TECHNICAL MEMORANDUM

To:	John Rozelle
From:	Andrew Harley
Date:	January 16, 2014
Cc:	File
Project No.:	114-311285, Task 050.05
Subject:	Mount Todd Project EIS Comment Response

1.0 INTRODUCTION

In response to the Northern Terroitory Environment Protection Authority letter dated 22 November 2013, Tetra Tech has prepared the following response. The issues to be addressed by Tetra Tech relate to three areas:

- Passive treatment of acid and metalliferous drainage;
- Water management; and
- Waste rock management

2.0 PASSIVE TREATMENT OF ACID AND METALLIFEROUS DRAINAGE

The preliminary design Waste Rock Disposal Area (WRDA) included a store and release cover with 3H:1V slopes consisting of a 0.3 meter (m) clay capillary break, 0.6 m fine non-potentially acid generating (Non-PAG or NAG) rock mixed with clay cover, and a shallow layer of growth medium. The cover would be placed over a mantle of coarser crushed Non-PAG waste rock surrounding/covering a potentially acid generating (PAG) material core. The new WRDA design under consideration has nine 30 m lifts with eight meter catch benches, a 34 degree interbench slope, and an overall slope of approximately 29 degrees. The proposed closure for the WRDA is to place Geosynthetic Clay Liner (GCL) on top of each of the catch benches, and under the next lift (Petticoat Closure Option). The total width of the GCL would be approximately 52 m, which corresponds to the width required to provide full overlap from bench to bench. A one foot layer of fines material will be placed on the GCL to provide confining pressure, and to maintain the GCL's moisture content. A one meter layer of Non-PAG material will be placed over the fines layer to prevent erosion.

Modeling was used to assess the drainage conditions and resulting water quality that would likely exist during the closure and post-closure periods (Attachment A). The focus of the modeling was on the interior flow dynamics that could affect the PAG material encapsulated within the interior portion of the facility, the rate of seepage from the base of the WRDA and the geochemical character of the resultant drainage.

Tetra Tech
350 Indiana Street, Suite 500, Golden, CO 80401
Tel 303.217.5700 Fax 303.217.5705 www. tetratech.com

Proper closure of the WRDA and seepage management is critical for preventing impacts to local waters, and to minimize long-term treatment and management costs. Acid rock drainage (ARD) commonly occurs in WRDAs with sulphide-enriched mine waste through the oxidation of pyrite (or other sulphide minerals) as it is exposed to oxygen and water. The geochemical characterization program for Mt Todd has determined that 38% of the waste rock will be low sulphur and non-PAG, 15 % of the waste rock is in the uncertain acid generating category, and 47% will be PAG. Modeling results indicate that approximately 8% of annual precipitation infiltrates into the WRDA. Additionally, the petticoat design also increases the runoff by approximately 20% over the uncovered facility. The disadvantage with this design is that water infiltrates along the uncovered waste rock slopes. However, a closer investigation of the modeled results show that the precipitation that readily infiltrates into the waste rock slopes, is quickly evaporated back out of the WRDA. Any water that infiltrates and is not quickly lost to evaporation travels vertically until it encounters the GCL and fines layer between the waste rock lifts. Once the infiltrated water reaches the GCL and fines layer, it travels laterally. Because the GCL layer is graded away from the center of the facility, the lateral flow is toward the outer edge of the facility and will minimize infiltration of some water into the PAG waste rock. The amount of water that will travel through the facility is minimal (reaches a steady state rate of <0.5 cubic meters per hour [m^3/hr] over the modeled period). During the wet season, an increased amount of water could be flushed from the waste rock in response to large storm event, however the increased flows still remain below 1.5m^3/hr.

The water quality estimates are based on three probable vertical flow paths that the infiltration water is likely to take within the WRDA:

- Flow Path A represents the optimal scenario with regard to limiting ARD formation such as the scenario that could be envisioned for the outer portion of the lower most lift where water will contact non-PAG rock first (~50%), interact with PAG/uncertain rock within the core (~35%) and contact non-PAG rock again (~15%) before reporting to RP1.

- The horizontal flow induced by the petticoat option would be similar to Flow Path B, and would result in contact with non-PAG rock (~33.3%), followed by PAG/uncertain rock (66.6%).

- Flow Path C represents percolation through the GCL and into the PAG/uncertain rock core only. This worst case scenario represents a scenario without flow through a non-PAG cover.

The following modeling results for each scenario indicates that water treatment of acid and metalliferous drainage will be required:

Description	Scenario C	Scenario B	Scenario A
	PAG/Uncertain Only (100%)	Non-PAG>PAG/ Uncertain (33.3%, 66.6%)	Non-PAG>PAG>Non-PAG (50%, 37%, 13%)
pH	3.8	3.8	4.0
Sulphate	1,220	816	448
Al	38.8	22.3	6.7
As	0.0119	0.0097	0.0078
Ca	77.4	52.9	31.0
Cd	0.107	0.071	0.039
Cl	9.21	7.64	6.24
Co	1.52	1.02	0.56

Cr	0.00079	0.00061	0.00045
Cu	8.38	5.59	3.10
Fe	0.000060	0.000040	0.000022
K	5.26	3.68	0.60
Mg	191	127	71
Mn	0.0067	0.0045	0.0022
Mo	0.00025	0.00018	0.00012
Na	22.9	15.8	9.4
Ni	12.9	8.64	4.79
Pb	0.053	0.036	0.020
Zn	25.13	16.76	9.30

Passive treatment systems have been effectively applied to treat mine impacted water of a wide range of pH and metal concentrations. The Global Acid Rock Drainage (GARD) guide (INAP, 2009) suggests that passive systems are most effective when the acid loading of the water is less than 300 milligrams per liter (mg/L) (Section 7.5.2.2). Acid loading above this concentration could impact the pH sensitive microbial activity. The most effective passive systems are those with low flow rates and moderate water quality.

The acid loading can be calculated from the analytical data using the pH, iron, manganese, and aluminum concentrations (Kirby and Cravotta, 2005):

$$Acidity_{calculated} = 50[1000(10\text{-}pH) + 2(Fe)/56 + 2(Mn)/55 + 3(Al)/27]$$

Based on water quality estimates (Attachment A), the calculated acidity of these scenarios is 223 mg/L, 132 mg/L, and 43 mg/L, suggesting that the water quality is sufficient to be treated using a passive system. Additionally, the simulated flow rates of the seepage from the facility is expected to stabilize around 1.5 cubic meters per hour (m^3/hr) (6.6 gallons per minute [gpm]) approximately three years after closure. This flow rate is within the range of flow rates successfully treated with passive systems.

There are many case studies of passive treatment systems that have been successfully used to treat mine water. The Haile Mine Site in Lancaster County, South Carolina, Wheal Jane Mine in Cornwall, United Kindgom, and Golinsky Mine Site in Shasta County, California are all similar to conditions that are expected for WRD at Mt. Todd. The Haile Mine Site was a gold mine and the passive treatment system was operated with an influent pH of 2.0 to 4.9 and a flow rate of 6 gpm. The system was started in 2004 and during the first five years of operation the system operated without interruption, and the sulphate and metal removal were balanced and the pH of the effluent raised to 6.5. The Wheal Jane Mine was a tin mine and the passive treatment influent water pH is 3 and a flow rate of 9 gpm. The passive system raised the pH above 5, and decreased the sulphate and metals by approximately 25%. Some of the challenges in the metal removal were determined to be attributed to the amount of oxygen in the influent water. The final example, Golinsky Mine Site was a copper mine with a 10 gpm influent at a pH of 2.5 to 4. This passive system has been operated with a 91% removal of metals and sulphate, and an increase in pH to approximately 6.6. (ITRC, 2013).

3.0 WATER MANAGEMENT

Initial conditions for the production phase model are the end conditions from the pre-production phase model (which begins in October and runs for 2.25 years). The initial conditions for the pre-production phase model are based on site observed water surface elevations from October 1, 2013. RP3 is currently undergoing in-situ treatment. Pre-production modeling shows a minimum removal of water from RP3 of 62 percent, an average removal of 92 percent and a maximum removal of all water from the Pit. Thus, Batman Pit is not modeled as being empty at the beginning of production and water levels within the other RPs are set using the best available information.

The production model includes the following contingencies for RP1:

- Increased capacity due to 2-meter spillway raise
- Reduced contributing watershed due diversion channel installation
- Increased capacity due to deepening the pond bottom by 3-meters

The production model currently does not contain RP7. The following contingencies for RP7 (TSF1) are proposed for production and as updates to the production model:

- Multi-phase embankment raise from existing crest elevation of 140 to 158 meters.
- Transition to TSF2 during production year 4/5
- Maintaining a minimum 1-meter freeboard between embankment crest and water surface within the TSF

RP2 (retention pond for the Low Grade Ore Stockpile) will be relocated and enlarged, thus overtopping events are anticipated to be minimized or eliminated. Stage-storage relationships for the improved RP2 will be incorporated into the production model once they are defined..

4.0 WASTE ROCK MANAGEMENT

The WRDA design is considered by NTEPA unsuitable for relatively flat terrain based on long-term geomorphic stability concerns. Additionally, NTEPA indicated that this design is unsuitable based on economic issues. The design presented in the EIS is based on the footprint available for construction of the WRDA and economic analyses have been undertaken during mine feasibility analysis that have been shown to be suitable.

With respect to stability and GCL issues, there are addressed in Attachments B and C, with the results summarized below:

- a stability analysis of the WRDA indicating that the landform and the GCL is stable as designed;
- quantitiative and qualitative erosional analysis of the WRDA indicates that there is no long-term geomorphic concerns;

- responses to concerns of GCL including punctures, wet-dry cycles, liner resistance to wet-dry cycles indicate that a GCL is suitbale as degradation of the liner has already been considered in design criteria.

These Attachments indicate that the preliminary feasibility design is suitable for the WRDA is suitable.

5.0 TAILINGS STORAGE FACILITIES

5.1 MATERIAL PROPERTIES

Tailings materials were tested for compaction and permeability by Modified Proctor Compaction (AS 1289.5.2.1) and Falling Head Permeability (AS 1289.6.7.2) methods, respectively. These tests require samples to be dried to a specified value. The maximum dry density presented in Table 3-3 of the Preliminary Feasibility Study (Tetra Tech, 2013) may be considered the maximum expected value, but is not typically replicated in the field. Results presented in Table 3-4 of Preliminary Feasibility Study (Tetra Tech, 2013) show samples that were run on 95 percent of the proctor dry density, and so the samples are at a slightly lower water content (if you compare the numbers within the two tables, the first sample dry density of 1.83 is equivalent to 95-percent of the previous test dry density of 1.92). The dry densities presented in the Preliminary Feasibility Study (Tetra Tech, 2013) should not be considered as typical field values. Rather, they are laboratory modified to conform to testing procedures and represent an optimum value. Dry density cannot be measured directly within the field as the sample is disturbed upon collection. Dry density values must therefore be predicted within the laboratory. Tailings storage facility design used laboratory predictions by Knight Piesold (1996) ranging from 1.7-1.8 t/m^3 as a material characteristic when designing the Tailings Storage Facility (TSF2).

Tailings grain size, percent solids and specific gravity are dictated by milling and thickener performance within the process circuit. Grain size is a function of the grinding capability of the ball mill, which reduces the incoming materials to a P_{80} of 90 µm. Solids content of the thickened tailings is expected to be in the range of 51 to 54 percent and specific gravity is anticipated to be 1.49. Design criteria for the ball mill and tailings thickener are presented in Proteus (2013).

5.2 TAILINGS CLOSURE

The design concepts of store and release covers hold true on both slopes and flat surfaces, and store and release covers have been shown to operate effectively on slopes (Albright, 2004, MEND, 2004). Store and release cover design does not preclude placement on slopes. On sloped surfaces, runoff of precipitation both reduces the storage capacity requirement of the cover material and increases the requirement for erosion protection. An evaluation of erosion from the closure cover will be included in detailed design. The results of this evaluation will influence closure cover design. As discussed in the PFS, erosion modeling will be designed to:

- Predict soil loss from facilities during operations and following closure;
- Develop and evaluate erosion and sediment control options; and
- Predict the rate and magnitude of sediment loads to operational and closure storm water drainage systems.

Waste and cover hydraulic properties will be used as inputs to empirical or process-based erosion and sedimentation prediction models (RUSLE, Water Erosion Prediction Project (WEPP), Erodibility Index Method, SEDCAD, and others) to estimate erosion and sedimentation rates and to develop and design facility drainage, erosion and sediment control and management measures. The closure cover infiltration model will be adjusted according to the erosion and sediment control measures selected to ensure proper functioning of the closure cover.

