



DUST ABATEMENT AND MONITORING PLAN

KENO HILL SILVER DISTRICT MINING OPERATIONS

September 2017

ALEXCO KENO HILL MINING CORP.



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1 INTRODUCTION

Alexco Keno Hill Mining Corp. (AKHM) is permitted to operate the Keno District Mill as well as the Bellekeno, Lucky Queen, Onek 990 and the Flame and Moth Mines in the vicinity of Keno City, Yukon. In addition, the Bermingham Mine development and production program is currently being proposed. A Dust Abatement and Monitoring Plan has been developed to address any potential air quality effects that may occur with the operations of the Mines and Keno District Mill.

The Dust Abatement and Monitoring Plan is based in part on results of an air dispersion model completed by Access Consulting Group in June 2014 during the *Yukon Environmental and Socio-Economic Assessment Act* (YESAA) process for the Flame & Moth Development and Production Program (Project 2013-0161). The model identified the potential dust sources from the Bellekeno, Lucky Queen/Onek 990 and Flame & Moth mining-related activities, as well as sensitive receptors, and predicted the anticipated ambient concentrations under different operation scenarios. Scenario 1 modeled the operation of the Bellekeno mine only, scenario 2 was for the operation of the Bellekeno and the Flame & Moth Mines concurrently and scenario 3 was for the operation of the Flame & Moth Mine concurrently with Onek 990/Lucky Queen. Additional modeling was carried out in September 2017 to account for a new scenario (Scenario 4) where Flame and Moth and Bermingham mines would operate concurrently.

2 YUKON AMBIENT AIR QUALITY STANDARDS

Dust, or particulate matter, can be divided into fractions of different sizes. PM₁₀ (aerodynamic diameter of less than 10 µm) is the fraction of TSP (total suspended particulate) that is inhalable, and therefore have the potential to cause adverse health effects. Fine particles (aerodynamic diameter of less than 2.5 µm) are able to penetrate deeper into the lungs and are generally considered a stronger risk factor than the coarse fraction of PM₁₀ (particles in the 2.5-10 µm range) (WHO, 2013).

Environment Yukon implemented Ambient Air Quality Standards for TSP and PM_{2.5} in 2010, and more recently for PM₁₀. Those standards and averaging periods are presented in Table 1.

Table 1 Yukon Ambient Air Quality Standards (µg/m³)

Parameter	24-hour	Annual
TSP	120	60
PM ₁₀	50	n/a
PM _{2.5}	28	n/a

3 AIR DISPERSION MODEL SUMMARY

Air dispersion modelling was carried out using CALPUFF, a recognized and approved air dispersion model by the United States (US) Environmental Protection Agency (EPA) and the British Columbia Ministry of Environment (BCMOE).

3.1 POTENTIAL DUST SOURCES

The main dust sources considered in the air dispersion model include the dry stack tailings facility (DSTF), mineral processing and the traffic on unpaved roads (see Figure 1).

3.1.1 DSTF

The DSTF is subject to wind erosion and as such, represents a potential source of airborne dust. The existing DSTF footprint was used for modeling the existing conditions (Scenario 1), while for Scenarios 2, 3 and 4, it was assumed that the existing DSTF would be fully reclaimed and that no more than 50% of the area of the proposed expanded DSTF (corresponding to about 13 ha) would be exposed at any given time, due to progressive reclamation.

