Evaluation of Liner Requirement – Integrated Mine Waste Facility
Dundee Precious Metals Krumovgrad
Ada Tepe Gold Project, Bulgaria



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EXECUTIVE SUMMARY

Data is presented in this report describing the setting, design concept, geochemical and geotechnical characteristics of the waste rock and tailings for the proposed Integrated Mine Waste Facility (IMWF) for the Krumovgrad Gold Project

The concept of the IMWF is to place thickened tailings into cells constructed from mine rock. The mine rock provides strength required for overall stability and also internal drainage. Water reporting to the under-drains will be pumped to the Raw and Process Water Reservoir ("RPWR") located southwest of the open pit. The IMWF will be constructed within two small valleys, being operated as two separate facilities early in the life of the project and later merging into a single facility as operations progress. Rehabilitation of the lower slopes of the IMWF will begin during the early stages of mine operation. Dundee Precious Minerals (DPM) Krumovgrad have an approved Mine waste management plan from the Ministry of Economy and Energy.

The geochemical characterization programme concluded that the waste rock and the tailings are unlikely to generate acidity and that metal leachability is not a concern and therefore the leachate will contain metals in solution below or very close to instrumental detection limits, provided operational practices are correctly implemented.

Seepage from the IMWF will be intercepted by and managed by the facilities dedicated under drainage system, and interim drains formed within the respective cell walls. Tailings will then be sequentially discharged into the cells as a thickened product, minimising the build up of supernatant water on the IMWF. The under-drainage system has consequently been designed of sufficient capacity to be able to transport the expected volumes of seepage. All recovered seepage will then be returned to the process to augment make-up requirements.

Based on a qualitative risk assessment using the source-pathway-receptor model it was concluded that the risk of seepage capable of impacting the environment is very low. Use of thickened tailings disposal with associated under-drains, means that the pathway to transport any excess seepage to the environment is also minimised. It was consequently concluded that the environmental benefits of developing a geosynthetic or engineered liner below the IMWF would not justify the extra cost to the project.

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1.0 INTRODUCTION

Dundee Precious Metals (DPM) has negotiated an amended financial package with a consortium of banks for which the European Bank for Reconstruction and Development (EBRD) acts as environmental agent. According to the EBRD's Environmental and Social Policy (2008), and its associated Performance Requirements (PRs), a project of this type and scale requires a full Environmental and Social Impact Assessment (ESIA). The Project undertook a local national environmental impact assessment (EIA) to Bulgarian standards in 2010 and an environmental permit No. 18-8, 11/2011 was issue. Following an independent review of the local EIA reports, the EBRD required a number of supplementary environmental and social studies and documents to fill the gaps necessary to meet the EBRD PRs and international good practice. In addition to the EBRD PRs, some of the consortium banks refer to the Equator Principles and therefore the Project also references the IFC's Performances Standards (2012). The package of supplementary environmental and social documents as well as the local EIA reports together form the Project ESIA. The Project ESIA is summarised in a Non-Technical Summary.

1.1 Evaluation of Liner Requirement – Integrated Mine Waste Facility (IMWF)

The evaluation of a potential liner requirement for the IMWF has been addressed by AMEC Earth and Environmental (henceforth referred to as 'the Consultant') for Dundee Precious Metals Krumovgrad (henceforth referred to as 'the Client' or 'DPM')'.

Study Objective

The initial gap analysis carried by the EBRD requested DCM to validate if a liner is required. DPM subsequently indicated that the tailings to be deposited are not acid generating, non-hazardous, non-inert and that therefore the requirement for a liner is not clear.

This report consequently presents a summary of relevant information regarding the requirements for a liner, or not, at the proposed Krumovgrad Integrated Mine Waste Facility (IMWF), based on the current project description and the following available documentation:

- Bulgarian regulations
- Best Available Techniques Reference Document (BREF) on Management of Tailings and Waste Rock in Mining Activities
- International Best Practice
- Geochemical characterisation Report for Krumovgrad Tailings

- Geochemical characterisation of the process waters (if available from bench scale tests)

- Kinetic Testing Report

- Relevant Technical Reports containing information on geotechnical characteristics of the tailings and their consolidation and long term permeability characteristics

- Relevant Technical Reports containing information on geotechnical parameters of the IMWF basin area with respect to in situ characteristics such as permeability

- Baseline information regarding the site (Morphology, Hydrology, Hydrogeology, Meteorological Data, Habitat, Downstream Receptors, etc.

Based on the above information, a qualitative technical risk analysis is presented to assist with the evaluation and conclusions reached.

1.2 Documents Consulted

In preparing this report, AMEC consulted the following documentation provided by DPM Krumovgrad:

- Golders Associates – Integrated Mine Waste Facility General Explanatory Note KGP100-0500-1210-RPT-1004 E Dated: 26/02/2014

- Golders Associates – Integrated Mine Waste Facility Design Criteria KGP100-0500-1210-DSC-1001 F Dated: 22/01/2014

- Golders Associates – Starter Platform Typical Detail KGP100-0500-1210-GAD-1005_D Dated: 22/01/2014

- Golders Associates – Starter Platform Typical Detail KGP100-0500-1210-GAD-1006_D Dated: 22/01/2014

- Golders Associates – North Sump Typical Detail KGP100-0500-1210-GAD-1007_D Dated: 22/01/2014

- Golders Associates – South Sump Typical Detail KGP100-0500-1210-GAD-1008_D Dated: 22/01/2014

- Golders Associates – Part General Master Plot Plan KGP100-0500-1210-GAD-1201 C Dated: 26/02/2014

- Golders Associates – Part General KGP100-0500-1210-GAD-1202 D Dated: 26/02/2014

- Golders Associates – Krumovgrad IMWF Detailed Design – IMWF Hydraulic Conductivity Analysis IMWF Spring Survey and Infiltration Testing KGP100-0500-1000-MEM-1202 C Dated: 09/01/2014
- Prof. D. Sci. Peter Marchev - Arsenic mineralogy and geochemistry in the Ada Tepe gold deposit Dated: January 2012
- Ecotech Consult Ltd. - The Life-cycle of Arsenic from the Ada Tepe region near Krumovgrad Date: January 2012
- Eurotest Control EAD - Mine Waste Characterisation – Static and Kinetic Testwork, ADA TEPE, KRUMOVGRAD Dated: August 2011
- Eldridge', T. et al., Integrated Mine Waste Storage Concept, Krumovgrad Gold Project, Bulgaria, Proceedings Tailings and Mine Waste 2011, Vancouver, BC, November 6 to 9, 2011
- Dango Project Consultant EOOD, Environmental Impact statement of Krumovgrad Project, December 2010.
- DPM "Metallurgical Samples Final.XLSX" – No date
- DPM Mine Waste Management Plan, December 2010.
- CSA Global, DPM NI 43-101 Technical report Ada Tepe Deposit, Krumovgrad project, Bulgaria, Dated: 21st March 2014.

2.0 PROJECT DESCRIPTION (*TEXT AMENDED FROM THE DESCRIPTION PROVIDED BY THE DPM TEAM*)

2.1 Project Description and Location

The Krumovgrad Project is a planned 850,000 tonnes per year ("tpa") open pit gold mine located in Bulgaria which is consistent with existing permitting and environmental submissions, and is financially viable. The mill facilities and mine will be developed, constructed, and operated by DPMKr, a wholly owned subsidiary of DPM. The size of the IMWF landtake footprint has been optimised to 85 ha, with a maximum of approximately 134 ha's when anticipated buffer zones are added.

The license area (Figure 2.1) is located in the East Rhodope Mountains, approximately 320 km (by road) southeast of Sofia, in the Kardzali District immediately south of the regional township of Krumovgrad (25° 39' 15"E and 41° 26' 15"N). Krumovgrad is located approximately 320 km by paved road southeast of Sofia and some 12.5 km (measured by air) north of the border with Greece.

The Ada Tepe deposit is located 3 km south of the Krumovgrad town site and trends in a north south direction. The morphology of the site is hilly rising in elevation from 492,4 masl abutting the major regional Krumovitsa River system, to 220 masl within the zone of mineralization

Figure 2-1 Location Plan of the Krumovgrad Gold Project Area

2.2 Climate

The average annual precipitation is 703.5 mm (between 676 mm and 912 mm). The bulk of this falls in autumn and winter, occasionally as snow in the coldest months. The highest rainfall occurs in December (96.9 mm average) and the lowest in August (24.1 mm). The annual average temperature is 12.6°C. The minimum temperature is in January and the average is about 2°C. The first snowfall in the region occurs in the second week of December, the snow cover does no stay longer than 5 to 6 days in the winter. The average July temperature varies between 23.2°C and 23.6°C, which makes the region one of the warmest in the country.

The Town of Krumovgrad is around 230 m above mean sea level and is characterised by a rugged landscape. The Ada Tepe deposit is located in an area of moderate, hilly topography abutting the Krumovitsa River. The project area is readily accessible at all times of the year.

2.3 Groundwater

The background concentration in the groundwater in the project area is summarised in Table 2-1 below.

Table 2-1: Background Concentrations in the Ground Water within the Project Area

Components	Reg 1/2007	Groundwater Ada Tepe Area 1/	Allowable Limits – Regulation 1/2007 2/	Regulations 7/1986 and 6/2000	Allowable Limits - Regulation7/1986 3/	Allowable Limits – Regulation 6/2000 4/
pH	-	6.80-7.57	6.50 - 9.50	-	6.0-8.50	6-9
Conductivity	µS/cm	353-1028	2000	µS/cm	1300	-
Total hardness	mgeqv/l	2.67-7.49	12.0	mgeqv/l	10.0	-
Permanganate oxidisable C	mgO2/l	0.99-1.91	5.0	mgO2/l	30.0	-
Ammonium	mg/l	0.013-0.074	0.5	mg/l	2.0	-
Nitrites	mg/l	< 0.05	0.5	mg/l	0.04	-
Nitrates	mg/l	0.1 - 4.3	50.0	mg/l	10.0	-
Fluorides	mg/l	0.17-0.53	1.5	mg/l	1.5	-
Phosphates	mg/l	< 0.1	0.5	mg/l	1.0	-
Sulphates (as SO_4^{2-})	mg/l	30.6-66.0	250.0	mg/l	300.0	-
Chlorides (as Cl^-)	mg/l	6.0-108.7	250.0	mg/l	300.0	-
Sodium	mg/l	7.0-140.0	200.0	-	-	-
Cyanide (total)	µg/l	< 2.0	50.0	mg/l	0.5	1.0
Mercury	µg/l	< 1.0	1.0	mg/l	0.001	0.01
Cadmium	µg/l	< 1.0	5.0	mg/l	0.01	0.1
Cu	mg/l	0.003-0.0057	0.2	mg/l	0.1	0.5
Nickel	µg/l	< 2.0	20.0	mg/l	0.2	0.5
Lead	µg/l	< 10.0	10.0	mg/l	0.05	0.2
Selenium	µg/l	< 10.0	10.0	mg/l	0.01	-
Chromium	µg/l	1.0-4.0	50.0	mg/l	0.05	0.1
Aluminum	µg/l	10.0-50.0	200.0	-	-	-
Iron	µg/l	20.0-180.0*	200.0	mg/l	1.5	3.5
Zinc	mg/l	0.001-0.07	1.0	mg/l	5.0	2.0
Boron	mg/l	0.01-0.12	1.0	Not allowed	-	
Antimony	µg/l	< 5.0	5.0	-	-	-
Arsenic	µg/l	< 10.0	10.0	mg/l	0.05	0.1
Magnesium	mg/l	5.2-35.3	80.0	-	-	-
Calcium	mg/l	26.9-141.5	150.0	-	-	-
Natural uranium	mg/l	< 0.001	0.06	mg/l	0.6	2.0
Petroleum products	µg/l	20.0-100.0 (in one of the boreholes)	50.0	mg/l	0.3	10.0

	1/Groundwater samples from the Ada Tepe area (Protocols 4145/29.04.2020 - Eurotest Control AD); 2/ Appendix 1 to art. 10, par. 2, item 1 of Regulation 1/10.10.2007 on Groundwater Exploration, Use and Protection; last amendment SG issue 2/08.01.2010 (The presence of iron in ATDDEX 025 is attributed to the corroded casing, which did not allow taking a non-contaminated sample.) 3/ According to Regulation 7/1986 on Surface Waters (Category II Receiving Water) 4/ Regulation 6/09.10.2000 on Emission Limits for Allowable Concentration of Harmful and Hazardous Substances in Wastewater Discharged in Water Bodies. (SG issue 97/2000).

Ref: Table V.2.1-13 EIA page 185.

2.4 Integrated Mine Waste Facility (IMWF)

The IMWF was designed by Golder Associates. Appendix A contains drawing showing the location of the facility with respect to other components and design details for the starter platform and sump details.

2.4.1 Background and Site Selection

The concept of a conventional slurry disposal facility as proposed in the 2005 mining study has been replaced with an IMWF which will receive both the thickened tailings and the mine waste rock from the Ada Tepe pit. The tailings storage location was revised to minimise land use and the environmental footprint. Two sites were initially identified for a potential IMWF, located north and south of the open pit respectively. Preliminary capacity assessments as well as optimisation of the mine and road layout resulted in selection of the south site.

2.4.2 General Description

The concept of the IMWF is to place thickened tailings into cells constructed from mine rock. The mine rock provides strength required for overall stability and also internal drainage. Water reporting to the underdrain will be pumped to the Raw and Process Water Reservoir ("RPWR") located southwest of the open pit. The IMWF will be constructed within two small valleys, being operated as two separate facilities early in the life of the project and later merging into a single facility as operations progress. Rehabilitation of the lower slopes of the IMWF will begin during the early stages of mine operation. DPMKr have an approved Mine waste management plan from the Ministry of Economy and Energy.

The IMWF structures required for commencement of mining operations will be constructed from the soil and rock excavated to create the platform for the process plant and the roads on the mine site. Once the mining operation begins, the mine rock will be trucked from the open-pit to the IMWF, dumped and spread to construct containment cells for the tailings. Tailings will be thickened in the tailings thickening plant to the maximum practical amount (between 56-68% solids), and then conveyed by pump and pipeline to the containment cells. The IMWF will be a fully drained facility and will not contain a water pond at any time during its operation. A system of under-drains will be constructed along the axis of each small surface water channel in the footprint of the IMWF and these drains will discharge to one of two sumps located at the toe of the facility. To minimize pond formation,the IMWF is formed into a 'honycomb' structure which reduces the drainage pathway lengths (both horizontally and vertically) and optimizes the structure's ability to drain water away. The drainage berms have a significantly higher permeability than the tailings, and there is no ponding expected both from the supernatant water and rainfall. Based on the information available to AMEC, AMEC is unable to judge the efficiency of this system at avoiding the formation of a water pond at any time during the operation of the IMWF. AMEC believes that the deposition strategy to maintain suitable beach profile to naturally drain towards the peripheral high permeability berms will require strict site control.

The IMWF will be sequentially constructed from the bottom up, with mine wastes placed on starting platforms at the bottom of the valley at approximately 300 m elevation and then progressively built up in benches during the mine life to elevation 450 m. This will allow the lower, completed sections of the facility to be reclaimed and closed during the life of the mining operation.

Given the economic parameters used for this study, (i.e., 0.6 g/t COG), 15.1 million tonnes of mine rock and 6.2 million tonnes of tailings will be stored within the IMWF over 8 years during the life of the mine.

A dual reservoir system has been developed which has resulted in the mine being able to adopt a zero discharge water management strategy. These two reservoirs are adjacent to each other and have differing functions with regard to water management, these being management of process water and storage of storm water and pit inflows.

2.5 Closure and Rehabilitation

DPMKr have an approved Mine Closure Plan for mine decommissioning and rehabilitation of disturbed lands for the Ada Tepe prospect from the Ministry of Economy and Energy. The plan provides for removal of constructed facilities and roads (except where an agreement is reached for post-closure use by the Community) and re-vegetation of operational areas in order to attain an end-use for the site as agreed with Project stakeholders.

2.6 Design Basis for IMWF

The engineering design process associated with mining project follows a series of steps and each step more engineering is carried out in order to achieve the optimum designs. The following bullets points describe AMEC's approach. The actual amount of engineering carried out in each step varies from design group to design group but in general the process is followed:

- Conceptual
- Pre feasibility
- Feasibility
- Detailed Design.

DPMK followed the practice in Bulgaria of sub-dividing the detailed design stage into three by following the Feasibility stage with:

- Basic Design,
- Technical Phase Design.

The Technical Phase Design supports the application for the construction permit and it is estimated that 80% of the engineering has been undertaken.

The following tables summarise the design basis adopted for the IMWF.

Table 2-2: Basic Design Criteria

Items	DFS Stage	Detailed Design Stage
Process Plant Operation	24 hours/day – 365 days/year	24 hours/day – 365 days/year
Thickener Feed Rate (design)	138 tonnes/hour or 3300 tonnes/day	105 tonnes/ hour
Mill nominal throughput	1,100,000 tonnes/year	840,000 tonnes/year
Thickener flux		0.065 m^2/tonne/day
% solids (by weight) tailings slurry feed from the mill	23%	23.9% (Woodgrove Flotation Area Mass Balance)
% solids (by weight) tailings to the IMWF	56% to 68% (depending on ore type)	56% - Worst case to be allowed for
Average tailings density in place	1.45 t/m^3	1.45 t/m^3
All water from consolidation of tailings, infiltration and runoff within the IMWF	To be recycled to the mill through the water management system	To be recycled to the mill through the water management system

Golder Associates.KGP 100-0500-1210-DSC-1001 F.

Table 2-3: Surface Water Design Criteria

System	Component	Design Criteria
Contact Water Collection System	Design Flow	100-year, 24-hour event
	Treatment Prior to Discharge	Enhanced evaporation or consumption in process
Non-Contact Water System	Design Flow	25-year, 24-hour event
	Treatment Prior to Discharge	None, disturbed areas will require sediment and erosion controls
IMWF Collection Sumps	Design Flow	100 year, 24 hour event
	Discharge	Will discharge into the environment when flows exceed design flow
IMWF Under-drain	Design Flow	100-year, 24 hour event
Open Pit Contact Water Collection System	Design Flow	100-year, 24 hour event
	Freeboard	Minimum of 0.3m
	Discharge	Collected in sumps. Pumped to Raw and Process Water Reservoir
	Collection Sump Volume	Storage volume of 2000 m3, depth of 6m and a surface area of 334m2 (design by others)

Golder Associates.KGP 100-0500-1210-DSC-1001 F.

The design flows for the diversion and collection channels were estimated using the Hydrologic Engineering Centre Hydrologic Modelling System software (HEC-HMS) (USACE, 2008).

The underdrain system will collect and convey the rainfall and the excess pore water from the consolidation of the tailings. A two zone filter system will be placed to prevent tailings being carried through the outer rock berm.

The surface interception drain will divert the runoff from the IMWF upstream catchment and prevent it from entering into the facility.

Two collection sumps will be set up at the toe of the IMWF north and south catchments to collect drainage from the IMWF area. Both sumps will be provided with pumps, which will operate depending on the sump level and return the drainage for reuse as process water. Each sump will have two pump units, one in operation and the other one on standby.

The original design assumed the use of a geosynthetic liner for the facility and this is good practice as it assumed the worst case scenario following the (no longer in force for Tailings Management Facilities) Landfill Directive requiring 1 metre thick clay liner with a maximum hydraulic conductivity of 1 x 10^{-9} m/s. By the time that the IMWF Design Criteria KGP100-0500-1210-DSC-1001 F Dated: 22/01/2014 was written the assumption was that the waste rock and tailings were inert. Every engineering decision is a trade-off, and liners are not exception. Liners have positive effect where necessary and negative ones where they are superfluous to the requirements to obtain the optimum design.

The next chapter will provide an evaluation of the liner requirements based on the scope described in Section 1.1.

3.0 EVALUATION OF REQUIREMENT FOR A LINER

The previous section provided a project description, including the location of the project, climate summary, design basis of IMWF and other background information. In this section data will be described to assist with the evaluation of requirements for a liner.

3.1 Type of deposit

The Ada Tepe deposit is a low-sulphidation adularia-sericite gold-silver epithermal deposit formed during the Neogene within the Southern Rhodope tectonic zone and located within Paleocene sedimentary rock overlying the north-eastern end of the Kessebir core complex (CSA Global, NI 43-101)

3.2 Bulgarian Legislation and Regulations

The IMWF will be constructed in a seismic area and therefore the seismic hazard analysis carried for the site suggests that the average and 85% values of the maximum ground acceleration with an annual probability for exceeding of 10^{-3} are 0.15g and 0.17g respectively.

For a Class I facility and a design earthquake with a peak ground acceleration of 0.17g, the siesmic loading (design sesimic horizontal acceleration) to be applied in the pseudoi-static slope stability analysis is obtained as 0.102g, in acordance with the Bulgarian Regulations 07/2 on Buildings and facilities Design in Seismic Zone (2007). Further slope stability work will be carried out during the Technical Phase of Design to ensure that the IMWF as designed meets thr required factor of safety criteria.

3.3 Best Available Techniques Reference Document (BREF) on Management of Tailings and Waste Rock in Mining Activities and International Best Practice

Golder Associates took into consideration the following guidelines in the design of the IMWF:

- The Canadian Dam Association (CDA) Dam safety Guidelines (CDA, 2007)
- BC MWRPRC, 2001. British Columbia Mine Waste Rock Pile Research Committee. Mined Rock and Overburden Piles Investigation and Design Manual Interim Guidelines,
- EU Mine Waste Directive , (2006/21/EC)
- Best Available Techniques Reference Document (BREF) on Management of Tailings and Waste Rock in Mining Activities, and

- Natura 2000 Constraints, which consists of fencing around the whole project area and the use of native species during the closure stage of the project?

3.4 Technical Reports – Geochemistry and Geotechnics

3.4.1 Spring Survey

Golder located a total of 15 of potential springs in the IMWF valleys based on infra-red data review. The correlations appear to correlate with topographic low points across the South and North Valleys and this could have represented areas of surface flow. Each location was visited and observations recorded.

None of the 15 spring locations showed sign of water discharge at the time of their site visit. In general, the ground conditions across both the North and South Valleys were observed to be very dry. No distinct changes in vegetation types or colour were observed in the vicinity of the potential locations.

Few discrete sections of the South and North Valleys were observed to be damp or contain shallow, small pools of stagnant water suggesting the presence of low transmissivity surficial soils in these locations.

3.4.2 Infiltration Testing

A total of 15 infiltration tests were carried out across the North and South Valleys. Soil saturated hydraulic conductivities (Kfs in m/s) were found to be in the range from 4.04×10^{-7} to 2.52×10^{-5} m/s. Testing depths ranged between 0.18 m and 0.8 m. There is no significant trend in the spatial distribution of the results. Golder states that these results are broadly in line with previous studies from falling head tests across the IMWF footprint carried out in 2010.

The consolidated assessment and dilution modelling as mentioned in the Golders Associates – Krumovgrad IMWF Detailed Design – IMWF Hydraulic Conductivity Analysis IMWF Spring Survey and Infiltration Testing KGP100-0500-1000-MEM-1202 C Dated: 09/01/2014 have not been reviewed.

The EIA states that consolidation testing indicates that tailings deposited at 56% solids will change in volume by approximately 40% due to release of pore water under a load of approximately 15 m of additional mine rock and tailings.

3.4.3 Geochemical Characterisation of Future Waste

Waste Rock

The waste rock mostly consists of breccia conglomerates with occasional boulders of metamorphic rocks – amphibolites, gneiss and schists. A total of 14,950,000 tons of waste rock are expected to be produced during the life of the Ada Tepe mine. The waste rock is classified as fresh (25 %), oxidised (20 %) and strongly oxidised (55 %) depending on the weathering grade.

The mineralogy of the waste rock is shown in Table 3-1.

Table 3-1: Mineralogy of Mine Rock (% by weight)

Mineral	Molecular formula	Fresh rock sample (wall zone)	Fresh host rock sample	Sample oxidized rock	Sample strongly oxidized rock
Quartz	SiO_2	44.4	22.8	62.1	46.5
Muscovite	$KAl_2AlSi_3O_{10}(OH)_2$	4.0	6.5	2.0	4.9
Potash feldspar	$KAlSi_3O_8$	28.7	8.4	11.5	33.1
Plagioclase	$NaAlSi_3O_8 – CaAl_2Si_2O_8$		18.5		3.5
Clinochlore	4.0 $(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$		21.1		
Pargsite	$NaCa_2(Mg_4Al)Si_6Al_2O_{22}(OH)_2$		1.4		
Kaolinite	$Al_2Si_2O_5(OH)_4$	8.8	5.0	15.3	8.6
Calcite	$CaCO_3$	0.7	14.0		
Ankerite	$Ca(Fe^{2+},Mg,Mn)(CO_3)_2$	11.8	1.6		
Goethite	$\alpha–Fe^{3+}O(OH)$			9.0	3.3
Pyrite	FeS_2	1.7	0.8		
Total		100.0	100.0	100.0	100.0

Quartz, aluminum silicates, carbonates and pyrite prevail in the fresh rock samples (25% of the mine rock). The occurrence of ankerite in the fresh rock from the Wall Zone reduces the neutralization potential due to the presence of iron (II) in the mineral. Despite that, the alkalinity of the whole mineral is sufficient to prevent acid generation. The dominant carbonate mineral in the fresh host rock sample is calcite. The oxidised and strongly oxidised rock (75 % of the mine rock) does not contain pyrite or other sulphides. The available goethite is probably a product of the oxidation of the original sulphide. Like fresh rock, the main phases of the material contain quartz and aluminum silicates.

The mine rock composition has been compared against the average crustal abundance. Except for the fresh host rock samples, all other rock samples contain elevated concentrations of SiO_2 compared to average crustal abundance. The iron oxide concentration is higher than the average in all samples: it is associated with the ankerite, goethite and less with the pyrite. The concentrations in the oxidised rock and fresh host rock samples are lower than the average, while the strongly oxidised rock samples and the fresh rock samples from the Wall Zone contain elevated concentrations compared to average crustal abundance. This is attributed to the varying concentrations of potassium feldspar in the different samples. The concentration of the rest of the oxides is generally below the average crustal abundance. Except for the iron concentrations, the results of the element analysis are similar to the average crustal abundance.