The current design for the TSFs includes deposition of thickened tailings (58% solids by volume) into the tailings impoundments. Thickened tailings from the process plant shall be pumped to a tailings distribution pipeline along the crest of the impoundment through pressure rated high density polyethylene (HDPE) pipelines. The tailings delivery pipelines for TSF1 shall be diverted to TSF2 upon cessation of tailings deposition in TSF1. The sub-aerial tailings distribution system at the crest of the TSF2 embankment consists of a header and manifold system with controlled, intermittent and repeated discharge of tailings through multiple spigots connected to a peripheral tailings distribution header pipeline. The sub aerial deposition technique allows tailings to settle out during operations on the beach where they are hydraulically worked and segregated by subsequent tailings streams. As the beach tailings dry out and consolidate their density and strength increase. Vista will promote further drainage, consolidation and strengthening of tailings during operations by installing wick drains or decants and through diligent tailings water management. Excess water will drain to supernatant pond, where it will evaporate or be conveyed back to the Mill for reuse. The extent and location of the supernatant pond within the impoundment shall be controlled during operations by selective operation of the spigots such that the pond location is constrained to the center of the impoundment away from the embankment faces at all times during operation. Following cessation of tailings deposition, water will drain from the toe of the TSFs, the supernatant pond will evaporate and be pumped to the water treatment plant for treatment and discharge, and the top surface of the tailings will be allowed to dry. These practices not only results in tailing surfaces suitable for equipment access and application of cover materials, but also increase the capacity of the facility to store tailings.

The tailings deposited below the supernatant pond will likely be composed of clay- and silt -sized particle commonly known as tailings slimes. These tailings slimes are typically thixotropic (thick like a solid but flow like a liquid when a sideways force is applied) and maintain a high degree of saturation. The active dewatering and consolidation of the tailings planned during operations (i.e. wick drains or decants) will increase the strength of the tailings slimes, which should improve equipment accessibility along the perimeter of the tailings slimes. Capping techniques will include gradual and unidirectional application of cover materials in wide and narrow sections (panels) along the perimeter of the tailings slimes. Application of subsequent panels of cover will be applied following tailings consolidation below the previous panel. This will gradually apply surcharge to the slimes, accelerate tailings dewatering and consolidation, and prevent equipment from being engulfed or isolated. Trenches will be excavated around the perimeter of the work area to collect the excess water produced by tailings consolidation. This water pumped to the water treatment plant for treatment and discharge. This process will be repeated across the tailings slimes until the closure cover is applied over the area of tailings slimes.

As discussed in the PFS, an evaluation of the trafficability of the tailings shall be completed as part of detailed design. Modeling will be conducted to assess the timeframes required for draindown and consolidation of the tailings, and the minimum thickness of material that will be needed to bridge thixotropic tailings.

6.0 REFERENCES

Albright, W. H., Benson, C. H., Gee, G. W., Roesler, A., Abichou, T., Apiwantragoon, P., Lyles, B. F., Rock, S. A., 2004. Field water balance of landfill final covers, Journal of Environmental Quality, 33, 2317-2332.

Interstate Technology & Regulatory Council (ITRC), 2013. Biochemical Reactors for Mining-Influence Water. Document number BCR-1.

International Network for Acid Prevention (INAP), 2009. Global Acid Rock Drainage (GARD) Guide

Kirby, C.S. and Cravotta, C.A., 2005. Net Alkalinity and net acidity 1: Theoretical considerations. Applied Geochemistry vol 20, pgs 1920-1940

Knight Piésold. 1996. Mt. Todd Gold Mine, Tailings Storage Facility Manual, Volume 1 Design Report.

Mine Environment Neutral Drainage Program (MEND), July 2004. Design, Construction and Performance Monitoring of Cover Systems for Waste Rock and Tailings, MEND 2.21.4, Volume 1(Editor: O'Kane Consultants Inc.) pgs 7 and 8.

Proteus. 2013. Mt Todd Gold Project Pre-Feasibility Study Report Appendix D.2: Process Design Criteria – 50,000 tpd Case.

Tetra Tech, 2013. NI 43-101 Technical Report – Mt. Todd Gold Project 50,000 tpd Preliminary Feasibility Study Northern Territory, Australia. Tetra Tech Document 11431128500-REP-R0001-00 prepared for Vista Gold dated May 29, 2013

ATTACHMENT A
SEEPAGE MODELING

TECHNICAL MEMORANDUM

To:	John Rozelle, Vista Gold Corporation
From:	Amy L. Hudson, REM
Date:	January 16, 2014
Cc:	Andrew Harley, Tetra Tech
Project No.:	114-311285
Subject:	Mt Todd Project EIS Comment Response – Preliminary Waste Rock Dump Drainage Evaluation

1.0 INTRODUCTION

Vista Gold is proposing a waste rock dump (WRD) with steeper slopes than those originally reported in the Mt Todd Project Preliminary Feasibility Study (PFS) based on additional geotechnical work and review of other operating mines. As a result, a review of the proposed WRD drainage closure conditions was conducted to provide a technical basis for the revised WRD design.

As detailed in the PFS, the WRD included a store and release cover with 3H:1V slopes consisting of a 0.3 meter (m) clay capillary break, 0.6 m fine non-potentially acid generating (Non-PAG or NAG) rock mixed with clay cover, and a shallow layer of growth medium. The cover would be placed over a mantle of coarser crushed Non-PAG waste rock surrounding/covering a potentially acid generating (PAG) material core. The new WRD design under consideration has nine 30 m lifts with eight meter catch benches, a 34 degree interbench slope, and an overall slope of approximately 29 degrees. The proposed closure for the WRD is to place Geosynthetic Clay Liner (GCL) on top of each of the catch benches, and under the next lift (Petticoat Closure Option). The total width of the GCL would be approximately 52m, which corresponds to the width required to provide full overlap from bench to bench. A one foot layer of fines material will be placed on the GCL to provide confining pressure, and to maintain the GCL's moisture content. A one meter layer of Non-PAG material will be placed over the fines layer to prevent erosion.

This Technical Memorandum presents the modeling used to assess the drainage conditions and resulting water quality that would likely exist during the closure and post-closure periods. The drainage modeling was completed using the VADOSE/W program from the GeoStudio 2007 software package (GEO-SLOPE, 2007). Modeling was performed on cross-section A-A', which is oriented north-south and cuts through the south facing slope of the WRD (Figure 1). The focus of the modeling was on the interior flow dynamics that could affect the PAG material encapsulated within the interior portion of the facility, and the rate of seepage from the base of the WRD. The geochemical modeling was conducted using the computer code PHREEQC (Parkhurst and Appelo, 1999), a reaction path chemical equilibrium model supplied by the U.S. Geological Survey (USGS).

Proper closure of the WRD and seepage management is critical for preventing impacts to local waters, and to minimize long-term treatment and management costs. Acid rock drainage (ARD) commonly

occurs in WRDs with sulphide-enriched mine waste through the oxidation of pyrite (or other sulphide minerals) as it is exposed to oxygen and water. The geochemical characterization program for Mt Todd has determined that 38% of the waste rock will be low sulphur and non-PAG, 15 % of the waste rock is in the uncertain acid generating category, and 47% will be PAG; however, it should be noted that the non-PAG material may not provide excess neutralization capacity. WRDs with significant PAG material and minimal neutralization require further management and control of water to prevent environmental impacts.

2.0 CONCEPTUAL MODEL

The conceptual model provided as Figure 2, shows the components of the WRD water balance including precipitation, evaporation (from soil surface), runoff, infiltration, and seepage. Seepage includes continued draindown of the residual water trapped in the waste rock, as well as any infiltration that reaches the waste rock through the internal and closure cover material. The internal and top closure covers are composed of a thin Geosynthetic Clay Liner (GCL) layer covered by approximately 305 millimeters (mm) (12 inches) of fines material for confining pressure and moisture retention. Details of the GCL closure cover are shown as Figure 3. The internal covers will be placed on top of each the catch bench to limit the flow of water into the encapsulated PAG waste rock. The GCL will be placed from the outer edge of the bench along the horizontal surface, and will be under the buttress of non-PAG material for the next lift. The catch bench surface will be graded to a five degree slope towards the outside of the WRD to ensure drainage of water away from the PAG waste rock material.

Modeling was performed to simulate the closure configuration of the facility. The transient conditions simulated the closure and post-closure conditions. No operational conditions were simulated.

