KENO HILL SILVER DISTRICT MINING OPERATIONS

MONITORING, SURVEILLANCE AND REPORTING PLAN

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Prepared for:

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1. INTRODUCTION

This plan is comprised of the monitoring, surveillance and reporting that will be carried out to ensure that the Keno Hill Silver District (KHSD) Mining Operations are managed in a manner that provides human and environmental protection. The framework of this plan includes monitoring and reporting of:

- The local and receiving environment through scheduled inspections and monitoring programs;
- Effluent discharge points and treatment system performance;
- Site facilities and incorporated design measures to ensure structural stability and prevention of accidents and malfunctions;
- Remediation success; and
- Adaptive management responses.

If monitoring indicates that physical structures, treatment systems or mitigative measures are not performing, then maintenance or contingency plans can be implemented following an adaptive management approach as discussed in Section 11 (Ensero, 2020a).

Prior to mine development in the KHSD, a number of monitoring programs and a surveillance network were already in place as per care and maintenance activities (Water Licence QZ06-074), advanced exploration and development activities at the Bellekeno, Flame and Moth and Bermingham mines (Water Licence QZ18-044) as well as district-wide closure and new mine permitting studies. These programs include but are not limited to physical inspections, a water quality surveillance network, old mine workings monitoring, aquatic resources monitoring for benthic invertebrate and fisheries populations, sediment monitoring, waste rock and mine wall sampling and the Adaptive Management Plan. Monitoring, surveillance and reporting applicable to Bellekeno, and Flame and Moth Mines are presented in this plan.

2. WATER SURVEILLANCE NETWORK

Currently water quality monitoring is required under care and maintenance Water Licence QZ17-076, and Keno Hill Silver District Mining operations Water Licence QZ18-044. Each Water Licence provides Effluent Quality Standards which dictate maximum concentrations of specific parameters allowed to be discharged at locations where water treatment is being undertaken. In addition to the monitoring of treated effluent discharge and associated adits, background surface water stations upstream of project facilities are also monitored along with the receiving environment. Monitoring wells are used to measure and sample groundwater in the receiving environment and have been established as per Water Licence QZ18-044. Refer to Type A Water Licence QZ18-044, which specifies Effluent Quality Standards (Part G), monitoring and surveillance (Part H and Schedule B) and Reporting (Part I) required for the Keno Hill District Mining Operations, which is available for download at www.yukonwaterboard.ca/waterline.

A Groundwater Monitoring Plan for the Project was developed in February 2011 and was last updated in October 2020 to include the Bermingham mine per Water Licence QZ18-044 (see Appendix A). This plan outlines monitoring locations and frequency for the Keno District mill and Dry Stack Tailings Facility, the N-AML waste rock disposal areas (Bermingham and Bellekeno), and Keno City. Groundwater wells are scheduled for monthly monitoring for both water level and quality for 12 months to establish well conditions, followed by quarterly sampling thereafter for the duration of the project, as per Clause 87(a). Groundwater data will be compared to the *Yukon Contaminated Sites Regulations (YCSR)* Schedule 3: Generic Numerical Water Standards (Aquatic Life) and to the YCSR Drinking Water Standards when near potable or potentially potable aquifers, as per Clauses 82 and 83.

Table 2-1 outlines the sampling stations and schedule for internal and external lab analysis in the area of the Bermingham, Bellekeno, and Flame and Moth mines and in the vicinity of the mill site. The table outlines the currently established stations and the pending stations to be established prior to commencing work at the respective mine. Figure 2-1, Figure 2-2 and Figure 2-3 show these existing and proposed surface water and groundwater monitoring station locations, respectively. Figure 2-1 includes three insets and shows the respective surface water quality location by mine component for the DSTF/Mill/Flame and Moth, Onek/Keno City, and Bellekeno. Figure 2-2 shows the groundwater locations for the District, while Figure 2-3 provides a zoomed in view of Flame and Moth, Mill and DSTF groundwater monitoring locations.

Hydrology monitoring is undertaken on a continuous basis during the open water season at stations on Christal Creek (KV-6), No Cash Creek (KV-21) and Lightning Creek (KV-41), as per part H, Clause 73. In June 2015, a water level recorder with staff gauge were installed in Christal Lake and KV-51 (Christal Creek downstream of Hinton Creek). Should flow be present at site KV-11 and KV-118 manual measurements will be completed, and data submitted as part of monthly report, as per part H, Clause 75. Instantaneous measurements of flow are also collected during monthly/quarterly sample events at all stations possible. Flow monitoring stations will be established for all locations where water is withdrawn from surface or ground for use with mining activities and discharged into the receiving environment.

Quality assurance and quality control (QA/QC) protocols have been implemented during collection, storage and shipping of samples. Standard QA/QC procedures conducted by field and laboratory staff

including duplicate, relative percent difference analysis, analytic matrix spikes, spike blanks, and field, trip and method blanks.

Laboratory quality control analysis includes method blanks, laboratory duplicates, matrix spikes and blank spikes which are required to be reported by the laboratory showing acceptability criteria prior to issuing Alexco the data.

One field blank is collected per monthly event and is completed by taking de-ionized water (analyte free media) to the sample station, opening it and exposing it to ambient air and 'collecting' it in the sample bottles. These samples are treated the same as the actual water samples, preserved and filtered as necessary, and their analysis can provide an indication of contamination that may affect the actual samples. Additionally, one travel blank will accompany the samples for each monthly event and will be analysed for the same parameters as the routine samples.

Field duplicates are collected at a rate of 10% or 1 for every 10 samples. Relative Percent Difference (RPD) is used to determine field variability and is the difference between the sample result and replicate result, divided by the average of the sample result and replicate result and expressed as a percentage. Where analyte results have RPD greater than 25% a subsequent check is done against the laboratory detection limit (DL) to establish if the practical quantitation limit (PQL) was met. The PQL is five times the DL and is defined as the minimum concentration that can be measured within specified limits of precision and accuracy. Both results need to be above the PQL for the analyte to be considered as 'meeting the PQL'. If one result from the sample or duplicate is greater than 5X DL and the other result is less than 5X DL then the 'PQL is not met'. An analyte with results not meeting the PQL indicates that the constituent being analyzed is not present in a sufficient amount to be reliably quantified. Typically, as parameters approach their detection limit, high variability is more likely to occur. The RPD of 25% can be used as a benchmark whereby an RPD greater than 25% warrants further comment or consideration.

All water quality data is stored in an EQwin database and additional QA/QC steps to determine potential outliers are identified from the preparation of a variance report that outlines the comparison off field vs laboratory pH and conductivity, and comparison to recent samples collected (i.e., RPD compared to samples from last 12 months).

2.1 WATER QUALITY NETWORK BY MINE COMPONENT

As part of evaluation of the data a number of environmental models are updated with the water quality and quantity information outlined in Section 2, which include groundwater models, water quality models, water balances and water quality objectives for Christal Creek and Lightning Creek. These tools are updated with additional water information available on an annual or as needed basis to inform decision making process or to further evaluate adaptive management responses. As an example, a number of stations (i.e., KV-6, KV-21 and KV-41) record continuous stream flow measurements. This information, in combination with the meteorology data, is used to refine the parameters and assumptions used in the water balances.

The surface water quality monitoring locations by mine are presented in Table 2-2. The water quality information collected under this plan is integrated into the existing water quality models to verify or adjust calibration factors used in the model. This advances the understanding of the dynamic nature of the district and numerous load sources including evaluation and determination of natural

attenuation capacity in the receiving environment. Additionally, the water quality data are compared with established thresholds (i.e., WQO) and Adaptive Management Plan triggers as part of the routine review.

The groundwater monitoring locations per mine is presented in Table 2-3. The groundwater levels collected as part of this program will be used to prepare groundwater contours maps twice per year and refinements to the groundwater models as required.

Table 2-1 Keno Hill Silver District Mining Operations Water Monitoring Program Summary

SITE	SITE DESCRIPTION	WATER LICENCE	INSITU MEASUREMENTS / INTERNAL ANALYSIS									EXTERNAL LAB ANALYSIS														
		QZ18-044 Monitoring Status	Level	Synoptic Levels	Flow	pH	Temperature	Conductivity	Total Zn	Ammonia	Turbidity	Total Metals	Dissolved Metals	Hardness	pH	Conductivity	TSS	Alkalinity	Sulphate	Nitrate	Nitrite	Ammonia-N	DOC	Total Phosphorous	Total and Free Chlorine	Radium 226	Acute Lethality LC50 Rainbow Trout 96 Hour
Mine Treatment / Effluent Discharge Sites																										
KV-42	Bellekeno 625 Adit	Existing	-		C	D	D	D	D	D	D	W	W	W	W	W	W	W	W	W	W	W	M	W		-	-
KV-43	Bellekeno 625 Settling Pond Decant	Existing	-		C	D	D	D	D	D	D	W	W	W	W	W	W	W	W	W	W	W	W	W		W/Q	M
KV-82	Flame and Moth Mill Site Collection and Sediment Pond	Existing	D		-	D	D	D	D	D	D	M	M	M	M	M	M	M	M	M	M	M	M	M		-	-
KV-83	Flame and Moth Mill Treatment Plant Discharge	Existing	-		C-WD	D-WD	D-WD	D-WD	D-WD	D-WD	D-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	Q-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD		W/Q	M
KV-105	Flame and Moth Adit Discharge	Existing	-		C	D-WD	D-WD	D-WD	D-WD	D-WD	D-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD		-	-
KV-104L	Flame and Moth Settling Pond Decant discharge to Lightning Creek	Existing	D		C-WD	D	D	D	D	D	D	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD		W/Q	M
KV-104C	Flame and Moth Settling Pond Decant discharge to Christal Creek	Existing	D		C-WD	D	D	D	D	D	D	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD		W/Q	M
KV-110	New Bermingham Portal	Existing	-		C-WD	D-WD	D-WD	D-WD	D-WD	D-WD	D-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	D-WD*	-	-
KV-114	New Bermingham Pond Decant	Existing	D		C-WD	D	D	D	D	D	D	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	W-WD	D-WD*	W/Q	M
Mine Surface Water Surveillance Sites																										
KV-1	South McQuesten River u/s Christal Creek	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-2	South McQuesten River @ Pumphouse	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-6	Christal Creek @ Keno Highway	Existing	-		C	M-WD	M-WD	M-WD	-	-	-	W-WD/M	W-WD/M	W-WD/M	W-WD	W-WD	W-WD	W-WD	W-WD/M	W-WD/M	W-WD/M	W-WD/M	W-WD/M	W-WD/M	W-WD/M		-	-
KV-7	Christal Creek @ Hanson Road	Existing	-		M	M	M	M	-	-	-	M	M	M	M	M	M	M	M	M	M	M	M	M		-	-
KV-8	Christal Creek @ mouth	Existing	-		Q	M	M	M	-	-	-	M	M	M	M	M	M	M	M	-	-	-	M	M		-	-
KV-21	No Cash Creek at Silver Trail Highway	Existing	-		C	M	M	M	-	-	-	M	M	M	M	M	M	M	M	M	M	M	M	M		-	-
KV-37	Lightning Creek u/s Hope Gulch	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-38	Lightning Creek u/s Thunder Gulch	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-39	Hope Gulch u/s Lightning Creek	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-40	Charity Gulch u/s Lightning Creek	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-41	Lightning Creek u/s Bridge @ Keno City	Existing	-		C	M	M	M	-	-	-	M	M	M	M	M	M	M	M	M	M	M	M	M		-	-
KV-44	Bellekeno 625 Seep	Existing	-		Ms	Ms	Ms	Ms	Ms	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	Q
KV-45	Onek 400 Adit	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-49	Hinton Creek u/s Christal Creek	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-50	Christal Creek u/s Hinton Creek	Existing	-		M-WD	M-WD	M-WD	M-WD	-	-	-	W-WD/M	W-WD/M	W-WD/M	W-WD	W-WD	W-WD	W-WD	W-WD/M	W-WD/M	W-WD/M	W-WD/M	W-WD/M	W-WD/M		-	-
KV-51	Christal Creek d/s Hinton Creek	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
KV-52	Natural spring to Christal Lake @ Old Mackeno Pumphouse	Existing	-		M	M	M	M	-	-	-	M	M	M	M	M	M	M	M	-	-	-	M	M		-	-
KV-56	Star Creek at Silver Trail Highway	Existing	-		M	M	M	M	-	-	-	M	M	M	M	M	M	M	M	M	M	M	M	M		-	-
KV-65	Thunder Gulch u/s of Bellekeno 625	Existing	-		Q	Q	Q	Q	-	-	-	M	M	M	M	M	M	M	M	-	-	-	M	M		-	-
KV-72	South McQuesten River at McQuesten Lake	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q				Q	Q			
KV-76	Thunder Gulch d/s Bellekeno 625	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-77	Thunder Gulch u/s Bellekeno East	Existing	-		Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-78B	Bellekeno East Temporary Waste Rock Storage Facility	Existing	Ms		-	Ms	Ms	Ms	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-79	Christal Creek d/s MacKeno Tailings	Existing	-		-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-80	Christal Creek u/s Mackeno Tailings	Existing	-		-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-81	Lightning Creek Southwest of Mill Site	Existing	-		M-WD	M-WD	M-WD	M-WD	-	-	-	W-WD/M	W-WD/M	W-WD/M	W-WD	W-WD	W-WD	W-WD	W-WD/M	W-WD/M	W-WD/M	W-WD/M	W-WD/M	W-WD/M		-	-
KV-106	Flame and Moth Temporary P-AML Waste Rock Storage Facility	Existing	Q		-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-111	No Cash Creek above No Cash 500 Adit	Existing	-		M	M	M	M	-	-	-	M	M	M	M	M	M	M	M	M	M	M	M	M		-	-
KV-115	Bermingham P-AML Facility #1	Existing	Ms		-	Ms	Ms	Ms	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-119	Bermingham P-AML Facility #2	Pending	Ms		-	Ms	Ms	Ms	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q		-	-
KV-118	No Cash Creek at Calumet Drive	Existing	-		M	M	M	M	-	-	-	M	M	M	M	M	M	M	M	M	M	M	M	M		-	-
Mine Groundwater Monitoring Wells																										
KV-84Nd	Keno City Well #1	Existing	Q	-	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
KV-85D	Keno Hill Silver Distirict Mill Site Groundwater Well #1 (PH2) Deep	Existing	Q		-	Q	Q	Q	-	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
KV-85S	Keno Hill Silver Distirict Mill Site Groundwater Well #2 (Shallow)	Existing	Q		-	Q	Q	Q	-	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
KV-86	Keno Hill Silver Distirict Mill Site Groundwater Well #3 (PH5)	Existing	Q		-	Q	Q	Q	-	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
KV-87	Keno Hill Silver Distirict Mill Site Groundwater Well #4 (PH6)	Existing	Q		-	Q	Q	Q	-	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
KV-88D	Keno Hill Silver Distirict Mill Site Groundwater Well #5 (Deep)	Existing	Q		-	Q	Q	Q	-	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
KV-88S	Keno Hill Silver Distirict Mill Site Groundwater Well #6 (Shallow)	Existing	Q		-	Q	Q	Q	-	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
KV-89D	Keno Hill Silver Distirict Mill Site Groundwater Well #7 (Deep)	Existing	Q		-	Q	Q	Q	-	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
KV-89S	Keno Hill Silver Distirict Mill Site Groundwater Well #8 (Shallow)	Existing	Q		-	Q	Q	Q	-	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
KV-122	Bermingham - downgradient of BH SW pit well #1	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
KV-123	Bermingham - downgradient of BH SW pit well #2	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
KV-124	Bermingham - upgradient of BH SW pit	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q			
KV-125	Bermingham - downgradient of BH P-AML well #1	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q			
KV-126	Bermingham - downgradient of BH P-AML well #2	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
KV-127	Bermingham - upgradient of BH P-AML	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
KC-MW-4	Keno City Well #3 (Well south of Onek 400 adit)	Existing	Q	-	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
ON-MW-2	Keno City Well #2 (Onek Monitoring Well d/g Project Facilities)	Existing	Q	-	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q		-	-
ON-MW-3	Keno City Well (Well south of Onek 400 adit)	Pending	M/Q	-	-	M/Q	M/Q	M/Q	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
FM-MW-01	Flame and Moth Well #1 (KAR-01)	Existing	M	SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
FM-MW-02	Flame and Moth Well #2 (KAR-02)	Existing	M	SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
FM-MW-03	Flame and Moth Well #3 (KAR-03)	Existing	M	SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
BH39	DSTF phase 1 area	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
KV-107	DSTF phase II expansion area	Pending	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
KV-108	Upgradient of DSTF Phase 2 Expansion Area	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q			
RB-MW-1	Ruby 400 adit Monitoring Well	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
BH-MW-1	Historical Bermingham 200 adit monitoring well	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
KV-116	Bermingham Waste Rock Disposal Area Well	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
NC-MW-1	No Cash 500	Existing	M/Q		-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
KV-109	Lightning Creek near KV-81	Existing	M/Q	-	-	M/Q	M/Q	M/Q	-	-	-	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		-	-
KV-103	District Mill Supply Well	Existing	Q	SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
KV-84	Overburden Monitoring Well	Existing	Q	SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
KC-MW-1B	Bedrock Groundwater Monitoring Well	Existing	Q	SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
KC-MW-2	Overburden Groundwater Monitoring Well	Existing	Q	SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
KC-MW-3	Bedrock Groundwater Monitoring Well	Existing	Q	SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
ON-MW-1	Onek Monitoring Well #1 d/g Project Facilities	Existing	Q	SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
ON-MW-4	Bedrock monitoring well	Existing	Q	SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-

Pending Stations to be established

C = Continuous
C-WD = Continuous While Discharging
D = Daily
D-WD = Daily While Discharging
D-WD* = Daily While Discharging from breakpoint chlorination system
W = Weekly
W-WD = Weekly While Discharging

W/Q = Weekly migrating to quarterly to accord with monitoring frequency pursuant to MDMER
M = Monthly
Ms = Monthly (May - Oct)
M/Q = Monitoring to occur monthly for first 12 months, reverting to quarterly thereafter.
Q = Quarterly
A = Annually

470000 480000 490000

7100000 7090000

DISTRICT MILL AND KENO CITY INSET

BELLEKENO INSET

BERMINGHAM INSET

McQuesten Lake KV-72 Cache Creek

Hanson Lakes Ladue Lake South McQuesten River HANSON/MCQUESTEN ROAD

Ladue Creek Faro Gulch Silver Basin Gulch Keno Ladue River McKay Gulch Gambler Gulch Sadie Ladue Creek Germaine Lake Gambler Lake Allen Creek Faith Creek

KV-1 KV-8 KV-7 Christal Creek KV-2 No Cash Creek Sandy Creek Star Creek KV-56 KV-21 KV-20 KV-111 NO CASH 500 KV-118 KV-19 Breriatt Creek

SILVER TRAIL HIGHWAY WERNECKE ROAD SIGN POST ROAD CALUMET DRIVE GALKENO 300 KENO 700 Hope Gulch Charity Gulch McMillan Gulch McNeill Gulch

KV-48 KV-39 KV-40 KV-37 Lightning Creek Thunder Gulch

VALLEY TAILINGS WEATHER STATION

CALUMET WEATHER STATION

BERMINGHAM INSET

DISTRICT MILL AND KENO CITY INSET

BELLEKENO INSET

1:7,500

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Datum: NAD 83; Map Projection: UTM Zone 8N

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1:90,000 (when printed on 11 x17 inch paper)

0 1 2 3 4 5 Kilometers

- Active Surface Water Quality Station
- Pending/Proposed Water Quality Station
- Weather Station
- Adit
- As Built Mine Feature
- Valley Tailings
- Silver Trail Highway
- Other Road
- Watercourse
- Waterbody

AKHM

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FIGURE 2-1
SURFACE WATER QUALITY STATION LOCATIONS

OCTOBER 2021

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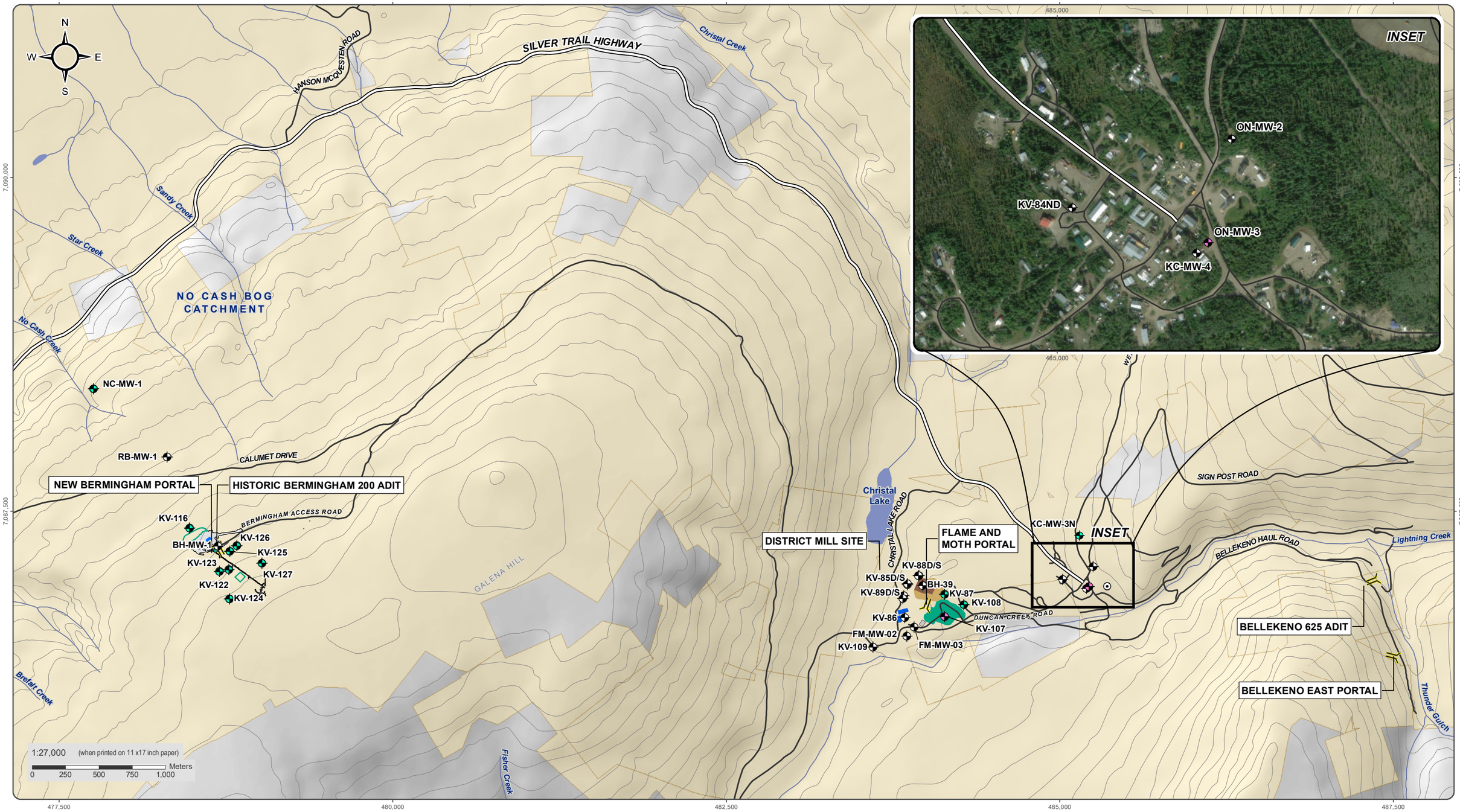

Datum: NAD 83; Map Projection: UTM Zone 8N

- Proposed Monitoring Well
- Monitoring Well
- Newly Installed Groundwater Monitoring Well
- Adit
- Infrastructure Footprint
- Pond
- DSTF 322k Tonnes Design
- Current DSTF
- To Be Constructed Mine Features
- Alexco/ERDC Quartz Claims
- Silver Trail Highway
- Other Road

