LYDIAN
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Amulsar Gold Mine

Further details of Lydian’s approach to adaptive management of ARD

October 2017

Abridged version - Report only (no Annexes)

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EXECUTIVE SUMMARY

This report has been prepared in response to commentary prepared by Blue Minerals et al. (October 2017), in a report entitled *Response to Lydian review of Bronozian-Commissioned Report*. The purpose of this report includes:

1. Providing a better understanding of the risk associated with ARD at Amulsar and to identify how this risk has been addressed primarily through pollution prevention and contamination control strategies, before treatment is required.
2. Confirming that the Passive Treatment System (PTS, see Appendix 3.1 of the ESIA) has been designed to treat any potential residual contaminate release after pollution prevention and control mitigation measures for ARD have been realised.
3. Confirming that the PTS is appropriate and has been designed for the predicted contaminant loading.
4. Confirming that all potential sources of ARD have been considered in the design process.
5. Confirming that an Adaptive Management Plan for ARD will appropriately reflect conditions and experience gained over the life of the mine, such that management planning can respond to take account of this experience.
6. Explaining, as appropriate, the wording used in the ESIA and to confirm that the likely risks associated with ARD has been considered in the design process.
7. Clarifying the availability of documentation available on the Lydian website that relates to the ESIA, 2016, the NI 43-101 Technical Report entitled *Amulsar Value Engineering and Optimization, Armenia*, 2015, and subsequent update of the technical report in 2017.

Further, this report confirms that the ARD Management Plan has been in place since pre-construction and the procedures required to separate PAG from NAG are currently being implemented for barren rock excavated during construction. In addition, committed, studies are also in progress at both laboratory and bench scale, to provide further analysis and advance the design of the PTS.

Finally, the following recommendations have been identified:

- An invitation to the authors of the Bronozian-Commissioned report to participate in a combined workshop / technical meeting to discuss the findings of all reports and additional studies currently being commissioned by Lydian. The workshop / technical meeting to be arranged between 15 and 22 January 2018 in Yerevan.
- Update Chapter 4.8 of the ESIA (see Annex 1).
- Disclose analysis from continuing on-site kinetic tests as reports are completed (2018).

- Disclose final reports from PTS laboratory and bench scale analysis currently ongoing for the detailed design of the passive treatment system, as and when reports have been completed (2018).
- Disclose digital copies of Appendices and Design Documents that have been referred to, and cross referenced, in the ESIA, 2016, with respect to ARD Management (see Table 3 of this report).

1 INTRODUCTION

1.1.1 This report has been prepared to consider the 'main concerns' that were identified in the report prepared by Blue Minerals et al. 2017[1] (entitled: *Response to Lydian review of Bronozian-Commissioned Reports*). By way of background, in July 2017, four technical reports, containing an analysis of specific chapters of the Lydian Gold Mine Environmental and Social Impact Assessment (ESIA, 2016) and NI 43-101 (Technical Report entitled Am*ulsar Value Engineering and Optimization, Armenia*[2]), were released by, and on behalf of, Mr. H. Bronozian. An analysis of these reports, was prepared by Golder Associates, Global Resource Engineering (GRE) and Wardell Armstrong and released in August, 2017[3]. The latest report authored by Blue Minerals et al., 2017[1] contains further questions and concerns/disagreements that relate to the risk of ARD at the Amulsar Gold Mine and the potential for such risk to result in a significant environmental impact.

1.1.2 This report (also prepared by GRE, Golder Associates and Wardell Armstrong) expands the information and background on the current programme of works of ARD Management at Amulsar Gold Mine. The report also contains information on Lydian's current programme of work to explain how the risks associated with ARD have, and continue to be, assessed to ensure that following hierarchy is in place during all phases of the gold mine's life:

1. ARD Prevention, as identified in the 43-101, Technical Report[2] by implementing the following methods:
    a. Engineered closure covers to limit oxygen and water ingress into the stored barren rock;
    b. Consumption and reuse of contact water during operations
    c. Suppression of the microorganisms that catalyse the ARD reactions;
2. From year 4, treatment of any excess contact water using a passive treatment system (PTS) that deploys a sequence of bioreactors and other elements to ensure that discharge meets quality standards defined in the ESIA, 2016.
3. Long term monitoring and management, effective until the water quality of discharge from the PTS, post closure, meets the limits for all potential contaminates and that the chemical composition of the discharge remains stable.

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[1] Response to Lydian review of Bronozian Reports, Blue Minerals Consulting, Buka Environmental, Clear Coast Consulting, October 2017

[2] NI 43-101 Technical Report Amulsar Value Engineering and Optimization, Armenia, Samuel Engineering, 2015

[3] Response to Reports Prepared for Mr. H. Bronozian, GRE Associates, Golder Associates & Wardell Armstrong, August 2017

1.1.3 The ARD prevention hierarchy has been adopted to ensure that the development of the mine is in accordance with the principles of pollution prevention and control (a requirement of the Environmental Health and Safety (EHS) Guidelines and Good International Industry Practice (GIIP)[4]. These principals been developed with respect to the design, control and management of mining operations, which form the basis of the ARD Management Plan (see Appendix 8.19 of the ESIA).

