7117 U-007-306.47

TRANSMITTAL OF RESPONSES TO THE U. S. ENVIRONMENTAL PROTECTION AGENCY (U.S. EPA) AND THE OHIO ENVIRONMENTAL PROTECTION AGENCY (OEPA) COMMENTS AND RESULTING CHANGE PAGES FOR THE OPERABLE UNIT 5 K1 SAMPLING AND ANALYSIS RESULTS REPORT

08/18/95

DOE-1381-95
DOE-FN EPAS
30
RESPONSES

Department of Energy
Fernald Environmental Management Project
P. O. Box 538705
Cincinnati, Ohio 45253-8705
(513) 648-3155

AUG 18 1995

DOE-1381-95

Mr. James A. Saric, Remedial Project Director
U.S. Environmental Protection Agency
Region V - 5HRE-8J
77 W. Jackson Boulevard
Chicago, Illinois 60604-3590

Mr. Tom Schneider, Project Manager
Ohio Environmental Protection Agency
401 East 5th Street
Dayton, Ohio 45402-2911

Dear Mr. Saric and Mr. Schneider:

TRANSMITTAL OF RESPONSES TO THE U.S. ENVIRONMENTAL PROTECTION AGENCY (U.S. EPA) AND THE OHIO ENVIRONMENTAL PROTECTION AGENCY (OEPA) COMMENTS AND RESULTING CHANGE PAGES FOR THE OPERABLE UNIT 5 K_1 SAMPLING AND ANALYSIS RESULTS REPORT

References: 1) Letter, James A. Saric (U.S. EPA) to Jack R. Craig (DOE-FN), "OU5 K_1 Sampling and Analysis Report," dated July 18, 1995.

2) Letter, Thomas A. Schneider (OEPA) to Jack R. Craig (DOE-FN), "Hamilton County Approval: K_1 Sampling and Analysis Report," dated July 7, 1995.

This letter serves to transmit responses to the U.S. Environmental Protection Agency (U.S. EPA) and the Ohio Environmental Protection Agency (OEPA) referenced comments on the subject report and the corresponding change pages. New and revised text are redlined for ease of reference.

If you or your staff have any questions regarding this transmittal, please contact John Kappa at (513) 648-3149.

Sincerely,

Johnny Reising

for Jack R. Craig
Fernald Remedial
Project Manager

FN:Kappa

Enclosure: As Stated

Recycled and Recyclable

cc w/enc:

K. H. Chaney, EM-423/GTN
L. Griffin, EM-423/GTN
B. Skokan, EM-423/GTN
G. Jablonowski, USEPA-V, 5HRE-8J
J. Kwasniewski, OEPA-Columbus
S. McClellan, PRC
D. Ward, GeoTrans
F. Bell, ATSDR
R. Owen, ODOH
D. J. Carr, FERMCO/52-5
R. D. George, FERMCO/52-2
T. Hagen, FERMCO/65-2
AR Coordinator, FERMCO

cc w/o enc:

C. Little, FERMCO
M. Yates, FERMCO

RESPONSES TO U.S. EPA AND OEPA COMMENTS ON THE OPERABLE UNIT 5 DRAFT K_l REPORT MAY 1995

U.S. EPA

1. Commenting Organization: U.S. EPA Commentor: Saric
Section#: General Pg.#: NA Line#: NA Code:
Original Comment# 1
Comment: Original Comment #3 of the U.S. Environmental Protection Agency (U.S. EPA) project-specific plan review comments requests that batch test sampling locations be collocated with the locations of the three lysimeter stations. The Department of Energy (DOE) response to this comment, in Appendix A of this report, indicates that samples were collocated as requested. However, no evaluation and comparison is performed of the source leaching coefficient (K_l) determined from the batch tests to the K_l values derived from the lysimeter data or soil- and perched water-derived K_l concentrations. The K_l values derived from the lysimeter data should provide the most accurate K_l estimates because the lysimeter water represents precipitation that migrated through the geologic system. An evaluation and comparison of the batch test K_l results to the lysimeter-derived K_l values should be performed. A discussion of the significance and implications, if any, of discrepancies between the two data sets should also be provided.

Response: Results from the lysimeter water samples were used in model calibration to determine K_d, which is used to define the media-specific mobility of uranium. A uranium K_d value of 3.1 L/kg in the gray clay layer was estimated. This low K_d value indicates that uranium migrates through the overburden and reaches the lysimeters within a time frame that is consistent with the measured conditions. This K_d value was subsequently used in all the FS fate and transport modeling. In this project, surface and near-surface soil samples were collected to determine K_l, which describes the leachability of a contaminant from a source material. In other words, this project was designed to characterize the source of contamination instead of the mobility of contaminants through the overburden. However, information collected in this project also verifies that uranium-contaminated soil can generate the levels of uranium measured in the lysimeters. As summarized in the following table, the toxicity characteristic leaching procedure (TCLP) results for soil samples collected near the lysimeters are compatible with concentrations observed in the lysimeter water samples. Figure 1 presents both the lysimeter and the soil sampling locations associated with this project.

Lysimeter	Total Uranium (μg/L) (unvalidated data)	Soil Sampling Location	Total Uranium (TCLP) (μg/L) (validated data)	
			0 - 2 inches	24 - 30 inches
11128	no data - replaced	KL-SS-05	18	9
11129	14 - 29			
11234	4 - 6			
11130	1 - 8	KL-SS-08	10	0.4
11131	7 - 12	KL-SS-09	23	0.5
11132	2 - 3	KL-SS-13	11	0.2
11133	9 - 52			

As shown in Table 2-2 of the report, the K_{t2} values determined have a geometric mean of 11.69 L/kg which is very close to the 15 L/kg value used for soluble uranium in the FS modeling. The remaining leachable portions of uranium in soil collected near the lysimeters (represented by K_e) range from 1.27 to 14.79 percent. The combinations of measured K_{t2} and K_e values in these locations can also explain the sources of the observed uranium concentrations in the lysimeters. For example, the surface soil sample collected at KL-SS-08 has a uranium concentration (C_{s0}) of 6.9 mg/kg, K_{t2} of 8.75 L/kg; and K_e of 1.27 percent. Using these values, a leachate concentration of 10 μg/L can be calculated (i.e., $C_{s0} * K_e / K_{t2}$) that matches the TCLP and lysimeter results very well.

In general, the findings of this project are consistent with the lysimeter data and fully support the FS modeling.

Action: None required.

2. Commenting Organization: U.S. EPA Commentor: Saric
Section#: General Pg.#: NA Line#: NA Code: NA
Original Comment# 2
Comment: As indicated in Specific Comment 1, the text states that method detection limits (MDL) for both liquid and solid analysis were apparently not achieved. Actual MDLs are not reported. Furthermore, practically none of the uranium data are validated, adding further uncertainty to the question of data quality. The revised report should fully present the actual MDLs achieved, fully justify the decision to submit and use unvalidated data, and clearly discuss these issues as they relate to data quality and the conclusions reached in the report.

Response: This comment relates to the data quality of the K_t project and the effect of this quality on the conclusions in the report. It is important to note that the main purpose of this report was to show that K_t values for contaminated soil (determined from literature values or calculated from preliminary unvalidated data) used in the RI/FS modeling were appropriate.

Table 1-1 of the report identifies the analytical support level (ASL) for each sample interval and analyte. This table was also included in the EPA- and OEPA-approved project specific plan (PSP) (Project Specific Plan for Operable Unit 5 K_t Soil Sampling and Analysis, Revision 0, July 1994). The ASL of D identified in the table indicates that this data was to be validated. The data validated in this project are summarized below:

- All TCLP results - 30 samples
- All final leachate results - 32 samples (Table 1-1 needs to be updated to reflect this)
- All final soil results from the desorption tests - 32 samples (Table 1-1 needs to be updated to reflect this)
- Initial soil results (HSL metals, TCLP, radiological suite, and total organic carbon analyses) for the 0- to 2- and 24- to 30-inch intervals - 152 samples

As mentioned above, the initial soil concentrations for the 0- to 2- and 24- to 30-inch intervals were validated. The initial uranium soil concentrations for the intermediate depths (0- to 6-, 6- to 12-, 12- to -18, and 18- to 24 inches) were not validated because these concentrations were used solely to provide a qualitative vertical profile for uranium. Figures 2-1 and 2-2 confirm that the source of contamination is on the surface. Therefore, it was not necessary to pay for ASL D analyses and validation for the intermediate depths.