AKHM

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FIGURE 2-2
KHSD GROUNDWATER MONITORING LOCATIONS

OCTOBER 2021

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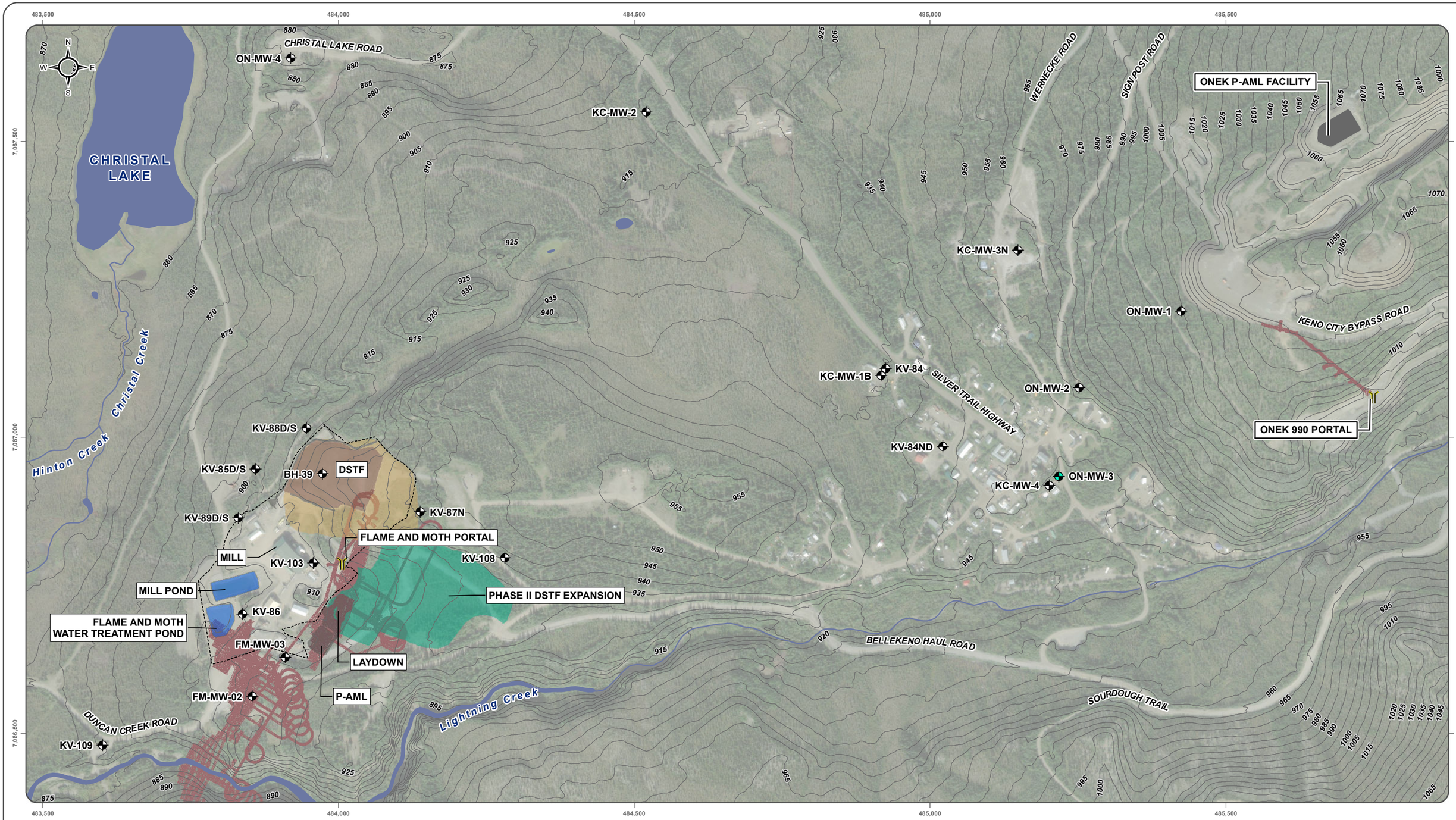

Satelite imagery obtained from ESRI Imagery map service http://goto.arcgisonline.com/maps/World_Imagery on October 2021

Datum: NAD 83; Projection: UTM Zone 8N

1:6,000 *(when printed on 11 x17 inch paper)*

0 50 100 150 200 250 Meters

- Proposed Monitoring Well
- Monitoring Well
- Adit
- Underground Workings
- Infrastructure Footprint
- Pond
- DSTF 322k Tonnes Design
- Current DSTF
- Permitted To Be Constructed Features
- Waterbody
- Watercourse
- Contour (5m)

AKHM

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FIGURE 2-3
GROUNDWATER MONITORING LOCATIONS AT DISTRICT MILL SITE, FLAME AND MOTH, ONEK 990 AND KENO CITY

OCTOBER 2021

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Table 2-2: Surface Water Quality Stations per Mine

Mine	Main Water Courses Monitored	Mine Associated Stations	Receiving Environment Stations Used for Water Balance and Water Quality model	Locations for Water Quality Predictions and Water Quality Objectives
Bellekeno	Lightning Creek and Thunder Gulch	KV-42, KV-43, KV-44, KV-78b	KV-37, KV-38, KV-39, KV-40, KV-41, KV-76, KV-77	KV-41
Flame and Moth	Christal Creek and Lightning Creek	KV-104, KV-105, KV-106	KV49, KV-50, KV-51, KV-6, KV-7, KV-41, KV-81	KV-81, KV-50, KV-6 and KV-7
District Mill/DSTF	Christal Creek	KV-82 and KV-83	KV-50, KV-6 and KV-7	KV-50, KV-6 and KV-7
Bermingham	No Cash Creek	KV-114, KV-115	KV-56, KV-111, KV-118	KV-21

Table 2-3: Groundwater Monitoring Stations per Mine

Mine	Mine Infrastructure Monitored	Upgradient Wells	Downgradient Wells
Bellekeno	N-AML WRDA	-	**KV-91, KV-92, KV-93, KV-94**
Flame and Moth	Mine and P-AML WRSF	**KV-108**	FM-MW-1, FM-MW-2 and FM-MW-3, KV-109
Keno City	P-AML WRDA	-	ON-MW-2, **ON-MW-3,** KV-84Nd, KC-MW-4
District Mill/DSTF	Mill and DSTF	KV-87, **KV-108**	KV-85D/S, KV-86, KV-88D/S, KV-89D/S, BH-39, **KV-107**
Bermingham	N-AML WRDA and P-AML WRSF	-	**KV-116**, BH-MW-1, RB-MW-1, **NC-MW-1, KV-122, KV-123, KV-124, KV-125, KV-126, KV-127**
Flat Creek Camp	Camp	ST-MW-1	-

Bold wells are pending

3. ENVIRONMENTAL EFFECTS MONITORING (UNDER MDMER)

The KHSD mines are subject to the Metal and Diamond Mining Effluent Regulations (MDMER), administered under the federal Fisheries Act, which apply to mining and milling operations that discharge effluent(s) at a rate greater than 50 m^3/day. The MDMER outline requirements for routine effluent monitoring, acute lethality testing, Environmental Effects Monitoring (EEM) and provides maximum authorized limits of deleterious substances.

Effluent monitoring under MDMER tends to overlap with that required under Water Licence QZ18-044; although, unlike the Water Licence a reduction or increase in monitoring frequency may be triggered based on analysis results. Maximum authorized concentrations of deleterious substances for MDMER Schedule 4 is presented below in Table 3-1 below. The MDMER also requires Daphnia magna monitoring tests at the same time as acute lethality testing.

Table 3-1: MDMER Authorized Limits of Deleterious Substances

Item	Column 1 Deleterious Substance	Column 2 Maximum Authorized Monthly Mean Concentration	Column 3 Maximum Authorized Concentration in a Composite Sample	Column 4 Maximum Authorized Concentration in a Grab Sample
1.	Arsenic	0.50 mg/L	0.75 mg/L	1.00 mg/L
2.	Copper	0.30 mg/L	0.45 mg/L	0.60 mg/L
3.	Cyanide	1.00 mg/L	1.50 mg/L	2.00 mg/L
4.	Lead	0.20 mg/L	0.30 mg/L	0.40 mg/L
5.	Nickel	0.50 mg/L	0.75 mg/L	1.00 mg/L
6.	Zinc	0.50 mg/L	0.75 mg/L	1.00 mg/L
7.	Total Suspended Solids	15.00 mg/L	22.50 mg/L	30.00 mg/L
8.	Radium 226	0.37 Bq/L	0.74 Bq/L	1.11 Bq/L

NOTE: All concentrations are total values.

The objective of EEM is to determine whether mining activity is causing an effect on fish or fish habitat, benthic invertebrate communities and/or the use of fisheries resources. A Bellekeno Mine Cycle 3 Environmental Effects Monitoring Study Design has been developed with Environment Canada and the interpretive report has been provided (March 2019; see Appendix K of 2018 annual Water Licence QZ09-092 report, https://apps.gov.yk.ca/waterline). Effluent monitoring, acute lethality testing and EEM Study Designs will also be implemented as required by MDMER for other mines brought online in the KHSD including Bermingham, and Flame and Moth.

Sampling requirements under the EEM program are as follows:

Part 1. Effluent and Water Quality Monitoring Studies

a) Effluent Characterization: Quarterly sampling from final discharge point includes extra parameters;

b) Water Quality Monitoring: Quarterly sampling of sites within reference and exposure areas:

c) Reference Area: Water frequented by fish that is not exposed to effluent and that has fish habitat that, as far as is practicable is most similar to the exposure area.

d) Exposure Area: All fish habitat and waters frequented by fish that are exposed to effluent; and

e) Sublethal Toxicity Testing: Semi-annual sampling required at each final discharge point and analysis of effects on reproduction or growth of a fish species, a plant species, an invertebrate species and an algal species as acceptable to MDMER.

Part 2: Biological Monitoring Studies

A number of study cycles that each include:

- A study design;
- Environment Canada and stakeholder review;
- A Field Sampling Program; and
- Submission of an Interpretive Report that indicates whether or not an effect is observed.

Within each cycle, studies are conducted to determine if the effluent is having an effect on the following biological components including:

a) Fish Population: Studies conducted in exposure and reference areas;

b) Fish Tissue Studies: Only required if concentrations in effluent is equal to or greater than 0.1 µg/l or ppb – as determined by the effluent characterization program);

c) Benthic Invertebrate Community: Studies conducted in exposure and reference areas following the Canadian Aquatic Biomonitoring Network's (CABIN) protocols; and

d) Sediment sampling for analysis of particle size distribution and total organic carbon content. Sediment samples will be collected in replicates of three from active channels, placed in plastic containers and sent to an accredited laboratory where they are dried and sieved. Frequency of benthic and sediment sampling required by QZ18-044 is presented in Table 3-2.

The first study cycle (Cycle 1) is 30 months in duration, while subsequent cycles are 24 to 72 months in duration, depending on previous results (i.e., if an effect is indicated). A final cycle is required if notification of mine closure is issued. To avoid redundancy in sampling sites and monitoring programs, final discharge points for MDMER will be considered final discharge points under Water Licence QZ18-044.

Table 3-2: KHSD Sediment and Benthic Invertebrate Sampling Frequency under QZ18-044

Station	Sediment Sampling	Benthic Sampling
KV-38	Annual	Annual
KV-41	Annual	Annual
KV-6	Biannual	Biannual
KV-21	Annual	Annual
KV-42	Annual	-
KV-82	Annual	-
KV-104L	Annual	-
KV-104C	Annual	-
KV-111	Annual	Annual

4. PERMAFROST MONITORING

While the broad region in which the KHSD is located is generally characterized by discontinuous permafrost, Alexco Resource Corp. has not encountered significant permafrost anywhere in the District. Notwithstanding, geotechnical programs have identified areas of permafrost within operational areas; specifically, some permafrost was encountered beneath the Bellekeno mine N-AML Waste Rock Storage Area (WRSA) and in the vicinity of the Dry Stack Tailings Facility (DSTF). Ground temperature and permafrost monitoring is currently in place at these locations. Details on monitoring for the DSTF are included in the DSTF Operation, Maintenance, and Surveillance Manual, which forms a part of the DSTF Development and Operations Plan. Details on permafrost monitoring for the N-AML WRDA and P-AML WRSF are included in the KHSD Mining Operations Mine Development and Operations Plan. Appendix A provides analysis for potential effects from blasting occurring during the development of the Flame and Moth decline to the monitoring wells in the vicinity of the District Mill and DSTF. The analysis shows that with appropriate management of the blasting the integrity of the monitoring wells including the ground temperature and slope indicator monitoring will not be compromised. Monitoring outlined in the analysis will be undertaken as part of the plan to ensure the integrity of the instrumentation is not compromised.

Similarly, permafrost monitoring will be implemented should it be encountered during construction of facilities for new mine development in the District. Monitoring activities will consider the use of ground temperature and slope indicator monitoring devices to track potential changes in the ground conditions. Since much of the surface development is likely to occur on previously disturbed areas, the likelihood of encountering permafrost at surface is relatively low. However, if significant permafrost is encountered in areas of development an engineer will be consulted on the best practice to mitigate further degradation and plan around the permafrost laden material.

Specifically, for the final design, construction and operations of the phase 2 of the DSTF permafrost characterization and monitoring will be undertaken per Water Licence Clause 18 (below) and subsurface investigation program listed in Schedule C 1.5 (d) in the Quartz Mining Licence.

> 18. Prior to construction of the DSTF expansion, the Licensee must conduct a subsurface investigation program and submit the results of that investigation to the Board. The program must provide for representative sampling from the entire footprint of the DSTF expansion and include, but not be limited to:
> a) a minimum of 12 holes advanced to bedrock using a drill capable of recovering undisturbed frozen overburden samples;
> b) installation of sub-surface monitoring instrumentation including slope indicators and ground temperature cables; and
> c) laboratory testing of samples for shear strength, particle size and moisture content,
> as described in the Application in exhibit 1.13 .4 of Register QZ09-092-2.

5. PHYSICAL INSPECTIONS AND REPORTING PLAN

The purpose of physical inspection is to observe and record sufficient information for mine related structures to determine a course of action, repair or rehabilitation if it is required. Physical inspections are conducted under the Physical Inspections and Reporting Plan updated in October 2020 (Appendix B). Photo documentation at photo hubs is undertaken on a monthly basis in order to aid in identifying temporal changes and as a record keeping tool. The Physical Inspection and Reporting Plan describes scheduled physical inspections of infrastructure associated with the Bermingham, Bellekeno Mine, Flame and Moth, and District Mill operations. Information is collected through use of weekly and monthly checklists and reporting forms and any damage or movement is noted. If any seepage is noted from any water retaining structures it will be noted on the next monthly inspection report and a plan will be in place sample, test and manage the discharge within 60 days of the discovery. All annual monitoring and inspections for water conveyance and retaining structures and associated mine waste and earthworks structures will be conducted by a professional engineer.

In the vicinity of the Bellekeno mine, physical inspections include the Bellekeno 625 settling ponds, the Bellekeno East Temporary P-AML Waste Rock Storage Facility, and the haul road and Lightning Creek Bridge along the Keno City Bypass road. In the vicinity of the mill, physical inspections include the water supply and discharge pipelines and infrastructure, the mill site water collection and diversion structures, the mill site collection and sedimentation pond, the Flame and Moth P-AML facility and the dry stack tailings facility.

The Physical Inspection and Reporting Plan was updated in accordance with Water Licence QZ18-044 to include provisions for the Bermingham structures. Such facilities for Bermingham include settling pond, N-AML waste rock disposal area, and P-AML waste rock storage facilities.

6. METEOROLOGICAL MONITORING

Meteorological data have been collected in the KHSD since 2007 at the Calumet weather station (Figure 6-1) as part of the development of the ESM Reclamation supporting studies), since 2011 at the Keno District Mill meteorological station (installed as part of Bellekeno mining operations) and since 2012 at the Valley Tailings meteorological station. All three stations collect air temperature, relative humidity, rainfall, solar radiation, wind speed and wind direction, as per Clause 80. In addition, the Keno District Mill station has a snowfall conversion adaptor and calculates evapotranspiration, while the Valley Tailings station collects barometric pressure and soil water content. The Calumet station collects soil temperature. Instrumentation used at each of the weather stations is listed in Table 6-1, Table 6-2, and Table 6-3.

Alexco conducted manual snow surveys at thirteen monitoring stations in order to adequately represent the varying snow conditions as a function of aspect, elevation, etc. A Yukon Government monitored snow course station located at 1,310 masl elevation also exists in the area and has been monitored for over 30 years. Thirteen snow survey locations have been established at Keno Hill Silver District Mill Site, Bellekeno and New Bermingham sites, as per Clause 81. Information collected is submitted as part of the annual report.

Data collected from these stations will be used to update meteorological/hydrological information and water balances.

Table 6-1: Galena Hill HOBO Meteorological Station Components

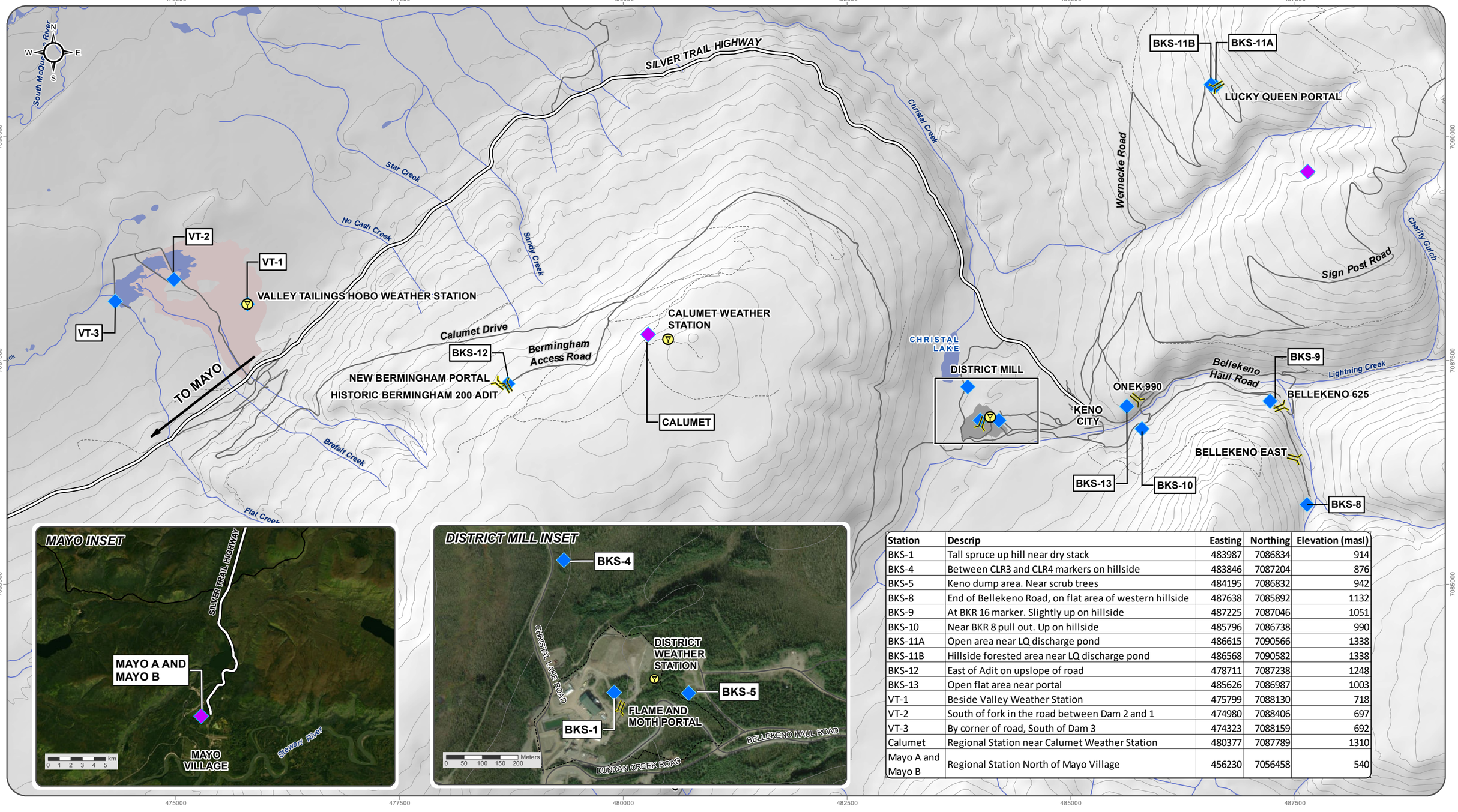
Component	Model	Serial Number
Datalogger	HOBO Weather Logger	1153440
Temp & RH Sensor	S-THB-XXXX	10064003
Soil Temp Sensor	S-TMB-XXXX	985390
Pyranometer	S-LIB-XXXX	1048627
Rain Gauge	S-RGB-M002	1017667
Wind Speed & Direction Sensor	S-WCA-XXXX	1254995
BP Sensor	S-BPA-XXXX	1037089

Table 6-2: District Mill Campbell Scientific Meteorological Station Components

Component	Model	Serial Number
Air Temperature and Relative Humidity Sensor	HMP45C212	n/a
Tipping Bucket Rain Gauge	TE525M	45303-910
Wind Speed and Direction Sensor	05103AP-10-L	WM105907
Solar Panel	SX320J	T21008289B30EC8
Datalogger	CR800	16119
Battery	PS-12120 F2	06299-HC
Pyranometer	SP Lite2	125766

Table 6-3: Valley Tailings HOBO Meteorological Station Components

Component	Model	Serial Number
Datalogger	U30 NRC	10231016
Input Expander kit		
Solar Panel	6W	
AC Power Adaptor	120V - 60Hz	
HOBOware	Pro	2580 2976 6309 4793
Temp & RH Sensor	THB-M002	10220040
Solar Radiation Shield	RS3	
Pyranometer	LIB-M003	10191222
Rain Gauge	RGB-M002	10222664
Light Sensor Bracket	LBB	
Light Sensor Level	LLA	
Wind Speed & Direction Sensor	WSET-A	10233230
Full Cross Arm	CAA	
BP Sensor	BPB-CM50	10212093
Soil Moisture Sensor	SMC-M005	10225679
Tripod	TPA-KIT 3m	



Station	Descrip	Easting	Northing	Elevation (masl)
BKS-1	Tall spruce up hill near dry stack	483987	7086834	914
BKS-4	Between CLR3 and CLR4 markers on hillside	483846	7087204	876
BKS-5	Keno dump area. Near scrub trees	484195	7086832	942
BKS-8	End of Bellekeno Road, on flat area of western hillside	487638	7085892	1132
BKS-9	At BKR 16 marker. Slightly up on hillside	487225	7087046	1051
BKS-10	Near BKR 8 pull out. Up on hillside	485796	7086738	990
BKS-11A	Open area near LQ discharge pond	486615	7090566	1338
BKS-11B	Hillside forested area near LQ discharge pond	486568	7090582	1338
BKS-12	East of Adit on upslope of road	478711	7087238	1248
BKS-13	Open flat area near portal	485626	7086987	1003
VT-1	Beside Valley Weather Station	475799	7088130	718
VT-2	South of fork in the road between Dam 2 and 1	474980	7088406	697
VT-3	By corner of road, South of Dam 3	474323	7088159	692
Calumet	Regional Station near Calumet Weather Station	480377	7087789	1310
Mayo A and Mayo B	Regional Station North of Mayo Village	456230	7056458	540

1:40,000 (when printed on 11 x17 inch paper)

0 500 1,000 1,500 2,000 Meters

- ERDC Snow Monitoring Station
- Regional Snow Monitoring Stations
- Audit
- AKHM District Mill
- Tailings Area
- Waterbody
- Watercourse
- Silver Trail Highway
- Other Road
- Limited-Use Road
- Contours (100 ft)

AKHM

ALEXCO KENO HILL MINING CORP.

