APPENDIX 4-W
ACTIVE AVALANCHE MANAGEMENT PLAN FOR THE KSM PROJECT

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PROJECT MEMORANDUM

Date : May 4, 2011
To : BGC Engineering
From : Brian Gould, P. Eng; John Tweedy, CAA
Re : Active Avalanche Management Plan for the KSM Project

1.0 Introduction

Snow avalanches have been identified as the primary contributor of High and Very High geohazard risk to many of the facilities and access routes for the proposed KSM project (BGC Engineering 2011b, 2011c). Two memorandums summarizing pre-feasibility level risk reduction measures to reduce risk from all geohazards have been submitted (BGC Engineering 2011a &2011d). As indicated in these memorandums, snow avalanche risk cannot be managed exclusively by deflecting/catchment dams and structural defense measures. Explosive avalanche control (including remote-control fixed exploders), snowpack supporting structures, and a comprehensive avalanche management plan are required to supplement other measures in order to reduce risk levels to Moderate.

The following memorandum provides a summary of key elements of the active avalanche management plan, as well as details regarding snow supporting structures and explosive control measures. A drawing indicating locations of fixed avalanche infrastructure has been appended to this memorandum.

1.1 Work Scope and Background

The following information is provided:

- details regarding an Active Avalanche Management Plan for the Mitchell Valley, at a conceptual level;
- additional details indicating Avalanche Management for other areas within the KSM Project, at a conceptual level; and
- preliminary layout and details of supporting structures and fixed exploder locations in the Mitchell Valley.

Alpine Solutions understands these details will be used for pre-feasibility cost estimates.

2.0 Active Avalanche Management and Safety Plan

The proposed active avalanche management and safety plan for the KSM project includes measures that contribute to:

1. Reducing the size of avalanches, and therefore the resulting impact pressures and distance travelled by avalanches into the runout zone.

2. Reducing the chance that workers or equipment at the mine will be affected by avalanches.

3. Reducing the length of closure (evacuation) times due to periods of elevated avalanche hazard, thereby maximizing productivity.

The overall strategy of the active avalanche management plan is to provide continuous monitoring of avalanche hazard (during winter and spring months), and controlled release of avalanches by a dedicated team of on-site avalanche technicians. Controlled release of avalanches is provided by explosive control measures, which may initiate from fixed exploders or from charges delivered by helicopters or artillery. Additional avalanche management is provided by snowpack supporting structures installed at strategic locations in avalanche start zones.

Descriptions of avalanche management measures for the project are described in Section 3.0 for the Mitchell Valley, and Section 4.0 for areas outside of the Mitchell Valley.

3.0 Mitchell Valley Avalanche Management Measures

The risk assessment for Mitchell Valley included in BGC Engineering (2011b) includes snow avalanche risk scenarios for most proposed facilities, including 25 scenarios rated as High or Very High risk. This is due to the high density of avalanche terrain, coupled with high exposure time of personnel and vehicles, and high vulnerability infrastructure. As a result the Mitchell Valley is considered a high priority area for avalanche protection within the KSM Project.

3.1 Fixed Remote-Control Exploder Devices

It is necessary to reduce the size and extent of dry snow avalanches in the Mitchell Valley by frequent artificial release of avalanches during storms (BGC Engineering 2011a &2011d). Although there are numerous methods to artificially trigger avalanches, options that have the ability to operate 24/7 are required in order to ensure avalanche control can be initiated when necessary. Remote control gas exploders are recommended due to their reliability, efficiency, and elimination of problems associated with using conventional explosive charges. These problems include misfires, disposal of duds, and the buildup of explosive residue compounds in the environment which can occur with widespread use of conventional explosives (USGS, 2005).

Remote control gas exploders are devices which create a gas explosion directed at the snowpack mantle. Gases used are typically propane and oxygen, and they are supplied by a nearby control shelter which houses gas bottles, radio telemetry, and the electronics required to initiate the blast sequence.

The control shelter allows the exploder to be initiated remotely by an avalanche technician several times during storm cycles.

Examples of two different types of gas exploder systems are included in Figure 3-1 and 3-2. Figure 3-1 illustrates a single remote control gas exploder and associated control shelter (which would support an array of exploders). Figure 3-2 illustrates an autonomous system which may be required for specialized installations requiring only one exploder.