The analytical laboratory cost of this project cost was approximately $200,000. To analyze/validate the entire data set at ASL D would have cost approximately $500,000. Note that the critical data points used to calculate the geochemical values for this report were validated. In addition, this report concludes that geochemical values used in the RI/FS modeling effort are more conservative than those values determined from the validated data set. For these reasons, it was determined that the benefits of validating the entire data set would not outweigh the cost.

Table 2-5 of the report presents the K_l values determined from literature/preliminary TCLP results and those determined from the validated TCLP results. The K_l values calculated from validated results are in the second and seventh columns of this table entitled "K_l (L/kg) geometric mean." K_l values calculated from the validated data set were typically greater than those K_l values determined from preliminary data or literature values. This indicates that values used in the model were conservative and acceptable. Higher K_l values indicate that the contaminants are less soluble (less leachable). All K_l values for radiological constituents used in the modeling were lower (more conservative) than those values calculated from the validated data set. All K_l values for inorganic constituents used in the modeling were also lower (more conservative) than those values calculated from the validated data set with the exception of barium, calcium and sodium. Calcium and sodium are not constituents of concern (COCs). As stated in the report (pages 3-2 to 3-3), "because the two K_l values for calcium were very close and because calcium has low toxicity, the TCLP K_l value does not impact the conclusions of the Operable Unit 5 RI and FS Reports." The report also stated that "although the TCLP K_l value for barium was lower than the previously calculated modeled value, the value was still high enough to exclude barium from being considered a COC in the groundwater pathway." For these reasons, values used in the modeling effort are considered conservative and appropriate.

Table 2-5 also identifies the number of sampling locations used to calculate K_l values. For radiological parameters, positive detected concentrations and/or validated detection limits were used to calculate K_l; this was not clearly identified in Table 2-5. The table indicates that nondetect data were not used to calculate K_l, but this is incorrect. The only values not used were negative concentrations. These concentrations were given negative values during validation and indicate that there were no detected concentrations above instrument background readings. The nondetect data were used to determine K_l values because the laboratory did have some problem achieving the method detection limits (MDLs). By using the nondetect data, more conservative K_l values were calculated. For inorganic parameters, only positive detected concentrations were used to calculate K_l. Nondetect data were not used because the laboratories did not have much difficulty in achieving inorganic MDLs. No negative concentrations were associated with inorganic constituents.

The MDLs that DOE requested the laboratories to meet are provided in Appendix B.1.2. The MDLs requested of the laboratories were set at, or as near as technically feasible to, a level approximating a 1×10^{-6} incremental lifetime cancer risk (ILCR) for the reasonable maximum exposure (RME) farmer/child scenario because of risk assessment calculations. Most of the MDLs requested for radiological constituents were lower than those used in previous Fernald Environmental Management Project (FEMP) RI/FS samples. Actual detection limits achieved by the off-site laboratories for initial soil concentrations were reported in Appendix B.1.1 under the column entitled "Detect." The following table summarizes the number of samples per parameter and media with detection limits above the requested MDLs. The total number of samples for each parameter should be approximately 32 (depending on quality assurance requirements).

Analyses	Media	Parameters that had Detections Limits above the requested MDLs	Number of Samples with Detection Limits above the MDLs
Inorganic	Soil	Arsenic Thallium	31 5
Radiological	Soil	Neptunium-237 Strontium-90 Uranium-235/236	10 22 4
Radiological	Leachate	Uranium-235/236	4
Radiological	TCLP (Leachate)	Neptunium-237 Plutonium-238 Plutonium-239/240 Plutonium-241 Radium-228 Strontium-90 Thorium-228 Thorium-232	2 8 5 2 3 2 11 1

As stated above, K_l values for radiological parameters were calculated using validated detection limits for nondetect data. This was done because the laboratories did have some problems achieving the requested MDLs and so that K_l values calculated would be conservative. The table above indicates that the laboratories did not have a problem achieving inorganic MDLs except for five thallium results and 31 arsenic results. The requested detection limit for arsenic was 0.0545 mg/kg. The laboratory did have a difficult time achieving this detection limit. They usually achieved a detection limit of 0.1 mg/kg. It is important to note that the background value (95th percentile) for arsenic in surface soil used in the Operable Unit 5 RI Report is 8.2 mg/kg. Although the requested detection limits for arsenic weren't achieved by the laboratory, the detection limit that they did achieve was significantly below the background value for arsenic. Also, it should be noted that the K_l value used in the modeling effort was more conservative than the value calculated in this report. The laboratory did not have difficulties achieving other inorganic MDLs. For this reason, nondetect data were not used to calculate K_l values for inorganic parameters.

Action: Table B.1.2-3 will be added to Appendix B.1.2 to reflect the analyses and parameters for which the requested detection limits were not met. Tables B.1.2-1 and B.1.2-2 were inadvertently named F.1.2-1 and F.1.2-2 and will also be corrected. Table 2-5 will explain that only negative values were not used to calculate K_l for radiological constituents. Table 1-1 will reflect the additional data that was validated.

3. Commenting Organization: U.S. EPA Commentor: Saric
Section#: General Pg.#: NA Line#: NA Code: NA
Original Comment# 3
Comment: Final leachate samples were collected for off-site analysis when Fernald Environmental Management Project (FEMP) laboratory data indicated that leachate concentrations reached equilibrium. However, the two-phase desorption batch test curves in Appendix E.1 indicate that leachate concentrations in over half of the runs were still rising when the final sample for the determination of equilibrium concentration (C_{w1} and C_{w2}) was collected and analyzed. It appears that these desorption batch tests were stopped prematurely. The determination of final equilibrium was based on onsite laboratory data. It is not clear why higher equilibrium

concentrations were not extrapolated from the curves. The report should clarify why the batch tests were stopped before equilibrium was reached and why higher equilibrium concentrations were not extrapolated. Also, the potential errors and the impact of potential errors on the calculated leaching coefficient for the extractable mass (K_l) and the percent of extractable contaminant K_e) values should be quantified.

Response: A 10 percent rule, consistent with other FEMP batch tests, was applied to determine when equilibrium was reached. Specifically, if the last leachate result is within 10 percent of the second to last leachate result, equilibrium has been considered to be achieved.

Note that the source of contamination is on the surface and that the soil concentrations in the 24- to 30-inch intervals are in the range of background (refer to Tables 2-2 and 2-3). The report identified that the laboratory had difficulties in reporting the very low concentrations associated with soil and leachate samples from the 24- to 30-inch intervals. Laboratory analytical uncertainty is greater than 10 percent in this concentration level (typically greater than 100 percent). Therefore, the 10 percent rule is not practical/reasonable in determining equilibrium for the 24- to 30-inch interval. For these reasons, this discussion will focus on the equilibrium conditions of the 0- to 2-inch interval.

According to Table 2-1 in the report (Phase 1: 0 to 2 inches), only 5 locations from the 0- to 2-inch interval did not meet the 10 percent rule. These locations were KL-SS-07, KL-SS-09, KL-SS-11 (duplicate), KL-SS-13, and KL-SS-14.

First, the sample from location KL-SS-11 was within the 10 percent rule (eight percent) but the duplicate sample was not. The K_l calculated from the sample was more conservative (617 L/kg) than the value calculated from the duplicate sample (2700 L/kg). It is important to note that a K_l value of 325 L/kg was used in the model and is even more conservative than the lowest K_l value calculated from this location (617 L/kg). In the case of location KL-SS-13, the leachate extraction in which equilibrium was reached was marked incorrectly in Table 2-1; the eighth extraction should have been marked as when equilibrium was achieved, not the seventh. The leachate concentration from the seventh and eighth extractions were identical and therefore the difference between the two values would be zero. For locations KL-SS-07 and KL-SS-14 in which the 10 percent rule was not achieved, it is important to note that high C_{wl} values (higher than the final leachate concentrations from both the on-site and off-site laboratories) were used to calculate K_l. This leads to a lower and more conservative K_l value. The following table provides the relevant information associated with locations KL-SS-07, KL-SS-14, and KL-SS-09.

