Geotehnical conditions for construction of sanitary disposal site »Lukavačka rijeka«, B&H

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Abstract: Construction of regional sanitary waste disposal site "Lukavačka rijeka" is planned on the place of internal overburden disposal site of surface coalmine, 3 km in the north of Lukavac city. In the area of 56 ha, disposed are coherent materials that were created during removal of overburden in surface mine in quantity of $V \approx 5.5 \cdot 10^6$ m^3. Geological structure of terrain is composed of remains of coal seams and sand of upper Pontian (Pl_1^2), thick 150 m. In the roof, disposed are pre-consolidated clay and clayey-dusty sand. In the aim of reduction of settlement effects, that realistically cannot be absolutely removed, it is proposed to remove upper part in thickness of 5.0 m, in order to provide acceptable total settlement. Analyses of stability for the most unsatisfactory case when the water content is the highest, they resulted with stability factor F = 1.56. In case of water level at depth of 4.0 m, stability factor is F = 3.16, what proves that base of the disposal site is stabile. Researches proved that this location could be accepted for construction of sanitary disposal site.

Key words: sanitary waste disposal site, research works, classes of material, construction conditions, drainage system

INTRODUCTION

Waste material is disposed at wild disposal sites in Tuzla Canton. One of significant steps of this acute problem and rehabilitation of wild disposal sites is proposed construction of regional sanitary disposal site. During selection of location, care was primarily taken about parameters of production of waste at present condition and also for further 20 years. Tuzla Canton is placed in the area of 2649 km². It includes 13 municipalities with population of 500,504 citizens. In future 20 years prognoses are that population will increase to 625,630 (increase of 1.25 % annually), specific production of waste 380 kg/citizen/year, in total quantity of V = 4.8 million tons. Noted quantity of waste should be placed at sanitary disposal site in approximate surface of F = 17 - 20 ha and height h = 35 m.

Multidisciplinary analyses of numerous natural, economic, social-politic, administrative and other factors, out of nominated

Scientific paper

6 potential locations, for construction of regional disposal site, selected location Lukavačka rijeka. Construction of regional sanitary disposal site Lukavačka rijeka is planned on the place of internal disposal site of overburden of surface coal mine, 3 km in the north of city of Lukavac.

In the area of overburden disposal site in surface of 56 ha, disposed are loose materials that are created in process of removal of overburden of surface mine in quantity of $V = 5.5 \cdot 10^6$ m^3. Materials are disposed without any special requirements in aspect of regularity of surface of disposal site and without compaction. Over those materials of the fill pack, planned is construction of regional sanitary disposal site.

Task and coal of researches was provision of necessary geological-geotechnical basis for preparation of the main project design for construction of Regional sanitary disposal site. In the aim of determination of geotechnical conditions of construction, research works are done together with geological-geotechnical researches. In this paper, results of performed researches are represented.

Regarding detailed research of this area (for requirements of exploitation of coal) the following research works were conducted on purpose:

Site and laboratory works:
- Geodetic survey of terrain;
- 9 research boreholes with core sampling and conduction of SPT tests, in total length of 140 m;
- 24 research boreholes without core sampling and with conduction of SPT tests, in total length of 357 m;
- 220 SPT tests;
- Laboratory tests of 33 samples of core (standard geomechanical parameters, oedometric tests and Proctor's), and
- Geological mapping.

Office works:
- Collection and analyses of the existing data;
- Preparation of geological, engineering-geological and hydrogeological maps and profiles;
- Analyses of stability of the slope of mine disposal site, and
- Calculation of settlement.

RESULTS AND DISCUSSION

Geological structure

Locality of Lukavačka rijeka in its geographic placement belongs to northwest part of Kreka north synclinal area. In terrain, determined are sediments of the upper Miocene (Pontian) and recent Quaternary materials of the fill.

Lower Pontian (Pl_1^1) – Novorossian pack
The floor coal seam with belonging sediments in its roof belongs to this part of Pontian (clays in close and sand in further roof). Thickness of the floor coal seam varies in wide range from 0.6 to 9.9 m. In this locality, this coal seam was not subject of exploitation.

