SURFACE WATER MANAGEMENT PLAN
AMULSAR PROJECT
Armenia

Prepared for

LYDIAN INTERNATIONAL

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1.0 INTRODUCTION

The Amulsar Mine Project is a proposed gold mine development project located in southern Armenia. GRE has been retained by Lydian International (Lydian) to prepare a Surface Water Management Plan (SWMP) which comprises one of several reports prepared to support the Feasibility Study (FS). The purpose of the SWMP is to present design concepts and details for storm water management structures and for erosion control Best Management Practices (BMPs). The evaluations of pit dewatering and closure concepts are prepared by others under separate cover.

The project includes open pit mining, heap leaching in a Heap Leach Facility (HLF), and waste rock placement in an engineered Barren Rock Storage Facilities (BRSF). Additional facilities will include a truck shop, primary and secondary crushers, tertiary crushers, overland conveyors, roads, and ADR plant and support infrastructure. Several sediment ponds will be constructed to minimize mobilized sediment leaving the site.

The effective management of surface water runoff during the development of mineral resources at the Amulsar project is critical to the protection of downstream water resources. The design of hydraulic and sediment control structures included in the SWMP is intended to achieve the following primary objectives:

- To route runoff to ponds and collection sumps in order to minimize release of mobilized sediment;
- To prevent natural ground runoff and non-contact water from entering disturbed areas and mixing with contact water;
- To capture contact water runoff from mine facilities and treat if necessary;
- To minimize erosion of disturbed areas; and, when erosion does occur, to minimize suspended sediment in stream flows; and

The project lifecycle includes the following phases:

- A construction phase, where necessary facilities and infrastructure are constructed;
- An operations phase, where mineral resources will be mined and processed; and
- A closure phase, where facilities and infrastructure will be demolished, as appropriate, and project impacted areas will be stabilized and reclaimed.

This document addresses surface water management requirements through the construction, and operations phases. The closure plan will be fully defined in the Preliminary Reclamation and Closure Plan, which is currently being prepared by Golder Associates (Golder).

During project construction, operations, and closure activities, various surface water management details will be optimized to meet the overall SWMP objectives based on actual site experience and based on the as-built configuration of facilities (see Section 2.2). In general, surface water not impacted by development activities (non-contact water) will be diverted around areas of impact, and surface water potentially impacted by development activities (contact water) will be managed on site in sediment ponds. During the construction phase, potentially-impacted surface water will be routed to sediment ponds prior to discharge. During the operations phase runoff from the haul roads, conveyor, crushers and truck shop areas will be routed to sediment ponds and treated if required prior to discharge. Runoff from the BRSF will be routed to a sediment pond located downstream of the facility where it will be conveyed to a detention pond near the ADR plant where it will eventually be used as makeup water for the HLF. The HLF will be a closed system, and all precipitation within the HLF limits will be captured for use in operations. Runoff and groundwater collected in the pits will be conveyed to the HLF detention pond for use. Concepts related to the BRSF, HLF, and mine pits are covered in the design reports for those facilities.

Erosion control BMPs will seek to prevent erosion and/or to detain the potential sources of sediment at the source areas, preventing sediment from entering streams. Erosion control measures will reduce the sources of erosion and sediment generation. Passive storm-water controls will reduce or eliminate suspended fines before they are incorporated into the site surface water runoff. Also, sediment trapping structures in channels and streambeds will serve to reduce the sediment load that reaches streams despite BMP measures.

In order to effectively implement, manage, and maintain the Surface Water Management Plan, the mine will establish responsible parties in charge of the SWMP. This management team will use the SWMP to address ongoing surface water management issues at the site. To aid in the implementation of the SWMP, it may be advisable to formulate a SWMP Operations and Maintenance (O&M) Plan. The O&M plan will define details including:

- Staff responsibilities;
- Inspections and maintenance activities (including inspection frequencies);
- Record keeping;
- Logistics pertaining to supplies required by the SWMP; and
- Staff training.

With all surface mining operations, the project footprint changes significantly over time. Therefore, the SWMP and the SWMP-O&M Plan should be considered “living documents”, subject to revision, as appropriate, to meet changing site conditions. The design engineer should be consulted if presently unanticipated site conditions arise that dictate the need for SWMP design element revisions.

The following sections present the design basis and design concepts for the SWMP during the phased project development. Section 2.0 presents the SWMP design approach, design criteria, modeling methods, input parameters, and assumptions. Sections 3.0, 4.0, and 5.0 present surface water management details for the pre-production/construction, operations, and closure phases, respectively. Selected BMPs for sediment control that are believed to be applicable to the conditions of the Amulsar project have been compiled in Appendix A. It is the intent that BMP’s will be employed throughout all aspects of the project construction and operations, and that the BMP’s will complement and supplement the SWMP design features.

