Geological and Hydrological Survey for the Tintareni Landfill. Summary

Moldova: Chisinau Solid Waste Project Feasibility Study

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Summary Report

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Table of Contents

List of Figures

List of Tables

List of Abbreviations

EBRD	European Bank for Reconstruction and Development
EU	European Union
FMC	FICHTNER MANAGEMENT CONSULTING AG
BH	Borehole
SNiP	Construction standards and regulations
m	meter
m^2	square meter
m^3	cubic meter

1. General Overview

Geological prospecting works were carried on land in unincorporated area of the village Tintareni, Anenii Noi district, Chisinau Municipality landfill site. The works were carried out by a team of geologists and hydrogeologists in the period of May to July, 2016. Six drillings were executed on the polygon household waste land in the village Tintareni of Anenii Noi district, and has an average depth of: BH1=81 m, BH-2=33m. and BH3=33 m, BH-4=14m, BH-5=15m and BH-6=15 m.

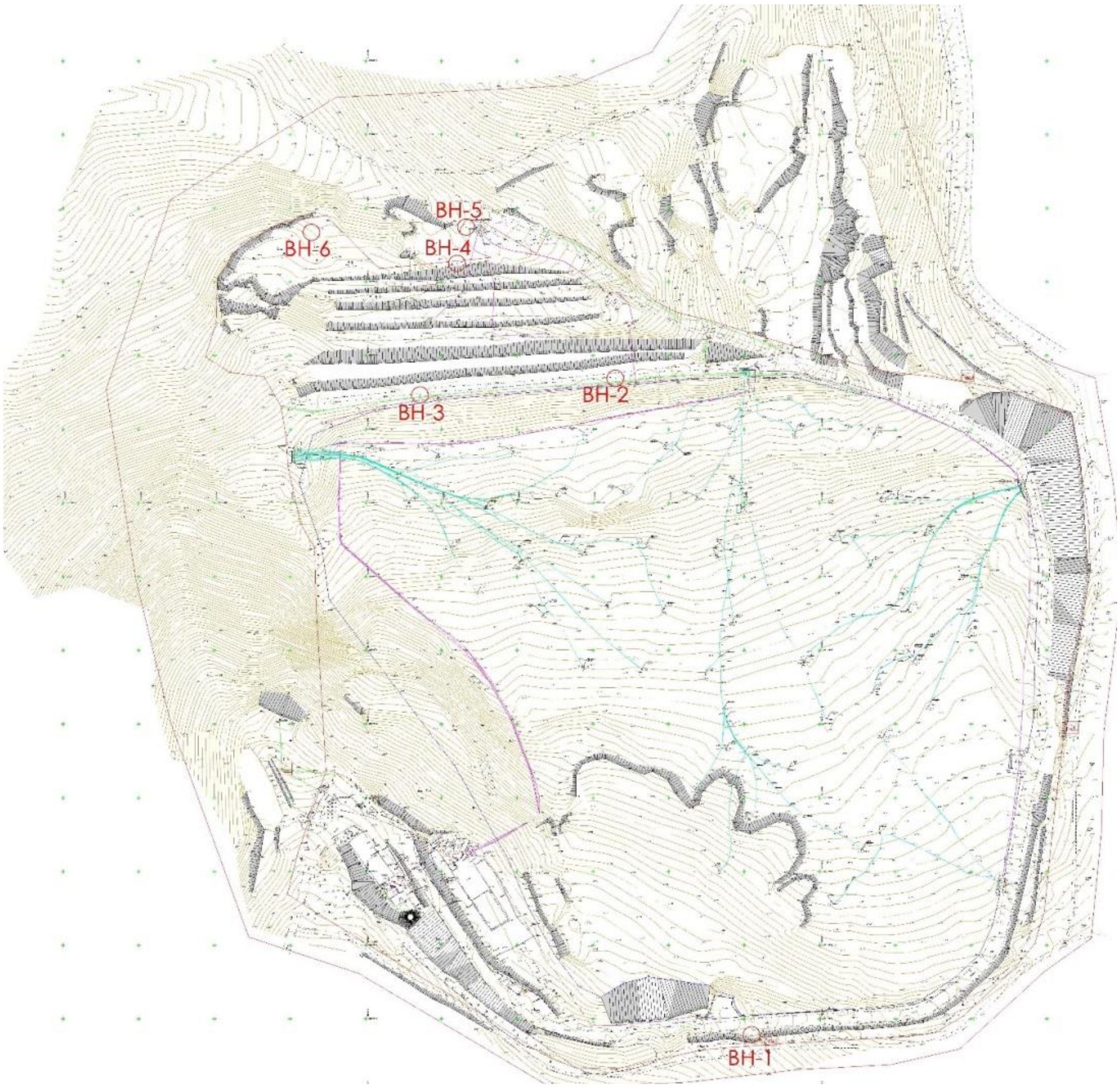

Figure 1: Location of boreholes (BH)

Samples were taken of rock with intact structure and non-monolithic structure. Determination of physical and mechanical characteristics of the rock samples was performed in specialized geotechnical laboratory, the results of which will be attached to this report.