Sampling Location (0-2 inch)	Phase 1 On-site Laboratory Second to Last Leachate (μg/L)	Phase 1 On-site Laboratory Final Leachate (μg/L)	Phase 1 Off-site Laboratory Final Leachate (μg/L)	Phase 1 Final Leachate[a] C_{wl} (μg/L)
KL-SS-07	1.6	1.9	10.49	11.10
KL-SS-09	10.00	12.00	5.36	6.20
KL-SS-14	23.00	41	47.68	48.00

[a]Determined from graphs to represent when equilibrium was achieved.

The last leachate concentration from location KL-SS-09 was within 17 percent of the second to last leachate concentration. However, the C_{w1} value used to calculate K_l was less than the final result from the on-site laboratory. In order to achieve a more conservative value, K_l was recalculated using a value of 12 μg/L for C_{w1}. The recalculated K_l value is 312.92 L/kg which is a value close to the value used in the modeling effort (325 L/kg). Again, the values used in the modeling were appropriate.

In general, Phase 2 for the 0- to 2-inch interval samples was ended before equilibrium was reached because of the length of time needed to reach equilibrium. By ending the test early, a lower C_{w2} value was determined. These lower C_{w2} values lead to lower and more conservative K_{l2} values. The equation for K_{l2} is in Appendix F of the report (page F.1-3). Note that the report states that the calculated geometric mean of K_{l2} (i.e., 11.69 L/kg) for the extractable portion of total uranium was very close to the K_l value of 15 L/kg used for modeling the contaminated soil with soluble uranium in the former production area (page 3-1). If Phase 2 had continued, C_{w2} would have been higher, and a higher and less conservative value for K_{l2} would have been calculated. Therefore, it is not a problem that Phase 2 was ended before equilibrium was reached.

Action: Table 2-1 will be corrected to accurately reflect when location KL-SS-13 reached equilibrium.

4. Commenting Organization: U.S. EPA Commentor: Saric
Section#: 1.2 Pg.#: 1-4 Line#: 27 to 29 Code: na
Original Comment# 4
Comment: The text states that not all MDLs were achieved but that data quality was determined sufficient to set geochemical values. However, problems with total uranium analyses when leachate concentrations were low caused the K_l and the K_e to remain largely undefined for the 24- to 30-inch below ground surface (bgs) interval. The text should state how K_l and K_e values for the 24- to 30-inch bgs interval were determined. Also, Table 1-1 indicates that of the 92 samples analyzed for total and isotopic uranium, data from only two samples were validated. The text should specify the analyses for which MDLs were not achieved. The text should also provide more specific information regarding how the adequacy of data quality was determined, and a re-evaluation of the conclusion regarding sufficient data quality should be considered.

Response: Again, this comment relates to the data quality of the K_l project and the effects on the conclusions in the report. Refer to the response to EPA comment #2 for the discussion on MDLs.

Based on analytical results, soil concentrations in the 24- to 30-inch intervals are in the range of background. The text stated that it was difficult for the laboratories to achieve the low concentrations. It is important to note these background conditions were not used in the modeling effort; only the source contaminants from the surface were used. It is not important that K_e and K_{l2} for these samples are undefined. Appendix F, entitled K_l and K_e Mathematical Procedures and Sample Calculations, shows how K_l and K_e are determined for both the 0- to 2-, and 24- to 30-inch intervals.

Table 1-1 will be updated to reflect the additional data validation mentioned in response to EPA comment #2. Approximately 126 samples from the 0- to 2- and 24- to 30-inch intervals were analyzed for radiological constituents (including uranium) at ASL D and validated. Additional samples from the 0- to 2-, and 24- to 30-inch intervals were analyzed at ASL D

and validated for inorganic constituents. These validated results were used to determine geochemical values. The 92 samples analyzed for total and isotopic uranium for the intermediate depths (0 to 6, 6 to 12, 12 to 18, and 18 to 24 inches) were not validated because these concentrations were solely used to provide a qualitative vertical profile for uranium. Figures 2-1 and 2-2 confirm that the source of uranium contamination is on the surface. Therefore, it was not necessary to spend a lot of money for analyses and validation for the intermediate depths.

Action: Table B.1.2-3 will be added to Appendix B.1.2 to reflect the analyses and parameters for which the requested detection limits were not met. Tables B.1.2-1 and B.1.2-2 were inadvertently named F.1.2-1 and F.1.2-2 and will also be corrected. Table 1-1 will reflect the additional data that was validated.

5. Commenting Organization: U.S. EPA Commentor: Saric
Section#: 1.2 Pg.#: 1-5 Line#: 5 to 7 Code:
Original Comment# 5
Comment: The text states that the batch test water was pH-adjusted to reflect acid rain conditions. Appendix E.2 of this report provides pH results through time; however, initial pH values are not provided. The initial batch test pH values should be provided. In addition, the majority of the figures in Appendix E.2 indicate that pH was maintained between 6 and 8. However, some of the figures, such as Figures E-2-2 and E-2-6, indicate that the pH for these samples were above or below the 6 to 8 pH range. The text should state why the pH values for the samples varied. Finally, pH values above 7 do not reflect acid rain conditions. The text should state why pH values above 7 were maintained during the batch tests.

Response: Initial pH of the water was adjusted to 4.5 and 5.0 as stated in Appendix A of the EPA- and OEPA-approved PSP. The water was pH adjusted by combining 3500 mL of deionized (DI) water with a mixture of sulfuric and nitric acid. The volume of leachate removed was 20 mL. After the removal of leachate samples, 20 mL of pH-adjusted water was added back to the reactor. The pH values in the graphs mimic what should be occurring in nature. The pH was not maintained at 7, but reflect the pH of "rainwater" mixed with soil. If the pH value was greater or less than 7, it was strictly due to the soil chemistry.

Action: None required.

6. Commenting Organization: U.S. EPA Commentor: Saric
Section#: Table 1-1 Pg.#: 1-7 Line#: NA Code:
Original Comment# 6
Comment: Table 7-1 lists sample analytical parameter requirements. The difference between the unvalidated data categories A and B in footnote b should be clarified. Also, it is unclear what the data in the second row entitled "Total and Isotopic Uranium" consisting of 60 samples represents. Finally, no information from the depth intervals of these 60 samples are discussed in the text. This information should be discussed.

Response: In Table 1-1, ASL A was used to determine sample shipment requirements. ASL A is data generated by field instruments and used for this project as a screening device (gross alpha/gross beta) to classify samples for shipping purposes. It is analogous to EPA DQO 1. ASL B for this project indicates that the data was generated from laboratory analyses (i.e., analysis using standard methods, conventional parameter analysis and some SW-846 method with self-defined quality assurance requirements). No validation was performed on ASL B data. The two rows in Table 1-1 entitled "Total and isotopic uranium" could have been

combined. These rows were separated in order to easily compare the on-site and off-site laboratory's analyses conducted for the 0- to 2- and 24- to 30-inch intervals and also to separately show the analyses for the intermediate depths (0- to 6-, 6- to 12-, 12- to 18-, and 18- to 24-inch intervals). Data from these analyses are provided in Figures 2-1 and 2-2 which present profiles of uranium concentrations from the 15 sampling locations. A discussion of this data is provided on pages 2-1 and 2-2 of the report. Location-specific uranium concentration profiles in a larger scale are provided in Appendix D.1. The following observations were made from the data:

- The highest surface soil uranium concentration (i.e., 79 μg/g) was found in the 0- to 2-inch-depth interval at location KL-SS-10 which is between the former production area and the sewage treatment plant.
- The maximum uranium concentrations at each of the sampling locations were detected in the top 6 inches. The only exception was location KL-SS-15 where the maximum concentration was measured in the 12- to 18-inch-depth interval. As mentioned, soil collected at location KL-SS-15 was suspected of being from a disturbed area.
- Uranium concentrations decreased sharply with depth; concentrations at the 24- to 30-inch-depth interval were at the background level.