It should be noted that although design details for specific water management structures are presented for two of the three project phases, hydraulic structures will be relocated or replaced as facilities expand throughout operations. For example, upstream diversion ditches for portions of the Tigranes/Artavasdes haul roads will be re-located and re-constructed as the pit is expanded. This report presents the water management design concepts for facility expansions, with the intent that hydraulic structures will be redesigned and optimized throughout the various phases of expansion.

1.1 Intended Use of This Report

Global Resource Engineering Ltd. has prepared this report at the request of Lydian International for the company's Amulsar gold mining project located in southern Armenia. The intended use for the Amulsar Project Surface Water Management Plan presented herein is to develop the concepts for water management at the project, to allow costing of SWMP components for feasibility design, and to aid in project permitting. This report is not to be construed as a project construction plan for bidding purposes, for economic evaluations, or for any other purpose other than those which have been described in this section. In the event that this document is translated into Armenian, the English language version of the document shall be considered the prevailing master control document, and any discrepancy in meaning between English and Armenian versions shall defer to the English language version.

2.0 DESIGN BASIS

This section of the SWMP defines key terms as they specifically relate to the project, presents the general design approach, and describes the design criteria for surface water management. In addition, this section describes the modeling methods and design assumptions used in the development of the SWMP.

2.1 Definitions

The following are key terms and their definitions as they apply to the SWMP.

- Soil: Unconsolidated rock material, containing varying percentages of sand, silt, and clay, as well as generally containing adequate moisture and organic matter to promote plant growth.

- BMPs: Best Management Practices – structures, techniques, maintenance procedures and management practices to prevent or minimize impacts to surface water quality.

- Contact Water Runoff: Surface water runoff derived from the mining, haul roads, crushing, conveyor, waste rock, and heap leach areas.

- Curve Number: An empirical parameter used in hydrology for predicting direct runoff or infiltration from rainfall. Curve numbers are used in SCS (Soil Conservation Service) hydrologic calculations.

- IFC: International Finance Corporation

- Diversion Ditch: An engineered linear excavation designed/constructed to divert surface water runoff from non-impacted areas around or away from potentially impacted areas.

- Dewatering Sump: An excavated depression within a larger depression (such as a mine pit) for the purpose of collecting all surface water within the larger depression so that the collected water can be pumped from the depression and managed appropriately.

- Riprap: Rock material with an engineered material size, used to armor water conveyance features (such as ditches) to prevent or minimize erosion.

- Grouted riprap: Rip rap material stabilized/bonded with Portland cement grout.

- Erosion Mat/ Blanket: Blanket of woven synthetic or natural materials used on slopes to slow surface water flow and minimize erosion.

- Straw Wattles: Manufactured cylinders of compressed straw, typically 200 to 300mm in diameter and 6.5 to 8m long, encased in nylon or other photo-degradable materials, generally installed across the base of ditches or along slopes to serve as a filter to catch sediment in surface water runoff.

- Coir Logs: A large-sized straw wattle (see straw wattle definition).

- Silt fence: A temporary barrier to impede sediment transport from small, disturbed areas. The fence consists of filter fabric anchored across the direction of flow and is supported by posts.

- ARD: Acid Rock Drainage; refers to water flows coming from areas where the natural rock has reacted with air, water and the sulfide minerals occurring naturally in the rock to form acid drainage.

- PAG: Potentially Acid Generating; refers to soil or rock materials that have concentrations of sulfide minerals that have the potential to weather and create ARD conditions.

- NAG: Non Acid Generating; refers to soil or rock materials that do not have the potential to create acidic surface water runoff due to low levels of sulfide mineralization.

- Natural Ground: Surface area devoid of mineral development or construction activities.

- Non-contact Water Runoff: Surface water runoff derived from natural ground, (i.e. areas outside of the disturbed areas of the mine, waste rock, heap leach, and mineral process plant development areas). This includes runoff from light-duty vehicle roads.

- Runoff Coefficient: The ratio of total runoff to total precipitation over a selected surface area.

- SCS: Soil Conservation Service (U.S. Dept. of Agriculture), a U.S. Government Agency that is a source of technical specifications and guidance regarding surface water management.

- NRCS: Natural Resources Conservation Services (formerly the Soil Conservation Service of the U.S. Dept. of Agriculture), a U.S. Government Agency that is a source of technical specifications and guidance regarding surface water management.

- Fresh Water: Non-contact surface water (see non-contact water runoff definition).

- TSS: Total suspended solids, in surface water, sediment that is suspended within the water and can be transported by water flows, the maximum TSS varies with surface water flow velocity.

- Watershed: Drainage catchment area that contributes runoff to a specific surface water catchment feature, such as a natural stream or constructed ditch.

2.2 General Design Approach

In general, surface water will be managed at the project to separate contact water from non-contact water. The volume of contact water will be minimized by diverting surface water from natural areas around project-impacted areas and back to natural drainages downstream of the project areas. Contact water from haul roads, crushers, the conveyor, and truck shop will be routed to sediment ponds. The ponds will settle total suspended solids (TSS) concentrations in the contained surface water (i.e. to clarify the water) and will serve as potential water treatment basins, if additional treatment such as flocculation or pH adjustment is required.

