**SYNOPSIS**

**of identified flaws in Amulsar mining related reports and studies**

**by Earth Link & Advanced Resources Development (ELARD)**

**and TRC Environmental Corporation (TRC)**

The following synopsis is based on a reading conducted from the original English version of *Environmental and Social Impact Assessment Review: Independent 3rd Party Assessment of the Impacts on Water Resources and Geology, Biodiversity and Air Quality,*  published on the website of the Republic of Armenia Investigative Committee as part of a criminal case.[[1]](#footnote-1)

First, some background. The history of Lydian’s Corporation’s interest in establishing an open pit mine in Amulsar has been well documented. During the entirety of this process there has been ongoing opposition to the project on the grounds that the mine represents a dire threat to the health of local residents as well as to the regional environment. In addition, those opposed to the mine have repeatedly warned of the dire long term adverse **economic** consequences as a result of the mine, leaving behind a region completely bereft of employment opportunities and an environment denuded of its flora and fauna.

Subsequent to these opposition efforts, criminal charges were filed against the then Ministry of Nature Protection, for withholding critical evidence regarding the hazards of the mine. This got the Investigative Service of Armenia involved in the process of conducting an investigation and who then contracted Earth Link & Advanced Resources Development (ELARD) and TRC Environmental Corporation (TRC) whose work was carried out in the framework of this criminal investigation. Following the assessment by ELARD-TRC, the Investigation Service of Armenia found no criminal wrongdoing on the part of the Ministry of Nature Protection.

What has followed however, with the release of the report, is that now the public has access to the analysis conducted by ELARD-TRC regarding the methodology, processes, procedures and conclusions of the original ESIA conducted by conducted by Global Resource Engineering Ltd (GRE). This analysis is significant it is replete with omissions, inconsistencies, inaccuracies, false and fraudulent reporting and a host of other spurious inclusions which, totalled, can best be described as “unscientific”.

What follows are excerpts from the ELARD-TRC report. The report from ELARD-TRC team covers the areas of Water & Geology, Biodiversity and Air Quality. The italicized bold sections indicate where the original Environmental and Social Impact Statement (ESIA), conducted by Global Resource Engineering Ltd (GRE) lacked clarity, completeness, scientific validity and so on.

***It does not cover the legal processes involved in obtaining licensure from RA Government and whether they were properly conducted. The legal processes cover a wide range of due process considerations, including those related to the current public opposition, centered in Jermuk, to the mining operations.***

This synopsis covers 8 broad sections listed below. They are simply referred to hereafter, in the synopsis as Sections 1, 2, 3 etc.

Section 1.3:

 -Bases & References Section 1

Section 2.1: Water & Geology

 - Structure & Amulsar Tectonic Block Section 2

 - Assessment of ESIA Characterization of ARD Potential Section 3

- Seismic Hazard Potential Section 4

- Hydraulic Conductivity Section 5

- Surface Water Hydrology Section 6

 Subsection 2.2

- Biodiversity Section 7

 Subsection 2.3

- Air Quality Section 8

TOR Questions & Responses # 1, 4, 5, 6, 8, 9 & 10

This synopsis does not cover “Summaries, Conclusions and Data Gaps” as these are essentially covered in the body of the synopsis.

This synopsis does not cover all the answers to Questions in the TOR. Included were the most significant in this current climate. These include # 1, 4, 5, 6, 8 & 10. Responses have been bulleted for ease of reading and understanding.

For the casual reader of this Synopsis, the Reviews for each Section immediately follow below with greater details provided in the main body of the Synopsis starting on Page 19.

SYNOPSIS SECTION REVIEWS

SECTION 1 BASES & REFERENCES ANALYSIS

The first section covered (pages 5-12) provided background on the data and information gathering phase to ELARD-TRC. Of note is the specific use of words such as “purported”, “purportedly” and “suggested to be”. These indicate that the information cannot be positively concluded to be valid as the information provided, may/may not be inaccurate, false or incomplete. ELARD-TRC suggests that in the Review Section (page 5) when they state:

***We understand the assessment may be limited because ELARD-TRC Team may have not been provided or may have not reviewed all the relevant information, data, and analyses.***

I would imagine this is a standard conditional disclaimer used frequently in this business but considering the past behavior of mining companies and the RA Government’s routine complicity in violating the RA Constitutional requirements regarding licensing and operating of mines, this statement takes on greater weight.

SECTION 2 STRUCTURE & AMULSAR TECTONIC BLOCK ANALYSIS

The section covered the area of tectonic activity in the area. The Amulsar mine is surrounded by 3 separate fault lines. The original ESIA provided to ELARD-TAC essentially concluded that in the event of seismic activity there was no danger of leaking toxins contaminating the areas fresh water resources as the Amulsar mine is a single autonomous block, surrounded by thrust faults that would naturally prevent leakage into these water sources. The water sources mentioned include:

* Lake Sevan
* Jermuk
* Kechut Reservoir
* Darb River
* Arpa River
* Vorotan River

The ELARD-TAC analysis took issue with the analysis of the original ESIA pointing out, among other discrepancies that:

1. Data analysis was conducted only on the high elevation areas in the vicinity of the mine itself. Areas of lower elevation, where groundwater is likely to move toward was not surveyed. As the report indicates:

***if geologic data are lacking for areas beyond the ridge or were obtained but not integrated into the conceptual model, this deficiency translates to poor understanding of the subsurface between sources and receptors of groundwater contaminants.***

***For such an environmentally-sensitive area, the omission of illustrations of the structural and stratigraphic relationships across the Project Area is a serious shortcoming in the ESIA conceptual model.***

***The ESIA description of the local geology is disorganized, incomplete, and incomprehensible without reading the original documents…...This conceptualization is unrealistic given the occurrence of folds and thrusts on the ridge and the existence of bordering rivers that are structurally controlled***

1. In regards to the project area itself, data is also incomplete and/or inaccurate. The ELARD-TAC report states:

***Detailed surface geologic mapping is lacking for the remainder of the Project Area.*** ……. ***One explanation for the absence of faults on surface geologic maps is that little effort was expended beyond the area of economic interest.***

1. Areas of the mining project outside of the ATB can also be adversely affected by leaking toxins. For example:

 ***A large part of the Kechut Reservoir is within the ATB near its northern vertex. Potential seepage to groundwater from the part of the BRSF north of the Zirak Fault could result in contaminated groundwater reaching the Madikenc springs. Contaminated groundwater below the mine pits can flow to the Darb and Vorotan Rivers.***

1. In the most damning statement in this section, ELARD-TAC went so far as to underline

one particular section:

However, with part of the BRSF and most of the mine pit areas outside the ATB, i***t is incorrect to state that the mine cannot impact regions (including fresh water springs) adjacent to the ATB.***

Additionally, f***aults may be conduits of groundwater flow***. Under such a setting, ***the Agarakadzor fault could conduct contaminated groundwater to the Darb and Arpa Rivers.*** Similarly,t***he Zirak Fault could conduct contaminated groundwater, including potential seepage from the BRSF (elevation approximately 2,600 m), to the Kechut Reservoir (elevation approximately 1,950 m) and/or the Vorotan River*** (elevation approximately 2,200 m at the projected intersection of the Zirak Fault).

1. In the case of Jermuk and the protection of the springs, the report indicated that, given the geologic information is correct:

***a probable hydraulic boundary.*** Even with part of the BRSF being north of the Zirak Fault, ***seepage from the BRSF will not reach Jermuk.*** Finally, Jermuk is northwest of the trace of the Kechut fault, which ***may also be a barrier to groundwater flow.***

SECTION 3 - ACID GENERATION AND METALS LEACHING POTENTIALS ANALYSIS

The analysis by ELARD-TAC indicates that the original ESIA was lacking, across the board in both accuracy and completeness of its research and findings. This section is replete with characterizations, of the original ESIA, such as:

* ***reveal little about specific mineralogic and rock characteristics…..***
* ***The number of samples is insufficient***
* ***The lack of correlation between rock sub-types and mineralogic data has repercussions for all other testing.***
* ***reveal significant variations …..***
* ***No mineralogic analyses were performed on….***
* ***There are no analyses of….***
* ***Unfortunately, none of the results can be related to rock sub-types with characteristic mineralogy and, and the results cannot be used to assess whether one particular sub-type suggests greater risk than another, which would be useful in selecting samples for other tests.***
* ***None of the existing static test results can be related to …..***
* ***This approach is clearly incorrect***.
* ***Negative values of NPR (impossible)*** ….
* ***No HC tests were performed for the Erato pit area. This data set is inadequate to cover the range of rock sub-types…..***
* ***None of the HC test results can be related to rock sub-types……***
* ***Noteworthy is the lack of NAG effluent testing for Tigranes/Artavazdes spent ore.***
* ***...the ESIA states that the VC is not acid generating.*** Appendix 4.6.2 ***Tables A-1 and A-2 show that there are many VC samples with significant pyritic sulfur, more than double the‎ cited‎“low‎total sulfide ….***
* ***ESIA suggests that the HC tests would be conducted for up to a year.*** ***Four of the tests were terminated at 20 weeks.***
* ***not been given sufficient time to determine final pH***
* ***It cannot be concluded that the ARD potential of the VC does not translate into ARD generation. Two of the HC tests on VC were terminated prematurely.***
* ***The leachate from the Site 27 Soviet era waste pile has a pH of 3.3 and high acidity. These data are a reasonable indicator of the potential of the ARD from the Amulsar Mine.***
* ***…..the objective of determining how fast the rock generates acid was not met, and that it will be necessary to redo the experiment.***
* ***Considerable release of stored acidity in secondary minerals is probable.***
* ***Unclear is how much additional oxidation occurred between December 2017 and May 2018***
* ***The results of the entire characterization program should be viewed with caution.*** ***Although all the basic types of characterization were performed, there appears to be little planning and continuity in the approach.***
* ***The conclusion……..is suspect***.
* ***The statement that two reactions are responsible for acidity from pyrite (FeS2) is incorrect.***
* ***However, GRE (2017) leaves out the ferrous iron oxidation reaction altogether, and in doing so leaves out half of the acid generating reactions in ARD. This significant oversight brings into question Lydian‟s assessment of acid generating potential of the rock and of the water quality in the ARD.***
* ***The GRE (2017) discussion of pyrite oxidation neglects half of the acid-generating reactions (Reactions 2 and 3) and thereby underestimates the potential ARD loading of the waters at the Site (for pH > 3.2) and the treatment needed to mitigate the corresponding impacts.***
* ***The GRE (2017) interpretation does not provide an explanation for the source of ferric iron to oxidize the pyrite.***
* ***The GRE (2017) assessment is misleading.***
* ***GRE (2017) assessment of ARD reactions that would occur in the Amulsar rocks is misleading because the analysis***:
* ***Underestimates the potential for ARD generation and the associated water quality, environmental impacts, and water treatment requirements.***

There are over 30 instances of misleading, inaccurate, incomplete, underestimated, neglectful “science”.

The bottom line is that the original EIA drastically underestimated, or did not estimate at all, the potential acid production and runoff produced as a result of the mining activities. It is not hyperbolic to say that the findings from Lydian could all be called into question as their methodology clearly has serious shortcomings.

SECTION 4 SEISMIC HAZARD POTENTIAL ANALYSIS

This section is relatively simple to analyze. There are  ***17 fault zones with a total of 53 fault segments within approximately 250 km of the project site.*** And that….***the ESIA) shows that the Project Area is surrounded by the epicenters of the historic earthquakes and “fault‎ seismic‎ sources”.***

Furthermore, ***the PSSF4 makes a strong contribution to Project Area seismic hazard because the PSSF fault system is the longest active structure in the RA with the greatest slip rates and strongest earthquakes*** (Golder, 2013).

Questions arising from this section are related to the structural integrity of mining structures including the tailings dams and other areas containing anything dangerous to the surrounding water ecosystems. Is it reasonable to expect that Lydian can guarantee for 100s of years that their structures can withstand all natural forces of nature, including catastrophic seismic events?

SECTION 5 - HYDRAULIC CONDUCTIVITY ANALYSIS

As with all the sections excerpted above, Section 5 begins with examples of serious omissions in the conduct of thorough scientific data gathering. The first example states:

***No pumping tests were undertaken, which is a serious omission in the characterization of hydraulic properties.*** Pumping tests are a standard procedure for hydraulic characterization and are indispensable for fractured rock…….***Pumping tests should have been performed in the areas of the mine facilities and pits at various depths, as well as several in each rock type across the GSA.***

Which leads to this rather blunt conclusion from ELARD-TRC:

***The calculated geometric means of [local] hydraulic conductivity*** (Table 4.8.1 of the ESIA) and the summary of [local] hydraulic conductivity values for impact assessment (Table 4.8.2 of the ESIA) ***are meaningless for comparisons of rock types***, unrepresentative due to the large ranges, and ***especially unreliable for assessments***.

Regarding the original ESIA’s lack of establishing any sort of scientific reliability on areas of “fracturing”, they state:

***Widespread fracture permeability, including bedding-plane fractures, is an important factor in groundwater flow and rates of transport throughout the GSA. The significance of this phenomenon cannot be understated. Transport of contaminated groundwater is many orders of magnitude greater in fractured media over porous media. The extent of connectivity of fractures, however, determines whether rapid flow and transport occur. Only through conducting pumping tests and groundwater tracer tests can fracture connectivity be assessed.***

Notice in the above paragraph the sentence, “The significance of this phenomenon cannot be understated”.

Regarding the surrounding springs, the ELARD-TRC team reiterated their earlier claim that the Jermuk springs are safe from mining activities in regards to water contamination as they are ***“well outside the GSA***.” Again, this data is contingent on the original geological surveys being accurate.

SECTION 6 - SURFACE WATER HYDROLOGY ANALYSIS

Early in this section ELARD-TRC included this statement and clarification in their report.

***Lake Sevan is protected by Armenian law which permits no activity that may negatively impact the lake and its ecosystem. The BRSF lies within the “immediate impact zone” of Lake Sevan.***

The BRSF is the Barren Rock Storage Facility that will be constructed to contain all of the lower grade “waste” rock produced at this open pit mine. The issue with the BRSF is the potential of toxic liquids being produced after contact with precipitation or other liquid sources. This facility is “permanent” in that it is supposed to successfully contain all harmful liquids until they become inert. The time frame in question is measured in generations, not a few decades. This is significant if one considers the seismic potential in this area.

In regards to what constitutes a “negative impact” on Lake Sevan, this is beyond the scope of the TOR and is a more suitable question for the Armenian Government and its people.

The modeling used in the original ESIA to determine seepage of polluted liquids from the mine, was shown to be problematic by ELARD-TRC. They point out that,

***The results of the 1D models are incorrect (GRE, 2014a Table 2).***

***Another problem with the Table 2 (GRE, 2014a) results is the water balance. The net infiltration based on the tabulated numbers is incorrect. Particularly large discrepancies are evident for both uncovered backfill scenarios.***

***Another problem with the Table 2 (GRE, 2014a) results is the water balance. The net infiltration based on the tabulated numbers is incorrect. Particularly large discrepancies are evident for both uncovered backfill scenarios……..However, the results for the Artavasdes pit are unclear with respect to the information presented on mine planning.***

***Results for the Arshak pit are incorrect.***

***The fluxes from the pit seepage modeling are incorrect. Use of these fluxes in the regional groundwater flow model results in incorrect assessments of impacts to groundwater levels and springs. Furthermore, solute transport simulations would severely underestimate potential impacts to groundwater and springs from acid mine drainage.***

In regards to a Regional model they note,

***Noteworthy is that the model was not used as a tool in the planning phase of locating mine facilities for minimizing risk to the environment***

 ...the Darb and Vorotan Rivers. ***These perennial streams should have been included***

***in the model.***

**A potentially unnecessarily long no-flow boundary was used along the southern perimeter, forcing flow parallel to this boundary to the northwest and southeast…..*The impact of the long no-flow boundary on simulated flow from Amulsar Peak cannot be determined based on available information.***

***each of the five hydrogeologic units is represented by a single set of hydraulic properties,*** i.e., all six model units are numerically homogenous, ***in spite of the hydraulic test data showing 4 or more orders of magnitude variation in hydraulic conductivity for each rock type.*** ***This deficiency can have a significant effect on the model predictions (e.g., will not identify preferential flow pathways).***

***The geology in the pit areas is poorly represented. Faults are completely absent in the model……...Some faults may be conduits for groundwater flow.***

***The simplistic numerical representation of the subsurface in the existing model is inadequate for making quantitative predictions. Notwithstanding this inadequacy, numerous quantitative predictions, which are unreliable, were made.***

***...Twenty-two of forty-one calibration targets (54%) have errors of 25 meters and more, and fourteen targets (34%) have errors of 40 meters and more, ranging up to 96 meters (twice the maximum recorded seasonal range in water levels)......is unreliable.***

***Despite the large model water level errors, the model was used to estimate operational water levels beneath the BRSF area (simulated baseline water level errors up to 80 m), the HLF area (simulated baseline water level errors up to 37 m), and the mine pits…...With such large errors in calibration water levels, the model is a poor indicator of head above ground surface and a poor indicator of the effects of mining activities on groundwater levels and groundwater flows (springs, river discharges, pit inflows).........Golder (2014a) acknowledges the model‟s ‎inability to predict pit inflows, yet pit inflows and the impacts of pit dewatering on water levels and on springs discharges and river flows were reported.***

Note above. The model used in the original ESIA was acknowledged by the company conducting the assessment as unable to be accurately predictive, yet the data was delivered anyway.

This section concluded with a note from ELARD-TRC, specifically regarding Solute Transport Solutions, but one which generally sums up the original ESIA from Lydian.