Figure 3-1 – Gas exploder and control shelter

Figure 3-2 Autonomous gas exploder system

Approximately 84 gas exploders and 26 control shelters will be required in strategic locations within the Mitchell Valley. Suggested locations for exploder sites are indicated on Drawing #1 attached, and a table indicating exploder (cannon) sizes and array structure is included in Appendix 1 The locations indicated on Drawing #1 are preliminary, and may need to be adjusted in future planning stages due to geotechnical conditions found at each specific site.

The implementation of fixed remote exploders involves costs related to initial materials and installation, consumables, and ongoing maintenance. Although initial estimates have been submitted for costing purposes, it must be understood that there are numerous factors that could increase or decrease costs. These include:

- geotechnical conditions at each installation site;
- extent of relocation of exploders and control shelters throughout the life of the mine; and
- ability to consolidate costs of construction by utilizing bulk shipping, as well as capitalize on the efficiency gained by a consistent construction team

Considering the extensive amount of infrastructure required to be constructed and installed, full build out of the entire remote-control exploder system and supporting structure infrastructure may take 5 years or longer.

3.2 Conventional Explosive Control Measures

Although fixed exploders will be effective for controlling most avalanches, helicopter-borne avalanche control, cornice control, case charging, and other explosive measures will be required to supplement the exploders on an intermittent basis. Conventional explosive materials are readily available and include ammonium nitrate, dynamite, gels, and other ‘high explosives’.

In addition to conventional delivery of the above explosives (by helicopter, or hand charging), it is recommended that a minimum of four avalanche ‘launchers’ be incorporated into the Mitchell Valley avalanche program. Launchers provide the capability to deliver conventional explosives to the starting zones of avalanche paths during storms, nightfall, and periods of reduced visibility. Such capability will be required for the Mitchell Valley, particularly during the construction phase until the fixed exploders are fully functional (potentially 5 years or longer).

3.3 Infrasound Sensors for Avalanche Monitoring

It will be necessary for avalanche technicians to actively monitor size and extent of all avalanches that occur in the Mitchell Valley. During extended storm cycles, avalanche technicians may have reduced ability to confirm avalanche release, and therefore have reduced confidence to keep specific worksites and access routes open. Considering the importance of confirming avalanche release during storm cycles, it is recommended that infrasound sensors be installed in strategic locations (adjacent to avalanche tracks and in runout) in order to help confirm avalanche release during explosive control measures.

3.4 Snowpack Supporting Structures

The central platform of the Ore Preparation Complex (OPC) is located at the bottom of Path M-N-5. Considering the high vulnerability of this location, combined with the type of avalanche terrain above, it is recommended that fixed facilities be protected by construction of several rows of snow supporting structures (snow nets, bridges, or fences). These supporting structures would serve to restrain snow on the slope, and limit avalanche initiation.

The extent of snow supporting structures required is indicated in Drawing #1. Preliminary calculations indicate approximately 6000 linear meters of structures will be required.

The rows of snow supporting structures have initial costs and ongoing maintenance costs. Although initial quantities have been submitted for costing purposes, it must be understood that there are numerous factors which could increase or decrease costs. These include:

- geotechnical conditions at supporting structure anchor sites;
- extent of relocation of supporting structures throughout the life of the mine; and
- ability to consolidate costs of construction by utilizing bulk shipping, as well as capitalize on the efficiency gained by a consistent construction team.

3.5 Additional Infrastructure required in the Mitchell Valley

The following additional infrastructure will be required for the Mitchell Valley:

- Personnel Shelters (or small buildings) located in strategic ridge top locations - for avalanche personnel monitoring avalanche conditions in starting zones during storms.
- Tracked snow vehicles (snow cats) which will be utilized to build and maintain access roads to specific avalanche monitoring and control sites.
- Remote-telemetry weather stations, located in at least 3 sites within the valley
- A reliable communications network that will allow avalanche information to be disseminated efficiently to workcrews. This may include radios, paging systems, or other technologies.
- Electronic 'check' stations for personnel entering and accessing high risk areas within the Mitchell Valley. This will be used to monitor crews, and confirm locations of personnel at any given time.
- Personal Protective Equipment (PPE) including transceivers for every mine worker exposed to avalanche risk.
- An emergency 'bunker' (100% safe area) within the OPC for short duration plant site operations during rare cases of extreme avalanche hazard. If technically feasible, this room could potentially allow for continued operation of high priority machinery while travel outside the bunker was restricted.
- Avalanche Search and Rescue Equipment cached in at least 4 locations in the Mitchell Valley.