Upper Pontian (Pl_1^1)
Zone of the main coal seam with belonging sediments (clays and sand in its floor and

roof) belongs to this part of Pontian, and I and II roof coal seams that are not developed in the area of Lukavačka rijeka but they outcrop in the distant southern parts.

Thickness of the main coal seam before exploitation varied in the range from 1.3 – 8.8 m. In conducted researches in 22 boreholes, thickness of "unexploited cloths" of the coal seam was confirmed to 0.2 – 1.3 m. Thickness of sand in the floor of the main coal seam is 150 m.

Quaternary sediments (Q) – recent anthropogenic creations of fills, are mainly of clayey, sandy, and detritus composition. Thickness of those sediments is variable and it varies in the range from 8.0 – 24.7 m, what is confirmed in conducted researches in boreholes B-9/5 and B-1.5/4.

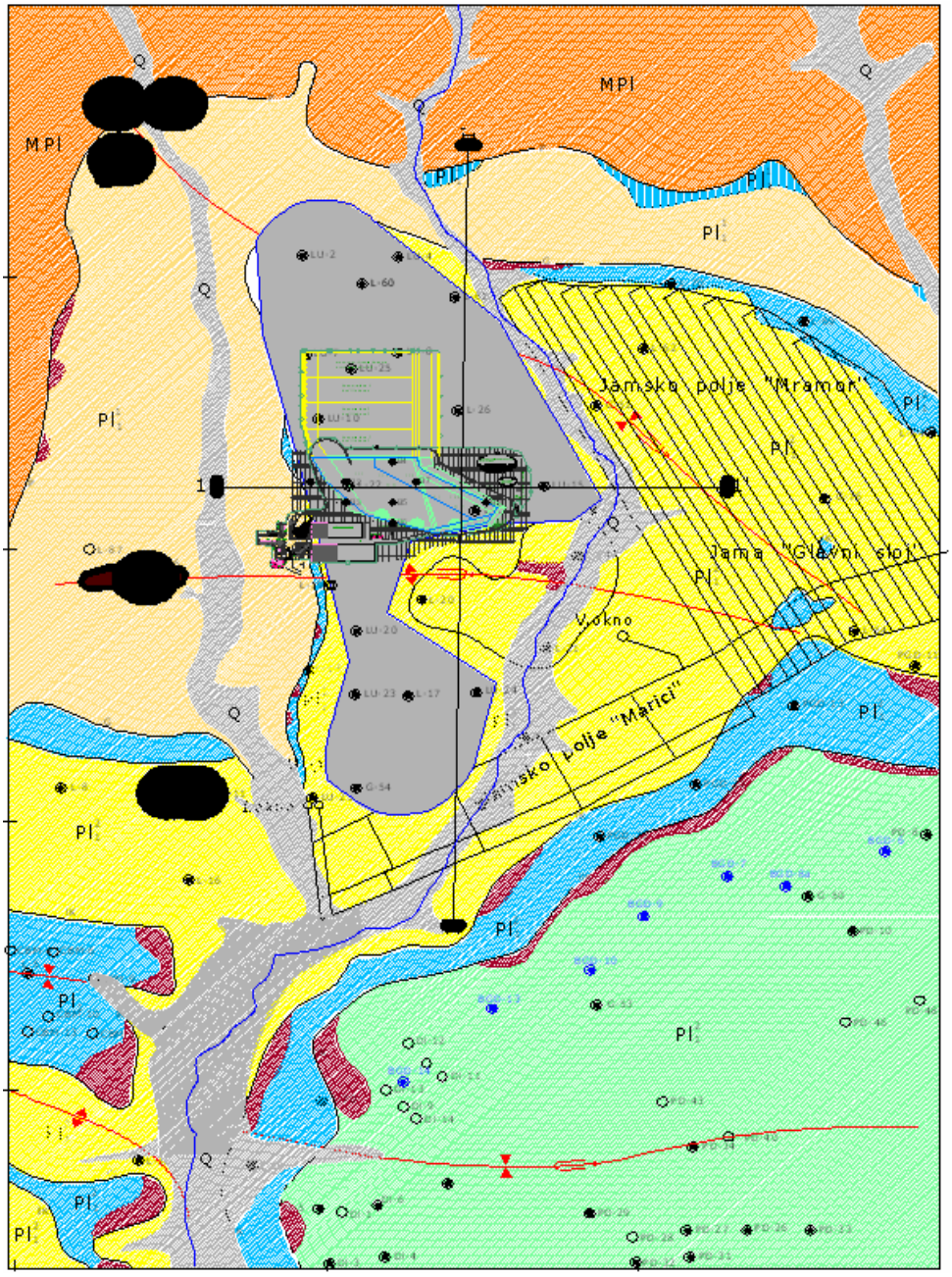
Representation of geological structure is given in geological map Figure 1.

