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RE: Revised Technical Memorandum: Calculation of Leaching-Based, Site-Specific Levels (LSSLs) for the Soil-to-Groundwater Pathway Using NDEP Guidance, Nevada Environmental Response Trust, Henderson, Nevada

INTRODUCTION

This revised technical memorandum provides a screening evaluation of the potential for leaching of site-related chemicals (SRCs) from soil to groundwater at the Nevada Environmental Response Trust site in Henderson, Nevada (the Site). The revised memorandum incorporates comments received from the Nevada Division of Environmental Protection (NDEP, March 21, 2011) after their review of the February 14, 2011 revised submission. Both the original and revised evaluations incorporate the methods presented in the *Soil to Groundwater Leaching Guidance* from the Nevada Division of Environmental Protection (NDEP), dated January 16, 2010 (guidance). This screening evaluation of leaching from soil to groundwater was conducted as discussed in telephone conversations between representatives of Tronox, LLC, Northgate, NDEP, and its consultant, Hackenberry Associates.

The purpose of the leaching evaluation is to identify chemicals of potential concern (COPCs) that have the potential to leach from unsaturated soil into shallow groundwater at the Site, and to calculate leaching-based, Site-specific levels (LSSLs) in accordance with the NDEP guidance document. This memorandum documents the methods used for identifying COPCs and calculating LSSLs based on risk-based groundwater concentrations (RBGCs) consisting of drinking water standards approved by NDEP for this evaluation.[1] The calculated LSSLs are not intended to be used as final cleanup

[1] COPCs are identified in Attachment 2. Input parameters used in this evaluation are presented in Attachment 3. Attachment 4 discusses the fate and transport of COPCs for which RBGCs have not been established, according to the hierarchy of drinking water standards approved by NDEP for

standards. Further evaluation, including fate and transport modeling and/or risk assessment, may be necessary to derive appropriate RBGCs and final vadose zone cleanup goals for the Site. A data usability evaluation conducted in accordance with US EPA and NDEP guidance will be submitted to NDEP in conjunction with submittal of the adjusted LSSLs for the site (i.e. proposed Site cleanup goals).

The data set used for evaluation of the soil-to-groundwater leaching pathway consists of Phase A and B soil samples from the Environmental Conditions Assessment (ECA) collected pursuant to the terms of a 1996 Consent Agreement between NDEP and Kerr-McGee Chemical Corporation (NDEP, 1996).[2] It is important to note that in 2010, and continuing in 2011, approximately 794,700 cubic yards (cy) of shallow soil (down to 10 feet below ground surface [bgs]) were excavated and removed from the Site to address potential health risks associated with direct human contact concerns, in accordance with plans approved by NDEP. However, none of the excavated Phase A and B soil samples were excluded from the data set used for this evaluation because soil source removal is ongoing. After the source removal for direct contact concerns is completed, the list of COPCs may be revised, and the LSSLs re-calculated using only data representative of remaining soil. We anticipate that the chemical-specific source lengths and dilution attenuation factors (DAFs) will need to be updated, according to the procedures presented in Attachment 3.

The methodology presented in this memorandum can be used to re-calculate LSSLs if other risk-based groundwater criteria are selected as target RBGCs (for example, if it is determined that groundwater below the Site is unsuitable as a source of drinking water). As part of the evaluation of long-term remedial alternatives, it may be appropriate to consider alternate, risk-based groundwater criteria for the soil-to-groundwater leaching pathway that are protective of current and future receptors.

Following NDEP's review and concurrence with the methodology of this evaluation, and the completion of ongoing source removal for direct contact concerns, the need for additional source control measures for leaching concerns will be assessed using data representing remaining soil and alternative risk-based RBGCs agreed upon by NDEP and the Trust. Remedial alternatives appropriate for the COPCs and protection of groundwater will be evaluated subsequently, as necessary.

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this evaluation. LSSLs have not been calculated for COPCs for which RBGCs have not been established.

[2] See Attachments 2 and 3 for a more detailed discussion of the data set used for this evaluation.