 ***This approach is not good science.***

The following from Page 57 to to Page 85 will consist solely of short excerpts detailing the findings, methods, processes, and other questionable activities of the Lydian assessments

:

* ***Elaborate schemes were devised***
* ***calculations…….that are too low***
* ***rates to groundwater are underestimated due to seepage rates from the pits that are too low***
* ***did not include descriptions of sampling methodologies or analytical methods or standards.***
* ***Moreover, no other information or details were provided about***
	+ ***the monitoring points or***
	+ ***about human or***
	+ ***other activities or***
	+ ***climatic conditions near the monitoring points.***
* ***some parameters are questionable and/or have very high uncertainty***
* ***evapotranspiration is much too high and infiltration and runoff are correspondingly low.***
* ***a number of the measures and plans***
	+ ***are partial***
	+ ***not-sufficiently protective***
	+ ***and/or unreliable with a high degree of, particularly due to***
		- ***deficient and questionable data***
		- ***models***
		- ***model simulations***
		- ***design bases***
		- ***and/or assessment.***
* ***There is clearly potential for contamination of groundwater by ARD-impacted pit seepage water***
* ***There are no contingency plans to mitigate groundwater contamination***
* ***no details are provided***
* ***key liner design criteria are unreliable***
* ***There are no descriptions of the decision-making process or details***
* ***Lydian provided no details or protocols for this approach***
* ***there is little discussion on the incoming nitrate concentrations, and no discussion of ammonia.***
* ***The incoming water is inexplicably projected***
* ***There are three major concerns with the proposed PTS design bases***
* ***may or may not be valid. If the simulated water quality is not valid, then the system will most likely fail***
* ***modeling has significant discrepancies***
* ***the treatment process for the ammonia is not discussed***
* ***did not elaborate the rationale or feasibility for using a passive system during mine operation.***
* ***The major concern is that the whole system depends on the accuracy of the initial water model***
* ***There are many places where this model could be off***
* ***there is no certainty that the proposed system would work***
* ***To select at PTS…..without a definitive analysis and actual measurements of the influent water quality is incorrect.***
* ***There are discrepancies***
* ***Iron concentrations are too low – key parameter for system as designed***
* ***the current design may not be able to treat the ARD***
* ***unrealistically low***
* ***does not include***
* ***The discrepancy and high uncertainty in iron concentrations does not give confidence in the modeled water quality***
* ***raises concerns about the certainty and reliability of other parameters***
* ***results have significant inconsistencies***
* ***This error is higher than the acceptable***
* ***is unrealistic as demonstrated***
* ***discrepancies further raise concerns about the reliability of the model projections and water quality.***
* ***was not appropriate for this water quality.***
* ***This discrepancy is further elaborated***
* ***This discrepancy in sulfate concentrations raises concerns and further increases uncertainty in the system design.***
* ***The modeled water quality is dependent on a number of factors that could be different from that originally modeled.***
* ***this will alter the proposed water quality projections***
* ***nor has there been much effort made to evaluate the changes in water quality after the mine pits are closed***
* ***Such changes highlight the uncertainty in the water quality modeling***
* ***no ability to adjust the system for high iron and aluminum concentrations if the modelling is not correct.***
* ***A key discrepancy is that the design...***
* ***The testing did not address ….***
* ***it is not clear from the reports…***
* ***these values are significantly over the criteria for surface water***
* ***These numbers are questionable since…***
* ***there is no projected concentration for….***
* ***there is no discussion of how….***
* ***The calcium and sodium concentrations in the laboratory testing are not representative of field solutions.***
* ***This is unrealistic….***
* ***did not estimate the concentration of nitrogen….*** ***saying the analysis was outside the scope of the memorandum.***
* values in Table 2.1.8 are ***inconsistent.***
* ***These values are simply incorrect as presented***
* T***he values shown in the Table 2 are questionable.***
* ***the charge balance results are inconsistent with the water quality***,
* t***he use of its questionable water quality data to model the water quality of the final leach solution***…….***is problematic and untenable.***
* ***then inexplicably disappearing.***
* ***There are no contingency plans in case of the PTS failure***
* ***The projected water quality……..is unrealistic.***
* ***tests that were not designed and not appropriate for assessment of environmental impacts***
* ***the water quality results have internal inconsistencies indicating that some of the results are incorrect.***
* ***There is no indication of how***
* ***The reports are not clear on how the HLS will be treated...thus it is difficult to determine whether treatment will be successful or what the impacts are…..***
* ***The seismic hazard risk is high for the Project Area.***
* ***could conduct ARD-impacted seepage water from the BRSF toward the Kechut Reservoir and/or to the Vorotan River.***
* ***….resulting in contact water being released to surface water and groundwater.***
* ***…..Any exposed PAG rock on pit walls or in the BRSF, HLF, or pit backfill due to earthquakes could impact the environment for hundreds, or possibly on the scale of a thousand or more years.***
* ***Historic landslides surrounding the Amulsar Mine are not documented in the ESIA, EIA, or supporting documents.***
* ***some cost items are questionable and the overall cost appears to be underestimated.***
* ***only five years……. post closure costs should be calculated for a revolving 30-year period (minimum), especially when contamination sources remain……***
* ***result in significantly underestimating the post closure costs.***
* accordingly, the unadjusted cost for the PTS OM&M alone for 30 years will ***be approximately $33.4M***. The total cost will likely be higher …...***approximately $40.5M***
* ***the total rehabilitation and closure cost would be estimated to increase to approximately $78M.***
* ***Treatment scope and costs are unrealistic***
* ***Professional/technical costs***…...***are underestimated***.
* ***The EMP does not specify locations or details of future monitoring***
* ***Notably, no locations on the Darb River or north of the Kechut Reservoir (including Jermuk) were sampled.***
* ***These omissions are unjustified, especially for a deficient baseline dataset***
* ***is deficient in springs sampling locations***
* ***This sampling program is unacceptable***
* ***There are no time-concentration graphs.***
* ***There is no discussion of results with respect to previous results and no discussion of analytical methods.***

There are 97 negative ascriptions applied after Page 57 of the assessment. This is a conservative count but should provide another clear indication of the issues with the original ESIA.

SECTION 7 - BIODIVERSITY ANALYSIS

Generally speaking this section was the most compact and straight to the point. There were issues with mapping, surveying and properly referring to the latin genus/species of the various flora and fauna to be found in the area affected by the mining operation.

1. There are issues with mapping, surveying and properly referring to the latin genus/species of the various flora and fauna to be found in the area affected by the mining operation.
2. Gaps exist throughout the entire section in the assessing of impacts on insects, reptiles, birds, bats, mammals, plants species and others.
3. Gaps exist throughout the entire section in the development of effective measures to mitigate the impacts on all the flora and fauna above mentioned.
4. The lack of Biodiversity Action and Monitoring Plans, which are essentially non-existent. As the assessment states:

***The biodiversity management plan is missing the operational section and map detailing the measures, their location, how to implement and who is responsible for implementation, and mostly how will those measures reduce the impact of each receptor***

1. The original ESIA relies on promises of action to protect species by relocation, in the vaguest sense and **without** any adherence to the viability of moving of species, particularly the vipers.
2. The idea of establishing a Jermuk National Park was mentioned by the original ESIA as the main offset for the project but again without detail, action plan or seemingly **any real intent.**
3. the fact that ….***the mitigation and offset measures do not enable to convincingly reach the No Net Loss and Net Gain on biodiversity as claimed, and some major impacts have been underestimated***
4. ***the offset program cannot be in development phase when the ESIA has been finalized.***

Additionally, not mentioned were:

1. Adherence to the Bern Convention and the Habitat’s Directive. The ELARD-TRC report basically glazed over this part.
2. Apparent inconsistency in the ELARD-TRC report regarding violations of International Law (Bern and Habitat’s directive) and National law (RA Law on Flora and Fauna). Balkani clearly believes both were violated and that the ELARD-TRC assessment clearly leads to this conclusion, but neglects to state it.
3. A major gap not mentioned by ELARD-TRC is that….. concerning mapping and assessing of impacts that were not completed on natural habitats and species according to the Bern Convention.
4. The process to establish Jermuk National Park has been stopped and was not mentioned by ELARD-TRC
5. Impacts on certain species were not assessed by the ESIA, and were not mentioned by ELARD-TRC. These include:
	1. bezoar goat
	2. Mouflon
	3. Leopard
	4. Indian crested porcupine

SECTION 8 - AIR QUALITY ANALYSIS

 The main area of concern is in its approach to Modeling the Effects of Boilers and Gold Ore Processing on the air quality. Their modeling was deemed “not adequate” for accurate scientific measurements.

***In summary, the model is not adequate for this assessment even though it is requested in the Republic of Armenia.***

TOR QUESTIONS AND RESPONSES

TOR Question #1: Are the assessments presented by Lydian in the ESIA and EIA Reports and in the appendices attached to them sufficient, qualified, scientifically justified and comprehensive, or not; did the conclusions, derive from the reliable and actual data and was the methodology developed for these conclusions comprehensive and reliable? Response:

* ***Most tools used in the assessment are suitable*** and are consistent with acceptable and standard practices.
* ***However,*** key elements of the ***assessments are inadequate, deficient, and inaccurate***.
* ***Baseline data deficiencies abound*** for geology, ARD characterization, hydrogeology, surface water and springs flow, and surface water and groundwater quality.
* ***Deficiencies led to questionable simplifications and interpretations.***
* ***Models for assisting with the assessments are oversimplified, incorrectly parameterized, procedurally incorrect, poorly calibrated, and not conservative.***
* ***Key data, conceptualizations, and modeling approaches are unreliable***
* ***impacts assessments are incomplete, leading to conclusions that are unreliable with a high degree of uncertainty.***
* (However) Good isotopic data were acquired, from which reliable conclusions can be reached.

TOR Question #4: Which risks, in particular, were not taken into account in terms of environmental security in the ESIA and EIA Reports? What dangers to the environment and to the health of the population may occur as a result of their omission? Are these possible negative consequences recoverable, or not, and if they are, what time frame and what type of financial resources would be necessary? Response:

* ***Known faults within the Project study area were not considered in the seismic hazards analysis.***
* ***Movement on the seismically-active PSSF fault system could cause fault slip in the study area, potentially compromising the liner beneath the BRSF and the cover and destabilize the waste rock pile (Zirak Fault beneath BRSF).***
* ***This fault could conduct ARD-impacted seepage water from the BRSF toward the Kechut Reservoir and/or to the Vorotan River.***
* ***Fault slip on the Agarakadzor Fault passing through the vicinity of the pits and BRSF could also impact the stability and integrity of the BRSF and pit backfill and cover systems.***
* ***Ground motion could also impact the stability of the HLF, liner, and cover and inflict damage on the contact water channels, ponds, and PTS, potentially resulting in releases of impacted water to surface water and groundwater.***
* ***The potential significance of fault and fracture flow in the groundwater study area was not considered in the analyses of potential impacts to the environment.***
* ***Solute transport is many orders-of-magnitude faster in fractures than rock and sediment matrices, with much less attenuation.***
* ***ARD-impacted groundwater could be rapidly transported to springs, streams, and rivers, potentially impacting community water supplies and livestock grazing activities.***
* ***Covers on the BRSF and pit backfill can be restored, if impaired by earthquakes. Breached liners beneath the BRSF and the HLF would be a challenging problem to address, requiring temporary or permanent relocation of the rock and spent ore.***
* ***A destabilized BRSF and/or pit backfill could result in permanent loss of the nonacid generating VC layer of rock between the cover and the PAG rock.***
* ***Any exposed PAG rock on pit walls or in the BRSF, HLF, or pit backfill due to earthquakes could impact the environment for hundreds, or possibly on the scale of a thousand or more years.***
* ***The concentrations of key constituents in contact water (e.g., iron, aluminum, nitrate, ammonia, and sulfate) are underestimated, which may cause the PTS to fail (unless redesigned or augmented).***
* ***Such failure may result in the release of contaminants to the environment (surface water and groundwater) at concentrations exceeding RA discharge criteria/MAC standards.***
* ***Mitigation measures for the Mine pits are limited to periodic pumping during operation and backfilling and the placement of an ET soil cover post closure.***
* ***Contingent and supplemental measures are necessary to mitigate ARD impacts on the groundwater quality.***

TOR Question #5: Is there any interaction between Amulsar water basin, the adjacent underground and the surface water, rivers, water reservoirs, SpandaryanKechut water reservoir hydro-technical structure and Jermuk mineral water reservoir, or not? Response:

* ***Groundwater flow and contaminant transport pathways between the Project Area and the Jermuk thermal springs do not exist.***
* ***Rivers and tributaries surrounding and within the Project Area are connected to groundwater. Groundwater discharges from the Project Area to springs and rivers.***
* ***Releases of untreated Mine contact water can contaminate groundwater and can reach and impact surface waters.***
* ***Groundwater from the Project Area also discharges to the Spandaryan-Kechut tunnel through sections of the tunnel where the walls/joints are leaky (i.e., areas of direct hydraulic connection between the groundwater and the tunnel)...... direct discharge of groundwater to the reservoir does not occur.***
* ***However, groundwater that discharges to springs, streams, and the Spandaryan-Kechut tunnel will flow into the reservoir. If a deep aquifer underlies the volcanic rocks in the area, interaction between groundwater in the volcanic rocks of the Project Area and the deep aquifer is unlikely. Groundwater originating in the Project Area by local infiltration of precipitation discharges to springs and the Arpa, Darb, and Vorotan Rivers and their tributaries.***

TOR Question #6: Is the data on sulfide compounds in the rock, presented in the ESIA and EIA, calculated correctly, or not, are the control methods of the acid drainage scientifically justified, or not, can they effectively prevent acid drainage water into the environment? Response:

* ***The acid-generating potential of the rock was calculated incorrectly***
* ***The methods to limit acid mine drainage are scientifically justified, but they cannot completely prevent ARD.***
* ***Pore space between these various rock particles will permit infiltration. Consequently, some ARD may occur.***
* ***Furthermore, the mine pit walls and bottom will be exposed and will permit seepage of accumulated water into the groundwater.***
* ***The design criteria of the clay liner under the BRSF are questionable and raise concerns about the integrity and protectiveness of the liner.***

TOR Question # 8: Can the waters flowing from acid drainage come into contact with surface and ground water systems? If so, how, in what period of time and with what consequences can this potential leakage contaminate surface and underground water systems, including those of Jermuk, Vorotan and Arpa rivers, adjacent tributaries and streams, Spandaryan and Kechut water reservoir hydro-technical structure, Lake Sevan, as well as change the chemical content of water and what consequences will occur as a result of this impact? Response:

* ***Under conditions resulting from earthquake impairment of the BRSF, ARD impacted groundwater could discharge at the northern end of the Spandaryan Kechut tunnel, resulting in impacts to Kechut Reservoir and potentially Lake Sevan through the Kechut-Sevan tunnel.***
* ***Likewise, impacted groundwater could discharge to springs and streams at the northern end of the Project area, in turn discharging to Kechut Reservoir.***
* ***The transit time of this groundwater cannot be estimated with available data.***
* ***Direct discharge of groundwater to the Kechut reservoir will not occur due to downward vertical hydraulic gradients beneath the reservoir.***
* ***ARD-impacted groundwater will not reach Jermuk.***
* ***Earthquake damage to HLF, process ponds, BRSF liner, and contact water channels could release impacted water to groundwater and potentially directly to the stream in the vicinity of the HLF.***
* ***A release to the stream would impact the Arpa River within a few hours.***

TOR Question #9: Has the extent of potential environmental damage, resulting from the exploitation of the mine, as well as the timeframe and cost of the mine's reclamation been properly calculated and subsequently justified in the EIA and the ESIA reports?

Response:

* **See the response to question xiii regarding environmental damage**.
* ***The total cost for Mine rehabilitation and closure and the duration of the post closure monitoring are underestimated as noted below:***
	+ The post closure operation, maintenance & monitoring ***(OM&M) period is limited to only five years***. In the US, Federal and State regulatory requirements and guides for closure (e.g., RCRA 40 CFR Part 264.117; Nevada NAC 445A.446; USEPA, 2000) indicate ***post closure costs, especially when contamination sources remain, should be calculated for a revolving 30-year period (minimum)***.
	+ Post closure costs should include routine OM&M activities as well as periodic replacement, maintenance and repair actions that ***will be required after 5 years, which can be significant.***
	+ The reduced post closure monitoring period and ***the omission of periodic replacement/repair costs will results in significantly underestimating the post closure costs.***
	+ ***Increasing*** the post closure monitoring period from 5 years in the ESIA ***to the conventional 30-year period***, the total Mine rehabilitation and closure cost will increase from approximately $34M to approximately ***$70M*** ***(without adjustment for periodic replacement costs or realistic contingency) .***
	+ ***Contingency (scope and bid) is too low at 6% and underestimates the actual Mine rehabilitation and closure cost***.
	+ The USEPA (2000) and AACE (2008a; 2008b; 2009) cost estimation guides indicate that ***at this level of project development*** (pre-feasibility) and the ***high degree of uncertainty (e.g., unreliable data and PTS and need for additional studies, etc.) the contingency will likely exceed 20%.***
	+ The Amulsar feasibility study (SGS, 2014 Table 21.5) used 16% for the initial capital phase. ***Using a realistic contingency of 20% instead of the ESIA 6%, the total indirect cost percent would increase from 21.3% to 35.3%.***
	+ Accordingly, ***the total Mine rehabilitation and closure cost will increase from approximately $34M (for the ESIA 6% contingency and 5-year post closure monitoring period) to approximately $78M (for 20% contingency and 30-year post closure monitoring period) without other adjustments.***
	+ ***Treatment requirements are likely unrealistic (actual costs are likely higher) due to incorrectly assumed low leachate concentrations and mass loading.***
	+ Technical/professional costs (design/engineering, project management/ administration, and construction management) are underestimated at about 3% of total construction cost. USEPA (2000) indicates these costs are commonly greater than 15% for similar projects. The Amulsar feasibility study (SGS, 2014 Table 21.5) used 10% for the initial capital phase. Using 15% for these services would increase the total rehabilitation and closure cost by an additional amount on the order of $4M to $5M.

TOR Question #10: Taking into account the location of Amulsar mine, its geographical position, adjacent residential and health resort areas, can the exploitation of the mine with all of its processes of open pit mining, heap leaching and barren rock storage facility, be conclusively considered safe, and if not, what type of environmental damage can this result in? Response:

* ***The ESIA/EIA assessments are deficient and corresponding conclusions are unreliable. Accordingly, the question of whether exploitation of the ore deposit can conclusively be considered safe cannot be answered.***
* ***The question about environmental damage is answered in responses to previous questions.***

SECTION 1 BASES & REFERENCES

MAIN BODY

Page 5 - Section 1.3 Bases & References

We understand *t****he assessment may be limited because ELARD-TRC Team may have not been provided or may have not reviewed all the relevant information, data, and analyses.*** We reserve the right to amend our report and supplement our conclusions expressed herein as additional information becomes available.

Page 11 - 2.1.1.2.2.2 Structure

The Amulsar gold deposit occurs within a ridge that is locally structurally-complex and ***purportedly***surrounded by regionally simple structure characterized as sub-horizontal to gently dipping strata with little internal structure, except offsets produced by high-angle faults

The subdivision of the Paleogene volcano-sedimentary rocks into VC and LV derives from stratiform nature of the base of the VC. The ***basal contact has been referred to*** as a disconformity (e.g., ESIA Section 4.6.1), but the occurrence of the same argillic andesite above and below the contact ***negates this interpretation***.

On the western side of the ridge, the lowest observed contact is a west-dipping, low-angle semiductile fault zone, with steeply dipping, locally folded VC rocks overlying the argillic LV rocks. This contact is *believed to be* an early northeast-directed thrust fault (Orontes Thrust). This structure was mapped through the horst block between Tigranes and Erato, and an east-dipping mylonitic zone on the eastern flank of the ridge is ***suggested to be*** structurally related.