The report also stated that these results/observations are consistent with Section 4.0 of the final Operable Unit 5 RI Report.

Action: Information about ASL A and ASL B will be added to Table 1-1.

7. Commenting Organization: U.S. EPA Commentor: Saric
Section#: 2.2 Pg.#: 2-2 Line#: 29 to 31 Code:
Original Comment# 7
Comment: The text states that a comparison between the initial soil uranium mass and the uranium mass in the final soil sample plus leachate mass did not balance well. To rectify this problem, initial soil concentrations were redefined as the leachate uranium mass plus the final soil sample uranium mass. The degree of error of this method is not known, and related error data should be presented. Also DOE suggests that the source of this error is incomplete initial soil sample homogenization. Although this could account for the mass imbalance, laboratory analytical error is not considered. Because DOE acknowledges having difficulty in quantifying low uranium concentrations and because the uranium data were not validated, laboratory error at high uranium concentrations seems equally plausible. The report should discuss the mass imbalance and laboratory analytical error possibilities.

Response: A table is provided in Appendix F that shows the amount of error associated with the mass balance of uranium mass (Table F.1-2). Of the 32 samples, 60 percent of the calculated initial concentrations were less than the initial reference concentrations and an additional 34 percent were approximately 1 μg/g different from the reference concentrations. Therefore, 94 percent of the samples were less then or very close to the initial reference concentration. This is important because lower initial concentrations yield lower and more conservative K_i values. While it is true that laboratory error as a possible reason for the imbalance should be mentioned in the text, even with this oversight, conservative K_i values were calculated.

Action: The text in Section 2.2 and Appendix F will be revised to state that laboratory error could have been a potential cause for the mass imbalance.

8. Commenting Organization: U.S. EPA Commentor: Saric
Section#: 2.2 Pg.#: 2-3 Line#: 17 to 21 Code:
Original Comment# 8
Comment: The text states that pH was adjusted to simulate acid rain conditions. Although this technique may be appropriate for the 0- to 2-inch bgs surface soil interval, the pH of the natural porewaters in the 24- to 30-inch bgs sample could be significantly different due to the porewaters interaction with soils. The text should indicate whether this interaction was considered for the preparation of the batch text water for the 24- to 30-inch bgs sample runs. Because differences of one-half of a pH unit can result in major differences in the amount of solute adsorbed (see Lines 16 to 17), the potential implications of using surface water pH for the subsurface soil batch tests should be evaluated and discussed.

Response: The difference of one-half of a pH unit can result in major differences in the amount of solute adsorbed. To reflect nature, water with a pH value of 7 should have been added to the soil from the 24- to 30-inch interval. However, using water with a lower pH value (4.5) made uranium more soluble or leachable; hence, lower and more conservative K_l values were calculated. For this reason, the K_l values provided in the report are considered conservative and reasonable. If water with a higher pH value had been used, the K_l values would be higher and less conservative.

Action: None required.

9. Commenting Organization: U.S. EPA Commentor: Saric
Section#: 2.2 Pg.#: 2-5 Line#: 7 to 11 Code:
Original Comment# 9
Comment: The text states that final leachate concentrations from the second phase (C_{w2}) may be greater than those from the first phase (C_{w1}) because of laboratory difficulties in accurately measuring uranium at concentrations below 1.0 micrograms per liter (μg/L). This situation occurred in half of the samples analyzed. However, sometimes this problem occurred in leachate samples with uranium concentrations as high as 25 μg/L (samples KL-SS-03 and KL-SS-09). This situation, together with the lack of proper data validation, again suggests that laboratory error could be a problem. The uranium data should be validated, and cause of the situations in which C_{w2} is greater than C_{w1} should be accounted for.

Response: Again, it is necessary to mention that the source of contamination is on the surface and that the 24- to 30-inch intervals represent background conditions (refer to Tables 2-2 and 2-3). The report identified that the laboratory had difficulties in measuring the very low concentrations associated with the 24- to 30-inch intervals. This is the reason final leachate concentrations from Phase 2 (C_{w2}) were greater than the final leachate concentrations from Phase 1 (C_{w1}) for over half of the samples from this interval. Note that all C_{w1} values were less than 1 μg/L (75 percent were less than 0.5 μg/L) except for location KL-SS-02 which had a C_{w1} value of 4 μg/L.

Sampling locations KL-SS-03 and KL-SS-09 were the only two locations with 0- to 2-inch interval samples that had Phase 2 final leachate concentrations (from the off-site laboratory) greater than the final concentrations from Phase 1. The Phase 2 leachate concentrations for these two locations are considered to be inaccurate because, while 15 of the concentrations for these locations show a trend, the final concentration from Phase 2 does not fit this trend. It is reasonable to assume that the 15 values are more correct than one. The typical difference between the leachate results from the on-site and off-site laboratories was about 20

percent. For this reason, the curves were drawn as they were in Appendix F for these two locations. In addition, both of the final values from the off-site laboratory were validated. Therefore, validation does not necessarily ensure that the C_{w1} value will be greater than the C_{w2} value.

Action: None required.

10. Commenting Organization: U.S. EPA Commentor: Saric
Section#: 2.4.1 Pg.#: 2-7 Line#: 18 to 24 Code:
Original Comment# 10
Comment: The text indicates that the measured total organic carbon (TOC) concentrations for the 0- to 2-inch bgs interval are significantly higher than the 10,000 milligrams per kilogram (mg/kg) value estimated for the remedial investigation fate and transport modeling. Similarly, the measured TOC values for the 24- to 30-inch bgs interval were significantly lower than estimated in the remedial investigation. The report should indicate whether the fate and transport model will be reevaluated using the new TOC data.

Response: The measured ranges of total organic carbon (TOC) concentrations presented on page 2-7 do not match the data presented in Appendix B.1.1. The correct ranges of TOC concentrations are 9610 to 421,000 mg/kg for the 0- to 2-inch interval and 2170 to 19,200 mg/kg for the 24- to 30-inch interval. The text will be corrected.

Due to modeling constraints, TOC concentrations are only required for modeling organic contaminants and are not specifically considered when modeling radionuclides and inorganics. Also, modeling results are more sensitive to the surface TOC values because the surface runoff pathway is the most significant pathway for organic contaminants due to a much shorter travel time to reach exposure points. Therefore, underestimated surface soil TOC values, which result in higher organic leachate concentrations, will yield more conservative predictions of impacts to the surface water and subsequently the groundwater. As explained in the following discussion, the TOC value used in the model was generally lower than the actual surface TOC value.

The representative TOC value of 10,000 mg/kg for surface soil used in the fate and transport modeling was obtained from the soil survey of Hamilton County (by USDA and Ohio DNR), as explained in Appendix F.2.3.2 of the Operable Unit 5 RI Report. The TOC value used for the modeling is in the range but generally lower than the actual surface soil TOC values (9610 and 421,000 mg/kg). The value used for the modeling is also in the range but generally higher than the actual subsurface soil value (2170 to 19,200 mg/kg). Therefore, it can be concluded that the soil TOC value used in the modeling for organic contaminants is adequate and conservative.

Action: Text in Section 2.4.1 will be corrected to show the accurate TOC ranges.

11. Commenting Organization: U.S. EPA Commentor: Saric
Section#: Figure 2-3 Pg.#: 2-19 Line#: na Code:
Original Comment# 11
Comment: The duplicate sample information for sample KL-SS-11 indicates a significant difference between the calculated K_l values. The causes and implications of this difference in regards to the predicted future contaminant concentrations and cleanup scenarios should be discussed.

Response: The difference between the sample and duplicate sample did yield different K_l values. The most conservative K_l value (617 L/kg) was calculated from the sample and the higher (2700 L/kg) was calculated from the duplicate sample. A value of 325 L/kg, used in the RI/FS modeling, was lower than both the calculated values. Therefore, predicted future contaminant concentrations and cleanup scenarios are conservative.