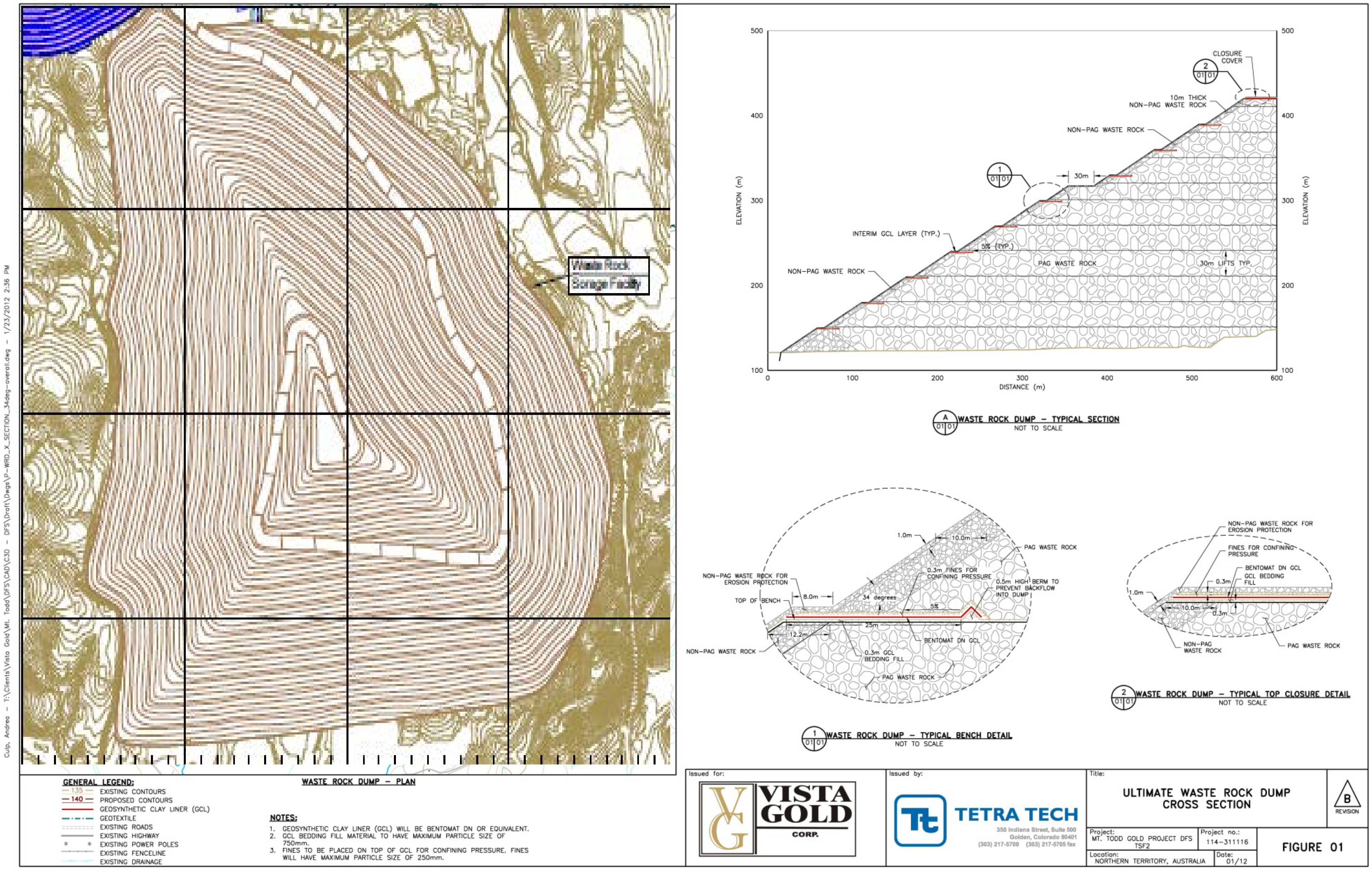


Figure 1 - Ultimate Waste Rock Dump Cross Section

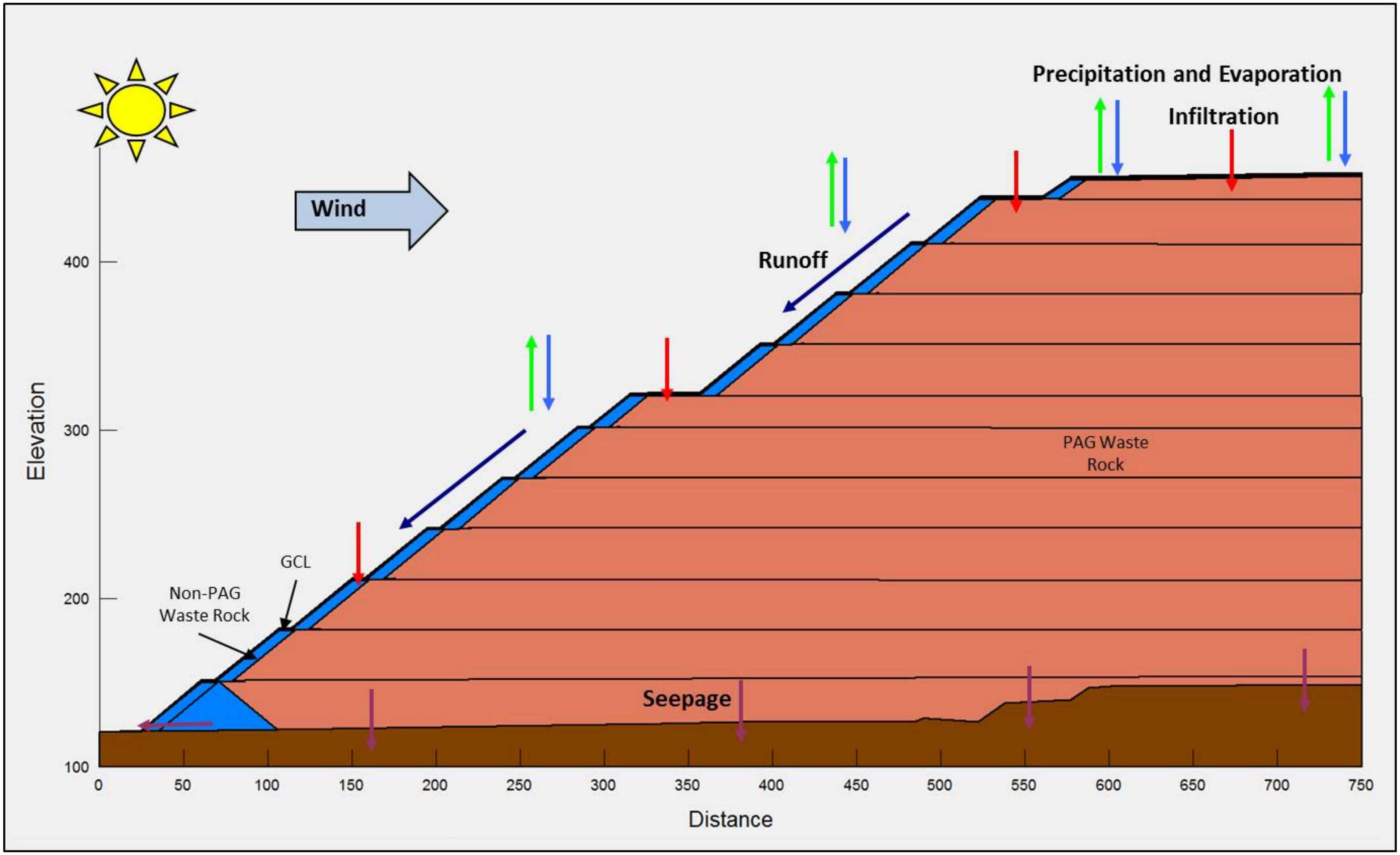


Figure 2 - Waste Rock Dump Conceptual Model

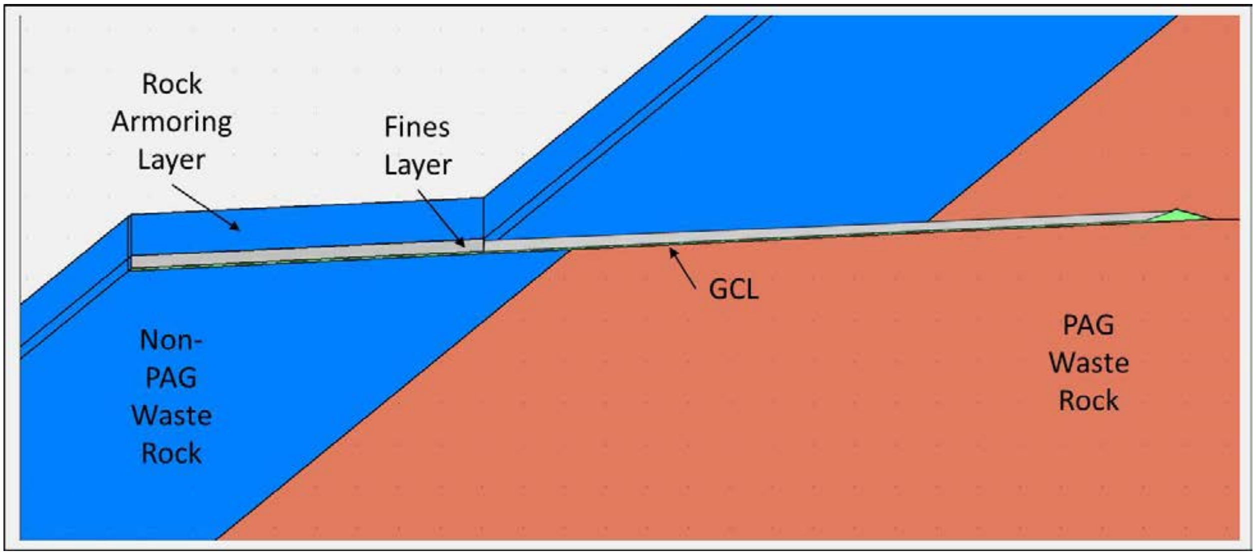


Figure 3 - GCL and Fine Layer Details

2.1 MODEL INPUT PARAMETERS

The following subsections present the data that was used in the seepage assessment.

2.1.1 Climate Data

Climate data from the Australian Government Bureau of Meteorology Katherine Council gage (gage #014902) was used in the model to evaluate the infiltration of precipitation and seepage from the waste rock. The parameters in the climate data file included:

- Minimum and maximum daily temperature;
- Daily precipitation;
- Minimum and maximum daily humidity;
- Daily evaporation or net radiation; and
- Average daily wind speed.

The Katherine Council gage is located approximately 50 kilometers south of the mine. The dataset applied to the modeling utilizes the daily data from 1888 to 2009. The period of record for the gage is 1874 to 2009, and only those years with complete precipitation data sets were used (1888-1984, 1988-1997, 2000, 2002, and 2005), resulting in a 110 year, daily dataset. By applying actual daily data versus average data, a more realistic distribution of precipitation events can be applied to the modeling, including the distinct wet and dry seasons of the site.

The water balance for the site is net negative (more evaporation than precipitation). The average annual precipitation is 1,200 mm and the average annual evaporation is approximately 2,500 mm. The data used for this modeling is a conservative evaluation of the actual climate impacts on the WRD over the period of actual data collection in the region. The model was run for a 110 year period to

minimize the "noise" in the model results and to be able to consider actual conditions over multiple full wet and dry season cycles.

2.2 MATERIAL PROPERTIES

The most significant difference between saturated and unsaturated flow is the hydraulic conductivity. The hydraulic conductivity in saturated media is a function of the material type. In unsaturated flow, the hydraulic conductivity is a function of the material properties and the moisture content of the material. The equation used to calculate water flow within unsaturated media is:

$$q = -K(\theta)\nabla H$$

Where:

- q = water flow velocity (L^2/t)
- K(θ) = hydraulic conductivity as a function of soil (or rock) moisture content (L/t)
- ∇H = hydraulic head (L)

The relationship between moisture content and hydraulic conductivity is non-linear, which further complicates the flow dynamics. In saturated material, the physics of flow are relatively simple and are driven by Darcy's Law where the flow is proportional to the saturated hydraulic conductivity, gravity, and pressure gradients. In simple terms, water flows downhill (downward pressure gradient) and flows faster through coarse material than fine material. However, in unsaturated flow, additional controlling forces include matric pressure (matric suction), absorption, and electrostatic forces.

Matric pressure (matric suction) is the suction created by capillary forces and the interaction of water, air, and solid surfaces. Matric pressure can be observed by placing a thin straw into a body of water. Driven by the surface tension forces, the water rises inside the straw, defying the force of gravity. The thinner the straw, the stronger the suction force will be and the higher the column of water will rise in the tube. The same process occurs in the voids between material particles in a WRD.

One of the most unusual properties of unsaturated zone flow is that different materials are preferentially conductive with varying moisture contents. Under high moisture conditions, pores are saturated and their suction decreases significantly. In this case, gravity is the strongest force and water will flow downhill from pore space to pore space. At low moisture conditions, the preferential flow changes, and the suction forces become stronger than gravitational forces. In this case, the tight materials are the most conductive with small voids that literally suck water through them. Under low moisture conditions, clay is more conductive than the sandy material.

The material properties used in the VADOSE/W (GEO-SLOPE, 2007) models were based on literature values and functions developed using past experience with mined materials. The material property used to represent the waste rock was from laboratory testing of a similar hard, competent waste rock with a limited amount of fine material. The GCL was simulated as a well graded high clay, and the fines layer was simulated as a uniform silt. Figure 4 presents the hydraulic conductivity functions of the waste rock, GCL, and fines layer materials. Figure 5 presents the water content functions of the same materials. The units used in these figures are those utilized by the modeling software.

The waste rock is expected to be very hard, competent material with a minimal amount of fines. This characterization is based on the current observations of an existing WRD from previous site operations. The function used to simulate this material has a saturated hydraulic conductivity of 4.2 centimeters per second (cm/sec) with a rapid, but smooth decrease with increased matrix suction. The hydraulic conductivity of the GCL layer was simulated as 10^{-6} cm/sec. This is higher (more conductive) than the specifications of this type of material, which is designed to be at 10^{-9} cm/sec. However, work completed by Benson and Meer (2009) suggests that GCL that will be exposed to high levels of sodium and/or magnesium in solution will be subject to ion exchange processes. Their research showed that the GCL composition will be altered by exchanging sodium and/or magnesium for the calcium. When also subjected to multiple wetting and drying cycles, the hydraulic conductivity can increase by several orders of magnitude. The leachate from the non-PAG waste rock is estimated to have 20 milligrams per liter (mg/L) sodium (Na) and 200 mg/L magnesium (Mg), which could be drawn up into the GCL during evaporation processes. The saturated hydraulic conductivity value used in this modeling is higher than the design specs, but lower than the worst case observed by Benson and Meer (2009) and provides a conservative, but reasonable estimate of GCL conditions during closure and post-closure. For this modeling, the fines layer that will be placed over the GCL is assumed to be uniform silt with a saturated hydraulic conductivity of approximately 10^{-5} cm/sec.

2.2.1 Boundary Conditions

The boundary conditions used in this modeling were limited to a zero pressure boundary at the base of the model, initial moisture (establish non-zero starting conditions), and the climate file. A climate file was used in this modeling to ensure an evaluation of the long term behavior of the waste rock and the cover under actual climatic conditions.

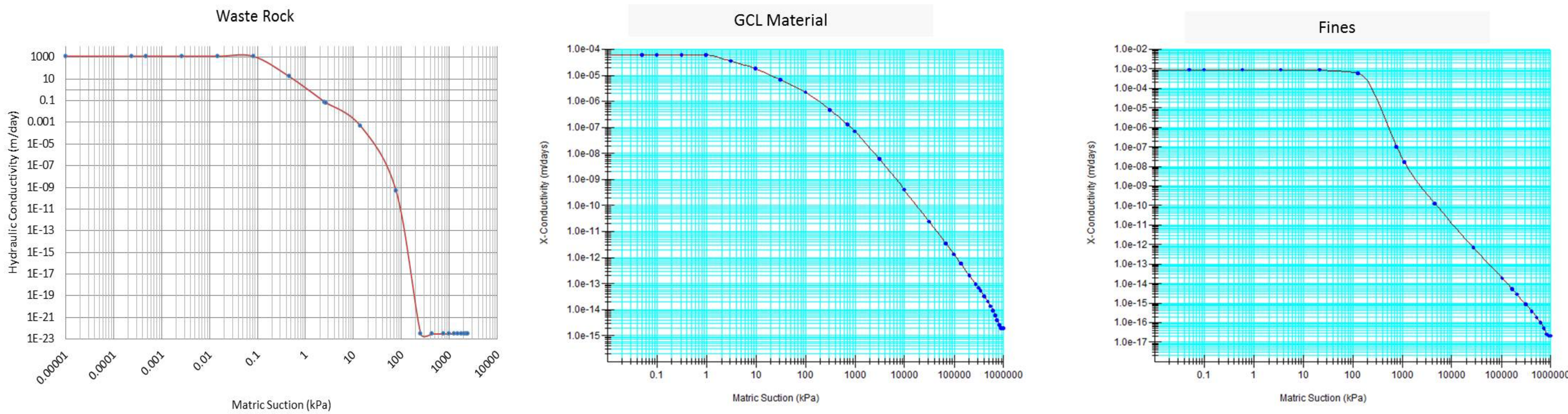


Figure 4 - Hydraulic Conductivity Functions

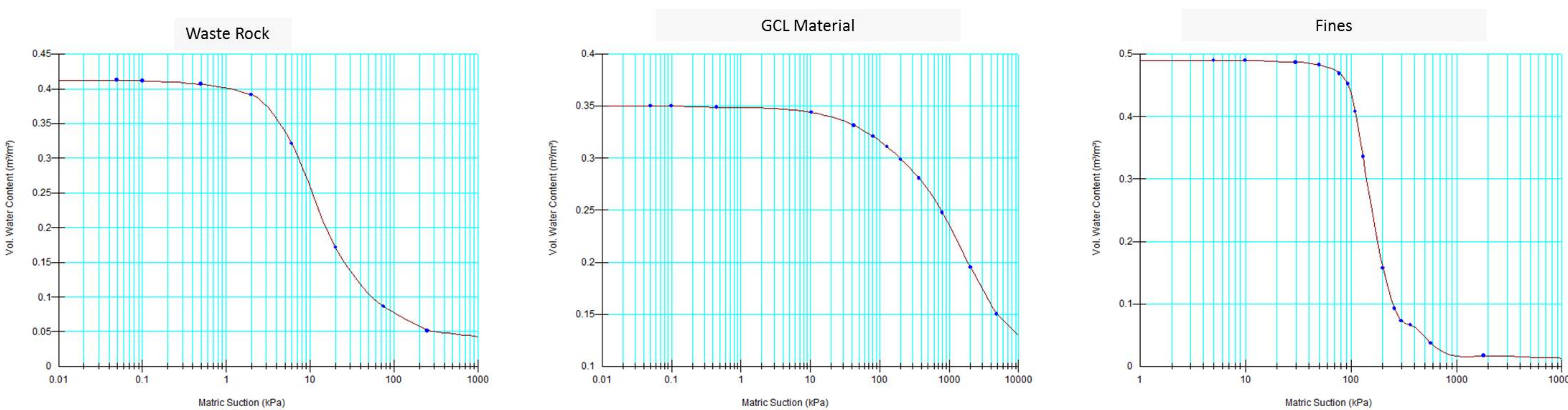


Figure 5 - Soil Water Characteristic Curves

2.3 MODELING TECHNIQUE

The modeling was completed as a steady state model followed by transient models to simulate the climate conditions.