Page 12 - 2.1.1.2.2.2 Structure (cont.)

Peripheral to the complex ridge structure, ***the structure is purportedly comparatively simple.*** Strata are sub-horizontal to gently dipping, and silica-altered VC rocks overly argillically-altered LV rocks. On the eastern side of Amulsar Mountain, the contact between the argillic LV rocks and the silicic VC rocks occurs at an undeformed stratiform contact (basal contact).

SECTION 1 BASES & REFERENCES ANALYSIS REDUX

The first section covered (pages 5-12) provided background on the data and information gathering phase to ELARD-TRC. Of note is the specific use of words such as “purported”, “purportedly” and “suggested to be”. These indicate that the information cannot be positively concluded to be valid as the information provided, may/may not be inaccurate, false or incomplete. ELARD-TRC suggests that in the Review Section (page 5) when they state:

***We understand the assessment may be limited because ELARD-TRC Team may have not been provided or may have not reviewed all the relevant information, data, and analyses.***

It is imagined that this is a standard conditional disclaimer used frequently in this business but considering the past behavior of mining companies and the RA Government’s routine complicity in violating the RA Constitutional requirements regarding licensing and operating of mines, this statement takes on greater weight.

SECTION 2 - STRUCTURE & AMULSAR TECTONIC BLOCK

MAIN BODY

Acronyms for this section

ATB - Amulsar Tectonic Block

BRSF - Barren Rock Storage Facility

VC - Upper Volcanics (a.k.a. UV)

 LV - Lower Volcanics

 LVA - Lower Volcanic Andesite

Page 12 - 2.1.1.2.2.1 Amulsar Tectonic Block

*The location and characteristics of the Amulsar Tectonic Block (ATB) are described in Geoteam (2014) and GRZ (2011).* *According to these documents,* the Project Area is located in the ATB, a **c*entral autonomous tectonic block*** comprised of an Eocene-Oligocene volcanic dome, and the ATB is located in the interfluve area of the Arpa, Vorotan, and Darb Rivers. *The ATB is triangular,* ***bounded entirely by three major tectonic faults*** *that intersect*, the Kechut Fault, the Agarakadzor Fault, and the Zirak Fault.

*According to GRZ (2011) and Geoteam (2014), the ATB is autonomous (independent or isolated) due to its hydrogeological characteristics.* They state that the ATB is not connected to adjacent regions, and t*he Mine cannot impact the hydrogeology and water quality*, including mineral and fresh water springs, of the regions adjacent to the ATB, particularly the Jermuk mineral springs. Similar statements are included on the Lydian web page.

Page 13 - 2.1.1.2.2.4 Assessment of the ESIA Characterization of Local Geology

***The geologic characterization work in the Project Area was focused on the high elevations of Amulsar Mountain in the vicinity of the ore deposits and the BRSF. The rest of the area bounded by the three rivers is only superficially described.*** Drawing 4.8.1 of the ESIA shows groundwater level monitoring locations for several other areas, where ***presumably*** subsurface geologic data were obtained, ***yet there are no cross-sections across the Project Area to depict the stratigraphy and structure.*** Cross-sections from the 3-D geologic model (Holcombe, 2013) only show the geologic relationships in the vicinity of the ridge (pits area). ***If geologic data are lacking for areas beyond the ridge or were obtained but not integrated into the conceptual model, this deficiency translates to poor understanding of the subsurface between sources and receptors of groundwater contaminants.***

***For such an environmentally-sensitive area, the omission of illustrations of the structural and stratigraphic relationships across the Project Area is a serious shortcoming in the ESIA conceptual model. The conceptual geologic model is the basis for models that numerically represent groundwater flow and contaminant transport.***

***The ESIA description of the local geology is disorganized, incomplete, and incomprehensible without reading the original documents. The text gives the impression of poorly understood structural and stratigraphic relationships, distribution and causes of alteration types, and the sequence of events in the genesis and occurrence of the various rock types along the ridge. The text also seems unclear as to whether all the rock types and alteration types are characterized for ARD.*** One omission in the distinction and delineation of rock types is the widespread phyllic alteration. This phyllic alteration was apparently lumped with the argillic alteration, which is a local overprint on the earlier phyllic alteration. The text and illustrations, supported by the cited references, portray isolated complex structure of the ridge and geologic simplicity of the rest of the Project Area. ***This conceptualization is unrealistic given the occurrence of folds and thrusts on the ridge and the existence of bordering rivers that are structurally controlled.***

Page 14 - 2.1.1.2.2.4 Assessment of the ESIA Characterization of Local Geology (cont).

***Detailed surface geologic mapping is lacking for the remainder of the Project Area.*** Faults are only delineated in the vicinity of the mineralization (ESIA Figures 4.6.3 and 4.6.7). ***One explanation for the absence of faults on surface geologic maps is that little effort was expended beyond the area of economic interest.***

Faults may be barriers and/or conduits of groundwater flow. Furthermore, ***volcanic rocks are brittle, with widespread fracture permeability***, including bedding-plane fractures. These characteristics influence groundwater flow and transport rates. ***The argillic rocks cannot be assumed to be a homogeneous clay zone, void of fractures.*** In fact, the processes associated with deposition of the ore superimposed brecciation on the altered rocks. ***Fracturing beyond the mineralized zone is not described in Section 4.6.2 of the ESIA or supporting documents on the geology, suggesting surface and borehole fracture characterization was not performed.*** The omissions of fault mapping and fracture characterization ***represent data deficiencies for conceptualization of the controls on groundwater flow paths and rock transmissivities.*** Correct numerical model representations of groundwater flow and solute transport from the pits and project facilities to receptors (rivers and springs) are dependent on the structure and characteristics of the rock throughout the flow and transport paths.

***The Project Area is only partially encompassed by the ATB*** (Appendix A of this report). The entire Tigranes-Artavasdes-Arshak pit area and at least part of the Erato Pit are south of the Agarakadzor Fault and the ATB. Moreover, the BRSF straddles the trace of the Zirak Fault, with parts of the BRSF being north of the fault and the ATB. ***A large part of the Kechut Reservoir is within the ATB near its northern vertex. Potential seepage to groundwater from the part of the BRSF north of the Zirak Fault could result in contaminated groundwater reaching the Madikenc springs. Contaminated groundwater below the mine pits can flow to the Darb and Vorotan Rivers.***

However, with part of the BRSF and most of the mine pit areas outside the ATB, i***t is incorrect to state that the mine cannot impact regions (including fresh water springs) adjacent to the ATB.*** (Underlined by ELARD-TRC) .Additionally, f***aults may be conduits of groundwater flow***. Under such a setting, ***the Agarakadzor fault could conduct contaminated groundwater to the Darb and Arpa Rivers.*** Similarly,t***he Zirak Fault could conduct contaminated groundwater, including potential seepage from the BRSF (elevation approximately 2,600 m), to the Kechut Reservoir (elevation approximately 1,950 m) and/or the Vorotan River*** (elevation approximately 2,200 m at the projected intersection of the Zirak Fault).

Furthermore, there is a northeast-oriented tributary to the Arpa River between Jermuk and the Mine facilities, which is ***a probable hydraulic boundary.*** Even with part of the BRSF being north of the Zirak Fault, ***seepage from the BRSF will not reach Jermuk.*** Finally, Jermuk is northwest of the trace of the Kechut fault, which ***may also be a barrier to groundwater flow.***

SECTION 2 STRUCTURE & AMULSAR TECTONIC BLOCK ANALYSIS REDUX

The section covered the area of tectonic activity in the area. The Amulsar mine is surrounded by 3 separate fault lines. The original ESIA provided to ELARD-TAC essentially concluded that in the event of seismic activity there was no danger of leaking toxins contaminating the areas fresh water resources as the Amulsar mine is a single autonomous block, surrounded by thrust faults that would naturally prevent leakage into these water sources. The water sources mentioned include:

* Lake Sevan
* Jermuk
* Kechut Reservoir
* Darb River
* Arpa River
* Vorotan River

The ELARD-TAC analysis took issue with the analysis of the original ESIA pointing out, among other discrepancies that:

1. Data analysis was conducted only on the high elevation areas in the vicinity of the mine itself. Areas of lower elevation, where groundwater is likely to move toward was not surveyed. As the report indicates:

***if geologic data are lacking for areas beyond the ridge or were obtained but not integrated into the conceptual model, this deficiency translates to poor understanding of the subsurface between sources and receptors of groundwater contaminants.***

***For such an environmentally-sensitive area, the omission of illustrations of the structural and stratigraphic relationships across the Project Area is a serious shortcoming in the ESIA conceptual model.***

***The ESIA description of the local geology is disorganized, incomplete, and incomprehensible without reading the original documents…...This conceptualization is unrealistic given the occurrence of folds and thrusts on the ridge and the existence of bordering rivers that are structurally controlled***

1. In regards to the project area itself, data is also incomplete and/or inaccurate. The ELARD-TAC report states:

***Detailed surface geologic mapping is lacking for the remainder of the Project Area.*** ……. ***One explanation for the absence of faults on surface geologic maps is that little effort was expended beyond the area of economic interest.***

1. Areas of the mining project outside of the ATB can also be adversely affected by leaking toxins. For example:

 ***A large part of the Kechut Reservoir is within the ATB near its northern vertex. Potential seepage to groundwater from the part of the BRSF north of the Zirak Fault could result in contaminated groundwater reaching the Madikenc springs. Contaminated groundwater below the mine pits can flow to the Darb and Vorotan Rivers.***

1. In the most damning statement in this section, ELARD-TAC went so far as to underline

one particular section:

However, with part of the BRSF and most of the mine pit areas outside the ATB, i***t is incorrect to state that the mine cannot impact regions (including fresh water springs) adjacent to the ATB.***

Additionally, f***aults may be conduits of groundwater flow***. Under such a setting, ***the Agarakadzor fault could conduct contaminated groundwater to the Darb and Arpa Rivers.*** Similarly,t***he Zirak Fault could conduct contaminated groundwater, including potential seepage from the BRSF (elevation approximately 2,600 m), to the Kechut Reservoir (elevation approximately 1,950 m) and/or the Vorotan River*** (elevation approximately 2,200 m at the projected intersection of the Zirak Fault).

1. In the case of Jermuk and the protection of the springs, the report indicated that, given the geologic information is correct:

***a probable hydraulic boundary.*** Even with part of the BRSF being north of the Zirak Fault, ***seepage from the BRSF will not reach Jermuk.*** Finally, Jermuk is northwest of the trace of the Kechut fault, which ***may also be a barrier to groundwater flow.***

SECTION 3 - ACID GENERATION AND METALS LEACHING POTENTIALS

Acronyms for: ARD Potential - **Acid Generation and Metals Leaching Potentials Section**

 ESIA - Environmental & Social Impact Assessment (refers to original conducted)

EIA - Environmental Impact Assessment (refers to original conducted)

ARD - Acid Rock Drainage

NAG - Net Acid Generation

VC - Upper Volcanics (a.k.a. UV)

 LV - Lower Volcanics

 LVA - Lower Volcanic Andesite

 NPR - Net Potential Ratio

 GRE - Global Resource Engineering Ltd. (conducted the original assessment)

Page 17 - 2.1.1.2.3.2 Assessment of the ESIA Characterization of ARD Potential

The distributions of sample locations for ARD assessment are reasonable for both pit areas. However, the ***sample categories of VC and LV reveal little about specific mineralogic and rock characteristics of each sample. There are significant variations*** in each category.

Mineralogical analyses were performed by XRD and transmitted and reflected light microscopy on 8 samples of Tigranes/Artavazdes and 12 samples from the Erato pit areas (Appendix 8.1.9). Only 5 LV and 3 VC samples were analyzed from the Tigranes/Artavazdes pit area, and only 5 LV, 4 VC, and 3 colluvium samples from the Erato pit area. ***The number of samples is insufficient for each category, and the choice of samples was not based on sub-types of VC and LV. There is no way to know whether all rock sub-types are represented for VC and LV or whether the set of mineralogic analyses for each category is representative of the range*** ***geochemical variability and whether a mineralogic analysis is representative of any particular rock sub-type.***

***The lack of correlation between rock sub-types and mineralogic data has repercussions for all other testing.***

Page 18 - 2.1.1.2.3.2 Assessment of the ESIA Characterization of ARD Potential (cont.)

Tables 4.6.2 and 4.6.3 of the ESIA and Table 9 of Appendix 8.19 (GRE, 2017), summarizing the mineralogic data for VC and LV, ***reveal significant variations in the mineralogy of the samples in each category*** which demonstrate the need for rock sub-types. Mineralogic analyses were not performed on the ore, but even composites of the ore reveal significant differences in whole rock analyses (ESIA Table 4.6.1) indicative of mineralogic differences. ***No mineralogic analyses were performed on colluvium in the Tigranes/Artavazdes pit area and no analyses were performed on borrow materials.***

A significant number of whole rock analyses were performed for barren rock in each pit area (Appendix 4.6.2 Table 4-1), but ***the vast majority of analyses were just total metals.*** Based on Appendix 4.6.2 Table B-4, the only major element analyses that were performed are for the ***Tigranes/Artavazdes pit area, where only 6 analyses were performed for LV and 3 for VC***. ***There are no analyses of Tigranes/Artavazdes spent ore.***

***Unfortunately, none of the results can be related to rock sub-types with characteristic mineralogy and, and the results cannot be used to assess whether one particular sub-type suggests greater risk than another, which would be useful in selecting samples for other tests.***

For the barren rock in the Tigranes/Artavazdes pit area, 154 ABA tests were performed ***without any NAG pH tests to complete the classification.*** Likewise, for the spent ore of this pit area, 6 ABA tests were conducted without complementary NAG pH tests. For the barren rock of the Erato pit area, 80 ABA tests were performed and only 50 NAG pH tests. ……..***None of the existing static test results can be related to rock sub-types with a characteristic mineral assemblage for interpretation of test results.***

***Noteworthy is that the Modified Sobek method was used for the Project ABA***, which determines AP based only on sulfide sulfur. ***This approach is clearly incorrect*** for the Project because nearly all samples from both pit areas have acidic paste pH values (Appendix 4.6.2 Tables A-1 and A2), indicative of acidic sulfate salts (e.g., alunite and jarosite), identified in both VC and LV. The analyzed percentage of sulfate should have been included in the AP calculation (INAP, 2009), which would have resulted in lower NPR values. ***Negative values of NPR (impossible)*** and units of TCaCO3/kt (NPR is a unitless ratio) are reported in Tables A-1 and A-2.

HC tests were performed on only 8 barren rock samples from the Tigranes/Artavazdes pit area. ***No HC tests were performed for the Erato pit area. This data set is inadequate to cover the range of rock sub-types*** *with uncertain status based on static test characterization,* ***especially with incorrectly calculated AP and the potential for some VC rocks to be acid generating*** *(see below).* ***None of the HC test results can be related to rock sub-types with a characteristic mineral assemblage for interpretation of test results.***

Page 19 - 2.1.1.2.3.2 Assessment of the ESIA Characterization of ARD Potential (cont.)

The main concern with the SPLP testing is whether the range of rocks with secondary minerals were tested without defined geochemical test units. Similarly, NAG effluent results cannot be correlated with characteristic mineral assemblages for interpretation of results. ***Noteworthy is the lack of NAG effluent testing for Tigranes/Artavazdes spent ore.***

Section 4.6.5 of ***the ESIA states that the VC is not acid generating.*** Appendix 4.6.2 ***Tables A-1 and A-2 show that there are many VC samples with significant pyritic sulfur, more than double the‎ cited‎“low‎total sulfide (***around 0.15%)”,‎ranging to more than 5% in the extreme in both pit areas. Although these samples are a minority among the VC samples, the higher sulfide percentages provide more evidence that the VC is not homogeneous and should be sub-divided into distinct rock sub-types (geochemical test units).

Section 4.7.5 of the ***ESIA suggests that the HC tests would be conducted for up to a year.*** ***Four of the tests were terminated at 20 weeks.*** VC samples ARD-78C and ARD-80C appear to have ***not been given sufficient time to determine final pH*** based on the plots of other samples with longer test periods. The other two 20-week tests attained low and stable pH, ***but other parameters were not stable, including acidity, conductivity, sulfate, iron, and aluminum***

***It cannot be concluded that the ARD potential of the VC does not translate into ARD generation. Two of the HC tests on VC were terminated prematurely.*** The three tested samples have low pyritic sulfur percentages (<0.01, 0.06, and 0.08). There are VC rocks with much higher percentages of sulfide that were not tested***.***

Section 4.7.10 of ***the ESIA states that three of the five LV kinetic cells showed strong resistance to pyrite oxidation by ferric iron and that these samples produced consistently mild pH (greater than 4.5)*** with low sulfate and iron concentrations despite long-duration testing. T***hese three samples have the low pyritic sulfur percentages (0.2, 0.3, and 0.8), which could not produce enough acidity to drive the pH below 3.5,*** where significant dissolved ferric iron concentrations greatly increase the rate of sulfide oxidation (INAP, 2009).

***The leachate from the Site 27 Soviet era waste pile has a pH of 3.3 and high acidity. These data are a reasonable indicator of the potential of the ARD from the Amulsar Mine.***

Page 20 - 2.1.1.2.3.2 Assessment of the ESIA Characterization of ARD Potential (cont.)

GRE (2018a) stated that due to the drilling schedule, there was no fresh rock available for testing, necessitating using old core rock. Furthermore, GRE (2018a) stated that the high AP rock had oxidized in the core boxes, ***the objective of determining how fast the rock generates acid was not met, and that it will be necessary to redo the experiment.*** The oxidation observed in the core boxes, however, provides an indication of the rapidity of acid generation (with respect to drilling dates). The ramifications of the initial rinse in November 2017, as well as parameters of the leachate, are unknown. ***Considerable release of stored acidity in secondary minerals is probable.*** Measurement results in May and June 2018 display a slow, very minor increase in pH for nine samples. Minor to moderate decrease in conductivity is also recorded. ***Unclear is how much additional oxidation occurred between December 2017 and May 2018*** and whether the increase in pH of these samples in May and June represents continued dissolution of residual secondary minerals or continued pyrite oxidation accompanied by a decrease in exposed surface area.

Page 21 - 2.1.1.2.3.2 Assessment of the ESIA Characterization of ARD Potential (cont.)

***The results of the entire characterization program should be viewed with caution.*** ***Although all the basic types of characterization were performed, there appears to be little planning and continuity in the approach.***

The block model only subdivides the LV. All VC is still considered non-PAG rock. ***The conclusion*** that the ABA data histogram (***GRE, 2018b Figure 1) “confirms”‎*** some‎ LV‎ samples‎ were‎ “incorrectly logged”‎ as‎ VC‎ or that‎ “some VC samples have very high sulfate sulfur” ***is suspect***. Even if the high total sulfur is sulfate sulfur in VC rocks, which is not necessarily correct (can also be sulfides in VC), the block model excludes these samples (because they are purportedly sulfates and VC).