3.6 Avalanche Hazard Levels

A mine-site operational strategy which incorporates avalanche hazard levels, and corresponding safety measures will be required in order to minimize risk to workcrews (see example – Figure 2-1). Avalanche technicians monitoring avalanche conditions would determine and communicate hazard levels as conditions change.

Hazard	Definition	Safety Measures	Closures
LOW	Avalanches are unlikely	• No special safety procedures required • Stationary work may occur in avalanche zones	None
MODERATE	Small avalanches are likely, but are expected to terminate above access roads and worksites Large avalanches are possible, but are expected to terminate far above access roads and worksites	• No personnel working outside of vehicles within avalanche zones • Stationary work in avalanche zones only on approval from Avalanche Technician • NOTIFY Safety Officer and/or Avalanche Technician immediately if you observe any new avalanche occurrences	None
CONSIDERABLE	Small avalanches may affect access roads and worksites Large avalanches are possible, but expected to terminate above access roads and worksites Snow dust events may affect access roads	• No personnel working outside of vehicles within avalanche zones • No stationary vehicles within avalanche zones • NOTIFY Safety Officer and/or Avalanche Technician immediately if you observe any new avalanche occurrences • Safe Travel Procedures employed for travel through avalanche zones (minimum 300 m spacing)	All worksites in avalanche zones closed, unless approved by Avalanche Technician All access road avalanche zones on standby for closure
HIGH	Numerous small avalanches are expected to affect access roads and worksites One or more large avalanches may affect access roads and worksites	• Close and sweep the avalanche zones using Standard Closure Procedures • Under no circumstance should there be workers in, or any travel through avalanche zones.	All access road and worksite avalanche zones closed
EXTREME	A widespread avalanche cycle is occurring Numerous large avalanches are expected to occur in all avalanche paths, all areas	• Close and sweep the avalanche zones using Standard Closure Procedures. • Under no circumstance should there be workers in, or any travel through avalanche zones	All access road and worksite avalanche zones closed

Figure 2-1 – Example Avalanche Hazard Scale

3.7 Avalanche Training

A comprehensive avalanche awareness training program will be required for all personnel on site. This will be mandatory, and will need to be completed by workers at the mine on an annual basis. Topics would be focused towards providing a basic understanding of avalanche hazard, locations of potential avalanche hazard for the project, the avalanche management system, and avalanche search and rescue procedures.

3.8 Avalanche Deposit Clearing

A well-managed avalanche monitoring and control program is expected to decrease risk to facilities and workers, as well as minimize loss of production associated with evacuation (closures), and road blockages. However, removal of the associated snow mass created by avalanche release must also be considered in the avalanche management strategy. Avalanche technicians must work in concert with a dedicated team of snow clearing equipment in order to keep closure times to a minimum. In addition, timely clearing of avalanche debris is an essential component of the OPC mitigation strategy (BGC Engineering, 2011d).

During more detailed stages of avalanche planning, the potential maximum rate of accumulated avalanche debris volumes (during avalanche cycles) should be calculated for critical areas. These will include areas of limited snow storage capacity upstream of, or within the OPC. They may also include high volume haul or access roads. Once these calculations are made, it is important that equipment with suitable snow clearing capacity (that exceeds the maximum potential accumulation rate) be continuously available throughout winter months.

4.0 Avalanche Management Measures for Facilities and Access Routes Outside Mitchell Valley

Avalanche management measures for facilities and access routes in areas outside of the Mitchell Valley include all of the components described above with the exception of fixed exploders and supporting structures. The primary method of avalanche control would be helicopter control, and temporary closure (evacuation) of facilities and worksites. It may be determined in future mine planning phases that fixed exploders, supporting structures, avalanche diversion/catchment dams, or other structures will be required to reduce closure times, and/or provide increased efficiency in operations.

