Appendix F

Fate and Transport

ECF-100KR1-11-0073	Comparison of 100-KR-1 and 100-KR-2 Source OU Exposure Point Concentrations to Soil Screening Levels Protective of Groundwater and Soil Screening Levels Protective of Surface Water
ECF-100KR1-11-0074	Comparison of 100-KR-1 and 100-KR-2 Source Operable Unit Exposure Point Concentrations to Preliminary Remediation Goals Protective of Groundwater and Preliminary Remediation Goals Protective of Surface Water
ECF-100KR4-11-0113	Modeling of RI/FS Design Alternatives for 100-KR-4
ECF-Hanford-11-0063	STOMP 1-D Modeling for Determination of Preliminary Remediation Goals for 100 Area D, H and K Source Areas
ECF-Hanford-11-0165	Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100 Area

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Plateau Remediation Company

Environmental Calculation Cover Page

Part 1: Completed by the Responsible Manager

Project: 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports

Date: August 30, 2011

Calculation Title & Description: **Comparison of 100-KR-1 and 100-KR-2 Source Operable Unit Exposure Point Concentrations to Soil Screening Levels Protective of Groundwater and Soil Screening Levels Protective of Surface Water**

Preparer: Ian Ross	**Basis of Qualification: Education and Experience**
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Senior Reviewer: Doug Evans	**Basis of Qualification: Education and Experience**

Part 2: Completed by Preparer

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Part 3: Document Review & Approval:

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Terms

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
ECF	Environmental Calculation File
EPA	Environmental Protection Agency
EPC	Exposure point concentration
FS	Feasibility study
MTCA	Model Toxics Control Act
OU	Operable unit
RI	Remedial investigation
STOMP	Subsurface Transport Over Multiple Phases

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1 Purpose

This environmental calculation documents the methodology used to determine if current site conditions for the 100-K Area based on post-remediation soil sample results exceed soil screening levels for the protection of groundwater and the protection of surface water. The 100-K Area is associated with two source operable units (OUs): the 100-KR-1 OU and 100-KR-2 OU. These OUs are referred to collectively herein as the 100-K Source OU. The exposure point concentrations (EPCs) for each waste site decision unit in the 100-K Source OU are compared to soil screening levels to identify contaminants of potential concern (COPCs) for the protection of groundwater pathway and the protection of surface water pathway. This procedure is consistent with the guidance described in EPA 540/R-96/018, *Soil Screening Guidance: Users Guide.* The identified COPCs will be used to support the remedial investigation/feasibility study (RI/FS) process being conducted for the 100 Areas and 300 Area under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA).

This environmental calculation supports DOE/RL-2010-97, *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, under CERCLA. A summary based upon the comparison of EPCs to soil screening levels described in this environmental calculation will be presented in the RI/FS report.

2 Background

Soil screening levels for the protection of groundwater and the protection of surface water were estimated using the STOMP 1D 100:0 Contaminant Source Model, which is a one-dimensional model that assumes 100 percent contamination of the vadose zone beneath a backfilled waste site (zero percent clean soil). The STOMP 1D 100:0 Contaminant Source Model includes recharge from irrigation and assumes that the entire vadose zone is contaminated below clean fill, that all contamination moves downward, and that there is no dispersion, volatilization, or credit for mixing with river water. Based on agreements with the Senior Executive Council, modeling with the STOMP simulator (PNNL-15782, *STOMP Subsurface Transport Over Multiple Phases, Version 4: User's Guide*) was performed to provide another basis for estimating soil screening levels for groundwater protection and surface water protection.

As an initial step in this environmental calculation, non-radionuclide analytes with a STOMP 1D 100:0 modeled time to peak groundwater concentration of greater than 10,000 years are identified and excluded from further consideration. For simplicity, all radionuclide analytes are conservatively assumed to reach a peak groundwater concentration within 10,000 years. Comparisons are then conducted between the analyte-specific soil screening levels and EPC values for each waste site decision unit. Finally, comparisons are conducted between the EPCs and Hanford Site soil background concentrations. Analytes with EPCs that exceed both the 90th percentile background concentration and a soil screening level, and that have a time to peak groundwater concentration of less than 10,000 years (non-radionuclides only), are considered COPCs and carried forward to the RI/FS report.

For informational purposes, the Fixed Parameter Three-Phase Partitioning Model, as defined in regulations promulgated under the State of Washington Model Toxics Control Act (MTCA) (Washington Administrative Code [WAC] Chapter 173-340-747, "Deriving Soil Concentrations for Groundwater Protection"), was also used to calculate an additional set of soil screening levels protective of groundwater and surface water. The fixed parameter three-phase equation is a highly simplified model with limited data inputs. The fixed parameter three-phase equation is drawn from Washington State Department of Ecology guidance presented in WAC 173-340-747(4), "Fixed Parameter Three-Phase Partitioning Model," and is based on conservative, simplifying assumptions about the release and transport of contaminants in the subsurface. Comparisons between the MTCA-based soil screening levels

and the EPC values for each waste site decision unit are conducted in this environmental calculation, but are presented for informational purposes only and are not used to determine final COPCs.

3 Methodology

This section describes the methodology used to compare EPCs for each waste site decision unit to soil screening levels for groundwater protection and surface water protection for both the MTCA Fixed Parameter Three-Phase Partitioning Model and the STOMP 1D 100:0 Contaminant Source Model.

The following steps are used to provide a list of analytes (non-radionuclides only) with a STOMP 1D 100:0 modeled time to peak groundwater concentration of less than 10,000 years.

1. Obtain the analyte-specific peak year modeled by the STOMP 1D 100:0 Contaminant Source Model (non-radionuclides only).
2. If the analyte-specific peak year is greater than 10,000 years in the future, then no further comparison is made.
3. If the analyte-specific peak year is less than 10,000 years in the future, then a comparison to STOMP 1D soil screening levels is made.

For all detected radionuclide analytes and detected non-radionuclide analytes with a time to peak groundwater concentration of less than 10,000 years for the 100-K waste site decision units, the following steps are performed:

4. Obtain soil screening levels for the protection of groundwater and the protection of surface water calculated using the MTCA Fixed Parameter Three-Phase Model.
5. Obtain soil screening levels for the protection of groundwater and the protection of surface water calculated using the STOMP 1D 100:0 Contaminant Source model.
6. Obtain EPC values for each waste site decision unit within the 100-K Source OU.
7. Individually compare EPCs for each waste site decision unit within the 100-K Source OU to soil screening levels for the protection of groundwater and the protection of surface water.

The previous steps are conducted for all detected analytes in the 100-K Source OU. The following steps are used to provide a list of analytes that also exceed applicable 90th background concentrations.

8. Obtain 90th percentile background values.
9. Compare the EPC value to the applicable lognormal 90th percentile background value.
10. If the EPC is less than or equal to the lognormal 90th percentile background value, then no further comparison is made.
11. If the EPC is greater than the lognormal 90th percentile value, then a comparison to soil screening levels is made.
12. If a lognormal 90th percentile value is not available, then a comparison to soil screening levels is made.

Those analytes with a peak year less than 10,000 years in the future (non-radionuclides only), and that have EPCs that exceed both the 90th percentile soil background concentration and a STOMP 1D soil screening level, are considered COPCs and carried forward to the RI/FS report.

4 Assumptions and Inputs

Assumptions and inputs associated with time to peak groundwater concentrations, soil screening levels, EPCs, and soil background concentrations are described below.

4.1 Analyte-Specific Peak Years

Peak years representing the future time frame when an analyte now in vadose zone soil will have a maximum impact on groundwater were estimated using the STOMP 1D model for the 100:0 scenario. The model was used to estimate a range of peak years for each analyte based on variations in 100-K Area hydrostratigraphic conditions. Those non-radionuclide analytes with a time to peak groundwater concentration of greater than 10,000 years are removed from further consideration. For simplicity, all radionuclide analytes are conservatively assumed to have a time to peak groundwater concentration of less than 10,000 years. Operable unit-specific peak years for the 100-K OU calculated using the STOMP 1D 100:0 Contaminant Source Model are documented in ECF-HANFORD-11-0063, *STOMP 1-D Modeling for Determination of Preliminary Remediation Goals for 100 Area Source Operable Units D, H, and K*. The analyte-specific peak years for the 100-K Source OU are presented in Table 4-1. (Note: Tables that are not inserted are located at the end of this document).

4.2 Soil Screening Levels

Table 4-2 documents the sources of information for soil screening levels.

Table 4-2. Soil Screening Level References

Soil Screening Level	Pathway	Reference
MTCA Fixed Parameter Three-Phase Partitioning Model	Groundwater	ECF-HANFORD-10-0442
	Surface Water	ECF-HANFORD-10-0439
STOMP 1D 100:0 Contaminant Source Model	Groundwater	ECF-HANFORD-11-0063
	Surface Water	ECF-HANFORD-11-0063

Notes:

ECF-HANFORD-10-0442, *Calculation of Nonradiological Preliminary Remediation Goals Using the Fixed Parameter 3-Phase Equilibrium Partitioning Equation for the Protection of Groundwater for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports.*

ECF-HANFORD-10-0439, *Calculation of Nonradiological Preliminary Remediation Goals Using the Fixed Parameter 3-Phase Partitioning Equation for Surface Water Protection for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports.*

ECF-HANFORD-11-0063, *STOMP1-D Modeling for Determination of Preliminary Remediation Goals for 100 Area Source Operable Units D, H, and K.*

4.2.1 Soil Screening Levels Protective of Groundwater

Soil screening levels for the protection of groundwater at and near the 100-K Source OU have been derived using the following models:

- MTCA Fixed Parameter Three-Phase Partitioning Model
- STOMP 1D 100:0 Contaminant Source Model

The STOMP 1D soil screening levels are used to identify COPCs based on a comparison to EPCs, while the MTCA-based soil screening levels are provided for informational purposes. The groundwater protective soil screening levels for all detected analytes in the 100-K Source OU are provided in Table 4-3.

MTCA Fixed Parameter Three-Phase Partitioning Model

Soil screening levels protective of groundwater for the 100 Areas and 300 Area calculated using the MTCA fixed parameter three-phase partitioning model are documented in ECF-HANFORD-10-0442, *Calculation of Nonradiological Preliminary Remediation Goals Using the Fixed Parameter 3-Phase Equilibrium Partitioning Equation for the Protection of Groundwater for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*.

STOMP 1D 100:0 Contaminant Source Model

The STOMP 1D 100:0 Contaminant Source Model uses an irrigation recharge scenario and assumes the entire vadose zone is contaminated below clean fill. Operable unit-specific soil screening levels protective of groundwater for the 100-K Source OU calculated using the STOMP 1D 100:0 Contaminant Source Model are documented in ECF-HANFORD-11-0063.

4.2.2 Soil Screening Levels Protective of Surface Water

Soil screening levels for the protection of surface water are used in the River Corridor RI/FS process because the operable units in this area abut surface water. Soil screening levels for the protection of surface water at and near the 100-K Source OU have been derived using the following models:

- MTCA Fixed Parameter Three-Phase Partitioning Model
- STOMP 1D 100:0 Contaminant Source Model

The STOMP 1D soil screening levels are used to identify COPCs based on a comparison to EPCs, while the MTCA-based soil screening levels are provided for informational purposes. The surface water protective soil screening levels for all detected analytes in the 100-K Source OU are provided in Table 4-4.

MTCA Fixed Parameter Three-Phase Partitioning Model

Soil screening levels protective of surface water for the 100 Areas and 300 Area calculated using the MTCA fixed parameter three-phase partitioning model are documented in ECF-HANFORD-10-0439, *Calculation of Nonradiological Preliminary Remediation Goals Using the Fixed Parameter 3-Phase Partitioning Equation for Surface Water Protection for the 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports*.

STOMP 1D 100:0 Contaminant Source Model

The STOMP 1D 100:0 Contaminant Source Model uses an irrigation recharge scenario and assumes the entire vadose zone is contaminated below clean fill. The model takes no credit for dilution of groundwater by mixing with surface water. Operable unit-specific soil screening levels protective of surface water for the 100-K Source OU calculated using the STOMP 1D 100:0 Contaminant Source Model are documented in ECF-HANFORD-11-0063.

4.3 Exposure Point Concentrations

OSWER 9285.6-10, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, states that, "an exposure point concentration (EPC) is a conservative estimate of the average chemical concentration in an exposure medium." OSWER Publication 9285.7-081, *Supplemental Guidance to RAGS: Calculating the Concentration Term,* states that, "because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent upper confidence limit (UCL) of the arithmetic mean should be used for this variable."

The EPCs used for comparison to soil screening levels are the analyte-specific values computed from the post-remediation soil sample results for each waste site decision unit in the 100-K Source OU, as described in ECF-100KR1-11-0008, *Computation of Exposure Point Concentrations for the 100-KR-1 and 100-KR-2 Source Operable Units*. The EPCs for each waste site decision unit are presented in Table 4-5 for the 100-K Source OU.

4.4 Hanford Site Background

EPA 540-R-01-003, *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*, provides national policy considerations for application of background data in risk assessment and remedy selection. This policy recommends an approach that addresses site-specific background issues in the risk characterization. EPA 540-R-01-003 indicates the following:

> "COPCs that have both release-related and background-related sources should be included in the risk assessment. When concentrations of naturally occurring elements at a site exceed risk-based screening levels, that information should be discussed qualitatively in the risk characterization."

EPA 540-R-01-003 defines background constituents as the following: (1) *anthropogenic* - natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA release in question), and (2) *naturally occurring* - substances present in the environment in forms that have not been influenced by human activity.

Lognormal 90th percentile background values for the Hanford Site (representative of both naturally occurring and anthropogenic substances) have been developed for inorganic chemicals and identified in DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, Summary Table 2. Radionuclide background values are identified in DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*, Table 5-1. ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*, reports lognormal 90th percentile background values for most of the metals that are absent from DOE/RL-92-24. The analyte-specific background concentrations are presented in Table 4-6.

5 Software Applications

Microsoft Excel® was used to tabulate the data in electronic spreadsheets. These spreadsheets are provided as tables that accompany this environmental calculation.

6 Calculation

Contaminants of potential concern for groundwater protection and surface water protection at the 100-K Source OU are identified by comparing EPCs to soil screening levels and background concentrations, and

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by considering time to peak groundwater concentration, as described in Sections 3. Results of the comparisons are presented in the accompanying tables. The results are provided in summary in Section 7 and in full in Appendix A. The accompanying tables all share a similar format, providing both the values being compared as well as a "Yes/No" column indicating the outcome of the comparison.

7 Results/Conclusions

A summary of the 100-K Source OU waste site decision unit EPCs that exceed soil screening levels for groundwater protection and surface water protection, *without consideration of soil background concentrations*, are presented in Tables 7-1 and 7-2, respectively. For non-radionuclide analytes, comparisons to the STOMP 1D soil screening levels are performed only for analytes predicted to reach peak groundwater concentration within 10,000 years.

A summary of the 100-K Source OU waste site decision unit EPCs that exceed soil screening levels for groundwater protection and surface water protection, *as well as soil background concentrations*, are presented in Tables 7-3 and 7-4, respectively. Again, for non-radionuclide analytes comparisons to the STOMP 1D soil screening levels are performed only for analytes predicted to reach peak groundwater concentration within 10,000 years.

Analytes with a time to peak groundwater concentration of less than 10,000 years (non-radionuclides only), and that have an EPC that exceeds both the 90th percentile background concentration as well as a STOMP 1D soil screening level, are considered COPCs to be carried forward for further analysis.

Detailed tables showing the full series of comparison steps carried out in producing the summary tables presented in Tables 7-1 through 7-4 are provided in Appendix A.

8 References

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EPA/540/R-96/018, 1996, *Soil Screening Guidance: Users Guide*, Publication 9355.4-23, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://www.epa.gov/superfund/health/conmedia/soil/index.htm.

OSWER 9285.6-10, 2002, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: http://epa.gov/oswer/riskassessment/pdf/ucl.pdf.

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Appendix A
Detailed Comparison Tables

The full series of comparison steps carried out in identifying COPCs for groundwater protection and surface water protection for the 100-K Source OU are presented in the tables listed below.

Tables for the 100-K Source Operable Unit EPC Comparison to Groundwater Protective Soil Screening Levels and Surface Water Protective Soil Screening Levels

100-K Source Operable Unit
Table A-1. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (Without Background Consideration)
Table A-2. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D Soil Screening Levels Protective of Groundwater (Without Background Consideration)
Table A-3. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (Without Background Consideration)
Table A-4. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D Model Soil Screening Levels Protective of Surface Water (Without Background Consideration)
Table A-5. Comparison of EPCs for Waste Site Decision Units in 100-K Source OU to Hanford Site Soil Background Values
Table A-6. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (With Background Consideration)
Table A-7. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D Model Soil Screening Levels Protective of Groundwater (With Background Consideration)
Table A-8. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (With Background Consideration)
Table A-9. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D Model Soil Screening Levels Protective of Surface Water (With Background Consideration)

Table 4-1. 100-K Analyte-Specific Time to Peak Groundwater Concentrations

Analyte Name	Selected K_d (L/kg)	100-0 Irrigation Case Recharge Scenario	
		Min Time to Peak (Years)	Max Time to Peak (Years)
Ethylene glycol	0.0010	--	--
Hexavalent Chromium	0.80	209	488
Uranium-233/234	2.0	--[1]	--[1]
Uranium-235	2.0	--[1]	--[1]
Uranium-238	2.0	--[1]	--[1]
Arsenic	3.0	740	1,754
Boron	3.0	740	1,754
Antimony	3.8	924	2,191
Selenium	5.0	1,223	2,904
Molybdenum	20	4,844	11,531
Copper	22	5,326	12,681
Barium	25	6,051	14,407
Iron	25	6,051	14,407
Total beta radiostrontium	25	--[1]	--[1]
Cadmium	30	7,258	17,283
Lead	30	7,258	17,283
Mercury	30	7,258	17,283
Nickel-63	30	--[1]	--[1]
Zinc	30	7,258	17,283
Cesium-137	50	--[1]	--[1]
Cobalt-60	50	--[1]	--[1]
Americium-241	200	--[1]	--[1]
Europium-152	200	--[1]	--[1]
Europium-154	200	--[1]	--[1]
Plutonium-238	200	--[1]	--[1]
Plutonium-239/240	200	--[1]	--[1]
Carbon-14	200	--[1]	--[1]
Fluoranthene	49	11,868	28,268
Cobalt	50	12,085	28,785

Table 4-1. 100-K Analyte-Specific Time to Peak Groundwater Concentrations

Analyte Name	Selected K_d (L/kg)	100-0 Irrigation Case Recharge Scenario	
		Min Time to Peak (Years)	Max Time to Peak (Years)
Manganese	50	12,085	28,785
Nickel	65	15,706	37,412
Pyrene	68	16,430	39,138
Aroclor-1254	76	18,265	43,509
Bis(2-ethylhexyl) phthalate	110	26,568	63,293
Chromium	200	48,293	115,056
Chrysene	200	48,293	115,056
Benzo(a)anthracene	360	86,914	207,078
Beryllium	790	190,709	454,386
Benzo(b)fluoranthene	803	193,847	461,863
Vanadium	1,000	241,399	575,165
Benzo(k)fluoranthene	1,230	296,917	707,446
Aluminum	1,500	362,090	862,733
Indeno(1,2,3-cd)pyrene	3,470	837,615	2.00E+06
Benzo(a)pyrene	5,500	1.33E+06	3.16E+06
Total petroleum hydrocarbons	--	--	--

Notes:

Shaded values are those analytes with a peak greater than 10,000 years

1. Radionuclides are conservatively assumed to have a time to peak groundwater concentration of less than 10,000 years.

-- For analytes with no applicable STOMP 1D Soil Screening Level, a time to peak was not calculated

Table 4-3. Summary of Groundwater Protective Soil Screening Levels for the 100-K Source Operable Unit

Analyte	90th Percentile Background	Fixed Parameter Three-Phase Soil Screening Level for Groundwater Protection	STOMP 1D (100:0 Contaminant Source Model) Soil Screening Level for Groundwater Protection
Radionuclides (pCi/g)			
Americium-241	--	--	1.21E+03
Carbon-14	--	--	4.32E+01
Cesium-137	1.05E+00	--	5.98E+04
Cobalt-60	8.42E-03	--	1.78E+05
Europium-152	--	--	1.62E+04
Europium-154	3.34E-02	--	4.85E+03
Nickel-63	--	--	2.31E+03
Plutonium-238	3.78E-03	--	1.21E+03
Plutonium-239/240	2.48E-02	--	1.21E+03
Total beta radiostrontium	1.78E-01	--	6.72E+02
Uranium-233/234	1.10E+00	--	1.70E+01
Uranium-235	1.09E-01	--	1.70E+01
Uranium-238	1.06E+00	--	1.70E+01
Nonradionuclides (µg/kg)			
Aluminum	1.18E+07	1.50E+06	--[2]
Antimony	1.30E+02	4.75E+02	9.27E+03
Aroclor-1254	--	6.63E+01	--[2]
Arsenic	6.47E+03	3.73E+00	7.22E+01
Barium	1.32E+05	1.01E+06	2.02E+07
Benzo(a)anthracene	--	8.63E+02	--[2]
Benzo(a)pyrene	--	1.32E+03	--[2]
Benzo(b)fluoranthene	--	1.93E+03	--[2]
Benzo(k)fluoranthene	--	2.95E+03	--[2]
Beryllium	1.51E+03	6.32E+04	--[2]
Bis(2-ethylhexyl) phthalate	--	1.32E+04	--[2]
Boron	3.89E+03	2.05E+05	3.96E+06
Cadmium	5.63E+02	3.02E+03	6.07E+04
Chromium	1.85E+04	4.00E+05	--[2]
Chrysene	--	4.80E+03	--[2]
Cobalt	1.57E+04	4.82E+03	--[2]
Copper	2.20E+04	2.84E+05	5.70E+06

Table 4-3. Summary of Groundwater Protective Soil Screening Levels for the 100-K Source Operable Unit

Analyte	90th Percentile Background	Fixed Parameter Three-Phase Soil Screening Level for Groundwater Protection	STOMP 1D (100:0 Contaminant Source Model) Soil Screening Level for Groundwater Protection
Ethylene glycol	--	6.43E+04	--[1]
Fluoranthene	--	6.31E+05	--[2]
Hexavalent Chromium	--	1.92E+02	1.68E+04
Indeno(1,2,3-cd)pyrene	--	8.32E+03	--[2]
Iron	3.26E+07	1.51E+05	3.04E+06
Lead	1.02E+04	9.06E+03	1.82E+05
Manganese	5.12E+05	5.02E+04	--[2]
Mercury	1.31E+01	1.21E+03	2.43E+04
Molybdenum	4.70E+02	3.23E+04	6.48E+05
Nickel	1.91E+04	1.30E+05	--[2]
Pyrene	--	6.55E+05	--[2]
Selenium	7.80E+02	5.20E+03	1.02E+05
Total petroleum hydrocarbons	--	--	--[1]
Vanadium	8.51E+04	1.60E+06	--[2]
Zinc	6.78E+04	2.90E+06	5.83E+07

Note:

-- = Not Applicable

1. A Soil Screening Level is not calculated because a groundwater cleanup level or MCL is not available for this analyte.
2. For calculated soil activities or Soil Screening Levels protective of groundwater STOMP1D predicts these analytes will not reach peak groundwater concentration within 10,000

Table 4-4. Summary of Surface Water Protective Soil Screening Levels for the 100-K Source Operable Unit

Analyte	90th Percentile Background	Fixed Parameter Three-Phase Soil Screening Level for Surface Water Protection	STOMP 1D (100:0 Contaminant Source Model) Soil Screening Level for Surface Water Protection
Radionuclides (pCi/g)			
Americium-241	--	--	1.21E+03
Carbon-14	--	--	4.32E+01
Cesium-137	1.05E+00	--	5.98E+04
Cobalt-60	8.42E-03	--	1.78E+05
Europium-152	--	--	1.62E+04
Europium-154	3.34E-02	--	4.85E+03
Nickel-63	--	--	2.31E+03
Plutonium-238	3.78E-03	--	1.21E+03
Plutonium-239/240	2.48E-02	--	1.21E+03
Total beta radiostrontium	1.78E-01	--	6.72E+02
Uranium-233/234	1.10E+00	--	1.70E+01
Uranium-235	1.09E-01	--	1.70E+01
Uranium-238	1.06E+00	--	1.70E+01
Nonradionuclides (µg/kg)			
Aluminum	1.18E+07	2.61E+06	--[2]
Antimony	1.30E+02	4.44E+02	8.65E+03
Aroclor-1254	--	9.70E-02	--[2]
Arsenic	6.47E+03	1.15E+00	2.23E+01
Barium	1.32E+05	5.04E+05	1.01E+07
Benzo(a)anthracene	--	2.02E+01	--[2]
Benzo(a)pyrene	--	3.08E+02	--[2]
Benzo(b)fluoranthene	--	4.50E+01	--[2]
Benzo(k)fluoranthene	--	6.89E+01	--[2]
Beryllium	1.51E+03	4.31E+06	--[2]
Bis(2-ethylhexyl) phthalate	--	2.64E+03	--[2]
Boron	3.89E+03	--	--[1]
Cadmium	5.63E+02	1.51E+02	3.03E+03
Chromium	1.85E+04	2.60E+05	--[2]
Chrysene	--	1.12E+01	--[2]
Cobalt	1.57E+04	2.60E+03	--[2]
Copper	2.20E+04	4.00E+03	8.02E+04
Ethylene glycol	--	--	--[1]
Fluoranthene	--	8.89E+04	--[2]

Table 4-4. Summary of Surface Water Protective Soil Screening Levels for the 100-K Source Operable Unit

Analyte	90th Percentile Background	Fixed Parameter Three-Phase Soil Screening Level for Surface Water Protection	STOMP 1D (100:0 Contaminant Source Model) Soil Screening Level for Surface Water Protection
Hexavalent Chromium	--	4.00E+01	3.49E+03
Indeno(1,2,3-cd)pyrene	--	1.94E+02	--[2]
Iron	3.26E+07	1.51E+05	3.04E+06
Lead	1.02E+04	1.27E+03	2.56E+04
Manganese	5.12E+05	5.02E+04	--[2]
Mercury	1.31E+01	7.26E+00	1.46E+02
Molybdenum	4.70E+02	5.24E+05	1.05E+07
Nickel	1.91E+04	6.78E+04	--[2]
Pyrene	--	1.13E+06	--[2]
Selenium	7.80E+02	5.20E+02	1.02E+04
Total petroleum hydrocarbons	--	--	--[1]
Vanadium	8.51E+04	--	--[2]
Zinc	6.78E+04	5.50E+04	1.11E+06

Note:

-- = Not Applicable

1. A Soil Screening Level is not calculated because a groundwater cleanup level or MCL is not available for this analyte.
2. For calculated soil activities or Soil Screening Levels protective of groundwater STOMP1D predicts these analytes will not reach peak groundwater concentration within 1(

Table 4-5. Exposure Point Concentrations for Each Waste Site Decision Unit in the 100-K Source Operable Unit

Waste Site Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98
100-K-29_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,300
100-K-29_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	66,400
100-K-29_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	130
100-K-29_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	24,700
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50
100-K-30_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600
100-K-30_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	69,700
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640
100-K-30_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	15,200
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500
100-K-31_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800
100-K-31_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	169,000
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750
100-K-31_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	10,300
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200
100-K-31_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	400
100-K-32_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,000
100-K-32_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	97,400
100-K-32_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	200
100-K-32_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	16,900
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230
100-K-32_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	7,100
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700
100-K-33_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	105,000
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000
100-K-33_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	22,900
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800
100-K-55:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	1.0
100-K-55:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	0.60
100-K-55:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	0.86
100-K-55:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	0.29
100-K-55:1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.31
100-K-55:1_Overburden	Rad	Cobalt-60	10198-40-0	pCi/g	0.056
100-K-55:1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.34

Table 4-5. Exposure Point Concentrations for Each Waste Site Decision Unit in the 100-K Source Operable Unit

Waste Site Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration
100-K-55:1_Overburden	Rad	Europium-154	15585-10-1	pCi/g	0.33
100-K-55:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.29
100-K-55:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.19
100-K-55:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.81
100-K-55:1_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.52
100-K-55:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.61
100-K-55:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.11
100-K-55:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	1.3
100-K-55:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.19
100-K-55:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.37
100-K-55:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.70
100-K-55:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.78
100-K-56:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	21
100-K-56:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	1.1
100-K-56:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	22
100-K-56:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.1
100-K-56:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	1.3
100-K-56:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.32
100-K-56:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.9
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937
100-K-56:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.31
100-K-56:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.15
100-K-56:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	3.1
100-K-56:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.33
100-K-56:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.50
100-K-56:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.45
100-K-56:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.49
100-K-78_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	1.08E+07
100-K-78_Shallow_Focused	non-Rad	Antimony	7440-36-0	µg/kg	391
100-K-78_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	4,330
100-K-78_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	85,300
100-K-78_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	357
100-K-78_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,570
100-K-78_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	136
100-K-78_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000
100-K-78_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	6,110
100-K-78_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	19,500
100-K-78_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	1.96E+07
100-K-78_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	6,380
100-K-78_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	288,000
100-K-78_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	452
100-K-78_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	14,800
100-K-78_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	42,900
100-K-78_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	47,000

Table 4-5. Exposure Point Concentrations for Each Waste Site Decision Unit in the 100-K Source Operable Unit

Waste Site Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration
100-K-78_Shallow_Focused	Rad	Carbon-14	14762-75-5	pCi/g	1.7
100-K-78_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.32
100-K-78_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.073
100-K-78_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	0.27
100-K-78_Shallow_Focused	Rad	Nickel-63	13981-37-8	pCi/g	7.2
100-K-78_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.84
100-K-78_Shallow_Focused	Rad	Uranium-235	15117-96-1	pCi/g	0.048
100-K-78_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.93
100-K-85_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	7.65E+06
100-K-85_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800
100-K-85_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	56,700
100-K-85_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	230
100-K-85_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,100
100-K-85_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	62
100-K-85_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	7,800
100-K-85_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	8,400
100-K-85_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	18,100
100-K-85_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	2.27E+07
100-K-85_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,800
100-K-85_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	327,000
100-K-85_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	9.9
100-K-85_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	360
100-K-85_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	9,900
100-K-85_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	52,800
100-K-85_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	46,500
116-K-1_Deep	non-Rad	Chromium	7440-47-3	µg/kg	14,607
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560
116-K-1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	11
116-K-1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	3.3
116-K-1_Deep	Rad	Europium-152	14683-23-9	pCi/g	9.0
116-K-1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.5
116-K-1_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	8.6
116-K-1_Overburden	non-Rad	Chromium	7440-47-3	µg/kg	12,619
116-K-1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.28
116-K-1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.26
116-K-1_Overburden	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.92
116-K-1_Shallow	non-Rad	Chromium	7440-47-3	µg/kg	13,705
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260
116-K-1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.91
116-K-1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.038
116-K-1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.22
116-K-1_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	1.9
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153
116-K-2_Deep	Rad	Americium-241	14596-10-2	pCi/g	3.2

Table 4-5. Exposure Point Concentrations for Each Waste Site Decision Unit in the 100-K Source Operable Unit

Waste Site Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration
116-K-2_Deep	Rad	Carbon-14	14762-75-5	pCi/g	3.6
116-K-2_Deep	Rad	Cesium-137	10045-97-3	pCi/g	119
116-K-2_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	5.3
116-K-2_Deep	Rad	Europium-152	14683-23-9	pCi/g	103
116-K-2_Deep	Rad	Europium-154	15585-10-1	pCi/g	7.0
116-K-2_Deep	Rad	Nickel-63	13981-37-8	pCi/g	763
116-K-2_Deep	Rad	Plutonium-238	13981-16-3	pCi/g	0.53
116-K-2_Deep	Rad	Plutonium-239/240	PU-239/240	pCi/g	5.1
116-K-2_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	6.3
116-K-2_Deep	Rad	Uranium-233/234	U-233/234	pCi/g	0.74
116-K-2_Deep	Rad	Uranium-235	15117-96-1	pCi/g	0.045
116-K-2_Deep	Rad	Uranium-238	U-238	pCi/g	0.71
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300
116-K-2_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.13
116-K-2_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.21
116-K-2_Overburden	Rad	Uranium-233/234	U-233/234	pCi/g	0.66
116-K-2_Overburden	Rad	Uranium-238	U-238	pCi/g	0.68
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308
116-K-2_Shallow	Rad	Carbon-14	14762-75-5	pCi/g	3.0
116-K-2_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.93
116-K-2_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.59
116-K-2_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.30
116-K-2_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.8
116-K-2_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.26
116-K-2_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.69
116-K-2_Shallow	Rad	Uranium-238	U-238	pCi/g	0.63
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583
116-KE-4_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.37
116-KE-4_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.086
116-KE-4_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.70
116-KE-4_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.28
116-KE-4_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.5
116-KE-4_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.32
116-KE-4_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.61
116-KE-4_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.041
116-KE-4_Shallow	Rad	Uranium-238	U-238	pCi/g	0.56
116-KE-5_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700
116-KE-5_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	100,000
116-KE-5_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	195
116-KE-5_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000
116-KE-5_Shallow_Focused	non-Rad	Ethylene glycol	107-21-1	µg/kg	59
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102

Table 4-5. Exposure Point Concentrations for Each Waste Site Decision Unit in the 100-K Source Operable Unit

Waste Site Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749
116-KW-3_Shallow	Rad	Americium-241	14596-10-2	pCi/g	0.53
116-KW-3_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.22
116-KW-3_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.10
116-KW-3_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.5
116-KW-3_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.29
116-KW-3_Shallow	Rad	Plutonium-239/240	PU-239/240	pCi/g	0.92
116-KW-3_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.66
116-KW-3_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.039
116-KW-3_Shallow	Rad	Uranium-238	U-238	pCi/g	0.65
116-KW-4_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600
116-KW-4_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	59,300
116-KW-4_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	12,100
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240
116-KW-4_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,500
128-K-1_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700
128-K-1_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	71,500
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103
128-K-1_Shallow_Focused	non-Rad	Benzo(a)pyrene	50-32-8	µg/kg	51
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78
128-K-1_Shallow_Focused	non-Rad	Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	870
128-K-1_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	350
128-K-1_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	13,500
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148
128-K-1_Shallow_Focused	non-Rad	Fluoranthene	206-44-0	µg/kg	220
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480
128-K-1_Shallow_Focused	non-Rad	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	29
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30
128-K-1_Shallow_Focused	non-Rad	Pyrene	129-00-0	µg/kg	150
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800
128-K-1_Shallow_Focused	non-Rad	Total petroleum hydrocarbons	TPH	µg/kg	14,400

Notes:
ECF-100KR4-11-0008, *Computation of Exposure Point Concentrations for the 100-KR-1 and 100-KR-2 Source Operable Units*

Table 4-6 Hanford Site Soil Background Values

Analyte Name	Analyte Class	Units	Lognormal 90th Percentile Background Value	Source of Background Values
Cesium-137	RAD	pCi/g	1.1	DOE/RL-96-12, Rev.0
Cobalt-60	RAD	pCi/g	0.0084	DOE/RL-96-12, Rev.0
Europium-154	RAD	pCi/g	0.033	DOE/RL-96-12, Rev.0
Europium-155	RAD	pCi/g	0.054	DOE/RL-96-12, Rev.0
Gross beta	RAD	pCi/g	23	DOE/RL-96-12, Rev.0
Plutonium-238	RAD	pCi/g	0.0038	DOE/RL-96-12, Rev.0
Plutonium-239/240	RAD	pCi/g	0.025	DOE/RL-96-12, Rev.0
Potassium-40	RAD	pCi/g	17	DOE/RL-96-12, Rev.0
Radium-226	RAD	pCi/g	0.82	DOE/RL-96-12, Rev.0
Strontium-90	RAD	pCi/g	0.18	DOE/RL-96-12, Rev.0
Thorium-232	RAD	pCi/g	1.3	DOE/RL-96-12, Rev.0
Total beta radiostrontium	RAD	pCi/g	0.18	DOE/RL-96-12, Rev.0
Uranium-233/234	RAD	pCi/g	1.1	DOE/RL-96-12, Rev.0
Uranium-234	RAD	pCi/g	1.1	DOE/RL-96-12, Rev.0
Uranium-235	RAD	pCi/g	0.11	DOE/RL-96-12, Rev.0
Uranium-238	RAD	pCi/g	1.1	DOE/RL-96-12, Rev.0
Aluminum	METAL	µg/kg	1.18E+07	DOE/RL-92-24, V.1, Rev.4
Antimony	METAL	µg/kg	130	ECF-HANFORD-11-0038
Arsenic	METAL	µg/kg	6,470	DOE/RL-92-24, V.1, Rev.4
Barium	METAL	µg/kg	132,000	DOE/RL-92-24, V.1, Rev.4
Beryllium	METAL	µg/kg	1,510	DOE/RL-92-24, V.1, Rev.4
Cadmium	METAL	µg/kg	563	ECF-HANFORD-11-0038
Calcium	METAL	µg/kg	1.72E+07	DOE/RL-92-24, V.1, Rev.4
Chromium	METAL	µg/kg	18,500	DOE/RL-92-24, V.1, Rev.4
Cobalt	METAL	µg/kg	15,700	DOE/RL-92-24, V.1, Rev.4
Copper	METAL	µg/kg	22,000	DOE/RL-92-24, V.1, Rev.4
Iron	METAL	µg/kg	3.26E+07	DOE/RL-92-24, V.1, Rev.4
Lead	METAL	µg/kg	10,200	DOE/RL-92-24, V.1, Rev.4
Lithium	METAL	µg/kg	13,300	ECF-HANFORD-11-0038
Magnesium	METAL	µg/kg	7.06E+06	DOE/RL-92-24, V.1, Rev.4

Table 4-6 Hanford Site Soil Background Values

Analyte Name	Analyte Class	Units	Lognormal 90th Percentile Background Value	Source of Background Values
Manganese	METAL	µg/kg	512,000	DOE/RL-92-24, V.1, Rev.4
Mercury	METAL	µg/kg	13	ECF-HANFORD-11-0038
Molybdenum	METAL	µg/kg	470	ECF-HANFORD-11-0038
Nickel	METAL	µg/kg	19,100	DOE/RL-92-24, V.1, Rev.4
Potassium	METAL	µg/kg	2.15E+06	DOE/RL-92-24, V.1, Rev.4
Silver	METAL	µg/kg	167	ECF-HANFORD-11-0038
Sodium	METAL	µg/kg	690,000	DOE/RL-92-24, V.1, Rev.4
Uranium	METAL	µg/kg	3,210	Isotopic Activity Conversion based on DOE/RL-96-12 values
Vanadium	METAL	µg/kg	85,100	DOE/RL-92-24, V.1, Rev.4
Zinc	METAL	µg/kg	67,800	DOE/RL-92-24, V.1, Rev.4
Ammonia	ANIONS	µg/kg	9,230	DOE/RL-92-24, V.1, Rev.4
Chloride	ANIONS	µg/kg	100,000	DOE/RL-92-24, V.1, Rev.4
Fluoride	ANIONS	µg/kg	2,810	DOE/RL-92-24, V.1, Rev.4
Nitrate	ANIONS	µg/kg	52,000	DOE/RL-92-24, V.1, Rev.4
Phosphate	ANIONS	µg/kg	785	DOE/RL-92-24, V.1, Rev.4
Sulfate	ANIONS	µg/kg	237,000	DOE/RL-92-24, V.1, Rev.4
Boron	METAL	µg/kg	3,890	ECF-HANFORD-11-0038
Selenium	METAL	µg/kg	780	Ecology 94-115
Thallium	METAL	µg/kg	185	ECF-HANFORD-11-0038

Notes:

DOE/RL-92-24, Volume 1, Rev. 4, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analyte*

DOE/RL-96-12, Rev. 0, *Hanford Site Background: Part 2, Soil Background for Radionuclides*

Ecology 94-115, *Natural Background Soil Metals Concentrations in Washington State*

ECF-HANFORD-11-0038, *Soil Background Data for Interim Use at the Hanford Site*

Table 7-1. Summary of Analytes that Exceed MTCA Fixed Parameter Three-Phase or STOMP 1D Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter 3-Phase Soil Screening Level Protective of Groundwater	Is EPC > Soil Screening Level Protective of Groundwater?	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	66	Yes	--[1]	--
100-K-29_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,300	3.7	Yes	72	Yes
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	192	Yes	16,800	No
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	9,060	Yes	182,070	No
100-K-30_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	3.7	Yes	72	Yes
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	192	Yes	16,800	No
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	9,060	Yes	182,070	No
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	1,210	Yes	24,276	No
100-K-31_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	3.7	Yes	72	Yes
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	192	Yes	16,800	No
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	9,060	Yes	182,070	No
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	1,210	Yes	24,276	No
100-K-32_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,000	3.7	Yes	72	Yes
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	192	Yes	16,800	No
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	1,210	Yes	24,276	No
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	3.7	Yes	72	Yes
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	192	Yes	16,800	No
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	9,060	Yes	182,070	No
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	1,210	Yes	24,276	No
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	192	Yes	16,800	No
100-K-78_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	1.08E+07	1.50E+06	Yes	--[1]	--
100-K-78_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	4,330	3.7	Yes	72	Yes
100-K-78_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	6,110	4,820	Yes	--[1]	--
100-K-78_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	1.96E+07	151,000	Yes	3.04E+06	Yes
100-K-78_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	288,000	50,200	Yes	--[1]	--
100-K-85_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	7.65E+06	1.50E+06	Yes	--[1]	--
100-K-85_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	3.7	Yes	72	Yes
100-K-85_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	8,400	4,820	Yes	--[1]	--
100-K-85_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	2.27E+07	151,000	Yes	3.04E+06	Yes
100-K-85_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	327,000	50,200	Yes	--[1]	--
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	192	Yes	16,800	No
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	192	Yes	16,800	No
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	192	Yes	16,800	No
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	192	Yes	16,800	No
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	192	Yes	16,800	No
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	192	Yes	16,800	No
116-KE-5_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	3.7	Yes	72	Yes
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	192	Yes	16,800	No
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	9,060	Yes	182,070	No
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	192	Yes	16,800	No
116-KW-4_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	3.7	Yes	72	Yes
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	192	Yes	16,800	No
128-K-1_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	3.7	Yes	72	Yes
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	192	Yes	16,800	No
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	9,060	Yes	182,070	No

1. For calculated soil activities or Soil Screening Levels protective of groundwater STOMP1D predicts these analytes will not reach peak groundwater concentration within 10,000 years assuming that 100% of the vadose zone is conta

Table 7-2. Summary of Analytes that Exceed MTCA Fixed Parameter Three-Phase or STOMP 1D Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter 3-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	0.097	Yes	--[1]	--
100-K-29_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,300	1.2	Yes	22	Yes
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	40	Yes	3,490	No
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	1,270	Yes	25,582	Yes
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	7.3	Yes	146	No
100-K-30_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	1.2	Yes	22	Yes
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	151	Yes	3,035	No
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	40	Yes	3,490	No
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	1,270	Yes	25,582	Yes
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	7.3	Yes	146	Yes
100-K-31_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	1.2	Yes	22	Yes
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	151	Yes	3,035	No
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	40	Yes	3,490	No
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	1,270	Yes	25,582	Yes
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	7.3	Yes	146	Yes
100-K-32_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,000	1.2	Yes	22	Yes
100-K-32_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	200	151	Yes	3,035	No
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	40	Yes	3,490	No
100-K-32_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	7,100	1,270	Yes	25,582	No
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	7.3	Yes	146	Yes
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	1.2	Yes	22	Yes
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	151	Yes	3,035	No
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	40	Yes	3,490	No
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	1,270	Yes	25,582	Yes
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	7.3	Yes	146	Yes
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	40	Yes	3,490	No
100-K-78_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	1.08E+07	2.61E+06	Yes	--[1]	--
100-K-78_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	4,330	1.2	Yes	22	Yes
100-K-78_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	6,110	2,600	Yes	--[1]	--
100-K-78_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	19,500	4,000	Yes	80,173	No
100-K-78_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	1.96E+07	151,000	Yes	3.04E+06	Yes
100-K-78_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	6,380	1,270	Yes	25,582	No
100-K-78_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	288,000	50,200	Yes	--[1]	--
100-K-85_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	7.65E+06	2.61E+06	Yes	--[1]	--
100-K-85_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	1.2	Yes	22	Yes
100-K-85_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	8,400	2,600	Yes	--[1]	--
100-K-85_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	18,100	4,000	Yes	80,173	No
100-K-85_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	2.27E+07	151,000	Yes	3.04E+06	Yes
100-K-85_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,800	1,270	Yes	25,582	No
100-K-85_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	327,000	50,200	Yes	--[1]	--
100-K-85_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	9.9	7.3	Yes	146	No
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	40	Yes	3,490	No
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	40	Yes	3,490	No

Table 7-2. Summary of Analytes that Exceed MTCA Fixed Parameter Three-Phase or STOMP 1D Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter 3-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	40	Yes	3,490	No
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	40	Yes	3,490	No
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	40	Yes	3,490	No
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	40	Yes	3,490	No
116-KE-5_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	1.2	Yes	22	Yes
116-KE-5_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	195	151	Yes	3,035	No
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	40	Yes	3,490	No
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	1,270	Yes	25,582	No
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	7.3	Yes	146	No
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	40	Yes	3,490	No
116-KW-4_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	1.2	Yes	22	Yes
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	40	Yes	3,490	No
116-KW-4_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,500	1,270	Yes	25,582	No
128-K-1_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	1.2	Yes	22	Yes
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	20	Yes	--[1]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	45	Yes	--[1]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	69	Yes	--[1]	--
128-K-1_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	350	151	Yes	3,035	No
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	11	Yes	--[1]	--
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	40	Yes	3,490	No
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	1,270	Yes	25,582	No
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	7.3	Yes	146	No
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	520	Yes	10,225	No

1. For calculated soil activities or Soil Screening Levels protective of groundwater STOMP1D predicts these analytes will not reach peak groundwater concentration within 10,000 years assuming that 100% of the vadose zor

Table 7-3. Summary of Analytes that Exceed MTCA Fixed Parameter Three-Phase or STOMP 1D Soil Screening Levels Protective of Groundwater (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Groundwater	Is EPC > Soil Screening Level Protective of Groundwater?	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	66	Yes	--[1]	--
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	192	Yes	16,800	No
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	9,060	Yes	182,070	No
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	192	Yes	16,800	No
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	9,060	Yes	182,070	No
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	1,210	Yes	24,276	No
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	192	Yes	16,800	No
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	9,060	Yes	182,070	No
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	1,210	Yes	24,276	No
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	192	Yes	16,800	No
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	1,210	Yes	24,276	No
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	3.7	Yes	72	Yes
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	192	Yes	16,800	No
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	9,060	Yes	182,070	No
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	1,210	Yes	24,276	No
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	192	Yes	16,800	No
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	192	Yes	16,800	No
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	192	Yes	16,800	No
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	192	Yes	16,800	No
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	192	Yes	16,800	No
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	192	Yes	16,800	No
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	192	Yes	16,800	No
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	192	Yes	16,800	No
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	9,060	Yes	182,070	No
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	192	Yes	16,800	No
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	192	Yes	16,800	No
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	192	Yes	16,800	No
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	9,060	Yes	182,070	No

1. For calculated soil activities or Soil Screening Levels protective of groundwater STOMP1D predicts these analytes will not reach peak groundwater concentration within 10,000 years assuming that 100% of the vadose zone is contaminated.

Table 7-4. Summary of Analytes that Exceed MTCA Fixed Parameter Three-Phase or STOMP 1D Soil Screening Levels Protective of Surface Water (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	0.097	Yes	--[1]	--
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	40	Yes	3,490	No
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	1,270	Yes	25,582	Yes
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	7.3	Yes	146	No
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	151	Yes	3,035	No
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	40	Yes	3,490	No
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	1,270	Yes	25,582	Yes
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	7.3	Yes	146	Yes
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	151	Yes	3,035	No
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	40	Yes	3,490	No
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	1,270	Yes	25,582	Yes
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	7.3	Yes	146	Yes
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	40	Yes	3,490	No
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	7.3	Yes	146	Yes
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	1.2	Yes	22	Yes
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	151	Yes	3,035	No
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	40	Yes	3,490	No
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	1,270	Yes	25,582	Yes
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	7.3	Yes	146	Yes
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	40	Yes	3,490	No
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	40	Yes	3,490	No
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	40	Yes	3,490	No
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	40	Yes	3,490	No
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	40	Yes	3,490	No
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	40	Yes	3,490	No
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	40	Yes	3,490	No
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	40	Yes	3,490	No
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	1,270	Yes	25,582	No
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	7.3	Yes	146	No
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	40	Yes	3,490	No
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	40	Yes	3,490	No
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	20	Yes	--[1]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	45	Yes	--[1]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	69	Yes	--[1]	--
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	11	Yes	--[1]	--
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	40	Yes	3,490	No
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	1,270	Yes	25,582	No
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	7.3	Yes	146	No
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	520	Yes	10,225	No

1. For calculated soil activities or Soil Screening Levels protective of groundwater STOMP1D predicts these analytes will not reach peak groundwater concentration within 10,000 years assuming that 100% of the vadose zone is contaminated.

Table A-1. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Groundwater	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	66	Yes
100-K-29_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,300	3.7	Yes
100-K-29_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	66,400	1.01E+06	No
100-K-29_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	130	3,020	No
100-K-29_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	24,700	400,000	No
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	192	Yes
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	9,060	Yes
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	1,210	No
100-K-30_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	3.7	Yes
100-K-30_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	69,700	1.01E+06	No
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	3,020	No
100-K-30_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	15,200	400,000	No
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	192	Yes
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	9,060	Yes
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	1,210	Yes
100-K-31_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	3.7	Yes
100-K-31_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	169,000	1.01E+06	No
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	3,020	No
100-K-31_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	10,300	400,000	No
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	192	Yes
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	9,060	Yes
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	1,210	Yes
100-K-31_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	400	5,200	No
100-K-32_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,000	3.7	Yes
100-K-32_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	97,400	1.01E+06	No
100-K-32_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	200	3,020	No
100-K-32_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	16,900	400,000	No
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	192	Yes
100-K-32_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	7,100	9,060	No
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	1,210	Yes
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	3.7	Yes
100-K-33_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	105,000	1.01E+06	No
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	3,020	No
100-K-33_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	22,900	400,000	No
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	192	Yes
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	9,060	Yes
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	1,210	Yes
100-K-55:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	1.0	--	--
100-K-55:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	0.60	--	--
100-K-55:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	0.86	--	--

Table A-1. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Groundwater	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-55:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	0.29	--	--
100-K-55:1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.31	--	--
100-K-55:1_Overburden	Rad	Cobalt-60	10198-40-0	pCi/g	0.056	--	--
100-K-55:1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.34	--	--
100-K-55:1_Overburden	Rad	Europium-154	15585-10-1	pCi/g	0.33	--	--
100-K-55:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.29	--	--
100-K-55:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.19	--	--
100-K-55:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.81	--	--
100-K-55:1_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.52	--	--
100-K-55:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.61	--	--
100-K-55:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.11	--	--
100-K-55:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	1.3	--	--
100-K-55:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.19	--	--
100-K-55:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.37	--	--
100-K-55:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.70	--	--
100-K-55:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.78	--	--
100-K-56:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	21	--	--
100-K-56:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	1.1	--	--
100-K-56:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	22	--	--
100-K-56:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.1	--	--
100-K-56:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	1.3	--	--
100-K-56:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.32	--	--
100-K-56:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.9	--	--
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	192	Yes
100-K-56:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.31	--	--
100-K-56:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.15	--	--
100-K-56:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	3.1	--	--
100-K-56:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.33	--	--
100-K-56:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.50	--	--
100-K-56:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.45	--	--
100-K-56:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.49	--	--
100-K-78_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	1.08E+07	1.50E+06	Yes
100-K-78_Shallow_Focused	non-Rad	Antimony	7440-36-0	µg/kg	391	475	No
100-K-78_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	4,330	3.7	Yes
100-K-78_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	85,300	1.01E+06	No
100-K-78_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	357	63,200	No
100-K-78_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,570	205,000	No
100-K-78_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	136	3,020	No
100-K-78_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	400,000	No
100-K-78_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	6,110	4,820	Yes

Table A-1. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Groundwater	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-78_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	19,500	284,000	No
100-K-78_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	1.96E+07	151,000	Yes
100-K-78_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	6,380	9,060	No
100-K-78_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	288,000	50,200	Yes
100-K-78_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	452	32,300	No
100-K-78_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	14,800	130,000	No
100-K-78_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	42,900	1.60E+06	No
100-K-78_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	47,000	2.90E+06	No
100-K-78_Shallow_Focused	Rad	Carbon-14	14762-75-5	pCi/g	1.7	--	--
100-K-78_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.32	--	--
100-K-78_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.073	--	--
100-K-78_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	0.27	--	--
100-K-78_Shallow_Focused	Rad	Nickel-63	13981-37-8	pCi/g	7.2	--	--
100-K-78_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.84	--	--
100-K-78_Shallow_Focused	Rad	Uranium-235	15117-96-1	pCi/g	0.048	--	--
100-K-78_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.93	--	--
100-K-85_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	7.65E+06	1.50E+06	Yes
100-K-85_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	3.7	Yes
100-K-85_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	56,700	1.01E+06	No
100-K-85_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	230	63,200	No
100-K-85_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,100	205,000	No
100-K-85_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	62	3,020	No
100-K-85_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	7,800	400,000	No
100-K-85_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	8,400	4,820	Yes
100-K-85_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	18,100	284,000	No
100-K-85_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	2.27E+07	151,000	Yes
100-K-85_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,800	9,060	No
100-K-85_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	327,000	50,200	Yes
100-K-85_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	9.9	1,210	No
100-K-85_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	360	32,300	No
100-K-85_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	9,900	130,000	No
100-K-85_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	52,800	1.60E+06	No
100-K-85_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	46,500	2.90E+06	No
116-K-1_Deep	non-Rad	Chromium	7440-47-3	µg/kg	14,607	400,000	No
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	192	Yes
116-K-1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	11	--	--
116-K-1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	3.3	--	--
116-K-1_Deep	Rad	Europium-152	14683-23-9	pCi/g	9.0	--	--
116-K-1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.5	--	--
116-K-1_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	8.6	--	--

Table A-1. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Groundwater	Is EPC > Soil Screening Level Protective of Groundwater?
116-K-1_Overburden	non-Rad	Chromium	7440-47-3	µg/kg	12,619	400,000	No
116-K-1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.28	--	--
116-K-1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.26	--	--
116-K-1_Overburden	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.92	--	--
116-K-1_Shallow	non-Rad	Chromium	7440-47-3	µg/kg	13,705	400,000	No
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	192	Yes
116-K-1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.91	--	--
116-K-1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.038	--	--
116-K-1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.22	--	--
116-K-1_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	1.9	--	--
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	192	Yes
116-K-2_Deep	Rad	Americium-241	14596-10-2	pCi/g	3.2	--	--
116-K-2_Deep	Rad	Carbon-14	14762-75-5	pCi/g	3.6	--	--
116-K-2_Deep	Rad	Cesium-137	10045-97-3	pCi/g	119	--	--
116-K-2_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	5.3	--	--
116-K-2_Deep	Rad	Europium-152	14683-23-9	pCi/g	103	--	--
116-K-2_Deep	Rad	Europium-154	15585-10-1	pCi/g	7.0	--	--
116-K-2_Deep	Rad	Nickel-63	13981-37-8	pCi/g	763	--	--
116-K-2_Deep	Rad	Plutonium-238	13981-16-3	pCi/g	0.53	--	--
116-K-2_Deep	Rad	Plutonium-239/240	PU-239/240	pCi/g	5.1	--	--
116-K-2_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	6.3	--	--
116-K-2_Deep	Rad	Uranium-233/234	U-233/234	pCi/g	0.74	--	--
116-K-2_Deep	Rad	Uranium-235	15117-96-1	pCi/g	0.045	--	--
116-K-2_Deep	Rad	Uranium-238	U-238	pCi/g	0.71	--	--
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	192	Yes
116-K-2_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.13	--	--
116-K-2_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.21	--	--
116-K-2_Overburden	Rad	Uranium-233/234	U-233/234	pCi/g	0.66	--	--
116-K-2_Overburden	Rad	Uranium-238	U-238	pCi/g	0.68	--	--
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	192	Yes
116-K-2_Shallow	Rad	Carbon-14	14762-75-5	pCi/g	3.0	--	--
116-K-2_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.93	--	--
116-K-2_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.59	--	--
116-K-2_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.30	--	--
116-K-2_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.8	--	--
116-K-2_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.26	--	--
116-K-2_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.69	--	--
116-K-2_Shallow	Rad	Uranium-238	U-238	pCi/g	0.63	--	--
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	192	Yes
116-KE-4_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.37	--	--

Table A-1. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Groundwater	Is EPC > Soil Screening Level Protective of Groundwater?
116-KE-4_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.086	--	--
116-KE-4_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.70	--	--
116-KE-4_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.28	--	--
116-KE-4_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.5	--	--
116-KE-4_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.32	--	--
116-KE-4_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.61	--	--
116-KE-4_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.041	--	--
116-KE-4_Shallow	Rad	Uranium-238	U-238	pCi/g	0.56	--	--
116-KE-5_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	3.7	Yes
116-KE-5_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	100,000	1.01E+06	No
116-KE-5_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	195	3,020	No
116-KE-5_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	400,000	No
116-KE-5_Shallow_Focused	non-Rad	Ethylene glycol	107-21-1	µg/kg	59	64,300	No
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	192	Yes
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	9,060	Yes
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	1,210	No
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	192	Yes
116-KW-3_Shallow	Rad	Americium-241	14596-10-2	pCi/g	0.53	--	--
116-KW-3_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.22	--	--
116-KW-3_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.10	--	--
116-KW-3_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.5	--	--
116-KW-3_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.29	--	--
116-KW-3_Shallow	Rad	Plutonium-239/240	PU-239/240	pCi/g	0.92	--	--
116-KW-3_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.66	--	--
116-KW-3_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.039	--	--
116-KW-3_Shallow	Rad	Uranium-238	U-238	pCi/g	0.65	--	--
116-KW-4_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	3.7	Yes
116-KW-4_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	59,300	1.01E+06	No
116-KW-4_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	12,100	400,000	No
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	192	Yes
116-KW-4_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,500	9,060	No
128-K-1_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	3.7	Yes
128-K-1_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	71,500	1.01E+06	No
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	863	No
128-K-1_Shallow_Focused	non-Rad	Benzo(a)pyrene	50-32-8	µg/kg	51	1,320	No
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	1,930	No
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	2,950	No
128-K-1_Shallow_Focused	non-Rad	Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	870	13,200	No
128-K-1_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	350	3,020	No
128-K-1_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	13,500	400,000	No

Table A-1. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Groundwater	Is EPC > Soil Screening Level Protective of Groundwater?
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	4,800	No
128-K-1_Shallow_Focused	non-Rad	Fluoranthene	206-44-0	µg/kg	220	631,000	No
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	192	Yes
128-K-1_Shallow_Focused	non-Rad	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	29	8,320	No
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	9,060	Yes
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	1,210	No
128-K-1_Shallow_Focused	non-Rad	Pyrene	129-00-0	µg/kg	150	655,000	No
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	5,200	No
128-K-1_Shallow_Focused	non-Rad	Total petroleum hydrocarbons	TPH	µg/kg	14,400	--	--

Table A-2. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	--[2]	--
100-K-29_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,300	72	Yes
100-K-29_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	66,400	2.02E+07	No
100-K-29_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	130	60,689	No
100-K-29_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	24,700	--[2]	--
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	16,800	No
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	182,070	No
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	24,276	No
100-K-30_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	72	Yes
100-K-30_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	69,700	2.02E+07	No
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	60,689	No
100-K-30_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	15,200	--[2]	--
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	16,800	No
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	182,070	No
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	24,276	No
100-K-31_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	72	Yes
100-K-31_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	169,000	2.02E+07	No
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	60,689	No
100-K-31_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	10,300	--[2]	--
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	16,800	No
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	182,070	No
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	24,276	No
100-K-31_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	400	102,250	No
100-K-32_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,000	72	Yes
100-K-32_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	97,400	2.02E+07	No
100-K-32_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	200	60,689	No
100-K-32_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	16,900	--[2]	--
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	16,800	No
100-K-32_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	7,100	182,070	No
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	24,276	No
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	72	Yes
100-K-33_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	105,000	2.02E+07	No
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	60,689	No
100-K-33_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	22,900	--[2]	--
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	16,800	No

Table A-2. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	182,070	No
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	24,276	No
100-K-55:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	1.0	59,822	No
100-K-55:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	0.60	177,690	No
100-K-55:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	0.86	16,154	No
100-K-55:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	0.29	4,846	No
100-K-55:1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.31	59,822	No
100-K-55:1_Overburden	Rad	Cobalt-60	10198-40-0	pCi/g	0.056	177,690	No
100-K-55:1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.34	16,154	No
100-K-55:1_Overburden	Rad	Europium-154	15585-10-1	pCi/g	0.33	4,846	No
100-K-55:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.29	59,822	No
100-K-55:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.19	177,690	No
100-K-55:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.81	16,154	No
100-K-55:1_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.52	4,846	No
100-K-55:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.61	59,822	No
100-K-55:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.11	177,690	No
100-K-55:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	1.3	16,154	No
100-K-55:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.19	4,846	No
100-K-55:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.37	672	No
100-K-55:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.70	17	No
100-K-55:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.78	17	No
100-K-56:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	21	59,822	No
100-K-56:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	1.1	177,690	No
100-K-56:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	22	16,154	No
100-K-56:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.1	4,846	No
100-K-56:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	1.3	59,822	No
100-K-56:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.32	177,690	No
100-K-56:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.9	16,154	No
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	16,800	No
100-K-56:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.31	59,822	No
100-K-56:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.15	177,690	No
100-K-56:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	3.1	16,154	No
100-K-56:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.33	4,846	No
100-K-56:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.50	672	No
100-K-56:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.45	17	No

Table A-2. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-56:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.49	17	No
100-K-78_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	1.08E+07	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Antimony	7440-36-0	µg/kg	391	9,266	No
100-K-78_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	4,330	72	Yes
100-K-78_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	85,300	2.02E+07	No
100-K-78_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	357	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,570	3.96E+06	No
100-K-78_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	136	60,689	No
100-K-78_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	6,110	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	19,500	5.70E+06	No
100-K-78_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	1.96E+07	3.04E+06	Yes
100-K-78_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	6,380	182,070	No
100-K-78_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	288,000	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	452	648,050	No
100-K-78_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	14,800	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	42,900	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	47,000	5.83E+07	No
100-K-78_Shallow_Focused	Rad	Carbon-14	14762-75-5	pCi/g	1.7	43	No
100-K-78_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.32	59,822	No
100-K-78_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.073	177,690	No
100-K-78_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	0.27	16,154	No
100-K-78_Shallow_Focused	Rad	Nickel-63	13981-37-8	pCi/g	7.2	2,314	No
100-K-78_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.84	17	No
100-K-78_Shallow_Focused	Rad	Uranium-235	15117-96-1	pCi/g	0.048	17	No
100-K-78_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.93	17	No
100-K-85_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	7.65E+06	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	72	Yes
100-K-85_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	56,700	2.02E+07	No
100-K-85_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	230	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,100	3.96E+06	No
100-K-85_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	62	60,689	No
100-K-85_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	7,800	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	8,400	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	18,100	5.70E+06	No

Table A-2. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-85_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	2.27E+07	3.04E+06	Yes
100-K-85_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,800	182,070	No
100-K-85_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	327,000	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	9.9	24,276	No
100-K-85_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	360	648,050	No
100-K-85_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	9,900	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	52,800	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	46,500	5.83E+07	No
116-K-1_Deep	non-Rad	Chromium	7440-47-3	µg/kg	14,607	--[2]	--
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	16,800	No
116-K-1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	11	59,822	No
116-K-1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	3.3	177,690	No
116-K-1_Deep	Rad	Europium-152	14683-23-9	pCi/g	9.0	16,154	No
116-K-1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.5	4,846	No
116-K-1_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	8.6	672	No
116-K-1_Overburden	non-Rad	Chromium	7440-47-3	µg/kg	12,619	--[2]	--
116-K-1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.28	59,822	No
116-K-1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.26	16,154	No
116-K-1_Overburden	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.92	672	No
116-K-1_Shallow	non-Rad	Chromium	7440-47-3	µg/kg	13,705	--[2]	--
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	16,800	No
116-K-1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.91	59,822	No
116-K-1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.038	177,690	No
116-K-1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.22	16,154	No
116-K-1_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	1.9	672	No
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	16,800	No
116-K-2_Deep	Rad	Americium-241	14596-10-2	pCi/g	3.2	1,212	No
116-K-2_Deep	Rad	Carbon-14	14762-75-5	pCi/g	3.6	43	No
116-K-2_Deep	Rad	Cesium-137	10045-97-3	pCi/g	119	59,822	No
116-K-2_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	5.3	177,690	No
116-K-2_Deep	Rad	Europium-152	14683-23-9	pCi/g	103	16,154	No
116-K-2_Deep	Rad	Europium-154	15585-10-1	pCi/g	7.0	4,846	No
116-K-2_Deep	Rad	Nickel-63	13981-37-8	pCi/g	763	2,314	No
116-K-2_Deep	Rad	Plutonium-238	13981-16-3	pCi/g	0.53	1,212	No
116-K-2_Deep	Rad	Plutonium-239/240	PU-239/240	pCi/g	5.1	1,212	No

Table A-2. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
116-K-2_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	6.3	672	No
116-K-2_Deep	Rad	Uranium-233/234	U-233/234	pCi/g	0.74	17	No
116-K-2_Deep	Rad	Uranium-235	15117-96-1	pCi/g	0.045	17	No
116-K-2_Deep	Rad	Uranium-238	U-238	pCi/g	0.71	17	No
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	16,800	No
116-K-2_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.13	59,822	No
116-K-2_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.21	16,154	No
116-K-2_Overburden	Rad	Uranium-233/234	U-233/234	pCi/g	0.66	17	No
116-K-2_Overburden	Rad	Uranium-238	U-238	pCi/g	0.68	17	No
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	16,800	No
116-K-2_Shallow	Rad	Carbon-14	14762-75-5	pCi/g	3.0	43	No
116-K-2_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.93	59,822	No
116-K-2_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.59	16,154	No
116-K-2_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.30	4,846	No
116-K-2_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.8	2,314	No
116-K-2_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.26	672	No
116-K-2_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.69	17	No
116-K-2_Shallow	Rad	Uranium-238	U-238	pCi/g	0.63	17	No
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	16,800	No
116-KE-4_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.37	59,822	No
116-KE-4_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.086	177,690	No
116-KE-4_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.70	16,154	No
116-KE-4_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.28	4,846	No
116-KE-4_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.5	2,314	No
116-KE-4_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.32	672	No
116-KE-4_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.61	17	No
116-KE-4_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.041	17	No
116-KE-4_Shallow	Rad	Uranium-238	U-238	pCi/g	0.56	17	No
116-KE-5_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	72	Yes
116-KE-5_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	100,000	2.02E+07	No
116-KE-5_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	195	60,689	No
116-KE-5_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	--[2]	--
116-KE-5_Shallow_Focused	non-Rad	Ethylene glycol	107-21-1	µg/kg	59	--[1]	--
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	16,800	No
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	182,070	No

Table A-2. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Groundwater (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	24,276	No
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	16,800	No
116-KW-3_Shallow	Rad	Americium-241	14596-10-2	pCi/g	0.53	1,212	No
116-KW-3_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.22	59,822	No
116-KW-3_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.10	177,690	No
116-KW-3_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.5	16,154	No
116-KW-3_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.29	4,846	No
116-KW-3_Shallow	Rad	Plutonium-239/240	PU-239/240	pCi/g	0.92	1,212	No
116-KW-3_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.66	17	No
116-KW-3_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.039	17	No
116-KW-3_Shallow	Rad	Uranium-238	U-238	pCi/g	0.65	17	No
116-KW-4_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	72	Yes
116-KW-4_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	59,300	2.02E+07	No
116-KW-4_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	12,100	--[2]	--
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	16,800	No
116-KW-4_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,500	182,070	No
128-K-1_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	72	Yes
128-K-1_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	71,500	2.02E+07	No
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(a)pyrene	50-32-8	µg/kg	51	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	870	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	350	60,689	No
128-K-1_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	13,500	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Fluoranthene	206-44-0	µg/kg	220	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	16,800	No
128-K-1_Shallow_Focused	non-Rad	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	29	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	182,070	No
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	24,276	No
128-K-1_Shallow_Focused	non-Rad	Pyrene	129-00-0	µg/kg	150	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	102,250	No
128-K-1_Shallow_Focused	non-Rad	Total petroleum hydrocarbons	TPH	µg/kg	14,400	--[2]	--

1. A Soil Screening Level is not calculated because a groundwater cleanup level or MCL is not available for this analyte.
2. For calculated soil activities or Soil Screening Levels protective of groundwater STOMP1D predicts these analytes will not reach peak groundwater concentration within 10,000 years assuming that 100% of t

Table A-3. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	0.097	Yes
100-K-29_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,300	1.2	Yes
100-K-29_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	66,400	504,000	No
100-K-29_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	130	151	No
100-K-29_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	24,700	260,000	No
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	40	Yes
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	1,270	Yes
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	7.3	Yes
100-K-30_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	1.2	Yes
100-K-30_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	69,700	504,000	No
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	151	Yes
100-K-30_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	15,200	260,000	No
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	40	Yes
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	1,270	Yes
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	7.3	Yes
100-K-31_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	1.2	Yes
100-K-31_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	169,000	504,000	No
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	151	Yes
100-K-31_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	10,300	260,000	No
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	40	Yes
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	1,270	Yes
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	7.3	Yes
100-K-31_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	400	520	No
100-K-32_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,000	1.2	Yes
100-K-32_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	97,400	504,000	No
100-K-32_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	200	151	Yes
100-K-32_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	16,900	260,000	No
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	40	Yes
100-K-32_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	7,100	1,270	Yes
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	7.3	Yes
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	1.2	Yes
100-K-33_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	105,000	504,000	No
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	151	Yes
100-K-33_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	22,900	260,000	No
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	40	Yes
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	1,270	Yes
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	7.3	Yes
100-K-55:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	1.0	--	--
100-K-55:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	0.60	--	--

Table A-3. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-55:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	0.86	--	--
100-K-55:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	0.29	--	--
100-K-55:1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.31	--	--
100-K-55:1_Overburden	Rad	Cobalt-60	10198-40-0	pCi/g	0.056	--	--
100-K-55:1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.34	--	--
100-K-55:1_Overburden	Rad	Europium-154	15585-10-1	pCi/g	0.33	--	--
100-K-55:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.29	--	--
100-K-55:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.19	--	--
100-K-55:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.81	--	--
100-K-55:1_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.52	--	--
100-K-55:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.61	--	--
100-K-55:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.11	--	--
100-K-55:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	1.3	--	--
100-K-55:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.19	--	--
100-K-55:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.37	--	--
100-K-55:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.70	--	--
100-K-55:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.78	--	--
100-K-56:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	21	--	--
100-K-56:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	1.1	--	--
100-K-56:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	22	--	--
100-K-56:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.1	--	--
100-K-56:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	1.3	--	--
100-K-56:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.32	--	--
100-K-56:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.9	--	--
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	40	Yes
100-K-56:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.31	--	--
100-K-56:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.15	--	--
100-K-56:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	3.1	--	--
100-K-56:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.33	--	--
100-K-56:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.50	--	--
100-K-56:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.45	--	--
100-K-56:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.49	--	--
100-K-78_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	1.08E+07	2.61E+06	Yes
100-K-78_Shallow_Focused	non-Rad	Antimony	7440-36-0	µg/kg	391	444	No
100-K-78_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	4,330	1.2	Yes
100-K-78_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	85,300	504,000	No
100-K-78_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	357	4.31E+06	No
100-K-78_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,570	--	--
100-K-78_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	136	151	No

Table A-3. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-78_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	260,000	No
100-K-78_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	6,110	2,600	Yes
100-K-78_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	19,500	4,000	Yes
100-K-78_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	1.96E+07	151,000	Yes
100-K-78_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	6,380	1,270	Yes
100-K-78_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	288,000	50,200	Yes
100-K-78_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	452	524,000	No
100-K-78_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	14,800	67,800	No
100-K-78_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	42,900	--	--
100-K-78_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	47,000	55,000	No
100-K-78_Shallow_Focused	Rad	Carbon-14	14762-75-5	pCi/g	1.7	--	--
100-K-78_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.32	--	--
100-K-78_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.073	--	--
100-K-78_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	0.27	--	--
100-K-78_Shallow_Focused	Rad	Nickel-63	13981-37-8	pCi/g	7.2	--	--
100-K-78_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.84	--	--
100-K-78_Shallow_Focused	Rad	Uranium-235	15117-96-1	pCi/g	0.048	--	--
100-K-78_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.93	--	--
100-K-85_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	7.65E+06	2.61E+06	Yes
100-K-85_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	1.2	Yes
100-K-85_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	56,700	504,000	No
100-K-85_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	230	4.31E+06	No
100-K-85_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,100	--	--
100-K-85_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	62	151	No
100-K-85_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	7,800	260,000	No
100-K-85_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	8,400	2,600	Yes
100-K-85_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	18,100	4,000	Yes
100-K-85_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	2.27E+07	151,000	Yes
100-K-85_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,800	1,270	Yes
100-K-85_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	327,000	50,200	Yes
100-K-85_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	9.9	7.3	Yes
100-K-85_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	360	524,000	No
100-K-85_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	9,900	67,800	No
100-K-85_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	52,800	--	--
100-K-85_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	46,500	55,000	No
116-K-1_Deep	non-Rad	Chromium	7440-47-3	µg/kg	14,607	260,000	No
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	40	Yes
116-K-1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	11	--	--
116-K-1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	3.3	--	--

Table A-3. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?
116-K-1_Deep	Rad	Europium-152	14683-23-9	pCi/g	9.0	--	--
116-K-1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.5	--	--
116-K-1_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	8.6	--	--
116-K-1_Overburden	non-Rad	Chromium	7440-47-3	µg/kg	12,619	260,000	No
116-K-1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.28	--	--
116-K-1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.26	--	--
116-K-1_Overburden	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.92	--	--
116-K-1_Shallow	non-Rad	Chromium	7440-47-3	µg/kg	13,705	260,000	No
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	40	Yes
116-K-1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.91	--	--
116-K-1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.038	--	--
116-K-1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.22	--	--
116-K-1_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	1.9	--	--
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	40	Yes
116-K-2_Deep	Rad	Americium-241	14596-10-2	pCi/g	3.2	--	--
116-K-2_Deep	Rad	Carbon-14	14762-75-5	pCi/g	3.6	--	--
116-K-2_Deep	Rad	Cesium-137	10045-97-3	pCi/g	119	--	--
116-K-2_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	5.3	--	--
116-K-2_Deep	Rad	Europium-152	14683-23-9	pCi/g	103	--	--
116-K-2_Deep	Rad	Europium-154	15585-10-1	pCi/g	7.0	--	--
116-K-2_Deep	Rad	Nickel-63	13981-37-8	pCi/g	763	--	--
116-K-2_Deep	Rad	Plutonium-238	13981-16-3	pCi/g	0.53	--	--
116-K-2_Deep	Rad	Plutonium-239/240	PU-239/240	pCi/g	5.1	--	--
116-K-2_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	6.3	--	--
116-K-2_Deep	Rad	Uranium-233/234	U-233/234	pCi/g	0.74	--	--
116-K-2_Deep	Rad	Uranium-235	15117-96-1	pCi/g	0.045	--	--
116-K-2_Deep	Rad	Uranium-238	U-238	pCi/g	0.71	--	--
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	40	Yes
116-K-2_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.13	--	--
116-K-2_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.21	--	--
116-K-2_Overburden	Rad	Uranium-233/234	U-233/234	pCi/g	0.66	--	--
116-K-2_Overburden	Rad	Uranium-238	U-238	pCi/g	0.68	--	--
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	40	Yes
116-K-2_Shallow	Rad	Carbon-14	14762-75-5	pCi/g	3.0	--	--
116-K-2_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.93	--	--
116-K-2_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.59	--	--
116-K-2_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.30	--	--
116-K-2_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.8	--	--
116-K-2_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.26	--	--

Table A-3. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?
116-K-2_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.69	--	--
116-K-2_Shallow	Rad	Uranium-238	U-238	pCi/g	0.63	--	--
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	40	Yes
116-KE-4_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.37	--	--
116-KE-4_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.086	--	--
116-KE-4_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.70	--	--
116-KE-4_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.28	--	--
116-KE-4_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.5	--	--
116-KE-4_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.32	--	--
116-KE-4_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.61	--	--
116-KE-4_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.041	--	--
116-KE-4_Shallow	Rad	Uranium-238	U-238	pCi/g	0.56	--	--
116-KE-5_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	1.2	Yes
116-KE-5_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	100,000	504,000	No
116-KE-5_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	195	151	Yes
116-KE-5_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	260,000	No
116-KE-5_Shallow_Focused	non-Rad	Ethylene glycol	107-21-1	µg/kg	59	--	--
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	40	Yes
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	1,270	Yes
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	7.3	Yes
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	40	Yes
116-KW-3_Shallow	Rad	Americium-241	14596-10-2	pCi/g	0.53	--	--
116-KW-3_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.22	--	--
116-KW-3_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.10	--	--
116-KW-3_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.5	--	--
116-KW-3_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.29	--	--
116-KW-3_Shallow	Rad	Plutonium-239/240	PU-239/240	pCi/g	0.92	--	--
116-KW-3_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.66	--	--
116-KW-3_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.039	--	--
116-KW-3_Shallow	Rad	Uranium-238	U-238	pCi/g	0.65	--	--
116-KW-4_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	1.2	Yes
116-KW-4_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	59,300	504,000	No
116-KW-4_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	12,100	260,000	No
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	40	Yes
116-KW-4_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,500	1,270	Yes
128-K-1_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	1.2	Yes
128-K-1_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	71,500	504,000	No
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	20	Yes
128-K-1_Shallow_Focused	non-Rad	Benzo(a)pyrene	50-32-8	µg/kg	51	308	No

Table A-3. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	45	Yes
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	69	Yes
128-K-1_Shallow_Focused	non-Rad	Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	870	2,640	No
128-K-1_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	350	151	Yes
128-K-1_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	13,500	260,000	No
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	11	Yes
128-K-1_Shallow_Focused	non-Rad	Fluoranthene	206-44-0	µg/kg	220	88,900	No
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	40	Yes
128-K-1_Shallow_Focused	non-Rad	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	29	194	No
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	1,270	Yes
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	7.3	Yes
128-K-1_Shallow_Focused	non-Rad	Pyrene	129-00-0	µg/kg	150	1.13E+06	No
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	520	Yes
128-K-1_Shallow_Focused	non-Rad	Total petroleum hydrocarbons	TPH	µg/kg	14,400	--	--

Table A-4. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	--[2]	--
100-K-29_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,300	22	Yes
100-K-29_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	66,400	1.01E+07	No
100-K-29_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	130	3,035	No
100-K-29_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	24,700	--[2]	--
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	3,490	No
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	25,582	Yes
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	146	No
100-K-30_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	22	Yes
100-K-30_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	69,700	1.01E+07	No
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	3,035	No
100-K-30_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	15,200	--[2]	--
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	3,490	No
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	25,582	Yes
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	146	Yes
100-K-31_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	22	Yes
100-K-31_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	169,000	1.01E+07	No
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	3,035	No
100-K-31_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	10,300	--[2]	--
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	3,490	No
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	25,582	Yes
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	146	Yes
100-K-31_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	400	10,225	No
100-K-32_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,000	22	Yes
100-K-32_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	97,400	1.01E+07	No
100-K-32_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	200	3,035	No
100-K-32_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	16,900	--[2]	--
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	3,490	No
100-K-32_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	7,100	25,582	No
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	146	Yes
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	22	Yes
100-K-33_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	105,000	1.01E+07	No
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	3,035	No
100-K-33_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	22,900	--[2]	--
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	3,490	No

Table A-4. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	25,582	Yes
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	146	Yes
100-K-55:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	1.0	59,822	No
100-K-55:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	0.60	177,690	No
100-K-55:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	0.86	16,154	No
100-K-55:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	0.29	4,846	No
100-K-55:1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.31	59,822	No
100-K-55:1_Overburden	Rad	Cobalt-60	10198-40-0	pCi/g	0.056	177,690	No
100-K-55:1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.34	16,154	No
100-K-55:1_Overburden	Rad	Europium-154	15585-10-1	pCi/g	0.33	4,846	No
100-K-55:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.29	59,822	No
100-K-55:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.19	177,690	No
100-K-55:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.81	16,154	No
100-K-55:1_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.52	4,846	No
100-K-55:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.61	59,822	No
100-K-55:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.11	177,690	No
100-K-55:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	1.3	16,154	No
100-K-55:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.19	4,846	No
100-K-55:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.37	672	No
100-K-55:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.70	17	No
100-K-55:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.78	17	No
100-K-56:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	21	59,822	No
100-K-56:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	1.1	177,690	No
100-K-56:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	22	16,154	No
100-K-56:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.1	4,846	No
100-K-56:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	1.3	59,822	No
100-K-56:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.32	177,690	No
100-K-56:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.9	16,154	No
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	3,490	No
100-K-56:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.31	59,822	No
100-K-56:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.15	177,690	No
100-K-56:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	3.1	16,154	No
100-K-56:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.33	4,846	No
100-K-56:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.50	672	No
100-K-56:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.45	17	No

Table A-4. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-56:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.49	17	No
100-K-78_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	1.08E+07	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Antimony	7440-36-0	µg/kg	391	8,648	No
100-K-78_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	4,330	22	Yes
100-K-78_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	85,300	1.01E+07	No
100-K-78_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	357	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,570	--[1]	--
100-K-78_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	136	3,035	No
100-K-78_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	6,110	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	19,500	80,173	No
100-K-78_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	1.96E+07	3.04E+06	Yes
100-K-78_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	6,380	25,582	No
100-K-78_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	288,000	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	452	1.05E+07	No
100-K-78_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	14,800	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	42,900	--[2]	--
100-K-78_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	47,000	1.11E+06	No
100-K-78_Shallow_Focused	Rad	Carbon-14	14762-75-5	pCi/g	1.7	43	No
100-K-78_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.32	59,822	No
100-K-78_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.073	177,690	No
100-K-78_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	0.27	16,154	No
100-K-78_Shallow_Focused	Rad	Nickel-63	13981-37-8	pCi/g	7.2	2,314	No
100-K-78_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.84	17	No
100-K-78_Shallow_Focused	Rad	Uranium-235	15117-96-1	pCi/g	0.048	17	No
100-K-78_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.93	17	No
100-K-85_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	7.65E+06	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	22	Yes
100-K-85_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	56,700	1.01E+07	No
100-K-85_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	230	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,100	--[1]	--
100-K-85_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	62	3,035	No
100-K-85_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	7,800	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	8,400	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	18,100	80,173	No

Table A-4. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-85_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	2.27E+07	3.04E+06	Yes
100-K-85_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,800	25,582	No
100-K-85_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	327,000	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	9.9	146	No
100-K-85_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	360	1.05E+07	No
100-K-85_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	9,900	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	52,800	--[2]	--
100-K-85_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	46,500	1.11E+06	No
116-K-1_Deep	non-Rad	Chromium	7440-47-3	µg/kg	14,607	--[2]	--
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	3,490	No
116-K-1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	11	59,822	No
116-K-1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	3.3	177,690	No
116-K-1_Deep	Rad	Europium-152	14683-23-9	pCi/g	9.0	16,154	No
116-K-1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.5	4,846	No
116-K-1_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	8.6	672	No
116-K-1_Overburden	non-Rad	Chromium	7440-47-3	µg/kg	12,619	--[2]	--
116-K-1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.28	59,822	No
116-K-1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.26	16,154	No
116-K-1_Overburden	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.92	672	No
116-K-1_Shallow	non-Rad	Chromium	7440-47-3	µg/kg	13,705	--[2]	--
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	3,490	No
116-K-1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.91	59,822	No
116-K-1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.038	177,690	No
116-K-1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.22	16,154	No
116-K-1_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	1.9	672	No
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	3,490	No
116-K-2_Deep	Rad	Americium-241	14596-10-2	pCi/g	3.2	1,212	No
116-K-2_Deep	Rad	Carbon-14	14762-75-5	pCi/g	3.6	43	No
116-K-2_Deep	Rad	Cesium-137	10045-97-3	pCi/g	119	59,822	No
116-K-2_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	5.3	177,690	No
116-K-2_Deep	Rad	Europium-152	14683-23-9	pCi/g	103	16,154	No
116-K-2_Deep	Rad	Europium-154	15585-10-1	pCi/g	7.0	4,846	No
116-K-2_Deep	Rad	Nickel-63	13981-37-8	pCi/g	763	2,314	No
116-K-2_Deep	Rad	Plutonium-238	13981-16-3	pCi/g	0.53	1,212	No
116-K-2_Deep	Rad	Plutonium-239/240	PU-239/240	pCi/g	5.1	1,212	No

Table A-4. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
116-K-2_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	6.3	672	No
116-K-2_Deep	Rad	Uranium-233/234	U-233/234	pCi/g	0.74	17	No
116-K-2_Deep	Rad	Uranium-235	15117-96-1	pCi/g	0.045	17	No
116-K-2_Deep	Rad	Uranium-238	U-238	pCi/g	0.71	17	No
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	3,490	No
116-K-2_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.13	59,822	No
116-K-2_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.21	16,154	No
116-K-2_Overburden	Rad	Uranium-233/234	U-233/234	pCi/g	0.66	17	No
116-K-2_Overburden	Rad	Uranium-238	U-238	pCi/g	0.68	17	No
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	3,490	No
116-K-2_Shallow	Rad	Carbon-14	14762-75-5	pCi/g	3.0	43	No
116-K-2_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.93	59,822	No
116-K-2_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.59	16,154	No
116-K-2_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.30	4,846	No
116-K-2_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.8	2,314	No
116-K-2_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.26	672	No
116-K-2_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.69	17	No
116-K-2_Shallow	Rad	Uranium-238	U-238	pCi/g	0.63	17	No
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	3,490	No
116-KE-4_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.37	59,822	No
116-KE-4_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.086	177,690	No
116-KE-4_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.70	16,154	No
116-KE-4_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.28	4,846	No
116-KE-4_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.5	2,314	No
116-KE-4_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.32	672	No
116-KE-4_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.61	17	No
116-KE-4_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.041	17	No
116-KE-4_Shallow	Rad	Uranium-238	U-238	pCi/g	0.56	17	No
116-KE-5_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	22	Yes
116-KE-5_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	100,000	1.01E+07	No
116-KE-5_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	195	3,035	No
116-KE-5_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	--[2]	--
116-KE-5_Shallow_Focused	non-Rad	Ethylene glycol	107-21-1	µg/kg	59	--[1]	--
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	3,490	No
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	25,582	No

Table A-4. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	146	No
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	3,490	No
116-KW-3_Shallow	Rad	Americium-241	14596-10-2	pCi/g	0.53	1,212	No
116-KW-3_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.22	59,822	No
116-KW-3_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.10	177,690	No
116-KW-3_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.5	16,154	No
116-KW-3_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.29	4,846	No
116-KW-3_Shallow	Rad	Plutonium-239/240	PU-239/240	pCi/g	0.92	1,212	No
116-KW-3_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.66	17	No
116-KW-3_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.039	17	No
116-KW-3_Shallow	Rad	Uranium-238	U-238	pCi/g	0.65	17	No
116-KW-4_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	22	Yes
116-KW-4_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	59,300	1.01E+07	No
116-KW-4_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	12,100	--[2]	--
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	3,490	No
116-KW-4_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,500	25,582	No
128-K-1_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	22	Yes
128-K-1_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	71,500	1.01E+07	No
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(a)pyrene	50-32-8	µg/kg	51	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	870	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	350	3,035	No
128-K-1_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	13,500	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Fluoranthene	206-44-0	µg/kg	220	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	3,490	No
128-K-1_Shallow_Focused	non-Rad	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	29	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	25,582	No
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	146	No
128-K-1_Shallow_Focused	non-Rad	Pyrene	129-00-0	µg/kg	150	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	10,225	No
128-K-1_Shallow_Focused	non-Rad	Total petroleum hydrocarbons	TPH	µg/kg	14,400	--[2]	--

1. A Soil Screening Level is not calculated because a groundwater cleanup level or MCL is not available for this analyte.