Structural – tectonic characteristics and morphology

Kreka basin, to which area disposal site also belongs, is formed as depression most probably in the first stage of alpine organogenesis. Occurrences in this basin are in causal connection with general occurrences in the inner parts of Dinarides.

In the basin, several plication structures are formed, among which the most significant is anticline Ravna trešnja, Krekanska and Lukavačka syncline. In Lukavačka syncline, more exactly in its northwest part (area of disposal site), seams are formed in syncline, with mild centripetal inclination of 10 º. In this part of basin, faults tectonics are not expressed just folding tectonics.

Geological structure and structural-tectonic structure of the area of Lukavačka rijeka are represented in Figure 1.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MPl
Jamsko polje "Mramor"
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Vokno
Jamsko polje "Marici"
Pl
Q

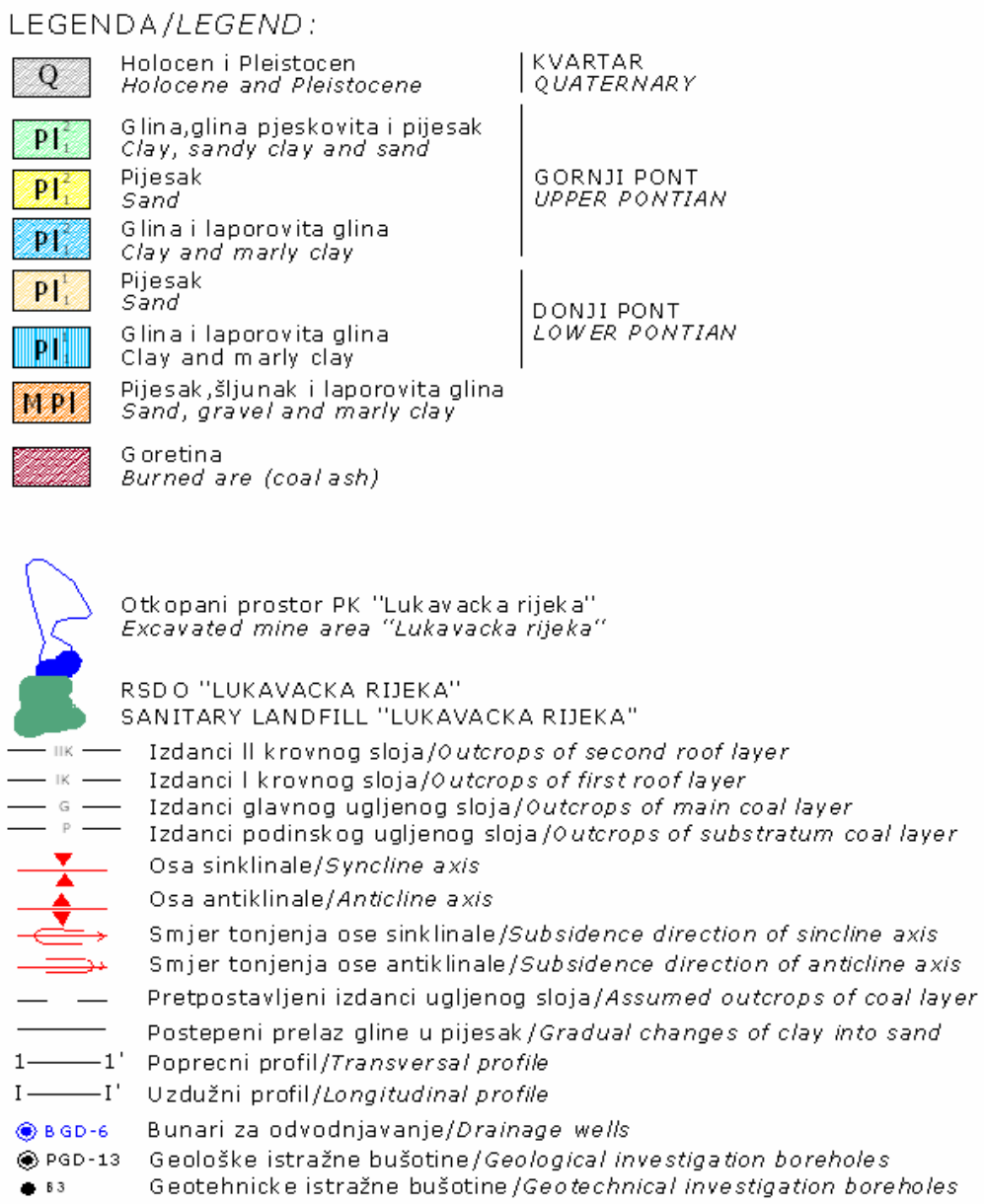

Figure 1. Geological map of wider area of RSDO "Lukavačka rijeka"

In morphological aspect, present appearance of terrain is in the shape of amphitheatre. That is a result of techno genetic activities, more exactly formation of internal disposal site of surface coal mine. Inclination of terrain is relatively mild, most often 6 º - 10 º.
Additional processes of pre-consolidation, erosion and denudation, and sliding of disposed material on technically unprepared slopes, have caused irregular forms, unsatisfactory for sanitary disposal of waste, and prior to construction of sanitary disposal site, it will be necessary to perform satisfactory preparation and shaping of the surface base.

Seismic characteristics

From the aspect of macro seismic belonging (Seismic map of BH for returning period of 500 years, Association for seismology SFRY, Belgrade 1987), area of disposal site belongs to zone of 7 º MCS. On the basis of determined geological structures, rocks in the basis and determined levels of underground water, regarding the fact that purposeful researches were not conducted, for determination of seismic hazard and risk, it should be considered with increase of seismicity of + 2.3–2.6 º MCS.