The purpose of this exploration:

- outlining of physical-geological processes;
- studying of the geologic structure of rocks within the sector;
- description of the conditions and nature of foundation soil stratification;
- studying of hydrogeological conditions;
- determination of physical and mechanical characteristics;
- determination of the seismicity level of the sector;
- analysis of results, obtained in field researches in order to determine the bearing capacity of rock layers;
- conclusions drawing;

The main conclusions of the survey are presented below.

Table 1: Conclusions of the survey

Survey	Conclusions
Hydrological survey	▪ No impact from the landfill has been observed in drinking water in Tintareni or agricultural groundwater well near the landfill ▪ The main substances whose concentration in groundwater well in Tintareni exceeds the standards are SO_4^{2-} and NO_3^-. The source of thse substances are neither the landfill nor Bic river, where these substances' concentration is lower. Such pollution is mostly common to be caused by agricultural activity. Most common sources are: exceed of mineral fertilizers and animal growing activity.
Geological survey	▪ The rock bed below the landfill is stable and no leachate penetration through the base sealing has been observed ▪ There is a minor local pollution in the region of the dam. The pollution is limited to small area and had no effect in the nearby boreholes. Additional local dam sealing is required to block it. ▪ The dam and the slope are not stable for the case of a strong earthquake (stability for a 7 degree earthquake is required in the region). The dam should be reinforced with geogrid and gravel materials.

Current report represents a summary of the results of the survey and is also available in the more detailed form.

2. Physical-geographical Conditions

This object is geographically located in the central part of the Republic of Moldova, and namely in the Hilly Plain of Southern Moldova, in the catchment area of the river Bic. The investigated area is located in the unincorporated area of Tintareni village, and namely in the south-east of Cretoaia village. The Polygon is located in a dale, formed of a slope in the form of the letter "V" with direction towards the southeast. Versatile slopes have medium and large inclination.

The average amount of rainfall is 490-500 mm. Absolute height varies between 115.5 m and 182.5 m. The land presents an uneven relief with dislevelments in which water is collecting during rainy weather, with a general inclination of 6-14 ° to the northwest. Numerous signs of small and medium-scale flat and linear erosion are observed on the land surface.

3. Geomorphology and Geology of the Investigated Area

Waste disposal polygon belongs to old alluvial formations of southern hills of Central Moldavian Plateau. Dniester and the upper terraces of the left bank of the river Bic of the slope with northern exposure of the slope forming the watershed of the rivers Bic and Calinder.

Within the limits of the depths, opened by drilling, the field lithology is generated of the formations of Neogene and Quaternary period of Cahul formations. The total thickness of sandy clays in the limits of deposit is changing clearly. In the water border part it reaches 11 m. Sandy clays all over the surface are sealed by a soil-vegetation stage or technogenic stage.

Geotechnical prospection highlights current Quaternary and Neogene sedimentations of Sarmatian period. Seismic intensity, according to the “Map of seismic zoning of the territory of the Republic of Moldova” developed by the Institute of geology and geophysics of the Scientific Academy of Moldova in 2006, amounts to 7 degrees after MSK-64 scale, and the seismic coefficient equals to k s=0.2, taking into consideration the geological condition of rocks and area surveyed (category II), the seismic degree of the site should equal to 7 according to SNiP II-7-81 table 1.

4. Results of the Evaluation of the Drilling Works

19 samples were collected (19 monoliths with undisturbed structure) through geotechnical boreholes that underwent specific laboratory tests (physical and mechanical tests).

Slope is subject to works on solid waste depositing and waste gas exploitation. The site has an inclination towards the NW direction. The slope is located on the sediments of an ancient slide, with observed surface irregularities and well-developed planar and linear erosions.