Table A-4. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (Without Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?

2. For calculated soil activities or Soil Screening Levels protective of groundwater STOMP1D predicts these analytes will not reach peak groundwater concentration within 10,000 years assuming that 100% of the vadose zone is contami

Table A-5. Comparison of EPCs for Waste Site Decision Units in 100-K Source OU to Hanford Site Soil Background Values

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	Lognormal 90th Percentile Background Value	Is EPC > Background?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	--	--
100-K-29_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,300	6,470	No
100-K-29_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	66,400	132,000	No
100-K-29_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	130	563	No
100-K-29_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	24,700	18,500	Yes
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	--	--
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	10,200	Yes
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	13	Yes
100-K-30_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	6,470	No
100-K-30_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	69,700	132,000	No
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	563	Yes
100-K-30_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	15,200	18,500	No
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	--	--
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	10,200	Yes
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	13	Yes
100-K-31_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	6,470	No
100-K-31_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	169,000	132,000	Yes
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	563	Yes
100-K-31_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	10,300	18,500	No
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	--	--
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	10,200	Yes
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	13	Yes
100-K-31_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	400	780	No
100-K-32_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,000	6,470	No
100-K-32_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	97,400	132,000	No
100-K-32_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	200	563	No
100-K-32_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	16,900	18,500	No
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	--	--
100-K-32_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	7,100	10,200	No
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	13	Yes
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	6,470	Yes
100-K-33_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	105,000	132,000	No
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	563	Yes
100-K-33_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	22,900	18,500	Yes
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	--	--
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	10,200	Yes
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	13	Yes
100-K-55:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	1.0	1.1	No
100-K-55:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	0.60	0.0084	Yes
100-K-55:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	0.86	--	--
100-K-55:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	0.29	0.033	Yes
100-K-55:1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.31	1.1	No
100-K-55:1_Overburden	Rad	Cobalt-60	10198-40-0	pCi/g	0.056	0.0084	Yes

Table A-5. Comparison of EPCs for Waste Site Decision Units in 100-K Source OU to Hanford Site Soil Background Values

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	Lognormal 90th Percentile Background Value	Is EPC > Background?
100-K-55:1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.34	--	--
100-K-55:1_Overburden	Rad	Europium-154	15585-10-1	pCi/g	0.33	0.033	Yes
100-K-55:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.29	1.1	No
100-K-55:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.19	0.0084	Yes
100-K-55:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.81	--	--
100-K-55:1_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.52	0.033	Yes
100-K-55:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.61	1.1	No
100-K-55:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.11	0.0084	Yes
100-K-55:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	1.3	--	--
100-K-55:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.19	0.033	Yes
100-K-55:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.37	0.18	Yes
100-K-55:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.70	1.1	No
100-K-55:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.78	1.1	No
100-K-56:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	21	1.1	Yes
100-K-56:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	1.1	0.0084	Yes
100-K-56:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	22	--	--
100-K-56:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.1	0.033	Yes
100-K-56:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	1.3	1.1	Yes
100-K-56:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.32	0.0084	Yes
100-K-56:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.9	--	--
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	--	--
100-K-56:1_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.31	1.1	No
100-K-56:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.15	0.0084	Yes
100-K-56:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	3.1	--	--
100-K-56:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.33	0.033	Yes
100-K-56:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.50	0.18	Yes
100-K-56:1_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.45	1.1	No
100-K-56:1_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.49	1.1	No
100-K-78_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	1.08E+07	1.18E+07	No
100-K-78_Shallow_Focused	non-Rad	Antimony	7440-36-0	µg/kg	391	130	Yes
100-K-78_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	4,330	6,470	No
100-K-78_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	85,300	132,000	No
100-K-78_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	357	1,510	No
100-K-78_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,570	3,890	No
100-K-78_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	136	563	No
100-K-78_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	18,500	Yes
100-K-78_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	6,110	15,700	No
100-K-78_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	19,500	22,000	No
100-K-78_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	1.96E+07	3.26E+07	No
100-K-78_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	6,380	10,200	No
100-K-78_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	288,000	512,000	No
100-K-78_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	452	470	No
100-K-78_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	14,800	19,100	No

Table A-5. Comparison of EPCs for Waste Site Decision Units in 100-K Source OU to Hanford Site Soil Background Values

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	Lognormal 90th Percentile Background Value	Is EPC > Background?
100-K-78_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	42,900	85,100	No
100-K-78_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	47,000	67,800	No
100-K-78_Shallow_Focused	Rad	Carbon-14	14762-75-5	pCi/g	1.7	--	--
100-K-78_Shallow_Focused	Rad	Cesium-137	10045-97-3	pCi/g	0.32	1.1	No
100-K-78_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.073	0.0084	Yes
100-K-78_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	0.27	--	--
100-K-78_Shallow_Focused	Rad	Nickel-63	13981-37-8	pCi/g	7.2	--	--
100-K-78_Shallow_Focused	Rad	Uranium-233/234	U-233/234	pCi/g	0.84	1.1	No
100-K-78_Shallow_Focused	Rad	Uranium-235	15117-96-1	pCi/g	0.048	0.11	No
100-K-78_Shallow_Focused	Rad	Uranium-238	U-238	pCi/g	0.93	1.1	No
100-K-85_Shallow_Focused	non-Rad	Aluminum	7429-90-5	µg/kg	7.65E+06	1.18E+07	No
100-K-85_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,800	6,470	No
100-K-85_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	56,700	132,000	No
100-K-85_Shallow_Focused	non-Rad	Beryllium	7440-41-7	µg/kg	230	1,510	No
100-K-85_Shallow_Focused	non-Rad	Boron	7440-42-8	µg/kg	1,100	3,890	No
100-K-85_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	62	563	No
100-K-85_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	7,800	18,500	No
100-K-85_Shallow_Focused	non-Rad	Cobalt	7440-48-4	µg/kg	8,400	15,700	No
100-K-85_Shallow_Focused	non-Rad	Copper	7440-50-8	µg/kg	18,100	22,000	No
100-K-85_Shallow_Focused	non-Rad	Iron	7439-89-6	µg/kg	2.27E+07	3.26E+07	No
100-K-85_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,800	10,200	No
100-K-85_Shallow_Focused	non-Rad	Manganese	7439-96-5	µg/kg	327,000	512,000	No
100-K-85_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	9.9	13	No
100-K-85_Shallow_Focused	non-Rad	Molybdenum	7439-98-7	µg/kg	360	470	No
100-K-85_Shallow_Focused	non-Rad	Nickel	7440-02-0	µg/kg	9,900	19,100	No
100-K-85_Shallow_Focused	non-Rad	Vanadium	7440-62-2	µg/kg	52,800	85,100	No
100-K-85_Shallow_Focused	non-Rad	Zinc	7440-66-6	µg/kg	46,500	67,800	No
116-K-1_Deep	non-Rad	Chromium	7440-47-3	µg/kg	14,607	18,500	No
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	--	--
116-K-1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	11	1.1	Yes
116-K-1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	3.3	0.0084	Yes
116-K-1_Deep	Rad	Europium-152	14683-23-9	pCi/g	9.0	--	--
116-K-1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.5	0.033	Yes
116-K-1_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	8.6	0.18	Yes
116-K-1_Overburden	non-Rad	Chromium	7440-47-3	µg/kg	12,619	18,500	No
116-K-1_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.28	1.1	No
116-K-1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.26	--	--
116-K-1_Overburden	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.92	0.18	Yes
116-K-1_Shallow	non-Rad	Chromium	7440-47-3	µg/kg	13,705	18,500	No
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	--	--
116-K-1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.91	1.1	No
116-K-1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.038	0.0084	Yes
116-K-1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.22	--	--

Table A-5. Comparison of EPCs for Waste Site Decision Units in 100-K Source OU to Hanford Site Soil Background Values

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	Lognormal 90th Percentile Background Value	Is EPC > Background?
116-K-1_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	1.9	0.18	Yes
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	--	--
116-K-2_Deep	Rad	Americium-241	14596-10-2	pCi/g	3.2	--	--
116-K-2_Deep	Rad	Carbon-14	14762-75-5	pCi/g	3.6	--	--
116-K-2_Deep	Rad	Cesium-137	10045-97-3	pCi/g	119	1.1	Yes
116-K-2_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	5.3	0.0084	Yes
116-K-2_Deep	Rad	Europium-152	14683-23-9	pCi/g	103	--	--
116-K-2_Deep	Rad	Europium-154	15585-10-1	pCi/g	7.0	0.033	Yes
116-K-2_Deep	Rad	Nickel-63	13981-37-8	pCi/g	763	--	--
116-K-2_Deep	Rad	Plutonium-238	13981-16-3	pCi/g	0.53	0.0038	Yes
116-K-2_Deep	Rad	Plutonium-239/240	PU-239/240	pCi/g	5.1	0.025	Yes
116-K-2_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	6.3	0.18	Yes
116-K-2_Deep	Rad	Uranium-233/234	U-233/234	pCi/g	0.74	1.1	No
116-K-2_Deep	Rad	Uranium-235	15117-96-1	pCi/g	0.045	0.11	No
116-K-2_Deep	Rad	Uranium-238	U-238	pCi/g	0.71	1.1	No
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	--	--
116-K-2_Overburden	Rad	Cesium-137	10045-97-3	pCi/g	0.13	1.1	No
116-K-2_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.21	--	--
116-K-2_Overburden	Rad	Uranium-233/234	U-233/234	pCi/g	0.66	1.1	No
116-K-2_Overburden	Rad	Uranium-238	U-238	pCi/g	0.68	1.1	No
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	--	--
116-K-2_Shallow	Rad	Carbon-14	14762-75-5	pCi/g	3.0	--	--
116-K-2_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.93	1.1	No
116-K-2_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.59	--	--
116-K-2_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.30	0.033	Yes
116-K-2_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.8	--	--
116-K-2_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.26	0.18	Yes
116-K-2_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.69	1.1	No
116-K-2_Shallow	Rad	Uranium-238	U-238	pCi/g	0.63	1.1	No
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	--	--
116-KE-4_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.37	1.1	No
116-KE-4_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.086	0.0084	Yes
116-KE-4_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.70	--	--
116-KE-4_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.28	0.033	Yes
116-KE-4_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.5	--	--
116-KE-4_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.32	0.18	Yes
116-KE-4_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.61	1.1	No
116-KE-4_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.041	0.11	No
116-KE-4_Shallow	Rad	Uranium-238	U-238	pCi/g	0.56	1.1	No
116-KE-5_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	6,470	No
116-KE-5_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	100,000	132,000	No
116-KE-5_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	195	563	No
116-KE-5_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	18,500	Yes

Table A-5. Comparison of EPCs for Waste Site Decision Units in 100-K Source OU to Hanford Site Soil Background Values

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	Lognormal 90th Percentile Background Value	Is EPC > Background?
116-KE-5_Shallow_Focused	non-Rad	Ethylene glycol	107-21-1	µg/kg	59	--	--
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	--	--
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	10,200	Yes
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	13	Yes
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	--	--
116-KW-3_Shallow	Rad	Americium-241	14596-10-2	pCi/g	0.53	--	--
116-KW-3_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	0.22	1.1	No
116-KW-3_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.10	0.0084	Yes
116-KW-3_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.5	--	--
116-KW-3_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.29	0.033	Yes
116-KW-3_Shallow	Rad	Plutonium-239/240	PU-239/240	pCi/g	0.92	0.025	Yes
116-KW-3_Shallow	Rad	Uranium-233/234	U-233/234	pCi/g	0.66	1.1	No
116-KW-3_Shallow	Rad	Uranium-235	15117-96-1	pCi/g	0.039	0.11	No
116-KW-3_Shallow	Rad	Uranium-238	U-238	pCi/g	0.65	1.1	No
116-KW-4_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	2,600	6,470	No
116-KW-4_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	59,300	132,000	No
116-KW-4_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	12,100	18,500	No
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	--	--
116-KW-4_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	4,500	10,200	No
128-K-1_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	3,700	6,470	No
128-K-1_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	71,500	132,000	No
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	--	--
128-K-1_Shallow_Focused	non-Rad	Benzo(a)pyrene	50-32-8	µg/kg	51	--	--
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	--	--
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	--	--
128-K-1_Shallow_Focused	non-Rad	Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	870	--	--
128-K-1_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	350	563	No
128-K-1_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	13,500	18,500	No
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	--	--
128-K-1_Shallow_Focused	non-Rad	Fluoranthene	206-44-0	µg/kg	220	--	--
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	--	--
128-K-1_Shallow_Focused	non-Rad	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	29	--	--
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	10,200	Yes
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	13	Yes
128-K-1_Shallow_Focused	non-Rad	Pyrene	129-00-0	µg/kg	150	--	--
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	780	Yes
128-K-1_Shallow_Focused	non-Rad	Total petroleum hydrocarbons	TPH	µg/kg	14,400	--	--

Table A-6. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	66	Yes
100-K-29_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	24,700	400,000	No
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	192	Yes
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	9,060	Yes
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	1,210	No
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	3,020	No
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	192	Yes
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	9,060	Yes
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	1,210	Yes
100-K-31_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	169,000	1.01E+06	No
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	3,020	No
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	192	Yes
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	9,060	Yes
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	1,210	Yes
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	192	Yes
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	1,210	Yes
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	3.7	Yes
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	3,020	No
100-K-33_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	22,900	400,000	No
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	192	Yes
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	9,060	Yes
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	1,210	Yes
100-K-55:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	0.60	--	--
100-K-55:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	0.86	--	--
100-K-55:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	0.29	--	--
100-K-55:1_Overburden	Rad	Cobalt-60	10198-40-0	pCi/g	0.056	--	--
100-K-55:1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.34	--	--
100-K-55:1_Overburden	Rad	Europium-154	15585-10-1	pCi/g	0.33	--	--
100-K-55:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.19	--	--
100-K-55:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.81	--	--
100-K-55:1_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.52	--	--
100-K-55:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.11	--	--
100-K-55:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	1.3	--	--
100-K-55:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.19	--	--
100-K-55:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.37	--	--
100-K-56:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	21	--	--
100-K-56:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	1.1	--	--
100-K-56:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	22	--	--
100-K-56:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.1	--	--
100-K-56:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	1.3	--	--
100-K-56:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.32	--	--

Table A-6. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-56:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.9	--	--
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	192	Yes
100-K-56:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.15	--	--
100-K-56:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	3.1	--	--
100-K-56:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.33	--	--
100-K-56:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.50	--	--
100-K-78_Shallow_Focused	non-Rad	Antimony	7440-36-0	µg/kg	391	475	No
100-K-78_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	400,000	No
100-K-78_Shallow_Focused	Rad	Carbon-14	14762-75-5	pCi/g	1.7	--	--
100-K-78_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.073	--	--
100-K-78_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	0.27	--	--
100-K-78_Shallow_Focused	Rad	Nickel-63	13981-37-8	pCi/g	7.2	--	--
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	192	Yes
116-K-1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	11	--	--
116-K-1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	3.3	--	--
116-K-1_Deep	Rad	Europium-152	14683-23-9	pCi/g	9.0	--	--
116-K-1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.5	--	--
116-K-1_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	8.6	--	--
116-K-1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.26	--	--
116-K-1_Overburden	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.92	--	--
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	192	Yes
116-K-1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.038	--	--
116-K-1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.22	--	--
116-K-1_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	1.9	--	--
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	192	Yes
116-K-2_Deep	Rad	Americium-241	14596-10-2	pCi/g	3.2	--	--
116-K-2_Deep	Rad	Carbon-14	14762-75-5	pCi/g	3.6	--	--
116-K-2_Deep	Rad	Cesium-137	10045-97-3	pCi/g	119	--	--
116-K-2_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	5.3	--	--
116-K-2_Deep	Rad	Europium-152	14683-23-9	pCi/g	103	--	--
116-K-2_Deep	Rad	Europium-154	15585-10-1	pCi/g	7.0	--	--
116-K-2_Deep	Rad	Nickel-63	13981-37-8	pCi/g	763	--	--
116-K-2_Deep	Rad	Plutonium-238	13981-16-3	pCi/g	0.53	--	--
116-K-2_Deep	Rad	Plutonium-239/240	PU-239/240	pCi/g	5.1	--	--
116-K-2_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	6.3	--	--
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	192	Yes
116-K-2_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.21	--	--
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	192	Yes
116-K-2_Shallow	Rad	Carbon-14	14762-75-5	pCi/g	3.0	--	--
116-K-2_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.59	--	--
116-K-2_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.30	--	--

Table A-6. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Groundwater (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
116-K-2_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.8	--	--
116-K-2_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.26	--	--
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	192	Yes
116-KE-4_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.086	--	--
116-KE-4_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.70	--	--
116-KE-4_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.28	--	--
116-KE-4_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.5	--	--
116-KE-4_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.32	--	--
116-KE-5_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	400,000	No
116-KE-5_Shallow_Focused	non-Rad	Ethylene glycol	107-21-1	µg/kg	59	64,300	No
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	192	Yes
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	9,060	Yes
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	1,210	No
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	192	Yes
116-KW-3_Shallow	Rad	Americium-241	14596-10-2	pCi/g	0.53	--	--
116-KW-3_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.10	--	--
116-KW-3_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.5	--	--
116-KW-3_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.29	--	--
116-KW-3_Shallow	Rad	Plutonium-239/240	PU-239/240	pCi/g	0.92	--	--
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	192	Yes
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	863	No
128-K-1_Shallow_Focused	non-Rad	Benzo(a)pyrene	50-32-8	µg/kg	51	1,320	No
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	1,930	No
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	2,950	No
128-K-1_Shallow_Focused	non-Rad	Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	870	13,200	No
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	4,800	No
128-K-1_Shallow_Focused	non-Rad	Fluoranthene	206-44-0	µg/kg	220	631,000	No
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	192	Yes
128-K-1_Shallow_Focused	non-Rad	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	29	8,320	No
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	9,060	Yes
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	1,210	No
128-K-1_Shallow_Focused	non-Rad	Pyrene	129-00-0	µg/kg	150	655,000	No
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	5,200	No
128-K-1_Shallow_Focused	non-Rad	Total petroleum hydrocarbons	TPH	µg/kg	14,400	--	--

Table A-7. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Groundwater (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	--[2]	--
100-K-29_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	24,700	--[2]	--
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	16,800	No
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	182,070	No
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	24,276	No
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	60,689	No
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	16,800	No
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	182,070	No
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	24,276	No
100-K-31_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	169,000	2.02E+07	No
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	60,689	No
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	16,800	No
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	182,070	No
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	24,276	No
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	16,800	No
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	24,276	No
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	72	Yes
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	60,689	No
100-K-33_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	22,900	--[2]	--
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	16,800	No
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	182,070	No
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	24,276	No
100-K-55:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	0.60	177,690	No
100-K-55:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	0.86	16,154	No
100-K-55:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	0.29	4,846	No
100-K-55:1_Overburden	Rad	Cobalt-60	10198-40-0	pCi/g	0.056	177,690	No
100-K-55:1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.34	16,154	No
100-K-55:1_Overburden	Rad	Europium-154	15585-10-1	pCi/g	0.33	4,846	No
100-K-55:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.19	177,690	No
100-K-55:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.81	16,154	No
100-K-55:1_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.52	4,846	No
100-K-55:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.11	177,690	No
100-K-55:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	1.3	16,154	No
100-K-55:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.19	4,846	No

Table A-7. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Groundwater (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
100-K-55:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.37	672	No
100-K-56:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	21	59,822	No
100-K-56:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	1.1	177,690	No
100-K-56:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	22	16,154	No
100-K-56:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.1	4,846	No
100-K-56:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	1.3	59,822	No
100-K-56:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.32	177,690	No
100-K-56:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.9	16,154	No
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	16,800	No
100-K-56:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.15	177,690	No
100-K-56:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	3.1	16,154	No
100-K-56:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.33	4,846	No
100-K-56:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.50	672	No
100-K-78_Shallow_Focused	non-Rad	Antimony	7440-36-0	µg/kg	391	9,266	No
100-K-78_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	--[2]	--
100-K-78_Shallow_Focused	Rad	Carbon-14	14762-75-5	pCi/g	1.7	43	No
100-K-78_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.073	177,690	No
100-K-78_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	0.27	16,154	No
100-K-78_Shallow_Focused	Rad	Nickel-63	13981-37-8	pCi/g	7.2	2,314	No
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	16,800	No
116-K-1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	11	59,822	No
116-K-1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	3.3	177,690	No
116-K-1_Deep	Rad	Europium-152	14683-23-9	pCi/g	9.0	16,154	No
116-K-1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.5	4,846	No
116-K-1_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	8.6	672	No
116-K-1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.26	16,154	No
116-K-1_Overburden	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.92	672	No
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	16,800	No
116-K-1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.038	177,690	No
116-K-1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.22	16,154	No
116-K-1_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	1.9	672	No
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	16,800	No
116-K-2_Deep	Rad	Americium-241	14596-10-2	pCi/g	3.2	1,212	No
116-K-2_Deep	Rad	Carbon-14	14762-75-5	pCi/g	3.6	43	No

Table A-7. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Groundwater (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
116-K-2_Deep	Rad	Cesium-137	10045-97-3	pCi/g	119	59,822	No
116-K-2_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	5.3	177,690	No
116-K-2_Deep	Rad	Europium-152	14683-23-9	pCi/g	103	16,154	No
116-K-2_Deep	Rad	Europium-154	15585-10-1	pCi/g	7.0	4,846	No
116-K-2_Deep	Rad	Nickel-63	13981-37-8	pCi/g	763	2,314	No
116-K-2_Deep	Rad	Plutonium-238	13981-16-3	pCi/g	0.53	1,212	No
116-K-2_Deep	Rad	Plutonium-239/240	PU-239/240	pCi/g	5.1	1,212	No
116-K-2_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	6.3	672	No
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	16,800	No
116-K-2_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.21	16,154	No
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	16,800	No
116-K-2_Shallow	Rad	Carbon-14	14762-75-5	pCi/g	3.0	43	No
116-K-2_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.59	16,154	No
116-K-2_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.30	4,846	No
116-K-2_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.8	2,314	No
116-K-2_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.26	672	No
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	16,800	No
116-KE-4_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.086	177,690	No
116-KE-4_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.70	16,154	No
116-KE-4_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.28	4,846	No
116-KE-4_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.5	2,314	No
116-KE-4_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.32	672	No
116-KE-5_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	--[2]	--
116-KE-5_Shallow_Focused	non-Rad	Ethylene glycol	107-21-1	µg/kg	59	--[1]	--
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	16,800	No
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	182,070	No
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	24,276	No
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	16,800	No
116-KW-3_Shallow	Rad	Americium-241	14596-10-2	pCi/g	0.53	1,212	No
116-KW-3_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.10	177,690	No
116-KW-3_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.5	16,154	No
116-KW-3_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.29	4,846	No
116-KW-3_Shallow	Rad	Plutonium-239/240	PU-239/240	pCi/g	0.92	1,212	No
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	16,800	No

Table A-7. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Groundwater (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Groundwater Protection	Is EPC > Soil Screening Level Protective of Groundwater?
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(a)pyrene	50-32-8	µg/kg	51	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	870	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Fluoranthene	206-44-0	µg/kg	220	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	16,800	No
128-K-1_Shallow_Focused	non-Rad	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	29	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	182,070	No
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	24,276	No
128-K-1_Shallow_Focused	non-Rad	Pyrene	129-00-0	µg/kg	150	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	102,250	No
128-K-1_Shallow_Focused	non-Rad	Total petroleum hydrocarbons	TPH	µg/kg	14,400	--[1]	--

1. A Soil Screening Level is not calculated because a groundwater cleanup level or MCL is not available for this analyte.
2. For calculated soil activities or Soil Screening Levels protective of groundwater STOMP1D predicts these analytes will not reach peak groundwater concentration within 10,000 years assuming that 100% of the va

Table A-8. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	0.097	Yes
100-K-29_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	24,700	260,000	No
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	40	Yes
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	1,270	Yes
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	7.3	Yes
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	151	Yes
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	40	Yes
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	1,270	Yes
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	7.3	Yes
100-K-31_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	169,000	504,000	No
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	151	Yes
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	40	Yes
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	1,270	Yes
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	7.3	Yes
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	40	Yes
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	7.3	Yes
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	1.2	Yes
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	151	Yes
100-K-33_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	22,900	260,000	No
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	40	Yes
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	1,270	Yes
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	7.3	Yes
100-K-55:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	0.60	--	--
100-K-55:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	0.86	--	--
100-K-55:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	0.29	--	--
100-K-55:1_Overburden	Rad	Cobalt-60	10198-40-0	pCi/g	0.056	--	--
100-K-55:1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.34	--	--
100-K-55:1_Overburden	Rad	Europium-154	15585-10-1	pCi/g	0.33	--	--
100-K-55:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.19	--	--
100-K-55:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.81	--	--
100-K-55:1_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.52	--	--
100-K-55:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.11	--	--
100-K-55:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	1.3	--	--
100-K-55:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.19	--	--
100-K-55:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.37	--	--
100-K-56:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	21	--	--
100-K-56:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	1.1	--	--
100-K-56:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	22	--	--

Table A-8. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-56:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.1	--	--
100-K-56:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	1.3	--	--
100-K-56:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.32	--	--
100-K-56:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.9	--	--
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	40	Yes
100-K-56:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.15	--	--
100-K-56:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	3.1	--	--
100-K-56:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.33	--	--
100-K-56:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.50	--	--
100-K-78_Shallow_Focused	non-Rad	Antimony	7440-36-0	µg/kg	391	444	No
100-K-78_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	260,000	No
100-K-78_Shallow_Focused	Rad	Carbon-14	14762-75-5	pCi/g	1.7	--	--
100-K-78_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.073	--	--
100-K-78_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	0.27	--	--
100-K-78_Shallow_Focused	Rad	Nickel-63	13981-37-8	pCi/g	7.2	--	--
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	40	Yes
116-K-1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	11	--	--
116-K-1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	3.3	--	--
116-K-1_Deep	Rad	Europium-152	14683-23-9	pCi/g	9.0	--	--
116-K-1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.5	--	--
116-K-1_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	8.6	--	--
116-K-1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.26	--	--
116-K-1_Overburden	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.92	--	--
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	40	Yes
116-K-1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.038	--	--
116-K-1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.22	--	--
116-K-1_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	1.9	--	--
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	40	Yes
116-K-2_Deep	Rad	Americium-241	14596-10-2	pCi/g	3.2	--	--
116-K-2_Deep	Rad	Carbon-14	14762-75-5	pCi/g	3.6	--	--
116-K-2_Deep	Rad	Cesium-137	10045-97-3	pCi/g	119	--	--
116-K-2_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	5.3	--	--
116-K-2_Deep	Rad	Europium-152	14683-23-9	pCi/g	103	--	--
116-K-2_Deep	Rad	Europium-154	15585-10-1	pCi/g	7.0	--	--
116-K-2_Deep	Rad	Nickel-63	13981-37-8	pCi/g	763	--	--
116-K-2_Deep	Rad	Plutonium-238	13981-16-3	pCi/g	0.53	--	--
116-K-2_Deep	Rad	Plutonium-239/240	PU-239/240	pCi/g	5.1	--	--
116-K-2_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	6.3	--	--

Table A-8. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	40	Yes
116-K-2_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.21	--	--
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	40	Yes
116-K-2_Shallow	Rad	Carbon-14	14762-75-5	pCi/g	3.0	--	--
116-K-2_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.59	--	--
116-K-2_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.30	--	--
116-K-2_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.8	--	--
116-K-2_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.26	--	--
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	40	Yes
116-KE-4_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.086	--	--
116-KE-4_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.70	--	--
116-KE-4_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.28	--	--
116-KE-4_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.5	--	--
116-KE-4_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.32	--	--
116-KE-5_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	260,000	No
116-KE-5_Shallow_Focused	non-Rad	Ethylene glycol	107-21-1	µg/kg	59	--	--
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	40	Yes
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	1,270	Yes
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	7.3	Yes
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	40	Yes
116-KW-3_Shallow	Rad	Americium-241	14596-10-2	pCi/g	0.53	--	--
116-KW-3_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.10	--	--
116-KW-3_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.5	--	--
116-KW-3_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.29	--	--
116-KW-3_Shallow	Rad	Plutonium-239/240	PU-239/240	pCi/g	0.92	--	--
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	40	Yes
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	20	Yes
128-K-1_Shallow_Focused	non-Rad	Benzo(a)pyrene	50-32-8	µg/kg	51	308	No
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	45	Yes
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	69	Yes
128-K-1_Shallow_Focused	non-Rad	Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	870	2,640	No
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	11	Yes
128-K-1_Shallow_Focused	non-Rad	Fluoranthene	206-44-0	µg/kg	220	88,900	No
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	40	Yes
128-K-1_Shallow_Focused	non-Rad	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	29	194	No
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	1,270	Yes
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	7.3	Yes
128-K-1_Shallow_Focused	non-Rad	Pyrene	129-00-0	µg/kg	150	1.13E+06	No

Table A-8. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to MTCA Fixed Parameter Three-Phase Partitioning Model Soil Screening Levels Protective of Surface Water (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	MTCA Fixed Parameter Three-Phase Soil Screening Level Protective of Surface Water	Is EPC > Soil Screening Level Protective of Surface Water?
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	520	Yes
128-K-1_Shallow_Focused	non-Rad	Total petroleum hydrocarbons	TPH	µg/kg	14,400	--	--

Table A-9. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-29_Shallow_Focused	non-Rad	Aroclor-1254	11097-69-1	µg/kg	98	--[2]	--
100-K-29_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	24,700	--[2]	--
100-K-29_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,200	3,490	No
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	25,582	Yes
100-K-29_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	50	146	No
100-K-30_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	640	3,035	No
100-K-30_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	702	3,490	No
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	25,582	Yes
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	146	Yes
100-K-31_Shallow_Focused	non-Rad	Barium	7440-39-3	µg/kg	169,000	1.01E+07	No
100-K-31_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	750	3,035	No
100-K-31_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	220	3,490	No
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	25,582	Yes
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	146	Yes
100-K-32_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	230	3,490	No
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	146	Yes
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	22	Yes
100-K-33_Shallow_Focused	non-Rad	Cadmium	7440-43-9	µg/kg	1,000	3,035	No
100-K-33_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	22,900	--[2]	--
100-K-33_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	1,400	3,490	No
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	25,582	Yes
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	146	Yes
100-K-55:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	0.60	177,690	No
100-K-55:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	0.86	16,154	No
100-K-55:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	0.29	4,846	No
100-K-55:1_Overburden	Rad	Cobalt-60	10198-40-0	pCi/g	0.056	177,690	No
100-K-55:1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.34	16,154	No
100-K-55:1_Overburden	Rad	Europium-154	15585-10-1	pCi/g	0.33	4,846	No
100-K-55:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.19	177,690	No
100-K-55:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.81	16,154	No
100-K-55:1_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.52	4,846	No
100-K-55:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.11	177,690	No
100-K-55:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	1.3	16,154	No
100-K-55:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.19	4,846	No
100-K-55:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.37	672	No

Table A-9. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
100-K-56:1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	21	59,822	No
100-K-56:1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	1.1	177,690	No
100-K-56:1_Deep	Rad	Europium-152	14683-23-9	pCi/g	22	16,154	No
100-K-56:1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.1	4,846	No
100-K-56:1_Shallow	Rad	Cesium-137	10045-97-3	pCi/g	1.3	59,822	No
100-K-56:1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.32	177,690	No
100-K-56:1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.9	16,154	No
100-K-56:1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	937	3,490	No
100-K-56:1_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.15	177,690	No
100-K-56:1_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	3.1	16,154	No
100-K-56:1_Shallow_Focused	Rad	Europium-154	15585-10-1	pCi/g	0.33	4,846	No
100-K-56:1_Shallow_Focused	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.50	672	No
100-K-78_Shallow_Focused	non-Rad	Antimony	7440-36-0	µg/kg	391	8,648	No
100-K-78_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	--[2]	--
100-K-78_Shallow_Focused	Rad	Carbon-14	14762-75-5	pCi/g	1.7	43	No
100-K-78_Shallow_Focused	Rad	Cobalt-60	10198-40-0	pCi/g	0.073	177,690	No
100-K-78_Shallow_Focused	Rad	Europium-152	14683-23-9	pCi/g	0.27	16,154	No
100-K-78_Shallow_Focused	Rad	Nickel-63	13981-37-8	pCi/g	7.2	2,314	No
116-K-1_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	560	3,490	No
116-K-1_Deep	Rad	Cesium-137	10045-97-3	pCi/g	11	59,822	No
116-K-1_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	3.3	177,690	No
116-K-1_Deep	Rad	Europium-152	14683-23-9	pCi/g	9.0	16,154	No
116-K-1_Deep	Rad	Europium-154	15585-10-1	pCi/g	2.5	4,846	No
116-K-1_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	8.6	672	No
116-K-1_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.26	16,154	No
116-K-1_Overburden	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.92	672	No
116-K-1_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	260	3,490	No
116-K-1_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.038	177,690	No
116-K-1_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.22	16,154	No
116-K-1_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	1.9	672	No
116-K-2_Deep	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	3,153	3,490	No
116-K-2_Deep	Rad	Americium-241	14596-10-2	pCi/g	3.2	1,212	No
116-K-2_Deep	Rad	Carbon-14	14762-75-5	pCi/g	3.6	43	No
116-K-2_Deep	Rad	Cesium-137	10045-97-3	pCi/g	119	59,822	No
116-K-2_Deep	Rad	Cobalt-60	10198-40-0	pCi/g	5.3	177,690	No

Table A-9. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
116-K-2_Deep	Rad	Europium-152	14683-23-9	pCi/g	103	16,154	No
116-K-2_Deep	Rad	Europium-154	15585-10-1	pCi/g	7.0	4,846	No
116-K-2_Deep	Rad	Nickel-63	13981-37-8	pCi/g	763	2,314	No
116-K-2_Deep	Rad	Plutonium-238	13981-16-3	pCi/g	0.53	1,212	No
116-K-2_Deep	Rad	Plutonium-239/240	PU-239/240	pCi/g	5.1	1,212	No
116-K-2_Deep	Rad	Total beta radiostrontium	SR-RAD	pCi/g	6.3	672	No
116-K-2_Overburden	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	300	3,490	No
116-K-2_Overburden	Rad	Europium-152	14683-23-9	pCi/g	0.21	16,154	No
116-K-2_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	308	3,490	No
116-K-2_Shallow	Rad	Carbon-14	14762-75-5	pCi/g	3.0	43	No
116-K-2_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.59	16,154	No
116-K-2_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.30	4,846	No
116-K-2_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.8	2,314	No
116-K-2_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.26	672	No
116-KE-4_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	583	3,490	No
116-KE-4_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.086	177,690	No
116-KE-4_Shallow	Rad	Europium-152	14683-23-9	pCi/g	0.70	16,154	No
116-KE-4_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.28	4,846	No
116-KE-4_Shallow	Rad	Nickel-63	13981-37-8	pCi/g	7.5	2,314	No
116-KE-4_Shallow	Rad	Total beta radiostrontium	SR-RAD	pCi/g	0.32	672	No
116-KE-5_Shallow_Focused	non-Rad	Chromium	7440-47-3	µg/kg	30,000	--[2]	--
116-KE-5_Shallow_Focused	non-Rad	Ethylene glycol	107-21-1	µg/kg	59	--[1]	--
116-KE-5_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	330	3,490	No
116-KE-5_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	11,300	25,582	No
116-KE-5_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	102	146	No
116-KW-3_Shallow	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	749	3,490	No
116-KW-3_Shallow	Rad	Americium-241	14596-10-2	pCi/g	0.53	1,212	No
116-KW-3_Shallow	Rad	Cobalt-60	10198-40-0	pCi/g	0.10	177,690	No
116-KW-3_Shallow	Rad	Europium-152	14683-23-9	pCi/g	1.5	16,154	No
116-KW-3_Shallow	Rad	Europium-154	15585-10-1	pCi/g	0.29	4,846	No
116-KW-3_Shallow	Rad	Plutonium-239/240	PU-239/240	pCi/g	0.92	1,212	No
116-KW-4_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	240	3,490	No
128-K-1_Shallow_Focused	non-Rad	Benzo(a)anthracene	56-55-3	µg/kg	103	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(a)pyrene	50-32-8	µg/kg	51	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Benzo(b)fluoranthene	205-99-2	µg/kg	75	--[2]	--

Table A-9. Comparison of EPCs from 100-K Source OU Waste Site Decision Units to STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Levels Protective of Surface Water (With Background Consideration)

Waste Site/Decision Unit	Analyte Group	Analyte Name	CAS No.	Units	Exposure Point Concentration	STOMP 1D 100:0 Contaminant Source Model (Irrigation Recharge Scenario) Soil Screening Level for Surface Water Protection	Is EPC > Soil Screening Level Protective of Surface Water?
128-K-1_Shallow_Focused	non-Rad	Benzo(k)fluoranthene	207-08-9	µg/kg	78	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Bis(2-ethylhexyl) phthalate	117-81-7	µg/kg	870	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Chrysene	218-01-9	µg/kg	148	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Fluoranthene	206-44-0	µg/kg	220	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Hexavalent Chromium	18540-29-9	µg/kg	480	3,490	No
128-K-1_Shallow_Focused	non-Rad	Indeno(1,2,3-cd)pyrene	193-39-5	µg/kg	29	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	10,800	25,582	No
128-K-1_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	30	146	No
128-K-1_Shallow_Focused	non-Rad	Pyrene	129-00-0	µg/kg	150	--[2]	--
128-K-1_Shallow_Focused	non-Rad	Selenium	7782-49-2	µg/kg	800	10,225	No
128-K-1_Shallow_Focused	non-Rad	Total petroleum hydrocarbons	TPH	µg/kg	14,400	--[1]	--

1. A Soil Screening Level is not calculated because a groundwater cleanup level or MCL is not available for this analyte.
2. For calculated soil activities or Soil Screening Levels protective of groundwater STOMP1D predicts these analytes will not reach peak groundwater concentration within 10,000 years assuming that 100% of the vadose zone is co

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Environmental Calculation Cover Page

Part 1: Completed by the Responsible Manager

Project: 100 Areas and 300 Area Remedial Investigation/Feasibility Study Reports

Date: August 30, 2011

Calculation Title & Description: **Comparison of 100-KR-1 and 100-KR-2 Source Operable Unit Exposure Point Concentrations to Preliminary Remediation Goals Protective of Groundwater and Preliminary Remediation Goals Protective of Surface Water**

Preparer: Ian Ross	**Basis of Qualification: Education and Experience**
Checker: Doug Evans	**Basis of Qualification: Education and Experience**
Senior Reviewer: Doug Evans	**Basis of Qualification: Education and Experience**

Part 2: Completed by Preparer

Calculation No.: ECF-100KR1-11-0074

Revision No.: Draft

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Part 3: Document Review & Approval:

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Terms

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COPC	Contaminant of potential concern
DOE	U.S. Department of Energy
ECF	Environmental Calculation File
EPA	Environmental Protection Agency
EPC	Exposure point concentration
FS	Feasibility study
OU	Operable unit
PRG	Preliminary Remediation Goal
RI	Remedial investigation
STOMP	Subsurface Transport Over Multiple Phases

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1 Purpose

This environmental calculation documents the methodology used to identify waste sites in the 100-K Area where post-remediation soil sample results exceed soil preliminary remediation goals (PRGs) for the protection of groundwater and the protection of surface water. The 100-K Area is associated with two source operable units (OUs): the 100-KR-1 OU and 100-KR-2 OU. These OUs are referred to collectively herein as the 100-K Source OU. The exposure point concentrations (EPCs) for identified constituents of potential concern (COPCs) for each waste site decision unit in the 100-K Source OU are compared to both groundwater protective and surface water protective PRGs for the base case recharge scenario. The waste sites where EPCs exceed a PRG will be evaluated through the remedial investigation/feasibility study (RI/FS) process being conducted for the 100 Areas and 300 Area under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA).

This environmental calculation supports DOE/RL-2010-97, *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*. A summary based upon the comparison of EPCs to PRGs described in this environmental calculation will be presented in the RI/FS report.

2 Background

PRGs for the protection of groundwater and the protection of surface water were estimated with the STOMP 1D 100:0 Contaminant Source Model, which is a one-dimensional model that assumes 100 percent contamination of the vadose zone beneath a backfilled waste site (zero percent clean soil). The STOMP 1D 100:0 Contaminant Source Model assumes that the entire vadose zone is contaminated below clean fill, that all contamination moves downward, and that there is no dispersion, volatilization, or credit for mixing with river water. The STOMP 1D 100:0 Contaminant Source Model was used to develop PRGs for a base case scenario. The recharge rate for the base case scenario represents a site re-vegetated with natural (shrub steppe) land cover.

Based on agreements with the Senior Executive Council, modeling with the STOMP simulator (PNNL-15782, *STOMP Subsurface Transport Over Multiple, Phases, Version 4.0: User's Guide*) was performed to provide a site-specific basis for estimating PRGs for groundwater protection and surface water protection. The STOMP 1D 100:0 Contaminant Source Model was used to develop PRGs the irrigation recharge scenario. The irrigation recharge scenario assumes a natural land cover plus irrigation of the waste site.

Comparisons are conducted herein between EPCs and the PRGs for both groundwater protection and surface water protection for the identified COPCs at each waste site decision unit in the 100-K Source OU.

3 Methodology

This section describes the methodology used to compare EPCs for identified COPCs at each waste site decision unit to PRGs for groundwater protection and surface water protection for the base case and irrigation recharge scenarios.

For all of the COPCs identified at the 100-K waste site decision units, the following steps are performed:

1. Obtain COPCs for the for each waste site decision unit in the 100-K Source OU.
2. Obtain PRGs for the protection of groundwater and the protection of surface water for the STOMP 1D 100:0 base case scenario.

3. Obtain EPC values for each waste site decision unit in the 100-K Source OU.
4. Individually compare EPCs for each waste site decision unit in the 100-K Source OU to soil PRGs for the protection of groundwater and the protection of surface water.

4 Assumptions and Inputs

Assumptions and inputs associated with COPCs, PRGs, and EPCs are described below.

Table 4-1 documents the sources of information for the PRGs.

Table 4-1. Reference Sources

Preliminary Remediation Goal	Pathway	Reference
STOMP 1D 100:0 Contaminant Source Model –Base Case Scenario	Groundwater	ECF-HANFORD-11-0063
	Surface Water	ECF-HANFORD-11-0063

Notes: ECF-HANFORD-11-0063, *STOMP1-D Modeling for Determination of Preliminary Remediation Goals for 100 Area Source Operable Units D, H, and K.*

4.1 Identification of COPCs

For the purposes of this environmental calculation, a COPC is defined as an analyte suspected of being associated with site-related activities, which represents a potential threat to human health or the environment, and whose data are of sufficient quality for use in a quantitative baseline risk assessment.

All analytes identified as exceeding background soil concentrations and soil screening levels in a waste site decision unit, and that have a predicted time to peak groundwater concentration of less than 10,000 years, are identified as COPCs because the soil sample results represent post-remediation conditions. COPCs for the 100-K Source OU are identified in ECF-100KR1-11-0073, C*omparison of 100-KR-1 and 100-KR-2 Source Operable Unit Exposure Point Concentrations to Soil Screening Levels Protective of Groundwater and Soil Screening Levels Protective of Surface Water*. The COPCs for groundwater protection for each waste site decision unit are presented in Table 4-2. The COPCs for surface water protection for each waste site decision unit are presented in Table 4-3.

Table 4-2. Summary of COPCs and EPCs for Groundwater Protection for the 100-K Source OU

Waste Site/Decision Unit	Analyte Group	COPC[a]	CAS No.	Units	Exposure Point Concentration[b]
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700

a- ECF-100KR1-11-0073, Comparison of 100-KR-1 and 100-KR-2 Source Operable Unit Exposure Point Concentrations to Soil Screening Levels Protective of Groundwater and Soil Screening Levels Protective of Surface Water

b- ECF-100KR1-11-0008, Computation of Exposure Point Concentrations for the 100-KR-1 and 100-KR-2 Source Operable Units

Table 4-2. Summary of COPCs and EPCs for Groundwater Protection for the 100-K Source OU

Waste Site/Decision Unit	Analyte Group	COPC[a]	CAS No.	Units	Exposure Point Concentration[b]
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700

a- ECF-100KR1-11-0073, Comparison of 100-KR-1 and 100-KR-2 Source Operable Unit Exposure Point Concentrations to Soil Screening Levels Protective of Groundwater and Soil Screening Levels Protective of Surface Water

b- ECF-100KR1-11-0008, Computation of Exposure Point Concentrations for the 100-KR-1 and 100-KR-2 Source Operable Units

4.2 Preliminary Remediation Goals for the Protection of Groundwater

PRGs for the protection of groundwater at and near the 100-K Source OU have been derived using the following model:

- STOMP 1D 100:0 Contaminant Source Model, base case scenario

The STOMP 1D 100:0 Contaminant Source Model assumes the entire vadose zone is contaminated below clean fill. The recharge rate for the base case scenario represents a site re-vegetated with natural (shrub steppe) land cover. OU-specific PRGs protective of groundwater for the 100-K Source OU calculated using the STOMP 1D 100:0 Contaminant Source Model are documented in ECF-HANFORD-11-0063, *STOMP 1-D Modeling for Determination of Preliminary Remediation Goals for 100 Area Source Operable Units D, H, and K*. The STOMP 1D 100:0 groundwater protective PRGs are presented in Table 4-4.

Table 4-4. STOMP 1D 100:0Contaminant Source Model Preliminary Remediation Goals for Groundwater Protection for Identified COPCs at the 100-K Source OU

COPC[a]	CAS No.	100-0 Source Base Case GWP Preliminary Remediation Goal
Nonradionuclides (µg/kg)		
Arsenic	7440-38-2	164

a- ECF-100KR1-11-0073, *Comparison of 100-KR-1 and 100-KR-2 Source Operable Unit Exposure Point Concentrations to Soil Screening Levels Protective of Groundwater and Soil Screening Levels Protective of Surface Water*

4.3 Preliminary Remediation Goals for the Protection of Surface Water

PRGs for the protection of surface water at and near the 100-K Source OU have been derived using the following model:

- STOMP 1D 100:0 Contaminant Source Model, base case scenario

The STOMP 1D 100:0 Contaminant Source Model assumes the entire vadose zone is contaminated below clean fill. The recharge rate for the base case scenario represents a site re-vegetated with natural (shrub

steppe) land cover. The model takes no credit for dilution of groundwater by mixing with surface water. OU-specific PRGs protective of surface water for the 100-K Source OU calculated using the STOMP 1D 100:0 Contaminant Source Model are documented in ECF-HANFORD-11-0063. The STOMP 1D 100:0 surface water protective PRGs are presented in Table 4-5.

Table 4-5. STOMP 1D 100:0 Contaminant Source Model Preliminary Remediation Goals for Surface Water Protection for Identified COPCs at the 100-K Source Operable Unit

COPC[a]	CAS No.	100-0 Source Base Case SWP Preliminary Remediation Goal
Nonradionuclides (µg/kg)		
Arsenic	7440-38-2	51
Lead	7439-92-1	210,624
Mercury	7439-97-6	1,199

a- ECF-100KR1-11-0073, Comparison of 100-KR-1 and 100-KR-2 Source Operable Unit Exposure Point Concentrations to Soil Screening Levels Protective of Groundwater and Soil Screening Levels Protective of Surface Water

4.4 Exposure Point Concentrations

OSWER 9285.6-10, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, states that, "an exposure point concentration (EPC) is a conservative estimate of the average chemical concentration in an exposure medium." OSWER Publication 9285.7-081, *Supplemental Guidance to RAGS: Calculating the Concentration Term,* states that, "because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent upper confidence limit (UCL) of the arithmetic mean should be used for this variable."

The EPCs used for comparison to PRGs are the analyte-specific values computed from the post-remediation soil sample results for each waste site decision unit in the 100-K Source OU, as described in ECF-100KR1-11-0008, *Computation of Exposure Point Concentrations for the 100-KR-1 and 100-KR-2 Source Operable Units*. The EPCs corresponding to the identified COPCs for each waste site decision unit in the 100-K Source OU are presented in Tables 4-2 and 4-3.

5 Software Applications

Microsoft Excel® was used to tabulate the data in electronic spreadsheets. These spreadsheets are provided as tables in this environmental calculation.

6 Calculation

Comparison of EPCs to PRGs is conducted as described in Sections 3 to determine which COPCs exceed a PRG. Results of the comparisons are presented in the accompanying tables, as discussed in Section 7. The tables share a similar format, providing both the values being compared as well as a "Yes/No" column indicating the outcome of the comparison.

® Microsoft Excel is a registered product of the Microsoft Corporation.

7 Results/Conclusions

A summary of the 100-K Source OU waste site decision unit COPCs with EPCs that exceed PRGs protective of groundwater is presented in Table 7-1. A summary of the 100-K Source OU waste site decision unit COPCs with EPCs that exceed PRGs protective of surface water is presented in Table 7-2.

Table 7-1. Comparison of EPCs for 100-K Source OU COPCs to STOMP 1D 100:0 Contaminant Source Model Preliminary Remediation Goals Protective of Groundwater

Waste Site/Decision Unit	Analyte Group	COPC	CAS No.	Units	Exposure Point Concentration	100-0 Source Base Case GWP Preliminary Remediation Goal	Is EPC > 100-0 Source Base Case GWP PRG?
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	164	Yes

Table 7-2. Comparison of EPCs for 100-K Source OU COPCs to STOMP 1D 100:0 Contaminant Source Model Preliminary Remediation Goals Protective of Surface Water

Waste Site/ Decision Unit	Analyte Group	COPC	CAS No.	Units	Exposure Point Concentration	100-0 Source Base Case SWP Preliminary Remediation Goal	Is EPC > 100-0 Source Base Case SWP PRG?
100-K-29_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	63,200	210,624	No
100-K-30_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	36,000	210,624	No
100-K-30_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	17,500	1,199	Yes
100-K-31_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	43,400	210,624	No
100-K-31_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	5,200	1,199	Yes
100-K-32_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	2,400	1,199	Yes
100-K-33_Shallow_Focused	non-Rad	Arsenic	7440-38-2	µg/kg	6,700	51	Yes
100-K-33_Shallow_Focused	non-Rad	Lead	7439-92-1	µg/kg	27,800	210,624	No
100-K-33_Shallow_Focused	non-Rad	Mercury	7439-97-6	µg/kg	6,800	1,199	Yes

8 References

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Environmental Calculation Cover Page

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CH2MHILL Plateau Remediation Company

Environmental Calculation Cover Page

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1. Purpose

The purpose of this environmental calculation brief is to present the results of groundwater flow and contaminant transport modeling for the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) Remedial Investigation (RI) and Feasibility Study (FS) undertaken for the 100-K portion of the Hanford Site that will support final remedy selection and provide the basis for a final Record of Decision (ROD) for 100-K. The modeling effort focused on the evaluation of remedy alternatives to prevent the migration of contaminants of concern (COC) toward the Columbia River and reduce COC concentrations in the aquifer below target values.

The model was used as the basis for the evaluation of three alternative remedy designs:

(a) Alternative 1 – No Action: operation of interim action pump-and-treat (P&T) until December 2012. No further remedial actions after December 2012 with COC plume migration and discharge to the river under ambient aquifer conditions.

(b) Alternative 2 – Expanded P&T with implementation of other technologies: operation of the interim action P&T until December 2012, and an expanded P&T with implementation of in-situ treatment (bioremediation) for the period 2013-2020. A limited number of wells remain operational past 2020 to ensure river protection from remaining COCs discharging to the river and continuous aquifer cleanup. All operations cease in 2037.

(c) Alternative 3 – Aggressive P&T: expanded P&T with additional system capacity to lower COC concentrations in the aquifer below target values by 2020. No further remedial action after December 2020.

2. Methodology

2.1 Overview of the 100 Area Groundwater Model

A groundwater flow and contaminant transport model has been developed and calibrated for remedy design evaluation purposes in the 100 Areas. Groundwater flow and advective-dispersive-reactive contaminant transport simulations, together with advective particle tracking analyses, were performed for each conceptual remedy design to determine the feasibility of each design and - if feasible - corresponding pumping rates to evaluate whether the resulting hydraulic conditions would prevent the migration of COC above the target levels to the Columbia River and would reduce COC concentrations in the aquifer below target levels.

The model development and calibration is documented in a comprehensive modeling report (*Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*, SGW-46279, Rev. 2). The groundwater flow model is constructed using the U.S. Geological Survey (USGS) modular groundwater flow model MODFLOW (*A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model* [McDonald and Harbaugh 1988]; *User Documentation for MODFLOW 96, An Update to the U.S. Geological Survey Modular Finite-Difference Ground-Water Flow Model* [Harbaugh and McDonald 1996]; *MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process* [Harbaugh et al. 2000]; *MODFLOW-2005, The U.S. Geological Survey Modular Ground-Water Model – The Ground-Water Flow Process* [Harbaugh 2005]). Particle tracking was performed using the USGS program MODPATH (*User's Guide for MODPATH/MODPATH-PLOT, Version 3: A Particle Tracking Post-Processing Package for MODFLOW, the U.S. Geological Survey Finite-Difference Ground-Water Flow Model* [Pollock 1994]). MT3DMS (1998 to present) was used to simulate the contaminant plume migration (*MT3DMS, A Modular Three-Dimensional Multi-Species Transport Model for Simulation of*

Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide [Zheng and Wang 1999]; *MT3DMS v5.2: Supplemental User's Guide – Technical Report* [Zheng 2006]).

Predictive simulations were based on transient-state (i.e., time-varying) conditions in the aquifer that reflect water-level changes due to river-stage variation. The modeling timeframe corresponds to a 77-year period (calendar years [CY] 2011 to 2087). For the period 2011-2037 the simulations are discretized into twelve monthly stress periods, reflecting the seasonally-varying river stage, that are repeated in the same sequence: each stress period corresponds to monthly average river stages, each representing the average river stage for the particular calendar month over the period 2006-2010 (excluding 2007 values, when the river stage variation pattern was inconsistent with the other years). It is assumed that these conditions are representative of the typical conditions in the field and that future conditions will not vary significantly from these conditions. For the period 2038-2087 a single transient stress period is used, with the river stage elevation remaining constant reflecting annual average conditions, corresponding to 2006-2010 average elevations for the month of January.

The migration of hexavalent chrome (CrVI) in response to current and projected extraction and injection well operations in the 100-KR-4 Area was simulated. In addition to CrVI, transport simulations were performed for four other COCs - Tritium, Strontium-90, Nitrate and Carbon 14 - to evaluate corresponding migration patterns as a result of the current and projected extraction and injection well operations. Transport simulations were based on the transient flow fields calculated by the groundwater flow model using the stress periods described above; a mapped initial distribution for each COC in groundwater; and a dual-domain formulation representing plume migration in a dual-porosity continuum with mass transfer between mobile and immobile domains.

Carbon-14, Nitrate and Strontium-90 passing through the Ion Exchange (IX) Treatment System are not removed under the current treatment process. They are therefore recirculated in the aquifer via injection at the injection wells connected to each treatment plant. Carbon-14, Nitrate and Strontium-90 concentrations injected back into the aquifer are equal to the blended influent concentration at the treatment plant.

2.2 Predictive Hydraulic Containment Calculations

A systematic approach was developed and applied to estimated hydraulic containment in 2012 using the groundwater model. An estimate of the approximate extent of hydraulic capture was calculated using the transient model using an approach similar to that described in "The Capture Efficiency Map: The Capture Zone Under Time-Varying Flow" (Festger and Walter, 2002) and "Sources of Water to Wells for Transient Cyclic Systems" (Reilly and Pollock, 1996), focusing on the evaluation of the temporal variation in capture due to changing flow patterns and hydraulic gradients:

- Releasing particles near the end of each of the twelve monthly stress periods and simulating their migration using a very low effective porosity, ensuring that particle travel times are essentially instantaneous.
- Recording the instantaneous fate of each particle during each stress period.
- Calculating a capture zone for each stress period based on the "snapshot" of aquifer conditions at the time of the particle release, in this case producing twelve instantaneous "snapshots" of the extent of capture.
- Constructing a capture efficiency map (CEM) by counting the number of times a particle originating from a location was captured by a well, and dividing this count by the total number of releases (i.e., twelve).

2.3 Predictive Modeling Process

For each alternative design, a systematic process was followed to develop model input files, to perform the model simulation, and to post-process the model results to evaluate system performance. This procedure is described by the following steps:

1. Well locations for injection and extraction wells were proposed, discussed and selected.
2. Injection and extraction rates were proposed, discussed and assigned to each well.
3. An input file for the MODFLOW Multi-Node Well (MNW2) Package (Konikow et al., 2009) was constructed to describe the spatial and temporal configuration of the well operations.
4. The flow model was executed to simulate transient hydraulic head distributions, together with accessory outputs including model-wide and cell-by-cell flow budgets.
5. Input files for subsequent particle tracking analyses were constructed, including particle starting locations encompassing an area equivalent to the footprint of the corresponding COC plume.
6. MODPATH was executed to simulate the conservative, advective transport of groundwater and dissolved contaminants, and the results were post-processed to identify particles that - given sufficient time - would (a) ultimately migrate to the river or would (b) ultimately be captured by the extraction wells.
7. Maps of hydraulic capture efficiency (i.e., CEMs) were constructed, using the method described above.
8. Input files for the advective-dispersive-reactive contaminant transport model were constructed for each COC, including the initial distribution, COC-specific transport parameters such as decay rate, and the time-varying mass loading of any injected substraite at each bio-injection well (bio-injection alternatives only), where applicable.
9. MT3DMS was executed to simulate the advective-dispersive-reactive transport of each COC, and the results were post-processed.
10. Post-processing of the MT3DMS simulations was completed, comprising:
    a. Maps of the simulated distribution of each COC for 2012, 2016, 2020, 2037 and 2087.
    b. Concentration-versus-time graphs for CrVI at the river shoreline and within the aquifer.

3. Modeling Assumptions and Inputs

3.1 Model Structure

The groundwater flow model grid encompasses all 100-Area Operable Units (OU). The model finite-difference grid is constructed so that the north and northeast boundaries of the flow model are parallel to, and abut, the Columbia River. The model extends southward, toward Gable Butte and Gable Mountain. The grid spacing is relatively coarse (about 100 m) throughout much of the domain, but it is refined (15 m) in the area of each 100 Area OU to support remedy evaluations.

Groundwater flow is simulated as three-dimensional (3D) using four layers. These layers represent the Hanford formation (always present in Layer 1, across the model domain) and the Ringold E Formation (typically represented by Layers 2 through 4, except east of 100-D where it is absent and therefore all

model layers represent the Hanford formation). Throughout much of the western half of the modeled area (including 100-K and 100-D), the water table lies within the Ringold Unit E sands, whereas toward the east and north of the modeled area (including 100-H and 100-F), the water table lies within the Hanford formation sands and gravels. In the vicinity of 100-B/C the water table fluctuates between the two formations.

The base of the model is assumed to be the top of the Ringold Upper Mud (RUM) where present and the top of the basalt where the RUM is absent, which typically occurs in the southern portions of the model approaching Gable Butte. The geologic characterization compiled as part of the Model Data Packages (SGW-40781 Rev. 0, *100-HR-3 Remedial Process Optimization Modeling Data Package*; SGW-41213 Rev. 0, *100-KR-4 Remedial Process Optimization Modeling Data Package*; SGW-44022 Rev. 0, *Geohydrologic Data Package in Support of 100-BC-5 Modeling*; SGW-47040 Rev. 0, *Geohydrologic Data Package in Support of 100-FR-3 Modeling*) depicts a reasonably abrupt lateral transition from areas where the water table lies dominantly within the Ringold Unit E in the west and south of the model domain to areas where the water table lies dominantly within the Hanford formation sands and gravels in the east and north of the model domain, that occurs between the 100-D and 100-H areas.

The principal aquifer property specified in the flow model is the spatially varying hydraulic conductivity of the saturated aquifer materials. The hydraulic conductivity distribution in the model was developed based on the information included in the Model Data Packages and a pilot-point parameterization technique (Doherty, 2003) that was implemented in the model calibration process. Estimates of hydraulic conductivity compiled as part of the Model Data Packages were tabulated and assigned to their corresponding aquifer unit. The mean values for the aquifer hydraulic conductivity that resulted from the model calibration process are:

- 6 m/day for Ringold Unit E in the 100-K Area region of the aquifer.
- 63 m/day for the Hanford formation.

Areal recharge from precipitation was specified based on information included in the Groundwater Data Package for Hanford Assessments (*Groundwater Data Package for Hanford Assessments*, PNNL-14753). An electronic version of the recharge package developed and presented in PNNL-14753 was obtained; the data were spatially distributed to the model grid cells; and this initial distribution was subsequently adjusted during model calibration. Based on the results of the model calibration, the recharge value was set equal to 12 mm/yr throughout much of the model domain. Local recharge conditions (e.g. surface reservoirs) were assigned recharge rates based on specific reported values (*In Situ Redox Manipulation (ISRM) Annual Report Fiscal Year 2007*, DOE/RL-2008-10).

Initial effective porosity and specific yield values for the aquifer were identified from published sources: these were revised during the model calibration and set equal to 18% and 10%, respectively. Both values are within the range of values documented in previous investigations for Hanford (*Development of a Three-Dimensional Ground-Water Model of the Hanford Site Unconfined Aquifer System,* PNNL-10886). As a result of the approach taken to the model calibration, the relatively low value of specific yield (versus the higher value of effective porosity) principally reflects periodic but incomplete draining and rewetting of aquifer materials near the shoreline in response to oscillatory river stage changes. Finally, riverbed conductance values were also determined during calibration, separately for the stretches of the Columbia River within each Area.

The groundwater flow model was calibrated to data included in the Model Data Packages for each OU, through a combined manual (i.e., trial-and-error) and automated process. Model calibration was facilitated by the use of PEST (Doherty, 2010) and post-processing programs that calculate simulated

water-level responses to stresses. The model was calibrated to data obtained from January 2006 to June 2009, and was then validated using data obtained from July 2009 to December 2010. Calibration focused on the transient response of water levels to changing stresses and how these compare to values measured at wells at each OU; in addition, maps of water-level contours calculated by the model were compared to contours included in published reports to ensure that the simulated hydraulic gradient magnitude and direction is in agreement with prior independent interpretations.

Further details about all parameter values used in the model are provided in the comprehensive modeling report (*Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*, SGW-46279, Rev. 2).

3.2 Contaminant Transport Processes

The migration of CrVI in response to current and projected extraction and injection well operations in the 100-KR-4 Area was simulated to support remedy design evaluation. In addition to CrVI, transport simulations were performed for four other COCs (Tritium, Strontium-90, Nitrate, Carbon-14 and TCE), to evaluate corresponding migration patterns as a result of the current and projected extraction and injection well operations. Transport simulations were based on transient flow fields calculated by the groundwater flow model; a mapped initial distribution of each COC in groundwater; and a dual-domain formulation representing plume migration in a dual-porosity continuum with mass transfer between the mobile and immobile domains.

Although often assumed to be conservative, recent studies by PNNL (*Geochemical Characterization of Chromate Contamination in the 100 Area Vadose Zone at the Hanford Site*, PNNL-17674) suggest that CrVI within soils of the 100 Areas exhibits migration characteristics that may be more complex than can be represented using simple advection. According to these tests, although the majority of the mass is highly mobile and migrates principally by advection, CrVI mass can be held in heterogeneous parts of the aquifer that possess a low hydraulic conductivity. This relatively less mobile CrVI constitutes a longer-term source of chromium to the mobile domain that is facilitated by mass transfer between the two domains. Based on these observations, the migration of CrVI can be reasonably described by a dual-domain (or dual-porosity) approach that divides the aquifer into two domains: mobile and immobile. Advective-dispersive transport occurs predominantly in the mobile domain while mass transfer occurs between the mobile and immobile domains.

MT3DMS supports the use of a dual-domain formulation to simulate the transport of a contaminant in groundwater. To do so, the following parameters must be defined for the dual domain formulation: the fraction of mobile and immobile domains; the mass transfer coefficient between the mobile and immobile domains; and when considering sorption or related retardation processes, distribution coefficients that describe sorption within the mobile and immobile domains. For the 100 Area transport model, it was assumed that limited sorption occurs within the immobile domain, and that no sorption occurs within the mobile domain. The parameter values used for the dual-domain formulation for the advective-dispersive-reactive transport simulations for all COCs are listed in Table 3-1. Further details on the development of the dual-domain parameters can be found in the comprehensive modeling report (*Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*, SGW-46279, Rev. 2).

Table 3-1. Parameter Values for the MT3DMS Dual-Domain Formulation.

Parameter	Value
Bulk Density, ρ_b (g/cc)	1.72
Mobile water content, θ_m (cc/cc)	0.18
Immobile water content, θ_{im} (cc/cc)	0.045
Total water content, θ (cc/cc)	0.225
Fraction of mobile water content, f (-)	0.8
Mass-transfer coefficient, α (-)	0.01
Soil-water distribution coefficient for immobile domain, K_d (cc/g)	0.3
CrVI Soil-water distribution coefficient for mobile domain, K_d (cc/g)[1]	0.0[2]
Tritium Soil-water distribution coefficient for mobile domain, K_d (cc/g)	0.0[2]
Strontium-90 Soil-water distribution coefficient for mobile domain, K_d (cc/g)	12.0[2]
Nitrate Soil-water distribution coefficient for mobile domain, K_d (cc/g)	0.0[2]
Carbon-14 Soil-water distribution coefficient for mobile domain, K_d (cc/g)	0.02[3]
TCE Soil-water distribution coefficient for mobile domain, K_d (cc/g)	0.025[4]

[2] PNNL-18564, Table 6.9, Sandy Gravel sediment type

[3] Reference pending

[4] Based on empirical calculation (PNNL-13560 (Equations 1 & 2, p. C.16), assuming foc = 0.00027, solubility of TCE of 1100 mg/L)

In addition to these transport parameters, radioactive decay was simulated for Tritium, Strontium-90 and Carbon-14. The corresponding half-life values used in the model are shown in Table 3-2.

Table 3-2. Radioactive Decay Parameters.

COC	Half-Life (years)
Tritium	12.3
Strontium-90	28.8
Carbon-14	5,730

[1] Recent leach tests conducted on vadose zone sediment samples indicate that a higher-valued distribution coefficient (k_d) of 0.8 may be appropriate as a conservative lower limit when representing residual hexavalent chromium that is present in fine sediment after several pore-volume flushes of contaminated sediments have occurred (ECF-Hanford-11-0165). Future revisions of the groundwater fate and transport models will incorporate this new information. Model parameters will also be calibrated to match observed conditions and available information for hexavalent chromium plumes across the River Corridor.

3.3 Initial Distribution of COCs

The initial distribution of each COC in groundwater within the 100-KR-4 OU was obtained using maximum sampled COC concentrations at each monitoring location during the period 2009-2010. Calculation of the initial distribution was performed using Quantile Kriging, a robust interpolation method (*Spatial Interpolation Methods for Nonstationary Plume Data*, [Reed et al. 2004]), and was based on a stepwise procedure that includes adjustments to the interpolated distribution to reflect institutional knowledge of the historic plume migration and the local conditions affecting the actual COC distribution in the aquifer (*Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*, SGW-46279, Rev. 2). Initial concentrations in the mobile and immobile domains were the same for each COC. Figures 3-1 through 3-6 show the initial distribution of CrVI, Tritium, Strontium-90, Nitrate, Carbon-14 and TCE, respectively.

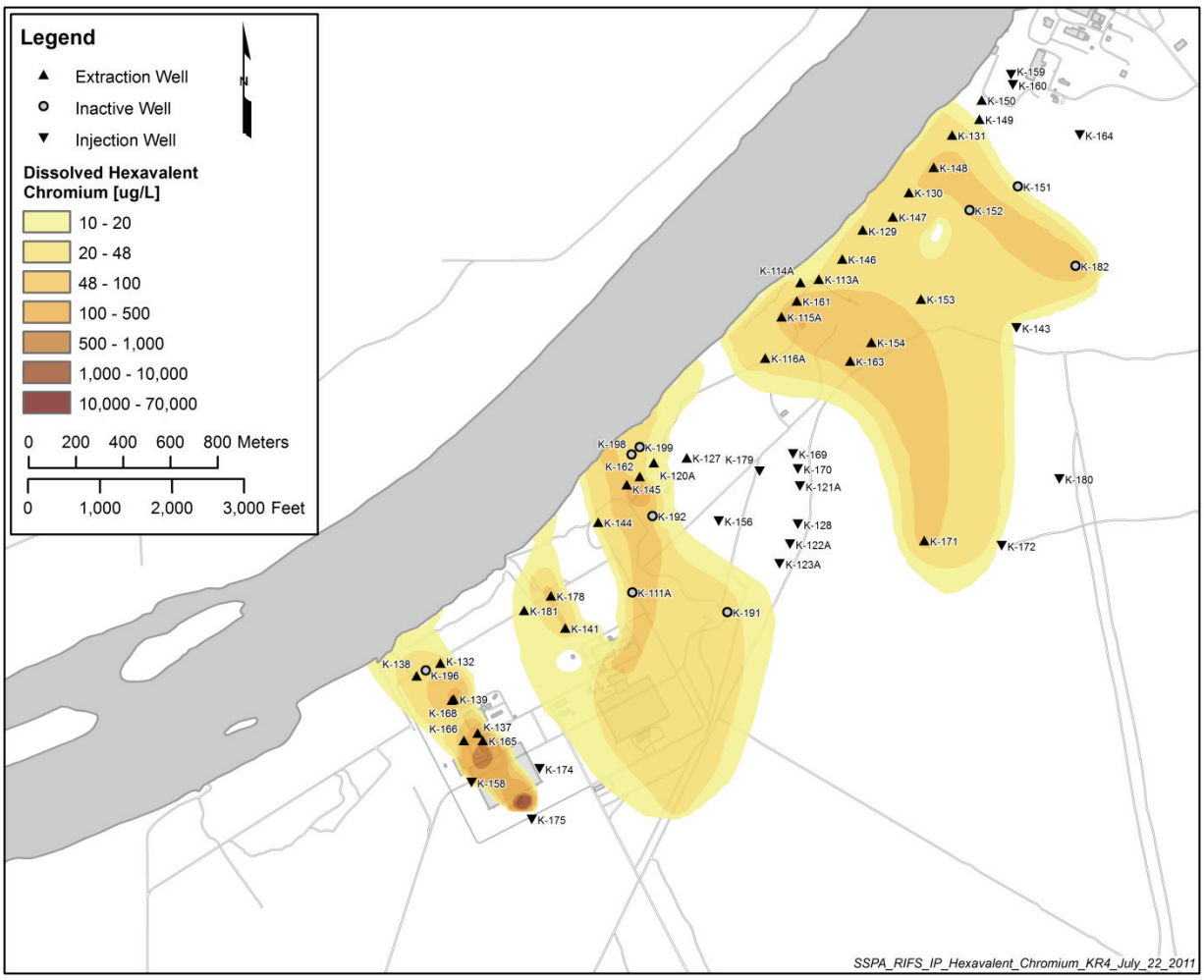


Figure 3-1. Initial CrVI Distribution in 100-KR-4.

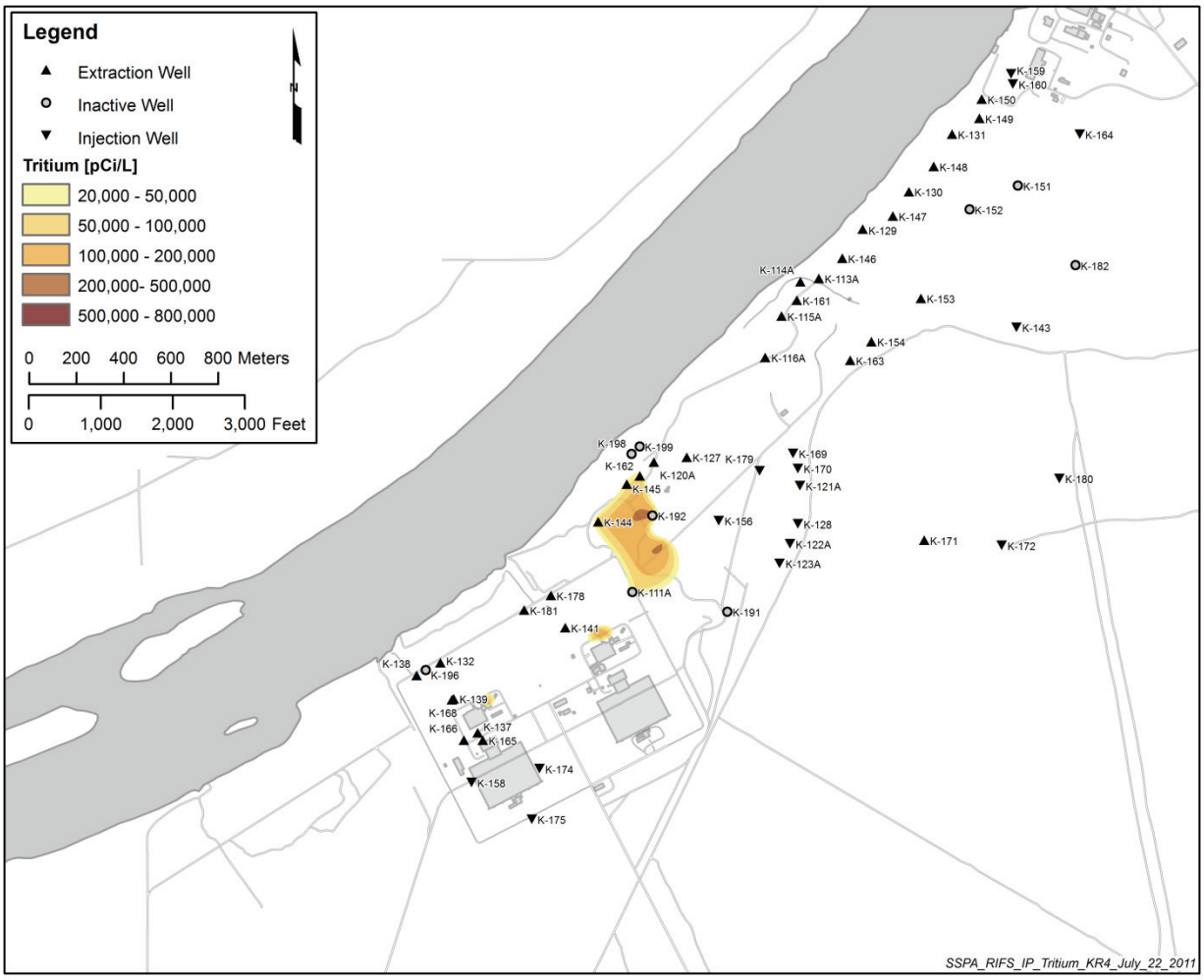


Figure 3-2. Initial Tritium Distribution in 100-KR-4.

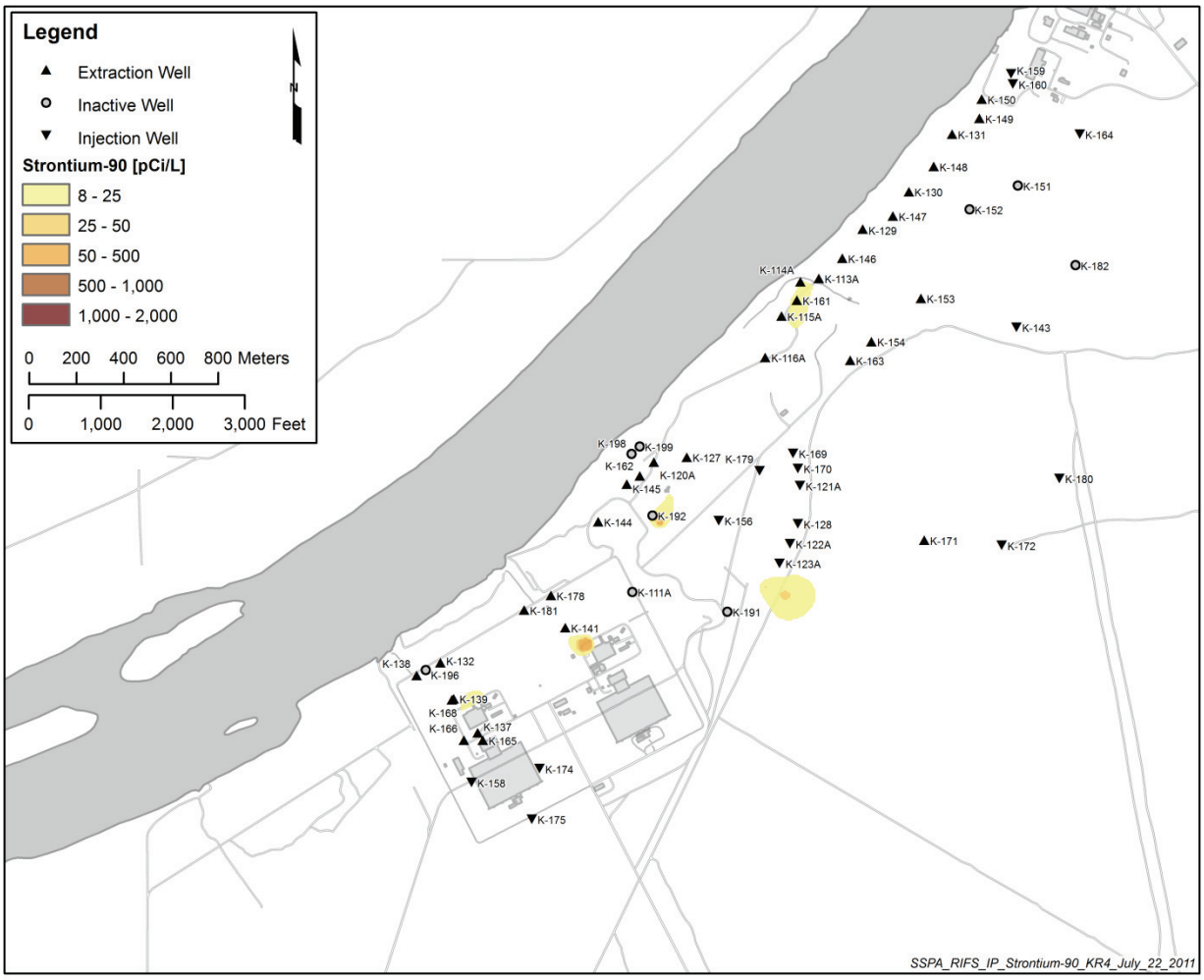


Figure 3-3. Initial Strontium-90 Distribution in 100-KR-4.