Hydrogeological relations

Geological structure and structural terrain structure have caused specific hydrogeological relations. Cyclic change of sand in function of aquifer with clay and coal seams, as aqui kludges, resulted in formation of artesian and sub-artesian water bearing horizons, in each of sand layers. Sand layers in locality of Lukavačka rijeka are separated from each other in two water-bearing horizons:

- I water bearing layer – sand in the floor of floor coal seam, and
- II water bearing layer – sand in the floor of the main coal seam.

Recharge of those water bearing layers in natural conditions is from outcropping surfaces of sand members that, depending on inclination of the layer and terrain configuration, create significant surfaces for infiltration of water into undergrounds. Due to mutual relations of water bearing layers and hydrogeological barriers, aquifers are mutually separated and under pressure. Both aquifers are characterised with intergranular porosity and good water permeability. An outcrop in the floor sand layer of the main coal seam is drained with battery of wells for drainage of the mine. Drainage reduces level of underground water to depth of 80 - 100 m under terrain surface. On the basis of data of pumping, calculations for those sand layers provided values of coefficients of filtration K = 2.98·10 m/s, transmission T = 1.54·10 m²/s and piezo-permeability a = $8.58 \cdot 10^{-2}$ m²/s and specific capacity $k = 2.5 \cdot 10^{-2}$ in average. Anthropogenic material from mining operations – fills is disposed directly over sand of II water bearing layer. Materials of fill, according to results of conducted researches, represent hydro-geological complex of poorly water permeable rock masses of intergranular porosity. Average coefficient of filtration for those materials is determined in the value of $K = 2 \cdot 10^{-7}$ m/s. Even though poorly water permeable materials of fill do not fulfil basic criteria of water tightness towards basis (water bearing sand) with $K_{min} = 1 \cdot 10^{-8}$ m/s, what about should be taken special consideration during construction of sanitary waste disposal site.