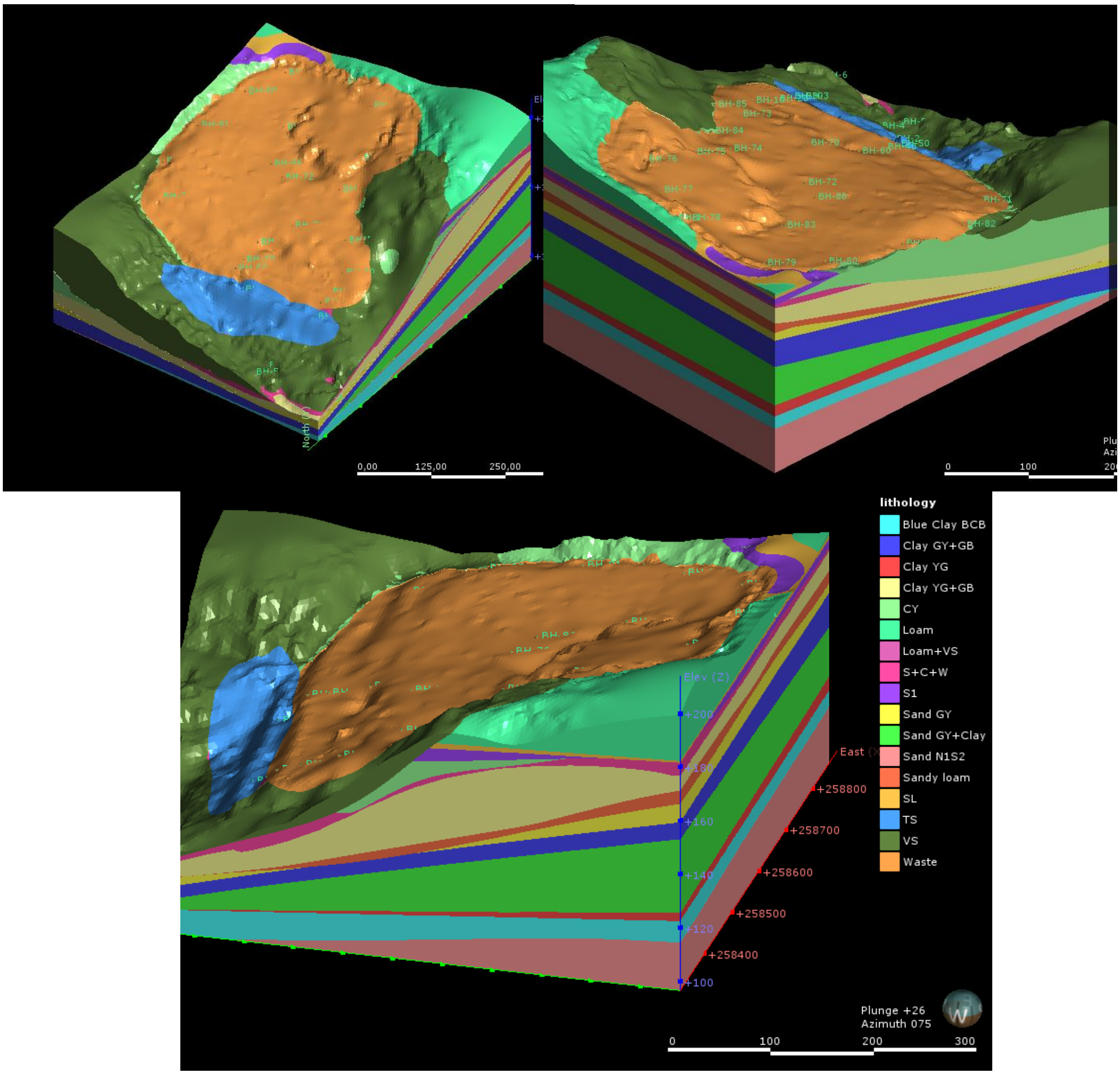

Figure 2: 3D representation of intersecting lithologies

5. Hydrologic Characteristics

Tintareni landfill is located on the watershed of the catchment area of the r. Bic and its right inflow - Calinder. Till r. Bic - 5,5km; till r. Calinder - 4,3km. Absolute surface altitude - 156,9m.

Two unnamed beams of the r. Bic and the beam of the r. Calinder with the distance to the upper reaches from the landfill of 1.2; 1.3 km and 1.7 km, respectively, have no permanent watercourse.

Average annual water consumption of the r. Bic near Chisinau - 1 m³/s, the highest at flood season - 220 m³/sec. Observations on the r. Calinder – not available.

However, the main source for centralized public water supply purposes is groundwater confined to limestone of mid-Sarmatian age, due to their relatively superficial bedding, good protection from surface contamination and a relatively high abundance of water.

Aquifer of the mid-Sarmatian limestone is widespread, by the nature of the strata bedding, well extended along the strike on the area. Water-bearing rocks are fractured oolitic-detrital and other limestone interbedded with marl, and in some places with sandstone and sand. Their roofing in the area of production wells works is opened within the abs.mark. + 30 ÷ + 15m. Capacity of the limestone strata – up to 90m.

All six boreholes and additional locations (river Bic, leachate tank, well 400m to the dam, well for drinking water and artesian well) have been sampled for water. BH3 is located in the section remediated after the land slide in 2003 and thus in addition to the clay layers contains some sand bands (three thin layers, approx. 10-15cm). These unwanted sand bands contain liquid coming from the waste cell. The impact assessed at the location of BH3 is not high, however it clearly shows a leakage. The impact migrates towards north where it can be verified by the analysis of the water samples taken from other boreholes (BH4 and BH6). The analysis shows that the magnitude of the impact is significantly lower due to the more distant location of the boreholes to the point of leakage. The analysis of all other samples as listed above (except for the leachate tank), do not show any impact from the landfill.

