

ALEXCO KENO HILL
MINING CORP.

MONITORING, SURVEILLANCE AND REPORTING PLAN

KENO HILL SILVER DISTRICT MINING OPERATIONS

January 2018

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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 (Access Consulting Group, 2015a).

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 preliminary development activities at the Bellekeno mine (Water Licence QZ07-078) 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, Onek 990 and Lucky Queen Mines are presented in this plan. Additionally, this Plan has been updated to include the Flame and Moth Mine and the associated additional monitoring included in Water Licence QZ09-092-2.

2 WATER QUALITY SURVEILLANCE NETWORK

Currently water quality monitoring is required under care and maintenance Water Licence QZ12-057, and Keno Hill Silver District Mining operations Water Licence QZ09-092-2 (amendment 2 of QZ09-092). 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 QZ09-092-2. Refer to Type A Water Licence QZ09-092-2, which specifies Effluent Quality Standards (Part D), monitoring and surveillance (Part F and Schedule B) and Reporting (Part B) required for the Keno Hill District Mining Operations, which is available for download at www.yukonwaterboard.ca/waterline.

A Groundwater Monitoring Plan for the Bellekeno mine has been developed per Water Licence QZ09-092 in February 2011 and was last updated in January 2018 to include the Flame and Moth mine (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 (Bellekeno and Lucky Queen), 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. 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.

Table 1 outlines the sampling stations and schedule for internal and external lab analysis in the area of the Bellekeno, Onek, Lucky Queen, and Flame and Moth mines and in the vicinity of the mill site. Figure 1 and Figure 2 show these existing and proposed surface water and groundwater monitoring station locations, respectively.

Hydrology monitoring is undertaken on a continuous basis during the open water season at stations on Christal Creek (KV-6 and KV-7) and Lightning Creek (KV-41). In June 2015, a water level recorder with staff gauge were installed in Christal Lake and KV-51 (Christal Creek downstream of Hinton Creek). 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. 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.

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

SITE	SITE DESCRIPTION	WATER LICENCE	INSITU MEASUREMENTS / INTERNAL ANALYSIS								EXTERNAL LAB ANALYSIS													
		QZ09-092 Existing & Proposed Monitoring	Level	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	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-Revised	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	Pending	-	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/Q	M
KV-96	Onek 990 Settling Pond Decant	Pending	D-WD	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	W-WD/Q	SA
KV-34	Lucky Queen Adit (underground)	Existing	-	C	D	D	D	D	D	D	W	W	W	W	W	W	W	W	W	W	W	W	W	-	-
KV-97	Lucky Queen Settling Pond Decant	Pending	-	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	W-WD/Q	SA
KV-100	Onek Settling Pond	Pending-revised	D	-	W	W	W	W	W	W	M	M	M	M	M	M	M	M	-	-	M	M	M	-	-
KV-101	Lucky Queen treatment plant discharge	Pending	-	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	W-WD/Q	SA
KV-102	Lucky Queen Settling pond	Pending-revised	D	-	W	W	W	W	W	W	M	M	M	M	M	M	M	M	M	M	M	M	M		
KV-105	Flame and Moth Adit	Pending	-	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	-	-
KV-104	Flame and Moth Settling Pond Decant	Pending	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-WD/Q	M-WD
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	W-WD/M	W-WD/M	W-WD/M	-	-	-	W-WD/M	W-WD/M	W-WD/M	W-WD/M	W-WD/M	W-WD/M	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	-	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 - Revised	-	Ms	Ms	Ms	Ms	Ms	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	Q
KV-45	Onek Adit	Existing	-	Q	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-49	Hinton Creek u/s Christal Creek	Existing	-	M/Q	M/Q	M/Q	M/Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q	-	-
KV-50	Christal Creek u/s Hinton Creek	Existing	-	W-WD/M	W-WD/M	W-WD/M	W-WD/M	-	-	-	W-WD/M	W-WD/M	W-WD/M	W-WD/M	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-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 - Revised		Q	Q	Q	Q				Q	Q	Q	Q	Q	Q	Q	Q				Q	Q		
KV-76	Thunder Gulch d/s Bellekeno 625	Existing - Revised	-	Q	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-78A	Onek P-AML Waste Rock Storage Facility	Existing - Revised	Ms	-	Ms	Ms	Ms	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
KV-78B	Bellekeno East Temporary Waste Rock Storage Facility	Existing - Revised	Ms	-	Ms	Ms	Ms	-	-	-	Q	Q	Q	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	Q	-	-
KV-80	Christal Creek u/s Mackeno Tailings	Existing	-	Q	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/M	W-WD/M	W-WD/M	W-WD/M	W-WD/M	-	-	-	W-WD/M	W-WD/M	-	-
KV-98	Lucky Queen N-AML WRDA Seep Survey	Pending	-	Ms	Ms	Ms	Ms	Ms	-	-	Ms	Ms	Ms	Ms	Ms	Ms	Ms	Ms	Ms	Ms	Ms	Ms	Ms		
KV-99	Lucky Queen P-AML WRSF	Pending-revised	-	Ms	Ms	Ms	Ms	Ms	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q	-	-
KV-106	Flame and Moth Temporary Waste Rock Storage Facility	Pending	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q	-	-
Mine Groundwater Monitoring Wells																									
KV-84Nd	New Well on Fire Hall lot; Keno City Well (ON-MW-3)	Existing - Revised	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	-	Q	Q	-	-
KV-85D	Flame and Moth Site Groundwater Well #1 (PH2) Deep	Existing	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q	-	-
KV-85S	Flame and Moth Site Groundwater Well #1 (Shallow)	Existing	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q	-	-
KV-86	Flame and Moth Site Groundwater Well #2 (PH5)	Existing	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q	-	-
KV-87	Flame and Moth Site Groundwater Well #3 (PH6)	Existing	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q	-	-
KV-88D	Flame and Moth Site Groundwater Well #4 (Deep)	Existing	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q	-	-
KV-88S	Flame and Moth Site Groundwater Well #4 (Shallow)	Existing	Q	-	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	Q	-	-
KV-89S	Flame and Moth Site Groundwater Well #5 (Shallow)	Existing	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q	-	-
KV-91	Bellekeno Waste Rock Disposal Area well #1	Pending	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q	-	-
KV-92	Bellekeno Waste Rock Disposal Area well #2	Pending	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q	-	-
KV-93	Bellekeno Waste Rock Disposal Area well #3	Pending	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	-	-	Q	Q	Q	-	-
KV-94	Bellekeno Waste Rock Disposal Area well #4	Pending	Q	-	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 d/g Project Facilities	Existing	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
LQ-MW-1	Lucky Queen Monitoring Well d/g N-AML WRDA	Existing	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
LQ-MW-2	Lucky Queen Monitoring Well d/g P-AML WRSF	Pending	Q	-	Q	Q	Q	-	-	-	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-	-
FM-MW-01	Flame and Moth Well #1 (KAR-01)	Existing	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FM-MW-02	Flame and Moth Well #2 (KAR-02)	Existing	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FM-MW-03	Flame and Moth Well #3 (KAR-03)	Existing	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH39	DSTF phase 1 area	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	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	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-109	Lightning Creek near KV-81	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		

C = Continuous
C-WD = Continuous While Discharging
D = Daily
D-WD = Daily While Discharging
W = Weekly
W-WD = Weekly While Discharging
W/Q = Weekly migrating to quarterly to accord with monitoring frequency pursuant to MMER
M = Monthly
Ms = Monthly (May - Oct)
M/Q = Monitoring to occur monthly for first 12 months, reverting to quarterly thereafter.
Q = Quarterly
A = Annually
SA = Semi-Annually / twice per year (Monitoring to occur semi-annually during the first three years of the study program, with the first sample collected 6 months following the start of operations, and once each year after the third year)
BA = Bi-Annually (every 2 years)

470000 480000 490000

7100000 7090000

DISTRICT MILL, ONEK AND KENO CITY INSET

KV-6 Christal Creek Chris
KV-79 KV-80 KV-52
SILVER TRAIL HIGHWAY
CHRISTAL LAKE ROAD
WERNIECKE ROAD
SIGN POST ROAD
ONEK P-AML WRSF
KV-78A
ONEK 400 ADIT
KV-45
ONEK 990 PORTAL
KV-96 KV-100
Christal Lake
KV-51 KV-49 KV-50
FLAME AND MOTH ADIT
DISTRICT MILL WEATHER STATION
KV-83 KV-82 KV-105 KV-104 KV-106
BELLEKENO HAUL ROAD
Lightning Creek
KV-41
KV-81
1:20,000

BELLEKENO INSET

SIGN POST ROAD
KV-38
KV-76 Lightning Creek
BELLEKENO HAUL ROAD
KV-44
KV-43
KV-42
KV-65
BELLEKENO 625 ADIT
BELLEKENO EAST PORTAL
KV-78B
KV-77
TEMPORARY P-AML WRSF
Thunder Gulch
1:30,000

LUCKY QUEEN INSET

N-AML WRDA
LUCKY QUEEN RAIN GAUGE
KV-98
KV-97
KV-34
LUCKY QUEEN ADIT
KV-99
P-AML WRSF
LUCKY QUEEN ACCESS
KV-68
1:10,000

McQuesten Lake
KV-72
Cache Creek
Hanson Lakes
South McQuesten River
HANSON/MCQUESTEN ROAD
Germaine Lake
Gambler Lake
Ladue Creek
Faro Gulch
Keno Ladue River
Gambler Gulch
Sadie Ladue Creek
McKay Gulch
KV-1
KV-8
KV-7
Christal Creek
Shanghai Creek
KV-2
No Cash Creek
Star Creek
Sandy Creek
VALLEY TAILINGS WEATHER STATION
CALUMET WEATHER STATION
CALUMET DRIVE
Flat Creek
Galena Creek
Bifrafi Creek
SILVER TRAIL HIGHWAY
Fisher Creek
LUCKY QUEEN INSET
SIGN POST ROAD
Charity Gulch
WERNIECKE ROAD
Christal Lake
DUNCAN CREEK ROAD
Bellekeno Haul Road
DISTRICT MILL, ONEK AND KENO CITY INSET
BELLEKENO INSET
KV-40 KV-39 KV-37
Lightning Creek
Thunder Gulch
McNeill Gulch

N W E S

1:90,000 (when printed on 11 x17 inch paper)
0 1 2 3 4 5 Kilometers

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.