FIGURE 6-1

METEOROLOGICAL STATIONS AND SNOW SURVEY STATIONS LOCATION

OCTOBER 2021

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(Last edited by: amadashevska; 2021-10-19/10:28 AM)

7. AIR QUALITY MONITORING

In accordance with Clause 69 of the Decision Document for the assessment of the Bellekeno Mine Project (YESAB File Number 2009-0030), dustfall monitoring was installed at two initial locations near the Keno District Mill site in March 2011 and two additional sampling locations were established in August 2011. Bergerhoff dust monitoring gauges were initially selected as the appropriate instrumentation to carry out this program. In accordance with Clauses 36 and 37 of the Decision Document for the assessment of the Onek and Lucky Queen Deposit production (YESAB File Number 2011-0315), total suspended particulates (TSP) monitoring was subsequently initiated in August 2012 and dustfall monitoring was discontinued in January 2013. Additional sampling for coarse and fine fractions of particulate matter (PM_{10} and $PM_{2.5}$ respectively) was instigated in August 2015, in accordance with the revised Dust Abatement and Monitoring Plan required in the Decision Document (Clause 19) for the assessment of the Flame & Moth Development and Production Program (YESAB file Number 2013-0161). This memorandum presents the results of the ambient air quality monitoring to date.

Two BGI Omni Ambient Air Quality Samplers (see Figure 7-1) were commissioned in August 2012, one to the East of the mill and crusher (TSP-1) and one at the toe of the dry stack tailings facility (TSP-2). A third sampler (TSP-3), located in Keno City, was commissioned in December 2014, in accordance with the revised Dust Abatement and Monitoring Plan required in the Decision Document for the assessment of the Flame & Moth Development and Production Program (YESAB file Number 2013-0161). The monitoring locations are shown on Figure 7-1.

The BGI Omni samplers are set up with TSP, PM_{10} or $PM_{2.5}$ inlets, and use the filter reference method. Samples are collected over 24-hour periods and sent to Maxxam Analytics laboratory for gravimetric analysis and ICP metals mass spectrometry (from TSP samples only). The sampling program aims to collect three samples per location every month, in order to capture the different weather conditions that may affect dust sources and transport. The BGI Omni Ambient Air Quality Samplers cannot collect samples below -20°C and therefore some winter months will have reduced data.

Results from TSP monitoring are compared to the Yukon Ambient Air Quality Standards (YAAQS) under the Environment Act. These standards for TSP are set at 120 µg/m^3 for a 24-hour average, and 60 µg/m^3 as an annual geometric mean. There are however no standards for metal concentrations in TSP in Yukon so results of metal speciation are compared to the Ontario Ambient Air Quality Criteria for reference. These criteria are summarized in Table 7-1.

Table 7-1: Ontario Ambient Air Quality Criteria (µg/m^3)

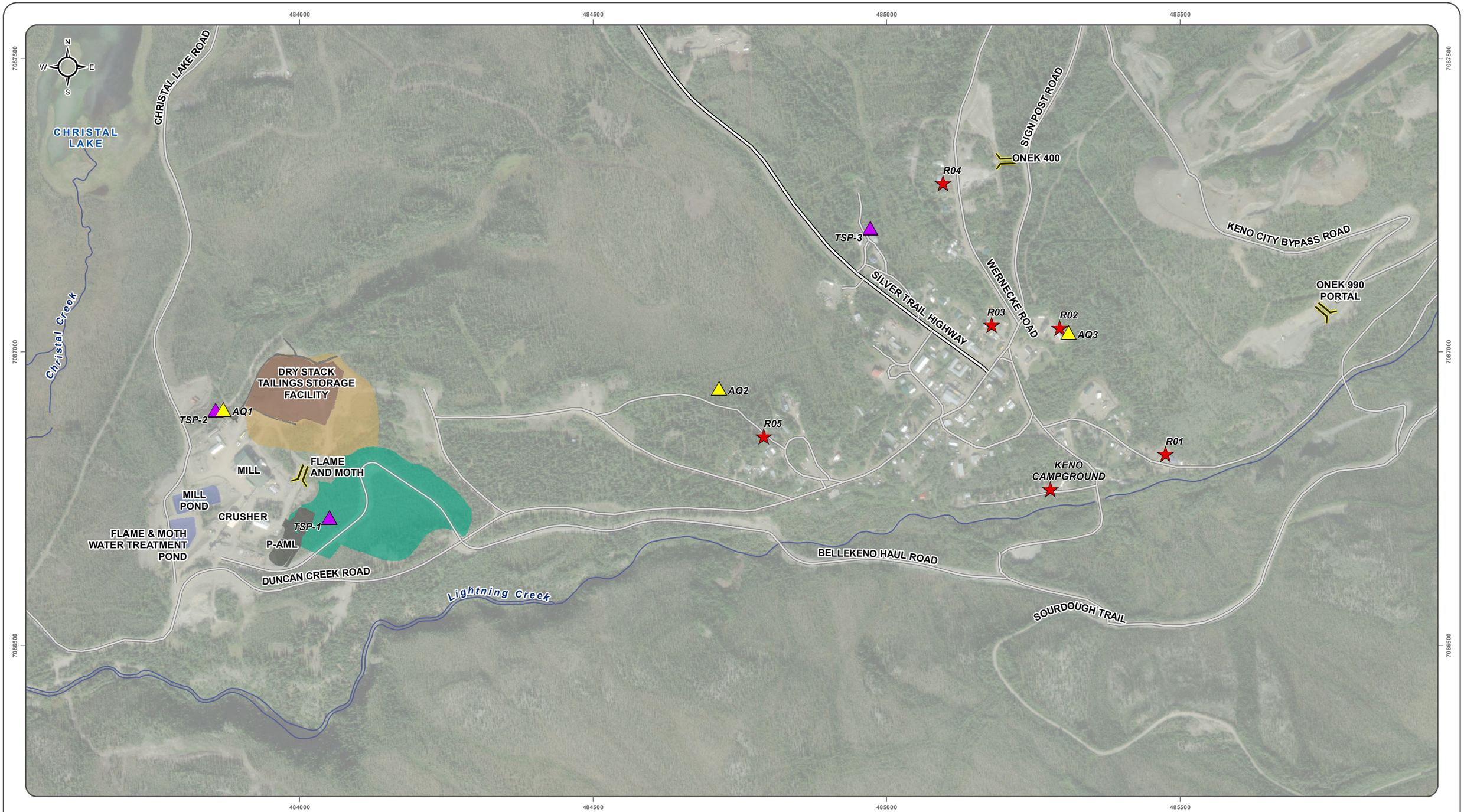
Parameter	Criteria
Antimony	25
Arsenic	0.3
Barium	10
Beryllium	0.01
Boron	120
Cadmium	0.025

Parameter	Criteria
Chromium	0.5
Cobalt	0.1
Copper	50
Iron	4
Lead	0.5
Manganese	0.4
Molybdenum	120
Nickel	0.2
Selenium	10
Silver	1
Strontium	120
Tin	10
Titanium	120
Vanadium	2
Zinc	120

As part of the YESAA process for Flame and Moth, an air dispersion model was run to predict ambient concentration of TSP, PM_{10} and $PM_{2.5}$ at sensitive receptors under three different operation scenarios. The main dust sources considered in the air dispersion model included the dry stack tailings facility (DSTF), mineral processing and the traffic on unpaved roads. In consideration of the results the air dispersion model, and in response to concerns raised during the YESAA process for Flame & Moth, AKHM will implement the following changes to its air quality monitoring program prior to resuming production at the District Mill:

- In addition to TSP monitoring which allows for metal speciation and comparison with the Ontario Ambient Air Quality Criteria, monitoring for PM_{10} and $PM_{2.5}$ will be carried out, as it represents the coarse and fine fractions of TSP that are inhalable and that may therefore have health impacts. This can be done by changing the inlet on the BGI Omni Samplers. Three samples per month will be collected from each location, for TSP, PM_{10} and $PM_{2.5}$. The 24-hour Yukon Ambient Air Quality Standard for PM_{10} is 50 µg/m^3 and 30 µg/m^3 for $PM_{2.5}$.
- The sampler located at TSP-1 will be relocated to the western limit of Keno City (AQ2; near receptor R05) to characterize ambient concentrations at sensitive receptors in Keno City (see Figure 7-1). Of the six discrete receptors used in the model, receptor R05 is where the highest concentrations were estimated under the three different scenarios.
- The sampler located at TSP-3 will be relocated to the eastern end of Keno City (AQ3; near receptor R02), to provide an understanding of how ambient concentrations vary throughout town (see Figure 7-1).
- The sampler located at TSP-2 (see Figure 7-1) remains in operation at the same location (renamed AQ1) to provide information on ambient concentrations within the Project area and to provide data continuity as this site has been monitored for TSP since August 2012.

In addition to air quality monitoring, continuation of pre-emptive and reactive dust control procedures as outlined in the DSTF Construction and Operation Plan, and Traffic Management Plan, will ensure that fugitive dusting does not become an issue.



Satellite imagery obtained from Yukon Geomatics map service http://mapservices.gov.yk.ca/ArcGIS/services on October 2021

Datum: NAD 83; Projection: UTM Zone 8N

1:6,000 *(when printed on 11 x17 inch paper)*

0 50 100 150 200 250 Meters

- Noise Monitoring Stations
- Former Air Quality Monitoring Station
- Proposed Air Quality Monitoring Station
- Adit

- Infrastructure Footprint
- Pond
- DSTF 322k Tonnes Design
- Current DSTF
- Permitted To Be Constructed Features

- Watercourse
- Silver Trail Highway
- Secondary Road

AKHM

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FIGURE 7-1

AIT QUALITY AND NOISE MONITORING STATIONS

OCTOBER 2021

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(Last edited by: amatlashevska;2021-10-19/14:14 PM)

8. NOISE MONITORING

AKHM has monitored noise at the five locations selected in the NIA as being potential noise receptors within a 2 km radius study area around Keno City. Since November 2013, noise has also been monitored at a sixth location, the Keno City Campground. These monitoring locations are listed in Table 8-1 and shown in Figure 7-1.

Table 8-1: Representative Locations Assessed in Keno City

Monitoring Location	GPS Location	Description
R01	N63.90827 W135.29599	East end Residence, north side of Lightning Creek Road
R02	N63.91019 W135.29968	Residence, east side of Sign Post Road
R03	N63.91023 W135.30205	Town Center, north from the Snack Bar
R04	N63.91239 W135.30376	Residence, west side of Wernecke Road
R05	N63.90851 W135.30993	Residence, about 850 m east from the Mill
Campground	N63.90772 W135.29998	Keno City campground

The background noise levels experienced by these locations vary considerably, depending on location and local activities. Climate parameters, such as relative humidity, temperature, and temperature inversions impact the sound level and propagation experienced by each of these receptors.

All readings prior to December 2014 were taken using an Extech integrating sound level datalogger model 407780 to measure average dBA over 10 minutes. All results were found to be below 70 dBA, and only occasionally exceeded 50 dBA. Results were however difficult to generalize due to the short sampling period, and interpretation can be confounded by extraneous events contaminating the noise record.

As of December 2014, noise monitoring was converted to 24-hr periods on a monthly basis, using a Casella CEL-63X Sound Level Meter and Casella CEL-495 Microphone (which includes a wind screen for outdoor use). Longer sampling periods were recommended by PAAE (2014), as well as measurement of Leq, percentile noise levels, octave and 1/3 octave band readings recorded. The isolation of contaminated noise sources is facilitated by the use of statistical noise levels in addition to Leq. This instrument also allows for the monitoring of low frequency noise (C-scale), which can now also be considered when assessing noise impacts.

Supporting information recorded at time of sampling includes detailed recording of mining intensity and wind conditions at time of noise measurements.

Additionally, AKHM will conduct instantaneous monitoring at specific locations, if it is warranted by a noise complaint.

Noise Impacts and sound monitoring are further discussed in the Noise Monitoring and Management Plan. The plan has been updated for Bermingham and includes the District Mill, and Flame and Moth (AEG, 2018).

9. WASTE ROCK MONITORING

Between May and October of each year, all waste rock management facilities are subject to monitoring for physical and geochemical stability (acid rock drainage and/or metal leaching) including seep surveys, as per Clause 96. The waste rock management plan presents rock characterization processes, field screening protocols, rock management, confirmatory testing and rock monitoring. A complete Waste Rock Management Plan was first prepared in 2009 and includes detailed descriptions of waste rock monitoring and mine wall testing. The waste rock monitoring plan was implemented in 2012 at the Bellekeno Mine with a detailed report testing and describing the effectiveness of waste rock screen procedures as presented in the plan (ACG, 2013). The Waste Rock Management Plan was updated in October 2020 to include the Bermingham deposit (Ensero, 2020b).

As part of annual reports for the Quartz Mining License and Water Licence a waste rock management summary report will be submitted presenting the results for all of the static and kinetic data generated from the Waste Rock Management Plan in a given year. The report will compare the field screening and on site classification of waste rock to the laboratory analysis outlining the effectiveness of the implementation of the plan including tonnage of waste rock brought to the surface and a percentage breakdown of the N-AML and P-AML for each mine site, as per Clause 97.

10. SPILL CONTINGENCY PLAN

The Spill Contingency Plan has been updated per Clauses 110 to 115 of Water Licence QZ18-044 that specifies:

> 110. Where a spill or an unauthorized discharge occurs that is of a reportable quantity under the Yukon *Spills Regulations*, the Licensee must immediately contact the 24-hour Yukon Spill Report telephone number, (867) 667-7244 and implement the Spill Contingency Plan. A detailed written report on any such event including, but not limited to, dates, quantities, parameters, causes and other relevant details and explanations, must be submitted to the Board not later than 10 days after the occurrence.
>
> 111. The Licensee must apply the relevant procedures in the Spill Contingency Plan. The Licensee must review the Spill Contingency Plan annually and must provide a summary of that review, including any revisions to the plan, as a component of the annual report.
>
> 112. The Licensee must maintain a log book of all spills or unauthorized discharge occurrences, including spills that are less than the reportable quantities under the Yukon *Spills Regulations*. The log book must be made available at the request of an Inspector. The log book must include, but not necessarily be limited to the:
> a) date and time of the spill;
> b) substance spilt or discharged;
> c) approximate amount spilt or discharged;
> d) location of the spill;
> e) distance between the spill or discharge and the nearest Watercourse; and
> f) remedial measures taken to contain and clean-up the spill area or to cease the unauthorized discharge.
>
> 113. The Licensee must include a summary of all spills or unauthorized discharges that occur, as part of the monthly reports, within 30 days of the spill occurrence.
>
> 114. The Licensee must ensure all relevant personnel are trained in procedures to be followed and equipment to be used in the containment of a spill.
>
> 115. The Licensee must post the Spill Contingency Plan on site for the duration of the project.

For more details, see the Spill Contingency Plan and the Emergency Response Plan updated in October 2020. All incident reports including the occurrence of a spill, should it occur, will be forwarded to the First Nations of Na-Cho Nyak Dun (FNNND).

11. ADAPTIVE MANAGEMENT PLAN (AMP)

The updated Adaptive Management Plan (AMP) (Ensero, 2020a) was prepared in October 2020 to fulfill Water Licence QZ18-044 conditions (Clause 58-59). The most recent AMP outlines the quantitative thresholds which trigger implementation of Adaptive Management with the summary AMP table provided below as Table 11-1: AMP Summary .

Table 11-1: AMP Summary

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
1. CHANGE IN WATER QUALITY OR QUANTITY					
a. Significant change in water quality of Bellekeno water treatment plant discharge, District Mill decant pond, Bermingham water treatment pond decant or Flame & Moth water treatment pond decant	Decline in discharge pH noted or effluent quality trending towards possible exceedance of standards or exceeds licenced standards.	All effluent quality standard parameters	Bellekeno and Mill discharge: Treated effluent: TSS>20 mg/L for three consecutive days; OR pH < 7.0 for three consecutive days; OR total zinc > 0.40 mg/L and pH < 7.0 for three consecutive days; OR total cadmium > 0.0075 mg/L and pH < 7.0 for three consecutive days; OR total arsenic > 0.075 mg/L and pH < 7.0 for three consecutive days; OR ammonia > 4.0 mg/L and pH > 9.0 for three consecutive days; OR weekly samples exceeds Effluent quality standards (EQS). Flame& Moth or Bermingham Discharge: Treated effluent: pH < 7.0 for three consecutive days; OR zinc or ammonia trending towards exceedance of EQS; OR three consecutive samples exceed 80% of the EQS; OR weekly sample exceeds EQS.	Bellekeno Water Treatment Facilities (KV-43), Mill Decant pond (KV-83), Flame & Moth settling pond decant (KV-104), Bermingham settling pond decant (KV-114)	Routine in-situ including ammonia and on-site total zinc, external multi-element ICP, hardness, pH, conductivity, TSS, ammonia
b. Significant change in water quality of adit discharge	Significant decline in field pH or increase in conductivity, zinc, cadmium or ammonia from mine adit discharge to treatment plant	Field pH and conductivity, zinc, cadmium, ammonia	Adit discharge field pH more than 1 pH standard unit lower than historical average or increasing trend towards historical maximum for ammonia, conductivity, cadmium, and zinc	Bellekeno adit (KV-42), Flame & Moth adit (KV-105), Bermingham adit (KV-110)	Same as indicators
c. Bellekeno adit discharge quantity significantly increases	Observed or measured flows display a sustained and statistically significant increase over historical flow conditions	Flow	Increase of flow to within 10% of the licenced maximum discharge rate (864 m^3/day) for seven consecutive days	Bellekeno Water Treatment Facilities (KV-43)	Same as indicators
d. Flame & Moth or Bermingham underground workings inflow rate significantly greater than	Observed or measured flows display a sustained and statistically significant increase	Flow	Increase of flow rate to within 10% of 3,024 m^3/day for seven consecutive days for Flame & Moth or increase of flow rate	Flame & Moth adit (KV-105) and Bermingham adit (KV-110)	Same as indicators

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
expected resulting in greater discharge than predicted	over predicted monthly inflow conditions		to within 10% of 1,200 m^3/day for seven consecutive days for Bermingham		
e. Identification and assessment of trends in water quality in discharges from the District Mill or the Bermingham, Bellekeno or Flame & Moth Mine sites for parameters without effluent discharge standards	Effluent quality trending towards decreased water quality	Parameters without effluent discharge standards (i.e., nitrate, nitrite, selenium, uranium, sulphate)	Increasing trend resulting in exceedance of water quality objectives in receiving environment	Bellekeno Water Treatment Facilities (KV-43), Mill Decant pond (KV-83), Flame & Moth pond decant (KV-104), Bermingham pond decant (KV-114)	Same as indicators
2. WASTE ROCK SEEPAGE EXHIBITS AML					
a. Waste rock seepage or runoff trending to AML conditions	Seepages from waste rock disposal areas or from works constructed or upgraded with N-AML material show significant decline in pH or alkalinity and/or an increase in conductivity, sulphate, zinc or cadmium OR approaching licenced effluent quality standards	pH, conductivity, zinc, cadmium, sulphate, alkalinity	Significant decline in pH between measurements or pH <7.0 and/or conductivity, zinc, cadmium, or sulphate or showing a significant increasing trend or alkalinity shows a significant decreasing trend; OR indicators approaching licenced effluent quality standards	Bellekeno 625 seep and WRDA, Bermingham WRDA and works or features constructed from N-AML material including Bellekeno Haul road, Mill area	pH, conductivity, alkalinity, sulphate, routine multi-element ICP
b. Identification of water quality changes from N-AML Waste Rock or tailings, including results from kinetic testing	Kinetic testing of N-AML waste rock or tailings shows significant decline in pH or alkalinity and/or an increase in conductivity, sulphate, zinc or cadmium	pH, conductivity, zinc, cadmium, sulphate, alkalinity	Significant decline in pH between measurements or pH <6.0 and/ or conductivity, zinc, cadmium or sulphate showing a significant increasing trend or decreasing trend in alkalinity; OR indicators approaching licenced effluent quality standards	Field bins or humidity cells with N-AML waste rock or tailings, DSTF and waste rock disposal areas	pH, conductivity, alkalinity, sulphate, routine multi-element ICP
3. SLUDGE STORAGE AREA EFFECTIVENESS COMPROMISED					
a. Seepage observed near sludge storage areas	Routine inspection of sludge storage area shows seepage	Total zinc, cadmium, pH	pH <7.5, total zinc > 0.5 mg/L, total cadmium > 0.01 mg/L	DSTF, Valley Tailings, and Bermingham SW pit sludge storage areas	Same as indicator
b. Sludge storage area approaching capacity	Sludge storage area approaching minimum freeboard of 1.0 metre below the decant point	Visual observation of freeboard	Freeboard is at 1.5 metre below decant point	DSTF, Bermingham SW pit and Valley Tailings sludge storage cell	Same as indicator

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
4. PHYSICAL INSTABILITIES					
a. Area of significant surface subsidence has occurred	An observed subsidence has exposed an opening to surface or resulted in slope failure	Visible slope failure, ground subsidence or opening on surface	Opening to underground workings or area of subsidence effects public safety or down gradient environment	Keno Hill Silver District Mining Operations	Same as indicators
b. Rock fall or landslide is observed that affects road right-of-way or intrudes into stream	An observed rock fall or landslide effects a road right-of-way, infrastructure or intrudes into stream	Mine source material movement	Source material affects road or stream	Keno Hill Silver District Mining Operations	Same as indicators
5. SITE SECURITY COMPROMISED					
a. Security gate, fence, sign damaged	Public health and wildlife safety measure damaged or removed	Sign, fence, gates, locks	Security feature damaged, removed, or compromised	Keno Hill Silver District Mining Operations	Same as indicators
6. DEVELOPMENT OF HIGH PORE PRESSURES UNDERNEATH OR WITHIN THE DSTF					
a. High porewater pressure within groundwater monitoring wells in the DSTF	Porewater pressure is observed in groundwater monitoring wells in the DSTF	Porewater pressure	Tip @1.0m or 1.7m depth – Porewater pressure parameter (Ru) exceeds 0.15	Groundwater monitoring wells in the DSTF	Same as indicators
7. DEVELOPMENT OF SIGNIFICANT EROSION OF EXPOSED DSTF SURFACES					
a. Area of significant erosion on exposed DSTF surface	An observed movement of tailings caused by erosion on surface	Visual inspection of tailings surface	Geotechnical engineer or operator inspection identifies adverse operating condition	DSTF	Same as indicators
8. DEVELOPMENT OF EROSION AT THE DISTRICT MILL OR FLAME & MOTH SITE DISCHARGE AREAS					
a. Erosion at the District Mill or Flame & Moth site discharge areas	Erosion and ground degradation is observed in area downgradient of the discharge locations	Visual inspection of area downgradient of discharge location	Geotechnical engineer or operator inspection identifies adverse operating condition	Visual inspection of area downgradient of discharge locations	Same as indicators
9. TRANSPORT OF SEDIMENT FROM THE DISTRICT MILL SITE, BERMINGHAM, OR FLAME & MOTH DISCHARGE AREAS INTO CHRISTAL CREEK					
a. Transport of sediment from the Mill site or Flame & Moth discharge areas to Christal Creek	An observation of significant erosion is observed in area downgradient of the discharge location resulting in high TSS discharge	TSS in discharge after final control point and visual inspection of area downgradient of discharge locations	TSS of 20 mg/L in daylighted discharge. TSS of 15 mg/L greater than monthly seasonal average calculated from existing conditions concentration at KV-50 and KV-21.	Area downgradient of Mill pond discharge (KV-83), Flame & Moth pond decant (KV-104), and Bermingham pond decant (KV-110)	TSS