1.1.4 The objective of this report combines:

1. Further clarification and details of the principles of pollution prevention and control and how this approach has been adopted to reduce risk of ARD and contaminant leaching, that may result because of the mining operations at Amulsar.
2. Additional information to demonstrate that the mitigation measures, developed in the ESIA, and implemented in the management plan are sufficient to mitigate ARD risk.
3. The confirmation that the management plan process developed in the ESIA is responsive and can be adapted to manage all sources of contaminated water throughout the mine's life (including post mine closure).
4. Further clarification of the analysis presented in the ESIA and confirmation that the methodology included worst-case conditions in terms of risk.
5. Further evidence that demonstrates the use of pollution prevention and control mitigations, designed to minimise risk prior to the production discharge water from the site, are robust and align with the design of the final treatment technology, which is based on the use of a passive treatment system (PTS); currently predicted as occurring from Year 4 of mining.
6. The provision of links to additional documents that contain information that previously the authors (Blue Minerals et al., 2017[1]) have not been unable to gain access.

1.1.5 In this report, it should be noted that:

a) The baseline data presented in the ESIA (Chapter 4, see Sections 4.6, 4.8 & 4.9) has been used to inform the impact assessment, mitigation design and determine the objectives set out in management plans. In addition, the baseline data is essential to understanding the context of the mine design criteria (specifically management

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[4] http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines

of contact water and the design of the BRSF, the details of which are presented in the 43-101 Technical Report[2]). This is also a requirement for operational controls and management that have been implemented during the construction period.

b) The baseline data includes evidence of naturally-occurring ARD in springs and surface water. In addition, ARD is generated from waste rock left from soviet-era exploration. The baseline data also includes the database of static and kinetic geochemical characterization performed to date.

c) The ARD mitigation plan was considered in all stages of the ESIA process, and has been based on the specific design criteria for the construction, operation and closure of Amulsar Mine.

d) Potentially Acid Generating (PAG) rock has been managed from the start of the construction process (see: Section 5.6 of the ARD Management Plan, Appendix 8.19 of the ESIA). The methodology for identifying and therefore separating PAG from Non Acid Generating (NAG) rock was developed by GRE and has been overseen by Golder Associates, field engineers (in their Quality Assurance role) to ensure compliance with this mitigation measure.

e) The separation, handling and storage of PAG is integral to the design of the BRSF (see Section 4.3, Appendix 8.19 of the ESIA). It can, therefore, be confirmed that PAG rock has been managed in accordance with the requirements of Appendix 8.19. In addition, these management procedures have been implemented with respect to all relevant operations, from the commencement of the construction and will remain in place during the remainder of construction continuing through mining operations, where the application of these procedures will focus on the removal and storage of barren rock excavated from the open pits.

2 POLLUTION PREVENTION AND CONTROL STRATEGY

2.1 Defining the worst-case condition

2.1.1 The potential for ARD, considered in the ESIA, defined a worst-case ARD condition that was based on the highest observed concentrations of acidity and other associated contaminants likely to adversely affect water quality, using the analysis of data from all tests in the characterization performed thus far. The worst-case scenario was used to establish the most critical conditions in the baseline environment. However, it is not, therefore, correct to infer that this worst-case will happen at any location or at any time during construction and operation of the mine. In fact, the mitigation measures identified in the ARD Management Plan reduce the unlikely probability that the worse-case scenario would ever be realised in operational conditions.

2.1.2 It is, therefore, inappropriate to design treatment systems based on worst-case conditions on the assumption that they occur from all locations and at all the times during construction, operation, and closure of the mine. The EHS Guidelines[4] require that ARD control is based on a combination of both design and mitigation techniques such that the approach adopted accords with the requirements of GIIP. The approach developed in the ESIA provides the effective management required to prevent, control and mitigate ARD through all stages of the mine's life. Modern effective ARD management emphasises ARD prevention and suppression combined with the treatment of residual ARD prior to discharge. An alternative approach, described in Blue Minerals et al., 2017[1], appears to be based on the use of no specific pollution prevention and control techniques but instead appears to rely solely on "end of pipeline" treatment. This approach does not conform to the EHS Guidelines[4] and is not therefore GIIP.

2.1.3 The pollution prevention and control approach designed for Amulsar uses proven environmental engineering methods to prevent contaminant loading, as opposed to the treatment of ARD once it has been formed. The principal components of this pollution prevention strategy are as follows:

1. Encapsulation of PAG in the BRSF to reduce ingress of air and water;
2. Suppression of microorganisms, through encapsulation and liquid/solid additives to prevent severe "biotic" or "ferric iron oxidized" ARD;
3. Reuse or consumption of contact water in mining operations and other mitigation measures such as dust control on haul roads etc.; and
4. Treatment of any excess contact water during mining and post closure using proven and effective the passive treatment methods such as sulphate reducing bioreactors, prior to discharge[5].