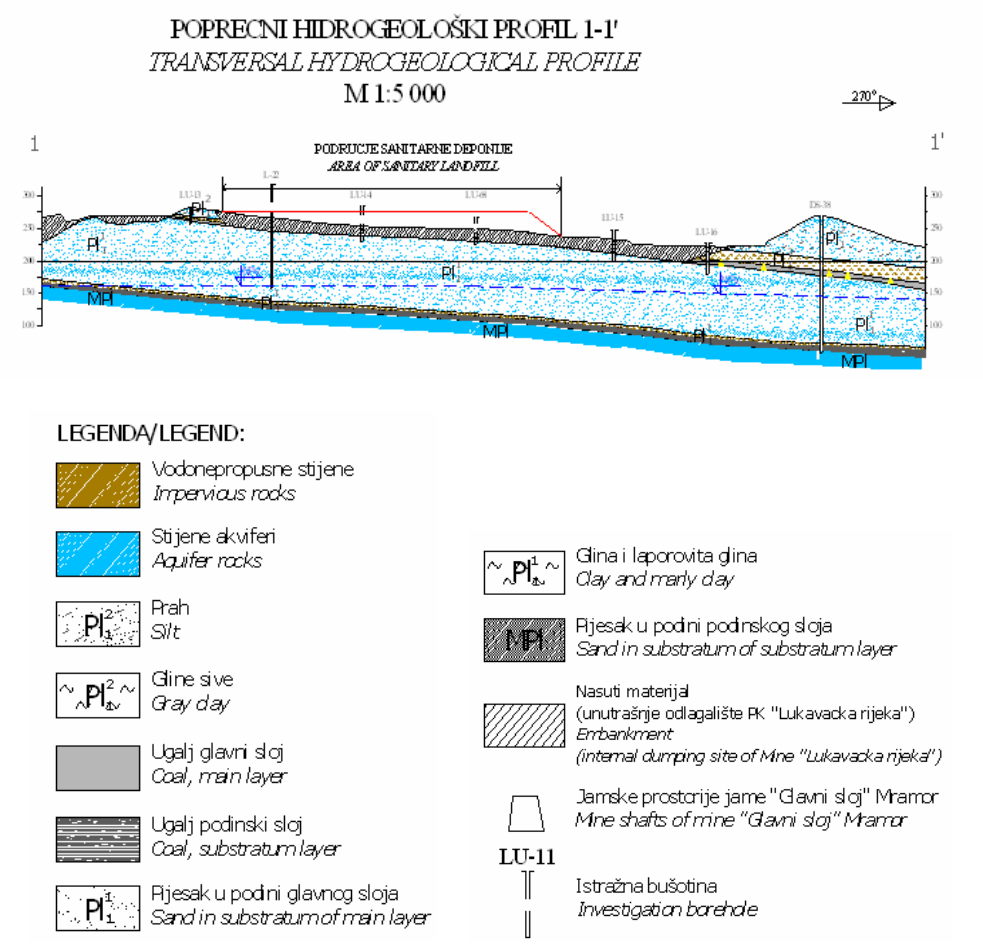

Figure 2. Hydrogeological cross section 1-1' of the area of RSDO "Lukavačka rijeka"

Engineering geological characteristics

According to engineering geological classification, rock masses are selected as basic mapped units and selected into basic taxonometric units: lithological types (LT) and complexes (LC). According to grade of diagenesis and hardness of the bonds of mineral aggregates, separated units are selected into two basic groups:

- Solid and soft rocks, in other words coal of the main and floor seam;
- Incoherent and coherent soils, in other words clays and sand of geological substrata and anthropogenic creations of the fill of mainly clayey, dusty, sandy and detritus composition.

On the basis of engineering geological characteristics, prepared is classification

and determination of rock masses as real environments where sanitary waste disposal site would be constructed. In terrain three basic material classes are selected:

Class I – deposits with poor geomechanical characteristics;
Class II – deposits with satisfactory geomechanical characteristics;
Class III – geological substrata and parts of deposit with satisfactory geomechanical characteristics.