The laboratory results for water from the wells located in Tintareni village showed that no impact from the landfill is present. Based on composition of the water from the well a conclusion could be made that the most possible cause of water contamination is agricultural activity. Rehabilitation measures required in order to avoid any leachate leakage from the waste cell shall be included into the project proposal.

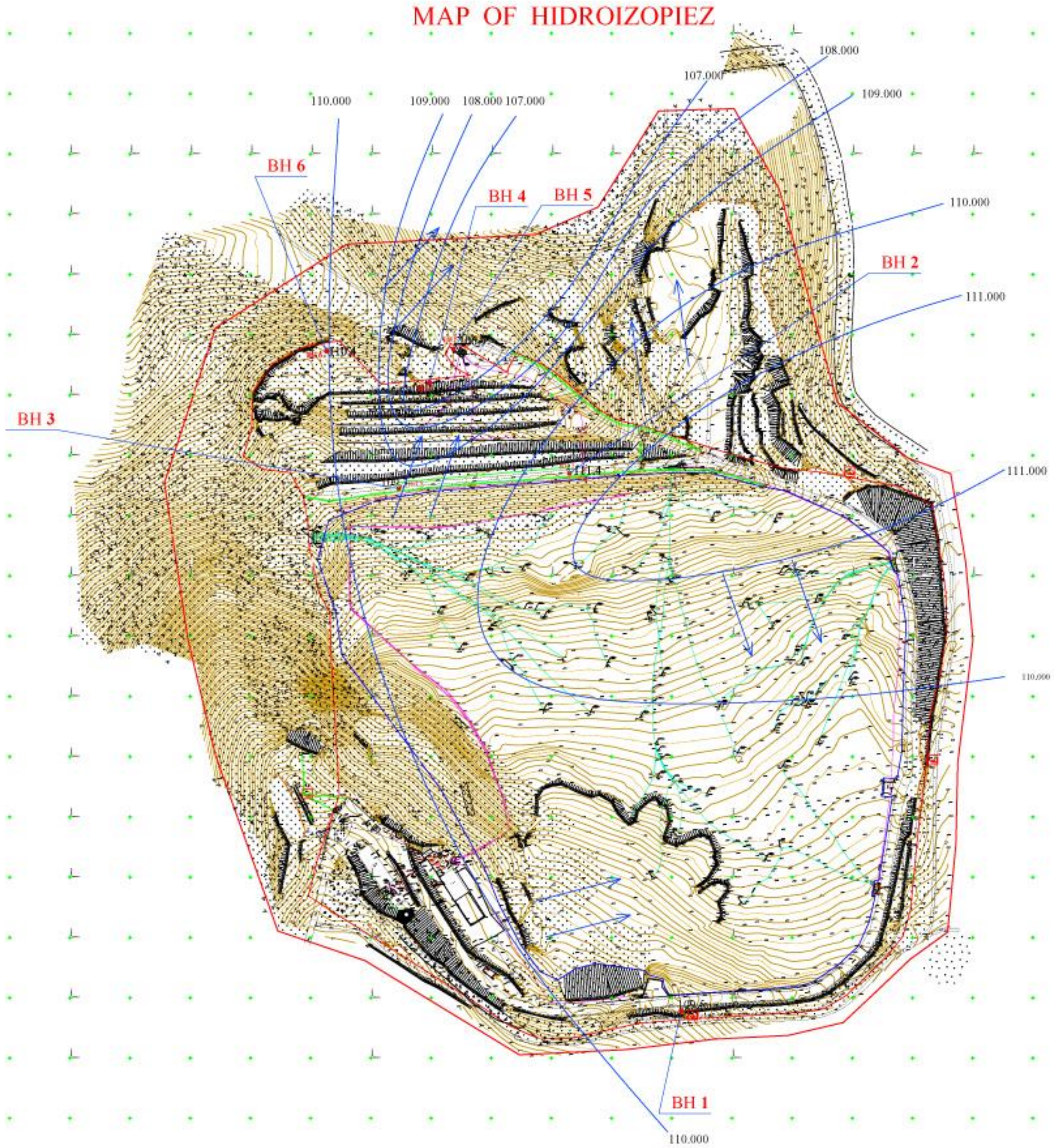

Figure 3: Map of hidroizopiez and groundwater flow direction

6. Geological and Engineering Characteristics of the Investigated Site

During the rigorously prospecting period, the hydrogeology and engineering-geological conditions of the terrain were researched, as well as possible adverse geological processes. Samples of rocks characteristic of the researched sector were collected and described. Research and laboratory processing works were carried out on the collected rock samples.

Such dangerous geological processes, as carstic processes, collapse of rocks are not present in this area. No dangerous geological processes, such as active landslides of the sectors researched were observed, but the massive erosion process on the south-west side slope of the sector may cause a potential slip of rocks over the landfill surface.