2.1.4 Therefore, the Amulsar ARD Management Plan is a multi-faceted approach to pollution prevention that is consistent with GIIP, and the plan has well-defined ARD management protocols that can be adapted to take account of experience and the ongoing environmental monitoring that will continue during the life of the mine and

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[5] Global Acid Rock Drainage Guide (GARD guide)[5] (INAP, 2009)

post closure. Using this approach, the risk of negative impact on the environment from ARD is considered very low.

2.2 Supporting Science

2.2.1 It is critical to understand the role of the geochemical reactions in the management of ARD. The two primary reactions governing the production of ARD are shown below:

Abiotic ARD

$FeS_2 + 7/2O_2 + H_2O \rightarrow 2SO_4 + 2H^+ + Fe^2$ (H_2SO_4 – product is sulphuric acid.) *[1]*

Biotic ARD – Ferric Iron Oxidation

$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4 + 16H^+$ (at pH less than 3.0) *[2]*

2.2.2 The first (Abiotic ARD) reaction is slow; the second (Biotic ARD) reaction is fast. The first reaction is dominated by physical chemical processes, and the second reaction is catalysed by microorganisms. The balance between these reactions will make the difference between mild ARD and severe ARD being present in the contact water at Amulsar. The ARD management plan is designed to prevent the formation of Biotic ARD (Equation *[2]*), while accepting that abiotic ARD (Equation *[1]*) will form and must be managed through protocols in the ARD Management Plan (Appendix 8.19 of the ESIA).

2.2.3 Abiotic ARD can be managed through evaporation and/or by using it as dust suppression. This permits a zero-discharge water balance for early in mine life. After year 4 of mining, residual contact water contaminated with Abiotic ARD will be subject to passive treatment, prior to discharge.

2.2.4 Additional geochemical background information is available in the Geochemical Characterization Report (GRE, 2016, see Table 3). It should also be noted that the evidence from baseline analysis demonstrates the ability to suppress biotic ARD. In fact, existing ARD impacted seeps are producing only mild ARD without any designed prevention methods in place.

2.2.5 Only in select humidity cell tests, where the environment is unnaturally maintained to promote the formation of ARD, did biotic ARD conditions form. It is in these select tests that the worst-case ARD conditions developed (See Section 2.1); however, it should also be recognised that these humidity cell tests to not take account of the following;

- Amulsar climate;
- On-site microbial community;
- Barren rock encapsulation; and
- ARD suppression methods designed to inhibit the formation of ARD.

2.2.6 The direct applicability of the humidity cells is limited in this case. However, they are an indication that a pollution prevent approach may be required, but they are not an obligatory design criteria, due to the use of modern methods which expressly and effectively prevent the formation of worst-case conditions observed in selected humidity cells.

2.2.7 ARD production and suppression is complex with respect to both the chemical and biological reactions. The foregoing explanation provides the basic nature and importance of these reactions. It should also be recognised that while both ferric iron oxidation and biotically catalysed ARD have been mentioned in several of the reports, prepared to date, these are essentially the same chemical reaction. The nature of ferric-iron oxidized ARD has been considered in depth in the Blue Minerals et al, 2017[1], report and in the Lydian response to comments (Wardell Armstrong, et al, 2017)[3]. The supporting science (see paragraph 2.2.1) is relevant to understanding the approach to prevention/suppression of ARD formation at operational mine sites. The nature of ferric-iron oxidized ARD has been considered in depth in the Blue Minerals et al., 2017[1], report and in the Lydian response to comments (Wardell Armstrong, et al., 2017)[3]. The supporting science (see paragraph 2.2.1) is relevant to understanding the approach to prevention/suppression of ARD formation at operational mine sites. Additional information on the formation of ARD can be found in INAP 2007[5].

2.2.8 In summary, control of ferric-iron oxidized ARD is the cornerstone to the pollution prevention strategy and is integral to the development of the ARD management plan adopted for Amulsar Mine. It is not clear from the comments provided by the reviewers that an understanding of ferric iron oxidation (Equation *[2]*) as the key driver of severe ARD as observed in the analysis from humidity cells results has been applied appropriate to conditions at Amulsar. This may be the largest single advantage of convening a combined workshop / technical meeting to discuss and clarify this aspect of the management plan (see Section 7.1.3).

2.3 Further information on baseline conditions

2.3.1 The data in Table 1 (reproduced from the Blue Minerals Consulting et al., 2017[1] and the ESIA) identifies the existence of naturally-occurring ARD in spring water on Amulsar Mountain. This data was made available in the ESIA in 2016 and confirms the presence of ARD on site; however, it is important to note that these samples have a low concentration of total acidity. This data was also consistent in the baseline data collected from Amulsar Mountain. The pH and sulphate concentrations in Table 1 of Blue Minerals et al. 2017[1] (see Table 1 that replicates this data) are indicative of ARD resulting from abiotic (slow) ARD reactions (see Equation *[1]*). However, they are entirely dissimilar (orders of magnitude lower in acidity and sulphate) from the humidity cells HC 74C and 76C and therefore not directly comparable. The logical reason for this discrepancy is that the environment present at Amulsar (cold winters, dry periods, etc.) is not very conducive to ARD generation even when there is no designed ARD prevention in place. This contrasts with the conditions for humidity cells tests, which are managed in an environment designed to promote the production of ARD.