5.0 Avalanche Personnel

A team of highly experienced avalanche technicians and forecasters will be required to reduce to tolerable levels the likelihood of avalanches overwhelming avalanche defense measures. Considering the current General Arrangement and proposed mitigation measures, avalanche management within the Mitchell Valley will require 4 full time avalanche staff. An additional 4 staff would be required for areas outside of the Mitchell Valley (Coulter Creek, Sulphurets Creek, Teigen Access Road, and the Tailings Management Facility (TMF) site). During exceptional storms, all avalanche staff may be required to focus on the Mitchell Valley, in order to reduce the risk to facilities and infrastructure at the OPC.

It is essential that avalanche management techniques be best practices to minimize the chance of avalanche forecasting errors. Specific quality control measures should be incorporated in the avalanche management program where possible. In addition, intermittent analysis of operations should be undertaken by avalanche consultants, engineers, and technical representatives of the avalanche control manufacturing companies, to ensure high reliability.

6.0 Avalanche Management and Safety Plan over the Life of Project

Numerous changes in the landscape are expected to occur throughout the life of the project. These changes include creation of cut slopes, and piling of waste rock. In addition, new mine infrastructure will be built, locations of work crews will change, and haul and access routes will be re-routed.

In order to maintain sufficient avalanche protection, the avalanche management and safety plan will need to adapt to changing demands of the project. Avalanche planners will have to work with mine planners to relocate fixed infrastructure (e.g. Gazex, Supporting structures). In addition, there may be options to take advantage of project construction plans to reduce or eliminate exposure. Examples of these options may include:

- piling waste rock in areas that would serve as catchment or diversion for more frequent avalanches, reducing closure times attributed to avalanche deposit clearing;
- relocating access roads to higher ground that is created by waste rock piles; and
- creating 'stepped' terrain above worksites in pits to reduce extent of avalanche slopes.

7.0 Limitations

The avalanche management strategy described in this memorandum is intended to provide an overview of components involved and measures incorporated to reduce risk to workers and facilities for the KSM Project. Information contained within this memorandum is based on a preliminary layout of facilities, and project requirements and limitations as provided by Seabridge and its consultants.

An early estimate of costs was provided to Wardrop in an email dated April 1, 2011. It was based on initial layout of avalanche control structures as well as an understanding of operational requirements for the mine. There are several factors which may change these initial estimates. These include, but are not limited to:

- Price adjustments from manufacturers of avalanche control equipment;
- change in exchange rates which would impact imported products;
- variations in geotechnical conditions where fixed structures are installed;
- change in the General Arrangement of facilities and access routes; and
- adjustments in the Consumer Price Index, which may impact labor rates.

8.0 Closure

This document was prepared by Alpine Solutions Avalanche Services for the account of BGC Engineering Inc. and Seabridge Gold. The material in it reflects Alpine Solutions best judgment in light of the information available to Alpine Solutions at the time of preparation. Any use which a third party makes of this document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Alpine Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions, based on this document.

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Yours Sincerely,
Alpine Solutions Avalanche Services
Per:

Brian Gould, P. Eng.
Avalanche Specialist

John Tweedy, CAA
Avalanche Specialist

References

BGC Engineering, 2011a. KSM Project Preliminary Geohazard Risk Reduction Concepts. Draft Memorandum prepared for Seabridge Gold, dated January 7, 2011. 15 pp.

BGC Engineering, 2011b. KSM Project Geohazard and Risk Assessment, Minesite and Coulter Creek Access, Revision A. Final Report prepared for Seabridge Gold, dated April 8, 2011. 105 pp.

BGC Engineering, 2011c. KSM Project Geohazard and Risk Assessment, TMF and Teigen Creek Access, Revision A. Final Report prepared for Seabridge Gold, dated April 8, 2011. 49 pp.

BGC Engineering, 2011d. KSM Geohazards: OPC Pre-feasibility Geohazards Risk Reduction – Rev. A. Final Memorandum prepared for Seabridge Gold, dated March 30, 2011. 19 pp.