Action: None required.

OEPA

12. Commenting Organization: Ohio EPA Commentor: TMO
Section#: 2 Pg.#: Table 2-5 Line#: Code:
Original Comment# 1
Comment: The K_l determined in this study is much higher than that used in the OU5 FS report. A discussion of the effects this will have on the estimated time to effect ground water remediation is appropriate.

Response: The K_l and K_e parameters are used to define the leachability of contaminant mass from contaminated material. Based on the values of these two parameters and the initial soil concentrations, source leachate concentrations can be estimated for use in the surface water and groundwater modeling. However, these two parameters are not directly related to contaminant mobility through the overburden or in the aquifer. In the fate and transport modeling, contaminant mobility is defined by the K_d parameter which does not change as a result of this study. In general, results of this study confirm that the contaminant leachability values assumed or estimated in the Operable Unit 5 RI/FS modeling are conservative. Other aspects of the conceptual model and contaminant mobility used in the RI/FS fate and transport modeling remain the same.

The K_l values generated from the validated data set are higher than those used in the Operable Unit 5 RI/FS modeling efforts. This indicates that values used in the model were conservative and acceptable. Higher K_l values indicate that the contaminants are less soluble (less leachable). All K_l values for radiological constituents used in the modeling effort were lower (more conservative) than those calculated from the validated data set. All K_l values for inorganic constituents used in the modeling effort were also lower (more conservative) than those calculated from the validated data set with the exception of the K_l values calculated for barium, calcium and sodium. As stated in the response to EPA comment #2, these differences are not significant and do not impact the conclusions of the Operable Unit 5 RI and FS Reports. For these reasons, values used in the modeling effort are considered conservative and appropriate.

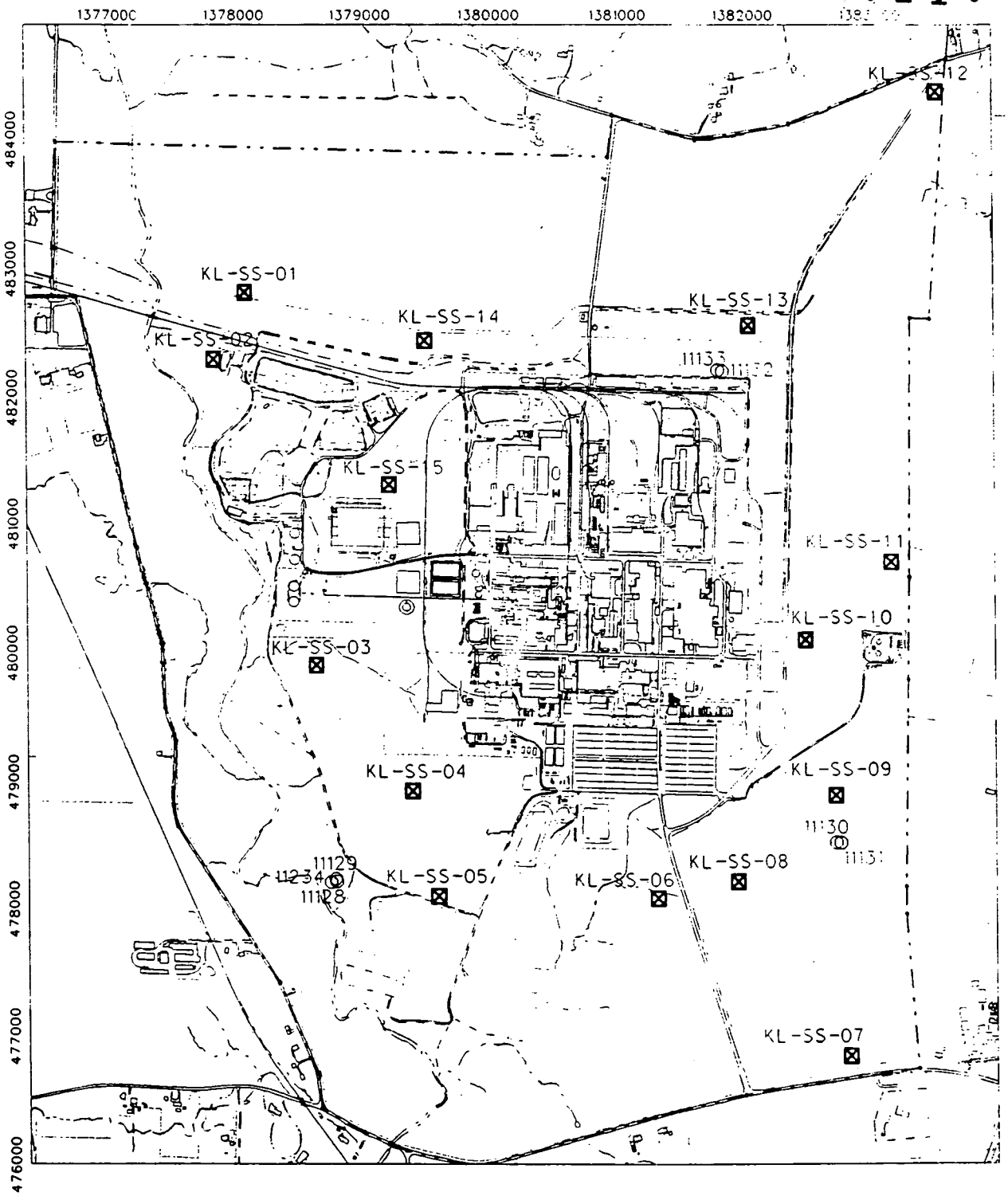
It should also be stated that only source loading areas will impact the remediation time of the Great Miami Aquifer. The areas investigated and the findings determined in this report will not effect groundwater remediation time.

Action: None required.

13. Commenting Organization: Ohio EPA Commentor: TMO
Section#: 2 Pg.#: Table 2-6 Line#: Code:
Original Comment# 2
Comment: Has an attempt been made to correlate the K_l data to USDA soil types? The soil types in this table are inferred to be estimated from the sample locations on a soil map as opposed to actual lab determination of soil types. It is possible that the wide range of K_l values are a result of the different soil types.

Response: No attempt has been made to correlate K_l values to USDA soil types. The soil types in Table 2-6 were estimated from USDA soil maps, not researched in the laboratory. It is possible that K_l values could be correlated to soil types, but since most of the site is disturbed, it is doubtful that an accurate correlation could be determined. Therefore, it would not be beneficial to try to determine a correlation between soil type and K_l.

Action: None required.



LEGEND:

- ○ LYSIMETER LOCATION
- ⊠ SOIL SAMPLING LOCATION
- —··—·· FEMP BOUNDARY

DRAFT

SCALE

1200 600 0 1200 FEET

FIGURE 1. K_1 SOIL SAMPLING AND LYSIMETER LOCATIONS

COMMENT CHANGE PAGES
FOR U.S. EPA AND OEPA COMMENTS
ON THE OPERABLE UNIT 5 MAY 1995 DRAFT K_1 REPORT

identified in Figure 1-2, was still suspected of being from a disturbed area. Therefore, analytical results may not be representative or comparable to other samples collected from the other undisturbed areas.

After collection, the soil samples were prepared by the following procedure. Each soil sample was passed through a No. 10 (2.0-millimeter) stainless steel sieve into a stainless steel container and then homogenized using a sample splitter or a riffle sampler. The sample splitter/riffle sampler separated the sample into multiple fractions of approximately equal volume. These samples were recombined and passed through the riffle sampler a second time to ensure sample homogeneity. Then the sample material was placed in the containers specified in Table 1-1; other details on sample preparation (e.g., preservatives and holding times) are also provided in Table 1-1.