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

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- Monitored Water Quality Station
- Pending/Proposed Water Quality Station
- Weather Station
- Adit
- Valley Tailings Pond
- Valley Tailings
- Keno District Mill Site
- Silver Trail Highway
- Other Road
- Watercourse
- Waterbody

AKHM AEG

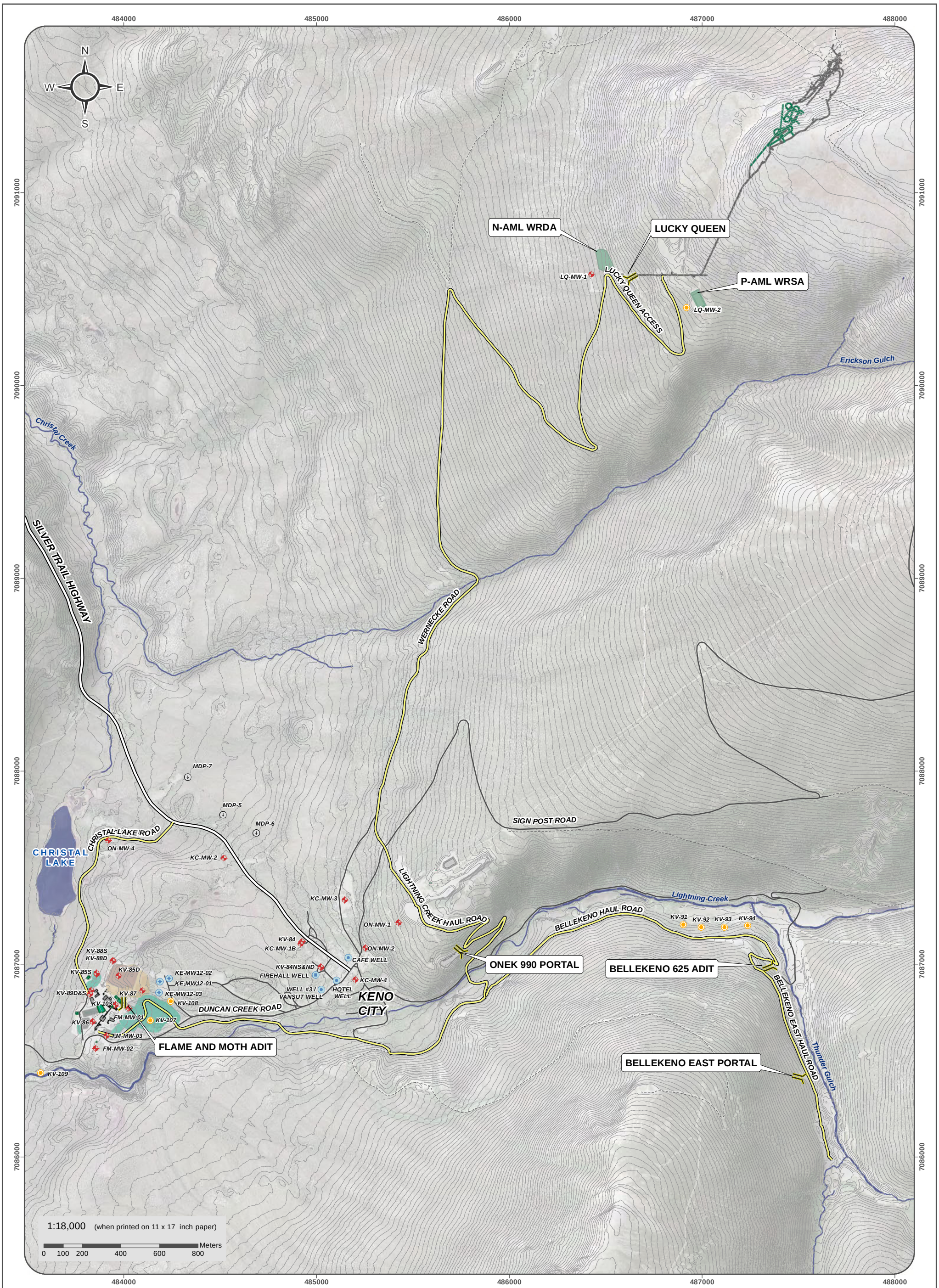
ALEXCO KENO HILL MINING CORP.

FIGURE 1

KENO HILL SURFACE WATER QUALITY MONITORING LOCATIONS LICENCE QZ09-092

JANUARY 2018

D:\Projects\All\Projects\ALEX-05-01\gis\mxd\Overview_Maps\WQ\02-SURFACEWATER\Specific_Topic\Licenses\SWMonitoring_KenoHill_Qz09-092_20180109.mxd
(Last edited by: amafas/nevska; 10/01/2018/12:39 PM)



- Pending Monitoring Well
- Monitoring Well
- Private Drilled Well
- Public Drilled Well
- Water Supply Well
- Decommissioned Manual Drive Point

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

- Adit
- Haul Road
- Silver Trail Highway
- Other Road
- Limited-Use Road

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

Datum: NAD 83; Projection: UTM Zone 8N

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FIGURE 2

KENO HILL SILVER DISTRICT GROUNDWATER MONITORING LOCATIONS

JANUARY 2018

D:\Project\All\Projects\Keno_Area_Mines\ALL-SITES\02-Map\01_Overview\02-Specific_Topics\WQ Monitoring\GW_monitoring_locations_20180108.mxd
(Last edited by: amatiashevska;12/01/2018/13:35 PM)

3 ENVIRONMENTAL EFFECTS MONITORING (UNDER MMER)

The KHSD mines are subject to the Metal Mining Effluent Regulations (MMER), 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 MMER outline requirements for routine effluent monitoring, acute lethality testing, Environmental Effects Monitoring (EEM) and provides maximum authorized limits of deleterious substances.

Effluent monitoring under MMER tends to overlap with that required under Water Licence QZ09-092; 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 MMER Schedule 4 is presented below in Table 2 below. The MMER also requires Daphnia magna monitoring tests at the same time as acute lethality testing.

Table 2 MMER Authorized Limits of Deleterious Substances

	Column 1	Column 2	Column 3	Column 4
Item	Deleterious Substance	Maximum Authorized Monthly Mean Concentration	Maximum Authorized Concentration in a Composite Sample	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 1 Environmental Effects Monitoring Study Design has been developed with Environment Canada and the interpretive report has been provided (March 2013; see Appendix T of 2012 QML annual report http://www.emr.gov.yk.ca/mining/pdf/mml_keno_2012_annual_report.pdf). Cycle 2 study was undertaken in the summer of 2015 and the interpretive report has been provided (March 2016; see Appendix D of 2015 QML annual report http://www.emr.gov.yk.ca/mining/pdf/mml_keno_2015_annual_report_20160330.pdf) Effluent monitoring, acute lethality testing and EEM Study Designs will also be implemented as required by MMER for other mines brought online in the KHSD including Flame and Moth, Lucky Queen and Onek.

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 MMER.

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 is presented in Table 3.

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 MMER will be considered final discharge points under Water Licence QZ09-092.

Table 3 KHSD Sediment and Benthic Invertebrate Sampling Frequency

Station	Sediment Sampling	Benthic Sampling
KV-37	Annual	-
KV-38	Annual	Annual
KV-41	Annual	Annual
KV-43	Annual	-
KV-6	Biannual	Biannual
KV-83	Annual	-
KV-104	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 45 (below) and subsurface investigation program listed in Schedule C 1.5 (d) in the Quartz Mining Licence.

45. Prior to construction of the DSTF expansion, the Licensee shall conduct a subsurface investigation program and submit the results of that investigation to the Board. The program shall 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 January 2018 (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 Bellekeno Mine, Flame and Moth, District Mill, Onek 990 Mine and Lucky Queen Mine 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 Waste Rock Storage Facility, the non-AML Waste Rock Disposal Area, 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, and the dry stack tailings facility.

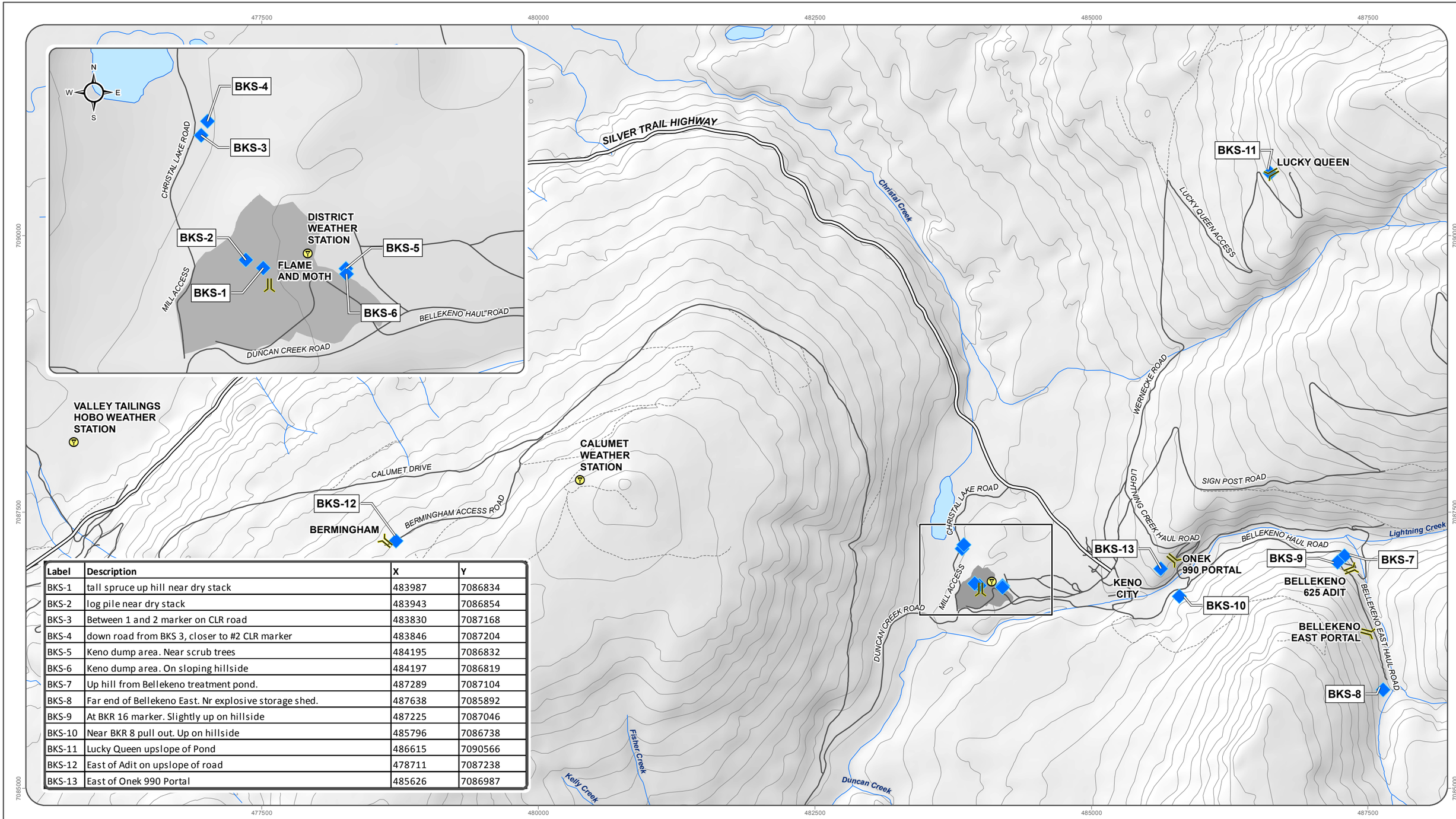
The Physical Inspection and Reporting Plan was updated in accordance with an amended Water Licence QZ09-092-2 to include provisions for the Flame and Moth, Onek and Lucky Queen structures. Such facilities would include settling ponds temporary ore stockpile, N-AML waste rock disposal area, and P-AML waste rock storage facilities.

6 METEOROLOGICAL MONITORING

Meteorological data have been collected in the KHSD since 2007 at the Calumet weather station (Figure 3) 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. 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.

Alexco conducted manual snow surveys from 2011 to 2017 at thirteen monitoring stations (with the addition of one station in 2016 and two stations in 2017 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.

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



Label	Description	X	Y
BKS-1	tall spruce up hill near dry stack	483987	7086834
BKS-2	log pile near dry stack	483943	7086854
BKS-3	Between 1 and 2 marker on CLR road	483830	7087168
BKS-4	down road from BKS 3, closer to #2 CLR marker	483846	7087204
BKS-5	Keno dump area. Near scrub trees	484195	7086832
BKS-6	Keno dump area. On sloping hillside	484197	7086819
BKS-7	Up hill from Bellekeno treatment pond.	487289	7087104
BKS-8	Far end of Bellekeno East. Nr explosive storage shed.	487638	7085892
BKS-9	At BKR 16 marker. Slightly up on hillside	487225	7087046
BKS-10	Near BKR 8 pull out. Up on hillside	485796	7086738
BKS-11	Lucky Queen upslope of Pond	486615	7090566
BKS-12	East of Adit on upslope of road	478711	7087238
BKS-13	East of Onek 990 Portal	485626	7086987

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

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1:32,000 (when printed on 11 x17 inch paper)

0 500 1,000 1,500 Meters

- Snow Monitoring Station
- Adit
- District Mill
- Silver Trail Highway
- Other Road
- Limited-Use Road
- Contours (100 ft)
- Watercourse
- Waterbody

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FIGURE 3

METEOROLOGICAL STATIONS AND SNOW SURVEY STATIONS LOCATION

JANUARY 2018

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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 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 5.