The results from acid base accounting were reviewed by AMEC.

A total of 81 samples of future Ada Tepe waste rock with a good horizontal and vertical spatial distribution were subjected to Total Sulphur and percentage sulphide. Selected samples were subjected to inorganic carbon determination, Acid Base Accounting (ABA) following EN 15875. Total Sulphur is a conservative measure of the potential for acid generation and it is adopted as the basis of this discussion. The following table summarises the results from the Total Sulphur analysis.

Table 3-2: Total number of samples by interval of Total Sulphur content

Total Sulphur, %	No of samples in interval
Below detection limits (dl)	31
>dl to <0.1	12
>0.1 to < 1	18
>1	20
Total number of samples	81

The maximum Total Sulphur determined was 1.85%, the maximum percentage sulphide determined was 1.54%.

From the 81 samples tested, only 36 were subjected to ABA, as the majority of the samples were below detection limit or fairly close to the detection limit. . Despite this of the 36 samples tested only 2 samples had neutralisation potential ratio (NPR) of less than 2 and these samples were not samples with the higher Total Sulphur content. Only 5 samples out of 36 tested had NPR less than 3. High NPR for many samples indicated that there is excess neutralisation potential overall. So it can be concluded that the waste rock from Krumovgrad project is unlikely to generate acidity and that there is excess neutralisation potential in a significant proportion of the samples.

EUROTEST CONTROL AD carried out kinetic static and kinetic testing of four samples supplied by DPM Krumovgrad EAD. The samples were described as follows:

1. ATMET 068 - material from the Wall Zone, which comprises intensely, silicified Palaeogene breccia, waste rock.

2. ATMET 069 - fresh rock from the Upper Zone, where the Palaeogene conglomerate is weakly silicified and argillised.

3. ATMET 070 - material from the oxidised Upper Zone, usually affected by argillisation and silicification.

4. FLOTATION TAILINGS – from Ada Tepe ore.

Samples were subjected to short term leaching (EN12457) and kinetic testing for 20 weeks following the D5744-07 - Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell (ATSM, 2007). The flotation tailings results will be discussed in the subsection for tailings.

ATMET 068 and 069 had 0.22 and 0.59 Total Sulphur respectively and showed a high level of NPR while ATMET 070 was 0.08% and therefore it is not expected that acid generation would occur of any significance.

The EN 12457 short term leaching test was performed on the waste rock samples. The criteria for acceptance of non-hazardous waste to landfill in Bulgaria were used as a reference point. The results showed that the three samples comply with this criteria and exhibit low solubilisation of the usual elements of concern such as As, Cd, Pb, Sb, Se, etc.

Kinetic testwork using humidity cells and the ASTM standard was performed. Over a 20 weeks period, samples ATMET 068 and 069 maintain a pH in the range between 8 and 9 indicating that no acidity was generated. Usual elements of concern such as As, Cr, Cd, Se, Sb, Pb, and Hg were below instrumental detection of limits. Sulphate and conductivity measurements were consistent with the behaviour described above.

ATMET 070 maintains a pH between 8 and 6 with a tendency toward pH 6 as time progressed. This was ascribed to the slower kinetics of dolomite at releasing alkalinity. The level of dissolved metals in the leachate was in general higher than with the previous two samples and specifically Fe, As and Zn for instance. However, the increase was not substantial in absolute terms. The conductivity of the eluate showed a fluctuating behaviour. Sulphate concentrations are lower for ATMET 070 than ATMET 068 and 069 which is consistent with the different initial sulphur content of these samples.

In conclusion, the results presented from the static, short term and kinetic testwork suggest that despite the fact that there is a potential for acid generation, this potential seems not to be realized resulting in a leachate with metal content below the instrumental detection limits or above but very close to it. The concentration found with the short and long term testing indicate that metal leachability of elements of concern is within acceptable limits for the acceptance of the waste rock in landfills for inert materials. Appendix B contains the Eurotest report documenting the findings from the characterization of the 3 waste rock samples and the tailings.

Tailings

Tailings were tested for grain size, specific gravity, shrinkage limit, soil water characteristic curve, consolidation and hydraulic conductivity and for shear strength by drained direct shear test. Tailings properties were as follows:

- Fine grained, with d80 value of near 30 microns
- Non-plastic
- Shrinkage limit 25%
- Specific gravity 2.74 t/m^3
- Friction angle of dewatered tailings 30 degrees
- Tailings at 64% solids content had a slump of 241 mm.

Values of hydraulic conductivity k were measured near 3 x 10-8 m/s at low confining stress (14kPa) and near 5 x 10-9 m/s at higher confining stress (655kPa).

Pressure plate test results for soil water characteristic curve showed an air entry value greater than 100 kPa, indicating that tailings will not readily desaturate under gravity drainage, in other words tailings will remain saturated unless higher temperature provides the force for water evaporation or as the tailings are buried due to the load of the new tailings deposited on top as the height of the facility increases.

Table 3-3 shows the average concentration of selected major and trace elements of the Ada Tepe ore. The ore is processed and some elements associated with the minerals of value will be removed while other (gangue minerals) will be concentrated in the tailings

Table 3-3: Average Concentration of Major and Trace Elements in the Ada Tepe Ore, Khan Krum Deposit in g/t

Prospect	Au	Ag	Co	As	Fe	Cu	Zn	Pb	Ni	Cr	Mn	Cd
Ada Tepe	5	2	14	145	3.1	10	34	<5	43	250	509	<5

Table II.5.1 EIA page 32.

Table 3-4 shows the whole rock analysis (XRF) for the ore. Around 86% is basically silicates and alumino-silicates which are the most abundant minerals in the Earth Crust.

Table 3-4: Whole Rock Analysis (WRA) of Ada Tepe Ore

Type	Unit	Fresh	Oxidized ores	Average for the deposit
SiO_2	%	69.80	81.00	80.20
Al_2O_3	%	4.70	6.96	5.90
CaO	%	8.63	1.59	2.85
Fe_2O_3	%	2.75	3.51	3.28
K_2O	%	2.19	3.18	2.60
MgO	%	1.53	0.17	0.44
Na_2O	%	0.09	0.11	0.14
TiO_2	%	0.22	0.37	0.30
MnO	%	0.07	0.08	0.08
BaO	%	0.02	0.03	0.03
SO_3	%	1.02	0.10	0.22
P_2O_5	%	0.04	0.07	0.06
Tempering losses	%	8.74	2.75	3.65
Total				99.75%

Table II.5.2 EIA page 32.

The table also showed that the average composition of the ore contains less than 0.1 Total Sulphur. Table 3-5 below shows the mineralogy of the tailings from the processing of the ore. The main phase is quartz followed by Phlogopite and Plagioclase. None of these minerals have significant neutralisation capacity; but the potential for acid generation is also very limited.

Table 3-5: Mineralogy of Tailings

Mineral	Molecular formula	Flotation tailings from ore processing
Quartz	SiO_2	56
Phlogopite (rombic mica)	$KMg_3\ AlSi_3O_{10}(F,OH)_2$	23
Plagioclase	$(Na, Ca)(Si, Al)_4O_8$	17
Chlorite	$(Mg,Fe)_3\ (SiAl)_4O_{10}(OH)_2.(Mg,Fe)_3(OH)_6$	3
Amphibole	$(Mg,Fe)_7\ Si_8O_{22}(OH)_2$	1
Total		100.0

Table V.6.1-2 EIA page 213

A tailings sample was subjected to short term leaching and kinetic testing over a period of 20 weeks. The sample had a Total Sulphur of 0.04% which is consistent with the average concentration in the ore. The majority of the sulphide and arsenic in the ore will follow the concentrate in the flotation process. The kinetic testing results show that As, Ni, Cd, Sb, Pb, Hg and to a certain extent Cr are below detection limit or fairly close to it. The pH in the leachate from the kinetic test remained above neutral for the 20 cycles and mostly hovering around pH 8. The conductivity measurements were low indicating that most elements in solution were at low concentration.

In conclusion the tailings are not acid generating and there is no metal leachability concern.

4.1 Qualitative Technical Risk Analysis

The sub-sections above have provided relevant information regarding the setting of the project, description of the Integrated Mine Waste Facility (IMWF) and geochemical and geotechnical parameters associated with the waste rock and tailings to be disposed in the facility.

The proposed method is disposal in the IMWF, where the flotation tailings (thickened to 56% solids) will be placed together with the waste rock from the open pit development. The IMWF design is based on the "thickened tailings" method BREF Code Management of Tailings and Waste Rock -MTWR, Section 2.4.3 and further developed to achieve accelerated dewatering and consolidation of tailings by placement of waste rock over it. The requirements of the BREF document for deposition of tailings (at 50 to 70 % solids) and arrangement of drainage systems have been implemented. Drainage water will be recycled back into the main process.

Section 4.3.10 of the BREF document states that if seepage is of good quality it may be allowed to seep into the ground and that the thickened tailings disposal method reduced the seepage. Furthermore the provision for under-drainage and preferential flow path for the excess pore water that will be expelled as the tailings consolidate will decrease further any potential for seepage to occur to the groundwater.

It is known that tailings tend to have a lower vertical permeability than horizontal permeability and the IMWF exploits this characteristic fully by depositing the tailings into cells and the berms acting as dewatering pathways.

The water expelled from the tailings will be collected and re-used within the process.

One convenient and efficient way to carry out a qualitative risk assessment is the source-pathway-receptor model. This model relies on investigating the likely presence and significance of a pollutant linkage; for a risk to exist there must be a source of contamination, a receptor that may be impacted and a pathway connecting them. Such a source-pathway-receptor relationship is termed a pollutant linkage. If the source, pathway or receptor is absent, no linkage exists and thus no likelihood of risk.

A relative rigorous characterisation programme of the waste rock to be used in the IMWF and the tailings to be disposed was carried out and concluded that the potential for acid generation from either of these components is very low, as the deposit is a low-sulphidation type. In terms of metal leachability, the results for the majority of elements of concern were either below detection limit or very close to it. So there is a low risk from the potential source for impacting potential receptors. The characterization programme used a 20 cycles kinetic test using Humidity Cells. Humidity Cells testing is designed to create ideal conditions for the generation of acidity or highlight metal leachability issues by providing an environment containing maximum amount of oxygen and the flush of oxidation products in every cycle.

Considering that the tailings will remain saturated unless other forces than gravity is applied then the tailings will remain saturated and therefore with limited exposure to oxygen. The only other possibility is during the summer months when the temperature increases enough for evaporation to occur and potential ingress of oxygen will occur. Even in this scenario, the results generated by the kinetic testing are still the worst case scenario.

Furthermore IMWFs are dynamic by nature. As the tailings and waste rock deposition progresses, the facility evolves from an initial oxidative environment to the development of a transition and eventually a mildly reductive zone at the bottom of the IMWF. As the mildly reductive zone is developed, acid generation is no longer possible and other chemical processes take place. The implication of this evolution is that a certain capacity to mitigate any metal leachability is developed with time.

In terms of pathways, the design provides for the reduction of the amount of water in the facility by using thickened disposal method, and the formation of preferential pathways to collect any excess water generated from the consolidation of the tailings, this significantly decreases the potential for seepage to report to the groundwater.

The potential receptors are not well defined; but basically would be groundwater. Based on the analysis above, the quality of the seepage impacting the groundwater would be limited (See Appendix B)

Based on the above qualitative analysis it is concluded that the risk of impacting the environment is very low i.e., both the source and the pathways exhibit limited potential to impact on receptors. The installation of a geosythentic or modified liner will consequently not significantly reduce this already a very low risk.

During closure of the facility, standard procedures to ensure that ponding on the surface of the facility will be followed. This will minimise future infiltration into the facility. It is likely that following the EU Mine Waste Directive an active phase during the closure will monitor the drainage from the facility and if this does not meet discharge regulations the local authority will not considered the facility closed. Once the discharge quality is met then the closure of the facility can be completed.

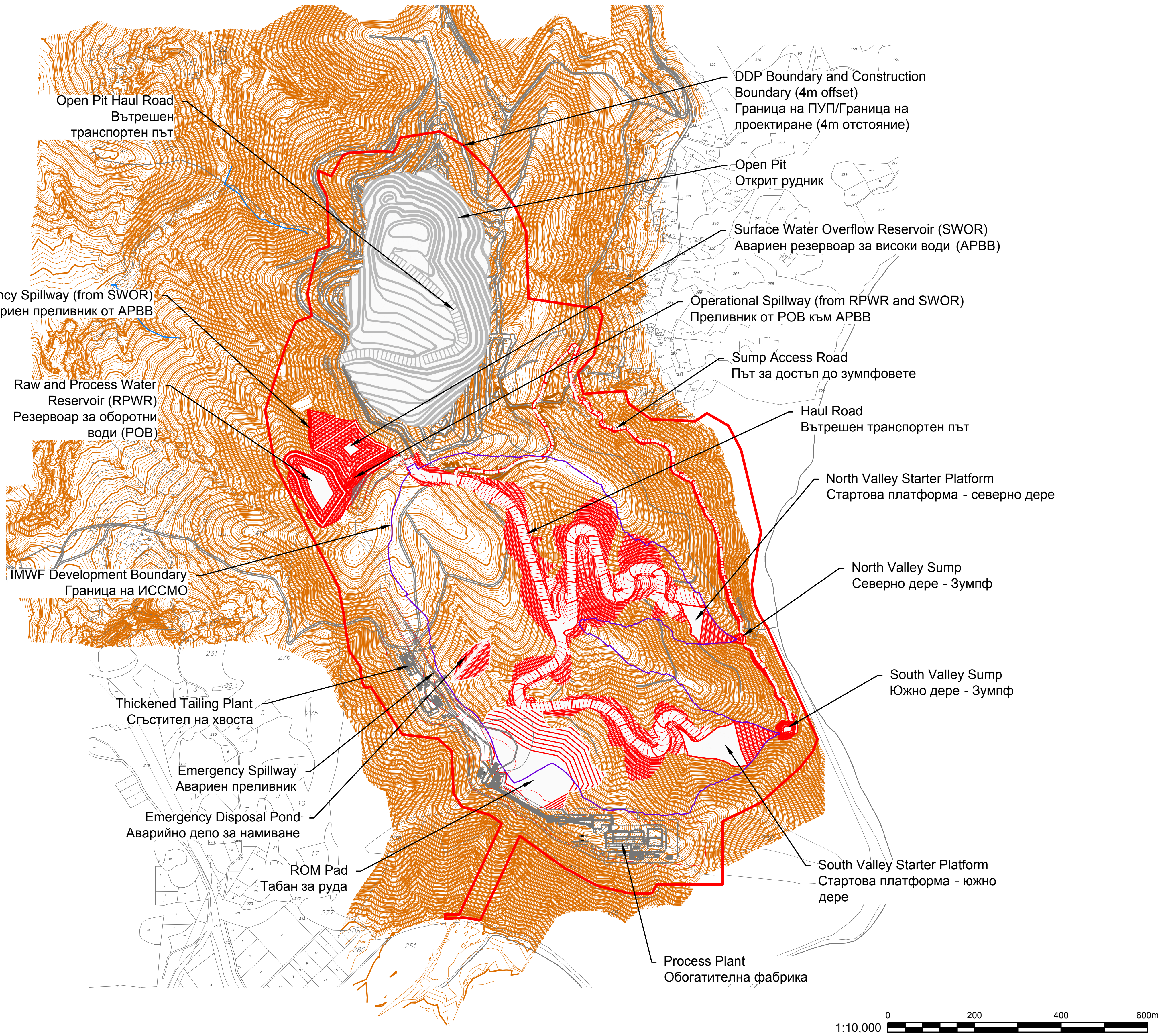
5.0 CONCLUSIONS

Based on the information collated in this report and the qualitative risk analysis based on the source- pathway – receptor model, it is concluded that if a full risk analysis were to be carried out, the likely conclusion reached would be that the environmental benefits of installing a liner under the IMWF does not justify the extra cost involved, since the risk of seepage of unacceptable quality generated by the source (waste rock and tailings) is very low. In addition, the thickened disposal method, under-drainage and lateral drainage integrated within the design of the IMWF means that the pathway to carry any seepage (good or bad quality) to receptors would be also limited.

APPENDICES

APPENDIX A

IMWF Design Drawings



1970 State Coordinate System and Baltic System
Българска координатна система 1970 и Балтийска система

KRUMOVGRAD MUNICIPALITY	ОБЩИНА КРУМОВГРАД
THE ASSIGNOR	ВЪЗЛОЖИТЕЛ
Dundee PRECIOUS METALS KRUMOVGRAD	
BULGARIAN DESIGNER	БЪЛГАРСКИ ПРОЕКТАНТ
ПРОЕКТИРАНЕ И АНАЛИЗИ ЕООД СОФИЯ	
THE DESIGN SUPERVISOR	КОНСУЛТАНТ ЗА ОЦЕНЯВАНЕ НА ПРОЕКТА
LIRA CONSULT CONSTRUCTION CONTROL	
INTERNAL REVIEW	ВЪТРЕШЕН ПРЕГЛЕД
CONTRACTOR	ИЗПЪЛНИТЕЛ
Golder Associates	

ПРОЕКТ:
ДОБИВ И ПРЕРАБОТКА НА ЗЛАТОСЪДЪРЖАЩИ РУДИ ОТ УЧАСТЪК „АДА ТЕПЕ“ НА НАХОДИЩЕ “ХАН КРУМ”, ГР. КРУМОВГРАД ОБОГАТИТЕЛНА ФАБРИКА

Чертеж:
Допълнителен чертеж

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Golder Associates

CLIENT: Dundee PRECIOUS METALS KRUMOVGRAD

No.	BY	DATE	REVISION	CHECKED	APPROV.
C	TS	26/02/14	ISSUED FOR PERMITTING	MD	PC
B	AD	30/01/14	ISSUED FOR DPMK REVIEW	MD	PC
A	AD	27/01/14	ISSUED FOR INTERNAL REVIEW	MD	PC

	BY	DATE
PROJECT APPR.		
DESIGN APPR.		
DESIGNED		
CHECKED		
DRAWN	A.DUGDALE	30/08/13

SCALE МАЩАБ 1:10,000
PROJECT No. KGP100
DRG SIZE A3

CLIENT КЛИЕНТ DUNDEE PRECIOUS METALS

TITLE
KRUMOVGRAD GOLD PROJECT
PART GENERAL
MASTER PLOT PLAN

DRAWING No. ЧЕРТЕЖ № KGP100-0500-1210-GAD-1201
REV No. C

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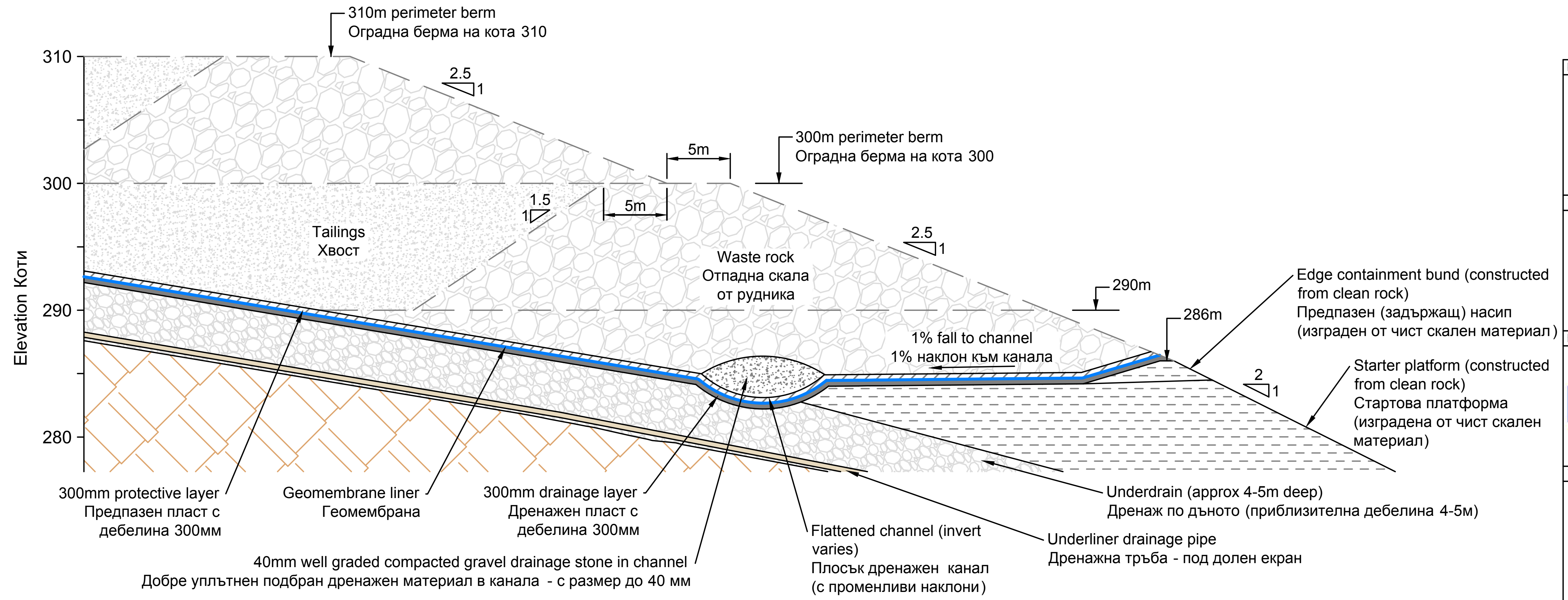
Координатна система 1970 и Височинна система Балтийска



Cross Section A-A Through Centre of Starter Platform
Напречен разрез А-А по ос Стартова Платформа
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Съгласно черт. No KGP100-0500-1210-GAD-1003
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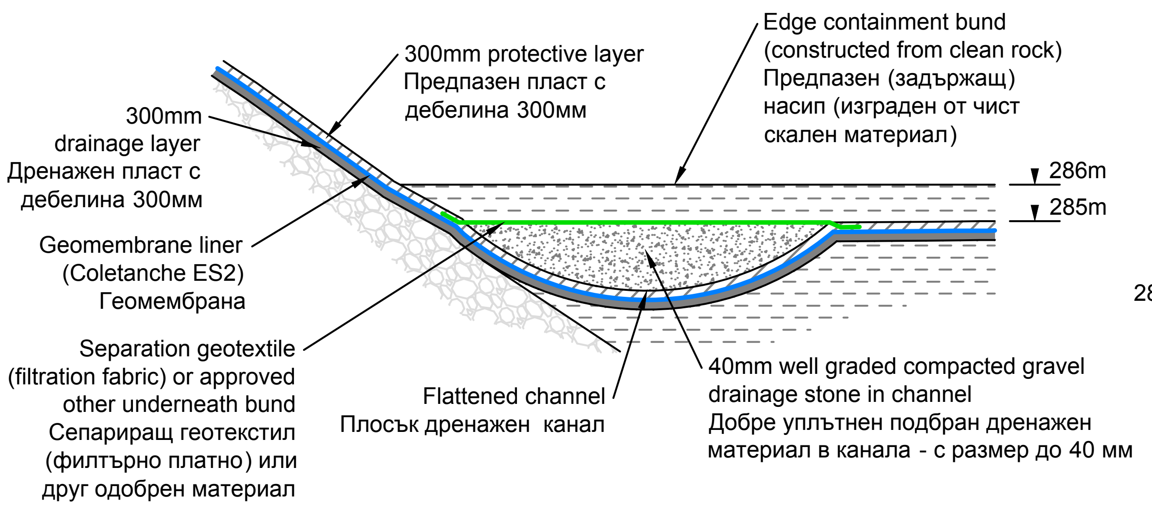

Cross Section B-B Through Intersection of Channel and Edge Containment Bund
Напречен разрез B-B през Дренажния Канал и Предпазен (задържащ) насип
Refer to Drg No KGP100-0500-1210-GAD-1003
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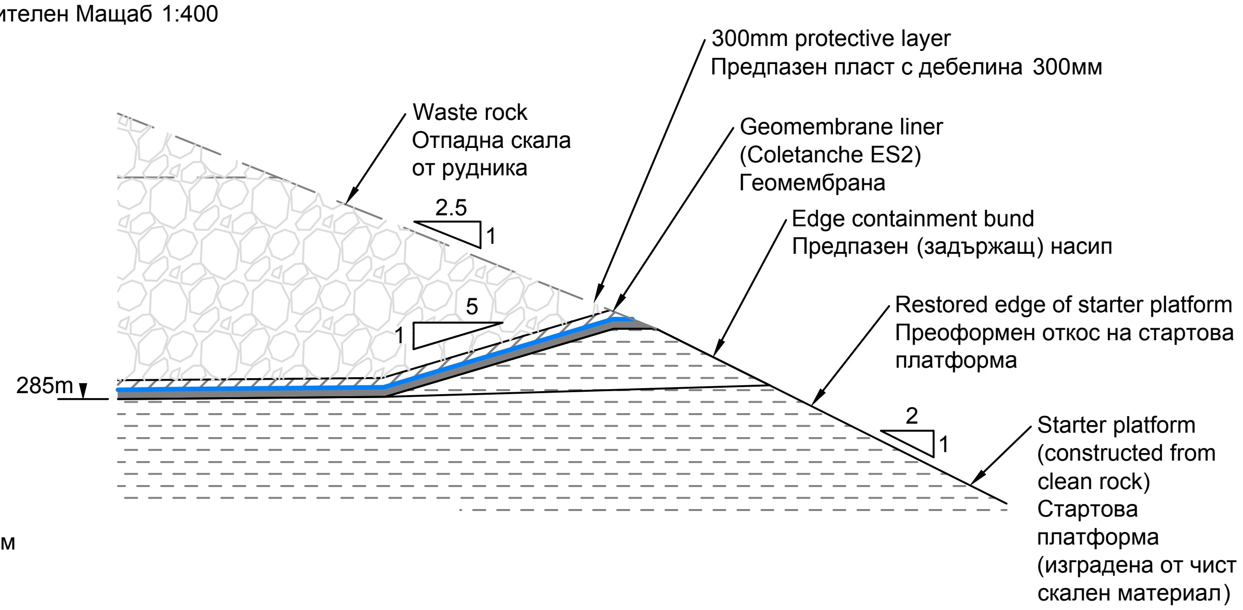