2.3.1 Steady State Modeling

Steady state modeling is challenging when analyzing mining sites because the facilities change quickly and do not reach true steady state conditions until mine closure. To account for this, the WRD was modeled using an initial non-zero moisture condition to define the starting point of the facility at the completion of mining. The moisture content of the steady state model was in the range of 5% to 15% by volume. The results of the steady state model have been generally calibrated to site conditions (flow rates observed at Weirs 1, 2, and 3), but are only intended to offer non-zero starting values for the subsequent transient modeling scenarios and to evaluate the seepage rate from the waste rock.

2.3.2 Transient Modeling

Transient modeling provides a reasonable simulation of flow conditions within the WRD material. The upper most layer of these models is a surface region representing the top surface layer of the facility (the GCL, fines layer, and rock armor cover). It is in this part of the model that atmospheric conditions and soil come in contact, driving the water balance. The water within the facility then moves according to the rules of unsaturated flow physics through the waste rock material. Finally, and if applicable, the water reaches the base of the modeled region, where it moves to the model discharge point.

2.3.2.1 Transient Model Scenarios

This study focused on one transient scenario that represents the preferred construction and closure alternative. The preferred alternative has interbench slopes of 34 degrees (overall slope of approximately 29 degrees) and the Petticoat cover option – GCL and fines layer on horizontal surfaces between the lifts of waste rock and on the top surface of the WRD.

2.3.2.2 Surface Layer

VADOSE/W (Geo-Slope, 2007) simulates the dynamics of the facility surface by considering climate and soil interactions. VADOSE/W (Geo-Slope, 2007) simulates precipitation using time increments with a maximum step size of two (2) hours. The daily precipitation data is distributed according to a sinusoidal function that peaks at noon (normal distribution). This distribution pattern was compared with the constant averaged and the sloped averaged distribution patterns, and it was determined that the sinusoidal pattern resulted in the most mathematically stable calculation of the results. Potential evaporation or net radiation measurements are used to calculate the actual evaporation that is possible based on the conditions provided in the surface layer of the model. Evaporation is calculated from the following climate and soil factors:

- Air temperature;
- Soil temperature and thermal properties;
- Relative humidity;

- Solar intensity (from latitude);
- Soil temperature;
- Soil moisture content;
- Wind speed; and
- Measured pan evaporation.

The combination of the factors listed above provides a reasonable estimate of water lost from the system through evaporative processes. Infiltration is based on the unsaturated hydraulic conductivity of the material at a given time and the moisture content of the material. Excess precipitation that has not evaporated, transpired, or infiltrated is tabulated as runoff. The surface region for the model was constructed with three layers to simulate the materials of the petticoat cover design.

2.3.2.3 Transient Flow within the Facilities

The transient flow dynamics within the tailings material are simulated over time and space. The model accounts for transitions between material types and produces the following data sets:

- Water flux within the model domain;
- Moisture content;
- Water flow velocity; and
- Seepage discharge, if applicable (out of the model domain).

The following sections present the infiltration and seepage model results.

3.0 MODEL RESULTS

Table 1 presents the key components of the modeled facility water balance as a percentage of total annual precipitation. The petticoat closure cover limits the amount of precipitation that is able to infiltrate into the PAG waste rock to approximately 8% of annual precipitation compared to no cover, which allows approximately 21% of annual precipitation to infiltrate. Additionally, the petticoat design also increases the runoff by approximately 30% over the uncovered facility. The disadvantage with this design is that water infiltrates along the uncovered waste rock slopes. However, a closer investigation of the modeled results show that the precipitation that readily infiltrates into the waste rock slopes, is quickly evaporated back out of the WRD. Any water that infiltrates and is not quickly lost to evaporation travels vertically until it encounters the GCL and fines layer between the waste rock lifts. Once the infiltrated water reaches the GCL and fines layer, it travels laterally. Because the GCL layer is graded away from the center of the facility, the lateral flow is toward the outer edge of the facility and will minimize infiltration of some water into the PAG waste rock.

Table 1 - Water Balance of Model Scenarios

	Cumulative Infiltration	Cumulative Runoff Mesh	Cumulative Storage	Cumulative Surface Evaporation
No Closure Cover	21%	13%	-1%	67%
34 degree - Petticoat cover	8%	44%	-0.14%	48%

The draindown rate of the WRD was also considered and is presented in Figure 6. The gap in data was an error in the model and the draindown results were not captured, but the climate during this period is similar to other years and the rates during this period are expected to be similar to those presented. The amount of water that will travel through the facility is minimal (remains at a steady state rate of less than 0.5 cubic meters per hour [m^3/hr] over the modeled period), and will be captured and treated through a passive engineered wetland system. This type of treatment design requires that some moisture flow into the engineered wetland system on a continuous basis to prevent the system from drying out and to help maintain a healthy bacterial population.

During the wet season, the WRD could have an increased amount of water flushed from the waste rock in response to large storm events, as is illustrated by the spikes seen, but these increased flows still remain below 1.5 m^3/hr. This flow rate is within the range of flow rates successfully treated with passive systems.

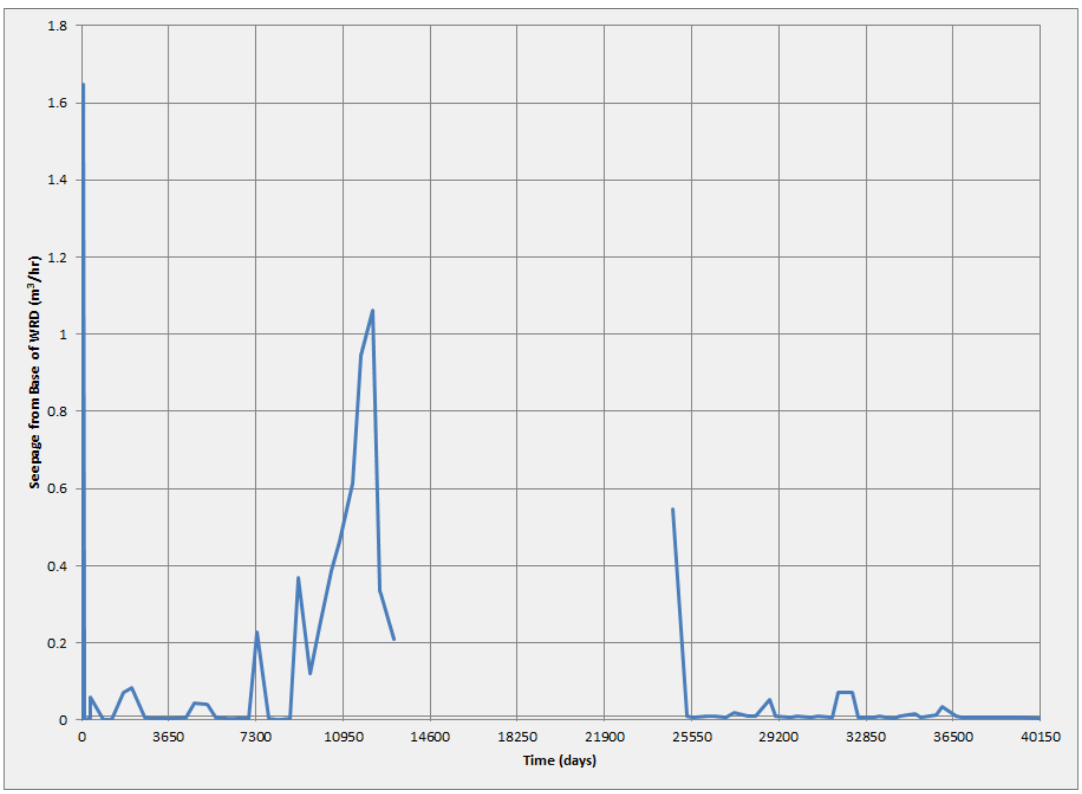


Figure 6 - Draindown Flux Rate of WRD

Even though the waste rock material is quite hard and competent, the WRD will still be a dual porosity system. The primary porosity is the space between the pieces of rock. The secondary source of porosity is the fractures present in the rock that will "relax" and potentially open once the confining pressure of overlying rocks is removed. The secondary porosity is difficult to define and could allow ARD to happen in isolated fractures, that could be flushed by a passing wetting front, creating significantly impacted drainage water. These conditions need to be further defined as additional data is collected and site observations are made.

4.0 WATER QUALITY ASSESSMENTS

The water quality modeling approach and results are provided in the following subsections. Input parameters are summarized in Attachment 1.

4.1 MODELING CODE AND DATABASE

The geochemical modeling was conducted using the computer code PHREEQC (Parkhurst and Appelo, 1999), a reaction path chemical equilibrium model supplied by the U.S. Geological Survey (USGS). PHREEQC is able to process multiple equilibria and mixing reactions to produce the final chemical speciation of a system. In addition to a computer code, geochemical modeling requires a database of the thermodynamic and kinetic parameters. For this study, the MINTEQ.V5 database (Allison et al, 1991) was chosen. However, this database does not include all of the relevant metals; therefore, to obtain a broad range of metals, data for Ti, Th, Bi were added from the Lawrence Livermore National Laboratory database (llnl.dat).

4.2 GEOCHEMICAL CONCEPTUAL MODEL

The water quality estimates are based on three probable vertical flow paths that the infiltration water is likely to take within the WRD (Figure 7). In summary:

- Flow Path A represents the optimal scenario with regard to limiting ARD formation such as the scenario that could be envisioned for the outer portion of the lower most lift where water will contact non-PAG rock first (~50%), interact with PAG/uncertain rock within the core (~35%) and contact non-PAG rock again (~15%) before reporting to RP1.

- The horizontal flow induced by the petticoat option would be similar to Flow Path B, and would result in contact with non-PAG rock (~33.3%), followed by PAG/uncertain rock (66.6%).

- Flow Path C represents percolation through the GCL and into the PAG/uncertain rock core only. This worst case scenario represents a scenario without flow through a non-PAG cover.

4.3 MODELING APPROACH

The geochemical models were constructed as a series of mixing and reaction steps that represent the flow paths shown in Figure 8. The percentages of each waste rock type to be placed in the WRD and the associated potential to generate acid are based on the geochemical characterization program described

in Tetra Tech (2011a) and the sulphur cutoffs based on the sulfur block model described in Tetra Tech (2011b).

Tonnages are based on the feasibility study ultimate pit design provided by the project mine planner (Tom Dyer). Micromine software was utilized to cut the pit into the 18 lithologic codes within the block model. Non-PAG, uncertain and PAG criteria were based on the total sulphur concentrations as follows:

- Non-PAG waste rock contains up to 0.25 wt. % total sulphur;
- Uncertain waste rock contains from 0.25 to 0.4 wt. % total sulphur; and
- PAG waste rock contains greater than 0.4 wt. % total sulphur.