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 4 below.

Table 4 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	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:

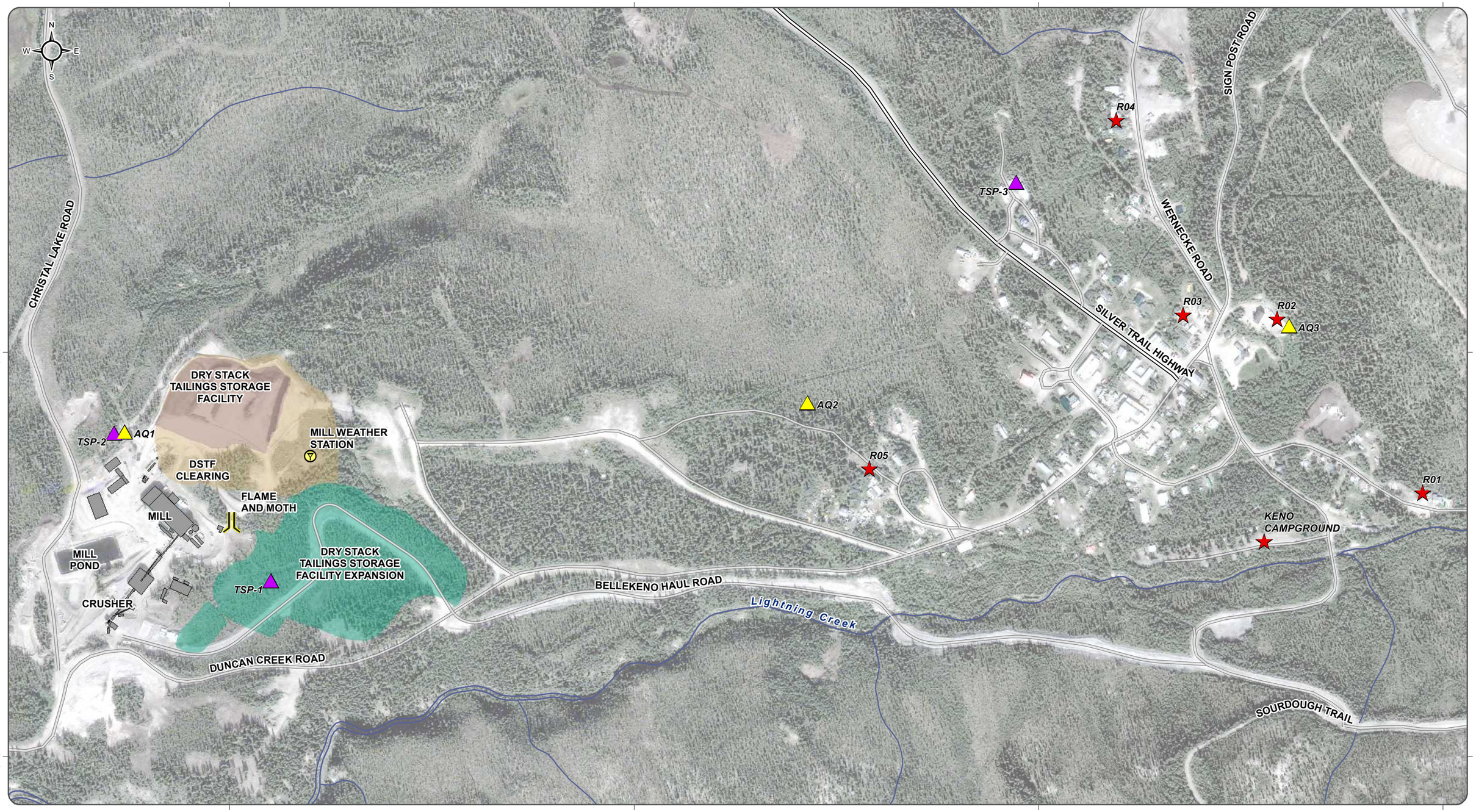
- In addition to TSP monitoring which allows for metal speciation and comparison with the Ontario Ambient Air Quality Criteria, monitoring for PM_{10} and $PM_{2.5}$ will be carried out, as it represents the coarse and fine fractions of TSP that are inhalable and that may therefore have health impacts. 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 2). 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 2).

- The sampler located at TSP-2 (see Figure 2) 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.



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

Datum: NAD 83; Projection: UTM Zone 8N

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1:4,500 *(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
- Weather Station
- Adit
- DSTF 322k Tonnes Design
- Current DSTF
- To Be Constructed Features
- Silver Trail Highway
- Secondary Road

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FIGURE 4

AIR QUALITY AND NOISE MONITORING STATIONS

JANUARY 2018

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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 5 and shown in Figure 4.

Table 5 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 Flame and Moth and includes the District Mill, Onek and Lucky Queen (Access Consulting, 2015b).

9 WASTE ROCK MONITORING

All waste rock management facilities are subject to monitoring for physical and geochemical stability (acid rock drainage and/or metal leaching) including seep surveys. 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 (Access Consulting, 2013). The Waste Rock Management Plan was updated in January 2018 include the Flame and Moth deposit (AEG, 2018).

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 rock misclassified as N-AML and P-AML.

10 SPILL CONTINGENCY PLAN

The Spill Contingency Plan has been updated per clauses 4 to 9 of Water Licence QZ09-092-2 that specifies:

4. Where a spill or an unauthorized discharge occurs, that is of a reportable quantity under the Yukon Spills Regulations, the Licensee shall immediately contact the 24-hour Yukon Spill Report telephone number (867) 667-7244, and implement the most recent Spill Contingency Plan that has been filed with the Board. A detailed written report on any such event, including but not limited to, dates, quantities, parameters, causes and other relevant details and explanations, shall be delivered to the Board not later than 10 days after its occurrence."

5. The Licensee shall apply the relevant procedures in the Spill Contingency Plan. The Licensee shall review the Spill Contingency Plan annually and shall provide a summary of that review, including any revisions to the plan, as a component of the annual report.

6. The Licensee shall maintain a log book of all spill or unauthorized discharge occurrences, including spills that are less than the reportable quantities under the Yukon Spills Regulations. The log book shall be made available at the request of an Inspector. The log book shall 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.

7. The Licensee shall include a summary of all spills or unauthorized discharges that occurred during the year reported, as part of the annual report.

8. All personnel shall be trained in procedures to be followed and equipment to be used in the containment of a spill.

9. Prior to the commencement of construction, the Licensee shall update the Spill Contingency Plan and provide the updated plan to the Board. The Spill Contingency Plan shall be posted on site for the duration of the works.

For more details, see the Spill Contingency Plan and the Emergency Response Plan updated in January 2018. 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 Bellekeno Adaptive Management Plan (AMP) was prepared in April 2011 to fulfill Water Licence QZ09-092 conditions. An Adaptive Management Plan inclusive of the activities at Onek and Lucky Queen was submitted to the Water Board in January 2014 as part of the Licence requirements. The AMP is currently being updated as required in Water Licence QZ09-092-2 and Quartz Mining License QML-0009 for Flame and Moth, and will be submitted by March 22, 2018.

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 QZ09-092-2 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 4 – June 2015) 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 B) and Quartz Mining License (Condition 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

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APPENDIX A

GROUNDWATER MONITORING PLAN (JANUARY 2018)

KENO HILL SILVER DISTRICT MINING OPERATIONS

GROUNDWATER MONITORING PLAN

January 2018

Prepared for:

ALEXCO KENO HILL MINING CORP.

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APPENDIX A KENO HILL DISTRICT MILL SITE – BLASTING PLAN ANALYSIS

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) 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. This revised version of the Plan has been updated to fulfill the conditions set out in Part G, Clauses 105, 106, 107, 108 and 109 of Water Licence QZ09-092-2 (hereafter referred to as the Licence) issued to Alexco Keno Hill Mining Corp. (AKHM) on December 22, 2017.

105. Within 90 days of the effective date of this licence, the Licensee shall submit to the Board an updated Groundwater Monitoring Plan for the Keno Hill District Undertaking, including at a minimum the Bellekeno Waste Rock Disposal Area, Keno Hill Silver District Mill Site, and Lucky Queen, Onek and Flame and Moth Mines, and shall implement that plan.

106. The plan for the Bellekeno Waste Rock Disposal Area shall include the installation of at least four groundwater monitoring wells prior to placement of material.

107. The plan for the Lucky Queen P-AML shall include the installation of at least one downgradient groundwater monitoring well prior to placement of P-AML.

108. The plan for Flame and Month shall include the installation of the following:
a) one well within the DSTF Phase 2 Expansion area (KV-107) to be installed as part of the DSTF expansion;
b) one well upgradient of the DSTF Phase 2 Expansion area (KV-108) six month prior to the expansion; and
c) one well in the Lightning Creek watershed located near KV-81 (KV-109), down-gradient of the Lightning Creek diffuser, prior to construction of the expanded mill area and development of the underground mine.

109. For the Keno Hill Silver District Mill Site, the plan shall be developed by considering existing knowledge of geological structures at the site and the consideration of groundwater table mapping based on sampling ofKV-85, KV-86, KV-87 and KV-88. The developed plan shall include, but not necessarily be limited to the following:
a) installing at least three multi-level groundwater monitoring wells down gradient of DSTF;
b) coring of bedrock, where wells are installed into bedrock;
c) development of detailed geological logs for all new well installations including:
identification of soil or rock types; soil condition or rock quality; and geological and hydrogeological features such as joints and fractures. The logs are also to include details of the well installations; and
d) based on baseline groundwater quality, development of trigger levels that would be used to enact the adaptive management strategy and provide early warning of the need for mitigative measures and/or changes in facility design/operations.

In addition, Part F Clauses 67, 68, 69 and 70 of the Licence provided additional guidance on the groundwater monitoring program:

67. Groundwater monitoring shall follow the schedule defined in Schedule B of this licence, with the exception that:

    a) Sampling of all wells shall be completed monthly for the first twelve months that they contain water. Sampling can revert to quarterly as show in Schedule B, following the first twelve samples.

    b) The Licensee shall monitor the water level in all groundwater monitoring wells where water is present at least monthly for the first year. Level monitoring can be reduced to quarterly after the first twelve monthly readings are completed.

68. Monitoring results should be reviewed after each sampling event to identify groundwater changes, should they occur.

69. Groundwater monitoring data shall be included in the annual report and shall be compared 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 Drinking Water Standards.