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U.S. Geological Survey (USGS). 2005. Explosive-Residue Compounds Resulting From Snow Avalanche Control in the Wasatch Mountains of Utah. Water-Resources Investigations Report 03-4007

Yount, J., Naisbitt, A., and Scott, E.; 2008. Operational Highway Avalanche Forecasting using the Infrasonic Avalanche Detection System. Proceedings of International Snow Science Workshop, Whistler, BC, Sept. 21-27, 2008.

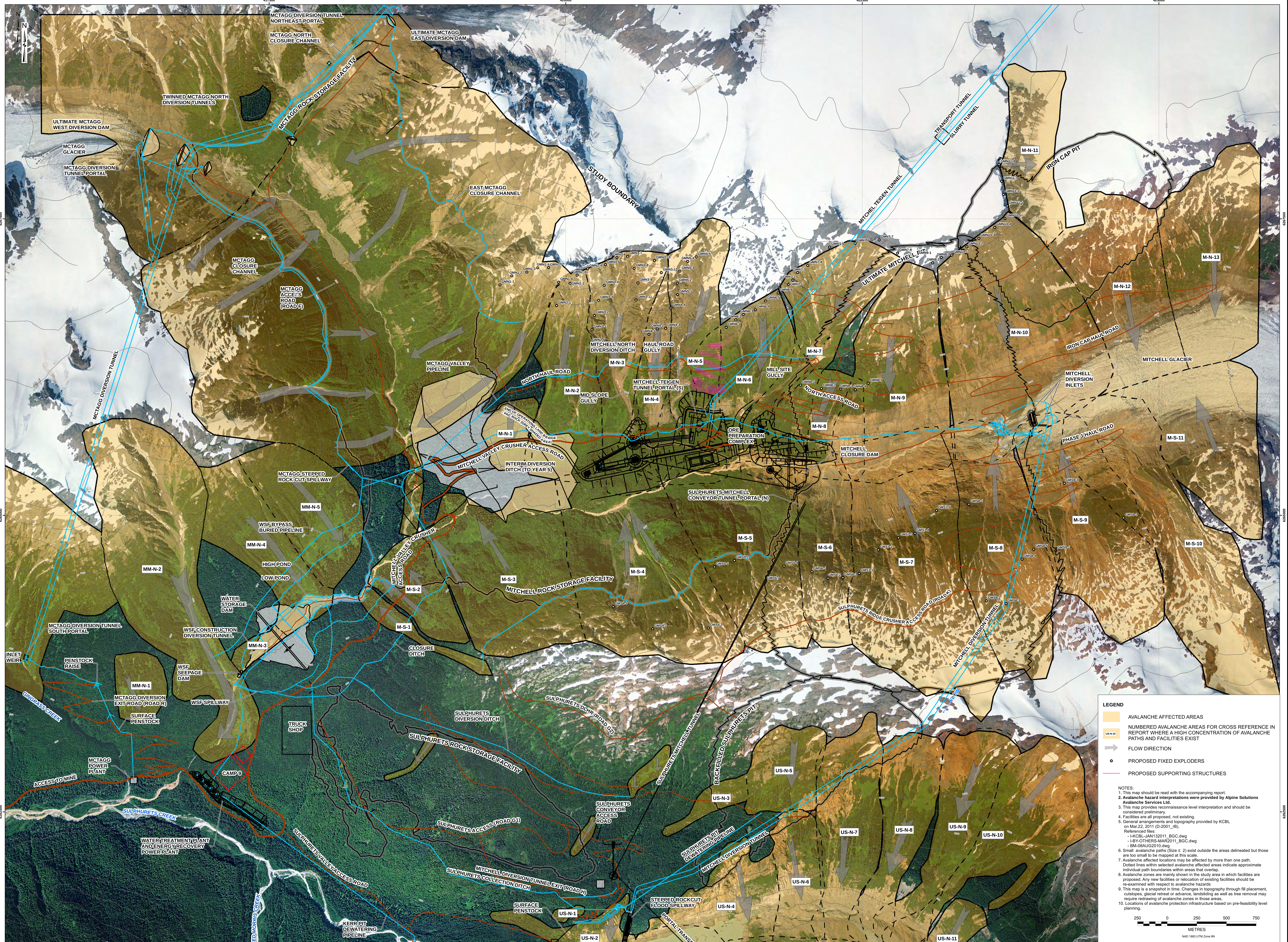
Weick, Karl E.; Kathleen M. Sutcliffe (2001). Managing the Unexpected - Assuring High Performance in an Age of Complexity. San Francisco, CA, USA, Jossey-Bass.