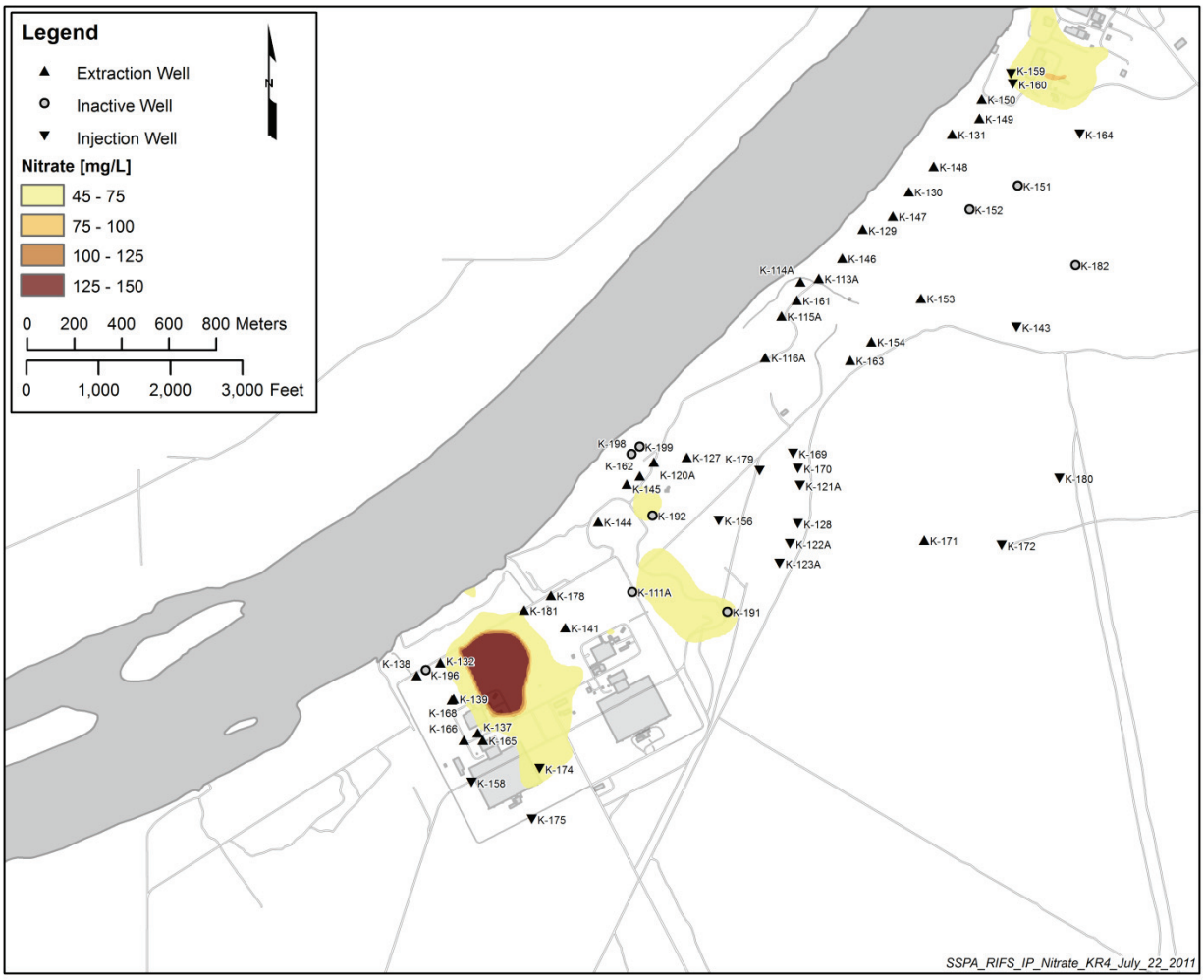


Figure 3-4. Initial Nitrate Distribution in 100-KR-4.

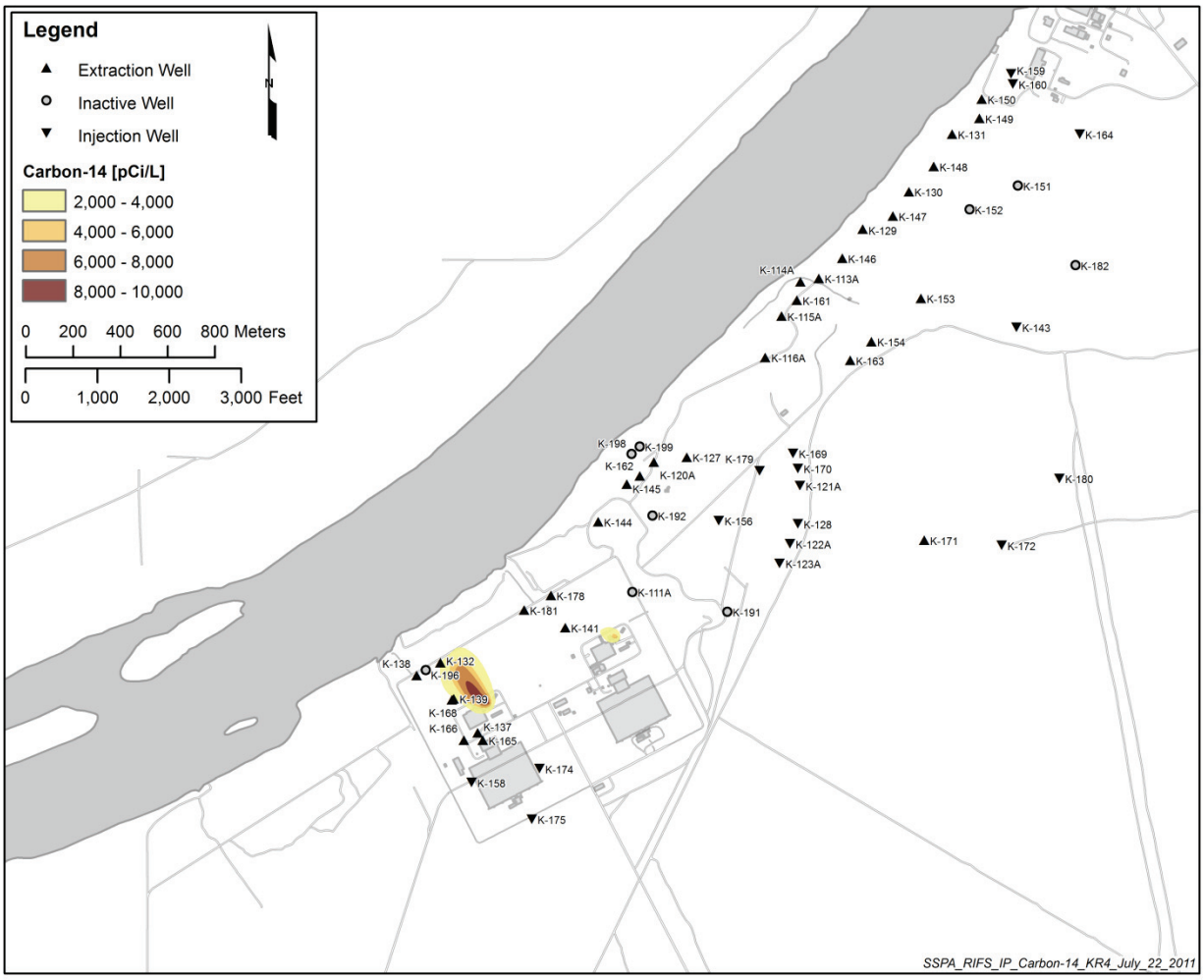


Figure 3-5. Initial Carbon-14 Distribution in 100-KR-4.

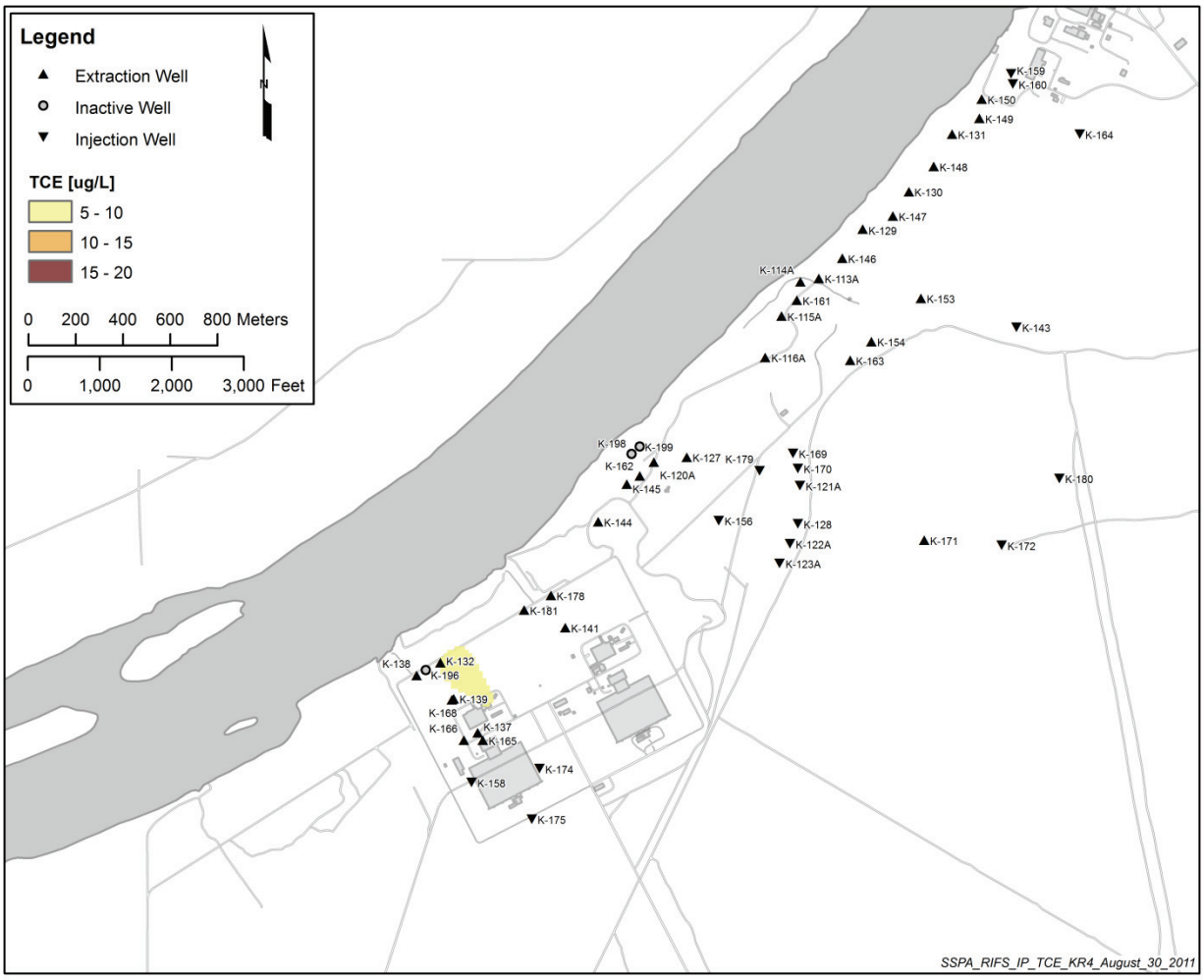


Figure 3-6. Initial TCE Distribution in 100-KR-4.

3.4 Wells

Flow and transport model simulations were performed for three alternative remedy designs. The basis of all designs is the currently operational interim action P&T system in 100-KR-4. Alternative 1 consider only wells of the interim (current) P&T remedy, while Alternatives 2 and 3 incorporate additional extraction and injection wells. In addition, alternative 2 includes in-situ treatment at selected wells; whereas, alternatives 1 and 3 consider only variations on traditional, un-amended, P&T operations.

Detailed descriptions of each alternative well configuration are presented in the following subsections.

3.4.1 Alternative 1: No Action

Alternative 1 comprises extraction and injection wells as part of the interim action P&T system currently operating in 100-KR-4. The P&T includes three ion exchange (IX) treatment systems, namely KW, KR, and KX, for a total treatment capacity of 1,100 gpm. It is assumed that scheduled and unforeseen system shut-down period will occur during the system operation timeframe. For that reason a capacity reduction

of 15% is assumed to account for the time the system will not be operational. This reduction is applied to the total treated water volume during every model stress period.

P&T well configuration reflects current system operations which remain unchanged until December 2012 when the system is assumed to be shut-down. Plume migration patterns for all COCs are simulated assuming ambient aquifer conditions for the period 2013-2087.

Figure 3-7 shows the extraction and injection well configuration for this Alternative. Detailed account of the pumping rates for all wells is included in Table 3-3.

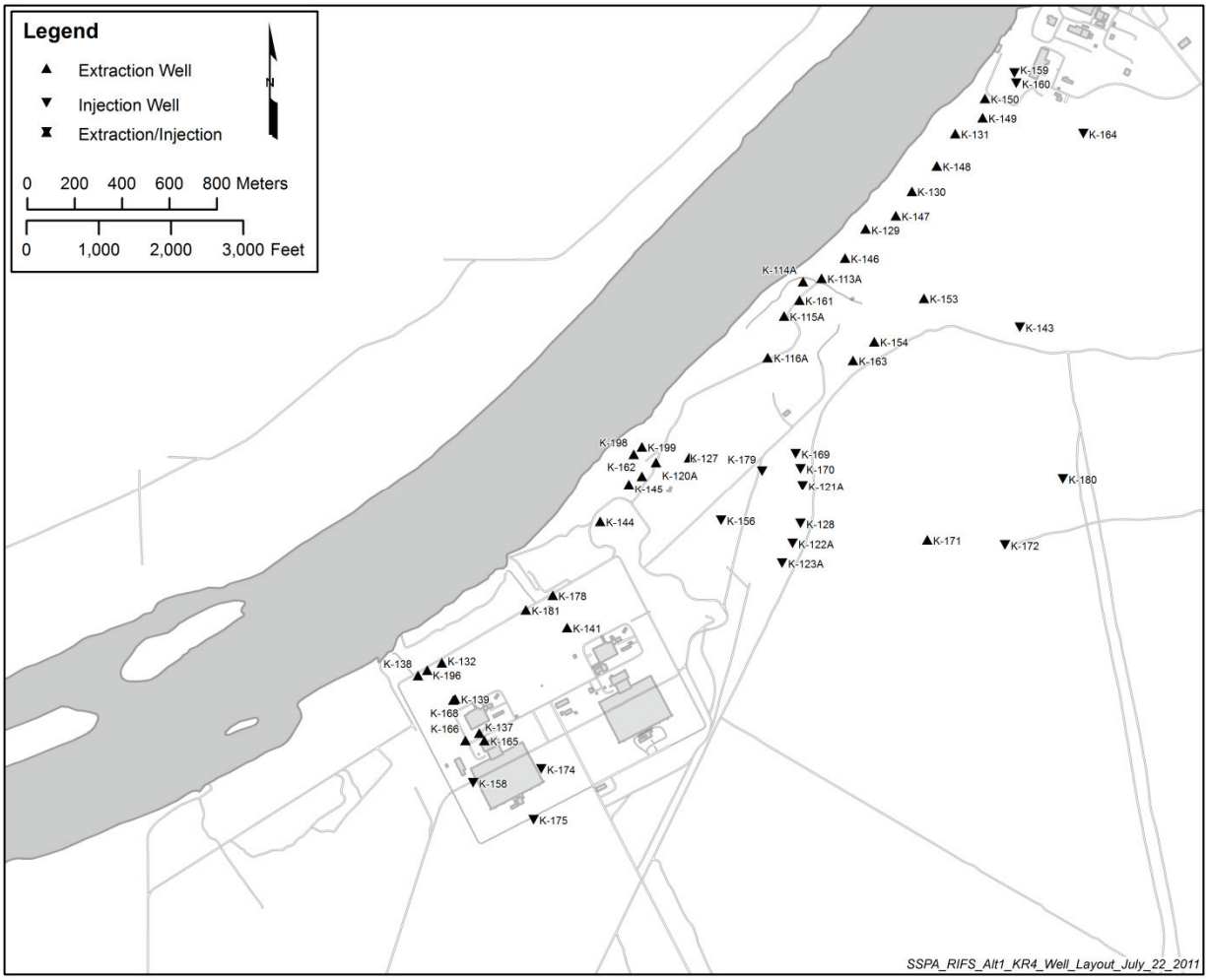


Figure 3-7. Extraction/Injection Well Configuration – Alternative 1.

Table 3-3. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 1

Well Name	Easting	Northing	Jan 2011 – Dec 2011	Jan 2012 – Dec 2012
199-K-120A	569399.6150	147518.4770	-20.0[1,2]	-20.0
199-K-127	569539.2340	147539.0020	-10.0	0.0
199-K-144	569163.3400	147265.9600	-35.0	-25.0
199-K-145	569284.6000	147425.6600	-35.0	-25.0
199-K-162	569340.0000	147459.9700	-25.0	-25.0
199-K-198	569305.6900	147552.2200	0.0	-25.0
199-K-199	569339.6500	147584.4200	0.0	-25.0
199-K-179	569847.2500	147481.9200	60.0	60.0
199-K-113A	570098.0700	148294.4530	-20.0	-15.0
199-K-114A	570020.3020	148280.5500	-30.0	-25.0
199-K-115A	569939.9880	148135.4170	-30.0	-25.0
199-K-116A	569871.1490	147960.4950	-25.0	-20.0
199-K-129	570283.6500	148503.0700	-25.0	-25.0
199-K-121A	570017.1650	147418.2600	35.0	35.0
199-K-122A	569975.0680	147172.8590	50.0	50.0
199-K-123A	569931.1030	147090.2440	60.0	60.0
199-K-128	570009.5380	147257.5200	50.0	50.0
199-K-132	568495.1200	146670.8200	-30.0	-25.0
199-K-138	568395.2200	146616.6400	-30.0	-25.0
199-K-168	568544.3700	146513.6300	-20.0	-15.0
199-K-166	568594.5600	146342.9700	-20.0	-15.0
199-K-137	568653.3700	146374.5100	-20.0	-15.0
199-K-165	568674.9600	146342.4200	-30.0	-30.0
199-K-139	568551.3900	146518.3900	-20.0	-10.0
199-K-196	568433.3900	146639.0300	0.0	-35.0
199-K-158	568627.4500	146164.4100	50.0	50.0
199-K-174	568915.3800	146222.4700	40.0	40.0
199-K-175	568882.7200	146008.8400	80.0	80.0

Table 3-3. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 1

Well Name	Easting	Northing	Jan 2011 – Dec 2011	Jan 2012 – Dec 2012
199-K-141	569024.2200	146818.4900	-25.0	-25.0
199-K-178	568963.0100	146954.4300	-40.0	-40.0
199-K-181	568849.7500	146892.8200	-20.0	-20.0
199-K-111A	569308.1690	146968.8750	0.0	0.0
199-K-192	569394.0200	147292.6400	0.0	0.0
199-K-156	569674.0100	147270.9100	60.0	60.0
199-K-191	569710.7600	146885.9700	0.0	0.0
199-K-130	570478.9900	148661.1800	-40.0	-40.0
199-K-131	570662.0000	148903.8500	-45.0	-45.0
199-K-146	570197.6000	148379.7800	-15.0	-15.0
199-K-147	570411.6400	148558.0700	-20.0	-20.0
199-K-148	570584.7400	148767.8600	-45.0	-45.0
199-K-149	570778.2500	148970.7400	-30.0	-30.0
199-K-150	570787.6700	149051.9300	-25.0	-25.0
199-K-153	570530.0400	148210.0800	-25.0	-25.0
199-K-154	570320.6900	148027.7200	-35.0	-35.0
199-K-161	570004.4300	148202.1300	-30.0	-30.0
199-K-163	570230.6600	147947.9300	-30.0	-30.0
199-K-151	570941.3200	148686.4400	0.0	0.0
199-K-152	570736.2500	148585.8900	0.0	0.0
199-K-143	570934.4100	148088.2800	60.0	60.0
199-K-159	570911.9800	149159.8600	20.0	20.0
199-K-160	570919.5800	149116.0200	20.0	20.0
199-K-164	571202.2200	148903.7400	45.0	45.0
199-K-169	569988.9700	147554.9800	60.0	60.0
199-K-170	570009.0100	147491.3700	60.0	60.0
199-K-171	570544.0300	147187.8600	-30.0	-30.0
199-K-172	570871.6900	147166.3700	70.0	70.0

Table 3-3. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 1

Well Name	Easting	Northing	Jan 2011 – Dec 2011	Jan 2012 – Dec 2012
199-K-180	571116.0800	147449.1400	60.0	60.0
199-K-182	571185.3200	148350.2400	0.0	0.0

[1] Pumping rates in gallons per minute (gpm)

[2] Negative values indicate extraction

3.4.2 Alternative 2: Expanded P&T with Implementation of Other Technologies

The interim action P&T system is expanded in Alternative 2 to include additional extraction and injection wells, thus encompassing a larger area of the COC plumes to expedite hydraulic containment and recovery. In addition, in-situ treatment is considered in the form of bio-injection at selected wells and periods to further enhance the reduction of dissolved COC concentrations in the aquifer and improve cleanup times. Well locations were determined based on the COC plume distributions, although spatial restrictions due to cultural and other constraints were considered.

For the period 2011-2012 only wells of the interim action P&T are considered. The expanded system is operational for the period 2013-2020 with bio-injection occurring at selected wells during that period. Selected wells remain operational between 2021 and 2037 to prevent discharge of COCs to the river and maintain continuous aquifer cleanup. The P&T system capacity is assumed to be reduced by 15% to account for scheduled/unforeseen shut-down periods. During periods of in-situ treatment implementation, bio-amended water injected at the designated injection wells is recovered at downgradient extraction wells but bypasses the IX treatment system.

Figure 3-8 shows the extraction and injection well configuration for Alternative 2. Detailed account of the pumping rates for all wells is included in Table 3-4, with shaded cells indicating bio-infiltration/injection.

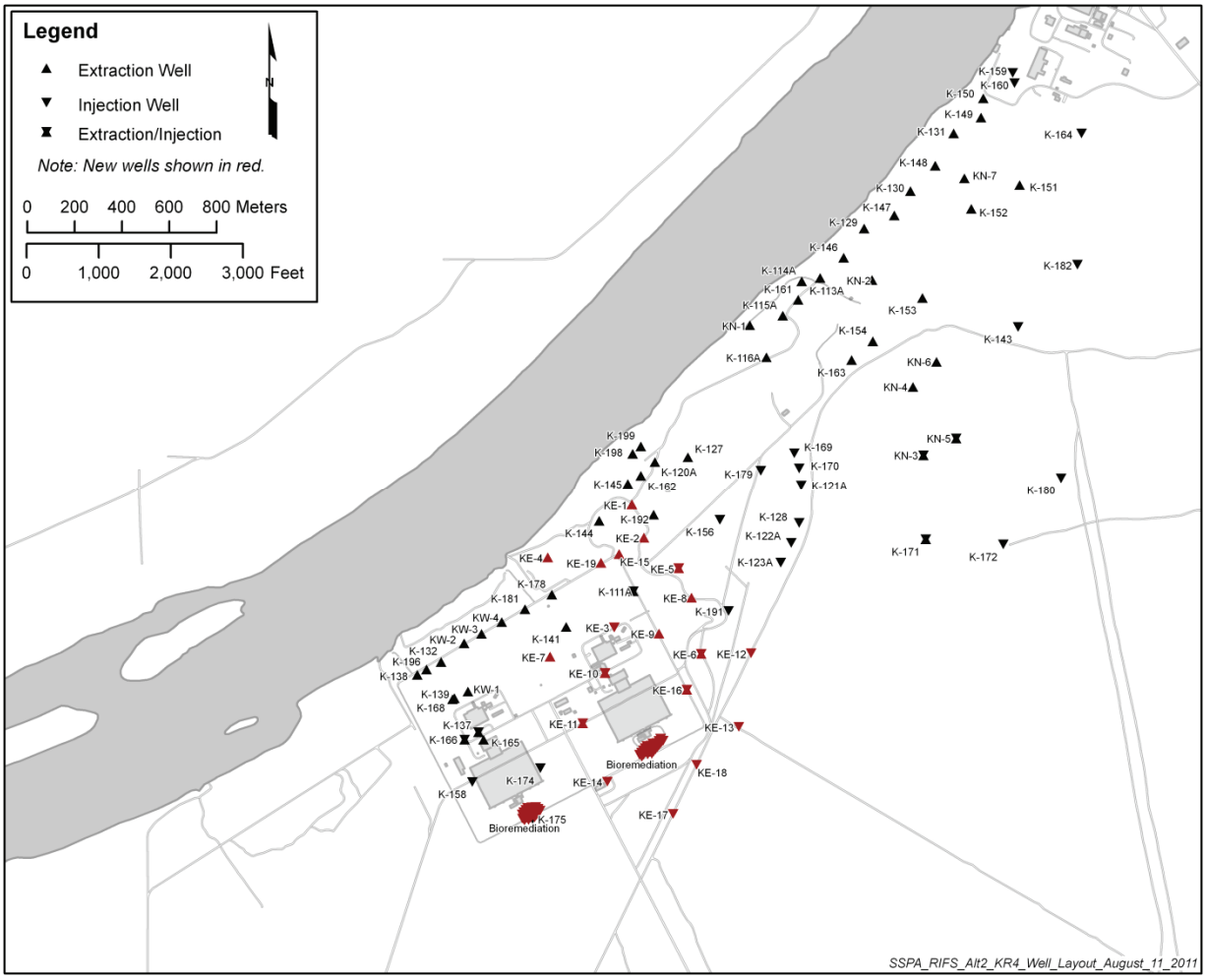


Figure 3-8. Extraction/Injection Well Configuration – Alternative 2.

Table 3-4. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 2

Well Name	Easting	Northing	Jan 2011-Dec 2011	Jan 2012-Dec 2012	Jan 2013-Dec 2013	Jan 2014-Dec 2014	Jan 2015-Dec 2015	Jan 2016-Dec 2016	Jan 2017-Dec 2017	Jan 2018-Dec 2018	Jan 2019-Dec 2019	Jan 2020-Dec 2020	Jan 2021-Dec 2037
199-K-120A	569399.6150	147518.4770	-20.0	-20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
199-K-127	569539.2340	147539.0020	-10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
199-K-144	569163.3400	147265.9600	-35.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0
199-K-145	569284.6000	147425.6600	-35.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	0.0
199-K-162	569340.0000	147459.9700	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	0.0
199-K-198	569305.6900	147552.2200	0.0	-25.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	0.0
199-K-199	569339.6500	147584.4200	0.0	-25.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	0.0
199-K-179	569847.2500	147481.9200	60.0	60.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	0.0
199-K-113A	570098.0700	148294.4530	-20.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0
199-K-114A	570020.3020	148280.5500	-30.0	-25.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	0.0
199-K-115A	569939.9880	148135.4170	-30.0	-25.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	0.0
199-K-116A	569871.1490	147960.4950	-25.0	-20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
199-K-129	570283.6500	148503.0700	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0
199-K-121A	570017.1650	147418.2600	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
199-K-122A	569975.0680	147172.8590	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
199-K-123A	569931.1030	147090.2440	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
199-K-128	570009.5380	147257.5200	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	30.0
199-K-132	568495.1200	146670.8200	-30.0	-25.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0
199-K-138	568395.2200	146616.6400	-30.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0
199-K-168	568544.3700	146513.6300	-20.0	-15.0	-20.0	-20.0	-20.0	-20.0	-20.0	-20.0	-20.0	-20.0	0.0
199-K-166	568594.5600	146342.9700	-20.0	-15.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	20.0	20.0	0.0
199-K-137	568653.3700	146374.5100	-20.0	-15.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	20.0	20.0	0.0
199-K-165	568674.9600	146342.4200	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	0.0	0.0	0.0
199-K-139	568551.3900	146518.3900	-20.0	-10.0	-20.0	-20.0	-20.0	-20.0	-20.0	-20.0	-20.0	-20.0	0.0
199-K-196	568433.3900	146639.0300	0.0	-35.0	-40.0	-40.0	-40.0	-35.0	-35.0	-35.0	-40.0	-40.0	-40.0
KW-1	568609.0000	146546.0000	0.0	0.0	0.0	0.0	0.0	-35.0	-35.0	-35.0	-40.0	-40.0	0.0

Table 3-4. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 2

Well Name	Easting	Northing	Jan 2011-Dec 2011	Jan 2012-Dec 2012	Jan 2013-Dec 2013	Jan 2014-Dec 2014	Jan 2015-Dec 2015	Jan 2016-Dec 2016	Jan 2017-Dec 2017	Jan 2018-Dec 2018	Jan 2019-Dec 2019	Jan 2020-Dec 2020	Jan 2021-Dec 2037
199-K-158	568627.4500	146164.4100	50.0	50.0	40.0	40.0	40.0	70.0	70.0	70.0	0.0	0.0	0.0
199-K-174	568915.3800	146222.4700	40.0	40.0	20.0	20.0	20.0	110.0	110.0	110.0	75.0	75.0	100.0
199-K-175	568882.7200	146008.8400	80.0	80.0	0.0	0.0	0.0	70.0	70.0	70.0	65.0	65.0	0.0
Bio-Infiltration KW Head House	568881.3270	146022.5057	0.0	0.0	160	160	160	0.0	0.0	0.0	0.0	0.0	0.0
199-K-141	569024.2200	146818.4900	-25.0	-25.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	0.0
199-K-178	568963.0100	146954.4300	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0
199-K-181	568849.7500	146892.8200	-20.0	-20.0	-30.0	-30.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-20.0
199-K-111A	569308.1690	146968.8750	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	50.0	50.0	0.0
199-K-192	569394.0200	147292.6400	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0
KE-1	569302.0000	147335.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0
KE-2	569353.0000	147195.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0
KE-3	569227.0000	146817.0000	0.0	0.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	0.0
KE-4	568946.0000	147112.0000	0.0	0.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-30.0
KE-5	569500.0000	147066.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	90.0	90.0	90.0
KE-6	569595.0000	146705.0000	0.0	0.0	-35.0	-35.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
KE-7	568956.0000	146693.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	0.0
KE-8	569554.0000	146942.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	90.0	90.0	0.0	0.0	0.0
KE-9	569417.0000	146791.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	90.0	90.0	0.0	0.0	0.0
KE-10	569188.0000	146624.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	90.0	90.0	90.0	90.0	100.0
KE-11	569094.0000	146412.0000	0.0	0.0	-35.0	-35.0	100.0	100.0	90.0	90.0	0.0	0.0	0.0
KE-12	569806.0000	146707.0000	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KE-13	569754.0000	146397.0000	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KE-14	569198.0000	146166.0000	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KE-15	569248.0000	147126.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-25.0
KE-16	569534.0000	146554.0000	0.0	0.0	-35.0	-35.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
KE-17	569476.0000	146029.0000	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3-4. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 2

Well Name	Easting	Northing	Jan 2011-Dec 2011	Jan 2012-Dec 2012	Jan 2013-Dec 2013	Jan 2014-Dec 2014	Jan 2015-Dec 2015	Jan 2016-Dec 2016	Jan 2017-Dec 2017	Jan 2018-Dec 2018	Jan 2019-Dec 2019	Jan 2020-Dec 2020	Jan 2021-Dec 2037
KE-18	569575.0000	146237.0000	0.0	0.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KE-19	569171.0000	147089.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	0.0
199-K-156	569674.0100	147270.9100	60.0	60.0	100.0	100.0	60.0	60.0	60.0	50.0	55.0	55.0	55.0
199-K-191	569710.7600	146885.9700	0.0	0.0	100.0	100.0	100.0	100.0	0.0	0.0	0.0	0.0	0.0
Bio-Infiltration KE Head House	569359.3500	146289.7300	0.0	0.0	0.0	0.0	285	285	140	140	140	140	0.0
199-K-130	570478.9900	148661.1800	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-40.0	-15.0
199-K-131	570662.0000	148903.8500	-45.0	-45.0	-45.0	-45.0	-45.0	-45.0	-45.0	-45.0	-45.0	-45.0	-20.0
199-K-146	570197.6000	148379.7800	-15.0	-15.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0
199-K-147	570411.6400	148558.0700	-20.0	-20.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0
199-K-148	570584.7400	148767.8600	-45.0	-45.0	-45.0	-45.0	-45.0	-45.0	-45.0	-45.0	-45.0	-45.0	-25.0
199-K-149	570778.2500	148970.7400	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	0.0	0.0	0.0	0.0
199-K-150	570787.6700	149051.9300	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	0.0	0.0	0.0	0.0
199-K-153	570530.0400	148210.0800	-25.0	-25.0	-25.0	-25.0	-25.0	-25.0	-15.0	-25.0	-25.0	-25.0	-25.0
199-K-154	570320.6900	148027.7200	-35.0	-35.0	-35.0	-35.0	-30.0	-30.0	-30.0	-35.0	-35.0	-35.0	-30.0
199-K-161	570004.4300	148202.1300	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	0.0	0.0	0.0	0.0
199-K-163	570230.6600	147947.9300	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-15.0	-30.0	-30.0	-30.0	0.0
199-K-151	570941.3200	148686.4400	0.0	0.0	-20.0	-20.0	-20.0	-20.0	-20.0	-20.0	0.0	0.0	0.0
199-K-152	570736.2500	148585.8900	0.0	0.0	-20.0	-20.0	-20.0	-20.0	-20.0	-20.0	-20.0	-20.0	0.0
KN-1	569800.0000	148095.0000	0.0	0.0	-30.0	-30.0	-30.0	-30.0	-15.0	0.0	0.0	0.0	0.0
KN-2	570317.0000	148286.0000	0.0	0.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0
199-K-143	570934.4100	148088.2800	60.0	60.0	110.0	110.0	95.0	95.0	60.0	50.0	80.0	80.0	0.0
199-K-159	570911.9800	149159.8600	20.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
199-K-160	570919.5800	149116.0200	20.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
199-K-164	571202.2200	148903.7400	45.0	45.0	100.0	100.0	70.0	70.0	40.0	0.0	0.0	0.0	0.0
199-K-169	569988.9700	147554.9800	60.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
199-K-170	570009.0100	147491.3700	60.0	60.0	100.0	100.0	60.0	60.0	35.0	0.0	0.0	0.0	0.0

Table 3-4. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 2

Well Name	Easting	Northing	Jan 2011-Dec 2011	Jan 2012-Dec 2012	Jan 2013-Dec 2013	Jan 2014-Dec 2014	Jan 2015-Dec 2015	Jan 2016-Dec 2016	Jan 2017-Dec 2017	Jan 2018-Dec 2018	Jan 2019-Dec 2019	Jan 2020-Dec 2020	Jan 2021-Dec 2037
199-K-171	570544.0300	147187.8600	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	-30.0	95.0	100.0	100.0	65.0
199-K-172	570871.6900	147166.3700	70.0	70.0	110.0	110.0	90.0	90.0	70.0	0.0	0.0	0.0	0.0
199-K-180	571116.0800	147449.1400	60.0	60.0	110.0	110.0	90.0	90.0	0.0	0.0	0.0	0.0	0.0
199-K-182	571185.3200	148350.2400	0.0	0.0	105.0	105.0	85.0	85.0	70.0	40.0	40.0	40.0	0.0
KW-2	568593.0000	146749.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	0.0
KW-3	568666.0000	146789.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	0.0
KW-4	568752.0000	146839.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	-35.0	0.0
KN-3	570534.0000	147546.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	100.0	100.0	100.0	100.0	0.0
KN-4	570490.0000	147835.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-40.0	-40.0	-40.0	-40.0	0.0
KN-5	570673.0000	147618.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	100.0	100.0	100.0	100.0	0.0
KN-6	570590.0000	147941.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-40.0	-40.0	-40.0	-40.0	0.0
KN-7	570707.0000	148715.0000	0.0	0.0	-35.0	-35.0	-35.0	-35.0	-40.0	-40.0	-40.0	-40.0	0.0

[1] Pumping rates in gallons per minute (gpm)
[2] Negative values indicate extraction
[3] Shaded cells indicate bioremediation

3.4.3 Alternative 3: Aggressive P&T

Alternative 3 considers operation of the interim action P&T during 2011-2012 and an expanded network of P&T extraction and injection wells for the period 2013-2020. The required system capacity is significantly increased compared to the interim action P&T. Additional extraction and injection well locations were determined based on the CrVI plume distribution to expedite plume recovery and attain cleanup targets by 2020 without consideration of any spatial restrictions. Ambient aquifer conditions are simulated for the period 2021-2087.

Figure 3-9 shows the extraction and injection well configuration for Alternative 3. Detailed account of the pumping rates for all wells is included in Table 3-5.

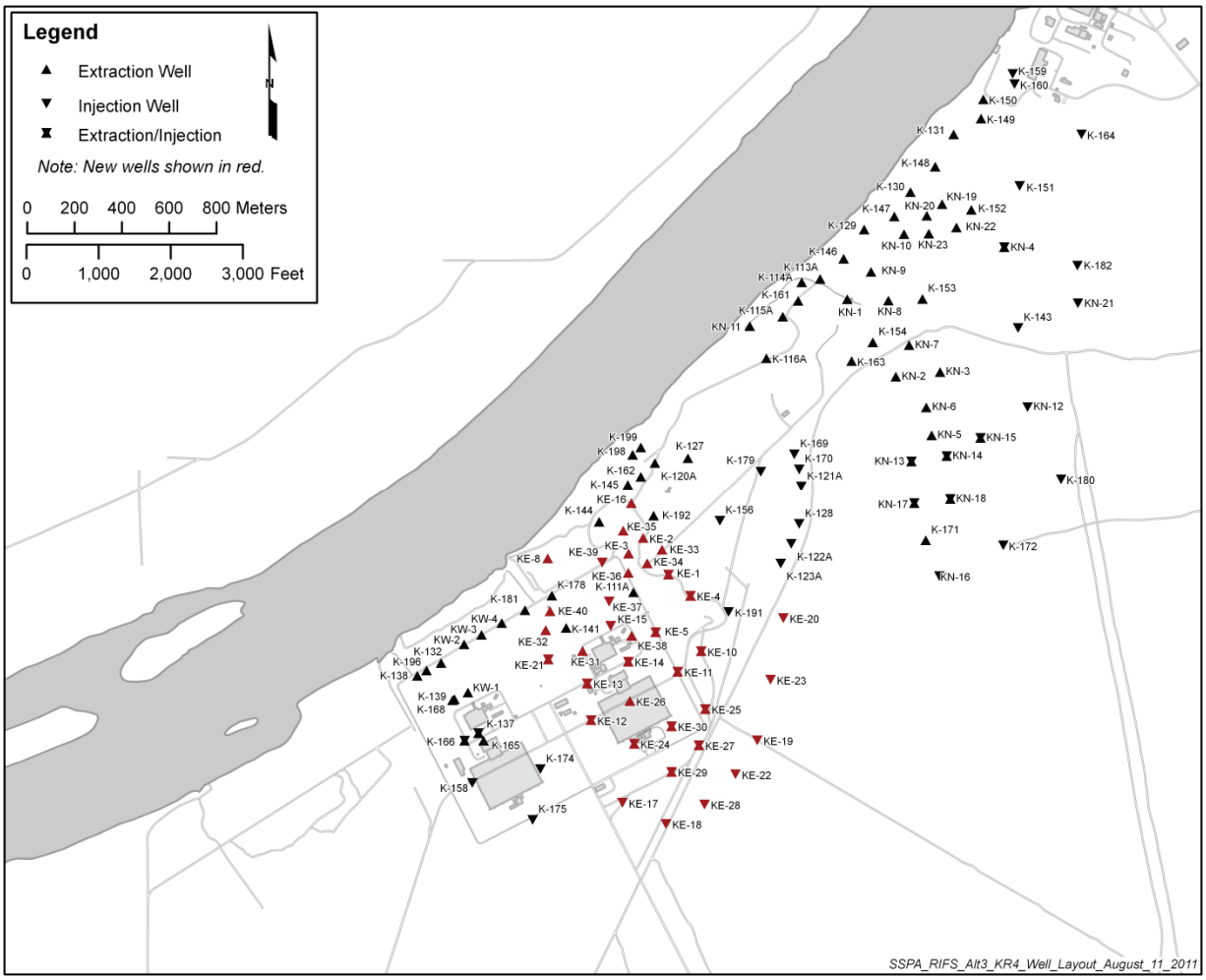


Figure 3-9. Extraction/Injection Well Configuration – Alternative 3.

Table 3-5. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 3

Well Name	Easting	Northing	Jan 2011 – Dec 2011	Jan 2012 – Dec 2012	Jan 2013 – Dec 2013	Jan 2014 – Dec 2014	Jan 2015 – Dec 2015	Jan 2016 – Dec 2016	Jan 2017 – Dec 2017	Jan 2018 – Dec 2018	Jan 2019 – Dec 2019	Jan 2020 – Dec 2020	Jan 2021 – Dec 2087
199-K-120A	569399.6150	147518.4770	-20[1,2]	-20	0	0	0	0	0	0	0	0	0
199-K-127	569539.2340	147539.0020	-10	0	0	0	0	0	0	0	0	0	0
199-K-144	569163.3400	147265.9600	-35	-25	-25	-25	-25	-25	-25	-25	-25	-25	0
199-K-145	569284.6000	147425.6600	-35	-25	-25	-25	-25	-25	-25	-25	-25	-25	0
199-K-162	569340.0000	147459.9700	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	0
199-K-198	569305.6900	147552.2200	0	-25	-30	-30	-30	-30	-30	-30	-30	-30	0
199-K-199	569339.6500	147584.4200	0	-25	-30	-30	-30	-30	-30	-30	-30	-30	0
199-K-179	569847.2500	147481.9200	60	60	40	40	40	40	40	40	40	40	0
199-K-113A	570098.0700	148294.4530	-20	-15	-15	-15	-15	-15	-15	-15	-15	-15	0
199-K-114A	570020.3020	148280.5500	-30	-25	-30	-30	-30	-30	-30	-30	-30	-30	0
199-K-115A	569939.9880	148135.4170	-30	-25	-30	-30	-30	-30	-30	-30	-30	-30	0
199-K-116A	569871.1490	147960.4950	-25	-20	0	0	0	0	0	0	0	0	0
199-K-129	570283.6500	148503.0700	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	0
199-K-121A	570017.1650	147418.2600	35	35	35	35	35	35	35	35	35	35	0
199-K-122A	569975.0680	147172.8590	50	50	50	50	50	50	50	50	50	50	0
199-K-123A	569931.1030	147090.2440	60	60	60	60	60	60	60	60	60	60	0
199-K-128	570009.5380	147257.5200	50	50	50	50	50	50	50	50	50	50	0
199-K-132	568495.1200	146670.8200	-30	-25	-35	-35	-35	-35	-35	-35	-35	-35	0
199-K-138	568395.2200	146616.6400	-30	-25	-25	-25	-25	-25	-25	-25	-25	-25	0
199-K-168	568544.3700	146513.6300	-20	-15	-20	-20	-20	-20	-20	-20	-20	-20	0
199-K-166	568594.5600	146342.9700	-20	-15	-25	-25	-25	-25	-25	-25	20	20	0
199-K-137	568653.3700	146374.5100	-20	-15	-25	-25	-25	-25	-25	-25	20	20	0
199-K-165	568674.9600	146342.4200	-30	-30	-30	-30	-30	-30	-30	-30	0	0	0
199-K-139	568551.3900	146518.3900	-20	-10	-20	-20	-20	-20	-20	-20	-20	-20	0
199-K-196	568433.3900	146639.0300	0	-35	-40	-40	-40	-35	-35	-35	-40	-40	0
KW-1	568609.0000	146546.0000	0	0	0	0	0	-35	-35	-35	-40	-40	0
199-K-158	568627.4500	146164.4100	50	50	60	60	60	70	70	70	0	0	0
199-K-174	568915.3800	146222.4700	40	40	70	70	70	70	70	70	75	75	0

Table 3-5. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 3

Well Name	Easting	Northing	Jan 2011 – Dec 2011	Jan 2012 – Dec 2012	Jan 2013 – Dec 2013	Jan 2014 – Dec 2014	Jan 2015 – Dec 2015	Jan 2016 – Dec 2016	Jan 2017 – Dec 2017	Jan 2018 – Dec 2018	Jan 2019 – Dec 2019	Jan 2020 – Dec 2020	Jan 2021 – Dec 2087
199-K-175	568882.7200	146008.8400	80	80	90	90	90	110	110	110	65	65	0
199-K-141	569024.2200	146818.4900	-25	-25	-25	-25	-25	-30	-30	-30	-30	-30	0
199-K-178	568963.0100	146954.4300	-40	-40	-35	-35	-35	-35	-35	-35	-35	-35	0
199-K-181	568849.7500	146892.8200	-20	-20	-20	-20	-20	-20	-20	-20	-20	-20	0
199-K-156	569674.0100	147270.9100	60	60	100	100	100	100	100	80	100	100	0
199-K-130	570478.9900	148661.1800	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	0
199-K-131	570662.0000	148903.8500	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	0
199-K-146	570197.6000	148379.7800	-15	-15	-25	-25	-25	-25	-25	-25	-25	-25	0
199-K-147	570411.6400	148558.0700	-20	-20	-30	-30	-30	-30	-30	-30	-30	-30	0
199-K-148	570584.7400	148767.8600	-45	-45	-45	-45	-45	-45	-45	-45	-45	-45	0
199-K-149	570778.2500	148970.7400	-30	-30	-30	-30	-30	0	0	0	0	0	0
199-K-150	570787.6700	149051.9300	-25	-25	-20	-20	-20	0	0	0	0	0	0
199-K-153	570530.0400	148210.0800	-25	-25	-10	-10	-10	-25	-25	-25	-25	-25	0
199-K-154	570320.6900	148027.7200	-35	-35	-25	-25	-25	-30	-30	-30	-30	-30	0
199-K-161	570004.4300	148202.1300	-30	-30	-25	-25	-25	0	0	0	0	0	0
199-K-163	570230.6600	147947.9300	-30	-30	-10	-10	-10	0	0	0	0	0	0
199-K-143	570934.4100	148088.2800	60	60	80	80	80	70	70	70	50	50	0
199-K-159	570911.7300	149159.6100	20	20	0	0	0	0	0	0	0	0	0
199-K-160	570919.5800	149116.0200	20	20	0	0	0	0	0	0	0	0	0
199-K-164	571202.2200	148903.7400	45	45	100	100	100	0	0	0	0	0	0
199-K-169	569988.9700	147554.9800	60	60	100	100	100	60	60	60	60	60	0
199-K-170	570009.0100	147491.3700	60	60	100	100	100	60	60	60	60	60	0
199-K-171	570544.0300	147187.8600	-30	-30	-30	-30	-30	-30	100	0	0	0	0
199-K-172	570871.6900	147166.3700	70	70	100	100	100	0	0	0	0	0	0
199-K-180	571116.0800	147449.1400	60	60	100	100	100	0	0	0	0	0	0
199-K-111A	569308.1690	146968.8750	0	0	-30	-30	-30	-30	-30	-35	-35	-35	0
199-K-192	569394.0200	147292.6400	0	0	-20	-20	-20	-30	-30	-35	-30	-30	0
199-K-191	569710.7600	146885.9700	0	0	-20	-20	-20	80	80	50	0	0	0

Table 3-5. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 3

Well Name	Easting	Northing	Jan 2011 – Dec 2011	Jan 2012 – Dec 2012	Jan 2013 – Dec 2013	Jan 2014 – Dec 2014	Jan 2015 – Dec 2015	Jan 2016 – Dec 2016	Jan 2017 – Dec 2017	Jan 2018 – Dec 2018	Jan 2019 – Dec 2019	Jan 2020 – Dec 2020	Jan 2021 – Dec 2087
199-K-151	570941.3200	148686.4400	0	0	-15	-15	-15	40	40	40	40	40	0
199-K-152	570736.2500	148585.8900	0	0	-15	-15	-15	-20	-20	-20	-30	-30	0
199-K-182	571185.3200	148350.2400	0	0	100	100	100	80	90	95	0	0	0
KE-1	569457.0000	147043.0000	0	0	-30	-30	-30	-35	-35	-35	90	90	0
KE-2	569349.0000	147198.0000	0	0	-30	-30	-30	-35	-35	-35	-40	-40	0
KE-3	569288.0000	147132.0000	0	0	-30	-30	-30	-35	-35	-35	-40	-40	0
KE-4	569549.0000	146954.0000	0	0	-30	-30	-30	-35	-35	90	90	85	0
KE-5	569402.0000	146800.0000	0	0	-30	-30	-30	-35	-35	90	90	85	0
KE-8	568946.0000	147112.0000	0	0	-30	-30	-30	-35	-35	-35	-40	-40	0
KE-10	569595.0000	146720.0000	0	0	-30	-30	-30	-35	90	90	30	35	0
KE-11	569496.0000	146634.0000	0	0	-30	-30	-30	-35	90	90	30	35	0
KE-12	569129.0000	146429.0000	0	0	-30	-30	-30	-35	90	80	35	35	0
KE-13	569113.0000	146584.0000	0	0	-30	-30	-30	-35	-35	90	35	35	0
KE-14	569287.0000	146676.0000	0	0	-30	-30	-30	-35	-35	90	35	35	0
KE-15	569212.0000	146827.0000	0	0	100	100	100	60	100	100	100	100	0
KE-16	569300.0000	147345.0000	0	0	-30	-30	-30	-35	-35	-35	-40	-40	0
KE-17	569262.0000	146081.0000	0	0	100	100	100	90	45	45	45	45	0
KE-18	569446.0000	145992.0000	0	0	100	100	100	90	0	0	0	0	0
KE-19	569832.0000	146344.0000	0	0	100	100	100	0	0	0	0	0	0
KE-20	569942.0000	146860.0000	0	0	100	100	100	100	0	0	0	0	0
KE-22	569740.0000	146201.0000	0	0	100	100	100	0	0	0	0	0	0
KE-23	569888.0000	146600.0000	0	0	100	100	100	100	0	0	0	0	0
KE-24	569312.0000	146330.0000	0	0	-30	-30	-30	90	95	0	0	0	0
KE-25	569612.0000	146476.0000	0	0	-30	-30	-30	90	95	0	0	0	0
KE-26	569293.0000	146510.0000	0	0	-30	-30	-30	-35	95	0	0	0	0
KE-27	569585.0000	146324.0000	0	0	-30	-30	-30	90	0	0	0	0	0
KE-28	569609.0000	146074.0000	0	0	100	100	100	100	0	0	0	0	0
KE-29	569470.0000	146211.0000	0	0	-30	-30	-30	90	0	0	0	0	0

Table 3-5. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 3

Well Name	Easting	Northing	Jan 2011 – Dec 2011	Jan 2012 – Dec 2012	Jan 2013 – Dec 2013	Jan 2014 – Dec 2014	Jan 2015 – Dec 2015	Jan 2016 – Dec 2016	Jan 2017 – Dec 2017	Jan 2018 – Dec 2018	Jan 2019 – Dec 2019	Jan 2020 – Dec 2020	Jan 2021 – Dec 2087
KE-30	569470.0000	146404.0000	0	0	-30	-30	-30	90	100	0	0	0	0
KE-31	569093.0000	146721.0000	0	0	-30	-30	-30	-35	-35	-35	-35	-35	0
KE-32	568938.0000	146809.0000	0	0	-30	-30	-30	-35	-35	-35	-35	-35	0
KE-33	569430.0000	147148.0000	0	0	-30	-30	-30	-35	-35	-35	-35	-35	0
KE-34	569367.0000	147091.0000	0	0	-30	-30	-30	-35	-35	-35	-35	-35	0
KE-35	569265.0000	147228.0000	0	0	-30	-30	-30	-35	-35	-35	-35	-35	0
KE-36	569287.0000	147051.0000	0	0	-30	-30	-30	-35	-35	-35	-35	-35	0
KE-37	569206.0000	146930.0000	0	0	92.5	92.5	92.5	100	100	100	100	100	0
KE-38	569301.0000	146785.0000	0	0	-30	-30	-30	-35	-35	-35	-35	-35	0
KE-39	569176.0000	147094.0000	0	0	92.5	92.5	92.5	100	100	100	100	100	0
KE-40	568956.0000	146889.0000	0	0	-30	-30	-30	-35	-35	-35	-35	-35	0
KE-21	568948.0000	146686.0000	0	0	-30	-30	-30	-35	-35	-35	60	60	0
KN-9	570313.0000	148325.0000	0	0	-30	-30	-30	-30	-30	-30	-30	-30	0
KN-10	570452.0000	148484.0000	0	0	-30	-30	-30	-30	-30	-30	-40	-40	0
KN-11	569800.0000	148095.0000	0	0	-20	-20	-20	-30	-20	-20	-20	-20	0
KN-12	570975.0000	147754.0000	0	0	100	100	100	100	0	0	0	0	0
KN-1	570212.0000	148209.0000	0	0	-10	-10	-10	-30	-30	-30	-40	-40	0
KN-2	570418.0000	147882.0000	0	0	-25	-25	-25	-40	-40	-40	-40	-40	0
KN-3	570605.0000	147902.0000	0	0	-25	-25	-25	-40	-40	-40	-40	-40	0
KN-4	570876.0000	148428.0000	0	0	-25	-25	-25	-40	-40	-40	45	45	0
KN-5	570569.0000	147635.0000	0	0	-25	-25	-25	-40	-40	-40	-40	-40	0
KN-6	570546.0000	147753.0000	0	0	-25	-25	-25	-40	-40	-40	-40	-40	0
KN-7	570474.0000	148015.0000	0	0	-20	-20	-20	-40	-40	-40	-40	-40	0
KN-8	570386.0000	148204.0000	0	0	-20	-20	-20	-40	-40	-40	-40	-40	0
KN-13	570484.0000	147525.0000	0	0	-25	-25	-25	-30	-30	-35	60	60	0
KN-14	570633.0000	147547.0000	0	0	-25	-25	-25	-30	-30	-35	60	60	0
KN-15	570776.0000	147624.0000	0	0	-25	-25	-25	-30	-30	-30	60	60	0
KN-17	570496.0000	147345.0000	0	0	-30	-30	-30	-30	-30	60	60	60	0

Table 3-5. Names, Geographic Coordinates, and Extraction and Injection Rates of 100-KR-4 Wells - Alternative 3

Well Name	Easting	Northing	Jan 2011 – Dec 2011	Jan 2012 – Dec 2012	Jan 2013 – Dec 2013	Jan 2014 – Dec 2014	Jan 2015 – Dec 2015	Jan 2016 – Dec 2016	Jan 2017 – Dec 2017	Jan 2018 – Dec 2018	Jan 2019 – Dec 2019	Jan 2020 – Dec 2020	Jan 2021 – Dec 2087
KN-18	570648.0000	147362.0000	0	0	-30	-30	-30	-30	-30	60	60	60	0
KN-19	570613.0000	148610.0000	0	0	-30	-30	-30	-30	-30	-30	-40	-40	0
KN-20	570549.0000	148562.0000	0	0	-30	-30	-30	-30	-30	-30	-40	-40	0
KN-21	571187.0000	148192.0000	0	0	100	100	100	100	100	80	0	0	0
KN-22	570674.0000	148512.0000	0	0	-30	-30	-30	-30	-30	-30	-40	-40	0
KN-23	570557.0000	148486.0000	0	0	-30	-30	-30	-30	-30	-30	-40	-40	0
KN-16	570601.0000	147037.0000	0	0	-25	-25	-25	100	100	0	0	0	0
KW-2	568593.0000	146749.0000	0	0	-35	-35	-35	-35	-35	-35	-35	-35	0
KW-3	568666.0000	146789.0000	0	0	-35	-35	-35	-35	-35	-35	-35	-35	0
KW-4	568752.0000	146839.0000	0	0	-35	-35	-35	-35	-35	-35	-35	-35	0

[1] Pumping rates in gallons per minute (gpm)

[2] Negative values indicate extraction

3.5 Model Assumptions and Limitations

The principal assumptions and limitations of the modeling analyses are described below:

- The Ringold Upper Mud Formation, where present, is considered a vertical no-flow boundary. However, sensitivity analysis should be performed to examine the effects, if any, of possible flow across the bottom of the model on plume migration and on the efficiency of the proposed remedies.
- The initial CrVI distribution is based on currently available data from a finite number of sampling points. Acquisition of new data (including new sampling locations) could lead to different plume distributions and different projections of plume migration and mass recovery.
- Small-scale heterogeneity and its effect on CrVI transport are incorporated in the model through a dual-domain formulation. However, the parameters that describe mass transfer between the mobile and immobile phases are calculated based on limited information from soil column experiments. Actual field-scale values could vary significantly and should be evaluated through model calibration when remedy mass recovery data are collected.
- The model does not include continuing sources in the vadose zone or the RUM. The presence of such sources could significantly prolong aquifer cleanup times.
- Any scheduled or unforeseen shut-down periods of the proposed treatment systems (or components of them) will have direct impacts on plume migration. The nature and extent of those impacts cannot be determined a-priori and result in remedy performance that differs from that presented in this report.

As a result of the above - and consistent with recommendations made throughout the remedy design process - simulated COC distributions in the future, under a variety of potential remedy alternatives, should be interpreted as relative estimates and not as absolute predictions of actual plume migration patterns. Upon implementation of any remedy design, monitoring data should be compiled and analyzed to further improve estimation of the parameters associated with the simulation of the fate and transport of the COCs and performance of the implemented remedies. The model should be updated to provide improving estimates of remedy performance. The same procedure should be followed if well operation and performance in the future are different from those described for each Alternative, as predicted plume migration patterns are contingent upon the extraction/injection well operation and performance that those predictions were based on.

4. Software Applications, Descriptions, Installation & Checkout, and Statements of Validity

Software use for this calculation was in accordance with PRC-PRO-IRM-309, Controlled Software Management.

4.1 Approved Software

The following software was used to perform calculations and was approved and compliant with PRC-PRO-IRM-309 (PRC-PRO-IRM-309, Controlled Software Management). These software are managed under the following documents consistent with PRC-PRO-IRM-309: CHPRC-00257 Rev 1, MODFLOW and Related Codes Functional Requirements Document, CHPRC-00258 Rev 2, MODFLOW and Related Codes Software Management Plan, CHPRC-00259 Rev 1, MODFLOW and Related Codes Software Test Plan, CHPRC-00260 Rev 2, MODFLOW and Related Codes Acceptance Test Report, and CHPRC-

00261 Rev 1, MODFLOW and Related Codes Requirements Traceability Matrix. CHPRC-00258 Rev 2 distinguishes between safety software and support software based on whether the software managed calculates reportable results or provides run support, visualization, or other similar functions. Brief descriptions of the software are provided below.

4.2 Descriptions

4.2.1 MODFLOW (Controlled Calculation Software)

- Software Title: MODFLOW-2000 (Open File Report 00-92, MODFLOW-2000, the US. Geological Survey Modular Ground-water model -- User Guide to Modularization Concepts and the Ground- Water Flow); solves transient groundwater flow equations using the finite-difference discretization technique.
- Software Version: Version 2.1.18 modified by S.S. Papadopulos and Associates, Inc. (SSP&A) for minimum saturated thickness and to use the Orthomnin solver; approved as CHPRC Build 0004 using executable mf2k-mst-0004dp (compiled to default double precision for real variables).
- Hanford Information Systems Inventory (HISI) Identification Number: 2517 (Safety Software, graded Level C).
- Workstation type and property number (from which software is run):
    - S.S. Papadopulos and Assoc, Inc, FE406, FE407, FE410, and FE420.

4.2.2 MT3DMS (Controlled Calculation Software)

- Software Title: MT3DMS (Zheng and Wang 1999), MT3DMS: A Modular Three-dimensional Multispecies Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide); MT3DMS V5.2 Supplemental User's Guide [Zheng 2006])
- Software Version: Version 5.2 modified by S.S. Papadopulos and Associates, Inc. (SSP&A) for minimum saturated thickness; approved as CHPRC Build 0004 using executable mt3d-mst-0004dp (compiled to default double precision for real variables).
- HISI Identification Number: 2518 (Safety Software, graded Level C).
- Workstation type and property number (from which software is run):
    - S.S. Papadopulos and Assoc, Inc, FE406, FE407, FE410, and FE420.

4.2.3 Software Installation and Checkout

Safety Software (CHPRC Build 0004 of MODFLOW-2000-SSPA) is checked out in accordance with procedures specified in CHPRC-00258 Rev 2. Executables are obtained from the CHPRC software owner who maintains the configuration managed copies in MKS Integrity™[2], installation tests identified in CHPRC-00259 Rev 1 performed and successful installation confirmed, and Software Installation and Checkout Forms are required and must be approved for installations used to perform model runs. Approved Users are registered in HISI for safety software.

4.2.4 Statement of Valid Software Application

- The software identified above was used consistent with intended use for CHPRC as identified in CHPRC-00257 Rev 1 and is a valid use of this software for the problem addressed in this application.
- The software was used within its limitations as identified in CBiPRC-00257 Rev 1.

[1] MKS Integrity is a trademark of MKS, Incorporated.

5. Calculation

The following maps and graphs were constructed for each alternative, to provide the basis for the evaluation of system performance:

1. Maps of hydraulic capture efficiency.
2. Maps depicting the simulated spatial distribution of each COC in December 2012, 2016, 2020, 2037 (if the COC is still present in the aquifer), and 2087 (if the COC is still present in the aquifer).
3. Graphs of concentration-versus-time time series for CrVI concentrations at the shoreline and in the aquifer.

5.1 Alternative 1: No Action

Figure 5-1 illustrates the hydraulic capture efficiency in 2012 for the interim action P&T. Figures 5-2 to 5-6 illustrate the simulated distribution of CrVI in 2012, 2016, 2020, 2037, and 2087, respectively. Figures 5-7 and 5-8 show the simulated time-series of concentration-versus-time for CrVI along the shoreline and in the aquifer during the simulation timeframe. Figure 5-7 illustrates the effects on the maximum shoreline concentration of (a) ceasing all well operations in 2037, and (b) a varying river stage versus a constant river stage for years 2011-2037 and 2038-2087, respectively. Figures 5-9 to 5-13 illustrate the simulated distribution of Tritium in 2012, 2016, 2020, 2037, and 2087, respectively. Figures 5-14 to 5-18 illustrate the simulated distribution of Strontium-90 in 2012, 2016, 2020, 2037, and 2087, respectively. Figures 5-19 to 5-23 illustrate the simulated distribution of Nitrate in 2012, 2016, 2020, 2037, and 2087, respectively. Figures 5-24 to 5-27 illustrate the simulated distribution of Carbon-14 in 2012, 2016, 2020, and 2037, respectively. Figures 5-28 to 5-30 illustrate the simulated distribution of TCE in 2012, 2016 and 2020, respectively.

Figure 5-1. Capture Efficiency Map for CY2012 – Alternative 1.

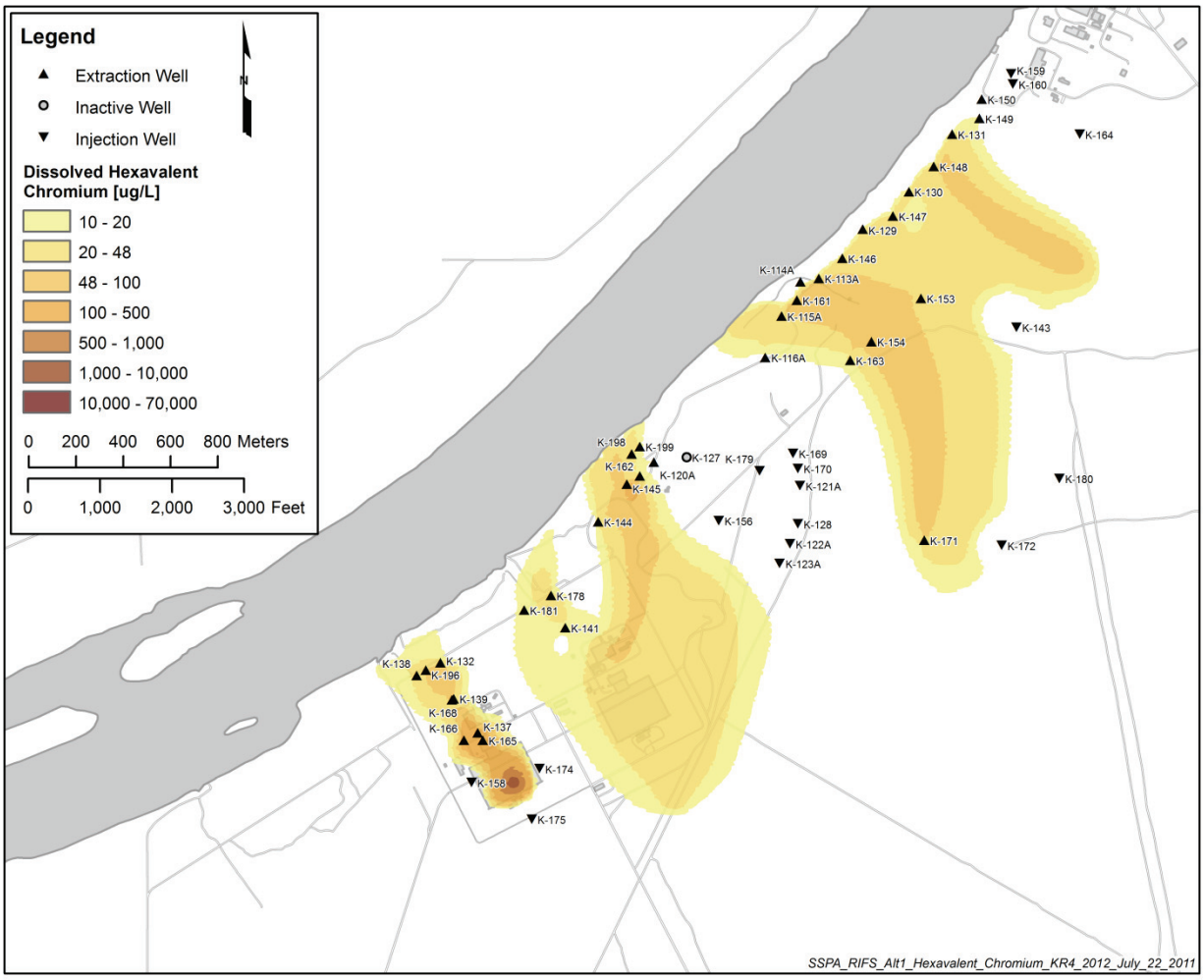


Figure 5-2. Simulated Distribution of CrVI in December 2012 – Alternative 1.

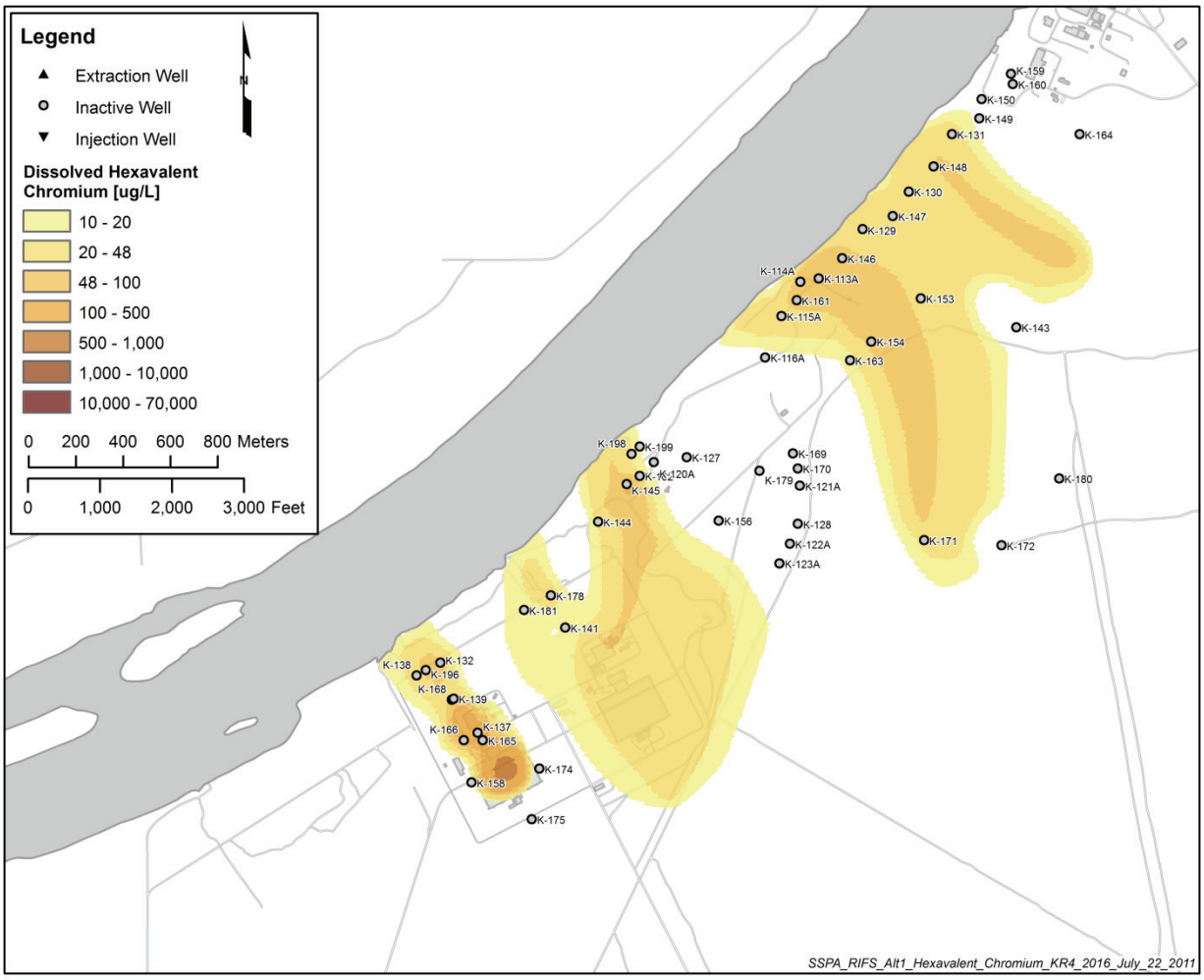


Figure 5-3. Simulated Distribution of CrVI in December 2016 – Alternative 1.

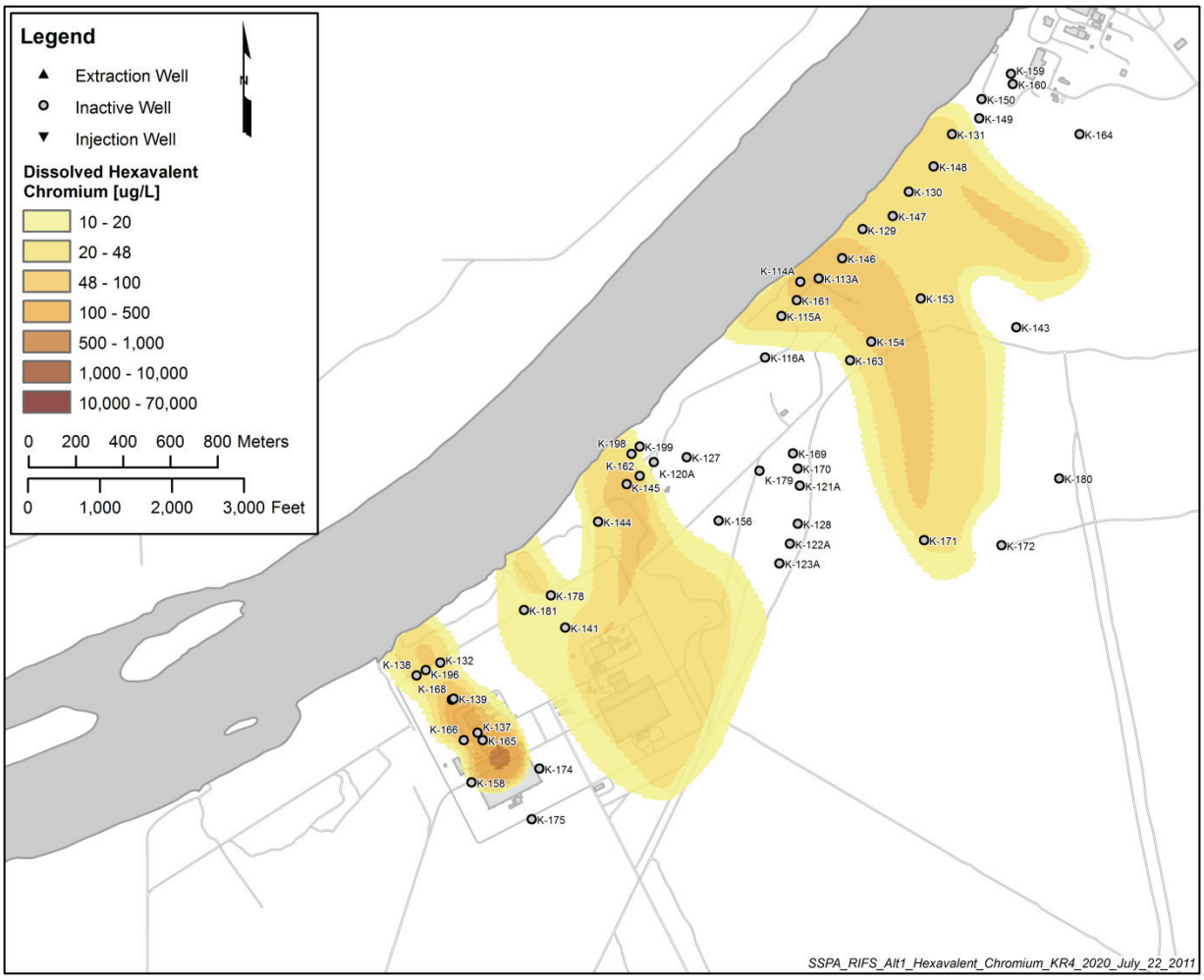


Figure 5-4. Simulated Distribution of CrVI in December 2020 – Alternative 1.

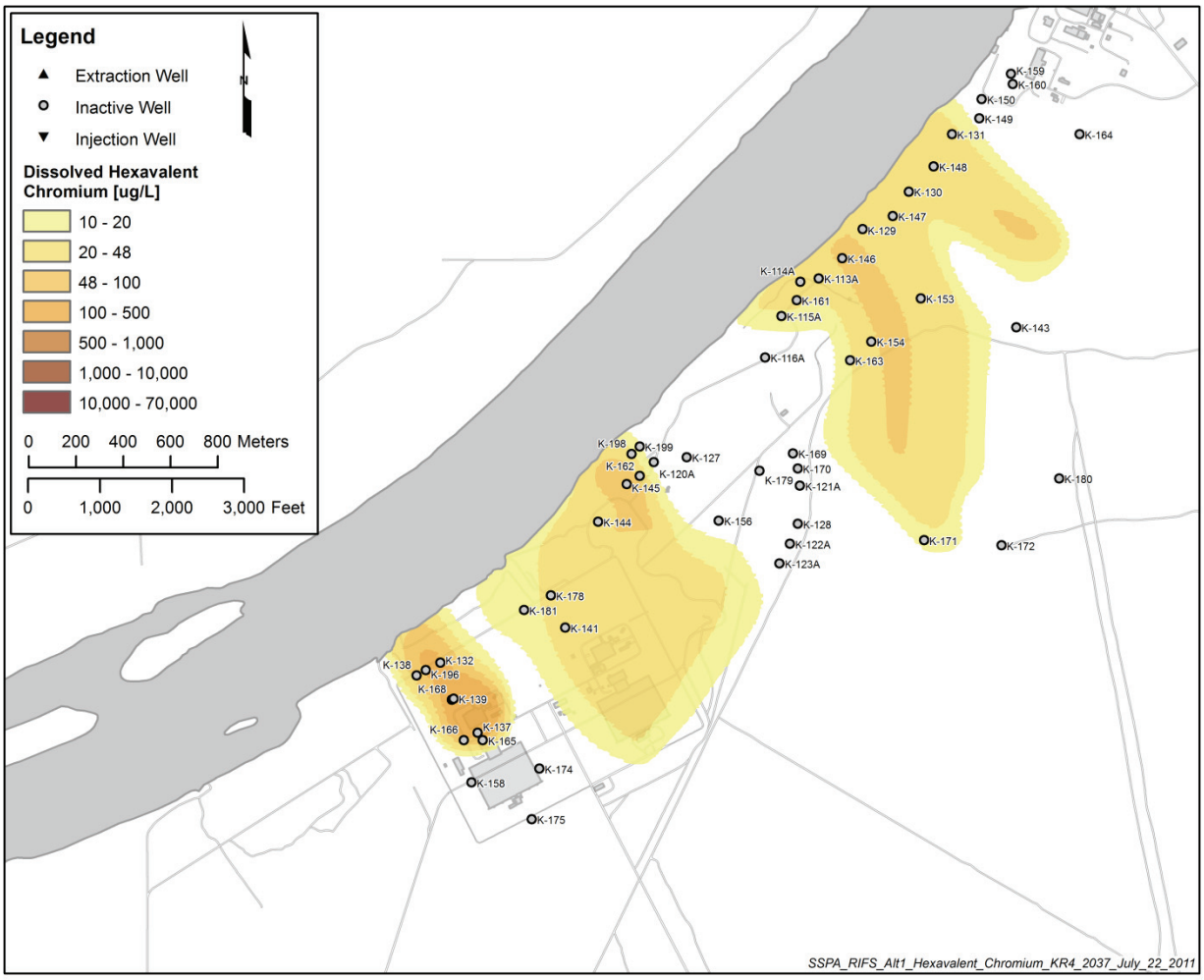


Figure 5-5. Simulated Distribution of CrVI in December 2037 – Alternative 1.

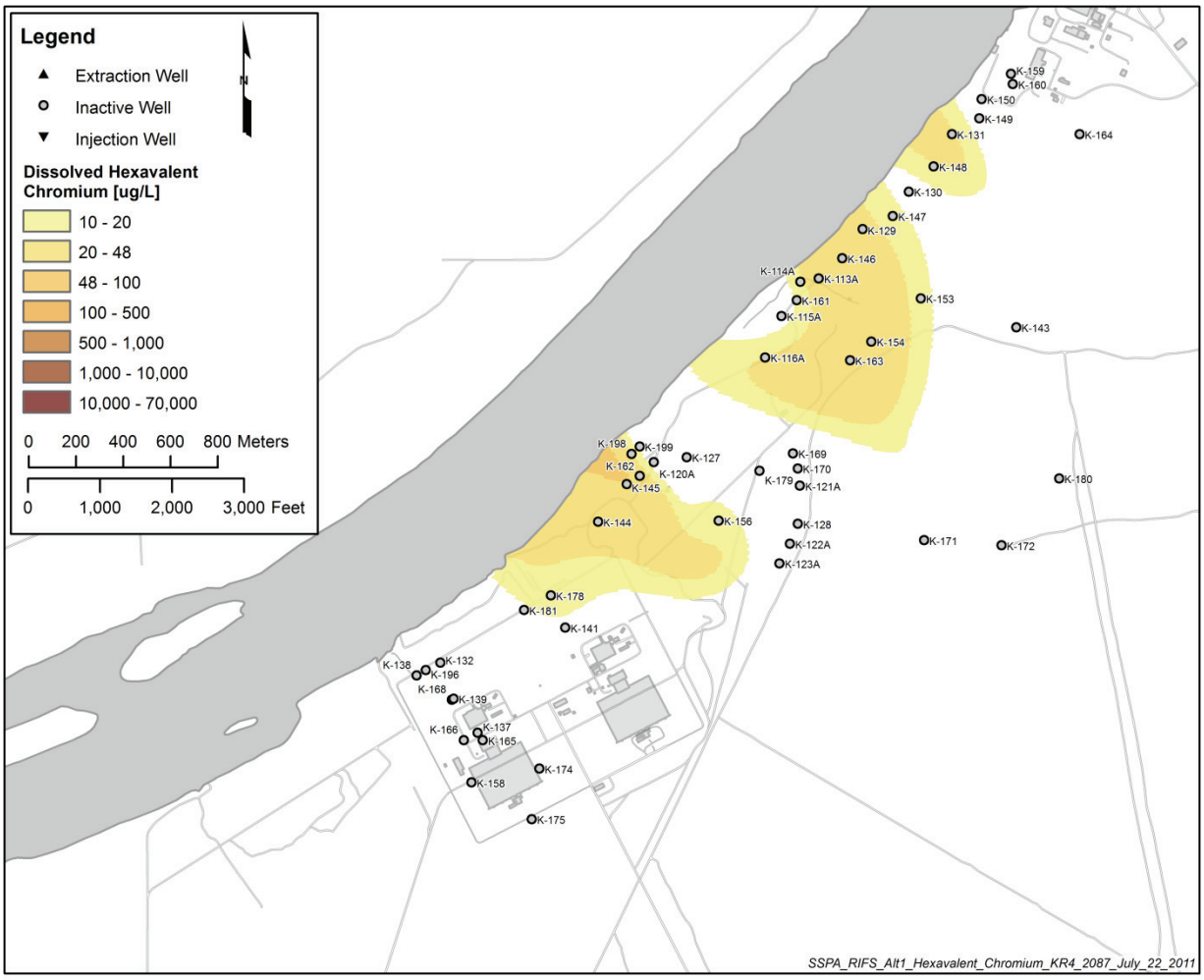


Figure 5-6. Simulated Distribution of CrVI in December 2087 – Alternative 1.

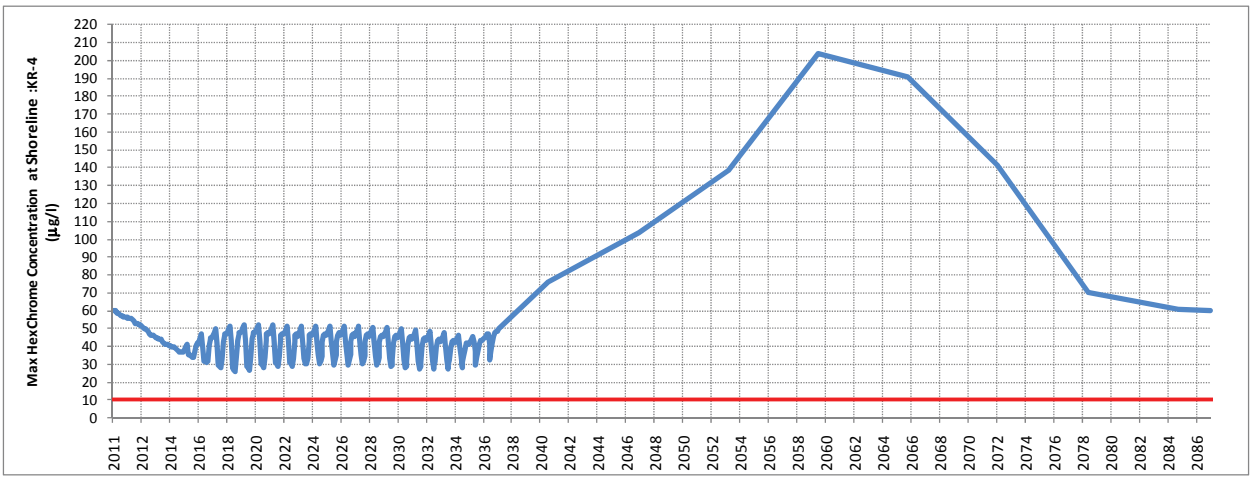


Figure 5-7. Simulated Maximum Dissolved CrVI Concentration along the Shoreline – Alternative 1.