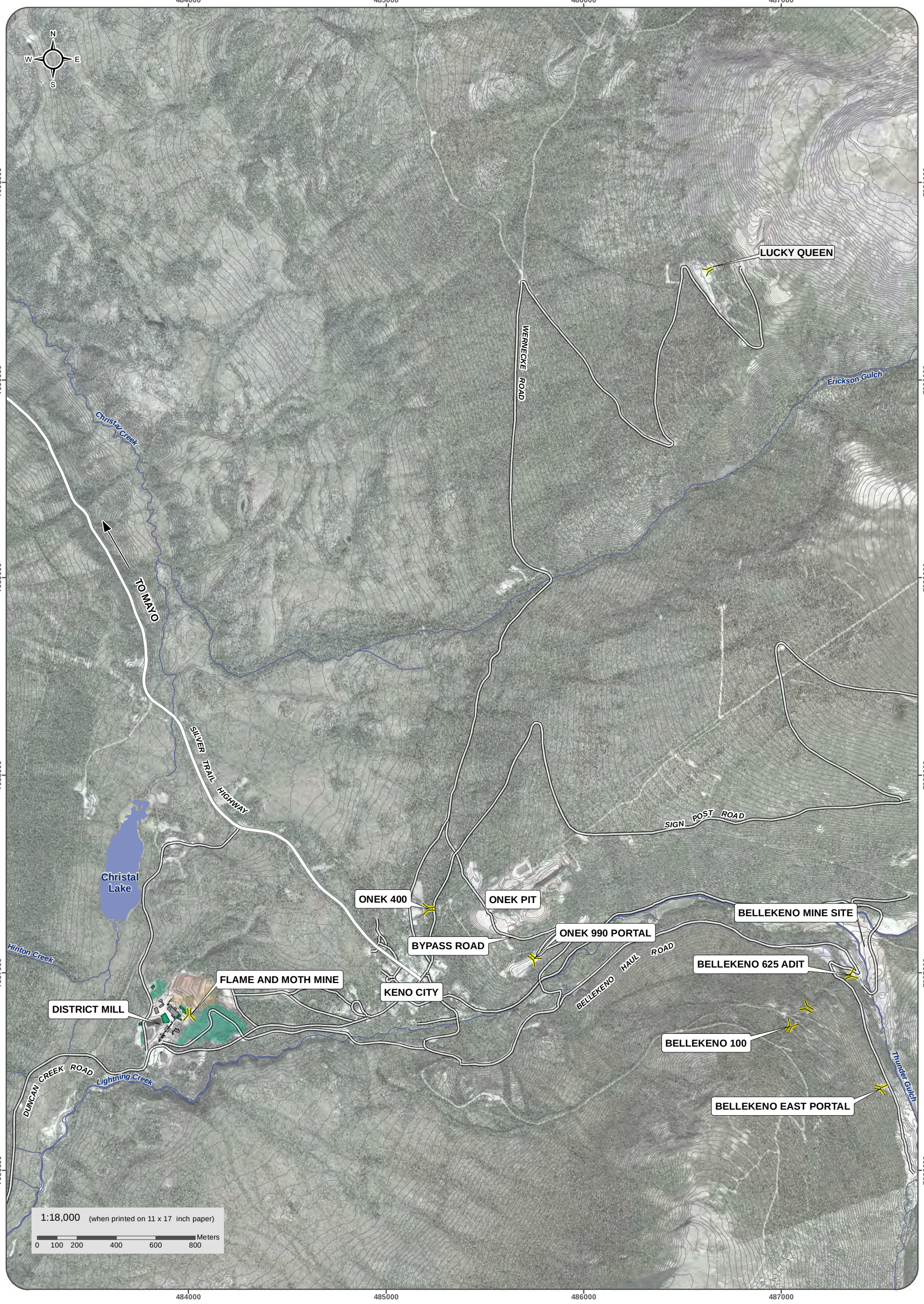
70. Groundwater wells determined to be subject to seasonal freezing shall have pressure transducers installed when cleared of seasonal ice.

The Plan has also been updated to include the proposed Flame and Moth mine and associated footprint expansion at the District Mill and DSTF.

2 MINE LOCATION AND DESCRIPTION

The Keno Hill Silver District (KHSD) 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 KHSD. Lucky Queen is located approximately 4 km northeast of Keno City and Onek is situated about 500 m northeast of Keno City. The mill site and Dry Stack Tailings Facility (hereinafter referred to as the "DSTF") are located approximately 1 km west of Keno City.

The portal at Bellekeno East is located on a steep slope above Thunder Gulch, a narrow tributary of Lightning Creek, and the haul road access to the mill site is provided by an approximately 3 km access road which crosses Lightning Creek approximately 2,200 m downstream from the confluence of Thunder Gulch and Lightning Creek. The Flame and Moth mine is located adjacent to the District Mill. Please see Figure 1 for the site map.



DSTF 322k Tonnes Design
Proposed Mill Pond
Current DSTF
To Be Constructed Features
Infrastructure Footprint
Adit
Silver Trail Highway
Other Road
Contours (5m)

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

Datum: NAD 83; Projection: UTM Zone 8N

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FIGURE 1-1

OVERVIEW

JANUARY 2018

D:\Project\AllProjects\Keno_Area_Mines\ALL-SITES\02-Map\01_Overview\01-Property Overview\Overview_Portrait_Tab_2(
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3 PREVIOUS GROUNDWATER STUDIES

SRK Consulting Canada Inc. (SRK) was retained by AKHM to investigate groundwater gradients of 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-85, KV-86 and KV-87, respectively. Key findings of the SRK groundwater investigation (SRK, 2010) include:

- The water table within the bedrock aquifer under the site and within a relatively thick overburden aquifer to the south is at considerable depth (>25 m);
- Water level data from monitoring wells at site and Keno City indicate that groundwater flows from east to west, or from Keno City towards the mill site and Christal Lake;
- These water level data also indicate a shallow gradient between Lightning Creek towards Christal Lake;
- Water quality analyses of samples taken immediately following monitoring well development indicate that in general, concentrations of dissolved anions and metal are low;
- The only notable exceptions are elevated levels concentrations of chloride and sodium in KV-87, which is located downgradient and could be indicative of seepage from the Keno City dump and; elevated concentrations of sulphate in KV-86 and KV-87, which are deemed to be indicative of natural mineralization in this area;
- The likelihood of effects to groundwater quality in general related to the mill and DSTF are considered very low, due to site water management plans for seepage and runoff interception, and collection and treatment if necessary;
- Because groundwater extraction is not planned at the mill site, there will be no effects on the amount of water available for extraction from wells in Keno City, and;
- The chance of water quality being affected in wells in Keno City is considered insignificant due to current understanding of the local groundwater gradient and the large distance between the mill site and Keno City water wells.

The SRK groundwater report, entitled "Bellekeno Groundwater Program" was issued in May 2010, and was submitted to the Board as supplemental information in support of the application for QZ09-092 (Exhibit 1.12 of the public registry). This report is available at http://www.yukonwaterboard.ca/registers/quartz/QZ09-092/Volume%204/1.12/1.12.pdf.. Prior to issuance of their 2010 Bellekeno Groundwater report, SRK was also retained to complete initial (desktop) assessments of potential impacts of the proposed mill and DSTF site on groundwater quantity and quality (SRK, 2009a; SRK, 2009b).

Interralogic, Inc. conducted a groundwater evaluation for Keno City between October 2010 and March 2012. Two trenches were excavated within a dry stream channel downgradient of the Onek 400 adit in October 2010 to determine if discharge from the adit was following the channel. As part

of the groundwater evaluation Interralogic also completed a Keno City water supply wells field program in fall 2010 to determine water levels, quality, and approximate material transmissivities. Interralogic also sampled five new monitoring wells drilled under the Keno Closure Plan, as well as a monitoring well (ON-MW-01) that was installed in 2011 to understand groundwater elevations near the historic Onek waste rock dumps and open pit.

In order to evaluate the groundwater flow path the wells that were available to measure groundwater levels were gauged and Interralogic came to the following conclusions, which are taken directly from there memo:

- 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 feature that appears to have higher permeability than adjacent geologic units. Evidence for this is (1) the interpretation that groundwater converges toward this feature, (2) 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 (3) the relatively high initial yield of the Firehall well (57 to 96 lpm). The higher permeability feature could be associated with a buried glacial valley (overburden) and/or fracture zone (bedrock).
- Water level contours suggest that groundwater discharges to Lightning Creek east of Keno City. South of Keno City, there appears to be seepage loss from the stream that recharges the groundwater system below the townsite. The zone of high seepage loss from the stream could be associated with the southeast extension of the postulated higher permeability feature.
- At and downstream (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 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. has summarised the results from the drilling and associated air lift testing from the three monitoring well completed. An air lift pump test conducted on well FM-MW-1 for 72 consecutive hours to calculate the potential mine inflows for the Flame and Moth Mine. The maximum predicted flow rate for the Flame and Moth mine has been conservatively calculated to be 35 L/s (Interralogic Inc., 2013).

The Interralogic report concludes that Flame and Moth Mine dewatering will not have a significant impact on surface water flows in Lightning Creek and it is highly unlikely that mine dewatering will have an effect on groundwater levels and the availability of water supply in the Keno City area.

4 REGIONAL GEOLOGY AND HYDROGEOLOGICAL IMPLICATIONS

The long history of mining and exploration in the Keno Hill Silver District 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 (ACG, 2009).

> The Keno Hill District 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 is host to most of the past producing ore bodies. Structurally juxtaposed below the quartzite is the Lower Schist which has been correlated with the Devonian-Mississippian Earn Group. The Lower Schist 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. The sills and boudins form bodies up to one kilometre long and thirty metres thick. Regional, greenschist facies metamorphism of all units is believed to have occurred in the Middle Cretaceous, about 105 million years ago.
>
> 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; reports of occurrences in the Central Quartzite are inconclusive and vague. The quartz-porphyry sills are believed to be of Cretaceous age.
>
> Structurally, the property is characterized by four sets of faults; many of which have been filled by hydrothermal minerals, forming veins. The oldest fault set consists of south dipping structures that are generally parallel to foliation and are apparently associated with the Tombstone Thrust Fault since movement was contemporaneous or slightly later. 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. The latest movement along these faults is sinistral with offsets locally reaching more than 150 metres; however, more than one episode of movement commonly is indicated. 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 west with a dip of sixty degrees west to south west and offset vein or longitudinal faults by up to 2,000 metres. In the western part of the property, dextral movement is the most recent event along these structures, whereas in the eastern part of the property sinistral movement with less magnitude prevails."

SRK (2009a) 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 (2009a) 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 SITE GROUNDWATER MONITORING

As per Clause 109a of the Licence, three multi-level groundwater monitoring wells were installed down gradient of the DSTF. Clause 97 specifies 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 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 through the use of the groundwater monitoring network described below in Table 1 and shown on Figure 2. The selection of these wells was 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 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	7086952	483864
KV-85S	TBD2	Shallow or perched groundwater monitoring	4.2	4.2	-	483858	7086952
KV-86	PH5	Overburden Groundwater Monitoring Well with Pressure Transducer Wire	36	36	-	7086707	483836
KV-87	PH6	Bedrock Groundwater Monitoring Well with Pressure Transducer Wire	57.9	2.7	55.2	7086854	484104
KV-88D		Deep bedrock groundwater monitoring	51.2	-	-	7087016	483946
KV-88S		Shallow or perched groundwater monitoring	3.72	3.72	-	7087016	483942
KV-89D		Deep bedrock groundwater monitoring	39.12	14.5	20.5	7086864	483831
KV-89S	BH17	Shallow or perched groundwater monitoring	4.8	4.8	0	7086844	483825

KV-103		District Mill Supply Well					
FM-MW-1	KAR1301	Christal Zone	182.3	12	160	7086770	484026
FM-MW-2	KAR1302	Lightning Zone	244.4	0	244.4	7086562	483854
FM-MW-3	KAR1016	Mill Fault	195.7	15	180.7	7086628	483910
BH39	BH39	DSTF phase I GW monitoring	7.5	-	-	7086938	483973
KV-107		Proposed well in phase II of DSTF	TBD	-	-	TBD	TBD
KV-108		Proposed well upgradient of phase II of DSTF				TBD	TBD
KV-109		Proposed well near KV-81 on Lightning Creek				TBD	TBD

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-107 will be installed in phase II of the DSTF following the completion of the initial bench. Well KV-108 will be installed six months prior to the DSTF phase 2 expansion, while KV-109 will be installed prior to the construction of the expanded mill area and development of the underground mine.