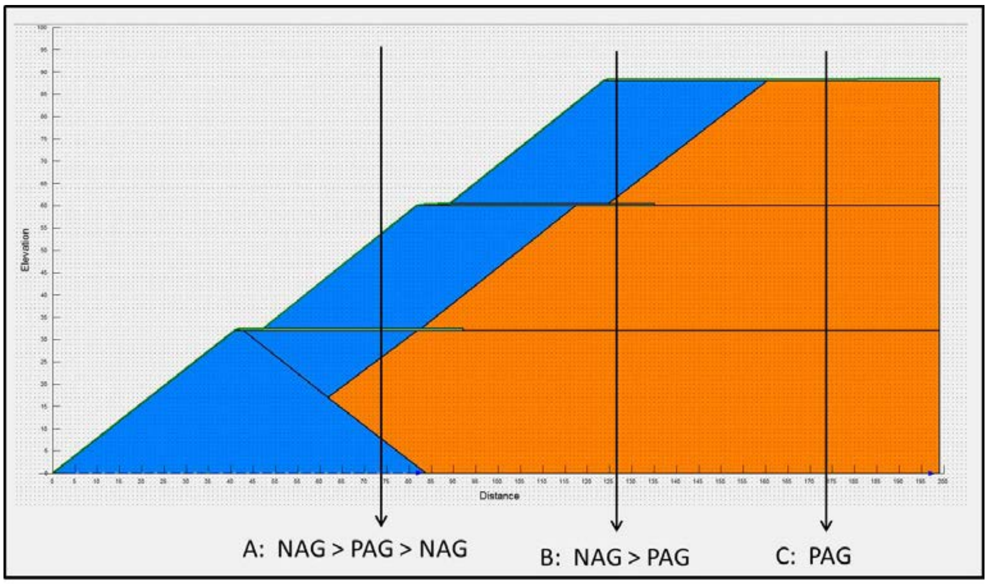


Figure 7 - Expected Flow Paths and Material Contacts

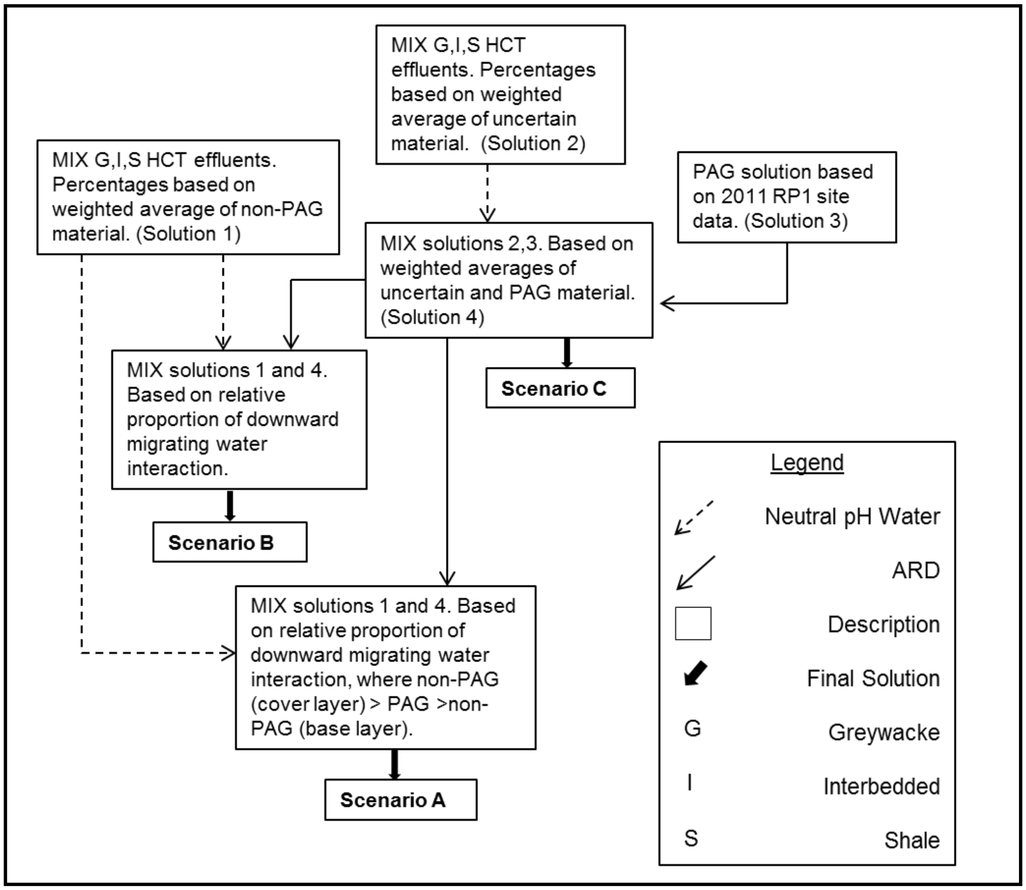


Figure 8 - Geochemical Conceptual Model

Tonnages were obtained by querying all waste rock blocks (< 0.4 ppm Au) with 50% in or out of the topographic surface and ultimate pit surface. Tonnages of each rock type were initially compiled based on the 18 lithologic codes and then grouped into the three larger rock types defined as greywacke, interbedded and shale. Finally, the tonnages of non-PAG, uncertain and PAG waste rock from each rock types were determined (Attachment 1, Table A-1). Blocks identified as felsic tuff (~ 2% of the total tonnages) are also presented in Table A-1 but were not included in the geochemical modeling.

Initial solutions (Attachment 1, Table A-2) were based on kinetic humidity cell test (HCT) results including stable long-term concentrations associated with non-PAG and uncertain waste rock samples that generated neutral to alkaline pH for over one year and "first flush" concentrations from uncertain samples that also did not generate acid during the testing period. Alkalinity values less than 30 mg $CaCO_3$/L are commonplace in the HCT leachates. These initial solutions were mixed together based on the percentages of each rock type with the same acid-generating potential characteristics (Attachment 1, Table A-3). For example, stable concentrations from the non-PAG greywacke, shale and interbedded HCT leachates were mixed at a ratio of 0.4:0.18:0.42, to make solution 1. Likewise, solution 2 is comprised of first flush HCT concentrations of greywacke, shale and interbedded HCT leachates at a ratio of 0.35:0.15:0.5. Solution 3 was based on results from the November 2011 RP1 sampling event and represents ARD from PAG rock without consideration of rock type.

The seepage quality is based on stable long-term and first flush concentrations from the laboratory kinetic testing or ARD from RP1. Therefore, the model is considered to approximate water quality at the

onset of the wet season when flushing of constituents will be the highest. The water quality predictions to be conducted for the water balance study will include kinetic oxidation of pyrite

4.4 MODEL RESULTS

The geochemical model scenario results are summarized in Table 2. The results show that even partial encapsulation with non-PAG rock (scenario A) does not result in seepage with acceptable water quality as defined by ANZECC 95% species protection TVs/ISSTV (Table 3). The non-PAG rock primarily acts as a source of dilution of the regulated constituents. However, acidic pH remains because the alkalinity emanating from the non-PAG rock is insufficient to neutralize the acidity generated by the PAG rock. The model results show that acceptable pH (6 – 8) and associated decrease in constituent concentrations will require a source of neutralization potential (e.g., limestone).

5.0 CONCLUSIONS AND RECOMMENDATIONS

The primary conclusions that can be drawn from this preliminary assessment of the drainage conditions and the water quality associated with different configurations of stacking and covering include:

- The petticoat option for both the 35° and 20° slopes limits the amount of precipitation that is able to infiltrate; however, water that infiltrates along the uncovered waste rock slopes interacts with the PAG waste rock unless the GCL layer is graded away from the center of the WRD.
- The beanie option performed the worst of the scenarios considered because only the top surface of the WRD is cover and the uncovered slopes and benches receive a significant amount of infiltration.
- The most protective option investigated is to fully cover the WRD; however, this option does not appear technically feasible for the 35° slopes.
- The non-PAG rock largely acts to dilute the ARD from the PAG rock because it does not contribute much to the regulated constituent load (e.g., metals, sulphate) but also is not a significant source of alkalinity.
- All three scenarios produce acidic pH solutions due to the minimal available alkalinity in the non-PAG rock to neutralize the acidity generated by the PAG rock. Addition of a neutralization potential source will be needed to prevent/minimize ARD.

Based on the findings of this study, the following recommendations should be considered to advance the current understanding of the drainage conditions associated with Vista Gold's preferred WRD closure configuration:

- Confirm that the WRD design chosen for the feasibility study is geotechnically stable.
- Confirm the composition and hydraulic properties of the fines material that will be placed to obtain the confining pressures.
- Quantify the concentrations of sodium and magnesium associated with the fines material and rainwater due to the potential for elevated sodium and magnesium concentrations to increase the GCL permeability these ions to impact the hydraulic permeability of the GCL.

The heap leach pad residues have high sodium and magnesium concentrations compared to the non-PAG waste rock.

- Confirm the viability of an engineered wetland to treat ARD emanating from the WRD and prevent impacts to local waters.

Table 2 - Summary of Model Results

Description	Scenario C	Scenario B	Scenario A
	PAG/Uncertain Only (100%)	**Non-PAG>PAG/ Uncertain (33.3%, 66.6%)**	**Non-PAG>PAG>Non-PAG (50%, 37%, 13%)**
pH	3.79	3.83	3.95
Sulphate	1220	816	448
Al	38.83	22.33	6.73
As	0.0119	0.0097	0.0078
Ca	77.4	52.9	31.0
Cd	0.107	0.071	0.039
Cl	9.21	7.64	6.24
Co	1.52	1.02	0.56
Cr	0.00079	0.00061	0.00045
Cu	8.38	5.59	3.10
Fe	0.000060	0.000040	0.000022
K	5.26	3.68	0.60
Mg	191	127	71
Mn	0.0067	0.0045	0.0022
Mo	0.00025	0.00018	0.00012
Na	22.9	15.8	9.4
Ni	12.9	8.64	4.79
Pb	0.053	0.036	0.020
Zn	25.13	16.76	9.30

Note: All values mg/L except pH (Standard Units).

Table 3 – ANZECC 95% Species Protection TVs/ISSTV (GHD, 2014)

Parameter	Units	TVs/ISSTV
pH	pH Units	6 - 8
Electrical Conductivity	uS/cm	20-250
Magnesium	mg/L	2.5
Sulphate	mg/L	129
Aluminum	mg/L	0.149
Cadmium	mg/L	0.0002
Cobalt	mg/L	0.090
Chromium	mg/L	0.0010
Copper	mg/L	0.0014
Manganese	mg/L	1.7
Nickel	mg/L	0.011
Lead	mg/L	0.0034
Iron	mg/L	0.300
Mercury	mg/L	0.0006
Zinc	mg/L	0.0080

6.0 REFERENCES

Allison JD, Brown DS, Novo-Gradac KJ. 1991. MINTEQA2/PROD-EFA2, A Geochemical Assessment Model for Environmental Systems: Version 3·0 Users' Manual. U.S. EPA, Athens, Georgia, EPA/600/3-91/021.

Benson, C. and S. Meer, 2009. Relative Abundance of Monovalent and Divalent Cations and the Impact of Desiccation on Geosynthetic Clay Liners. Journal of Geotechnical and Geoenvironmental Engineering 135:3 (349).

Allison JD, Brown DS, Novo-Gradac KJ., 1991. MINTEQA2/PROD-EFA2, A Geochemical Assessment Model for Environmental Systems: Version 3·0 Users' Manual. U.S. EPA, Athens, Georgia, EPA/600/3-91/021.

GEO-SLOPE International, Ltd. (GEO-SLOPE), 2007. *Vadose Zone Modeling with VADOSE/W 2007: An Engineering Methodology*. GEO-SLOPE International Ltd.: Calgary, Alberta, Canada.

GHD, 2014. Treated Retention Pond 3 Ecotoxicological Report. GHD Report 43/21801/35 prepared for Vista Gold Australia Pty Ltd. January, 2014.

Parkhurst, David L. and Appelo, C.A.J., 1999. User's Guide to PHREEQC (Version 2) – A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations. USGS WRIR 99-4259.

Tetra Tech, 2011a. 10.65 MTPY Preliminary Feasibility Study, NI 43-101 Technical Report, Mt Todd Gold Project, Northern Territory, Australia. Report with Appendices A- M. Prepared for Vista Gold Corp. January 28, 2011.

Tetra Tech, 2011b. Mt Todd Waste Rock Handling Criteria. Mt Todd Gold Project, Northern Territory, Australia. Prepared for Vista Gold Corp. September 26, 2011.