2.3.2 It is also essential to note that the range of ARD conditions shown in Table 1 is entirely consistent with the ARD strength that can be treated through a passive system.

Table 1: The pH and sulphate values for springs declared to be alkaline in the 2016 ESIA

Spring ID	# Samples	pH Value (SU)	SO_4 (mg/L)
SP32	No data		
GA2	1	3.96	21.5
GA3	1	3.82	27
GA4	1	4.21	20.2
AW035	4	3.45 – 3.74	36.3 – 49.2

Source: ESIA, 2016, Appendix 4.8.5 Groundwater Quality

2.3.3 Humidity cells were used as a component of the confirmatory ARD testing for the Amulsar project. By design, these cells provide an environment for generation of ARD, which is generally unlike any of the conditions predicted to be experienced in the field. Consequently, the test cells provide a prediction of the worst potential case, for production of ARD. The humidity cell test analysis has, therefore, been used for the evaluation of worst-case predictions for the consideration of environmental design criteria. Specifically, in the case of ARD this includes the design of pollution prevention and control techniques, as opposed to the sole reliance of the design of end of pipeline treatment solutions. This is a factor that should be recognised and appreciated, to understand the philosophy developed in the ESIA. It should also be acknowledged that this approach conforms to the requirements of GIIP.

2.4 Baseline Geology

2.4.1 Evidence presented in the ESIA (Chapter 4.6) demonstrates that within the Lower Volcanic strata (LV), there is sufficient sulphide for ARD to form as per Equation *[1]* and Equation *[2]* in Section 2.2 of this report. As mentioned in Section 2.2, the reaction rate of ARD is more dependent on microbes than total sulphide concentration, and a higher concentration of sulphides does not equate, in all conditions, to a faster ARD reaction rate. Furthermore, it is important to recognise that many of the barren rock samples placed in humidity cells with sulphide concentrations, comparable to the average concentration of sulphide in the dataset (based on baseline data), failed to produce severe concentrations of ARD in the humidity cell leachate.

2.4.2 Similarly, samples with high alunite and jarosite subject to humidity cell testing did not result in severe concentrations of ARD in the leachate water. As explained in paragraph 2.3.2, humidity cells are designed to maximize ARD formation. Therefore, if these samples failed to make severe ARD in a humidity cell, it can be predicted to behave similarly in field conditions. Geotechnical baseline analysis has, therefore proven that alunite and jarosite are not significant sources of ARD.

2.5 ARD test work

2.5.1 The ESIA identified that a proportion of UV and colluvium had uncertain ARD potential (see Chapter 4.7 of the ESIA). However, this potential was not realized in testing. Whereas, humidity cells use ideal conditions to determine whether ARD formation is realised (See tests 74C and 76C (Table 4.6.15 and paras 4.7.8 /9 of the ESIA), the opposite is also true. If a sample has the potential for ARD, and if this potential is not realized over long-duration humidity cell test work, it is a positive indication that ARD formation is unlikely in field conditions. This is the case with all but two of the humidity cell tests, including all the humidity cells that contained UV or high alunite rock.

2.5.2 In conclusion, under worst-case realized (empirical) conditions, the UV, colluvium and high-alunite samples failed to form ARD. In all but two samples of LV, the humidity test cells failed to produce severe ARD.

2.5.3 The statement that the humidity cells show every rock will produce acid at Amulsar (Blue Minerals et al., 2017[1]) is incorrect and is a fundamental misunderstanding of the testing performed, and in consequence the characterization for ARD articulated in the

ESIA. To restate, all testing, excepting the two samples of LV, did not generate strong ARD. UV samples started to oxidize, but "ran out" of sulphide, which is consistent with the finding that they are largely oxidized in-place over geologic time and did not produce acidic leachate much stronger than rainfall (which has pH of 5.5). High alunite samples also failed to generate acidity. Finally, due to the actual on-site conditions (established in the baseline) combined with the design criteria that implements pollution prevention, it is not realistic (or responsible) to assume that ferric iron oxidation conditions (see Equation *[2]*) will result. Therefore, severe ARD contamination in contact water is not predicted, which is one of the main findings that has been used to determine the correct approach to treatment using the PTS, and considered in the ESIA.

2.5.4 It is also important to reiterate that considerable effort has been invested in developing environmental design criteria with the objective of implementing pollution prevention, such that concentrations of ARD in contact water are minimised and the risk to the environment is, therefore, low and not significant. The approach has been subject to independent review, which concluded that this approach accorded to the requirements of GIIP[4].

2.6 Baseline water resources

2.6.1 The ESIA recorded that the baseline water quality in the Amulsar Project area is generally good or very good and does not appear to be notably affected by natural acid drainage, therefore the risk of ARD and contaminant leaching at Amulsar having a significant effect will be clearly identified in the surface water monitoring programme and can be directly correlated with activity at the mine.