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).

The remaining wells, KV-85S, KV-86, KV-87, KV-88D, KV-88S, and KV-89D, in accordance with Clause 109c of the Licence, which states that all new well installations will include collection of information on soil and rock types, soil condition or rock quality and geological and hydrogeological features such as joints or fractures where possible, and will include details of well installations.

Clause 70 of the Licence, states that all groundwater wells determined to be subject to seasonal freezing shall have pressure transducers installed. AHKM will install data loggers in groundwater wells deemed to be subject to seasonal freezing and these installations will be measured monthly for the first year (twelve monthly readings) as per Clause 67 and then quarterly for water level as per Schedule B (also summarized in Table 7 of this report)

Although Clause 109b, requires that where wells are installed into bedrock, the bedrock shall be cored, AKHM's preference was to complete these groundwater well installations (including bedrock holes) using more conventional drilling technology for the installation of monitoring wells (air-rotary, ODEX). Air-rotary drilling is preferable to diamond drilling for monitoring well installation for a number of reasons including:

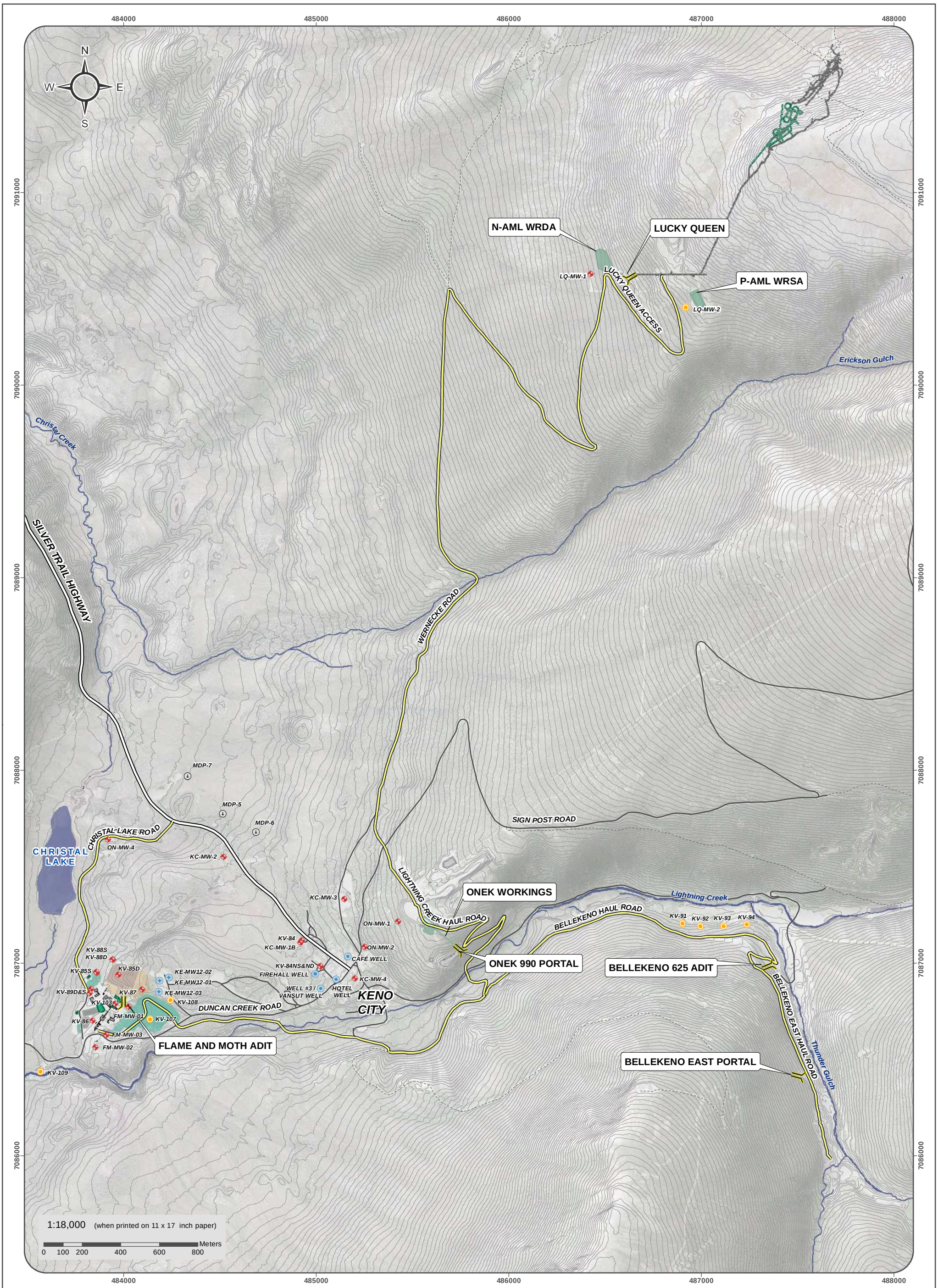
- More efficient drilling of both overburden and bedrock;

- Larger diameter borehole produced using an air-rotary drilling rig is preferable and reduces the chance of bridging during well completion;
- AKHM did not have a diamond drill program active at site while the monitoring wells were being installed, and;
- An air-rotary drilling rig was on site in late February for other groundwater investigations related to District Closure, which meant that costs could be optimized when combined with that program.

The Reasons for Decision document for the Licence does not provide additional information regarding Clause 109b; however, Alexco believes that the intent of this Clause was to ensure that adequate data and information regarding the subsurface conditions (overburden and especially bedrock and structural geology) of the DSTF and mill site area were collected to better inform AKHM's mill site area construction plans and ensure that the monitoring strategy was appropriate. AKHM believes that information collected in both the shallow subsurface soils and the deeper bedrock is sufficient to inform the groundwater monitoring plan. These data are presented in Sections 5.1 and 5.2 below.

No additional groundwater locations have been proposed for the Flame and Moth mine as the proposed DSTF expansion and expanded mill site foot print are located upgradient of the existing ground water monitoring network (Figure 2). The Plan will be revised as the Flame and Moth project is advanced in the regulatory process.

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.



- Proposed Monitoring Well
- Monitoring Well
- Private Drilled Well
- Public Drilled Well
- Water Supply Well
- Decommissioned Manual Drive Point

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

- Adit
- Haul Road
- Silver Trail Highway
- Other Road
- Limited-Use Road

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

Datum: NAD 83; Projection: UTM Zone 8N

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FIGURE 2

KENO HILL SILVER DISTRICT GROUNDWATER MONITORING LOCATIONS

JANUARY 2018

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5.1 SHALLOW SUBSURFACE CONDITIONS IN THE DISTRICT MILL AREA

A considerable amount of geotechnical information has been collected from the mill site and the area beneath the DSTF during geotechnical studies in support of preliminary and final design of the DSTF, mill building, mill site pond, ancillary facilities, and site water management infrastructure. This work was carried out by EBA Engineering Consultants Ltd. A summary of the subsurface conditions of the DSTF is provided below and is from the Preliminary Design Report (EBA, 2010):

> "Nine boreholes were drilled near the DSTF. Information gathered in these boreholes indicates two general soil profiles in the area:
>
> - glaciofluvial GRAVEL underlain by bedrock and
> - SILT and SAND till underlain by gravel and bedrock.
>
> The gravel was encountered along the ridge that crosses the site. The gravel in the area of the DSTF was found in both frozen and unfrozen states. It is typically sandy with trace silt, compact, medium grained, well graded, and brown, and it is underlain by a thin layer of silt and sand till and then bedrock. Bedrock encountered in testholes is a competent quartzite. Subsurface conditions for the gravel area are summarized in Table 2.

Table 2 General Subsurface Conditions for Gravel Area

Soil Unit	Min thickness (m)	Max Thickness (m)	Average Thickness (m)
Gravel	1.3	3.7	2.5
Silt and Sand till	0.2	1.3	1.0
Bedrock (quartzite)	@2.1 mbgs*	@5.0 mbgs*	@3.4 mbgs*

*Meters below ground surface

> All silt and sand till encountered in the area of the DSTF was frozen. The silt and sand till typically contains trace gravel and trace clay, is low to non-plastic, olive grey, is underlain by gravel seams within the till and then by quartzite bedrock. Two boreholes on the west side of the ridge, BH15 and BH17, were drilled through the silt and sand layer. The gravel seams were encountered below 16 m depth in BH15, and bedrock was encountered at 14.2 m depth in BH17. One borehole, BH23, was drilled through the till deposit on the east side of the ridge and gravel seams were encountered at 7.6 m depth. Two boreholes, BH24 and BH25, were drilled near a proposed water collection pond. The general soil conditions in this area are gravel fill over glaciofluvial gravel over silt and sand till over glaciofluvial gravel. The glaciofluvial gravel and silt and sand till are similar to the soils described above and are all unfrozen."

5.2 BEDROCK GEOLOGY AND STRUCTURE IN THE DISTRICT MILL AREA

Exploration drilling in the vicinity of the DSTF by AKHM during the 2010 season has provided additional data from the deeper subsurface in the form of information on rock quality and geological features. This drilling was designed to investigate the historically known mineralisation about the Flame and Moth (District Mill area) underground mine workings and comprised 13 holes for a total of 3,974 metres that were completed from five locations.

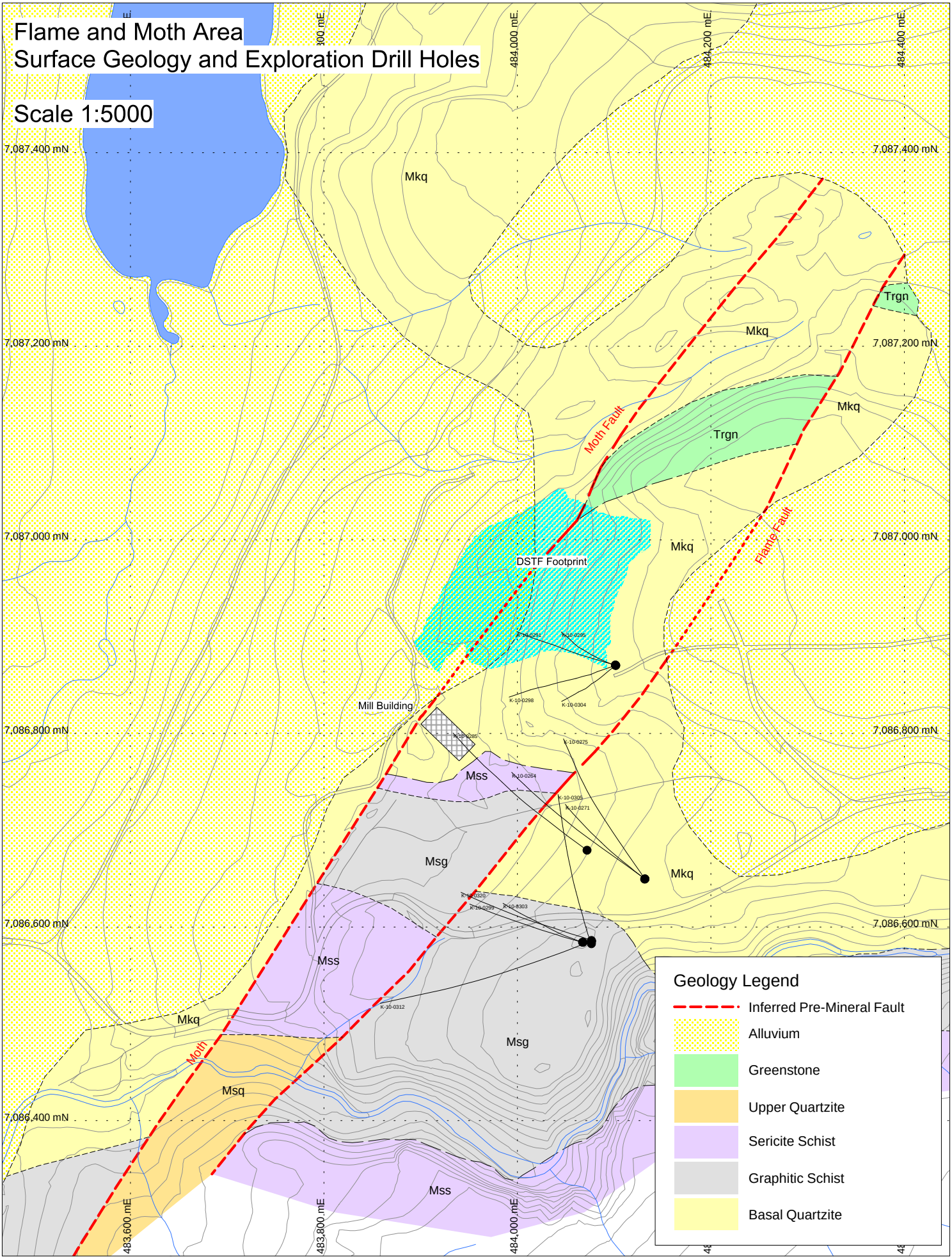
Basic rock quality designation (RQD) information that is routinely logged for exploration diamond drill core was supplemented with additional data including Rock Strength, Total Fracture Count, Total Vein Count, Vein Strength and % Vein for some of the District Mill holes.