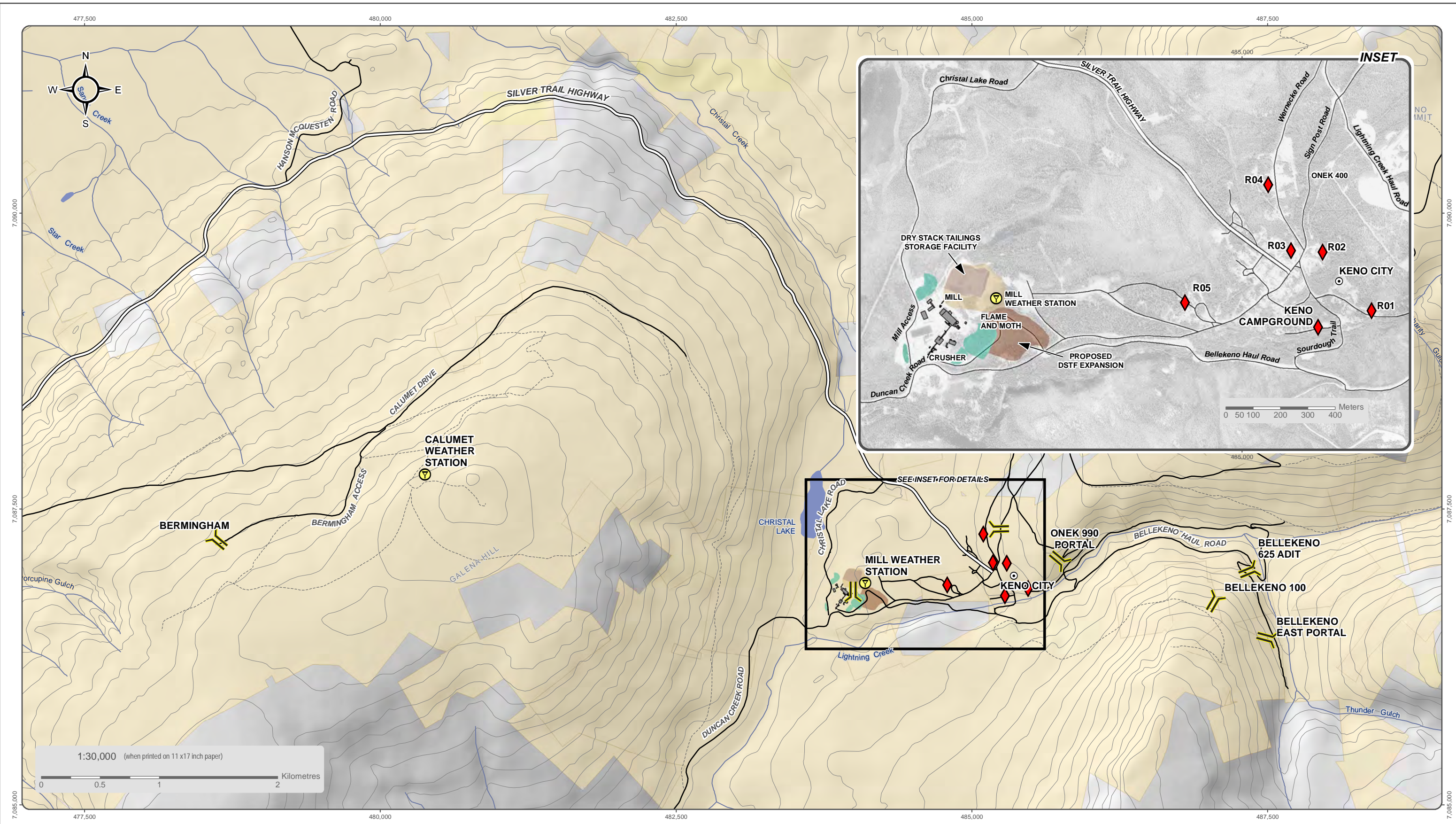
3.1.2 Mineral Processing

The main processes taking place at the mill and crusher include primary and secondary crushing, wet grinding and various material transfers and handling. Fugitive emissions can be reduced by enclosing the crusher in a ventilated building, which was assumed to be the case in the model.

3.1.3 Unpaved Roads

Estimated mine-related traffic volumes on unpaved roads for Bellekeno, Onek 990/Lucky Queen, Flame & Moth and Bermingham are presented in the Traffic Management Plan, and include Christal Lake Road, Bellekeno Haul Road, the road between the F&M adit and the crusher, Wernecke Road, Keno City Bypass Road, the roads between Bermingham and the crusher and the Silver Trail Highway between Christal Lake Road and Keno City.

Fugitive dust emissions from unpaved roads are naturally mitigated by precipitation and can also be controlled with the use of chemical suppressants or road watering. Both types of mitigations were assumed in the model.