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
			TSS at KV-81 in Lightning Creek is 25 mg/L higher than upstream of Flame & Moth discharge area on Lightning Creek.		
10. DEVELOPMENT OF LARGE DIFFERENTIAL SETTLEMENTS AT THE DSTF					
a. Significant differential settlements are observed in the DSTF	An observation of significant differential settlements is observed at the DSTF	Displacement of survey monitors and slope indicators	Displacements greater than 25 mm in any direction	Survey monuments and slope inclinometers	Same as indicators
11. DEVELOPMENT OF LARGE DIFFERENTIAL SETTLEMENTS ALONG THE CONVEYANCE FLUME FROM THE DSTF TO DISTRICT MILL SITE COLLECTION AND SEDIMENT POND					
a. Significant differential settlements are observed along the conveyance flume	An observation of significant differential settlements is observed in the conveyance flume	Displacement of survey monuments	Displacements greater than 25 mm in any direction	Survey monuments	Same as indicators
12. EXCEEDENCE OF WATER QUALITY OBJECTIVES IN THE RECEIVING ENVIRONMENT OCCURRING IRRESPECTIVE OF COMPLIANCE WITH EFFLUENT QUALITY STANDARDS					
a. A significant increasing trend is observed in receiving environment even though authorized licenced discharges are within effluent quality standards; Exceedance of WQO	Receiving environment water quality are trending towards exceeding the WQOs or exceed the WQO.	Arsenic, cadmium, copper, lead, nickel, selenium, silver, uranium, zinc, ammonia, nitrate, nitrite, sulphate	Trending towards or exceedance of water quality objective at a receiving environment monitoring station based on seasonal norms compared to preceding 3 years data.	Receiving environment monitoring stations (Christal Creek at KV-50, KV-6, and KV-7, Lightning Creek at KV-81, No Cash Creek at KV-111 and KV-21, and Star Creek at KV-56)	Same as indicators
13. IDENTIFICATION OF GROUNDWATER QUALITY IMPACTS WITHIN THE KENO HILL SILVER DISTRICT MINING OPERATIONS					
a. A significant increasing trend is observed in groundwater near the District Mill (including DSTF) or N-AML Waste Rock Disposal Areas	Constituent concentration exceeds baseline measurements for a given monitoring well or shows statistically significant increasing trend	Sulphate, ammonia, nitrite, nitrate, dissolved arsenic, cadmium, copper, lead, nickel, selenium, silver, uranium, and zinc	Exceedance of the 95th percentile for constituents that have a surface water quality objective OR YCSR standard. Statistically significant increasing trend compared to past three years of data	KV-85 to KV-89, KV-107, KV-108, KV-109, BH-39, KV91 to KV-94, KV-116, RB-MW-1, NC-MW-1	Same as indicators
b. Water level within groundwater monitoring wells in the DSTF and water quality is approaching KV-83 EQS	Water level is observed in monitoring wells within the DSTF	Water level, ammonia, dissolved arsenic, cadmium, copper, lead, nickel, silver, and zinc	More than 30 cm of water is in well and water quality trending towards KV-83 EQS	Groundwater monitoring wells in the DSTF (BH39, KV-107)	Same as indicators

Event	Narrative Trigger	Indicators	Thresholds	Monitoring Locations	Monitoring Parameters
14. FUGITIVE DUST GENERATED FROM THE DSTF RESULTS IN THE EXCEEDANCE OF YUKON AMBIENT AIR QUALITY STANDARDS					
a. Dust generated from the DSTF exceeds Yukon ambient air quality standards and metal guidelines	An increasing trend in fugitive dust from the DSTF and/or haul roads is observed	TSP, PM10, PM2.5 and metals	An increasing trend in TSP, PM10 or PM2.5 measurements or in metal concentrations towards Yukon Ambient Air Quality Standards or Ontario Ambient Air Quality Criteria for metals; An exceedance of the Yukon Ambient Air Quality Standards for particulate matter or the Ontario Ambient Air Quality Criteria for metals in TSP at AQ3.	AQ1, AQ2 and AQ3	Same as indicators
15. ATTENUATION OF THE FLAME & MOTH OR BERMINGHAM DISCHARGE TO CHRISTAL CREEK AND NO CASH CREEK, RESPECTIVELY, DOES NOT PERFORM AS PREDICTED					
a. Natural attenuation does not remove metals to the degree expected from Flame & Moth or Bermingham Mine discharge and water quality in Christal Creek or No Cash Creek may be degraded and not meet the water quality objectives	The calculated natural attenuation at KV-50 or KV-21 is less than 50% for any of these elements and the WQOs are exceeded for KV-50 or KV-21	Cadmium, nickel and zinc for Christal Creek and silver, arsenic, copper, nickel, lead and ammonia For No Cash Creek	Calculated natural attenuation at KV-50 or KV-21 is less than 50% for any of these elements and the WQOs for KV-50 or KV-21 are not met	KV-6, KV-50, KV-104, KV-21, KV-111, KV-114	Same as indicators

12. RECLAMATION EFFECTIVENESS MONITORING PROGRAM

With the cessation of mining, the monitoring and surveillance programs will be tailored to assess closure measures and continue as necessary. At closure, Water Licence QZ18-044 will undergo amendment to regulate activities around reclamation and reclamation monitoring. Post closure reclamation benchmarks should be well defined, measurable and documented. A thorough effectiveness monitoring program will allow for recognition of restoration successes and needed improvements.

The Conceptual Reclamation and Closure Plan for Keno Hill District Mining Operations (Revision 5 – July 2018) states:

> *"Monitoring activity will be required to determine the on-going and continued success of closure measures in meeting the closure objectives for a period of 10 years. The adaptive management approach will be used to determine thresholds identifying when remedial action have been triggered, and then the success of the remedial measures will need to be incorporated into the monitoring and surveillance regime."*

Proposed closure monitoring activities include:

- Water quality monitoring at some of the stations identified in the Water Licence;
- Monitoring of road bank and drainage along access road;
- Physical inspection of the passive water treatment systems;
- Physical stability of all waste rock disposal areas;
- Success of revegetation measures (principally portal area, DSTF and mill pad area);
- Monitoring of cover system integrity (P-AML WRSFs and DSTF); and
- Physical inspection of impacted earthen surfaces for evidence of erosion, gullying or sediment transport to watercourses.

Permafrost beneath the waste rock disposal areas will be monitored at least 10 years post closure, after which time the necessity of the requirement will be reviewed. An annual geotechnical inspection should be conducted on the waste rock disposal areas for at least 5 years post closure, after which time the necessity of this requirement will also be re-evaluated. Success of implementation of final reclamation will be measured by the ability to achieve stated closure objectives in the Reclamation and Closure Plan. The Reclamation and Closure Plan has been updated to include Flame and Moth.

As part of progressive reclamation monitoring will be completed to assess the effectiveness of the progressive reclamation activities completed on an annual basis. For example, the progressive reclamation completed for the DSTF cover, monitoring has been conducted and will continue to be conducted to assess the cover effectiveness including infiltration, stability/erosion, vegetation establishment and metal uptake in cover vegetation. The vegetation monitoring program will be established to measure the success of interim revegetation and gain information about cover effectiveness, vegetation health and metal uptake to inform final closure revegetation prescriptions. Vegetation monitoring will occur on a reoccurring timeline to build a temporal dataset of vegetation success and performance.

13. REPORTING

Reporting on water quality monitoring and management issues will be directed to the Yukon Water Board (YWB) and YG Energy, Mines and Resources in accordance with the requirements of the Water Licence (Part I, Clause 119 and 120) and Quartz Mining License (Clause 13). Monthly and annual reporting will be carried out during mine development activities and through the implementation of site decommissioning until it can be demonstrated through the monitoring results that the final closure objectives have been achieved.

Alexco also continues to liaise with the regulatory agencies, FNNND, the Mayo Renewable Resource Council and the local communities on environmental issues relating to KHSD mining operations; all monthly and annual reports are provided to FNNND.

14. REFERENCES

Access Consulting Group (ACG), 2013. 2012 Waste Rock Management Plan, Keno Hill Silver District Mining Operations.

Alexco Environmental Group (AEG), 2018. Noise Monitoring and Management Plan Keno Hill Silver District Mining Operations.

Ensero Solutions Canada Inc. (Ensero), 2020a. Adaptive Management Plan Keno Hill Silver District Mining Operations

Ensero Solutions Canada Inc.. (Ensero), 2020b. Waste Rock Management Plan Keno Hill Silver District Mining Operations, Revision 6.4.

Patching Associates Acoustical Engineering Ltd. (PAAE), 2014. Noise Impact Assessment Update, Alexco Keno Hill Mining Corp., Proposed Flame and Moth Mine Project, Yukon Territory. Prepared for Yukon Environmental and Socio-Economic Assessment Board (YESAB), September 23, 2014.

APPENDIX A

GROUNDWATER MONITORING PLAN (OCTOBER 2020)

KENO HILL SILVER DISTRICT MINING OPERATIONS

GROUNDWATER MONITORING PLAN

October 2021

Prepared for:

ALEXCO KENO HILL MINING CORP.

Prepared by:

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1. INTRODUCTION

1.1 PURPOSE OF THE PLAN

This plan was originally submitted to fulfill the conditions set out in Part H, Clauses 85, 86, and 87 of Water Licence QZ09-092 issued to Alexco Keno Hill Mining Corp. (AKHM or the Company) on August 19th, 2010. This plan was subsequently updated to fulfill the conditions set out in Part G, Clauses 94, 95, 96 and 97 of Water Licence QZ12-053 issued to Alexco Keno Hill Mining Corp. (AKHM) on May 16th, 2013. The Plan was revised to fulfill the conditions set out in Part G, Clauses 105, 106, 107, 108 and 109 of Water Licence QZ09-092-2 issued to AKHM on December 22, 2017.

This version of the Plan has been updated to fulfill the conditions set out in Part F, Clauses 45, 46 and 47 of Water Licence QZ18-044 (hereafter referred to as the Licence) issued to AKHM on July 22, 2020 as summarized below:

45. Within 90 days of the effective date of this Licence, the Licensee must submit to the Board an update to the Keno Hill Silver District Mining Operations: Groundwater Monitoring Plan (GMP), dated January 2018. The updated plan must include all groundwater monitoring associated with the Bellekeno Mine, Keno Hill Silver District Mill Site, and Flame and Moth Mine, Historic Bermingham SW Open Pit and New Bermingham Mine.
46. With respect to groundwater monitoring:
    a. the Licensee must install the following:
        i. one groundwater well within the DSTF Phase 2 Expansion area (KV-107) to be installed as part of the DSTF expansion;
        ii. one groundwater well upgradient of the DSTF Phase 2 Expansion area (KV-108) six months prior to the expansion;
        iii. at least three groundwater monitoring wells within 100 meters of the Historic Bermingham SW Open Pit prior to placement of any sludge;
        iv. at least three groundwater monitoring wells within 100 meters of the historical waste rock dump underlying the proposed New Bermingham P-AML facility prior to commencement of operations at the New Bermingham Mine; and
        v. at least three groundwater monitoring wells within 100 meters of the VTBSSA prior to disposal of any sludge;
    b. groundwater monitoring wells must be:
        i. designed, installed, and developed under the supervision of a qualified professional;
        ii. individually completed at all depths required to monitor upgradient and downgradient groundwater level and quality for these features;
        iii. equipped with datalogging pressure transducers (and an associated barometric logger) to log groundwater level, at minimum frequency of daily; and
        iv. sampled and manually monitored monthly for groundwater level and a full suite of field and laboratory parameters for the first 12 months from installation after which time sampling frequency can occur quarterly.
47. Upon installation of a groundwater monitoring well(s), the Licensee must submit as part of the next monthly report, the geographical coordinates for any newly finalized monitoring stations.

In addition, Part H Clauses 82, 83, 84, 85, 86 87,119 and 120of the Licence provided additional guidance on the groundwater monitoring program:

82. The Licensee must compare groundwater monitoring data to the Yukon Contaminated Sites Regulation (YCSR) Schedule 3: Generic Numerical Water Standards (Aquatic Life) and submit the data and analysis as part of the annual report.
83. The Licensee must compare data from wells screened in the potable, or potentially potable aquifer near Keno City to the YCSR Schedule 3: Generic Numerical Water Standards (Drinking Water Standards) and submit the data and analysis as part of the annual report.
84. The Licensee must submit all documentation and data produced by the Groundwater Monitoring Plan (GMP) as part of the monthly report and ensure all monitoring and reporting is certified by a professional hydrogeologist registered with a provincial regulatory organization.
85. The Licensee must provide the Board with a summary of hydrogeological monitoring which interprets the sources of inflows and contaminant loads into the underground mine workings as part of the annual report.
86. For those wells subject to freezing, pressure transducers must be installed as soon as wells are ice-free.
87. The Licensee must adhere to the groundwater monitoring schedule in Schedule B3 with the exception that:
    a. Sampling of all wells must be completed monthly after installation for the first twelve months where they contain water. Sampling can revert to quarterly as shown in Schedule B3, following the first twelve samples; and
    b. The Licensee must monitor the water level in all groundwater monitoring wells where water is present at least monthly for the first year. Water level monitoring can be reduced to quarterly after the first twelve monthly readings are completed.

119. The Licensee must submit an annual report to the Board for the period of January 1 to December 31 of each year. Annual reports are to be submitted on or before March 31 of the year following the year reported. The annual report must include the information required by the Regulation as well as:

    f. documentation and data produced by the HMP as required by Clause 49;
    g. updated site groundwater contour maps as required by Clause 50;
    h. if required by Clause 50, an update to the conceptual site groundwater model as required by Clause 51;
    x. all data generated as a result of the monitoring requirements of this licence, including analysis and interpretation by a qualified individual or firm and a discussion of any variances from baseline conditions or from previous years' data; analysis of predictions vs real data model trajectory;
    z. a discussion of any proposed changes to the monitoring programs or WQOs; and

120. Unless otherwise specified in this Licence, the Licensee must submit to the Board a copy of all monitoring data no more than 30 days after the conclusion of the month in which that data was collected. Monthly reports must include:

a. a summary of recent groundwater monitoring well(s) installation as required by Clause 47, when applicable;
f. all data collected in accordance with Schedule B3.

2. MINE LOCATION AND DESCRIPTION

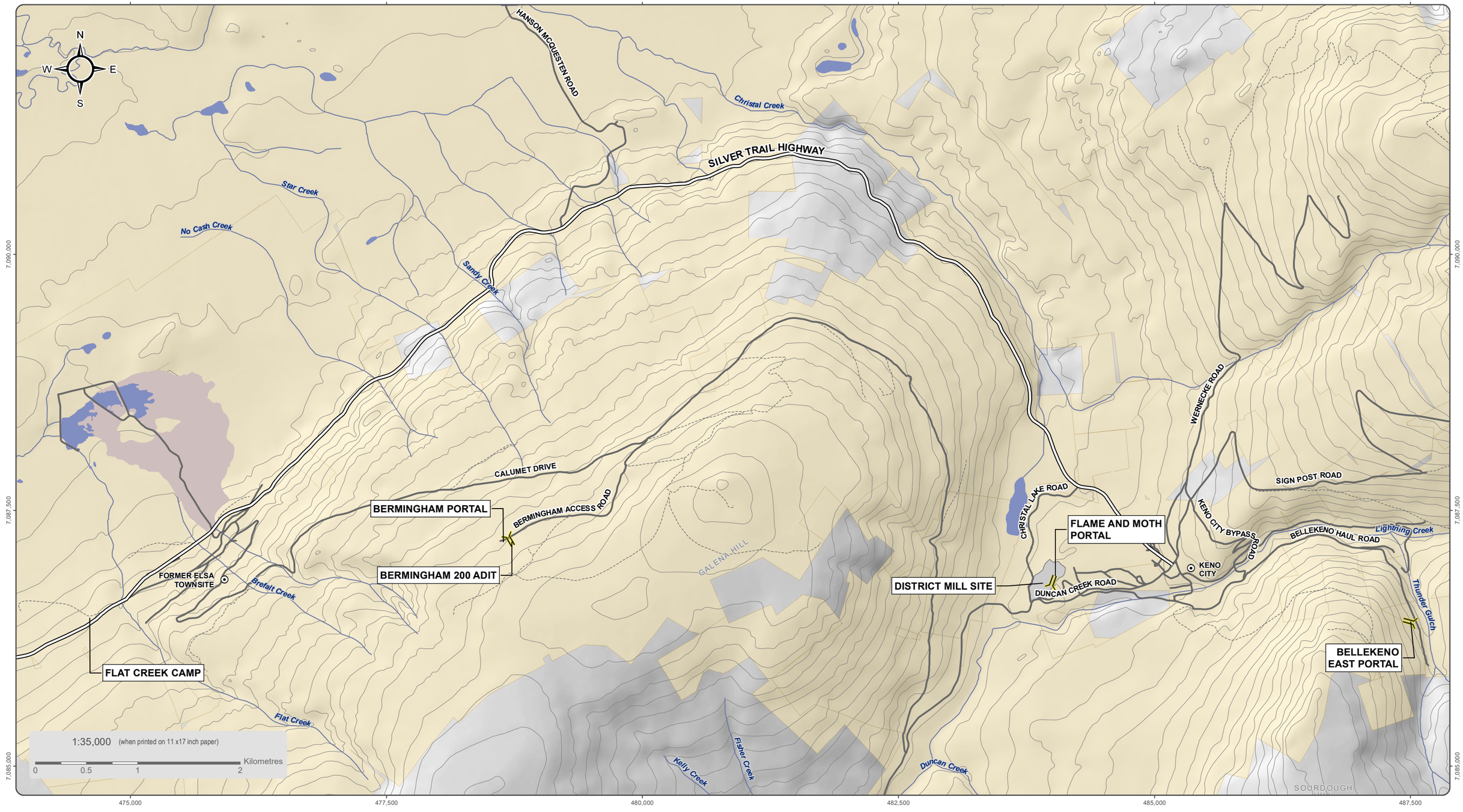
The KHSD is located in central Yukon (63° 54' 32" N, 135° 19' 18" W; NTS 105M/14 & 105M/13), 354 km due north of Whitehorse. Access to the property is via the Alaska, Klondike and Silver Trail Highways from Whitehorse to Mayo (407 km) and an all-weather gravel road northeast from Mayo to Elsa (45 km); a total distance of 452 km. The KHSD is located on and around Galena Hill, Keno Hill and Sourdough Hill and are collectively known as the KHSD. The property lies along the broad McQuesten River valley with three prominent hills to the south of the valley. The property, as well as the mines covered under the water license are located on Figure 2-1.

The District Mill Site and Dry Stack Tailings Facility (DSTF) are located approximately 1 km west of Keno City. The mill site contains offices, crusher, water management ponds, water supply well, and other infrastructure.

The Flame and Moth mine is located adjacent to the District Mill. Currently the portal and the first 20 m of ramp down towards the ore body have been constructed. Up to 8,000 m^3 of mine workings are planned for future development.

The Bellekeno portal is located on a slope in Thunder Gulch, which is narrow tributary of Lightning Creek. The mine site is ~ 3km to the mill site, which crosses over Lightning Creek. The Flame and Moth mine is located adjacent to the District Mill.

The Bermingham deposit is located on northwest slope of Galena Hill ~6.8 km east of Keno City in the No Cash Bog catchment. Bermingham Mine is located up gradient from the Ruby Mine and is drained by the Bermingham 200 adit, which is located at an elevation of ~1,250 masl. The Bermingham 200 adit is near the plateau area of Galena Hill, which limits the available gradient towards the mine opening and there is some recharge from the overlying pit.



Datum: NAD 83; Map Projection: UTM Zone 8N

- Place of Interest
- Adit
- Alexco/ERDC Quartz Claims
- Tailings Area
- Waterbody
- Watercourse
- Silver Trail Highway
- Road
- Limited-Use Road

AKHM

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FIGURE 2-1
KENO HILL SILVER DISTRICT MINING OPERATIONS OVERVIEW

OCTOBER 2020

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3. PREVIOUS GROUNDWATER STUDIES

Surface and underground mining conducted throughout the KHSD have altered natural groundwater flow such that mine workings dictate recharge/discharge. Groundwater is most likely to travel from high elevation to low elevation, resulting in a water table (phreatic surface) that is a muted image of the surface topography. Much of the groundwater flow is concentrated at relatively shallow depths, as shallower material typically has higher hydraulic conductivities.

Extensive groundwater studies have been conducted throughout the KHSD, which include reasonably extensive mapping of the geology and mine development in the District, hydrogeological investigations and ongoing monitoring, as well as a Conceptual Model and Preliminary 3D Groundwater Model that also includes preliminary particle tracking to map of the potential groundwater flow paths.

The following subsections summarise the main findings for groundwater flow paths from the AKHM proposed and license mines.

3.1 FLAME AND MOTH, ONEK, AND KENO CITY

In 2009, SRK Consulting Canada Inc. (SRK) was retained by AKHM to investigate groundwater conditions at the Mill Site in relation to Keno City and Lightning Creek. Three groundwater monitoring wells were installed for this program (PH2, PH5, and PH6). These wells will be referred to in this plan according to their KV station numbers as listed in Schedule A of the Licence (KV-85D, KV-86 and KV-87), respectively. Key findings of the SRK groundwater investigation (SRK, 2010) include the following:

- The water table is in bedrock beneath the site. South of the site, the water table in a relatively thick overburden unit at a depth of greater than 25 meters below ground surface;
- Water-level data from monitoring wells at site and Keno City indicate that groundwater flows from east to west/northwest); that is, from Keno City towards the Mill Site and Christal Lake;
- Water level data also indicate ground water flow from Lightning Creek towards the Keno City area; and
- The probability of groundwater wells in Keno City being affected by Mill activities is very low given the current understanding of local groundwater gradients and large distance between the Mill Site and Keno City.

Interralogic, Inc. conducted a groundwater evaluation for Keno City between October 2010 and March 2012. During this program, two trenches were excavated within the dry stream channel downstream of the Onek 400 adit, and these verified that the adit discharge was not flowing within the channel alluvium. As part of the groundwater evaluation, Interralogic installed five monitoring wells in the Keno City area (KC-MW-1a, 1b, 2, 3, and 4) to determine water levels, water chemistry, and approximate material transmissivities. Interralogic sampled these five wells, as well as a monitoring well, ON-MW-1, installed in 2011 to understand groundwater elevations near the historic Onek waste rock dumps and open pit.

To evaluate groundwater flow paths, water levels in available wells were measured and water-level contour maps were prepared (ITL, 2012a). Based on this evaluation, Interralogic set forth the following conclusions:

- There is a convergence of southwest and northward flowing groundwater below the central portion of Keno City.

- The groundwater below Keno City is conveyed northwest along a postulated feature that appears to have higher permeability than adjacent geologic units. Evidence for this is:
    - The interpretation that groundwater converges toward this feature;
    - The change in hydraulic head is relatively small between upgradient wells in Keno City and downgradient wells MW-1A, MW-1B, and MW-2; and
    - The relatively high initial yield of the Firehall well (57 to 96 litres per minute), which is located within the postulated high permeability feature.
- Water-level contours suggest that groundwater discharges to Lightning Creek east of Keno City. However, South of Keno City, there appears to be seepage loss from the stream that recharges the groundwater system below the townsite. The zone of seepage loss from the stream could be associated with the southeast extension of the postulated higher permeability feature.
- At and downgradient (west) of the Onek 400 portal, the groundwater flow direction is generally southwest towards the postulated higher permeability feature, but not towards any of the Keno City water wells.

In September 2012, Interralogic completed a preliminary conceptual groundwater model for the proposed Onek 990 mine workings and two potential pathways were identified (ITL, 2012b). The first was a direct pathway from the mine to Keno City, with bedrock monitoring well ON-MW-02 providing an adequate monitoring location to identify if Onek 990 mine water were to migrate in that direction. The second pathway was perpendicular to the water-level contours, but following a trajectory where groundwater would veer east of the mine before migrating through Keno City. The overburden monitoring well KC-MW-4 is along this pathway; however, a bedrock well (ON-MW-3), was recommended as an additional monitoring point along the pathway. The overburden/bedrock well combination was considered adequate to monitor if Onek 990 mine water were to migrate along this pathway (ITL, 2012b).