Selected classes of material are in the following authoritative geotechnical characteristics:

CLASS I – disposed material of lower values
Standard penetration N = 1 to 10 hits (very compressible material)
Consistency index I_c = 0.55 (soft materials)
Natural moisture W = 36 % (very wet soils)
Cohesion c = 8 kN/m^2 (low value of cohesion)
Angle of inner friction φ = 7 º (very low value)
Compressibility modulus M_S=3,500 kN/m^2 (very compressible soil)

CLASS II - disposed materials with satisfactory values
Standard penetration N = 11 to 30 hits (moderately compressible material)
Consistency index I_c = 0.8 (moderately plastic materials)
Natural moisture W = 33% (very wet soils)
Cohesion c = 12 kN/m^2 (low value of cohesion)
Angle of inner friction φ = 13 º (very low value)
Compressibility modulus M_S=6,000 kN/m^2 (erately compressible soil)

CLASS III – substrata and parts of disposed materials
Standard penetration N > 30 hits (very hard material)
Consistency index I_c = 1.2 (hard consistency)
Natural moisture W = 9.3% (low soil moisture)
Cohesion c = 0.0 kN/m^2 (without cohesion)
Angle of inner friction φ = 35º (high value)
Compressibility modulus M_S>40,000 kN/m^2 (low compressible soil)