2.6.2 There is a typographical error in the baseline surface water chapter of the ESIA (Chapter 4.8) where the text refers to "alkali pH" rather than alkaline pH. There is also a lack of appropriate referencing in the Section 4.8.7 (page 4.8.82). The context of the section to which Blue Minerals et al., 2017[1] refers, had regard to the field measurements of pH, which for the dates and locations mentioned were in fact alkaline. This information is presented in Golder 2014[6] (see Table 3). The published ESIA has been updated (see Annex 1). In consideration of the pH in the ESIA, greater reliance was placed on field measurements over laboratory measurements (the data referenced by Blue Minerals et al., 2017[1]). The field measurements clearly indicate

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[6] Golder Associates, 2014. Spring Survey Interpretive Report – Update. June 2014.

acidic conditions in spring discharges from the upper part of the mountain. It should also be noted, however that the pH of some of the springs, as identified in the ESIA, identified temporal variation over the duration of baseline monitoring. It is considered that range in pH value may relate either to seasonal variations in groundwater levels at higher elevations on Amulsar peak, or as noted in the ESIA (page 4.8.83) the flush of water from snowmelt.

3 THE MANAGEMENT OF ALL POTENTIAL SOURCES OF CONTACT WATER DURING CONSTRUCTION, MINING, CLOSURE, AND POST CLOSURE

3.1 Water balance assumptions and effects

3.1.1 Blue Minerals et al., 2017[1] focus their comments on three main areas in this section of their report, managing:

- Groundwater flow into pits;
- The water balance; and
- The effects of climate on the water balance

3.2 Pit inflows and Water Balance

3.2.1 Referring to water inflow to the pit, it can be confirmed that there was uncertainty in the estimation of groundwater and surface flow into the pit, and this was identified in the limitations of the studies in the ESIA. This uncertainty, however, was considered as part of the development of the ESIA in order to provide a conservative assessment of design and mitigation. A facility water balance was completed and integrated into the site wide water balance (SWWB, see Appendix 6.10.1 and Table 3), that is consistent with GIIP.

3.2.2 Blue Minerals et al., 2017[1], have identified an apparent discrepancy in the ESIA in that the modelling study indicated the potential for groundwater levels higher than the pit floor, however the ESIA states that they are not in the baseline conditions (see Chapter 4.8). It can be confirmed that this is not a discrepancy, as the modelling study, which has several well identified limitations, overestimates groundwater levels in the vicinity of the pit when compared to measured baseline conditions. This limitation is exacerbated by the presence of perched water lenses within the pit area. The limitations and resultant approach to the modelling study has been clearly documented in the ESIA. It can also be confirmed that perched water inflows have been incorporated in the water balance.

3.2.3 The water balance presented in the ESIA (see Appendix 6.10.1, also Table 3 and NI 43-101, Technical Report[2] evaluates surface flow using reasonable runoff coefficients from precipitation events and groundwater inflow from seasonal, perched groundwater as well as the "regional" groundwater. It is recognised that there was uncertainty in predicting pit dewatering rates and these have addressed by evaluating the sensitivity of some of the water balance input parameters. The sensitivity analysis provides a reasonable upper and lower bound required to predict the potential volumes of water that will be managed in the pits. As identified in the ESIA, the groundwater inflow into the pits can be a significant source of contact water. The first generation of pit water modelling scaled the inflows in a linear fashion from those assumed based on the maximum pit development. This method greatly over-estimates the amount of pit inflow in the first few years of development. The updated model established in 2017, reflects on-going water monitoring results and enhanced mining engineering detail recently available, and indicates there will be very little water in-flow during the first few years of operations.

3.2.4 It can be confirmed that in-pit dewatering has been assessed, based on the hydrogeological regime at the site and the estimated inflows. External dewatering using perimeter wells is not an appropriate way to manage groundwater at Amulsar for several reasons. External dewatering can be very effective in either high permeability relatively homogeneous isotropic strata or where specific high permeability structures are identified. Neither is the case at Amulsar. In addition, due the mountain top location of the open pits, perimeter wells are simply not practical.

3.2.5 Blue Minerals et al., 2017[1] recommends water treatment at commencement of operations. However, the water balance supports the approach in the ESIA. Treatment is not required based on observed ARD kinetics (i.e. reaction rates), effective pollution prevention and control (refer to barren rock storage design, see also) which means that during the early mine life, all contact water can be safely reused within the site. The design is supported through construction of appropriately sized and lined contact water ponds which eliminate the need for a discharge until year 4 of mining operations. This approach is considered proportionate to the risk (refer to Section 2 of this report).

3.3 Climate

3.3.1 The SWWB (see also Table 3) developed in the ESIA has been advanced from the deterministic approach of average monthly precipitation and wet year precipitation to the use of a probabilistic (and stochastic) climate generation tool (presented in Appendix 6.10.1 of the ESIA)). The stochastic climate tool not only models peak 24-hour events, but also wet durations (i.e. a high precipitation week, month, year) to better evaluate the range of potential precipitation scenarios over the life of the mine. All the contact water ponds have been designed to the 99% percentile wet conditions under the stochastic and probabilistic water balance conditions. This includes the peak 24 hour events as well as the "wet year" conditions with long-duration heavy rain events and/or snowfall. It is important to note that probabilistic water balances are the industry-standard and that typically projects are designed to the 95th percentile, and not the 99th percentile. It is acknowledged that the water balance assumes the contact water can be used in operations but Lydian has identified the use of evaporators as a contingency should this be required. Evaporators are standard mining water management equipment in use in many operations globally.

