population). The storm tank that is included in the full design has been omitted from the Minimum and Phase 1 designs. To further reduce the initial cost of the Minimum WWTP the process parameters have been amended so that Nitrogen and Phosphorus removal is reduced. Both the Phase 1 and the full WWTPs include Nitrogen and Phosphorus removal to the level required by Montenegrin and EC regulations.

Before the project realization, certain preparatory works need to be done. After the location is thoroughly identified, it is necessary to fence it, that is, mark the place of construction for each segment, actually, each square area occupied by buildings.

In order to comply with WWTP construction and operation demands, it is proposed to build up a separate access road that would run through unpopulated part of the site.

Preliminary work includes a range of activities required for all tasks completion. Plan of organization anticipates continuous construction. All anticipated preparatory works is adjusted to continuous tasks performance.

Before the work starts and during setting up of the building site, it is necessary to provide temporary objects, as well as all infrastructures necessary for tasks performance.

The contractor is required to arrange setting up of the building site, so that it is temporary buildings, machinery, equipment, etc do not affect the third party.

After the work completion, the contractor shall remove all temporary objects set for construction, and restore all the terrain.

Feasibility Study for Water and Wastewater Development Project in Berane (WYG International, 2012), reviews the possibilities for secondary treatment of wastewater such as:

- Lagoon or constructed wetland
- Attached and suspended growth.

Attached and suspended growth system with a process using Suspended growth – Sequential Biological Reactor (SBR) within it, was chosen as better solution for Berane.

Advantages of Sequential Biological Reactor are: occupation of small space, settlement tanks and sludge recycle are not necessary, and disadvantages are: high automation requirement, relatively complex control and drainage systems.

The Phase 1 design includes 75% of the 2035 capacity of the SBR tanks but, as mentioned above, excludes the storm tank.

The plant is composed of the following parts:

- Inlet pump station,
- Fine screens,
- Grit and grease removal,
- Overflow chamber,
- Storm tank,
- SBR tanks,
- Sludge thickening/dewatering,
- Sludge buffer storage tank,
- Dewatered sludge storage,
- Air blower house,
- Electricity substation and
- Office and laboratory.

The SBR process is a very flexible process that is capable of producing high quality treated effluent. The small land requirement for the process is a particular advantage for Berane where the available land for the treatment plant is very limited. Although the SBR process is somewhat more complex to maintain than some processes due to the extensive automated control systems, it is not considered that this should present any great problem to ViK given the proper training from the supplier.

The plant is equipped with the following elements: system for drainage of treated wastewater, device for sludge separation, and system for control of the process. Wastewater treatment process takes place in timed series of different phases (filling, reaction, settling, drainage).

Effluent from WWTP, discharged into Lim has to comply with the following standards:

- Biochemical Oxygen Demand (BOD5)* 25 mg O₂/l,
- Chemical Oxygen Demand* 125 mg O₂/l,
- Suspended Solids* 60 mg/l,
- Total Nitrogen 15 mg N/l
- Total Phosphorus 2 mgP/l

*(These standards have to be met on a 95% basis)

Sludge is the product obtained from the process of wastewater treatment, which should be treated properly, and later disposed safely. From the experience, around 70-80% of organic carbon turns into dry, solid material during biological treatment in the plants. The obtained deposition – sludge is one of the toxic pollutants, environmentally harmful, and of very unpleasant smell. It absorbs and keeps in itself pathogenic organisms and toxic substances. The amount of sludge separated in the plant, depends primarily on quality of treated water, and on treatment technology itself. If the process is more complete, the amounts of sludge are larger. According to so far experiences, the amount of separated sludge ranges from 40 to 60g of dry content per equivalent inhabitant per day.

Several very different methods of sludge treatment have been developed and demonstrated. They could be combined mutually in different ways, depending on the size of the device, and the way of further sludge usage. The aim is the same for all methods: reduction of sludge volume, or removing as much water from the sludge as possible. To achieve that, the following processes are used: dewatering, sludge thickening and drying, sludge stabilization, sludge usage for economy purposes, sludge disposal and incineration.

Sludge treatment method depends on its use or disposal. According to the Law on Waste Management (Official Gazette of Montenegro No 64/11) Article 49, sludge can be used in:

- Agriculture
- Green areas and parks
- Land reclamation
- Landfills as the final coating layer and
- Making a specially purposed land, according to waste management plans and regulations on spatial planning.

According to the Law on Waste Management, temporary disposal of sludge on the future landfill in Berane, in a form of a final coating layer, is suggested as most favourable solution for WWTP in Berane. If construction of WWTP completes before the construction of landfill, the use of sludge for land reclamation, primarily in forests, is suggested as an alternative solution.