Appendix 1 – Fixed Remote-Control Exploder Arrays

Path	Cannon #	Exploder Size	Shelter	Facility protecting
M-N-1	1	1.5	**"ALPHA"**	North Haul Road, McTagg RSF
	2	1.5	"	North Haul Road, McTagg RSF
	3	1.5	"	North Haul Road, McTagg RSF
	4	3	"	North Haul Road, McTagg RSF
	5	3	"	North Haul Road, McTagg RSF
	6	3	"	North Haul Road, McTagg RSF
M-N-2	1	3	**"BRAVO" AUTONOMOUS**	North Haul Road
	2	3	**"CHARLIE"**	North Haul Road
	3	3	"	North Haul Road
	4	3	"	North Haul Road
	5		"	North Haul Road
M-N-3	1	1.5	**"DELTA"**	North Haul Road, Ore stockpiles
	2	3	"	North Haul Road, Ore stockpiles
	3	3	"	North Haul Road, Ore stockpiles
	4	3	"	North Haul Road, Ore stockpiles
	5	3	"	North Haul Road, Ore stockpiles
	6	3	**"ECHO"**	North Haul Road, Ore stockpiles
	7	3	"	North Haul Road, Ore stockpiles
	8	1.5	"	North Haul Road, Ore stockpiles
	9	1.5	"	North Haul Road, Ore stockpiles
	10	3	"	North Haul Road, Ore stockpiles
	11	1.5	**"FOX AUTONOMOUS**	North Haul Road, Ore stockpiles
	12	3	**"GOLF" AUTONOMOUS**	North Haul Road, Ore stockpiles
M-N-4	1	1.5	**"HOTEL" AUTO**	North Haul Road, Access Road to Plantsite
	2	1.5	**"INDIGO" AUTO**	North Haul Road, Access Road to Plantsite
	3	1.5	**WITH "INDIGO"**	North Haul Road, Access Road to Plantsite
	4	3	**"JUILETT" AUTO**	North Haul Road, Access Road to Plantsite
M-N-5	1	1.5	**"KILO"**	North Haul Road, Central Platform
	2	1.5	"	North Haul Road, Central Platform
	3	3	"	North Haul Road, Central Platform
	4	3	"	North Haul Road, Central Platform
	5	3		North Haul Road, Central Platform
M-N-6	1	3	**"LIMA"**	North Haul Road, Central Platform
	2	3	"	North Haul Road, Central Platform
	3	1.5	"	North Haul Road, Central Platform
	4	3	"	North Haul Road, Central Platform
	5	3		North Haul Road, Central Platform
	6	3	**"MARY" AUTO**	North Haul Road, Central Platform
M-N-7	1	1.5	**"NOVEMBER"**	North Haul Road, East Platform, Haul and Access
	2	3	"	North Haul Road, East Platform, Haul and Access
	3	3	"	North Haul Road, East Platform, Haul and Access
	4	3	"	North Haul Road, East Platform, Haul and Access
	5	3	"	North Haul Road, East Platform, Haul and Access
	6	3	**"OSCAR"**	North Haul Road, East Platform, Haul and Access
	7	3		North Haul Road, East Platform, Haul and Access
	8	3		North Haul Road, East Platform, Haul and Access
M-N-8	1	3	**"PETER"**	Mitchell Haul Road
	2	3	"	Mitchell Haul Road
	3	3	"	Mitchell Haul Road
	4	3	"	Mitchell Haul Road
	5	3	"	Mitchell Haul Road