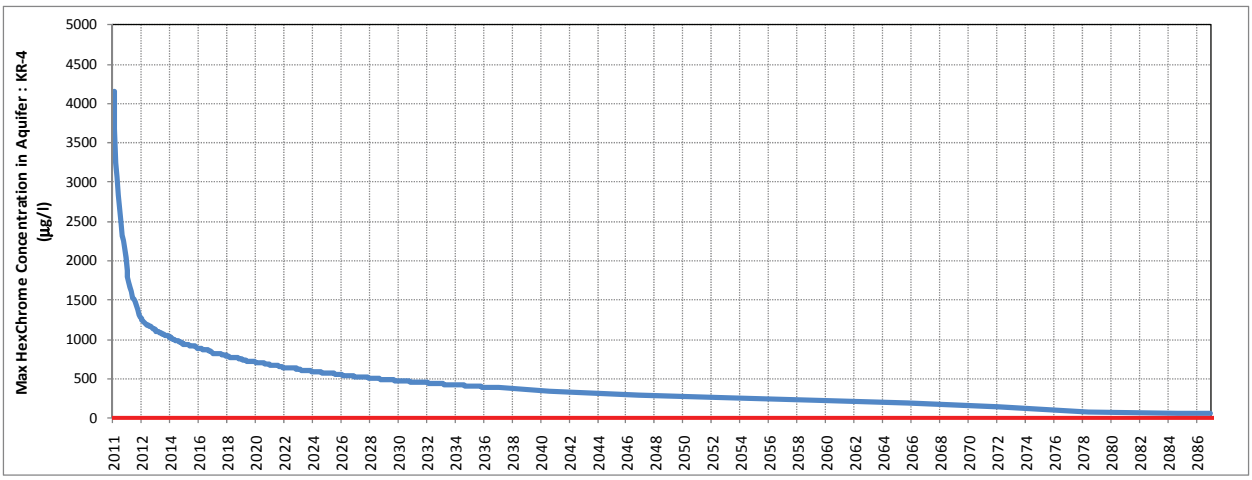


Figure 5-8. Simulated Maximum Dissolved CrVI Concentration in the Aquifer – Alternative 1.

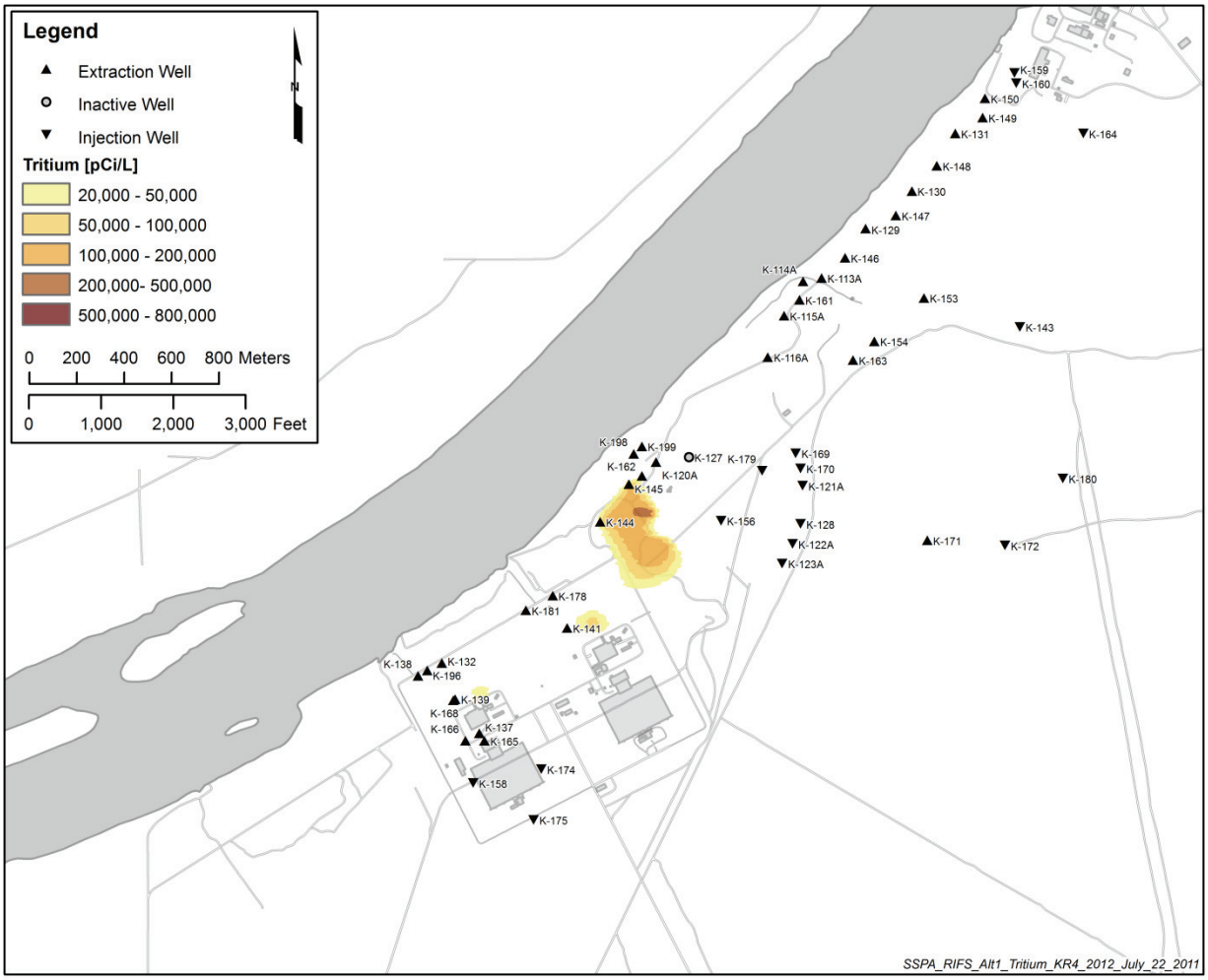


Figure 5-9. Simulated Distribution of Tritium in December 2012 – Alternative 1.

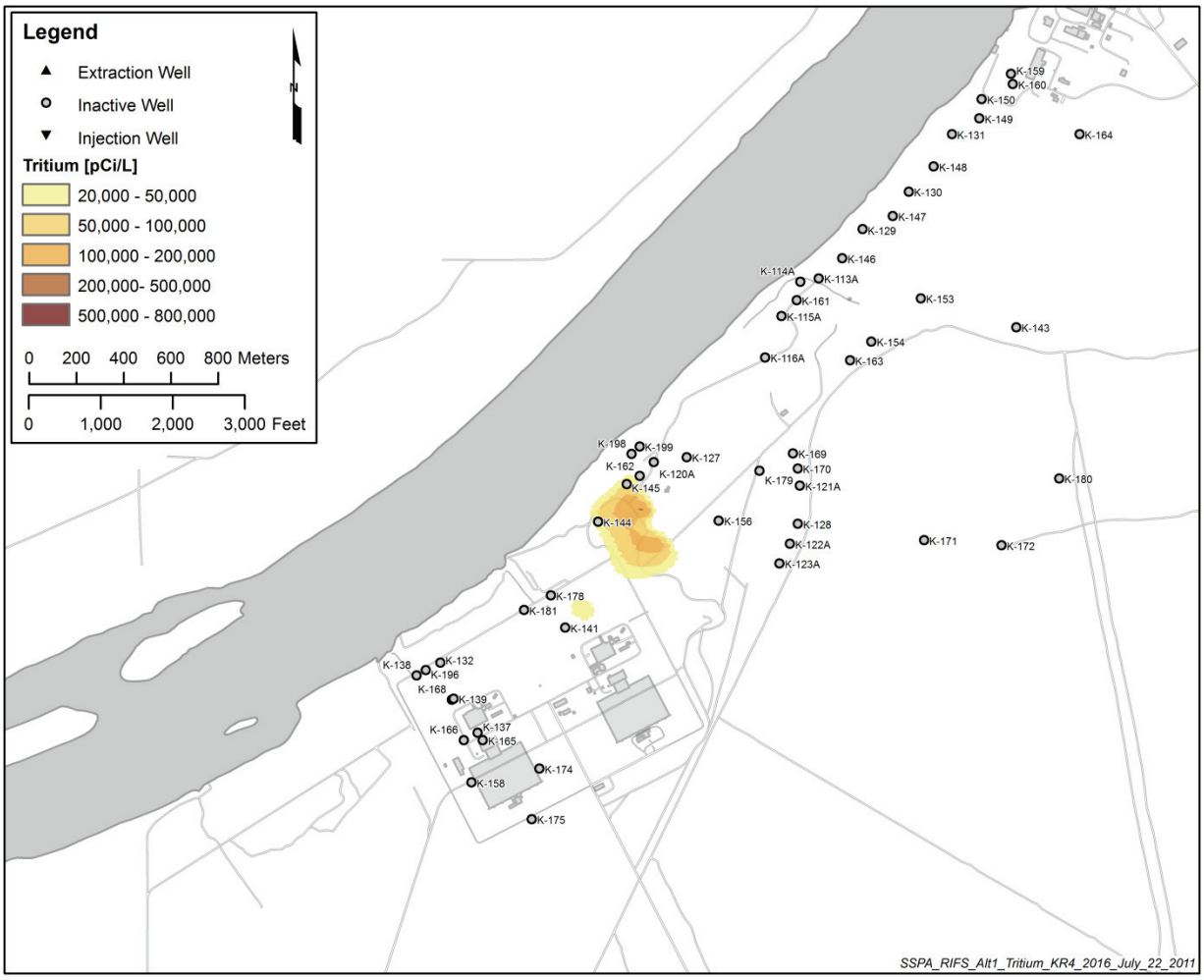


Figure 5-10. Simulated Distribution of Tritium in December 2016 – Alternative 1.

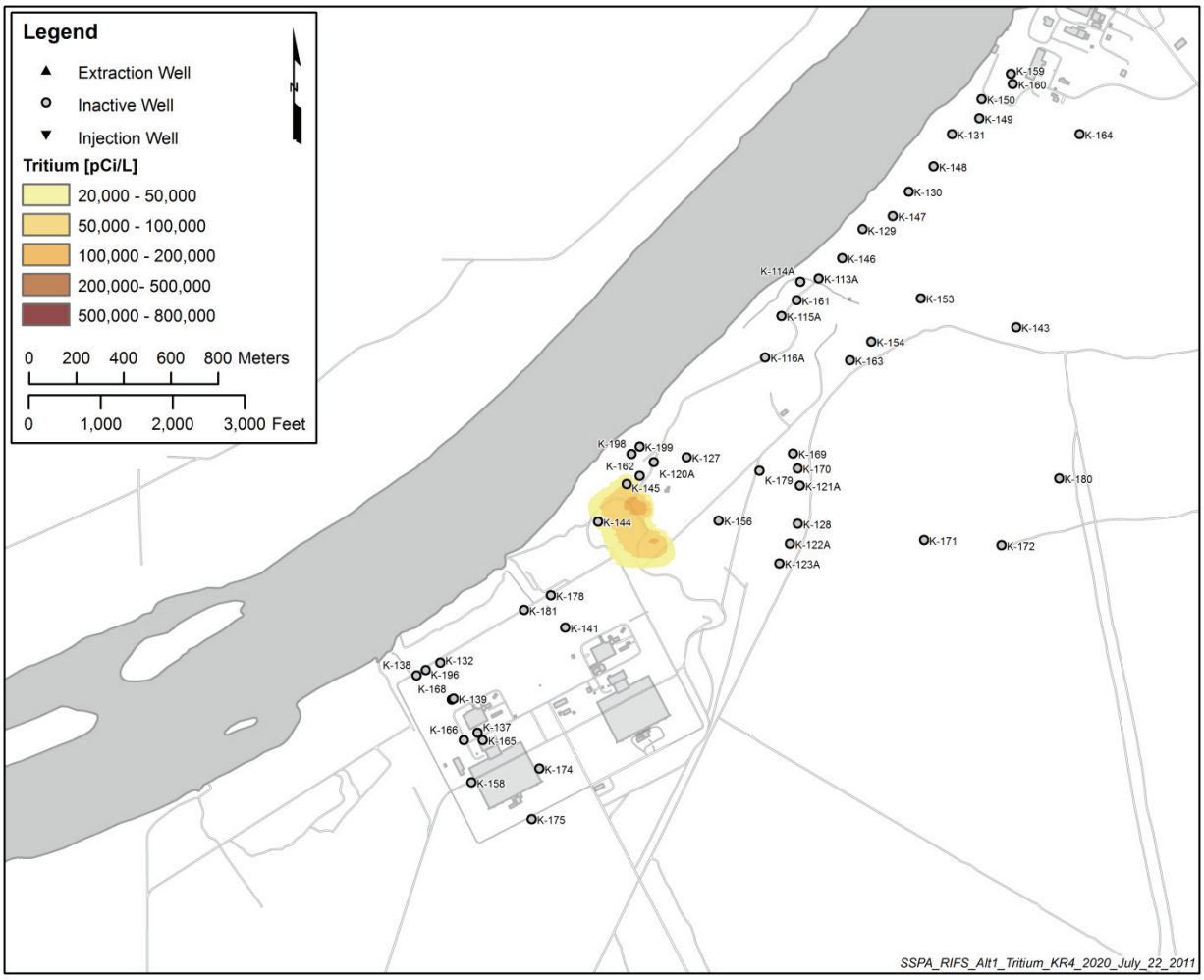


Figure 5-11. Simulated Distribution of Tritium in December 2020 – Alternative 1.

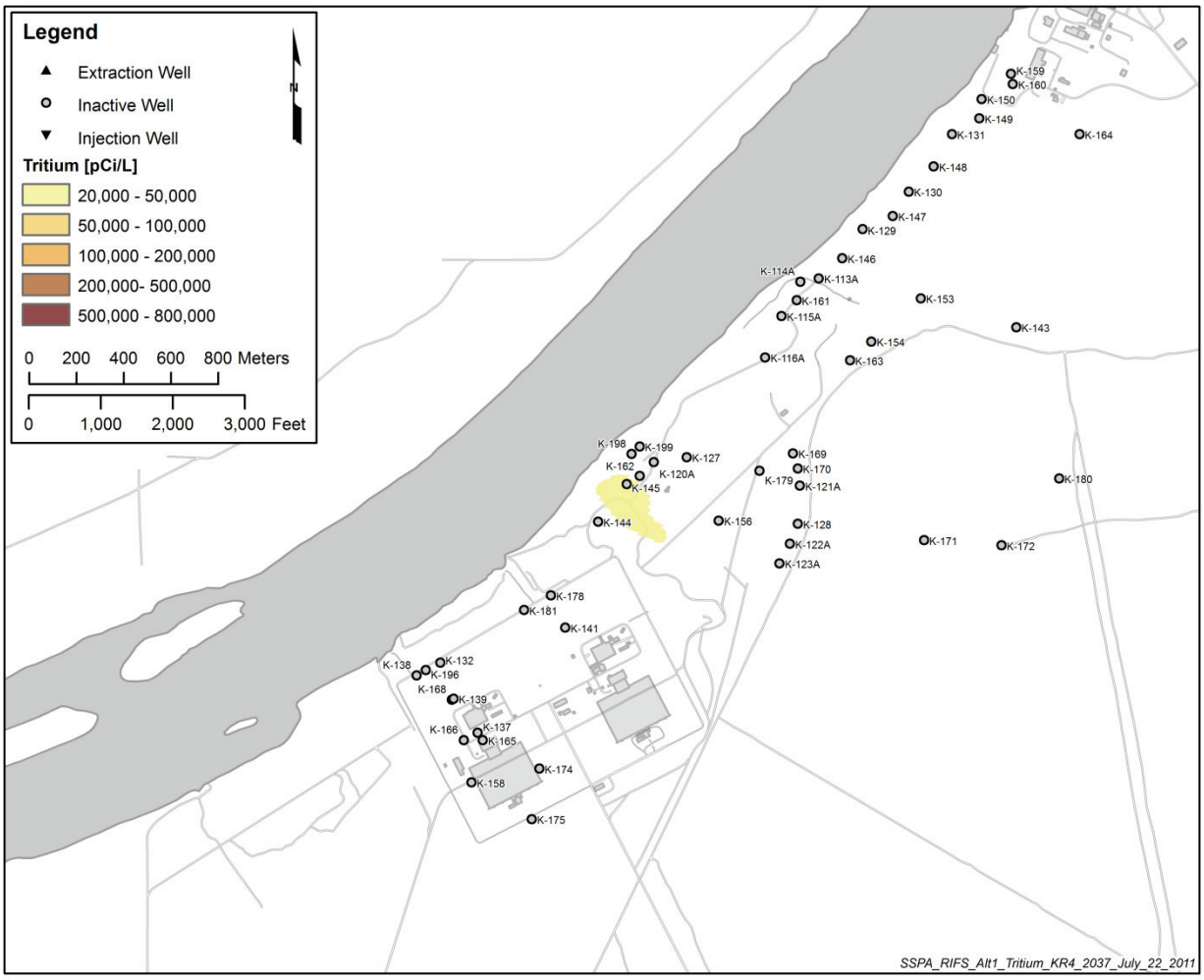


Figure 5-12. Simulated Distribution of Tritium in December 2037 – Alternative 1.

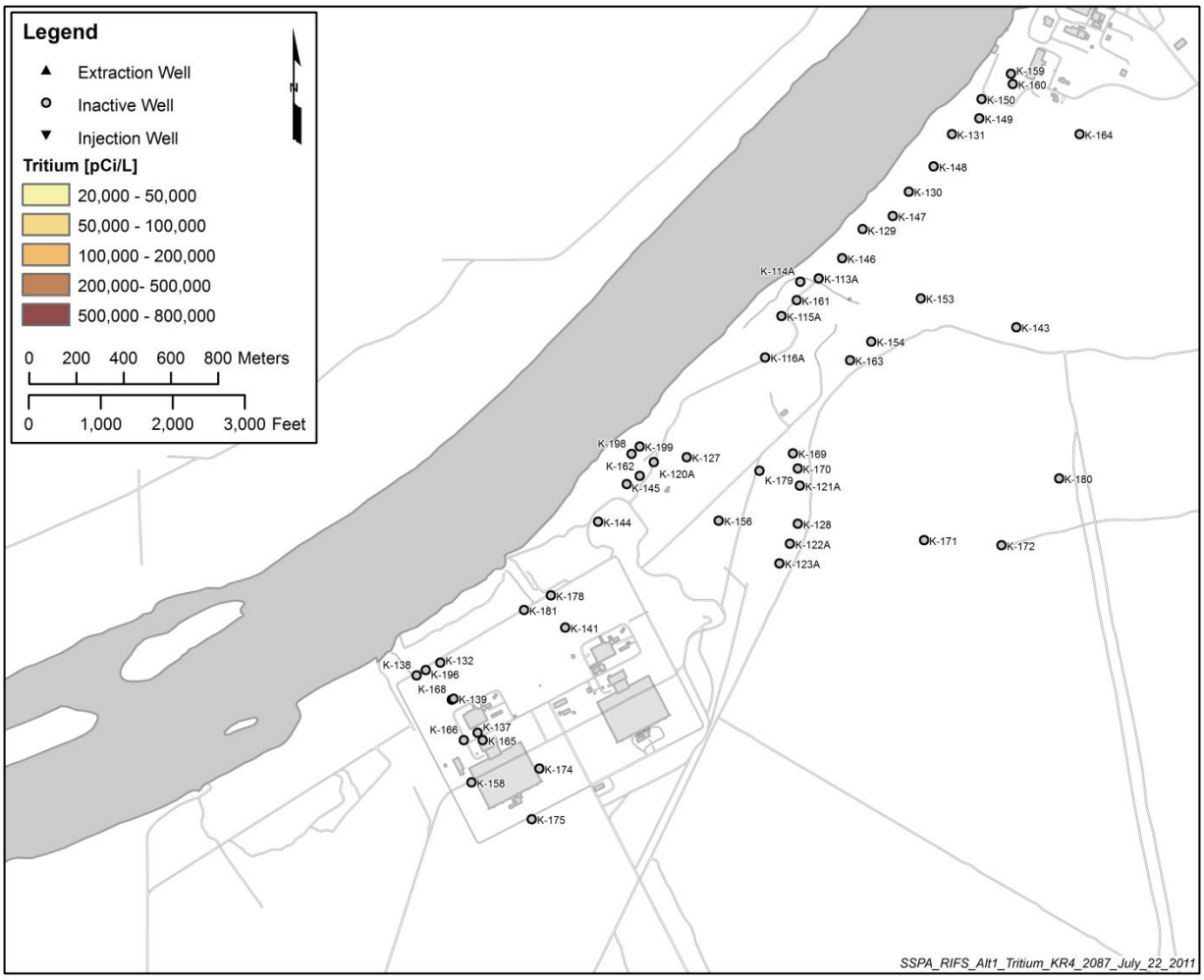


Figure 5-13. Simulated Distribution of Tritium in December 2087 – Alternative 1.

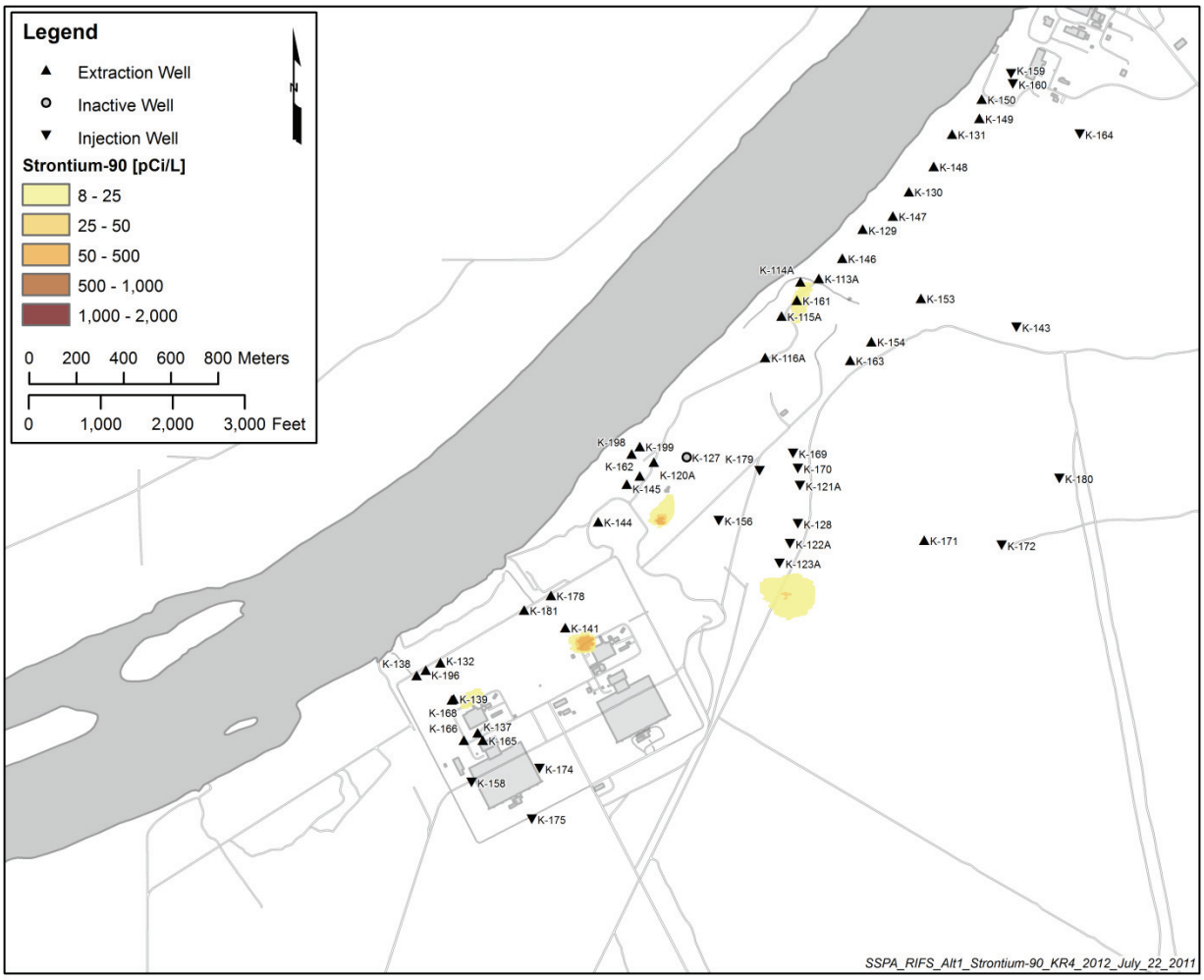


Figure 5-14. Simulated Distribution of Strontium-90 in December 2012 – Alternative 1.

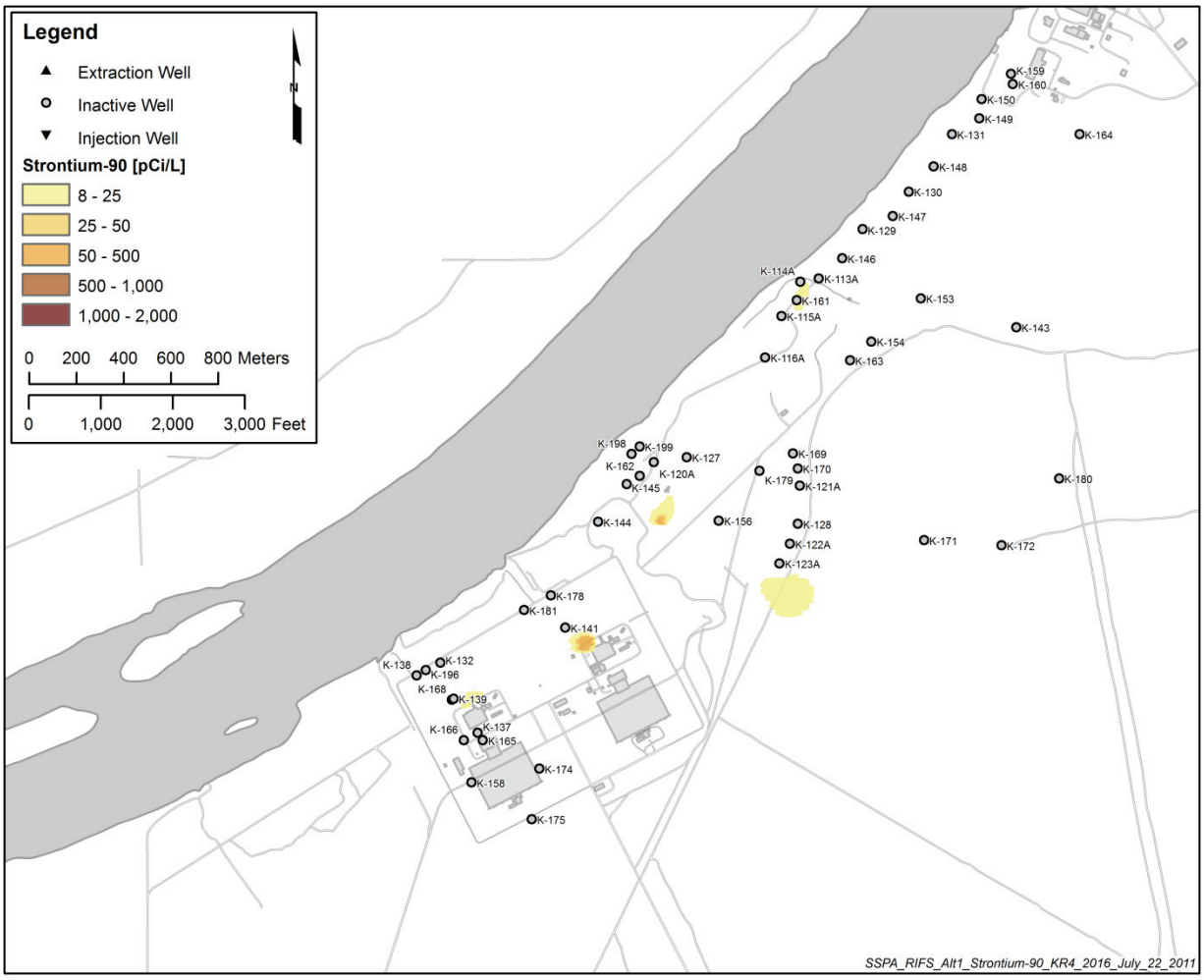


Figure 5-15. Simulated Distribution of Strontium-90 in December 2016 – Alternative 1.

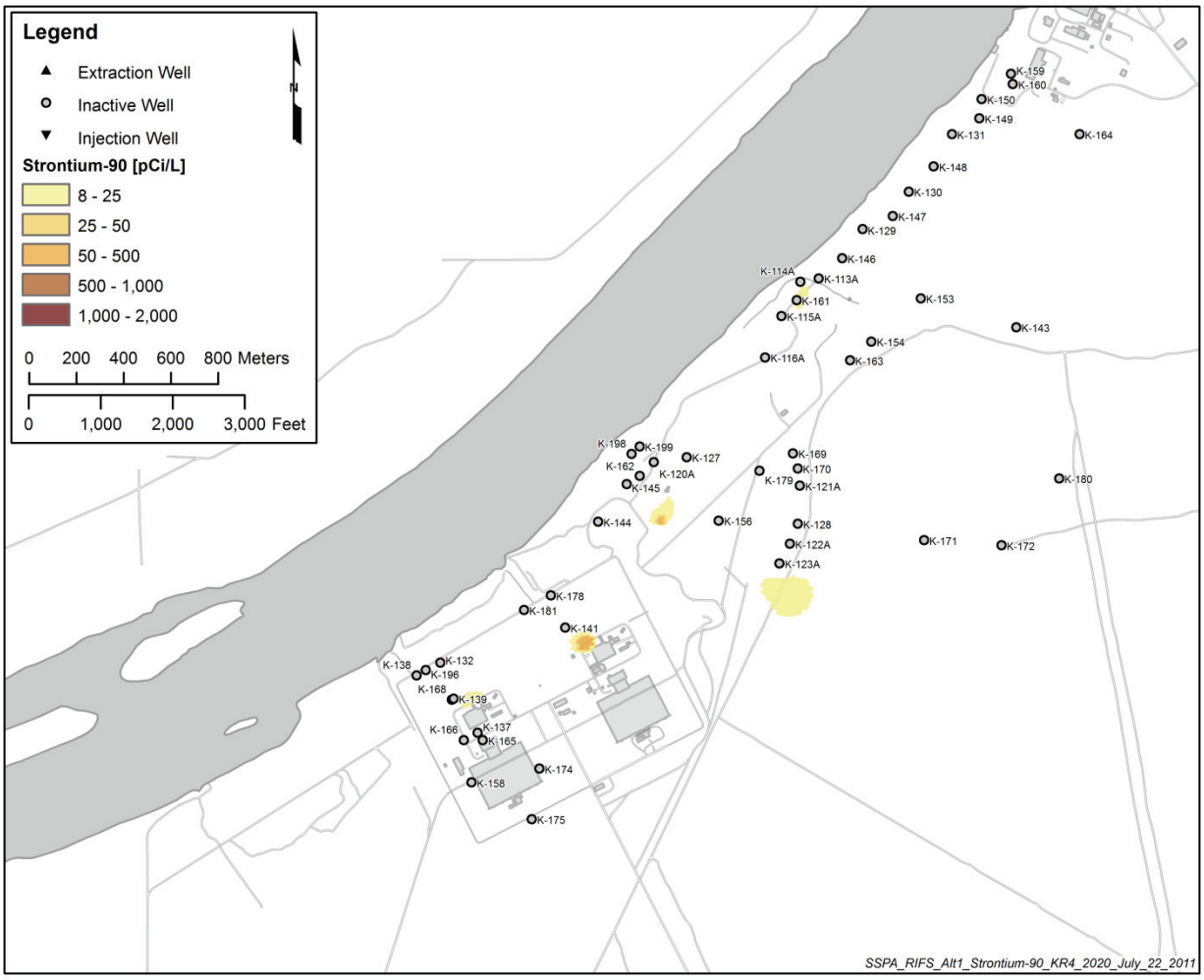


Figure 5-16. Simulated Distribution of Strontium-90 in December 2020 – Alternative 1.

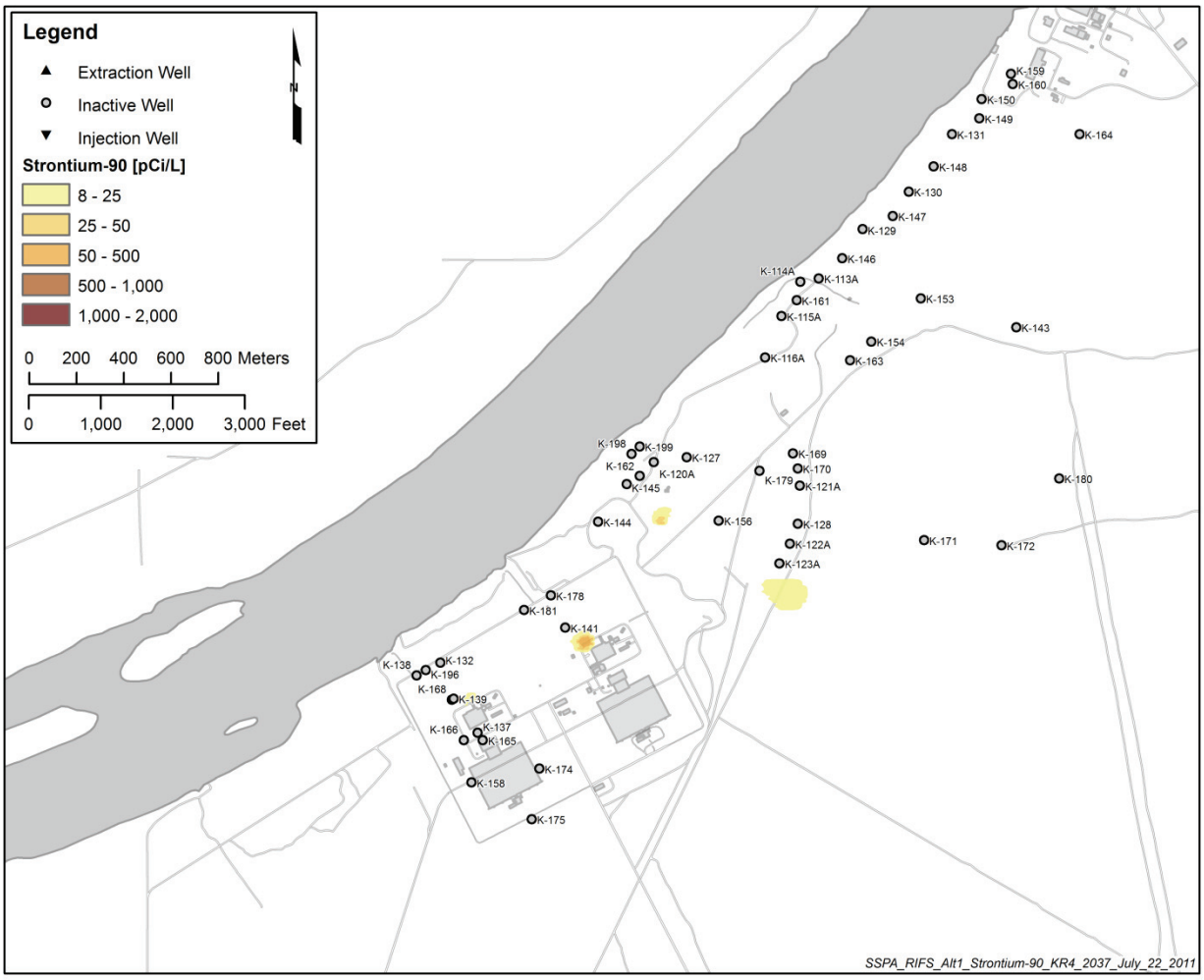


Figure 5-17. Simulated Distribution of Strontium-90 in December 2037 – Alternative 1.

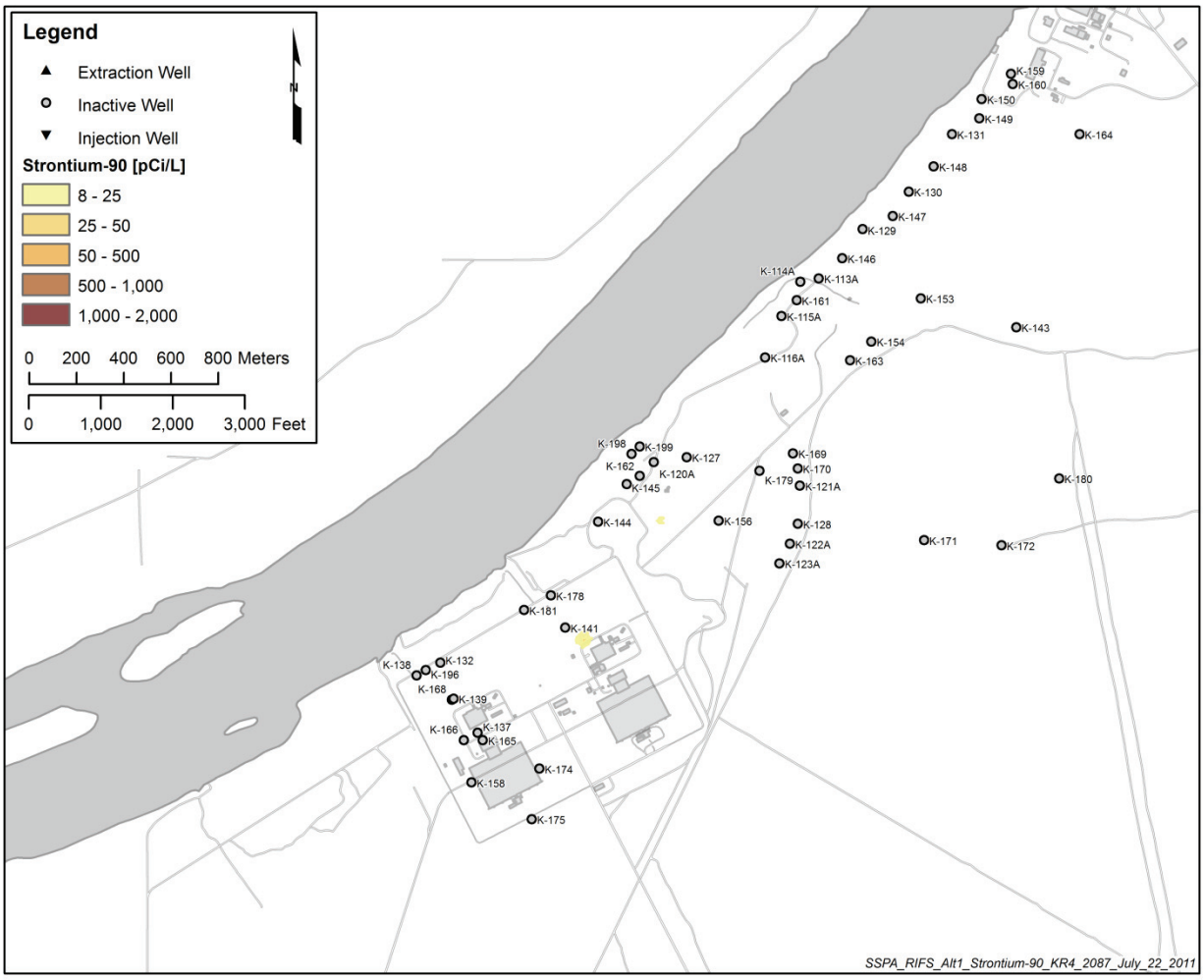


Figure 5-18. Simulated Distribution of Strontium-90 in December 2087 – Alternative 1.

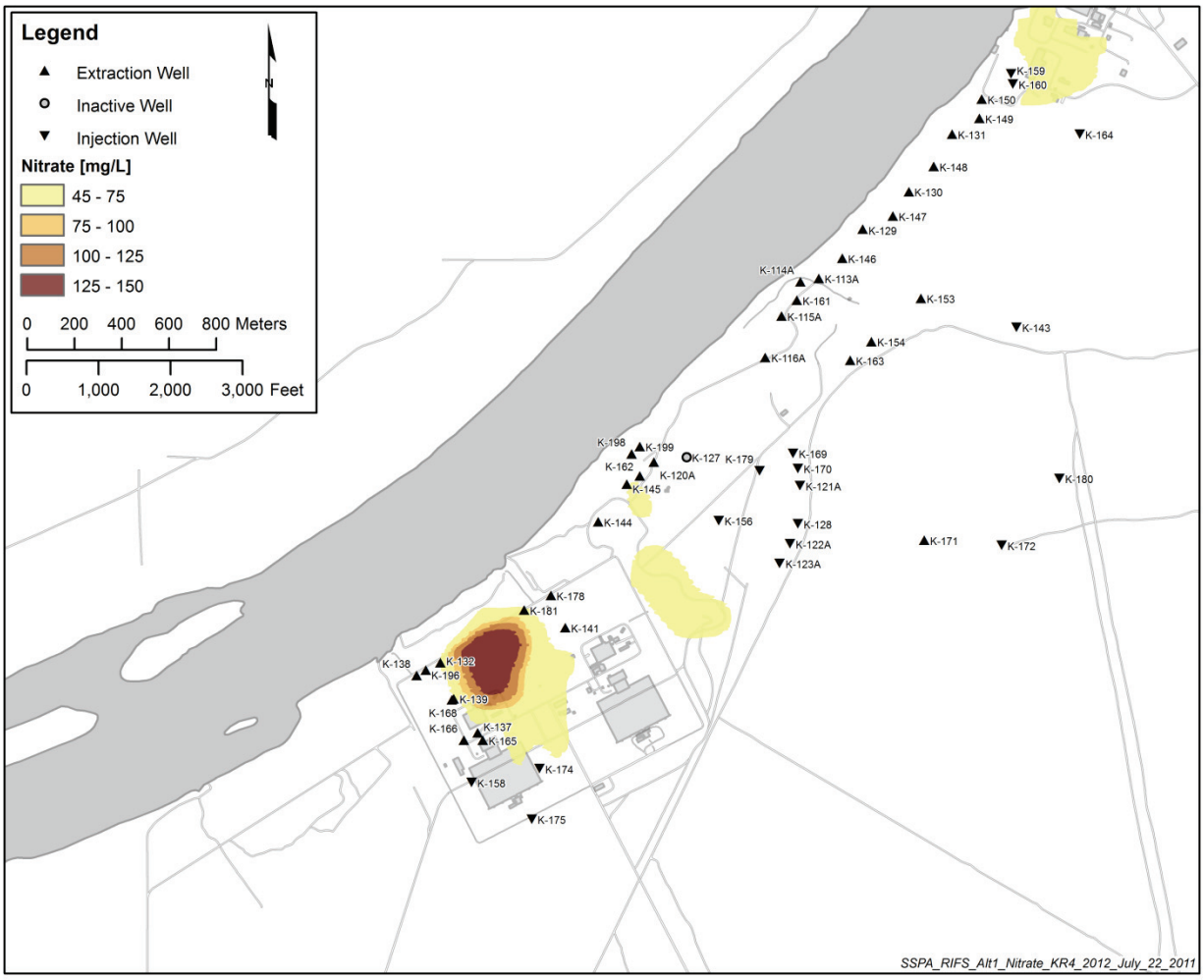


Figure 5-19. Simulated Distribution of Nitrate in December 2012 – Alternative 1.

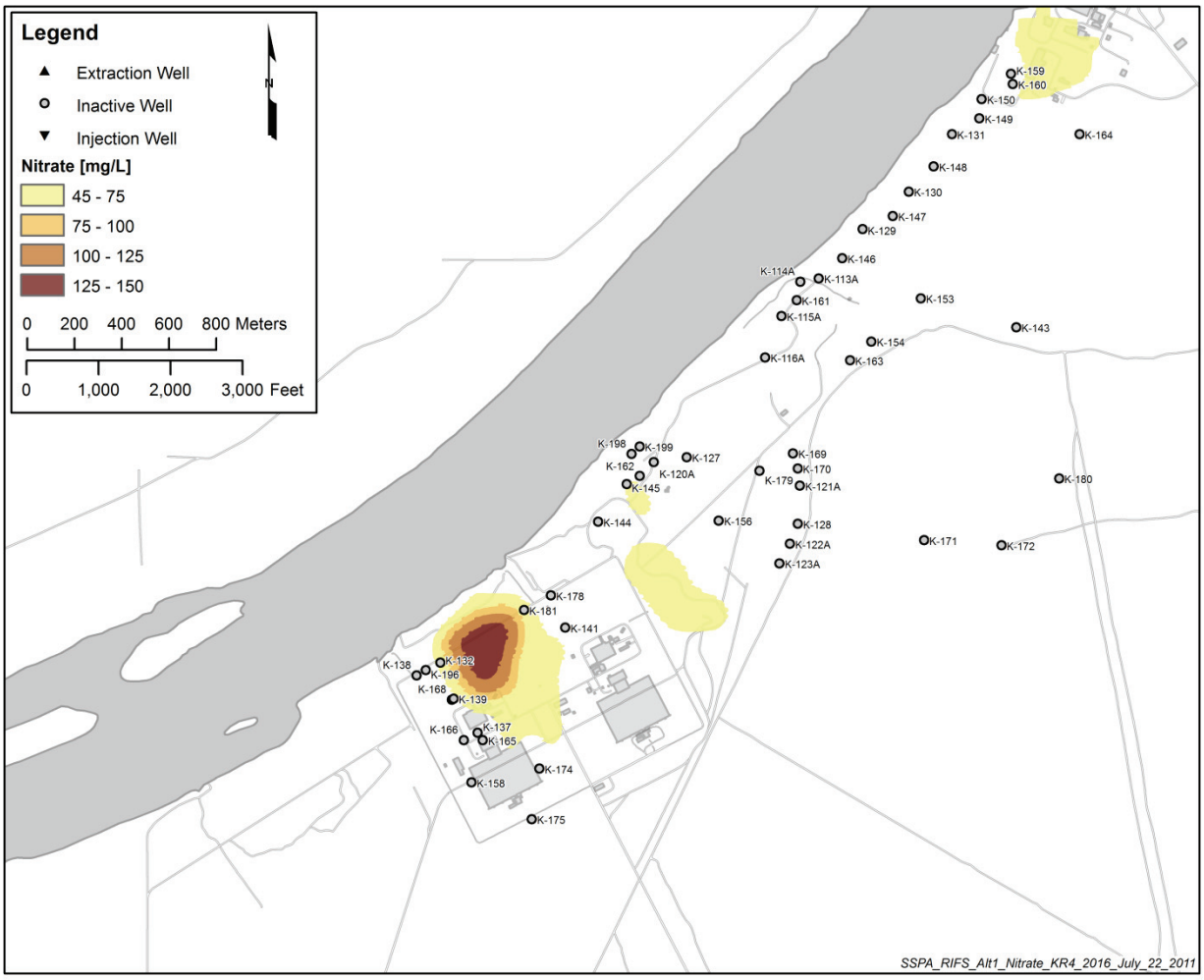


Figure 5-20. Simulated Distribution of Nitrate in December 2016 – Alternative 1.

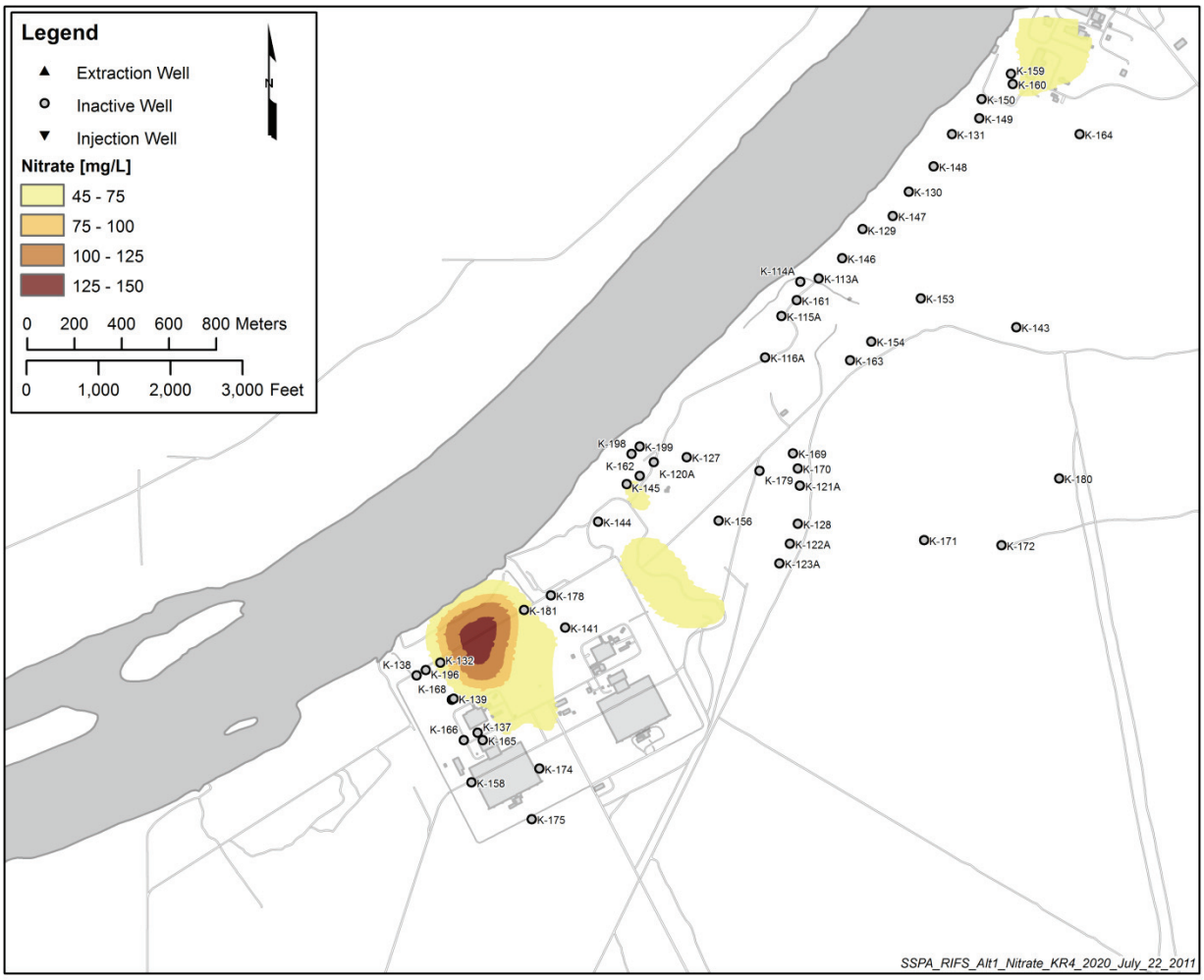


Figure 5-21. Simulated Distribution of Nitrate in December 2020 – Alternative 1.

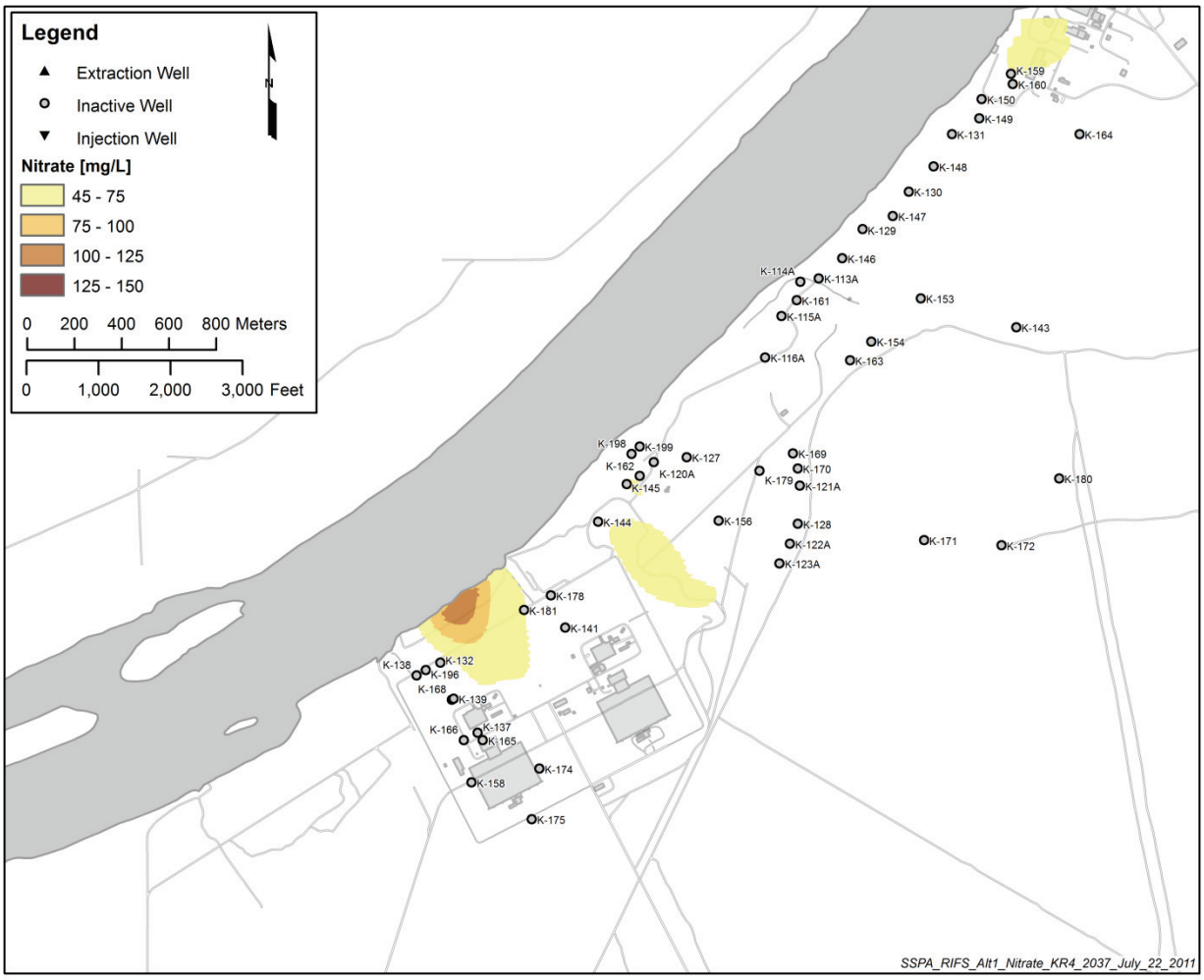


Figure 5-22. Simulated Distribution of Nitrate in December 2037 – Alternative 1.

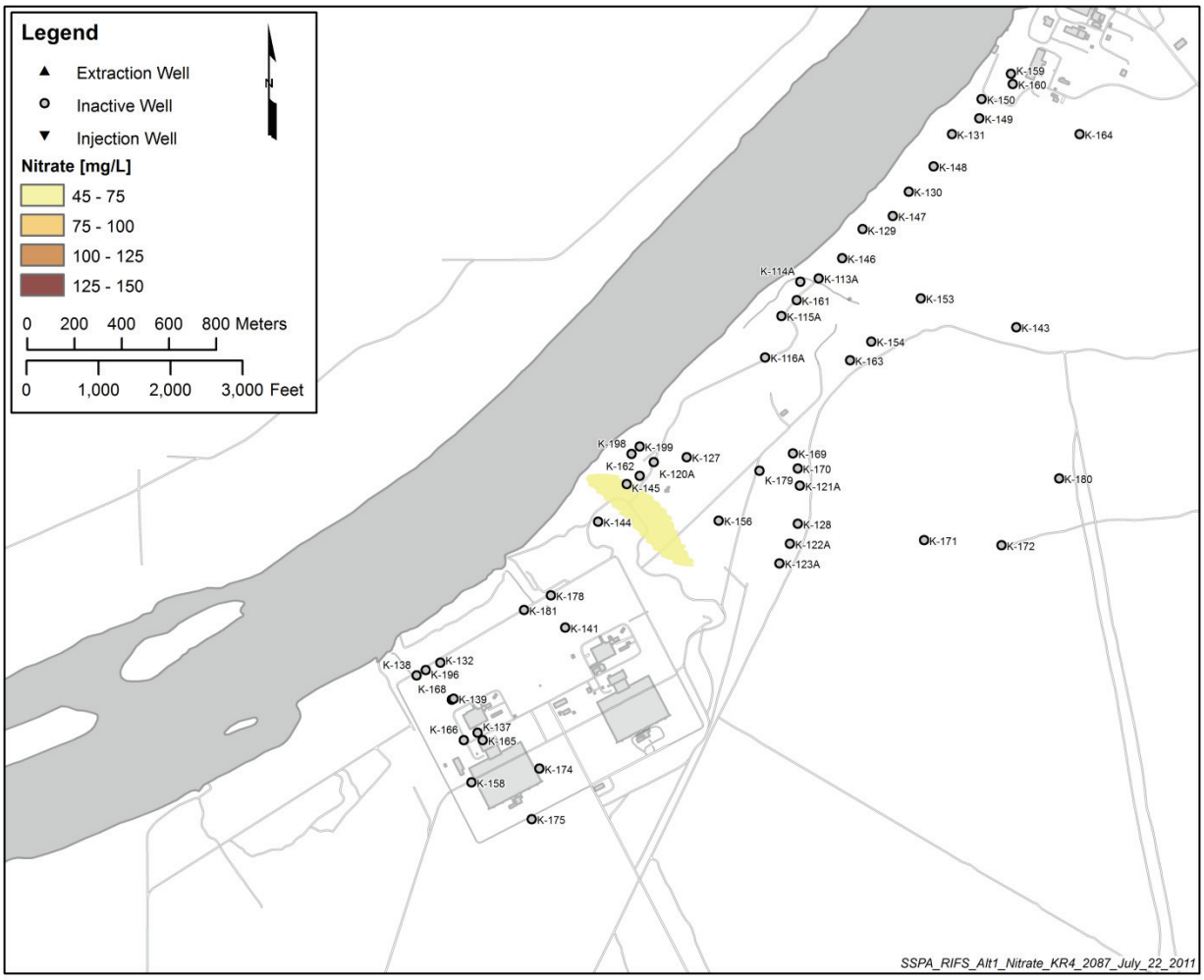


Figure 5-23. Simulated Distribution of Nitrate in December 2087 – Alternative 1.

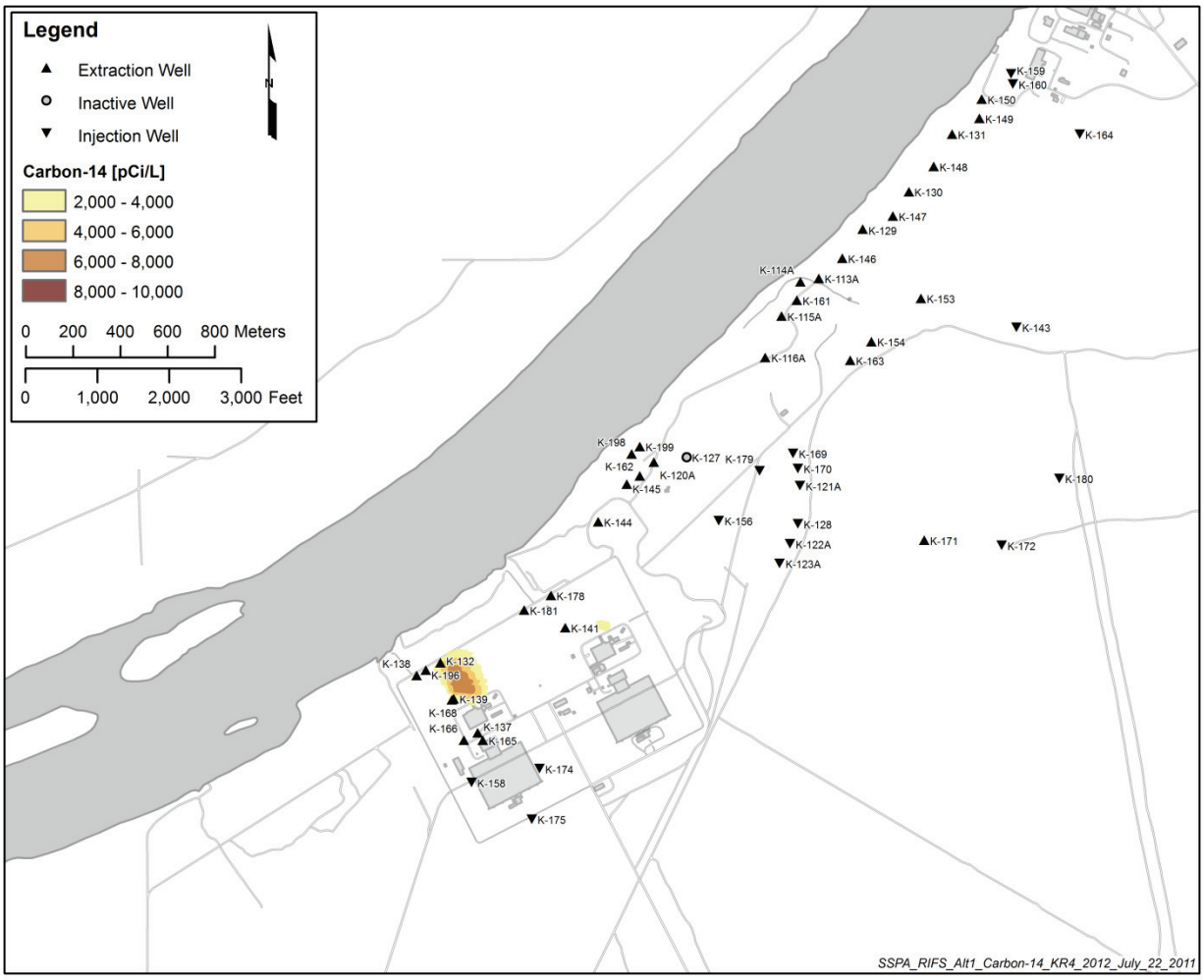


Figure 5-24. Simulated Distribution of Carbon-14 in December 2012 – Alternative 1.

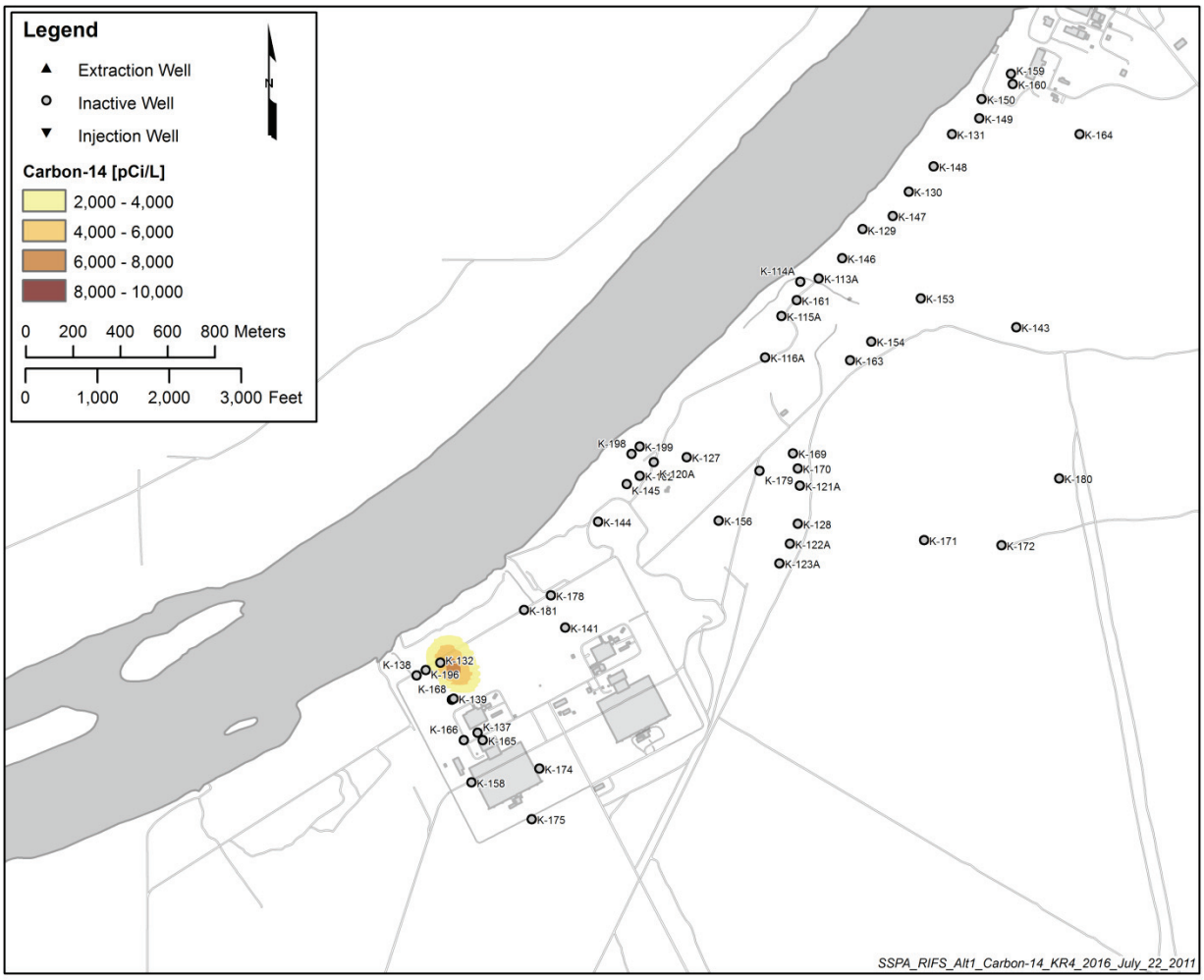


Figure 5-25. Simulated Distribution of Carbon-14 in December 2016 – Alternative 1.

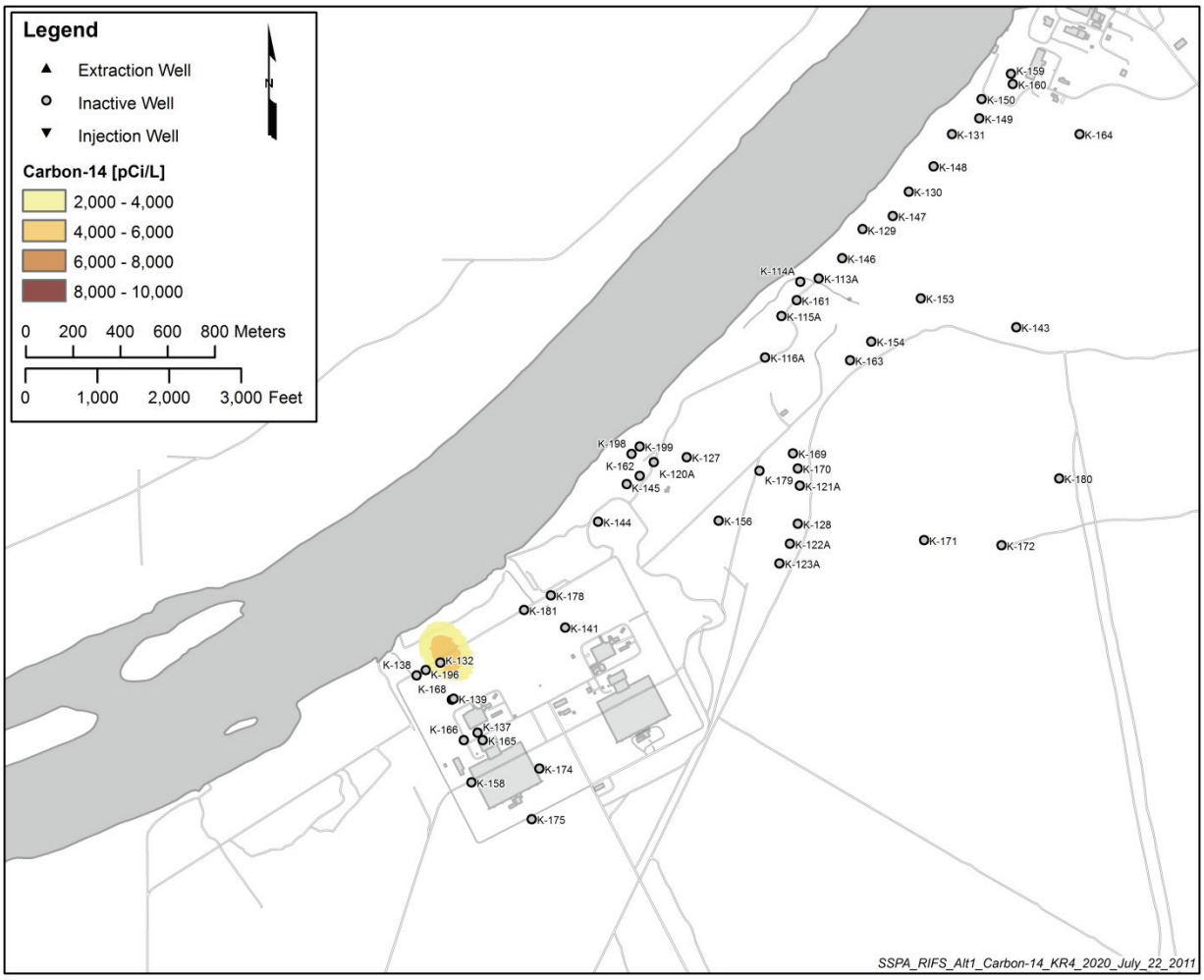


Figure 5-26. Simulated Distribution of Carbon-14 in December 2020 – Alternative 1.

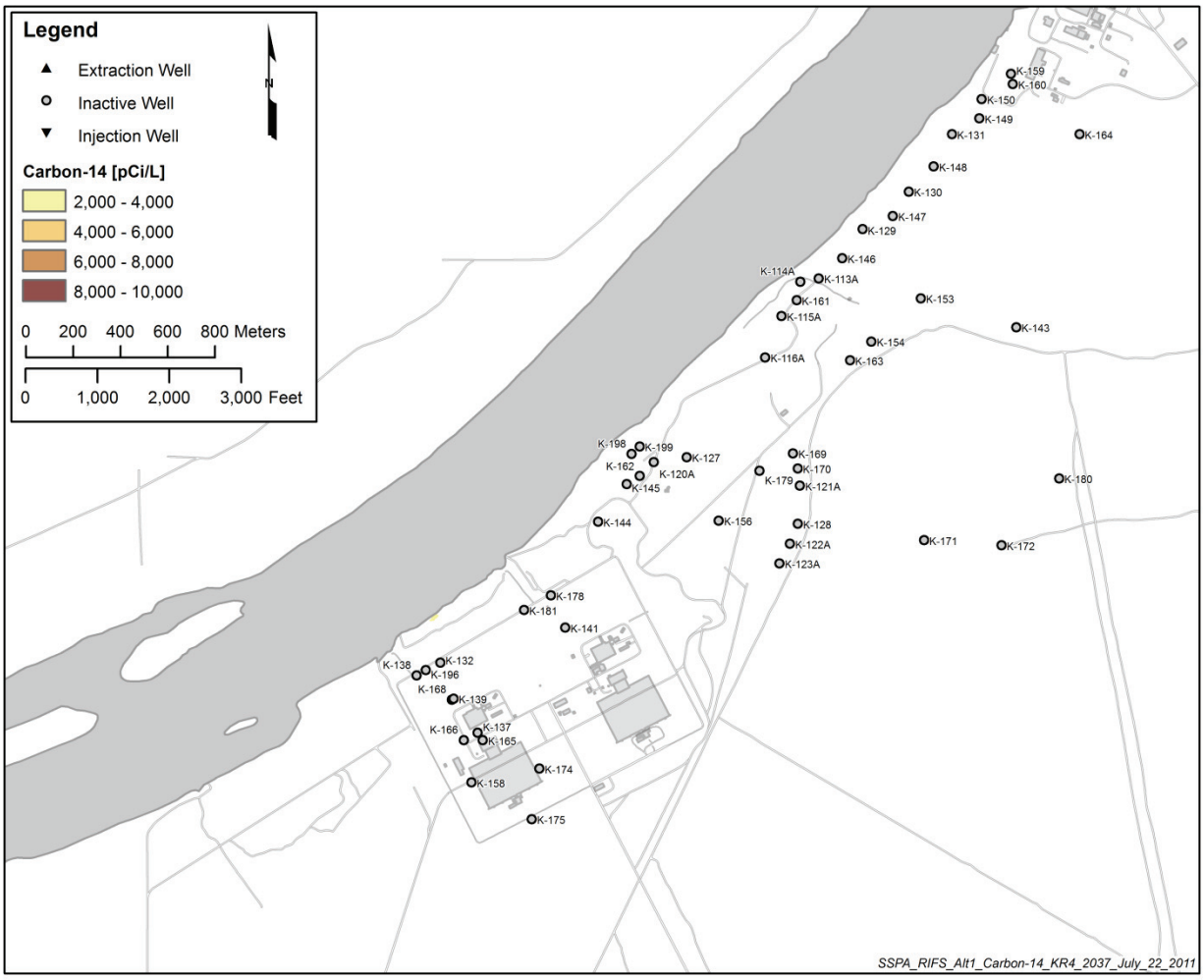


Figure 5-27. Simulated Distribution of Carbon-14 in December 2037 – Alternative 1.

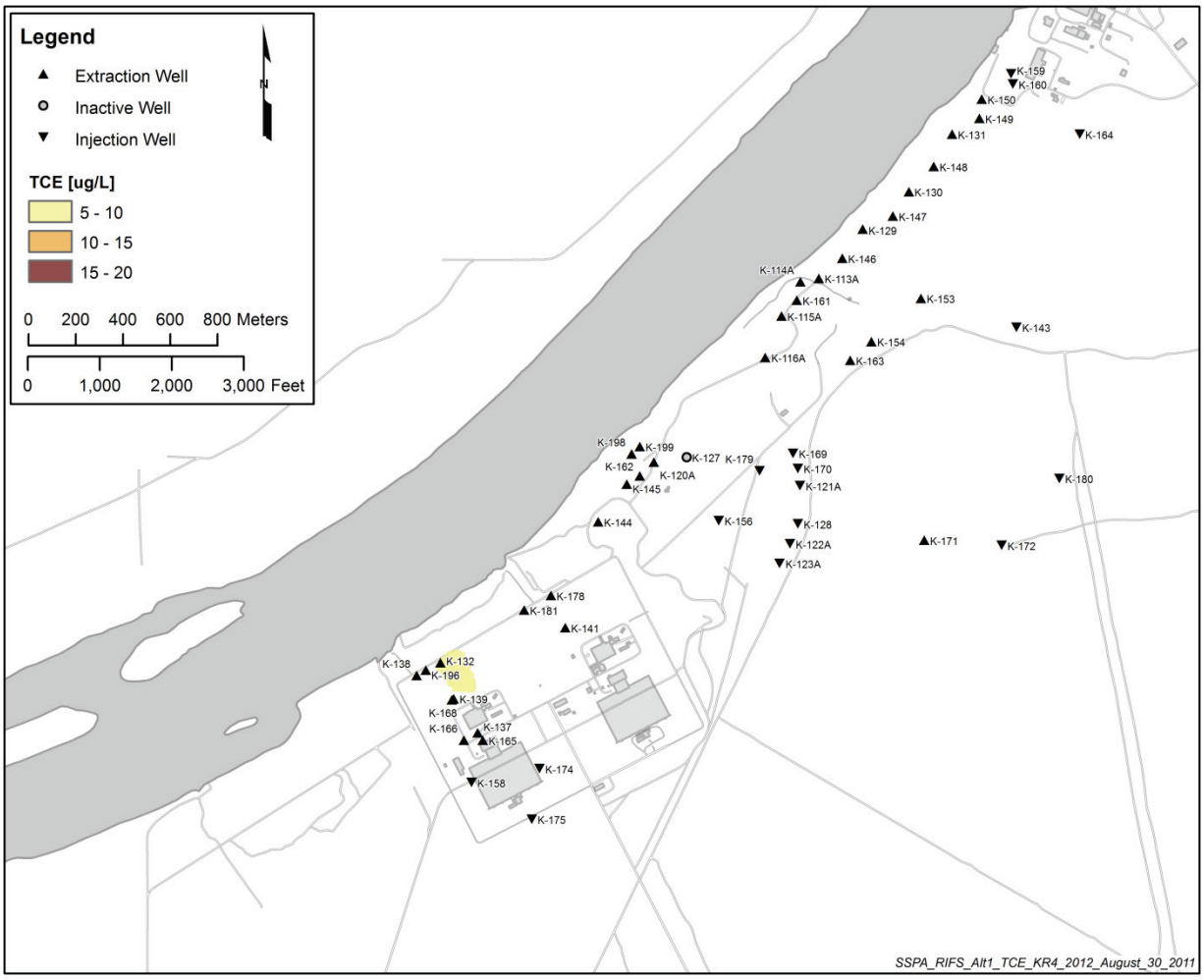


Figure 5-28. Simulated Distribution of TCE in December 2012 – Alternative 1.

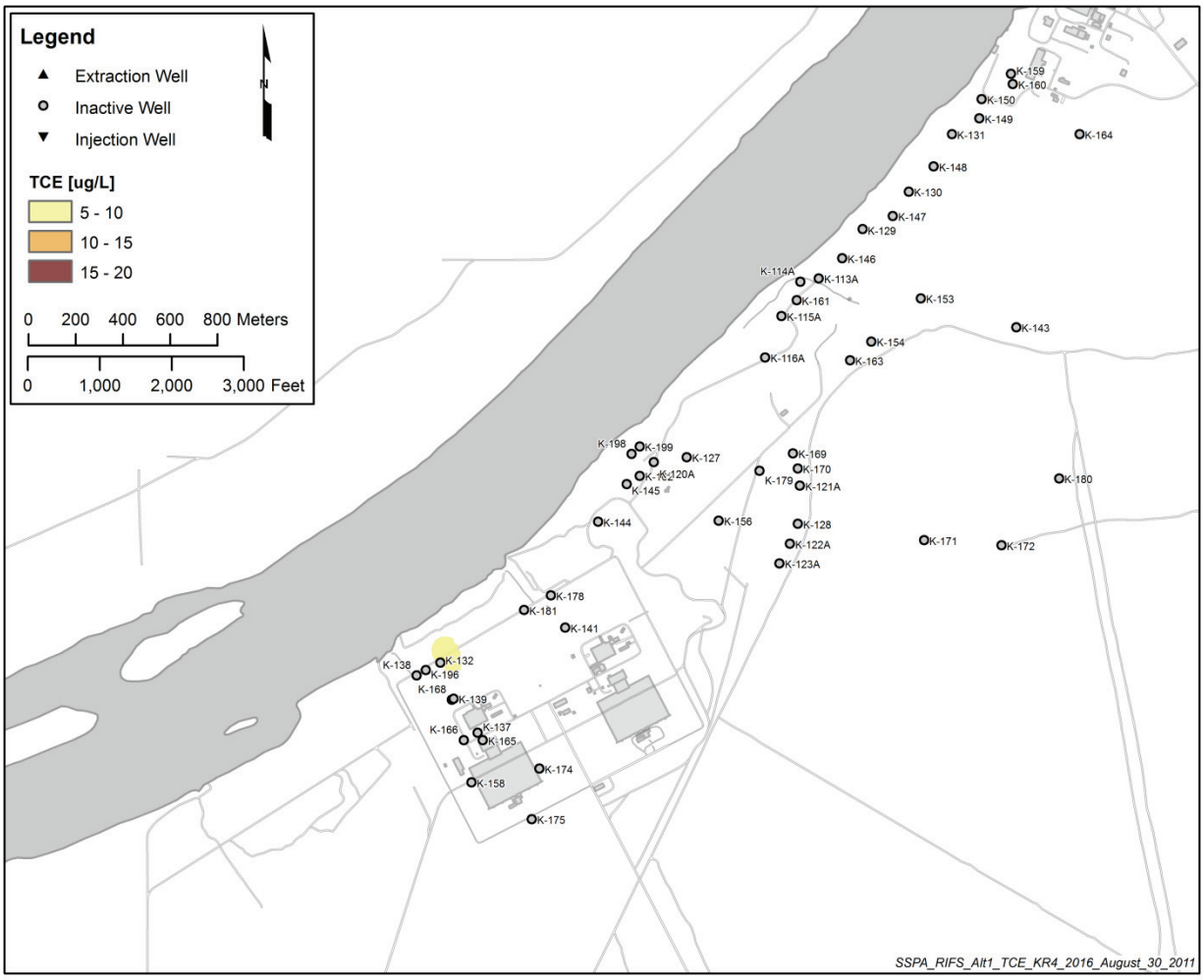


Figure 5-29. Simulated Distribution of TCE in December 2016 – Alternative 1.

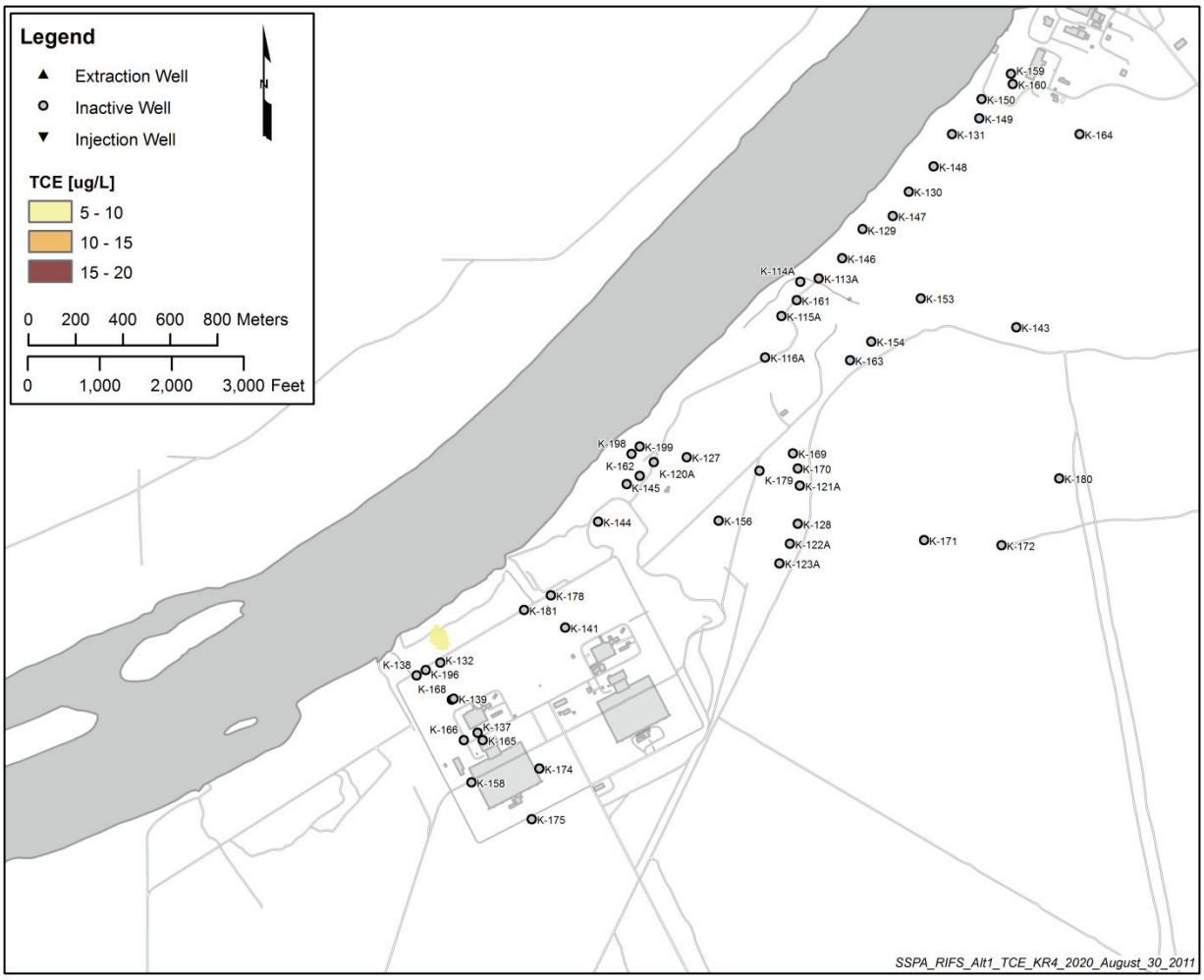


Figure 5-30. Simulated Distribution of TCE in December 2020 – Alternative 1.