3.3.2 It is also noted, based on the IPCC (2014)[7] "conservative climate change scenario", projections for the 2011-2040 time-frame of the project that the annual precipitation is expected to decrease by about 7% (incorporating a 5% increase in autumn precipitation). As noted above, there is inherent uncertainty with the climatic parameters which Golder has addressed through the use of stochastic climatic inputs. Given the life of mine is 10 years, it is considered that any short-term variation in climate is likely to be within the range of the stochastic analysis (which went from the 1st percentile driest case, to the 99th percentile wet case), hence the climatic uncertainties are captured within the stochastic analysis used.

3.4 Backfilling segregated sulphide rich minerals to mining void and submerge below groundwater.

3.4.1 Evidence advanced by Blue Minerals et al., 2017[1] refers to adopting mine design and operational techniques that enable the backfill of sulphide rich minerals into mined out pit voids and allowing the barren rock to be submerged in groundwater, to inhibit ARD[8].

3.4.2 At Amulsar, the baseline groundwater conditions provide clear evidence that the open pits will not become inundated with groundwater following closure (see Section 3.2 of this report), therefore the site-specific conditions do not fulfil the circumstances

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[7] IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyers (eds)]. IPCC, Geneva, Switzerland

[8] BC MEND/ARD Annual Workshop 2015 see: http://bc-mlard.ca/workshop-proceedings/2015-workshop for proceedings.

where ARD can be prevented using this technique. However, the barren rock placed in the Artavazdes and Tigranes pits will have an evapotranspiration (ET) cover. Modelling has shown that the ET cover is effective in reducing infiltration and oxygen diffusion into barren rock. The reduced flux of oxygen and water will slow ARD kinetics.

3.4.3 It should also be recognised that the backfill of the Artavazdes and Tigranes pit occurs later in mine life using barren rock taken from the Erato pit. Backfilling the Artavazdes and Tigranes pit is only feasible once these pits have reached their maximum extents. Therefore, the optional design solution for barren rock, at Amulsar, is to construct a permanent storage facility for barren rock, designed to prevent ARD production and manage contact water. This solution has been delivered through the design of the BRSF. The facility has drainage control, and ET cover, and provisions for the re-use or evaporation of leachate water in the mine water balance. It is not feasible, nor desired, to disrupt the closed-and-covered BRSF to place the stored barren rock within the Erato pit. In fact, doing so would risk accelerating ARD by re-oxygenating previously encapsulated barren rock.

3.4.4 It is therefore, incorrect to state that in pit disposal of sulphide rich minerals is the norm for modern mining methods, without first taking account of site specific conditions. Although it is appropriate to consider pit backfill as an alternative for barren rock coming from the Erato pit, site-specific conditions prevent further backfilling of pits, and the submergence of waste within the pits is not possible.

4 PASSIVE TREATMENT SYSTEM, ADDITIONAL INFORMATION

4.1.1 The passive treatment is part of the multi-faceted approach to ARD management that has been designed for Amulsar, and it is important to recognise that it is not a stand-alone solution, as such, comments in Blue Minerals et al. 2017[1] are a significant misrepresentation of the ARD management plan.

4.2 General concepts

Sludge management

4.2.1 The passive treatment system has been designed to effectively control sludge resulting from water treatment through the reduction of sulphate. This chemical process produces hydrogen sulphide gas and elemental sulphur. In addition, the treatment system incorporates a change-out of the bioreactor substrate to manage sludge build-up (typically once every 20 years). The same applies to the scrap iron or similar sulphur-sequestering media that would be used in the sulphide polishing units. Passive treatment at Amulsar is an advantageous treatment method for sludge management, when compared to high density sludge (HDS) treatment, because HDS produces a continuous stream of hazardous material that must be managed and accounted for, whereas passive treatment systems do not.

Dentrification

4.2.2 The conditions in the denitrifying biochemical reactor (BCR) are unlikely to precipitate iron and aluminium. Bench scale testing, which is currently in progress, will corroborate this assumption. If any aluminium removal occurs in the denitrifying BCR, it is likely due to the formation of denser aluminium hydroxy-sulphate mineral phases rather than the plug-forming aluminium hydroxide. Ferric iron, if present, would be reduced to ferrous iron, which is similar in behaviour to a traditional SAPS treatment unit. Literature on the geochemistry of BCRs supports this approach[9 & 10].

Arsenic and thiocyanate removal

4.2.3 Arsenic and thiocyanate can be removed with passive treatment techniques. The Amulsar team has experience in passively treating arsenic at design flows of 4.5 m^3 per minute (Gallagher, et al., 2016)[11]. Passive thiocyanate removal was documented by Cellan in 1997[12]. The differences between the chemistries of these mining influenced waters and the Lydian HLF drain down chemistry will be assessed in further bench scale testing that can only be undertaken once the HLF is commissioned and spent ore and its associated solutions are available for testing and analysis. This is appropriate adaptive management practice.