ATTACHMENT 1

GEOCHEMICAL MODEL INPUT

Table A-1 Tonnages of Waste Rock by Rock Type and Acid Generation Potential

Non-PAG (NAG)	Uncertain	PAG	Tonnages
WRD Total Tonnages			
153,272,511	59,312,252	191,504,986	404,089,750
Greywacke			
15,321,580	4,390,589	5,912,050	25,624,218
9,536,460	3,297,542	20,343,018	33,177,021
987,232	473,265	579,468	2,039,964
2,603,673	1,411,577	1,386,072	5,401,322
31,826,883	11,015,559	14,381,721	57,224,163
60,275,828	20,588,532	42,602,328	123,466,688
Shale			
1,381,787	596,333	836,473	2,814,592
7,762,928	2,276,364	14,269,617	24,308,908
4,711,936	996,702	7,833,784	13,542,422
2,378,765	348,555	3,816,297	6,543,616
4,129,073	1,475,496	6,832,763	12,437,332
7,026,696	2,754,181	10,214,260	19,995,137
27,391,185	8,447,630	43,803,193	79,642,008
Interbedded			
38,006,384	22,906,817	57,696,866	118,610,067
1,098,274	417,269	2,306,794	3,822,336
23,393,716	5,794,675	40,389,417	69,577,808
62,498,373	29,118,761	100,393,076	192,010,211
Felsic Tuff			
3,107,125	1,157,328	4,706,389	8,970,843

Table A-2 Initial Geochemical Model Input Solutions

Description	Non-PAG (Greywacke)	Non-PAG (Shale)	Non-PAG (Interbedded)	Uncertain (Greywacke)	Uncertain (Shale)	Uncertain (Interbedded)
Humidity Cell	**HC-1B (stable)**	**HC-2B (stable)**	**HC-3B (stable)**	**HC-1B (1st flush)**	**HC-2B (1st flush)**	**HC-3B (1st flush)**
pH	7.2	7.42	6.97	8.68	7.96	8.61
Sulphate	4.00	5.00	10.0	8.00	11.0	5.00
Al	0.028	0.043	0.026	0.056	0.047	0.090
As	0.0068	0.0034	0.0047	0.0490	0.0470	0.0130
Ca	3.50	4.23	3.79	6.06	4.61	5.01
Cd	0.00003	0.00001	0.00002	0.00001	0.00001	0.00001
Cl	4.50	4.50	4.50	2.00	2.00	2.00
Co	0.0004	0.0001	0.0009	0.0003	0.0002	0.0001
Cr	0.0003	0.0003	0.0002	0.0001	0.0001	0.0001
Cu	0.0011	0.0013	0.0026	0.0027	0.0032	0.0032
Fe	0.0020	0.0030	0.0040	0.0050	0.0000	0.0050
K	0.23	0.28	0.86	2.90	4.27	4.38
Mg	0.36	1.85	0.60	1.01	1.53	1.07
Mn	0.0050	0.0018	0.0565	0.0270	0.0390	0.0240
Mo	0.00003	0.00003	0.0001	0.0009	0.0014	0.0010
Na	1.00	0.50	2.50	50.0	5.70	40.0
Ni	0.0013	0.0010	0.0011	0.0017	0.0010	0.0006
Pb	0.0004	0.00004	0.0002	0.0002	0.00003	0.00003
Sb	0.0003	0.0001	0.0001	0.0026	0.0016	0.0016
Se	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001
Zn	0.0085	0.0128	0.0025	0.0030	0.0010	0.0010

Table A-3 Solutions used in PHREEQC model

Solutions	Solution 1	Solution 2	Solution 3
Description	Using initial solutions: non-PAG(G), non-PAG(S), non-PAG(I) percentages	Using initial solutions: uncertain(G), uncertain(S), uncertain(I) percentages	RP1-PAG (Nov 2011)
pH	8.30	8.60	3.71
Sulphate	6.70	6.95	1603
Al	0.00088	0.00170	51.1
As	0.0053	0.0307	0.0060
Ca	3.75	5.32	100
Cd	0.0000226	0.000010	0.14
Cl	4.5	0.30	12.0
Co	0.00055	0.00016	2.0042
Cr	0.00026	0.00010	0.0010
Cu	0.00178	0.00303	11.0
Fe	5.01E-09	4.91E-09	0.30
K	0.50	3.8	5.7
Mg	0.73	1.1	250
Mn	5.26E-12	6.40E-12	18.038
Na	1.54	38.4	18.0
Ni	0.00117	0.00105	17.0
Pb	0.00027	0.00007	0.070
Sb	0.00019	0.00195	Not Determined
Se	0.00003	0.00010	Not Determined
Zn	0.00675	0.00170	33.1

TETRA TECH

ATTACHMENT B

WASTE ROCK MANAGEMENT

TECHNICAL MEMORANDUM

To:	John Rozelle
Cc:	Andrew Harley, Amy Hudson, Jackie Blumberg
From:	Brad, Bijold, Tony Monasterio
Date:	January 10, 2014
Subject:	Mt. Todd - Waste Rock Management - Response to NT EPA Comments

The purpose of this memorandum is to respond to comments provided by the Northern Territory Environmental Protection Authority (NT EPA) regarding the supplement to the draft Environmental Impact Statement (EIS) produced by Vista Gold Australia Pty Ltd (Vista Gold) for the Mount Todd Gold Project (Mt. Todd). The NT EPA provided comments for a range of issues in the supplement to the EIS; this memorandum addresses those focused upon stability of the Waste Rock Dump (WRD) and the Geosynthetic Clay Liner (GCL).

STABILITY OF WRD

Golder Associates Pty Ltd (Golder) produced a report dated 25 January, 2012 which addresses the stability of the WRD. Golder analyzed the stability of the WRD for failures occurring both in a single 30 meter (m) bench and over the full dump height under both static and earthquake conditions. The analyses showed the WRD is expected to be stable under the modeled conditions.

Tetra Tech has reviewed this report and independently confirmed the results. The modeling input parameters reported by Golder are consistent with previous recommendations from Tetra Tech. Tetra Tech performed independent slope stability analyses to confirm the results produced by Golder.

The stability analysis was conducted on an idealized two-dimensional cross-section of the embankment using the Slope/W component of GeoStudio 2007 by Geo-Slope International, Ltd (2010). The stability was analyzed using limiting equilibrium principles. Potential failure surfaces utilized the Morgenstern-Price method, which satisfies both force and moment equilibrium. The Slope/W program incorporates a search routine to locate those failure surfaces with the lowest factor of safety within user defined search limits. Trial failure surfaces were defined with block specified parameters, resulting in a range of possible locations to search for the most critical (lowest factor of safety) potential failure surface. The analysis was performed using Mohr-Coulomb strength criteria for the materials. Material Properties were assumed based on knowledge of the site materials and engineering judgment.

Results of the analysis are presented in Figure 1 and are comparable to Golder results.

LONG-TERM GEOMORPHIC STABILITY

Tetra Tech has performed quantitative analyses to show that erosion rates from the WRD are low (Tetra Tech, 2014a).

Tetra Tech
350 Indiana Street, Suite 500, Golden, CO 80401
Tel 303.217.5700 Fax 303.217.5705 www. tetratech.com

Qualitatively, the surficial material of the existing WRD has experienced at least 10 years of weathering since the mine originally closed; no signs of weathering of the rock can be seen. Considering that the WRD material needs only to resist weathering and erosion until closure of the facility at the end of the life of the mine when a vegetative cover will be employed, the effects of weathering processes are not expected to be noticed.

The existing WRD has experienced multiple design-level storm events during the 2011-12 wet season which resulted in no noticeable erosion. If erosion of the coarse fraction had occurred, miniature alluvial fans would be seen at the toe. If erosion of the fines had occurred, the fines would have muddied the waters of RP1 after the storm event. Tetra Tech is not aware of reports of either indicator of erosion.

LINER PUNCTURES

A layer of fine-grained bedding material has been proposed to overlay the GCL. Tetra Tech proposes an additional bedding layer beneath the GCL, such that GCL is not in contact with waste rock at any location. Bedding both above and below the GCL typically provides protection from puncture, but GCL has the ability to heal punctures by swelling should the bedding fail.

Should this bedding style fail, GCL has been shown (in LaGatta et al, 1997) to maintain hydraulic conductivity of 10^{-7} centimeters per second (cm/s) or less when subjected to strains up to 10%. This strain could be caused by large scale differential settlement or small scale intrusions of rounded rock. The tests performed by LaGatta et al only included strains induced over a large area; a sharp rock can cause failure in GCL. The number of these failures can be reduced by thorough inspection of the fine-grained bedding material during installation of the liner system as part of a QA/QC program.

LINER RESISTANCE TO WET-DRY CYCLES

The exchange of sodium ions in the bentonite for calcium during wet-dry cycles can increase the hydraulic conductivity of GCL by up to 3 orders of magnitude in as little as 6 cycles (Lin & Benson, 2000; Benson & Meer, 2009). Once the calcium ions replace the sodium in the bentonite, the cracks formed during desiccation cannot fully heal upon re-saturation. The same studies showed no increase in hydraulic conductivity when either little or no calcium ions were present, or when the GCL remained saturated.

The WRD is not expected to leach calcium into percolating water (Tetra Tech, 2014b). The fine-grained bedding surrounding the GCL is expected to maintain saturation in the GCL through the extended dry season typical of the NT. Both the conditions required to decrease the performance of the GCL are not expected to be present in the WRD, so the proposed liner system is considered effective.

OTHER POTENTIAL LINERS

While the proposed liner is sufficient to limit percolation through the WRD, does not produce unacceptable slope stability issues, and is suited to the climate of the site. The NT EPA has suggested investigation of other liner possibilities which may perform better than GCL under the site conditions. A

preliminary investigation of other liner systems revealed two possible alternatives: low linear density polyethylene (LLDPE) and bituminous geomembrane. LLDPE is generally cheap, readily available for quick installation; bituminous geomembranes offer exceptional puncture resistance and high interface friction angles. Both LLDPE and bituminous geomembrane can be installed more easily and offer a higher resistance to weathering than GCL. LLDPE, bituminous geomembrane and GCL will be compared during final design of the WRD.

REFERENCES

Benson, C. H., and S. R. Meer, *Relative Abundance of Monovalent and Divalent Cations and the Impact of Desiccation on Geosynthetic Clay Liners,* Journal of Geotechnical and Geoenvironmental Engineering, Mar. 2009.

Golder Associates Pty Ltd, 2012, *Batman Pit Waste Dump Design Review, Mt. Todd, N.T., Australia*, Report Number 117661009-007-R-Rev2.

LaGatta, M. D., B. T. Boardman, B. H. Cooley, and D. E. Daniel, *Geosynthetic Clay Liners Subjected to Differential Settlement*, Journal of Geotechnical and Geoenvironmental Engineering, May 1997.

Lin, L. C., and C. H. Benson, *Effect of Wet-Dry Cycling on Swelling and Hydraulic Conductivity of GCLs*, Journal of Geotechnical and Geoenvironmental Engineering, Jan. 2000.

Tetra Tech, 2014a Mt Todd Project EIS Comment Response - WRDA RUSLE Analysis. Technical Memorandum prepared for John Rozelle, Vista Gold dated January 8, 2014

Tetra Tech 2014b Mt Todd Project EIS Response – WRDA Design and Drainage Evaluation. Technical Memorandum prepared for John Rozelle, Vista Gold Dated January 9, 2014