We have observed the signs of rehabilitation of north dam destabilization (west side of the dam) that slipped in 2002. In the process of drilling in this area we have discovered rocks, from which the dam and bedrock were made. It was found that the technogenic thickness of the rocks (compacted) of the dike in this area is about 11 m. It was found that the mass of the breakwater rock contains a large amount of small calcareous concretions and layers of sand saturated with water, with a thickness of 5-10 cm plus the sand lens, put question marks over the accuracy of introducing rocks required and compacting these layers. The dam body also contains the black clayey soil, which is unfit for the execution of earthworks. Drillings made in the dam body confirm the local existence of black clay (impregnated with humus). The results on samples taken from drilling indicate a proper compaction, virtually uniform, from a drilling to a drilling.

According to the results of laboratory tests on compression, the rocks by relative deformation are attributed to weak deforming and averagely deforming.

The same tests resulted that the rocks after the deformation module (elasticity) are attributed to weak deformable rocks.

According to permeability test results, it was determined that the clay rocks are virtually impermeable and poorly permeable, while as the sandy rocks are attributed to permeable and poorly permeable.

Shear tests highlight the reference of rocks from the boreholes 1, 2, 4, 5 and 6 to those with high resistance and those from the borehole 3 to medium resistance.

According to classification by pH value. Rocks are assigned to basic pH = 7.4

Regarding previous slip, it supposedly occurred after the ingress of water in dam that served as a dam in the way of water flow, and slipped due to the water pressure. Water seeping through the levee is confirmed by the humidity of the dam material, determined in laboratory on samples taken from the boreholes.

7. Slope and Dam Stability

In this paper, the calculation on the transverse profile has been made on the line of greatest slope intersecting the borehole 3 and for the borehole 2 on scenarios when the cell is filled with waste and when it is filled with waste and the leachate level is high. This profile was chosen because here the dam has slipped and because in these areas the slope is the largest and for answering the question: what are the causes of slipping. The calculations showed that stability coefficient is less than one, so the slope will be unstable.

The calculations were made assuming full cell and earthquake of 7 degrees (the conditions, proposed by beneficiaries). Using the lower characteristic values of internal friction angle and cohesion given above for both material from the dam and for the natural terrain beneath the dam and partial factors, below par values were obtained for the safety factor for both slope slip and the investigated slope. Therefore, theoretically, the dam will have to slip. 125 sliding surfaces were used to detect the worst.

However, using local characteristic values, safety factor is below 1(F of S: 0.943), so the slope is unstable.

For calculating the dam stability, calculations were made on transverse profile, designed by boreholes 5-4-3 and analog through boreholes 4-2 drilling into south direction.

Water seeping through the dam is confirmed by the humidity of material from the dam, determined in laboratory from samples, taken from boreholes. It seems that the boreholes Bh-3 and Bh-2, samples from the anthropic layer from the depths of under 9 m have a degree of saturation equal to 1 or very close to unity, with humidity greater than 21%, it worsens at sandy substrates saturated with water.

Always a slope, inclined of filler and natural land make up a pre-existing sliding surface, which when moistened, may easily turn into an active slip area. On such a surface, the cohesion is usually considered zero. Performing calculations with the resulting safety factor of 0.918 for the area BH-3 and 0.815 for Bh-2, so the slip is certain to happen. Therefore, the inclined surface beneath the filling and infiltrations of water from the cell can explain the potential production of slipping.

Considering:

- the unsatisfactory quality of the dam execution, water seepage through dam;
- stability calculations results of this survey indicates that also indicate the subunit or limit values of the safety coefficient of sliding into different assumptions
- degradation through sliding of the northern slope (BH3) and high slope (BH2)
- the risk of groundwater accumulation in drainage under the cell with serious consequences on the stability of the dam, just as it happened in the previous slipping;
- local pollution migration through the dam

It is proposed:

- Slope strengthening by reducing the slope and/or applying geogrid materials with gravel filling
- Reinforcing of the dam
- Evacuation of the leachate from the waste body
- Local sealing of the dam in the place where pollution takes place.

8. Annex

The annex includes the overview of the boreholes as well as results of the soil and water tests.