The Administration building for the plant management will be constructed within the Project, and it is going to have the following premises:

- Control centre,
- Laboratory,
- Shared rooms
- Workshop and warehouses and
- Boiler room.

Certain number of parking spaces is going to be built around the Administration building, while free area on the location is going to be cultivated according to the design on spatial planning. It involves planting of the herbs characteristic for the observed area, as well as planting tree lines around the WWTP.

For the building are planned all types of installations required by prescribed standard or technology, or it is required according sanitary and technical conditions and standards for this type of object.

Electricity supply of the facility is planned to be from the transformer station, which is going to be built up for the facility necessities. The transformer station will be built up in accordance with requirements and standards for this type of objects, issued by the appropriate Power Company.

In case of blackout, supporting generator will provide the electricity for the facility. Capacity of the generator is sufficient for the basic needs, first pump station operation and lighting.

Devices for electricity supply, as well as supporting generator will be installed in a separate building on the facility location.

Facility will be connected to the town water supply network with pipes of proper diameter, and in accordance with requirements of PE »Water Supply and Sewage System« Berane.

Before coming into operation, the entire water supply network has to be flushed and disinfected, in accordance with current law regulations.

For the purposes of fire fighting, special water supply network is anticipated, according to the Study on fire fighting.

Separate sewerage and storm sewer systems are planned for the Administration Building. It is planned that the Administration Building sewer system is connected to the WWTP.

A special system is planned for draining water, which has been left after washing the handling areas and the parking, because that water can be loaded with soil, sand or light liquids from the trucks. Water collected from these surfaces by specific network, before discharging into the river, goes through the separator where it is treated, or soil and sand are deposited, and light liquids (fuel and oil) are separated.

Material from the excavation of the foundations, and all urban waste, that appears during the facility construction, will be collected with control, and Utility Company in charge will transport it to the location determined for that purpose.

During the facility exploitation, temporary waste disposal, until its transport to the town landfill by utility vehicle, will be provided in the standardized hygienic containers at the collection point.

According to the Feasibility Study for Water and Wastewater Development Project in Berane (2010), created under the auspices of the EU which finances Infrastructure Project of the Western Balkans, for which WYG International has been appointed as Consultant, competent local authority together with the consent of engaged professional team, among alternatives in terms of the location, waste water treatment process, sludge processing and storage, has chosen most favourable solutions, and started the elaboration of the project in accordance with the received urban and technical requirements issued by the competent state authority responsible for drafting of technical documentation and construction of WWTP in Berane.

According to review of different environmental characteristics, and based on site visit, there are no existing sources of pollution in the wider area.

Possible impacts of the facility on the environment at the location and its surrounding may occur during the construction phase, the exploitation phase, and in the event of an accident.

From the adverse impacts during construction of the project, the following are specifically emphasized: space occupation, possible pollution of air, water and soil, occurrence of odours, noise and impacts on flora and fauna.

Negative effects during the exploitation phase may occur in case of inadequate project management, while the accident cases are considered to be adverse events occurring during the project exploitation, either because of disasters or because of major force.

The results clearly show that the extracted amounts of pollutants cannot cause a significant negative impact on air quality in this area, so in this respect there is no need to do the particular monitoring of environmental state during the facility construction. However, in order to minimize negative impacts of dust during the dry season and in time of wind, wetting of the excavations is necessary.

There will not be air pollution at the site and its surrounding in the exploitation of the building, because WWTP does not have the equipment using fuel, and consequently there cannot arise by-products that are harmful and dangerous.

It is possible that odour impacts from the WWTP will be detected. Odour intensity depends on the amount of discharged matters, air and water temperature, as well as on the wind strength and direction.

During the construction work, Lim water quality could be endangered by uncontrolled leakage and discharge of oil, grease and fuel from used machinery. However, the use of

technically correct machinery for the excavation and filling, and its regular daily and periodic review, make the occurrence of this accident slightly possible.

In the operational phase water will not be polluted, provided that the technology used for treatment of waste water (WWTP) in Berane meets the requirements prescribed by the Rulebook (Official Gazette of Montenegro No 45/08) and Rulebook Amending the Rulebook (Official Gazette of Montenegro No 09/10) and amendments to the Rulebook (Official Gazette of Montenegro No 26/12) and Directive EU 91/271/EEC.

Impact of the facility exploitation on land use and natural treasures in the area, excluding the land occupied by the object, will not be significant.

Potential negative environmental impacts may occur due to improper disposal of waste, which is generated during the exploitation of the facility, and those are screenings and contraries from the screens, grit, sand and grease from the traps, and stabilised and dewatered sewage sludge.

The waste from the screen need to be disposed of to landfill, while the waste mentioned in the second items, mostly oil, grease, pathogens, and other potentially harmful contaminants, have to be disposed on a sanitary landfill.