Surface water conveyance structures will be engineered and constructed to manage storm water runoff and to minimize erosion of disturbed areas. Drawing 01 shows the project general arrangement and highlights some of the key surface water management concepts for the project facilities. Key concepts include, but are not limited to:

- Upstream diversions to route runoff around disturbed areas and project infrastructure;
- Engineered culvert crossings to route stream flows below roads;
- Riprap, grouted riprap, or other engineered channel reinforcement to prevent channel scour over erodible subgrade;
- Use of silt fence, straw wattles, erosion control matts and other BMPs to minimize sediment transport;
- Collection sumps and check dams to reduce sediment concentration in runoff;
- Sediment ponds to reduce sediment load in runoff downstream of disturbed areas.

BMP’s will be employed to control specific types of erosion and to reduce sediment load in runoff. The BMP’s described in Appendix A have been selected considering the project development activities in the context of the site climate, geology, and vegetation conditions. BMP’s are generally defined as part of a final design construction plan and are field engineered during construction. This SWMP presents only the BMP concepts anticipated to be applied to the project. The reader is referred to Appendix A for further discussion of BMP’s.

2.3 Design Criteria

Table 2-1 Design Criteria

Design Item	Criteria or Approach	Reference
Operation and Base Engineering		
Life of Project	2 years of startup construction + 9 years of operations	Lydian
Construction Phase Surface Water Management Concept	Upstream diversion and BMP sediment source control. Sediment ponds or sumps downstream of mine and plant construction areas.	GRE
Operations Phase Surface Water Management Concept	Upstream diversion and BMP sediment source control. Separate contact and non-contact water runoff where practical. Downstream release of non-contact runoff from light-duty vehicle roads and natural areas.	Lydian
Design Storm Events		
Storm distribution	SCS Type II Storm	
100-year, 24-hour storm depth	95mm	Golder
Hydraulic Structures		
Ditch Freeboard	20% of peak flow depth	NRCS
Sediment Pond Freeboard	20% of 24-hour storm volume	NRCS

At the current study level only the primary hydraulic structures have been evaluated. Hydraulic modeling of drop structures, channel bends, and grade breaks must be performed for detailed design. Similarly, for purposes of the present study the sediment ponds have been conservatively sized based on retention of the design storm event followed by pump-out over a 48-hour period. Sedimentology data was not available for this study, and will need to be obtained for detailed design of the sediment ponds.

2.4 Modeling Methods

2.4.1 HydroCAD Model

The HydroCAD model was used in designing/sizing water management features. HydroCAD is a computer-aided design system for modeling the hydrology and hydraulics of storm water runoff. It is based largely on the hydrology techniques developed by the U.S. Soil Conservation Service (SCS/NRCS), combined with other hydrology and hydraulics calculations. For a given rainfall event, these techniques are used to generate hydrographs throughout a watershed. Typically, this allows the engineer to verify that a given drainage system is adequate for the area under consideration or to predict where flooding or erosion is likely to occur.

A hydrograph routing operation determines the changes to an inflow hydrograph as it passes through a specific node, such as a reach or pond. Different routing methods are available to handle various requirements. For the Amulsar project, the storage-indication method was used because it has the advantages of being fast, widely-used, and compatible with TR-20 pond routing. In addition, this sequential routing procedure can be used for most projects with free discharge or fixed tailwater conditions similar to those anticipated at the Amulsar project.

The SCS Unit Hydrograph method was selected for surface water calculations. The SCS unit hydrograph procedure (also known as the TR-20 runoff method) generates a runoff hydrograph by the following basic steps:

1) A rainfall distribution is selected which indicates how the storm precipitation will be distributed over time. The SCS Type II storm distribution was applied to the project analyses, as it will provide the most conservative design estimates.

2) The design storm depth is generally determined from rainfall maps, based on the return period being modeled. Combined with rainfall distribution, this specifies the cumulative rainfall depth at all times during a design storm. The design storm for the Amulsar project was based on data generated by Golder and presented in their 2011 report (Golder Associates Inc., 2011). The antecedent moisture condition (AMC) was assumed to be 100% which simulates an impervious surface (the condition that exists when rain falls on snow and frozen ground).

3) Based on the Time-of-Concentration, the storm is divided into “bursts” of equal duration. For each burst, the SCS runoff equation and the average curve number are used to determine the portion of that burst that will appear as runoff.

4) A unit hydrograph, in conjunction with the Time-of-Concentration, is used to determine how the runoff from a single burst is distributed over time. The result is a complete runoff hydrograph for a single burst.

5) Individual hydrographs are added together for all bursts in the storm, yielding the complete runoff hydrograph for the storm.