A summary of revisions prompted by NDEP's comments on the February 14, 2011 revised technical memorandum is provided in a "response to comments" letter in Attachment 1.

SCREENING EVALUATION BASED ON NDEP GUIDANCE

The NDEP guidance outlines the following progression of steps for evaluating the soil-to-groundwater leaching pathway:

1. Comparison of Site soil concentration data with leaching-based, basic comparison levels (LBCLs), which are calculated using generic default values as input parameters for the soil-water partitioning (SWP) equation;
2. Comparison of Site soil concentration data with LSSLs, which are calculated using Site-specific chemical and soil properties in the SWP equation;
3. Unsaturated zone fate-and-transport modeling, employing Site-specific data; and
4. Synthetic precipitation leaching procedure (SPLP; U.S. EPA, 1994) testing, as required to support either the SWP equation or unsaturated zone fate-and-transport modeling.

This memorandum presents the results of the first two of these steps used to evaluate COPCs for the soil leaching to groundwater pathway. The methods for selection of organic and inorganic COPCs for the leaching evaluation are described in detail in Attachments 2 and 3.

METHODS USED TO SELECT CHEMICALS OF POTENTIAL CONCERN FOR THE LEACHING EVALUATION

The data set evaluated for leaching in RZ-A through RZ-E includes unsaturated Phase A and Phase B samples collected from the Quaternary alluvium (Qal) between the ground surface and the contact with the Upper Muddy Creek formation (UMCf).

As an initial step, and in accordance with previous discussions and correspondence with NDEP, Site soil concentrations of metals were initially screened by comparison with the background dataset (RZ-A) approved by NDEP to select chemicals for further evaluation. Methods and results of the background metals evaluation are provided in Attachment 2.

Metals retained for further evaluation, as well as organics, were then evaluated in accordance with NDEP guidance by comparing Site soil concentration data with LBCLs (NDEP, 2009). For chemicals without established LBCLs, generic LBCLs were

calculated using default values as input parameters for the soil-water partitioning (SWP) equation (Attachment 3). For some metals, LBCLs were adjusted based on the hierarchy of RBGCs approved by NDEP for this project.[3] Attachment 3 describes in detail the parameters and methods used to calculate generic and adjusted LBCLs. COPCs that did not exceed LBCLs using a dilution attenuation factor (DAF) of 20 were not carried forward for further analysis (Attachment 2). The screening tables also include comparisons of Site soil concentration data with LBCLs for DAF=1, in accordance with the guidance.

The selection of COPCs for inorganic and organic chemicals is summarized below. Inorganic chemicals selected as COPCs are summarized by RZ area and depth, to be consistent with the background comparisons in Attachment 2, Tables 5A through 5E. Organic COPCs are selected based on a Site-wide comparison of soil concentrations with LBCLs for RZ-A through RZ-E (Attachment 2, Table 6), and are summarized following the inorganic COPCs.

Inorganic Chemicals Selected as COPCs for Leaching Evaluation

Inorganic COPCs for RZ-B through RZ-E and LOU 62 (in RZ-A) were selected using the steps described in Attachment 2. The depth intervals for screening of inorganic COPCs are based on the statistical background comparisons presented in Attachment 2. The selection of inorganic COPCs for the leaching evaluation is summarized in Attachment 2, Tables 5A through 5E.

Perchlorate was selected as a COPC in all RZs for all depth intervals in the Qal, based on perchlorate's exceedance of the calculated generic LBCL for a dilution attenuation factor (DAF) of 20, as described in Attachment 3.

In addition to perchlorate, the inorganic COPCs for each RZ are the following:

- Antimony: RZ-C (0-10 feet bgs); RZ-E (0-10 feet bgs)
- Arsenic: RZ-B (0-2 feet bgs, 2-10 feet bgs); RZ-C (0-2 feet bgs); RZ-E (0-2 feet bgs)
- Barium: RZ-C (0-10 feet bgs); RZ-D (0-10 feet bgs)
- Boron: RZ-C (0-10 feet bgs); RZ-D (0-10 feet bgs)
- Chromium (total): RZ-C (0-2 feet bgs); RZ-D (0-2 feet bgs); RZ-E (0-2 feet bgs)

[3] In accordance with minutes of the meetings with NDEP on February 12 and 17, 2010, the following hierarchy was used for RBGCs: 1) primary Maximum Contaminant Levels (MCLs); 2) BCLs; and 3) secondary MCLs.