Page 22 - 2.1.1.2.3.3 Assessment of ARD Geochemistry

***The statement that two reactions are responsible for acidity from pyrite (FeS2) is incorrect.***

 ***However, GRE (2017) leaves out the ferrous iron oxidation reaction altogether, and in doing so leaves out half of the acid generating reactions in ARD. This significant oversight brings into question Lydian‟s assessment of acid generating potential of the rock and of the water quality in the ARD.***

Page 24 - 2.1.1.2.3.3 Assessment of ARD Geochemistry (cont.)

***The GRE (2017) discussion of pyrite oxidation neglects half of the acid-generating reactions (Reactions 2 and 3) and thereby underestimates the potential ARD loading of the waters at the Site (for pH > 3.2) and the treatment needed to mitigate the corresponding impacts.*** The ARD mitigation and treatment plan presented in GRE (2017) may prove insufficient to treat the ARD. The ferrous iron oxidation is an important process to consider because additional acidity can be generated at some distance from the location of the pyrite oxidation. …….. A major risk for implementing PTS during operations is not knowing in advance the ferrous iron load in the water entering the system.

Page 26 - 2.1.1.2.3.3 Assessment of ARD Geochemistry (cont.)

***The HC results for sample ARD-74C show a dramatic increase in ARD generation after 12 weeks, with the iron concentration increasing by an order of magnitude*** and pH decreasing by 0.5 units to less than 3. T***he GRE (2017) interpretation does not provide an explanation for the source of ferric iron to oxidize the pyrite.*** Furthermore, the HC ARD-74C behavior is not simply the result of ferric iron oxidation of pyrite.

GRE (2017, page 26) ‎further ‎posits ‎that ‎there ‎is‎ some‎“suppression agent”‎ that‎ is‎ inhibiting ‎the‎ reaction between ferric iron and pyrite, as stated below: ……..***The GRE (2017) assessment is misleading.*** The rate of pyrite oxidation is limited when the bacterial population is low and the pH is too high for ferric iron to be to be soluble.

***GRE (2017) assessment of ARD reactions that would occur in the Amulsar rocks is misleading because the analysis***:

1. Fails to recognize the importance of ferrous iron oxidation in the ARD reaction sequence in generating acid and precipitating mineral phases (solids).

2. Postulates that the reaction of pyrite by ferric iron has a higher stoichiometric ratio between pyrite and acidity. The overall reaction between pyrite and ferric iron is the same as the reaction between pyrite and oxygen. The reaction with ferric iron is faster, with the ferric iron acting as a catalyst, but the overall stoichiometry is the same. The ferric iron oxidation is just one of the two pathways for pyrite to be oxidized, and the two pathways cannot be distinguished based on the products generated.

3. Postulates‎ that‎ there‎ is‎ some‎ “natural suppression agent”‎ inhibiting‎ the‎ oxidation‎ of‎ pyrite by ferric iron in the LV ores, but the rate of pyrite oxidation is limited when the bacterial population is low and the pH is too high for ferric iron to be soluble.

4. ***Underestimates the potential for ARD generation and the associated water quality, environmental impacts, and water treatment requirements.***

SECTION 3 - ACID GENERATION AND METALS LEACHING POTENTIALS ANALYSIS REDUX

The analysis by ELARD-TAC indicates that the original ESIA was lacking, across the board in both accuracy and completeness of its research and findings. This section is replete with characterizations, of the original ESIA, such as:

* ***reveal little about specific mineralogic and rock characteristics…..***
* ***The number of samples is insufficient***
* ***The lack of correlation between rock sub-types and mineralogic data has repercussions for all other testing.***
* ***reveal significant variations …..***
* ***No mineralogic analyses were performed on….***
* ***There are no analyses of….***
* ***Unfortunately, none of the results can be related to rock sub-types with characteristic mineralogy and, and the results cannot be used to assess whether one particular sub-type suggests greater risk than another, which would be useful in selecting samples for other tests.***
* ***None of the existing static test results can be related to …..***
* ***This approach is clearly incorrect***.
* ***Negative values of NPR (impossible)*** ….
* ***No HC tests were performed for the Erato pit area. This data set is inadequate to cover the range of rock sub-types…..***
* ***None of the HC test results can be related to rock sub-types……***
* ***Noteworthy is the lack of NAG effluent testing for Tigranes/Artavazdes spent ore.***
* ***...the ESIA states that the VC is not acid generating.*** Appendix 4.6.2 ***Tables A-1 and A-2 show that there are many VC samples with significant pyritic sulfur, more than double the‎ cited‎“low‎total sulfide ….***
* ***ESIA suggests that the HC tests would be conducted for up to a year.*** ***Four of the tests were terminated at 20 weeks.***
* ***not been given sufficient time to determine final pH***
* ***It cannot be concluded that the ARD potential of the VC does not translate into ARD generation. Two of the HC tests on VC were terminated prematurely.***
* ***The leachate from the Site 27 Soviet era waste pile has a pH of 3.3 and high acidity. These data are a reasonable indicator of the potential of the ARD from the Amulsar Mine.***
* ***…..the objective of determining how fast the rock generates acid was not met, and that it will be necessary to redo the experiment.***
* ***Considerable release of stored acidity in secondary minerals is probable.***
* ***Unclear is how much additional oxidation occurred between December 2017 and May 2018***
* ***The results of the entire characterization program should be viewed with caution.*** ***Although all the basic types of characterization were performed, there appears to be little planning and continuity in the approach.***
* ***The conclusion……..is suspect***.
* ***The statement that two reactions are responsible for acidity from pyrite (FeS2) is incorrect.***
* ***However, GRE (2017) leaves out the ferrous iron oxidation reaction altogether, and in doing so leaves out half of the acid generating reactions in ARD. This significant oversight brings into question Lydian‟s assessment of acid generating potential of the rock and of the water quality in the ARD.***
* ***The GRE (2017) discussion of pyrite oxidation neglects half of the acid-generating reactions (Reactions 2 and 3) and thereby underestimates the potential ARD loading of the waters at the Site (for pH > 3.2) and the treatment needed to mitigate the corresponding impacts.***
* ***The GRE (2017) interpretation does not provide an explanation for the source of ferric iron to oxidize the pyrite.***
* ***The GRE (2017) assessment is misleading.***
* ***GRE (2017) assessment of ARD reactions that would occur in the Amulsar rocks is misleading because the analysis***:
* ***Underestimates the potential for ARD generation and the associated water quality, environmental impacts, and water treatment requirements.***

Listed are over 30 instances of misleading, inaccurate, incomplete, underestimated, neglectful “science”.

Even at this early stage of this assessment it is evident that the original EIA was shoddy scientific work that drastically underestimated, or did not estimate at all, the potential acid production and runoff produced as a result of the mining activities. It is not hyperbolic to say that the findings from Lydian could all be called into question as their methodology clearly has serious shortcomings.

SECTION 4 - SEISMIC HAZARD POTENTIAL

Acronyms for: **SEISMIC HAZARD POTENTIAL**

 PSSF - Pambak-Sevan-Sunik Fault Segment

Page 27 - 2.1.1.3.2 Seismicity

Section 4.6.1 of the ***ESIA states that the Project Area is NOT located within the major zones of tectonic activity in Armenia***, ***but that the area is geologically active based on the occurrence of young basalt scoria cones***.

***On the other hand, Section 4.6.4 of the ESIA states that “the Project licence is located within a seismically active region of the Arabia-Eurasia plate boundary zone” and “that there are 17 fault zones with a total of 53 fault segments within approximately 250 km of the project site”.***

Section 4.6.4 of the ESIA indicates that historical records document the occurrence of 107 strongly-felt earthquakes in the Republic of Armenia (RA) from 600 B.C. to 2003. Armenian records indicate that the Site has experienced strong to very strong shaking at least three times in the last 900 years (Golder, 2013). ***Figure 4.6.8 (Section 4.6.4 of the ESIA) shows that the Project Area is surrounded by the epicenters of the historic earthquakes and “fault‎ seismic‎ sources”***

Page 28 - 2.1.1.3.2 Seismicity

The foregoing text underscores the seismic hazard risk for the Project Area. The historical record of pre-instrumental and instrumental earthquakes indicates that strong to very strong earthquake shaking has probably occurred at the Project Area at least three times in the last 900 years (Golder, 2013). Golder‟s seismo-tectonic model defines the active and potentially active seismic sources that can contribute to earthquake ground motions in the Project Area. The PSSF4 makes a strong contribution to Project Area seismic hazard because the PSSF fault system is the longest active structure in the RA with the greatest slip rates and strongest earthquakes (Golder, 2013).

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Page 29 - 2.1.1.3.3 Assessment of Active Faults in the Project Area

Section 2.1.1.2.2.2.1 of ***this report makes it clear that there are major faults within the Project Area***, including the vicinity of the mine pits and beneath the BRSF. The bounding rivers are expressions of major faults, including potentially the Vorotan River, which may reflect the occurrence of PSSF5a adjacent to the Project Area (Golder, 2013 Figure 2). ***The PSSF fault system is active.***

SECTION 4 SEISMIC HAZARD POTENTIAL ANALYSIS REDUX

This section is relatively simple to analyze. There are ***…. 17 fault zones with a total of 53 fault segments within approximately 250 km of the project site.*** And that….***the ESIA) shows that the Project Area is surrounded by the epicenters of the historic earthquakes and “fault‎ seismic‎ sources”.***

Furthermore, ***the PSSF4 makes a strong contribution to Project Area seismic hazard because the PSSF fault system is the longest active structure in the RA with the greatest slip rates and strongest earthquakes*** (Golder, 2013).

Questions arising from this section are related to the structural integrity of mining structures including the tailings dams and other areas containing anything dangerous to the surrounding water ecosystems. Is it reasonable to expect that Lydian can guarantee for 100s of years that their structures can withstand all natural forces of nature, including catastrophic seismic events?

SECTION 5 HYDRAULIC CONDUCTIVITY

Acronyms for Groundwater Flow Section

GSA - The Groundwater Study Area

Page 31 - 2.1.1.4.2 Hydraulic Conductivity

***No pumping tests were undertaken, which is a serious omission in the characterization of hydraulic properties.*** Pumping tests are a standard procedure for hydraulic characterization and are indispensable for fractured rock…….***Pumping tests should have been performed in the areas of the mine facilities and pits at various depths, as well as several in each rock type across the GSA.*** If cross-sections had been constructed across the GSA, they may have revealed the occurrence of structures, which would be important in the planning for pumping tests. In addition to the bulk hydraulic properties, pumping tests are essential to identify and assess anisotropy and boundaries (e.g., faults and rivers/streams). Properly planned observation well locations can reveal the locations of boundaries and the extent of influence. For example, the extent of fracture connectivity to a river could be investigated.

***Given the environmentally-sensitive setting, the limited distribution of hydraulic tests and the lack of pumping tests are inadequate for characterizing the hydraulic properties across the GSA.*** Fractured rock has heterogeneous hydraulic properties (Table 4.8.1 and Figure 4.8.8 show a range of 4 or more orders of magnitude), which are dependent on rock type and stratification (which are variable across the GSA) and proximity to structures. The rivers are structurally controlled, and these structures may be assumed to have uniquely imparted structural fabric and fracture characteristics in their region of influence. ***Large areas of the GSA, from the mine pits and facilities to the rivers and reservoirs are uncharacterized and cannot be assumed to have the same hydraulic properties of the tested areas.***

***The calculated geometric means of [local] hydraulic conductivity*** (Table 4.8.1 of the ESIA) and the summary of [local] hydraulic conductivity values for impact assessment (Table 4.8.2 of the ESIA) ***are meaningless for comparisons of rock types***, unrepresentative due to the large ranges, and ***especially unreliable for assessments***.

Page 32 - 2.1.1.4.5 Fracture Flow

***Widespread fracture permeability, including bedding-plane fractures, is an important factor in groundwater flow and rates of transport throughout the GSA. The significance of this phenomenon cannot be understated. Transport of contaminated groundwater is many orders of magnitude greater in fractured media over porous media. The extent of connectivity of fractures, however, determines whether rapid flow and transport occur. Only through conducting pumping tests and groundwater tracer tests can fracture connectivity be assessed.***

Page 33 - 2.1.1.4.6 Springs

***The Type 1 springs around Jermuk are all north of the GSA and would not be impacted by the Mine.*** ***Type 2 springs include the Sevan group, which supplies the community of Gndevaz, but is well outside the GSA and would not be impacted by the Mine.*** Type 3 springs presumably have extremely variable flow rates, dependent on annual precipitation and snowpack, and flow measurements are unnecessary.

Figure 2 of Appendix 4.9.5 of the ESIA shows several other springs within the GSA in the vicinity of Kechut that apparently‎weren‟t ‎evaluated during the survey (no assigned number). The text in Section 4.8.6 of the ESIA states that the November 2013 survey identified only a small number of flowing springs and that a further five flowing locations had no flow estimate. The latter springs are not specified. It is unclear whether the other 3 springs on Drawing 4.8.3 were flowing, as well as the other springs on Figure 2 of Appendix 4.9.5. ***Because springs in this area supply Kechut, this information should have been provided, and if the springs were flowing, the rates should have been measured.***

Page 34 - 2.1.1.4.6 Springs

Section 4.8.6 of the ESIA states that several potentially significant springs were not visited during the November 2013 survey. There were only two surveys, and the November 2013 survey is the only survey in the dry season when perennial springs are identified and characterized. Drawing 4.8.3 in Appendix 4.8.7 shows a large number of springs, especially in the vicinity of the Amulsar Mountain ridge. ***In general, given the importance of springs to the local communities, including shepherds and ranchers, and the potential for impacts to the springs from the mine pits, the springs flow characterization is inadequate***

Page 34 - 2.1.1.4.7 Kechut-Spandaryan Tunnel and Mineral Exploration Adit

***Discharge at the Kechut Reservoir indicates that groundwater is entering the tunnel.***

An excavation for mineral exploration (AWO30 adit) east of the BRSF extends from monitoring location AW030 (or SP13.7) with multiple branches at least 650 m to a location below the BRSF valley, where it is estimated to be 80 m below ground surface. ***A continuous groundwater discharge occurs from the adit.***

SECTION 5 - HYDRAULIC CONDUCTIVITY ANALYSIS REDUX

As with all the sections excerpted above, Section 5 begins with example of serious omissions in the conduct of thorough scientific data gathering. The first example states:

***No pumping tests were undertaken, which is a serious omission in the characterization of hydraulic properties.*** Pumping tests are a standard procedure for hydraulic characterization and are indispensable for fractured rock…….***Pumping tests should have been performed in the areas of the mine facilities and pits at various depths, as well as several in each rock type across the GSA.***

Which leads to this rather blunt conclusion from ELARD-TRC:

***The calculated geometric means of [local] hydraulic conductivity*** (Table 4.8.1 of the ESIA) and the summary of [local] hydraulic conductivity values for impact assessment (Table 4.8.2 of the ESIA) ***are meaningless for comparisons of rock types***, unrepresentative due to the large ranges, and ***especially unreliable for assessments***.

Regarding the original ESIA’s lack of establishing any sort of scientific reliability on areas of “fracturing”, they state:

***Widespread fracture permeability, including bedding-plane fractures, is an important factor in groundwater flow and rates of transport throughout the GSA. The significance of this phenomenon cannot be understated.\* Transport of contaminated groundwater is many orders of magnitude greater in fractured media over porous media. The extent of connectivity of fractures, however, determines whether rapid flow and transport occur. Only through conducting pumping tests and groundwater tracer tests can fracture connectivity be assessed.***

\*Notice in the above paragraph the sentence, “The significance of this phenomenon cannot be understated”. (writer’s asterisk)

Regarding the surrounding springs, the ELARD-TRC team reiterated their earlier claim that the Jermuk springs are safe from mining activities in regards to water contamination as they are ***“well outside the GSA***.” Again, this data is contingent on the original geological surveys being accurate.

Regarding groundwater seepage into water supply tunnels, ELARD-TRC note,

 ***Discharge at the Kechut Reservoir indicates that groundwater is entering the***

 ***tunnel.***

An excavation for mineral exploration (AWO30 adit) east of the BRSF extends from monitoring location AW030 (or SP13.7) with multiple branches at least 650 m to a location below the BRSF valley, where it is estimated to be 80 m below ground surface. ***A continuous groundwater discharge occurs from the adit.***

SECTION 6 - SURFACE WATER HYDROLOGY SECTION

Acronyms for this section

BRSF - Barren Rock Storage Facility

Page 35 - 2.1.1.5.1 Regional Setting

Figure 4.9.1 of the ESIA shows the location of the Amulsar Project in the context of the two major rivers adjacent to the Project Area and Lake Sevan. Lake Sevan and the Kechut Reservoir are linked by a tunnel that directs flow by gravity to Lake Sevan. The Spandaryan Kechut tunnel connects the Spandaryan Reservoir south of the Project Area with the Kechut Reservoir north of the Project Area, but surface water flow does not occur through this tunnel.

***Lake Sevan is protected by Armenian law which permits no activity that may negatively impact the lake and its ecosystem. The BRSF lies within the “immediate impact zone” of Lake Sevan.***

Page 40 - 2.1.1.6.2 Surface Water and Groundwater Quality

The status of current and future groundwater sampling locations is uncertain due to the inclusion of “historical” in the title of Drawing 4.8.2 of the ESIA. The report does not explain why so few springs around Amulsar Mountain and the BRSF are monitored (compared to locations shown on Drawing 4.8.3 of the ESIA) given the importance to livestock. With respect to springs sampling locations shown on Drawing 4.8.2, which appear to have been chosen based on surface water drainage, flow in fractured rock may not follow the local topography. Given the large number of springs that can be monitored (spring melt and low flow conditions), few additional wells are recommended to monitor groundwater quality.

Page 41 - 2.1.2.1 Pit Seepage Sub-Models

GRE developed a series of numerical unsaturated flow models for estimating time-transient seepage rates to the saturated zone through the rock underlying the walls and bottoms of the evolving and coalescing Tigranes-Artavasdes-Arshak pit (GRE, 2014a)

Page 42 - 2.1.2.1 Pit Seepage Sub-Models

***The results of the 1D models are incorrect (GRE, 2014a Table 2).***

***Another problem with the Table 2 (GRE, 2014a) results is the water balance. The net infiltration based on the tabulated numbers is incorrect. Particularly large discrepancies are evident for both uncovered backfill scenarios.***

***Another problem with the Table 2 (GRE, 2014a) results is the water balance. The net infiltration based on the tabulated numbers is incorrect. Particularly large discrepancies are evident for both uncovered backfill scenarios……..However, the results for the Artavasdes pit are unclear with respect to the information presented on mine planning. T***he cross-sections illustrating stages of pit backfill indicate that Artavasdes backfilling is finished at year 8. Peak infiltration is simulated to occur at year 11, suggesting emplacement of topsoil occurs 3 years after the termination of backfilling

***Results for the Arshak pit are incorrect.*** The pit will be fully excavated at year 8, at which time a closed depression will exist, and a seasonal pit lake will develop. Also, runoff from Artavazdes pit backfill toward Arshak would not occur until approximately year 8.