The Lag/Curve Number Method was selected to compute Time of Concentration (Tc). The Tc is calculated using the average land slope and the hydraulic length of the watershed. These input parameters were calculated electronically from the project drawings. The SCS Curve Number (CN) is also utilized in the Tc calculation. The curve number depends on the vegetation, surface treatment, and the hydrologic soil group, which may be determined from soil type. For calculation purposes, all project soils were conservatively assumed to be Group C soils. Group C soils have low infiltration rates when thoroughly wetted, and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture.

The ‘dynamic storage indication’ method was used to account for storage effects along diversion ditch reaches. This method first performs storage-indication routing, and then translates (delays) the resulting hydrograph in proportion to the hydraulic travel time. With this method, the peak discharge does not correspond to a point on the inflow curve, but more realistically is attenuated to account for storage effects and travel time. The reach’s stage-discharge is calculated using Manning’s equation, assuming steady, normal flow. The stage-storage relationship is determined from the reach cross-section multiplied by the length. The stage-discharge and stage-storage curves are used to create a storage-indication curve. Routing is performed using the specified time span and time increment. At each point in time, a storage-indication value is calculated. The original storage-indication curve is consulted to determine the elevation that corresponds to the new stage-indication value. Using the new elevation, the stage-storage and stage-discharge curves are consulted to determine the new storage and discharge. This process is repeated for all points in the inflow hydrograph. The travel time is calculated by dividing the length of the reach, channel, or pipe, by the outflow velocity. For a reach routing, the average and minimum travel time are calculated using the average and maximum velocity, respectively.

Ditch and pond sizing become an iterative process using the program with the inputs described above. Culverts were designed assuming catch basins with negligible storage assumed at the culvert inlets. The program automatically accounts for inlet, outlet, and barrel control flow regimes in culvert designs.

The HydroCAD model employs a summary report to provide a comprehensive view of all data and results for a single node. Each report provides standard information, plus specialized data for each sub-catchment, reach, pond, and link. The reports are used to confirm that ditches are not designed to be either over-flowing or under-utilized, as well as to confirm that culverts are designed with the correct capacities. Both ditches and ponds targeted minimum 20% of maximum flow depth for freeboard.

2.4.2 Naming Convention of Conveyance Structures

Design details in the following sections and on the project drawings are referenced by an established naming convention. Each specific watershed type has been assigned a numerical/alpha label; for example “H6” indicates a ditch along a haul road. “C” indicates ditches diverting water around the crusher/conveyor areas, and “R” indicates ditches along light-duty vehicle roads. Water conveyance ditches have been assigned a numerical label, preceded by the alpha designation “RE”. Ditch station numbers have been assigned to locations along each ditch, based upon the distance downstream of the initiation point of the ditch; for example, “0+300” along RE1 indicates a station 300 meters downstream from the start of ditch number 1. Ditch station numbers are used to locate features along the length of each ditch, such as culverts. Also, station numbers are used to identify ditch reaches with specific design details, such as ditch width, height, slope, and length.

2.5 Input Parameters and Assumptions

This SWMP report presents design concepts for the surface water management details to be used during construction, expansion, and operation. Detailed engineering of these concepts must be completed prior to construction and operations. Along road and conveyor corridor’s the degree of competence of the ground and the appropriate channel lining material will not be known until site grading occurs. In other cases, such as for the proposed sediment ponds, it will be necessary to perform field investigations to support final design and subsequent construction.

The project site geochemistry and PAG waste management issues are addressed in the waste rock and mine pit operations plans, under separate cover. Also, groundwater management and project water treatment issues are addressed in the pending Closure Plan. It should also be noted that potential pollutants other than sediment at the project site, such as hydrocarbons or dissolved metals, are not addressed in this SWMP. These other potential pollutants are addressed in the project feasibility study.

Observations from prior studies by Golder (Golder Associates Inc., 2011) as well as field data collected by GRE during May 2014 were used in selecting project-specific surface water engineering design parameters. A 100-year, 24-hour storm was selected as the project design storm for the SWMP. The curve number was selected from literature values and based on observation of the site conditions. The SCS Type II storm distribution was selected as it provides a conservative estimation of peak flow relative to the other SCS storm types. The model considers the potential increase in peak runoff that can occur when rain falls on snow. Site observations indicated that the velocities generated by this condition exceed the snowmelt driven stream velocities observed onsite during the field visit.

The Manning's number used for channel design assumed all structures to be constructed of riprap to provide a conservative estimate of peak flow depth. It is anticipated that most of the channels will be excavated into competent ground with roughness equivalent to riprap. Actual channel lining requirements must be determined during detailed design, and it many cases must be field engineered during construction. The Manning numbers ("n") assumed for modeling purposes were the following: 0.05 for diversion ditches, 0.011 for corrugated plastic culverts, and 0.013 for concrete box culverts. Culverts were generally assumed to follow natural ground grades, or where culverts must outfall on fill material, outlet protection is assumed.