During August and September 2013, three deep monitoring wells (FM-MW-1, FM-MW-2 and FM-MW-3) were installed in and around the Flame and Moth deposit. Interralogic Inc. summarised the results from the drilling and associated air-lift testing of these wells (ITL, 2013). A long-term (72 hour) air-lift pump test was conducted on well FM-MW-1 to provide data for estimating the potential mine inflows for the Flame and Moth Mine. At maximum mine depth of about 270 mbgs the computed inflow rate is 35 L/s (ITL, 2013). The Interralogic report concludes that Flame and Moth Mine dewatering would not have a significant impact on surface water flows in Lightning Creek and it is highly unlikely that mine dewatering would have an effect on groundwater levels and the availability of water supply in the Keno City area.

Morrison Hershfield (MH) was retained by Yukon Government (YG) Community Services (CS) in 2015 to upgrade the Keno City Firehall well to meet current well-head construction standards. During the rehabilitation, an open portion of the hole collapsed and had to be re-bored with steel casing driven down the hole to prevent further collapse. Following the rehabilitation work, the Fire hall well was sampled and it was found that the water quality had deteriorated such that concentrations of arsenic and uranium no longer met the Guidelines for Canadian Drinking Water Quality.

In 2016 MH was retained by YG CS to conduct a review of the groundwater resources around Keno City and provide support for future water supply options. MH created a conceptual hydrogeological model which describes two distinct aquifer systems below Keno City; the overburden aquifer and the bedrock aquifer (MH, 2017).

- The saturated thickness of the overburden aquifer within Keno City is thin, generally less than 10 m, and is not suitable for water production, even for low-flow, small scale, municipal groundwater supply. The groundwater chemistry of the overburden aquifer is variable from well to well, but is typically quite mineralized and contains parameters that do not meet the aesthetic and health-related parameters of the GCDWQ.
- The bedrock aquifer is fractured and has a greater potential for groundwater production; however, the wells are typically low-yield (produce only a few gallons per minute). The bedrock groundwater is typically of lower quality than the overburden aquifer, with water chemistry that is very mineralized and contains parameters that do not meet the aesthetic and health-related parameters of the GCDWQ.

The overarching conclusion of the MH report was that any groundwater in the Keno City area used for municipal water supply would likely require advanced treatment to meet the GCDWQ (MH, 2017).

3.2 BERMINGHAM

In 2016, Piteau Associates Engineering Ltd. (Piteau) developed a preliminary groundwater model for the KHSD for Elsa Reclamation and Development Corporation for mine reclamation. The preliminary model included particle tracking to determine probable groundwater flow paths from historic mine workings. The particle tracking indicates that regional groundwater derived from the Ruby, Bermingham, and No Cash Mine workings discharges downgradient between the lower reaches of Star Creek and Christal Creek (Piteau, 2017).

In October 2016 drilling and testing of two boreholes at Bermingham were performed. The best-estimate hydraulic conductivities were calculated for the two boreholes and were found to be similar, providing evidence that the rock mass is relatively homogeneous with regard to hydraulic properties. The average of the calculated hydraulic conductivities is 4.3×10^{-6} cm/s, which is taken as the best-estimate of the large-scale (bulk) hydraulic conductivity for rock within the mine area. Based on the average hydraulic conductivities a portal discharge rate during closure was estimated to be 2.L/s (AEG, 2017).

4. REGIONAL GEOLOGY AND HYDROGEOLOGICAL IMPLICATIONS

The long history of mining and exploration in the KHSD means that regional geology has been well studied. Although no comprehensive studies specific to groundwater have been completed in the district, a number of observations can be made relating to bedrock and surficial geology and their hydrogeological characteristics. Some background information pertinent to district geology and groundwater, are summarized below from the Environmental Conditions Report (Ensero, 2020a).

The KHSD is underlain primarily by Yukon Group metasedimentary rocks, locally divided into three formations; Upper Schist, Central Quartzite and Lower Schist. The Upper Schist (Hyland Group, pre-Cambrian to Cambrian age) overlies the quartzite in what is inferred to be a thrust contact (Robert Service Thrust) and consists of quartz-mica schist, quartzite, graphitic schist and minor limestone.

The Central Quartzite (Keno Hill Quartzite, Mississippian age) contains thick-and thin-bedded quartzite, massive quartzite, graphitic phyllite, graphitic schist, calcareous schist and minor Triassic greenstone. This unit is approximately 700 m thick and host most of the past producing ore bodies. Structurally juxtaposed below the quartzite is the Lower Schist which includes graphitic schist, argillite, thin-bedded quartzite, calcareous schist, phyllite, slate, sericite schist, minor thick-bedded quartzite and locally significant intervals of Triassic greenstone. The greenstone forms sills and / or boudins and consists of metadiorite and metagabbro. A number of quartz-feldspar porphyritic sills have intruded the stratigraphy parallel to schistosity. The sills are most common in the Lower and Upper Schists and can reach thicknesses of up to fifty metres.

Structurally, the property is characterized by four sets of faults; many of which have been filled by hydrothermal minerals veins. The oldest fault set consists of south dipping structures that are generally parallel to foliation. Locally, brittle deformation has been observed along these structures. A second fault set, known as “longitudinal veins”, strikes north east to east northeast and dips steeply southeast. Depending on the competency of the host rock, longitudinal veins can be up to thirty metres wide in an anastomosing system of sub-veins. Essentially, all mineralized rock was mined from these longitudinal veins. A third set of faults, known as “transverse faults”, is north-west striking and dips steeply to the north. Transverse faults typically do not contain silver and lead mineralization but are commonly filled by quartz with trace to minor arsenopyrite, pyrite and jamesonite.

A younger set of faults, known as cross faults, strike north to north east with a dip of sixty degrees west to south west and offset vein or longitudinal faults by up to 2,000 metres.

At Keno Hill, the largest accumulation of ore minerals occurred in structurally prepared competent rocks, such as the Central Quartzite, resulting in areas of increased fluid flow. Incompetent rocks like phyllites tend to produce fewer and smaller, if any, open spaces, limiting fluid flow and resulting mineral precipitation.

Mineralization in the District is of the polymetallic silver-lead-zinc vein type. In general, common gangue minerals include manganiferous siderite and to a lesser extent quartz and quartz breccia as well as calcite. Silver occurs in argentiferous galena and argentiferous tetrahedrite (freibergite). In supergene assemblages, silver is further found as native silver, in polybasite, stephanite, and pyrargyrite. Lead occurs in galena and

zinc in iron-rich sphalerite. Other sulphides include pyrite, arsenopyrite (locally gold-bearing) and chalcopyrite.

The veins of the District display characteristics associated with both mesothermal and epithermal deposits and it is not clear if a continuum exists or if separate and distinct mineralizing events are involved. The most prominent examples of epithermal style mineralization are found in the western part of the District, although the Lucky Queen mine on Keno Hill produced native silver and ruby silver in quantity. Proximity to a magmatic heat source has often been called upon to explain the District zonation, though this is by no means a complete explanation.

Mineral zonation is common within base metal-rich veins (zinc-rich margin and silver/lead-rich center). Changes in mineralogy within individual ore shoots are less clearly documented, although there has long been a conviction that silver and lead rich zones occur higher in the veins while zinc becomes dominant at depth. Anecdotal evidence suggests that vertically stacked ore shoots may repeatedly show zoning of lead rich upper portions to zinc dominant roots, but data confirming this has not been found. In general, lead-zinc mineralization appears to be nearly contemporaneous in age.

Irrespective of stratigraphic formations or regional map units only a few major rock types are commonly encountered in the area of the old mine workings. These are:

- schists and phyllites with variable carbonate content;
- chloritic phyllites or schists;
- quartzites and phyllitic quartzites;
- sericite-quartz phyllites; and
- greenstones.

SRK (2009) further described the bedrock geology of the site as it relates to hydrogeological characteristics:

"The bedrock geology of the area around Keno consists predominantly of layered metasedimentary rocks consisting mainly of quartzite, schist and phyllite. Unlike high yielding aquifer rocks such as sandstone, where groundwater can flow through connected 'pores' in the rock mass, the metasediments typically found in the Keno Hill district have a very low permeability, with little or no space between rock grains due to the metamorphosed character. The main medium through which water travels in these metasedimentary rocks therefore is via fractures and joints within the rock. The permeability of the rock (or the ease at which groundwater can flow through the rock formation) in this case is dependent on how many fractures are within the rock, and how well they are connected to each other, and how well connected to a water source (such as rainfall, a lake or a river) these fractures are."

SRK (2009) also describes surficial sediments and their hydrology:

"Shallow surficial sediments are found locally and typically are present in topographic lows which control surface drainage patterns. These overburden deposits have limited thickness and lateral extent, and likely form only small local aquifers. It is generally recognised that metasedimentary rocks do not commonly form high yielding aquifers. Fractures are not typically well connected and the resulting permeability is low. Evidence for this around Keno City can be seen in the characteristic marshy conditions seen in the area. The surface water found within these marshy areas is unable to drain easily

down through the underlying rocks. The regional groundwater flowpaths can be generally described as mimicking surface water pathways."

It is further recognized in that the presence of complex glacial and glaciofluvial sediments present in the valley bottoms and along the margins of the hills produces complex overburden stratigraphy. Overburden thickness and composition are known to vary widely, which can result in complex hydrology (e.g., perched aquifers) and generally poor drainage and low permeability. Also, the ubiquitous presence of permafrost and, in some areas, massive ground ice further complicate near surface groundwater regimes. In general, surficial sediment drainage can be described as generally poor, and complex, while bedrock hydrogeology can be described as generally low permeability with groundwater flow controlled by fractures and joints.

5. DISTRICT MILL AND FLAME & MOTH GROUNDWATER MONITORING

As per Clause 109a of Licence QZ09-092, three multi-level groundwater monitoring wells were installed down gradient of the DSTF. Clause 97 of Water Licence QZ09-092 specified that three multi-level groundwater monitoring wells (e.g., Westbay type) are to be installed down gradient of the DSTF. However, because of the known challenges in the ground conditions near the DSTF (the presence of permafrost and massive ice, in some cases), AKHM believes that separate boreholes to monitor each potential groundwater zone (shallow overburden, and deep bedrock) are more likely to provide reliable results than complicated multi-level monitoring well systems, which are more likely to fail. The decision to use individual monitoring wells was also based on discussions with professional hydrogeologists experienced in monitoring well installations.

AKHM believes that the intention of Clause 109a of QZ09-092 was to ensure that three relatively shallow overburden monitoring wells and three deeper, bedrock groundwater monitoring points were installed down gradient of the DSTF to allow for monitoring of both shallow and deep groundwater. AKHM complied with Clause 109a of QZ09-092 through the use of the groundwater monitoring network described below in Table 5-1 and shown on Figure 5-1. The selection of these wells were based on a review of available geotechnical and hydrogeological information for the site and in discussion with EBA Engineering Consultants on the location of ground ice in this area.

Table 5-1: District Mill Site Groundwater Monitoring Well Summary

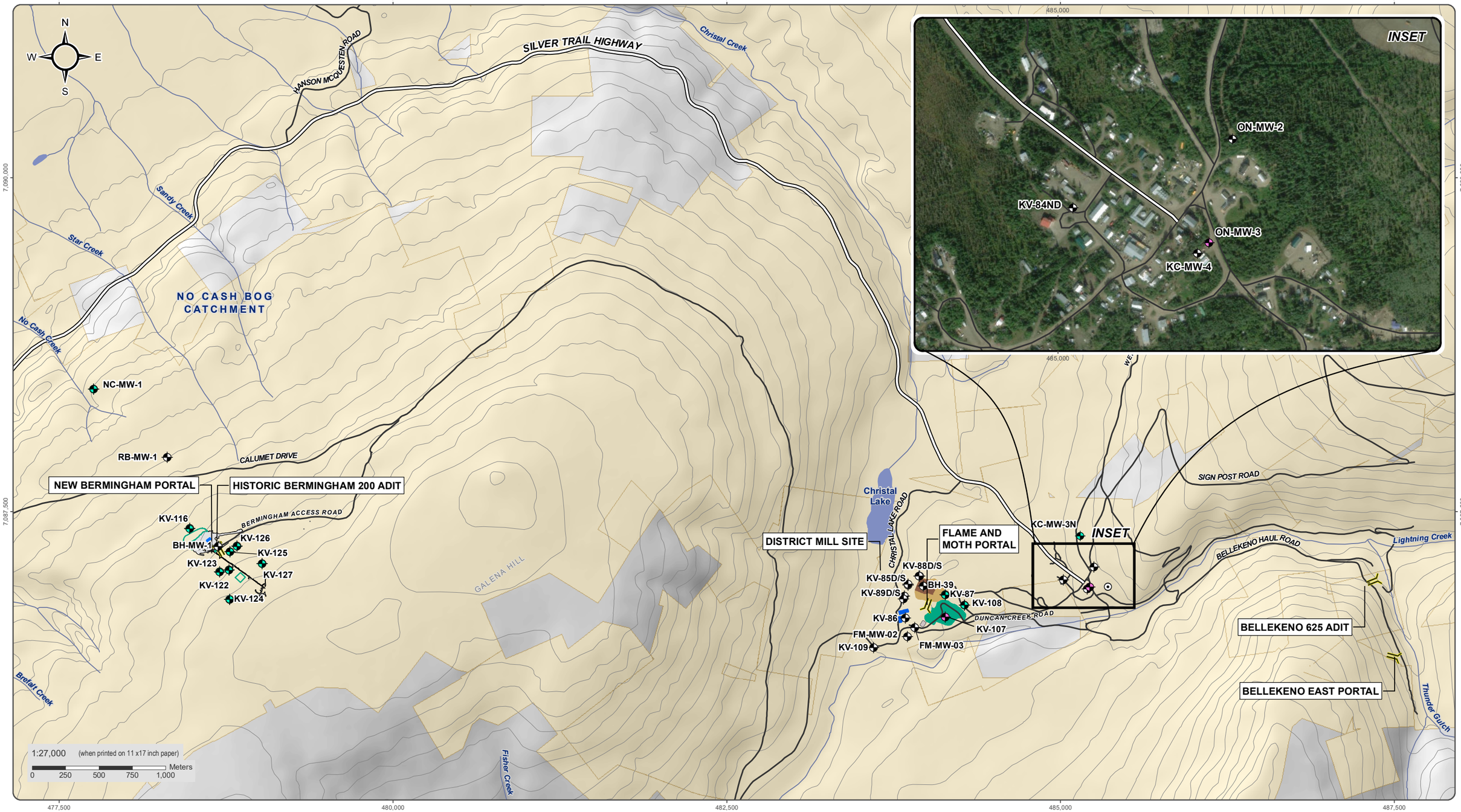
Station #	Hole #	Purpose	Total Depth (m)	Depth in Overburden (m)	Depth in Bedrock (m)	Northing[1]	Easting[1]
KV-85D	PH2	Deep bedrock groundwater monitoring	42.7	11.5	31.2	7,086,952	483,864
KV-85S	TBD2	Shallow or perched groundwater monitoring	4.2	4.2	-	7,086,952	483,858
KV-86	PH5	Overburden Groundwater Monitoring Well with Pressure Transducer Wire	36	36	-	7,086,707	483,836
KV-87	PH6	Bedrock Groundwater Monitoring Well upgradient of DSTF	94.79	-	94.79	7,086,865	484,138
KV-88D	-	Deep bedrock groundwater monitoring	50.1	4.3	45.8	7,087,016	483,946
KV-88S	-	Shallow or perched groundwater monitoring	3.72	3.72	-	7,087,016	483,942
KV-89D	-	Deep bedrock groundwater monitoring	39.12	14.5	20.5	7,086,864	483,831
KV-89S	BH17	Shallow or perched groundwater monitoring	4.8	4.8	-	7,086,844	483,825
KV-103	-	District Mill Supply Well	85.3	2.4	82.9	7,086,752	483,778
FM-MW-1	KAR1301	Christal Zone	182.3	12	160	7,086,770	484,026
FM-MW-2	KAR1302	Lightning Zone	244.4	0	244.4	7,086,562	483,854
FM-MW-3	KAR13016	Mill Fault	195.7	15	180.7	7,086,628	483,910
BH39	BH39	DSTF phase I GW monitoring	7.5	-	-	7,086,938	483,973
KV-107		Proposed well in phase II of DSTF	TBD	-	-	TBD	TBD
KV-108		well upgradient of phase II of DSTF	90.68	-	90.68-	7,086,795	484,284
KV-109	-	Well near KV-81 on Lightning Creek	26.7	4.0	22.7	7,086,479	483,601

1Coordinates are UTM Zone 8 NAD 1983
*Estimated based on nearby wells or boreholes

Well BH39 is a monitoring well within phase I of the DSTF which is screened within tailings to identify if porewater is present. Well KV-109 has been installed prior to the construction of the expanded mill area and development of the underground mine. Well KV-107 will be installed in phase II of the DSTF following the completion of the initial bench. Well KV-108 will be installed in the fall of 2020, which will be at least six months prior to the DSTF phase 2 expansion.

KV-85D and KV-89s are monitoring wells that were installed down gradient of the DSTF. These serve as one of the deep and shallow groundwater monitoring locations (PH2 and BH17, respectively). KV-85D is located in an ice wedge and is currently frozen.

Appendix A, EBA blasting analysis, provides analysis for potential effects from blasting occurring during the development of the Flame and Moth decline to the monitoring wells in the vicinity of the District Mill and DSTF. The blasting analysis shows that with appropriate management of the blasting the integrity of the monitoring wells, including the ground temperature and slope indicator monitoring, will not be compromised. Monitoring outlined in the analysis will be undertaken as part of the plan to ensure the integrity of the instrumentation is not compromised.



Datum: NAD 83; Map Projection: UTM Zone 8N

- Proposed Monitoring Well
- Monitoring Well
- Newly Installed Groundwater Monitoring Well
- Adit
- Infrastructure Footprint
- Pond
- DSTF 322k Tonnes Design
- Current DSTF
- To Be Constructed Mine Features
- Alexco/ERDC Quartz Claims
- Silver Trail Highway
- Other Road

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FIGURE 5-1
KHSD GROUNDWATER MONITORING LOCATIONS

OCTOBER 2021

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6. BERMINGHAM GROUNDWATER MONITORING

Groundwater around the Bermingham project has been studied and understood over the last several years as part of permitting process for the Bermingham mine and licensing of the Elsa Reclamation and Development Company (ERDC) Care and Maintenance activities (QZ17-076). Groundwater flow direction is to the northwest following the contours of Galena Hill and groundwater in the vicinity is monitored by ten wells: BH-MW-1, RB-MW-01, NC-MW-1, KV-116, KV-122, KV-123, KV-124, KV-125, KV-126 and KV-127.

Table 6-1: Bermingham Groundwater Monitoring Wells

Station #	Purpose	Total Depth (mbgs)	Depth in Overburden (m)	Depth in Bedrock (m)	Northing[1]	Easting[1]
BH-MW-1	Well d/g of Bermingham 200 Adit	21.3	3.8	17.5	7,087,273	478,690
RB-MW-1	Well d/g of Ruby 400 Adit	13.4	12.4	1.0	7,087,905	478,309
NC-MW-1	Well downgradient of No Cash 500	34.44	-	34.44	7,088,416	477,766
KV-116	Well downgradient of Bermingham Portal	12.04	-	12.04	7,087,372	485,156
KV-122	Bermingham - downgradient of BH SW pit well #1	25.78	-	25.78	7,087,037	484,284
KV-123	Bermingham - downgradient of BH SW pit well #2	43.43	-	43.43	7,087,059	478,472
KV-124	Bermingham - upgradient of BH SW pit	14.84	1.75	13.09	7,086,840	478,702
KV-125	Bermingham - downgradient of BH P-AML well #1	58.19	-	58.19	7,087,199	478,768
KV-126	Bermingham - downgradient of BH P-AML well #2	70.61	-	70.61	7,087,235	478,779
KV-127	Bermingham - upgradient of BH P-AML	26.64	1.25	25.39	7,087,109	478,781

7. REVIEW OF RESULTS

Results of all groundwater monitoring activities will be subject to periodic review and interpretation by AKHM as part of the monthly and the annual reports, which will compare the data to the Yukon Contaminated Sites Regulation (YCSR) Schedule 3: Generic Numerical Water Standards (Aquatic Life). Data from wells screened in the potable, or potentially potable aquifer near Keno City shall also be compared to the YCSR Schedule 3: Generic Numerical Water Standards (Drinking Water Standards). This review and interpretation is important in identifying any potential changes in baseline conditions, and if necessary, trigger mitigation and/or adaptive management measures.

8. GROUNDWATER MONITORING SCHEDULE

Groundwater monitoring will follow the schedule as described in Table 8-1. Groundwater sampling and monitoring will be carried out by competent and trained field operators. The operators will also document the condition of the well at each location and record any non-standard observations (e.g., icing, blockage, physical damage to wellhead) for maintenance planning.

A groundwater quantity monitoring plan that assesses potential effects from the District Mill well to the Keno City and Mill areas, in terms of water levels, water contour maps, and flow paths is described under the Keno Hill Silver District Mining Operations Hydrogeological Monitoring Plan (Ensero, 2020b). These sites are summarized in Table 8-2.

8.1 MONITORING WELL SAMPLING

Representative groundwater samples will be collected from each identified site as per Groundwater Standard Operating Procedure (GW SOP). Below is a summary of sampling activities to take place:

- Depth to water level will be recorded prior to sampling.
- The well volume will be calculated.
- Purging will consist of either removal of three (3) well volumes (volume of standing water in the well) by an appropriate method (manually, submersible pump, hydrolift, etc.) or by utilizing a low-flow sampling method, such that the discharge rate does not exceed 500 ml/min, drawdown within the well is not greater than 0.1m and stabilization of water quality parameters inclusive of oxidation reduction potential (ORP), dissolved oxygen (DO), pH, conductivity, and temperature have been achieved.
- Following purging of three volumes with stabilization of parameters, or low flow stabilization of parameters, groundwater sample collection can then take place.
- For quality assurance/quality control, field duplicates and blank will be collected with a frequency of 1 in 10 groundwater samples collected.

8.2 GROUNDWATER SAMPLE COLLECTION AND ANALYSES

Groundwater samples will be collected in appropriately labelled laboratory grade bottleware with preservation for the analytes requested as per GW SOP.

8.3 GROUNDWATER SAMPLE CHAIN-OF-CUSTODY RECORD, PACKING AND SHIPPING

Based on the remote location of the sites, groundwater samples will be collected and shipped to coincide with immediate offsite transportation. The samples will be shipped via air courier from Whitehorse to a lab in the Vancouver area for analyses.