Table 2: Boreholes overview

No	Borehole no.	a.m. of the borehole mouth	a.m. of the ground	Borehole depth, m	Diameter of the lining tubes, mm	Tubing interval, m from	Tubing interval, m to	Filter type	Filter, m	Static Level., m/ a.m.	Water-bearing rocks
1	BH-1	183,5	182,5	81	160	0	6	water strainer with c sand mat	76-81	74/ 109,5	
					86	0	81				
2	BH-2		138,4	33	160	0	20,0	water strainer with c sand mat	26-31	27/111,4	fine and medium-grained sand
					86	0	32,5				
3	BH-3	139,4	138,4	33	160	0	12,0	water strainer with c sand mat	26-31	29,1/109,3	fine and medium-grained sand
					86	0	32,5				
4	BH-4	118,1	117,1	14	160	0	6,0	water strainer with c sand mat	8-13	10,2/106,9	fine-grained sand
					86	0	13,4				
5	BH-5	116,4	115,4	15	160	0	6,0	water strainer with c sand mat	7-12	8,5/106,9	fine-grained sand
					86	0	13				
6	BH-6	117,6	116,6	15	160	0	4,5	water strainer with c sand mat	4-9	5/110,4	medium-grained sand
					86	0	13				

Table 3: Soil samples laboratory tests

Lab No.	Borehole	Sampling depth, m	Sample name	Granulometry Particles content 2.0-0.05 mm, %	Filtration coefficient (permeability results), m/day	Bulk unit weight γ, kN^3/m	Unit weight of soil skeleton (Specific gravity), kN^3/m	Dry unit weight, kN^3/m	Water content,%	Porosity,%	Void ratio	pH;	Upper plasticity limit (Liquid limit), %	Lower plasticity limit (Plastic limit), %	Plasticity index	Liquidity index	Degree of Swelling, %	Inflation pressure , kPa	Swelling humidity	Free swelling,%
1	BH 1	12.6	Heavy sandy clay	43.5	0.008	1.97	2.70	1.60	0.23	40.7	0.687	7.4	0.37	0.25	0.12	<0	0.90	-	0.30	0.032
2	BH 1	18.6	Light clay	59.0	0	2.18	2.70	1.86	0.17	31.1	0.452	7.4	0.39	0.20	0.19	<0	1.00	385	0.28	0.161
3	BH 1	20.5	Sand			1.47	2.64	1.40	0.05	47.0	0.886	7.4					0.15			
4	BH 2	8.2	Light clay	41.5	0.004	2.07	2.73	1.67	0.24	38.8	0.635	7.4	0.45	0.22	0.23	0.09	1.00		0.26	0.013
5	BH 2	24.8	Heavy loam	50.0	0	2.15	2.70	1.85	0.16	31.5	0.459	7.4	0.36	0.20	0.16	<0	0.94	230	0.25	0.105
6	BH 2	27.0	Clayey sand	21.5	0.286	1.69	2.68	1.50	0.13	44.0	0.787	7.4	0.26	0.20	0.06	<0	0.44			
7	BH 2	32.3	Light clay	60.5	0	2.20	2.74	1.82	0.21	33.6	0.505	7.4	0.49	0.24	0.25	<0	1.00	300	0.25	0.144
8	BH 3	4.0	Light clay	41.0	0.007	2.09	2.74	1.67	0.25	39.1	0.641	7.4	0.50	0.23	0.27	0.07	1.00		0.29	0.026
9	BH 3	6.0	Light clay	53.5	0	2.10	2.70	1.73	0.21	35.9	0.561	7.4	0.39	0.20	0.19	0.05	1.00		0.23	0.020
10	BH 3	7.5	Light clay	49.0	0	2.08	2.70	1.72	0.21	36.3	0.570	7.4	0.39	0.20	0.19	0.05	1.00		0.25	0.027
11	BH 3	28.2	Hard sandy clay	54.0	0.007	2.10	2.69	1.75	0.20	34.9	0.537	7.4	0.32	0.20	0.12	0	1.00	110	0.25	0.055
12	BH 3	29.3	Clayey sand	21.0	0.090				0.23			7.4	0.24	0.22	0.02	0.50				
13	BH 3	32.1	Light clay	37.5	0	2.14	2.69	1.81	0.18	32.7	0.486	7.4	0.32	0.21	0.11	<0	1.00	130	0.22	0.062
14	BH 4	2.3	Light clay	38.0	0.001	2.15	2.71	1.75	0.23	35.4	0.548	7.4	0.40	0.20	0.20	0.15	1.00	300	0.29	0.145
15	BH 4	11.1	Hard sandy clay	60.0	0.005	2.07	2.70	1.66	0.25	38.5	0.626	7.4	0.36	0.20	0.16	0.31	1.00		0.28	0.027
16	BH 5	4.5	Light clay	30.0	0.002	2.17	2.70	1.81	0.20	33.0	0.492	7.4	0.39	0.20	0.19	0	1.00		0.22	0.023
17	BH 6	2.5	Light clay	51.0	0.001	2.18	2.70	1.82	0.20	32.6	0.483	7.4	0.38	0.20	0.18	0	1.00	150	0.22	0.067
18	BH 6	6.0	Clayey sand	25.5	0.010	2.11	2.68	1.71	0.23	36.2	0.567	7.4	0.24	0.21	0.03	0.67	1.00			
19	BH 6	13.8	Light clay	49.0	0	2.17	2.72	1.78	0.22	34.6	0.528	7.4	0.42	0.22	0.20	0	1.00	180	0.28	0.062