Cross Section C-C Through Starter Edge Containment Bund
Напречен разрез С-С през Предпазен (задържащ) насип на Стартова платформа
Refer to Drg No KGP100-0500-1210-GAD-1003
Съгласно черт. No KGP100-0500-1210-GAD-1003
Approx Scale 1:200 Приблизителен Мащаб 1:200

KRUMOVGRAD MUNICIPALITY	ОБЩИНА КРУМОВГРАД
THE ASSIGNOR	ВЪЗЛОЖИТЕЛ
BULGARIAN DESIGNER	БЪЛГАРСКИ ПРОЕКТАНТ
THE DESIGN SUPERVISOR	КОНСУЛТАНТ ЗА ОЦЕНЯВАНЕ НА ПРОЕКТА
INTERNAL REVIEW	ВЪТРЕШЕН ПРЕГЛЕД
CONTRACTOR	ИЗПЪЛНИТЕЛ

Проект:
ДОБИВ И ПРЕРАБОТКА НА ЗЛАТОСЪДЪРЖАЩИ РУДИ ОТ УЧАСТЪК „АДА ТЕПЕ" НА НАХОДИЩЕ "ХАН КРУМ", ГР. КРУМОВГРАД ОБОГАТИТЕЛНА ФАБРИКА

Чертеж:
Стартова платформа
Типови детайли

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No.	BY	DATE	REVISION	CHECKED	APPROV.
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C	AO	09/12/13	Issued for Translation	PC	MD
B	ECS	27/08/13	Issued for DPMK Review / Proektirane Review	MD	PC
A	ECS	23/07/13	Issued for internal review	MD	PC

	BY	DATE
PROJECT APPR.	-	-
DESIGN APPR.	-	-
DESIGNED	-	-
CHECKED	-	-
DRAWN	L SKINNER	24/07/13

DRAWING No. | REFERENCE DRAWINGS

CLIENT:

SCALE МАЩАБ: As Shown

PROJECT No. KGP100 | DRG SIZE A3

CLIENT КЛИЕНТ: DUNDEE PRECIOUS METALS

TITLE: KRUMOVGRAD GOLD PROJECT
STARTER PLATFORM
TYPICAL DETAILS

DRAWING No. ЧЕРТЕЖ №: KGP100-0500-1210-GAD-1005

REV No.: D

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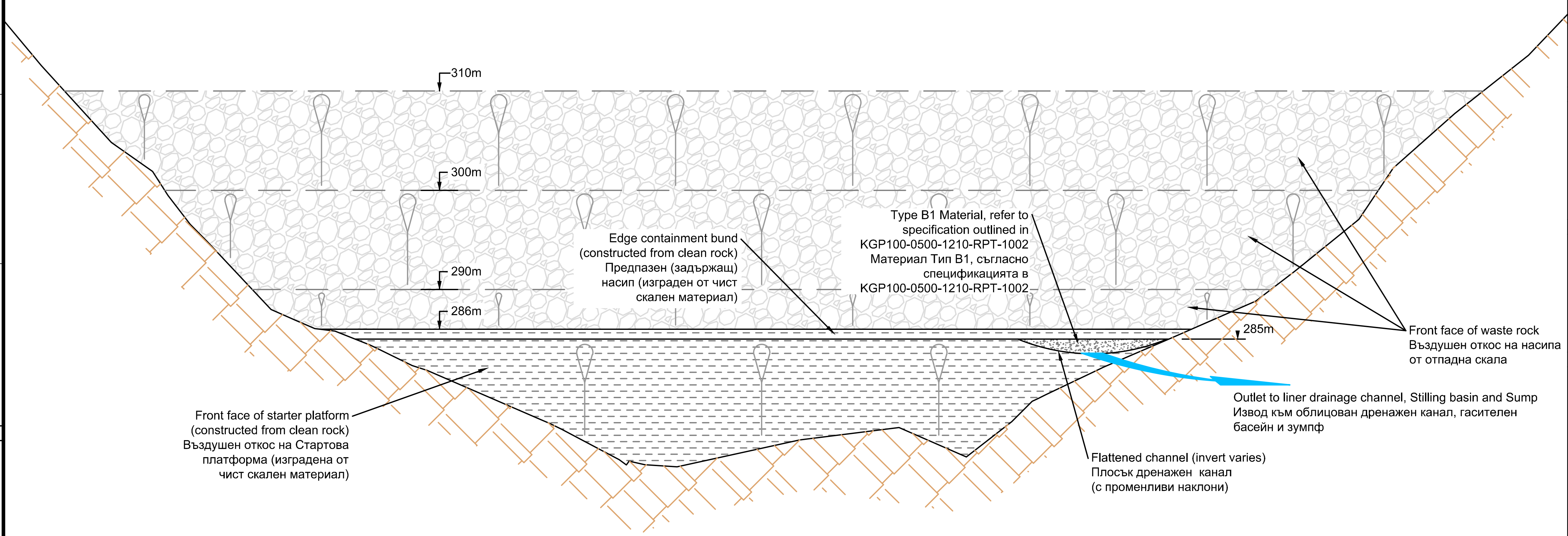

Typical Long Section D-D Along Starter Edge Containment Bund
Типов Напречен разрез D-D по дължина на Предпазен (задържащ) насип на Стартова платформа
Refer to Drg No KGP100-0500-1210-GAD-1003
Съгласно черт. No KGP100-0500-1210-GAD-1003
Approx Scale 1:500
Приблизителен Мащаб 1:500

KRUMOVGRAD MUNICIPALITY	ОБЩИНА КРУМОВГРАД
THE ASSIGNOR	ВЪЗЛОЖИТЕЛ
BULGARIAN DESIGNER	БЪЛГАРСКИ ПРОЕКТАНТ
ПРОЕКТИРАНЕ И АНАЛИЗИ ЕООД СОФИЯ	
THE DESIGN SUPERVISOR	КОНСУЛТАНТ ЗА ОЦЕНЯВАНЕ НА ПРОЕКТА
LIRA CONSULT CONSTRUCTION CONTROL	
INTERNAL REVIEW	ВЪТРЕШЕН ПРЕГЛЕД
CONTRACTOR	ИЗПЪЛНИТЕЛ

ПРОЕКТ:
ДОБИВ И ПРЕРАБОТКА НА ЗЛАТОСЪДЪРЖАЩИ РУДИ ОТ УЧАСТЪК „АДА ТЕПЕ“ НА НАХОДИЩЕ “ХАН КРУМ”, ГР. КРУМОВГРАД ОБОГАТИТЕЛНА ФАБРИКА

Чертеж:
Стартова платформа
Типови детайли

GOLDER DRAWING No.

No.	BY	DATE	REVISION	CHECKED	APPROV.
D	AD	22/01/14	Issued for Permitting	MD	PC
C	AD	10/12/13	Issued for Translation	MD	PC
B	ECS	26/11/13	Issued for DPMK Review / Proektirane Review	MD	PC
A	ECS	23/07/13	Issued for internal review	MD	PC

DRAWING No. | REFERENCE DRAWINGS

CLIENT:

	BY	DATE
PROJECT APPR.	-	-
DESIGN APPR.	-	-
DESIGNED	-	-
CHECKED	-	-
DRAWN	L SKINNER	24/07/13

SCALE МАЩАБ 1:500

PROJECT No. KGP100 | DRG SIZE A3

CLIENT КЛИЕНТ DUNDEE PRECIOUS METALS

TITLE
KRUMOVGRAD GOLD PROJECT
STARTER PLATFORM
TYPICAL DETAILS

DRAWING No. ЧЕРТЕЖ № KGP100-0500-1210-GAD-1006

REV No. D

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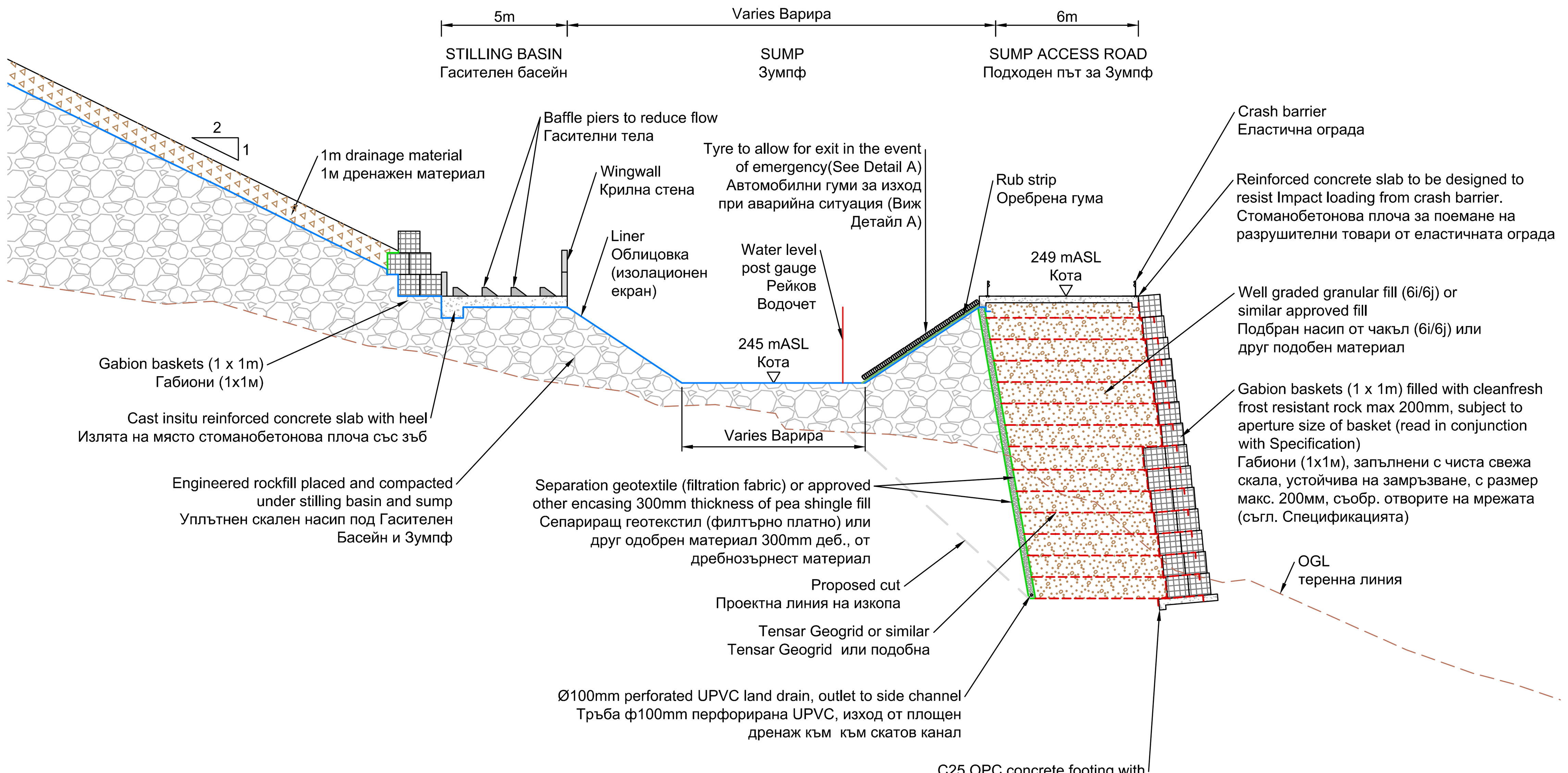

SECTION E-E THROUGH DRAINAGE CHANNEL, STILLING BASIN AND SUMP FOR LINER DRAINAGE
РАЗРЕЗ Е-Е ПРЕЗ ДРЕНАЖЕН КАНАЛ, ГАСИТЕЛЕН БАСЕЙН И ЗУМПФ - ДРЕНАЖ НАД ИЗОЛАЦИОНЕН ЕКРАН
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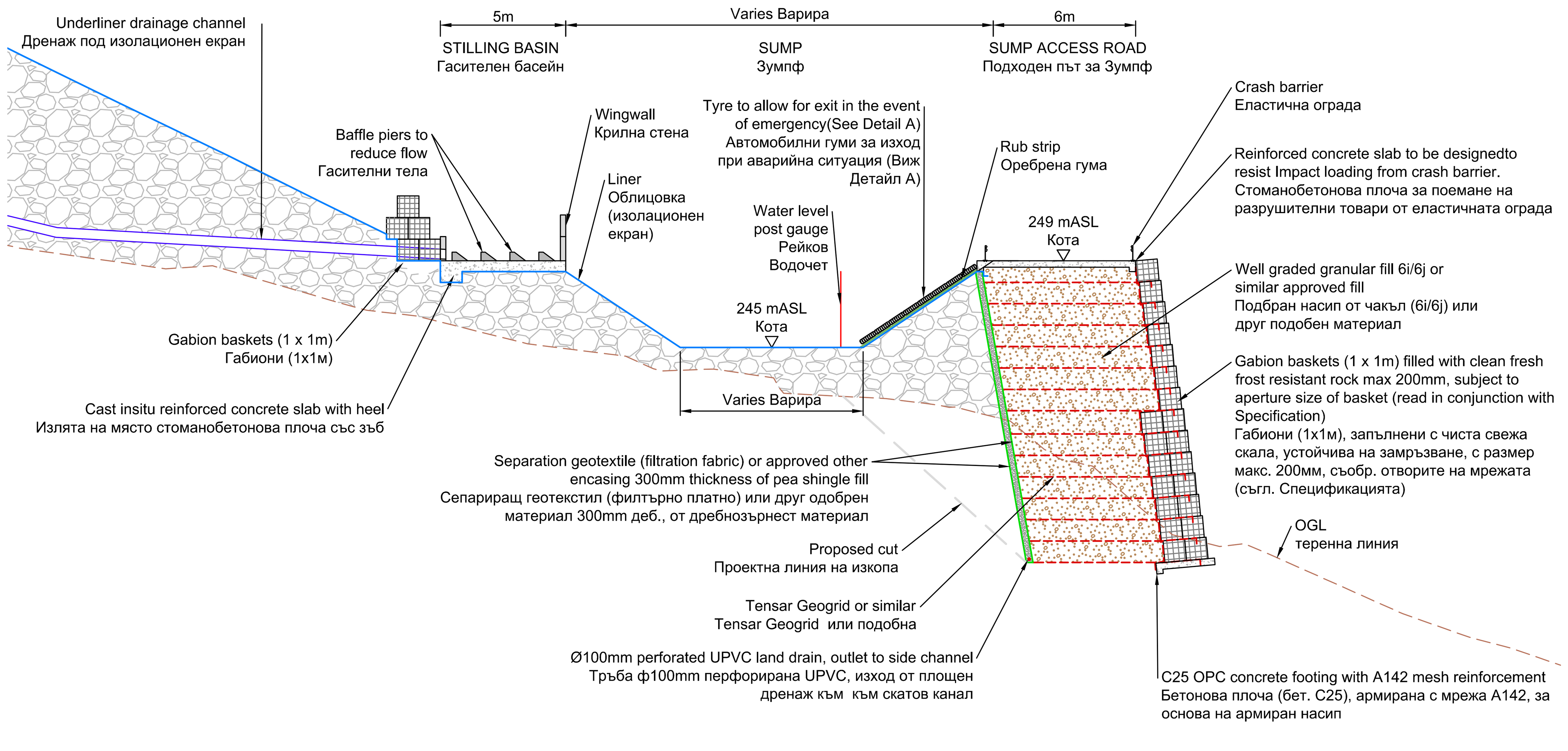

SECTION F-FSHOWING FRONT FACE OF FILL SLOPE, STILLINGBASIN AND SUMP FOR UNDERLINER DRAINAGE
РАЗРЕЗ F-F ИЗХОД НА ДЪНЕН ДРЕНАЖ В ПЕТАТА НА ВЪЗДУШНИЯ ОТКОС КЪМ ГАСИТЕЛЕН БАСЕЙН И ЗУМПФ
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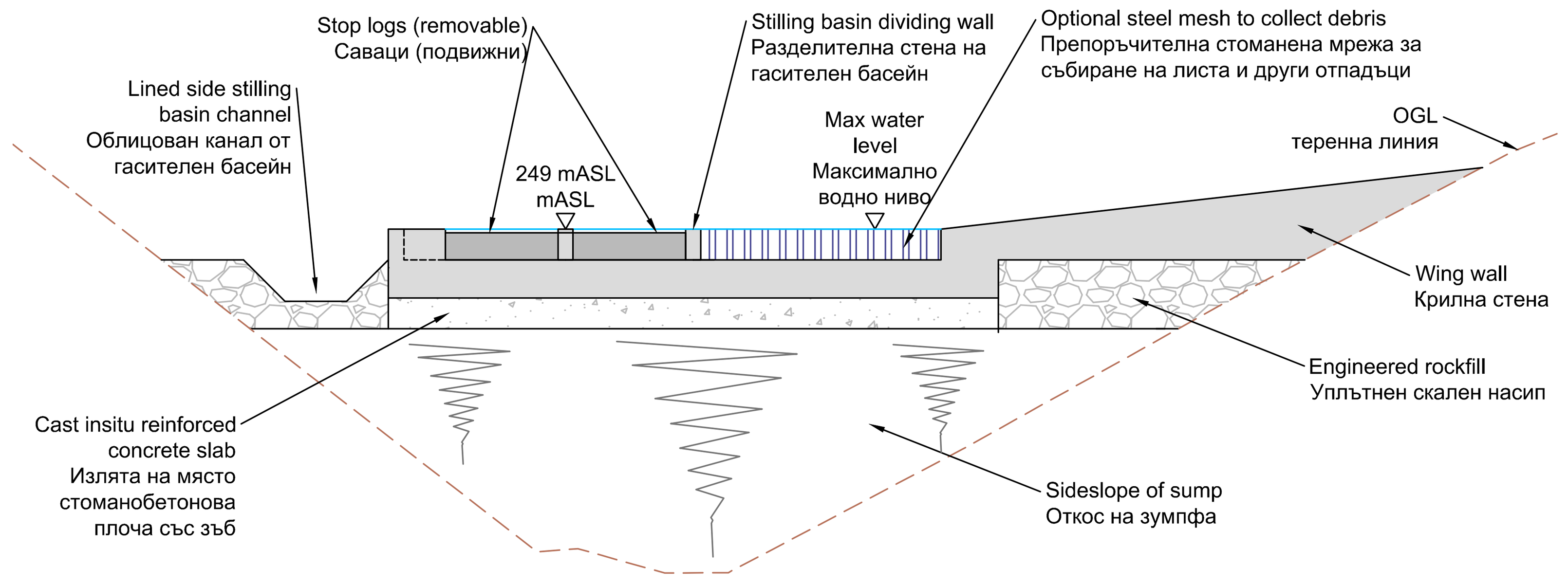

FRONT ELEVATION OF STILLING BASIN
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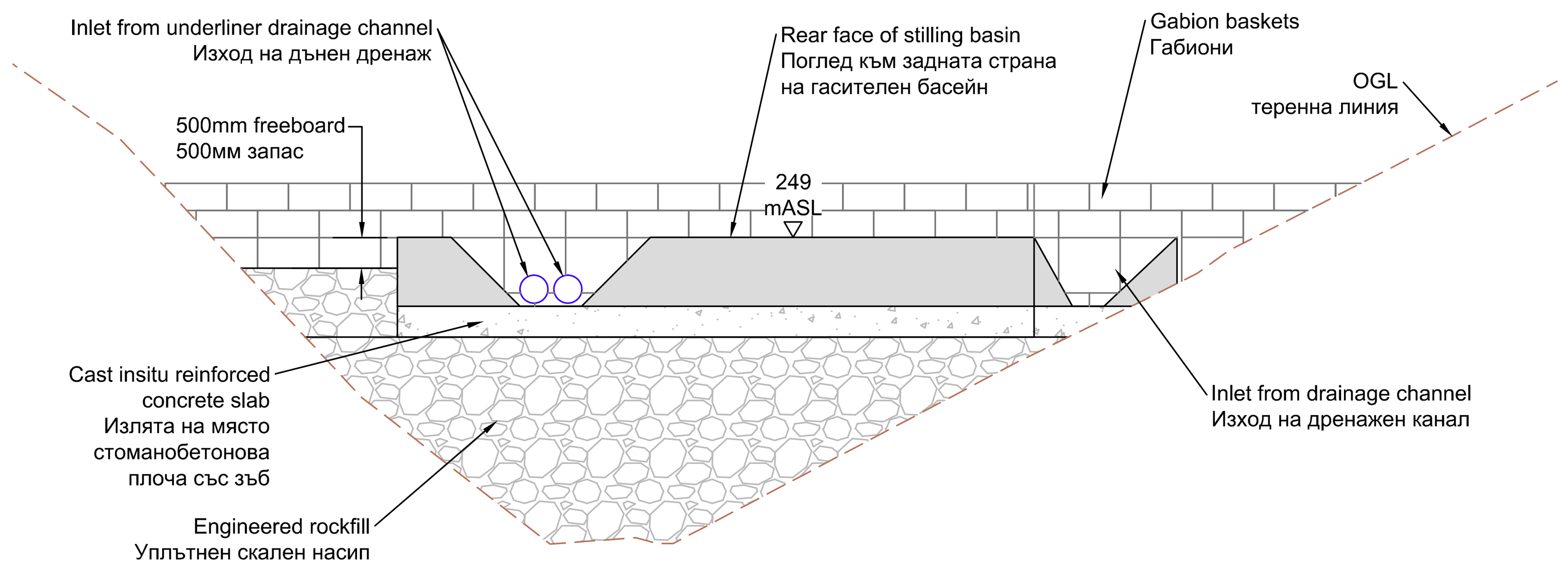
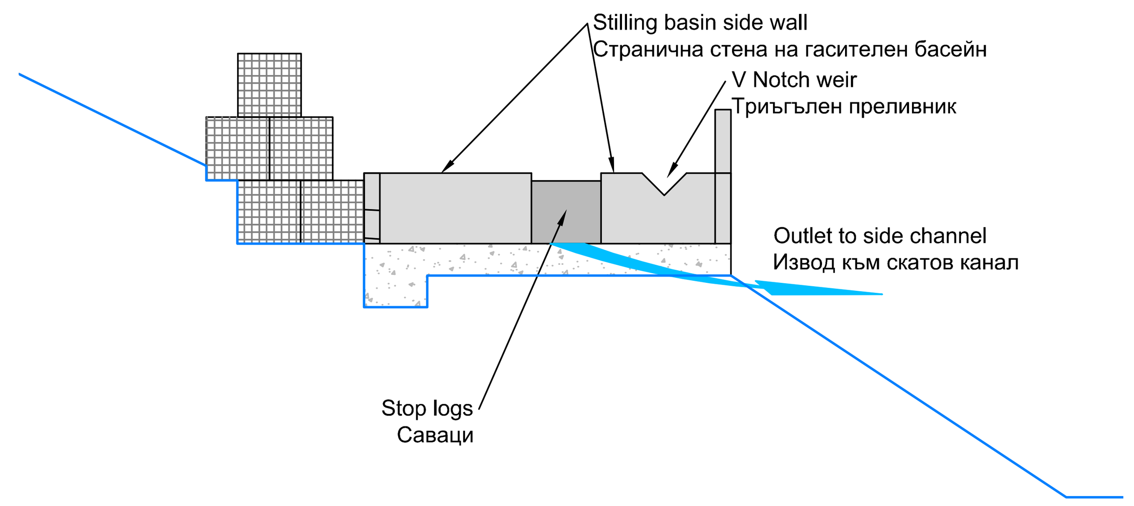
SCALE 1:100



CONCEPTUAL ELEVATION OF STILLING BASIN WALL AT BASE OF FRONT FACE
КОНЦЕПТУАЛНО РЕШЕНИЕ НА СТЕНАТА НА ГАСИТЕЛЕН БАСЕЙН В ПЕТАТА НА ОТКОСА
SCALE 1:100 МАЩАБ 1:100