Table 8-1: Groundwater Monitoring Program Summary

Site	Description	Water Licence	In situ Measurements/ Internal Analysis				External Lab Analysis												
		Proposed & Existing Monitoring	Level	pH	Temp.	Conductivity	Total Metals	Diss. Metals	Hardness	pH	Conductivity	TSS	Alkalinity	Sulphate	Nitrate	Nitrite	Ammonia(-N)	DOC	Phosphorous
KV-84Nd	Bedrock well on Keno Firehall lot to replace KV-84	Existing	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q
KV-85D	DSTF and Mill Site Groundwater Well #1 (PH2) Deep	Existing	Q	Q	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q
KV-85S	DSTF and Mill Site Groundwater Well #1 (Shallow)	Existing	Q	Q	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q
KV-86	DSTF and Mill Site Groundwater Well #2 (PH5)	Existing	Q	Q	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q
KV-87	DSTF and Mill Site Groundwater Well #3 (PH6)	Existing	Q	Q	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q
KV-88D	DSTF and Site Groundwater Well #4 (Deep)	Existing	Q	Q	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q
KV-88S	DSTF and Mill Site Groundwater Well #4 (Shallow)	Existing	Q	Q	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q
KV-89D	Flame and Moth Site Groundwater Well #5 (Deep)	Existing	Q	Q	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q
KV-89S	DSTD and Mill Site Groundwater Well #5 (Shallow)	Existing	Q	Q	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q
KC-MW-4	Well south of Onek 400 adit	Existing	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
ON-MW-2	Onek Monitoring Well #1 d/g Project Facilities	Existing	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
ON-MW-3	Well south of Onek 400 adit	To be developed	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q
FM-MW-1	Flame and Moth Well #1 (KAR-01)	Existing	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FM-MW-2	Flame and Moth Well #2 (KAR-02)	Existing	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FM-MW-3	Flame and Moth Well #3 (KAR-16)	Existing	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH39	Phase I of DSTF	Existing	M	M	M	M	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		M/Q	M/Q	M/Q	M/Q
KV-107	Proposed DSTF expansion area	To be developed	M/Q	M/Q	M/Q	M/Q	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		M/Q	M/Q	M/Q	M/Q
KV-108	Upgradient of proposed DSTF expansion area	Existing	M/Q	M/Q	M/Q	M/Q	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		M/Q	M/Q	M/Q	M/Q
KV-109	Flame and Moth Lightning Creek Discharge area near KV-81	Existing	M/Q	M/Q	M/Q	M/Q	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q		M/Q	M/Q	M/Q	M/Q
BH-MW-1	Well d/g of the Bermingham 200 Adit	Existing	Q	Q	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
RB-MW-1	Well d/g of the Ruby 400 Adit and WRSA	Existing	Q	Q	Q	Q	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NC-MW-1	Well near NC 500 Adit	Existing	M/Q	M/Q	M/Q	M/Q	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q
KV-116	Bermingham Waste Rock Disposal Area	Existing	M/Q	M/Q	M/Q	M/Q	-	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q
KV-122	Bermingham - downgradient of BH SW pit well #1	Existing	M/Q	M/Q	M/Q	M/Q		M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q
KV-123	Bermingham - downgradient of BH SW pit well #2	Existing	M/Q	M/Q	M/Q	M/Q		M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q
KV-124	Bermingham - upgradient of BH SW pit	Existing	M/Q	M/Q	M/Q	M/Q		M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q
KV-125	Bermingham - downgradient of BH P-AML well #2	Existing	M/Q	M/Q	M/Q	M/Q		M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q
KV-126	Bermingham - downgradient of BH P-AML well #2	Existing	M/Q	M/Q	M/Q	M/Q		M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q
KV-127	Bermingham - upgradient of BH P-AML	Existing	M/Q	M/Q	M/Q	M/Q		M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q	M/Q

Legend:
Q = Quarterly, M = Monthly, M/Q = Monitoring to occur monthly for first 12 months, reverting to quarterly thereafter

Table 8-2: Hydrogeological Monitoring Schedule

Site	Alternate Well IDs	Description	Proposed & Existing Monitoring	Hydrogeology		
				Discrete WLs	Synoptic WL	Download Logger
KV-84Nd	-	Bedrock well on Keno Firehall lot to replace KV-84	Existing	Q	SA	Q
KV-85D	PH2	DSTF and Mill Site Groundwater Well #1 (PH2) Deep	Existing	Q	SA	
KV-86	PH5	DSTF and Mill Site Groundwater Well #2 (PH5)	Existing	Q	SA	
KV-87	PH6	DSTF and Mill Site Groundwater Well #3 (PH6)	Existing	Q	SA	
KV-88D	-	DSTF and Site Groundwater Well #4 (Deep)	Existing	Q	SA	Q
KV-89D	-	Flame and Moth Site Groundwater Well #5 (Deep)	Existing	Q	SA	Q
KV-103	Mill Well	District Mill Supply Well	Existing	Q	SA	
KV-109	-	Well near KV-81 on Lightning Creek	Existing	Q	SA	
KV-108	-	Upgradient of proposed DSTF expansion area	Existing	Q	SA	
KV-84	MW-5	Overburden Monitoring Well	Existing	Q	SA	
KC-MW-1B	MW-1	Bedrock Groundwater Monitoring Well	Existing	Q	SA	
KC-MW-2	MW-2	Overburden Groundwater Monitoring Well	Existing	Q	SA	
KC-MW-3	MW-3	Bedrock Groundwater Monitoring Well	Existing	Q	SA	
KC-MW-4		Well south of Onek 400 adit	Existing	Q	BA	
FM-MW-01	KAR13-02	Mill / Flame and Moth - Christal Zone	Existing	Q	SA	Q
FM-MW-02	KAR13-01	Mill / Flame and Moth - Lightning Zone	Existing	Q	SA	Q
FM-MW-03	KAR13-16	Mill / Flame and Moth - Mill Zone	Existing	Q	SA	Q
KV-116		Bermingham Waste Rock Disposal Area Well	Existing	M/Q	SA	Q
KV-122		Bermingham - downgradient of BH SW pit well #1	Existing	M/Q	SA	Q
KV-123		Bermingham - downgradient of BH SW pit well #2	Existing	M/Q	SA	Q
KV-124		Bermingham - upgradient of BH SW pit	Existing	M/Q	SA	Q
KV-125		Bermingham - downgradient of BH P-AML well #2	Existing	M/Q	SA	Q
KV-126		Bermingham - downgradient of BH P-AML well #2	Existing	M/Q	SA	Q
KV-127		Bermingham - upgradient of BH P-AML	Existing	M/Q	SA	Q

**Quarterly once the monitoring well is installed, SA = semi-annual, in May and November*

9. REPORTING

As per Clauses 121 and 122 of Water Licence QZ18-044:

> 121. The Licensee shall provide to the Board, one unbound, single-sided, paper copy of all deliverables required by this Licence. All deliverables, with the exception of design drawings, must be reproducible by standard photocopier.
>
> 122. The Licensee must upload electronic copies of all deliverables required by this Licence to the Yukon Water Board's online licensing registry. Electronic copies must be submitted in one of the following formats: MS Word, MS Excel, or Adobe .pdf format. Water quality results must be in the format outlined in the Laboratory Data Submission Standards for Water Quality, as amended from time to time and available on the Board website.

10. REFERENCES

Alexco Environmental Group Inc. 2017. Bermingham Mine Groundwater Evaluation.

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APPENDIX A

KENO HILL DISTRICT MILL SITE – BLASTING PLAN ANALYSIS

TETRA TECH EBA

TECHNICAL MEMO

ISSUED FOR USE

To:	Brad Thrall, Kai Woloshyn	**Date:**	July 23, 2015
c:	Anders Frappell, P.Eng.; Aaron Nickoli; Justin Pigage	**Memo No.:**	1
From:	James Kidd	**File:**	W14103353-01
Subject:	Keno Hill District Mill Site – Blast Plan Analysis		

1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech EBA) has been commissioned by Alexco Resource Corp. (Alexco) to provide guidance with regards to blast vibrations and specifically to estimate and assess the potential effects blasting may have on instrumentation installed at the Flame and Moth site. The site is being developed as a new underground mine operation from a portal located in the vicinity of existing mine infrastructure such as the processing plant and dry stack tailings facility. In the development of the decline from the portal blasting will occur which will induce vibrations on existing infrastructure. Elements of the instrumentational infrastructure is considered sensitive to blast induce vibrations. It is understood that the instrumentation consists of 12 ground monitoring wells, 3 proposed ground monitoring wells, 5 ground temperature cells (GTC), and 2 slope inclinometers (SI) installed in the area of the proposed portal.

It is further understood that the blast analysis detailed within this memo will be used as the basis for development of a Peak Particle Velocity threshold limit, for which blasting can move ahead without producing permanent harmful effects on various geotechnical instruments.

1.1 Scope of Work

1. Review of proposed blast report data – Tetra Tech EBA reviewed the following data:

    (i) AutoCAD site plan; containing 22 locations of known geotechnical instrumentation and existing structure.

    (ii) Typical Blast Round Summary Sheet: Amex/Packaged Powder.

    (iii) Grout-Well® – Product Information Sheet: Which contained information pertaining to the ground wells.

2. Engineering Analysis and Evaluation - The information obtained from Alexco was analyzed and evaluated in order to establish recommendations for the proposed blast operations.

3. Report – This report provides comments on the proposed blast plan and makes recommendations for attenuation. Figures 2a and 2b shows the location of the well sites and instrumentation.

2.0 BLAST VIBRATIONS

This section of the memo details how blast vibrations can be predicted and controlled if the charge weight per delay is known.

Tetra Tech EBA Inc.
61 Wasson Place
Whitehorse, YT Y1A 0H7 CANADA
Tel 867.668.3068 Fax 867.668.4349

2.1 Simultaneous charge

The primary means of controlling vibrations is by controlling the explosive charge weight per delay during firing. A simultaneous charge is defined as anything less than 8 milliseconds per delay. The control of the explosive charge per delay can be obtained by reducing the drilled length per hole or providing more than one delay in each hole, known as decking. Decking is a method of creating unloaded zones within the borehole to enhance explosive performance or limit the charge weight initiated at any given time.

2.2 Scaled distance

Scaled distance is an equation that reduces two controllable variables in the blast to a single variable. The scaled distance is defined as:

$$SD = \left(\frac{D}{\sqrt{W}}\right)$$

Where;

D = Distance from the blast
W = Mass of the explosive per simultaneous charge

2.3 Peak Particle Velocity Predictions

To determine the Peak Particle Velocity (PPV but often referred to as the mean Peak Vector Sum or PVS) the following equation is used;

$$\mathrm{PPV}=\mathrm{k}\left(\frac{\mathrm{D}}{\sqrt{\mathrm{W}}}\right)^{\beta}$$

k and β are site specific constants developed through a scaled distance plot.

We are not aware of any site specific constants determined from previous blasts, therefore Tetra Tech EBA suggests using the following 'Upper Bound – High Confinement' site constants based on the findings of Blasters handbook 18th Edition for measurements of the proposed blasts. We note that these constants are conservative and are mainly dependent on the lithology, number, and nature of fractures plus other site specific conditions.

k = 4320

β = - 1.6

By recording actual blast vibrations on site at known locations and distances from a planned blast, the site specific constants k and β can be determined for the Flame and Moth site and used to better predict future blast vibrations. To carry this out will require a blast monitoring program.

3.0 PROPOSED BLASTS

It is understood that Alexco proposes to develop the portal at the Flame and Moth site by conducting blasting with the utilization of two separately weighted blast plans. These are detailed in Figure 1.

3.1 Typical round loaded with Amex

297.4 kg of Amex explosive (63 % Anfo, 8 % Geldyne, 28 % Xactex) will be distributed over 60 holes. Assuming that the explosives are distributed evenly throughout the holes this gives 4.96 kg / hole.

3.2 Typical round loaded with packaged explosive

348.1 kg of packaged explosive (72 % Geldyne, 28 % Xactex) will distributed over 60 holes. Assuming that the explosives are distributed evenly throughout the holes this gives 5.8 kg / hole.

4.0 DISCUSSION

Due to the proximity of certain sensitive structures (including instrumentation) blast vibration levels should be controlled. Blasting at the specified site should follow either of the two proposed options detailed below. The first option is essentially a prescriptive basis for blast design and considered to have a low risk, the second option is a risk based approach using an observational methodology.

4.1 Option 1

We recommend a peak particle vibration threshold of 50 mm / second be adopted at each sensitive structure (geotechnical instrumentation). Sensitive instrumentation structures are listed in Appendix B.

The vibration threshold for this option is taken as a conservative approach to sensitive structures, and was determined using the following conservative constants.

k = 4320

β = - 1.6

The 50 mm / s PPV level has been estimated from case studies in which Tetra Tech monitored the effects of ground vibrations in close proximity to sensitive structures. Furthermore, case studies by Matheson (2000) on the blast vibration damage to water supply wells in the United States concluded similar PPV threshold limits at 50 mm / s. For this reason we recommend the blasts be designed to produce vibrations with a velocity less than 50 mm / s.

Figures 2a and 2b present locations of sensitive structures that might be affected by a blast that will produce vibrations greater than 50 mm / sec. Analysis was conducted on Option 1 PPV threshold, relative minimum distances were able to be determined based on the proposed charge weight per delay discussed in Section 3.0.

The minimum required distance for each blast / hole delay are detailed further in Table 1.

Table 1: Typical Blast Round Analysis

Holes per delay	Proposed minimum distance required from blast for estimate PPV ≤ 50 mm / sec (m)	
	Amex	Packaged Explosives
0.333 (2 decks per hole)	24	24
0.5 (1 deck hole)	28	28
1	36	40
2	52	56
3	64	68
4	72	80
5	83	

4.2 Blast Plan Option Two – Risk Based Approach

As an alternative to Option 1, Alexco may elect to take a risk based approach towards the blasting. In this case we recommend that a PPV of 75 mm / second for fully bentonite grouted Ground Monitoring Wells is used, and 100 mm / second for grouted inclinometers. It is understood the ground water monitoring wells are installed with Grout-Well bentonite grouting materials. The bentonite grouting material creates an effective measure for sealing the annular space between a well casing and the borehole wall.

The threshold for Option 2 should be adopted as a risk based approach to blasting and was determined using the following constants.

$k\,(1)$ = 1730 (Blast rounds 1 and 2; during initial open area blast conditions are present).

$k\,(2)$ = 4320 (Blast rounds 3 onwards; Should be adopted after confinement has increased into tunneling conditions unless a monitoring program has developed a site specific constant).

β = - 1.6.

Specific PPV data constants should be developed for the site in the first few blasts and refined accordingly as blasting progresses into full confinement conditions, where an appropriate k constant can be estimated from measured vibrations.

Aside from the initial blast of the portal, tunneling excavations for the proposed project will mostly have one free vertical face, which is also the drilling face, and for this reason relief of the blast is expected to be poor. This results in a high degree of confinement of the blast and therefore higher vibrations can be expected. This is reflected in the selection of 4320 for the k site constant in Options 1 and 2 in lieu of a site specific constant.

The $k\,(1)$ value was adopted as an upper bound blasting constant from the High Confinement site constants based on the findings of Blasters handbook 18th Edition for measurements of the proposed blasts.

4.3 Vibration Analysis:

Respective to Option Plan 1 (Section 4.1), provided five or less holes are not simultaneously detonated, damage to the monitoring wells and inclinometers outside of the minimum distance is unlikely to be caused from the proposed blasts. Blast vibrations inside the minimum distance (Figure 2a, 2b) may have an effect on the surrounding rock by opening and closing of discontinuities, which may affect the rate of discharge/recharge of monitoring wells.

Option 2 (Section 4.2) is designed with a greater risk approach to development of the heading with respect to the integrity of the instrumentation. Blasting using Option 2 should be undertaken accepting that unknown site constants in the blast analysis may result in alteration or damage to instrumentation which may require repair or replacement after blasting.

When an explosive charge is confined in the ground and detonated, the volume that is permanently deformed is ideally a conical solid with the open end of the cone along the ground surface, or free face. The radius of the open end of the cone is approximately equal to the depth of the borehole. According to Matheson (1997), outside of this conical volume, little permanent deformation takes place. Therefore, in theory instrumentation located outside the 'crater zone' should not sustain damage. Provided blast vibrations surrounding inclinometers do not affect the movement of the probe up and down the PVC piping, there should be no major issues blasting with PPV below the specified threshold limit.

5.0 RECOMMENDATIONS

5.1 Pre Blast evaluation of Instrumentation and Blast Review

- All blast monitoring should be undertaken as described by the International Society of Explosive Engineers Field Practice Guidelines for Blasting Seismographs (2009). This document can be found in Appendix A.
- Site specific constants (k and β) should be developed as blasting progresses.
- If Option 1 is adopted it is recommended that blasts not exceed the PPV threshold limit of 50 mm / second at each sensitive structure (Appendix B).
- An initial blast condition survey should be undertaken on all ground water monitoring wells, slope inclinometers; and ground temperature monitoring wells. This would entail taking a pre and post reading for each of the 22 instruments under analysis, subject instrumentation is presented in Appendix B. Instrumentation within zones of interest (Figure 2a, 2b) should be monitored before and after each scheduled blast until no further change is noted. Zones of interest include boreholes; BH23, BH36, BH39, BH40, KV87, KV103, FM-MW-01, FM-MW-03.
- Instrumentation showing movement in measured data should continue to be monitored until the change in movement is not noted.

6.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Alexco Resource Company and their agents. Tetra Tech EBA Inc. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Alexco Resource Company, or for any Project other than the blast monitoring program at the Keno Hill site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA's Services Agreement. Tetra Tech EBA's General Conditions (Appendix C) are attached to this memo.

7.0 CLOSURE

We trust that this meets your current requirements. Should you have any further questions, please don't hesitate to contact the undersigned.

Respectfully submitted,
Tetra Tech EBA Inc.

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FIGURES

Typical Round loaded with Amex

Holes	Round length Meters	Total Meters	Load Density per meter of hole	Kg/meter	Totals		
38	4	152	1.14	42.5	169.8	63%	Anfo
5	4	20	1.48	7.3	29.0	8%	Geldyne
17	4	68	1.48	24.7	98.6	28%	Xactex
60				74.4	297.4		

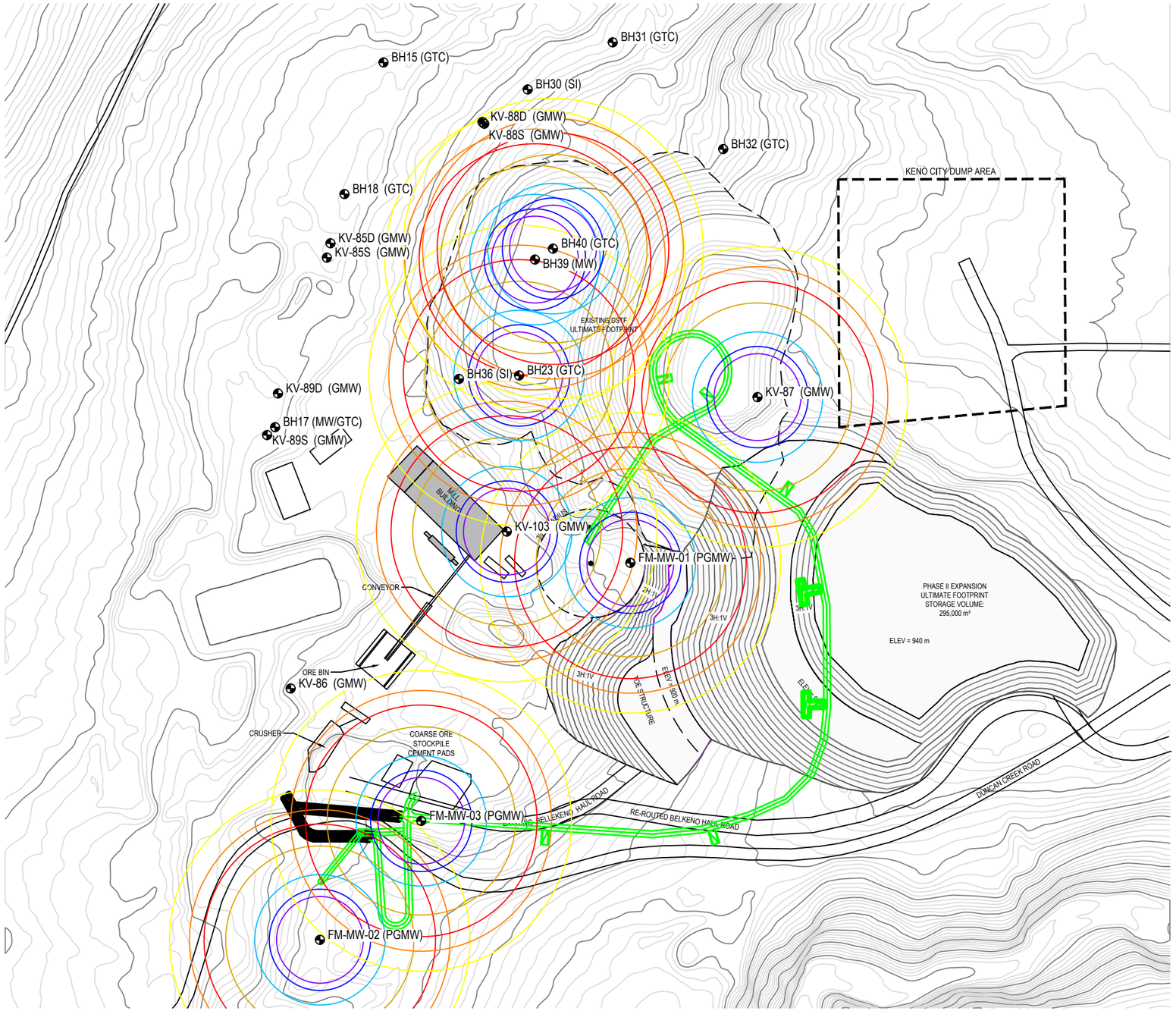
Typical Round loaded with Stick powder

43	4	172	1.48	62.4	249.5	72%	Geldyne
17	4	68	1.48	24.7	98.6	28%	Xactex
60				87.0	348.1		

Summary

A 4 x 4 x4 meter round with a combination of Anfo, Sitick powder will use 298 Kg of explosive per

A 4 x 4 x4 meter round with Sitick powder will use 298 Kg of explosive per round.



ISSUED FOR USE

LEGEND

- Instrumentation Location

AMEX

- 24 m minimum distance (2 decks per hole)
- 28 m minimum distance (1 deck hole)
- 36 m minimum distance
- 52 m minimum distance
- 64 m minimum distance
- 72 m minimum distance
- 83 m minimum distance

SCALE 1:2500

20 0 20 60 100m

NOTES

1. Based on Figure 3-29, Flame and Moth Monitoring Locations

CLIENT

ALEXCO

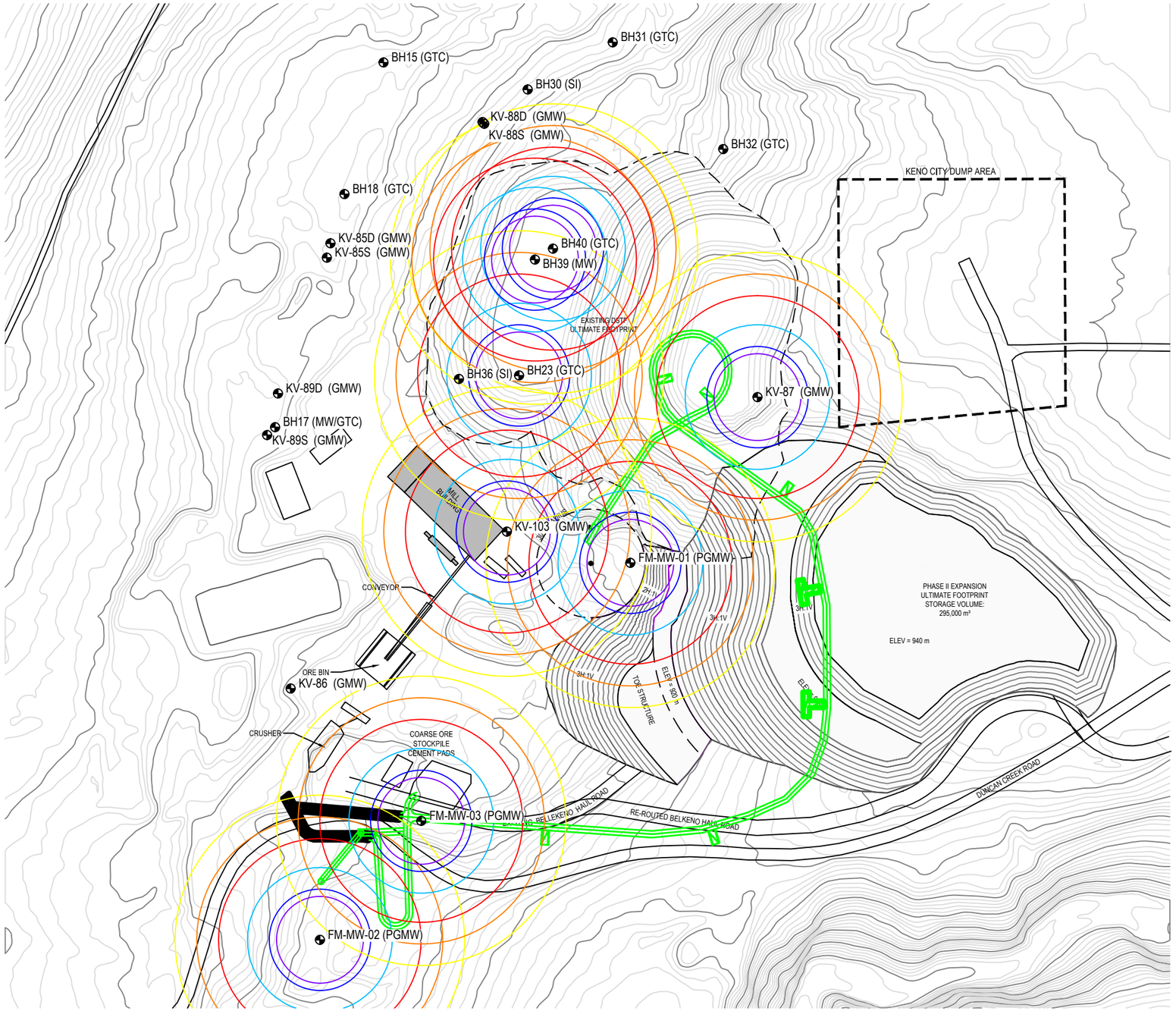
TETRA TECH EBA

KENO HILL SILVER DISTRICT MINING OPERATIONS

"PPV THRESHOLD CONTOUR HOLES 1-5" AMEX EXPLOSIVE

PROJECT NO.	DWN	CKD	REV
W14103303-01	RH	JK	0
OFFICE: EBA-VANC	DATE: June 16, 2015		

Figure 2a



ISSUED FOR USE

LEGEND

- Instrumentation Location

PACKAGED EXPLOSIVE

- 24 m minimum distance (2 decks per hole)
- 28 m minimum distance (1 deck hole)
- 40 m minimum distance
- 56 m minimum distance
- 68 m minimum distance
- 80 m minimum distance

SCALE 1:2500

20 0 20 60 100m

NOTES

1. Based on Figure 3-29, Flame and Moth Monitoring Locations

CLIENT

ALEXCO

KENO HILL SILVER DISTRICT MINING OPERATIONS

"PPV THRESHOLD CONTOUR HOLES 1-4" PACKAGED EXPLOSIVE

TETRA TECH EBA

PROJECT NO.	DWN	CKD	REV
W14103303-01	RH	JK	0

OFFICE	DATE
EBA-VANC	June 16, 2015

Figure 2b

APPENDIX A

INTERNATIONAL SOCIETY OF EXPLOSIVES ENGINEERS BLAST VIBRATIONS AND SEISMOGRAPH SECTION

INTERNATIONAL SOCIETY OF EXPLOSIVES ENGINEERS
BLAST VIBRATIONS AND SEISMOGRAPH SECTION

ISEE Field Practice Guidelines for Blasting Seismographs

Disclaimer: These field practice recommendations are intended to serve as general guidelines, and cannot describe all types of field conditions. It is incumbent on the operator to evaluate these conditions and to obtain good coupling between monitoring instrument and the surface to be monitored. In all cases, the operator should describe the field conditions and setup procedures in the permanent record of each blast.