1.1 Alternative 2: Expanded P&T with Implementation of Other Technologies

Figure 5-31 illustrates the hydraulic capture efficiency in 2012 for the expanded P&T. Figures 5-32 to 5-36 illustrate the simulated distribution of CrVI in 2012, 2016, 2020, 2037, and 2087, respectively. Figures 5-37 and 5-38 show the simulated time-series of concentration-versus-time for CrVI along the shoreline and in the aquifer during the simulation timeframe. Figures 5-39 to 5-41 illustrate the simulated distribution of Tritium in 2012, 2016, and 2020, respectively. Figures 5-42 to 5-46 illustrate the simulated distribution of Strontium-90 in 2012, 2016, 2020, 2037, and 2087, respectively. Figures 5-47 to 5-51 illustrate the simulated distribution of Nitrate in 2012, 2016, 2020, 2037, and 2087, respectively. Figures 5-52 to 5-54 illustrate the simulated distribution of Carbon-14 in 2012, 2016, and 2020, respectively. Figures 5-55 to 5-57 illustrate the simulated distribution of TCE in 2012, 2016, and 2020, respectively.

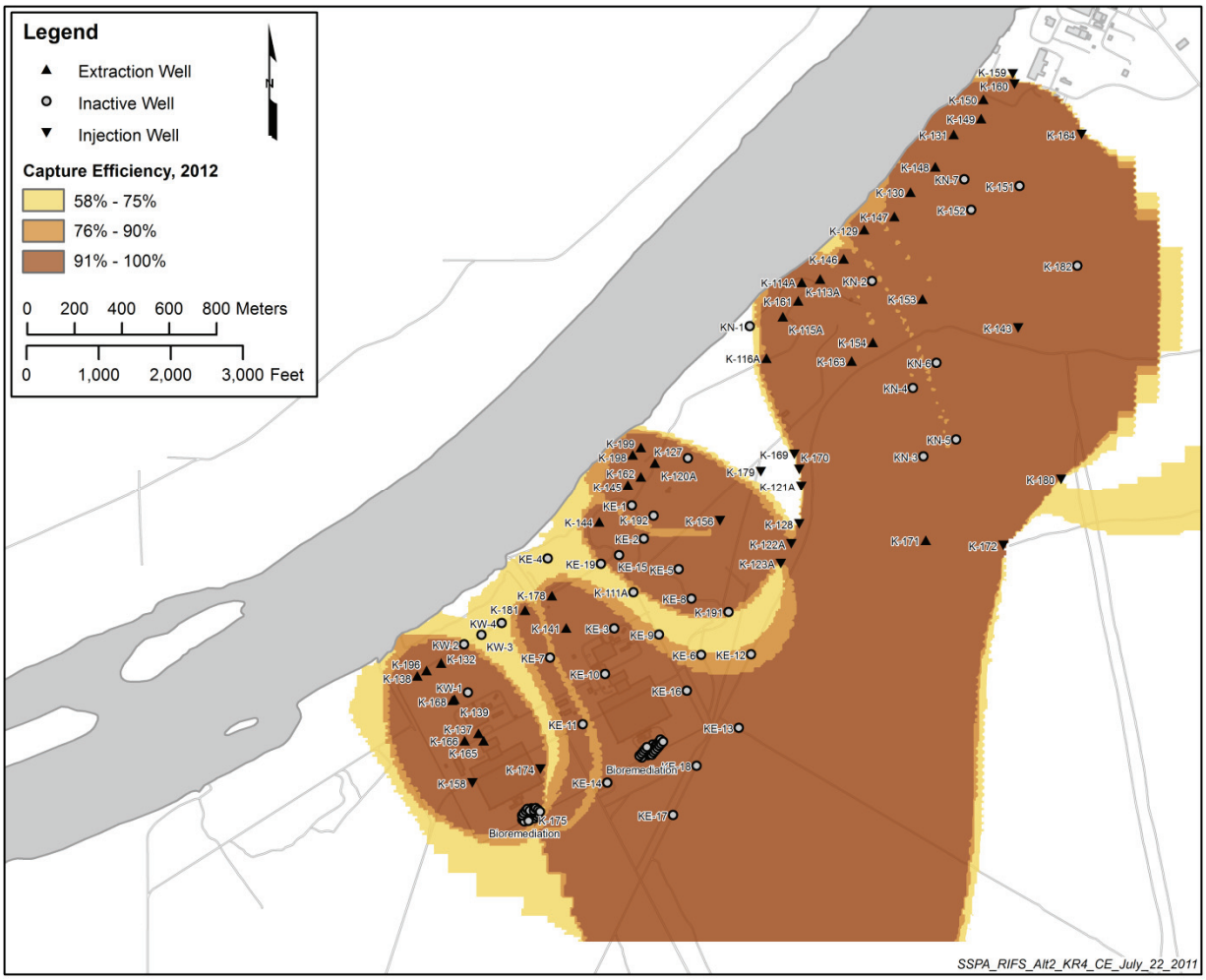


Figure 5-31. Capture Efficiency Map for CY2012 – Alternative 2.

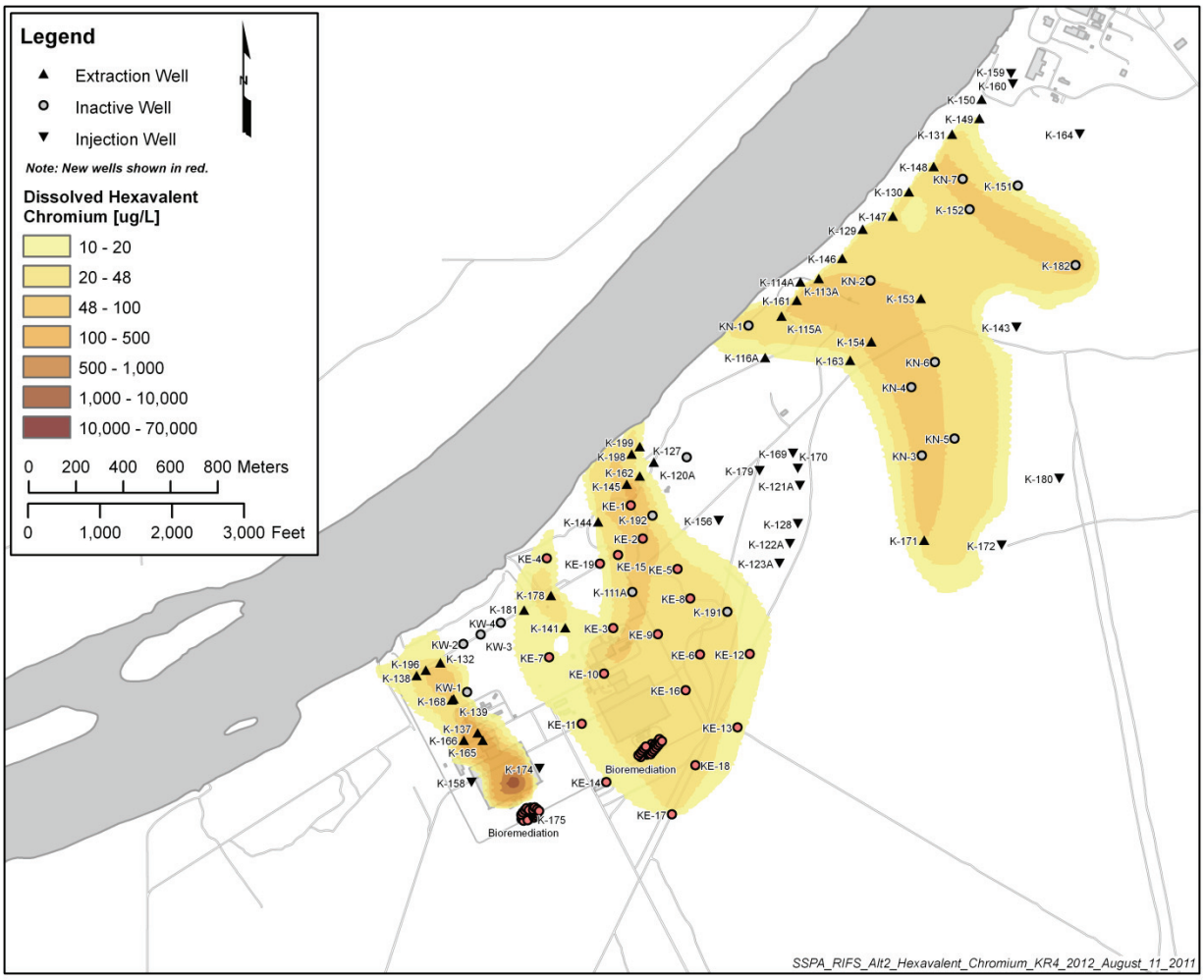


Figure 5-32. Simulated Distribution of CrVI in December 2012 – Alternative 2.

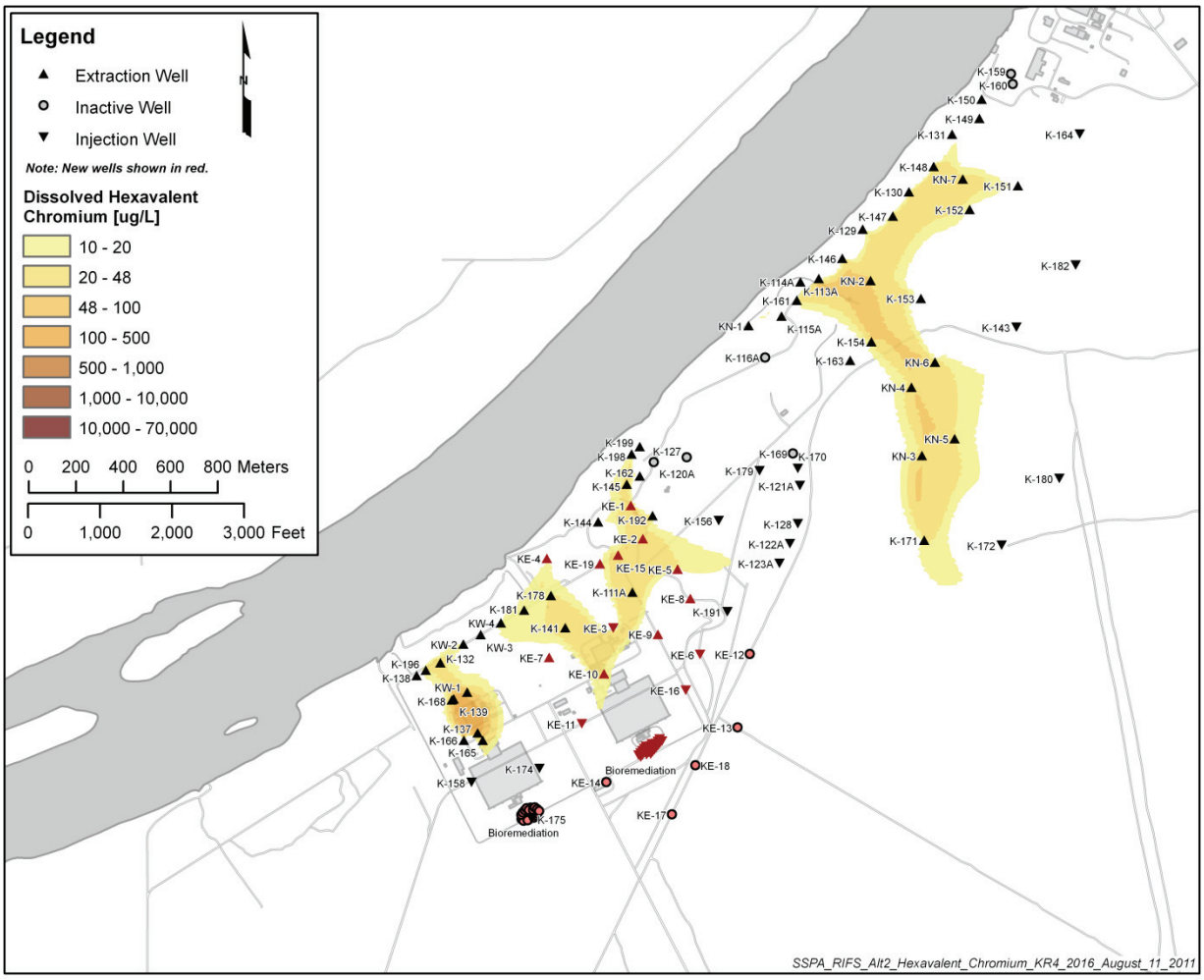


Figure 5-33. Simulated Distribution of CrVI in December 2016 – Alternative 2.

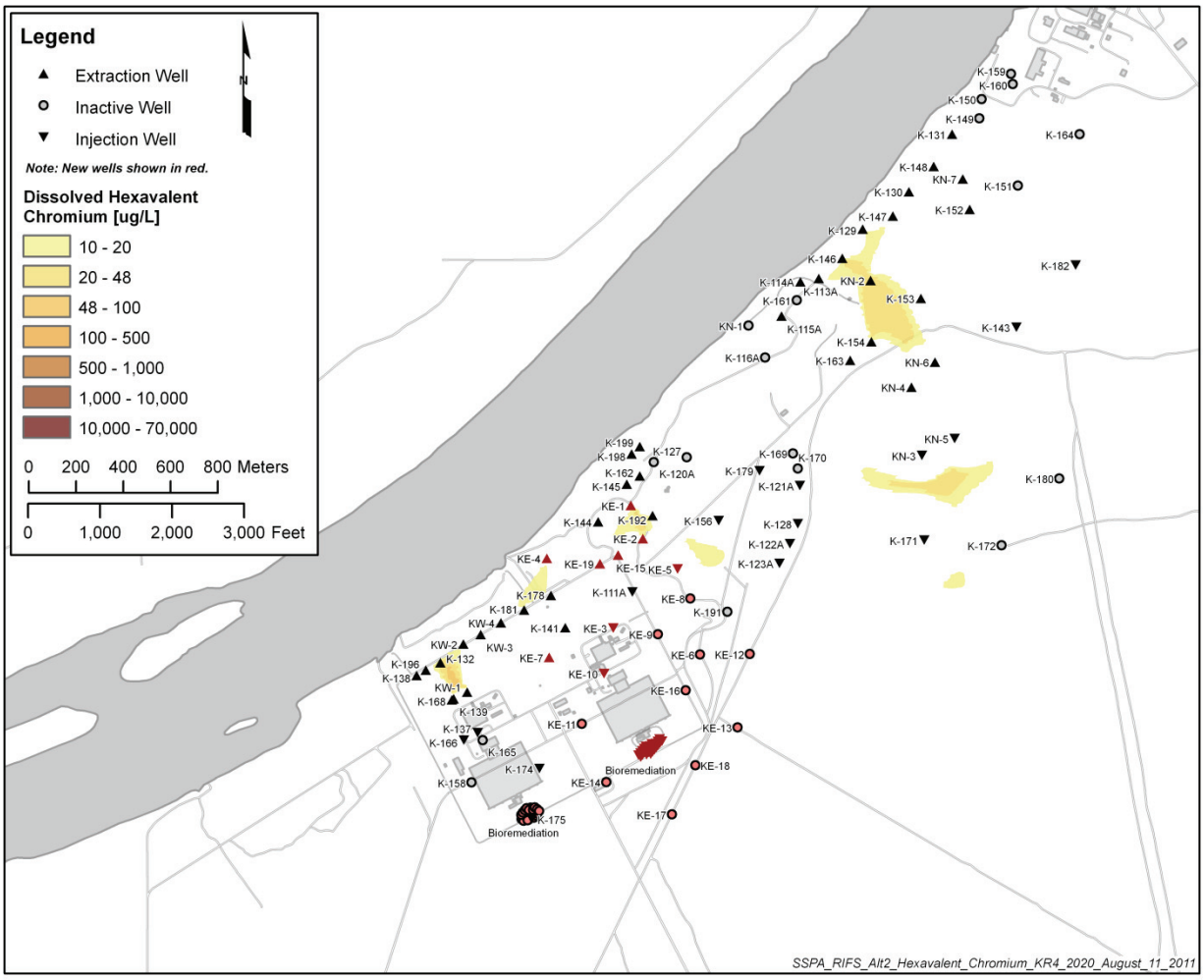


Figure 5-34. Simulated Distribution of CrVI in December 2020 – Alternative 2.

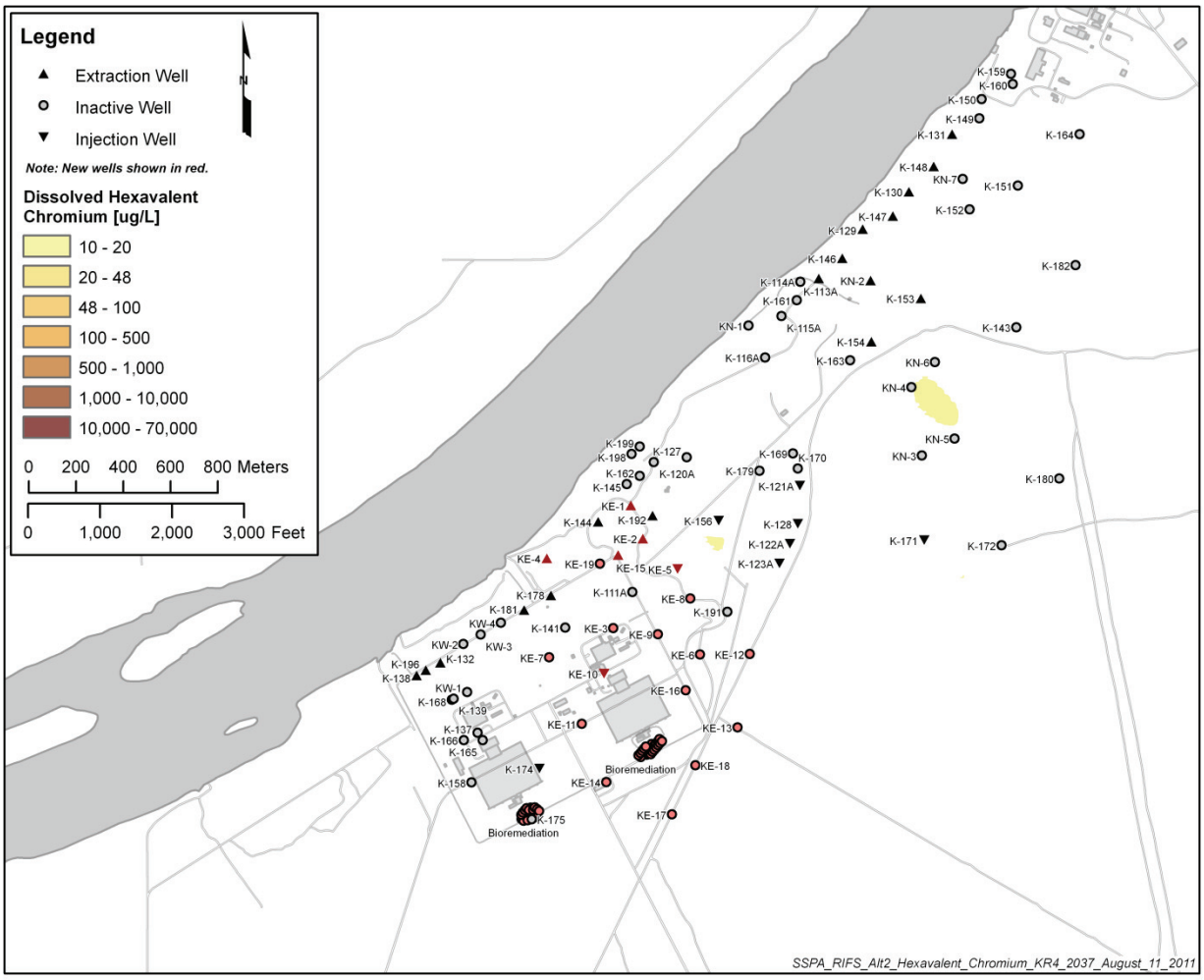


Figure 5-35. Simulated Distribution of CrVI in December 2037 – Alternative 2.

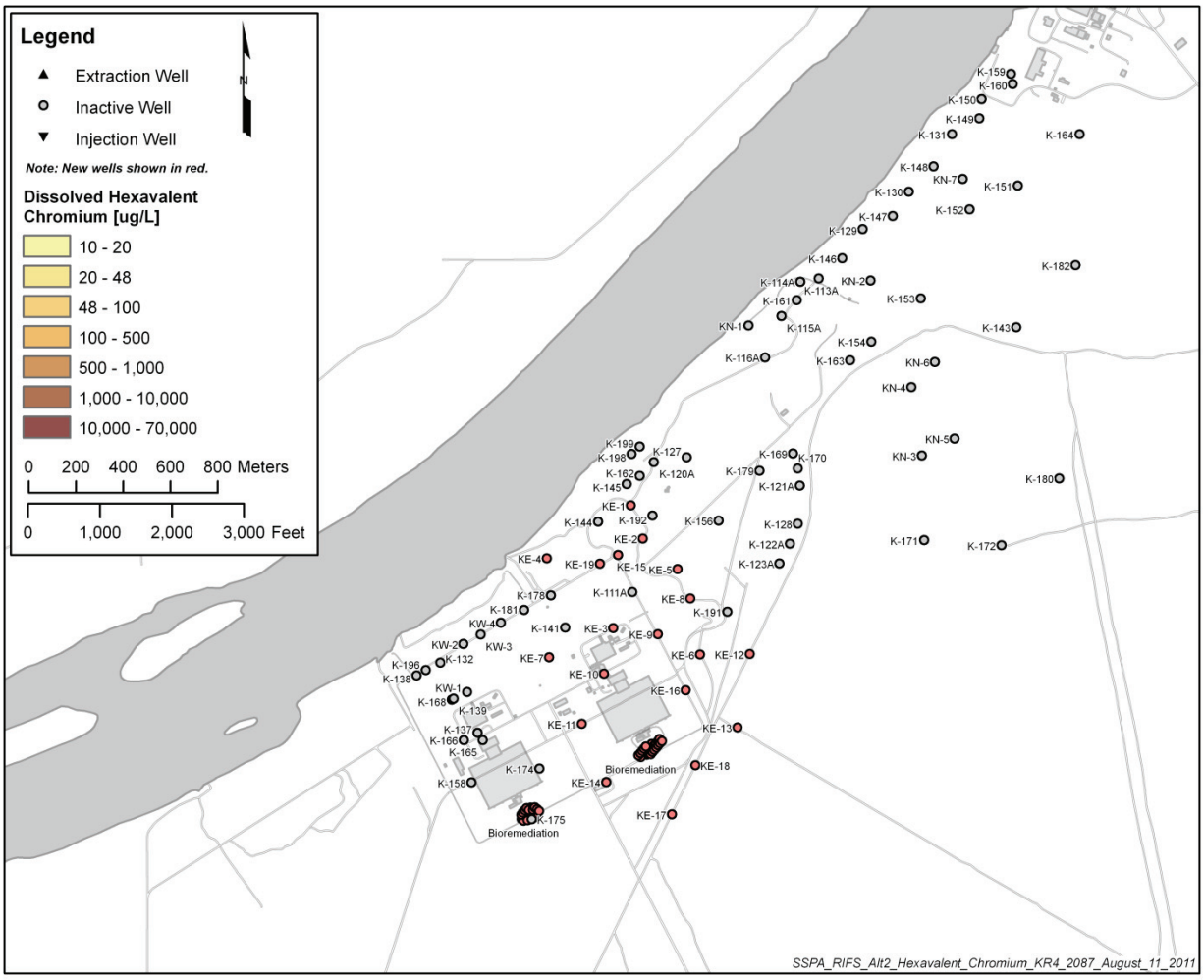


Figure 5-36. Simulated Distribution of CrVI in December 2087 – Alternative 2.

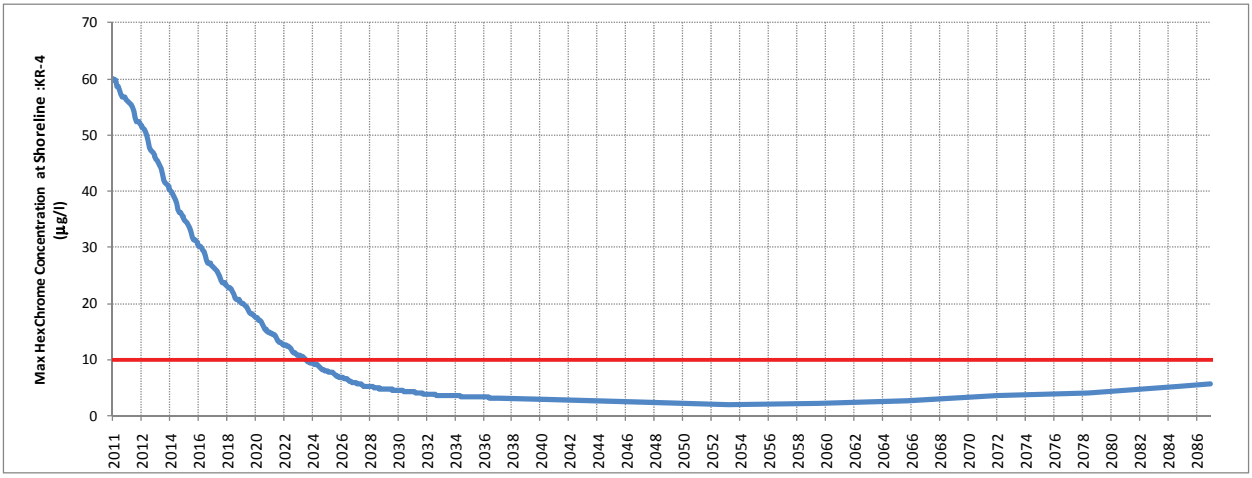
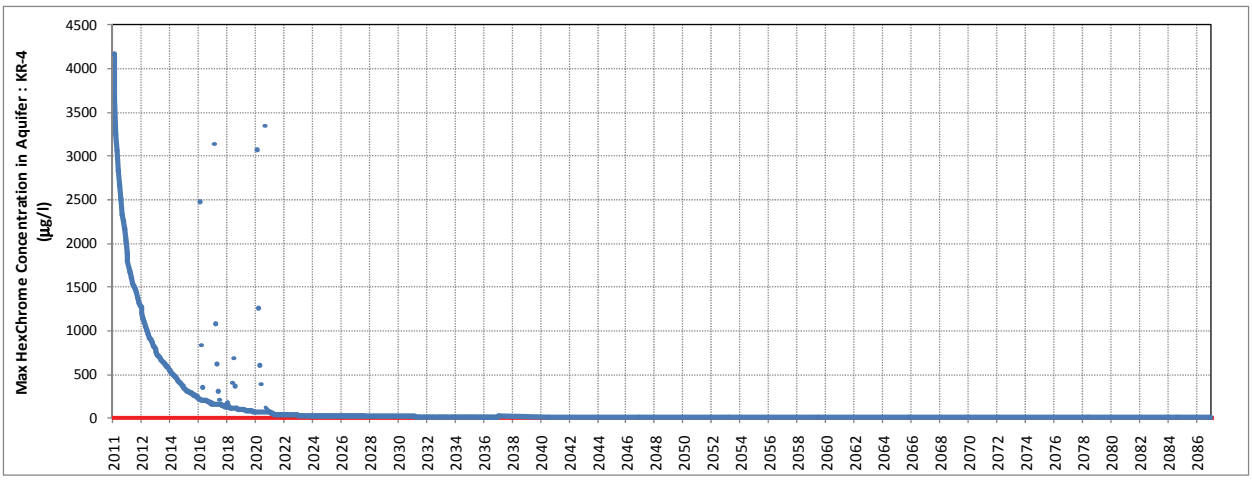


Figure 5-37. Simulated Maximum Dissolved CrVI Concentration along the Shoreline – Alternative 2.



Note: dots represent local scale (typically single-cell) oscillations in the transport solution as a model cell re-saturates.

Figure 5-38. Simulated Maximum Dissolved CrVI Concentration in the Aquifer – Alternative 2.

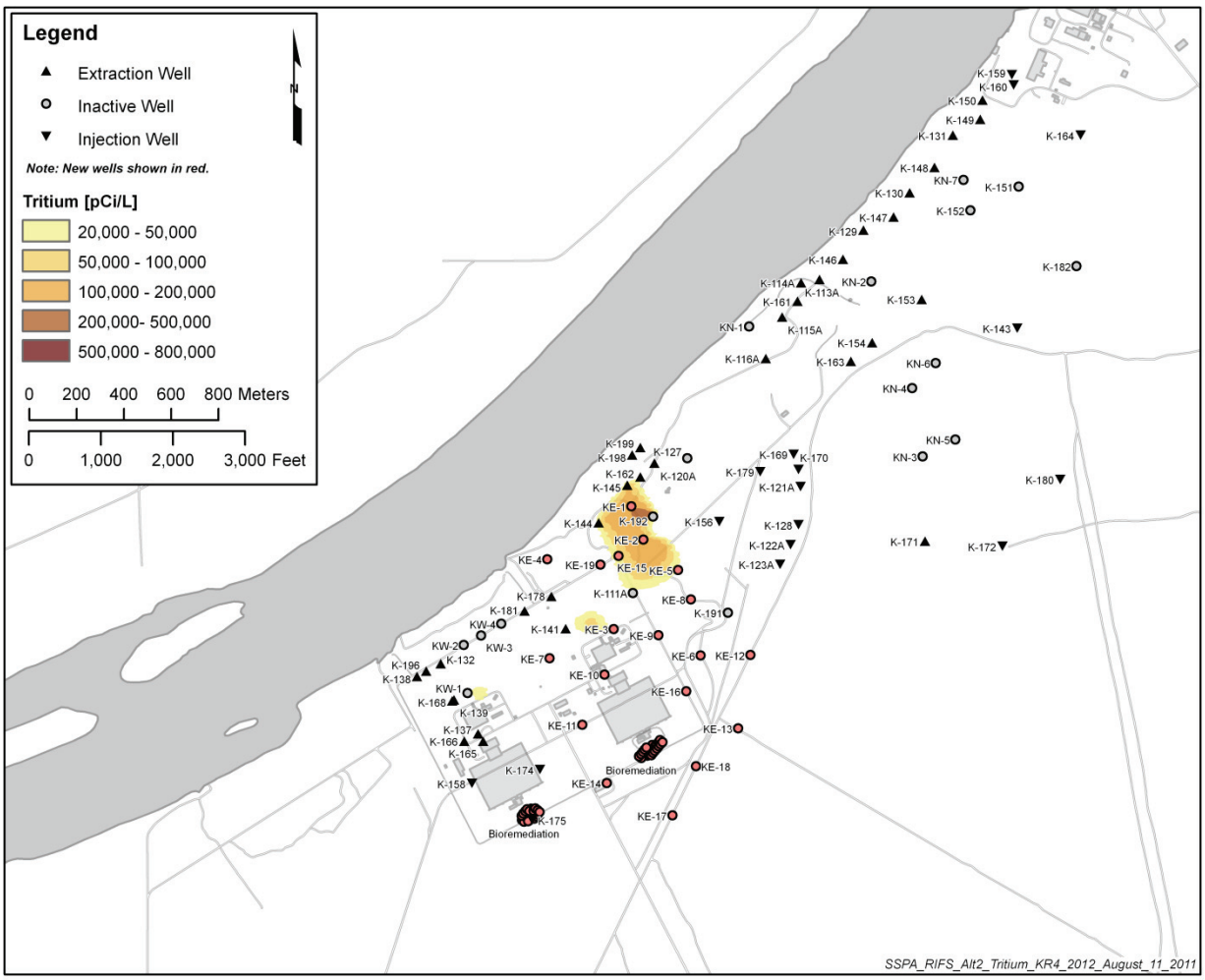


Figure 5-39. Simulated Distribution of Tritium in December 2012 – Alternative 2.

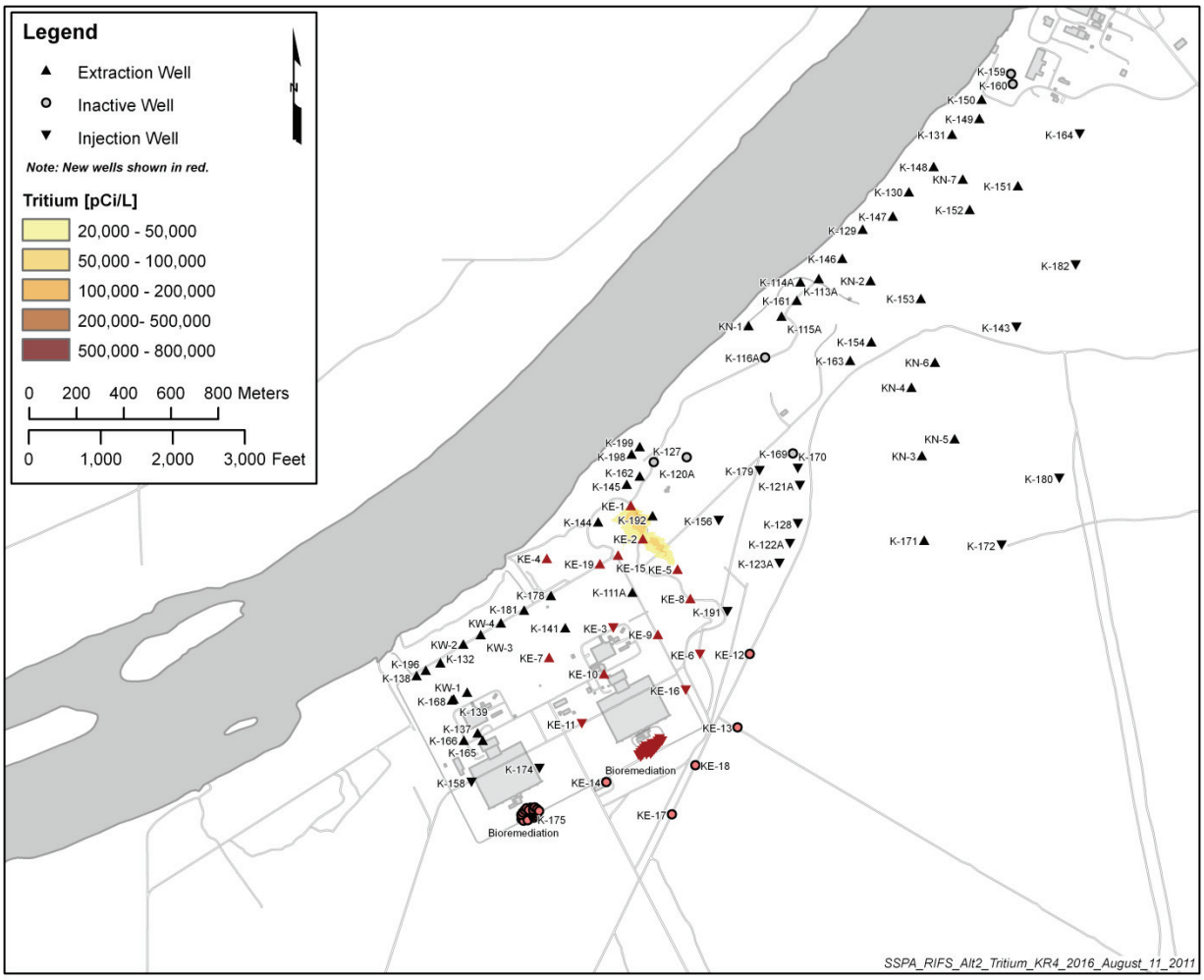


Figure 5-40. Simulated Distribution of Tritium in December 2016 – Alternative 2.

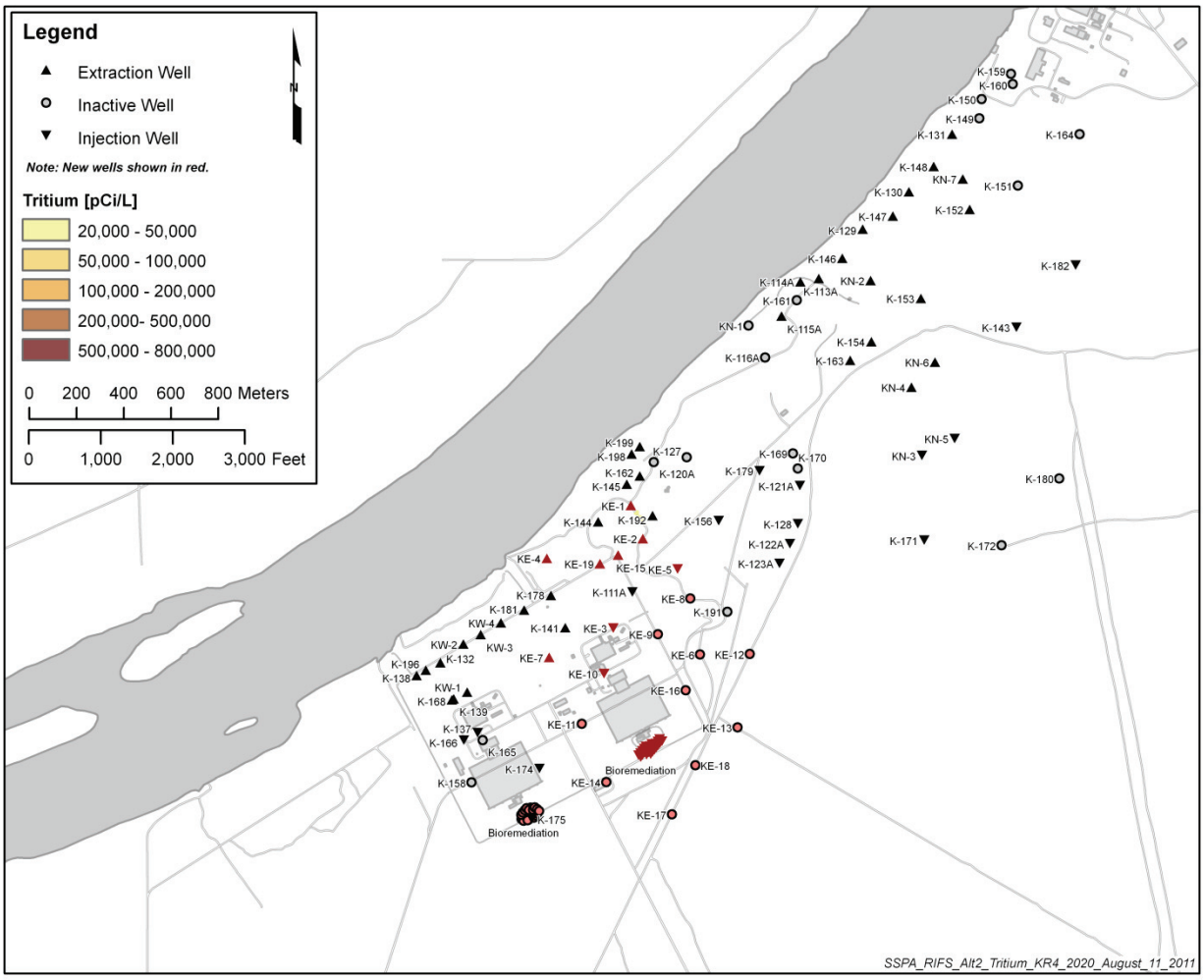


Figure 5-41. Simulated Distribution of Tritium in December 2020 – Alternative 2.

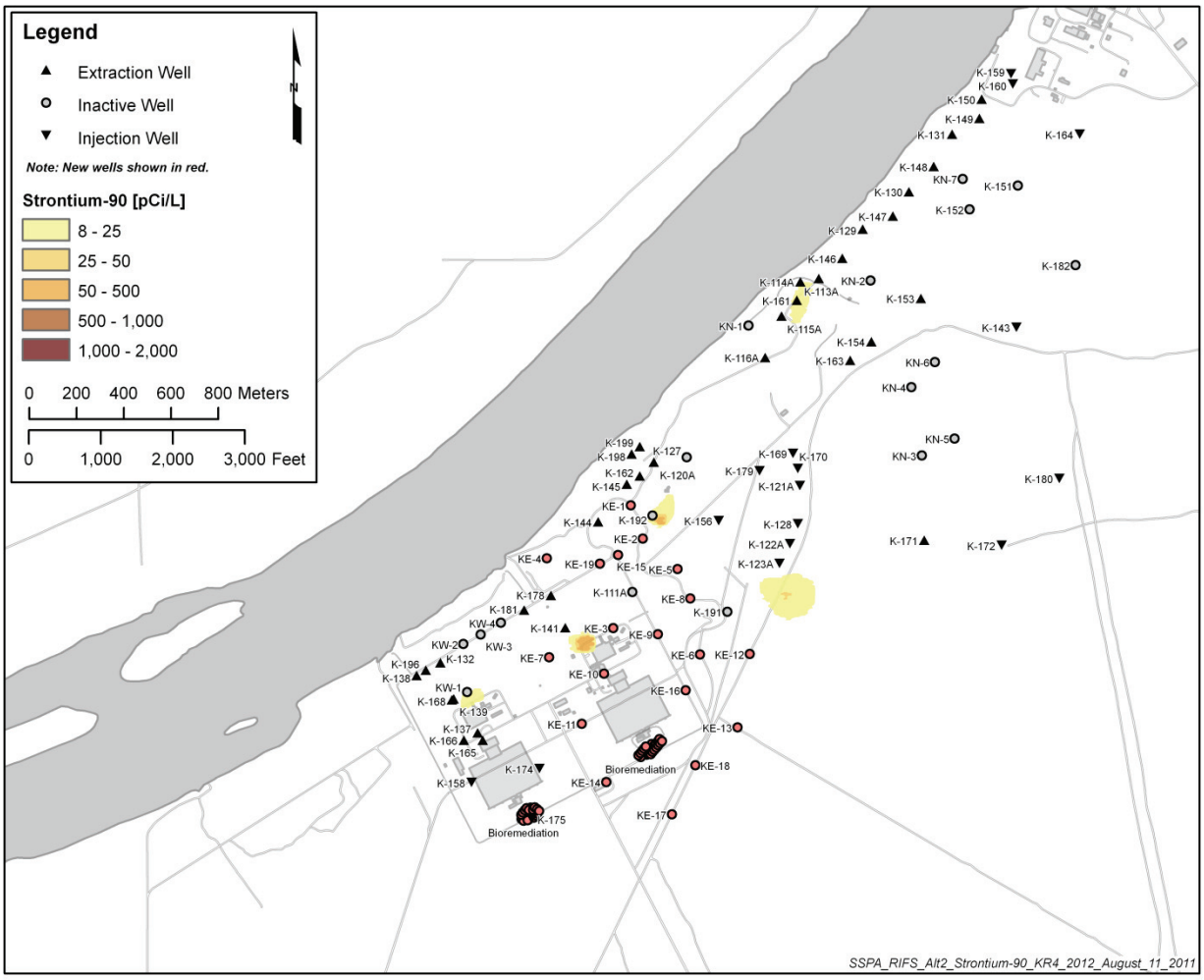


Figure 5-42. Simulated Distribution of Strontium-90 in December 2012 – Alternative 2.

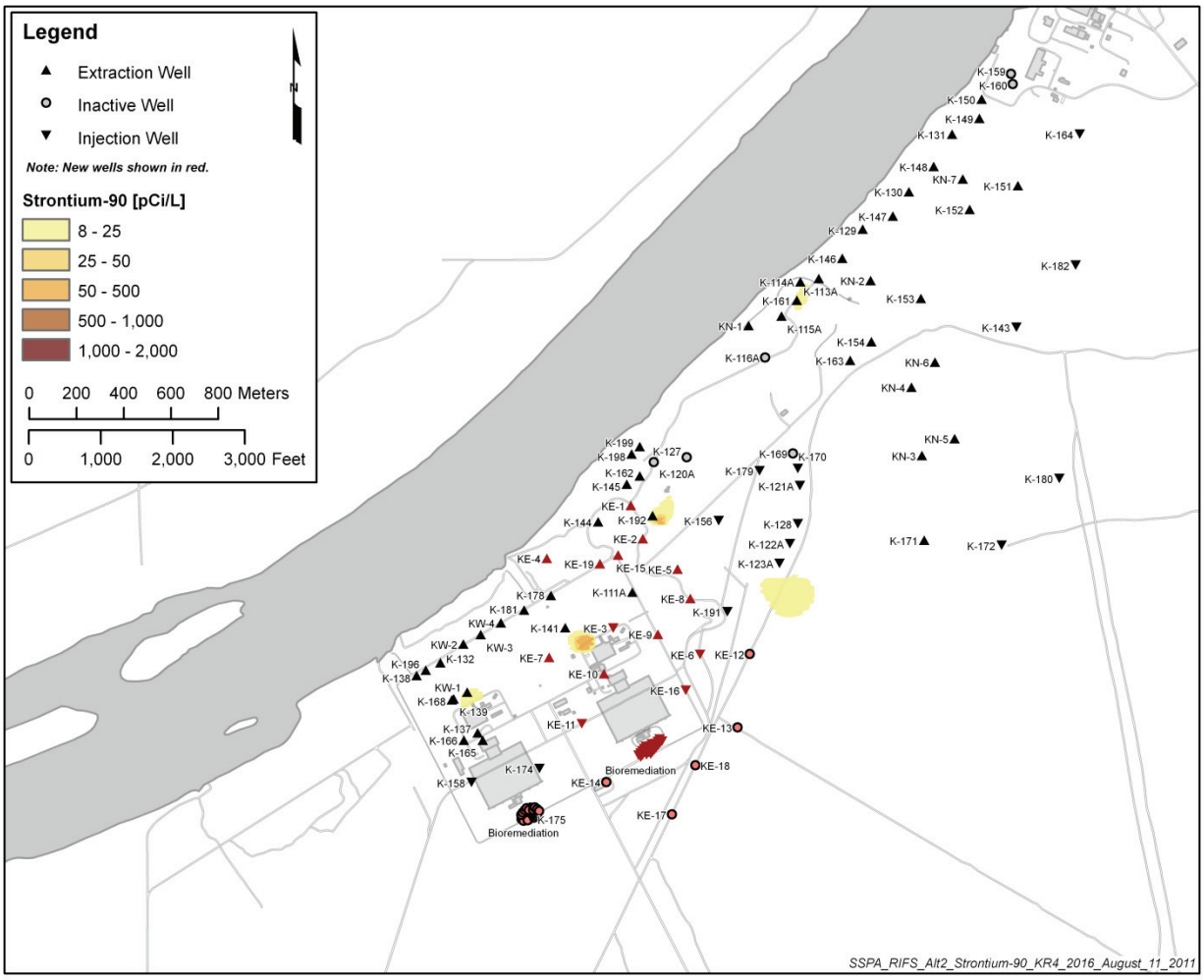


Figure 5-43. Simulated Distribution of Strontium-90 in December 2016 – Alternative 2.

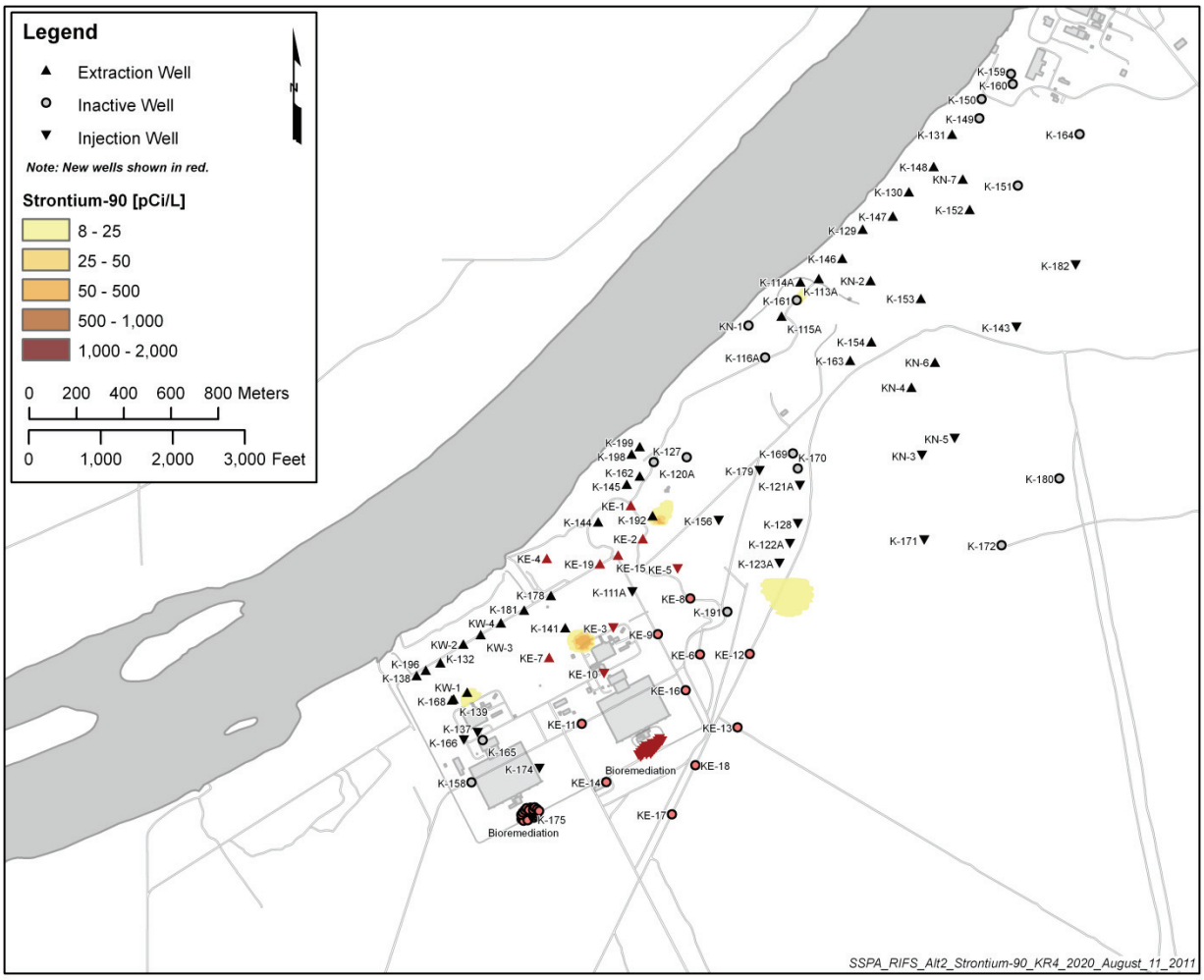


Figure 5-44. Simulated Distribution of Strontium-90 in December 2020 – Alternative 2.

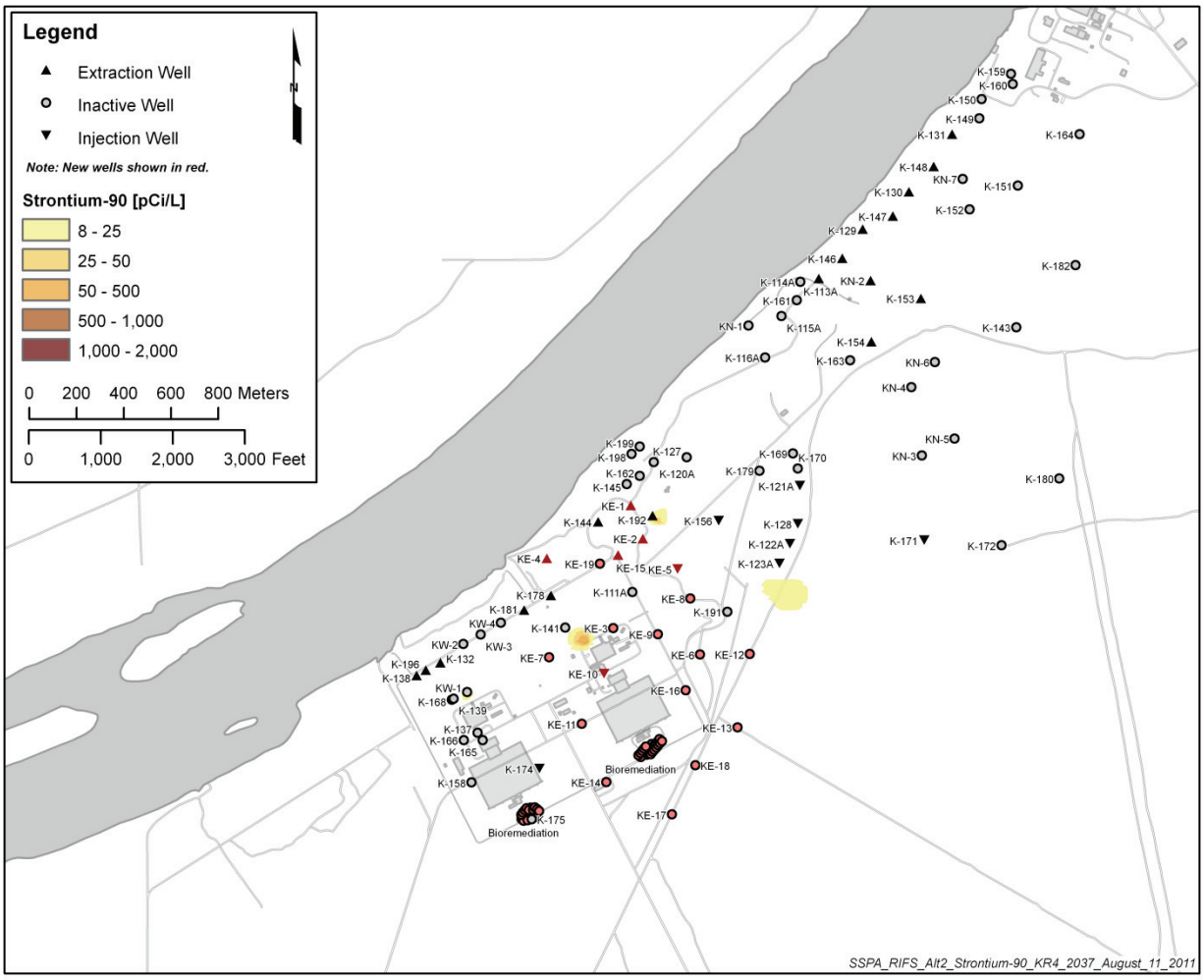


Figure 5-45. Simulated Distribution of Strontium-90 in December 2037 – Alternative 2.

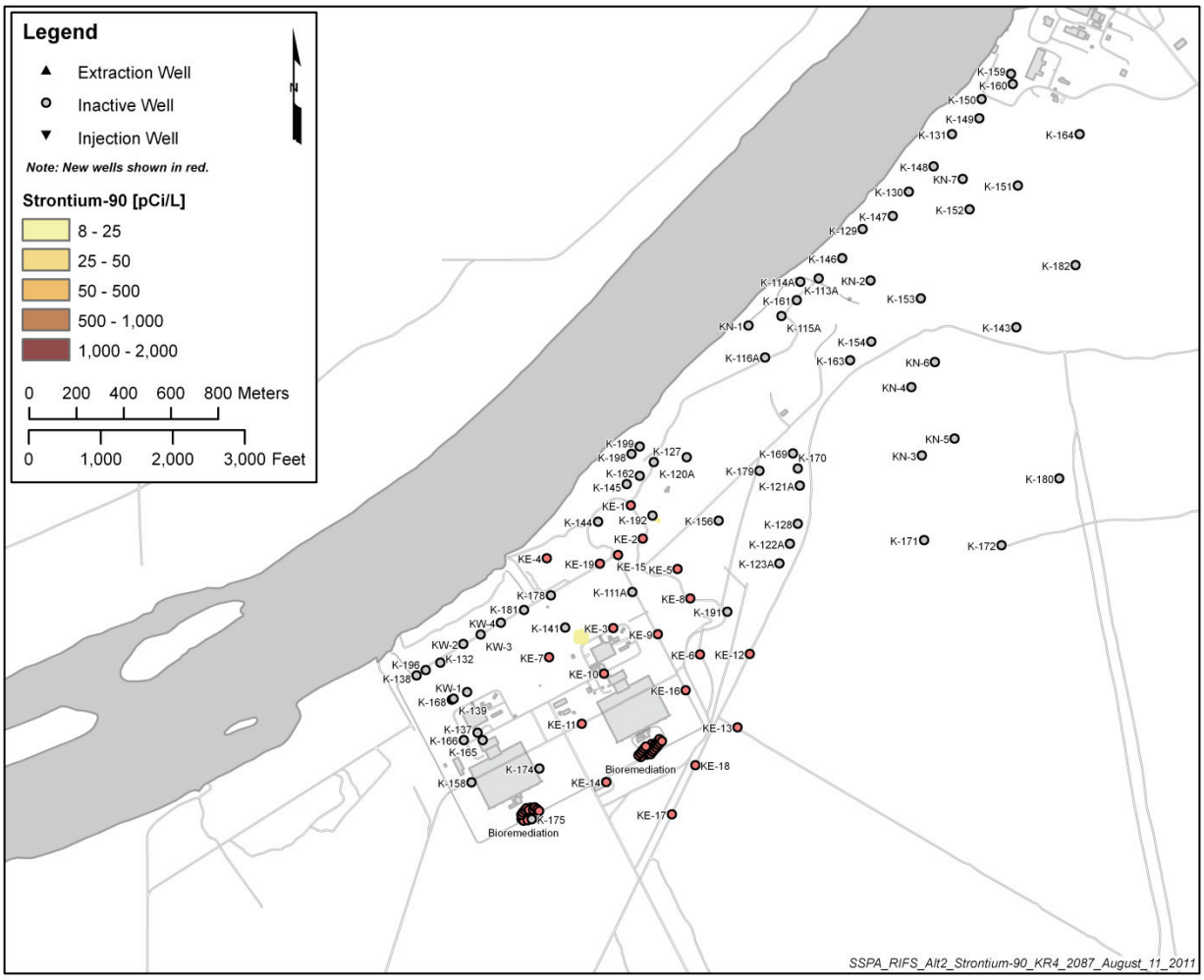


Figure 5-46. Simulated Distribution of Strontium-90 in December 2087 – Alternative 2.

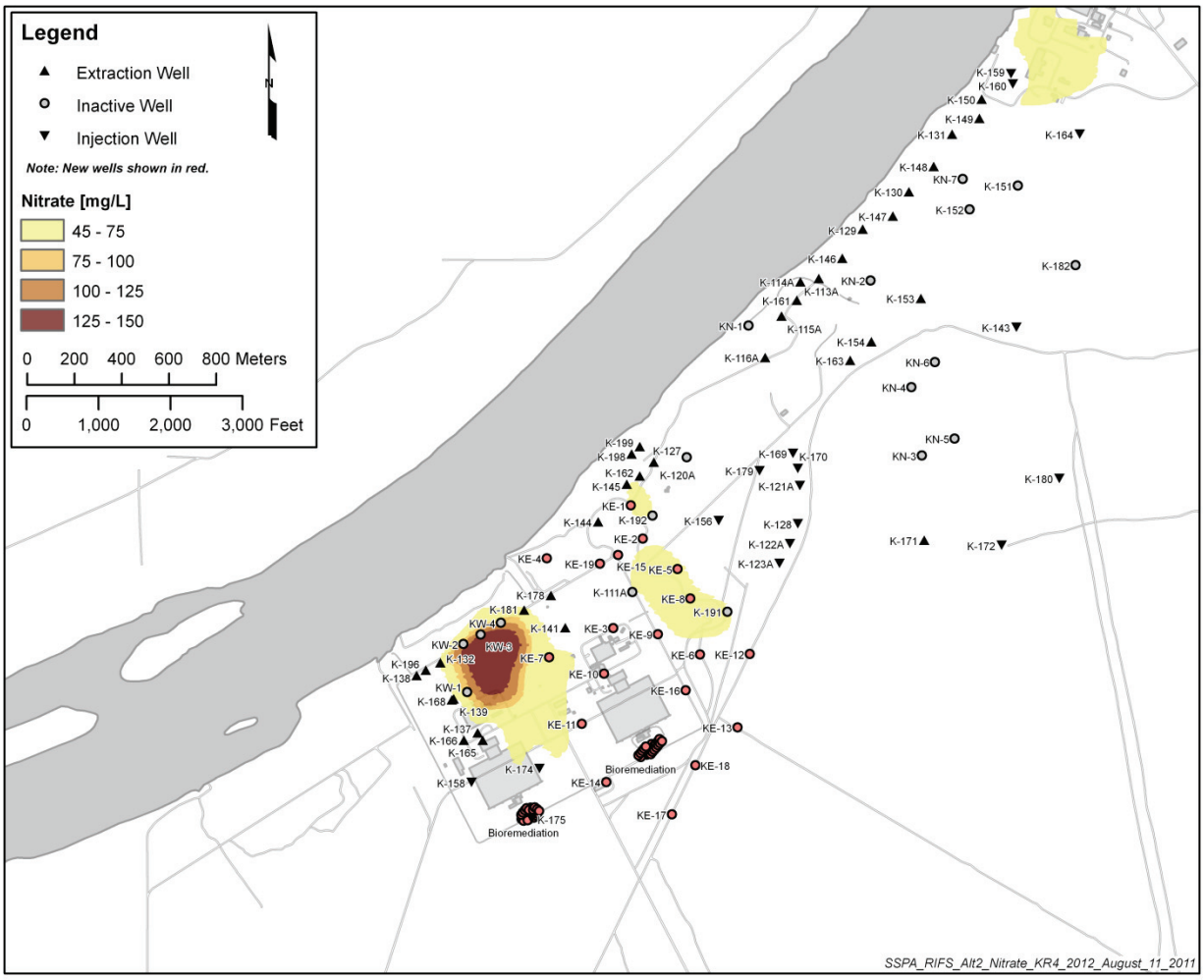


Figure 5-47. Simulated Distribution of Nitrate in December 2012 – Alternative 2.

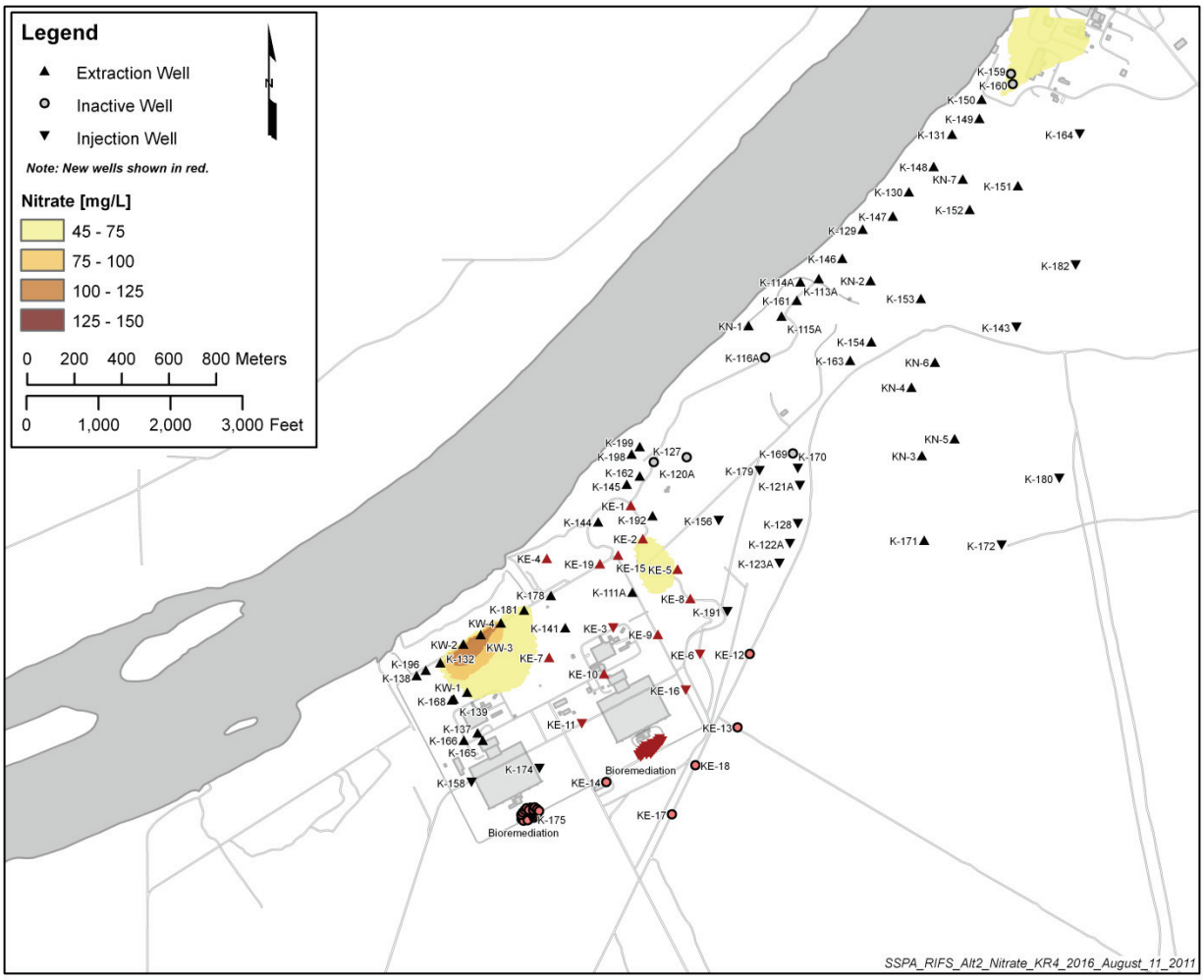


Figure 5-48. Simulated Distribution of Nitrate in December 2016 – Alternative 2.

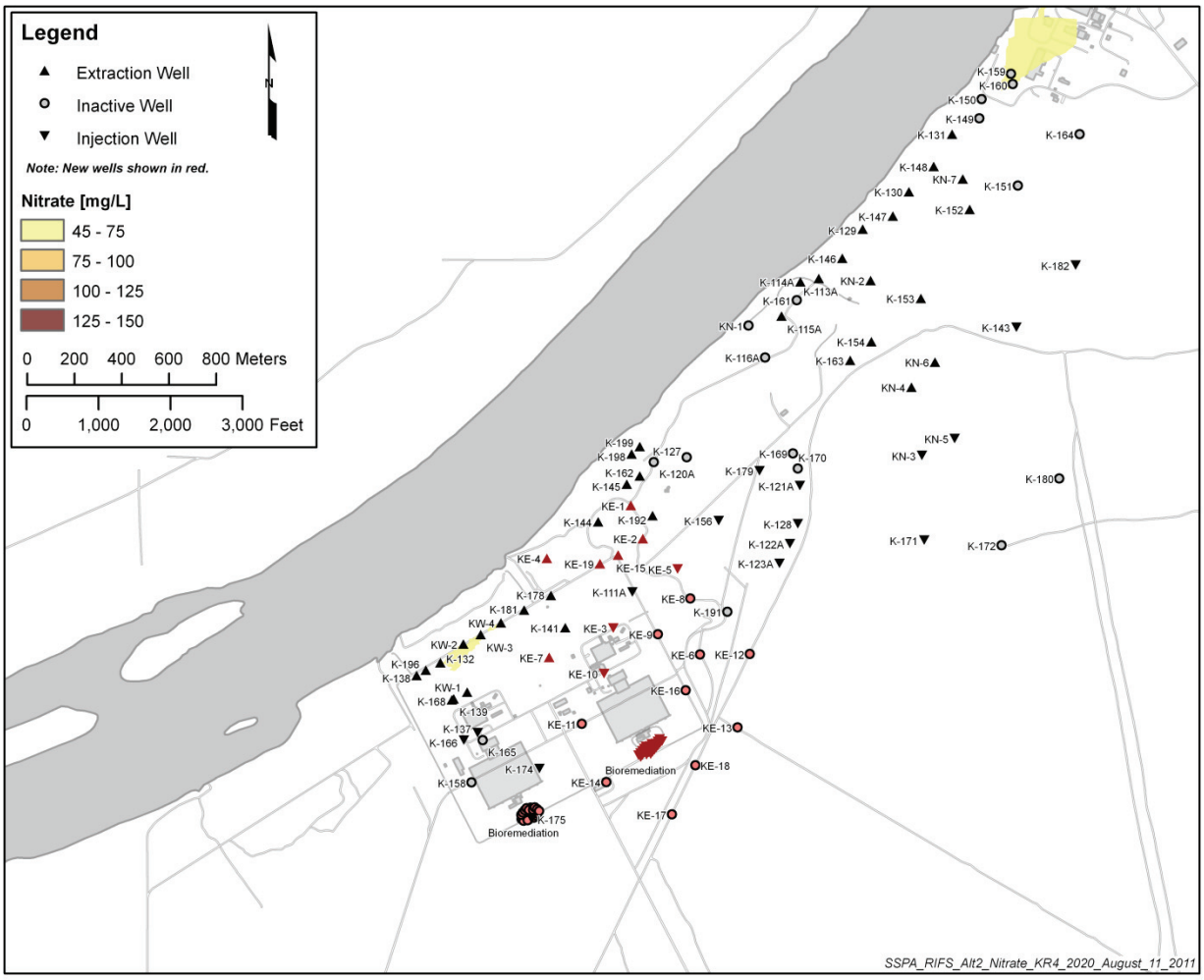


Figure 5-49. Simulated Distribution of Nitrate in December 2020 – Alternative 2.

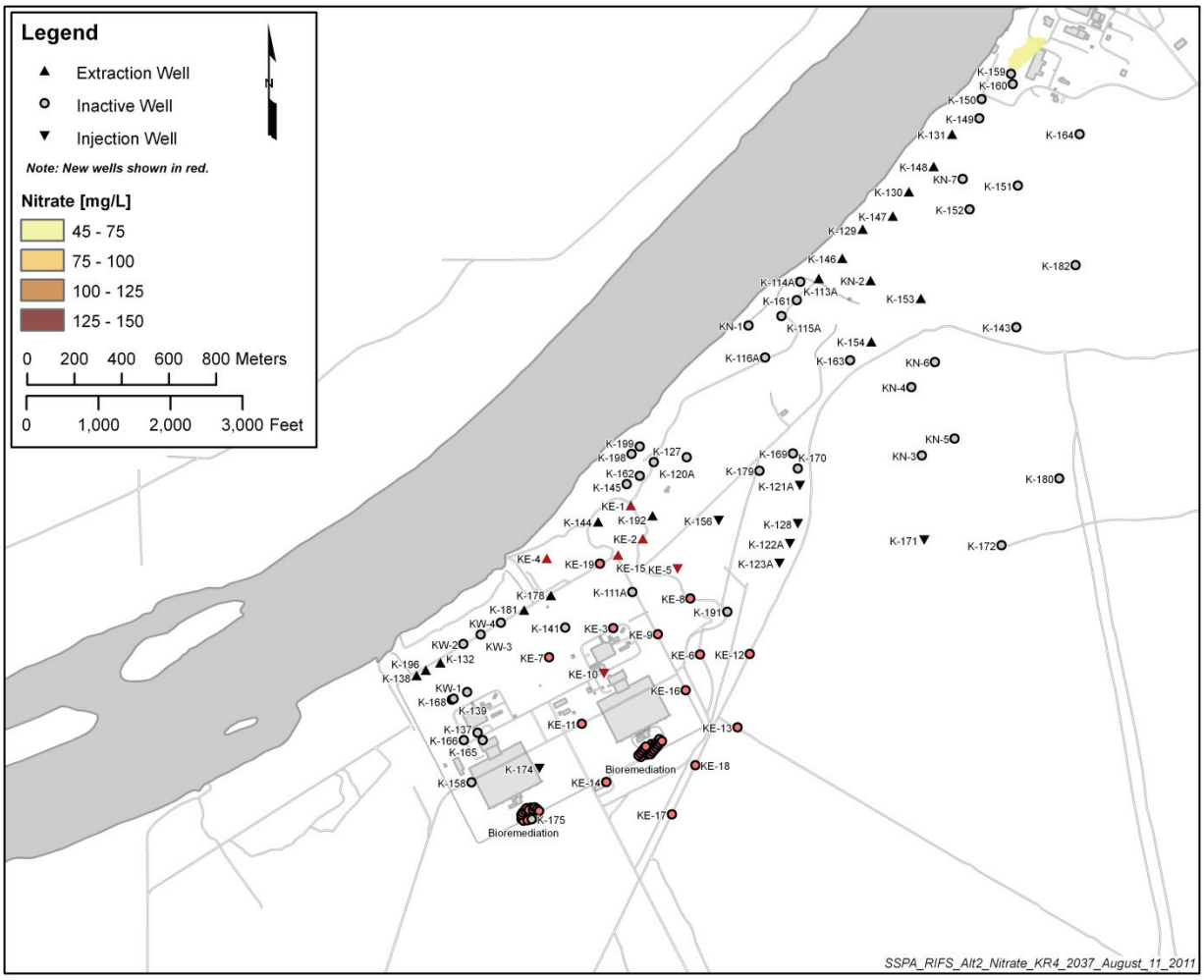


Figure 5-50. Simulated Distribution of Nitrate in December 2037 – Alternative 2.

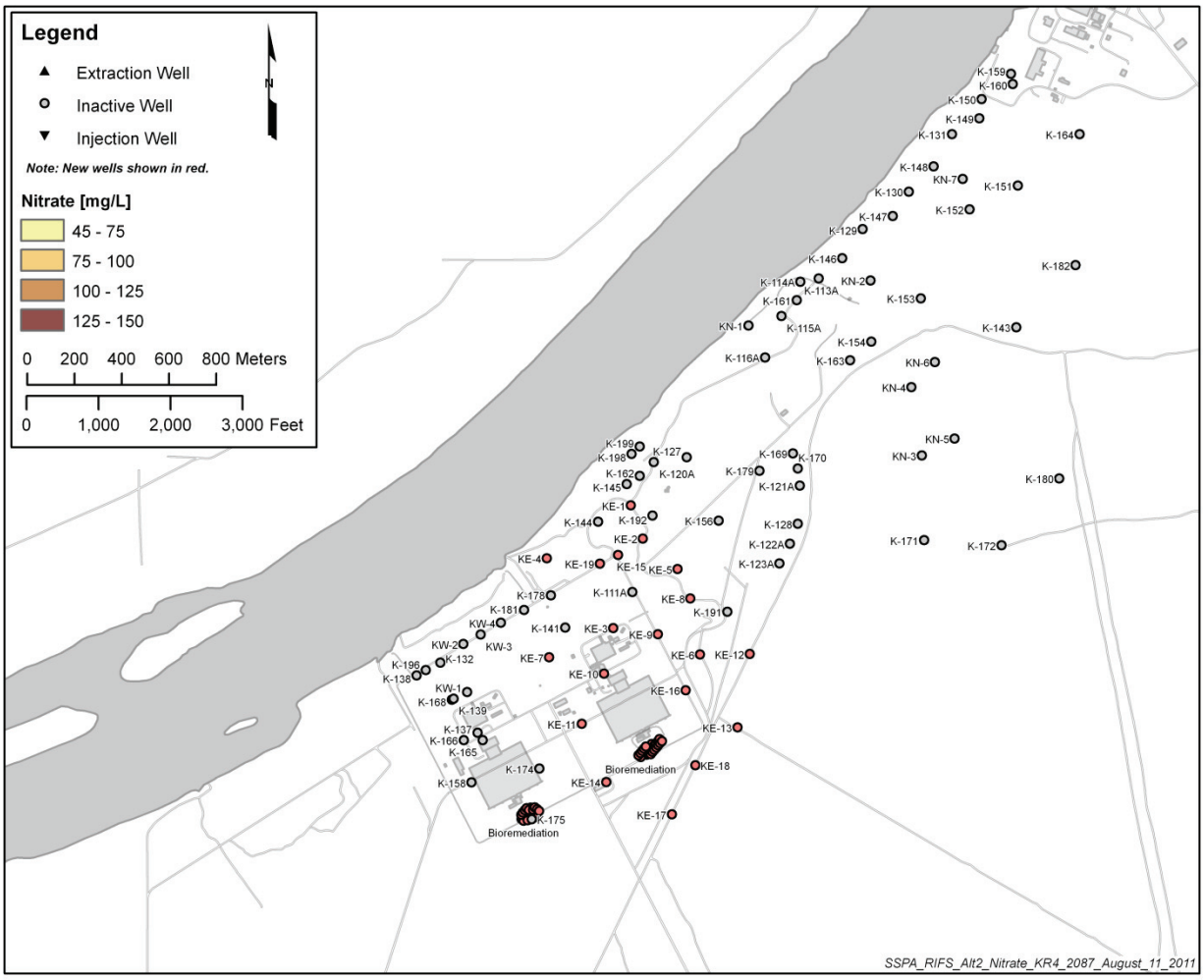


Figure 5-51. Simulated Distribution of Nitrate in December 2087 – Alternative 2.

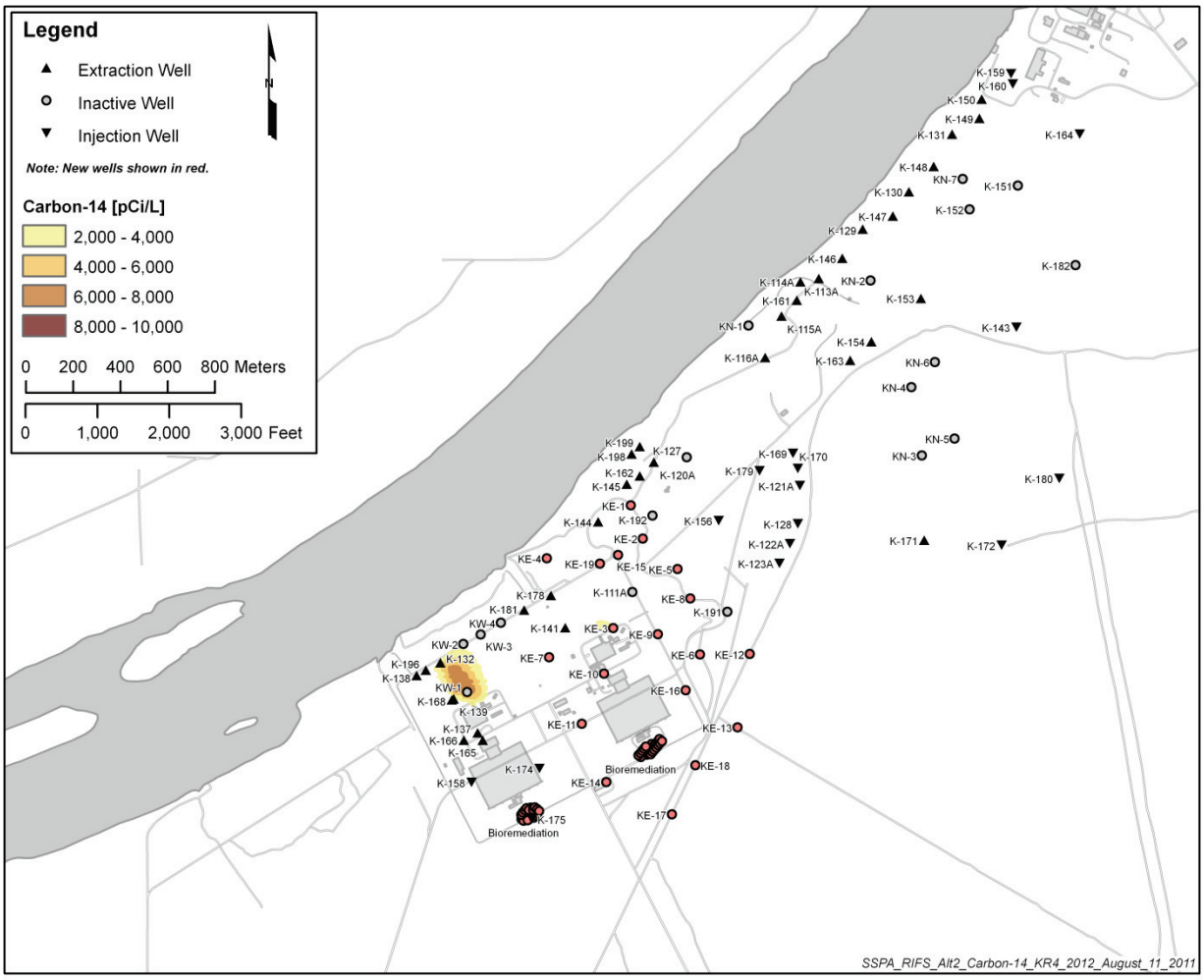


Figure 5-52. Simulated Distribution of Carbon-14 in December 2012 – Alternative 2.