Justification of passive treatment after year 4 of mining operations

4.2.4 It is important to note that for the time periods mentioned (up to Year 4 of mining) there is no pit high wall and, therefore, no source from which to receive groundwater into the pit. This is due to the pit geometry that will be excavated from the mountain top, during early stage of construction and mining. It is also essential to recognise

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[9] Biochemical Reactor Module Construction Golinsky Mine, California. *National Meeting of the American Society of Mining and Reclamation.* Bismark ND. Gusek, J. (2011).

[10] Infiltration-Diverting Cap and Full-Scale Biochemical Reactor Operation at the Iron King/Copper Chief Mine, Arizona. *International Mine Water Association Conference Proceedings.* Golden, Colorado: IMWA. Gusek, J. (2013).

[11] Passive Treatment System for Arsenic, Manganese, & Iron. *Presented at the 2016 National Meeting of the American Society of Mining and Reclamation.* Spokane, WA, Gallagher, N. (2016)

[12] *Design and Construction of an InSitu Anaerobic Biochemical System for Passively Treating Residual Cyanide Drainage,* Austin, Texas, Cellan in 1997. May 10-15, 1997.: Proceedings of the National Meeting of the American Society for Surface Mining and Reclamation

that because mining will develop an open-pit excavation starting on the top of the mountain, the baseline water table will be below the base of the open pit floor for virtually all of mine life. However, it is recognized that perched water may exist and flow into the pit from the highwalls. This has been accounted for in the SWWB (refer to Table 3). In fact, the water balance conservatively considers the inflow of thousands of cubic meters per year of perched groundwater as the pit is depth increases during the life of the mine. This is clearly identified as a source of mine contact water. Despite recommendations in Blue Minerals et al., 2017[1], there is no technical justification for a lime neutralization or RO plant being required for pit dewatering water. The ARD impact of pit dewatering water will be mild (see prior comments about the ARD characterization and management plan) and the volume can be consumed (see Section 3.2).

4.2.5 It is important to note that an RO plant would also discharge a contaminated brine stream that must be managed.

4.2.6 In conclusion, there is no demonstrable need for HDS and/or RO systems. The site storage ponds combined with reuse of contact water has been assessed and demonstrated that the design takes account of extreme climate conditions, and in consequence, there is no requirement for the treatment of contact water in the first four years of the mine life. Finally, the ARD management plan will maintain contaminant loading in contact water at such a level that surplus ARD-impacted water, after year 4 of mining operations can be treated, prior to discharge in the PTS.

5 RECOMMENDATIONS

5.1.1 Table 2 provides a review of the recommendations identified in Blue Minerals et al., 2017[1], and refers to the additional information provided in this report.

Table 2: Recommendations (Blue Minerals Consulting et al., 2017[1]) and response with respect to the ARD Management plan

Recommendation identified by Blue Minerals Consulting et al., 2017[1]	Response ESIA & ARD Management Plan
Statements in the ESIA about the acidity of springs should be compared to the water quality data and corrected.	The ESIA Chapter 4.8 – update October 2017 (see Annex 1).
Short-term leach tests with lower or variable liquid:solid ratios should be conducted on representative mined materials.	Additional kinetic tests to be commenced on-site in October 2017, will be a more-reliable method for determining metals leaching. Reports will be released when test work and resultant analysis has been completed.

Table 2: Recommendations (Blue Minerals Consulting et al., 2017[1]) and response with respect to the ARD Management plan

Recommendation identified by Blue Minerals Consulting et al., 2017[1]	Response ESIA & ARD Management Plan
It is stated in several places in the reply from the reviewers that considerably more geochemical testing will be undertaken during 2017 and thereafter. This should serve to address such issues as stored acidity (i.e. the presence of jarosite and alunite) and rate and degree of acid generation due to pyrite oxidation. However, the test samples need to be properly representative – those chosen previously were not – and sufficient in number and duration.	Additional characterization, commenced in October 2017 and the recommendations will be considered with respect to the testing regime.
Based on further testing and planned rates of waste rock accumulation, the evolution of acid generation should be modelled and mitigation measures should be planned to specifically address the time scale of this evolution.	This analysis will be commenced once the results are available from the lysimeter testing, water balance verification work, and on-site kinetic cell testing.
The ESIA, design criteria and ARD management plan describe a comprehensive multi-faceted plan for the pollution prevention and ARD control adopted at the site, which precludes the requirement for active treatment of all contact water. In addition, active treatment has social, environmental and economic impacts that are more complex than use of PTS.	It is agreed that it is best practice to segregate waste, this is the foundation of the encapsulation plan that is part of the pollution prevention and control strategy within the ARD management plan. Barren rock with sulphide will be encapsulated in the BRSF or the Tigranes/Artavazdes backfill. Flooding the pits is not practical, because the regional water table is below the floor level of the Tigranes/Artavazdes pits which are the only pits that will be backfilled. Additionally, the backfilled Tigranes/Artavazdes pits will be covered and encapsulated during mine closure.
An Adaptive Management Plan to address changes in water quality, stream flows, and groundwater elevations should be in place now. The plan should identify trigger levels, mitigation measures to be taken, responsibilities, and evaluation of mitigation effectiveness.	It is important to recognise that the current ARD management plan is an adaptive management plan and the procedure apply to all current construction taking place at the mine. This is integral to the ESMS, see Chapter 8, specifically Figure 8.5 and the accompanying paragraphs.
The basis for only needing treatment starting in Year 4 of operation is not substantiated. Given the geochemical testing results indicting a strong potential to develop acid drainage, the acknowledged uncertainties in the site water balance, and the close proximity to water resources, an active treatment system should be installed before mining begins. The system should be designed conservatively and be capable of treating large volumes of mine-influenced waters with elevated levels of metals, sulphate, and acidity.	The ESIA, design criteria and ARD management plan describe a comprehensive multi-faceted plan for the pollution prevention and ARD control adopted at the site which precludes that requirement for active treatment. In addition, active treatment has social, environmental and economic impacts that are more complex than use of PTS.