Table 4: Water samples field tests

No	Parameters	Leachate	400 m from the dam	Drinking well	River Bic	Artesian well	Well BH-1	Well BH-2	Well BH-3	Well BH-4	Well BH-5	Well BH-6
1	Smell	Strong smell	Without smell	Without smell	Without smell	Weak smell H2S	Without smell	Without smell	Without smell	Without smell	Without smell	Without smell
2	Turbidity, EM	-	7	1	11	0	27	20	20	19	20	23
3	Color, degrees	70	30	15	25	13	31	25	27	25		31
4	Oxygen, mg O/l	-	-	1,03	8,4	2,85	1,65	89	90,4	-	-	-
5	Temperature, °C	20	19	19	20	14	16		17			16
6	pH	-	7,84	7,76	7,63	8,41	7,45	7,17	7,3	7,13	7,34	6,7

Table 5: Water samples laboratory tests (Part 1)

Nr.	Index	Concentrations detected						
		(Sonda 3, 10,9)	(Sonda 3, 14,6)	Sonda 4	Sonda 3	Sonda 2	Sonda 5	Sonda 6
1	pH, unit pH	6,48	6,68	7,13	7,30	7,17	7,34	6,70
2	Conductivitatea, µS/cm	14580,0	11090,0	3780,0	485,0	2160,0	1685,0	6120,0
3	TDS, mg/L	7760,00	6020,00	1990,00	260,00	1140,00	904,00	3270,00
4	Calciu, Ca^{+2}, mg/L	918,43	918,43	215,63	40,87	127,78	125,78	334,43
5	Magneziu Mg^{+2}, mg/L	3004,72	3037,42	136,03	25,04	137,97	97,49	454,15
6	Sodiu+potasiu, Na^{+} +K^{+}, mg/L	2627,5	1136,2	486,51	28,11	156,28	124,30	469,89
	Duritatea (Ca+Mg) mg-eq/L	104,61	105,61	21,95	5,39	17,73	14,3	54,05
7	Duritatea (Ca+Mg), German grad	292,91	295,70	61,47	15,08	49,66	40,03	151,34
8	Cloruri, Cl^{-}, mg/l	6937,00	5190,50	671,41	22,84	339,19	230,34	1607,34
9	Sulfaţi, SO_4^{-2} mg/l	30,66	65,41	212,03	31,11	125,78	116,59	126,01
10	Hidrogenocarbonaţi, HCO_3^{-} mg/l	1207,80	362,95	689,30	244,00	750,30	652,70	1207,80
11	Nitraţi, NO_3^{-} mg/l	113,0	182,0	519,86	< 0,1	0,70	3,32	425,23
12	Nitriţi, $N0_2^{-}$, mg/l	0,14	0,13	7,92	0,28	0,01	3,05	2,30
13	Amoniac (total), NH_4^{+} , mg/l	4,66	1,72	1,07	0,51	0,99	0,58	0,80

Nr.	Index	Concentrations detected						
		(Sonda 3, 10,9)	(Sonda 3, 14,6)	Sonda 4	Sonda 3	Sonda 2	Sonda 5	Sonda 6
14	Nitrogen total, mg/l	25,52	41,10	120,63	0,71	0,93	2,13	97,34
15	Nitrogen amoniacal, mg/l	3,84	1,42	0,83	0,40	0,77	0,45	0,62
16	Mineralizarea, g/l	14908,0	10823,9	2930,80	392,97	1638,00	1350,40	4624,85
17	Reziduul sec, mg/l	11602,30	7776,33	2468,00	292,00	1313,50	1074,50	4259,50
18	Plumb, Pb, µg/l	2,39	334,65	<2	<2	<2	2,98	1,85
19	Cadmiu, Cd, µg/l	1,30	0,79	0,36	<0,2	<0,2	<0,2	0,633
20	Crom (total), Cr, µg/l	41,61	26,96	<0,9	<0,9	<0,9	<0,9	<0,9
21	Mangan, Mn, µg/l	2181,0	4430,0	708,0	370,9	2808	383,05	454,6
22	Nichel, Ni, µg/l	1155,9	287,2	42,0	13,06	65,2	7,3	36,86
23	Cupru, µg/l	110,1	86,5	56,3	68,1	6,4	51,3	105,1
24	Arsen, As, µg/l	29,2	26,3	5,44	1,83	4,99	6,19	2,46
25	Fluoruri, (F^-), mg/l	0,48	0,23	0,43	1,17	0,66	0,51	0,20
26	Fier total (Fe), mg/l	0,15	0,12	< 0,05	< 0,05	< 0,05	< 0,05	< 0,05
27	Oxidabilitatea permanganată, mgO/l	302,20	90,40	28,80	22,00	44,40	15,50	60,20
27	Mercur, µg/l	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5
28	Zinc, mg/L	< 0,08	0,10	< 0,08	< 0,08	< 0,08	< 0,08	< 0,08
29	Bor, mg/l	< 0,1	< 0,1	< 0,1	< 0,1	0,15	< 0,1	< 0,1
30	Cianuri, mg/l	< 0,15	< 0,15	< 0,15	< 0,15	< 0,15	< 0,15	< 0,15
31	Consumul chimic de oxigen CCO	1798,0	632,8	204,70	157,60	315,10	110,40	409,40
32	Consumul biochimic de oxigen CBO	1260,0	515,0	153,5	125,0	218,0	85,0	319,0
33	Produse petroliere + grăsimi, mg/l	3,8	2,8	0,4	2,4	2,0	0,2	0,8