Table 3 Details of Diamond Drill Hole at the Flame & Moth Prospect (District Mill Site)

Hole_ID	Total Depth (m)	UTM Easting (m)	UTM Northing (m)	Elev. (m)	Collar Azimuth	Collar Dip	Started	Completed	Core Size
K-10-0264	336.80	484131.8	7086649.8	927.98	306	-60	05/07/2010	20/07/2010	HQ
K-10-0271	347.47	484131.8	7086649.8	927.98	306	-70	21/07/2010	31/07/2010	HQ
K-10-0275	346.57	484131.5	7086649.5	927.98	328	-62	01/08/2010	24/08/2010	HQ
K-10-0285	324.31	484071.9	7086679.4	919.59	306	-50	25/08/2010	06/09/2010	HQ
K-10-0291	192.67	484101.3	7086870.8	936.78	285	-54	08/09/2010	13/09/2010	HQ
K-10-0295	313.94	484101.4	7086870.5	936.78	285	-80	13/09/2010	03/10/2010	HQ
K-10-0298	220.68	484101.5	7086870.4	936.78	250	-60	03/10/2010	11/10/2010	HQ
K-10-0299	306.32	484067.2	7086584.3	923.86	285	-68	05/10/2010	10/10/2010	HQ
K-10-0303	348.08	484067.9	7086584.2	923.85	285	-75	10/10/2010	19/10/2010	HQ
K-10-0304	252.07	484101.7	7086870.3	936.78	230	-75	11/10/2010	19/10/2010	HQ
K-10-0305	352.35	484076.4	7086582.7	924.14	340	-65	20/10/2010	30/10/2010	HQ
K-10-0312	388.93	484076.7	7086585.3	923.89	250	-55	30/10/2010	16/11/2010	HQ
K-10-0320	243.84	484076.5	7086586.1	923.99	290	-55	19/11/2010	26/11/2010	HQ

The interpreted surface geology of the District Mill area is shown in Figure 3. The area is underlain by the Keno Hill Quartzite. Several distinctive east – west striking map units that dip moderately to the south are identified in this area:

- Upper Quartzite (Msq) - Comprising light to dark grey, platey quartzite with grey schist (phyllite) layers.
- Sericite Schist Marker (Mss) – Sericite +/-chlorite schist, schistose grit, minor light grey crystalline limestone.
- Graphitic Schist Marker (Msg) – Medium to dark grey schist (phyllite), locally calcareous.
- Basal Quartzite (Mkq) – Blocky buff, light to medium grey quartzite, locally calcareous. Thin graphitic schist bands are common.
- Greenstone (Trgn) – Chlorite-actinolite+/-calcite greenstone sills, locally with relict phaneritic texture.


Flame and Moth Area
Surface Geology and Exploration Drill Holes
Scale 1:5000
7,087,400 mN
7,087,200 mN
7,087,000 mN
7,086,800 mN
7,086,600 mN
7,086,400 mN
483,600 mE
483,800 mE
484,000 mE
484,200 mE
484,400 mE
Mkq
Trgn
Msg
Mss
Msq
Moth Fault
Flame Fault
DSTF Footprint
Mill Building
K-10-0298
K-10-0304
K-10-0285
K-10-0275
K-10-0264
K-10-0305
K-10-0271
K-10-0320
K-10-0299
K-10-0303
K-10-0312
Geology Legend
Inferred Pre-Mineral Fault
Alluvium
Greenstone
Upper Quartzite
Sericite Schist
Graphitic Schist
Basal Quartzite

As the amount of surface outcrop in the area is poor, the distribution of these rock units as shown on the map is somewhat interpretative. There is however evidence of possibly two significant north-east trending fault structures (Moth and Flame Faults) that offset the stratigraphy and that also host mineralised veins.

There is currently no surface geologic evidence for the presence of any later cross-cutting north-west trending faults.

Two diamond drill holes (K-10-0291, K-10-0295) were completed beneath the footprint of the DSTF from a site that was essentially on outcropping Basal Quartzite. These holes were however drilled at an oblique angle to the dominant stratigraphic structure, and this may ffect the quality of the RQD information.

In K-10-0291, two zones displayed increased density of fracture development:

- In quartzite between 88.85 – 96.32 m,
- In a faulted quartzite zone associated with minor mineralisation between 129.84 – 157.28 m.

In K-10-0295, much wider zones in the Basal Quartzite display increased density of fracture development associated:

- Between 8.23 – 87.48 m,
- Between 166.73 – end of hole at 313.94 m.

Some of these fracture zones are associated with minor mineralisation, but may also reflect the thin bedded nature of some of the units.

6 BELLEKENO NON-AML WASTE ROCK DISPOSAL AREA GROUNDWATER MONITORING

Preliminary engineering design based on five (5) boreholes for the Bellekeno Non-Acidic/Metal Leaching (N-AML) Waste Rock Disposal Area (WRDA) was undertaken by EBA Engineering Consultants Ltd. in late 2008 (EBA, 2008). Additional work in support of final design is expected prior to construction. Relevant findings on the subsurface conditions at the proposed WRDA site are excerpted below:

Subsurface Conditions

The subsurface conditions at the site were determined through interpretation of data from the five boreholes advanced by EBA on October 30, 2008. The subsurface conditions consist of sand that is gravely and silty. Bedrock was not encountered in any of the boreholes. The drill lost circulation in the boreholes and prevented the return of cuttings to the surface. A summary of the boreholes and their respective depths is shown in Table 3.

Table 4 Borehole Depths at Bellekeno Site

Borehole Number	Termination Depth (m)
W14101178-BH11(1)	9.0
W14101178-BH12	18.0
W14101178-BH13	12.0
W14101178-BH14	6.0
W14101178-BH15	10.0

Groundwater

Groundwater was not encountered in any of the boreholes at the Bellekeno site.

Permafrost

The moisture content testing completed on the samples collected indicates elevated moisture contents attributed to either the presence of permafrost or increased silt contents of the soils. A ground temperature cable was installed in W14101178-BH11 to 8.0 m. Preliminary readings taken from the ground temperature cable indicate the presence of warm permafrost (-1 to -0.5°C).

Commencement of construction of the (WRDA) is not scheduled at this time. Four groundwater monitoring wells below the Bellekeno WRDA (as per Clause 106 of the Licence) will be installed according to WRDA final design when. Due to the known presence of permafrost and sloping topography in the area beneath the proposed WRDA, AKHM expects any seepage to be deflected by the frozen layer, causing it to run downslope within the active layer. Because of this, relatively shallow monitoring wells are considered appropriate and most likely to intersect and monitor for any seepage from the WRDA. Proposed monitoring wells in the vicinity of the WRDA are summarized in Table 5.

Table 5 Bellekeno WRDA Groundwater Monitoring Well Summary

Station Number	Purpose	Estimated Total Depth (m)	Estimated Overburden Depth (m)	Northing[1]	Easting[1]
KV-91	Seepage/shallow groundwater monitoring	10	10	TBD[2]	TBD[2]
KV-92	Seepage/shallow groundwater monitoring	10	10	TBD[2]	TBD[2]
KV-93	Seepage/shallow groundwater monitoring	10	10	TBD[2]	TBD[2]
KV-94	Seepage/shallow groundwater monitoring	10	10	TBD[2]	TBD[2]

[1]Coordinates are UTM Zone 8 NAD 1983

[2]TBD – "to be determined", station not established at this time.

Appropriate layout and borehole locations for the WRDA monitoring wells will be selected based on field conditions prior to construction and will depend on final WRDA and with the input from design engineers. Conceptual WRDA monitoring well locations are shown on Figure 2.

7 ONEK GROUNDWATER MONITORING

The licence requirement for monitoring of KV-84 requires that a Keno City Well be monitored on a quarterly basis. This monitoring is also subject to Clause 67, requiring that all wells be sampled monthly for the first twelve months that they contain water. Initial sampling as reported in the SRK Bellekeno Groundwater Study (SRK, 2010) used Keno City Well #3 which is owned by a private resident of Keno City. Well #3 and the Keno City Firehall well have been sampled since issuance of the original Licence in order to fulfill monitoring requirements for KV-84, but due to difficulties coordinating sampling, this has not been viewed as a satisfactory solution for the duration of the Licence. In September 2013, KV-84Nd was drilled on the Firehall lot to replace KV-84 as a surrogate to the Firehall well. The details for Well KV-84Nd is presented below in Table 6.

Table 6 Onek and Lucky Queen Monitoring Well details

Station #	Purpose	Total Depth (m)	Depth in Overburden (m)	Depth in Bedrock (m)	Northing[1]	Easting[1]
KV-84	Keno City	93.9	80.2	13.7	7087117	484925
KV-84Nd	Firehall well surrogate	88.4	71	17.4	7086984	485022
ON-MW-2	Downgradient of Onek990 mine	68	7	61	7087083	485244
ON-MW-3	Downgradient bedrock well of Onek 990 mine near KC-MW-4	TBD	-	-	TBD	TBD
KC-MW-4	Downgradient overburden well of Onek 990 mine	67.1	67.1	0	7086921	485197
LQ-MW-1	Downgradient of LQ N-AML	24	11	13	7090576	486426
LQ-MW-2	Downgradient of LQ P-AML	TBD	-	-	TBD	TBD

AKHM, through part of the District Closure Planning, has installed of five wells (KC-MW-1A, KC-MW-1B, KC-MW-2, KC-MW-3, and KC-MW-4) around Keno City as part of a hydrogeologic study of the Keno City area during March and April 2011. Monitoring well KC-MW-1A was selected for reporting for KV-84. A notification was submitted to the YWB and Water Resources to provide notification to regulators of the final sampling location of the Keno City well. The locations of the existing Keno City area wells including location for KV-84, KC-MW-1B, KC-MW-2, KC-MW-3, and KC-MW-4 are also shown on Figure 2. In September 2013 two additional wells were installed on the Keno City Firehall well lot (KV-84Nd and KV-84Ns) as part of District Closure Planning. Well KV-84Nd will replace well KV-84 as it is in a more suitable location then KV-84 relative to the Onek 990 mine.

Monitoring well ON-MW-02 was installed on August 5, 2012 and has been monitored on monthly frequency as part of routine monitoring for the Onek mine site (Figure 2). The new monitoring wells will be monitored on a monthly basis for the first year and on a quarterly basis thereafter.