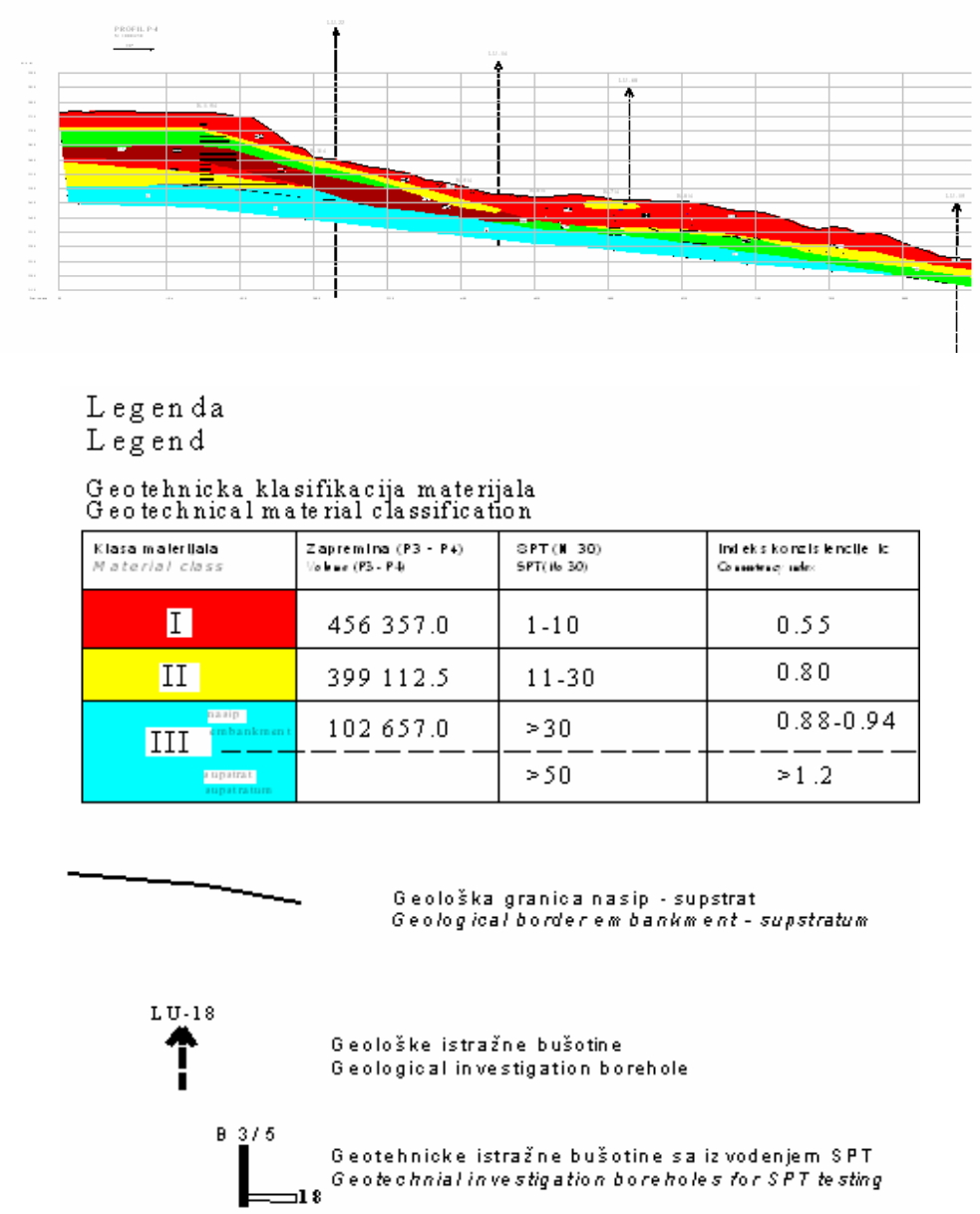

Figure 3. Vertical engineering geological profile of the area of RSDO "Lukavačka rijeka"

Analysis of stability and value of settlement

It is known that in case of disposal site that not only values of load bearing capacity of the base are authoritative but also settlement and resistance to sliding and especially unequal settling. For tension of weight goes σ = 250 kN/m^2 and condition of removal of the upper layer of class I to 5.0 m thickness, calculated was total value of settlement S_u = 0.25 m and differences in settlement in different layers in value of S_r = 0.126 m. Evaluation of influence of permitted values of unequal settlements depends on rigidness of water permeable system and final evaluation will be provided only after detailed analyses.

According to acknowledgements of conducted researches, those values of total settlements and differences in settlement due to different thickness of layers should not be critical for system. Analyses of stability proved that base of sanitary disposal site is stabile:

F = 1.56 – stability factor for case of complete wateriness;
F = 3.16 – stability factor for measured level of water at the depth of 4.0 m.

Geotechnical conditions for construction

Regarding geotechnical aspects of construction, the following can be summarised:

- In the aspect of satisfaction for construction, terrain belongs to category of conditionally stabile terrain.
- Irregular morphological forms of disposed material are unsatisfactory for sanitary disposal of waste, and before construction of sanitary disposal site appropriate preparation and shaping of the surface shall be done.
- In the aspect of seismic hazard and risk, terrain belongs to category of unsatisfactory terrain with possibility of increase of seismicity, what should be considered during designing and shaping of construction of sanitary disposal site.
- Disposed material is characterised with heterogeneous lithological composition and variable physical-mechanical characteristics that makes complex geotechnical conditions of construction.
- Main problem that has to be solved in disposed material is related to reduction of scope of settlement, especially unequal settlement.
- In the aim of reduction of the settlement effects, that cannot realistically be absolutely removed, proposed is removal of the upper part (class I) in thickness of 5.0 m, as well as construction of drainage system, what will provide consolidation of the surface and acceptable total settlement could be provided.
- Floor sand represent water permeable layers ($K = 2.98 \cdot 10^{-6}$ m/s), and materials of the fill represent poorly water permeable rock masses ($K = 2 \cdot 10^{-7}$ m/s), that does not fulfil the basic criteria for initiation of the water towards the base (water bearing sand) of $K_{min} = 1 \cdot 10^{-8}$ m/s. In the aim of protection of pollution of aquifer, it is necessary to construct anti filtration structures.

CONCLUSIONS

It has been proved with research works that this location with complex geotechnical conditions can be accepted for construction of sanitary waste disposal site with application of appropriate technical measures:

- In the aim of reduction of the effect of settlement it is necessary to remove upper part (class I) in thickness of 5.0 m, what can provide acceptable total settlement;
- In the aim of increase of consolidation of the base it is necessary to construct drainage system;
- In the aim of protection of aquifer it is necessary to construct anti filtration structure in the base.

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