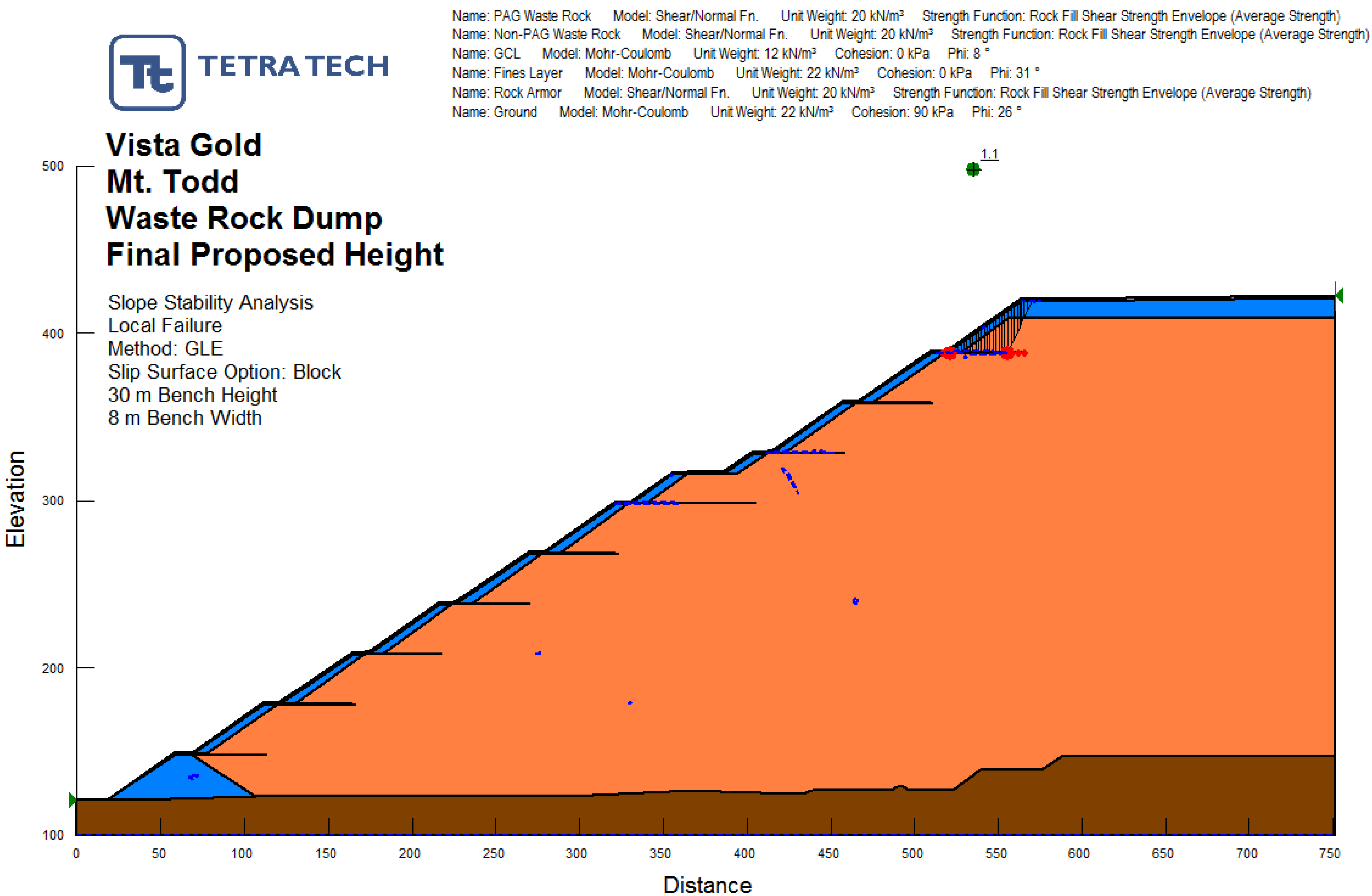


Figure 1 - Waste Rock Dump Final Proposed Height

TETRA TECH

ATTACHMENT C

EROSIONAL STABILITY ANALYSIS

TETRA TECH

TECHNICAL MEMORANDUM

To:	John Rozelle
From:	Henry Sauer
Date:	January 10, 2014
Cc:	Andrew Harley, Jackie Blumberg, file
Project No.:	114-311285, task 050.05
Subject:	Mount Todd Project EIS Comment Response – WRDA RUSLE Analysis

1. INTRODUCTION

This technical memorandum contains preliminary estimates of soil erosion rates from the Mt Todd Project Waste Rock Disposal Area (WRDA) based on existing conditions. It has been prepared in response to agency comments pertaining to the Draft Environmental Impact Statement (EIS) prepare by GHD.

The methods, inputs and assumptions used to estimate erosion, and the results of the erosion analysis are provided in this technical memorandum.

It is important to note that the Revised Universal Soil Loss Equation (RUSLE) approach used for this soil erosion analysis is a relative predictor of soil loss from hillslopes and does not predict gully and rill erosion. To improve accuracy of erosion estimates predicted using RUSLE, additional laboratory and field testing of soil material and application of process-based erosion prediction models should be considered.

2. METHODS

The average annual soil erosion from the WRDA, based on existing conditions was estimated using the Revised Universal Soil Loss Equation (RUSLE). The RUSLE (Renard et al. 1997) is a series of analytical tools for estimating soil loss from most native lands, from lands undergoing construction, and from newly or established reclaimed lands (Toy and Foster 1997). RUSLE is a relative predictor of soil loss from hillslopes. The approach is based upon the Universal Soil Loss Equation (USLE; described in handbooks by Wischmeier and Smith 1965, 1978). The RUSLE equation is described in detail in Guidelines for the use of the RUSLE Version 1.06 (Toy and Foster 1997) and Design Hydrology and Sedimentology for Small Catchments (Haan et. al.).

The RUSLE was applied to the 10 RUSLE slope segments shown on Figure 1. The RUSLE was used to estimate soil loss from these segments of the WRDA given existing site conditions – exposed run-of-mine waste rock. Of the 10 RUSLE segments, 7 are steeper than 2H:1V and 3 are gentler that 3H:1V. These RUSLE segments generally represent the longest slopes on the exterior face of the WRDAs, with the minimum and maximum slope lengths of the 7 steep segments being 11 and 29 meters, respectively. The minimum and maximum slope lengths of the 3 gentle segments are 25 and 70 meters, respectively.

RUSLE was also applied to a hypothetical slope segment that combines the average slope gradient with average slope lenght of the 10 slope segments. The resulting hypothetical slope segment is 2.3H:1V and 25 meters, respectively.

Soil loss is dependent upon many factors, including slope, slope length, soil characteristics, vegetation, and rainfall. The RUSLE is a simple multiplicative relationship (Haan et al. 1994):

A=R*K*LS*C*P

Where:

A = Average Soil Loss per unit area (tons/acre/year)

R = Rainfall Eroson Factor (100 ft * tons/acre * in/hr)

K = Soil Erodibility Factor (tons/acre per unit of R)

Ls = Slope Length and Slope Steepness Factor, dimensionless

C = Cover and Management Factor, dimensionless

P = Erosion Control Practice Factor, dimensionless

An explanation of each factor and the methods used to generate specific values for each factor analyzed is provided below.

3. RUSLE INPUTS AND ASSUMPTIONS

The input data, assumptions and methods for calculating soil loss are provided in Tables 1 through 4 and summarized below. RUSLE inputs were calculated or derived from site or region specific data, literature references and best professional judgment.

Rainfall Eroson Factor – "R": This constant is a measure of the erosive force and intensity of rain in a normal year; it incorporates both an energy component and an intensity component. The R-values was taken from the Australian Natural Resources Atlas (2001) (http://www.sunshinecoast.qld.gov.au/sitePage.cfm?code=erosion-sediment-manual). The Mt Todd Project is located within the zone of erosivity equal to 5,000-10,000 MJ*mm/ha*hr*yr or 2.94 - 5.88 100s ft*tonf*in/acre*hr*year. The maximum this range was used to estimate annual (i.e., 10,000 MJ*mm/ha*hr*yr or 5.88 100s ft*tonf*in/acre*hr*year) average annual soil erosion from the WRDA.

Soil Erodibility Factor – "K": This variable is a measure of the susceptibility of soil particles to detachment and subsequent transport by rainfall and runoff. The value of "K" is a function of the particle size distribution, organic matter, soil structure and permeability of the surface material. To estimate the erodibility values for the WRDA, waste rock data were derived from the technical memorandum titled *Waste Rock Dump Design and Drainage Evaluation* (Tetra Tech, 2012).

Numerical representation of the Soil Erodibility nomograph by Wischmeier, W.H. and Smith, D.D. (1978) were used to calculate fine earth (Kf) erodibility values (Table 3). The whole soil erodibility values (Kw) were

calculated based on Section 618.92, National Soil Survey Handbook, Natural Resources Conservation Science 2014 (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054241). The erodibility values for exposed waste rock on the WRDA were derived from estimates of waste rock particle size distribution and saturated hydraulic conductivity (Ksat) provided in Table 4. The particle size distribution used where based on a gradational analysis of andesitic waste rock and Ksat was calculated based on this particle size distribution.

Slope Length and Gradient – "Ls": This non-dimensional factor accounts for the combined effect of slope length and slope gradient on rates of soil loss. The value increases as hill slope length and steepness increase, under the assumption that runoff accumulates and accelerates in the downslope direction. The Ls factor is most dependent on slope length. The Ls factor was calculate based on the 10 slope segments shown on Figure 1. The slope gradient and lengths for these segments and the average of the 10 segments is provided in Table 2.

Cover Management Factor – "C": The "C" factor is an expression of the effects of surface cover and roughness, soil biomass, and soil-disturbing activities on rates of soil loss at a particular site. It is the ratio of soil loss from land under specified conditions to the corresponding loss from tilled, bare soil. The value of the C-factor decreases as surface cover (i.e., rock, and plant canopy and litter cover) and soil organic matter increase, thus reducing soil loss attributable to rain splash and runoff erosion.

The C Factor was assumed to be worst case conditions in that vegetation, litter or other forms of surface cover are absent.

Erosion Control Practice Factor – "P": The P factor represents the effects on soil loss of conservation practices, such as contouring, buffer strips of vegetation and terracing. The value of "P" decreases with the implementation of practices that reduce runoff volume and velocity and encourage the deposition of sediment.

The P Factor was assumed to be worst case conditions in that conservation practices (e.g., surface roughening, terraces, contour furrows, check structures) are assumed to be absent.

4. ESTIMATED EROSION RATES AND DISCUSSION

The estimated soil loss from the 10 segments of the WRDA based on the existing conditions of exposed waster rock is provided in Table 1. The estimated soil loss rates for exposed waste rock ranged from 0.7 to 2.7 tonne/hectare/yr. For the slope segments steeper than 2H:1V the estimated soil loss rates for exposed waste rock ranged from 1.6 to 2.7 tonne/hectare/yr. For the slope segment gentler than 3H:1V the estimated soil loss rates for exposed waste rock ranged from 0.7 to 1.4 tonne/hectare/yr. For the hypothetical slope segment that combined the average slope gradient and with the average slope length of the 10 segments evaluated, the estimated soil loss rates for exposed waste rock was 2.1 tonne/hectare/yr.

These low soil loss rates are primarily attributable to the fraction of coarse fragments in the waste rock material and the relatively low erosivity values in this area. Variations in soil loss rates are primarily due to differences in slope gradient and slope length.

5. REFERENCES

Australian Natural Resources Atlas. 2001. *R-Factors for Australia*. http://www.sunshinecoast.qld.gov.au/sitePage.cfm?code=erosion-sediment-manual. Visited on January 6, 2014.

Haan C.T., B. J. Barfield, and J.C. Hayes. 1994. *Design Hydrology and Sedimentology for Small Catchments*. San Diego CA : Academic Press Inc.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder. 1997. *Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE)*. United State Department of Agriculture (USDA)-ARS Agriculture Handbook Number 703.

Tetra Tech Inc. 2012. Technical Memorandum From: Amy L. Hudson (Tetra Tech) To: John Rozelle (Vista Gold Corp), Title: *Waste Rock Dump Design and Drainage Evaluation*, June 11, 2012.

Toy T. J. and G. R. Foster. 1998. *Guidelines for the use of the Revised Universal Soil Loss Equation (RUSLE) Version 1.06 on Mined Lands, Construction Sites and Reclaimed Lands*, Office of Surface Mining (OSM).

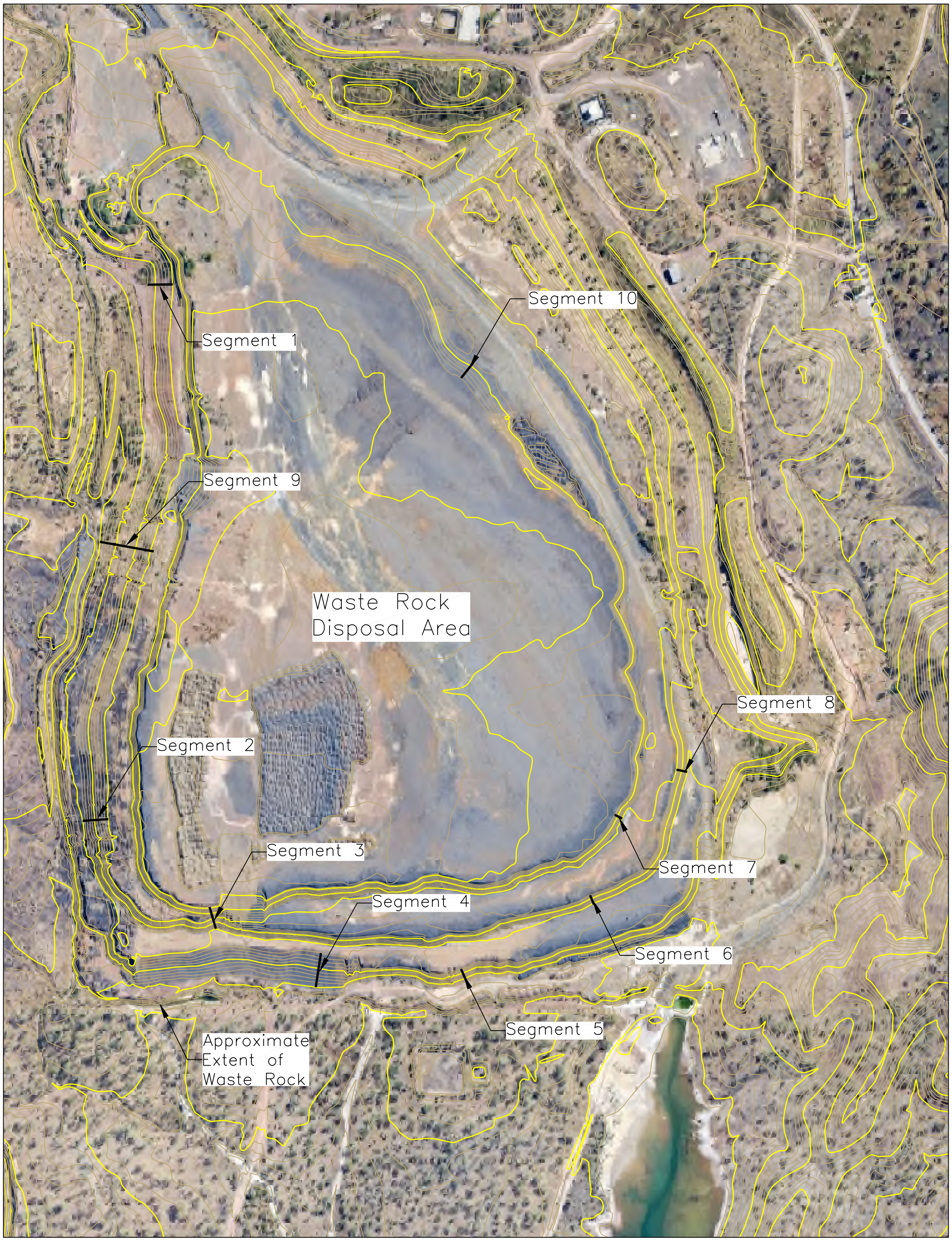
National Soil Survey Handbook. 2014. Natural Resources Conservation Science (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054241). Visited on January 7, 2014.