Path	Cannon #	Exploder Size	Shelter	Facility protecting
M-N-9	1	3	**"QUEBEC"**	Mitchell Pit
	2	1.5	"	Mitchell Pit
	3	3	**"ROMEO"**	Mitchell Pit
M-N-10	1	3	"	Mitchell Pit
	2	3	"	Mitchell Pit
	3	3	"	Mitchell Pit
	4	3	"	Mitchell Pit
	5	3	"	Mitchell Pit
M-N-11	1	1.5	**"SAM"**	Iron Cap Pit
	2	1.5	"	Iron Cap Pit
	3	1.5	"	Iron Cap Pit
	4	1.5	"	Iron Cap Pit
M-S-4	1	3	**"TANGO" AUTONOMOUS**	Access Road
	2	1.5	**"UNIFORM" AUTO**	Access Road
	3	1.5	**DOUBLE BOOMER WITH "UNIFORM"**	Access Road, Central Platform
M-S-5	1	3	**"VICTOR"**	Access Road, Central Platform
	2	3	"	Access Road, Central Platform
	3	3	"	Access Road, Central Platform
	4	3	"	Access Road, Central Platform
M-S-6	1	3	**"WINTER"**	Mitchell Pit, Road
	2	3	"	Mitchell Pit, Road
	3	3	"	Mitchell Pit, Road
M-S-7	1	3	**"X-RAY"**	Mitchell Pit, Road
	2	3	"	Mitchell Pit, Road
	3	3	"	Mitchell Pit, Road
	4	3	"	Mitchell Pit, Road
	5	3	"	Mitchell Pit, Road
M-S-8	1	3	**"YANKEE"**	Phase 1 Haul Road
	2	3	"	Phase 1 Haul Road
	3	3	"	Phase 1 Haul Road
	4	3	"	Phase 1 Haul Road
	5	3	"	Phase 1 Haul Road
M-S-9	1	3	**"ZULU"**	Phase 1 Haul Road
	2	3	"	Phase 1 Haul Road
	3	3	"	Phase 1 Haul Road

Drawings



LEGEND

AVALANCHE AFFECTED AREAS

US-N-10 NUMBERED AVALANCHE AREAS FOR CROSS REFERENCE IN REPORT WHERE A HIGH CONCENTRATION OF AVALANCHE PATHS AND FACILITIES EXIST

FLOW DIRECTION

PROPOSED FIXED EXPLODERS

PROPOSED SUPPORTING STRUCTURES

NOTES:
1. This map should be read with the accompanying report.
2. **Avalanche hazard interpretations were provided by Alpine Solutions Avalanche Services Ltd.**
3. This map provides reconnaissance level interpretation and should be considered preliminary.
4. Facilities are all proposed, not existing.
5. General arrangements and topography provided by KCBL on Mar.22, 2011 (D-2001_rB).
   Referenced files:
   - I-KCBL-JAN132011_BGC.dwg
   - I-BY-OTHERS-MAR2011_BGC.dwg
   - BM-08AUG2010.dwg
6. Small avalanche paths (Size ≤ 2) exist outside the areas delineated but those are too small to be mapped at this scale.
7. Avalanche affected locations may be affected by more than one path. Dotted lines within selected avalanche affected areas indicate approximate individual path boundaries within areas that overlap.
8. Avalanche zones are mainly shown in the study area in which facilities are proposed. Any new facilities or relocation of existing facilities should be re-examined with respect to avalanche hazards
9. This map is a snapshot in time. Changes in topography through fill placement, cutslopes, glacial retreat or advance, landsliding as well as tree removal may require redrawing of avalanche zones in those areas.
10. Locations of avalanche protection infrastructure based on pre-feasibility level planning.

250 0 250 500 750
METRES
NAD 1983 UTM Zone 9N

REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	1:10,000
DATE:	MAY 2011
DRAWN:	LL, JS
DESIGNED:	KH, BG
CHECKED:	KH, BG
APPROVED:	BG

PROFESSIONAL SEAL:

DRAFT

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: SEABRIDGE GOLD INC.

PROJECT: KSM GEOHAZARDS PROJECT

TITLE: MITCHELL VALLEY AVALANCHE GEOHAZARDS FIXED EXPLODER AND SUPPORTING STRUCTURE LOCATIONS

PROJECT No.:	DWG No.:	REV.:
0638-005	01	A

DWG TO BE READ WITH BGC REPORT TITLED "GEOHAZARD AND RISK ASSESSMENT KSM PROJECT, MINESITE AND COULTER CREEK ACCESS. FINAL" DATED MAY 2011