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*Comments on Additional Information Related to Class V Treated
Water Infiltration System Application*

Prepared for the United States Environmental Protection Agency – Region 5

By The Cadmus Group, Inc. under contract # EP-C-08-015

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Kennecott Eagle Minerals (Kennecott) provided the U.S. Environmental Protection Agency (EPA) with additional information related to their application for a Treated Water Infiltration System (TWIS) permit in documents dated November 21, 2008; December 19, 2008; and January 22, 2009. Based on previous reviews, EPA had identified several data gaps, and had requested additional information related to the hydrogeology and hydrochemistry of the proposed project area. Kennecott has provided responses to the request for additional information, and an assessment of these responses is presented below, focusing on the following three issues:

- (a) What is the likelihood that the clay layer approximately 60 feet below the ground is continuous?
- (b) If the clay layer 60 feet below the ground is a continuous layer, qualitatively, what are the chances that this would result in overland surface flow if the TWIS was accepting fluids at its full capacity?
- (c) Will the fluid passing through the TWIS and into the surrounding ground water result in the mobilization of any material that would result in an exceedance of a primary drinking water standard?

Comments:

- (a) Regarding the subsurface stratigraphy, boring log data are now available for approximately 17 soil borings and monitoring well installations in and near the TWIS area. Eight of these are relatively newly installed (March, 2008). The lacustrine clay layer is entirely absent from five of the logs in the immediate TWIS area (QAL031, QAL041, QAL050A, QAL052A, and QAL053A). In some logs, the clay layer is present below the water table (QAL056A, QAL036, QAL037).

The log for QAL057A is inconsistent; the symbol for clay is used, and the unit is labeled as "Lacustrine Deposits," but it is also labeled as "silt, with some fine sand, brown" and the soil classification code for silt is used (ML). The same layer in QAL057D is labeled as Transitional Deposit. We assume, therefore, that the clay layer is absent in QAL057A as well. Where present, the clay unit is often only two feet thick (except in the area of QAL037, where it is nearly 20 feet thick). Nevertheless, the data provided by Kennecott in the November 21, 2008 submission, specifically the absence of the clay layer from five logs in the immediate vicinity of the TWIS, provide evidence consistent with the clay layer being discontinuous in the area of the TWIS.

- (b) Given the additional evidence of discontinuity of the clay layer presented by Kennecott, there is no reason to further investigate the possibility of overland surface flow due to the clay layer.

- (c) To address questions regarding the potential interactions between the infiltrating effluent and the sediments, Kennecott performed a leaching test, discussed below. Additional points of discussion include how Kennecott extracted samples for analysis, and Kennecott's new ground water analyses. These tests and analyses are discussed below.

1. Synthetic Precipitation Leaching Procedure:

To address questions regarding the potential interactions between the infiltrating effluent and the sediments, Kennecott performed a leaching test on four samples of quaternary alluvium from the TWIS area. Samples included fine sand, silt, and clay and were taken from four depths to obtain representative materials. The leaching experiment was performed using EPA Method 1312, the Synthetic Precipitation Leaching Procedure (SPLP). The details of this method were not provided in the submission, but are publicly available. In executing the SPLP, the pH of the nitric acid/sulfuric acid extraction solution depends on the location of the site; a pH of 4.2 is used for regions east of the Mississippi, and a pH of 5 is used for regions west of the Mississippi. Although it is not stated in the report, we make the assumption that a pH of 4.2 was used by Kennecott.

The SPLP test is not a perfect representation of field conditions and may be conservative in some respects and less conservative in others. Conservative aspects (those which might cause greater metal mobility in SPLP leachate than what would be expected in the field) include use of a lower pH than the anticipated TWIS water and the use of a shaker device. An aspect of the SPLP that might tend to underestimate metals mobility is the high liquid to solid ratio used in the SPLP. These issues will be discussed below.