- Chromium (VI): RZ-C (0-10 feet bgs, 10 feet bgs to UMCf)
- Cobalt: RZ-C (0-10 feet bgs, 10 feet bgs to UMCf); RZ-E (0-10 feet bgs)
- Iron: LOU 62 in RZ-A (0-10 feet bgs)
- Lead: RZ-C (0-10 feet bgs, 10 feet bgs-UMCf); RZ-E (0-10 feet bgs)
- Magnesium: RZ-B (10 feet bgs to UMCf); RZ-C (0-2 feet bgs); RZ-D (0-2 feet bgs); RZ-E (0-2 feet bgs)
- Manganese: RZ-B (0-10 feet bgs); RZ-C (0-10 feet bgs, 10 feet bgs to UMCf); RZ-D (0-10 feet bgs); RZ-E (0-10 feet bgs)
- Molybdenum: RZ-C (0-2 feet bgs)
- Thallium: RZ-C (0-10 feet bgs)

In addition, the following detected inorganic chemicals exceeded RZ-A background but did not have established RBGCs and were selected as COPCs by default (see Attachments 2 and 4):

- Platinum: LOU 62 in RZ-A (0-10 feet bgs), RZ-C (0-10 feet bgs), and RZ-E (0-10 feet bgs)
- Potassium: RZ-B (2-10 feet bgs)
- Sodium: LOU 62 in RZ-A and RZ-B through RZ-E (0-2 feet bgs; 2-10 feet bgs; 10 feet bgs to UMCf)

Organic Chemicals Selected as COPCs for Leaching Evaluation

Organic COPCs were selected by screening Site-wide (RZ-A through RZ-E) soil concentrations against LBCLs for DAFs of 1 and 20 (Attachment 2, Table 6). The following organic COPCs exceeded LBCLs for DAF=20, and were retained for further evaluation of their leaching potential:

Organochlorine Pesticides (OCPs): 4,4'-DDE, 4,4'-DDT, Aldrin, alpha-, beta-, and gamma BHC (Lindane), and Dieldrin.

Semivolatile Organic Compounds (SVOCs): Benz(a)anthracene, benzo(b)fluoranthene, and hexachlorobenzene.

Volatile Organic Compounds (VOCs): 1,2,3-trichloropropane, benzene, carbon tetrachloride, chloroform, and 1,2,4-trichlorobenzene.

In addition, the following detected organic chemicals did not have established RBGCs and were selected as COPCs by default (see Attachments 2 and 4):

Organophosphate Pesticides (OPPs): Azinphos-methyl, Coumaphos, Demeton-O, Dimethoate, and Merphos

OCPs: delta- BHC, Endrin aldehyde, and Endrin ketone

SVOCs: 2-Methylnaphthalene, di-n-octyl phthalate, and octachlorostyrene

VOCs: ethyl butyl ether and 1,2,3-trichlorobenzene

CALCULATION OF LEACHING-BASED, SITE-SPECIFIC LEVELS AND SCREENING OF SITE SOIL DATA

Attachment 3 describes in detail the parameters and methods used to calculate LSSLs. LSSLs for chemicals present above LBCLs were calculated using the SWP equation presented in the guidance, with Site-specific soil physical properties and chemical-specific DAFs. The DAFs, in turn, are based on hydrogeologic properties and the length of the chemical source (***L***) in the unsaturated zone. To determine the source lengths, we used the LBCL for DAF=20 to define the extent of source areas for each COPC. As shown on Tables 4A and 4B of Attachment 3, with the exception of perchlorate, the DAFs for inorganics and organics ranged from approximately 36 to over 700 when calculated using this definition of source length. These DAFs were then used to calculate LSSLs in the SWP equation, as detailed in Attachment 3.