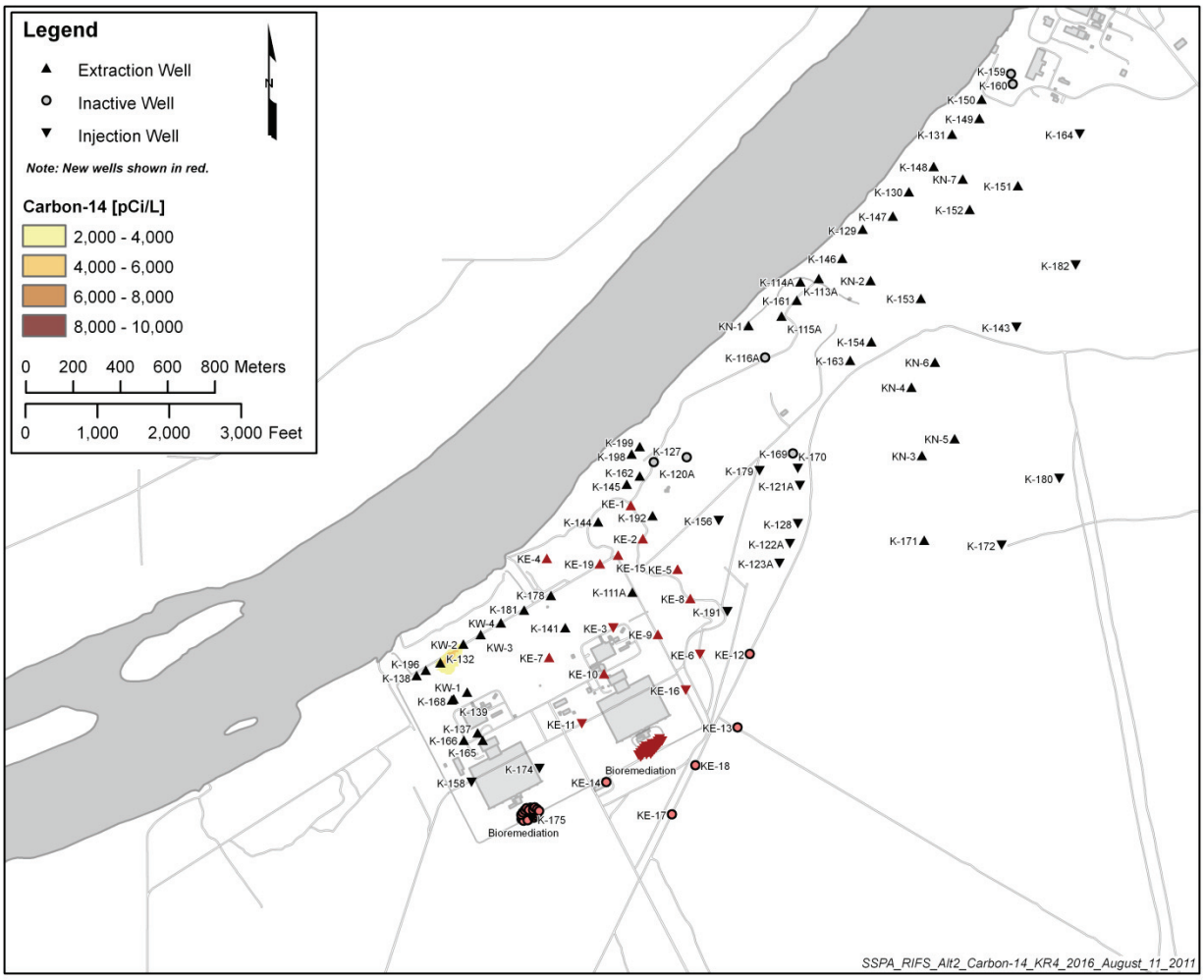


Figure 5-53. Simulated Distribution of Carbon-14 in December 2016 – Alternative 2.

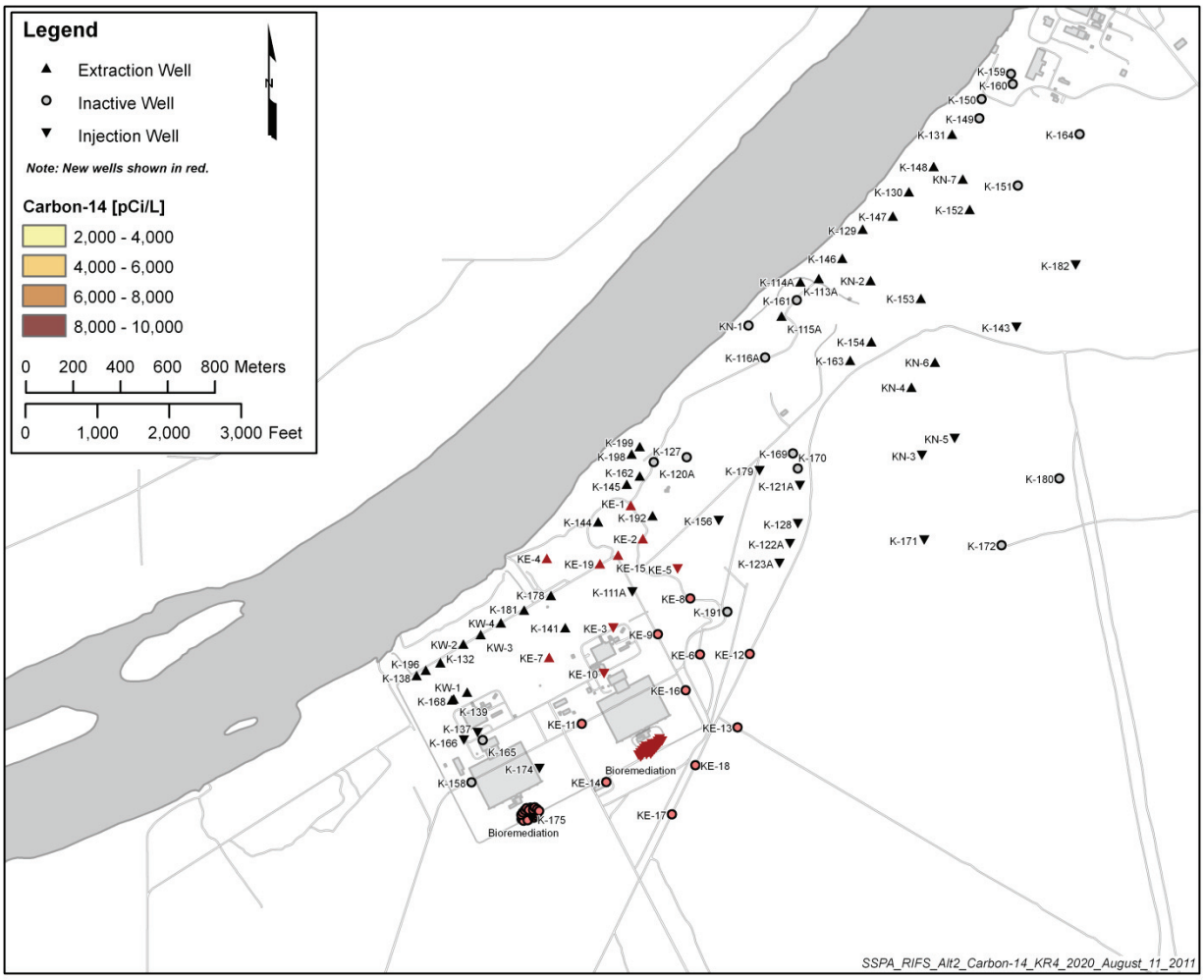


Figure 5-54. Simulated Distribution of Carbon-14 in December 2020 – Alternative 2.

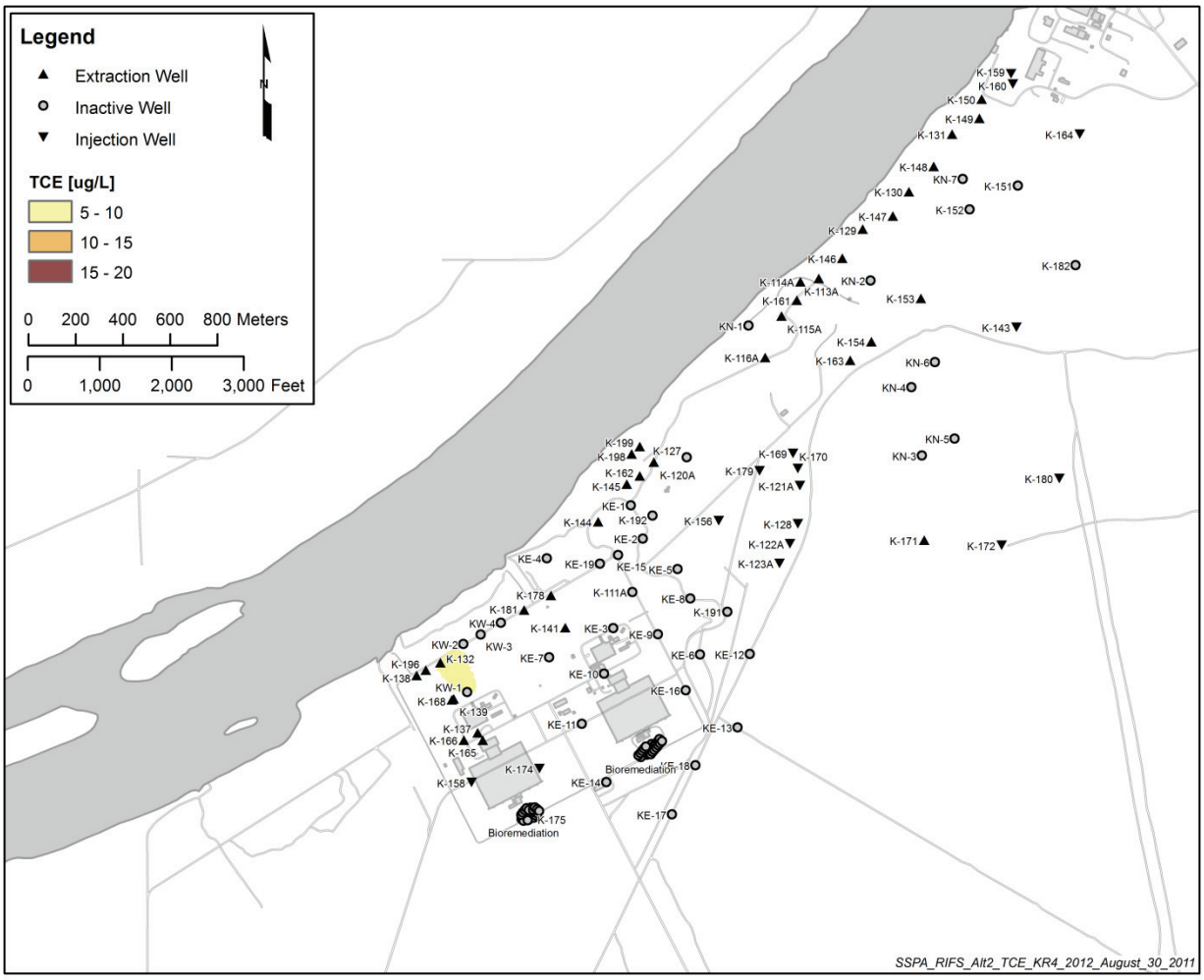


Figure 5-55. Simulated Distribution of TCE in December 2012 – Alternative 2.

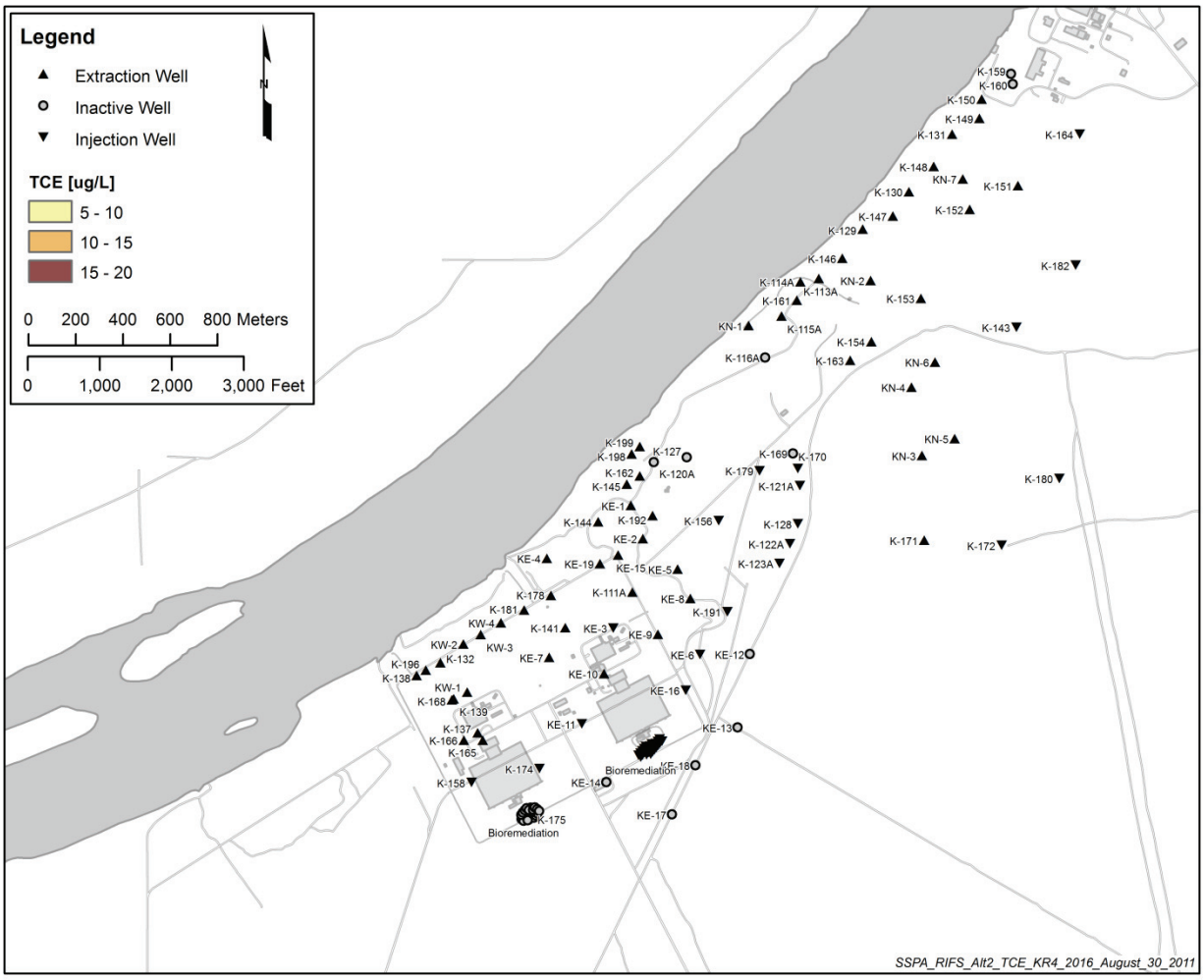


Figure 5-56. Simulated Distribution of TCE in December 2016 – Alternative 2.

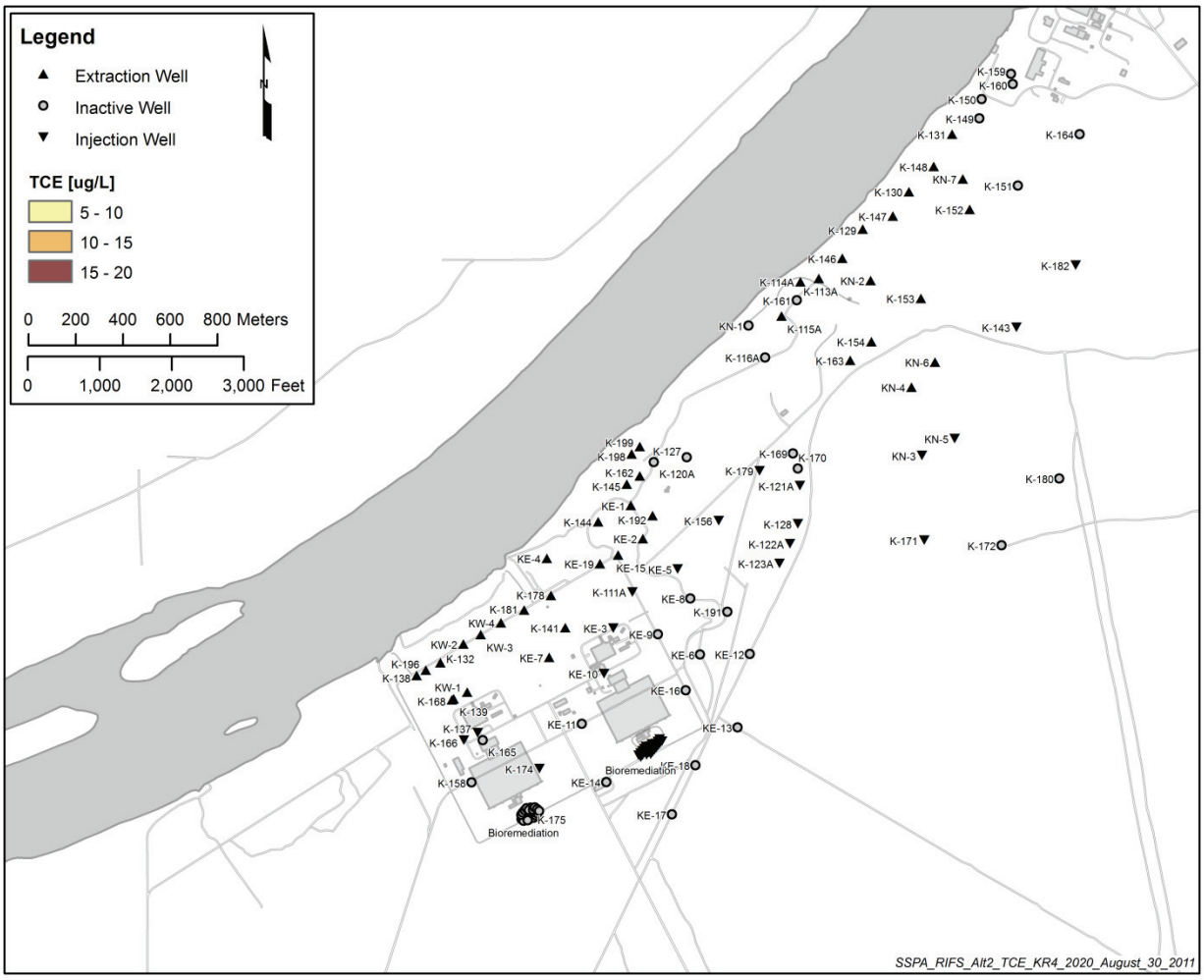


Figure 5-57. Simulated Distribution of TCE in December 2020 – Alternative 2.

1.2 Alternative 3: Aggressive P&T

Figure 5-58 illustrates the hydraulic capture efficiency in 2012 for the aggressive P&T. Figures 5-59 to 5-63 illustrate the simulated distribution of CrVI in 2012, 2016, 2020, 2037, and 2087, respectively. Figures 5-64 and 5-65 show the simulated time-series of concentration-versus-time for CrVI along the shoreline and in the aquifer during the simulation timeframe. Figures 5-66 to 5-68 illustrate the simulated distribution of Tritium in 2012, 2016, and 2020, respectively. Figures 5-69 to 5-73 illustrate the simulated distribution of Strontium-90 in 2012, 2016, 2020, 2037, and 2087, respectively. Figures 5-74 to 5-78 illustrate the simulated distribution of Nitrate in 2012, 2016, 2020, 2037, and 2087, respectively. Figures 5-79 to 5-81 illustrate the simulated distribution of Carbon-14 in 2012, 2016, and 2020, respectively. Figures 5-82 to 5-84 illustrate the simulated distribution of TCE in 2012, 2016, and 2020, respectively.

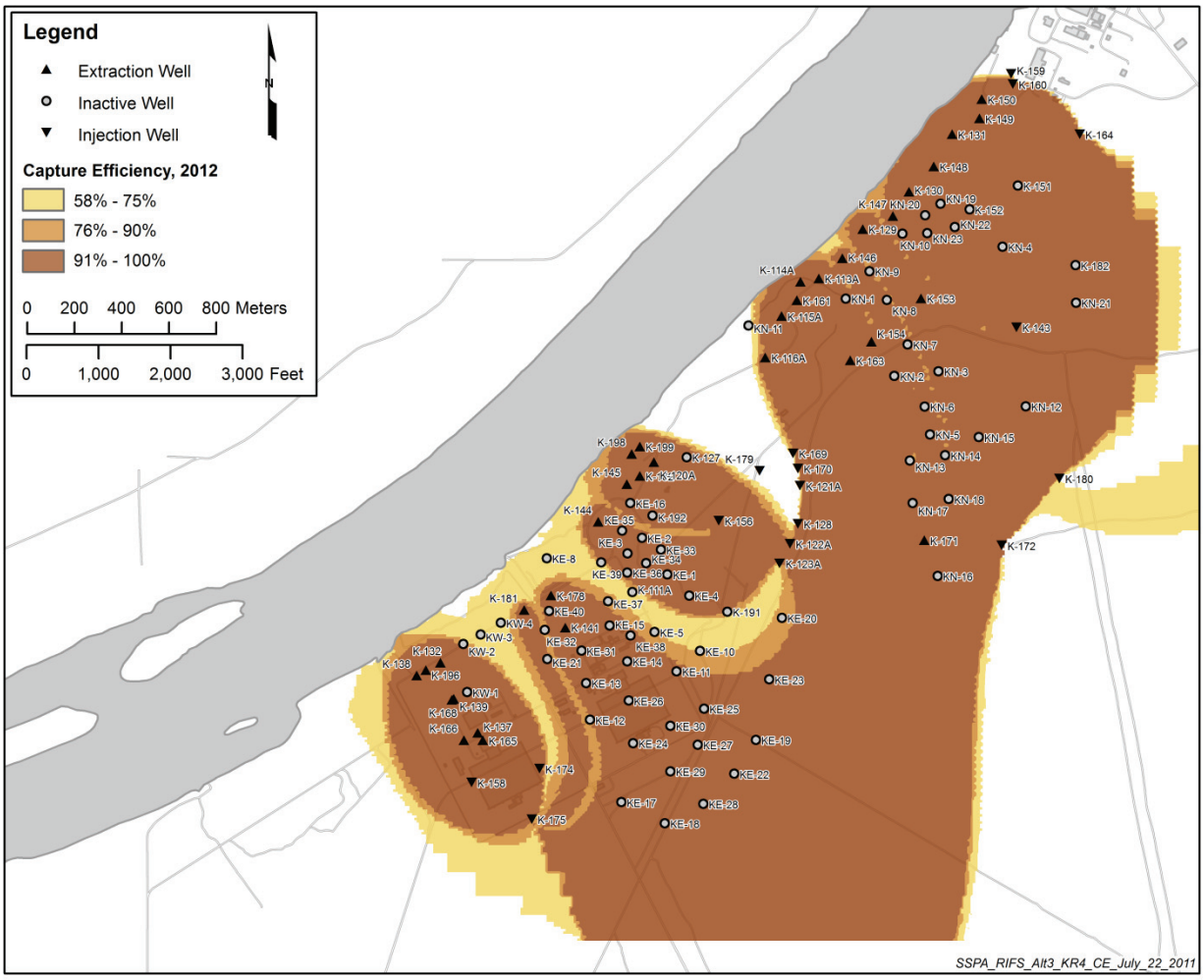


Figure 5-58. Capture Efficiency Map for CY2012 – Alternative 3.

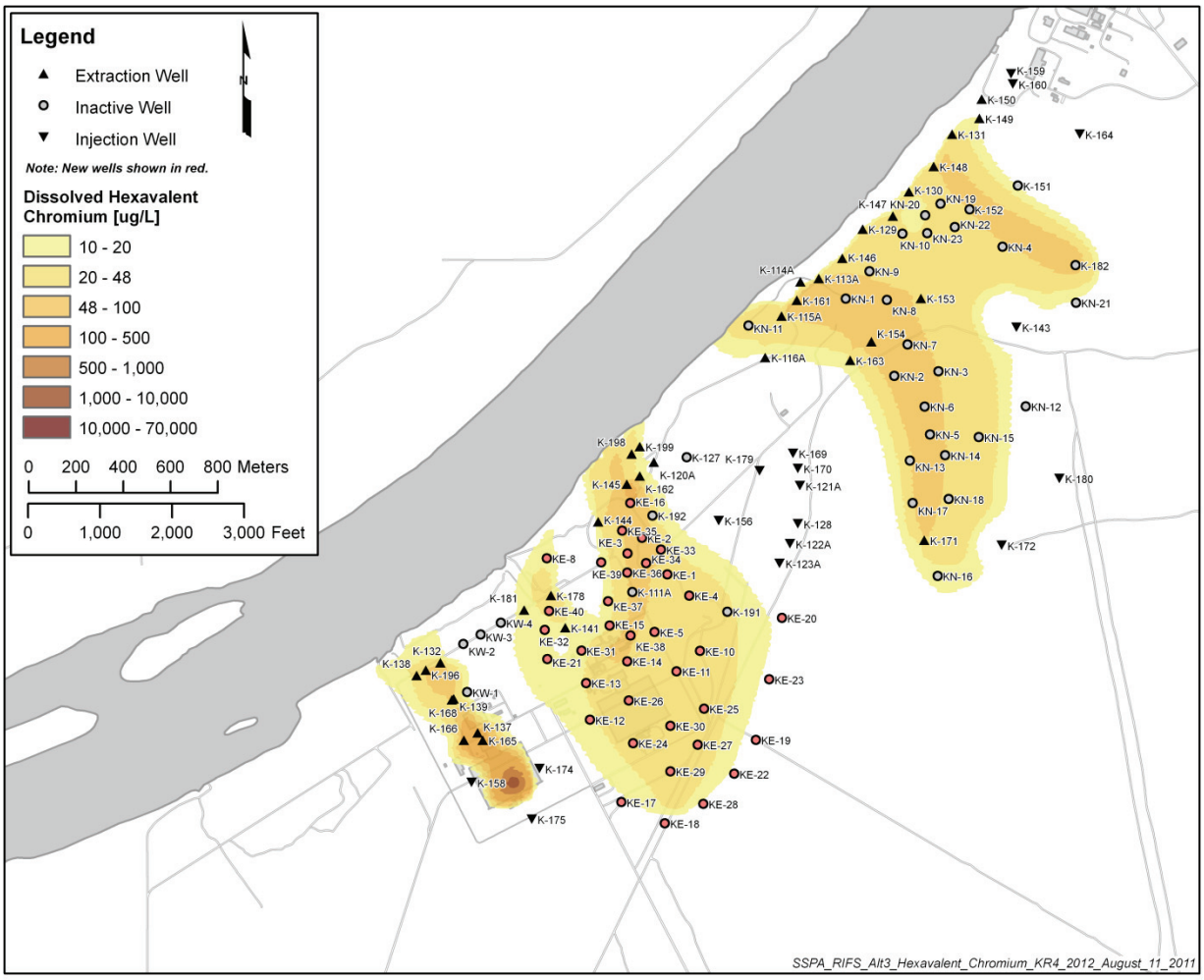


Figure 5-59. Simulated Distribution of CrVI in December 2012 – Alternative 3.

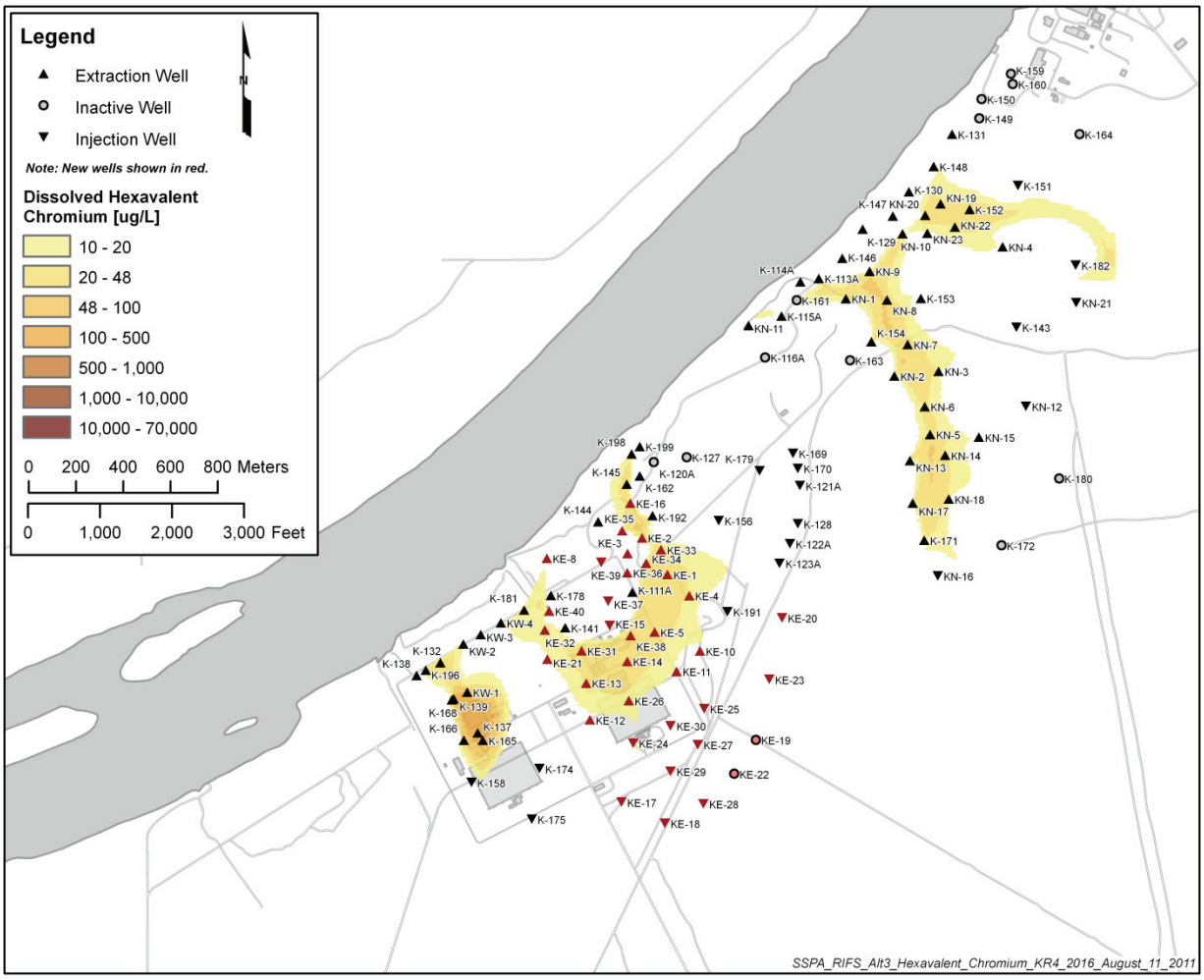


Figure 5-60. Simulated Distribution of CrVI in December 2016 – Alternative 3.

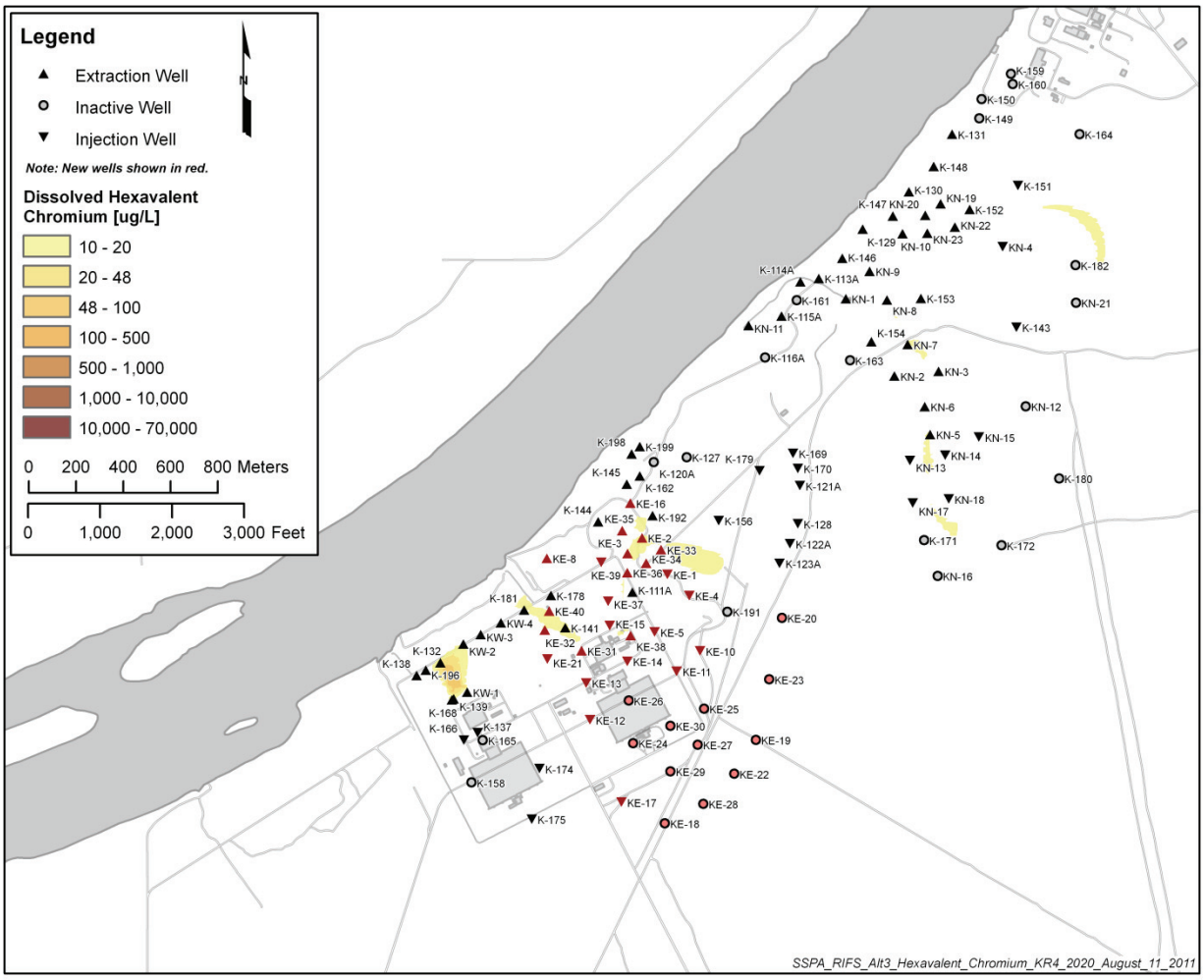


Figure 5-61. Simulated Distribution of CrVI in December 2020 – Alternative 3.

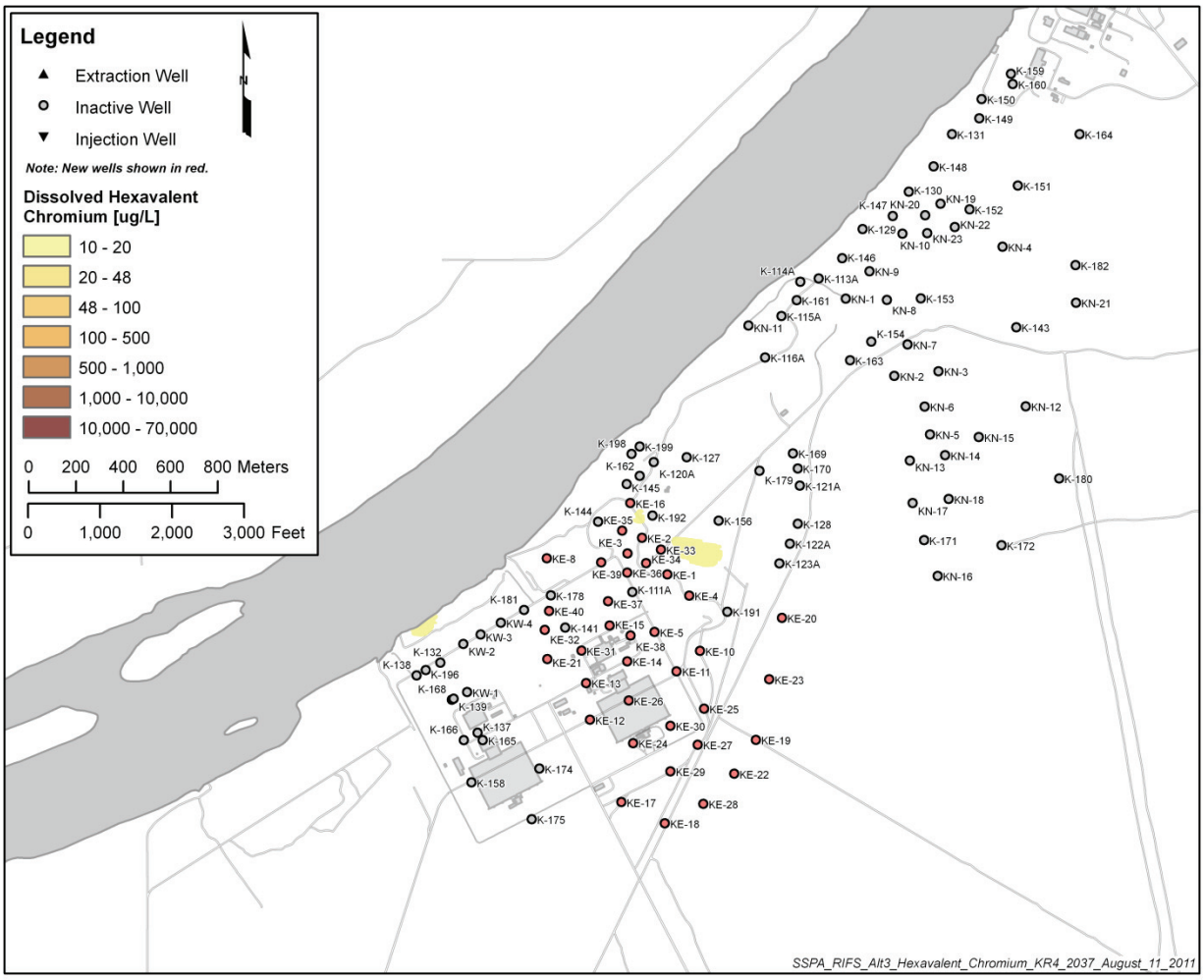


Figure 5-62. Simulated Distribution of CrVI in December 2037 – Alternative 3.

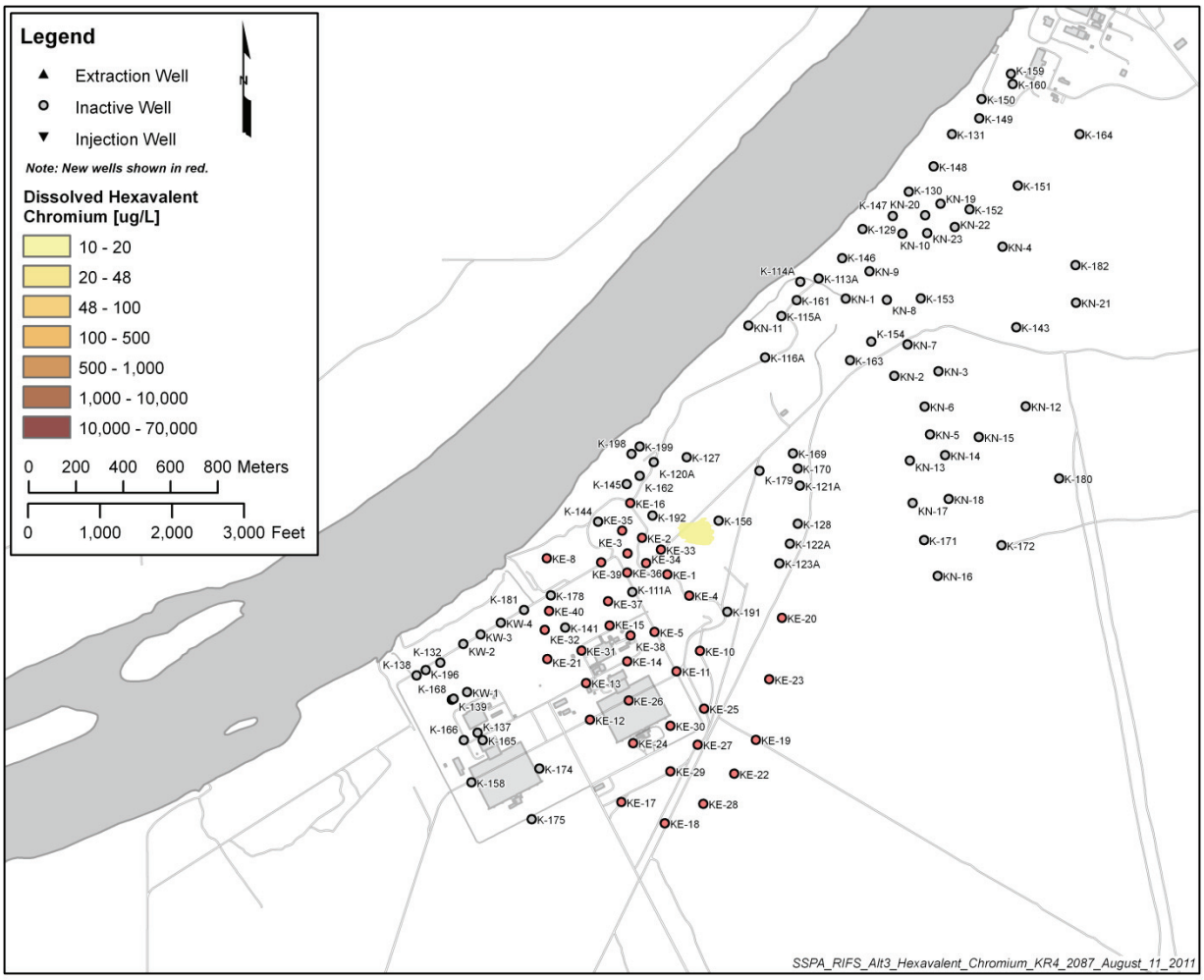


Figure 5-63. Simulated Distribution of CrVI in December 2087 – Alternative 3.

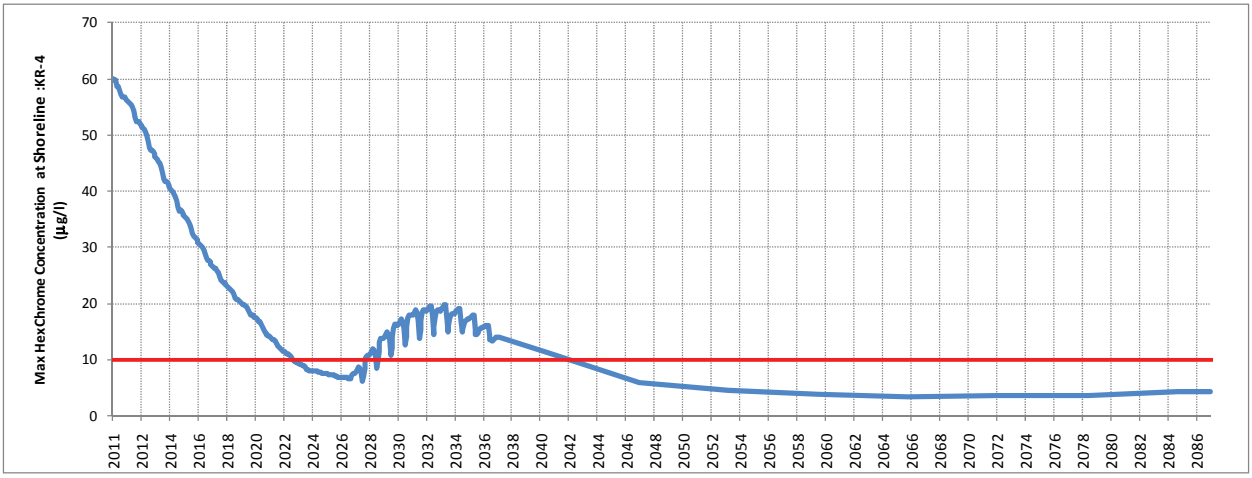


Figure 5-64. Simulated Maximum Dissolved CrVI Concentration along the Shoreline – Alternative 3.

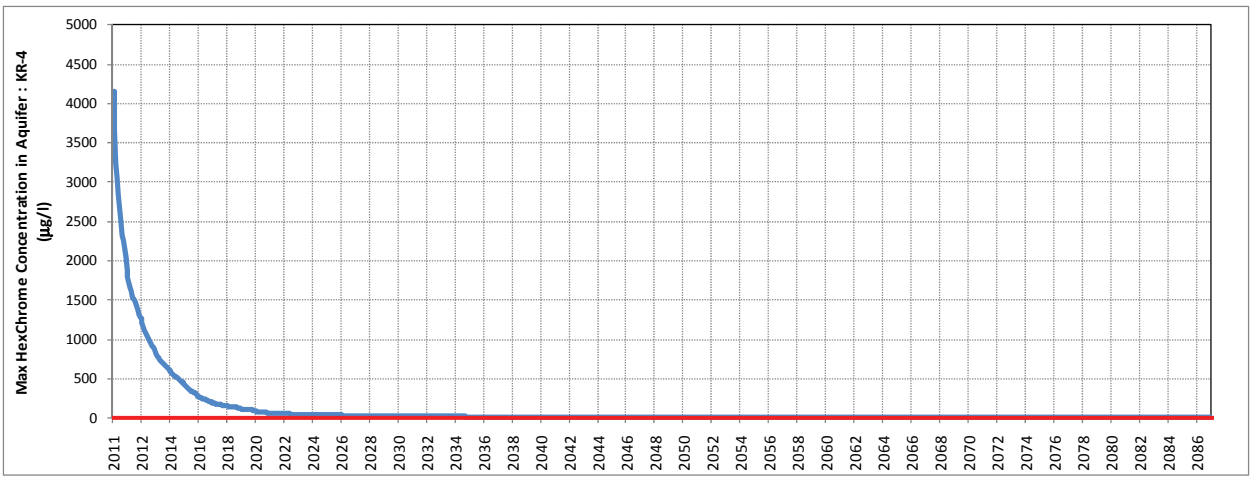


Figure 5-65. Simulated Maximum Dissolved CrVI Concentration in the Aquifer – Alternative 3.

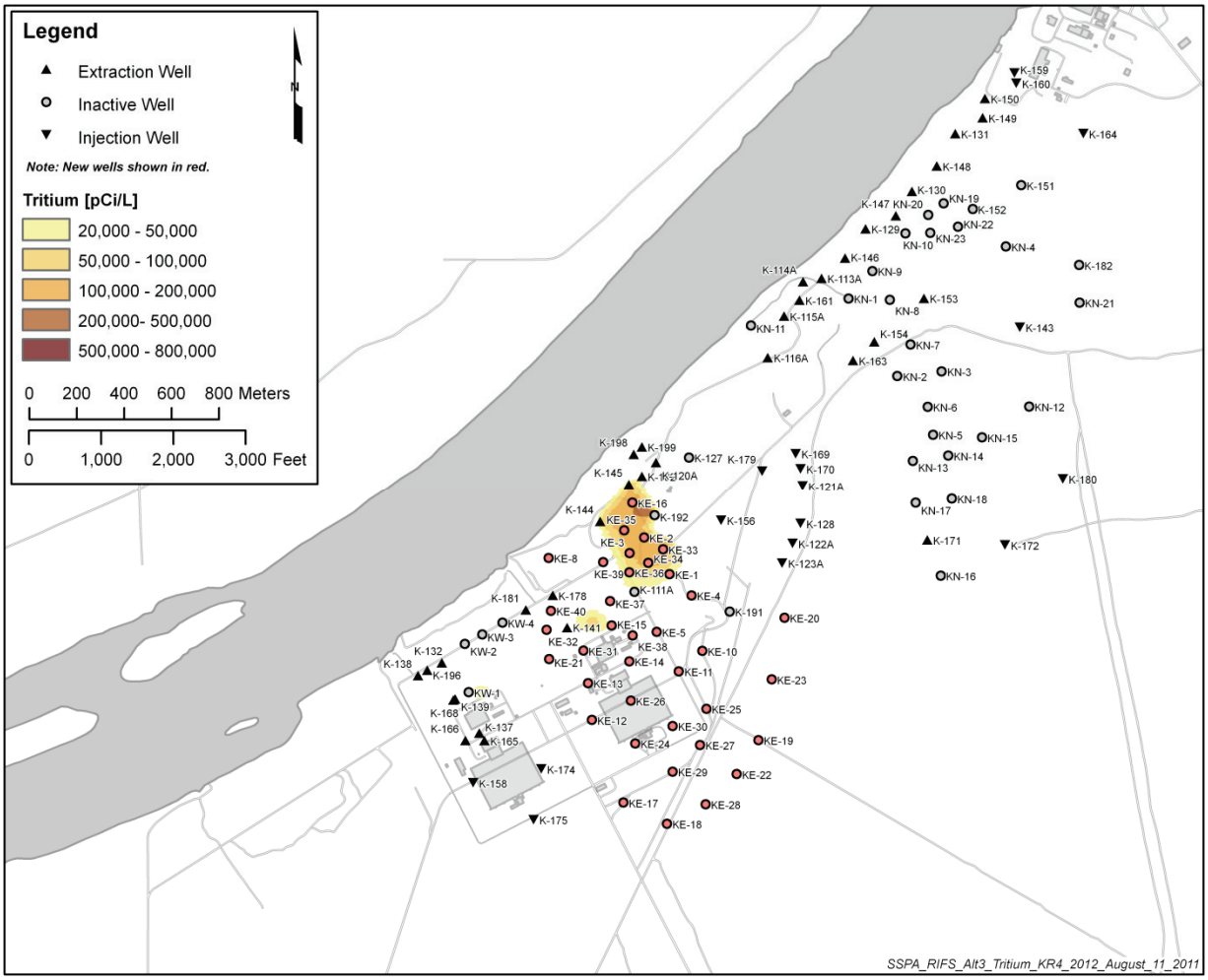
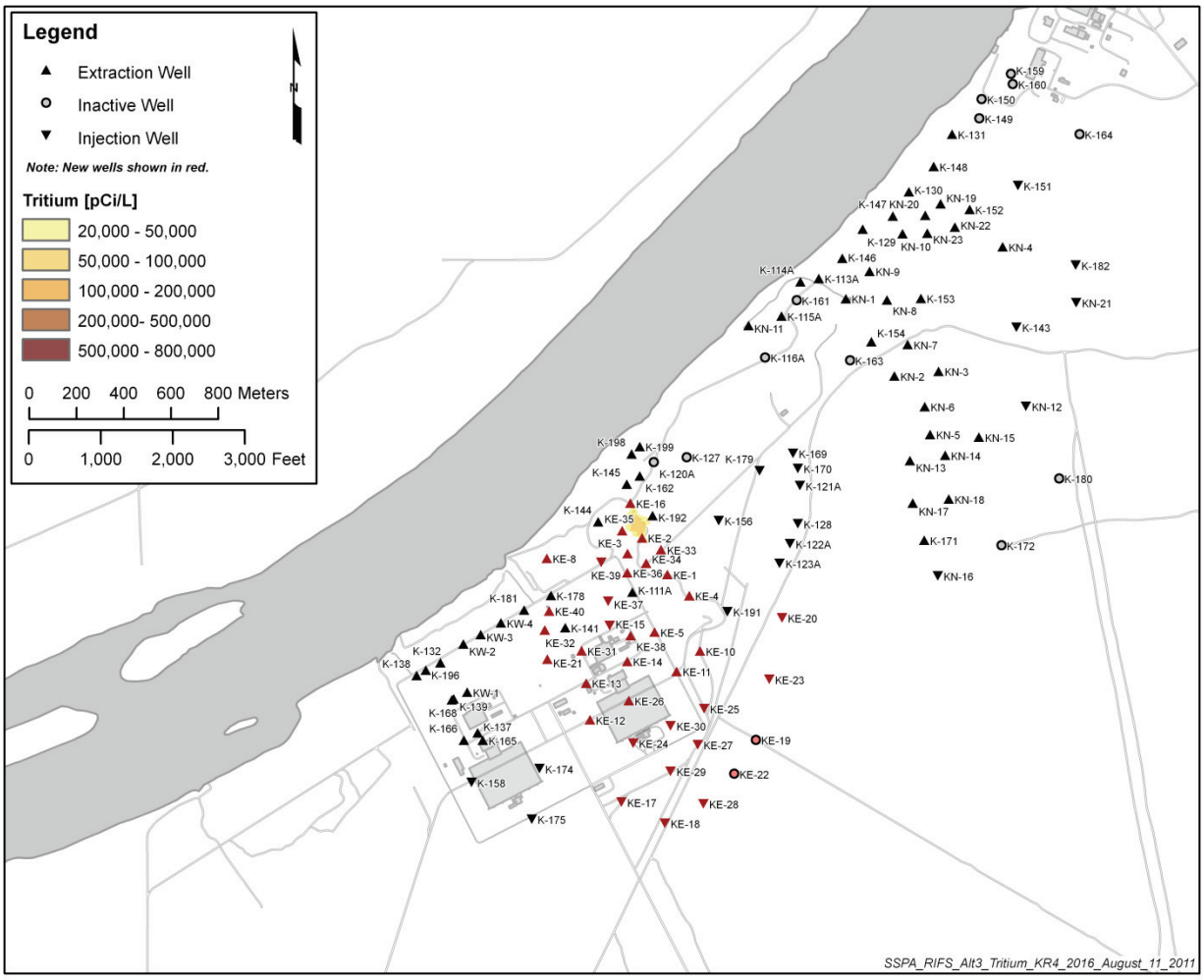


Figure 5-66. Simulated Distribution of Tritium in December 2012 – Alternative 3.



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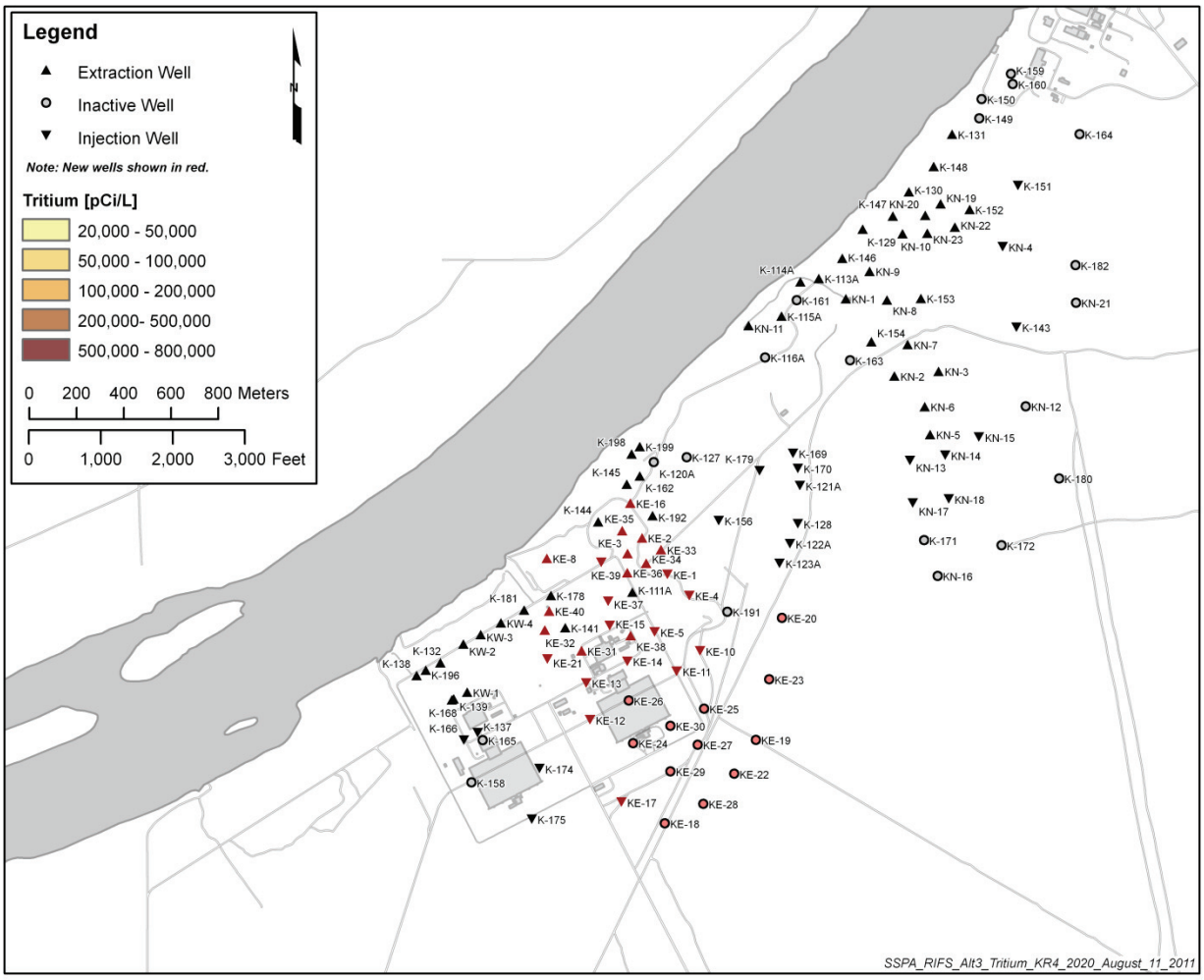


Figure 5-68. Simulated Distribution of Tritium in December 2020 – Alternative 3.

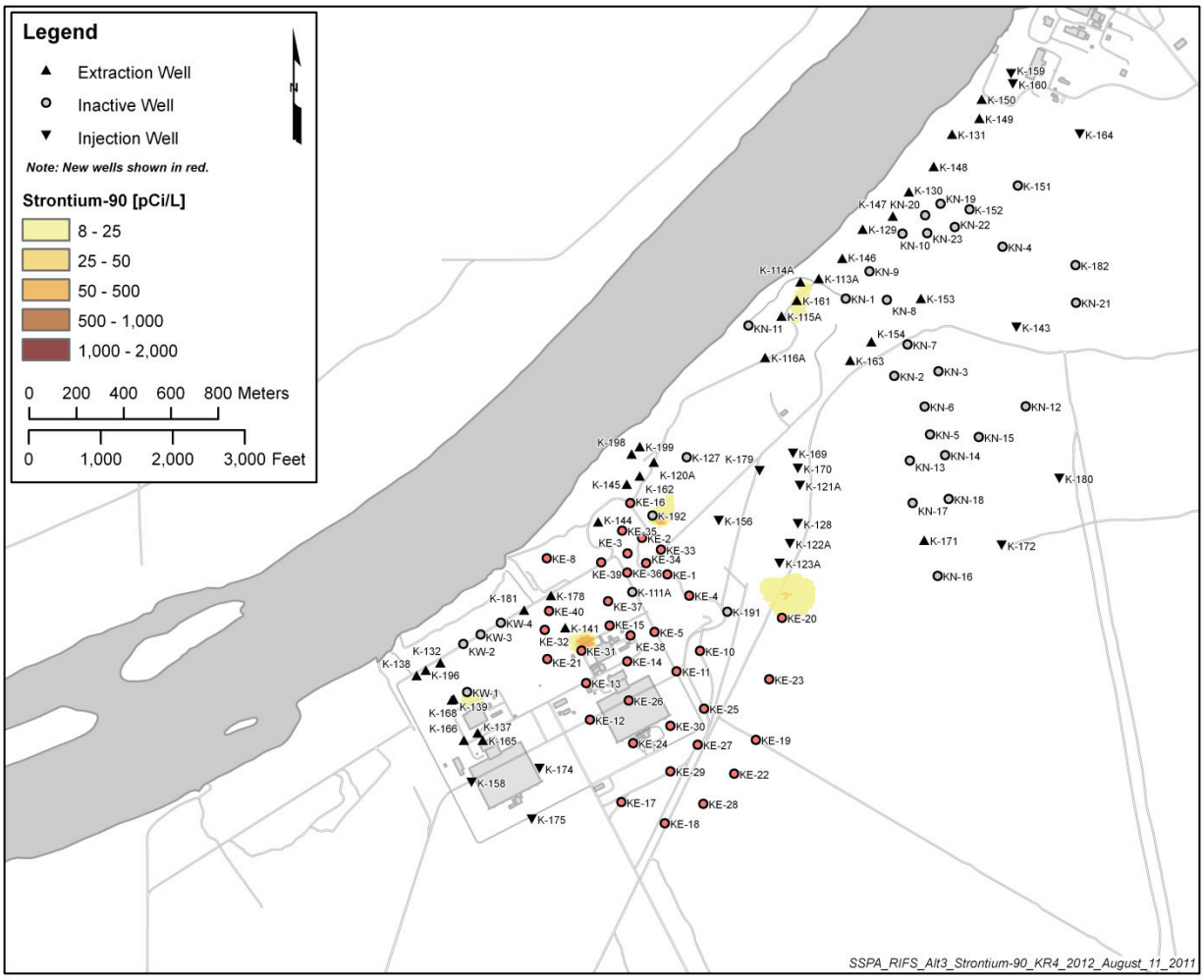
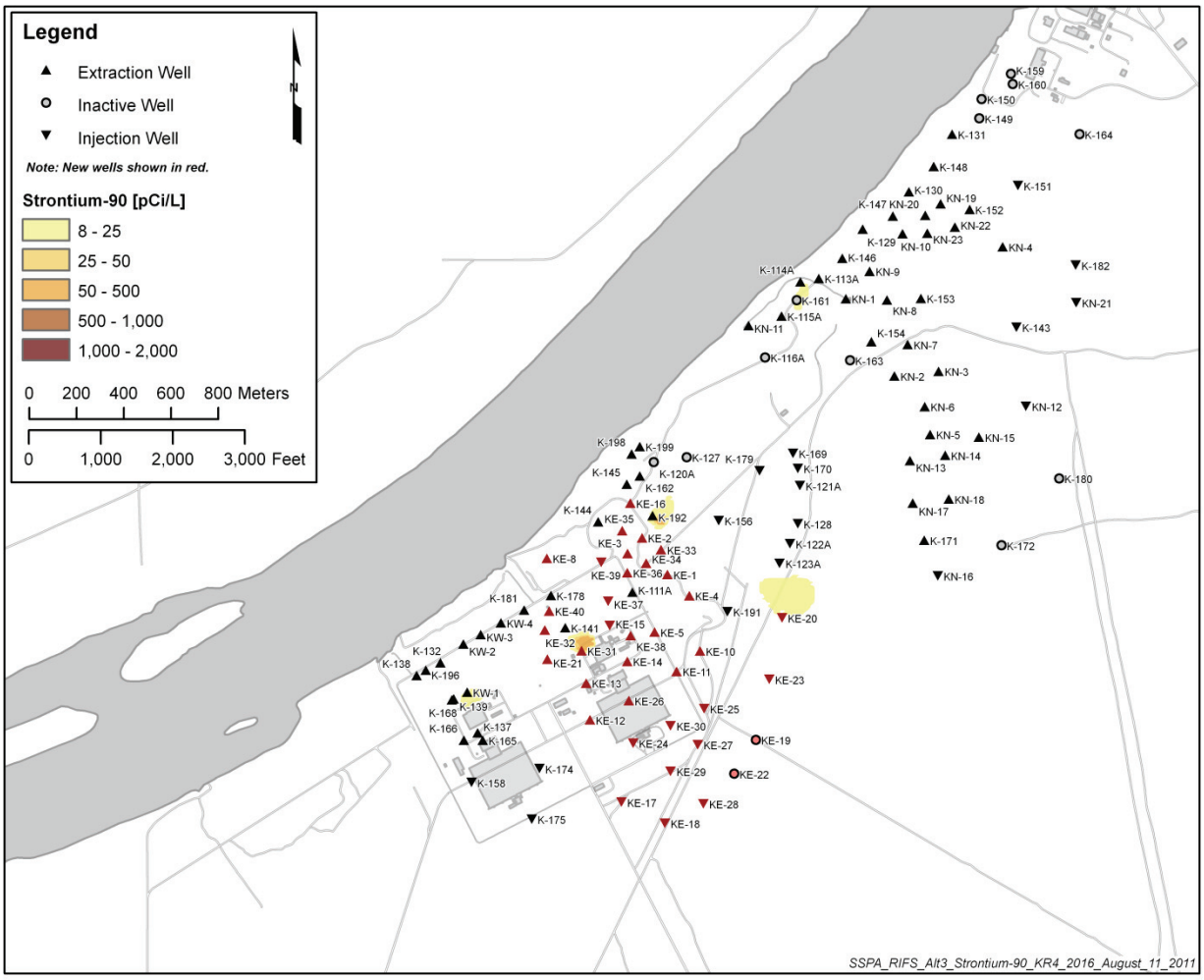


Figure 5-69. Simulated Distribution of Strontium-90 in December 2012 – Alternative 3.



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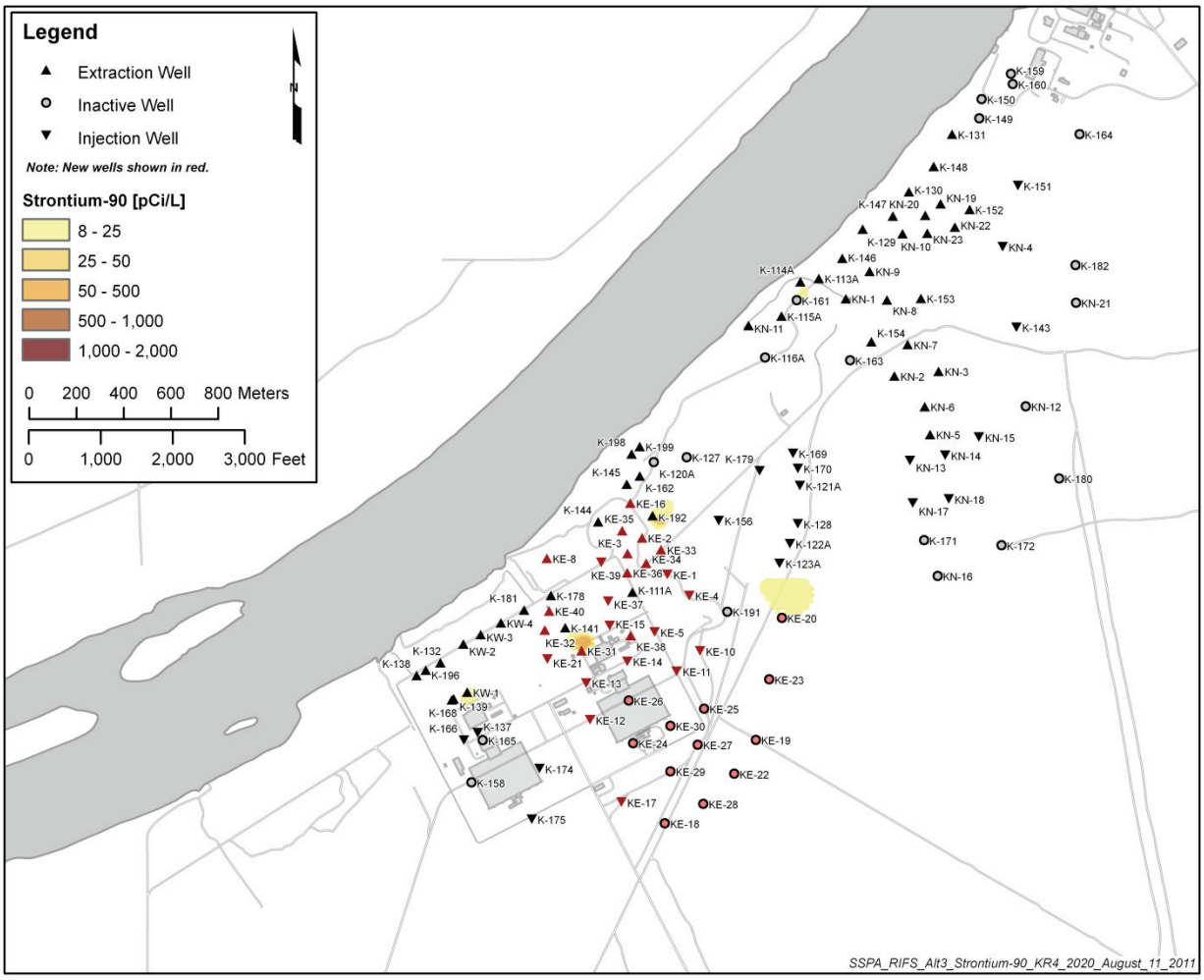


Figure 5-71. Simulated Distribution of Strontium-90 in December 2020 – Alternative 3.

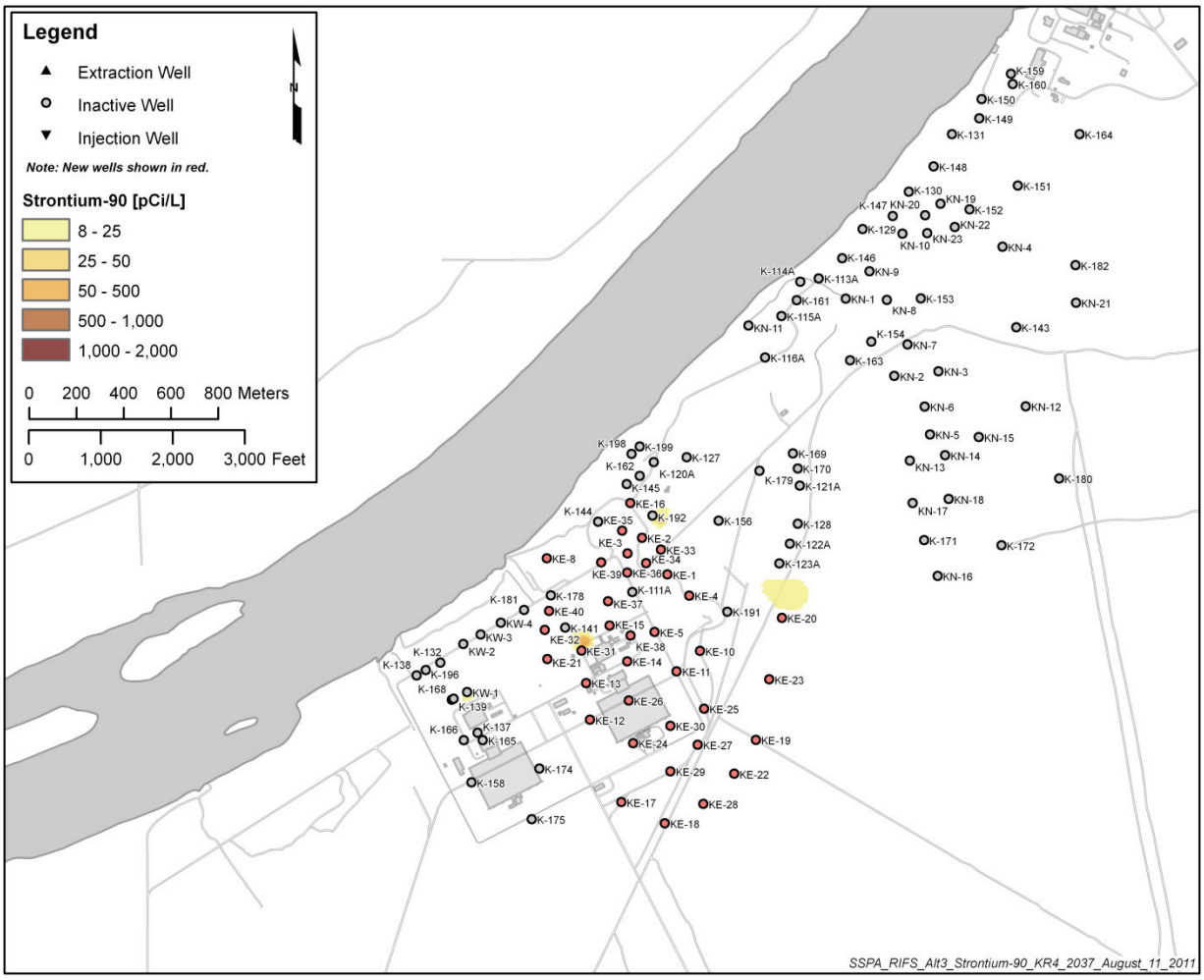
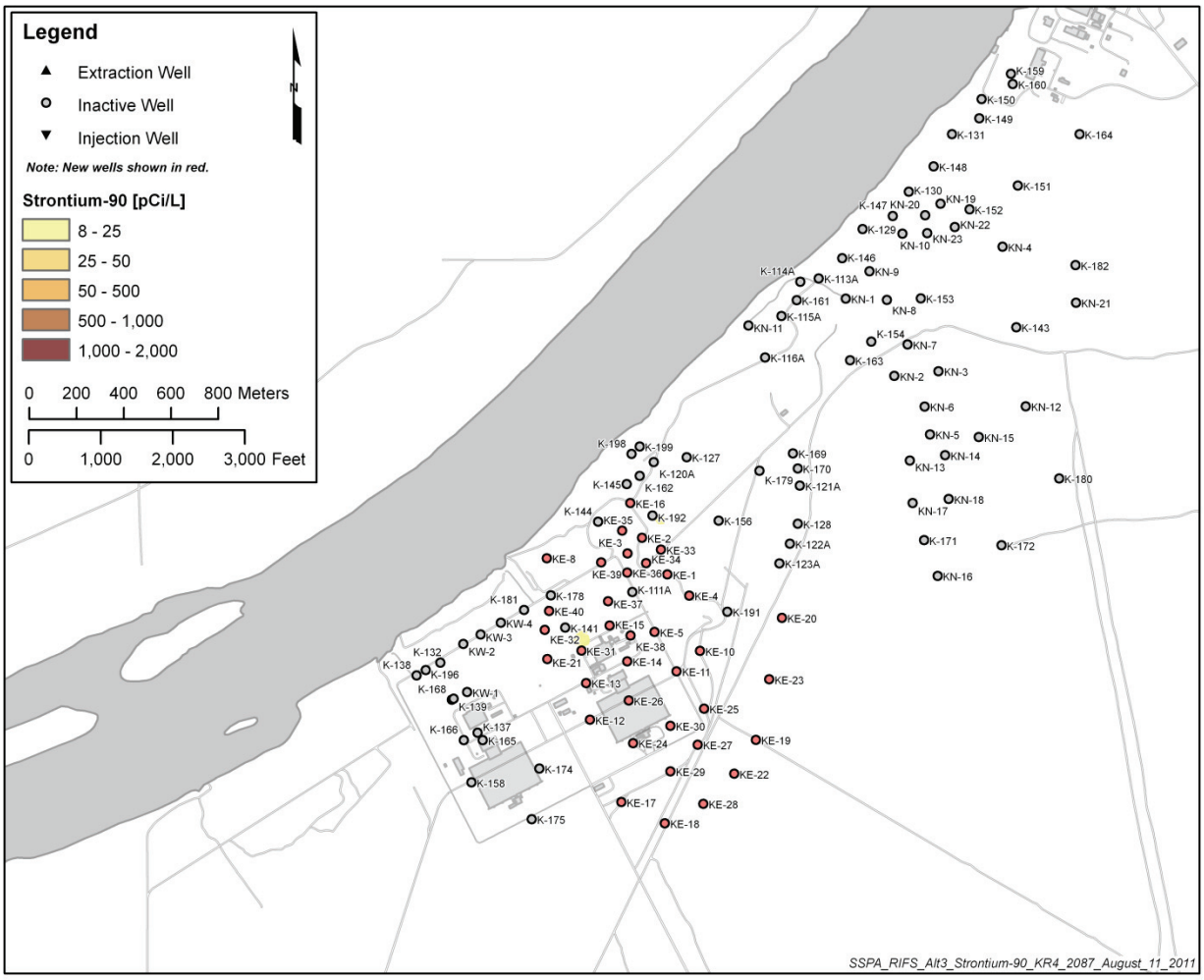


Figure 5-72. Simulated Distribution of Strontium-90 in December 2037 – Alternative 3.