Table 2: Recommendations (Blue Minerals Consulting et al., 2017[1]) and response with respect to the ARD Management plan

Recommendation identified by Blue Minerals Consulting et al., 2017[1]	Response ESIA & ARD Management Plan
The site-wide water balance should be recalculated assuming the need for perimeter dewatering wells and taking more extreme events (>100-yr storm) into account.	Extreme storm events are included in the water balance results. However, there is no need, nor any possibility for the requirement of perimeter dewatering wells based on the geometry of the Amulsar ore body, because the open pits will be excavated from the high mountain peak. The gradient of the slopes adjacent to the pit rim is very steep therefore any perimeter wells would be deep and ineffective, below the base of the pit.
See Table 3, which provides an update and cross referenced list of disclosed reports.	

6 ESIA AND 43-101 TECHNICAL REPORT APPENDICES

Transparency of documents

6.1.1 Blue Minerals et al., 2017[1] refer to several documents, including Appendices and Figures that are not available for review (see Table 3).

Table 3: Summary of disclosed documents (refer to full report for Annexes)

Reports	Blue Minerals et al., 2017[1], comment	Refer to Annex:
43-101 Technical report[2] and appendices	Appendices A & B can be viewed after signing confidentiality agreements at Lydian's Jersey offices	Reports relevant to the analysis of ARD have been included as Annex 1 – 6 (see below).
3.1 Feasibility Design of BRSF	2016 Appendix 3.1 is titled BRSF design but is instead a report on the passive treatment system (PTS). Appendix A of Appendix 8.1.9 also addresses the PTS for the BRSF.	Annex 2: *Appendix 13 Site 27 Barren Rock Storage Facility - Design Report*
3.4 Feasibility Design of HLF	The feasibility design for the HLF and the BRSF are not included in the 2016 ESIA.	Annex 3: *Appendix 12 HLF Drawings*
4.6.2 Geochemical Characterization and Prediction Report	This report contains critical information on the contaminant leaching characteristics of Amulsar mined materials.	Annex 4: *Appendix 15 Geochemical Characterization and Prediction Report - Update*
6.5.1 Figures	Contains 103 pages of maps and drawings showing the visibility of the mine throughout the years of mining from various vantage points in the area, including Jermuk and Gndevez Village.	See: Volume 5 ESIA (updated on Lydian International website)

Table 3: Summary of disclosed documents (refer to full report for Annexes)

Reports	Blue Minerals et al., 2017[1], comment	Refer to Annex:
6.10.1 Site Wide Water Balance and Water Management Plan (2014)	The 2015 site wide water balance ESIA appendix contained no numeric information on flows at the mine site during operations and references to reports without providing links. The referenced reports are not available on the Lydian website. The 2016 ESIA eliminated Appendix 6.10.1.	Annex 5: *Appendix 6.10.1 Site Wide Water Balance*
Other information:		
Appendix 4.9.5 Springs Water User Summary (2013)	The survey report was accompanied by an interpretative report, not disclosed with the ESIA but formed a part of the baseline assessment. The full report is entitled: Spring Survey Interpretative Report (2014)	Annex 6: *Appendix 4.9.5 Spring Survey Interpretative Report - Update*

7 NEXT STEPS

7.1.1 Update Chapter 4.8 of the ESIA (see Annex 1, refer to full report for Annexes).

7.1.2 Update Lydian International website with reports identified in Table 3.

7.1.3 Commissioned work at Amulsar will continue, with respect to further studies required for ARD management, water balance verification and testing schedule to inform the design of the PTS. These reports, which include:

- The interpretive reports from continuing on-site kinetic tests currently ongoing;
- Final reports from PTS (laboratory and bench scale) analysis currently ongoing;
- Report of SWWB verification; and
- Detailed design of the PTS, informed by the analytical work identified in the previous bullet points.

7.1.4 Workshop and technical meeting to which the authors of Blue Mineral et al., 2017[1] will be invited to attend. The agenda will include a discussion of the findings of all reports and additional studies currently being commissioned by Lydian. This meeting will be arranged between 15 and 22 January 2018 in Yerevan and attended by environmental advisors working for Lydian International together with invited specialists comprising the authors contributing to Blue Minerals et al., 2017[1].

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5. Global Acid Rock Drainage Guide (GARD guide)[1] (INAP, 2009)
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