Tables 1A-E and 2A-E provide tabulated results of the comparison of Site soil concentrations with LBCLs and LSSLs for inorganic and organic COPCs, respectively, for each RZ area. These tables show the number of samples containing chemicals at concentrations exceeding the LBCLs and LSSLs. For the inorganic chemicals, the screening of chemicals is carried out for the same depth intervals that were determined for the statistical background comparison (Tables 1A-E and Attachment 2).

In addition to perchlorate, the following COPCs were detected in Site soils at concentrations above their respective LSSLs, as shown in Tables 1A-E and 2A-E:

COPCs Exceeding LSSLs in RZ-A (excluding LOU 62)

- Inorganics: None
- Organics: Beta-BHC

COPCs Exceeding LSSLs in RZ-B

- Inorganics (0-2 feet bgs): Arsenic
- Organics: Alpha- and beta-BHC, and 1,2,3-trichloropropane

COPCs Exceeding LSSLs in RZ-C

- Inorganics (0-2 feet bgs): arsenic and magnesium
- Inorganics (0-10 feet bgs): cobalt and manganese
- Inorganics (>10 feet bgs to UMCf): cobalt
- Organics: Alpha- and beta-BHC, hexachlorobenzene, and chloroform[4]

COPCs Exceeding LSSLs in RZ-D

- Inorganics (0-2 feet bgs): magnesium
- Organics: Alpha-, beta-, and gamma-BHC (Lindane), hexachlorobenzene, and chloroform[5]

COPCs Exceeding LSSLs in RZ-E

- Inorganics (0-2 feet bgs): arsenic
- Inorganics (0-10 feet bgs): cobalt
- Organics: Alpha- and beta-BHC, Dieldrin, and chloroform[6]

COPCs Exceeding LSSLs in LOU 62

- Inorganics: None
- Organics: None

SUMMARY AND CONCLUSIONS

Inorganic chemicals for the leaching evaluation for each RZ were identified by comparing Site soil concentration data to the RZ-A background dataset approved by

[4] The LSSL is less than the LBCL (DAF=20) for chloroform because the target risk-based groundwater concentration (RBGC) used to calculate the LSSL (0.0016 milligrams per liter [mg/L] is less than the RBGC used to calculate the LBCL (0.1 mg/L). In RZ-C, 1 detection of chloroform exceeded the LBCL for DAF=20, and 10 soil samples contained chloroform at concentrations greater than the LSSL.

[5] See footnote 4. In RZ-D, chloroform did not exceed the LBCL for DAF=20, but 1 soil sample in RZ-D contained chloroform at concentrations greater than the LSSL.

[6] See footnote 4. In RZ-E, 1 detection of chloroform exceeded the LBCL for DAF=20, and 2 soil samples contained chloroform at concentrations greater than the LSSL.

NDEP in their August 17, 2010 letter. After the background comparison was completed, inorganic and organic COPCs were selected by comparison to LBCLs for DAF=1 and DAF=20. LSSLs were then calculated for each COPC using Site-specific values of soil pH and fraction of organic carbon, f_{oc} , to derive Site-specific values of the distribution coefficient, K_d, following methods and procedures described in NDEP's January 16, 2010 guidance and in accordance with discussions and correspondence with NDEP. For each COPC and RZ, the number of Phase A and B soil samples that exceeded the calculated LSSLs before soil was excavated are tabulated in Tables 1A-1E and 2A-2E.

Upon NDEP's acceptance of the methods used in this revised technical memorandum to evaluate the soil-to-groundwater leaching pathway, and following completion of the on-going soil excavation in accordance with the plans approved by NDEP to address potential direct-contact human health concerns, the soil data set should be revised to exclude soil samples that have been removed by excavation. The final soil data set representing chemical concentrations in soil remaining in-place should then be used to reevaluate which COPCs exceed the RZ-A background levels and LBCLs, and to recalculate the source lengths, DAFs, and LSSLs. Further evaluation, including fate and transport modeling and/or risk assessment, may be necessary to derive appropriate RBGCs and risk-based vadose zone cleanup goals for the Site.

ENCLOSURES

Tables

Figures

Attachments

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