Disposal of sludge on the future landfill was proposed as the optimal solution for the WWTP in Berane. The sludge generated in the wastewater treatment process will be subjected to retention and mechanical dehydration, thereby ensuring that the negative impact on the land will not be significant.

During the facility exploitation, temporary disposal of utility waste, until it is transported to the town landfill by utility vehicle, will be provided in the containers, so there will be no significant impact on the environment arising there from.

The number of employees that will execute these works during the construction (that are of temporary character) shall not change the number or the structure of the population which further on could negatively affect the quality of the environment.

During the course of the construction of the plant, visual effect shall not be most favourable; however, the same shall not be visible to a great number of people considering the population density in this area. Naturally, these effects are of temporary character.

Noise appears on the site during construction work due to construction machinery, transportation equipment and other tools.

During the exploitation of the building noise occurs due to the pump operation, compressor station, and backup generators.

Bearing in mind that this equipment is enclosed in the soundproof object, and the immediate area around the building is inhabited, so the noise level to the first housing units that are located at distance of over 80m will be much lower than the permissible value.

During the project realization, it will be necessary to do the excavation of soil and rocks for construction. Therefore, this work has to be carried out in a way that it will not have major consequences for wildlife, i.e. must not be of large dimensions and has to be limited to a narrow strip at the site. Positive side of this phase of work is that it is temporary.

Works to be performed during the construction of the object entail increased presence of the people and construction mechanization, and consequently an increased noise level. Animals living around this area shall temporarily abandon their inhabitants and migrate further away (this especially and to a largest extent refers to the wildlife living in the zone of direct impact of the planned project). This negative impact is of temporary character and refers to the time during which the object shall be constructed.

During site visit it was stated that there, as well as in the direct vicinity of the site, there is no rare, sparse, endemic or endangered plant or animal species “Off. Gazette of Montenegro”, no. 76/2006, i.e. the impact of the construction and exploitation of the object on the flora and fauna in the surrounding area of the location shall not be significant.

During the construction of the plant no damage shall be caused to the geological, paleontological or geomorphologic features of the location because the location of the object does not cover mineral deposits, paleontological or mineralogical phenomena that are or ought to be protected.

Proposed design solution shall not affect the existing utility infrastructure in the wider surrounding area of the location, i.e. it will not have any impact on the traffic and power and water supply.

There are no cultural heritage and protected natural assets on the location and its close surrounding, so it cannot be spoken about the effect of the facility construction and exploitation on them.

Project realization and functioning will result in certain effect on the landscape characteristics of the zone that contains the location of the planned project.

The greatest negative impact, during construction and exploitation of the project, on some segments of the environment (air, water and land) may occur in the event of an accident, and above all, oil and fuel leakages from the machinery and vehicles, plant damage, fire, and due to major force – an earthquake.

Protection measures derive from primary identified and quantified impacts and contribute to the maintenance of existing environmental state.

Prevention, reduction and elimination of harmful impacts is going to be taken into consideration through the measures of protection foreseen by the technical documentation, measures of protection foreseen during the construction of the object, measures of protection during the exploitation of the object and measures of protection in the event of an accident.

By the analysis of facility impact on the environment, and by application of appropriate safety measures, it is concluded that during the facility construction and exploitation certain adverse impacts on some environmental segments could be expected, so their monitoring is suggested.

It is also recommended that the Investor before starting the project, does the testing of environmental quality (testing of the segments for which there are no the exact data for the location) through the relevant institution, and all that in order to obtain more complete picture of the environment in this area.

Based on the analysis of project documentation and the insight into the situation on the terrain, it can be concluded that Waste Water Treatment Plant (WWTP) in Berane, together with the prescribed safety measures taken will not significantly affect the quality of the environment on the location and its surrounding.

It should be noted that the construction of Water Treatment Plant would positively affect the environment, because it will include the construction of new sewerage system,

together with the network of main collectors, which will eliminate the use of septic tanks. On the other hand, elimination of untreated discharges, which is going to be achieved by construction of WWTP, will have significant positive effects, especially on reduction of Lim water pollution.

10. INFORMATION ON POSSIBLE DIFFICULTIES

All solutions suggested by Feasibility Study for Water and Wastewater Development Project in Berane (WYG International, 2010.) for WWTP realization, were technically acceptable and the Study processors did not have difficulties on that part.

However, the Study processors did have difficulties about analyzing the quality of some environmental segments, since there was no such data about the location and its close surrounding, it has not been collected, so for the Study making, data for Berane were used.

III GRAPHIC DOCUMENTATION

- **Contribution I: UTC**
- **Contribution II: SITUATION WWTP**