For preliminary budgetary purposes, it has been assumed that ditches on shallow gradients will be grass lined and will include an erosion blanket to help establish vegetation and to increase erosion resistance. Concrete, grouted-riprap, or similar high-strength reinforcement has been assumed for ditches along reaches that contain greater than 10% grade. Natural bedrock with hydraulic properties equivalent to riprap was assumed for all other ditches. An allowance was included for lining 10% of the remaining ditches with riprap where they cross erodible subgrade. SWMP budgetary requirements in excess of this allowance are assumed to be included within the contingency for the overall Amulsar project capital and operating cost estimations.

The SWMP shows dimensions, lines, and grades at representative mine life "snap shots" in time throughout the project timeline. The intent is that many components of the management plan will be modified regularly based on the expanding facility limits throughout the life of the project. The hydraulic structures described in the SWMP will also require maintenance throughout the life of the project. Inadvertent overtopping or failure of the hydraulic structures would be expected to cause minor damage and temporary interruption of operations. Most of the SWMP structures are only required during the construction and operation of the project and may be removed for closure. The preliminary design concepts presented here attempt to balance the need to have a robust water management system with the need to consider project economics and the relatively short operating mine life. The proposed concepts are believed to invest a limited but prudent amount in capital expenditures without placing an undue burden on operating expenditures.

3.0 PRE-PRODUCTION / CONSTRUCTION PHASE SURFACE WATER MANAGEMENT THROUGH YEAR 1 OF MINING

3.1 Introduction

During the construction phase and year 1 of the project, access and haul roads will be constructed to provide access to mine facilities. In addition, the conveyor, and crusher infrastructure will be developed.

Drainage ditches will be constructed and culverts placed, as required, to convey surface water along and under access roads. Diversion channels will be constructed to convey storm runoff around disturbed areas. Diversion channels will be constructed along haul roads to route runoff to sedimentation ponds.

BMPs, along with the major surface water management features listed above, will be used to minimize erosion in disturbed areas and to minimize the transport of sediment in surface water flows. Specific BMPs to be used in the construction phase are discussed in more detail in the sections below. Appendix A provides guidance regarding the use and applicability of specific BMPs.

Water conveyance structures have been designed to manage the site surface water flow. Water conveyance ditches are assumed trapezoidal, earthen ditches, lined with riprap, grass or concrete where they cross erodible subgrade. Culverts will be constructed of N-12 (or equivalent) dual wall high-density round polyethylene pipe with a smooth interior wall and a corrugated exterior wall or will be reinforced concrete box culverts. Drawings 02 through 05 show the diversion ditches and culverts to be developed during the construction phase, as described in the following sections. Typical ditch and culvert design details are shown on Drawing 09.

3.2 Roads

A main access road, entering the project area from the north, will be constructed to provide off-site access to the mine and plant site area. Also as part of project construction activities, haul roads will be constructed from the pit area to the BRSF, truck shop, and crushers. In addition, a haul road will be constructed between the end of the conveyor and the HLF.

Several light-duty vehicle roads will be constructed between the primary and secondary crusher, around the truck shop area, and around the perimeter of BRSF. The locations of temporary access roads and/or construction roads are not defined at this time. Design of water management structures for any additional roads or temporary facilities must be performed for detailed design.

BMPs will be used to minimize erosion and sediment load to surface water derived from areas disturbed by road construction. Silt fencing and/or straw wattles will be used on the up-hill side of road cuts and on the down-hill side of roads to minimize sediment transport, as per guidance provided in Appendix A. In addition, rock check dams will be used, as needed, in drainage ditches along the road cuts. Erosion control measures, such as erosion control matting or crushed rock cover, will be used on the down-hill side of roads and ditches, as appropriate, to minimize erosion.

3.2.1 Main Access Road

The main access road runs south of the conveyor, roughly east-west, following the divide between the Darb River and Arpa River watersheds. Since this road follows the ridgeline and has very little catchment, only a small ditch (not shown) will be required to handle runoff from the road.

3.2.2 Light-duty Vehicle Roads

Several light-duty vehicle roads will be constructed for the project. The most substantial light-duty vehicle road runs between the beginning and end of the conveyor corridor, crossing the main access road. Runoff from the upstream catchment area and road will be conveyed in a ditch along this road. A culvert at RE21 1+700 will divert the water from the eastern portion of the road, under the road, and into a natural drainage that eventually drains to the HLF impoundment. Though this water is considered non-contact and does not require sediment treatment, routing this water to the HLF is the most convenient option for this water considering the other surface water management infrastructure. This water could also be used as irrigation water for community relations projects if deemed appropriate. Water from the western portion of the road will be conveyed in ditches on the upstream (northern) side of the road and diverted under the road through culverts where the road crosses natural drainages to the Darb River. Again, this water is considered non-contact and does not require sediment treatment.