Wischmeier, W.H. and D.D. Smith. 1965. *Predicting rainfall erosion losses from cropland East of the Rocky Mountains – Guide for selection of practices for soil and water conservation.* Agriculture Handbook No. 283. Washington, D.C.

Wischmeier, W.H. and D.D. Smith. 1978. *Predicting rainfall erosion losses – a guide to conservation planning.* Agriculture Handbook 537. Science and Education Administration, U.S. Department of Agriculture, 58 pages.Insert text

TETRA TECH

FIGURES



N

KEY

Existing Contours
1-meter
5-meter

Segment	Length (meters)	Grade (H:1V)
1	17.5	1.4
2	17.2	1.4
3	11.0	1.4
4	12.8	1.5
5	29.0	1.5
6	20.3	1.6
7	33.0	3.2
8	14.2	1.4
9	70.3	4.6
10	24.8	5.4

0 200 400 Meters

Scale: 1:400

Designed by:

Drawn by: JB

Checked by:

Approved by: HS

Revision

Issued by: TETRA TECH

Title: **EIS Comment Response - RUSLE Slope Segments**

Issued for: VISTA GOLD CORP.

Project: Mt Todd

Location: Northern Territory, Australia

Project no.: 114-311285

Date: 8Jan2014

Figure no.: 1

T:\Clients\Vista Gold\Mt. Todd\Water Management\CAD\WRD_RUSLE.dwg, JACKIE.BLUMBERG, 1/8/2014 3:42 PM, ----

TETRA TECH

TABLES

Table 1
Vista Gold Corp - Mt Todd Project
EIS Comment Response
Estimated Average Annual Erosion Rate (USDA - Revised Universal Soil Loss Equation[1]) - Waste Rock Disposal Area Existing Conditions (i.e. Exposed Waste Rock)

RUSLE SLOPE SEGMENTS[2]	R 100s ft*tonf*in/acre*hr*year	K_w ton*ac-hr/hundredths ac-ft*tonf*in	SLOPE (ft/ft)	SLOPE LENGTH (l) (ft)	SLOPE LENGTH (l) (m)	THETA atan (Slope)	SLOPE FACTOR (S)	RILL SUSCEPTABILITY low, mod, high	BETA	m	SLOPE LENGTH FACTOR L	L_S	C	P	**A_i** **ton/ac/yr**
WRDA Slope-Segment 1	5.88	0.02	0.71	57	18	0.6202	9.265	low	1.295	0.5644	0.876	8.11	1.00	1.00	**1.0**
WRDA Slope-Segment 2	5.88	0.02	0.71	57	17	0.6202	9.265	low	1.295	0.5644	0.868	8.05	1.00	1.00	**0.9**
WRDA Slope-Segment 3	5.88	0.02	0.71	36	11	0.6202	9.265	low	1.295	0.5644	0.674	6.24	1.00	1.00	**0.7**
WRDA Slope-Segment 4	5.88	0.02	0.67	42	13	0.5880	8.819	low	1.273	0.5600	0.736	6.49	1.00	1.00	**0.8**
WRDA Slope-Segment 5	5.88	0.02	0.67	95	29	0.5880	8.819	low	1.273	0.5600	1.163	10.26	1.00	1.00	**1.2**
WRDA Slope-Segment 6	5.88	0.02	0.63	67	20	0.5586	8.404	low	1.250	0.5556	0.953	8.01	1.00	1.00	**0.9**
WRDA Slope-Segment 7	5.88	0.02	0.31	108	33	0.3029	4.511	low	0.979	0.4947	1.218	5.50	1.00	1.00	**0.6**
WRDA Slope-Segment 8	5.88	0.02	0.71	47	14	0.6202	9.265	low	1.295	0.5644	0.778	7.21	1.00	1.00	**0.8**
WRDA Slope-Segment 9	5.88	0.02	0.22	231	70	0.2141	3.069	low	0.830	0.4534	1.689	5.18	1.00	1.00	**0.6**
WRDA Slope-Segment 10	5.88	0.02	0.19	81	25	0.1831	2.559	low	0.765	0.4335	1.051	2.69	1.00	1.00	**0.3**
WRDA Slope-Segment 1-10 Average	5.88	0.02	0.55	82	25	0.5052	7.631	low	1.206	0.5468	1.069	8.16	1.00	1.00	**1.0**

[1] **RUSLE =** $R \times K \times L_S \times C \times P = A$

where:

R = rainfall erosivity factor
K = soil erodibility factor
L_S = slope length and steepness factor
C = vegetative cover factor
P = erosion control practice factor
A = soil loss, tons/(acre - year)

[2] RUSLE slope segment locations shown on Figure 1.

References and Derivation of RUSLE Input Parameters:

R Assume 5,000-10,000 MJ*mm/ha*hr*yr or 2.94 - 5.88 100s ft*tonf*in/acre*hr*year. Australian Natural Resources Atlas, 2001. *R-Factors for Australia.* http://www.sunshinecoast.qld.gov.au/sitePage.cfm?code=erosion-sediment-manual. Visited on January 6, 2014.

K Calculated based on Soil (Fine Earth Faction) Erodibility nomograph (See Table 3) from Wischmeier et al. (1971) - Wischmeier, W.H. and Smith, D.D. (1978). *Predicting rainfall erosion losses - A guide to conservative planning,* Agriculture Handbook No. 537. U.S.

Whole Soil Erodibility Factor (Kw) (includes coarse fragments) calculated based on Section 618.92, *National Soil Survey Handbook* . http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054241. Visited on January 7, 2014.

L_S Calculated based Equations 8.39-41 and 43 (p. 261) *Design Hydrology and Sedimentology for Small Catchments* from Haan C.T., B.J. Darfield, and J.C. Hayes. 1994. Academic Press Inc. San Diego, CA. Assumes uniform hillslope profiles.

RUSLE Slope Segments Modeled - Waste Rock Disposal Area Slope Segments 1-10 existing configuration (See Figure 1).

WRDA Slope-Segment 1-10 Average = Average slope distance and slope angle of Segments 1-10.

C Assumed to be worst case conditions in that vegetation and surface mulch are not present.

P Assumed to be worst case conditions in that conservation practices (e.g. surface roughening, contour furrows, check structures) are not present.

Table 2
Vista Gold Corp - Mt Todd Project
EIS Comment Response
Waste Rock Disposal Area Slope Dimensions

RUSLE SLOPE SEGMENTS				SLOPE LENGTH	SLOPE LENGTH
SLOPE SEGMENTS[1]	AVG. RUSLE SLOPE				
	RUN (H)	RISE (V)	SLOPE GRADIENT	(m)	(ft)
WRDA Slope-Segment 1	1.4	1.0	71%	17.5	57
WRDA Slope-Segment 2	1.4	1.0	71%	17.2	57
WRDA Slope-Segment 3	1.4	1.0	71%	11.0	36
WRDA Slope-Segment 4	1.5	1.0	67%	12.8	42
WRDA Slope-Segment 5	1.5	1.0	67%	29.0	95
WRDA Slope-Segment 6	1.6	1.0	63%	20.3	67
WRDA Slope-Segment 7	3.2	1.0	31%	33.0	108
WRDA Slope-Segment 8	1.4	1.0	71%	14.2	47
WRDA Slope-Segment 9	4.6	1.0	22%	70.3	231
WRDA Slope-Segment 10	5.4	1.0	19%	24.8	81
WRDA Slope-Segment 1-10 Average	2.3	1.0	55%	25.0	82

[1] RUSLE slope segment locations shown on Figure 1.

Table 3
Vista Gold Corp - Mt Todd Project
EIS Comment Response
Material Erodibility (K) Factor

MATERIAL TYPE	SAMPLE ID	SAND 2.0 - 0.1 mm	SILT 0.1 - 0.002 mm	CLAY < 0.002 mm	M^2 (part. size fct.)	ORGANIC MATTER (%)	STRUCTURE S^3	PERMEABILITY P^4	FINE EARTH FRACTION ERODIBILITY FACTOR Kf^5	WHOLE WASTE ROCK (INCLUDES COARSE FRAGMENTS)ERODIBILITY FACTOR Kw^5
Competent Waste Rock[1]	NA	75	25	0.0	2534.2	0.0	3	1	0.17	0.02

NA-Not applicable

[1] See Table 4 for waste rock properties used as RUSLE inputs.

[2] M (particle size function) was calculated from Eq. 8.37 (p. 256) - *Design Hydrology and Sedimentology for Small Catchments* from Haan C.T., B.J. Darfield, and J.C. Hayes. 1994. Academic Press Inc. San Diego, CA.

[3]Soil Structure Class

1	Very fine Granular
2	Fine granular
3	Coarse granular
4	Blocky, platy, or massive

Source: Soil Erodibility nomograph of Wischmeier et al. (1971) - Wischmeier, W.H. and Smith, D.D. (1978). *Predicting rainfall erosion losses - A guide to conservative planning* , Agriculture Handbook No. 537. U.S. Department of Agriculture, Washington, D.C.

[4] Permeability Class for Major Textural Class

Permeability Class		Texture	Sat Hydraulic Conductivity in/hr	Hydrologic Soil Group
6	Very slow	Silty clay, clay	< 0.04	D
5	Slow	Silty clay loam, sandy clay	0.04 - 0.08	C-D
4	Slow to Moderate	Sandy clay loam, clay loam	0.08 - 0.20	C-D
3	Moderate	Loam, silt loam	0.20 - 0.80	B
2	Moderate to Rapid	Loamy sand, sandy loam	0.80 - 2.40	A
1	Rapid	Sand	> 2.40	A+

Source: Rawls et al. (1982) - Rawls, W.J., Brakensiek, D.L., and Saxton, K.E. (1982). *Estimation of Soil Water Properties* Trans. Am. Soc. Agric. Eng. 25(5): 1316-1320.

[5]Erodibility Factor (**Kw and Kf**) calculated based on Section 618.92, *National Soil Survey Handbook* .http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054241. Visited on January 7, 2014

Table 4

Vista Gold Corp - Mt Todd Project

EIS Comment Response

Waste Rock Properties Used in RUSLE Analysis[1]

Waste Rock Particle Size Distribution[2]		Equivalent USDA Texture Classes and Soil Texture Classification	
Seive (mm)	% pass	Texture Class	%
76.2	100.0	Coarse Fragments[3]	85
38.1	100.0	Fine Earth Fraction Texture	
19.1	76.6	Very coarse sand*	40
9.5	41.6	Coarse sand	16
4.8	26.3	Medium sand	8
2.0	14.6	Fine sand	10
0.850	8.7	Very fine sand	-
0.425	6.3	∑ of Sand Separates	75
0.250	5.1	Silt	25
0.150	4.1	Clay	-
0.106	3.7		
0.075[4]	3.1	USDA Texture Classification	**Loamy Sand**

[1]Waste rock properties from: '*Waste Rock Dump Design and Drainage Evaluation* , Technical Memorandum, Tetra Tech, June 2012.

[2]Size limits (diameter in millimeters) of soil separates in the USDA soil textural classification system as follows:

Name of Soil Separate	Diameter Limits (mm)
Very coarse sand*	2.00 - 1.00
Coarse sand	1.00 - 0.50
Medium sand	0.50 - 0.25
Fine sand	0.25 - 0.10
Very fine sand	0.10 - 0.05
Silt	0.05 - 0.002
Clay	less than 0.002

* Note that the sand separate is split into five sizes (very coarse sand, coarse sand, etc.). The size range for sands, considered broadly, comprises the entire range from very coarse sand to very fine sand, i.e., 2.00-0.05 mm.

[3] Coarse Fragments > 2.00 mm diameter

[4] Assume particle passing seive are silt. Conservative assumption in terms of erosion potential.

Parameter	Value	unit
Ksat	1.44	cm/sec
Ksat	2,041	in/hr
Porosity	41	%