STILLING BASIN SIDE ELEVATION
ГАСИТЕЛЕН БАСЕЙН - ВЕРТИКАЛЕН РАЗРЕЗ ПРЕЗ СТРАНИЧНА СТЕНА
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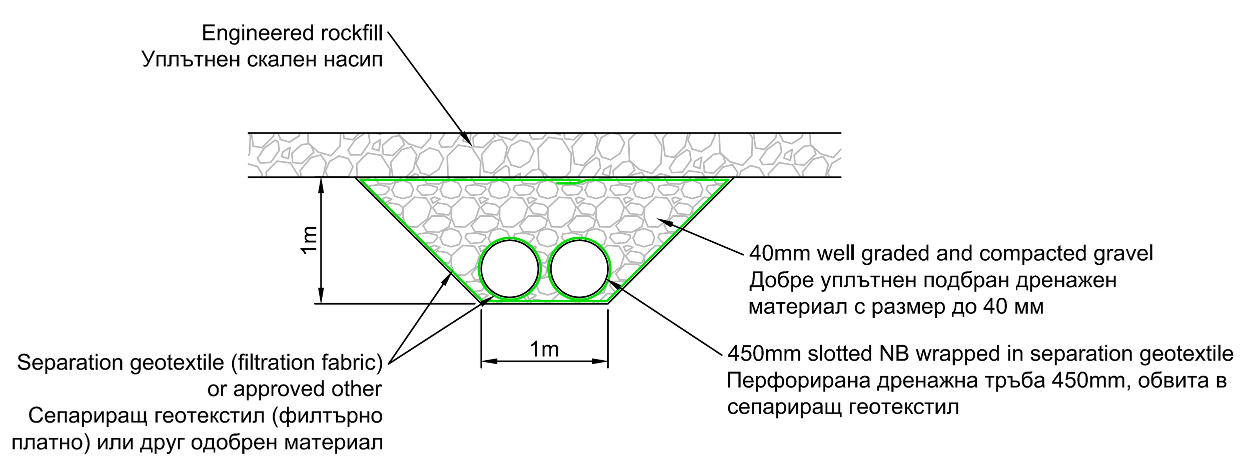
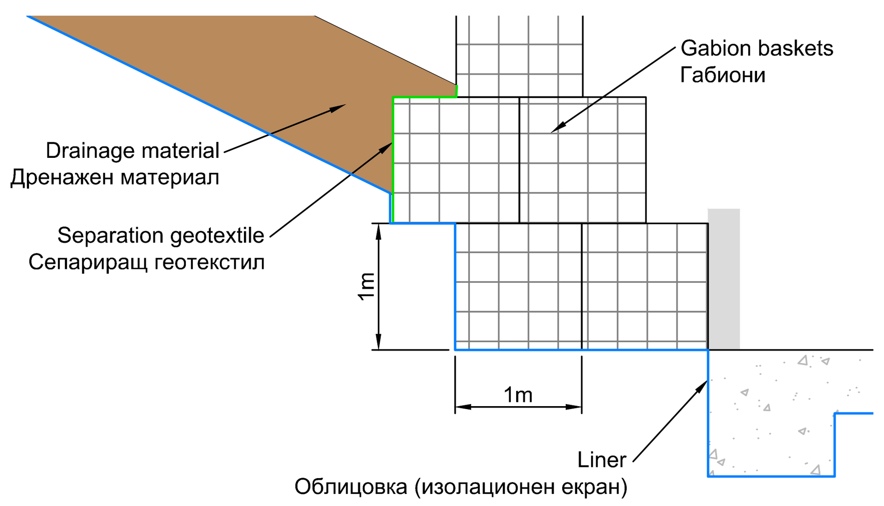
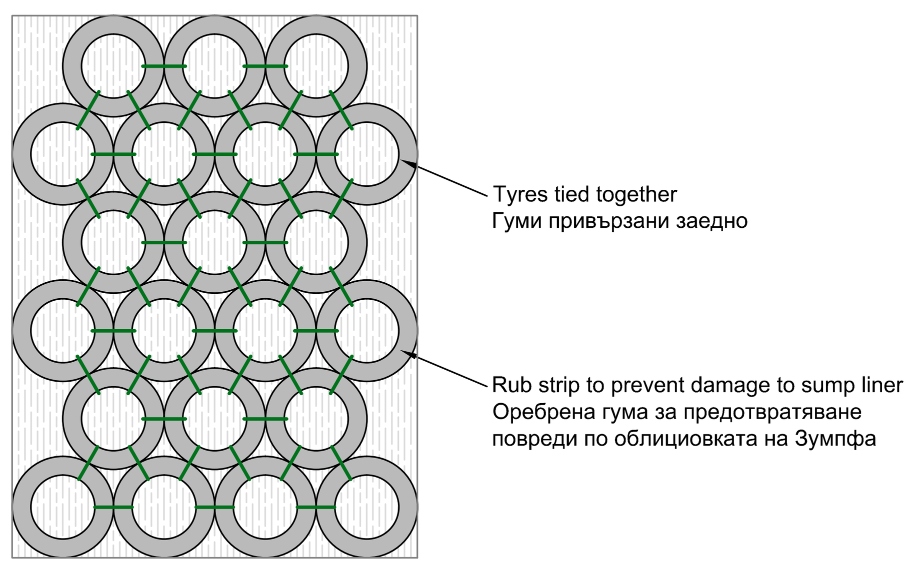


UNDERLINER DRAINAGE DETAIL
ДЕТАЙЛ НА ДЪНЕН ДРЕНАЖ
SCALE 1:50 МАЩАБ 1:50



GABION BASKET DETAILS
ДЕТАЙЛ НА ГАБИОНИ
SCALE 1:50 МАЩАБ 1:50



DETAIL A - TYRE LADDER
ДЕТАЙЛ A - СТЪЛБА ОТ АВТОМОБИЛНИ ГУМИ
SCALE 1:50 МАЩАБ 1:200

KRUMOVGRAD MUNICIPALITY	ОБЩИНА КРУМОВГРАД
THE ASSIGNOR	ВЪЗЛОЖИТЕЛ
BULGARIAN DESIGNER	БЪЛГАРСКИ ПРОЕКТАНТ
THE DESIGN SUPERVISOR	КОНСУЛТАНТ ЗА ОЦЕНЯВАНЕ НА ПРОЕКТА
INTERNAL REVIEW	ВЪТРЕШЕН ПРЕГЛЕД
CONTRACTOR	ИЗПЪЛНИТЕЛ

ПРОЕКТ:
ДОБИВ И ПРЕРАБОТКА НА ЗЛАТОСЪДЪРЖАЩИ РУДИ ОТ УЧАСТЪК „АДА ТЕПЕ“ НА НАХОДИЩЕ “ХАН КРУМ”, ГР. КРУМОВГРАД ОБОГАТИТЕЛНА ФАБРИКА

Чертеж:
Северен Зумпф Типови Детайли

GOLDER DRAWING No. 12514950442

No.	BY	DATE	REVISION	CHECKED	APPROV.
D	AD	22/01/14	ISSUED FOR PERMITTING	PC	MD
C	AD	09/12/13	ISSUED FOR TRANSLATION	PC	MD
B	ECS	06/09/13	ISSUED FOR DPMK REVIEW/PROEKTIRANE REVIEW	MD	PC
A	ECS	06/09/13	ISSUED FOR INTERNAL REVIEW	MD	PC

	BY	DATE
PROJECT APPR.	-	-
DESIGN APPR.	-	-
DESIGNED	-	-
CHECKED	-	-
DRAWN	E SKINNER	19/04/13

DRAWING No. | REFERENCE DRAWINGS

CLIENT:

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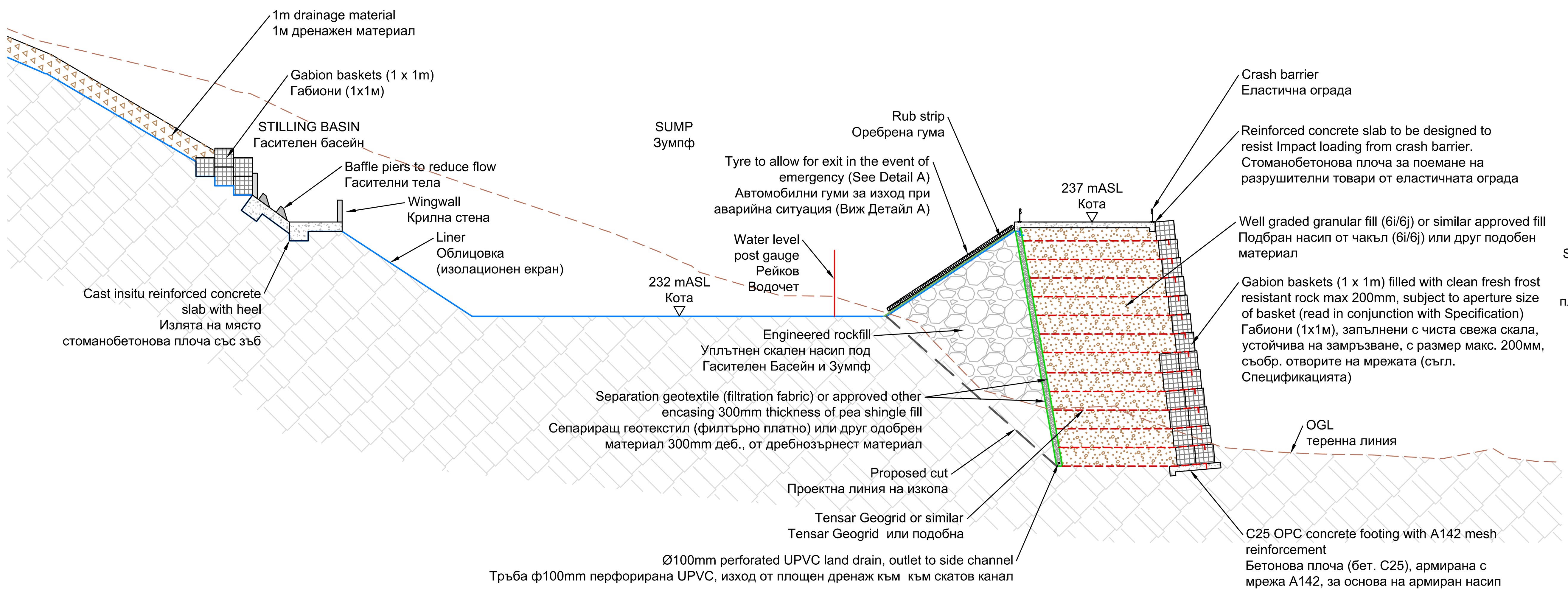
PROJECT No. KGP100
DRG SIZE A3
CLIENT КЛИЕНТ: DUNDEE PRECIOUS METALS
TITLE: KRUMOVGRAD GOLD PROJECT
NORTH SUMP TYPICAL DETAILS
DRAWING No. ЧЕРТЕЖ №: KGP100-0500-1210-GAD-1007
REV No. D
ISSUE#: 12

1970 State Coordinate System and Baltic System
Координатна система 1970 и Височинна система Балтийска



SECTION E-E THROUGH DRAINAGE CHANNEL, STILLING BASIN AND SUMP FOR LINER DRAINAGE
РАЗРЕЗ Е-Е ПРЕЗ ДРЕНАЖЕН КАНАЛ, ГАСИТЕЛЕН БАСЕЙН И ЗУМПФ - ДРЕНАЖ НАД ИЗОЛАЦИОНЕН ЕКРАН
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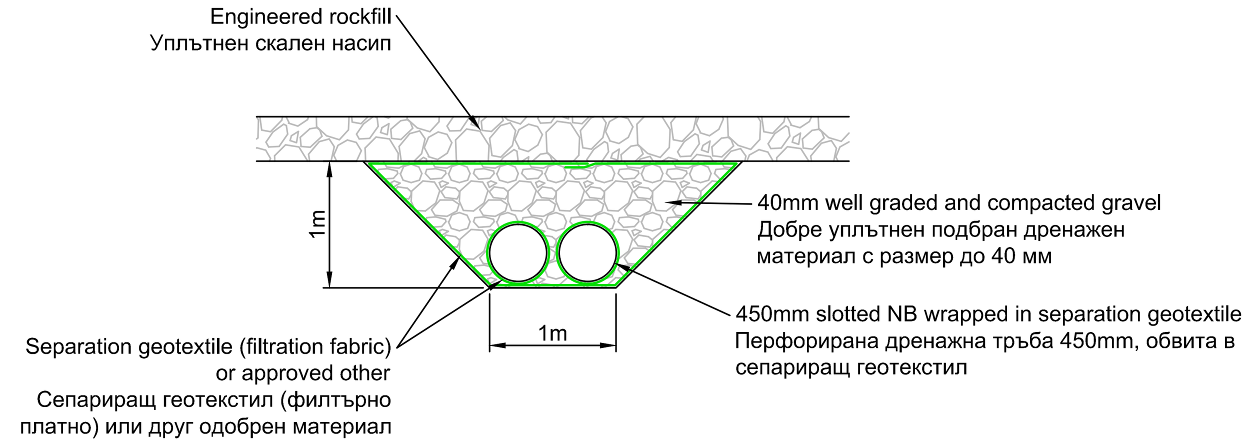

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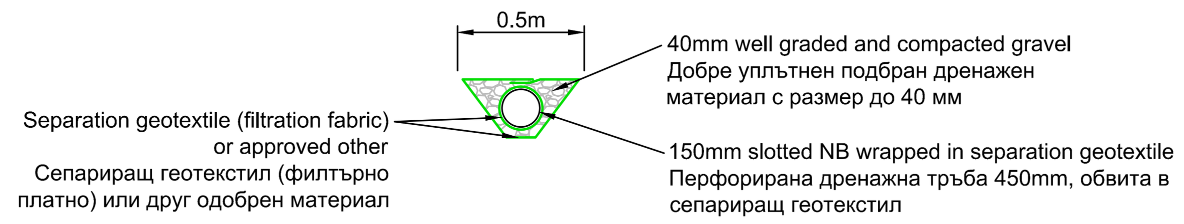

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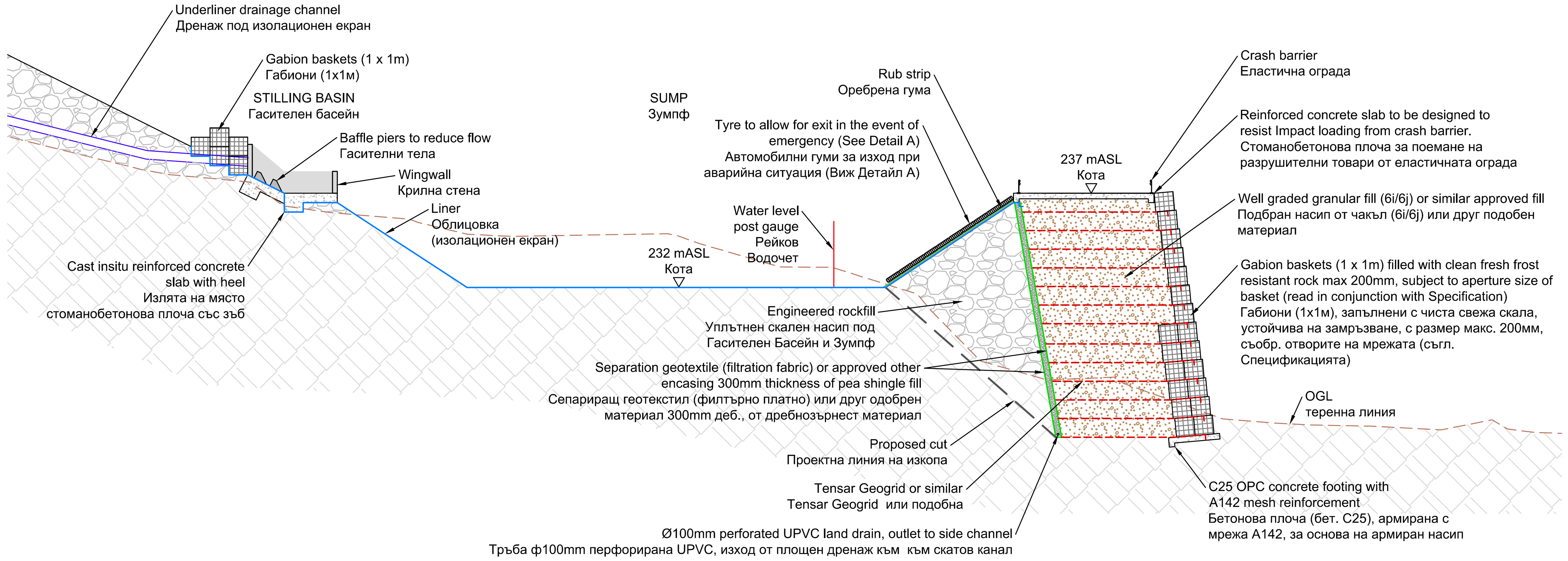

SECTION F-F SHOWING FRONT FACE OF FILL SLOPE, STILLING BASIN AND SUMP FOR UNDERLINER DRAINAGE
РАЗРЕЗ Е-Е ИЗХОД НА ДЪНЕН ДРЕНАЖ В ПЕТАТА НА ВЪЗДУШНИЯ ОТКОС КЪМ ГАСИТЕЛЕН БАСЕЙН И ЗУМПФ
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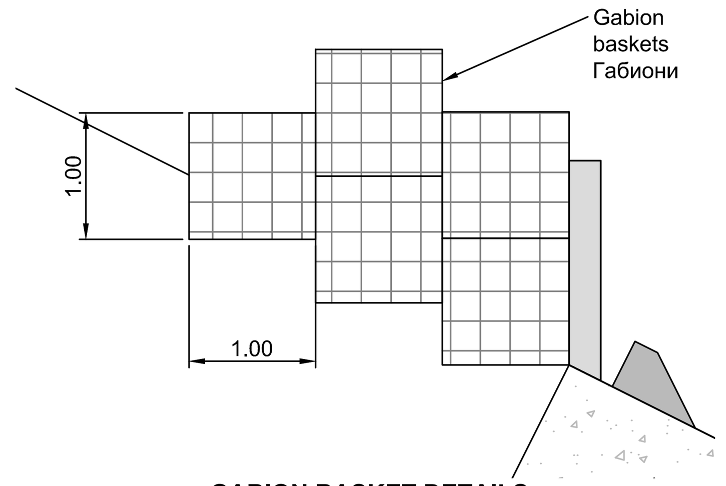

GABION BASKET DETAILS
ДЕТАЙЛ НА ГАБИОНИ
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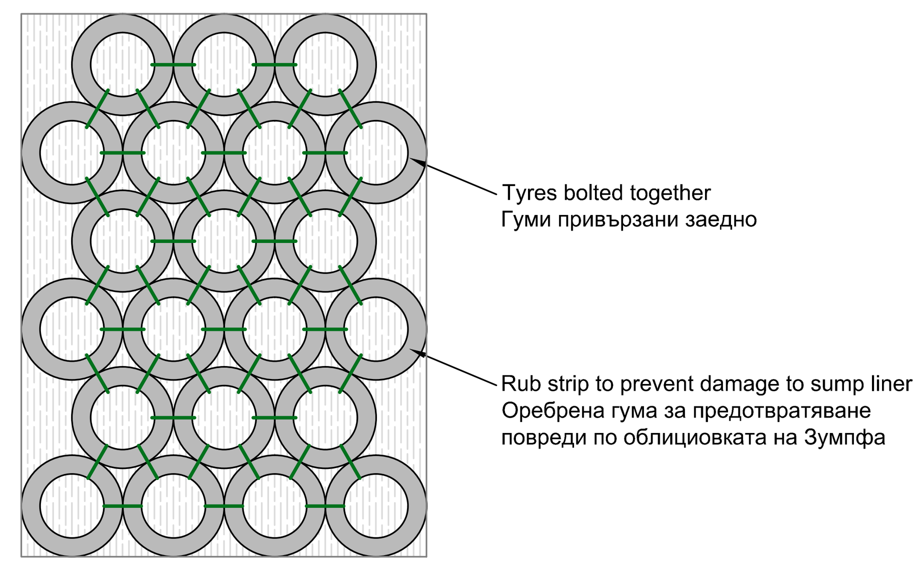

DETAIL A - TYRE LADDER
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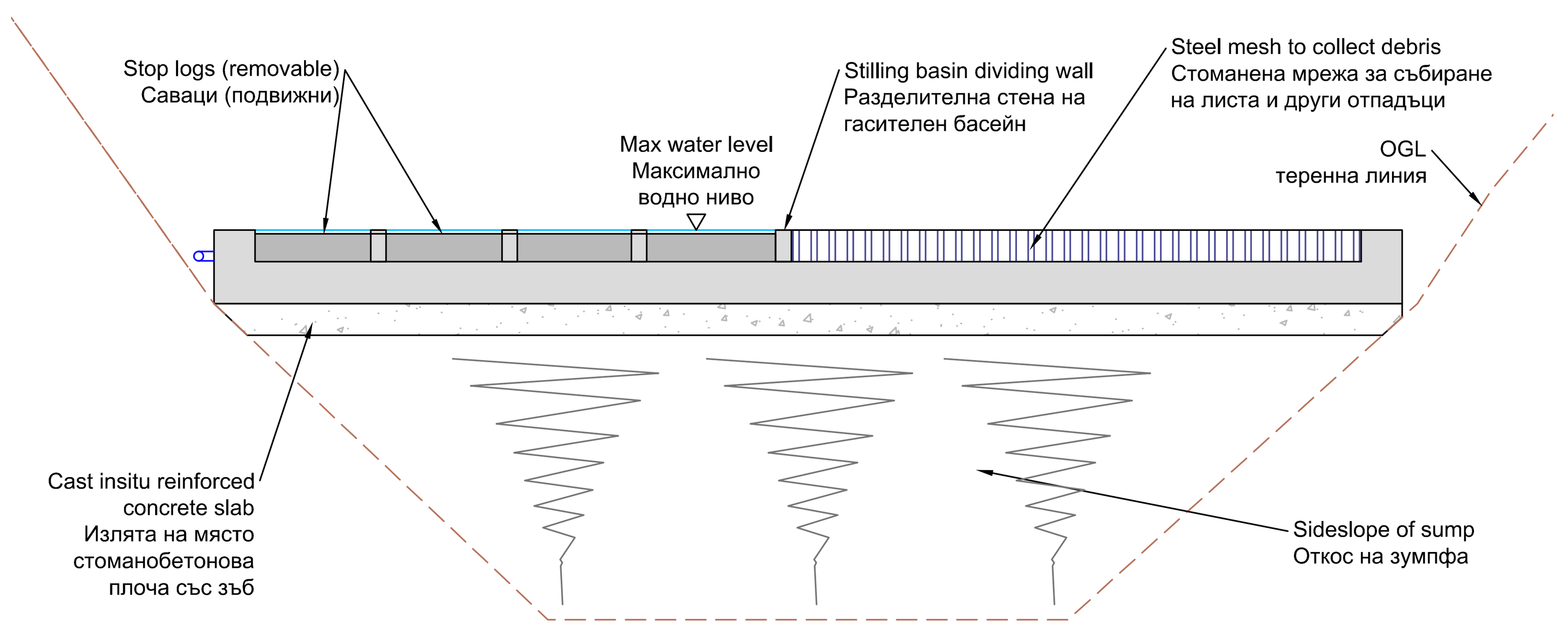

FRONT ELEVATION OF STILLING BASIN
ГАСИТЕЛЕН БАСЕЙН - ПОГЛЕД ОТПРЕД
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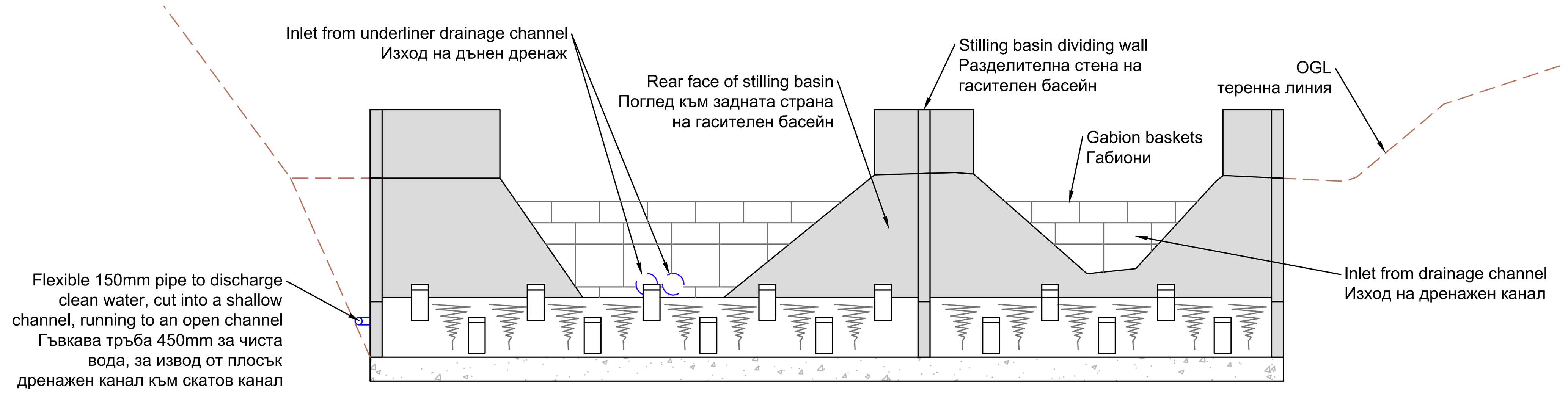

CONCEPTUAL ELEVATION OF STILLING BASIN WALL AT BASE OF FRONT FACE
КОНЦЕПТУАЛНО РЕШЕНИЕ НА СТЕНАТА НА ГАСИТЕЛЕН БАСЕЙН В ПЕТАТА НА ОТКОСА
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KRUMOVGRAD MUNICIPALITY	ОБЩИНА КРУМОВГРАД
THE ASSIGNOR	ВЪЗЛОЖИТЕЛ
BULGARIAN DESIGNER	БЪЛГАРСКИ ПРОЕКТАНТ
THE DESIGN SUPERVISOR	КОНСУЛТАНТ ЗА ОЦЕНЯВАНЕ НА ПРОЕКТА
INTERNAL REVIEW	ВЪТРЕШЕН ПРЕГЛЕД
CONTRACTOR	ИЗПЪЛНИТЕЛ

ПРОЕКТ:
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Чертеж:
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PROJECT APPR.	-	-
DESIGN APPR.	-	-
DESIGNED	-	-
CHECKED	-	-
DRAWN	E SKINNER	19/04/13

SCALE МАЩАБ As Shown
PROJECT No. KGP100 | DRG SIZE A3
CLIENT КЛИЕНТ DUNDEE PRECIOUS METALS
TITLE KRUMOVGRAD GOLD PROJECT
SOUTH SUMP TYPICAL DETAILS
DRAWING No. ЧЕРТЕЖ № KGP100-0500-1210-GAD-1008
REV No. D
ISSUE#: 12

DRAWING No. | REFERENCE DRAWINGS

APPENDIX B

EUROTEST CONTROL AD Report August 2011

LABORATORY TESTWORK DIVISION OF
EUROTEST CONTROL EAD

1797 Sofia, 16 G. M. Dimitrov Blvd., phone: (02) 9651-600; phone/fax (02) 8720 596;
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ISO 9001/2008 certified, No. SOF0207186 LRQA

REPORT

UNDER CONTRACT NO.

UNDER CONTRACT FOR MINE WASTE CHARACTERISATION – STATIC AND KINETIC TESTWORK

ADA TEPE, KRUMOVGRAD

COMPANY: BMM EAD

CONTRACTOR: EUROTEST CONTROL AD

Director of Eurotest Control AD

/S. Kozhuharova/

Sofia, August 2011

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Testwork protocols

1. Introduction

Balkan Mineral and Mining EAD ("BMM") has formulated a Mine Waste Management Plan in compliance with the *Underground Resources Act ("URA")*, prom., SG 23/12.03.1999, last amendment SG 70/8.08.2008, and the *Regulation on the Specific Requirements to Mine Waste Management*, prom., SG 10/06.02.2009 г. This Plan is also compliant with the provisions of art. 22 par. 3 of the URA and an integral part of the Krumovgrad Gold Project. The Mine Waste Management Plan has been developed to achieve the following *objectives*:

- Reduce the harmful impact of mine wastes by implementing technological solutions for primary processing of underground resources which will enable fixation of their harmful and hazardous components;
- Ensure the safe storage of mining wastes via:
    - maintaining the long-term geotechnical stability of the facility;
    - monitoring, controlling and managing the mine waste facility during project operation and after project closure;
    - preventing or minimising long-term negative impacts on human health and the environment.