8 LUCKY QUEEN GROUNDWATER MONITORING

One monitoring well at Lucky Queen that (LQ-MW-1) was installed on August 6, 2012 downgradient of the proposed N-AML Waste Rock Dump proposed adjacent to the Lucky Queen adit (Figure 2). This monitoring well will be monitored on a monthly basis for the first year and on a quarterly basis thereafter. The water licence requires an additional monitoring well to be installed downgradient of the Lucky Queen P-AML facility. This well will be installed when the Lucky Queen P-AML facility is constructed.

9 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 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.

10 GROUNDWATER MONITORING SCHEDULE

Groundwater monitoring will follow the schedule as described in Table 7. 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).

Monitoring Well Sampling:
Representative groundwater samples will be collected from each identified site identified in Table 7. 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 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.

Groundwater Sample Collection and Analyses:
Groundwater samples will be collected in appropriately labelled laboratory grade bottleware with preservation for the analytes requested. At each monitoring well, at the point of sample collection, care will be taken to prevent contact with the inside of the sample containers. In addition, a clean pair of nitrile or latex gloves will be worn during sample collection and handling.

G*roundwater Sample Chain-of-Custody Record, Packing and Shipping*

Once the groundwater samples have been collected the sample information will be added to the chain of custody form, the bottles will then be placed in a cooler with sufficient ice content to cool the samples for shipping. When full, the cooler will be closed, and the lid tightly taped shut to reduce the rate of ice melting.

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 7 Groundwater Monitoring Program Summary

Site	Description	Water Licence	Insitu 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	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-85D	DSTF and Mill Site Groundwater Well #1 (PH2) Deep	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-85S	DSTF and Mill Site Groundwater Well #1 (Shallow)	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-86	DSTF and Mill Site Groundwater Well #2 (PH5)	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-87	DSTF and Mill Site Groundwater Well #3 (PH6)	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-88D	DSTF and Site Groundwater Well #4 (Deep)	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-88S	DSTF and Mill Site Groundwater Well #4 (Shallow)	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-89D	Flame and Moth Site Groundwater Well #5 (Deep)	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-89S	DSTD and Mill Site Groundwater Well #5 (Shallow)	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-91	Bellekeno Waste Rock Disposal Area well #1	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-92	Bellekeno Waste Rock Disposal Area well #2	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-93	Bellekeno Waste Rock Disposal Area well #3	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-94	Bellekeno Waste Rock Disposal Area well #4	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
KC-MW-4	Well south of Onek 400 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
ON-MW-2	Onek Monitoring Well #1 d/g Project Facilities	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	M/Q
LQ-MW-1	Lucky Queen Monitoring Well d/g N-AML WRDA	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	M/Q
LQ-MW-2	Lucky Queen Monitoring Well d/g N-AML WRDA	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
BH39	Phase I of DSTF	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	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	M/Q
KV-108	Upgradient of 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	M/Q
KV-109	Flame and Moth Lightning Creek Discharge area near KV-81	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
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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Legend:

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

11 REPORTING

As per Clauses 25, 26 and 27 of Water Licence QZ09-092-2:

25. The Licensee shall provide to the Board one unbound, single-sided, paper copy of all reports required by this licence. All reports must be reproducible by standard photocopier.

26. The Licensee shall upload electronic copies of all reports required by this licence to the Board's online licensing registry, the WATERLINE. Electronic copies shall be submitted in one of the following formats: Word 97 - 2003, Excel 97 - 2003 workbooks, or Adobe . pdf format.

27. All water quality, water quantity and water level data shall also be submitted in Excel format. Water quality results must be uploaded to Waterline in the format outlined in the most recent version of Yukon's "Laboratory Data Submission Standards for Water Quality". This guide is available on the Board website.

12 REFERENCES

Access Consulting Group, 2009. Keno Hill Silver District Environmental Conditions Report Version 1. Report prepared for Alexco Resource Corp.

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SRK Consulting (Canada) Inc. (2010) 2010 Bellekeno Groundwater Program. Report Prepared for Alexco Keno Hill Mining Corp. SRK Project # 1CA009.003.

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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,
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Robertson, D. A., Gould, J. A., Straw, J, A., and Dayton, M, A., "Survey of Blasting Effects on Ground Water Supplies in Appalachia: Volumes I and II. BuMines Open File Report 8 (1)-82, 1980, 400 pp. Available from National Technical Information Service, Springfield, VA PB 82-152125.

FIGURES

Figure 1 Typical Round Loaded With Amex
Figure 2a Amex Threshold Locations
Figure 2b Packaged Explosive Threshold Locations

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		

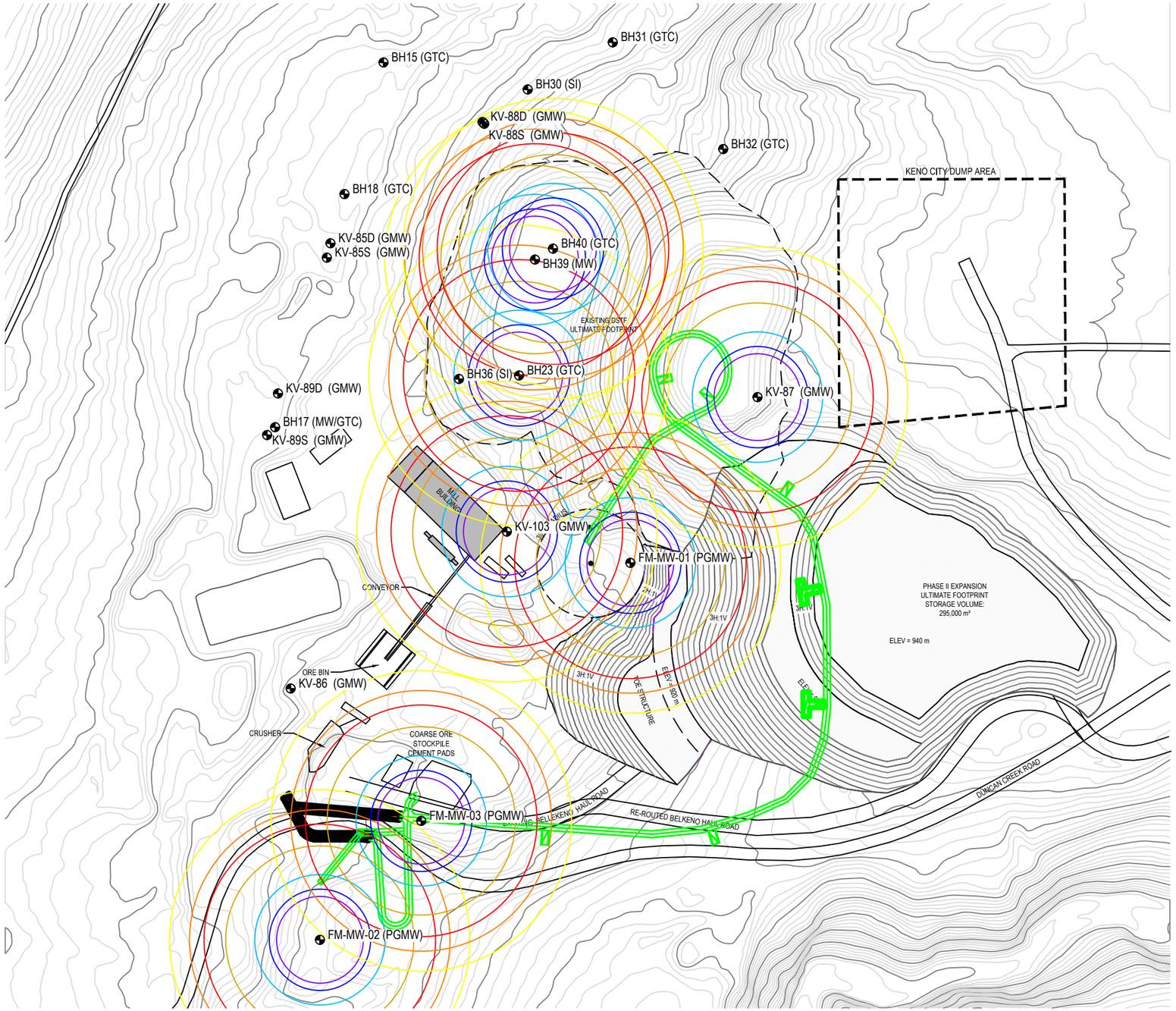
Typical Round loaded with Stick powder

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

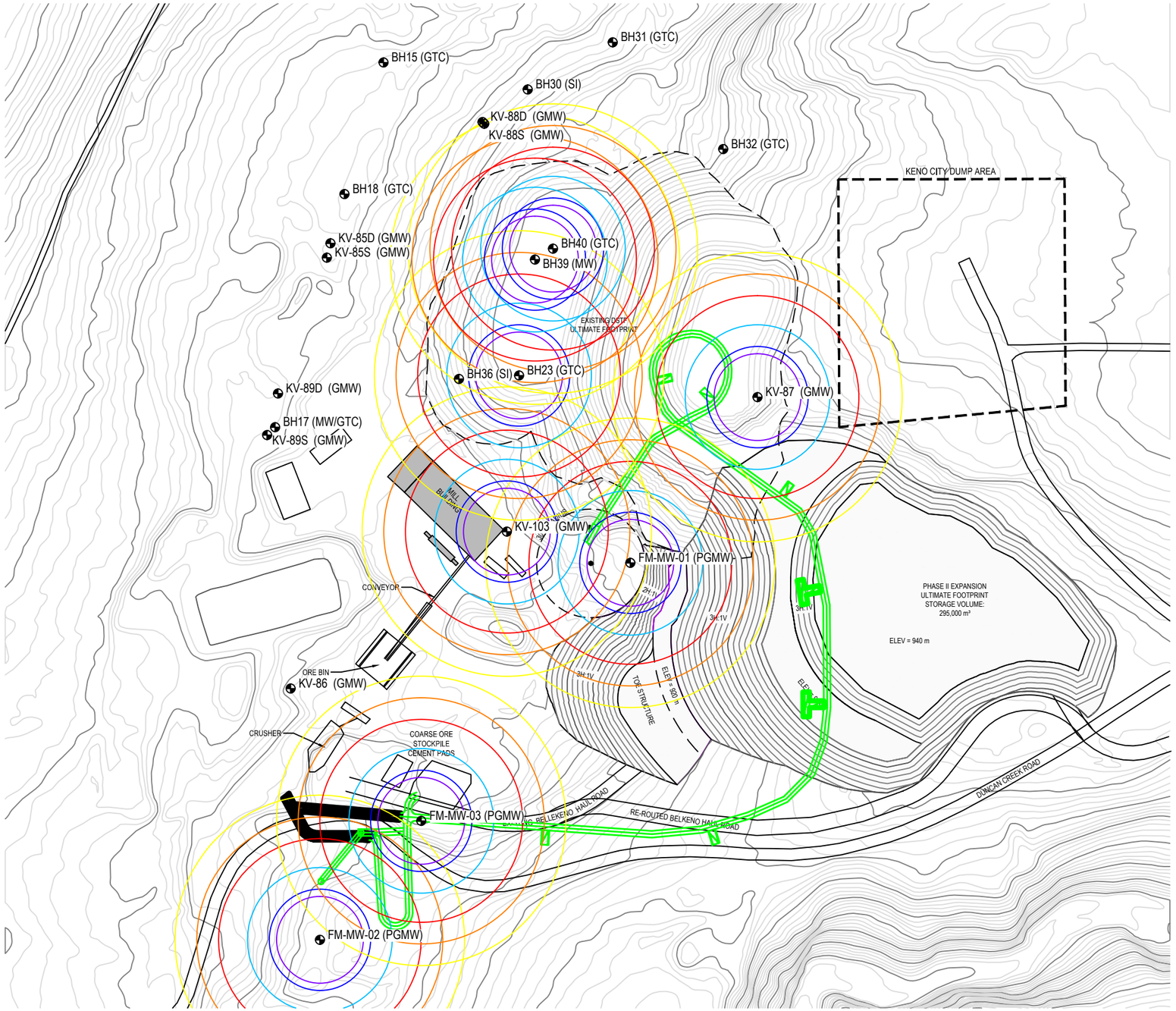
KENO HILL SILVER DISTRICT MINING OPERATIONS

"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

Q:\Vancouver\Drafting\Engineering\W14\W14103303-01\Site Plan - June 2015\W14103303-01 amex and stick powder R0a.dwg [FIGURE 2A] June 16, 2015 - 4:51:42 pm (BY: HALL, ROBERT J)



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

Q:\Vancouver\Drafting\Engineering\W14\W14103303-01\Site Plan - June 2015\W14103303-01 amex and stick powder R0a.dwg [FIGURE 2B] June 16, 2015 - 4:51:15 pm (BY: HALL, ROBERT J)

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

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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.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of Tetra Tech EBA. Additional copies of the report, if required, may be obtained upon request.