Other light-duty vehicle roads run between the primary and secondary crusher and along the south side of the BRSF. Ditches along these roads divert water to the Crusher Sediment Pond. Many of these ditches are low gradient and may be grass lined. However a few, such as RE7 have grades as high as 10% and may require rip-rap to prevent erosion where they cross erodible subgrade. Culverts are required to convey water across switchbacks in the roads so that ditches remain on the ‘cut’ side of the roads.

3.2.3 Pit Haul Road Area

A diversion ditch system will be constructed to manage surface water to be derived from watersheds up-slope of (west of) the portions of the haul road that run roughly north-south between the Tigranes/Artavasdes and Erato pit areas. Culverts, sediment ponds, and ditches were sized to include, the entire undisturbed watersheds on the eastern side of the ridgeline. As the pit develops, these watersheds will decrease in size as runoff from the pits will be internally drained to dewatering sumps and pumped via pipeline for treatment (if required) or consumption in the process circuit.

Runoff from the haul road in the pit area will be discharge to two sediment ponds. One pond is located east of Tigranes/Artavasdes (Tig/Art Sediment Pond) and will receive runoff from the portion of the haul road that runs around Tigranes/Artavasdes. Small culverts will be required along RE1 and RE3 where there are switchbacks in the haul road, so that the ditch continues along the upstream ‘cut’ side of the haul road. A culvert at RE2 2+300 will convey water under the haul road to the sediment pond. This pond has an estimated 24-hour storm storage capacity of 48.9 million liters. This pond was sized to receive 120% of the 24-hour storm volume in order to allow for freeboard and dead storage requirements. The sediment pond includes a spillway channel and sump pumps capable of pumping out the pond in 48 hours.

The second pond (Erato Sediment Pond) is located to the northeast of Erato and will receive runoff from the haul road that runs along the east side of Erato. Where the haul road splits, two ditches (RE5 and RE6) will convey water along both lengths of the haul road. A culvert (RE5 1+300) will convey the water beneath the fork in the haul road so that ditch RE5 can continue along the upstream side of the southern haul road. A culvert will convey water from RE6 under the northern haul road to a ditch. This ditch connects to a second culvert on the upstream side of the southern portion of haul road and conveys water from RE5 and RE6 to the Erato Sediment Pond. Due to the steep topography, both the ditch between RE5 and RE6 and the ditch leading from the haul road to the sediment pond will be constructed of concrete or grouted rip-rap. This pond has an estimated 24-hour storm storage capacity of 70.9 million liters. This pond was sized to receive 120% of this 24-hour storm volume in order to allow for freeboard and dead storage requirements. The design of the pond includes a spillway channel and sump pumps capable of pumping out the pond in 48 hours.

The sediment ponds will be actively managed to maximize their potential effectiveness at sediment removal. During the dry season and transition seasons, ponds will be operated as flow-through structures. During the wet season, ponds will be pumped out between storm events in order to maximize the retention time of subsequent storm events.

3.2.4 Crusher Haul Road Area

Runoff from the portion of haul road north of Erato that runs to the primary crusher and BRSF will be managed by a system of ditches that will convey water to a sediment pond (Crusher Sediment Pond) west of the secondary crusher. This pond will be discussed further in Section 3.4. The portion of haul road that connects to the truck shop will have a small ditch that conveys water to the system of ditches that manages water around the truck shop area (see Section 3.3).

3.2.5 HLF Haul Road

A short length of haul road runs between the HLF and the terminus of the conveyor. Ditches will run along the upstream portion of the haul road and convey water to culverts that discharge to a natural drainage. This natural drainage drains to the HLF impoundment.

3.3 Truck Shop

A truck shop will be constructed on the eastern side of the BRSF. A system of ditches will be constructed around the perimeter of this facility. A minimum 0.5% slope was assumed for the area in order to drain water to the perimeter ditches. This water will be drained by a ditch that runs along the eastern side of the BRSF to a treatment pond located at the toe of the BRSF. This treatment pond will also collect runoff and seepage from the BRSF, and as a result, the design of this impoundment will covered in the BRSF design report and is not shown in detail in these plans.

3.4 Crushers

3.4.1 Primary Crusher

The primary crusher areas will be drained by ditches (RE9 and RE10) that run along berms that enclose the facility. Culverts will be required to convey water from RE9 and RE10 to the ditches along the upstream side of the light-duty vehicle road that connects the primary and secondary crusher.

3.4.2 Secondary Crusher and Surge Pile

Light-duty vehicle roads that run around the surge pile will collect runoff from the surge pile and roads. A culvert located at RE7 2+100 will allow water from the light-duty vehicle roads to enter the diversion ditch that runs along the perimeter berm of the secondary crusher. The ditch will convey this water along with runoff from the secondary crusher to a concrete/grouted rip-rap ditch that runs down the hillside to a sediment pond (Crusher Sediment Pond). This system of ditches and sediment pond also handle water from the haul roads located north of Erato. This pond has an estimated 24-hour storm storage capacity of 76.9 million liters. This pond was sized to receive 120% of this 24-hour storm volume in order to allow for freeboard and dead storage requirements. The design of the pond includes a spillway channel and sump pumps capable of pumping out the pond in 48 hours.