1:30,000 (when printed on 11 x17 inch paper)

0 0.5 1 2 Kilometres

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Satellite imagery obtained from Yukon Geomatics map service <http://mapservices.gov.yk.ca/ArcGIS/services> on September 2017

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

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- Receptor
- Weather Station
- Adit
- Alexco/ERDC Quartz Claims

- Proposed Features
- DSTF 322k Tonnes Design
- Current DSTF
- DSTF Phase II Expansion
- Existing Building

- Waterbody
- Watercourse
- Silver Trail Highway
- Other Road
- Limited-Use Road



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FIGURE 1

POTENTIAL DUST SOURCES AND RECEPTORS

SEPTEMBER 2017

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3.2 DUST RECEPTORS

In order to assess potential effects of particulate matter, discrete receptors in Keno City were used. Table 2 presents the coordinates and description of the six receptors, which are shown on Figure 1. Those same receptors were used in the Noise Impact Assessment and are part of the Noise Monitoring and Management Plan.

Table 2 Discrete Receptors in Keno City

Residence	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 850m east from the Mill
Cmpgrnd	N63.90772 W135.29998	Keno City campground

3.3 BACKGROUND CONCENTRATIONS

Total suspended particulates (TSP) monitoring was initiated by AKHM at two locations near the Keno District Mill site in August 2012 and a third sampler, located in Keno City, was commissioned in December 2014. Additional sampling for coarse and fine fractions of particulate matter (PM₁₀ and PM_{2.5} respectively) was instigated in August 2015 at the three stations. Average background ambient 24-hour concentrations were calculated using only data collected during periods when no mining or exploration activities were taking place. Periods of care and maintenance include September 24, 2013 to March 25, 2013 and November 19, 2014 to December 31, 2016. Background concentrations (averaged over the three stations) used in the model are presented in Table 3 below.

Table 3 Air Contaminants Background Concentrations used in Model (µg/m³)

Contaminant	Background Concentration	
	24-hour	Annual
TSP	5.9	1.2
PM ₁₀	3.2	0.6
PM _{2.5}	4.1	0.8

3.4 PREDICTED AMBIENT CONCENTRATIONS

Predicted maximum 24-hr and annual concentrations (including background concentrations and Project-related emissions) at the six Keno City receptors, under the four modelled scenarios, are presented in Tables 4 to 7 below. No exceedences of the applicable Yukon Ambient Air Quality Standards (YAAQS) are predicted at any of the six discrete receptors located in Keno City, however, some exceedences of the YAAQS are possible for TSP and PM₁₀ in a very localised area near the sources.



Table 4 Predicted TSP, PM₁₀ and PM_{2.5} Concentrations (µg/m³) under Scenario 1

Receptor	TSP		PM ₁₀		PM _{2.5}	
	Max 24-hr Concentration	Annual Concentration	Max 24-hr Concentration	Annual Concentration	Max 24-hr Concentration	Annual Concentration
R01	50.5	13.3	16.0	5.3	5.4	4.3
R02	45.6	12.2	14.7	5.0	5.3	4.3
R03	51.4	12.6	16.4	5.1	5.5	4.3
R04	35.9	10.1	12.0	4.4	5.1	4.2
R05	77.5	17.7	24.6	6.6	6.5	4.5
Cmpgrnd	62.0	15.5	19.3	5.9	5.8	4.4
YAAQS	120	60	50	n/a	28	n/a

Table 5 Predicted TSP, PM₁₀ and PM_{2.5} Concentrations (µg/m³) under Scenario 2

Receptor	TSP		PM ₁₀		PM _{2.5}	
	Max 24-hr Concentration	Annual Concentration	Max 24-hr Concentration	Annual Concentration	Max 24-hr Concentration	Annual Concentration
R01	53.8	13.6	17.0	5.4	5.5	4.3
R02	49.9	12.6	16.0	5.1	5.5	4.3
R03	56.7	13.1	18.0	5.3	5.7	4.3
R04	42.6	10.6	14.0	4.6	5.3	4.2
R05	93.6	18.9	30.0	7.0	7.2	4.5
Cmpgrnd	65.8	15.9	20.4	6.1	5.9	4.4
YAAQS	120	60	50	n/a	28	n/a

Table 6 Predicted TSP, PM₁₀ and PM_{2.5} Concentrations (µg/m³) under Scenario 3

Receptor	TSP		PM ₁₀		PM _{2.5}	
	Max 24-hr Concentration	Annual Concentration	Max 24-hr Concentration	Annual Concentration	Max 24-hr Concentration	Annual Concentration
R01	32.5	10.8	11.0	4.6	4.9	4.3
R02	28.9	9.9	10.0	4.4	4.8	4.2
R03	28.0	10.7	9.9	4.6	4.9	4.3
R04	24.4	9.6	8.9	4.3	4.8	4.2
R05	44.9	10.7	16.3	4.7	5.8	4.3
Cmpgrnd	30.3	10.2	10.4	4.4	4.9	4.2
YAAQS	120	60	50	n/a	28	n/a