***The fluxes from the pit seepage modeling are incorrect. Use of these fluxes in the regional groundwater flow model results in incorrect assessments of impacts to groundwater levels and springs. Furthermore, solute transport simulations would severely underestimate potential impacts to groundwater and springs from acid mine drainage.***

Page 47 - 2.1.2.5 Regional Groundwater Flow Model

The report was evaluated for the technical merits of the model with respect to the Site hydrology and hydrogeology, its reliability for predictive analysis, as well as the numerical modeling procedures. The evaluation presented in the following text addresses the most significant aspects of the modeling.

Golder constructed a three-dimensional groundwater flow model for the GSA with the intention of improving understanding of the hydrogeologic setting of the proposed mine site and to estimate groundwater inflow to the mine pits (Golder, 2014a). The report describes the model construction, inputs, calibration to baseline conditions, and ***predictions of impacts to groundwater quantity for operational and post-closure phases*** of the mine. Particle tracking was used to illustrate simulated groundwater flow pathways. ***Noteworthy is that the model was not used as a tool in the planning phase of locating mine facilities for minimizing risk to the environment*** (e.g., Myers, 2016). A significant omission of the numerical modeling is the performance of solute transport simulations for predicting impacts to the quality of groundwater and surface water.

The modeling was performed with FEFLOW, a widely used, commercially-available groundwater modeling tool capable of generating defensible results.

Page 48 - 2.1.2.5 Regional Groundwater Flow Model

Section 4.9.5 of the EISA states that numerous minor perennial tributaries originating on the slopes of Amulsar and the plateau to the east of the Vorotan feed the Darb and Vorotan Rivers. ***These perennial streams should have been included in the model.***

**A potentially unnecessarily long no-flow boundary was used along the southern perimeter, forcing flow parallel to this boundary to the northwest and southeast.** A boundary condition that permits discharge (seepage face) at appropriate elevations could have been utilized along the upper Darb and the Porsughlu River (assuming both rivers are perennial in those locations) that flows to the southeast toward the Spandaryan Reservoir for nearly the entire length of the simulated no-flow boundary. No-flow would be appropriate for a very short length near the topographic divide. ***The impact of the long no-flow boundary on simulated flow from Amulsar Peak cannot be determined based on available information.***

Five conceptual hydrogeologic units were delineated in the GSA: Colluvium, VC, LVA, LV, and Basalt. With the exception of distinguishing a deep section of LV for assigning model properties, ***each of the five hydrogeologic units is represented by a single set of hydraulic properties,*** i.e., all six model units are numerically homogenous, ***in spite of the hydraulic test data showing 4 or more orders of magnitude variation in hydraulic conductivity for each rock type.*** ***This deficiency can have a significant effect on the model predictions (e.g., will not identify preferential flow pathways).***

Page 49 - 2.1.2.5 Regional Groundwater Flow Model

***The geology in the pit areas is poorly represented. Faults are completely absent in the model……...Some faults may be conduits for groundwater flow.*** Incorporation of these structural and lithologic elements, with calibration to water levels in wells screened in discrete lithologies and discharges of springs, holds the potential to understand many of the major ephemeral springs and better quantify net recharge to the underlying regional groundwater flow system.

T***he simplistic numerical representation of the subsurface in the existing model is inadequate for making quantitative predictions. Notwithstanding this inadequacy, numerous quantitative predictions, which are unreliable, were made.*** Transient simulations were performed to estimate pit inflows, but the model is also a poor predictor because a transient calibration was not performed, such as simulation of a pumping test.

The baseline model (calibration) represents average annual conditions as a steady-state simulation. The model was calibrated to the average groundwater elevations recorded in monitoring wells in the GSA11. ***Even with this simplification of site conditions and water level targets, there are many significant calibration errors (differences between simulated and target water levels). Twenty-two of forty-one calibration targets (54%) have errors of 25 meters and more, and fourteen targets (34%) have errors of 40 meters and more, ranging up to 96 meters (twice the maximum recorded seasonal range in water levels).*** Even without considering recorded seasonal differences in groundwater levels up to 48 meters in wells, the steady-state model, purported to represent average conditions, with such large calibration errors to predict groundwater elevations ***is unreliable***.

***Estimated errors in groundwater levels up to 25 m for the purpose of calibration are excessive.*** The report indicates that well elevations were determined in 40% of the locations with a handheld GPS and assigned an incremental error of 20 m. These devices are typically accurate within 10 m. The liberal estimated error appears to be a justification of the large model water level errors.

***Despite the large model water level errors, the model was used to estimate operational water levels beneath the BRSF area (simulated baseline water level errors up to 80 m), the HLF area (simulated baseline water level errors up to 37 m), and the mine pits*** (simulated baseline water level errors up to 90 m). Furthermore, the baseline model results were used to delineate the distribution of head at or above ground surface across the GSA which, only locally, roughly corresponds to the locations of springs. ***With such large errors in calibration water levels, the model is a poor indicator of head above ground surface and a poor indicator of the effects of mining activities on groundwater levels and groundwater flows (springs, river discharges, pit inflows).*** Noteworthy are the omissions of springs elevations and discharges as targets in the calibration (inconsistent‎ with‎ statement‎ made‎ during‎ Lydian‟s‎ March‎ 28,‎ 2019‎ presentation). ***Golder (2014a) acknowledges the model‟s ‎inability to predict pit inflows, yet pit inflows and the impacts of pit dewatering on water levels and on springs discharges and river flows were reported.***

Page 50 - 2.1.2.5 Regional Groundwater Flow Model

Section 4.8.4 of the ESIA states that hydrographs for wells in the BRSF site indicate that groundwater levels rise rapidly in the Spring in response to snowmelt and decline rapidly following snowmelt. This behavior is indicative of fracture permeability and connectivity. ***The predicted changes in groundwater levels are unrealistic. Fractures beneath the BRSF are connected with fractures outside the BRSF footprint. Furthermore, model hydraulic conductivity values are directly proportional to model recharge values, and the recharge is low.***

***An outdated approach (ASTM, 2016) was used to perform model sensitivity analysis.*** The results were not used or intended to be used to collect additional data for the most sensitive parameters to better constrain the model (Myers, 2016), nor were the results used to guide calibration of the model because the procedure was performed after calibration. ***The results determined that the model is very sensitive to the hydraulic conductivity of the colluvium, yet water levels in the colluvium were not used in calibration.*** The problem with this type of sensitivity analysis is that the model is no longer calibrated after making a large change to a single parameter. T***he modified model cannot be used with any confidence to evaluate uncertainty of predictions.***

Page 51 - 2.1.2.5 Regional Groundwater Flow Model

The model is a qualitative or screening tool, at best, for illustrating the generalized configuration of the potentiometric surface, generalized groundwater flow paths, and conceptual responses to mining and associated operational activities on groundwater levels. ***The model certainly does not contribute to understanding the hydrogeologic setting of the proposed mine.*** I***f a quantitative model was the objective for predicting changes in water levels and flows, more hydraulic testing (especially pumping tests) should have been performed, and considerably more effort should have been devoted to incorporating the main structural and stratigraphic elements in the pit areas.*** Long-term, large-scale pumping tests should have been performed in the areas of the mine facilities and pits at various depths, as well as several in each rock type across the GSA.

Surface water and groundwater are interconnected. Water is exchanged in both directions. There are a host of factors influencing groundwater recharge, which varies significantly in space and time at all scales. Assuming some fixed amount of water percolates through the ground uniformly across large areas of the site and recharges groundwater at a rate that is constant with time is an overly simplistic approach that leads to poor model representation of subsurface properties and unreliable conclusions about surface water and groundwater. ***Given the scope of the Mine and its potential impacts on the environment, watershed modeling should have been employed. Recharge values are best constrained using an integrated hydrologic modeling approach which links watershed modeling and groundwater modeling.***

Page 52 - 2.1.2.5 Regional Groundwater Flow Model

***The model does not correctly represent the GSA water balance.*** Total recharge is low with respect to estimated river baseflows. Furthermore, the model is intended to represent average annual conditions (calibration to average groundwater levels).

**Water Resources Impacts Assessment**

Page 53 - 2.1.3.1 BRSF (Barren Rock Storage Facility)

***Assessment of impacts to groundwater was not done, i.e., no mixing calculations were performed. Transport was not simulated in the regional groundwater model, nor by any other means.***

Page 53 - 2.1.3.3 Mine Pits

***The water fluxes (runoff, infiltration through backfill, seepage to groundwater) from the pit seepage modeling of the Tigranes-Artavasdes-Arshak pit are significantly underestimated*** (Section 2.1.2.1 of this report). Insufficient information is provided in the report for the Erato post-closure pit water balance (Golder, 2014c) to fully assess the pit inflows, the pit lake level and volume, and the calculated seepage rate to groundwater. However, perched water inflows are based on the incorrect, low recharge rate determined by the groundwater model calibration. N***oteworthy is that only 40% of precipitation on the pit walls was assumed to report to the pit bottom based on a water balance for the HLF (cited report12 was unavailable). This assumption is suspect because the pit walls and the HLF have very different surface properties and elevations.*** These issues suggest the steady-state pit lake surface water elevation is underestimated. Moreover, based on neglect of the effect of the head of water on the pit floor, the seepage rate would be underestimated. ***The seepage rate to groundwater from the Erato pit lake is underestimated.***

***Solute transport simulations based on the estimated pit seepage fluxes underestimate potential impacts to groundwater and surface water*** (independent of uncertainties introduced by questionable source concentrations, other assumptions, and approach). Predictions of impacts require an integrated approach that includes loading of constituents to groundwater and surface water from all potential sources. ***The impacts assessment presented by Golder (2014d) only considers the loading from the mine pits and thus the overall impact on the groundwater cannot be adequately assessed.***

Page 54 - 2.1.3.3.1 Pit Water Runoff

***Inappropriate results of the runoff water quality modeling (GRE, 2014e) can be illuminated with some examples of the multitude of issues identified with this modeling as noted below:*** (see full text for examples)

Page 55 - 2.1.3.3.2 Tigranes-Artavasdes Seepage and Arshak Pit Seepage

***…...Details of the modeling are not provided. However, some obvious deficiencies and inconsistencies are addressed below.***

***The text states that a buffer concentration was applied to alkalinity around detected values of 1 mg/L. This statement is not clear, and it appears that the stated concentration was arbitrarily assigned to solutions.***

***The description of oxygen diffusion modeling (GRE, 2014f) is cryptic and insufficient to evaluate.*** The oxygen consumption rates are reportedly taken from the geochemical modeling and are representative of the oxygen consumed by ARD reactions in the LV material. Based on that analysis, GRE derived an oxygen half-life of 700 days. The results of the oxygen consumption and oxygen diffusion modeling reportedly (GRE, 2014f) showed that oxygen penetration is limited to the uppermost 0.5 meter of the mine waste. However, GRE (2014f Figure 10) shows oxygen concentrations decreasing downward through 0.5 m of topsoil overlying backfill and arrows in the backfill point upward. Additionally, GRE (2014f) states that similar results were obtained for the Arshak pit bottom. ***Topsoil and fractured rock on the pit bottom have entirely different material properties. GRE (2014f) then states that the total depth of oxygen penetration is assumed to be 1.5 meters, consistent with results of analysis for the BRSF. This explanation is incomprehensible.***

Page 56 - 2.1.3.3.2 Tigranes-Artavasdes Seepage and Arshak Pit Seepage (cont.)

The final simulated water qualities of Arshak seepage and Tigranes-Artavasdes seepage are presented (GRE, 2014f Table 3) with a **statement that the water quality is consistent with water samples representing long-term ARD reactions** that are occurring in unmitigated LV waste piles located in Sites 13 and 27. ***The simulated solutions are very different from each other,*** and pH of the solutions are in the range of the pH of Site 27 leachate. Otherwise, ***little similarity is observed.***

Page 57 - 2.1.3.3.4 Solute Transport Simulations

The text (Golder, 2014d) states that the understanding of potential solute migration pathways from the pit areas is substantially based on groundwater flow modeling (Golder, 2014a). ***The text states that five flow paths are defined which represent the majority of the infiltration from the closed pits as seen by the concentration in flow lines for these pathways.*** This statement gives a lot of weight to the model-determined pathways, ***yet for the spreadsheet model, assumptions are made about depths of transport pathways that are completely different than the groundwater flow model particle paths.*** The flow model advective transport times are voided and replaced with arbitrary, up to an order-of-magnitude shorter travel times to receptors and are justified on the basis of conservatism. ***The regional groundwater flow model cannot be both correct and incorrect. This approach is not good science. It is obvious that Golder does not have confidence in the groundwater flow model.*** Neither the spreadsheet model nor the existing groundwater flow model is suitable for the transport calculations. The regional model should be revised (see Section 2.1.2.5) and used for solute transport.

Page 58 - 2.1.3.3.4 Solute Transport Simulations (cont.)

***Elaborate schemes were devised*** for partitioning fluxes from the base and walls of each pit subarea to various solute transport pathways and determining separate source concentrations for the pathways, based partly on division of the area around Amulsar Mountain into multiple subareas. ***The same approach was used for the local area scenario.***

***The spreadsheet calculations of solute transport*** and the local impacts scenario based on mixing are not conservative, with source concentrations ***determined by geochemical modeling that are too low***. ***Furthermore, loading rates to groundwater are underestimated due to seepage rates from the pits that are too low***, and the predicted concentrations in the spreadsheet model do not include the effects of the BRSF and HLF

Page 58 - 2.1.3.4 Potential Impacts due to Initial Mine Construction Work

As part of the assessment of potential impacts of initial Amulsar Mine construction activities on water resources, ELARD-TRC Team reviewed monitoring data obtained by the “Environmental Monitoring‎ and ‎Information‎ Center”‎ of‎t he‎ MNP (SNCO, 2019).

Pursuant to a Lydian press release (Appendix C of this report), groundbreaking of the Mine occurred on August 19, 2016. However, there was no information available as to the schedule or sequence of the initial construction activities or when these activities were suspended.

SNCO has been monitoring the surface water quality at three observation points in the region of the Amulsar Mountain since 2006. The monitoring frequency varied from monthly to quarterly. The last monitoring event was in November 2018.

***The provided data package did not include descriptions of sampling methodologies or analytical methods or standards. Moreover, no other information or details were provided about the monitoring points or about human or other activities or climatic conditions near the monitoring points. Therefore, only a preliminary comparative screening of data collected before and after the start of initial construction activities at the Amulsar Mine was conducted.***

Page 60 - 2.1.4 Project Water Balance

The objective of the SWWB (Site-Wide Water Balance) model is to estimate the volume of excess water generated and process make-up water demand over the construction period and operational life of the mine (LoM).

***The water balances illustrated and outlined for each facility are logical. However, some parameters are questionable and/or have very high uncertainty,*** such as the annual volume of groundwater reporting to the pits. Also, for pit backfill and the BRSF, a soil evapotranspiration parameter was applied. If this parameter is derived from (GRE, 2014b and GRE, 2014c), ***evapotranspiration is much too high and infiltration and runoff are correspondingly low.***

***Noteworthy*** is that the **water balance conceptualizations for the pits and BRSF are more realistic and meaningful in the SWWB** (Golder, 2018) ***than those presented in the Pit Seepage and BRSF Runoff and Seepage Sub-Models*** (GRE, 2014a/2014b/2014c).

Page 60 - 2.1.5 Mitigation Measures

***Generally, the design concepts used*** in the Amulsar ESIA/EIA for development of mitigation measures ***are reasonable and appropriate*** (e.g., low permeability liners, encapsulation, capping, drainage, and leachate treatment). ***However, a number of the measures and plans, are partial, not-sufficiently protective, and/or unreliable with a high degree of uncertainty, particularly due to deficient and questionable data, models, model simulations, design bases, and/or assessment.***

Page 61 - 2.1.5.1 Mine Pits

***There is clearly potential for contamination of groundwater by ARD-impacted pit seepage water. There are no contingency plans to mitigate groundwater contamination originating during operation and post closure from the pits beyond monitoring, for which no details are provided.***

Page 62 - 2.1.5.2 BRSF

***The design concept of using non-PAG drainage layer at the base of the waste rock pile*** and an underlying low permeability clay liner to deflect seepage through the BRSF to the subgrade drains and mitigate infiltration to groundwater ***is adequate.*** ***However, the key liner design criteria are unreliable and raise concerns about the long term integrity, performance, and protectiveness of the liner including:***

* The effectiveness of vehicle traffic in compacting native soil to develop a uniformly low permeability liner and the plasticity and homogeneity of the native soil across the BRSF area. Appropriate soil compaction equipment should be used.
* The small thickness of 0.3 m15 and the relatively high hydraulic conductivity of 1x10-5 cm/sec (vs.1x10-6 cm/sec specified in Golder (2107) and Geoteam (2015 Section 3.2.3)), particularly given the questionable modeling results and variability in subgrade conditions.
* The high degree of uncertainty associated with limiting the confirmatory hydraulic testing, particularly given the variability in subgrade conditions.

Page 63 - 2.1.5.4 Contact Water Treatment Systems

Treatment of the contact water discharged from the mine operations is important to ensure that surface water quality is not impacted above applicable Armenian water quality standards. The ESIA focuses on and proposes PTS for the Mine contact water.

The ESIA (Section 6.10, page 22) and ARD Management Plan – V. 3 (Geoteam, 2016c Section 1.1 Commitments) indicate that if treatment trials indicate that a PTS will not meet the discharge criteria (MAC II standards) then a conventional packaged active water treatment system will be used. ***There are no descriptions of the decision-making process or details about the active treatment processes or requirements.*** Noteworthy, however, is that the commitments made in the ARD Management Plan – V. 3 (Geoteam, 2016) including the commitment to use active treatment in case of PTS inability to meet MAC II Standards, have been omitted in the updated ARD Management Plan – V. 4 (GRE, 2017). Therefore, this option cannot be assessed.