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 (JANUARY 2018), WATER LICENCE QZ09-092-2



Alexco Keno Hill Mining Corp.
Keno Hill Silver District Mining Operations

Physical Inspection and Reporting Plan

Water Use Licence QZ09-092-2

January 2018

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1.0 INTRODUCTION

1.1 *Purpose of Plan*

This plan is submitted to fulfill the conditions set out in Part G, Clauses 117 to 119 of Water Licence QZ09-092-2 issued to Alexco Keno Hill Mining Corp. on December 22nd, 2017:

117. Within 90 days of the effective date of amendment to this licence, the Licensee shall submit to the Board an updated, Physical Inspection and Reporting Plan for all water retaining and conveying structures, and associated mine waste and earthworks structures in the Keno Hill Silver District that is consistent with this licence, and shall implement that plan.

118. Inspections will be conducted at least on a weekly basis for all structures identified in the Keno Hill Silver District Physical Inspection and Reporting Plan.

119. The Physical Inspection and Reporting Plan shall include the Bellekeno 625 settling ponds, the Lucky Queen and Onek water storage ponds, the Flame and Moth Water Treatment Pond, 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.

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.

2.0 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 portal at Bellekeno East is located on a steep slope above Thunder Gulch, a narrow tributary of Lightning Creek, and the haul road access to the mill site is provided by an approximately 3 km access road which crosses Lightning Creek approximately 2200 meters downstream from the confluence of Thunder Gulch and Lightning Creek. Lucky Queen is located approximately 4 km northeast of Keno City and Onek is situated about 500 m northeast of Keno City. Please refer to see Figure 1 for the site map.

484000 485000 486000 487000

7092000 7091000 7090000 7089000 7088000 7087000 7086000

N S E W

Christal Creek

CHRISTAL LAKE ROAD

DSTF RUNOFF COLLECTION SUMP

DRY STACK TAILINGS STORAGE FACILITY

FLAME AND MOTH CHRISTAL CREEK DISCHARGE AREA

MILL

FLAME AND MOTH PORTAL

MILL POND

DSTF EXPANSION

WATER TREATMENT POND

CRUSHER

BELLEKENO HAUL ROAD

DUNCAN CREEK ROAD

FLAME AND MOTH WATER TREATMENT POND

MILL ACCESS

FLAME AND MOTH P-AML WASTE ROCK STORAGE FACILITY

FLAME AND MOTH LIGHTNING CREEK DISCHARGE AREA

Lightning Creek

LUCKY QUEEN N-AML

LUCKY QUEEN SETTLING PONDS

LUCKY QUEEN

LUCKY QUEEN P-AML

LUCKY QUEEN ACCESS

Erickson Gulch

WERNECKE ROAD

SILVER TRAIL HIGHWAY

CHRISTAL LAKE ROAD

Christal Lake

SIGN POST ROAD

ONEK P-AML

LIGHTNING CREEK HAUL ROAD

BELLEKENO 625 SETTLING PONDS

Lightning Creek

BELLEKENO HAUL ROAD

BELLEKENO 625 N-AML

ONEK 990 STORAGE POND

ONEK 990 PORTAL

BELLEKENO 625

BELLEKENO EAST HAUL ROAD

LIGHTNING CREEK BRIDGE #2

Thunder Gulch

BELLEKENO EAST

BELLEKENO TEMPORARY P-AML

INSET

Hinton Creek

DUNCAN CREEK ROAD

LIGHTNING CREEK BRIDGE #1

KENO DISTRICT MILL SITE AND DSTF

1:17,500 (when printed on 11 x 17 inch paper)

0 100 200 400 600 800 Meters

Adit

PhotoHubLocations

To be constructed Pipeline

DSTF 322k Tonnes Design

Proposed Mill Pond

Current DSTF

To be Constructed Features

Infrastructure Footprint

Silver Trail Highway

Other Road

Contours (5m)

Watercourse

Waterbody

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

Datum: NAD 83; Projection: UTM Zone 8N

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AKHM

AEG

ALEXCO KENO HILL MINING CORP.

FIGURE 1

QZ09-12-2 PHYSICAL INSPECTION AND REPORTING PLAN SITE MAP

JANUARY 2018

D:\Project\AllProjects\ALEX-05-01\gis\mxd\Overview_Maps\SpecificTopics\Physical_Inspection\Physical_Inspection_PhotoHub_Location_20170105.mxd
Last edited by: amalishevska 05/01/2018 4:34 PM)

3.0 PHYSICAL INSPECTION LOCATIONS

As per Part G, Clause 119 of Water Licence QZ09-092-2, the areas to be inspected include:

- Bellekeno 625 settling ponds;
- Lucky Queen settling ponds;
- Onek 990 water storage pond;
- Flame and Moth Water Treatment Pond;
- Bellekeno N-AML Waste Rock Disposal Area (WRDAs);
- Lucky Queen N-AML Waste Rock Disposal Area (WRDAs);
- Bellekeno temporary P-AML Waste Rock Storage Facilities (WRSFs);
- Onek 990 P-AML Waste Rock Storage Facilities (WRSFs);
- Lucky Queen P-AML Waste Rock Storage Facilities (WRSFs);
- Access roads;
- Flame and Moth Christal Creek and Lightning Creek discharge areas;
- Mill pond; and
- Dry stack tailings facility (DSTF).

4.0 PHYSICAL INSPECTION SCHEDULE

The physical inspection for the all water retaining structures will be conducted on a weekly basis (once constructed). The water ponds include the Bellekeno 625 settling ponds, the Lucky Queen ponds, Onek 990 pond, Flame and Moth Water Treatment Pond and Mill Pond. The P-AML Waste Rock Storage Facilities at Bellekeno East, Flame and Moth, Onek and Lucky Queen. Additionally, the Bellekeno and Lucky Queen N-AML waste rock storage areas (once constructed) and access roads will be inspected weekly

The physical inspection schedule is shown in Table 1 below.

Table 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
Onek 990 storage pond	x
Lucky Queen settling ponds	x
Bellekeno temporary P-AML waste rock storage facility	x
Onek P-AML waste rock storage facility	x
Lucky Queen P-AML waste rock storage facility	x
Flame and Moth P-AML waste rock storage facility	x
Bellekeno N-AML waste rock disposal area	x
Lucky Queen N-AML waste rock disposal area	x
Access roads	x
DSTF	x

*See Appendix B for DSTF inspection schedule

5.0 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 1), and a detailed list and description of these photo hubs is included in Table 2 below.

Table 2 Photo Hub Descriptions

Photo Hub #	Photo Hub Description
1	Bellekeno Temporary P-AML waste rock storage facility
2	Onek P-AML waste rock storage facility
3	Lucky Queen P-AML waste rock storage facility
4	Bellekeno N-AML Waste Rock Staging Area 1 (BKR 16 facing North)
5	Bellekeno N-AML Waste Rock Staging Area 1 (BKR 17 facing South)
6	Lucky Queen N-AML Waste Rock Disposal Area
7	Bellekeno 625 settling pond 1
8	Bellekeno 625 settling pond 2
9	Onek 990 storage pond
10	Lucky Queen settling pond 1
11	Lucky Queen settling pond 2
12	Mill pond (from S corner, facing Mill)
13	DSTF runoff collection sump (on road, facing NW)
14	Flame and Moth Water Treatment Pond
15	Flame and Moth P-AML waste rock storage facility
16	Flame and Moth Christal Creek Discharge Area
17	Flame and Moth Lightning Creek Discharge Area

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 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.

6.0 REPORTING

As per clause 25 and 26 of Water Licence QZ09-092-2:

> 25. The Licensee shall provide to the Board one unbound, single-sided, paper copy of all reports required by this licence. All reports must be reproducible by standard photocopier.
> 26. The Licensee shall upload electronic copies of all reports required by this licence to the Board's online licensing registry, the WATERLINE. Electronic copies shall be submitted in one of the following formats: Word 97 - 2003, Excel 97 – 2003 workbooks, or Adobe .pdf format.

The results of the weekly physical inspection check list will be summarized and incorporated into the annual reports. Requirements of the annual reports are outlined in section 16 of the Water Licence.

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.

Additionally, a Physical Inspections and Monitoring Report will be prepared certified by a Professional Engineer and submitted as part of the annual report that includes the information outlined clauses 17 and 18 below.

17. The Licensee shall submit a report titled, "Physical Inspections and Monitoring Report" certified by a Professional Engineer. The report shall be submitted as a part of the annual report. The report shall include, but not necessarily be limited to:
a) documentation of the inspection locations and methodologies;
b) the results of the inspection;
c) all problems identified;
d) remedial measures recommended; and
e) the status of any remedial measures recommended in the previous year's report with an explanation regarding any recommendation not implemented.

18. Actions taken or planned in response to any identified issues and/or to prevent recurrence will be reported annually as part of the annual report.

Alexco Keno Hill Mining Corp.

Physical Inspections and Reporting Plan

Water Use Licence QZ09-092-2

Appendix A

Physical Inspections Checklist

Physical Monitoring Program Inspection Checklist	MINE								FLAME AND MOTH			DISTRICT MILL				ROADS							
	BK N-AML Waste Rock Disposal Area	BK P-AML Waste Rock Storage Facility	BK 625 Treatment Ponds	LQ N-AML Waste Rock Disposal Area	LQ P-AML Waste Rock Storage Facility	LQ Treatment Ponds	Onek P-AML Waste Rock Storage Facility	Onek Treatment Ponds	F&M P-AML Waste Rock Storage Facility	F&M WTP Pond	F&M Dischage Areas	Mill Pond	DSTF	Water Diversion Structures	Water Collection Structures	CLR 0-8	BKR 0-5	BKR 5-15	BKR 15-18	Onek Laydown to Onek Portal	Onek Portal - LC Bridge BKR	Onek Laydown to LQ1	LQ 0-5
General																							
Checked visually?	Y	Y	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	Survey		Y								
Checked after storm event?																							
Soil / Rock Structures																							
Materials being disposed of properly?	Y	Y		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	Y	Y	Y
Crest checked?	Y	Y		Y	Y		Y		Y					Y	Y								
Toe checked?	Y	Y		Y	Y		Y		Y					Y	Y								
No tension cracks?	Y	Y		Y	Y		Y		Y					Y	Y								
No creep?	Y	Y		Y	Y		Y		Y					Y	Y								
No failure?	Y	Y		Y	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	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	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

Alexco Keno Hill Mining Corp.

Physical Inspections and Reporting Plan

Water Use Licence QZ09-092-2

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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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.