The SPLP was developed to assess the risk of ground water contamination from leaching by precipitation through solid wastes. The leaching solution in this method contains only nitric acid and sulfuric acid. The anticipated waste water treatment plant (WWTP) effluent will be adjusted to a pH between 6.5 and 7.5 and will have somewhat elevated sodium and chloride concentrations (30 mg/L and 44 mg/L, respectively). Although the synthetic precipitation in the SPLP is not representative of the anticipated WWTP effluent, the lower pH used in the SPLP provides a more aggressive solution for mobilizing metals. In this respect, the test is conservative (i.e., this aspect of the SPLP is likely to result in leachate concentrations that are higher than would be obtained were the procedure to be run at the expected pH of the WWTP effluent). In this sense, there is a margin of safety in the pH used in the procedure.

The SPLP involves 18 hours of agitation at 30 rpm. Beneath the TWIS, in contrast, water percolates downward through sediments, and upon reaching the saturated zone, flows as ground water. The agitation process of the SPLP is an attempt to make the interaction between fluid and sediment in the laboratory more representative of subsurface

conditions than simply having the fluid in contact with the sediment with no movement. Nevertheless, the 30 rpm laboratory agitation, although not particularly aggressive, may mobilize slightly more metal from the sediments than would the relatively slow processes of percolation and subsurface flow. In this respect also, the test is conservative.

The results of the SPLP can be challenging to interpret, however, because the experimental setup does not represent environmental conditions. For a situation such as the proposed TWIS, in which water will be infiltrating through a sandy medium, a column setup would be a more accurate representation. However, the time and effort involved in setting up a column apparatus make it reasonable to look for alternatives, and the SPLP is an appropriate option. The major problem in interpretation lies in the fact that the liquid to solid ratio (L/S) of 20:1 (L/kg) used in the SPLP is much greater than what will occur in the environment. This would serve to make the concentrations in the SPLP leachate lower than what would be found in water moving through the sediment. This aspect of the SPLP is not conservative. However, the use of this method provides useful information on potential mobilization of elements beneath the TWIS, as explained below.

Townsend et al. (2006) have explored the use of the SPLP to evaluate risk to ground water from precipitation leaching through land-applied granular wastes. They experimented by leaching solid wastes at a variety of L/S ratios and confirmed that the concentrations of metals in the leachate increased with decreasing L/S. However, the increase was much less than what would be obtained if one were to simply take the concentrations in the SPLP leachate and multiply them by a factor to account for the dilution.

Additional study and analysis would be needed to extrapolate accurately how the results of the SPLP relate to the concentrations of metals to be expected in the field. However, the data provided by Kennecott can be used to approximate a conservative estimate. Based on an examination of data presented by Townsend et al. (2006), our analysis suggests that a factor of 10 would be an appropriate value by which to multiply the SPLP metals concentrations in Kennecott's data to arrive at a conservative estimate of metals concentrations in the field. This factor is intended to account, with a margin of safety, for the dilution inherent in the SPLP test.

Kennecott's results for the SPLP showed that metals concentrations were usually below reporting limits, with the exceptions of Ba and Cu. (Kennecott mistakenly states that the concentrations were below detection limits, which are not identical to reporting limits.) For those metals that were below reporting limits and that have MCLs (As, Cd, Cr, Se, Pb, and Hg), a worst case scenario would involve using the reporting limits as

hypothetical maximum concentrations. Applying the multiplier of 10 to the SPLP results, metals concentrations in the pore water would not exceed the MCLs.

For comparison purposes, Table 1 shows the range of concentrations in the SPLP results, the laboratory's reporting limits for the various metals, the MCLs, and, in the final column, the MCLs divided by the concentrations in the SPLP leachate. The ratio in the final column represents how far below the MCLs the SPLP leachate concentrations are (i.e., by what factor one would need to multiply the SPLP leachate concentrations to reach the MCL). Taking into account the estimate that metals concentrations in pore waters would be no more than 10 times the concentrations in the SPLP leachate, this shows that not only would the metals concentrations in the sediment pore water not exceed MCLs, but for most of the metals analyzed, there is an additional factor of safety.