Preface: Seismographs are used to establish compliance with regulations and evaluate explosive performance. Laws and regulations have been established to prevent damage to property and injury to people. The disposition of the rules is strongly dependant on the reliability and accuracy of ground vibration and airblast data. In terms of explosive performance the same holds true. One goal of the ISEE Blast Vibrations and Seismograph Section is to ensure reliable and consistent recording of ground vibrations and air blasts between all blasting seismographs.

Part I. General Guidelines

Seismographs are deployed in the field to record the levels of blast-induced ground vibration and airblast. Accuracy of the recordings is essential. These guidelines define the user's responsibilities when deploying seismographs in the field.

1. Read the instruction manual. Every seismograph comes with an instruction manual. Users are responsible for reading the appropriate sections before monitoring a blast.

2. Seismograph calibration. Annual calibration of the seismograph is recommended.

3. Keep proper records. A seismograph user's log should note: the user's name, date, time, place and other pertinent data.

4. Record the blast. When seismographs are deployed in the field, the time spent deploying the unit justifies recording an event. As practical, set the trigger levels low enough to record each blast.

5. Record the full waveform. It is not recommended that the continuous recording option available on many seismographs be used for monitoring blast-generated vibrations.

6. Document the location of the seismograph. This includes the name of the structure and where the seismograph was placed on the property relative to the structure. Any person should be able to locate and identify the exact monitoring location at a future date.

7. Know and record the distance to the blast. The horizontal distance from the seismograph to the blast should be known to at least two significant digits. For example, a blast within 1000 feet would be measured to the nearest tens of feet and a blast within 10,000 feet would be measured to the nearest hundreds of feet. Where elevation changes exceed 2.5h:1v, slant distances or true distance should be used.

8. Know the data processing time of the seismograph. Some units take up to 5 minutes to process and print data. If another blast occurs within this time the second blast may be missed.

9. Know the memory or record capacity of the seismograph. Enough memory must be available to store the event. The full waveform should be saved for future reference in either digital or analog form.

10. Know the nature of the report that is required. For example, provide a hard copy in the field, keep digital data as a permanent record or both. If an event is to be printed in the field, a printer with paper is needed.

11. Allow ample time for proper setup of the seismograph. Many errors occur when seismographs are hurriedly set-up. Generally, more than 15 minutes for set-up should be allowed from the time the user arrives at the monitoring location until the blast.

12. Know the temperature. Seismographs have varying manufacturer specified operating temperatures.

13. Secure cable. Suspended or freely moving cables can produce false triggers from the wind or other extraneous sources.

Part II. Ground Vibration Monitoring

Placement and coupling of the vibration sensor are the two most important factors to ensure accurate ground vibration recordings.

A. Sensor Placement

The sensor should be placed on or in the ground on the side of the structure towards the blast. A structure can be a house, pipeline, telephone pole, etc. Measurements on driveways, walkways, and slabs are to be avoided where possible.

1. Location relative to the structure. Sensor placement should ensure that the data obtained adequately represents the vibration levels received at the structure being protected. The sensor should be placed within 10 feet of the structure or less than 10% of the distance from the blast, whichever is less.

2. Soil density evaluation. The soil density should be greater than or equal to the sensor density. Fill material, sand, unconsolidated soils, flower-bed mulch or other unusual mediums may have an influence on the recording accuracy if not properly dealt with during geophone installation.

3. The sensor must be nearly level.

4. The longitudinal channel should be pointing directly at the blast and the bearing should be recorded.

5. Where access to the structure and/or property is not available, the sensor should be placed closer to the blast in undisturbed soil.

B. Sensor coupling

If the acceleration exceeds 0.2 g, slippage of the sensor may be a problem. Depending on the anticipated acceleration levels spiking, burial, or sandbagging of the geophone to the ground may be appropriate.

1. If the acceleration is expected to be:
   a. less than 0.2 g, no burial or attachment is necessary
   b. between 0.2 and 1.0 g, burial or attachment is preferred. Spiking may be acceptable.
   c. greater than 1.0 g, burial or firm attachment is required (USBM RI 8506).

The following table exemplifies the particle velocities and frequencies where accelerations are 0.2 g and 1.0 g.

Frequency, Hz	4	10	15	20	25	30	40	50	100	200
Particle Velocity - in/s at 0.2 g	3.07	1.23	0.82	0.61	0.49	0.41	0.31	0.25	0.12	0.06
Particle Velocity - in/s at 1.0 g	15.4	6.15	4.10	3.05	2.45	2.05	1.55	1.25	0.60	0.30

2. Burial or attachment methods.

   a. The preferred burial method is excavating a hole that is no less than three times the height of the sensor (ANSI S2.47-1990, R1997), spiking the sensor to the bottom of the hole, and firmly compacting soil around and over the sensor.

   b. Attachment to bedrock is achieved by bolting, clamping or gluing the sensor to the rock surface.

   c. The sensor may be attached to the foundation of the structure if it is located within $\pm$1.0 foot of ground level (USBM RI 8969). This should only be used if burial, spiking or sandbagging is not practical.

3. Other sensor placement methods.

   a. Shallow burial is anything less than described at 2a above.

   b. Spiking entails removing the sod, with minimal disturbance of the soil and firmly pressing the sensor with the attached spike(s) into the ground.

   c. Sand bagging requires removing the sod with minimal disturbance to the soil and placing the sensor on the bare spot with a sand bag over top. Sand bags should be large and loosely filled with about 10 pounds

of sand. When placed over the sensor the sandbag profile should be as low and wide as possible with a maximum amount of firm contact with the ground.

d. A combination of both spiking and sandbagging gives even greater assurance that good coupling is obtained.

C. Programming considerations

Site conditions dictate certain actions when programming the seismograph.

1. Ground vibration trigger level. The trigger level should be programmed low enough to trigger the unit from blast vibrations and high enough to minimize the occurrence of false events. The level should be slightly above the expected background vibrations for the area. A good starting level is 0.05 in/s.

2. Dynamic range and resolution. If the seismograph is not equipped with an auto-range function, the user should estimate the expected vibration level and set the appropriate range. The resolution of the printed waveform should allow verification of whether or not the event was a blast.

3. Recording duration - Set the record time for 2 seconds longer than the blast duration plus 1 second for each 1100 feet from the blast.

Part III Airblast Monitoring

Placement of the microphone relative to the structure is the most important factor.

A. Microphone placement

The microphone should be placed along the side of the structure nearest the blast.

1. The microphone should be mounted near the geophone with the manufacturer's windscreen attached.

2. The preferred microphone height is 3 feet above the ground or within 1.2 inches of the ground. Other heights may be acceptable for practical reasons. (ANSI S12.18-1994, ANSI S12.9-1992/Part2) (USBM RI 8508)

3. If practical, the microphone should not be shielded from the blast by nearby buildings, vehicles or other large barriers. If such shielding cannot be avoided, the horizontal distance between the microphone and shielding object should be greater than the height of the shielding object above the microphone.

4. If placed too close to a structure, the airblast may reflect from the house surface and record higher amplitudes. Structure response noise may also be recorded. Reflections can be minimized by placing the microphone near a corner of the structure. (RI 8508)

B. Programming considerations

Site conditions dictate certain actions when programming the seismograph to record airblast.

1. Trigger level. When only an airblast measurement is desired, the trigger level should be low enough to trigger the unit from the airblast and high enough to minimize the occurrence of false events. The level should be slightly above the expected background noise for the area. A good starting level is 120 dB.

2. Recording duration. When only recording airblast, set the recording time for at least 2 seconds more than the blast duration. When ground vibrations and airblast measurements are desired on the same record, follow the guidelines for ground vibration programming (Part II C.3).

Approved December 1999

APPENDIX B
INSTRUMENTATION LOCATION

Borehole ID	Easting	Northing	Elev (masl)	Depth (m)
FM-MW-01 (PGMW)	484025.71	7086770.45	911.72	183.5
FM-MW-02 (PGMW)	483854.14	7086562.16	911.41	244.4
FM-MW-03 (PGMW)	483910.16	7086627.86	904.96	195.7
BH15 (GTC)	483889.3	7087046.9	896.9	21.3
BH17 (MW/GTC)	483829.4	7086845.4	899.9	15.25
BH18 (GTC)	483867.7	7086974.2	898.9	8.5
BH23 (GTC)	483964.2	7086874	908.2	10.2
BH30 (SI)	483969	7087032	907.25	26
BH31 (GTC)	484016	7087058	907.79	24.4
BH32 (GTC)	484077	7086999	923.75	9
BH36 (SI)	483931	7086872	906.5	14
BH39 (MW)	483973	7086938	920	12.6
BH40 (GTC)	483983	7086944	920	13.7
KV-85D (GMW)	483860	7086947	898.5	41
KV-85S (GMW)	483858	7086939	897.5	4.6
KV-86 (GMW)	483838	7086701	900	36
KV-87 (GMW)	484096	7086862	937	56.4
KV-88D (GMW)	483944	7087014	906	50.1
KV-88S (GMW)	483945	7087013	906	4.1
KV-89D (GMW)	483831	7086864	898	38.3
KV-89S (GMW)	483825	7086841	899.9	15.25
KV-103 (GMW)	483957.4415	7086787.666	904	85.3

APPENDIX C
TETRA TECH EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these “General Conditions”.

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of Tetra Tech EBA’s Client. Tetra Tech EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than Tetra Tech EBA’s Client unless otherwise authorized in writing by Tetra Tech EBA. Any unauthorized use of the report is at the sole risk of the user.

2.0 ALTERNATE REPORT FORMAT

Where Tetra Tech EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed Tetra Tech EBA’s instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by Tetra Tech EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of Tetra Tech EBA’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Tetra Tech EBA. Tetra Tech EBA’s instruments of professional service will be used only and exactly as submitted by Tetra Tech EBA.

Electronic files submitted by Tetra Tech EBA have been prepared and submitted using specific software and hardware systems. Tetra Tech EBA makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, Tetra Tech EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. Tetra Tech EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of testholes and/or soil/rock exposures. Stratigraphy is known only at the locations of the testhole or exposure. Actual geology and stratigraphy between testholes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. Tetra Tech EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

7.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

11.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

13.0 SAMPLES

Tetra Tech EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

14.0 INFORMATION PROVIDED TO TETRA TECH EBA BY OTHERS

During the performance of the work and the preparation of the report, Tetra Tech EBA may rely on information provided by persons other than the Client. While Tetra Tech EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, Tetra Tech EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B

PHYSICAL INSPECTION AND REPORTING PLAN (OCTOBER 2020)

KENO HILL SILVER DISTRICT MINING OPERATIONS

PHYSICAL INSPECTION AND REPORTING PLAN

October 2020

Prepared for:

ALEXCO KENO HILL MINING CORP.

Prepared by:

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1. INTRODUCTION

1.1 PURPOSE OF PLAN

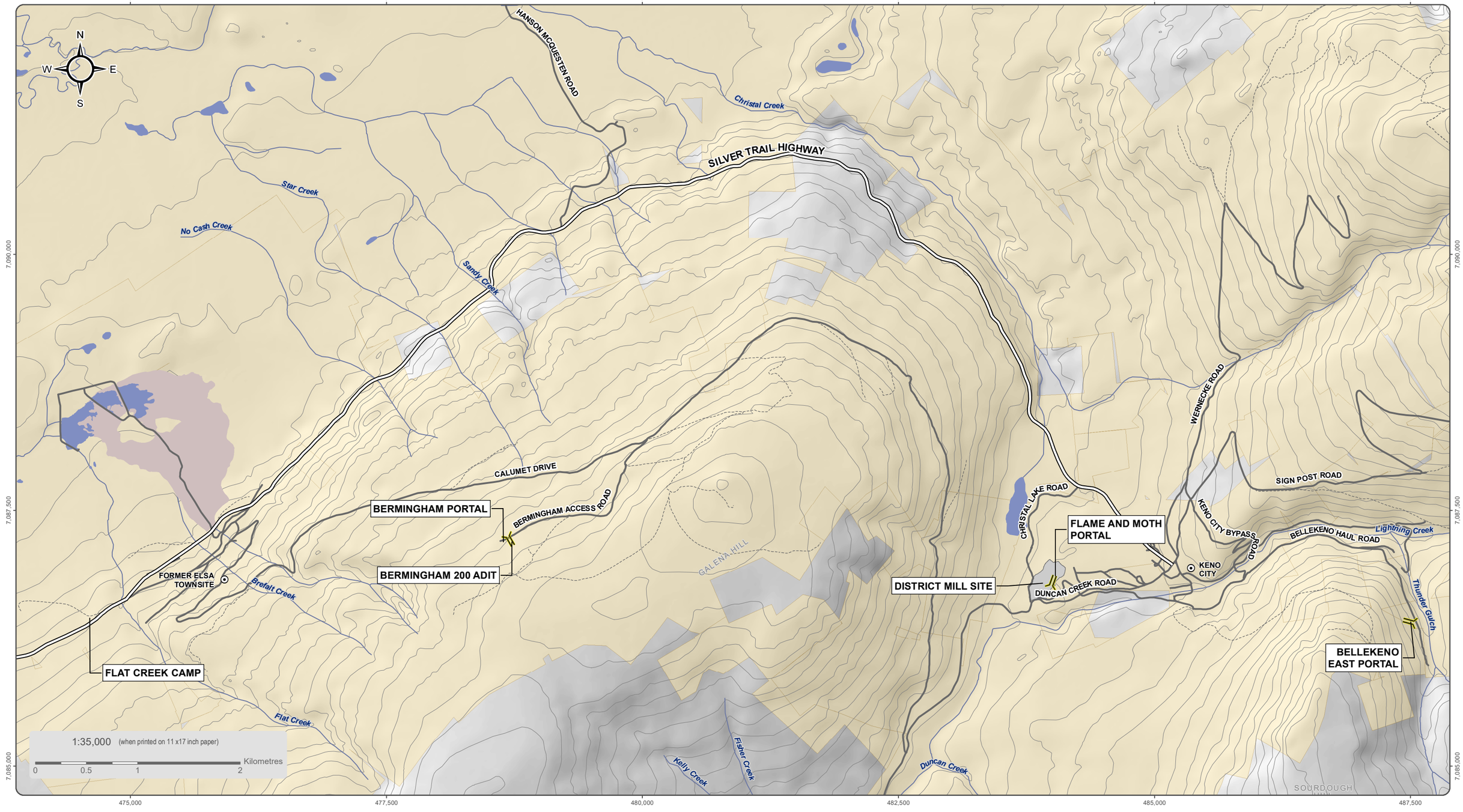
This plan is submitted to fulfill the conditions set out in Part H, Clauses 60 to 62 of Water Licence QZ18-044 issued to Alexco Keno Hill Mining Corp. on July 23rd, 2020:

> 60. Within 90 days of the effective date of this Licence, the Licensee must submit to the Board an update to *Alexco Keno Hill Mining Corp., Keno Hill Silver District Mining Operations: Physical Inspection and Reporting Plan* (PIRP), dated January 2018.
>
> 61. The Licensee must implement the PIRP for all Engineered Structures associated with the Bellekeno 625 settling ponds, the Flame and Moth water treatment pond, New Bermingham settling ponds, the Historic Bermingham SW Open Pit, the Valley Tailings Bellekeno Sludge Storage Area (VTBSSA), all N-AML Waste Rock disposal areas and all P-AML Waste Rock storage facilities, the access roads, the Flame and Moth Christal Creek and Lightning Creek discharge areas, DSTF, and Mill Pond.
>
> 62. The Licensee must inspect weekly, all structures identified in Clause 61 and submit inspection reports quarterly as part of the associated monthly report.

This plan outlines the Physical Inspection and Reporting methodology that will be used during mining and milling operations at Alexco's Keno Hill Silver District mining operations.

2. MINE LOCATION AND DESCRIPTION

The Keno Hill Silver District is located in central Yukon Territory, 354 km (by air) due north of Whitehorse. The Bellekeno mine area is located approximately 3 km east of Keno City within the Keno Hill Silver District. The Flame and Moth mine, District Mill site and Dry Stack Tailings Facility (hereinafter referred to as the "DSTF") are located approximately 1 km west of Keno City. The Bermingham deposit is located on northwest slope of Galena Hill ~6.8 km east of Keno City in the No Cash Bog catchment. Please refer to see Figure 2-1 for the site map.



Datum: NAD 83; Map Projection: UTM Zone 8N

- Place of Interest
- Adit
- Alexco/ERDC Quartz Claims
- Tailings Area
- Waterbody
- Watercourse
- Silver Trail Highway
- Road
- Limited-Use Road

AKHM

ALEXCO KENO HILL MINING CORP.

FIGURE 2-1
KENO HILL SILVER DISTRICT MINING OPERATIONS OVERVIEW

OCTOBER 2020

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(Last edited by: amallashevska;2020-09-03/15:24 PM)

3. PHYSICAL INSPECTION LOCATIONS

As per Part H, Clause 61 of Water Licence QZ18-044, the areas to be inspected include:

- Bellekeno 625 settling ponds;
- Flame and Moth Water Treatment Pond;
- New Bermingham settling ponds;
- Historic Bermingham SW Open Pit;
- VTBSSA;
- Bermingham N-AML Waste Rock Disposal Area (WRDAs);
- Bellekeno temporary P-AML Waste Rock Storage Facility (WRSFs);
- Flame and Moth P-AML Waste Rock Storage Facility(WRSFs);
- Bermingham P-AML Waste Rock Storage Facilities (WRSFs);
- Access roads;
- Flame and Moth Christal Creek and Lightning Creek discharge areas;
- Dry stack tailings facility (DSTF); and
- Mill pond.

4. PHYSICAL INSPECTION SCHEDULE

As per Clauses 91 of Water Licence QZ18-044

> 91. The Licensee must conduct weekly physical inspections of water retaining and conveyance structures, and associated mine waste and earthworks structures in accordance with the Keno Hill Silver District Physical Inspection and Reporting Plan and provide a summary as part of the annual report.

The physical inspection for all water retaining and conveyance structures will be conducted on a weekly basis (once constructed). The water ponds include the Bellekeno 625 settling ponds, the Bermingham settling pond, Flame and Moth Water Treatment Pond and Mill Pond. The P-AML Waste Rock Storage Facilities include: Bellekeno East, Flame and Moth and Bermingham. The Bermingham N-AML waste rock storage areas (once constructed) and access roads will be inspected weekly. Additionally, the discharge areas for Flame and Moth and the water conveyance structures for the sites will be inspected.

The physical inspection schedule is shown in Table 4-1 below.

Table 4-1: Physical Inspection Schedule

Physical Inspection Location	Inspection Schedule
	Weekly
Bellekeno 625 settling ponds	x
Mill pond	x
Flame and Moth Water Treatment Pond	x
VTBSSA	x
New Bermingham settling pond	x
Bellekeno temporary P-AML waste rock storage facility	x
Historic Bermingham SW Open Pit	x
Flame and Moth P-AML waste rock storage facility	x
Bellekeno N-AML waste rock disposal area	x
Access roads	x
DSTF	x
Bermingham Settling Pond	x*
Bermingham P-AML waste rock storage facilities	x
Bermingham N-AML waste rock disposal area	x

*See Appendix B for DSTF inspection schedule

5. PHYSICAL INSPECTION METHOD

The purpose of the physical inspection is to observe and record sufficient information to permit development of a course of action; repair or rehabilitation if it is required.