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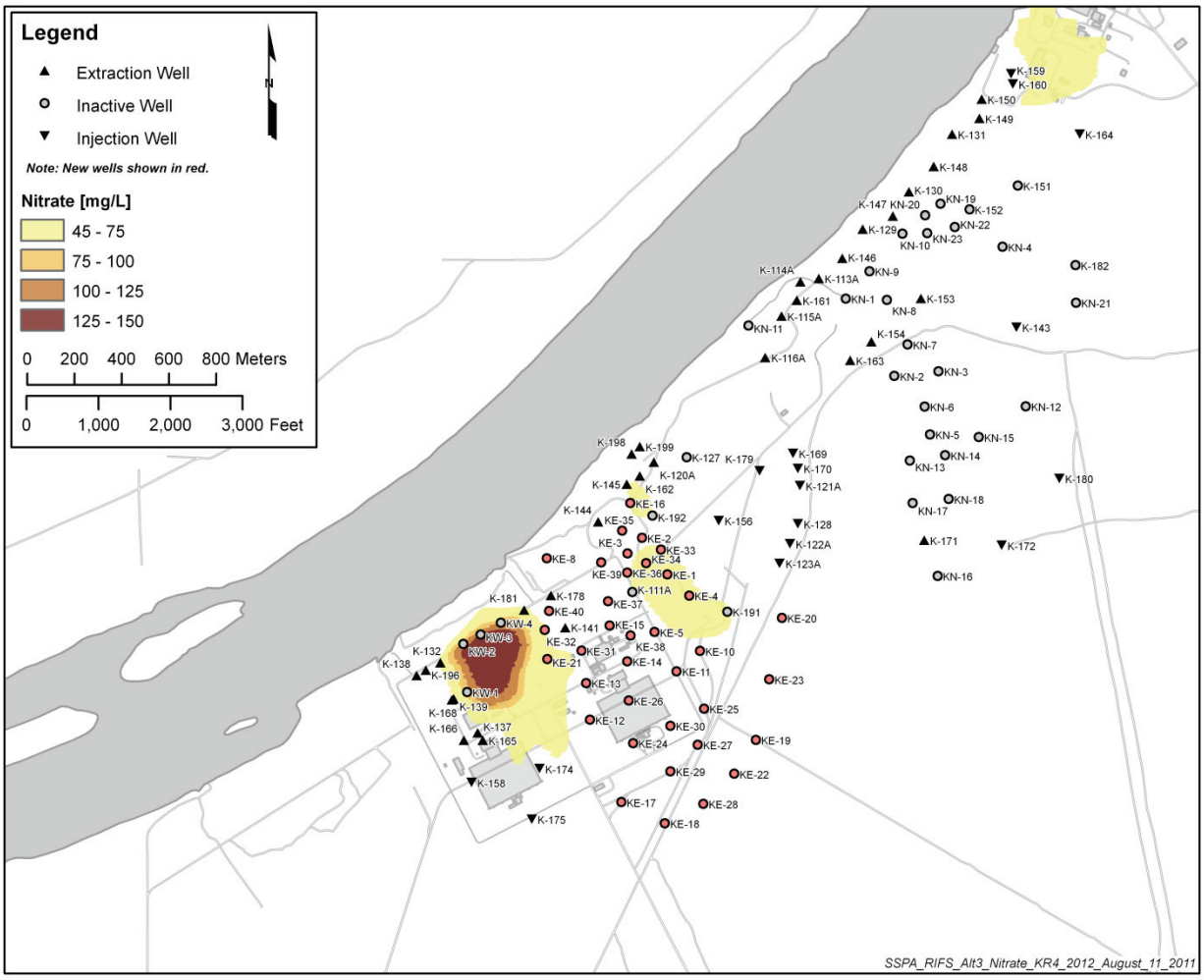

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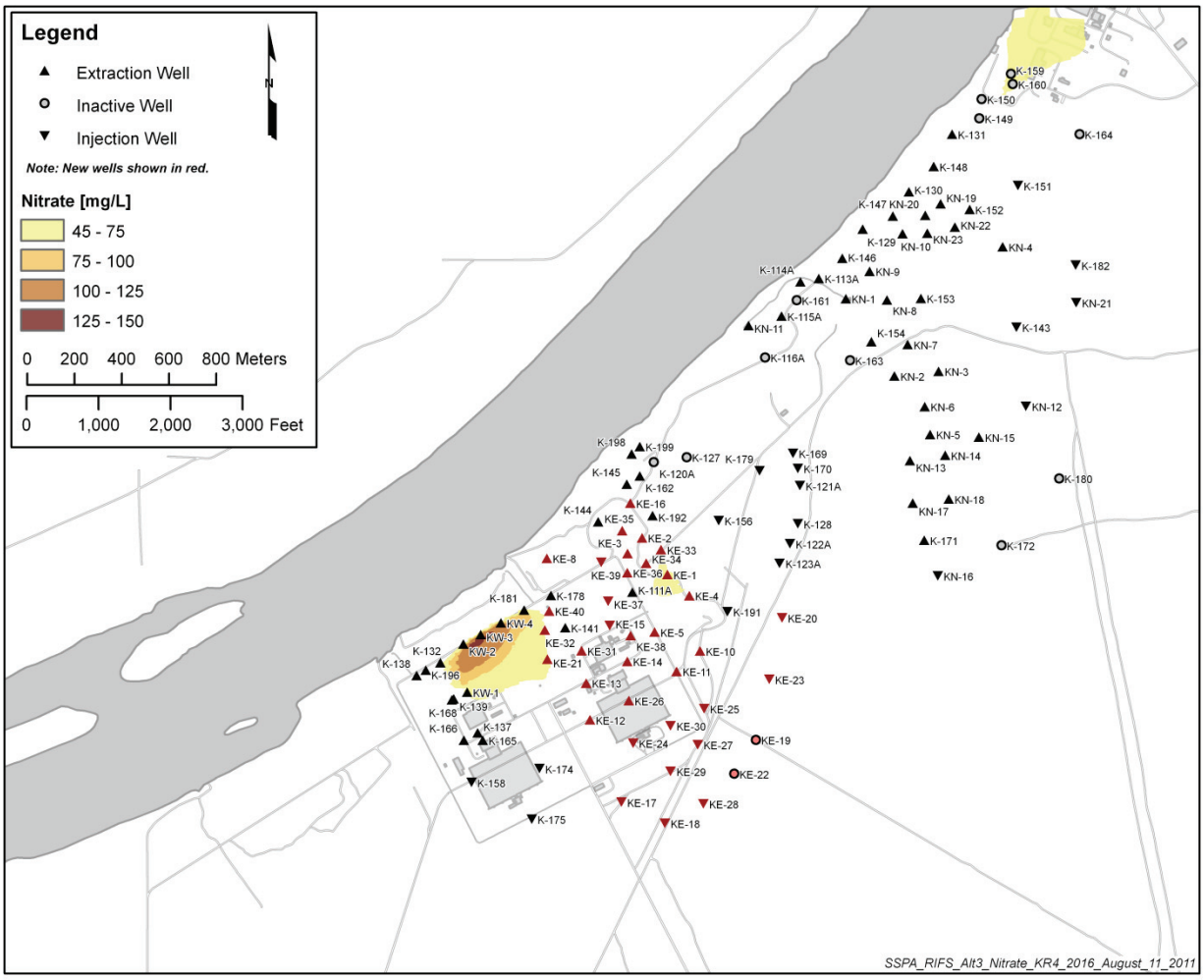

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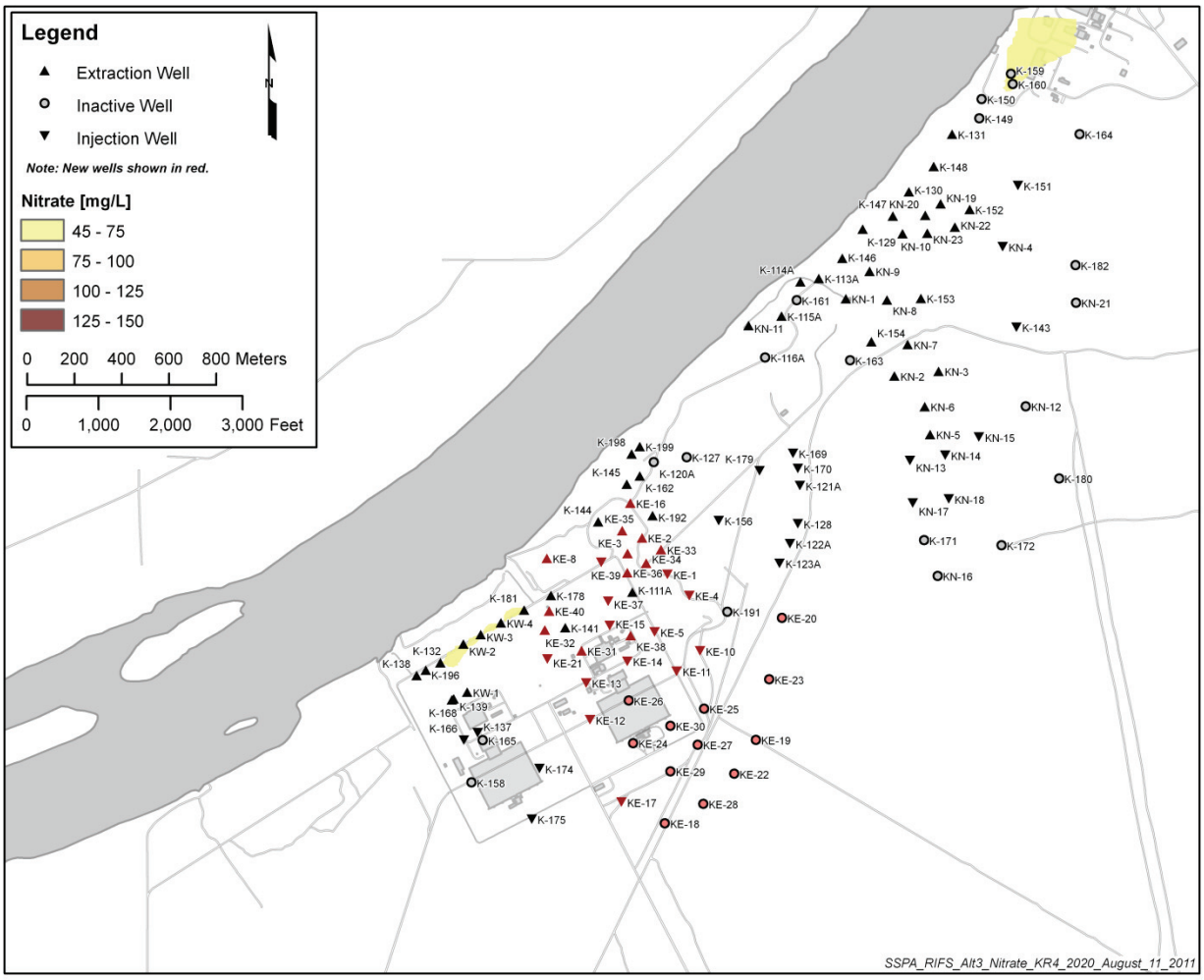

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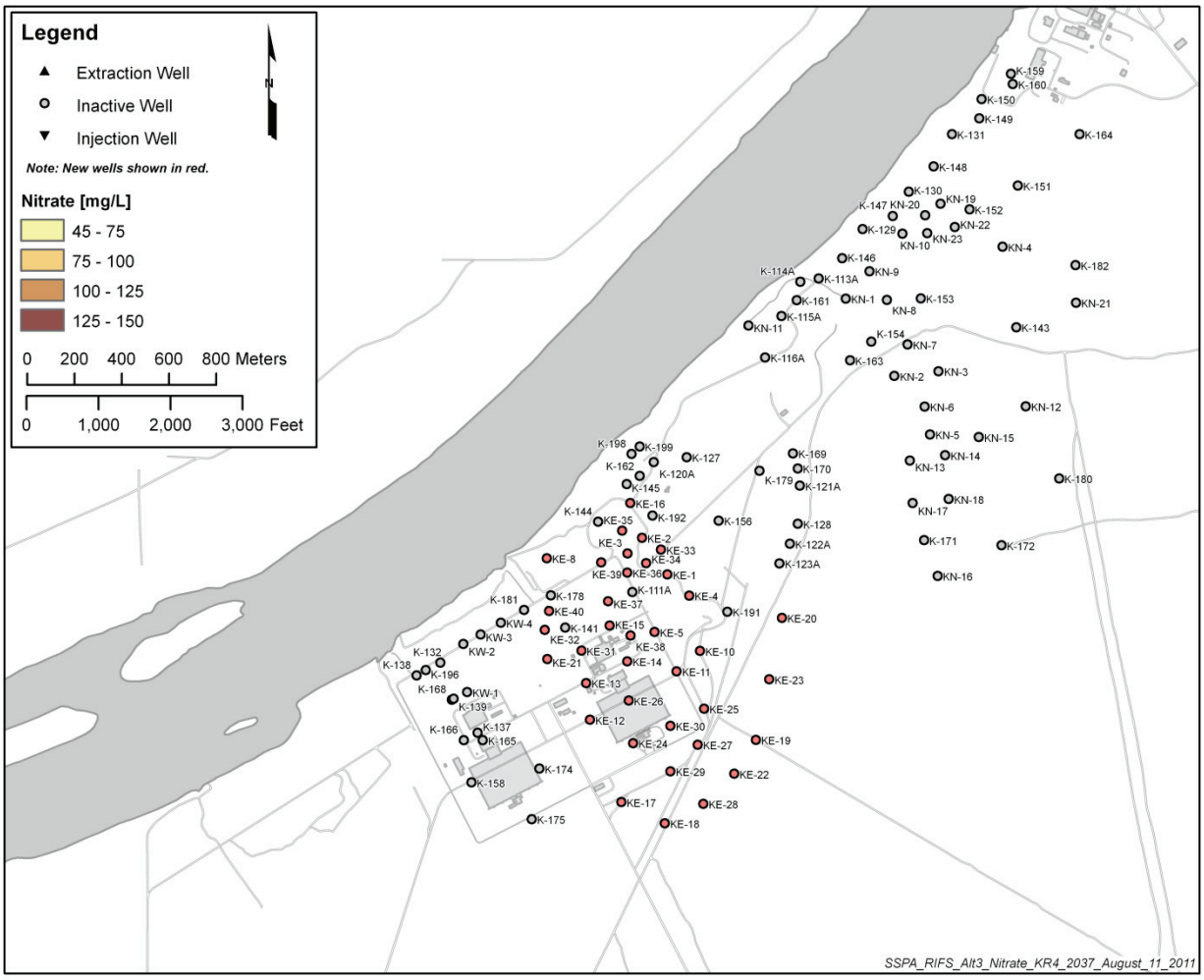

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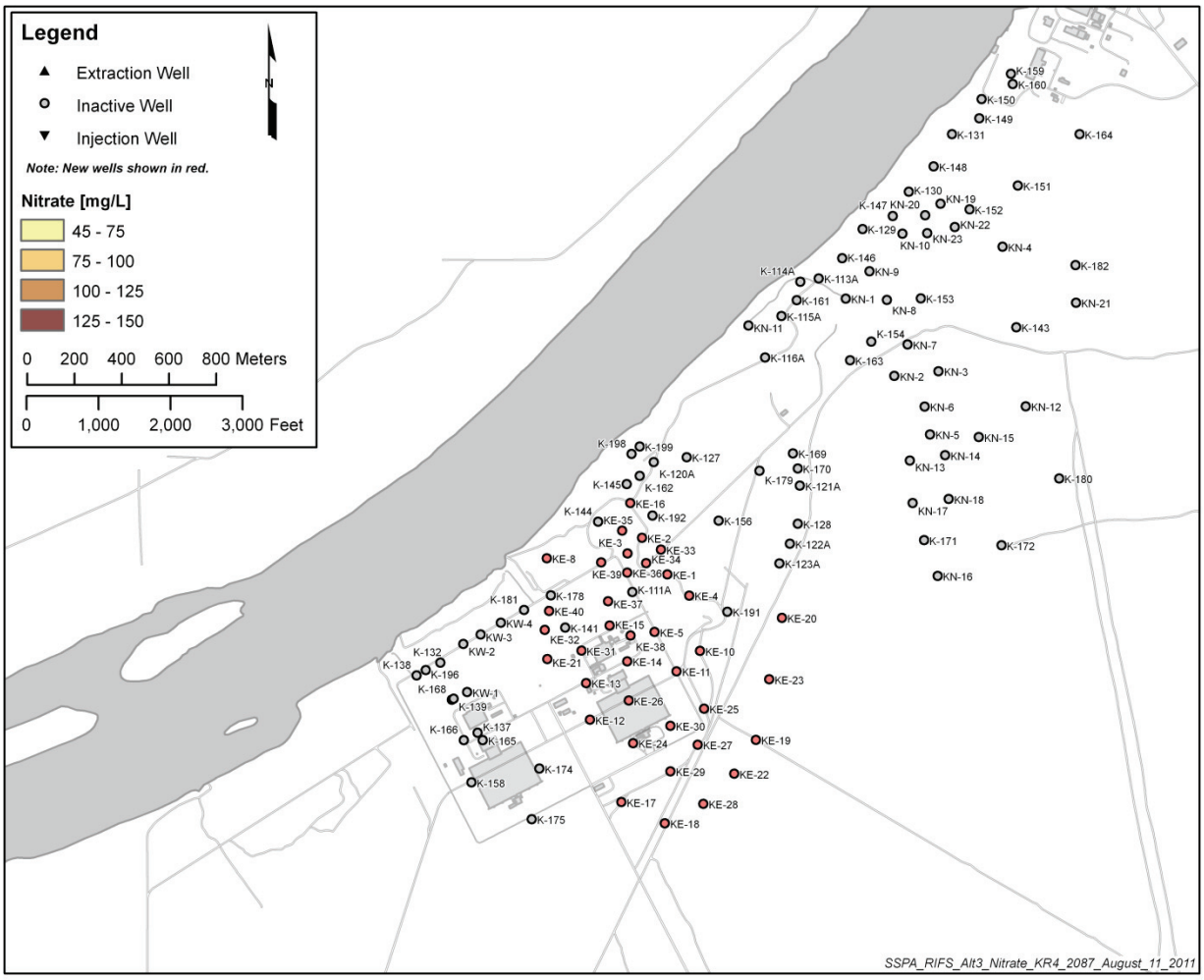

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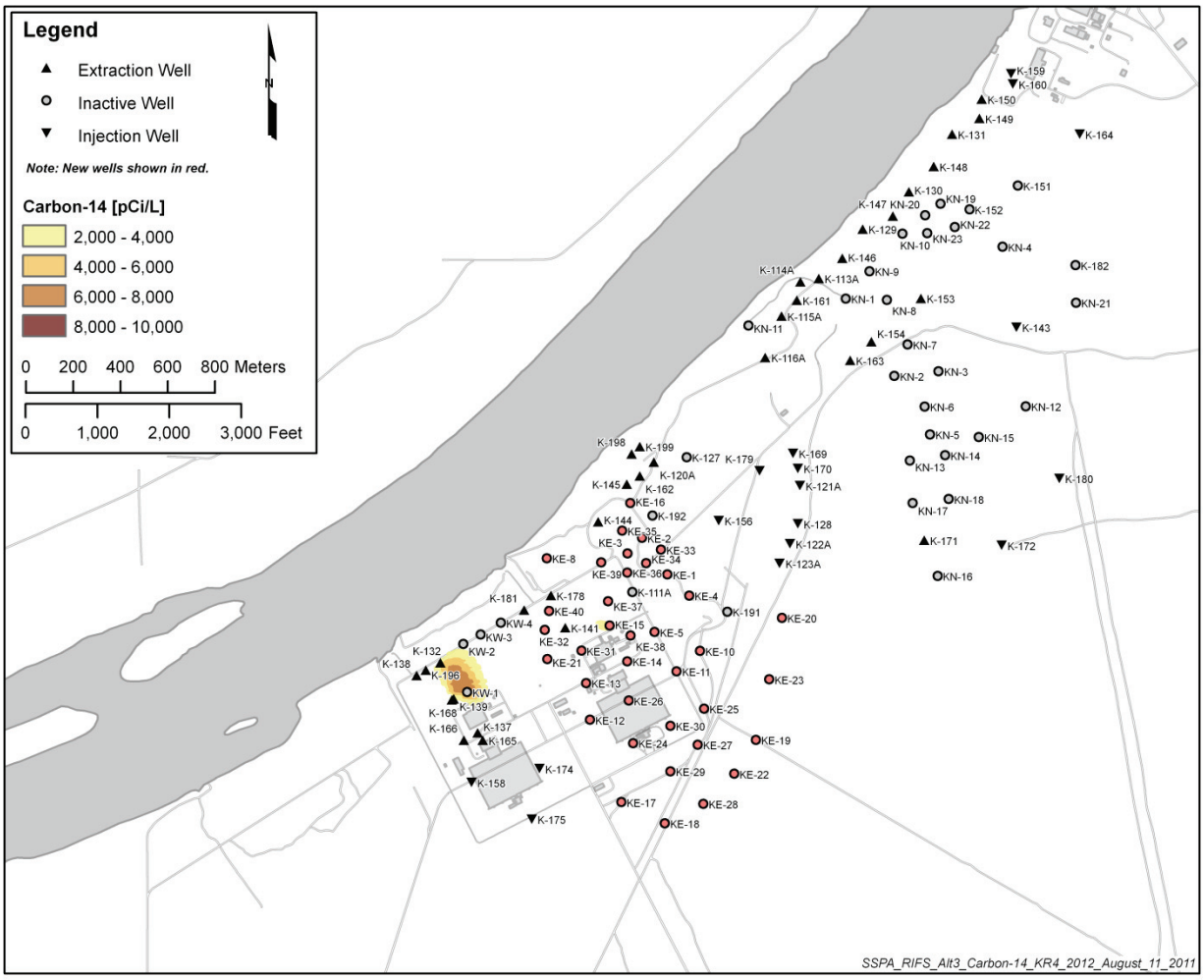
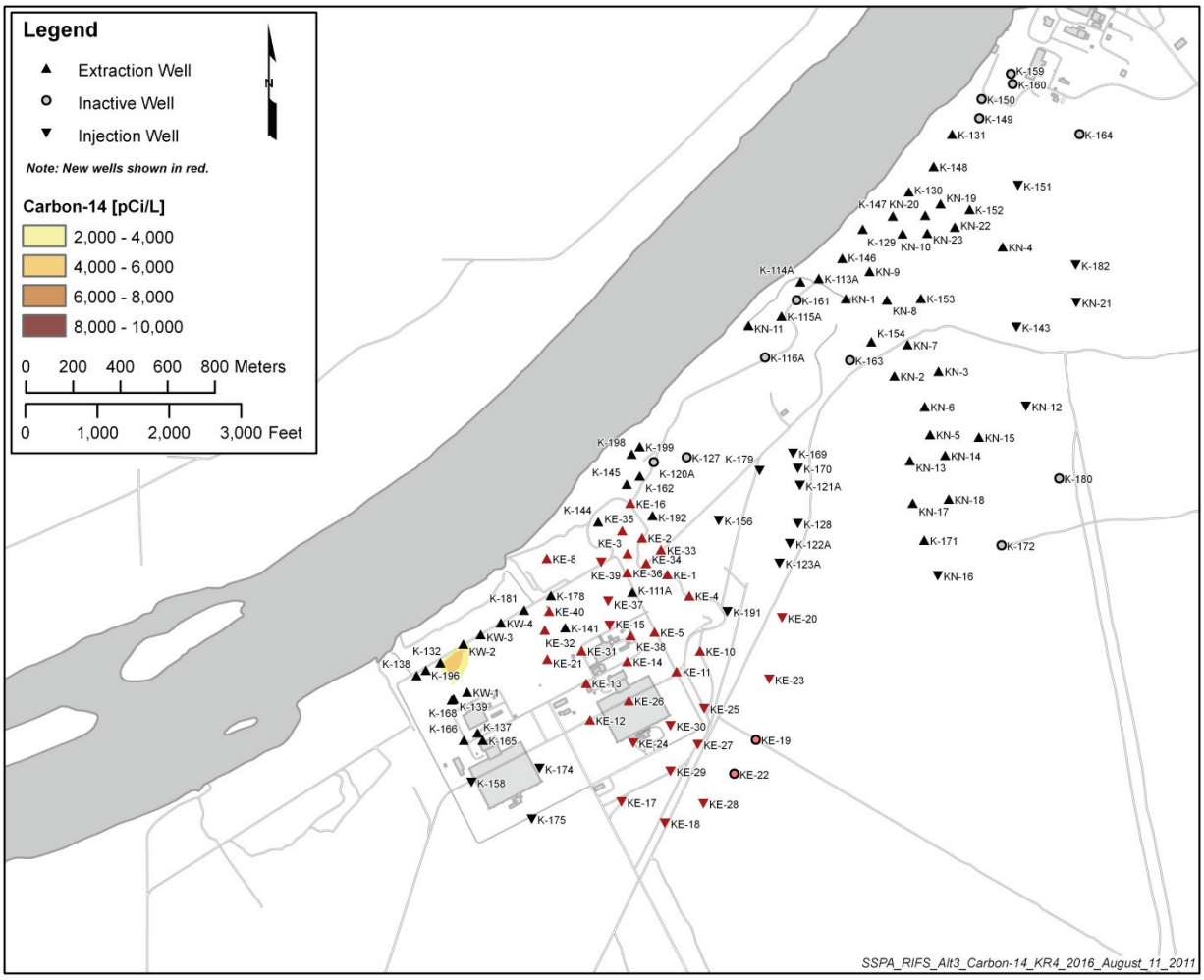


Figure 5-79. Simulated Distribution of Carbon-14 in December 2012 – Alternative 3.



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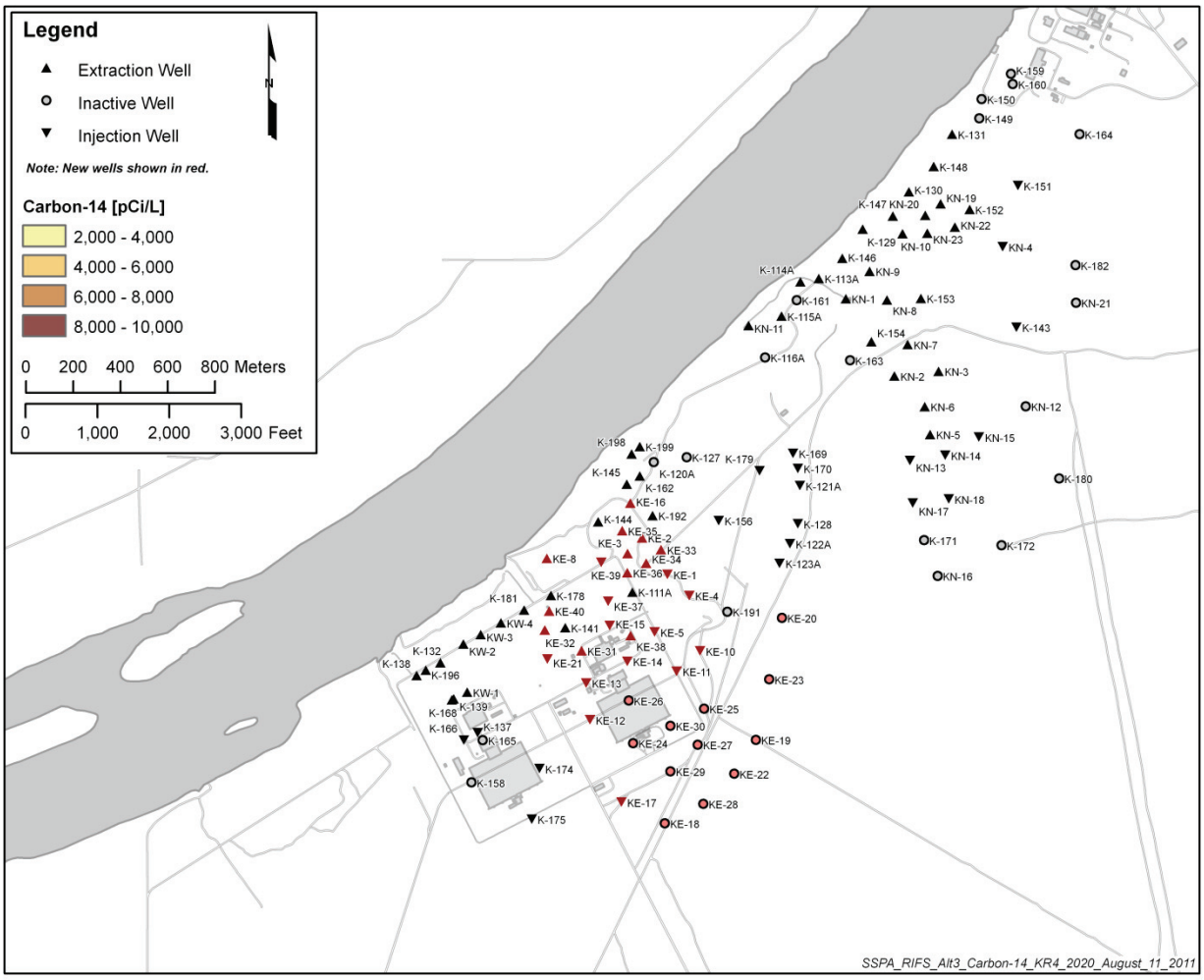


Figure 5-81. Simulated Distribution of Carbon-14 in December 2020 – Alternative 3.

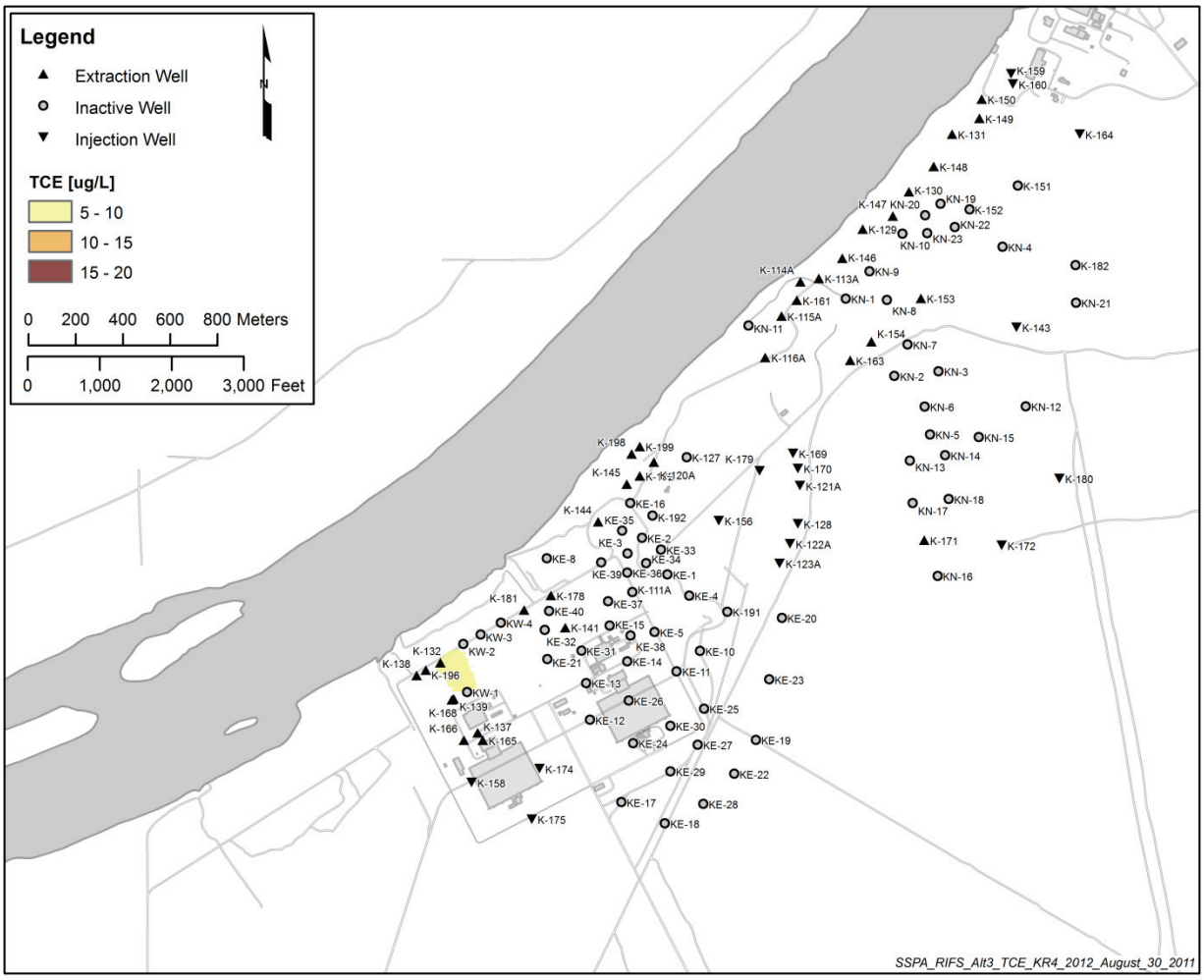
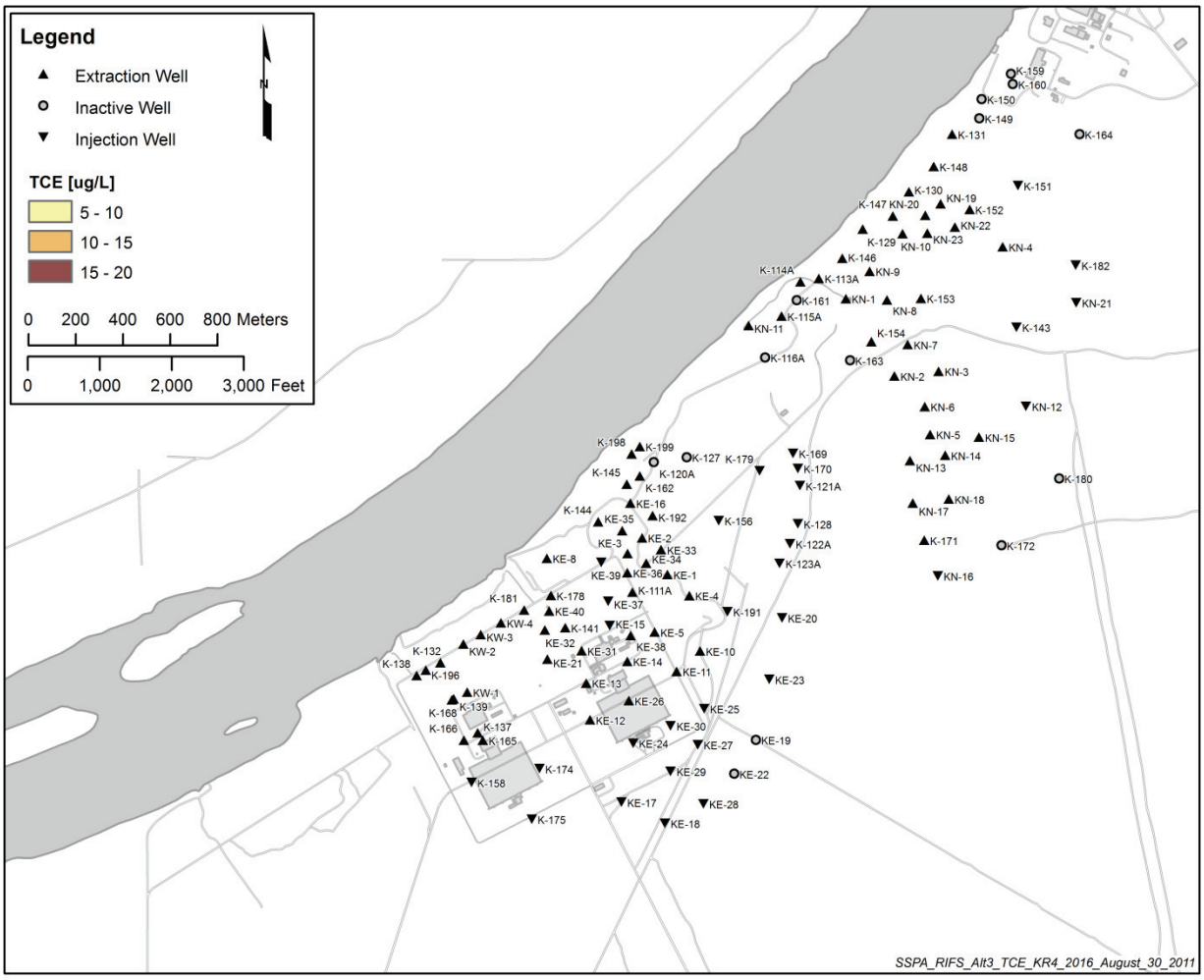


Figure 5-82. Simulated Distribution of TCE in December 2012 – Alternative 3.



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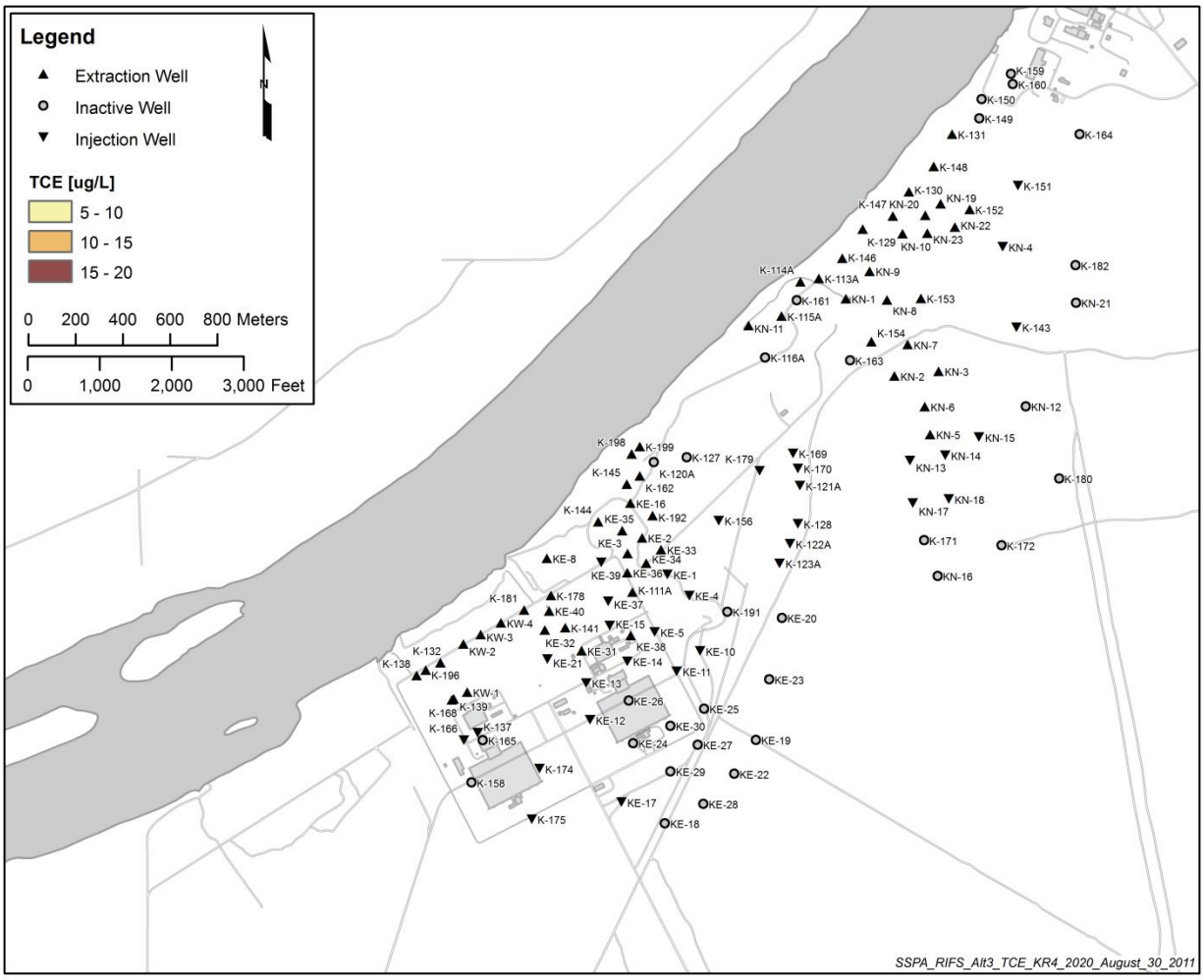

Figure 5-84. Simulated Distribution of TCE in December 2020 – Alternative 3.

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Environmental Calculation Cover Page

Part 1: Completed by the Responsible Manager

Project: Development of Soil Levels Protective of Groundwater

Date: 23-Aug-2011

Calculation Title & Description: STOMP 1-D modeling for determination of Preliminary Remediation Goals for 100 Area D, H, and K source areas

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Checkers: N Hasan (Rev 0, 0-A); H Rashid (Rev 1)	**Basis of Qualification:** Education & Experience
Senior Reviewer: W McMahon	**Basis of Qualification:** Education & Experience

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Terms

BF	back fill
CHPRC	CH2M-Hill Plateau Remediation Company
cm/s	centimeters per second
cm^3/g	cubic centimeters per gram
COPC	contaminant of potential concern
CPK	peak groundwater concentration
ET	evapotranspiration
FEPs	Features, Events, and Processes
HISI	Hanford Information System Inventory
m	meter(s)
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mm/yr	millimeters per year
PNNL	Pacific Northwest National Laboratory
POCal	point of calculation
PRG	preliminary remediation goal
OU	operable unit
RAG	remedial action goal
RESRAD	RESidual RADiation (modeling software)
RUM	Ringold upper mud
STOMP	Subsurface Transport Over Multiple Phases (modeling software)
SSL	Soil Screening Level
SZ	saturated zone
TINs	Triangulated Irregular Networks
VZ	vadose zone
WQS	water quality standard

1. Purpose

The purpose of this environmental calculation brief is to document the development of Preliminary Remediation Goals (PRGs) for protection of surface water and groundwater in the 100-D, 100-H, and 100-K source areas using one-dimensional soil column models and the STOMP (Subsurface Transport Over Multiple Phases) fate and transport code. For the purposes of this document, the 100-DR-1 and 100-DR-2 operable units (OUs) are called the 100-D area, 100-HR-1 and 100-HR-2 OUs are called the 100-H area, and 100-KR-1 and 100-KR-2 OUs are called the 100-K area. PRGs represent the soil concentration or radioisotope activity that can remain in the vadose zone at each area without causing an exceedance of groundwater or surface water regulatory standards. Based on numerical flow and solute transport simulations developed using a number of conservative assumptions, PRGs were calculated for 178 non-radionuclides and 12 radionuclides in groundwater and 178 non-radio-nuclides in surface water (the Columbia River). The resulting PRG values should only be used in accordance with the assumptions and conditions described herein.

Conceptual and numerical models of flow and solute transport under variably saturated conditions were developed for conditions that are representative of the lithology and hydrology observed at each source area. Given the absence of soil concentration data beneath the waste sites, the analysis investigates a scenario where the entire vadose zone beneath the backfill is assumed to be contaminated. Conditions specific to the 100 Area or source areas include time-varying recharge rates specific to the 100 Area, area-specific vadose zone thickness and lithology, area-specific hydraulic properties, and area-specific saturated groundwater fluxes in the aquifer. Assumptions include liquid-phase water flow and solute transport under variably saturated conditions according to the Richards equation and the advection-dispersion equation with radioactive decay and linear sorption and no volatilization or hydrodynamic dispersion.

Contaminant migration from waste sites in the 100-D, 100-H, and 100-K areas through the vadose zone to the underlying aquifer is controlled by the driving forces, interactions between water and sediments, and interactions between the contaminants and the sediments specific to each area. Driving forces include gravity; matric potential gradients; recharge, which is the end result of competition between precipitation, evaporation, transpiration, infiltration, run-off, and run-on; and man-made discharges, such as those from septic tank leach fields, ponds, lagoons, pipe and tank leaks, and irrigation. The types, thicknesses, and properties of the sediments can all affect the rate and direction of solute and water movement to the aquifer. A contaminant's concentration in the groundwater and its concentration in the downgradient Columbia River, including the peak concentration, are dependent on the solute flux from the vadose zone; aquifer thickness, properties, and flux rates; travel distance; groundwater and river water mixing; and the location sampled. Each contaminant's decay rate and propensity to sorb to vadose zone or aquifer materials can also be important controlling factors on the peak concentration, from which the PRG is calculated.

One-dimensional numerical models were constructed to represent the key facets of the conceptual model and were solved using the Subsurface Transport Over Multiple Phases (STOMP) code (PNNL-12030). The STOMP-w mode was used to solve the Richards equation and the advection-dispersion equation that govern water flow and solute transport, respectively, under variably saturated conditions in porous media. The STOMP numerical simulations provided predictions of groundwater concentration for contaminants for recharge rates and sediment types, thicknesses, and properties appropriate to the 100-D, 100-H, and 100-K areas. In keeping with time and resource constraints, simulation periods were limited to 3,000 years, thus only a subset of the evaluated contaminants that were likely to have peak groundwater concentrations occur within that period were explicitly simulated. Peak concentrations for other contaminants (with higher soil-water partitioning coefficients) were estimated through scaling by

retardation coefficient, as explained below. Simulated peak groundwater concentrations were then used to compute PRGs.

The PRG values resulting from the simulations and scaling calculations are only intended to apply to sites that share the same set of conditions and assumptions underpinning these calculations. Questions about whether the PRG values are appropriate for a given site should be forwarded to the authors of this calculation brief or the CH2M Hill Plateau Remediation Company (CHPRC) lead for modeling and risk assessment.

2. Methodology

Calculation of PRG values for the 100 Area's D, H, and K source areas included the use of one-dimensional numerical fate and transport simulations for some contaminants, and scaling computations for the remaining contaminants. The STOMP code was selected to perform the simulations on the basis of its ability to adequately simulate the vadose zone features, events, and processes (FEPs) relevant to calculating PRGs in the 100-Area and to satisfy the other code criteria and attributes identified in DOE/RL-2011-50, Rev. 0, which describes the basis for using STOMP in this type of evaluation.

Many of the methodologies, model inputs, and assumptions for computing PRGs were developed to determine remedial action goals (RAGs) as part of DOE/RL-96-17, Rev. 6, Appendix B. Although the calculation methods are similar, the RAGs were calculated with the RESRAD (RESidual RADiation) model (Argonne National Laboratory, 2001) and the PRGs in this calculation were calculated with STOMP.

This section of the calculation brief summarizes the methodology employed to produce PRGs for the 100-D, 100-H, and 100-K source areas in the 100 Area using STOMP. Sections 3 and 5 provide greater detail for the calculations and results are described in Section 6.

2.1 Preliminary Remediation Goals

Preliminary remediation goals (PRGs) represent the maximum quantity, whether soil concentration or radionuclide activity, of a contaminant that can remain in the vadose zone without causing an exceedance of standards. PRGs can be defined for protection of groundwater or protection of surface water simply by the choice of the applicable standard used in the calculation. The value of a PRG for a particular contaminant depends on a number of key factors. Waste site characteristics, specifically, source mass distribution and distance to the water table, are key factors. Another key factor is land cover condition and the associated net infiltration (recharge) rate. The interactions between the vadose zone geology and water movement and between vadose zone geology and contaminant chemistry are the two remaining key factors.

Model simulations were carried out for the non-radionuclide and radionuclide contaminants found in the 100 Area (see list of contaminants in Attachments 1 to 8). The list of contaminants is consistent with those evaluated in a previous remedial design (DOE/RL-96-17). Groundwater PRG values were calculated for each of these contaminants and surface water PRGs were calculated for all non-radionuclide contaminants. Results are discussed in Section 6 below and the tables of PRG values for the different source areas are presented in Attachments 1 to 8.

2.2 Identifying Representative Stratigraphic Columns

Borehole data were used to identify representative stratigraphic columns for each source area. Only two lithologic units are present in the 100-D, 100-H, and 100-K vadose zone: the gravel-dominated Hanford

formation and the Ringold Formation's E unit, which contains a slightly smaller percentage of coarse-grained sediments and a higher percentage of finer-grained sediments than the Hanford formation (SGW-40781, SGW-46279). Using the June 2008 water table elevations to represent the annually occurring highest water table, a conservative (smaller) thickness of the vadose zone was computed for each well and borehole. The borehole data were also used to estimate the thicknesses of each lithologic unit in each source within the vadose zone and within the aquifer. The boreholes were divided into groups based on the proportion of each lithologic unit and total vadose zone thickness. A representative stratigraphic column was selected for each borehole group within each source area, resulting in two to six stratigraphic columns to be used in the STOMP simulations (see section 3.1 below).

2.3 STOMP Flow and Transport Simulations

Peak groundwater concentrations in the aquifer beneath a typical waste site within each of the representative stratigraphic columns were calculated using STOMP to solve the governing equations for flow and solute transport under variably saturated conditions. Peak concentrations of selected contaminants (Section 3.3) were calculated for two different contaminant source distributions (Section 3.2.3) with four different recharge scenarios and three different soil types controlling infiltration (Section 3.2.1) for each representative stratigraphic column (Section 3.1).

2.4 Identification of Peak Groundwater Concentrations

Peak groundwater concentrations were calculated for each model time step along a portion of the domain's downgradient boundary corresponding to the top five meters of the aquifer. The average concentration for the topmost 5 m was assumed to be an estimate of the groundwater concentration that would be measured within a 20-ft-long monitoring well screen that straddled the water table. Using the upper 5 meters of the aquifer is consistent with the requirements for aquifer mixing zone thickness in WAC 173-340-747[5][f][i]. The concentration was conservatively estimated by calculating it in the aquifer beneath the downgradient edge of the waste site footprint. These groundwater concentrations and the year that they occurred were tabulated to find the peak concentration of contaminant in ground water and its year of occurrence. For contaminants not simulated in STOMP, peak groundwater concentration and year of occurrence were calculated instead by scaling with the retardation factor.

2.5 Estimating Peak Groundwater Concentrations by Retardation Factor Scaling

Depending on vadose zone thickness and hydraulic properties, the 3,000-year simulation time for the flow and transport simulations can suffice to identify peak groundwater concentrations for a limited number of contaminants. For the 100-D, 100-H, and 100-K conditions, only contaminants with distribution coefficients, the parameter governing linear sorption, that have values between 0 and 1 cm^3/g would typically yield a peak concentration within the simulation period. However, the distribution coefficients of the contaminants in the 100 Area span such a large range that simulation periods of 10^4 to 10^9 years would be necessary to predict the actual groundwater peaks. Such time-consuming simulations can be replaced with a straightforward scaling using the retardation factor (for example, see discussion in Selker et al. 1999, pages 243 to 248).

The dimensionless retardation factor, R, is defined (Selker et al., 1999) as

Eqn. 1

where ρ_B = bulk density (ML^{-3}), K_D = distribution coefficient (L^3M^{-1}), and θ = volumetric water content (L^3L^{-3}). For the STOMP one-dimensional flow and solute transport simulations used to calculate the peak groundwater concentration, ρ_B varies in space but is constant with time, K_D is constant in time and space, and θ varies in both space and time within each domain. Since we are scaling the peak groundwater

concentration as it leaves the domain, an average or effective bulk density for the entire domain beneath the clean fill can replace the spatially-varying ρ_B nodal values.

For the same set of model conditions, the retardation factor for a non-zero K_D value, X, can also be defined using the relationship between the non-retarded solute and the retarded solute (Selker et al., 1999). Assuming the domain, flow conditions, transport processes, and initial concentrations are all the same, the retardation factor for $K_D = X$ can be calculated directly as the ratio of peak groundwater concentration for $K_D = 0$ to the peak groundwater concentration for $K_D = X$:

Eqn. 2

where CPK is the peak groundwater concentration for the specified K_D value. Rearranging Eqn. 2 and substituting in Eqn. 1 for $R(K_D = X)$ shows that the inverse of the peak concentration is linear with regard to K_D:

Eqn. 3

where X represents different K_D values, and θ and ρ_B represent average or effective values specific to each different simulated soil column. An effective bulk density for a given soil column is constant and the peak concentration for $K_D = 0$, which means R=1, is also a constant for a given soil column under a given recharge scenario. Thus a plot of $1/CPK(K_D = \mathrm{X})$ versus K_D should yield a straight line assuming effective θ does not vary with K_D values. However, for any given recharge scenario, effective θ can vary over time such that the plot of $1/CPK(K_D = \mathrm{X})$ versus K_D is a function of soil column thickness and the time-varying recharge rate. In general, effective θ does not change significantly in relatively thick soil columns for the range of recharge rates used in the STOMP simulations (see Sections 3.2.1 and 5.3). If effective θ is essentially constant, then the slope of the line for $1/CPK(K_D = \mathrm{X})$ versus K_D equals the rightmost fraction in Equation 3.

Using the peak concentration predicted by STOMP for the input K_D value, an effective R and an average or effective θ can be calculated using Equations 2 and 4. These effective values can then be used to estimate peak concentrations for contaminants that were not simulated with STOMP. The method depends on whether effective θ decreases slightly and monotonically or whether it varies non-monotonically or over a larger range of K_D values (see Section 5.3 for details).

Given $R(K_D = \mathrm{X})$, the effective θ can be computed as

Eqn. 4

Using the method detailed in Section 5.3, a relationship between K_D and effective θ can be accurately determined for each representative column for each recharge scenario, so that effective θ can be estimated for the contaminants that were not simulated. Using Equation 1 and the estimated effective θ from Equation 4 gives an R value for a contaminant that was not simulated and for which $K_D = Y$. This R value is then used to compute the appropriate peak concentration with Equation 2. For example, if $K_D = Y$ did not have a STOMP simulation, then the peak concentration for $K_D = Y$ is simply

Eqn. 5

For radionuclides with radioactive decay and sufficiently large K_D values to preclude reaching a peak within the simulation period, Equations 2 through 6 are used to estimate the peak groundwater concentration by assuming there is no radioactive decay, and thereby yielding a conservative estimate of

the peak concentration. The end result is a table of K_D, peak concentration, effective θ, and effective R values for each combination of stratigraphic column, recharge scenario. These tables are then used to calculate the PRGs.

2.6 Calculating PRG Values

A simple calculation was employed to compute PRGs by scaling the peak concentration values against the regulatory compliance criteria and the initial soil concentration. As a measure of allowable quantity of contaminant in the soil, PRGs are expressed as contaminant mass per mass of soil for non-radionuclides or as contaminant activity per mass of soil for radionuclides. The PRG for each contaminant is computed as:

—— Eqn. 8

where *PRG* = Preliminary Remediation Goal (contaminant mass or activity / kg of soil]), *a* is a constant selected to balance units, C_I is the initial soil concentration (typically contaminant mass or activity / mass of soil), *WQS* = water quality standard (contaminant mass or activity / liter of water), and *CPK* = peak groundwater concentration (typically contaminant mass or activity / liter of water). The surface water quality standards are input as WQS to compute PRGs protective of surface water, whereas the groundwater quality standards are input as WQS to compute PRGs protective of groundwater.

3. Assumptions and Inputs

Two sequential STOMP simulations were used to determine peak groundwater concentrations. The first stage, called the pre-2010 model, simulated flow through the representative columns for a 2,010-year period. Review of first-stage matric potential and volumetric water content values revealed that they had reached equilibrium prior to the end of the simulation period. Results from the pre-2010 simulations provided initial aqueous pressure conditions for the 3,000-year-long second stage simulation, the post-2010 model, which solved for both flow and solute transport. The post-2010 solute transport simulations tracked the fate of contaminants with different distribution coefficients and decay constants through the vadose zone and into the aquifer. These results were used to identify the peak groundwater concentrations and year of peak concentration.

STOMP estimates of contaminant concentration depend on the model inputs and assumptions. Inputs to the models and their underlying assumptions can be divided into the following categories:

- Model domains
- Boundary conditions and initial conditions
- Hydraulic and transport parameters
- Contaminant source term

Each of these is discussed in the following sections.

3.1 Model Domains

Conceptually, the model represents a column of sediments that comprise a vadose zone underlain by an aquifer. Recharge-driven flow moves downward through the vadose zone, where it encounters contamination that is eventually transported to an underlying aquifer, across which a pressure gradient drives horizontal flow. At the start of each post-2010 simulation, the vadose zone comprises a cover of clean fill with constant thickness as well as contaminated and uncontaminated sediments of varying thickness. The aquifer constitutes the base of the column with a minimum thickness of 5 m so that a 5-m-

long monitoring well screen could be simulated. Depending on source-area-specific geology, the vadose zone comprises either Hanford formation alone or a combination of Hanford and Ringold E, whereas the saturated zone can comprise only Hanford, a combination of Hanford and Ringold E, or only Ringold E. If present, the contact between the Ringold E and the Ringold Upper Mud forms the bottom of the aquifer.

The model is represented numerically as a vertical one-dimensional column of evenly-spaced grid blocks, each containing a node at the centroid. In STOMP, boundary conditions are specified at the faces of the grid blocks, so each grid block is assigned an arbitrary but constant length to avoid large grid Courant numbers in the aquifer grid blocks during transport simulations. Each grid block is 0.25 m in height and 10 m in length. Grid block Courant numbers for the aquifer grid blocks, in which flow is horizontal under full saturated conditions, were all less than 0.09. Grid block Courant numbers for the vadose zone grid blocks, in which flow is vertical under variably saturated conditions, were all less 0.03 for all recharge scenarios.

The total column thickness and the thickness of the vadose zone vary according to the geology of each source area. Only the thickness of the clean back fill was held constant at 4.5 m. Thickness of the vadose zone (VZ), thickness of the aquifer (SZ), and the percentages of the different lithologic units in each were determined using borehole data from the Hanford Environmental Information System (HEIS) borehole database (Tables 1, 2, 3, and 4). A conservative (thinner) estimate of vadose zone thickness was calculated by taking the difference between ground surface elevation and the June 2008 water table elevation, which is representative of the seasonal high water table elevation. The tables, which contain the relevant data for all the boreholes for each source area, are summarized in the following table:

Table 1. Vadose and Saturated-Zone Thicknesses in the100-D, 100-H, and 100-K Source Areas.

Source Area	Vadose Zone Thickness (m)			Saturated Zone Thickness (m)		
	Minimum	Average	Maximum	Minimum	Average	Maximum
100-D	16.7	23.9	26.6	1.2	5.7	8.5
100-H	8.4	11.8	13.4	2.3	5.2	8.2
100-K	6.4	20.1	25.0	13.1	23.9	28.7

Representative stratigraphic columns for each source area were derived from the borehole data using vadose zone thickness and lithologic composition (Tables 2, 3, and 4; Figures 1, 2, and 3). Boreholes from each source area were divided into groups that represent the range of vadose zone thicknesses and lithologic composition. The objective was to create a limited number of representative stratigraphic columns for each source area so that the number of STOMP simulations would be reasonable, while capturing the range of variability throughout each area. This was accomplished by dividing the boreholes for each source area into groups based on a range of vadose zone-thickness intervals and then identifying one or more representative lithologic compositions. For example, 100-D boreholes can be divided into three groups according to vadose zone thickness: 25, 20, and 15 m, whereas the 100-H boreholes can be divided into two groups with 12 and 8 m thicknesses, respectively. Examination of all wells within the 100-D 25-m-thickness group reveals a range of compositions for the vadose zone, but the 12 boreholes in this group can easily be divided into three sub-groups:

- 100% Hanford formation,
- 80% Hanford formation – 20% Ringold E unit, or
- 60% Hanford formation – 40% Ringold E unit (Table 2).

If the thickness of the SZ was larger than 5 m, then the representative thickness of SZ was used in STOMP simulations; however, if the thickness of SZ was less than 5 m, then the thickness of SZ was assumed to be 5 m so that a 5-m-long monitoring well screen could be simulated (Tables 2, 3, and 4). Figures 1, 2, and 3 show the representative columns at each source area.

Each column was assumed to also contain clean backfill to represent conditions following interim remediation. Backfill was assumed to replace the uppermost 4.6 m of each column. Column names are defined by the lithologic composition of their vadose zones and ignore the presence of backfill.

Table 2. Determination of Vadose Zone Thickness and Geology for Source Area D at 100 Area (VZ: vadose zone; SZ: saturated zone).

Representative Column Index	Representative VZ thickness (m)	Representative VZ Composition	Thickness of Hanford in VZ (m)	Thickness of Ringold E in VZ (m)	Corresponding Wells	Actual VZ Composition	Actual VZ thickness (m)	Actual Aquifer thickness (m)	Average Aquifer thickness (m)	SZ Composition
1	25	100% Hanford	25	0	199-D4-83	100% Hanford	24.32	5.25	6.48	100% Hanford
					199-D5-17		25.4	6.15		
					199-D5-97		25.81	7.41		
					199-D5-99		26.09	7.29		
					199-D8-4		25.21	6.31		
2	20	100% Hanford	20	0	199-D2-5	100% Hanford	22.64	4.80	5.13	100% Hanford
					199-D8-97		23.14	5.06		
					199-D8-98		20.37	5.53		
3	25	80% Hanford 20% Ringold E	20	5	199-D4-101	76% Hanford 24% Ringold E	25.35	6.66	7.35	100% Ringold E
					199-D5-103	83% Hanford 17% Ringold E	25.69	8.05		
4	20	80% Hanford 20% Ringold E	16	4	199-D8-89	80% Hanford 20% Ringold E	19.76	4.01	4.01	100% Ringold E
5	25	60% Hanford 40% Ringold E	15	10	199-D4-25	63% Hanford 37% Ringold E	24.79	6.15	4.91	100% Ringold E
					199-D5-12	59% Hanford 41% Ringold E	25.96	1.17		
					199-D5-120	63% Hanford 37% Ringold E	25.76	7.16		
					199-D5-19	63% Hanford 37% Ringold E	24.14	4.66		
					199-D5-34	62% Hanford 38% Ringold E	26.6	5.40		
6	15	60% Hanford 40% Ringold E	9	6	199-D8-54B	63% Hanford 37% Ringold E	16.82	6.35	5.34	100% Ringold E
					199-D8-55	55% Hanford 45% Ringold E	16.7	4.33		

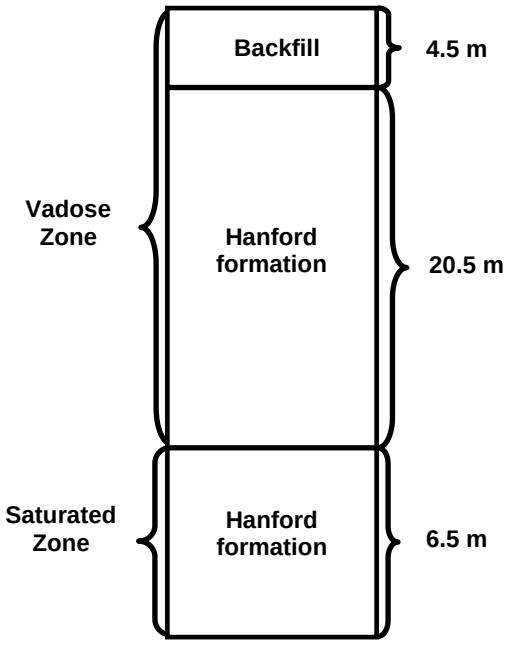
Table 3. Determination of Vadose Zone Thickness and Geology for Source Area H at 100 Area (VZ: vadose zone; SZ: saturated zone).

Representative Column Index	Representative VZ thickness (m)	Representative VZ Composition	Thickness of Hanford in VZ (m)	Thickness of Ringold E in VZ (m)	Corresponding Wells	Actual VZ Composition	Actual VZ thickness (m)	Actual Aquifer thickness (m)	Average Aquifer thickness (m)	SZ Composition
1	12	100% Hanford	12	0	199-H3-1	100% Hanford	12.90	4.17	5.25	100% Hanford
					199-H3-25		11.31	5.75		
					199-H3-2A		11.39	5.37		
					199-H3-2B		11.26	6.11		
					199-H3-2C		11.36	5.40		
					199-H4-1		11.62	6.14		
					199-H4-11		10.82	7.16		
					199-H4-14		11.42	6.56		
					199-H4-2		11.66	8.15		
					199-H4-46		13.07	5.53		
					199-H4-49		13.36	3.40		
					199-H4-69		12.53	5.75		
					199-H4-70		12.97	4.10		
					199-H4-72		11.90	5.17		
					199-H4-9		11.34	2.83		
					199-H6-2		12.92	2.32		
2	8	100% Hanford	8	0	699-99-41	100% Hanford	8.35	3.84	3.84	100% Hanford

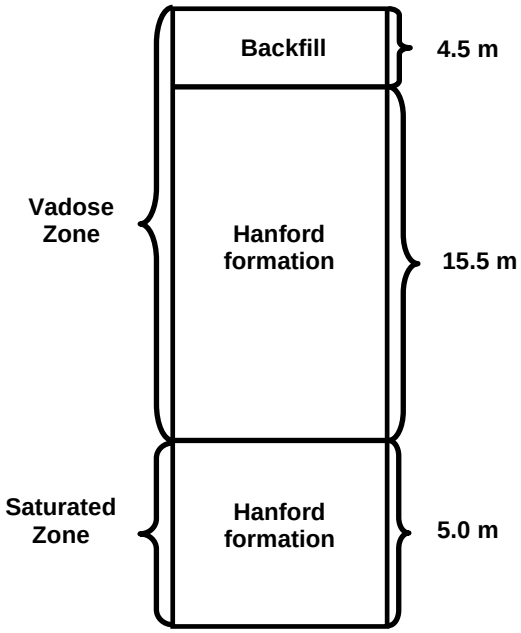
Table 4. Determination of Vadose Zone Thickness and Geology for Source Area K at 100 Area (VZ: vadose zone; SZ: saturated zone).

Representative Column Index	Representative VZ thickness (m)	Representative VZ Composition	Thickness of Hanford in VZ (m)	Thickness of Ringold E in VZ (m)	Corresponding Wells	Actual VZ Composition	Actual VZ thickness (m)	Actual Aquifer thickness (m)	Average Aquifer thickness (m)	SZ Composition
1	25	100% Hanford	25	0	199-K-173	100% Hanford	25.12	28.07	28.07	8% Hanford 92% Ringold E (100% Ringold E selected in the model)
2	18	100% Hanford	18	0	199-K-154	100% Hanford	17.98	13.11	18.125	100% Hanford
					199-K-157		19.23	23.14		
3	15	70% Hanford 30% Ringold E	10.5	4.5	199-K-32B	70% Hanford 30% Ringold E	15.77	25.68	20.305	100% Ringold E
					199-K-163	66% Hanford 34% Ringold E	18.6	14.93		
4	20	50% Hanford 50% Ringold E	10	10	199-K-109A	52% Hanford 48% Ringold E	22.71	24.54	24.51	100% Ringold E
5	20	40% Hanford 60% Ringold E	8	12	199-K-111A	38% Hanford 62% Ringold E	21.01	26.33	26.33	100% Ringold E
6	20	30% Hanford 70% Ringold E	6	14	199-K-165	35% Hanford 65% Ringold E	24.96	28.69	27.67	100% Ringold E
					199-K-166	34% Hanford 66% Ringold E	24.02	27.26		
					199-K-106A	28% Hanford 72% Ringold E	22.48	27.05		

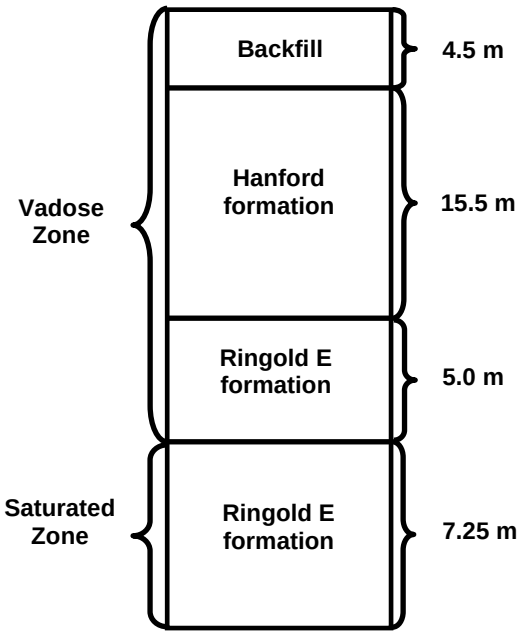
(1) 25-m thick vadose zone (100% Hanford in VZ)



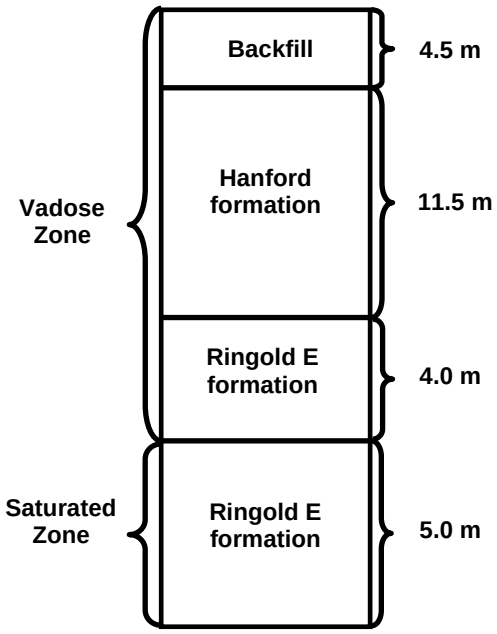
(2) 20-m thick vadose zone (100% Hanford in VZ)



(3) 25-m thick vadose zone (80% Hanford 20% Ringold E in VZ)



(4) 20-m thick vadose zone (80% Hanford 20% Ringold E in VZ)



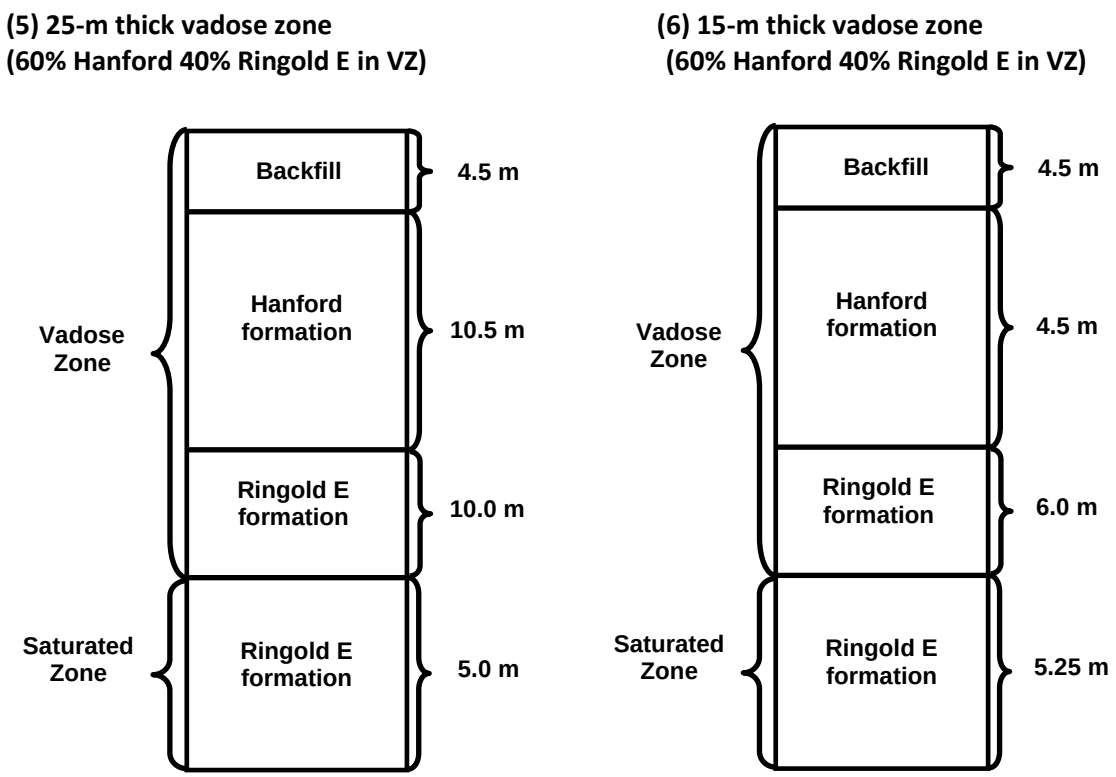


Figure 1. Representative stratigraphic columns for 100-D.

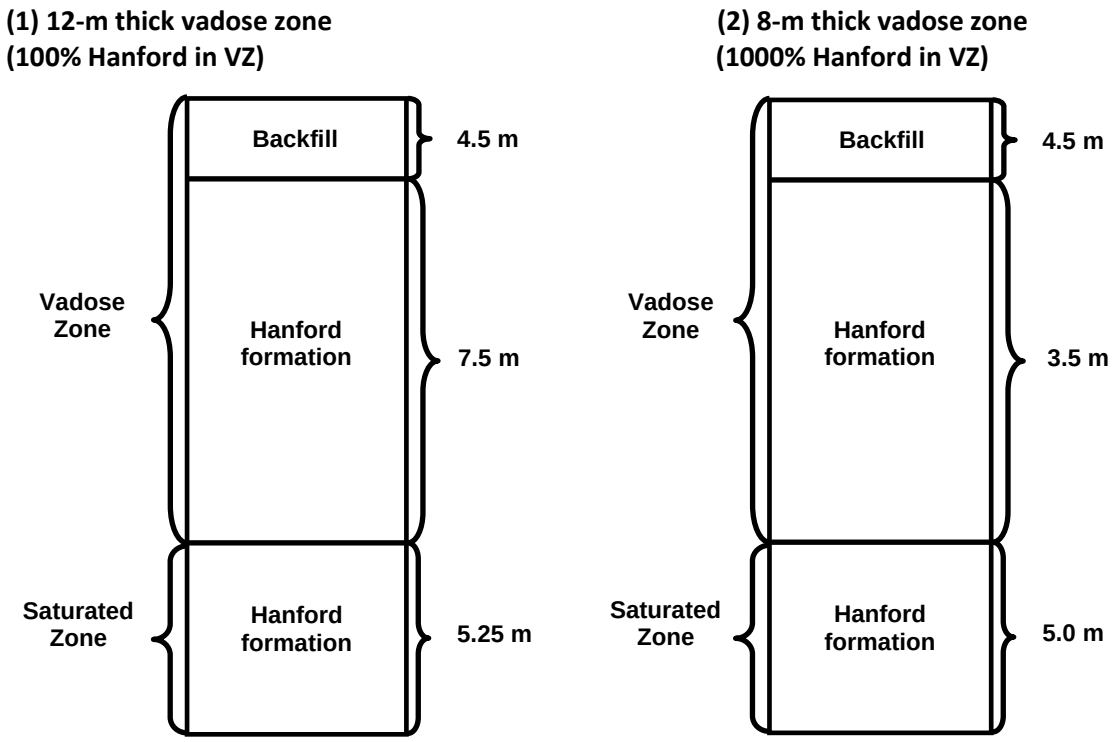
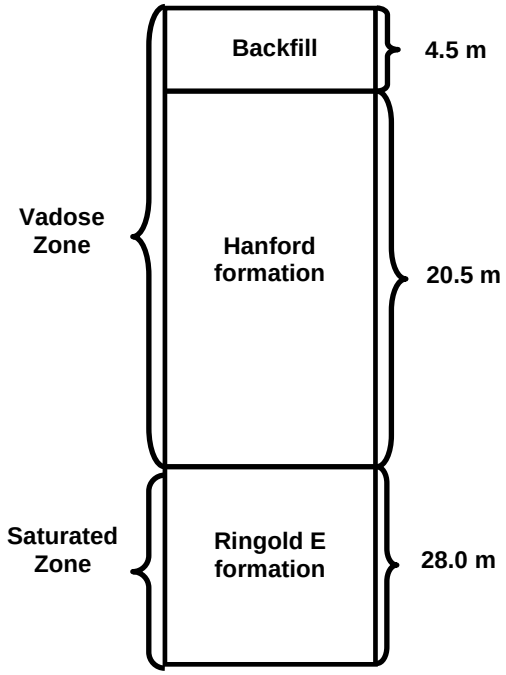
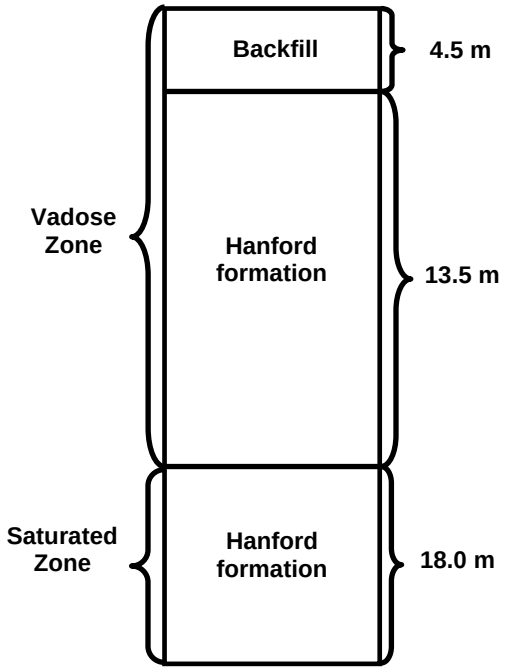


Figure 2. Representative stratigraphic columns for 100-H.

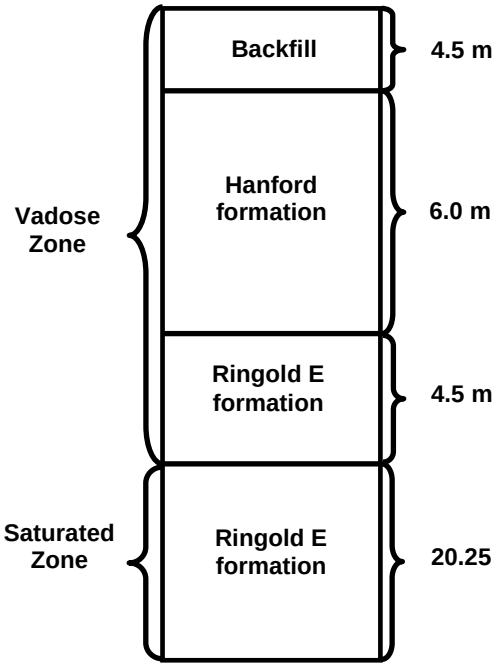
(1) 25-m thick vadose zone (100% Hanford in VZ)



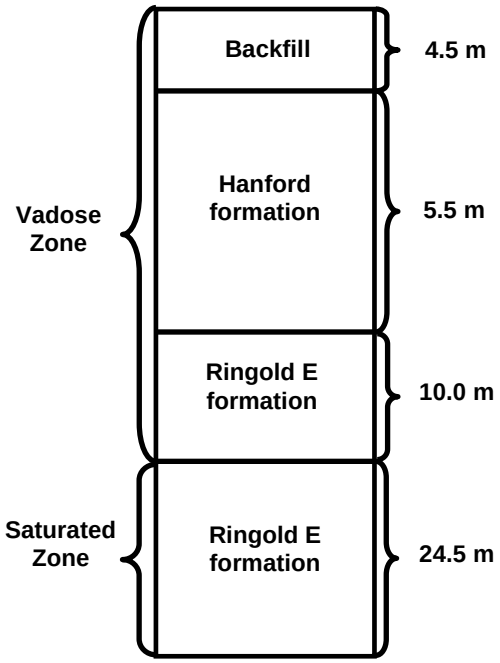
(2) 18-m thick vadose zone (100% Hanford in VZ)



(3) 15-m thick vadose zone (70% Hanford 30% Ringold E in VZ)



(4) 20-m thick vadose zone (50% Hanford 50% Ringold E in VZ)



(5) 20-m thick vadose zone

(6) 20-m thick vadose zone

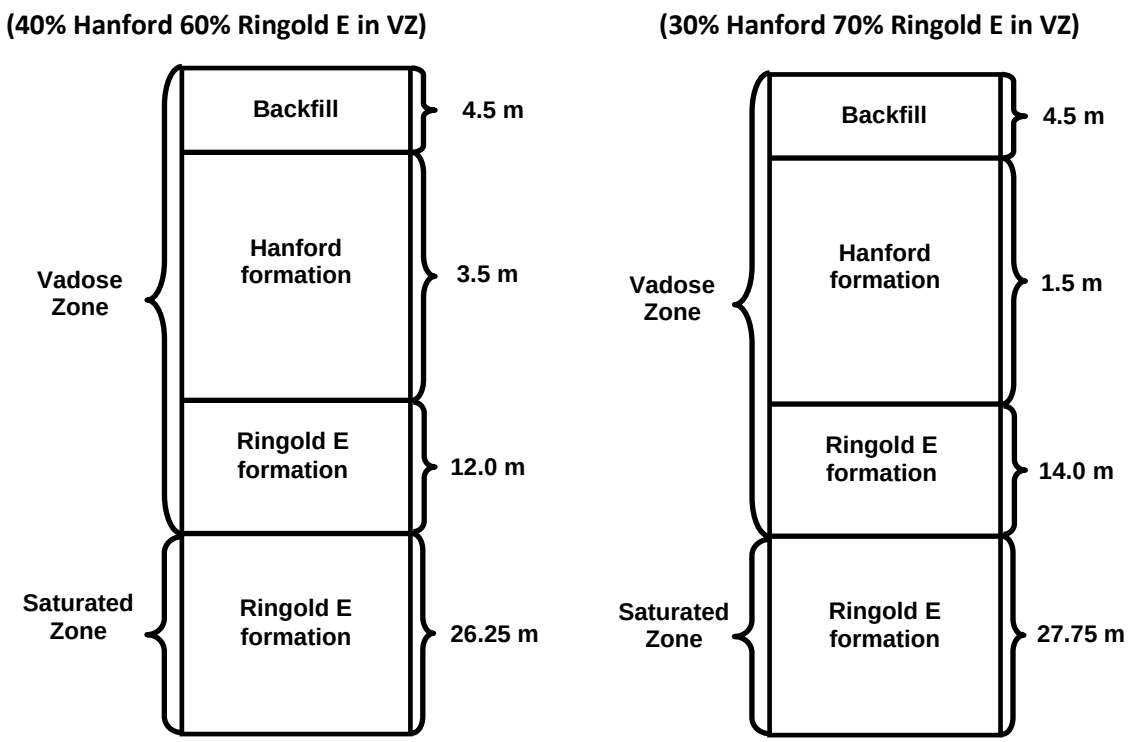


Figure 3. Representative stratigraphic columns for 100-K.

3.2 Boundary Conditions and Initial Conditions

Solving the governing equations for variably-saturated flow and transport requires stipulation of boundary conditions and initial conditions. A complete set of boundary and initial conditions must be stipulated for each governing equation.

For water flow, a specified-flux boundary condition was applied at the surface to simulate recharge, no-flow boundary conditions were assigned to the edges of the vadose zone and the bottom of the aquifer, and prescribed pressure boundaries were assigned to the edges of the aquifer (Figure 4). The prescribed pressures were selected to create the water table at the desired elevation and with the desired hydraulic gradient.

For solute transport, specified zero flux boundaries were applied at the top of the model domain, along the upgradient edges of the aquifer grid blocks, along both edges of the vadose zone, and the bottom of the aquifer (Figure 4). The downgradient edges of the aquifer grid blocks were assigned STOMP's outflow solute boundary condition (see page 6.21 of PNNL-12030 and page 4.4 of PNNL-15782), which transports solute out of the domain according to the advective flux term in the governing equation and does not allow solute to enter into the domain (Figure 4).

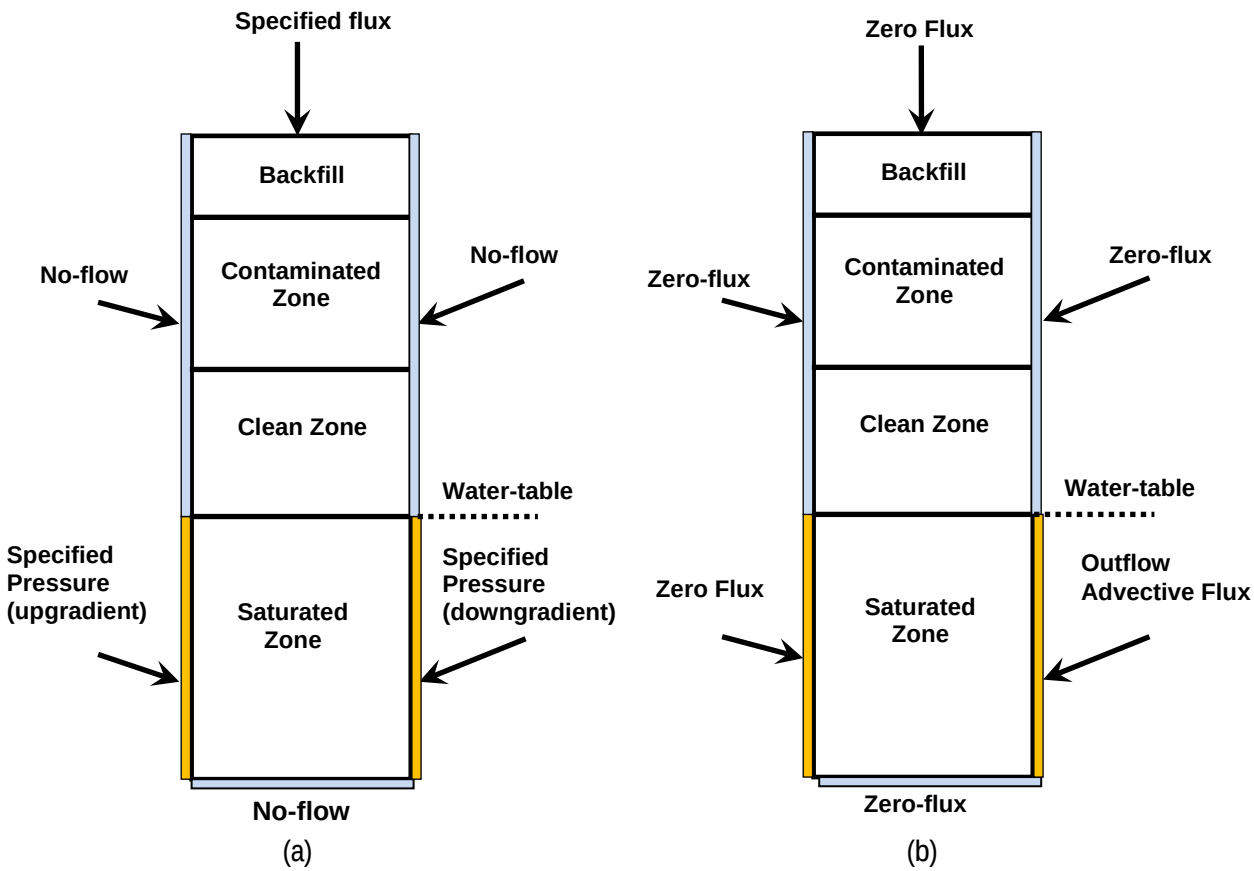


Figure 4. Flow Boundary Conditions (a) and Solute Transport Boundary Conditions (b).

3.2.1 Recharge

The net infiltration into the vadose zone, which is used in the model to represent the recharge into the aquifer, is driven by the competition between precipitation, potential evaporation, transpiration, run-off and run-on. In an arid climate, downward fluxes resulting from this competition are episodic and usually infrequent. A number of studies have been carried out at the Hanford site to ascertain representative long-term averages of the episodic fluxes, i.e., recharge rates, such as those compiled in Pacific Northwest National Laboratory (PNNL)-14702 for the 100 Area. The 100 Area-specific recharge rates in PNNL-14702 varied with surface soil type and so provide an estimate of the range of possible recharge rates for various land cover conditions. The four surface soil types were the Ephrata Sandy Loam, Ephrata Stony Loam, Burbank Loamy Sand, and Rupert Sand; however, recharge rates for the Ephrata Sandy Loam and the Ephrata Stony Loam were described as being identical (PNNL-14702), thus the three different surface soil types were assumed to represent recharge rate variability.

Two different time series of land use or land cover were evaluated in the post-2010 simulations. Maturation of shrub steppe from bare soil to mixed grass and shrub cover to mature shrub steppe cover was called the base case scenario. Irrigation following a period of bare soil cover was the irrigation scenario.

Recharge rates for each scenario were determined using the rates for each of the three surface soil types. In the STOMP simulations, recharge rates were conservatively simulated as a specified flux boundary condition applied to the uppermost boundary of the model (Figure 4) for each recharge scenario and each soil type. Rates were assumed to change over time in step function-fashion for the three scenarios. A fourth scenario, in which base case recharge rates linearly decreased, was created to evaluate the sensitivity to the step function changes in the base case scenario for the post-2010 simulations.

For the pre-2010 simulations, land use and recharge rates were assumed to change from shrub-steppe (pre-operations) to bare soil (operations). Recharge rates for each type of land cover for each soil type were applied to the top boundary from the year 0 to 1944 for the pre-operations period and from 1944 to 2010 for the operations period (Table 5).

Table 5. Recharge Rates of Pre-2010 Simulations.

Soil Type	Recharge Scenario	Type of Transition between Rates	Recharge Rate for Different Period (mm/yr)	
			0-1944	1944-2010
Ephrata Sandy Loam and Stony Loam	Base	Step function	1.5	17.0
	Irrigation			
Burbank Sandy Loam	Base	Step function	3.0	52.0
	Irrigation			
Rupert Sand	Base	Step function	4.0	44.0
	Irrigation			

Three recharge time periods were specified in the post-2010 simulations to represent changes in recharge rates (Table 6). Bare soil was assumed to be the land cover above the waste site during the first recharge period, which spanned 2010 to 2015, For the base case scenario, the second recharge period of 30 years in duration represented grasses and shrubs covering bare soil, followed by establishment of a mature shrub steppe for the remainder of the simulation period; thus recharge rates decreased with time (Table 6).

Recharge rates for the irrigation scenario were estimated using the same approach employed to assess interim remediation at 100 Area waste sites (DOE/RL-96-17 Rev. 6). These site assessments used Remedial Action Goals (RAGs) calculated from RESRAD simulations that assumed total recharge was a combination of irrigation and non-irrigation (base case) recharge rates. As the base case rates used in the RESRAD simulations were different than those adopted from PNNL-14702, the RESRAD equation for total recharge was solved to determine the rate attributable to irrigation alone. According to the RESRAD manual, total recharge is a function of precipitation, evapotranspiration, run-off, and applied irrigation and is defined as

Eqn. 9

in which I = annual recharge rate (LT^{-1}), C_e = evapotranspiration coefficient (dimensionless), C_r = runoff coefficient (dimensionless), P_r = annual precipitation rate (LT^{-1}), and I_{rr} = annual irrigation rate (LT^{-1}). Using Equation 9 and the DOE/RL-96-17 Rev. 6 RESRAD values for these parameters, C_e = 0.91, C_r = 0.2, P_r = 0.16 m/yr, and I_{rr} = 0.76 m/yr, yielded a total recharge rate of 80 mm/yr. Solving Equation 9 with I_{rr} = 0 yielded the non-irrigation total recharge rate of 11.6 mm/yr and therefore the recharge attributable to irrigation alone was 68.4 mm/yr, which was then added to the base case recharge rates to determine a recharge rate for the irrigation scenario for each soil type. For example, the irrigation scenario for the Ephrata soils set the recharge rate to 17 mm/yr from 2010 to 2015, 71.4 mm/yr from 2015 to 2045, and 69.9 mm/yr from 2045 to 5010 (Table 6).

Table 6. Recharge Rates for Post-2010 Simulations.

Soil Type	Recharge Scenario	Type of Transition between Rates	Recharge Rate (mm/yr)		
			Period 1[a]	Period 2	Period 3
Ephrata Sandy Loam and Stony Loam	Base case	Step function	17.0	3.0	1.5
	Irrigation	Step function	17.0	71.4	69.9
Burbank Sandy Loam	Base case	Step function	52.0	6.0	3.0
	Irrigation	Step function	52.0	74.4	71.4
Rupert Sand	Base case	Step function	44.0	8.0	4.0
	Irrigation	Step function	44.0	76.4	72.4

[a] Period 1 is from 2010 to 2015; period 2 lasts from 2015 to 2045; period 3 lasts from 2045 to 5010 for all recharge scenarios.