Table 7 Predicted TSP, PM₁₀ and PM_{2.5} Concentrations (µg/m³) under Scenario 4

Receptor	TSP		PM ₁₀		PM _{2.5}	
	Max 24-hr Concentration	Annual Concentration	Max 24-hr Concentration	Annual Concentration	Max 24-hr Concentration	Annual Concentration
R01	20.9	2.7	7.6	1.1	4.6	0.8
R02	20.9	2.9	7.7	1.1	4.6	0.9
R03	21.9	3.0	8.1	1.1	4.7	0.9
R04	22.2	3.0	8.3	1.1	4.7	0.9



Receptor	TSP		PM ₁₀		PM _{2.5}	
	Max 24-hr Concentration	Annual Concentration	Max 24-hr Concentration	Annual Concentration	Max 24-hr Concentration	Annual Concentration
R05	47.9	4.8	16.7	1.7	5.8	0.9
Cmpgrnd	20.9	3.0	8.1	1.1	4.6	0.9
YAAQS	120	60	50	n/a	28	n/a

The highest ambient concentrations are expected to occur under scenario 2, when the Flame & Moth and Bellekeno Mines are operated concurrently.

4 DUST MITIGATION MEASURES

AKHM has committed to the following measures which were incorporated into the air dispersion model:

- Progressive reclamation, such as placement of cover and revegetation, measures will be implemented on the existing and DSTF phase II.
- The crusher will be enclosed inside a ventilated building.
- Chemical dust suppressant (calcium chloride or similar) will be applied to the roads in addition to the road watering that will be carried between chemical dust suppressant applications.

Additional mitigation measures that could further reduce fugitive dust emissions include:

- Dust suppressant could be applied to the DSTF. Including the application of a tackifier product to the exposed tailings surfaces (as final slopes or benches are completed), to reduce potential wind erosion prior to progressive reclamation.

AKHM will notify Keno City residents regarding traffic increases, operation schedules and potential dust-generating events.

5 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.

Two BGI Omni Ambient Air Quality Samplers 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