Analyses were conducted for the extensive list of parameters contained in Table 1-1. Analytical results were used in risk assessment calculations; therefore for each parameter, laboratory method detection limits (MDLs) and highest allowable minimum detectable concentrations were set at, or as near as technically feasible to, a level approximating a 1×10^{-6} incremental lifetime cancer risk (ILCR) for the reasonable maximum exposure (RME) farmer/child risk scenario. A list of MDLs requested of the laboratories is provided in Appendix B.1.2. Most of the MDLs for radiological constituents requested in this study were lower than those used for previous FEMP RI/FS samples. In order for the off-site laboratory to achieve these low MDLs for the large number of analytes requested, large sample volumes were required. Approximately four to seven gallons of soil were collected at each depth interval to provide an adequate volume for the specified analytical program. Table 1-1 provides specific analytical volume/mass requirements from each depth interval per location in order to achieve analytical requirements. Analytical methods used by the off-site laboratories are provided in Appendix B.1.3. Table 1-2 shows the quality assurance/quality control (QA/QC) samples collected as part of the PSP with the exception of field duplicate frequency which is provided in Table 1-1. MDLs achieved for soil samples by the off-site laboratories are provided in Appendix B.1.1. Also provided in Appendix B.1.2 is a table which indicates the analyses and parameters for which the requested detection units were not met. Although not all MDLs originally requested were achieved, it has been determined that the quality of the data was sufficient to determine geochemical values.

Two items identified in Table 1-1 and Table 1-2 were not completed. Plutonium-241 was not analyzed due to the limited number of plutonium-238 and plutonium-239/240 detections. In addition, one of the rinsates required for field equipment (identified in Table 1-2) was not analyzed for

TABLE 1-1

SAMPLE ANALYTICAL PARAMETER REQUIREMENTS - K_1 SOIL SAMPLING AND ANALYSIS PROGRAM

Parameters (Sampling interval, in.)	Lab[a]	ASL[b]	No. of Samples	Mass/Volume (g/L)	Holding Time (days)	Preservative	Container
Total HSL metals[c] (0 - 2 and 24 - 30)	R/C	D	32[d]	250	180 (Hg 28)	Cool, 4°C	16 oz. glass
TCLP HSL metals[c] (0 - 2 and 24 - 30)	R/C	D	30	250	180 (Hg 28)	Cool, 4°C	16 oz. glass
Radiological suite[e] (0 - 2 and 24 - 30)	TOS	D	30	3000	180	None	1 1-gal. glass
TCLP radiological suite[e] (0 - 2 and 24 - 30)	TOS	D	30	7000	180	None	2 1-gal. glass
Total organic carbon (0 - 2 and 24 - 30)	R/C	B	30	100	28	Cool, 4°C	4 oz. amber glass
Dry bulk density (0 - 6 and 24 - 30)	UC	NA	30	900	NA	None	Butyrate tube or soil block
Gross alpha/beta[f] (0 - 2 and 24 - 30)	FEMP	A	32[d]	100	180	None	4 oz. glass
K_1 (leachate) (0 - 2 and 24 - 30)	FEMP	B	32[d]	1	180	Nitric acid	1 L plastic
K_1 (solid) (0 - 2 and 24 - 30)	FEMP	B	32[d]	400	180	None	16 oz. glass
K_1 (leachate) (0 - 2 and 24 - 30)	TOS	D	32[d]	1	180	Nitric acid	1 L plastic
K_1 (solid) (0 - 2 and 24 - 30)	TOS	D	32[d]	100	180	None	120 mL plastic
Total and isotopic uranium (0 - 2 and 24 - 30)	FEMP	B	32[d]	800	180	None	1 L glass
Total and isotopic uranium (0 - 6, 6 - 12, 12 - 18, and 18 - 24)	FEMP	B	60	800	180	None	1 L glass
Total uranium (KL-SS-11, 0 - 2) (KL-SS-09, 24 - 30)	TOS	D	2[d]	100	180	None	4 oz. glass

[a] Laboratories: FEMP (FERMCO Laboratory), R/C (RCRA/CERCLA Laboratory), TOS (Radiological Task Order Subcontract), and UC [University of Cincinnati Geotechnical Laboratory (On-Site)]

[b] Analytical support level (ASL): A (unvalidated data for shipping purposes), B (unvalidated data generated by laboratories), D (validated data). See Appendix B for a complete discussion of data validation.

[c] Hazardous substance list (HSL) metals include: Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Calcium, Chromium, Cobalt, Copper, Cyanide, Mercury, Iron, Lead, Magnesium, Manganese, Molybdenum, Nickel, Potassium, Sodium, Selenium, Silicon, Silver, Thallium, Vanadium, and Zinc.

[d] Includes two field duplicates [KL-SS-09 (24- to 30-inch) and KL-SS-11 (0- to 2-inch)]

[e] Radiological suite includes: Cesium-137, Neptunium-237, Plutonium-238, Plutonium-239/240, Plutonium-241, Radium-226, Radium-228, Strontium-90, Technetium-99, Thorium-227, Thorium-228, Thorium-232, Thorium-230, Uranium-234, Uranium-235/236, Uranium-238, and Uranium-Total

[f] Screen for shipping purposes only

NA Not applicable

- Total uranium concentrations decreased sharply with depth; concentrations at the 24- to 30-inch-depth interval were at the background level.

These results/observations are consistent with Section 4.0 of the final Operable Unit 5 RI Report (DOE 1995b). Concentrations from select inorganic and other radionuclide soil concentrations are provided in Appendix D.2.

2.2 K_l AND K_e VALUES FOR TOTAL URANIUM FROM DESORPTION BATCH TESTS

Provided in Appendix F.1 are definitions of variables, mathematical procedures, equations, and sample calculations for determining K_l and K_e values from desorption batch tests. The procedure for the two-phase desorption batch test was provided in Section 1.2.

Because equilibrium was reached twice, K_l is described with the terms K_{l1} and K_{l2}. These terms were described previously. K_{l1} is the leaching coefficient in soil for the total mass of the contaminant. K_{l2} is the leaching coefficient in soil for the extractable mass of the contaminant. K_e, the total extractable percent of contaminant in the soil, can also be calculated because equilibrium was reached twice. Below describes how these geochemical parameters were calculated.

All of the intermediate leachate samples were analyzed for total uranium at the FEMP Laboratory to allow the quick turnaround times required during the test. When it appeared that leachate concentrations were becoming steady (e.g., leachate concentrations analyzed onsite) final leachate samples from each phase were split between the off-site laboratory and FEMP Laboratory and analyzed for isotopic uranium and total uranium, respectively. All leachate results are provided in Appendix B.3.1 and are summarized in Table 2-1. Leachate curves, total uranium concentrations versus extraction times, are provided in Appendix E.1. After completion of the second phase, a soil sample was collected from the tumbler and split for on-site and off-site analysis of total and isotopic uranium. Results from these soil samples are provided in Appendix B.4.

A mass balance for total uranium was calculated to determine if the initial mass of uranium present in the soil before the desorption batch test equalled the remaining mass in the final soil sample plus the amount of uranium which was present in the leachate. In general, the mass did not balance well. This may have been caused by laboratory error, by an incomplete homogenization of the soil sample collected at each sampling location or due to the large volume of soil collected per depth interval. As mentioned in

different glacial overburden soil types and Table 2-6 contains a summary of this data. This data is considered to be representative of cation exchange capacity values in the glacial overburden at the FEMP.

Clay minerals accounted for about 15 percent of the average soil from the site characterization study and were comprised of illite, corrensite, chlorite, and iron-oxide minerals. In general, the percent of clay minerals in the soil controls the cation exchange capacity of the soil. This is largely a result of the greater surface area available for exchange and adsorption reactions in clay-rich soil. Values ranged from 13.05 to 0.4 milliequivalents/100 grams of soil, for a soil containing 95 to 2.5 percent clay, respectively. This data is considered to adequately bracket the range of cation exchange capacity for the glacial overburden soil.

TOC content was plotted against cation exchange capacity and is shown in Figure 2-8. Cation exchange capacity, as measured by exchangeable sodium ion, is independent of the TOC content. However, TOC will affect the degree to which organic, and some inorganic constituents will be absorbed by the soil.