3.5 Conveyor and Stockpiles

A ditch will run the entire length of the conveyor corridor. As this collection occurs upstream of the Gndevaz reservoir, it was assumed that this water will require sediment treatment and as a result, this water is routed to the HLF impoundment. If it is determined that this water is suitable for offsite release for use as irrigation water, water can be released at natural drainage intersections along the conveyor corridor, providing some cost savings.

The first section of the conveyor receives water from sub-catchment C1. Since this portion of the conveyor is relatively steep (up to 10%), a concrete ditch is required. This ditch drains to a culvert that diverts the water under the conveyor and to a grass-lined channel that leads to a natural drainage. This natural drainage drains to ditch RE21 which collects water upstream of the light-duty vehicle road, south of the conveyor.

Runoff from sub-catchment C2 is collected in ditch RE18, which runs along the conveyor to the transfer station. Due to the steep grades along the conveyor (up to27%), this ditch is concrete. Water in this ditch is conveyed to the end of the conveyor before the transfer station to a culvert that diverts the water under the conveyor to a ditch that runs along a light-duty vehicle road, where it continues south of the conveyor and rejoins with the conveyor corridor below the transfer station. From there, the water continues along RE18 until the conveyor crosses a natural drainage that leads to the Gndevaz reservoir. Since water cannot be released to the catchment of this reservoir, the water in RE18 will be diverted under the conveyor via the culvert at RE18 2+650, and then continue along the natural drainage. A ditch will be built on the north side of the corridor to divert water in the natural drainage to a culvert at RE18 3+150 that leads to a natural drainage eventually reporting to the HLF impoundment. Downstream of RE18 3+150, an additional culvert (RE18 3+555) is required to convey the water in the natural drainage under the main access road. Due to the large catchment upstream of this location, a concrete box culvert measuring 2.5 meters in height and 8 meters in width is required to handle the peak storm flow. Downstream of this point, the conveyor has very little catchment and as a result, only a small diversion (not shown) beyond RE22 1+400 will be required to handle runoff along the conveyor corridor.

3.6 Other Mine Facilities

Additional infrastructure at the site includes the transfer station at the approximate mid-point of the conveyor and the stockpile at the end of the conveyor. A small diversion (RE19) will be built upstream of the transfer station to divert non-contact water around the facility and to a natural drainage. Another small diversion will be built along the downstream perimeter of the stockpile area and convey water to a natural drainage that leads to the HLF impoundment.

4.0 YEAR 1 OF MINING TOEND OF MINE LIFE

During the operation phase of the project, parts of the haul road will be altered to accommodate the expanding mine pit footprint. Integral to operations will be the ongoing maintenance of associated surface water management features, as well as the modification of surface water management features to meet the needs of expanding facilities. Additional drainage ditches will be modified/constructed and culverts placed, as required, to convey surface water along and under the haul road roads. Because mining begins on the ridge top, the mine pit itself has no upstream catchment. Surface and groundwater collected within the mine pit will be collected in sumps and pumped via pipeline for consumption in the process circuit. The portion of the watershed between the pit and the haul road is largest at the beginning of mine operations and reduces in size as the mine pits increase in size. The diversions and ponds that will serve for the operating life of the project that are located downstream of the mine pits and haul roads have thus been sized to accommodate runoff from the pre-mining pit area topography.

BMPs, along with the major surface water management features, will be used to minimize erosion in disturbed areas and to minimize the transport of sediment in surface water flows. Specific BMPs to be used in the operations phase are discussed in more detail in the sections presenting major operational phase features/details below. Appendix A provides guidance regarding the use and applicability of specific BMPs.

Changes to the SWMP infrastructure after Year 1 are limited to the area around the pit. Snapshots of this area through mine life are shown in Drawings 06-08. Drawing 06 shows the area for the Year 1-3 period, Drawing 07 shows the area for the Year 3-5 period and Drawing 08 shows the area for the Year 5-end of mine life period.

4.1 Year 1-Year 3 Period

Following Year 1, the haul road that runs along the south side of Tigranes/Artavasdes will migrate to the southwest to accommodate the expanding pit footprint. At this point, the drainage ditch along the original haul road will be abandoned, and a new ditch will be required along the new haul road. This ditch (RE1 in Drawing 06) was sized based on the catchment area between the haul road and the end of Year 1 pit footprint. Culverts will be required to convey water along switchbacks where the haul road is expanded at the southern end of the pit. The water collected in ditch RE1 after Year 1, will be conveyed to a new sediment pond (Tig/Art South Sediment Pond). This sediment pond will be required due to the lower elevation of the expanded haul road which precludes conveying water to the Tig/Art Sediment Pond. This pond has an estimated 24-hour storm volume of 36.9 million liters. This pond was sized to receive 120% of this 24-hour storm volume. The design of the pond includes a spillway channel and sump pumps capable of removing the storm volume in 48 hours. The Tig/Art Sediment Pond will remain in use, but will only handle water from the unaltered portions of the haul road, from the north and northwest sides of Tigranes/Artavasdes.