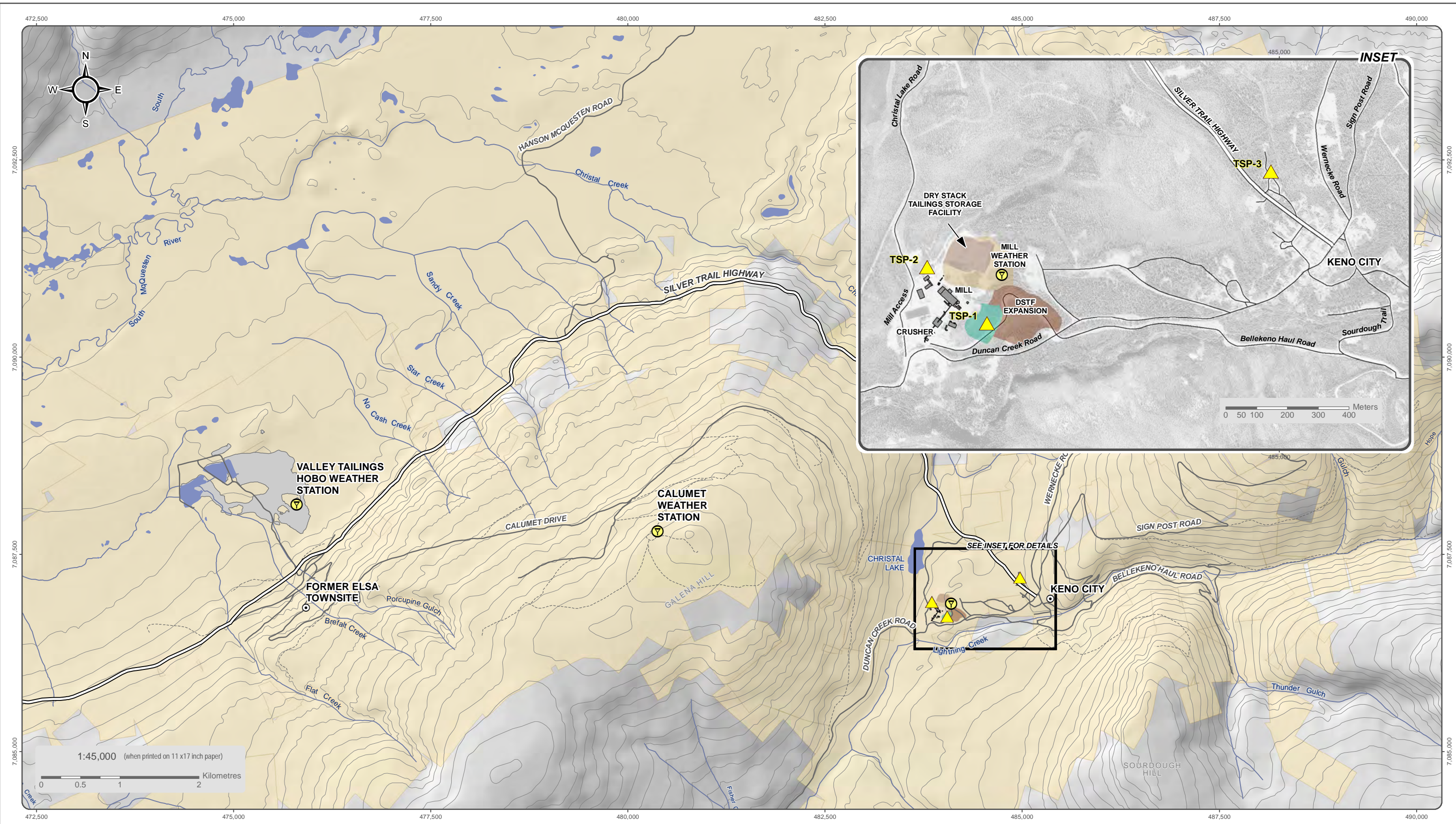
in Keno City, was commissioned in December 2014, in accordance with the revised Dust Abatement and Monitoring Plan required in the Decision Document for the assessment of the Flame & Moth Development and Production Program (YESAB file Number 2013-0161). The sampling locations are shown on Figure 2. The BGI Omni samplers are set up with TSP, PM₁₀ 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.

TSP, PM₁₀ and PM_{2.5} monitoring results are compared to the Yukon Ambient Air Quality Standards (YAAQS) under the Environment Act (see Table 1). 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 8 below.

Table 8 Ontario Ambient Air Quality Criteria (µg/m³)

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

No exceedances of the YAAQS or of the Ontario ambient air quality standards have been observed to date. Results are presented in detail the 2016 “Air Quality Data Summary, Keno, YT” (Appendix of the Project proposal). Monitoring will continue to be carried out as described above as the Keno Hill Silver District is developed and advanced.



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- | | | |
|--------------------------------|-------------------------|----------------------|
| Alexco TSP Monitoring Stations | Proposed Features | Valley Tailings |
| Weather Station | DSTF 322k Tonnes Design | Waterbody |
| Alexco/ERDC Quartz Claims | Current DSTF | Watercourse |
| | DSTF Phase II Expansion | Silver Trail Highway |
| | Existing Building | Other Road |
| | | Limited-Use Road |



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FIGURE 2

AIR QUALITY MONITORING STATIONS LOCATION

SEPTEMBER 2017

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(Last edited by: amath@alexco.com; 25/09/2017 10:54:44 AM)



5.1 UPDATED MONITORING PLAN

In response to concerns raised during the YESAA process for Flame & Moth and considering the results of the air dispersion model, AKHM will make the following changes to its air quality monitoring program prior to commencing operations of the District Mill:

- The sampler located at TSP-1 will be relocated to the western limit of Keno City to characterize ambient concentrations at sensitive receptors in Keno City. Of the six discrete receptors used in the model, receptor R05 (located at the western end of Keno city) is where the highest concentrations were estimated.
- The sampler located at TSP-3 will be relocated to the eastern end of Keno City (near receptor R02), to provide an understanding of how ambient concentrations vary throughout town.
- The sampler located at TSP-2 remains in operation at the same location 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.