TOC analysis was also performed on the samples from the 15 locations (0- to 2- and 24- to 30-inch-depth intervals) as part of the PSP for Operable Unit 5 K_1 Soil Sampling and Analysis. The range of TOC for the 0- to 2-inch-depth interval was 9610 to 412,000 mg/kg. The range of TOC for the 24- to 30-inch-depth interval was 2170 to 19,200 mg/kg. These results are presented in Appendix B.1.1. In Operable Unit 5 fate and transport modeling when site-specific literature-based values were not available, a total organic carbon concentration of 10,000 mg/kg was used to calculate geochemical values.

2.4.2 Physical Properties

Dry bulk density analysis was performed on soil samples from the 15 Operable Unit 5 K_1 Sampling and Analysis locations (0- to 6- and 24- to 30-inch-depth intervals). Dry bulk density, often referred to as dry unit weight, is the weight of oven-dried soil per unit of total volume of soil mass and is expressed in pounds per cubic feet (pcf). Surface samples had an average dry unit weight of 89.2 pcf (1.4 g/cm^3) while deeper samples (24 to 30 inches) had an average dry unit weight of 98.7 pcf (1.6 g/cm^3). Soil samples were classified predominately as silt and clay of low plasticity. The permeability of the samples was considered to be moderate at the surface and slow (low) to moderately slow (low) at the 24- to 30-inch-depth interval. The results from the dry bulk analysis are provided in Appendix C.

TABLE 2-1 (Continued)

Sampling Location[a]/ Depth Interval (in.)	Phase 1										Phase 2								
	Leachate Extractions (μg/L)								Final U-238 Sample, Off-Site Lab (pCi/L)	Final Total U Sample, Off-Site Lab (calc., μg/L)	Leachate Extractions (μg/L)							Final U-238 Sample, Off-Site Lab (pCi/L)	Final Total U Sample, Off-Site Lab (calc., μg/L)
	1	2	3	4	5	6	7	8			9	10	11	12	13	14	15		
[2] KL-SS-11/0-2	47.0	56.0	56.0	94.0	120.0	93.0	59.0*	54.0	19.899	59.70	19.0	20.0	22.0	16.0	18.0	26.0*		12.951	38.85
[24B2] KL-SS-11/0-2 DUP	12.0	29.0	31.0	16.0	18.0	12.0	13.0*	14.0	4.128	12.38	10.0	9.5	7.5	6.8	19.0	28.0*	22.0	3.316	9.95
[20B2] KL-SS-11/24-30	0.4	0.3	0.1	0.1	0.1	0.1	0.1*	0.2	0.085	0.26	<0.1	1.9	0.1	<0.1	<0.1	0.1*		0.122	0.37
[8] KL-SS-12/0-2	8.0	8.9	10.0	5.6	9.4	11.0	9.9*	2.5	1.136	3.41	1.6	3.2	2.2	1.6	2.0	3.9*		0.442	1.33
[14B2] KL-SS-12/24-30	0.7	0.5	0.2	0.3	0.3	0.1	0.1*	0.1	0.202	0.61	0.1	0.1	0.2	<0.1	<0.1	0.2*		0.361	1.08
[1] KL-SS-13/0-2	15.0	22.0	18.0	22.0	37.0	36.0	45.0	45.0*	12.254	36.76	7.2	7.8	6.3	2.4	5.4	4.8*		1.077	3.23
[21B2] KL-SS-13/24-30	1.0	0.3	0.2	0.1	0.2	0.3	0.28*	0.7	0.263	0.79	<0.1	0.4	0.3	0.1	0.3	0.5*		0.017	0.05
[15B2] KL-SS-14/0-2	14.0	31.0	35.0	25.0	15.0	23.0	41(41)*	11.0	15.894	47.68	8.5	4.9	21.0	16.0	27.0	13.0*		4.054	12.16
[22B2] KL-SS-14/24-30	0.7	0.5	0.2	0.1	0.1	0.2	0.1*	0.1	0.162	0.49	<0.1	0.7	0.1	0.1	<0.1	0.2*		0.163	0.49
[6] KL-SS-15/0-2	47.0	68.0	55.0	65.0	85.0	87.0	87.0*	99.0	27.828	83.48	23.0	40.0	29.0	39.0	48.0	51.0*		21.492	64.48
[16B2] KL-SS-15/24-30	0.1	0.2	0.2	0.1	0.2	0.3	0.1*	.04	0.032	0.10	<0.1	<0.1	0.3	0.8	0.1	0.1*		0.178	0.53

[a] [ ] Brackets indicate associated sample number
[b] * Reached equilibrium

TABLE 2-5

COMPARISON OF K_d VALUES CALCULATED WITH TCLP DATA AND VALUES USED IN OPERABLE UNIT 5 FATE AND TRANSPORT MODELING

Constituents of Concern	K_d (L/kg) Used in RI and FS Reports	K_d (L/kg) Geometric Mean (0-2 in.)	No. of Locations Used to Calculate K_d[a]	No. of Locations w/Conc. Detected in Soil but Leachate conc. is ND[b]	No. of Locations w/Conc. Detected in Leachate but Soil Conc. is ND	No. of Locations w/Soil and Leachate Concs. ND	K_d (L/kg) Geometric Mean (24-30 in.)	No. of Locations used to Calculate K_d	No. of Locations w/Conc. Detected in Soil but Leachate is ND	No. of Locations w/Conc. Detected in Leachate but Soil Conc. is ND	No. of Locations w/Soil and Leachate Concs. ND
Radionuclides:											
Cesium-137	1.81E+03	7.86E+03	10	5	0	0	7.29E+00	3	2	5	5
Neptunium-237	5.50E+01	4.96E+03	11	4	0	0	2.21E+03	10	4	1	0
Plutonium-238	1.70E+03	1.70E+03	12	3	0	0	3.97E+02	11	1	3	0
Plutonium-239/240	1.70E+03	1.70E+04	15	0	0	0	8.00E+02	14	1	0	0
Radium-226	6.96E+02	1.60E+03	15	0	0	0	2.37E+03	14	1	0	0
Radium-228	6.96E+02	7.36E+02	15	0	0	0	5.46E+02	14	1	0	0
Strontium-90	1.00E+01	NA[c]	0	0	14	1	2.56E+03	1	0	10	4
Technetium-99	3.00E+01	3.03E+01	15	0	0	0	5.47E+00	7	1	6	1
Thorium-228	5.80E+03	1.70E+04	15	0	0	0	2.04E+04	13	2	0	0
Thorium-230	5.80E+03	2.42E+04	15	0	0	0	1.12E+04	14	1	0	0
Thorium-232	5.80E+03	4.07E+04	12	3	0	0	2.95E+04	12	3	0	0
Uranium, Total	15[d]/325[e]	9.40E+02	15	0	0	0	6.31E+03	14	1	0	0
Uranium-234	15/325	1.99E+03	15	0	0	0	2.18E+03	14	1	0	0
Uranium-235/236	15/325	1.88E+03	15	0	0	0	1.47E+03	12	2	1	0
Uranium-238	15/325	1.51E+03	15	0	0	0	4.60E+03	14	1	0	0
Uranium Overall	15/325	1.52E+03					3.11E+03				

TABLE 2-5 (Continued)