According to the requirements under *Specific Requirements to Mine Waste Management*, the testwork includes static and kinetic tests. Kinetic testwork procedures, however, require longer test duration (20 weeks to a year) and tests are conducted using special equipment arrangement. **The idea of the kinetic testwork is to mimic the actual geochemical conditions and processes in the wastes in a laboratory environment and draw conclusions from the test results about the impact on the environment and eventually propose adequate measures to mitigate this impact.**

Kinetic tests are performed as laboratory tests with sample size ranging from a few kg to several hundreds of kg. Most tests, however, are conducted using small amounts of crushed material. The three most commonly used methods of determining kinetic ARD characteristics are:

- Humidity cell
- Column testwork
- Lysimeters
- Field investigations

Only the first procedure is standardized, while the other ones are site-specific and therefore non-standardized. The testwork performed by Eurotest Control was based on standardized procedures the main of which was Designation: D5744-07 - Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell (ATSM, 2007).

Wastes analysis has been performed by the Laboratory Testwork Division with Eurotest Control EAD, accredited by the Bulgarian Accreditation Service - Executive Agency under Certificate No.3-LIK as per BNS EN ISO/IEC 17025 and certified under ISO 9001/2008, No. SOF 0207186 LRQA on the grounds of contract for MINE WASTE CHARACTERISATION – STATIC AND KINETIC TESTWORK, Ada Tepe, Krumovgrad, and the report thereof was elaborated by:

- Sashka Kozhuharova
- Anita Raycheva
- Yulia Akrabova
- Hristo Stanchev
- Salza Hekimova
- PhD., M.Eng., Ass. Prof. Ekaterina Todorova - Consultant
- M.Eng. Etefan Stamenov - Consultant

2. Testwork Material

BMM provided 4 samples to be characterised by static and kinetic testing:

1. **ATMET 068** - material from the Wall Zone, which comprises intensely silicified varigrained Palaeogene breccia, waste rock.
2. **ATMET 069** - fresh rock from the Upper Zone, where the Palaeogene conglomerate is weakly silicified and argillised with non-homogenious quartz veins, waste rock.
3. **ATMET 070 -** material from the oxidised Upper Zone, where most of the fragments are affected by argillisation and silicification is manifested by non-homogenious quartz veins, waste rock.
4. **FLOTATION TAILINGS** – discarded material (tailings) from flotation of Ada Tepe ore.

Acid Base Accounting testwork procedures can be divided into static and kinetic. Static procedures are quick but they provide only indicative data based on the total sulphide sulphur content. Kinetic procedures require recovery and assaying of many samples over an extended period.

This Report gives the static test results for the samples tested, and it also gives the results of the 20 weeks long kinetic test, the purpose of which is to further specify the static test results.

The kinetic test of the 4 samples commenced on February 11th 2011 and the first seven days until February 17th was the so-called "zero" week when various measurements were taken to adjust the kinetic testwork procedure. The first week (week 1) of the procedure started on February 18th 2011.

3. Static Testing

3.1. Testing Data

3.1.1. Sulphur Content

The leach testing was conducted on the basis of Order RD-988/29.12.2006, which specified the procedures for base characterisation of wastes and testing to confirm compliance, Part I.2. Waste Leach Testing, according to Appendix 2 to the Order.

Table 3.1.1 - Sulphur Content in Ada Tepe Samples, prior and following the kinetic tests

No of the	Sample No.	S_{total}	$S_{sulphide}$	Acid	Neutraliz	Net	Neutralizing

protocol and date		**%**	**%**	**Generating Potential (AP) H^+ mol/kg**	**ation Potential (NP) H^+ mol/kg**	**Neutralization Potential (NNP) H^+ mol/kg**	**Potential Ratio NPR= NP/AP**
ATMET 068							
6.1-086/ 18.03.11	**before**	0.22	0.11	0.069	5.400	5.331	78.26
6919/03. 08.11	**after**	0.13	<0.10	-	-	-	-
ATMET 069							
6.1-087/ 18.03.11	**before**	0.59	0.31	0.194	3.430	3.236	17.68
6920/03. 08.11	**after**	0.44	0.26				
ATMET 070							
5900/18. 03.11	**before**	0.08	<0.10	-	-	-	-
6921/03.0 8.11	**after**	0.01	<0.10	-	-	-	-
FLOTATION TAILINGS							
No. 5901/ 18.03.11	**before**	0.04	<0.10	-	-	-	-
6922/03. 08.11	**after**	<0.10	<0.10	-	-	-	-

According to the Regulation on the Specific Requirements to Mine Waste Management (prom.SG 10/6.02.2009), art. 12 (3) items 2 and 3, mine waste can be classified as "inert" when:

- It has a maximum content of sulphide sulphur of 0.1%, which is the case with the ATMET 070 and flotation tailings samples;
- It has a maximum content of sulphide sulphur of 1 % and the neutralising potential ratio, defined as the ratio between the neutralising potential and the acid potential, which is the neutralising potential ratio, and determined on the basis of a static test prEN 15875 is greater than 3. These are ATMET 068 AND ATMET 069 samples;

In addition to the above requirements, „inert" waste should comply with the requirements under items 1, 4, 5, 6 and 7 of art.12 (3) of the *Regulation on the Specific Requirements to Mine Waste Management (2009)*, prom SG 10/06.02.2009, and this is discussed further in this Report.

Ada Tepe is a epithermal low-sulfide deposit, which is also confirmed by the static tests performed. As seen from the data shown in Table 3.1.1 on sulfide sulfur content, after the 20th the concentration decreased, where for ATEMET 068 it becomes <0,1%. Only for ATEMET 069 in the 20th week the concentration of 0,1% has not been reached, however, a trend towards decreasing concentration is noticable.

3.1.2. Leaching of Metals, Acidic Anions and Salts

Part 2 of Appendix 1 to Regulation 8/204 on Waste Disposal sets out the criteria for acceptance of granular wastes at landfills, which include limit values for leaching of components, for organic substances and for certain additional parameters.

According to the approved method under the BNS EN 12457 standard (parts 1 to 4), the waste is leached under "mild" extraction conditions for 24 hours and at its own pH value. The testwork was conducted at liquid/solid ratios (L/S) of 10 L/kg and 2 L/kg. The testing objective was to determine the mobility of the different metals and cations.

Table 3.1.1. shows the standard under Regulation 8/2004 for acceptance at non-hazardous waste facilities/landfills, in accordance with Appendix 1, item 2.2.1.1 of the same Regulation (Table 4 in it). The available amount of flotation tailings material was insufficient to conduct tests at L/S of 2 L/kg. The low liquid/solid ratios simulate the normal conditions in waste facilities while higher ratios simulate the processes that could occur in stored mine waste in case of seepage and circulation of storm water or another liquid.

Table 3.1.2 – Eluate Concentrations of Some Elements against the Relevant Standards under Regulation 8/2004

#	Parameter	Unit	Standard under **Table** 4 of Reg. 8/2004 by MEW	Test Results: ATMET 068	Test Results: ATMET 069	Test Results: ATMET 070	Test Results: Flotation tailings
1	**Eluate (10 L/kg at own pH)**						
-	pH	pH units	-	7.75	7.66	6.95	7.23
1.1	Chemical composition						
1.1.1	Chromium (Cr)	mg/kg	10	<0.010	<0.010	0.038	0.051
1.1.2	Iron (Fe)	mg/kg	-	0.409	0.103	16.36	2.957
1.1.3	Nickel (Ni)	mg/kg	10	<0.020	0.020	0.142	<0.020
1.1.4	Copper (Cu)	mg/kg	50	0.050	0.053	0.075	0.075
1.1.5	Zinc (Zn)	mg/kg	50	0.092	0.063	0.211	0.091
1.1.6	Arsenic (As)	mg/kg	2	<0.10	<0.10	0.40	<0.10
1.1.7	Molybdenum (Mo)	mg/kg	10	0.144	<0.050	<0.050	0.143
1.1.8	Cadmium (Cd)	mg/kg	1	<0.010	<0.010	<0.010	<0.010
1.1.9	Antimony (Sb)	mg/kg	0.7	<0.050	<0.050	<0.050	0.053
1.1.10	Barium (Ba)	mg/kg	100	0.026	<0.010	0.406	0.375
1.1.11	Lead (Pb)	mg/kg	10	<0.10	<0.10	<0.10	<0.10
1.1.12	Mercury (Hg)	mg/kg	0.2	<0.10	<0.10	<0.10	<0.10
1.1.13	Fluorides /F^-/	mg/kg	150	2.01	2.55	1.30	3.83
1.1.14	Sulphates (SO_4^{2-})	mg/kg	20000	150.5	266.8	57.1	73.9
1.1.15	Chlorides /Cl^-/	mg/kg	15000	9.0	10.5	10.3	9.4
1.1.16	Phosphates (PO_4^{3-})	mg/kg	-	<1.00	<1.00	<1.00	<1.00
1.1.17	Selenium (Se)	mg/kg	0.5	<0.10	<0.10	<0.10	[illegible]
1.2	Total dissolved solids (TDS)	mg/kg	60000	508	788	290	472
1.3	Dissolved organic substances (DOS)	mg/kg	800	212	258	235	245
2	Eluate (2 L/kg at own pH)						
-	pH	pH units	-	8.23	7.66	6.65	-
2.1	Chemical composition						
2.1.1	Chromium (Cr)	mg/kg	4	<0.0020	<0.0020	0.0269	-
2.1.2	Iron (Fe)	mg/kg	-	0.1061	0.0425	6.64	-
2.1.3	Nickel (Ni)	mg/kg	5	0.0094	0.0239	0.0385	-
2.1.4	Copper (Cu)	mg/kg	25	0.0091	0.0093	0.0218	-
2.1.5	Zinc (Zn)	mg/kg	25	0.0105	0.0092	0.0542	-
2.1.6	Arsenic (As)	mg/kg	0.4	<0.020	<0.020	0.109	-
2.1.7	Molybdenum (Mo)	mg/kg	5	0.221	0.156	<0.010	-
2.1.8	Cadmium (Cd)	mg/kg	0.6	<0.0020	<0.0020	<0.0020	-

#	Parameter	Unit	Standard under **Table** 4 of Reg. 8/2004 by MEW	Test Results: ATMET 068	Test Results: ATMET 069	Test Results: ATMET 070	Test Results: Flotation tailings
2.1.9	Antimony (Sb)	mg/kg	0.2	0.020	0.012	0.024	-
2.1.10	Barium (Ba)	mg/kg	30	0.0096	0.0148	0.0784	-
2.1.11	Lead (Pb)	mg/kg	5	<0.020	<0.020	<0.020	-
2.1.12	Mercury (Hg)	mg/kg	0.05	<0.05	<0.05	<0.05	-
2.1.13	Fluorides /F^-/	mg/kg	60	1.51	1.32	0.66	-
2.1.14	Sulphates (SO_4^{2-})	mg/kg	10000	130.0	245.0	49.9	-
2.1.15	Chlorides /Cl^-/	mg/kg	10000	6.7	8.1	6.3	-
1.1.16	Phosphates (PO_4^{3-})	mg/kg	-	<0.20	<0.20	<0.20	-
1.1.17	Selenium (Se)	mg/kg	0.3	<0.1	<0.02	<0.02	-
2.2	Total dissolved solids (TDS)	mg/kg	40000	318	568	183.0	-
2.3	Dissolved organic substances (DOS)	mg/kg	380	219	534	<50	-

As seen from the data given in Table 3.1.1, all values for leaching comply with the limit values for both solid: liquid, exclusive of the dissolved organic substances (DOS) for sample **ATMET 069** at L/S ration 2 l/kg, which is probably due to the increased content of humic acid solutions, because the sample is from the fresh rock from the Upper Zone.

In such cases, Regulation 8/2004 recommends testing at L/S of 10 L/kg, which was completed and reported on line 1.3 in the table. According to the Regulation (Note 2 under Table 4 in Regulation 8/2004), it is accepted that the waste meets the acceptance criteria for DOS if the leach test result does not exceed 800 mg/kg for non-hazardous wastes, and the result is 258 mg/kg. Therefore, mining waste fully meets the requirements for acceptance of hazardous to waste landfills.

The Mine Waste Management Plan of BMM EAD states that the gold mining and processing operations at Ada Tepe will generate mine rock waste and process (flotation) tailings. **These wastes will be co-disposed within a single footprint known as the Integrated Mine Waste Facility, and the quoted data indicates that the facility is for "non-hazardous" wastes.**

3.1.3. Mine Waste Mineralogical Characterisation

The mineral composition of the tested samples is shown in Table 3.1.3. It is evident that quartz is the dominant mineral in all samples and its content is lower only in sample **ATMET 069** – fresh waste rock from the Upper Zone, where the Palaeogene breccia conglomerate is weakly silicified and argillised with non-homogenious quartz veins. This sample contains high dolomite and calcite concentrations.

Table 8.1.3. Table 3.1.3.1 - Mineral Composition of the Tested Samples

#	Parameter	Unit	**ATMET 68**	**ATMET 69**	**ATMET 70**	**Flotation tailings**
1	Quartz	%	84.00	55.00	70.00	73.00
2	**Dolomite**	**%**	**9.63**	**25.00**	**4.00**	**2.00**
3	**Calcite**	**%**	**4.00**	**13.00**	**-**	**4.00**
4	Microcline	%	1.00	-	19.00	11.00
5	Kaolinite	%	-	5.00	6.00	6.00

6	Ilmenite	%	-	1.00	-	-
7	Albite	%	-	-	-	3.00
	Total	**%**	**98.63%**	**99.00**	**99**	**99**

The above data confirms the mineral composition stated in the Mine Waste Management Plan of BMM EAD, where the principal properties of the minerals are also discussed.

The samples are sandy-clayey and this was used in the process of comparing test results against the standards for safe concentrations of heavy metals and metalloids in soils according to Regulation 3/01.08.2008 on the Limits for Allowable Content of Harmful Substances in Solis (prom. SG 71/12.08.2008) The data indicates that the minerals comprise about 99% while the remaining micro elements are 1%.

Based on the data from Table 3.1.1., and the mineral composition given in Table 3.1.3 it ca be seen that calcium and magnesium minerals have sufficient buffer capacity, which together with the low sulphide sulfur content determines the impossibility for occurrence of acid drainage, i.e. the acid oxidation potential of sulfates does not exceed the buffer capacity of minerals in the waste. However, the reaction of acid generation will reduce the pH only if the rate of acid generation of exceeds the rate at which the buffer materials can neutralize the acidity produced, or if buffer minerals are consumed, which for the duration of the experiment did not happen.

3.1.4. Chemical Characterisation of the Mine Wastes

According to art. 12 (3) item 6 of the Regulation on the Specific Requirements to Mine Waste Management (2009), these wastes can be classified as "inert" if the content of certain substances potentially harmful to the environment or human health, in particular As, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, V and Zn, is sufficiently low to be of insignificant human and ecological risk in compliance with Regulation 3/2004.

Table 3.1.4.1 – Chemical composition and pH of the tested sample before and after the kinetic tests

Parameter	Unit	Test Results: ATMET 068		Test Results: ATMET 069		Test Results: ATMET 070		Test Results: Flotation tailings	
		before	after	before	after	before	after	before	after
pH	pH units	9.17	9.30	8.96	9.25	7.35	6.89	8.64	8.99
Phosphorus (P)	mg/kg	62	71	404	345	382	341	279	167
Vanadium (V)	mg/kg	7	16	67	64	95	86	45	23
Chromium (Cr)	mg/kg	375	62	221	66	324	129	150	70
Iron (Fe)	%	1.30	1.17	3.57	3.08	2.96	2.28	2.31	1.28
Cobalt (Co)	mg/kg	5	5	19	18	21	17	14	8
Nickel (Ni)	mg/kg	51	48	58	56	91	84	50	29
Copper (Cu)	mg/kg	32	177	18	21	34	31	36	37
Zinc (Zn)	mg/kg	18	45	65	61	62	64	45	40

Parameter	Unit	Test Results: ATMET 068		Test Results: ATMET 069		Test Results: ATMET 070		Test Results: Flotation tailings	
		before	after	before	after	before	after	before	after
Arsenic (As)	mg/kg	25	34	158	155	277	251	72	40
Molybdenum (Mo)	mg/kg	5	<3	4	<3	4	<3	3	<3
Cadmium (Cd)	mg/kg	<1,0	<1,0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Antimony (Sb)	mg/kg	14	15	16	17	29	26	18	10
Barium (Ba)	mg/kg	20	253	319	190	459	300	225	196
Lead (Pb)	mg/kg	5	7	12	12	12	12	13	13
Mercury (Hg)	mg/kg	0.11	<0.10	0.10	<0.10	0.36	0.14	<0.10	<0.10
Total organic carbon C (TOC)	%	2.57	2.57	2.32	2.22	0.05	0.06	0.72	0.72

Ultimately, comparing the results for the concentration of elements before and after 20 weeks of leaching, the concentrations of most elements remain the same or decrease slightly, which is explained by their low mobility under the conditions of the experiment.

The one-off elevation in concentration of some elements in the solid phase after the 20th week (primarily for **ATEMET 068** sample) may be due to accumulation of certain secondarily produced substances, despite the efforts to separate most or all of the reaction products during the weekly leaching, as noted in ASTM-Designation: D5744-07 - Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell (ATSM, 2007), to help interpret the results.

Table 3.1.4.2 – Combined concentration of "harmful" (Xn) and pH of the tested sample before and after the kinetic tests

Parameter	Unit	Test Results: ATMET 068		Test Results: ATMET 069		Test Results: ATMET 070		Test Results: Flotation tailings	
		before	after	before	after	before	after	before	after
Vanadium (V)	mg/kg	7	16	67	64	95	86	45	23
Chromium (Cr)	mg/kg	375	62	221	66	324	129	150	70
Cobalt (Co)	mg/kg	5	5	19	18	21	17	14	8
Nickel (Ni)	mg/kg	51	48	58	56	91	84	50	29
Copper (Cu)	mg/kg	32	177	18	21	34	31	36	37
Zinc (Zn)	mg/kg	18	45	65	61	62	64	45	40
Arsenic (As)	mg/kg	25	34	158	155	277	251	72	40
Molybdenum (Mo)	mg/kg	5	<3	4	<3	4	<3	3	<3
Cadmium (Cd)	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lead (Pb)	mg/kg	5	7	12	12	12	12	13	13
Mercury (Hg)	mg/kg	0.11	<0.10	0.10	<0.10	0.36	0.14	<0.10	<0.10

Total	%	0,052	0.040	0.062	0.046	0.092	0.068	0.043	0.026
Limit value according to Appendix 3 to Regulation 3/2004 on Waste	%	25		25		25		25	

The data above shows that the tested samples, both before and after the 20-week leaching, contain harmful substances in concentrations that are much lower than the limit value and therefore comply with the definition of "inert" waste under item 6 of art. 12 (3) of the *Regulation on the Specific Requirements to Mine Waste Management (prom. SG 10/6.02.2009)*.

According to Appendix 3 to art. 6, par. 2, item. 1 of Regulation 3/01.04.2004 on Waste Classification, when the total combined concentration of harmful substances is ≥ 25 % then the waste is classified as "hazardous". Of the remaining elements, the Ba content is 0.0020 - 0.0459% and the Antimony content is between 0.0014% and 0.0029%.

In accordance with Appendix 1 to art. 3 of Regulation 3/01.08.2008 on the Maximum Allowable Concentrations of Harmful Substances in the Soil, *SG 71/12.08.2008)* comparison is made between the standards for safe concentrations of heavy metals and metalloids in soils and the test results for the four Ada Tepe samples. **"Safe concentration"** is that concentration of a harmful substance in the soil, in mg/kg, which if exceeded does not affect the soil functions or threaten the environment and human health, according to the Additional Provisions to the same Regulation.

The samples tested can be described as sandy-clayey based on the data shown in Table 3.1.3.1. They have pH>6 and therefore the reference standards are the safe concentration standards for sandy-clayey soils under Regulation 3/2008 on the Maximum Allowable Concentrations of Harmful Substances in the Soil. SG 71/12.08.2008)

It is evident from Table 3.1.4.3 that none of the samples can be defined as "non-polluted" soil because all of them, compared to the reference soil concentrations, are polluted with As and Cr. Sample **ATMET 070** is also polluted with Ni and Hg, while **ATMET 068** and **ATMET 069** – with Hg.

Table 3.1.4.3 - Concentrations of Elements in the samples before the kinetic test that are governed by Regulation 3/2008 on the Maximum Allowable Concentrations of Harmful Substances in the Soil (prom. SG 71/12.08.2008)

Soil	**Metals and Metalloids, mg/kg Dry Soil**									
	As	***Cd***	***Cu***	***Cr***	***Ni***	***Pb***	***Zn***	***Hg***	***Co***	***pH***
Safe Concentration for Sandy-Clayey Soils	15	0.6	60	110	65	45	160	0,07	35	>6
ATMET 068	25	<0,1	32	375	51	5	18	0,11	5	9,17
ATMET 069	158	<0,1	18	221	58	12	65	0,10	19	8,96
ATMET 070	277	<0,1	34	324	91	12	62	0,36	21	7,35
Flotation tailings	72	<0,1	36	150	50	13	45	<0,10	14	8,64

Based on the testwork results and following the waste classification methodology under art. 12 par. 4 of the **Regulation on the Specific Requirements to Mine Waste Management (2009), the tested samples should be classified as "non-hazardous non-inert" waste as they do not satisfy the criteria under art. 12 (2), i.e. they exhibit concentrations exceeding the soil pollution limits.**

3.2. Conclusions

- Ada Tepe is a epithermal low-sulfide deposit, which is also confirmed by the static tests performed. As seen from the data received on sulfide sulfur content, after the 20th the concentration decreased, where for ATEMET 068 it becomes <0,1%. Only for ATEMET 069 in the 20th week the concentration of 0,1% has not been reached, however, a trend towards decreasing concentration is noticeable.

- The static tests prEN15875 confirm that all four samples are non-acid generating. The NPR values are below 1 for samples **ATMET 068** and **ATMET 069,** i.e. they have sufficient potential to neutralise generated acid solutions and therefore the samples are classified as non-acid generating. Sample **ATMET 070** and the **flotation tailings sample** have sulphide sulphur contents below 0.1 and are therefore classified as non-acid generating. The sulphide sulphur content of the flotation tailings sample is lower than that of the other two samples (**ATMET 068 and ATMET 069)**, which can be explained with the fact that much of the sulphide sulphur is recovered together with the gold in the concentrate. Arsenic and some of the metals associated with pyrite have similar behavior.

- According to the results from the static testing for leaching of metals, acidic anions and salts under BNS EN 12457 (parts 1 to 4), it is evident that the concentrations of pollutants in the eluate from the wastes at a L/S of 10 L/kg and 2 L/kg is below the limit value for granular non-hazardous wastes. Therefore, the wastes can be stored in waste management facilities for non-hazardous wastes or in an Integrated Mine Waste facility as provided in the Mine Waste Management Plan of BMM EAD.

- Leaching test results show that elements leach out at minor concentrations, i.e. their mobility is minimal, especially speaking of As, Sb, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ba. That confirms the exploration findings that most elements are present in the mineral composition of the waste (and the ore respectively) and are inert. The data show that the concentration of microelements is very low compared to the limit values for hazardous waste concentrations (Appendix 3 to Regulation 3/2004).

- Based on the mineral composition established it is seen that the samples are sandy-clayey and this was used in the process of comparing test results against the standards for safe concentrations of heavy metals and metalloids in soils according to Regulation 3/01.08.2008 on the Limits for Allowable Content of Harmful Substances in Solis. SG 71/12.08.2008)

- The samples do not exhibit hazardous properties because the concentrations of harmful elements in them are below 25% and therefore they are classified as non-hazardous waste according to the Waste Classification Regulation.

- The four samples, however, cannot be classified as "non-polluted" soils because all of them exceed the respective safe concentration values for As and Cr. Sample ATMET 070 is also polluted with Ni and Hg, while ATMET 068 and ATMET 069 – with Hg. Based on the testwork results and following the waste classification methodology under art. 12 par. 4 of the *Regulation on the Specific Requirements to Mine Waste Management (2009)*, the tested samples can be classified as "non-hazardous non-inert" waste as they do not satisfy the criteria under art. 12 (2), i.e. they exhibit concentrations exceeding the soil pollution limits.

4. Kinetic Testing

4.1. Procedure

The kinetic testing was based on the standard humidity cell technique according to Designation: D5744-07 - Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell (ATSM, 2007). A photo of the humidity cell testwork equipment arrangement is shown in Fig. 4.1.1.