Furthermore, Lydian during the March 28, 2019 presentation and the June 27, 2019 conference call indicated that it will adopt an adaptive management approach for the mitigation and treatment of the Amulsar Mine impacts on water resources. However, ***Lydian provided no details or protocols for this approach. Therefore, the adaptive management approach cannot be assessed.***

Page 64 - 2.1.5.4.1 ARD - BRSF 2.1.5.4.1.1 Overview

The PTS for the BRSF leachate is described in Appendix 8.19 of the ESIA (GRE, 2017) and in a design basis memorandum (Sovereign, 2015). The PTS will treat water from the BRSF and excess water from the HLF operation during the time the mine is active, and will treat the BRSF leachate after the mine closes.

The nitrate reducing bioreactor is obviously designed to remove nitrate from the blasting operation, but ***there is little discussion on the incoming nitrate concentrations, and no discussion of ammonia.*** The incoming water is ***inexplicably projected*** to have low iron and aluminum concentrations. ***This is a key and questionable assumption*** given‎ that ‎there ‎will ‎be ‎ARD ‎in ‎the‎ BRSF ‎and‎ the ‎pits ‟‎water ‎going ‎to‎ the HLF (GRE, 2014d), as will be discussed later.

***There are three major concerns with the proposed PTS design bases as discussed below:***

* 1. The system design using a PTS has been selected too early in the process and does not allow the flexibility needed to deal with such a complex water system. ***The design is based on simulated water quality that may or may not be valid. If the simulated water quality is not valid, then the system will most likely fail and not achieve the treatment objectives.***
* 2. ***The water quality modeling has significant discrepancies that make the modeling results highly uncertain and raise concerns about the ability of PTS to meet treatment objectives.***
* 3. A***mmonia in the wastewater will most likely be present at concentrations well in excess of the discharge criterion, but the treatment process for the ammonia is not discussed except in brief comments.*** Nitrate treatment is discussed in a little more detail, but is not given the focus that it should have and the nitrate concentrations appear to have been underestimated. Nitrate and ammonia are likely to be major contaminants that require treatment while the mine is operating along with the products of ARD. ***The system as designed may not be able to achieve the treatment criteria for either nitrate or ammonia.***

Page 65 - 2.1.5.4.1.2 PTS Approach

The approach has been to develop a model of the water requiring treatment, select and design a system to treat that water, and then build the treatment system early in the life of the mine…...As shown in the Table 2.1.1 below, the GARD Guide (INAP, 2009; Table 7-1) suggests that a passive system is most appropriate for closure and post-closure phases, while an ***active system is more appropriate for operational phases.***

***However, in contrast with INAP (2009) recommendations for using an active treatment system during mine operations, the ARD Management Plan for the Amulsar Mine (GRE, 2017) considers only a PTS for the BRSF during both operational and post-closure phases. GRE (2017) focused on the water quality and volume during the post closure phase and did not elaborate the rationale or feasibility for using a passive system during mine operation.***

The use of a passive (vs. active) treatment system was decided early in the design of the mine, as illustrated by Sovereign (2015). ***There is no indication that any review has been given since then as to whether an active system should be used (except in response to the comments by Bronozian as discussed below) despite the update of the site-wide water balance (Golder, 2018).***

***Further, the selected PTS depends on very low iron and aluminum concentrations in the incoming water, as projected in the geochemical model.***

***The major concern is that the whole system depends on the accuracy of the initial water model, both in terms of volumes and water quality, and on the biological systems behaving as predicted.***

***There are many places where this model could be off, both in terms of flow and more importantly in terms of water quality.***

Page 66 - 2.1.5.4.1.2 PTS Approach (cont.)

***Even if the model provides a good projection of the incoming water quality, there is no certainty that the proposed system would work…..***Bench scale and field scale pilot treatability studies are needed before the design is finalized. The success of studies will require good understanding and accurate representation of the incoming water quality, and of the range of concentrations of the key parameters in the incoming water.

However, the bench scale treatability tests currently being conducted are not aimed at evaluating the PTS performance under varying conditions or determining under what conditions the PTS will fail. ***Instead, the bench scale tests are focused on a specific set of treatment processes and on demonstrating that the PTS is successful for a very limited set of input water quality conditions.***

Page 67 - 2.1.5.4.1.2 PTS Approach (cont.)

***The above response along with the omission of the commitment to use active treatment in the updated ARD Management Plan (GRE, 2017) indicate that active treatment is not seriously considered……..But to select a PTS for an active mine, and even for post-closure strictly based on questionable modeling data (see discussion below) without a definitive analysis and actual measurements of the influent water quality is incorrect.***

Page 68 - 2.1.5.4.1.3 Geochemical Modeling

***There are discrepancies between modeled water quality shown in Table 2.1.2 and the water quality model given by GRE (2017) and that given by Sovereign (2015) as noted below. A.***

***Iron concentrations are too low – key parameter for system as designed***

….Thus, the influent water of the PTS needs to have significantly lower metal concentrations than those concentrations in order to justify the proposed low metal PTS layout, and ***the current design may not be able to treat the ARD generated at the Site.***

***The projected iron concentration*** in Table 2.1.2 (5.66x10-7 mg/L) for PD-8 water, which is presumably coming from an ARD process, i***s unrealistically low*** as summarized below:

* ***The GRE (2017) analysis does not include iron and aluminum concentrations typical of ARD, which can contain much higher iron concentrations.*** The GARD Guide (INAP, 2009) states that iron concentrations in ARD can range from 1,000s to 10,000s mg/L.

Page 69 - 2.1.5.4.1.3 Geochemical Modeling (cont.)

* ***GRE (2017) assumed the iron to be in the ferric oxidation state. However, pyrite oxidation first generates iron in the ferrous oxidation state***, which is much more soluble at low pH than is ferric iron.

***The discrepancy and high uncertainty in iron concentrations does not give confidence in the modeled water quality and raises concerns about the certainty and reliability of other parameters***.

B. Charge Balance

***The projected water quality results have significant inconsistencies in the cation-anion charge balance.***

Charge Balance Error (CBE) = (total cations-total anions) / (sum of anions and cations) = 24.9%. ***This error is higher than the acceptable CBE of (less than ±5%)*** (Standard Methods, 1999). ***Possible causes for electrical imbalance are: 1) laboratory errors; 2) some species (major ions) are not measured; and/or using unfiltered samples that contain solids which dissolve during sample preservation in acid.***

Page 70 - 2.1.5.4.1.3 Geochemical Modeling (cont.)

Golder (2014f) states that sodium and fluoride are used to balance slight differences in the charge balance during the modeling, but ***to have fluoride account for the charge difference in Table 2.1.3 would require a fluoride concentration of 33 mg/L, which is unrealistic as demonstrated by the Amulsar surface water, groundwater and rain water monitoring results***

Also, Table 2.1.3 shows no sodium in the incoming water to the PTS. Sodium is usually a major cation in water, and if there is much sodium in the water, the charge balance would become even worse. ***The charge balance discrepancies further raise concerns about the reliability of the model projections and water quality.***

C. Aluminum concentrations inconsistent

***The water quality model predictions (GRE, 2017; Table 14) and data used in the PTS design basis (Sovereign, 2015) are different as shown in the comparison in Table 2.1.4 below.***

Since the design of the PTS depends on having aluminum concentrations below 2 mg/L, the decrease in aluminum concentration from 27.2 mg/L to 2.27 mg/L is significant. ***The value of 27 mg/L (GRE, 2017 Table 14) indicates the selected PTS system (with a design criterion of less than 2 mg/L for aluminum) was not appropriate for this water quality.***

Page 71 - 2.1.5.4.1.3 Geochemical Modeling (cont.)

***This discrepancy is further elaborated*** by comparing the PTS influent data (Sovereign, 2015) to water quality from various test results and data sets including HC and modelled concentrations of key parameters for the BRSF seepage and underdrain (GRE, 2014g).

***This discrepancy in sulfate concentrations raises concerns and further increases uncertainty in the system design.***

***The modeled water quality is dependent on a number of factors that could be different from that originally modeled.***

Page 72 - 2.1.5.4.1.3 Geochemical Modeling (cont.)

***Presumably, this will alter the proposed water quality projections. These changes have not been incorporated in water quality modeling since the model was reported in 2014…….The water quality from the mine pits has also been modeled, but there is no indication that the water quality of the mixed water (which is what will go into the PTS) has been modelled, nor has there been much effort made to evaluate the changes in water quality after the mine pits are closed…...***

***…..Such changes highlight the uncertainty in the water quality modeling, and the risk in design treatment systems based on projections that may change.***

Page 72 - 2.1.5.4.1.4 PTS Design

GRE (2017) provides an updated ARD Management Plan while Sovereign (2015) provides the basis of the PTS design…...While the modeled water has low metals concentrations, there is no guarantee that the model is correct and ***no ability to adjust the system for high iron and aluminum concentrations if the modelling is not correct.***

 ***A key discrepancy is that the design (Sovereign, 2015) does not elaborate what happens to the acid, or why the two manganese removal beds are necessary.***

While it is valuable to have the bioreactors demonstrated, the focus again is on postclosure water with low metals concentrations. ***The testing did not address what would happen if the iron and aluminum concentrations were higher than projected in the water quality models.***

Page 73 - 2.1.5.4.1.5 Nitrate and Ammonia

The estimated flow from the pit sumps is 250,000 m3 /year for years five through nine, while the seepage from the BRSF is estimated at 63,000 m3 /year (2 L/sec). I***t is not clear from the reports how much of the pit water will be sent to the PTS***, ***but if it constitutes a significant portion, the water coming into the PTS could contain on the order of 100 mg/L nitrate and 100 mg/L ammonia. These values are significantly over the criteria for surface water*** (0.4 mg/L NH4 and 2.5 mg/L NO3 for Type II water in Arpa River basin, which is intended as the discharge water body). Thus, the water will need to be treated.

The projected influent PTS nitrate concentration during operations in the incoming water for the PTS used by Sovereign (2015) is 2.35 mg/L, while the post closure nitrate concentration is projected to be 42 mg/L. ***These numbers are questionable since the highest concentrations should be during operation not after, and are contradictory to the projected nitrate concentrations from Golder (2014f) estimates.***

***Furthermore, there is no projected concentration for ammonia in the influent water for the PTS.***

Moreover, treatment of the nitrate and ammonia during the last five years of the mine operation when the PTS is treating the water from both the BRSF and the excess water from the pit sumps needs to be addressed. ….***there is no discussion of how ammonia will be addressed.***

Page 74 - 2.1.5.4.1.6 Summary (Reviews all the points made above)

Page 75 - 2.1.5.4.2 HLF 2.1.5.4.2.1 Overview

At the end of mine operation, the ore pile continues to be leached until the gold is extracted, then it is rinsed with fresh water with hydrogen peroxide added to destroy residual cyanide. This water is collected separately. Following rinsing, the pile is capped and any leachate after capping is treated in a PTS designed just for the HL water. Lydian states that it is difficult to predict what will be in the heap pile leachate, that it is difficult to design a treatment system for this water at this point, and that the design will be done after a better understanding of the water quality of the HL water is available. The deferral of a final detailed design of the PTS until after mining operations start is a reasonable approach.

There are, however, several concerns about the HLS characterization, treatment, and discharge.

Page 76 - 2.1.5.4.2 HLF 2.1.5.4.2.1 Overview (cont.)

The testing was not intended to evaluate how the water quality of the HLS would be after ten years of operation with continuous recycling and cannot be used for that purpose, for several reasons:

* The reagents used in the laboratory testing are relatively different from those to be used in the full-scale operation, namely the laboratory testing used lime (CaO) to raise the pH whereas the full-scale operation will use sodium hydroxide (NaOH). ***The calcium and sodium concentrations in the laboratory testing are not representative of field solutions.***
* ***M***ore importantly, the HL water will be recycled for ten years in the HLF operation with no discharge. NaCN, NaOH, and HCl will be added at each pass through the pile (with a 60-day cycle, this corresponds to around 60 cycles). The concentrations of the continually added soluble ions (sodium, chloride) will increase, as will sulfate from the rock. ***Yet, the table shows the concentrations of sodium based on the concentration added in the initial wash of the HL pile. This is unrealistic,*** particularly when considering mass accumulation due to continued water loss due to evaporation in the HLF and contact water pond. For the soluble ions such as sodium, chloride, nitrate, and sulfate the concentrations given are ***obviously too low***, which would result in underestimating corresponding loading to and treatment requirements at the PTS.
* Golder (2014f) ***did not estimate the concentration of nitrogen in the HLS*** due to other sources of nitrogen, ***saying the analysis was outside the scope of the memorandum.***

Page 77 - 2.1.5.4.2 HLF 2.1.5.4.2.1 Overview (cont.)

The alkalinity values in Table 2.1.8 are ***inconsistent.***

***These values are simply incorrect as presented***….Therefore, one cannot have a hydroxide alkalinity of 3.4 mg/L CaCO3 at pH 9.74 as shown for Test 61790.

As discussed above, alkaline water that has been in contact with the atmosphere for ten years should have very high concentrations of both carbonate and bicarbonate, and the alkalinity results should reflect these high concentrations. T***he values shown in the Table 2 are questionable.***

Moreover, the laboratory results sheet for the Kappes-Cassidy (2012) study presents a charge balance for the water quality. However, ***the charge balance results are inconsistent with the water quality***, since in some samples the charge from sodium is greater than the total cationic charge.

Page 78 - 2.1.5.4.2 HLF 2.1.5.4.2.1 Overview (cont.)

Kappes-Cassidy (2012) study was performed to evaluate the effectiveness of cyanide at recovering gold and the ability of peroxide to destroy the cyanide, where water quality results may arguably be peripheral to the point of the study. However, t***he use of its questionable water quality data to model the water quality of the final leach solution***, design the PTS, and assess the potential environmental impacts and compliance ***is problematic and untenable.***

Page 78 - 2.1.5.4.2.3 HLS Treatment

At the end of the heap leaching operation, it is not clear what happens to the HLS used in the HL operation.

A flow chart of the water management during the closure phase presented as Figure 6.10.3 in Chapter 6.10 of the ESIA is shown below as Figure 2.1.2. The water from the residual leaching and rinsing are shown going to the ADR plant, and ***then inexplicably disappearing.***

Page 79 - 2.1.5.4.2.3 HLS Treatment (Cont.)

The ESIA proposes a dedicated PTS to be designed and implemented upon closure based on post-closure water quality monitoring and present generalized descriptions of processes for treating the leachate from the HLF post closure. ***This may be a reasonable approach; however, the ESIA should include plans for laboratory treatability and pilot testing*** to evaluate and confirm the feasibility and effectiveness of the PTS in treating the HLS and leachate and in achieving the discharge criteria. ***Furthermore, there are no contingency plans in case of the PTS failure*** to effectively treat the HLF wastewater or in future cases of PTS failure or emergency.

Page 79 - 2.1.5.4.2.4 Summary

The discussion of the heap leaching operations solutions has two major issues:

* ***The projected water quality at the end of operation, both before and after cyanide treatment is unrealistic.*** The water quality used for modeling the system comes from ***tests that were not designed and not appropriate for assessment of environmental impacts***, treatment, and compliance of the wastewater, and ***the water quality results have internal inconsistencies indicating that some of the results are incorrect.***

Page 79 - 2.1.5.4.2.4 Summary (cont.)

* ***There is no indication of how the HLS (the barren solution after the pass through the ADR) will be managed and treated and only a limited discussion of how the rinse water will be treated. This water may be on the order of 1 million m3 and may contain high concentrations of ions that can be difficult to treat (sodium, chloride, nitrate...), so how it is handled is important to prevent contamination of the receiving surface water.***

***The reports are not clear on how the HLS will be treated immediately after mining operations cease, thus it is difficult to determine whether treatment will be successful or what the impacts are if treatment is not successful.***

Page 80 - 2.1.5.5 Catastrophic Events

 River flood risk is extremely low.

***The seismic hazard risk is high for the Project Area.*** Seismicity was considered in the design of the HLF, BRSF, open pits, crushing plant, and overland conveyor system. However, an old construction standard was used for the analyses. Furthermore, known faults within the Project study area were not considered in the seismic hazards analysis. ***Movement on the seismically active PSSF fault system could cause fault slip in the study area, potentially compromising the liner beneath the BRSF and the cover and destabilize the waste rock pile (Zirak Fault beneath BRSF).*** This fault ***could conduct ARD-impacted seepage water from the BRSF toward the Kechut Reservoir and/or to the Vorotan River.*** Fault slip on the Agarakadzor Fault passing through the vicinity of the pits and BRSF could also impact the stability and integrity of the BRSF and pit backfill and cover systems. ***Ground motion could also impact the stability of the HLF, liner, piping, and cover and inflict damage on the contact water channels, the PTS, and system of process and stormwater ponds, resulting in contact water being released to surface water and groundwater.***

Page 80 - 2.1.5.5 Catastrophic Events (cont.)

Covers on the BRSF and pit backfill can be restored, if impaired by earthquakes. The repair of breached liners beneath the BRSF and the HLF will be challenging, requiring temporary or permanent relocation of the rock and spent ore. ***A destabilized BRSF or pit backfill could result in permanent loss of the non-acid generating VC layer of rock between the cover and the PAG*** ***rock…..***

***…..Any exposed PAG rock on pit walls or in the BRSF, HLF, or pit backfill due to earthquakes could impact the environment for hundreds, or possibly on the scale of a thousand or more years.***

Page 81 - 2.1.5.5 Catastrophic Events (cont.)

***Historic landslides surrounding the Amulsar Mine are not documented in the ESIA, EIA, or supporting documents.***

***The Golder (2013) earthquake hazard assessment does not address the potential for landslides resulting from blasting.*** An assessment of potential landslide activation and the consequences is not possible with the available information. ***The revised construction standard should be reviewed for compliance of all mining infrastructure including the need for reinforcement or double containment of piping.***

Page 81 - 2.1.5.6 Post Closure Cost

The Amulsar Mine closure cost bases and estimates are provided in Appendix 8.18 of the ESIA. The cost was reviewed for general consistency with standard practice. The cost estimates cover the major scope items. ***However, some cost items are questionable and the overall cost appears to be underestimated.***

* The post closure operation, maintenance & monitoring (OM&M) period is limited to ***only five years.*** In the US, regulatory requirements and guidelines for closure (e.g., RCRA 40 CFR Part 264.117; Nevada NAC 445A.446; USEPA, 2000) indicate ***post closure costs should be calculated for a revolving 30-year period (minimum), especially when contamination sources remain……***

The shortened post closure monitoring period and the omission of the periodic replacement/maintenance costs wil***l result in significantly underestimating the post closure costs.***

Appendix 8.18 of the ESIA provides a cost of $5,558,510 for monitoring and maintenance of the PTS. ***There is no breakdown for this cost.***

Page 82 - 2.1.5.6 Post Closure Cost (cont.)