4.2 Year 3-Year 5 Period

During this period, mining of Erato will commence. A ditch will be required along the portion of haul road that connects Erato with the main haul road. This ditch was sized to accommodate the undisturbed catchment area upstream of the planned haul road. The ditch will divert water to a culvert which will convey the water to the existing haul road diversion ditch that leads to the Erato Sediment Pond.

An additional length of haul road will be constructed between the Artavasdes and Tigranes pits. This haul road will require a small diversion (RE31 in Drawings 07 and 08) that will divert runoff from the road into the pit where it will be handled by the pit dewatering system.

4.3 Year 5-End of Mine Life

After year 5, there are no major changes to the haul road and infrastructure layout and therefore, the existing system of culverts, ditches, and sediment ponds will adequately handle surface runoff. Some existing culverts and ditches will become obsolete as the pit footprint expands and more water is handled by the pit dewatering system.

5.0 CLOSURE SURFACE WATER MANAGEMENT

A detailed project Closure Plan has not been developed at the time of writing this report. The closure concepts presented here reflect closure measures anticipated to be performed that impact surface water management and erosion control. The SWMP must be updated based on detailed closure planning in the future.

GRE has provided Golder with surface water management designs for the HLF, BRSF, and Pit Backfill. These designs will be integrated into Golder's closure plan.

Integral to closure and activities will be the establishment of surface water control features that will be used to minimize erosion in reclaimed areas and to minimize the transport of sediment in surface water runoff. Specific BMPs to be used in the closure and post-closure phase are discussed in more detail in the sections presenting major closure and post-closure phase features/details below. Appendix A provides guidance regarding the use and applicability of specific BMPs.

6.0 COST ESTIMATE

A cost estimate was calculated based on the estimated quantities required to construct the infrastructure discussed in this report and is included in Table 6-1. It is important to note that this cost estimate includes only the cost of excavation and materials for the ditches, culverts, and sediment ponds for the management of surface water onsite during operations. It does not include the cost of maintenance or the decommissioning of infrastructure post-closure. The cost does not include the cost of managing surface water in the following facilities:

- BRSF (including the collection pond);
- Pits; and
- HLF (including the impoundment and perimeter diversions)

The management of water in these facilities during operations will be addressed in the appropriate design reports. The management of water in these facilities and onsite post closure will be addressed in the closure plan.

In addition, the cost estimate does not include additional costs related to contingency, taxes, shipping, or acquisition of materials. The costs of materials and excavation should be updated to be consistent with in-country costs assumed for the construction of other project infrastructure.

Table 6-1 SWMP Cost Estimate

Item	Unit	Cost Per Unit	Year 0-1	Year 1-2	Year 3-5	Life of Mine
Culvert 600mm	each 20' unit	$ 323	$ 1,936	$ -	$ -	$ 1,936
Culvert 900mm	each 20' unit	$ 613	$ 17,153	$ 3,676	$ -	$ 20,828
Culvert 1200mm	each 20' unit	$ 1,050	$ 35,686	$ 6,298	$ -	$ 41,984
Culvert 1500mm	each 20' unit	$ 1,691	$ 135,280	$ 40,584	$ -	$ 175,864
Excavation of Ditches	m3	$ 5	$ 711,972	$ 46,064	$ 9,341	$ 767,376
Excavation of Sediment Ponds	m3	$ 4	$ 940,238	$ 177,158	$ -	$ 1,117,397
Spillway	#	$ 15,000	$ 45,000	$ 15,000	$ -	$ 60,000
Erosion Blanket	m2	$ 2	$ 67,995	$ 3,438	$ -	$ 71,433
Seeding Cost	m2	$ 5	$ 220,763	$ 11,162	$ -	$ 231,925
Sump Pumps	#	$ 40,000	$ 440,000	$ 80,000	$ -	$ 520,000
Concrete	m2	$ 55	$ 1,683,529	$ 118,160	$ -	$ 1,801,689
Rip-Rap	m2	$ 54	$ 756,535	$ 59,379	$ 195,603	$ 1,011,517
Box Culvert	#	$ 500	$ 466,650	$ -	$ -	$ 466,650
Total	**$**	**$ 59,300**	**$ 5,522,737**	**$ 560,919**	**$ 204,944**	**$ 6,288,599**

7.0 REFERENCES

Golder Associates Inc. (2011). *100-Year/24-Hour Storm Event Statistical Analysis, Amulsar Heap Leach facility. Included as Attachment D to Conceptual Design of Pilot Heap Leach Facility Technical Memorandum. Golder Project No. 113-81597. 2 pp. 7 April.*