Constituents of Concern	K_t (L/kg) Used in RI and FS Reports	K_t (L/kg) Geometric Mean (0-2 in.)	No. of Locations Used to Calculate K_t[a]	No. of Locations w/Conc. Detected in Soil but Leachate conc. is ND[b]	No. of Locations w/Conc. Detected in Leachate but Soil Conc. is ND	No. of Locations w/Soil and Leachate Concs. ND	K_t (L/kg) Geometric Mean (24-30 in.)	No. of Locations used to Calculate K_t	No. of Locations w/Conc. Detected in Soil but Leachate is ND	No. of Locations w/Conc. Detected in Leachate but Soil Conc. is ND	No. of Locations w/Soil and Leachate Concs. ND
Inorganics:											
Aluminum	1.50E+.03	4.48E+04	11	4	0	0	1.48E+05	15	0	0	0
Antimony	2.50E+02	NA	0	0	0	15	NA[c]	0	0	0	15
Arsenic	2.00E+02	1.85E+03	2	11	2	0	NA[c]	0	15	0	0
Barium	1.14E+03	1.82E+02	14	0	1	0	2.81E+02	12	3	0	0
Beryllium	1.30E+03	NA	0	13	0	2	NA[c]	0	15	0	0
Cadmium	5.00E+02	NA	0	1	0	14	NA[c]	0	0	0	15
Calcium	500E+01	2.90E+01	15	0	0	0	2.90E+01	15	0	0	0
Chromium	1.50E+03	NA	0	15	0	0	5.53E+02	1	14	0	0
Cobalt	5.50E+02	NA	0	15	0	0	NA[c]	0	15	0	0
Copper	1.25E+02	NA	0	15	0	0	NA[c]	0	15	0	0
Iron	1.65E+02	6.72E+04	5	10	0	0	2.21E+05	3	12	0	0
Lead	3.00E+03	4.63E+03	8	7	0	0	7.04E+03	11	4	0	0
Magnesium	4.50E+00	1.75E+02	15	0	0	0	2.62E+02	15	0	0	0
Manganese	1.80E+02	7.23E+02	14	1	0	0	3.60E+03	14	1	0	0
Mercury	1.00E+01	NA	0	0	0	15	NA[c]	0	1	0	14
Molybdenum	9.00E+01	NA	0	11	0	4	NA[c]	0	12	0	3
Nickel	6.50E+02	NA	0	15	0	0	NA[c]	0	15	0	0
Potassium	7.50E+01	3.51E+02	14	1	0	0	1.17E+03	7	8	0	0
Selenium	7.40E+02	NA	0	2	3	10	NA[c]	0	11	0	4
Silicon	NA[f]	1.33E+01	7	8	0	0	7.52E-02	10	5	0	0
Silver	1.80E+02	NA	0	3	0	12	NA[c]	0	0	0	15
Sodium	1.00E+02	3.28E+01	2	13	0	0	NA[c]	0	15	0	0

TABLE 2-5 (Continued)

Constituents of Concern	K_d (L/kg) Used in RI and FS Reports	K_d (L/kg) Geometric Mean (0-2 in.)	No. of Locations Used to Calculate K_d[a]	No. of Locations w/Conc. Detected in Soil but Leachate conc. is ND[b]	No. of Locations w/Conc. Detected in Leachate but Soil Conc. is ND	No. of Locations w/Soil and Leachate Concs. ND	K_d (L/kg) Geometric Mean (24-30 in.)	No. of Locations used to Calculate K_d	No. of Locations w/Conc. Detected in Soil but Leachate is ND	No. of Locations w/Conc. Detected in Leachate but Soil Conc. is ND	No. of Locations w/Soil and Leachate Concs. ND
Thallium	1.50E+03	NA	0	15	0	0	NA[c]	0	15	0	0
Vanadium	1.00E+03	4.25E+03	1	14	0	0	NA[c]	0	15	0	0
Zinc	2.40E+03	NA	0	15	0	0	NA[c]	0	15	0	0

[a]K_d for radiological constituents were calculated with detected concentrations and validated detection limits (no negative values were used). K_d for inorganic constituents were calculated only with detected concentrations.
[b]ND: Not detected
[c]NA: Not applicable. No samples were available to calculate K_d because either the solid or liquid concentration was not detected or rejected
[d]Soil contaminated with soluble uranium (see Operable Unit 5 FS, Figure F.3-2)
[e]Soil contaminated with less soluble uranium
[f]Silicon was not modeled in the FS

TABLE B.1.2-1: CHEMICAL ANALYTE AND DETECTION LEVEL

Analyte	Detection Level (mg/kg)
Cyanide	0.3
Antimony	0.615
Arsenic	0.0545
Barium	86.9
Beryllium	0.0367
Cadmium	0.133
Chromium VI	11.3
Copper	3.53
Lead	1
Magnesium	192
Manganese	83.0
Mercury	0.02
Molybdenum	0.912
Nickel	13.7
Selenium	2.47
Silver	0.0552
Thallium	0.109
Vanadium	58.3
Zinc	1.24

TABLE B.1.2-2: RADIOLOGICAL CONSTITUENTS AND DETECTION LIMITS

Analyte	Liquids	Soils
	pCi/L	Pci/g
Cesium-137	0.3	0.01
Neptunium-237	0.08	0.05
Plutonium-238; Plutonium-239/240	0.08	0.2
Plutonium-241	0.2	0.2
Radium-226	0.02	0.004
Radium-228	0.02	0.01
Strontium-90	0.3	0.015
Technetium-99	7.0	0.015
Thorium-227;	0.1	0.1
Thorium-228; Thorium-232	0.1	0.003
Thorium-230	0.2	0.1
Uranium-234; Uranium-235/236; Uranium-238	0.2	0.1
Gross alpha	2.0	15.0
Gross beta	4.0	30.0
Uranium-Total (*μg/unit*)	0.1	0.1

TABLE B.1.2-3

ANALYSES AND PARAMETERS FOR WHICH THE LABORATORIES DID NOT MEET DETECTION LIMITS

Analyses	Media	Parameters that had Detections Limits above the requested MDLs	Number of Samples with Detection Limits above the MDLs
Inorganic	Soil	Arsenic	31
		Thallium	5
Radiological	Soil	Neptunium-237	10
		Strontium-90	22
		Uranium-235/236	4
Radiological	Leachate	Uranium-235/236	4
Radiological	TCLP (Leachate)	Neptunium-237	2
		Plutonium-238	8
		Plutonium-239/240	5
		Plutonium-241	2
		Radium-228	3
		Strontium-90	2
		Thorium-228	11
		Thorium-232	1

F.1. K_l AND K_e MATHEMATICAL PROCEDURES AND SAMPLE CALCULATIONS FROM DESORPTION BATCH TESTS

Table F.1-1 lists the variables necessary to determine K_{l1}, K_{l2}, and K_e that are either measured or calculated tests. In order to better understand the definition of these variables, Figure F.1. graphically shows the concepts of the two-phase desorption batch test.

F.1.1 DERIVATION OF EQUATIONS

A mass balance for total uranium was completed first in order to determine if the initial mass of uranium present in the soil before the desorption batch test equalled the remaining mass in the final soil sample plus the amount of uranium which was present in the leachate. As mentioned in the document, the mass did not balance well. This may have been caused by laboratory error, by an incomplete homogenization of the soil sample collected from each sampling location. To account for this, initial soil concentrations (C_0) were calculated from final soil and leachate concentrations. The equation to calculate initial soil concentrations (C_0) is provided below. Table F.1-2 provides the mass balance results along with the calculated C_0 values used to calculate K_{l1}, K_{l2}, and K_e.

$$C_0 = \frac{C_f \, x \, W + (C_{w1} + C_{w2}) \, x \, V}{W} \qquad (1)$$

Calculated initial soil concentration (C_0) for samples from the 24- to 30-inch-depth interval were all below the FEMP total uranium background concentration level of 3.7 μg/g. For this reason, initial soil concentration results from the 24- to 30-inch depth interval were used as location-specific background values. For example, the initial total uranium soil concentration for location KL-SS-01 from the 24- to 30-inch-depth interval was subtracted from location KL-SS-01's 0- to 2-inch-depth interval initial soil concentration (C_0) to determine C_{s0} for location KL-SS-01's 0- to 2-inch-depth interval. Since C_0 for the 24- to 30-inch-depth interval was considered background, C_{s0} values for the 24- to 30-inch-depth interval were the same as C_0 values. Using these location-specific background concentrations yield more accurate K_{l1}, K_{l2}, and K_e values. The following equations explain how to calculate the initial soil concentration without background.

a) $C_{s0}^{(0\text{-}2)} = C_0^{(0\text{-}2)} - C_0^{(24\text{-}30)}$ **[0- to 2-inch-depth interval]** **(2)**

b) $C_{s0}^{(24\text{-}30)} = C_0^{(24\text{-}30)}$ **[24- to 30-inch-depth interval]**