Using the post closure period of five years assumed in the ESIA, the equivalent annual routine OM&M cost is estimated to be approximately $1.1M. Accordingly, the unadjusted cost (i.e., without indirect cost) for the PTS OM&M alone for 30 years will ***be approximately $33.4M***. The total cost will likely be higher …...***approximately $40.5M***

Appendix 8.18 of the ESIA provides a cost of $410,576 for monitoring, which includes $286,252 for rehabilitation monitoring and maintenance and $124,324 for groundwater and surface water monitoring).

Accordingly, the unadjusted cost of monitoring for 30 years will be ***approximately $2.5M…...will result in a total cost for monitoring to be approximately $3M***

***Combining items i and ii above with the other costs remaining unchanged indicates the total Mine rehabilitation and closure cost will increase from approximately $34M to approximately $70M (without adjustment for periodic replacement costs or realistic contingency).***

* Contingency (scope and bid) is too low at 6%.......

Using the adjusted indirect cost with a 20% contingency and a 30-year post closure OM&M period, ***the total rehabilitation and closure cost would be estimated to increase to approximately $78M.***

Page 83 - 2.1.5.6 Post Closure Cost (cont.)

* ***Treatment scope and costs are unrealistic*** due to incorrectly assumed low leachate concentrations and mass loading and missing processes as discussed in Section 2.1.5.4.
* ***Professional/technical costs*** (design/engineering, project management/administration, and construction management) at approximately 3% of total construction/capital costs (on the order of $1M) ***are underestimated***.

Page 83 - 2.1.6.1 Environmental Monitoring Plan (EMP)

***The EMP does not specify locations or details of future monitoring.*** The Project needs to develop a comprehensive plan for future monitoring (operations, closure, and post-closure). With respect to past monitoring locations, the following observations may be considered for future monitoring.

Page 84 - 2.1.6.2 Quarterly Environmental Monitoring Reports

Nine surface water quality monitoring locations were sampled in Q1 2017. The number of sampling locations increased to a maximum of 16 in the most recent quarterly monitoring report (Q1 2018), which is much less than the number of stations shown on Figure 4.10.1 of the ESIA (39). ***Notably, no locations on the Darb River or north of the Kechut Reservoir (including Jermuk) were sampled.*** Most locations north of the BRSF, including the stream in the vicinity of the Madikenc springs, the Spandaryan Reservoir, two locations around Gorayk, and all locations east and west of Amulsar Mountain were omitted. ***These omissions are unjustified, especially for a deficient baseline dataset (see Section 2.1.1.6).***

Page 85 - 2.1.6.2 Quarterly Environmental Monitoring Reports (cont.)

Five springs and groundwater quality monitoring locations were sampled in Q1 2017. A maximum of 21 locations was sampled in Q4 2017, ***far less than the number of stations shown on Drawing 4.8.2*** of the ESIA (24 groundwater and 28 springs), which itself ***is deficient in springs sampling locations*** (see Section 2.1.1.6). There are some differences in locations sampled each quarter. Only one spring (SP83, Madikenc) in the GSA was sampled twice. ***This sampling program is unacceptable*** with respect to the number of locations and the deficiency in baseline data (see Section 2.1.1.6).

***The monitoring reports do not include*** potentiometric surface contour maps or contour maps of key constituents in groundwater. ***There are no time-concentration graphs. There is no discussion of results with respect to previous results and no discussion of analytical methods.***

SECTION 6 - SURFACE WATER HYDROLOGY ANALYSIS REDUX

Early in this section ELARD-TRC included this statement and clarification in their report.

***Lake Sevan is protected by Armenian law which permits no activity that may negatively impact the lake and its ecosystem. The BRSF lies within the “immediate impact zone” of Lake Sevan.***

The BRSF is the Barren Rock Storage Facility that will be constructed to contain all of the lower grade “waste” rock produced at this open pit mine. The issue with the BRSF is the potential of toxic liquids being produced after contact with precipitation or other liquid sources. This facility is “permanent” in that it is supposed to successfully contain all harmful liquids until they become inert. The time frame in question is measured in generations, not a few decades. This is significant if one considers the seismic potential in this area.

In regards to what constitutes a “negative impact” on Lake Sevan, this is beyond the scope of the TOR and is a more suitable question for the Armenian Government and its people.

The modeling used in the original ESIA to determine seepage of polluted liquids from the mine, was shown to be problematic by ELARD-TRC. They point out that,

***The results of the 1D models are incorrect (GRE, 2014a Table 2).***

***Another problem with the Table 2 (GRE, 2014a) results is the water balance. The net infiltration based on the tabulated numbers is incorrect. Particularly large discrepancies are evident for both uncovered backfill scenarios.***

***Another problem with the Table 2 (GRE, 2014a) results is the water balance. The net infiltration based on the tabulated numbers is incorrect. Particularly large discrepancies are evident for both uncovered backfill scenarios……..However, the results for the Artavasdes pit are unclear with respect to the information presented on mine planning.***

***Results for the Arshak pit are incorrect.***

***The fluxes from the pit seepage modeling are incorrect. Use of these fluxes in the regional groundwater flow model results in incorrect assessments of impacts to groundwater levels and springs. Furthermore, solute transport simulations would severely underestimate potential impacts to groundwater and springs from acid mine drainage.***

In regards to a Regional model they note,

***Noteworthy is that the model was not used as a tool in the planning phase of locating mine facilities for minimizing risk to the environment***

 ...the Darb and Vorotan Rivers. ***These perennial streams should have been included***

***in the model.***

**A potentially unnecessarily long no-flow boundary was used along the southern perimeter, forcing flow parallel to this boundary to the northwest and southeast…..*The impact of the long no-flow boundary on simulated flow from Amulsar Peak cannot be determined based on available information.***

***each of the five hydrogeologic units is represented by a single set of hydraulic properties,*** i.e., all six model units are numerically homogenous, ***in spite of the hydraulic test data showing 4 or more orders of magnitude variation in hydraulic conductivity for each rock type.*** ***This deficiency can have a significant effect on the model predictions (e.g., will not identify preferential flow pathways).***

***The geology in the pit areas is poorly represented. Faults are completely absent in the model……...Some faults may be conduits for groundwater flow.***

***The simplistic numerical representation of the subsurface in the existing model is inadequate for making quantitative predictions. Notwithstanding this inadequacy, numerous quantitative predictions, which are unreliable, were made.***

***...Twenty-two of forty-one calibration targets (54%) have errors of 25 meters and more, and fourteen targets (34%) have errors of 40 meters and more, ranging up to 96 meters (twice the maximum recorded seasonal range in water levels)......is unreliable.***

***Despite the large model water level errors, the model was used to estimate operational water levels beneath the BRSF area (simulated baseline water level errors up to 80 m), the HLF area (simulated baseline water level errors up to 37 m), and the mine pits…...With such large errors in calibration water levels, the model is a poor indicator of head above ground surface and a poor indicator of the effects of mining activities on groundwater levels and groundwater flows (springs, river discharges, pit inflows).........Golder (2014a) acknowledges the model‟s ‎inability to predict pit inflows, yet pit inflows and the impacts of pit dewatering on water levels and on springs discharges and river flows were reported.***

Note above. The model used in the original ESIA was acknowledged by the company conducting the assessment as unable to be accurately predictive, yet the data was delivered anyway.

This section concludes with a note from ELARD-TRC, specifically regarding Solute Transport Solutions, but one which generally sums up the original ESIA from Lydian.

 ***This approach is not good science.***

The following from Page 57 to to Page 85 will consist solely of short excerpts detailing the findings, methods, processes, and other questionable activities of the Lydian assessments.

* ***Elaborate schemes were devised***
* ***calculations…….that are too low***
* ***rates to groundwater are underestimated due to seepage rates from the pits that are too low***
* ***did not include descriptions of sampling methodologies or analytical methods or standards.***
* ***Moreover, no other information or details were provided about***
	+ ***the monitoring points or***
	+ ***about human or***
	+ ***other activities or***
	+ ***climatic conditions near the monitoring points.***
* ***some parameters are questionable and/or have very high uncertainty***
* ***evapotranspiration is much too high and infiltration and runoff are correspondingly low.***
* ***a number of the measures and plans***
	+ ***are partial***
	+ ***not-sufficiently protective***
	+ ***and/or unreliable with a high degree of, particularly due to***
		- ***deficient and questionable data***
		- ***models***
		- ***model simulations***
		- ***design bases***
		- ***and/or assessment.***
* ***There is clearly potential for contamination of groundwater by ARD-impacted pit seepage water***
* ***There are no contingency plans to mitigate groundwater contamination***
* ***no details are provided***
* ***key liner design criteria are unreliable***
* ***There are no descriptions of the decision-making process or details***
* ***Lydian provided no details or protocols for this approach***
* ***there is little discussion on the incoming nitrate concentrations, and no discussion of ammonia.***
* ***The incoming water is inexplicably projected***
* ***There are three major concerns with the proposed PTS design bases***
* ***may or may not be valid. If the simulated water quality is not valid, then the system will most likely fail***
* ***modeling has significant discrepancies***
* ***the treatment process for the ammonia is not discussed***
* ***did not elaborate the rationale or feasibility for using a passive system during mine operation.***
* ***The major concern is that the whole system depends on the accuracy of the initial water model***
* ***There are many places where this model could be off***
* ***there is no certainty that the proposed system would work***
* ***To select at PTS…..without a definitive analysis and actual measurements of the influent water quality is incorrect.***
* ***There are discrepancies***
* ***Iron concentrations are too low – key parameter for system as designed***
* ***the current design may not be able to treat the ARD***
* ***unrealistically low***
* ***does not include***
* ***The discrepancy and high uncertainty in iron concentrations does not give confidence in the modeled water quality***
* ***raises concerns about the certainty and reliability of other parameters***
* ***results have significant inconsistencies***
* ***This error is higher than the acceptable***
* ***is unrealistic as demonstrated***
* ***discrepancies further raise concerns about the reliability of the model projections and water quality.***
* ***was not appropriate for this water quality.***
* ***This discrepancy is further elaborated***
* ***This discrepancy in sulfate concentrations raises concerns and further increases uncertainty in the system design.***
* ***The modeled water quality is dependent on a number of factors that could be different from that originally modeled.***
* ***this will alter the proposed water quality projections***
* ***nor has there been much effort made to evaluate the changes in water quality after the mine pits are closed***
* ***Such changes highlight the uncertainty in the water quality modeling***
* ***no ability to adjust the system for high iron and aluminum concentrations if the modelling is not correct.***
* ***A key discrepancy is that the design...***
* ***The testing did not address ….***
* ***it is not clear from the reports…***
* ***these values are significantly over the criteria for surface water***
* ***These numbers are questionable since…***
* ***there is no projected concentration for….***
* ***there is no discussion of how….***
* ***The calcium and sodium concentrations in the laboratory testing are not representative of field solutions.***
* ***This is unrealistic….***
* ***did not estimate the concentration of nitrogen….*** ***saying the analysis was outside the scope of the memorandum.***
* values in Table 2.1.8 are ***inconsistent.***
* ***These values are simply incorrect as presented***
* T***he values shown in the Table 2 are questionable.***
* ***the charge balance results are inconsistent with the water quality***,
* t***he use of its questionable water quality data to model the water quality of the final leach solution***…….***is problematic and untenable.***
* ***then inexplicably disappearing.***
* ***There are no contingency plans in case of the PTS failure***
* ***The projected water quality……..is unrealistic.***
* ***tests that were not designed and not appropriate for assessment of environmental impacts***
* ***the water quality results have internal inconsistencies indicating that some of the results are incorrect.***
* ***There is no indication of how***
* ***The reports are not clear on how the HLS will be treated...thus it is difficult to determine whether treatment will be successful or what the impacts are…..***
* ***The seismic hazard risk is high for the Project Area.***
* ***could conduct ARD-impacted seepage water from the BRSF toward the Kechut Reservoir and/or to the Vorotan River.***
* ***….resulting in contact water being released to surface water and groundwater.***
* ***…..Any exposed PAG rock on pit walls or in the BRSF, HLF, or pit backfill due to earthquakes could impact the environment for hundreds, or possibly on the scale of a thousand or more years.***
* ***Historic landslides surrounding the Amulsar Mine are not documented in the ESIA, EIA, or supporting documents.***
* ***some cost items are questionable and the overall cost appears to be underestimated.***
* ***only five years……. post closure costs should be calculated for a revolving 30-year period (minimum), especially when contamination sources remain……***
* ***result in significantly underestimating the post closure costs.***
* accordingly, the unadjusted cost for the PTS OM&M alone for 30 years will ***be approximately $33.4M***. The total cost will likely be higher …...***approximately $40.5M***
* ***the total rehabilitation and closure cost would be estimated to increase to approximately $78M.***
* ***Treatment scope and costs are unrealistic***
* ***Professional/technical costs***…...***are underestimated***.
* ***The EMP does not specify locations or details of future monitoring***
* ***Notably, no locations on the Darb River or north of the Kechut Reservoir (including Jermuk) were sampled.***
* ***These omissions are unjustified, especially for a deficient baseline dataset***
* ***is deficient in springs sampling locations***
* ***This sampling program is unacceptable***
* ***There are no time-concentration graphs.***
* ***There is no discussion of results with respect to previous results and no discussion of analytical methods.***

There are ***97 negative ascriptions*** applied ***after*** Page 57 and up to Page 85 of the assessment. This is a conservative count but should provide another clear indication of the issues with the original ESIA.

SECTION 7 - BIODIVERSITY

Page 85 - 2.2.1.2 Assessment

The Baseline Characterization in the ESIA/EIA…. is missing a detailed habitat map showing the 30 habitat types mentioned in the report that would guide the identification of the ecological functionalities of the key species on site.

Page 86 - 2.2.1.2 Assessment (cont.)

Information available in the baseline is not synthesized to enable a clear and direct understanding of the hierarchy of ecological significance; it also lacks reference to the status of those species in the Areas of Special Conservation Interest (ASCI) and the Bern Convention, as well as their local status in view of local evaluation of threats.

The baseline characterization section presents a description of species to be considered in the report while only distinguishing priority species (those reported in the Armenia Red Book) and the others. For instance, the report mentions 22 endemic plant species to be avoided where possible, though not in all cases, but refers to very few of those species by name.

**Missing as well are quantified observations and locations of observations, and definitions of habitat for each species at stake, with relevant surface areas.**

Page 86 - 2.2.1.2.1 Habitats and plants assessment

The ESIA summary explicitly states that the project will significantly change the rural landscape in which local people engage in traditional land management practices, but ***the project does not undertake efforts to survey and at least conserve the genetic diversity of economically important plants and crop wild relatives at Amulsar ex situ***

The distribution map of ***Potentilla porphyrantha*** shows all points that were sampled but ***does not clearly map the critical habitats for this species***. The critical habitat of this endangered species is identified ‎as‎“subalpine‎ meadow‎ with‎ alpine‎ elements”‎in‎ which‎ the‎ species ‎occurs‎ on‎ suitable‎ rock substrate. The physical footprint of the project is estimated to be on 150.5 hectares (12.5% of the total area of critical habitat). This assumes that the species occupies the entire area of critical habitat (1200 hectares) when it occurs only on a subset of the area where suitable habitat occurs. ***Therefore, 12.5% is an underestimate of the area occupied by this species.***

Page 86 - 2.2.1.2.2 Insects

***A clear description of the methodology*** used to justify the selection of the sampling points, which mostly fall outside the footprint area of the project, ***is lacking***, thus ***seriously compromising the ability to properly understand the baseline situation.***

W***ith regards to beetles, 14 species are reported in the Armenia Red book,*** of which Dorcadion bistriatum Motsch, Dorcadion sisianum Lazar and Dorcadion scabricolle sevangense are the most vulnerable endemic species of Armenia and s***hould be considered as a conservation priority***. Dorcadion bistriatum is reported in the vicinity of Ughedzor, Arpa river basin. A ***map of the habitat of these species of Dorcadion (endemic and vulnerable) is missing from the report to enable assessment of the species‟‎potential‎ presence‎ on ‎site.***

Page 87 - 2.2.1.2.3 Amphibians and reptiles

The report ***does not highlight the ecological significance of reptiles*** while two species of vipers Montivipera raddei and Vipera eriwanensis which are globally reported as vulnerable at International and National scale and reported in the red book and one additional species which is globally vulnerable and protected in the Red book of Armenia Telescopus falax occur ***and are reported in the direct footprint of the project. No further investigations were carried out to properly assess these priority species.***

The ESIA reports that the level of efforts invested for the field survey of reptiles and amphibians is not sufficient (7 days in total, for a total of 1800 ha, over 1 sampling season in non-optimal weather conditions) and yet n***o additional field work was done to complement this very preliminary assessment.*** ***This is especially of concern for the Ursini group of vipers, to which Vipera eriwanensis is affiliated. Throughout the report, this vulnerable species is said to be present in the general landscape without any precise scientific justification. Seven days is barely enough time to assess that the species is present without any notion of population quantities.***

Page 87 - 2.2.1.2.4 Birds

 The methodology reported is exhaustive and comprehensive

***Mapping and surface estimate*** of the functional areas for key species of concern (nearly 15) ***is missing from the ESIA*** report and should have been highlighted.

2.2.2 Impact Assessment on Biodiversity

Page 88 - 2.2.2.2 Assessment

The report includes different estimates of the footprint of the project on different biodiversity elements; for example, the impact is estimated to be 150.5 out of 1200 hectares for Potentilla porphyrantha but the total area of impact is 1766 ha + 160 ha which is confusing; for each receptor the report would benefit from a clear table with clearly annotated impacted surfaces. ***The evaluation of the significance of the impacts is not based on quantified figures and therefore is not defendable.***

Page 89 - 2.2.2.2 Assessment (cont.)

As examples:

On habitats and plants

The impact on the subalpine meadow with alpine elements has been ***under-evaluated*** – in view of the extent of the areas that will be impacted. The importance of the impact should be “significant”. For Potentilla porphyrantha the report mentions an overall positive impact in the long term. This statement is too ambitious and is not based on conclusive findings in the report.

On reptiles and amphibians For the vipers (especially in the urisini group), ***essential data is missing from the baseline*** to enable proper assessment of the impacts. The ESIA documents a non-significant residual impact without stating specific mitigation measures. The Ursini vipers are protected species, reported Vulnerable at global level, and‎ the ‎impact ‎cannot‎ therefore‎ be‎ considered ‎„Neutral”‎(as‎ reported in the ESIA). Besides, the justification provided states that these vipers occur in wider landscapes without providing supporting data from the literature to confirm this finding.

On birds For the Lesser Kestrel, ***the loss of feeding habitat is not to be considered neutral*** as the only colony feeding in Armenia is feeding on the project site.