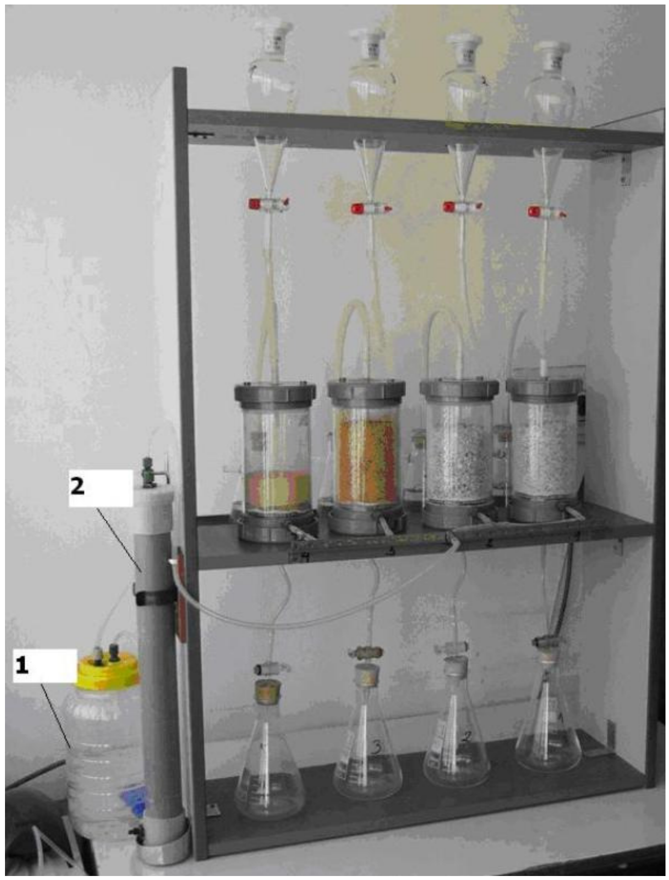


Fig.4.1.1 – Photo of the kinetic test installation, based on the Humidity Cell Test; *1 – Air humidifier; 2 – Air drying column*

The Humidity Cell Test installation has 4 cells, in each of which mined waste is placed, in the amount and particle size as per ASTM-Designation: D5744-07 - Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell (ATSM, 2007). The cells are mounted on a table, and in every cell there is an erlenmayr flask placed to collect the eluate. In the process of water saturation, the air supplied for the saturated water passes through the humidifier through the aerator and then to each cell. If cleaned with portions of dry air, air is blown to the bottom of each cell at a rate of 1 to 10 l/min. The dry air supplied passes through an air drying column, and then to each of the cells via collector pipe. A barbutator is also mounted onto each cell to maintain a constant air flow to each individual cell.

The installation for humidity cell kinetic test consists of:

- digital hygrometer/thermometer with humidity range 5 to 95% and temperature range between -40 up to 104°C;
- cylindrical dampening unit

The equipment that provides saturated air for a portion of humid air for three days for a weekly cycle includes:

- thermostatically controlled heating element to maintain the water temperature at 25 ° during the humid air cycle;
- gas-distribution cylinder for barbutation of the air in the water within the humidifying device;
- flowmeter - capable of supplying air to each cell at a rate of 1 to 10 liters per minute.
- Erlenmeyer flask with a rubber stopper and an air inflow tube, which is connected to the exit of the humidity cell via flexible tube and maintains constant pressure in the cell.
- flexible connection, placed in the middle so that the barbutator can be switched off to measure the air flow.
- desiccant column (air drying column), with caps on both sides so that the desiccant is interchangeable and so that the air can enter from the bottom and exit from the top;
- pipeline with branches for dry air - the air line right after the desiccant column directly goes to the cylinder which delivers dry air to each cell.

The method under the above standard is based on increasing the mass that is liberated in alkaline/acidic conditions for metals and other elements from a sample of a predetermined weight. This is achieved by creating conditions that ensure oxidation of the sample and then leaching using a fixed amount of a leaching agent.

In our particular case, the mass of samples **ATMET 068**, **ATMET 069** and**ATMET 070** was 1000 g, while the mass of the **flotation tailings sample** was 250 g. The standard allows each sample to be placed in an individual cylindrical cell. Four tests cells were arranged in parallel.

ASTM-Designation procedure: D5744-07- Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell (2007) consists of weekly alternation of sample treatment cycles, as described below:

- «dry cycle» - three days supply of dry air (with less than 10% of relative humidity) - the aimis to evaporate some of the water which has remained in the pores of the samples after the weekly leaching, without totally drying it. In result, the saturation of the sample decreases, and the air flow increases. During the dry air cycle the degree of diffusion of the air through the sample may increase several times compared to the diffusion in a media where leaching has been more intense. Such increase of the diffusion rate in nearly dry conditions facilitates oxidation of components such as the iron sulphide; The evaporation which occurs following the three-day dry air cleaning increases the concentration of cations/anions in the water and also increases the acidity - for example, by increasing the hydrogen ions generated by previous oxidation of iron sulfide.

- «"Humid cycle" - three days supply of humid air (approximately 95% relative humidity) - feeding the system with humid air during the weekly cycle helps maintain relatively constant volume of water in the pores of the sample. This leads to the diffusion of the weathering products in the water remaining in the pores, without saturation of the sample and without the adverse effect of the oxygen diffusion.
- one day of water washing (elution) with distilled water. The cell test to determine the humidity begins with the first leaching marked as week 0. Since the laboratory test is programmed for a 7 day cycle, the samples are always leached on the same day of the week - say Monday. On the day assigned for leaching in week 0 three successive leachings are performed using 500 ml of water. The choice of this quantity of water for leaching depends on the pore volume, the quantity of solution needed for this purpose and the detection limits of the elements in the analysis. After the leachings in week 0, the volume may have to be changed, and if it is not enough to wash the reaction away from the products in the sample, or if the rate of release is be too weak to produce detectable elements which may be subject of interest.

As indicated in Note 16 of ASTM-Designation: D5744-07-Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell (2007), preliminary studies with humidity cells of mining waste materials have showed that the concentrations of anions and cations in the extract of 0-500 ml are usually high. They are due to the dissolution of soluble salts existing prior to sampling. The first 3 to 5 weeks of leaching with 500 ml are needed to flush these salts away from the sample. The goal of the three consecutive leachings in week 0 is to reduce the influence of pre-existing salts on the quality of drainage, if this is considered a critical component of the test. Possibly, part of these salts will remain in the sample regardless of the three leachings.

Kinetic tests are intended to be used on a laboratory scale to simulate the weathering of the wastes during their storage in open facilities under the influence of typical weather conditions, which may cause release of ions, elements and salts in one or more environmental media. The laboratory test offers conditions that enable complete oxidation of the ingredients and facilitate the release of products in the weekly eluate obtained as a result of the weathering reaction. Additional amount of air pumped through the sample during the inflow of dry - humid air portions in the weekly cycle, reduces the oxidation potential, limited by low oxygen concentration. Weekly leachings with water of low ionic strength facilitate the release of mineral products from previous weathering cycles.

In accordance with the Agreement signed with the Company, the kinetic test on Ada Tepe samples included weekly assays to determine the following eluate parameters:

- pH
- Fe
- As

- SO_4
- Conductivity
- Alkalinity

A full range of determinations were made once every four weeks to identify, in addition to the above parameters, the concentration of major metals and ions, dissolved substances and dissolved organic substances, in accordance with the EU and Bulgarian legal requirements.

4.2. Analysis of the Test Results

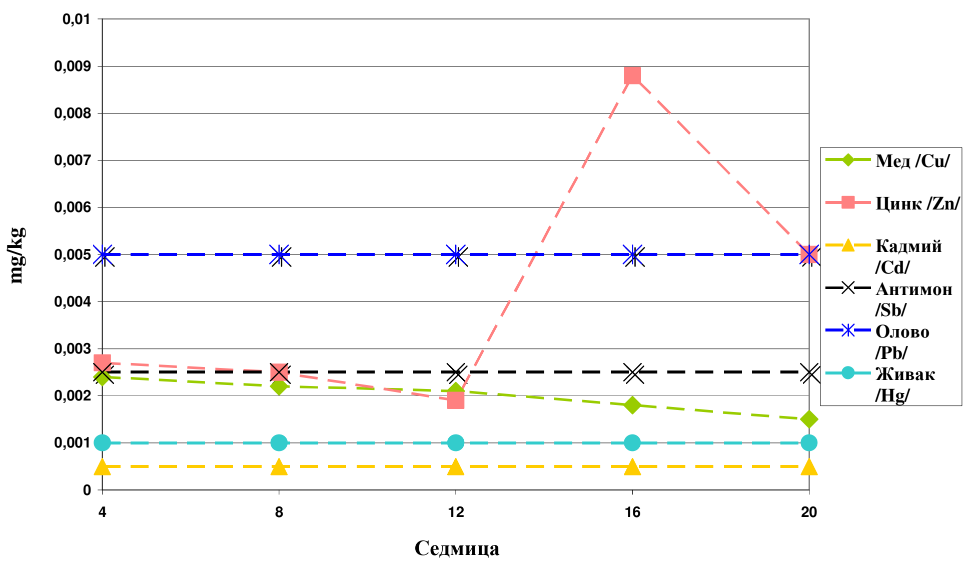
Kinetic testing is the determining method for characterisation of wastes, mine wastes in particular. It determines the potential for acid generation based on the sulphur content in the mine wastes (overburden rock or process tailings), and the data is shown in Table 3.1.1. The results are determinant for the classification of the wastes in terms of their hazardous properties, and for the classification of mine waste facilities in terms of the environmental protection measures that need to be taken.

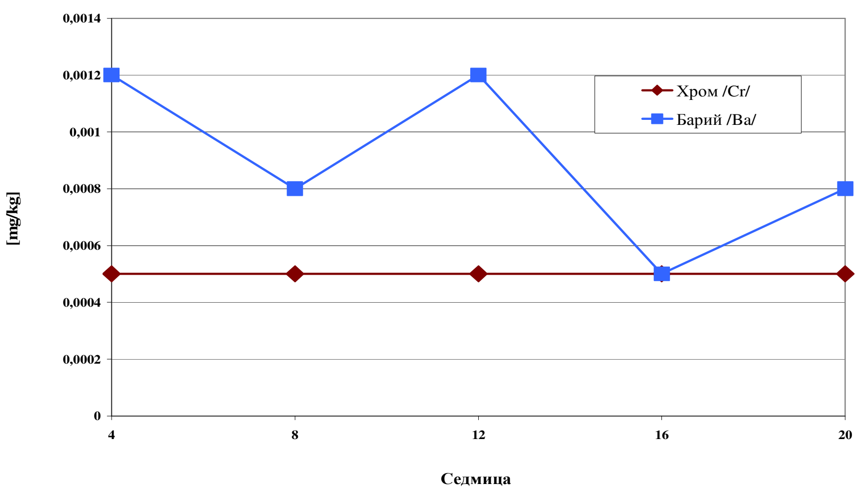
Table 4.2.1. - Eluates Released in week 4, 8, 12, 16 and 20 - Tested Data for Sample **ATEMET 068**

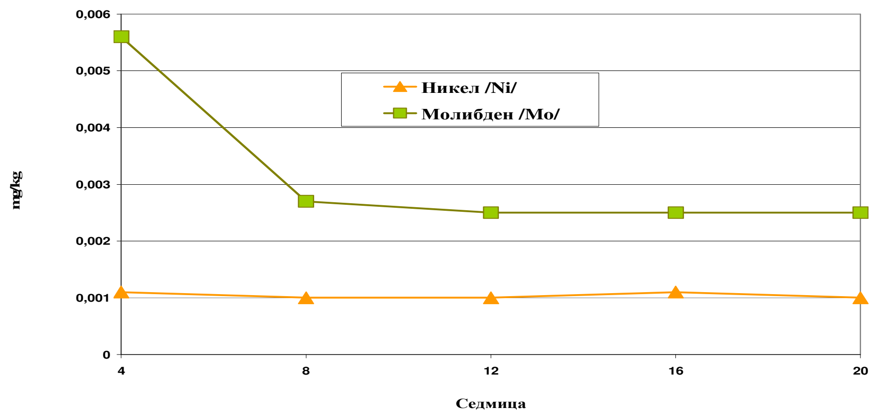
Tested parameters	Unit	ATEMET 068				
		Week 4	Week 8	Week 12	Week 16	Week 20
Eluate pH	pH units	8.96	8.89	8.28	8.23	8.48
Iron (Fe)	mg/kg	0.0031	0.0081	0.0042	0.0251	0.0068
Arsenic (As)	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium (Cr)	mg/kg	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel (Ni)	mg/kg	0.0011	<0.0010	<0.0010	<0.0010	<0.0010
Copper (Cu)	mg/kg	0.0024	0.0022	0.0021	0.0018	0.0015
Zinc (Zn)	mg/kg	0.0027	0.0025	0.0019	0.0088	0.0050
Molybdenum (Mo)	mg/kg	0.0056	0.0027	<0.0025	<0.0025	0.0025
Cadmium (Cd)	mg/kg	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Antimony (Sb)	mg/kg	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Barium (Ba)	mg/kg	0.0012	0.0008	0.0012	<0.0005	0.0008
Lead (Pb)	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005
Mercury (Hg)	mg/kg	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Fluorides /F^-/	mg/kg	0.11	0.05	<0.05	<0.05	<0.05
Sulphates (SO_4^{2-})	mg/kg	13.6	3.7	3.9	0.9	2.0
Chlorides /Cl^-/	mg/kg	<0.05	0.08	<0.05	<0.05	<0.05
Phosphates (PO_4^{3-})	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05
Total dissolved solids (TDS)	mg/kg	29.5	18.0	18.0	9.5	22.0
Dissolved organic substances (DOS)	mg/kg	<2.5	2.8	<2.5	<2.5	<2.5
Conductivity	μS/cm	98.2	76.1	72.1	46.9	62.8

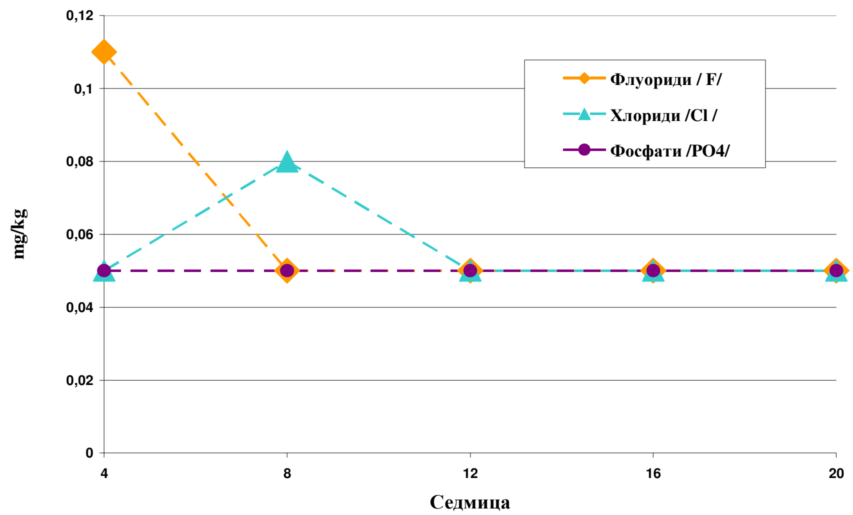
Eluate alkalinity	°H	<1.4	<1.4	<1.4	<1.4	<1.4
Selenium (Se)	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005

Figure 4.2.1 represents graphically the behavior in weeks 4, 8, 12, 16 and 20 of each of the elements while the kinetic test lasted.









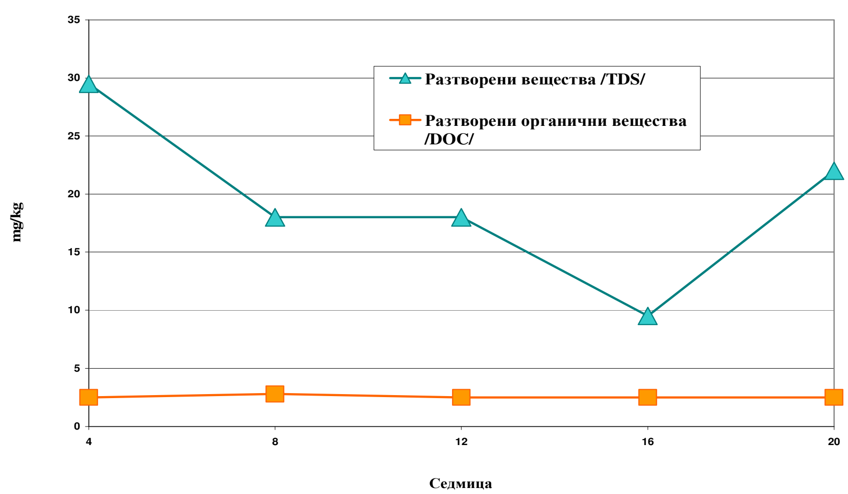
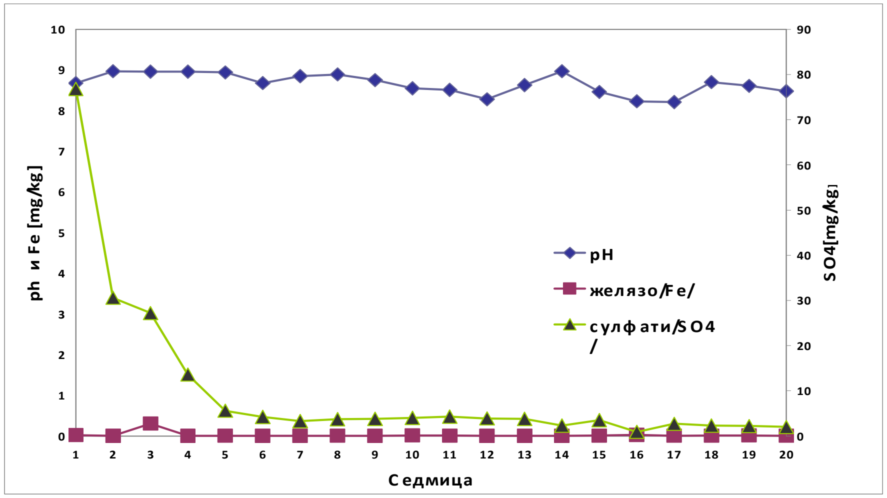
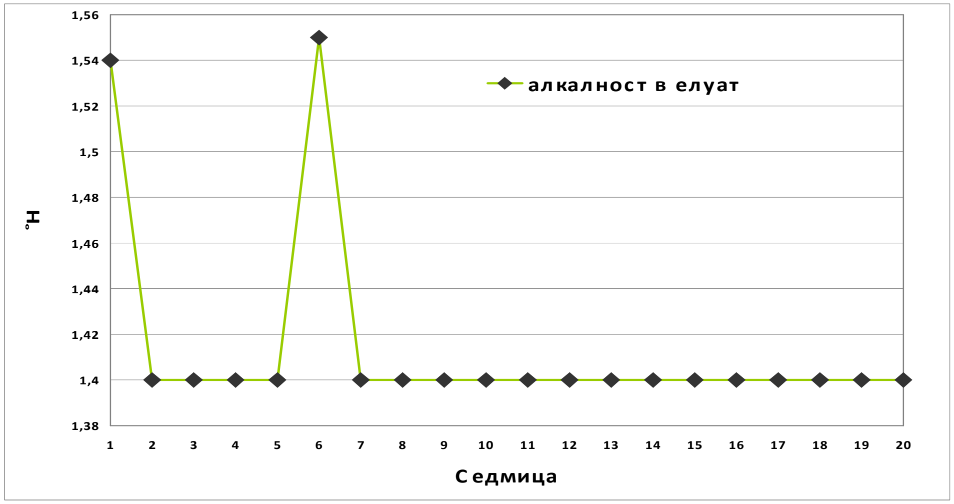
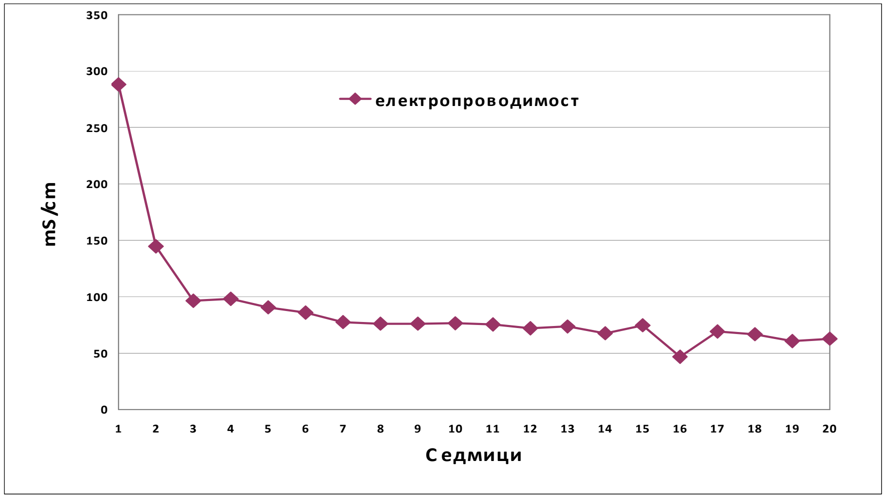


Fig. 4.2.1 – Behavior of the tested elements during the kinetic "humidity cell" test for weeks 4, 8, 12, 16 and 20 for sample **ATEMET 68**







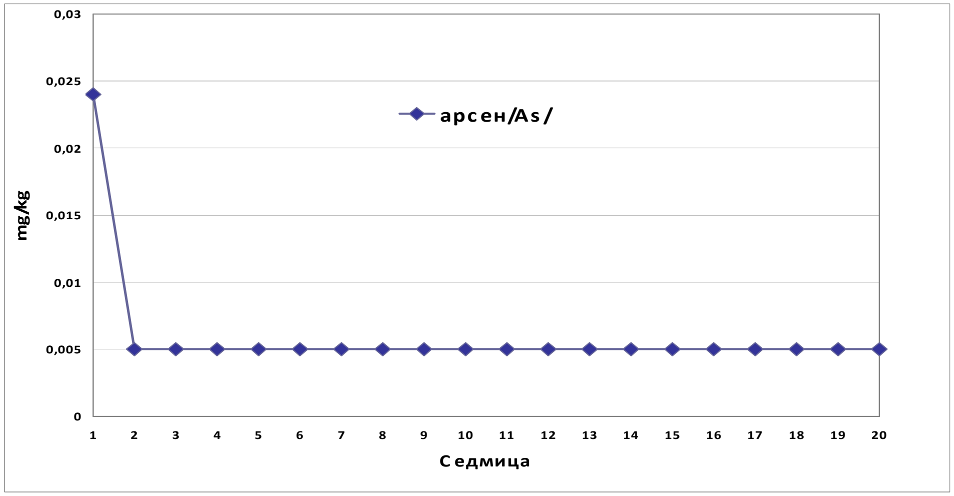


Fig.4.2.3 - Eluates Released from Week 1 through Week 20 – Tested Data for Sample **ATEMET 068**

In the course of the complete analysis of the eluate in each fourth week, as shown in fig.4.2.1 for ATEMET 68 sample, the following dependencies for the studied parameters are established:

- constant concentration in the eluate of the following: copper, cadmium, antimony, lead, mercury, chromium, nickel, phosphates, chlorides, dissolved organic matter;
- the concentration of zinc has a peak in the sixteenth week, which can not be explained by changes in pH, because it is > 8 (alkaline range) and remains constant throughout the period;
- the concentration of molybdenum, fluorine and solutes after the fourth weeks tends to reduce to a constant value, which remains unchanged until the end of the period, while the barium concentration begins to decrease only after the twelfth week.

the weekly concentration of the eluate for each of the 20 weeks for ATEMET 68 for the weekly surveyed parameters is given in Fig. 4.2.2.

ATMET 068 is the sample of material from the Wall Zone, which comprises intensely silicified varigrained Palaeogene breccia. As seen from Fig. The pH of the waste during each of the 20 weeks of the humidity cell tests exceeded 8, and the Fe concentration was extremely low and fairly consistent. The alkaline environment favors the development of the autotrophic bacterium Thiobacillus thiooxidans, of which, according to available literature, the growth optimum pH is 2,0 to 2,5 (S.M. JIN, W. M. YAN,* AND Z. N. WANG, Transfer of IncP Plasmids to Extremely Acidophilic Thiobacillus thiooxidans APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Jan. 1992, Vol.58, No1, p. 429-430).

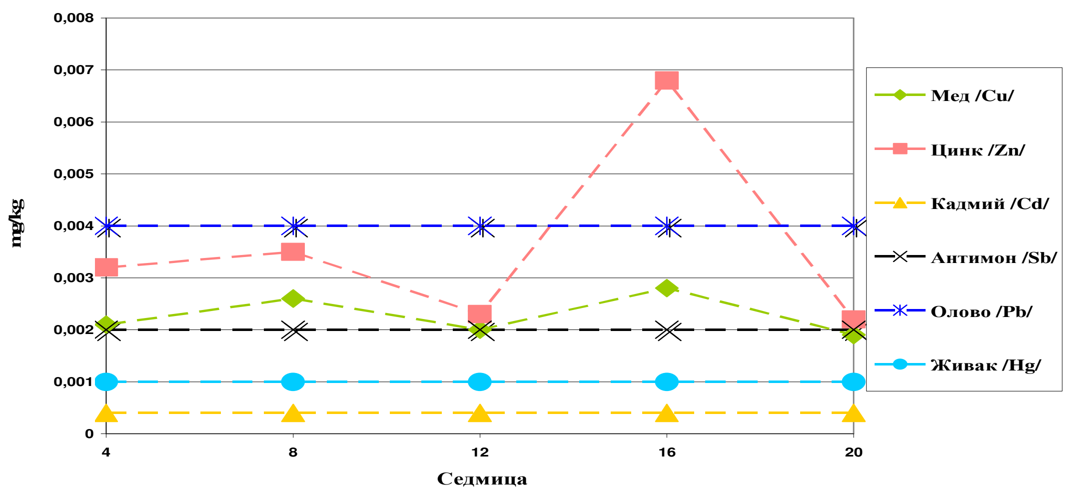
The sulphate concentrations in the eluate varied but the trend was from higher to lower values. Similar to sulphates, the conductivity and arsenic levels also decreased. This means that with the passing of time, the values of the weekly tested parameters tended to decrease while the waste material maintained its alkalinity.

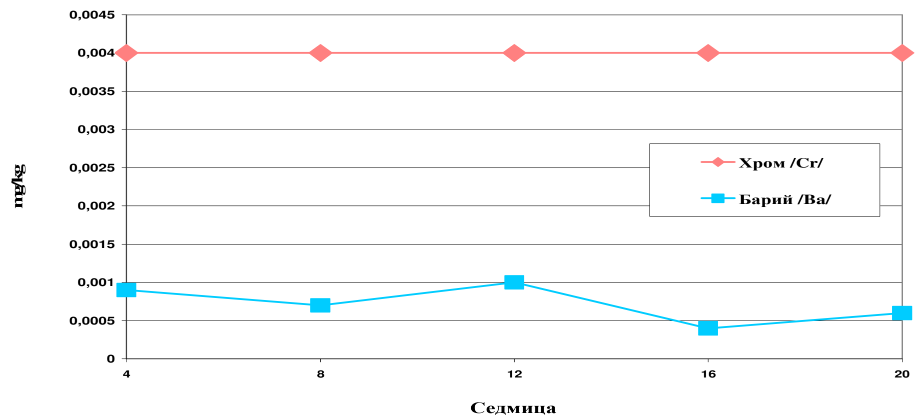
In result of the tests made, we can **conclude** that during storage of this waste no changes are expected which would provide for the increase of concentrations of the tested elements contained in the eluate, i.e. no negative impact can be expected onto the environment in the process of storage of this mine waste material.

