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MEMO

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From:
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Date:
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ARCADIS Project No.:
AZ001233.0017

Subject:
Transmittal of Odor Screening Results
Sierrita Mine

Dear Eric,

Attached please find the odor evaluation results for odor screening samples collected at Sierrita Mine operations. Please note these are screening level results that represent estimated odor parameters and should not be interpreted as absolute results.

On March 18, 2015, odor samples were collected from the following sources at Sierrita:

- Moly Roaster Stack
- Mill Rougher Flotation – Pack 1, Cell 1
- Copper-Moly Thickener Tank C
- Solvent Extraction Plant 1 E-Stripper Tank
- Decant Liquid
- Xanthate Liquid Mix Tank

Air samples from each source were collected into Tedlar® (inert plastic) bags using an evacuation chamber and shipped overnight under Chain-of-Custody record to St. Croix Sensory, Inc. (St. Croix) in Stillwater, Minnesota, for odor evaluation by an odor panel. St. Croix was engaged to evaluate the samples for the following odor parameters:

- Odor Strength – The number of times the original odor sample had to be diluted with an equal volume of odor free air before the average person cannot detect (detection threshold) that an odor is present or recognize (recognition threshold) the odor that is present.
- Odor Intensity – How strong the odor is perceived by the odor panel evaluators rated against an equivalent level of n-butanol and recorded as parts per million by volume in air (ppm) of n-butanol.
- Persistence – The rate at which the intensity of an air sample changed as it was diluted with odor free air. This parameter determines the nature of the air sample to be perceived at greater distances from the source.
- Hedonic Tone – The subjective rating of pleasantness (rating of 0 to +10) or unpleasantness (rating of 0 to -10) of the air sample as observed by the odor panel evaluators.
- Odor character – A list of standard descriptors used by the odor panel evaluators to define what the air sample smelled like, noted in order of significance.

Odor panels consist of individuals (panelists) that are selected and trained following the "Guidelines for Selection and Training of Sensory Panel Members" (ASTM Special Technical Publication 758). Odor panelists are recruited from the community at large and are tested to determine their individual olfactory sensitivity using standard odorants. The panelists receive training in olfactory awareness, sniffing techniques, standardized odor descriptors, and olfactometry responses.

The samples were submitted to St. Croix for analysis by the methods EN 13725, Air Quality - Determination of Odour Concentration by Dynamic Olfactometry, and ASTM E544, Standard Practices for Referencing Suprathreshold Odor Intensity. The European Standard EN 13725 defines a method for the objective determination of the odor concentration of a gaseous sample using dynamic olfactometry with human assessors (an odor panel). The American Standard ASTM E544 establishes practices for referencing the odor intensities of an odorous material in the suprathreshold region on the ASTM Odor Intensity Referencing Scale. The method is based on the reference odorant 1-butanol (n-butanol). The suprathreshold region is an odor of sufficient strength or quantity to produce a perceptible physiological effect.

The air samples were evaluated by St. Croix on March 19, 2015. Odor evaluation results are summarized in Table 1. A discussion of the results follows after the table.

**Table 1 - Summary Results of Sierrita Odor Samples Collected March 18, 2015
St. Croix Sensory, Inc.**

Sample Description	Odor Strength – European Standard EN13725		ASTM E544	PERSISTENCY	ODOR CHARACTER	
	Detection Threshold, Odor Units, OU ¹	Recognition Threshold, Odor Units, OU ¹	Intensity ² ppm n-butanol	Dose-Response Slope	Hedonic Tone	Principal Odor Descriptors
Moly Roaster Stack - Sample Port	580	310	46	-0.55	-1.2	Medicinal, Chemical, Earthy, Offensive
Flotation	330	180	117	-0.76	-4.0	Chemical, Offensive, Earthy, Fruity, Medicinal
"C" Copper/Moly Thickener Surface	150	85	58	-0.65	-2.8	Chemical, Offensive, Earthy, Medicinal
SX-1 "E" Stripper Tank Diluted 10:1 ³ (Adjusted Dilution Value)	290 (2,900)	150 (1,500)	95	-0.82	-3.6	Chemical, Offensive, Earthy, Medicinal
Decant Feed - Bottle Agitation	2,900	1,500	155	-0.61	-5.2	Offensive, Chemical, Earthy
Xanthate Mixed Diluted 10:1 ³ (Adjusted Dilution Value)	3,100 (31,000)	1,600 (16,000)	195	-0.63	-5.8	Offensive, Fishy, Earthy

1. The number of times the original odor sample had to be diluted with an equal volume of odor free air before the average person cannot detect (detection threshold) that an odor is present or recognize (recognition threshold) the odor that is present.
2. Reported as the equivalent concentration of n-butanol in ppm.
3. Sample diluted 10:1 due to potential high Detection Threshold values.

Odor Strength - The threshold values obtained from odor testing are derived from dilution ratios, and are therefore dimensionless. However, the pseudo-dimensions of “Odor Units” (OU) are commonly applied to represent the dilution ratios or ‘Dilution to Threshold’, D-to-T. The results for the Extraction Stripper Tank and Xanthate Mixed are from samples that were diluted 10:1 when they were collected in the field because of their potential high Detection Threshold values. Accordingly, the values posted in Table 1 for these two samples should be multiplied by 10 to obtain the actual field value. This is noted in the table as the Adjusted Dilution Value in parentheses. After making this dilution value adjustment, the odor strength values in Table 1 show that the order of the samples from stronger odor to weaker odor is Xanthate Mixing Tank, Decant Feed/Extraction Stripper Tank, Moly Roaster Stack, Flotation, and Copper/Moly Thickener Surface. The Recognition Threshold values were, as typically expected, consistently just over half of the Detection Threshold values.

Intensity - Table 1 displays the n-butanol concentration in ppm as a standard reference compound for odor intensity. The intensity values in Table 1 show that the order of the samples from more intense odor sources to less intense odor sources is the Xanthate Mixing Tank, Decant Feed, Flotation, Extraction Stripper Tank, Copper/Moly Thickener Surface, and the Moly Roaster.

Persistence - Odor sources with flatter slopes, i.e. lower negative values, are more persistent and will tend to retain their odor character over a longer distance than odor sources with steeper slopes, i.e. higher negative values. The dose-response slopes in Table 1 show that the order of the samples from more persistent odor sources to less persistent odor sources is the Moly Roaster, Decant Feed, Xanthate Mixing Tank, Copper/Moly Thickener Surface, Flotation, and the Extraction Stripper Tank.

Hedonic Tone - All six air samples evaluated by the odor laboratory were ranked on the negative side of the scale and were therefore classified as unpleasant.

Odor Character – Odor character is described by odor descriptors and sensation descriptors. There are eight odor descriptor macro-categories: floral, fruity, vegetable, earthy, offensive, fishy, chemical, and medicinal. Within these macro-categories are more than 100 specific descriptors, e.g. chlorinous, turpentine, solvent. There are eight sensation descriptors: warm, tingling, itching, metallic, cool, sharp, pungent, and burning. Regarding odor descriptors, all of the odor samples were defined as being offensive and most were also defined as chemical and medicinal. The odor panel also evaluated the odor samples for sensation, where pungent and burning were the two most consistent terms used to describe the odor samples, although the relative strengths recorded were low. Details for odor descriptors, sensation descriptors, and their relative strengths for each sample are provided in the St. Croix report.