2.2.3 Mitigation Measures

Page 90 - 2.2.3.2 Assessment

Some measures presented in the mitigation section cannot be considered as mitigation; the report suggests (Table 6.11) that monitoring would be carried out, and in case ongoing monitoring proves no residual impact, then in this case, the measures could be revised and reduced. ***The approach is misleading as mitigation measures should be proposed to address initial impacts, and in case of residual anticipated impact, then an offset program should be properly included.*** Without these, the IFC PS6 and EBRD PR6 are not properly addressed through this ESIA report.

***On habitats and plants***

Translocation for P. porphyrantha should be considered an ongoing experimental measure and cannot be considered as mitigation, since success is not guaranteed.

Reintroduction of the species in the restored pits is not really to be considered given that the conditions will not be favorable (altitude will be drastically lower and being in a pit will induce quite different local conditions than summit conditions).

***On reptiles and amphibians***

The unique mitigation measure suggested for vipers is related to the reduction of the areas of direct impact; however ***no specific measures are suggested***; moreover, the areas of direct impact for each protected species are not geolocated and their areas are not calculated.

2.2.4 Environmental Management plans

Page 92 - 2.2.4.2 Assessment 2.2.4.2.1 Biodiversity Management Plan (Appendix 8.21)

As presented, ***the biodiversity management plan is missing the operational section and map detailing the measures, their location, how to implement and who is responsible for implementation, and mostly how will those measures reduce the impact of each receptor*** (quantified estimates). As such the section is viewed as a “general recommendations” section rather than clear commitment‎from‎the‎project‟‎owner.

Page 93 - 2.2.4.2.2 Biodiversity Action Plan and Offset Measures (Appendix 8.20)

The establishment of the Jermuk National Park (JNP) is presented as the main offset measure for the project. ***However, the relevance of the added value of the JNP on biodiversity receptors affected by the project is yet to be demonstrated.***

***The‎“like-to-like”‎principle ‎of‎ the‎ offset ‎ifs not‎ clearly ‎demonstrated.‎***

***« An offset of 837 Habitat Impact Units (HIU) is required to achieve NNL of natural vegetation due to long term degradation and loss associated with Project development ».***

***Of those 837 units, only 500 are reported from JNP.***

***The summary of residual impact highlights the need to offset 22 species of plant, however no evidence is provided on the fact that these 22 species potentially occur in the JNP area. Moreover, a list of the 22 endemic plants concerned is not included. Neither is a list of species occurring at JNP for comparison.***

 ***It is surprising that no effort has been made to compile a list of crop wild relatives (and other economically important plant species in the area) and suggest measures to mitigate the impact of the project on these species.***

***As P. porphyrantha is not spontaneously found in the JNP, the conditions may not be suitable for the species.*** A statement such as « Research is ongoing on its ecology and growing conditions as outlined in the Species Action Plan, together with research on restoration techniques and searches for other populations in Armenia » ***cannot be considered valid for the JNP.***

Page 94 - 2.2.4.2.2 Biodiversity Action Plan and Offset Measures (Appendix 8.20) (cont.)

The report does not clearly demonstrate the possible Net gain on vipers within the future Jermuk National Park. ***No supporting elements are provided to assess the validity of this statement.***

The management ***actions suggested*** for viper by using prescribed fire, ***has proven drastic negative results in literature*** (http://www.vipere-orsini.com/fr/program-life-nature).

Moreover, the current conservation status of existing population of viper in the JNP is not properly assessed to justify eventual management actions for vipers.

Birds

The Eastern rock nuthatch is ***missing from the offset program*** while it should be considered as this species is a protected species and impact on its population is significant (table 6.11).

Page 95 - 2.2.4.2.2 Biodiversity Action Plan and Offset Measures (Appendix 8.20) (cont.)

This can hardly be considered in a Species Action Plan where every species has a specific ecology and consequently specific needs and cannot be grouped together, and because every possible effort could be considered.

Mammals

Set aside measures are suggested for the Brown Bear ***with no information as to their actual implementation and possible monitoring*** of efficiency to host the bears individuals.

Page 96 - 2.2.4.2.2 Biodiversity Action Plan and Offset Measures (Appendix 8.20) (cont.)

***The ESIA reports many promises while it should document commitments***; and the ESIA is supposed to be completed at date of submission and the latest statement undermines that the mitigation strategy is not yet fully developed.

The Biodiversity Offset Strategy (BOS) is missing a summary table summarizing for each receptor:

* Surface of critical habitat of this receptor and if possible number of individuals possibly affected by the project before mitigation
* Mitigation measures
* Surface of critical habitat of this receptor and if possible number of individuals possibly affected by the project after mitigation (residual impact)
* Units lost due to the project after mitigation
* Offsetting measures
* Units gained by offsetting program
* Balance, NNL or Net Gain

Page 96 - 2.2.4.2.3 Biodiversity Monitoring Plan (Appendix 8.12)

The Biodiversity monitoring is presented as part of the Environmental Monitoring plan (EMP), however ***no specific indicators for monitoring are provided*** for the natural habitats and biodiversity

Page 96 - 2.2.4.2.4 Mine closure and rehabilitation plan (Appendix 8.18)

This section is very general and ***in its current state is not directly implementable and operational.*** Actions are presented as objectives or aspirations and are built on experiments with no conclusive results. Ecological engineering techniques are not described in detail to enable proper assessment of relevance/adequacy.

SECTION 7 - BIODIVERSITY ANALYSIS REDUX

Generally speaking this section was the most compact and straight to the point. There were a few issues with mapping, surveying and properly referring to the latin genus/species of the various flora and fauna to be found in the area affected by the mining operation.

The main criticisms were levelled at the lack of Biodiversity Action and Monitoring Plans. In fact, these are essentially non-existent. As the assessment states:

***The biodiversity management plan is missing the operational section and map detailing the measures, their location, how to implement and who is responsible for implementation, and mostly how will those measures reduce the impact of each receptor***

The original ESIA relies on promises of action to protect species by relocation, in the vaguest sense and without any adherence to the viability of moving of species, particularly the vipers.

The idea of establishing a Jermuk National Park was mentioned by the original ESIA as the main offset for the project but again without detail, action plan or seemingly any real intent.

SECTION 8 - AIR QUALITY

Page 97 - 2.3.1.1 Expected Emissions Sources and Pollutants

The project consists of mining activities including blasting, loading and unloading of material, transport of material, crushing, but also the Gold processing including the auxiliary activities of electric power generation, organic liquid storage, and combustion of boilers. These activities will generate emissions into the air with the main pollutants being: CO, NOx, SO2, TSP, PM10, PM2.5 but also some that are more specific to the gold processing like Hg, HCN, and HCl.

Page 98 - 2.3.1.5 Methods Used for the Measurement of Pollutants

Moreover, ***no baseline assessment was conducted for gaseous Hg, HCN, and HCl.***

Page 103-104 2.3.2.5 Modeling of the Emissions Released by the Boilers and Gold Ore Processing

The modeling exercise using Raduga model was conducted for CO and NOx from the boilers and HCN and HCl from the ADR plant, and only in the EIA.

***No documentation was found or provided for Raduga model to assess its adequacy for Amulsar case.*** It is the regulatory model in the Republic of Armenia. What can be indicated based on the input file provided:

* Raduga is only a screening model
* It is a Gaussian model
* It does not take into account building downwash
* It only gives the highest concentration calculated It has a simple coefficient to account for topography
* It does not include a complete terrain module
* It does not take into account observed meteorological data hourly to assess the resulting concentrations
* It calculates wind directions for every 10-degree sector
* Values calculated are 1-hour average
* It cannot handle complex wind field

***In summary, the model is not adequate for this assessment even though it is requested in the Republic of Armenia.*** When the model was run, the resulting concentrations were not added to the background values to assess the breach of the local air quality standards.

Page 104 - 2.3.3 Mitigation Measures

The EIA and ESIA presented both the same mitigation measures and they are all relevant but ***their effectiveness in ensuring standards are not breached is uncertain given the identified deficiencies in the baseline and impact assessment.***

SECTION 8 - AIR QUALITY ANALYSIS REDUX

Similar to SECTION 7 - BIODIVERSITY, this section is generally acceptable in its approach to measuring air quality in and around the mining area. The main area of concern is in its approach to Modeling the Effects of Boilers and Gold Ore Processing on the air quality. Their modeling was deemed “not adequate” for accurate scientific measurements.

***In summary, the model is not adequate for this assessment even though it is requested in the Republic of Armenia.***

TOR QUESTIONS AND RESPONSES

4.0 Responses to Specific TOR Questions

4.1 Water and Geology This section presents responses (bold) to specific questions (italic) included in the TOR.

TOR Question #1: Are the assessments presented by Lydian in the ESIA and EIA Reports and in the appendices attached to them sufficient, qualified, scientifically justified and comprehensive, or not; did the conclusions, derive from the reliable and actual data and was the methodology developed for these conclusions comprehensive and reliable? Response:

* ***Most tools used in the assessment are suitable*** and are consistent with acceptable and standard practices.
* ***However,*** key elements of the ***assessments are inadequate, deficient, and inaccurate***.
* ***Baseline data deficiencies abound*** for geology, ARD characterization, hydrogeology, surface water and springs flow, and surface water and groundwater quality.
* ***Deficiencies led to questionable simplifications and interpretations.***
* ***Models for assisting with the assessments are oversimplified, incorrectly parameterized, procedurally incorrect, poorly calibrated, and not conservative.***
* ***Key data, conceptualizations, and modeling approaches are unreliable***
* ***impacts assessments are incomplete, leading to conclusions that are unreliable with a high degree of uncertainty.***
* (However) Good isotopic data were acquired, from which reliable conclusions can be reached.

TOR Question #4: Which risks, in particular, were not taken into account in terms of environmental security in the ESIA and EIA Reports? What dangers to the environment and to the health of the population may occur as a result of their omission? Are these possible negative consequences recoverable, or not, and if they are, what time frame and what type of financial resources would be necessary? Response:

* ***Known faults within the Project study area were not considered in the seismic hazards analysis.***
* ***Movement on the seismically-active PSSF fault system could cause fault slip in the study area, potentially compromising the liner beneath the BRSF and the cover and destabilize the waste rock pile (Zirak Fault beneath BRSF).***
* ***This fault could conduct ARD-impacted seepage water from the BRSF toward the Kechut Reservoir and/or to the Vorotan River.***
* ***Fault slip on the Agarakadzor Fault passing through the vicinity of the pits and BRSF could also impact the stability and integrity of the BRSF and pit backfill and cover systems.***
* ***Ground motion could also impact the stability of the HLF, liner, and cover and inflict damage on the contact water channels, ponds, and PTS, potentially resulting in releases of impacted water to surface water and groundwater.***
* ***The potential significance of fault and fracture flow in the groundwater study area was not considered in the analyses of potential impacts to the environment.***
* ***Solute transport is many orders-of-magnitude faster in fractures than rock and sediment matrices, with much less attenuation.***
* ***ARD-impacted groundwater could be rapidly transported to springs, streams, and rivers, potentially impacting community water supplies and livestock grazing activities.***
* ***Covers on the BRSF and pit backfill can be restored, if impaired by earthquakes. Breached liners beneath the BRSF and the HLF would be a challenging problem to address, requiring temporary or permanent relocation of the rock and spent ore.***
* ***A destabilized BRSF and/or pit backfill could result in permanent loss of the nonacid generating VC layer of rock between the cover and the PAG rock.***
* ***Any exposed PAG rock on pit walls or in the BRSF, HLF, or pit backfill due to earthquakes could impact the environment for hundreds, or possibly on the scale of a thousand or more years.***
* ***The concentrations of key constituents in contact water (e.g., iron, aluminum, nitrate, ammonia, and sulfate) are underestimated, which may cause the PTS to fail (unless redesigned or augmented).***
* ***Such failure may result in the release of contaminants to the environment (surface water and groundwater) at concentrations exceeding RA discharge criteria/MAC standards.***
* ***Mitigation measures for the Mine pits are limited to periodic pumping during operation and backfilling and the placement of an ET soil cover post closure.***
* ***Contingent and supplemental measures are necessary to mitigate ARD impacts on the groundwater quality.***

TOR Question #5: Is there any interaction between Amulsar water basin, the adjacent underground and the surface water, rivers, water reservoirs, SpandaryanKechut water reservoir hydro-technical structure and Jermuk mineral water reservoir, or not? Response:

* ***Groundwater flow and contaminant transport pathways between the Project Area and the Jermuk thermal springs do not exist.***
* ***Rivers and tributaries surrounding and within the Project Area are connected to groundwater. Groundwater discharges from the Project Area to springs and rivers.***
* ***Releases of untreated Mine contact water can contaminate groundwater and can reach and impact surface waters.***
* ***Groundwater from the Project Area also discharges to the Spandaryan-Kechut tunnel through sections of the tunnel where the walls/joints are leaky (i.e., areas of direct hydraulic connection between the groundwater and the tunnel)...... direct discharge of groundwater to the reservoir does not occur.***
* ***However, groundwater that discharges to springs, streams, and the Spandaryan-Kechut tunnel will flow into the reservoir. If a deep aquifer underlies the volcanic rocks in the area, interaction between groundwater in the volcanic rocks of the Project Area and the deep aquifer is unlikely. Groundwater originating in the Project Area by local infiltration of precipitation discharges to springs and the Arpa, Darb, and Vorotan Rivers and their tributaries.***

TOR Question #6: Is the data on sulfide compounds in the rock, presented in the ESIA and EIA, calculated correctly, or not, are the control methods of the acid drainage scientifically justified, or not, can they effectively prevent acid drainage water into the environment? Response:

* ***The acid-generating potential of the rock was calculated incorrectly***
* ***The methods to limit acid mine drainage are scientifically justified, but they cannot completely prevent ARD.***
* ***Pore space between these various rock particles will permit infiltration. Consequently, some ARD may occur.***
* ***Furthermore, the mine pit walls and bottom will be exposed and will permit seepage of accumulated water into the groundwater.***
* ***The design criteria of the clay liner under the BRSF are questionable and raise concerns about the integrity and protectiveness of the liner.***

TOR Question # 8: Can the waters flowing from acid drainage come into contact with surface and ground water systems? If so, how, in what period of time and with what consequences can this potential leakage contaminate surface and underground water systems, including those of Jermuk, Vorotan and Arpa rivers, adjacent tributaries and streams, Spandaryan and Kechut water reservoir hydro-technical structure, Lake Sevan, as well as change the chemical content of water and what consequences will occur as a result of this impact? Response:

* ***Under conditions resulting from earthquake impairment of the BRSF, ARD impacted groundwater could discharge at the northern end of the Spandaryan Kechut tunnel, resulting in impacts to Kechut Reservoir and potentially Lake Sevan through the Kechut-Sevan tunnel.***
* ***Likewise, impacted groundwater could discharge to springs and streams at the northern end of the Project area, in turn discharging to Kechut Reservoir.***
* ***The transit time of this groundwater cannot be estimated with available data.***
* ***Direct discharge of groundwater to the Kechut reservoir will not occur due to downward vertical hydraulic gradients beneath the reservoir.***
* ***ARD-impacted groundwater will not reach Jermuk.***
* ***Earthquake damage to HLF, process ponds, BRSF liner, and contact water channels could release impacted water to groundwater and potentially directly to the stream in the vicinity of the HLF.***
* ***A release to the stream would impact the Arpa River within a few hours.***

TOR Question #9: Has the extent of potential environmental damage, resulting from the exploitation of the mine, as well as the timeframe and cost of the mine's reclamation been properly calculated and subsequently justified in the EIA and the ESIA reports?

Response:

* **See the response to question xiii regarding environmental damage**.
* ***The total cost for Mine rehabilitation and closure and the duration of the post closure monitoring are underestimated as noted below:***
	+ The post closure operation, maintenance & monitoring ***(OM&M) period is limited to only five years***. In the US, Federal and State regulatory requirements and guides for closure (e.g., RCRA 40 CFR Part 264.117; Nevada NAC 445A.446; USEPA, 2000) indicate ***post closure costs, especially when contamination sources remain, should be calculated for a revolving 30-year period (minimum)***.
	+ Post closure costs should include routine OM&M activities as well as periodic replacement, maintenance and repair actions that ***will be required after 5 years, which can be significant.***
	+ The reduced post closure monitoring period and ***the omission of periodic replacement/repair costs will results in significantly underestimating the post closure costs.***
	+ ***Increasing*** the post closure monitoring period from 5 years in the ESIA ***to the conventional 30-year period***, the total Mine rehabilitation and closure cost will increase from approximately $34M to approximately ***$70M*** ***(without adjustment for periodic replacement costs or realistic contingency) .***
	+ ***Contingency (scope and bid) is too low at 6% and underestimates the actual Mine rehabilitation and closure cost***.
	+ The USEPA (2000) and AACE (2008a; 2008b; 2009) cost estimation guides indicate that ***at this level of project development*** (pre-feasibility) and the ***high degree of uncertainty (e.g., unreliable data and PTS and need for additional studies, etc.) the contingency will likely exceed 20%.***
	+ The Amulsar feasibility study (SGS, 2014 Table 21.5) used 16% for the initial capital phase. ***Using a realistic contingency of 20% instead of the ESIA 6%, the total indirect cost percent would increase from 21.3% to 35.3%.***
	+ Accordingly, ***the total Mine rehabilitation and closure cost will increase from approximately $34M (for the ESIA 6% contingency and 5-year post closure monitoring period) to approximately $78M (for 20% contingency and 30-year post closure monitoring period) without other adjustments.***
	+ ***Treatment requirements are likely unrealistic (actual costs are likely higher) due to incorrectly assumed low leachate concentrations and mass loading.***
	+ Technical/professional costs (design/engineering, project management/ administration, and construction management) are underestimated at about 3% of total construction cost. USEPA (2000) indicates these costs are commonly greater than 15% for similar projects. The Amulsar feasibility study (SGS, 2014 Table 21.5) used 10% for the initial capital phase. Using 15% for these services would increase the total rehabilitation and closure cost by an additional amount on the order of $4M to $5M.

TOR Question #10: Taking into account the location of Amulsar mine, its geographical position, adjacent residential and health resort areas, can the exploitation of the mine with all of its processes of open pit mining, heap leaching and barren rock storage facility, be conclusively considered safe, and if not, what type of environmental damage can this result in? Response:

* ***The ESIA/EIA assessments are deficient and corresponding conclusions are unreliable. Accordingly, the question of whether exploitation of the ore deposit can conclusively be considered safe cannot be answered.***
* ***The question about environmental damage is answered in responses to previous questions.***
1. <http://www.investigative.am/images/2019/lidian/porcaqnnutyun/amulsar11.pdf?fbclid=IwAR0Ws1R8asxI2UsfCVwCtaHZ3-qdn2m8ZBLIV8eUj-iHUpozOs8SLATwd7Y> [↑](#footnote-ref-1)