Table 4.2.2. - Eluates Released in week 4, 8, 12, 16 and 20 - Tested Data for Sample **ATEMET 069**

Tested parameters	**Unit**	**ATEMET 069**				
		Week 4	**Week 8**	**Week 12**	**Week 16**	**Week 20**
Eluate pH	pH units	8.55	8.23	7.78	8.35	8.17
Iron (Fe)	mg/kg	0.0194	0.0204	0.0141	0.0165	0.0148
Arsenic (As)	mg/kg	<0.004	<0.004	<0.004	<0.004	<0.004
Chromium (Cr)	mg/kg	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Nickel (Ni)	mg/kg	0.0010	0.0008	<0.0008	<0.0008	<0.0008
Copper (Cu)	mg/kg	0.0021	0.0026	0.0020	0.0028	0.0019

Zinc (Zn)	mg/kg	0.0032	0.0035	0.0023	0.0068	0.0022
Molybdenum (Mo)	mg/kg	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Cadmium (Cd)	mg/kg	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Antimony (Sb)	mg/kg	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Barium (Ba)	mg/kg	0.0009	0.0007	0.0010	<0.0004	0.0006
Lead (Pb)	mg/kg	<0.004	<0.004	<0.004	<0.004	<0.004
Mercury (Hg)	mg/kg	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Fluorides /F^-/	mg/kg	0.08	0.06	0.04	<0.04	<0.04
Sulphates (SO_4^{2-})	mg/kg	5.3	8.64	6.80	6.7	5.1
Chlorides /Cl^-/	mg/kg	0.11	0.06	<0.04	<0.04	<0.04
Phosphates (PO_4^{3-})	mg/kg	0.24	<0.04	<0.04	0.06	<0.04
Total dissolved solids (TDS)	mg/kg	31.9	24.0	23.0	28.0	27.2
Dissolved organic substances (DOS)	mg/kg	<2.0	2.4	<2.0	<2.0	<2.0
Conductivity	µS/cm	132.9	114.4	96.5	101.5	92.4
Eluate alkalinity	°H	1.60	1.47	1.54	1,56	1.67
Selenium (Se)	mg/kg	<0.004	<0.004	<0.004	<0.004	<0.004

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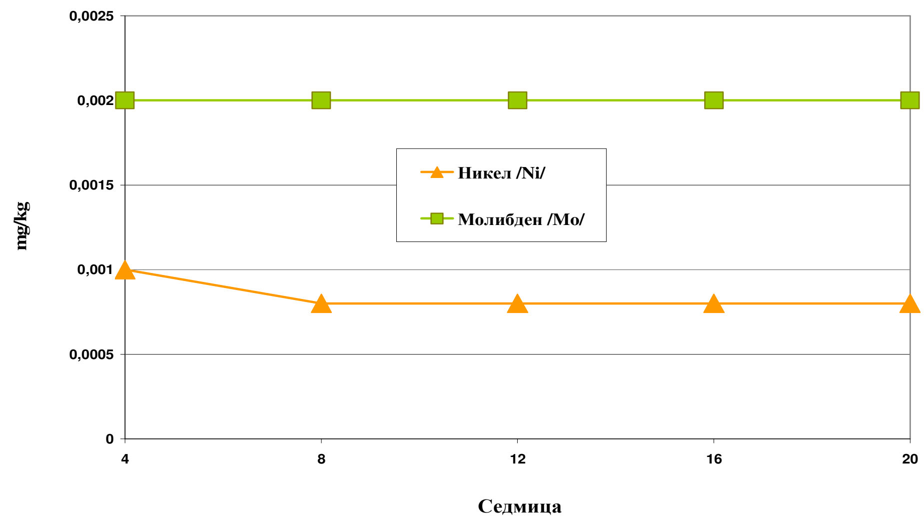
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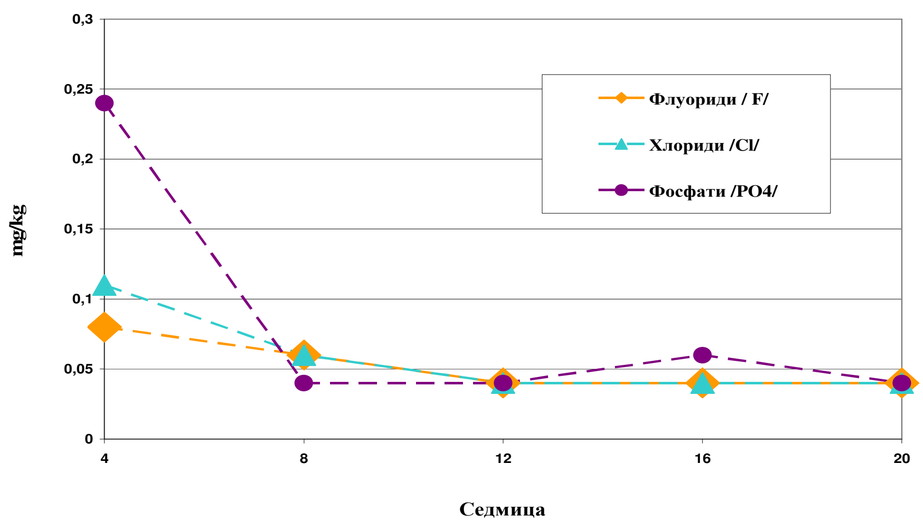
0,0005
0
mg/kg
4
8
12
16
20
Седмица
Никел /Ni/
Молибден /Mo/


0,3
0,25
0,2
0,15
0,1
0,05
0
mg/kg
4
8
12
16
20
Седмица
Флуориди / F/
Хлориди /Cl/
Фосфати /PO4/

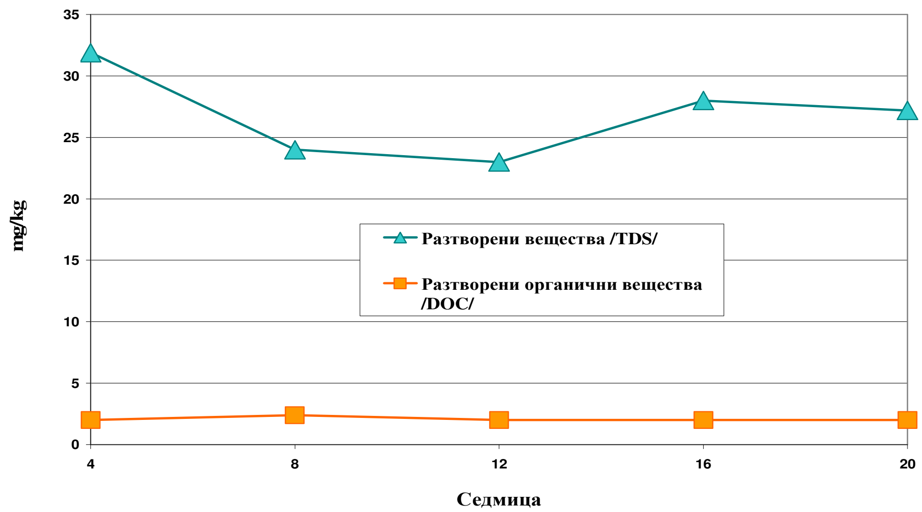


Fig. 4.2.3 – Behavior of the tested elements during the kinetic "humidity cell" test for weeks 4, 8, 12, 16 and 20 for sample **ATEMET 69**

During the full analysis of the eluate every fourth week (Fig. 4.2.3) and the weekly samples (Fig 4.2.4) for sample **ATEMET 69**, the following dependencies of in between its parameters have been established:

- constant concentration in the eluate of the following: copper, cadmium, antimony, lead, mercury, chromium, nickel, phosphates, chlorides, dissolved organic matter; That is also the trend in the behavior of the barium and the dissolved substances, the concentrations of which for the period of tests vary around a certain value.
- the concentration of the zinc goes through a peak in the 16th week, which cannot be explained with a changed pH, as it is >8 (alkaline range) and remains consistent for the entire period, as can be seen from Fig. 4.2.4;
- the concentration of molybdenum, fluorine and solutes after the fourth weeks tends to reduce to a constant value, which remains unchanged until the end of the period.

The weekly concentrations of the tested elements needed for full characterization of the eluate for sample **ATEMET 69** are represented graphically in ***Fig. 4.2.4.***

Sample **ATMET 069** is a fresh rock from the Upper Zone, where the Palaeogene conglomerate is weakly silicified and argillised with non-homogenious quartz veins, waste rock. This sample, analogically to the forest soils in the Ada Tepe area contains elevated concentrations of arsenic, chromium and nickel (Table 3.1.4.3) due to the soil natural chemistry. The data in Fig. 4.2.3 shows that the concentration of these elements remains constant for the 20 weeks of the experiment, and as for arsenic, as early as the 2nd week, the concentration harshly decreases and remains low until the end of the 20th week, as seen on Fig. 4.2.4.

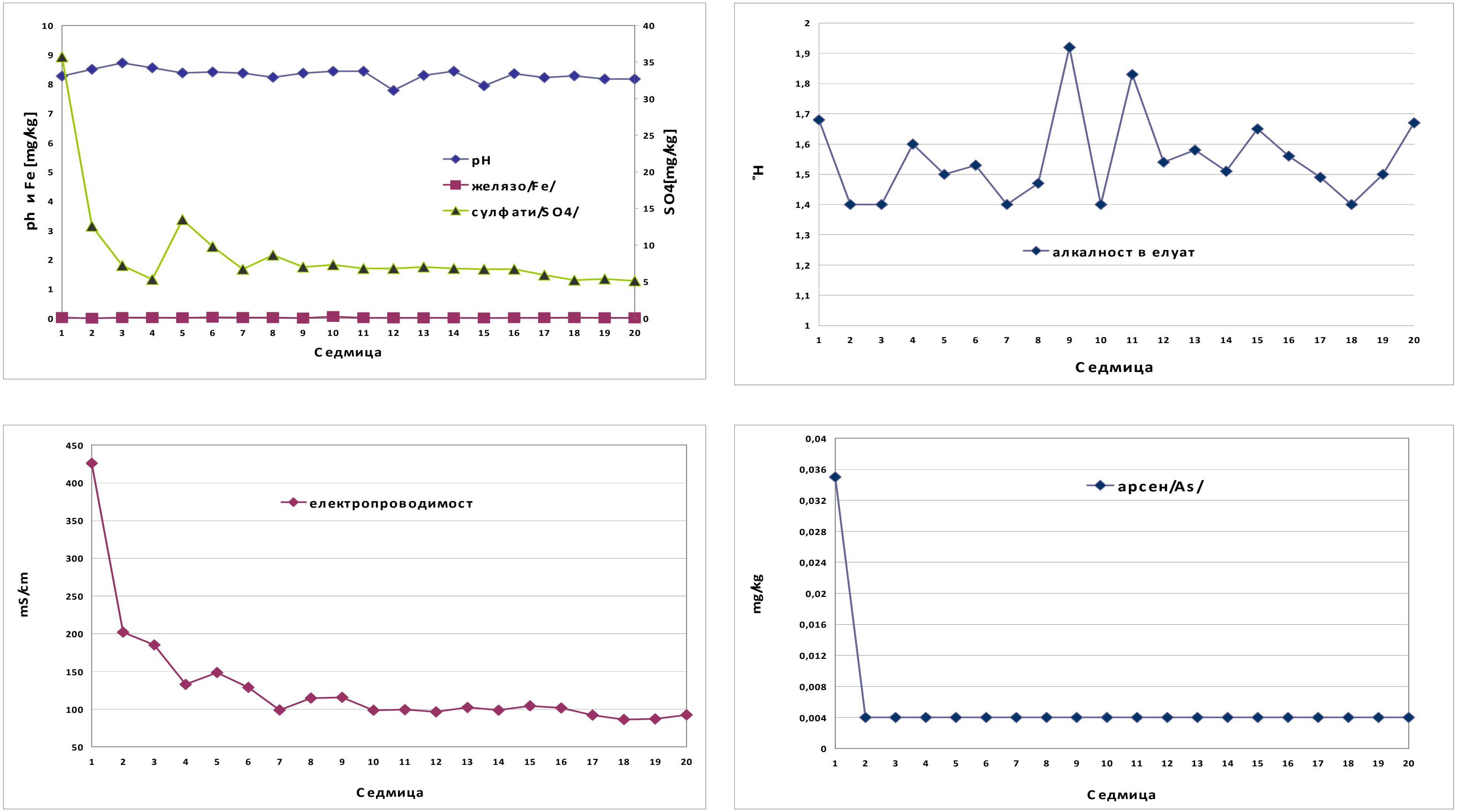


Fig.4.2.4 - Eluates Released from Week 1 through Week 20 – Tested Data for Sample **ATEMET 069**

On the same figure it is shown that the pH of the waste ,during each of the 20 weeks of the humidity cell tests, exceeded 8, and the Fe concentration was extremely low and fairly consistent. The alkaline environment favors the development of the autotrophic bacterium Thiobacillus thiooxidans, of which, according to available literature, the growth optimum pH is 2,0 to 2,5 (S.M. JIN, W. M. YAN,* AND Z. N. WANG, Transfer of IncP Plasmids to Extremely Acidophilic Thiobacillus thiooxidans APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Jan. 1992, Vol.58, No1, p. 429-430).

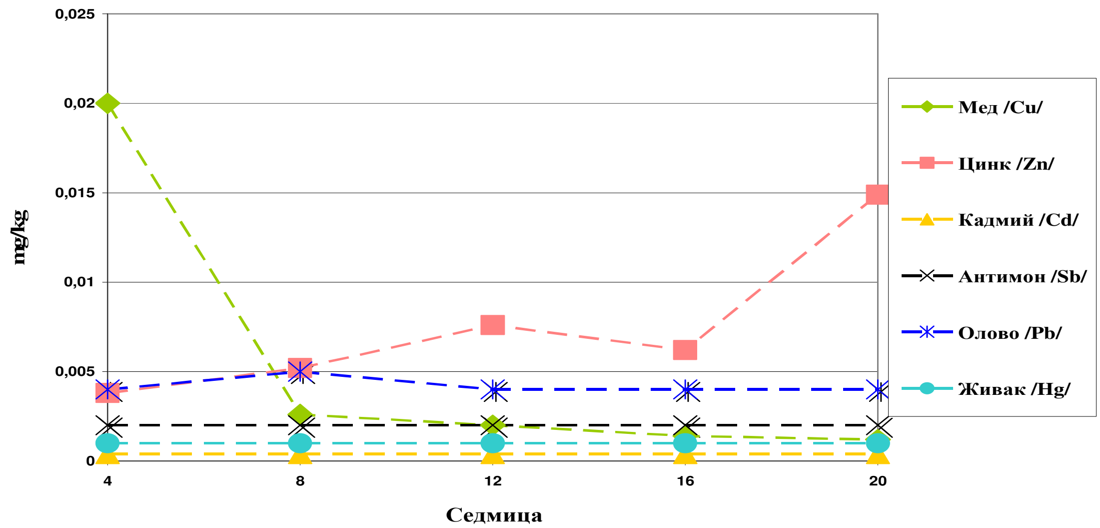
The sulphate concentrations in the eluate varied but the trend was from higher to lower values. Similarly to the sulphates, conductivity also decreases. This means that with the passing of time, the values of the weekly tested parameters tended to decrease while the alkalinity of the waste material varies around its initial value.

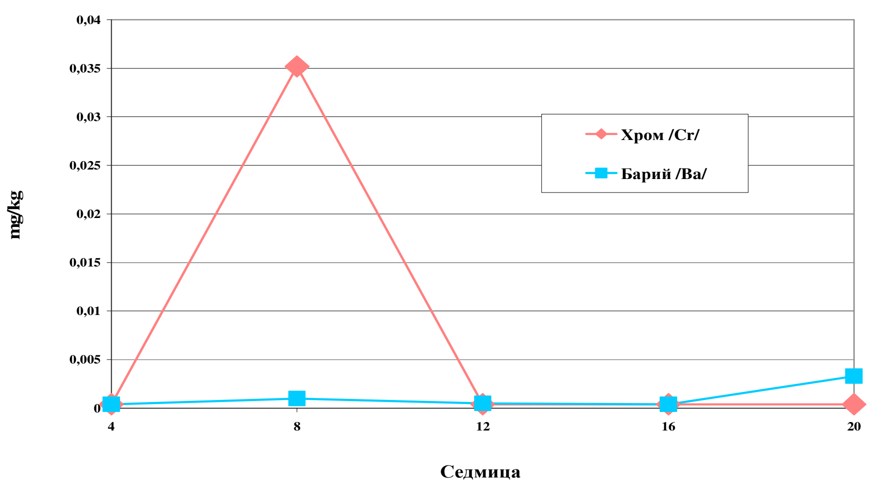
In result of the tests made, we can **conclude** that during storage of this waste no changes are expected which would provide for the increase of concentrations of the tested elements contained in the eluate, i.e. no negative impact can be expected onto the environment in the process of storage of this mine waste material.

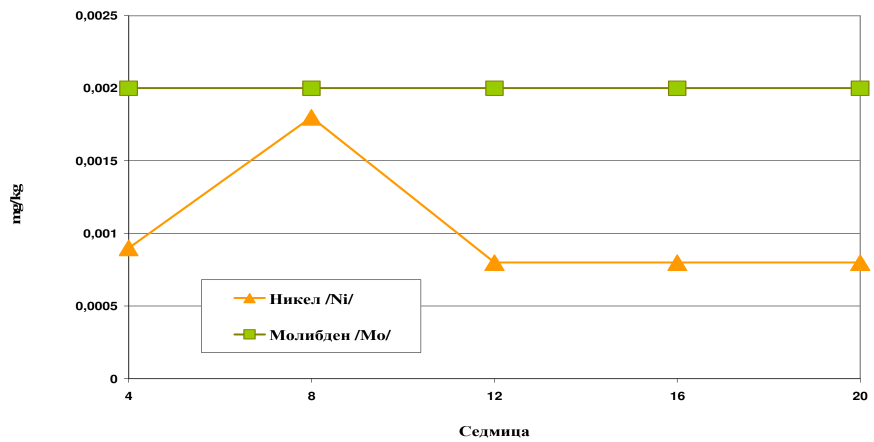
Table 4.2.3. - Eluates Released in week 4, 8, 12, 16 and 20 -
Tested Data for Sample **ATEMET 070**

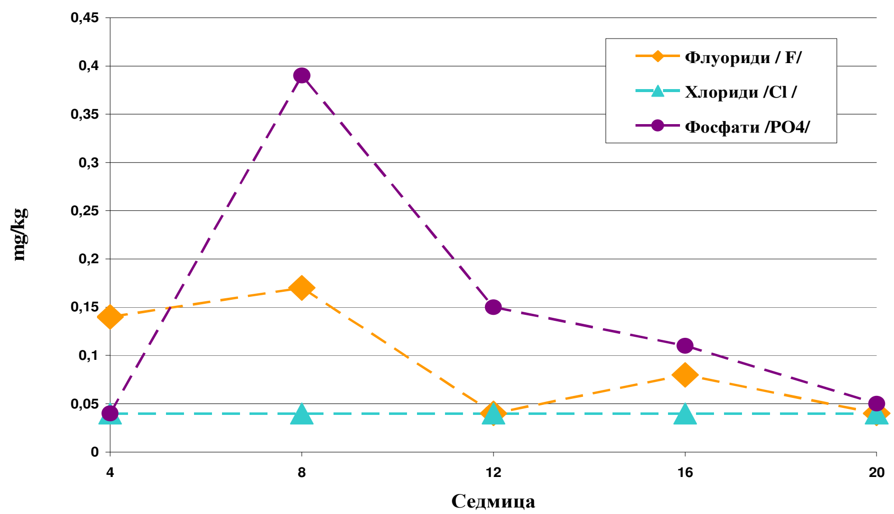
Tested parameters	**Unit**	**ATEMET 070**				
		Week 4	**Week 8**	**Week 12**	**Week 16**	**Week 20**
Eluate pH /active reaction/	pH units	7.66	7.46	6.90	7.04	6.23
Iron (Fe)	mg/kg	0.0217	0.364	0.0136	0.0179	0.0193
Arsenic (As)	mg/kg	0.017	0.029	0.010	0.013	<0.004
Chromium (Cr)	mg/kg	<0.0004	0.0352	<0.0004	<0.0004	<0.0004
Nickel (Ni)	mg/kg	0.0009	0.0018	<0.0008	<0.0008	<0.0008
Copper (Cu)	mg/kg	0.0020	0.0026	0.0020	0.0014	0.0012
Zinc (Zn)	mg/kg	0.0038	0.0052	0.0076	0.0062	0.0149
Molybdenum (Mo)	mg/kg	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Cadmium (Cd)	mg/kg	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Antimony (Sb)	mg/kg	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Barium (Ba)	mg/kg	<0.0004	0.0010	0.0005	<0.0004	0.0033
Lead (Pb)	mg/kg	<0.004	0.005	<0.004	<0.004	<0.004
Mercury (Hg)	mg/kg	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Fluorides /F^-/	mg/kg	0.14	0.17	<0.04	0.08	<0.04
Sulphates (SO_4^{2-})	mg/kg	3.6	1.1	0.64	0.32	0.29
Chlorides /Cl^-/	mg/kg	<0.04	<0.04	<0.04	<0.04	<0.04
Phosphates (PO_4^{3-})	mg/kg	<0.04	0.39	0.15	0.11	0.05
Total dissolved solids (TDS)	mg/kg	9.2	5.6	5.2	7.6	10.0

Dissolved organic substances (DOS)	mg/kg	<2.0	<2.0	<2.0	<2.0	<2.0
Conductivity	µS/cm	30.7	22.2	19.42	22.5	35.6
Eluate alkalinity	°H	<1.4	<1.4	<1.4	<1.4	<1.4
Selenium (Se)	mg/kg	<0.004	<0.004	<0.004	<0.004	<0.004









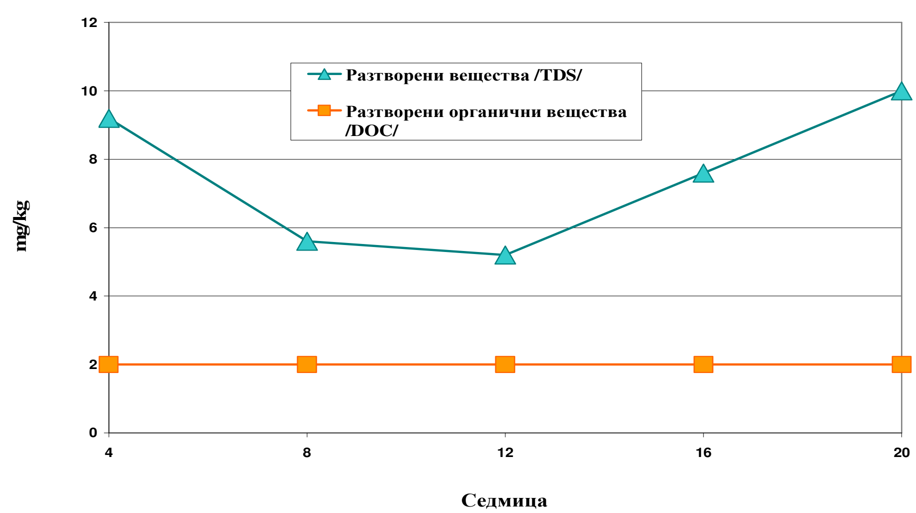


Fig. 4.2.5 – Behavior of the tested elements during the kinetic "humidity cell" test for weeks 4, 8, 12, 16 and 20 for sample **ATEMET 70**

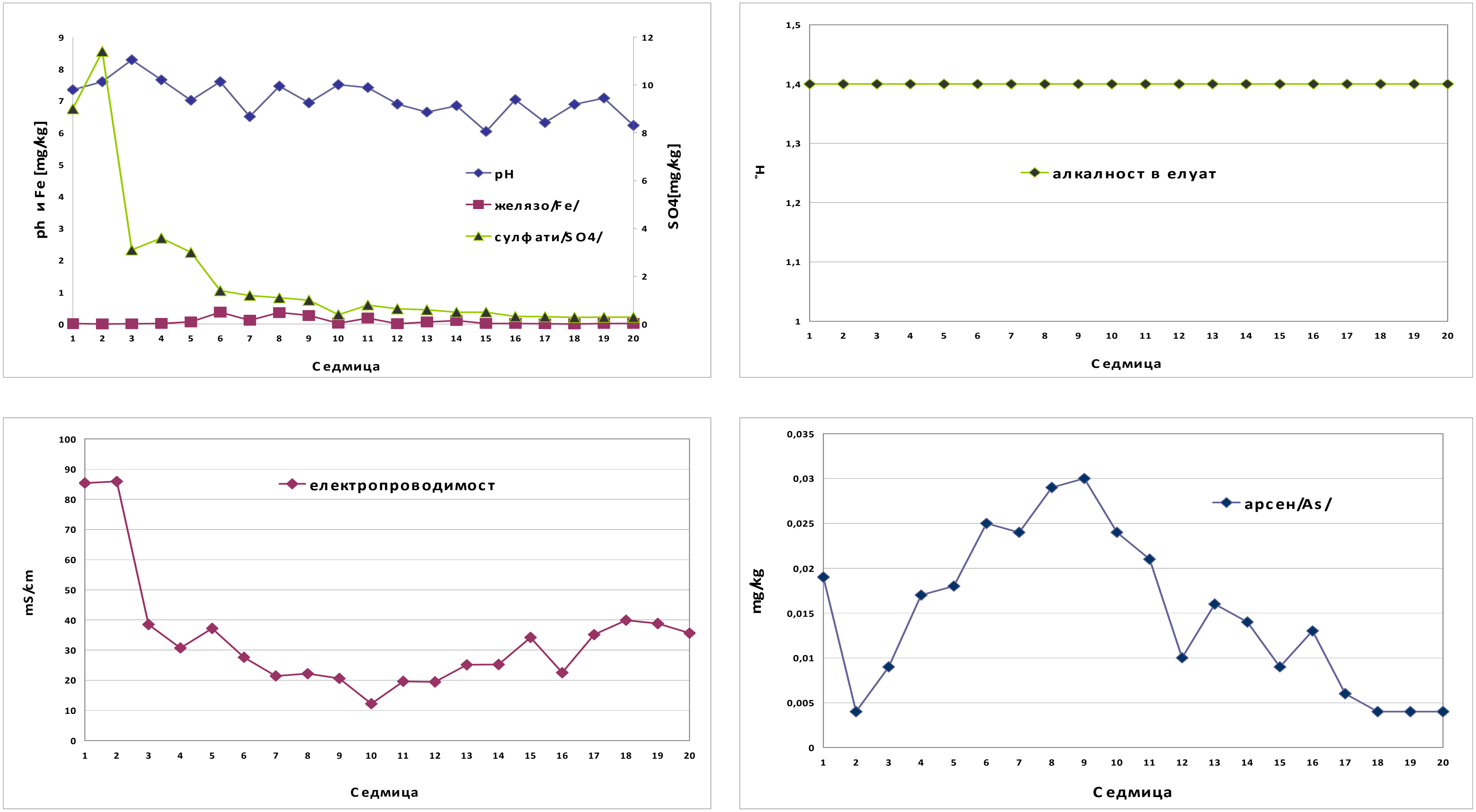


Fig.4.2.6 - Eluates Released from Week 1 through Week 20 – Tested Data for Sample **ATEMET 070**

During the full analysis of the eluate every fourth week (Fig. 4.2.5) and the weekly samples (Fig 4.2.6) for sample **ATEMET 70**, the following dependencies of in between its parameters have been established:

- constant concentration in the eluate of the following: cadmium, antimony, lead, mercury, barium, molybdenum, chlorides, iron, alkalinity in eluate, dissolved organic matter;
- As in the other tested samples, the Fe concentration is extremely low and consistent. The references made in literature sources show that the factors which influence the growth of the bacteria T. ferrooxidans are such as: temperature, water, pH and nutritional value. These organisms require temperatures of 75 to 100 degrees Fahrenheit for optimal growth and the change in temperature adversely affects the growth rate. The best pH for the T. ferrooxidans is between 6.5 and 7.5, but in optimal concentration of nitrogen, vitamins and minerals (Merrill Gillaspy, Thiobacillus Ferrooxidans Growth), which are not present in any of the studied waste samples;
- zinc concentration gradually elevates in the period from week 4 to 20, which may be explained by changes in the pH, because at the end of the period it reaches 6.23;
- the concentration of copper, chromium, nickel, fluoride, phosphates, arsenic, and the conductivity after a peak in week 8 express a tendency to reduce to a constant value which does not change until the end of the period.
- the concentration of solutes decreases, but after 12th week it reaches its original value.