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Table 6: Water samples laboratory tests (Part 2)

Nr.	Index	Detected Concentrations					
		(leachate)	(400 m from the dam)	Drinking well	Bâc river	Artezian well	BH-1
1	pH, unit pH	8,33	7,84	7,76	7,63	8,41	7,45
2	Conductivitatea, µS/cm	19250.0	1077,0	2190,0	1306,0	1073,0	1486,0
3	TDS, mg/L	10770,0	574,0	1170,0	696,0	572,0	792,0
4	Calciu, Ca^{+2}, mg/L	58,40	41,78	108,08	73,08	0,16	87,62
5	Magneziu Mg^{+2}, mg/L	56,40	27,40	33,20	29,00	3,88	44,64
6	Duritatea (Ca+Mg), mg-eq/l	7,55	7,86	14,72	7,16	0,65	8,04

Nr.	Index	Detected Concentrations					
		(leachate)	(400 m from the dam)	Drinking well	Bâc river	Artezian well	BH-1
7	Duritatea (Ca+Mg), German grad	21,14	22,08	41,13	20,05	1,85	22,52
8	Sodiu, Na^{+}, mg/L	2574,4	97,25	166,06	98,78	248,80	108,86
9	Potasiu, K^{+}, mg/L	1458,0	7,91	6,36	18,75	5,92	17,99
10	Cloruri, Cl^{-}, mg/l	7584,0	50,41	131,22	95,88	20,02	130,98
11	Sulfaţi, SO_4^{-2} mg/l	75,4	51,90	342,54	164,45	87,32	308,18
12	Hidrogenocarbonaţi, HCO_3^{-},mg/l	1350,0	570,35	558,15	561,20	402,60	427,00
13	Nitraţi, NO_3^{-}, mg/l	255,0	2,31	279,6	4,69	< 1,0	5,26
14	Nitriţi, $N0_2^{-}$, mg/l	2,50	1,63	0,08	0,14	< 0,055	3,71
15	Amoniac (total), NH_4^{+}, mg/l	2714,76	0,43	< 0,055	44,86	2,83	4,05
16	Nitrogen total, mg/l	2316,26	1,36	63,15	38,04	2,55	5,65
17	Nitrogen amoniacal, mg/l	2257,92	0,35		36,94	2,33	3,33
18	Mineralizarea, g/l	13411,20	884,34	1776,51	1133,17	819,65	1217,25
19	Reziduul sec, mg/l		622,25	1485,00	746,50	671,25	1125,0
20	Plumb, Pb, µg/l	8,14	8,32	3,45	< 2,0	< 2,0	13,26
21	Cadmiu, Cd, µg/l	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2	< 0,2
22	Crom (total), Cr, µg/l	3,41	1,2	< 0,9	15,9	< 0,9	< 0,9
23	Mangan, Mn, µg/l	5650,0	1568,0	2,45	256,5	6,5	10,4
24	Nichel, Ni, µg/l	1215,0	2,2	5,7	75,2	15,1	32,6
25	Cupru, µg/l	769,80	5,03	1,84	4,35	4,56	7,23
26	Arsen, As, µg/l	15,2	2,46	2,25	15,65	1,55	3,55
27	Fluoruri, (F^{-}), mg/l		0,22	0,10	0,14	0,47	0,26
28	Fier total (Fe), mg/l	6,47	0,36	0,52	0,75	0,88	0,43
29	Oxidabilitatea permanganată, mgO/l	267,12	6,38	1,03	38,90	2,85	1,65
30	Mercur, µg/l	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5
31	Zinc, mg/l	0,16	< 0,08	< 0,08	< 0,08	< 0,08	< 0,08
32	Bor, mg/l	0,45	< 0,1	< 0,1	0,25	0,10	< 0,1
33	Cianuri, mg/l	< 0,15	< 0,15	< 0,15	< 0,15	< 0,15	< 0,15
34	Consumul chimic de oxigen CCO	1950,0	< 50,0	< 50,0	264,60	< 50,0	< 50,0
35	Consumul biochimic de oxigen CBO	1460,0	5,3	0,8	30,9	2,1	1,4
36	Produse petroliere + grăsimi, mg/l	5,5	0,1	0,2	3,6	0,1	0,8