Furthermore, if the infiltrating water mixes with ground water, it will be diluted. (Some states, in fact, consider SPLP results to be more or less representative of ground water that has mixed with leachate.) Elements of concern (As, Ba, Hg) are already present in the ambient ground water sporadically and in low concentrations. Additional infiltrating water from the TWIS is not expected to cause significant changes in the metals concentrations of the ground water, assuming the TWIS water is of the anticipated quality.

Table 1. Laboratory reporting limits and maximum contaminant levels for metals analyzed in SPLP leachates.

Element	Concentrations in SPLP Leachates(mg/L)	Reporting Limit (mg/L)	MCL (mg/L)	MCL/Concentrations in SPLP Leachates
Arsenic	<0.001	0.001	0.01	>10
Barium	0.017 to 0.037	0.001	2	118-54
Cadmium	<0.0002	0.0002	0.005	>25
Chromium (total)	<0.001	0.001	0.1	>100
Copper	0.0012 to 0.0027	0.001	A.L.* = 1.3	481-1,083
Lead	<0.001	0.001	0.015	>15

Element	Concentrations in SPLP Leachates(mg/L)	Reporting Limit (mg/L)	MCL (mg/L)	MCL/Concentrations in SPLP Leachates
Mercury	<0.0002	0.0002	0.002	>10
Nickel	<0.001 to 0.0017	0.001	no MCL	N/A
Selenium	<0.001	0.001	0.05	>50
Silver	<0.0002	0.0002	no MCL	N/A

* A.L. = Action Level

A number of assumptions have gone into this analysis. However, the results of the SPLP do not generate concerns at this time, and routine monitoring below and downgradient of the TWIS should indicate if problems emerge after the TWIS is put into operation.

2. Extraction of Samples for Analysis:

With respect to the analysis of total metals, it is not stated in the report how the samples were extracted for analysis. However, the quality control report for total metals analyses lists digestion by EPA method 3050B. Method 3050B is intended for the measurement of elements that could become “environmentally available.” For the purposes of this review, it is assumed that method 3050B was applied to all samples analyzed for total metals. Method 3050B is an acid digestion for sediments, sludges, and soils. This is an aggressive method that involves repeated additions of nitric acid and hydrogen peroxide.

Please note that Kennecott’s comparison with the bulk composition of upper crustal rocks and sediments, which is based on whole rock analyses involving complete mineral dissolutions, is misleading and not relevant. This is because Method 3050B is not intended to, and does not, dissolve elements bound in silicate mineral structures. Most of the elements involved in potential interactions between the infiltrating effluent and the sediments beneath the TWIS would be on or near the surfaces of the minerals. Thus, while Method 3050B targets the elements that have the potential to become liberated in the environment, the method does not provide total metals concentrations for a sediment sample.

3. New Ground Water Analyses:

The new ground water analyses contains a few errors. In the 2008 Background Water Quality Report for Groundwater Discharge Permit, major anions are listed as having units of ug/L instead of mg/L. The data are consistent with mg/L, and the ug/L is clearly a typographical error. Also, dissolved oxygen concentrations for the ground water samples appear high. A footnote states that the high dissolved oxygen concentrations are biased due to field protocols, but it is not stated which aspects of the field sampling resulted in the high values.

4. Conclusions:

Although the methods and procedures used by Kennecott to evaluate the potential for the mobilization of metals by the proposed operation of the TWIS may not have been optimal, they are generally reasonable. Based upon the analysis outlined in the preceding section, we conclude that fluid passing from the proposed TWIS into the surrounding soil and groundwater is unlikely to result in the mobilization of materials that would result in the exceedance of any primary drinking water standard.

Reference:

Townsend, T., Dubey, B., and Tolaymat, T. 2006. Interpretation of synthetic precipitation leaching procedure (SPLP) results for assessing risk to groundwater from land-applied granular waste. *Environmental Engineering Science*, 23(1), 239-251.