The weekly concentrations of the tested elements for sample **ATEMET 90** are presented graphically in **Fig.** ***4.2.6.***

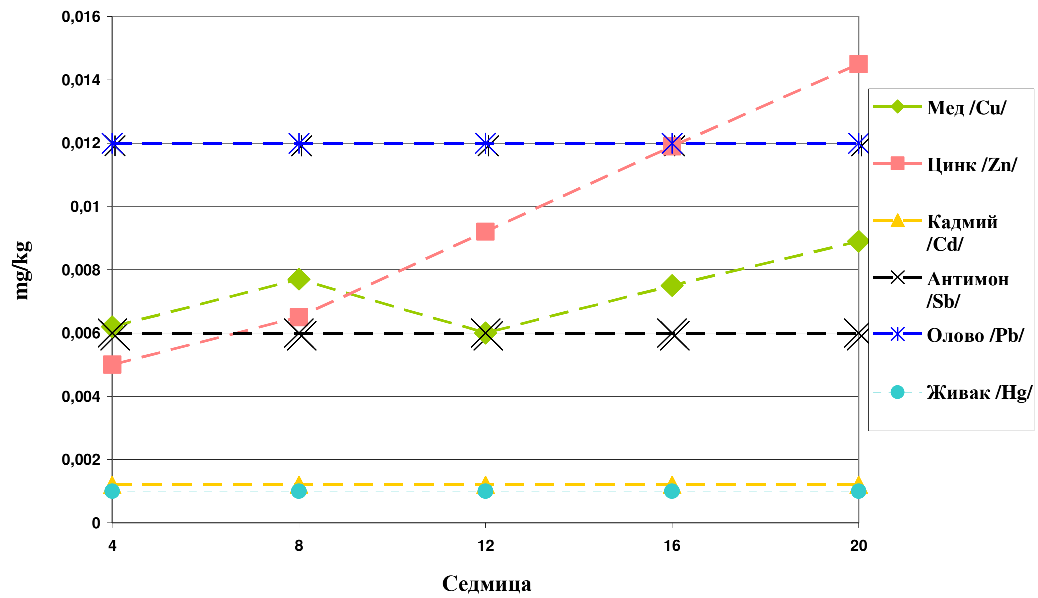
ATMET 070 is the sample of material from the oxidised Upper Zone, where most of the fragments are affected by argillisation and silicification is manifested by non-homogenious quartz veins. The initial pH of the waste drops to 6.23 at the end of week 20, which is due to the fact that the are no calcite in the sample, only dolomite - 4% (Table 3.1.3)

The sulphate concentrations in the eluate varied but the trend was from higher to lower values. Similar to sulphates, the conductivity and arsenic levels also decreased. Only for that sample, the arsenic started to increase its level slowly after the initial decrease in Week 2 and at the end of Week 8 exceeded its level at the start of the test, after this until week 20 it starts to slowly decrease. Overall, with the passing of time, the values of the weekly tested parameters tended to decrease while the tailings material maintained its alkalinity.

Table 4.2.4. - - Eluates Released in week 4, 8, 12, 16 and 20 - Tested Data for Sample **Flotation waste**

Tested	Unit	Flotation tailings

parameters		Week 4	Week 8	Week 12	Week 16	Week 20
Eluate pH	pH units	8.03	8.44	8.34	8.97	8.36
Iron (Fe)	mg/kg	0.0120	0.4328	0.3625	0.3320	0.3019
Arsenic (As)	mg/kg	<0.012	<0.012	<0.012	0.012	<0.012
Chromium (Cr)	mg/kg	<0.0012	0.0030	<0.0012	0.0090	<0.0012
Nickel (Ni)	mg/kg	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024
Copper (Cu)	mg/kg	0.0062	0.0077	0.0060	0.0075	0.0089
Zinc (Zn)	mg/kg	0.0050	0.0065	0.0092	0.0119	0.0147
Molybdenum (Mo)	mg/kg	0.0065	0.0060	<0.0060	0.0062	0.0072
Cadmium (Cd)	mg/kg	<0.0012	<0.0012	<0.0012	<0.0012	<0.0012
Antimony (Sb)	mg/kg	<0.0060	0.0060	<0.0060	<0.0060	<0.0060
Barium (Ba)	mg/kg	0.0048	0.0114	0.0062	0.0061	0.0060
Lead (Pb)	mg/kg	<0.012	<0.012	<0.012	<0.012	<0.012
Mercury (Hg)	mg/kg	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Fluorides /F^-/	mg/kg	0.17	0.17	<0.12	0.17	0.18
Sulphates (SO_4^{2-})	mg/kg	6.0	2.5	1.6	2.5	2.5
Chlorides /Cl^-/	mg/kg	<0.12	<0.12	<0.12	<0.12	<0.12
Phosphates (PO_4^{3-})	mg/kg	0.94	<0.12	<0.12	<0.12	<0.12
Total dissolved solids (TDS)	mg/kg	43.0	52.8	34.8	38.4	42.0
Dissolved organic substances (DOS)	mg/kg	<6.0	<6.0	<6.0	<6.0	<6.0
Conductivity	μS/cm	59.7	63.3	43.5	69.2	72.5
Eluate alkalinity	°H	<1.4	1.58	<1.4	<1.4	1.57
Selenium (Se)	mg/kg	<0.012	<0.012	<0.012	<0.012	<0.012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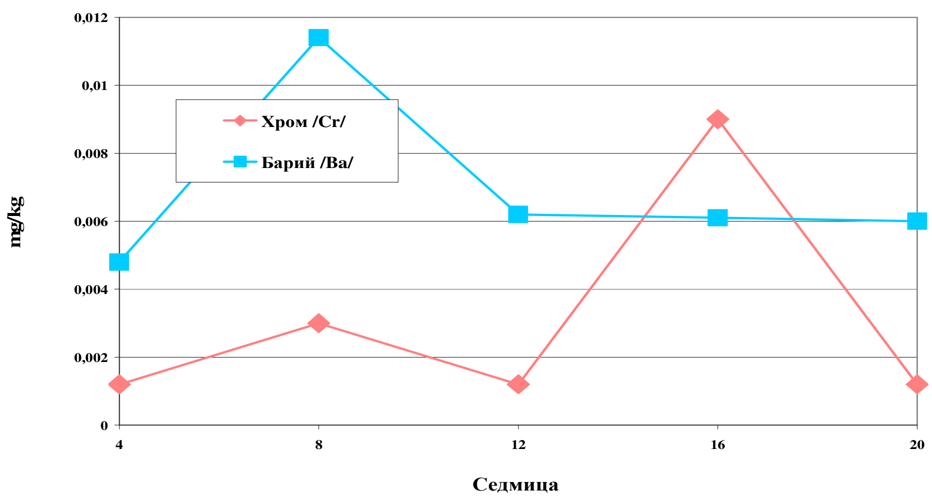
0,014
0,012
0,01
0,008
0,006
0,004
0,002
0
mg/kg
4
8
12
16
20
Седмица
Мед /Cu/
Цинк /Zn/
Кадмий /Cd/
Антимон /Sb/
Олово /Pb/
Живак /Hg/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0,01
0,008
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0
mg/kg
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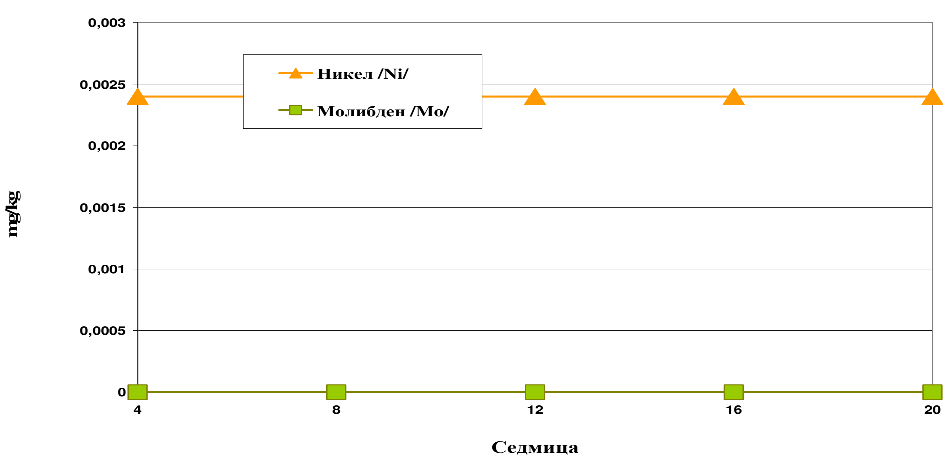
8
12
16
20
Седмица
Хром /Cr/
Барий /Ba/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mg/kg
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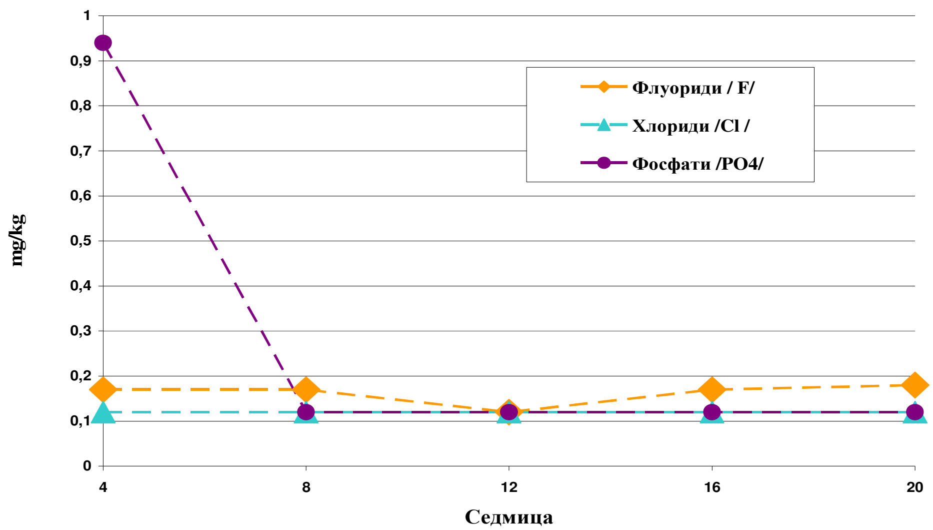
12
16
20
Седмица
Никел /Ni/
Молибден /Mo/



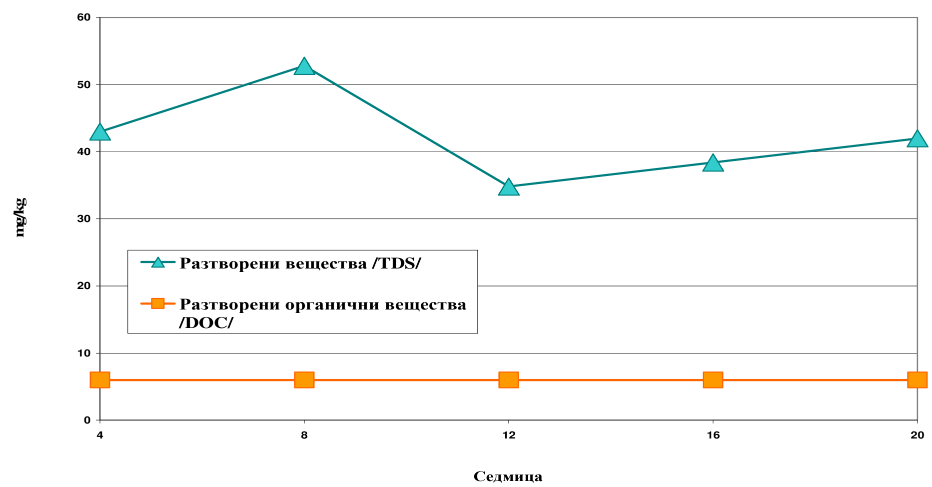
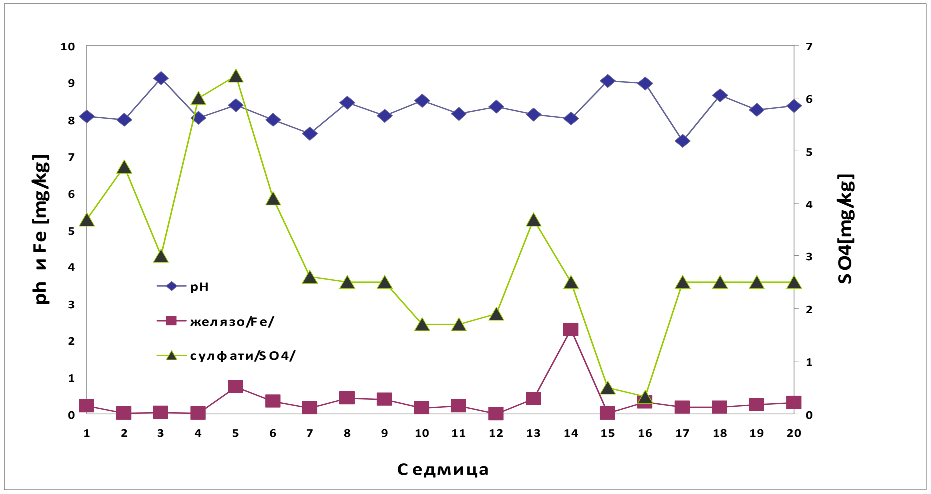
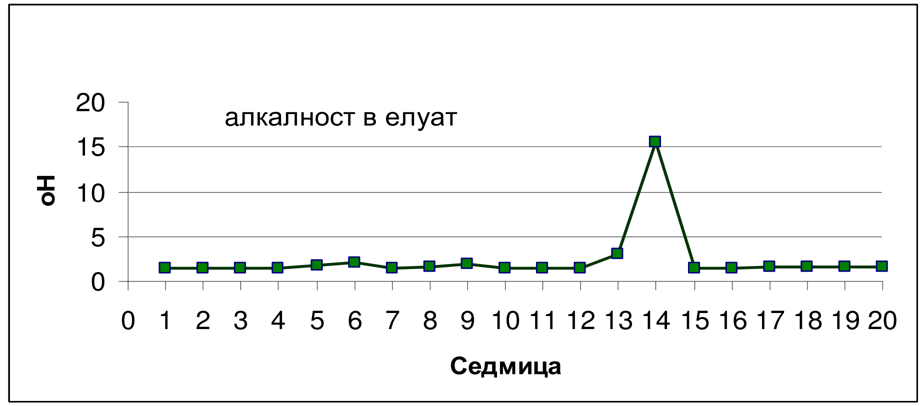


Fig. 4.2.7 – Behavior of the tested elements during the kinetic "humidity cell" test for weeks 4, 8, 12, 16 and 20 for sample **FLOTATION TAILINGS**

During the full analysis of the eluate every fourth week (Fig. 4.2.7) and the weekly data (Fig 4.2.8) for sample **FLOTATION TAILINGS** the following dependencies between its parameters have been established:

- constant concentration in the eluate of the following: cadmium, antimony, lead, mercury, nickel, molybdenum, chlorides, fluorides, dissolved organic matter;
- the concentration of the zinc and the copper gradually elevates in the period between week 4 and 20, where the elevation for the zinc is greater, which cannot be explained with change of the pH, as it remains in the alkaline range for the duration of the test;
- the concentration of barium and dissolved mater has a peak in week 8, and the chromium - the peak is in week 16, after which a trend towards decrease is noticeable;
- the concentration of the phosphates and the arsenic decreases for the period of the test.





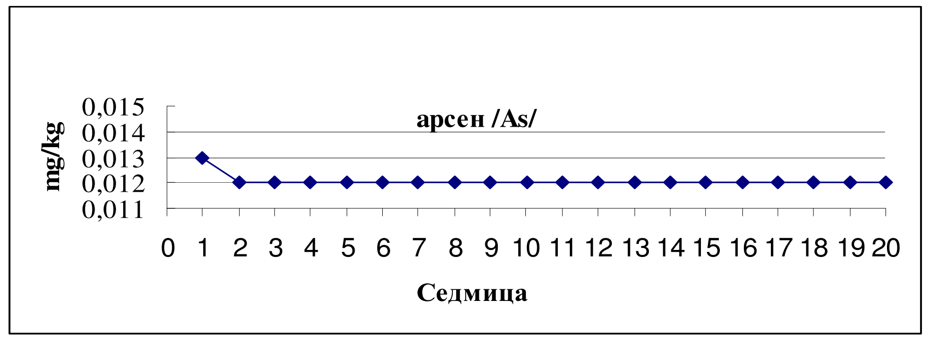


Fig.4.2.8 - Eluates Released from Week 1 through Week 20 – Tested Data for Sample **Flotation Tailings**

In the period week 4 to 20 for pH sample of the eluate stays in the alkaline range, and the values vary between 8,0 and 9,0. The alkaline environment favors the development of the autotrophic bacterium Thiobacillus thiooxidans, of which, according to available literature, the growth optimum pH is 2,0 to 2,5 (S.M. JIN, W. M. YAN,* AND Z. N. WANG, Transfer of IncP Plasmids to Extremely Acidophilic Thiobacillus thiooxidans APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Jan. 1992, Vol.58, No1, p. 429-430).

The conductivity potential of the eluate varies, but not in broad range.

FLOTATION TAILINGS is the sample of discarded material from flotation of Ada Tepe ore. The tailings sample contained ultra-fine solids, which was the reason to use 250 g instead of the typical 1000 g, which was the mass of the other tested samples. The behaviour of the waste during the test was different than that of the preceding samples, which could be attributed to its particle size. Overall, with the passing of time, the values of the weekly tested parameters tended to decrease while the tailings material maintained its alkalinity. The arsenic and the heavy metals are not in their mobile form as can be seen from the results received from the kinetic test, which explains why water sources containing these elements (as described in the Mining Waste Management Plan) and located in the vicinity are not contaminated, regardless of the elements' presence in the overburden.

4.3. Conclusions

Based on the humidity cell kinetic tests conducted on 4 samples from Ada Tepe, the initial esluate test data identified dissolved substances, which were the dissolved weathering products obtained diring the period from Week 1 through Week 20. It was established that:

- **The pH of three of the tested samples shows that the medium is alkaline and stays so for the entire test period, which is probably due to the fact that the neutralization potential available in the waste is enough to provide for pH>6 consistency in the conditions of the test.** The calcium and magnesium minerals have sufficient buffer capacity, which together with the low sulphide sulphur content determines the impossibility of occurrence of acid drainage, i.e. the acid potential for oxidation of the sulfates does not exceed the buffer capacity of minerals in the tailings. For the **ATEMET 70** sample, the initial pH of the tailings drops to 6.23 at the end of week 20, which is due to the fact that there is no calcite in the sample, only dolomite - 4%. When the pH is maintained at >6, the mining waste is non-hazardous to the environment according to the ASTM-Designation: D5744-07 - Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell (ATSM, 2007).
- The concentration of the sulphates and conductivity levels varied – **they decreased in time** for samples **ATEMET 068, ATEMET 069, ATEMET 070,** while for the **FLOTATION TAILINGS** sample they were more dynamic and started to drop **only after Week 6**, which could be attributed to the fact that the diffusion of oxygen through the sample probably improved during the dry air permeation cycle. Such an improvement in nearly dry conditions facilitates oxidation of components such as iron sulphide;

- The results for 20 weeks testing clearly show that in time the **concentration of arsenic in the eluate of all samples decreased**, except for **ATEMET 070**, for which reduction of the concentration begins in Week 12, i.e. **there is no risk of long-term leaching of arsenic in the eluate under the conditions of waste rock weathering.**
- The results for 20 weeks are that for all weeks in the eluate solution the following are liberated: iron, copper, sulfates, dissolved solids, and their concentrations either reduce or vary around a mean value, which is different for the 4 samples. Only the concentration of zinc in the eluate increased compared to the initial value.

In conclusion,

The results from the kinetic tests confirm the conclusions of the static tests, as well as those listed in the Mine Waste Management Plan, stating that the material has no potential to generate acidic drainage water, which is due to the low content of sulphide sulphur and the sufficient buffer capacity of calcite and dolomite in the tailings. Based on the results it can be concluded that the leachate quality has stabilized and the trend is to maintain low concentrations of leached elements.

In result of the tests made, we can **conclude** that no changes are expected to occur during storage of these tailings, where such could provide for the elevation of concentrations of the eluate elements tested, i.e. no negative impact can be expected onto the environment in the process of storage of this mine waste material.

5. References

- Underground Resources Act (URA), prom. SG 23/12.03.1999, last amendment SG 70/08.08.2008.
- Regulation on the Specific Requirements to Mine Waste Management (2009);
- ASTM-Designation: D5744-07 - Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell (ATSM, 2007).
- BS prEN 15875-2008: Characterization of waste. Static test for determination of acid potential of sulfidic waste
- CEN/TC 292/WG 8 Wastes from the extractive industry, Technical Report - Characterization of waste – kinetic testing for sulfidic waste from extractive industries"– Fourth draft
- Reference Document of BAT for Management of Tailings and Waste-rock in Mining Activities, Annex 4, EC, 2004
- Guidline to Directive 2006/21/EC,Friday, 21 August 2009, Definition of Inert Waste, Decision 2009/359/EC
- Regulation 3/2004 on the Classification of Wastes. 44/25.05.2004
- Regulation 3/08 on the Maximum Allowable Concentrations of Harmful Substances in the Soil; SG 71/12.08.2008)
- According to Commission Decision of 16 January 2001 amending Decision 2000/532/EC as regards to the list of wastes
- Commission Decision of 30 April 2009 for amendment of the definition of inert waste in connection to the application of Art. 22, para. 1, letter "e" of Directive 2006/21/EC of the European Parliament and the Council on the Management of Waste from Extractive Industries.
- Directive 2006/21/EC of the European Parliament and the Council dated 15 March 2006 on the Management of Waste from Extractive Industriesand for amendment of Directive 2004/35/EC;
- Regulation of the Manner and Order of Classification, Packaging and Labeling of Existing and Novelty Chemical Substances, Preparations and Products, (prom. SG 5/17.01.2003 , last amendment SG 66/30.07.2004, last amendment SG 50/2005, last amendment SG 57/2005, SG 20/2007 and SG 4 and SG 51/2008)
- Regulation 8/24.08.2004 on the Terms, Conditions and Requirements for Construction and Operation of Landfills and Other Facilities and Installations for Waste Recycling and Treatment (Prom. SG 83/26.10.2007), amended in SG 87/2007)
- MICON, based on data from Waters and Engineering Geology Dept., 1998
- Order 988/29.12.2006 of the MOEW on the methods for basic characterization of waste and for the testing of compliance provisions and main procedures for testing of waste, and for the requirements for on-site inspections, including methods for rapid testing of waste.
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- S. M. JIN, W. M. YAN, Z. N. WANG, Transfer of IncP Plasmids to Extremely Acidophilic Thiobacillus thiooxidans APPLIED AND ENVIRONMENTAL MICROBIOLOGY, Jan. 1992, Vol.58, No1, p. 429-430
- http://www.ehow.com/about_6060740_thiobacillus-ferrooxidans-growth.html

ПРИЛОЖЕНИЯ