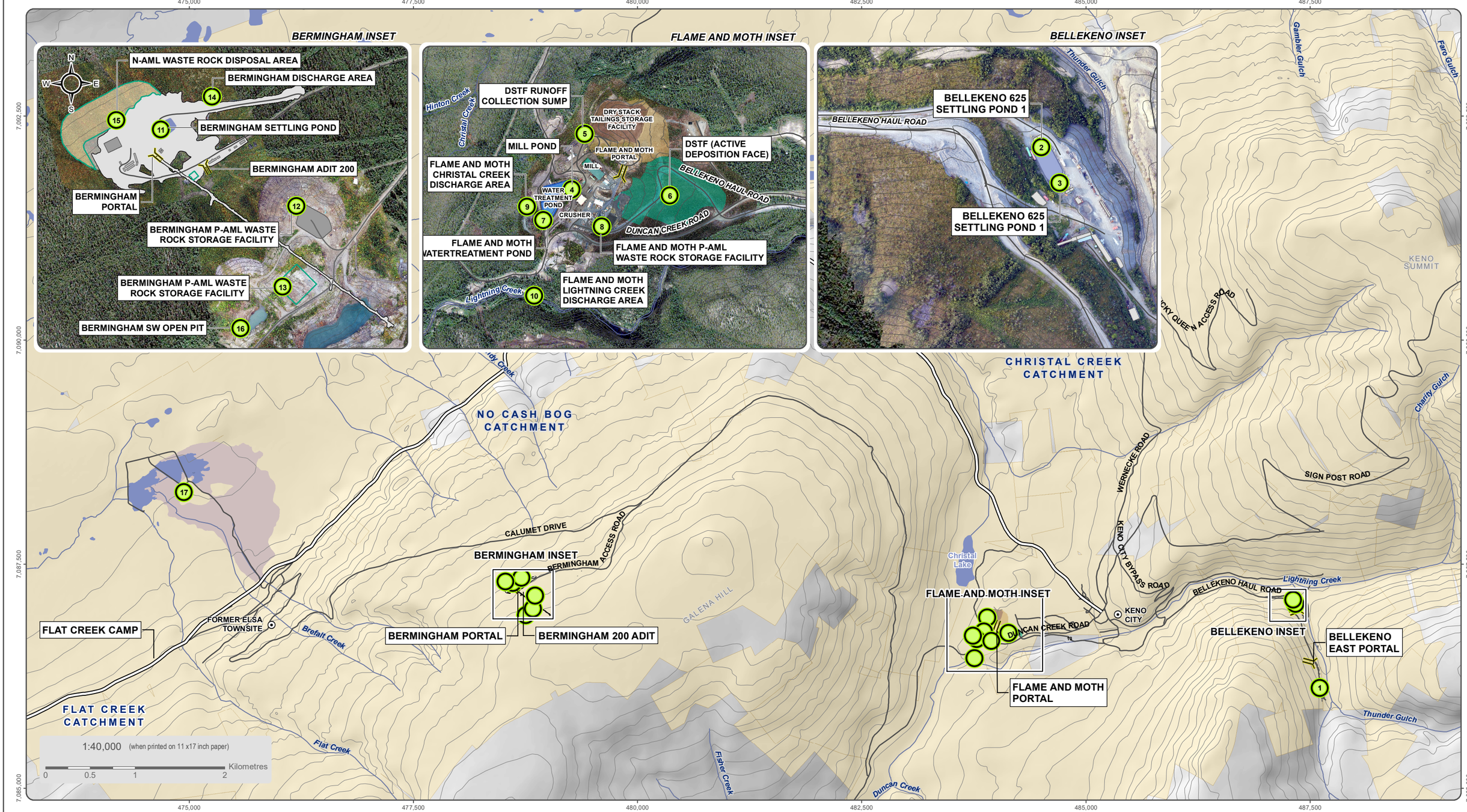
The physical inspection will comprise of completing visual inspection methods by competent and trained field operators. Maintaining clear and accurate records is as important as the physical inspection process itself, so documentation is carried out by the use of an inspection checklist. This will ensure that the inspections, even if carried out by different field personnel on different days, will record information of a similar nature.

5.1 PHOTO DOCUMENTATION

Photo hubs (physical locations where photos are to be repeatedly taken) will be selected to document the features as listed in Section 3 above. Approximate locations of photo hubs are shown in the overview map (Figure 5-1), and a detailed list and description of these photo hubs is included in Table 5-1below.

Table 5-1: Photo Hub Descriptions

Photo Hub #	Photo Hub Description
1	Bellekeno Temporary P-AML waste rock storage facility
2	Bellekeno 625 settling pond 1
3	Bellekeno 625 settling pond 2
4	Mill pond (from S corner, facing Mill)
5	DSTF runoff collection sump (on road, facing NW)
6	DSTF (active deposition face)
7	Flame and Moth Water Treatment Pond
8	Flame and Moth P-AML waste rock storage facility
9	Flame and Moth Christal Creek Discharge Area
10	Flame and Moth Lightning Creek Discharge Area
11	Bermingham Settling Pond
12	Bermingham P-AML Waste Rock Storage Facility North
13	Bermingham P-AML Waste Rock Storage Facility South
14	Bermingham Discharge Area
15	Bermingham N-AML Waste Rock Disposal Area
16	Bermingham SW open pit
17	Valley Tailings Bellekeno Sludge Storage Area



National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Cadastral data compiled by Natural Resources Canada. Reproduced underlicense from Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Satelite imagery obtained from Yukon Geomatics map service http://mapservices.gov.yk.ca/ArcGIS/services on October 2020. Aerial imagery obtained in 2018

Datum: NAD 83; Map Projection: UTM Zone 8N

- Photo Hub Locations
- Adit
- Infrastructure Footprint
- Pond
- DSTF 322k Tonnes Design
- Current DSTF
- To Be Constructed Features
- Tailings Area
- Waterbody
- Watercourse
- Contours (100 ft intervals)
- Silver Trail Highway
- Other Road

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FIGURE 5-1
PHYSICAL INSPECTIONS AND REPORTING PHOTO HUB LOCATIONS

OCTOBER 2020

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(Last edited by: amattashevska;2020-10-22(11:51AM))

GPS coordinates of the photo hubs will be uploaded onto the Site Inspection Map, to accompany inspection to ensure the inspections can be conducted by different personnel. The photo hub sites will be visited for photographic documentation on a monthly basis. The photos will be kept with the onsite Environmental Department for review as needed.

5.2 INSPECTION CHECKLISTS

Inspection checklists will be filled out on a weekly basis to ensure structural integrity of mine components and that runoff and discharge is being appropriately managed (see Appendix I). The following rating system will be used in the field reporting to evaluate the structural integrity of the areas to be physically inspected:

Excellent: "As New" Condition.

Good: System or element is sound and performing its function; although it shows signs of use and may require some minor repairs, mostly routine.

Fair: System or element is still performing adequately at this time but needs "priority" and/or "routine" repair to prevent future deterioration and to restore it to good condition. A fair rating will be reported to site manager after the inspection.

Poor: System or element cannot be relied upon to continue to perform its original function without "immediate" and/or "priority" repairs. A poor rating will be reported to site manager after the inspection.

If issues are identified during the weekly inspections the site manager will be informed immediately and the appropriate mitigative measures will be implemented. An inspection by a qualified geotechnical engineer would be undertaken for physical stability if necessary. Additional erosion and sediment controls may need to be implemented as required.

If geotechnical inspections are required, they will be carried out during the summer months when the surface and sides of the various rock-fill structures are not obscured by snow.

5.3 DSTF SURVEILLANCE, INSPECTION AND MONITORING

As a requirement of QML-0009, a dry stack tailings facility Operation Maintenance and Surveillance (OMS) manual was prepared by Tetra Tech Inc. (formerly EBA Engineering Consultants Ltd.) on behalf of Alexco. The OMS Manual forms part of the Dry Stack Tailings Facility Construction and Operation Plan under QML-0009. In addition to physical inspection and monitoring measures described in this plan, the OMS Manual describes more detailed operational physical inspection and monitoring.

Section 9 of the OMS Manual deals with surveillance and physical inspection of the DSTF, and is provided attached as Appendix B.

6. REPORTING

The weekly and monthly physical inspection checklists in addition to monthly photo documentation will be kept on file internally for proof of inspections and for reference as required.

The results of the weekly physical inspection check list will be summarized and incorporated into the annual reports.

In accordance with Clause 92 and 93 of Water Licence QZ18-044, identified seepage form any water retaining structures shall be reported as part of the monthly report. AKHM will submit and implement a plan for collection, testing and managing the seepage.

> 92. If the Licensee identifies seepage from any water retaining structures, the Licensee must:
>
> a) report on the seepage as part of the next monthly report in accordance with the Keno Hill Silver District Physical Inspection and Reporting Plan; and
>
> b) provide a summary of any new seepage or ponding locations identified through inspection and assign a unique identifier consistent with monitoring stations in this Licence as part of the annual report.

> 93. The Licensee must, within 60 days of the discovery of seepage from any water retaining structures, submit to the Board and implement a plan for collecting, testing, containing or managing the seepage. Reporting on the plan and any proposed mitigative actions are to be submitted as part of the annual report.

Additionally, an inspection report will be prepared certified by a Professional Engineer and submitted as part of the annual report. The report will include the information outlined Clause 94 below:

> 94. The Licensee must conduct an annual physical inspection of all Engineered Structures. The inspection must be conducted by a professional engineer licensed to practice in the Yukon. A report prepared by the professional engineer must be submitted as a part of each annual report and include:
>
> a) documentation of the inspection locations and methodologies;
>
> b) the results of the inspection;
>
> c) all problems identified;
>
> d) remedial measures recommended;
>
> e) the status of any remedial measures recommended in the previous year's report with an explanation regarding any recommendation not implemented; and
>
> f) actions taken or planned in response to any identified issues and/or to prevent recurrence.

APPENDIX A

PHYSICAL INSPECTIONS CHECKLIST

Physical Monitoring Program
Inspection Checklist

	BELLEKENO		FLAME AND MOTH			DISTRICT MILL			BERMINGHAM							ROADS					
	BK P-AML Waste Rock Storage Facility	BK 625 Treatment Ponds	F&M P-AML Waste Rock Storage Facility	F&M WTP Pond	F&M Dischage Areas	Mill Pond	DSTF	Water Diversion Structures	Treatment Pond	P-AML North	P-AML South	N-AML Waste Rock Disposal Area	Bermgingham SW Open Pit	Water Diversion Structures	BH Dischage Area	CLR 0-8	BKR 0-5	BKR 5-15	BKR 15-18	BH Road	Calumet Road
General																					
Checked visually?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Photo(s) taken?	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y		Y						
Checked after storm event?							Y	Y						Y		Y	Y	Y	Y	Y	Y
Soil / Rock Structures																					
Materials being disposed of properly?	Y		Y					Y		Y	Y	Y	Y	Y		Y	Y	Y	Y	Y	Y
Check for movement?	Y		Y					Y		Y	Y	Y		Y		Y	Y	Y	Y	Y	Y
Crest checked?	Y		Y					Y		Y	Y	Y		Y							
Toe checked?	Y		Y					Y		Y	Y	Y		Y							
No tension cracks?	Y		Y					Y		Y	Y	Y		Y							
No creep?	Y		Y					Y		Y	Y	Y		Y							
No failure?	Y		Y					Y		Y	Y	Y		Y		Y	Y	Y	Y	Y	Y
Safe for use next 24 hrs?	Y		Y					Y		Y	Y	Y		Y		Y	Y	Y	Y	Y	Y
Water Conveyance Structures																					
No loose material or exposed liner?	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y	Y		Y	Y						
Spillway clear?		Y		Y	Y	Y		Y	Y					Y	Y						
Good runoff management?		Y		Y	Y	Y		Y	Y					Y	Y						
Diversion clear?		Y		Y	Y	Y		Y	Y					Y	Y						
No seepage?		Y		Y	Y	Y		Y	Y					Y	Y						
No failure?		Y		Y	Y	Y		Y	Y					Y	Y						
Safe for use next 24 hrs?		Y		Y	Y	Y		Y	Y					Y	Y						
Limits adhered to?		Y		Y	Y	Y		Y	Y					Y	Y						
Piping																					
No leaks?		Y		Y	Y	Y			Y						Y						
No sags or deformation?		Y		Y	Y	Y			Y						Y						

Comments (recommendations / corrective actions required):

Inspected By: **Date:**

N/A MONTHLY WEEKLY

APPENDIX B

DRY STACK TAILINGS FACILITY SURVEILLANCE AND PHYSICAL INSPECTION

Alexco Keno Hill Mining Corp.

REVISION 2010-1

OPERATION, MAINTENANCE, AND SURVEILLANCE MANUAL
DRY STACK TAILINGS FACILITY
KENO HILL DISTRICT MILL, YT

EBA FILE: W14101178.008

September 2010

PREPARED BY EBA ENGINEERING CONSULTANTS LTD

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Calcite Business Centre • Unit 6, 151 Industrial Road • Whitehorse, Yukon Y1A 2V3 • CANADA

9.0 SURVEILLANCE

9.1 OBJECTIVE

Surveillance involves inspection and monitoring of the operation, structural integrity, and safety of the DSTF, and must be consistent with the life cycle and regulatory requirements of the facility. Surveillance of the DSTF consists of both routine and event-driven activities.

Key surveillance parameters and procedures must be identified for:

- Monitoring the operation, safety, and environmental performance of the DSTF;
- Promptly identifying and evaluating deviations from expected behaviour that affect operation safety, structural integrity, and environmental performance of the facility; and
- Reporting significant observations for response.

The DSTF surveillance program will continue to evolve as the facility changes in design or performance criteria, site conditions and/or the operation it is accommodating.

All personnel working at the DSTF will be involved in surveillance as a routine part of daily activities, maintaining visual awareness of the facility in the course of their regular and/or routine duties, in addition to surveillance-specific site engineering, instrument monitoring, analysis, inspection, periodic review and oversight.

It is the combination of all the regular inspections assisted by the eyes of all site personnel that ensures continued integrity and performance of the facility.

Outside consultants will also be on site periodically inspecting the facility as part of a regular program of expert review.

9.2 RESPONSIBILITY

A number of personnel conduct routine inspections of the DSTF. The Construction Monitor, or his designated replacement is assigned the responsibility of obtaining the monitoring information and preparing a monthly report for the facility designer and geotechnical consultant to review.

9.3 SURVEILLANCE PARAMETERS

Key parameters of surveillance are identified through identifying and describing potential failure modes of the DSTF.

Visual observations of the DSTF can indicate potential failure modes such as:

- Surface – cracking, bulging, depressions, sink holes;
- Seepage – new seepage areas, changes in seepage areas;
- Turbid water in the natural drainages around or downstream of the facility;
- Water or tailings flowing down the stack indicating improper grading; and

- A failure or breach of a component of the facility.

Routine monitoring for ensuring facility performance include:

- Checking for settlement or holes in embankment crest or benches;
- Checking for holes on the surface of the tailings indicating possible piping of material to outside;
- Checking for dust;
- Measuring water levels in monitoring wells located in the foundation soils during operation;
- Measuring ground temperatures using cables in the foundation soils during operation;
- Surveying DSTF components - displacements of survey monuments;
- Measuring slope inclinometers located in the foundation soils;
- Water sampling of Christal Creek; and
- Recording weather conditions.

These parameters are further described in the following sections.

9.4 SURVEILLANCE PROCEDURES

Table 13 summarizes surveillance requirements for the components of the DSTF. These surveillance requirements are the licensed monitoring requirements and conditions regarding the tailings presented in Alexco's Quartz Mining and Water Use licenses.

TABLE 13: OPERATIONAL MONITORING SCHEDULE FOR DSTF

Frequency	Provision	Source/Location	Personnel	Scope	Deliverable
Periodically During Construction	EBA Design Report and Quality Assurance Program	Entire Facility	Engineering Supervision	Follow monitoring and inspection procedures in Quality Assurance Program	Interim Reporting to Site Management with recommendations for construction process
Weekly	EBA Design Report and Quality Assurance Program	Structure of the tailings (toe, dam, tailings, etc.)	Operational personnel	Visual assessment of tailings, diversion berms, collection ditches, conveyance channel and water collection pond.	Daily Log, included in annual report.
Weekly	EBA Design Report and Quality Assurance Program	Tailings final runoff	Operational personnel	Visual inspection for suspended solids and erosion evidence.	Daily Log, included in annual report.

TABLE 13: OPERATIONAL MONITORING SCHEDULE FOR DSTF – CONT'D					
Weekly	EBA Design Report and Quality Assurance Program	Toe runoff collection ditches and conveyance channel	Operational personnel	Visual inspection for failures (possible or occurring) with more frequent checks during spring breakup period	Daily Log, included in annual report.
Weekly	EBA Design Report and Quality Assurance Program	Tailings Material	Operational personnel	Record tailings moisture content	Daily Log, included in annual report.
Weekly	Type A Water Licence Q209-092	Tailings Solids ABA Testing	Operational Personnel	Split a 200-500g sample from the daily 24-dried, metallurgical composite sample and retain in a plastic bag	Send a composite sample once per month to an accredited laboratory, as per Appendix C – evaluate results
Monthly	EBA Design Report	Groundwater Piezometer	Operational Personnel	Record readings and submit to VP Engineering for review	Results included in annual report.
Monthly	EBA Design Report	Ground Temperature Cable	Operational Personnel	Record readings and submit to VP Engineering for review	Results included in annual report.
Monthly	EBA Design Report	Settlement Monument Survey	Qualified Surveyor	Record elevations and submit to VP Engineering for review	Results included in annual report.
Monthly	Type A Water Licence Q209-092	Tailings Seepage	Operational Personnel	Sample and lab analysis of tailings supernatant, inspect for seepage, estimate flow	Representative samples shall be collected for laboratory analyses according to Set A[1] requirements outlined in the WUL.[2]
Monthly	EBA Design Report	Tailings Deposit	Operational Personnel	Confirm design moisture content density is being achieved	Results included in annual report.

TABLE 13: OPERATIONAL MONITORING SCHEDULE FOR DSTF – CONT'D					
Monthly	EBA Design Report	Tailings Disposal Basin	Qualified surveyor	A surface profile of the tailings along the centre line of the tailings disposal basin	Map and written description of profile.[2]
Annually	QML – Section 9.3.2	Tailings Disposal Basin	Professional engineer licensed to practice in the Yukon	Thorough visual assessment and physical inspection of the tailings, review of monitoring data to confirm design assumptions, preparation of inspection report	Representative samples shall be collected for laboratory analyses of grain size distribution, densities and moisture content.[2] Submission of inspection report.
Annually	Type A Water Licence Q209-092	Center Line of Tailings	Operational personnel	Full depth of tailings will be sampled at four stations along the center line.	Samples will be checked in the field for the presence of frozen tailings. Screen analyses will be done in the laboratory as a check on the homogeneity of the tailings and densities and moisture contents will be determined.[2]

Notes:

1 Set A - water quality analysis includes physical parameters, anions, nutrients, dissolved metals, total metals, and total suspended solids (Table 10.2 - WUL Application)

2 All results from the operation monitoring schedule will be included in the annual report to the Water Board

9.5 ADAPTIVE MANAGEMENT

Fundamental to successful adaptive management of the tailings production, handling and placement are triggers for management action. If the tailings handling and deposition is not meeting critical performance objectives according to specific conditions within either the WUL or the QML, the General Manager will be expected to follow Table 14 for appropriate corrective action. Close monitoring of the performance of the DSTF will be critical in determining if and when action will be required. It is expected that improvements will be made to the system on an ongoing basis once initial operating experience has been gained.

TABLE 14: TRIGGERS AND ACTIONS UNDER ADAPTIVE MANAGEMENT FOR TAILINGS MANAGEMENT			
Provision	Monitored Item	Triggers/Thresholds	Action
EBA Design Report	Groundwater Monitoring Wells	Tip @ 1.0 m or 1.7 m depth - Porewater pressure parameter (Ru) exceeds 0.15	Facility designer will review well data. Monitoring and review will be increased to semi-weekly until determined unnecessary.
		Tip @ 1.0 or 1.7 m depth - Porewater pressure parameter (Ru) exceeds 0.25	Facility designer will review existing well data Facility designer will conduct a site visit and determine if tailings placement and/or construction plan requires modification Monitoring and review will be increased to daily until determined unnecessary. Facility designer will determine if additional instrumentation is required. Facility designer will complete analysis of mitigative measures should exceedance continue.
EBA Design Report	Ground Temperature Cables	Temperature > 0°C at 1.5 m depth	Facility designer will review temperature data.
EBA Design Report	Ground Temperature Cables	Temperature > 0°C at 2.0 m depth and greater	Facility designer will review existing temperature data Facility designer will conduct a site visit and determine if tailings placement and/or construction plan requires modification Facility designer will determine if additional instrumentation or analysis is required. Facility designer will complete analysis of mitigative measures should exceedance continue. Alexco to complete survey of area of interest to monitor any future displacement, if any.

TABLE 13: TRIGGERS AND ACTIONS UNDER ADAPTIVE MANAGEMENT FOR TAILINGS MANAGEMENT – CONT.

Provision	Monitored Item	Triggers/Thresholds	Action
EBA Design Report	Survey Monuments and Slope Inclinometers	Displacements greater than 25 mm in any direction	Facility designer will review existing piezometer, temperature, and survey data. Facility designer will conduct a site visit and determine if tailings placement and/or construction plan requires modification. Monitoring and review will be increased to semi-weekly until determined unnecessary. Alexco to complete survey of area of interest to monitor any future displacement, if any. Facility designer will determine if additional instrumentation is required. Facility designer will complete analysis of mitigative measures should exceedance continue.
Water Licence Q209-092	Toe runoff collection ditches, conveyance channel and water collection pond	Presence of abnormal cracking or failure	Report to general manager, take corrective action as required
Water Licence Q209-092	Tailings Runoff	Visible turbidity in runoff and/or excessive erosion evidence	Address runoff at source; report to Water Board within 60 days Apply appropriate runoff, erosion or sediment control measures
Water Licence Q209-092	Tailings Solids	AML potential is indicated	Expand monitoring program Conduct study of options to minimize acid generation

9.6 DOCUMENTATION

Routine reporting of surveillance results is essential to provide time to make adjustments to existing systems or to initiate Emergency Response Plans. It is imperative that any unusual information (outliers) gathered from these undertakings be communicated to the facility designer, the General Manager and Chief Operating Officer.

Document control is vital to ensuring the ongoing performance of the facility. The topic was presented in Section 3.0.

Table 15 identifies the overall responsibilities for surveillance record keeping:

TABLE 15: DSTF SURVEILLANCE DOCUMENTATION		
Task	Responsible Party	Information Recipients
Daily Check Sheet	Completed by Construction Monitor	General Manager – copy; Mill Manager – copy; Bellekeno Mine Engineering Server
Monthly Placement As built	Completed by Construction Monitor	General Manager – copy; Mill Manager – copy; Bellekeno Mine Engineering Server EBA - copy
Instrumentation Data	Completed by Construction Monitor	General Manager – copy; Mill Manager – copy; Bellekeno Mine Engineering Server EBA – copy
Construction Photographs	Completed by Construction Monitor	General Manager – copy; Mill Manager – copy; Bellekeno Mine Engineering Server
ABA Testing	Completed by Geology Dept	General Manager – copy; Mill Manager – copy; Bellekeno Mine Engineering Server
Water Quality Monitoring	Completed by VP Corporate Affairs	General Manager, Mill Manager and Yukon Water Board Original reports located with General Manager

9.7 REPORTING

Observation of any unusual occurrence should be reported immediately to the General Manager, facility designer, and/or the Chief Operating Officer. Unusual occurrences include but are not limited to the following;

- Triggers/Thresholds outlined in Table 13;
- Any seismic event;
- Settlement, cracks or slumping of the tailings stack;
- Slope failure of any of the slopes;
- Abnormal seepage from any of the slopes;
- Increased or high turbidity flow from the drainage blanket; and
- Damage to any component of the DSTF.

All reports are to be maintained by the General Manager and filed in a suitable format and location for easy access by authorized mine personnel, and for review by government agencies. Annual performance reviews will be copied to the regulatory agencies.

The requirements of the consulting geotechnical engineer, other departments, or governmental agencies may dictate certain items that require inspection, monitoring, or reporting.

10.0 EMERGENCY PLANNING AND RESPONSE

10.1 BELLEKENO EMERGENCY PROCEDURES

The mine site has established procedures and response plans detailing in the following reports:

- A report by Access Consulting Group entitled "Alexco Keno Hill Mining Corp. Bellekeno Project, Monitoring and Surveillance Plan, QML-0009", dated November 2009 and submitted for the Type A Water Use License 2009.
- A report by Access Consulting Group entitled "Emergency Response Plan, QML-0009, Bellekeno Project", dated November 2009 and submitted for the Type A Water Use License 2009.
- MSDS documentation for any material used within the DSTF.

These documents provide the detailed plans on actions to be taken in case of an emergency. They also provide notification procedures.

10.2 DSTF EMERGENCY PROCEDURES

Daily visual and routine instrumentation monitoring programs outlined in Tables 12 and 13 are expected to forewarn of potential adverse conditions to the DSTF. Triggers/Thresholds presented in Table 13 must be adhered to and reported on as outlined.

The DSTF has been designed to maintain its structural integrity throughout its operational life; however, a number of conditions can affect the performance of the DSTF. Once the DSTF operations are being completed and instrumentation data is available, the requirement for additional emergency procedures will be reviewed as a part of the annual DSTF performance and OMS manual review.

10.3 ENVIRONMENTAL EMERGENCIES

Environmental emergencies of various natures and their specific response procedures are outlined in the project's Spill Contingency Plan. This document includes immediate response procedures and follow up and notification measures appropriate to the particular nature of the emergency.

10.4 KEY CONTACTS

Key contact information is detailed in Table A2, found in Appendix A.