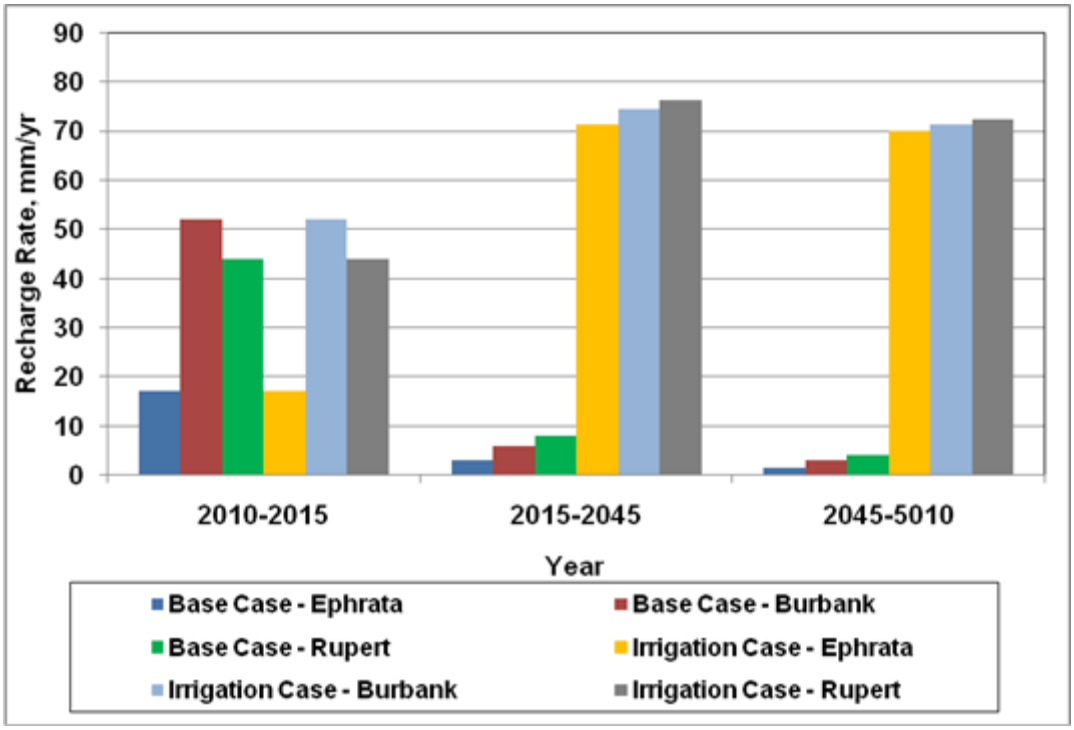


Figure 5. Recharge rates used in Post-2010 STOMP simulations.

3.2.2 Aquifer Flux

The specified pressure values assigned to the edges of the aquifer grid blocks were selected to create a hydraulic gradient across the model domain representative of each source area. The hydraulic gradients used for the simulations were based on head data for March 2008 because the greatest number of wells was measured in that month, yielding the greatest number of measurements for all 100 Area source areas. Triangulated Irregular Networks (TINs) were fitted to the wells using ArcGIS and hydraulic gradients

were computed for each TIN (Table 7). The gradient magnitudes typically varied across two or more orders of magnitude, so the median, a measure of the central tendency of the computed gradients, was selected as a representative value, yielding hydraulic gradients of 0.0011 m/m at 100-D, 0.0021 m/m at 100-H, and 0.0039 at 100-K.

Table 7. Hydraulic Gradients for March 2008.

Source Area	Number of TINS	Hydraulic Gradient (m/m)				
		Minimum	Maximum	Median	Arithmetic average	Geometric average
100-D	82	0.00018	0.00664	0.00110	0.00153	0.00113
100-H	28	0.00014	0.00592	0.00214	0.00258	0.00195
100-K	35	0.00085	0.00759	0.00389	0.00379	0.00341

3.2.3 Initial Conditions

An arbitrary value was assigned as the initial pressure for the pre-2010 flow simulations. A value of 86,656.7 Pascal, approximately equivalent to –1.5 m matric potential, was assigned to the nodes in the vadose zone whereas the aquifer grid blocks were assigned values that matched the boundary condition pressures. Final pressures from the pre-2010 simulations were used as the initial pressures for the post-2010 flow and transport simulations.

The source distribution, called the 100-0 source distribution, assigned a uniform concentration of 1 mg/kg soil to the entire vadose zone thickness beneath the clean cover and so constituted a worst case source distribution. The unit initial concentration is arbitrary but was chosen only for convenience in calculating PRG values and has no effect on the PRG values since the initial concentration C_I is accounted for in Equation 8.

3.3 Hydraulic and Transport Parameters

To the extent possible, source-area-specific hydraulic and transport parameter values were used in the STOMP simulations. Based on previous Hanford studies and on the fact that all available measurements of hydraulic properties made the same assumption, the sediments were assumed to follow the van Genuchten (1980) moisture retention constitutive relation and the Mualem –van Genuchten relative permeability constitutive relation (Mualem, 1976), thus requiring values to be specified in STOMP for each lithologic unit for

- saturated hydraulic conductivity, K_s, (LT^{-1});
- total porosity (L^3L^{-3});
- saturated volumetric water content, θ_s, called diffusive porosity in STOMP (L^3L^{-3});
- residual saturation (dimensionless), equal to the residual volumetric water content, θ_r, divided by the saturated volumetric water content;
- van Genuchten α (L^{-1}), proportional to the inverse of the air entry matric potential;
- the dimensionless van Genuchten n fitting parameter.

The van Genuchten m parameter was assumed to be fixed and equal to $(n - 1)/n$ and the Mualem β exponent was assumed to be fixed at 0.5 (Mualem, 1976; RPP-20621).

Hanford and Ringold E units are well to poorly sorted sandy gravels or sandy silty gravels whereas the backfill consists of poorly sorted sand and gravel with varying fractions of eolian loess and silt (RPP-20621; SGW-40781, REV. 1; SGW-41213, REV. 0; and SGW-46279 REV. 0; PNNL-18564). Within the 100-D, 100-H, and 100-K areas, the Hanford formation tends to be coarser grained than the Ringold E. The former tends to contain larger gravel clasts than the latter, but the Ringold E can locally contain significant amounts of gravel (SGW-40781, REV. 1; SGW-41213, REV. 0; and SGW-46279 REV. 0). The Ringold E unit in the vadose zone is described as silty sandy gravel in 100-D and a fluvial sandy gravel to silty sandy gravel in 100-H and 100-K. Where present, the Ringold upper mud (RUM) was assumed to act as a lower bound (aquitard) for the aquifer (SGW-46279 REV. 0) and so was not directly included in the STOMP simulations.

Operable-unit-specific values for several Mualem-van Genuchten hydraulic parameters were obtained for the Hanford formation from data packages SGW-40781, REV. 1 (100-D and 100-H), SGW-41213, REV. 0 (100-K), and SGW-46279 REV. 0 (entire 100 Area). The three data packages cite RPP-20621 as the source of the unsaturated hydraulic properties of 15 samples of sandy gravels from the 100 Area areas (Table 8). These 100 Area sediments are dominated by the gravel fraction (> 2-mm size), with gravel clasts accounting for 43 to 75% of the total sample mass (Table 8; RPP-20621). Moisture retention data were measured on the non-gravel sediment fraction (< 2mm size), whereas hydraulic conductivities were measured on the bulk samples that included the gravel fraction using the constant-head permeameter method for saturated hydraulic conductivity (K_s) and the unit gradient method for unsaturated hydraulic conductivity (RPP-20621). Although certain samples listed in Table 8 were collected from the Ringold Formation, all contain relatively high percentages of gravel. The Hanford formation is the most gravel-rich of the 100 Area lithologies, so the values in Table 8 were assumed to represent the Hanford formation for the purpose of estimating hydraulic properties. The K_s measurements were assumed to represent vertical hydraulic conductivity.

Table 8. Mualem-van Genuchten hydraulic parameters for sandy gravels in the 100 Area vadose zone.

Sample	Source Area	Well Number	Depth (m)	% Gravel	θ_s (cm^3/cm^3)	θ_r (cm^3/cm^3)	α (1/cm)	n (-)	Fitted K_s (cm/s)
2-1307	100-HR-3	199-D5-14	18.90	43	0.236	0.0089	0.0130	1.447	1.29E-04
2-1308	100-HR-3	199-D5-14	30.64	58	0.120	0.0208	0.0126	1.628	6.97E-05
2-1318	100-HR-3	199-D8-54A	15.54	60	0.124	0.0108	0.0081	1.496	1.67E-04
2-2663	100-BC-5	199-B2-12	8.20	61	0.135	0.0179	0.0067	1.527	6.73E-05
2-2664	100-BC-5	199-B2-12	24.84	73	0.125	0.0136	0.0152	1.516	1.12E-04
2-2666	100-BC-5	199-B4-9	21.49	71	0.138	0.00	0.0087	1.284	1.02E-04
2-2667	100-BC-5	199-B4-9	23.93	75	0.094	0.00	0.0104	1.296	1.40E-04
3-0570	100-KR-1	116-KE-4A	3.50	60	0.141	0.00	0.0869	1.195	2.06E-02
3-0577	100-FR-3	199-F5-43B	7.16	66	0.107	0.00	0.0166	1.359	2.49E-04
3-0686	100-FR-1	116-F-14	6.49	55	0.184	0.00	0.0123	1.600	5.93E-04
3-1702	100-DR-2	199-D5-30	9.78	68	0.103	0.00	0.0491	1.260	1.30E-03
4-1086	100-K	199-K-110A	12.77	65	0.137	0.00	0.1513	1.189	5.83E-02
4-1090	100-K	199-K-111A	8.20	50	0.152	0.0159	0.0159	1.619	4.05E-04
4-1118	100-K	199-K-109A	10.30	66	0.163	0.00	0.2481	1.183	3.89E-02
4-1120	100-K	199-K-109A	18.90	63	0.131	0.0070	0.0138	1.501	2.85E-04

Source: RPP-20621 (2004).

Source-area-specific values for Hanford and Ringold E saturated hydraulic properties were presented in a separate chapter from the vadose zone properties in SGW-40781, REV. 1; SGW-41213, REV. 0; and SGW-46279 REV. 0. Horizontal saturated hydraulic conductivity measurements from aquifer (pump) tests and slug tests for the several areas presented therein were reviewed and geometric means were calculated for each source area's aquifer test measurements only (Table 9). Geometric means were used instead of arithmetic means because the K_s values spanned several orders of magnitude. The mean K_s values ranged between 3 and 98 m/day (Table 9). There were no pumping test data for the Hanford unit in the 100-K area, so the horizontal K_s was set to be ten times the geometric mean vertical K_s for samples from the 100-K area shown in Table 8 on the basis of an assumed horizontal to vertical anisotropy ratio of 10:1.

The geometric mean horizontal K_s values shown in Table 9 for the Ringold E in 100-D and 100-K and Hanford unit in 100-H were checked against the range of preliminary calibration values currently in use for the 100 Area groundwater flow and transport model. In both cases, the mean horizontal K_s values from Table 9 fell towards the low end of the range of preliminary calibration values now in use in the 100 Area groundwater flow and transport model (M. Tonkin, personal communication) and thus can be considered applicable estimates.

Comparison of the aquifer horizontal K_s values in Table 9 with the vertical K_s values in Table 8 for the same units and source areas revealed differences of two or more orders of magnitude. For example, the aquifer horizontal K_s for the Hanford unit in 100-H is 0.0259 cm/s (Table 9), whereas the vertical K_s values for the 100-HR-3 area vary between 6×10^{-5} to 2×10^{-4} cm/s (Table 8), a difference of more than two orders of magnitude. Similarly, the aquifer horizontal K_s for the 100-D Hanford equals 0.0642 cm/s (Table 9), whereas the vertical K_s for the sole sample from 100-DR-2 area is 0.0013 cm/s (Table 8). Vertical anisotropy is commonly assumed to be 0.1 for the Hanford formation (SGW-40781, REV. 1; SGW-41213, REV. 0; and SGW-46279 REV. 0), but 0.1 is at least an order of magnitude larger than the differences described above. Possible explanations include the differences in sample scale between the large-scale aquifer test relative to the small-scale Table 8 samples characterized in the laboratory, the potential effects of sample disturbance or repacking prior to the Table 8 K_s measurements, and the limitations of the Mualem-van Genuchten relative permeability functions to adequately represent hydraulic conductivity across the range of matric potential values.

Table 9. Source-area-specific aquifer horizontal saturated hydraulic conductivity data.

Source Area	Aquifer Formation	Number of Tests	Minimum Horizontal K_s (m/day)	Maximum Horizontal K_s (m/day)	Geometric Mean Horizontal K_s (m/day)	Geometric Mean Horizontal K_s (cm/s)
100-D	Hanford	1	55.5	55.5	55.5	6.42E-02
100-D	Ringold	23	8.5	560	22.4	2.59E-02
100-H	Hanford	18	15.2	1810.5	97.9	1.13E-01
100-H	Ringold	3	0.04	106.7	3.7	4.28E-03
100-K	Ringold	7	0.88	33.8	4.2	4.86E-03

The Mualem-van Genuchten hydraulic properties for the Hanford formation were estimated for each source area by averaging the individual parameter values for all samples collected from that area (Table 10). For example, samples from boreholes 199-D5-14, 199-D5-30, 199-D8-54A, and 199-D5-30 were selected to provide mean properties for 100-D and 100-H areas. Vertical saturated hydraulic conductivity of Hanford formation was averaged using the geometric mean of the four measurements whereas the other parameters were averaged using the arithmetic mean. An exception is the saturated volumetric water

content, called θ_s in the van Genuchten moisture retention relation and diffusive porosity in STOMP. The θ_s values in Table 8 were determined by applying a gravel correction factor to the values determined in the laboratory on the <2mm fraction. The absence of the gravels may have resulted in underestimation of the void volume available for flow because it is very hard to reconcile the high K_s values with such small porosity values. Therefore, the Hanford-wide estimate of 0.25 was used.

Mualem-van Genuchten parameters for the Hanford formation in100-K were determined from the five samples taken from boreholes 199-K-39, 199-K-110A, 199-K-111A, and 199-K-109A. However, three of the samples have vertical K_s values that are roughly two orders of magnitude larger than the values for the other two measurements (Table 8). Consequently, two sets of Mualem-van Genuchten parameters were calculated by averaging values from the two sets of samples using the geometric mean for the vertical K_s measurements and the arithmetic mean for the other parameters (Table 10). One parameter set has a geometric mean vertical K_s of 0.036 cm/s whereas the other set has a geometric mean vertical K_s of 0.00034 cm/s (Table 10). Since there were no aquifer test data for the Hanford in 100-K, the horizontal aquifer K_s was estimated as 10 x vertical K_s for the first parameter set and the horizontal aquifer K_s value for the second set was assumed to equal the value for 100-H (Table 10). Compared to the Hanford unit, the Ringold E unit has a greater influence on determining the groundwater concentration in the aquifer, because the Ringold E unit usually has a much lower K_s value.

The document and database review for this calculation brief did not yield operable-unit-specific or even 100-Area-specific Mualem-van Genuchten property values for the Ringold E unit or the backfill. In the absence of more site-specific data, Hanford-wide mean parameter values for the backfill and the Ringold E units were taken from Table A.12 in *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses* (PNNL-18564). Mean hydraulic parameters for six samples of backfill and 18 samples of Ringold E gravels that were collected within the Hanford site (PNNL-18564) were selected to represent these units within the 100 Area. Thus, the Ringold E intervals located in the vadose zone had the same Mualem-van Genuchten properties in all source areas, as did the backfill. The backfill parameters used for the 100 Area simulations were also used in flow and transport simulations under variably-saturated conditions at other waste sites, such as the PW-1/3/6 waste sites in the 200 Area (Table E5-8 in Appendix E of DOE/RL-2007-27). Groundwater peak concentrations were insensitive to backfill parameters because contaminated vadose zone sediments are located beneath the backfill in all source distribution models for all simulations.

Table 10. Hydraulic parameters used for source areas D, H, and K (BF: back fill; VZ: vadose zone; SZ: saturated zone).

Operable Unit	Soil type	Formation	Total porosity	Diffusive porosity	van Genuchten alpha (1/cm)	van Genuchten n	Residual saturation	Horizontal Saturated K (cm/s)	Vertical Saturated K (cm/s)	Hydraulic gradient (m/m)
100-D	BF	Hanford	0.276	0.262	0.019	1.4	0.162	5.98E-04	5.98E-04	0.0011
	VZ	Hanford	0.28	0.25	0.021	1.458	0.04	2.10E-03	2.10E-04	
	VZ	Ringold E	0.28	0.28	0.008	1.66	0.093	4.13E-03	4.13E-04	
	SZ	Hanford	0.28	0.25	0.021	1.458	0.04	6.42E-02	6.42E-03	
	SZ	Ringold E	0.28	0.28	0.008	1.66	0.093	2.59E-02	2.59E-03	
100-H	BF	Hanford	0.276	0.262	0.019	1.4	0.162	5.98E-04	5.98E-04	0.0021
	VZ	Hanford	0.28	0.25	0.021	1.458	0.04	2.10E-03	2.10E-04	
	VZ	Ringold E	0.28	0.28	0.008	1.66	0.093	4.13E-03	4.13E-04	
	SZ	Hanford	0.28	0.25	0.021	1.458	0.04	1.13E-01	1.13E-02	
	SZ	Ringold E	0.28	0.28	0.008	1.66	0.093	4.28E-03	4.28E-04	
100-K set 1	BF	Hanford	0.276	0.262	0.019	1.4	0.162	5.98E-04	5.98E-04	0.0039
	VZ	Hanford	0.28	0.25	0.162	1.189	0	3.60E-01	3.60E-02	
	VZ	Ringold E	0.28	0.28	0.008	1.66	0.093	4.13E-03	4.13E-04	
	SZ	Hanford	0.28	0.25	0.162	1.189	0	3.60E-01	3.60E-02	
	SZ	Ringold E	0.28	0.28	0.008	1.66	0.093	4.86E-03	4.86E-04	
100-K set 2	BF	Hanford	0.276	0.262	0.019	1.4	0.162	5.98E-04	5.98E-04	
	VZ	Hanford	0.28	0.25	0.015	1.56	0.04	3.40E-03	3.40E-04	
	VZ	Ringold E	0.28	0.28	0.008	1.66	0.093	4.13E-03	4.13E-04	
	SZ	Hanford	0.28	0.25	0.015	1.56	0.04	1.13E-01	1.13E-02	
	SZ	Ringold E	0.28	0.28	0.008	1.66	0.093	4.86E-03	4.86E-04	

For transport simulations, STOMP requires the particle density (ρ_p) values of the backfill, Hanford, and Ringold units. The particle density of each unit can be calculated using the bulk density (ρ_B) and porosity. Bulk density is necessary for retardation scaling factor calculations. Estimates of bulk density for Hanford and Ringold units were obtained from PNNL-14702, which gave 1.91 g/cm^3 for the Hanford and 1.90 g/cm^3 for the Ringold. The bulk density estimate of 1.94 g/cm^3 for backfill was obtained from PNNL-18564. Dispersion was conservatively assumed to be negligible, so dispersivity values were all set to zero. Barring numerical dispersion introduced by the solution method, setting dispersivity values to zero yields higher peak concentrations than setting non-zero values and therefore yields conservative PRG values.

Distribution coefficient, K_D, and half life values were taken from DOE/RL-96-17 Rev. 6 and EPA 540-R-97-036, respectively, and are listed in Attachments 1 to 8 for each contaminant of potential concern. One exception to this is the K_D value for Hexavalent Chromium (Cr(VI)). The K_D value of Cr(VI), 0.8 cm^3/g, was estimated in ECF-Hanford-11-0165. As described in Section 2.3, simulations were run to produce peak groundwater concentrations for a subset of the entire range of distribution coefficients required for all contaminants. Typically, the subset comprised 18 distribution coefficients (Table 11) between 0 and 20 cm^3/g because these values almost always yielded peak groundwater concentrations within the 3,000-year simulation period for the range of vadose zone thicknesses and lithologies simulated. Peak concentrations were estimated for the remaining distribution coefficients using the scaling methods described in Section 2.4 to 2.5.

Table 11. Distribution Coefficients used in STOMP Simulations.

Distribution Coefficient (cm^3/g)
0
0.00001
0.0006
0.00277
0.00451
0.009
0.01
0.025
0.05
0.1
0.125
0.25
0.5
0.8
1
5
10
20

3.4 Point of Calculationand Protectiveness Metric

In accordance with risk assessment guidelines, the determination of soil contamination impacts to groundwater and surface water also requires the definition and rationale for (1) the Point of Calculation (POCal) i.e., the place/point in the groundwater domain where modeled groundwater concentrations are to

be assessed for potential impacts and protectiveness, and (2) the protectiveness metric, i.e., the groundwater and surface water metric(s) to be used in the assessment of protectiveness at the POCal (DOE/RL-2011-50, Rev. 0).

The POCal for the protection of groundwater and surface water is related to the "Exposure Point" in the context of conventional human health risk assessments (EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume 1, Human Health Evaluation Manual [Part A]*) and to "Point of Compliance" in federal and state regulations and guidelines (DOE/RL-2011-50, Rev. 0).

The POCal used for the modeling results was the location according to the model results where peak concentrations in groundwater occurred. For this evaluation, output groundwater concentrations were calculated at the outflow edge of the 1-D column for the grid blocks that were located in the topmost five meters of the aquifer and thereby represented the screen of a monitoring well. The peak value of concentration within the topmost five meters of the aquifer was used to compare to the regulatory compliance criteria.

The protectiveness metric is the set of applicable water quality standards for groundwater and surface water (e.g., ARARs, MCLs, or AWQLs) values for each contaminant. The applicable water quality standard for each contaminant for protectiveness of groundwater and surface water in the 100 Area are included in the Attachments.

3.5 Screening Levels and PRGs

The SSL and PRG values documented herein were calculated for the 100-0 source distribution and several different recharge scenarios based on surface soil type. SSL and PRG values for the base case recharge scenario were larger than those for the irrigation scenario. The SSL values were those calculated assuming a 100-0 source distribution and the most conservative irrigation recharge scenario. The PRG values were calculated assuming a 100-0 source distribution and the most conservative base case recharge scenario.

As is described below and in Section 5.6, source area-specific SSLs and PRGs were determined by selecting the smallest SSL or PRG value from all representative columns and surface soil types for a given recharge scenario. Decisions were made during preparation of this calculation brief, but independent of the calculation brief work, to use the most conservative area-specific SSL value as inputs to determining screening levels for waste site analytes in each area and to adopt the values for base case recharge with a 100-0 source distribution for use as area-specific PRGs in the RI/FS process.

In the absence of sufficient data to determine the subsurface extent of contaminants at individual waste sites, the contaminated interval was assumed to be the entire thickness of the vadose zone below the waste site in calculating SSLs and PRGs. This is a conservative assumption for many of the 100 Area waste sites. Data from the deep boreholes specified in the RI Work Plans for those waste sites where large volumes of liquid wastes were discharged to the vadose zone will be used to assess this conservatism. RESRAD simulations carried out for the Interim Action Record of Decision employed an assumption that contaminant extent encompassed the top half of the vadose zone thickness. The 100-0 source distribution assumption provides a more conservative approach with regard to SSL and PRG magnitude.

3.6 Uncertainties, Assumptions, and Conservatism

Potential sources of uncertainty in risk assessments are primarily in the categories of (1) model uncertainties, (2) scenario uncertainties, and (3) parameter uncertainties. Model uncertainty pertaining to

the equations used as numerical representations of the natural processes is expected to be relatively small (DOE/RL-2011-50, Rev. 0).

DOE/RL-2011-50, Rev. 0 provides a summary evaluation of the comparisons of field data and field test results to corresponding model results obtained using the STOMP code, and the evaluation indicates that the equations used in STOMP adequately simulate the natural processes. The technical basis regarding scenario and parameter selection and the evaluation of uncertainty and variability is also documented in DOE/RL-2011-50 Rev. 0. Documentation is provided in DOE/RL-2011-50 Rev. 0 on (1) dominant model factors, (2) model parameter values and plausible ranges of parameter values, (3) model assumptions and effects on model results, and (4) model limitations.

Application of the PRG values calculated herein requires an understanding of which assumptions and modeling choices were conservative and which were not. Conservative assumptions and modeling choices include:

- Non-area-specific PRGs were calculated for each recharge scenario by selecting the minimum value calculated for all of the representative columns.
- Source-area-specific PRGs were calculated for each recharge scenario by selecting the minimum value calculated for the representative columns simulated for the particular area.
- Recharge was represented in the numerical model by uniform flux rates specified over particular time periods so that vadose zone flow is always downward. In contrast, recharge in an arid vadose zone occurs only as often as the combination of precipitation and antecedent moisture conditions allow, i.e., sporadically or infrequently, so that there can be long periods when shallow vadose-zone porewater movement is controlled more by evaporation and transpiration near the surface than gravity, resulting in upward movement or reduced downward seepage velocity.
- The recharge rates used for Rupert sand were all significantly larger than the rates used for the other soils, and the Rupert sand results produced the minimum PRG or screening level values for most of the 3,000-year simulations.
- The smallest base case recharge rates are larger than the minimum of the range of rates determined for the Hanford shrub steppe.
- The one-dimensional simulations force all contamination through the vadose zone down to the aquifer, whereas infiltrating water and solutes tend to migrate laterally as the wetting front redistributes following an infiltration event.
- Dilution upon mixing of groundwater with Columbia River water is assumed to be negligible.
- Dispersion is assumed to be negligible, which leads to larger peak concentrations than if dispersion had been included.
- Volatile organic compounds are assumed to have negligible volatilization so that the resulting peak concentrations are larger than if volatilization had been included.
- Geometric means of measured aquifer horizontal hydraulic conductivity values are lower, and thus more conservative, than arithmetic means because the values typically span several orders of magnitude.
- Contaminant source mass within the domain is conservatively calculated by assuming that all the sediments, gravels and finer-grained materials (< 2mm size fraction) are active in transporting water and solutes. Under the recharge scenarios considered for the simulations, water and solutes do not have significant interaction with the gravel clasts because water and solutes are mostly restricted to the finer-grained materials under these relatively dry conditions. Since gravels constitute 43 to 75% of the vadose zone sediment mass, water and solutes do not interact with a significant fraction of vadose zone sediments. Thus the resulting PRG values are highly conservative because the initial contaminant mass was calculated using the mass of gravel and finer-grained sediments rather than using the mass of finer-grained sediments alone.

- Contaminant source mass within the domain is calculated using the bulk density value for gravels and finer-grained materials, whereas laboratory measurements of soil concentrations typically exclude the gravel fraction and measure the concentration of the finer-grained materials only. The bulk density for Hanford formation and Ringold E sediments with gravels is 1.93 gm/cm^3, whereas the bulk density of the < 2mm fraction is significantly lower.
- The simulations do not explicitly represent the alternation of thin intervals of finer-grained material with thicker intervals of coarser-grained materials commonly observed in the 100 Area, even though such alternations create local capillary impedances to downward transport through the juxtaposition of intervals with large pores below intervals with small pores.
- The initial conditions for matric potential at the start of the flow and transport simulations represent a wetter vadose zone than is expected for such gravel-dominated sediments in an arid climate, thus allowing significantly higher water and solute flux values.

Assumptions that may or may not be conservative include:

- The median hydraulic gradient value for each source area may be too large by several-fold for waste sites near the Columbia River and may be several times too large for waste sites that are far inland from the river.
- The assumption of a five-meter-thick aquifer may or may not be conservative for those 100 Area locations with aquifer thicknesses less than five meters.
- The Patankar solution algorithm used for solute transport through the one-dimensional columns may add more numerical dispersion than another solution algorithm (PNNL-12030). Numerical dispersion acts to reduce the calculated peak groundwater concentration.

Conservative assumptions specific to the screening level calculations include:

- Contaminant source distribution is assumed to span the entire thickness of the vadose zone beneath the clean fill.
- Only the irrigation recharge scenario is used.

Conservative assumptions specific to the PRG calculations include:

- Contaminant source distribution is assumed to span the entire thickness of the vadose zone beneath the clean fill.
- The smallest base case recharge rates are larger than the minimum of the range of rates determined for the Hanford shrub steppe.

4. Software Applications

The vadose zone fate and transport calculations were performed using the STOMP (Subsurface Transport Over Multiple Phases) Version 3.2 code, Hanford Information System Inventory (HISI) identification number 2471. STOMP simulations were executed on two separate computer clusters; 1) the INTERA Austin Linux®[1] Cluster that is owned and managed by INTERA, Inc. in Austin, TX and 2) the RANSAC Linux® Cluster (ransac-0.pnl.gov) that is managed by Pacific Northwest National Laboratory (PNNL). The INTERA cluster's computer property tag identifier for the frontend node is #378 at INTERA's Austin office. The frontend hardware (controller node) is a Dell® Optiplex® 760 with a 3.16-GHz Intel®

[1] Linux is the registered trademark of Linus Torvalds in the U.S. and other countries.

E8500 processor and 4 GB of RAM loaded. As given by the command name –a, the operating system details are "Linux version 2.6.29.4-167.fc11.i686.PAE (mockbuild@x86-5.fedora.phx.redhat.com) (gcc version 4.4.0 20090506 (Red Hat 4.4.0-4) (GCC)) #1 SMP Wed May 27 17:28:22 EDT 2009." The computer property tag identifier for the RANSAC cluster's frontend node is WD56054 (PNNL Property System). The frontend hardware (controller node) is a Dell® PowerEdge® 2550 with dual 3.00-GHz (Intel® Xeon®) processors and 2 GB of RAM loaded with the Red Hat® Enterprise Linux® Client release 5.5 (Tikanga) operating system.

Excel®[2] spreadsheets were used to calculate contaminant inventory values and approximate contaminant solute concentrations, back calculate PRG values, and evaluate the results produced by STOMP. These calculations were performed on several desktops. These include ID INTERA 00312 (Albequerque Office), ID INTERA 00295 (Richland Office), and WF16209 (CHPRC). The INTERA 00312 hardware is a Dell Precision T3500 with a 2.40-GHz Intel Xeon CPU processor and 6 GB of RAM loaded with the Windows 7 Professional 64-bit operating system. The INTERA 00295 hardware is a Dell Precision E7200 with a 2.53-GHz Intel(R) Core(TM)2 Duo CPU processor and 3.25 GB of RAM loaded with the Windows XP Professional 64-bit operating system. The WF16209 hardware is a Dell® Latitude® E6400 with a 2.26-GHz Intel Core™ 2 Duo CPU E8200 processor and 3 GB of RAM loaded with the HLAN Windows® XP Image Version 3.0.1.0 operating system.

DOE/RL-2011-50, Rev. 0 contains a summary of the main model attributes and code selection criteria that serve as the basis for the demonstration of the adequacy of the STOMP code for use in vadose zone modeling at Hanford. The results of the evaluation in DOE/RL-2011-50, Rev. 0 show that the STOMP code is capable of meeting or exceeding the identified attributes and criteria. The comparison of the code selection criteria to the STOMP code capabilities indicates the STOMP code is capable of simulating all of the necessary FEPs, and that STOMP meets all of the other required code selection criteria. DOE/RL-2011-50, Rev. 0 addresses code selection criteria, including quality assurance documentation of verification studies for specific model attributes (e.g., unsaturated flow, solute transport, infiltration, and drainage), and includes a discussion of other code related criteria (i.e., inter-code comparisons, hardware requirements, solution methodology, dimensionality, and output capability).

The results of CHPRC acceptance testing (CHPRC-00515, Rev. 0) demonstrate that the STOMP software is acceptable for its intended use by the CHPRC. Installations of the software are operating correctly, as demonstrated by the INTERA Linux Cluster system producing the same results as those presented for selected problems from the STOMP Application Guide (PNNL-11216) in accordance with CHPRC-00211 REV. 0.

5. Calculation

STOMP simulations were created and run using the domains, boundary conditions, initial conditions, and parameter values described in Section 3. The resulting peak groundwater concentrations for a subset of distribution coefficient values were identified within the STOMP surface flux files according to Section 2.4; scaled using the retardation factor to estimate peak concentrations for other K_D values according to Section 2.5; and the complete set of groundwater peak concentrations were then used to calculate PRGs using both surface water and groundwater regulatory standards, as described in Section 2.6.

[2] Excel and Windows are registered trademarks of Microsoft Corporation in the United States and other countries.

5.1 Time Steps and Solution Method

STOMP simulations were all run with a maximum time step of 1.0 years for the pre-2010 flow simulations and 0.01 years for the post-2010 simulations to keep the grid Courant numbers low. The pre-2010 flow simulations were run with the default solution technique, called the Patankar method, as were the post-2010 flow and transport simulations. STOMP's TVD solution technique, which can cause less numerical dispersion than the Patankar method, did not work for the STOMP simulations described herein. The STOMP-w executable with banded matric solver, which had been qualified for all the nodes in the computer cluster, was used for all simulations.

5.2 Calculating Groundwater Concentration from STOMP Surface Flux Files

Peak groundwater concentrations were calculated for each model time step along a portion of the domain's downgradient boundary corresponding to the top five meters of the aquifer. Fluxes through the downgradient boundary were written to a surface flux file, one of STOMP's standard output options. For each time step, STOMP writes the water mass and solute mass flux rates passing through the surface as well as the cumulative water and solute mass that have passed through the surface. Groundwater concentration within the 5-m-long surface was conservatively estimated by calculating it at the aquifer edge beneath the downgradient edge of the waste site footprint. The solute mass flux per unit time was divided by the water volume flux per unit time to yield a groundwater concentration at each time step.

5.3 Estimating Effective θ and Scaling Peak Concentration

For most of the recharge rates and column thicknesses, effective θ determined from the STOMP simulations decreases slightly and monotonically with time. In part, this is a result of all changes in the recharge rate that occur early in the 3,000-year simulation period, within the first 35 years for the base case, first 15 years for the irrigation scenario, and the first 500 years for the ET barrier scenario. Thus, an effective or average θ for the domain is at or near the long-term equilibrium value appropriate for the final recharge rate long before the end of the simulation. In such cases, the effective θ value for the last K_D value to show a peak within the 3,000-year simulation period is chosen to estimate effective θ for all larger K_D values.

Furthermore, the peak concentration for a K_D that was not simulated but fell in value between two simulated K_D values could be quickly estimated by using the arithmetic average of the effective θ values determined from the two simulated K_D values. This is demonstrated by inspection of Equation 3:

Eqn. 3

If effective θ is constant, then retardation factor is only a function of K_D, thus a plot of 1/CPK versus K_D will yield a linearly increasing relationship, such as that observed for 100-D's representative column 1 with the base case scenario with Ephrata loam (Figure 6). For these conditions, effective θ shows only small changes, all of which are monotonically decreasing, with the end result that effective θ is essentially constant.

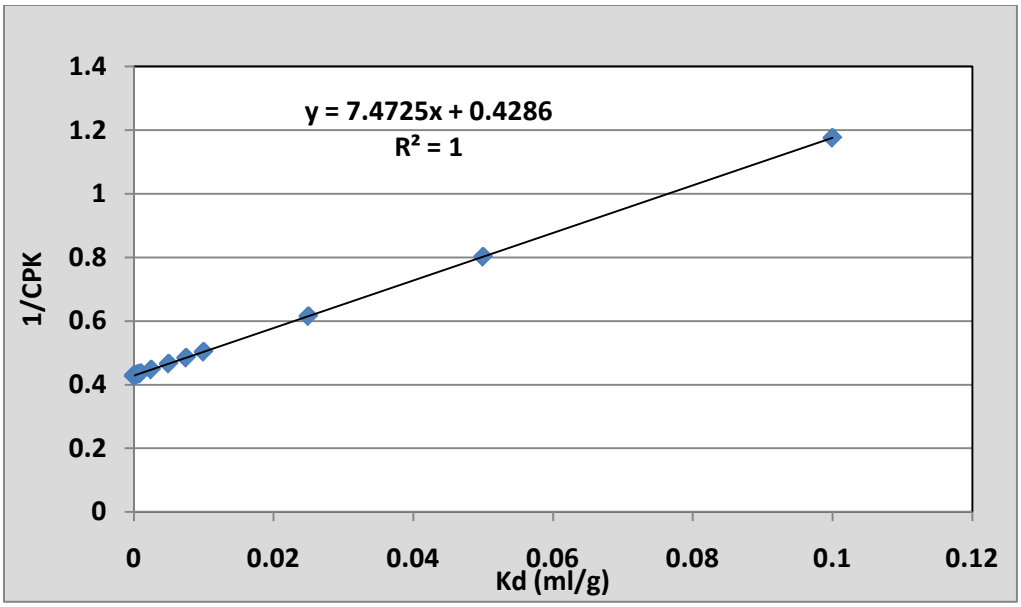


Figure 6. Simulated Peak Groundwater Concentration and K_d for 100-D Column 1 and Base Case Recharge

For any given recharge scenario, effective θ changes very little over time in thick soil columns, whereas effective θ can change more rapidly in thin soil columns. The representative columns for 100-D and 100-K were all relatively thick and so yielded linear plots like that shown in Figure 6, even when the recharge scenario did not change monotonically.

In the two representative columns for 100-H, changes in effective θ were not small or monotonic for the simulated set of K_D values under the ET barrier scenario. The 100-H columns are much thinner than those at 100-D or 100-K, allowing the effective θ for the entire column to change relatively quickly compared to the thicker columns. Thus the relationship between simulated peak concentration and K_D was not linear. However, the peak concentrations for K_D values that fall between simulated K_D values were estimated from nonlinear regressions that closely matched the observed points, as is shown in Figure 7 for the 100-H column 1 using the ET barrier scenario for the Burbank loam:

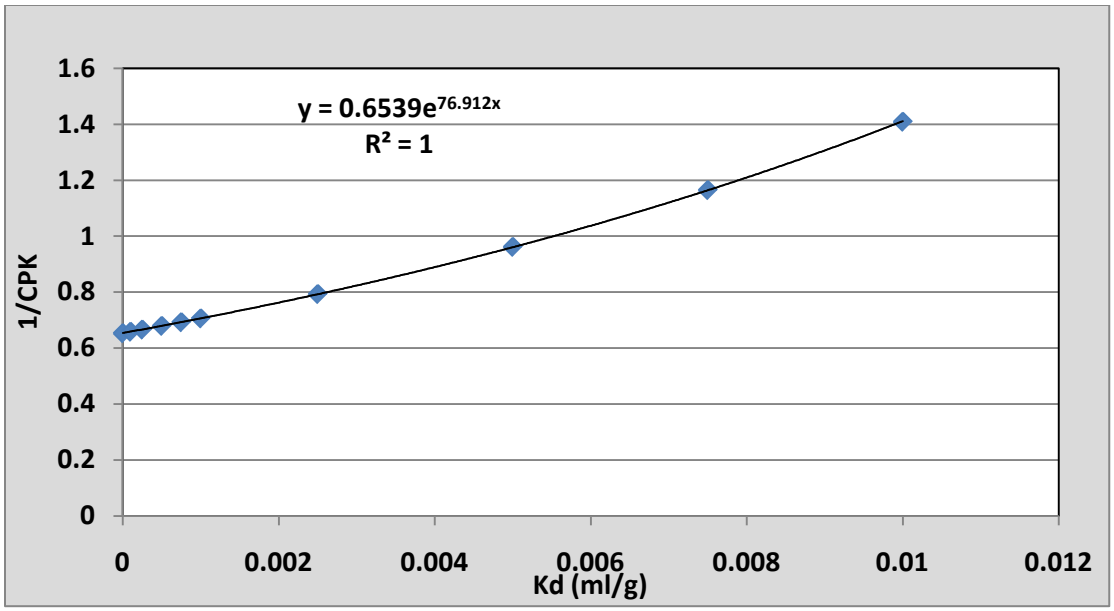


Figure 7. Simulated Peak Groundwater Concentration and K_d for 100-H Column 1 and ET Barrier Recharge

The nonlinear relationship was always restricted to a small range of the simulated K_D values and the linear relationship fit the remaining (larger) K_D values exactly. For the conditions shown in Figure 7, K_D values larger than 0.01 fit a linear relationship exactly, so that peak groundwater concentrations could be estimated using the appropriate effective θ value as described above.

5.4 PRG Values

PRGs were calculated from the peak groundwater concentrations using Equation 8 and the applicable surface water and groundwater regulatory standards. If simulated peak concentrations are very small, application of Equation 8 can lead to physically unrealistic soil concentrations, e.g., 10 kg of aluminum per kg of soil. Although not strictly necessary, the maximum PRG value was capped at an estimate of the total contaminant mass that could occupy the void volume within a kilogram of soil.

The bulk density (ρ_B) of the soil in the 100 Area is 1930 kg/m^3. For 1 kg of soil, the total volume (V_T) of the soil is:

$$\text{———}=5.18\times10^{-4}\ \text{m}^3$$

The contaminant is assumed to fully occupy all the pores. Thus, the maximum mass of contaminant in the soil is

where n is the total porosity and ρ_p is the particle density of the contaminant. In the 100 Area, the total porosity of Hanford or Ringold is 0.28, and the particle density of the contaminant is assumed to equal the particle density of the soil, 2650 kg/m^3. The maximum mass of contaminant in 1 kg soil is given by

$$0.28\times5.18\times10^{-4}\ \text{m}^3\times2650\ \text{kg/m}^3=0.384\ \text{kg} = 3.84\times10^5\ \text{mg}$$

Thus the maximum PRG for non-radionuclides is 384,000 mg per kg of soil. Any non-radionuclide PRG with a larger value was replaced by 384,000 mg per kg of soil.

For radionuclides in groundwater, the maximum contaminant mass was transformed into a maximum radionuclide activity using the specific activity of each radionuclide. The specific activity is defined as the amount of radioactivity of a particular radionuclide per unit mass of the radionuclide, which is calculated by:

Eqn. 10

where *SpA* is the specific activity (pCi/g), m_{amu} is the atomic mass unit (amu), and $t_{1/2}$ is the decay rate (yr). The specific activities for Nickel-63, Tritium, and Strontium-90, which were the only radionuclides with very large PRG values, were calculated using Equation 9 and the maximum PRG values were obtained by multiplying the specific activity by the maximum contaminant mass (Table 12).

Table 12. Specific Activity and Maximum PRG Value for Selected Radionuclides.

	Atomic mass	Half-life (yr)	Specific Activity (pCi/g)	Maximal PRG (pCi/g)
Nickel-63	58.6934	96	6.35E+13	2.44E+13
Tritium	3.0160492	12.35	9.61E+15	3.69E+15
Strontium-90	89.9	29.12	1.37E+14	5.26E+13

The PRG values represent soil concentrations in the vadose zone that should not exceed the surface water or ground water regulatory standard for each particular contaminant for a range of vadose zone thicknesses, lithologic composition, soil types, and recharge scenarios. As described in Section 3.4, PRG values calculated for the 100-0 source distribution model with irrigation represent the “worst case” estimate of potential impacts and were adopted to serve as a screening tool for preliminary site screening. PRGs for the 100-0 source distribution and base case recharge were selected for use in the RI/FS document process..

Examples of the estimated groundwater protection concentration values for three contaminants for the representative column 1 in source area 100-D are shown in Table 13. As expected, values for the irrigation recharge scenario are smaller and the values for the base case scenario are larger than the values for the irrigation scenario. As the magnitude of K_D increases, the magnitude of the values protective of groundwater also increases, all other conditions held constant. The values in Table 13 do not represent the final PRG values selected for these contaminants. Merely, the table presents a set of results based on the calculations using the equations and relationships described in the previous section.

Examination of Attachments 1 to 8 reveals that PRG values for the Rupert sand soil type tend to be the smallest whereas those for the Ephrata soils tend to be the largest PRG values. This behavior is a direct result of the relatively high recharge rates for the Rupert sand and the relatively small recharge rate for the Ephrata soils.

Table 13. Example groundwater protection concentration results for the first representative column in 100-D.

Contaminant	KD Value (cm^3/g)	Ground Water Standard (µg/L)	Soil Screening Level: (mg/kg)			Preliminary Remediation Goal: (mg/kg)		
			100-0 source distribution: irrigation step-function			100-0 source distribution: Base case step-function		
			Ephrata Loam	Burbank Loam	Rupert Sand	Ephrata Loam	Burbank Loam	Rupert Sand
Cr(VI)	0.8	48	6.6E+01	6.4E+01	6.2E+01	2.9E+02	9.4E+01	1.1E+02
Benzene	0.062	1.59	0.15	0.15	0.15	0.82	0.24	0.29
Trichloro-ethene	0.094	0.983	0.12	0.12	0.11	0.62	0.19	0.23

5.5 Calculating Dilution Factors

Lithologic composition in the saturated zone appears to have a very significant effect on PRG values. In general, aquifers composed of Ringold E only tend to have lower PRGs than aquifers with Hanford only because the horizontal saturated hydraulic conductivity of the Ringold E tends to be smaller than that for the Hanford (hydraulic gradient is constant within each source area). This is demonstrated by plotting the dilution factors for the representative columns for each source area (Figure 8). As defined in the Washington Administrative Code (WAC 173-340-747), the dilution factor is the ratio of the combined aquifer and vadose zone water fluxes to the vadose zone water flux:

Eqn. 11

for which Df = the dimensionless dilution factor, Q_{VZ} equals the volumetric flux from the vadose zone into the aquifer (L^3T^{-1})and Q_A represents the volumetric flux through the topmost five meters of the aquifer (L^3T^{-1}). The dilution factors for representative columns with aquifers of Ringold E are approximately one order of magnitude smaller than the dilution factors for Hanford aquifers for 100-K Area for all recharge scenarios (Figure 8). Also, for 100-D Area the Ringold dilution factor was 2 times less than the Hanford dilution factor.

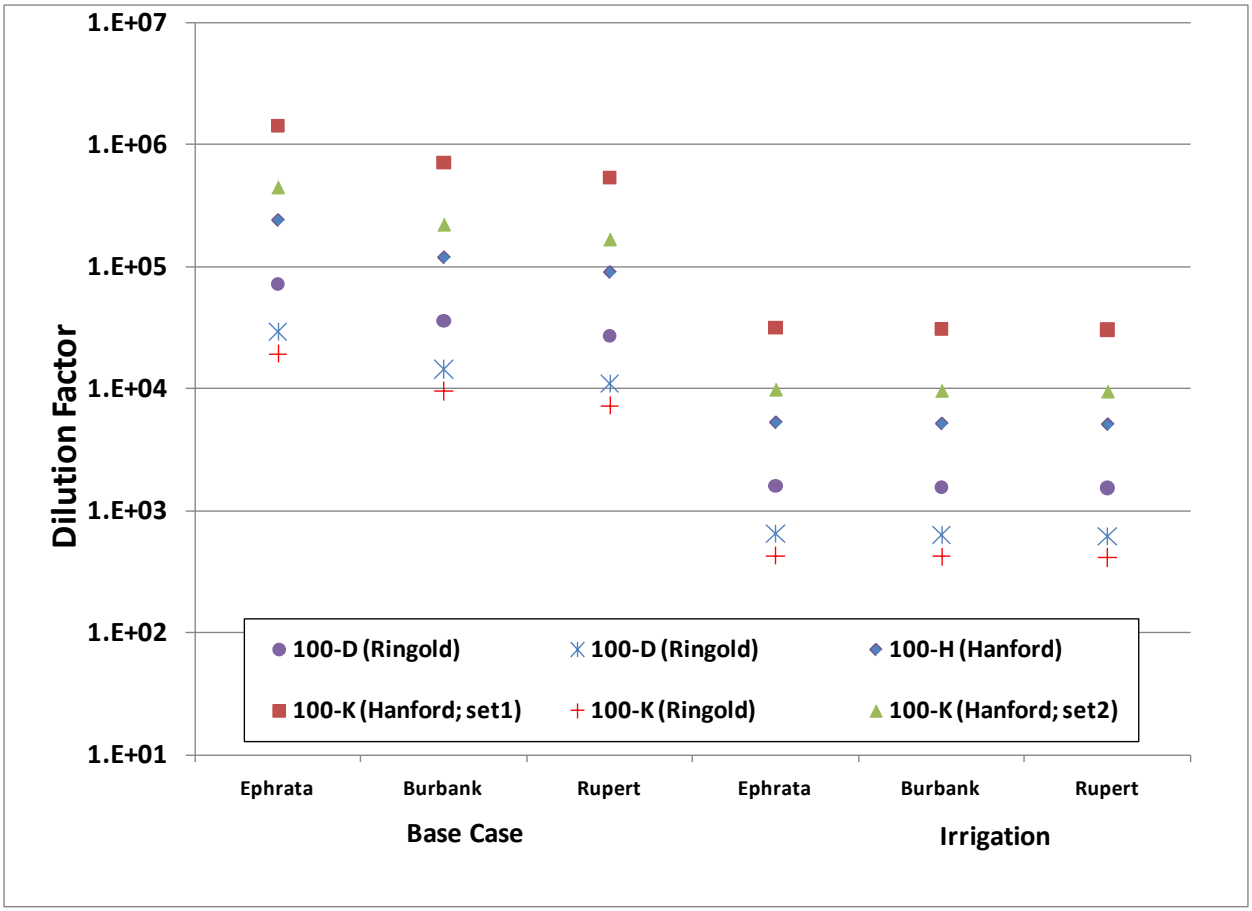


Figure 8. Dilution factors for representative columns.

5.6 Calculating Source-Area-Specific PRGs

Source-area-specific PRG values for a particular recharge scenario were conservatively calculated as the minimum PRG for all representative columns and all soil types. As was described in Section 3.5, the 100-K source area had two sets of hydraulic properties because of the two order of magnitude difference in saturated hydraulic conductivity. The minimum values resulting from these two sets K source area parameters were selected as the SSL and PRG values in Attachments 9 and 10, respectively.

6. Results/Conclusions

6.1 PRG values of Surface Water and Groundwater in the 100-D, 100-H, and 100-K Areas

STOMP simulations and scaling calculations were used to estimate PRG values specific to each of the source areas 100-D, 100-H, and 100-K over a representative range of vadose zone thicknesses, lithologic composition, soil types, and recharge scenarios.

Attachments 1 to 8 contain the surface water and groundwater PRG values for each soil type, recharge scenario, and representative column for the 100-D, 100-H, 100-K (parameter set 1), and 100-K (parameter set 2), respectively, using the 100-0 source distribution assumption.

Attachment 9 presents the minimum surface water and groundwater screening values for the 100-0 source distribution and irrigation together with the distribution coefficient, regulatory standard, and MTCA three-phase equation screening level for each contaminant. Attachment 10 presents the minimum surface and groundwater PRGs for each source area under the 100-0 source distribution.

The PRG values resulting from the simulations and back-calculations are only intended to be applied to sites that share the same set of conditions and assumptions underpinning these calculations. Questions about whether the PRG values are appropriate for a given site should be forwarded to the authors of this calculation brief or the CH2M Hill Plateau Remediation Company (CHPRC) lead for modeling and risk assessment.

Some waste sites may require a more rigorous investigation of site specific conditions than those underlying the PRG values found in Attachments 1 to 10. Other simulations and back calculations may be necessary if the assumptions and conditions for a particular site do not match those used in these calculations.

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Environmental Calculation Cover Page

Part 1: Completed by the Responsible Manager

Project: River Corridor Remedial Investigation Date: 08/08/2011

Calculation Title & Description: Evaluation of Hexavalent Chromium Leach Test Data Conducted on Vadose Zone Sediment Samples from the 100-Area

Preparer: TJ Budge	• **Basis of Qualification:** Education & Experience
Checker: N Hasan	• **Basis of Qualification:** Education & Experience
Senior Reviewer: S Mehta	• **Basis of Qualification:** Education & Experience

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Terms

CHPRC	CH2M-Hill Plateau Remediation Company
ECDF	empirical cumulative distribution function
ECF	environmental calculation file
HISI	Hanford Information System Inventory
HLAN	Hanford Local Area Network
K_d	linear distribution coefficient
m	meter(s)
mg/kg	milligrams per kilogram
mL/g	milliliters per gram
PNNL	Pacific Northwest National Laboratory
PRG	preliminary remediation goal
PQL	practical quantitation limit
OU	operable unit
SAP	sampling and analysis plan
SSL	soil screening level
STOMP	Subsurface Transport Over Multiple Phases (modeling software)
µg/L	micrograms per liter
µg/g	micrograms per gram
WAC	Washington Administrative Code

1. Purpose

The results of leach tests described in Calculation 0100K-CA-V0081, 0100K-CA-V0081, 0100X-CA-V0058, 0100X-CA-V0059, and 0100X-CA-V0060 have been analyzed to estimate the distribution coefficient (K_d) based on the assumption of linear sorption isotherm for residual Hexavalent Chromium (Cr(VI)) in the vadose zone. The soil samples were taken as part of River Corridor remedial investigation (RI) efforts, predominately from beneath previously remediated waste sites. This memorandum relies on collected field data and the corresponding lab analysis outlined in the sampling and analysis plan (SAP) DOE/RL-2009-41, Rev. 0, to recommend a K_d value for use in the 100-Area. All methods used to calculate a value for K_d were outlined in the various RI SAPs for the River Corridor. The objective of this environmental calculation (ECF) is to give a brief background associated with Cr(VI) leaching studies at the Hanford site and how these data relate to previous studies, summarize the data and analyses that are available to assess K_d in the River Corridor, analyze the results of the leach tests for trends, and recommend a K_d for use in the River Corridor based on the leach test results. These objectives are discussed in the following sections.

1.1 Introduction

Chromium (Cr) occurs naturally in Hanford soils in trivalent oxidation state [Cr(III)] but hexavalent Chromium [Cr(VI)] occurs as a common contaminant in the subsurface at reactor operations areas in the 100 Areas along the Columbia River. Historical records show that Cr [predominantly Cr(VI)] was released into the subsurface during the addition of sodium dichromate to cooling water for use in the reactors and by discharge of cooling water from the reactors. After a single pass through these reactors, the cooling waters were discharged to the surrounding environment by various routes. These disposal practices have resulted in contamination of the subsurface with Cr. Discharged Cr exists both in hexavalent state, Cr(VI), and a reduced trivalent state, Cr(III). Interim actions along the River Corridor have previously been completed that targeted the removal of Cr(VI) soil contamination above 2 – 8 mg/kg.

Fate and transport of different forms of Cr is an important factor in assessing the risk posed by the contamination. Various remedial strategies have already been implemented to reduce the amount of Cr(VI) in the 100-Area. Further, studies specific to attenuation of Cr(VI) at the Hanford site have been conducted to evaluate Cr(VI) migration and attenuation in the vadose zone and saturated groundwater aquifers. A detailed description of leaching experiments in soils retrieved below the 116-D-7 retention basin is provided in a remediation cleanup verification package document for that facility (CVP-99-00007, 2000). Also, a detailed leaching and characterization study has been completed using near surface soils (less than 3 m [10 ft]) bgs collected near sodium dichromate storage tanks and railroad tracks in the 100BC Area (PNNL-17674). Other Cr leaching studies have also been performed for residual soils at other 100 Area waste sites, and a range of K_d values are available in literature.

These experimental results suggest that after Cr(VI) discharged to the soil column, two primary chemical stages of chromium reactivity occur, which influence its transport characteristics. First, the majority of Cr(VI) remains mobile, transports readily, and contributes to groundwater concentrations commensurate with source term strength. Second, some Cr(VI) is sequestered by a variety of mechanisms that retard further migration rates and reduce groundwater concentrations. The effectiveness of these sequestration processes increases over time. In the soil column underneath the retention basins, it appears that the initial highly mobile component of discharged Cr(VI) has already been flushed from the sampled soil. This is expected, given the high leakage volume from the retention basins during operations. Conversely, the soil

column underneath the reactor area that is contaminated with Cr(VI) has been contacted by much smaller volumes of water since the contaminating event. Extensive flushing of the soil has not been completed in the natural setting.

Results presented in the PNNL-17674 report represent initial flushing of contaminant concentration as the soils were collected from reactor area. As such, the results may be appropriately applied to waste sites with high concentration contamination where few pore volumes have flushed the soil. However, PNNL-17674 does not adequately describe the portion of Cr(VI) that is sequestered in the soil even after many pore volumes have flushed through the system. The leach tests designed as part of the RI/FS process and described in DOE/RL-2009-41, Rev. 0, were completed to assess attenuation of Cr(VI) and various other contaminants. The leach tests were conducted on soil samples from a large number of locations across the River Corridor including both high concentration/low volume waste sites, low concentration effluent waste sites, and boreholes not associated with a waste site. This ECF focuses on recommending a K_d for Cr(VI) based on these data and identifying the assumptions and uncertainties associated with this recommendation. The following sections discuss how this was completed.

2. Methodology

A total of 509 soil samples were collected and quadruplicate analysis performed on the bulk sample for metals (arsenic, barium, calcium, chromium, hexavalent chromium, lead, silver, and selenium) under the RI. Soil samples were submitted for leaching using ASTM D3987-06, *Standard Test Method for Shake Extraction of Solid Waste with Water* at three ratios of soil to leachant (1:1, 1:2.5: and 1:5) by weight. Thus, for every 100 g of soil used in the leaching method 100 g, 250 g, and 500 g of water was added for leaching metals from the contaminated soil. One of the three ratios was randomly selected to be run as a duplicate analysis totaling four analyses for each of the 509 soil samples.

The K_d values were determined for each metal based on the bulk sample and leachate results. For the purpose of this ECF only Cr(VI) K_d determinations are evaluated further. For samples that had detectable levels of hexavalent chromium in both the soil and leachate solution, a K_d was calculated as the ratio of contaminant sorbed concentration in soil to the contaminant concentration in solution by the following equation:

$$K_d = \frac{(C_S \times M_S) - (C_L \times V_L)}{M_S} \times \frac{1}{C_L} \times \frac{1000\ mL}{1\ L} \qquad \text{Equation 1}$$

Where:

K_d = Distribution coefficient (mL/g)
C_S = Contaminant concentration in bulk soil matrix prior to leaching (µg/g)
M_S = Dry mass of soil used for leaching (g)
C_L = Contaminant concentration in leachate (µg/L)
V_L = Liquid volume used for leaching (L)

If the sorbed mass on any of the four bulk soil samples were flagged as a non-detect (i.e., flagged “U” by the laboratory as a non-detect), the average was reported as N/A and the K_d calculation was not performed because the inherent variability in the concentration near the

detection limit precludes a K_d determination that is reliable. Thus, the K_d results were reported as N/A.

If Cr(VI) was quantified in the four bulk soil sample analyses but an associated leachate result was non-detect (i.e., flagged "U" by the laboratory), the K_d was reported as a greater than value based on calculating the K_d using the practical quantitation limit (PQL) as the solute concentration (0100K-CA-V0081, 0100X-CA-V0058, 0100X-CA-V0059, 0100X-CA-V0060).In these cases the estimated lower limit on K_d was used in the analysis. However, the value used is a conservative estimate as the PQL is higher than the limit at which Cr(VI) can be detected.

A summary of the results from the K_d calculations is found in Table 1. A total of 509 samples from 58 locations resulting in a total of 2036 analyses were completed. Only 38 analyses from 4 locations had detections of Cr(VI) in both the soil and solute while 154 analyses exist where Cr(VI) was detected in the soil sample but not detected in the leachate following the leaching experiment. Comparing these two populations of data (Table 1) demonstrates that the range of K_d values given by the group with calculated K_d (based on 38 analyses) and estimated K_d (based on 154 analyses) are similar. However, medians and averages are more different. Given that many of the locations for these tests were selected to increase the likelihood of detection, it should be noted that the majority of the sites were not contaminated with detectable levels of Cr(VI) and those with detectable levels, the majority showed no detectable leaching of Cr(VI) into the water during the leaching experiment, further illustrating the lack of leachability for residual Cr(VI) after the interim remediation actions are implemented.

The leaching results were also grouped based on the geologic formation where the sample was taken. Thirty-eight samples from the Hanford formation from 14 locations produced data where a K_d could be calculated. While 10 samples from 4 locations were collected from the Ringold formation. The K_d values calculated for the Hanford formation samples have a significantly higher minimum value (7 mL/g) over the minimum value for samples from the Ringold (0 mL/g). Median and average values for the Hanford formation are also larger in magnitude than the results in the Ringold.

Table 1 – Summary of leach tests and K_d results used in analyzing K_d for use in the river corridor

Sample Group	Locations	Samples	Analyses	Minimum	Average	Median	Maximum
All Samples	58	509	2036	--	--	--	--
By Detection							
Soil Detection Only	15	39	154	0	27	25	66
Soil and Solute Detection	4	10	38	0.03	14	3.5	55
By Geologic Formation							
Hanford	14	38	152	7	28	26	66
Ringold	4	10	40	0	12	2.0	54

* K_d calculated by assuming dissolved concentration is at the practical quantitation limit

3. Assumptions and Inputs

Several attributes exist that may influence the results of the leaching tests and the estimated K_d value associated with each leaching test. In this analysis depth below ground surface, dilution

factor at which the leach experiment was conducted, type of waste site where the sample was collected, the operable unit where the sample was collected, geologic formation, and lithology were investigated to evaluate if there was an apparent influence of any of these attributes on the results. The analysis included plotting the cumulative distribution function for K_d results and illustrating the attributes listed above through the symbology of the points, creating scatter plots of depth vs. K_d, creating scatter plots of K_d with dilution factor 1:1 versus dilution factor of 1:2.5 and 1:5 for the same samples, and creating a scatter plot of Cr(VI) soil concentration versus estimated K_d. Because the evaluation includes only visual analysis of plots of these data, the analysis is qualitative.

Figure 1 shows the empirical cumulative distribution function (ECDF) created for K_d analysis values based on Weibull plotting position formula. It indicates that the probability at 10th, 50th, and 90th percentile is about 1.2 mL/g, 24 mL/g, and 48 mL/g, respectively. Converting this into a complimentary cumulative distribution function indicates a 90th, 50th, and 10th percentile exceedance of approximately 1.2 mL/g, 24 mL/g, and 48 mL/g, respectively. Note that the 90th percentile exceedance means that there is 0.9 probability that the K_d value will be greater than or equal to 1.2 ml/g. Based on visual inspection of the ECDF a cluster of results near the minimum can be observed from 0th Percentile to 10th Percentile. These low values (indicating greater than 90th percentile exceedance) are attributable to two primary locations, C7695 and C7866. In each case the estimated K_d values come from samples taken below a depth of 50 ft bgs. According to the field log for this location, this places these sediments within the Ringold formation. This indicates that the K_d results may be affected by attributes associated with the collection and analysis of the samples.

To investigate what attributes of the sample locations and analysis might influence or bias the resulting K_d values the ECDF is presented where portions of the ECDF are isolated on the plot based on common attributes. Figures 2 through 5 illustrate the ECDF based on waste site type, reactor (geographic) area, geologic unit, and sediment lithology, respectively. The following paragraphs discuss trends in each of these figures.

Waste Site Type – Where possible, soil borings were designated based on the type of waste site (high concentration/ low volume sites, low concentration liquid effluent sites, or not assigned) were close to the boring. When plotting the ECDF based on waste site type (see Figure 2) one noticeable feature is that K_d values from sites of low concentration liquid effluent sites don't have any K_d values lower than 6 ml/g (Figure 2a). High concentration/low volume waste sites (Figure 2b) indicate that the majority of the lower K_d values result from samples taken at these sites. This supports the idea that low concentration liquid effluent sites tend to have higher minimum K_d values than high concentration/low volume sites.

Reactor Area – The values shown in Figure 3 indicate that operable unit does not significantly affect the value of K_d. Only the B/C Area does not have values that span the majority of the range of K_d Values. B/C Area K_d values (Figure 3c) range from 6 ml/g to 22 ml/g. However, this may be due to the limited number of detections from samples in the B/C Area.

Geologic Unit – Visual inspection of the ECDF separated based on geologic unit (see Figure 4) indicates that values from the units in the Ringold Formation tend to be lower than those values in the Hanford formation. Although, it is noted that some K_d values from samples taken from the Ringold formation are as high as the upper percentiles of the range of the Hanford formation.

Lithology - Figure 5 shows the portions of the ECDF for each lithology on a separate plot. The lithology descriptions typically show a large range of K_d values except for "gravel" designation shown in Figure 5b. The range of K_d values for the gravel appears to be limited to a lower range of the entire K_d data set.

Figure 6 illustrates the variability of K_d with depth in the form of a scatter plot with superimposed trendlines. The dataset was plotted where Cr(VI) was detected in both soil and solute and when detection occurred in soil only (assuming PQL for solute concentration). The soil and solute detection data seem to indicate a strong depth trend while the soil only data does not appear to trend heavily with depth. The sparse amount of data with depth in the soil and solute data is likely to be causing the strong depth trend. All of the data with depth comes from two sample locations. Any change in those two locations would greatly affect the trend. Also, the R-squared fits to each of the trends is low. Therefore, the trend is considered to be an artifact of sparse data availability rather than a reflection of an existing trend.

Scatter plots of K_d values based on dilution factors used in the leaching analyses are shown in Figure 7. These figures illustrate that dilution factor may be affecting the resulting K_d value. Only K_d values resulting from samples where the soil and solute detection occurred are shown in this figure. The upper boundary value (PQL), used to estimate K_d when only a soil concentration was measured, is constant. The constant value used is based on the analytical method of Cr(VI) detection. Therefore, it may not illustrate a dilution effect. Any resulting trend that was inferred using this data could result as an artifact of the PQL used to estimate K_d. Therefore, these data were not included in the figures. Trend line analysis of the remaining data of K_d resulting from the 1:1 dilution versus the 1:5 (Figure 7a) and 1:2.5 (Figure 7b) dilution show that there is a 2.9 multiplier and a 2.1 multiplier in the trend in each case. This indicates that a larger dilution factor may result in a larger estimate of K_d. This may be attributable to the amount of mass available for leaching from the soil column. If the mass available for leaching is similar in each case, the resulting solute concentration would be lower for larger dilution factors. Thus, a larger K_d value would be estimated. While the dilution factor seems to have an effect, this analysis does not provide a methodology for determining which dilution factor provides more appropriate K_d values. Therefore all of the dilution factors were treated with equal weight so no particular dilution factor was an average of the K_d values estimated from all the analyses.

Figure 8 shows a scatter plot of Cr(VI) soil concentrations versus the corresponding K_d value from the leaching experiment. In general, the K_d values for soils with a soil concentration below 1 mg/kg tend to have a relatively limited range of K_d values ranging from 0 to 4 mL/g. Approaching and after a soil concentration of 1 mg/kg the range of K_d values increases significantly to values from near 0 to 56 mL/g. Soil detection only K_d results were not plotted because due to the constant PQL used to calculate K_d, a linear trend is displayed that is an artifact of the PQL used for estimating a conservative value for K_d.

3.1 Method Uncertainties

Several uncertainties exist in the methodology used to determine K_d values. These include uncertainties in the ASTM D3987-06 leaching method, the drilling of wells, and the equation (Equation 1) used to calculate the K_d value. These uncertainties and a discussion of the effect they have on the results are discussed below.

3.2 Leaching Method

One source of uncertainty in the results is identified in the ASTM D3987-06 documentation. The method specifies that the soil sample and water be placed in a batch reactor that is turned end over end for 18 hours. While appropriate for mixing these two substances together it is not necessarily representative of field conditions. The method specifies that it "is not intended to provide an extract that is representative of the actual leachate produced from a solid waste in the field." (ASTM, 2006). This may or may not have an impact on the K_d results depending on how well the results would match field conditions. It is also recognized that the amount of water that is used in the batch leach experiments exceeds the pore volume of the soil samples under saturated field conditions. Unfortunately, there is no analysis that can be made with the current data to quantify the level of uncertainty this produces in the results.

As part of the leaching methodology the water added to the soil sample was prescribed to have a pH of 5 in order to simulate rain water infiltration at the Hanford Site. No data exist that can determine the final pH of the added water after mixing water with the soil. Figure 9 presents the Eh-pH diagram for chromium and indicates the oxidation states and chemical forms that exist within specified Eh and pH ranges (Palmer and Wittbrodt, 1991; EPA, 2000). The figure shows that Cr(VI) remains stable when pH >4 and under oxygenated conditions that would be encountered in leaching experiments. The dominant species are $HCrO_4^-$ and CrO_4^{2-}. Any increase in pH alone would not lead to change in oxidation state of Cr(VI) and conversion to Cr(III). However, Cr(III) could undergo hydrolysis with increasing pH to form chromium hydroxy species [$CrOH^{+2}$, $Cr(OH)_2^+$]. Reduction of Cr(VI) to Cr(III) can only occur when reductants are introduced, such as, reduced manganese oxide (MnO), soil organic matter, soluble ferrous iron [Fe(II)], and reduced sulfur compounds.

It is possible that desorption characteristics from leaching at higher pH may be different due to speciation of chromium ions and surface complexation with the mineral surfaces where surface charge varies as a function of pH.

3.3 Sample Collection

A concern about the drilling and sample collection procedure may be a source of uncertainty in the K_d values. The wells and boreholes were drilled using the cable tool method. Periodically, water was added to the hole to allow removal of drill cuttings from the dry, unconsolidated sediments of the Hanford formation and Ringold Formation. The intent is to provide sufficient water for removing cuttings and advancing the borehole without disturbing the underlying material which is being tested for a variety of mobile and immobile contaminants. Typically, one gallon (0.13 cubic ft) of water was sufficient to provide some cohesion to the cuttings. However, occasionally 5-15 gallons (0.67 to 2.01 cubic feet) were used. Most of the additions were completed at least 2 feet above the planned split-spoon sample interval.

The hydraulic evidence indicates that the large majority of the samples are unlikely to be significantly disturbed. For scale, one gallon (0.13 cubic feet) of added water would fill a sphere of approximately 1 foot in diameter assuming a 20 percent porosity. Fifteen gallons (2.01 cubic feet) would fill a sphere of 2.7 feet in diameter. The high matric potential combined with the higher horizontal conductivity would tend to flatten the sphere out as water preferentially wets in the horizontal direction. This is generally confirmed by the results of neutron logging in the wells and boreholes that show close correlation between the depth of water addition and the presence of elevated water in the adjacent formation indicating water has moved laterally away from the borehole and away from the target split-spoon sample interval vertically below. While

there could be a few samples impacted, there does not appear to be a significant bias introduced to these data that would cause significant impact to the dataset used in this memorandum for recommending a K_d value for Cr(VI).

3.4 Dilution Factor

The trend analysis discussed in a previous section indicated that the K_d value increased as the dilution factor used in the ASTM method increased. This can partly be explained by the amount of mass that is leached from the soil sample. Figure 10 compares the amount of mass leached from the soil samples using a 1:1 dilution factor to the mass leached for both a 1:2.5 and 1:5 dilution factor. A trend line for each of the datasets shows a slope of 1.2 and 1.04 for the 1:2.5 and 1:5 dilution factor, respectively. The nearness to a slope of 1 indicates that on average the same amount of mass leached for one dilution factor is the same amount of mass leached for another dilution factor. This would indicate that the rise in the K_d value for a given dilution factor is simply an artifact of the volume of water added to the system (i.e., the same mass added to a larger volume of water result in lower concentration causing an increased value of K_d based on equation 1).

A basic normalization factor that would account for the difference in volume of water used in the leaching method can be applied to Equation 1. Equation 2 shows an alternate version of Equation 1 with a correction factor included. The factor (D_f) is achieved by dividing the volume of water added to the leaching method by the amount of water used at the lowest dilution factor in the ASTM method (100 g). This results in values for D_f of 1, 2.5, and 5 for the dilution factors 1:1, 1:2.5, and 1:5, respectively.

$$K_d = \frac{(C_S \times M_S) - (C_L \times V_L)}{M_S} \times \frac{1}{C_L * D_f} \times \frac{1000\ mL}{1\ L} \qquad \text{Equation 2}$$

Where:

K_d = Distribution coefficient (mL/g)
C_S = Contaminant concentration in bulk soil matrix prior to leaching (µg/g)
M_S = Dry mass of soil used for leaching (g)
C_L = Contaminant concentration in leachate (µg/L)
V_L = Liquid volume used for leaching (L)
D_f = The batch-leach-ratio specific dilution factor (i.e., 1, 2.5, or 5)

Figure 11 shows the ECDF for the K_d values adjusted based on the dilution factor. The ECDF indicates a 90th, 50th, and 10th percentile exceedance of approximately 0.8 mL/g, 9 mL/g, and 29 mL/g, respectively. The results of correcting based on the dilution factor have the impact of shifting the values of key Percentile points on the ECDF to a lower value.

4. Software Applications

Excel® spreadsheets were used to calculate ECDF distributions and evaluate linear trends in the K_d data presented as part of this ECF. These calculations were performed on a laptop computer with USDOE ID WF16209. The hardware is a Dell® Latitude® E6400 with a 2.26-GHz Intel Core™ 2 Duo CPU E8200 processor and 3 GB of RAM loaded with the HLAN Windows® XP Image Version 3.0.1.0 operating system.

This use of Excel® software is exempt from the requirements of PRC-PRO-IRM-309 because it constitutes a “flat-file” spreadsheet that is wholly incorporated into this ECF and the calculations,

mathematical formulas, and input data can be exactly verified during the technical review of this ECF (PRC-PRO-IRM-309, Rev. 1, Section 1.3, Exemptions).

5. Calculation

Each percentile from the ECDF value can be estimated based on linear interpretation of the values closest to the given percentile. Hence, the 10th percentile can be estimated through linear interpolation of the two values closest to it. Figure 11 shows the ECDF for the K_d values adjusted based on the dilution factor. The ECDF indicates a 90th percentile exceedance of can be calculated based on the two values in Table 2. The resulting value for the 90th percentile exceedance is 0.8 mL/g.

6. Results/Conclusions

6.1 Summary

A large number of samples were collected (509) that generated results from leach tests (192) that are usable for evaluating the leaching potential of residual Cr(VI) in the River Corridor. Out of the attributes selected for evaluation, two (dilution factor and geologic formation) were noted as potentially having an effect on calculated K_d values. The trend with respect to geologic formation is likely attributable to the small sample size (the majority of these results came from two locations C7695 and C7866). The range of the K_d values from these samples was smaller than the results from shallower formations. Further, there appears to be a relationship between the dilution factor and the resultant K_d. When the dilution factor of soil to leachant was higher, a slightly larger K_d was typically estimated for the sample but the range of variability is well within the range of natural variability for the estimated values.

Table 2 – ECDF locations used to calculate the 90th percentile exceedance for the dilution factor corrected ECDF.

Point ID	Weibull Plotting Position	K_d (mL/g)
1	0.098	0.74
2	0.103	0.99
Interpolation	0.1	0.8

6.2 Recommendations

The large number of K_d measurements and the lack of correlation of calculated K_d with possible explanatory parameters allows a conservative value to be used across the River Corridor for evaluation of future fate and transport of residual Cr(VI) after interim remedial actions have been implemented for source waste sites in the vadose zone. The ECDF of K_d for the soil samples indicates that more than 90% of the values are higher than 1.2 mL/g and greater than 95% of the values are higher than 0.65 mL/g. If the K_d values are adjusted for the amount of water used during the tests, the 90th percentile drops to about 0.8 mL/g. Based on the presented results in the previous section a K_d value of 0.8 mL/g is recommended as a conservative estimate for the lower limit on residual Cr(VI) K_d value for the River Corridor. This value is conservative relative to values available in literature (e.g., a Kd of 19 mL/g was selected for promulgation under WAC 173-340).

7. References

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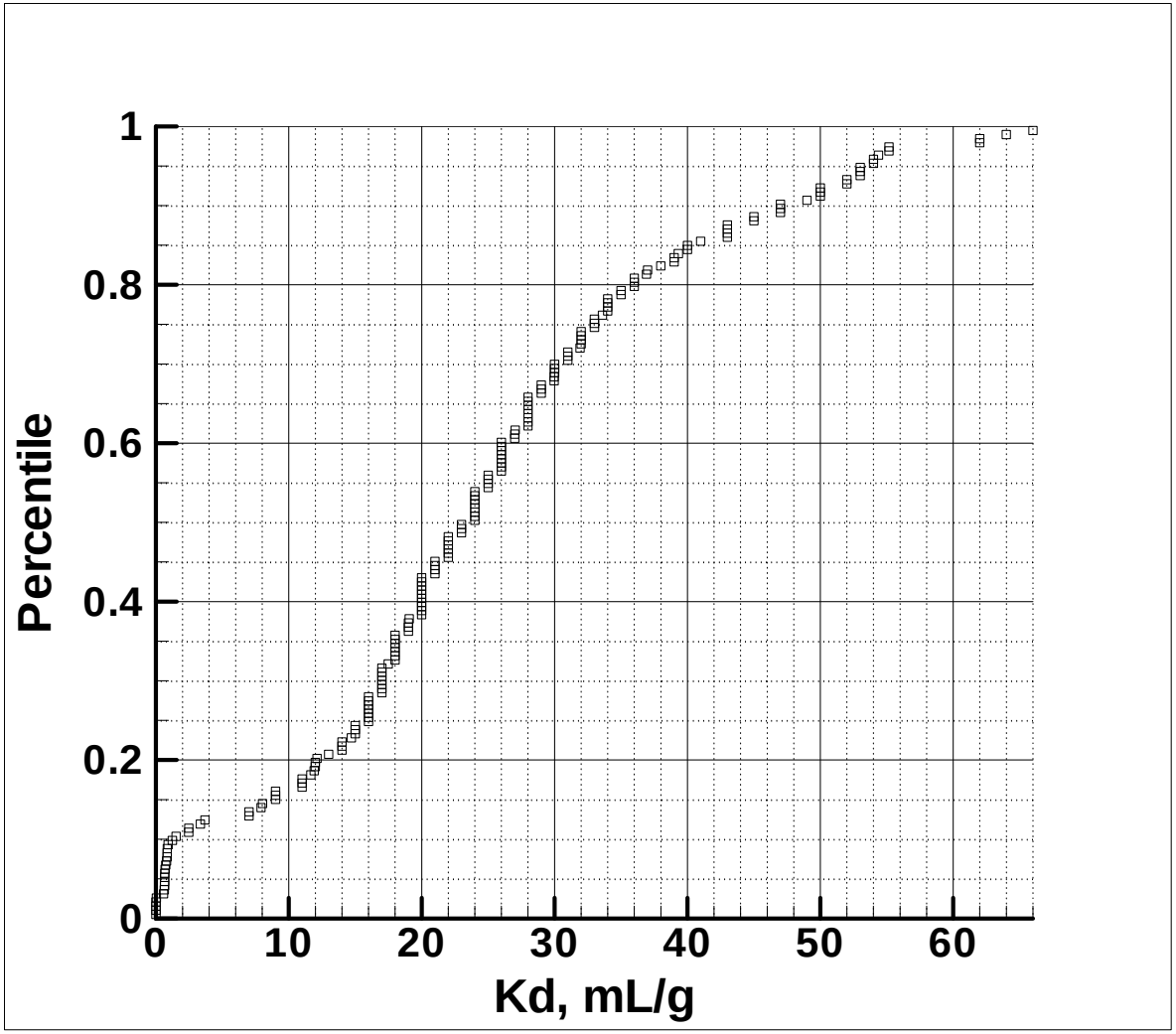


Figure 1 – Empirical cumulative distribution function for K_d estimates from leaching tests.

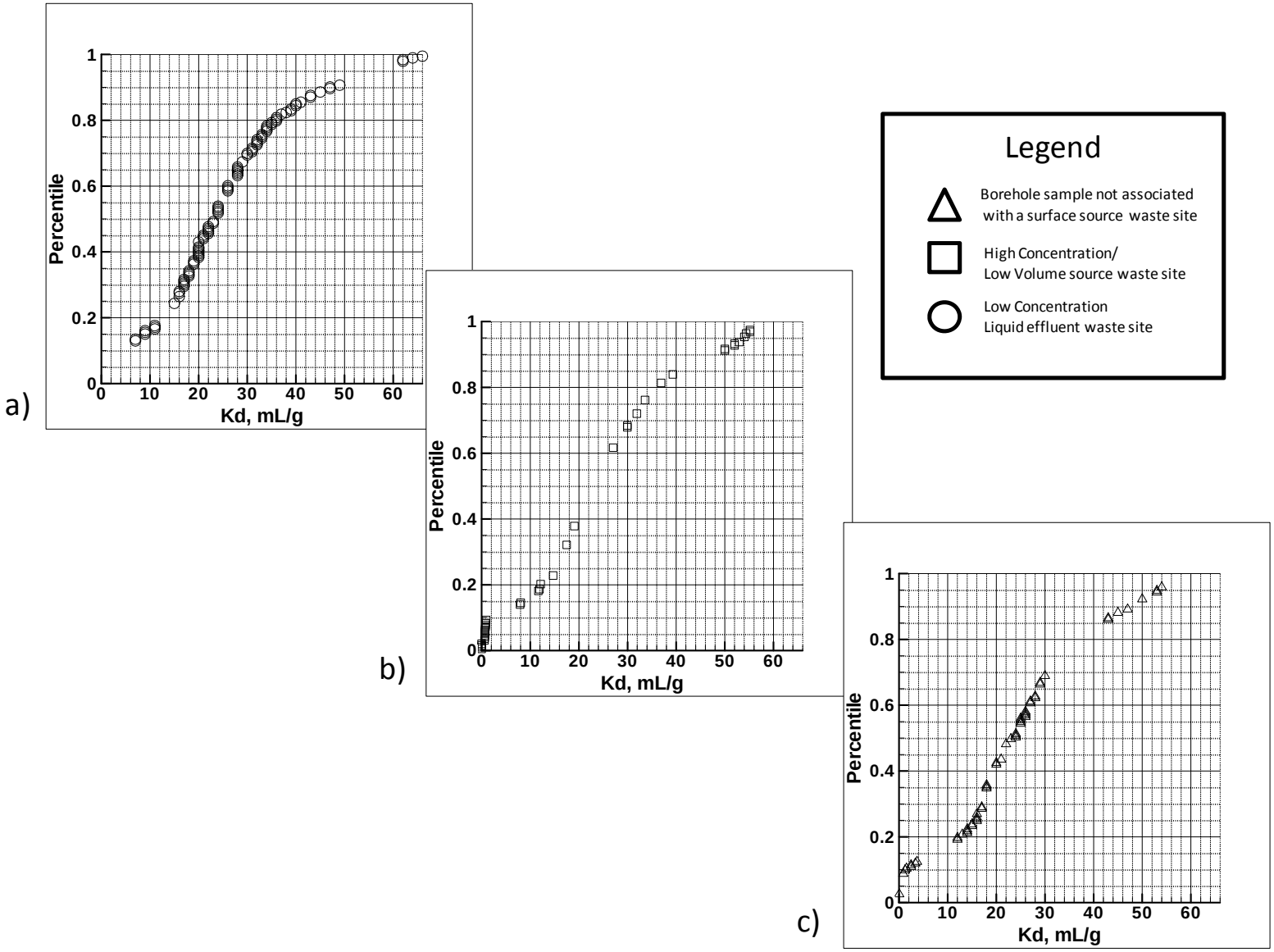


Figure 2 – Empirical cumulative distribution function for K_d estimates from leaching tests broken up by waste site type.

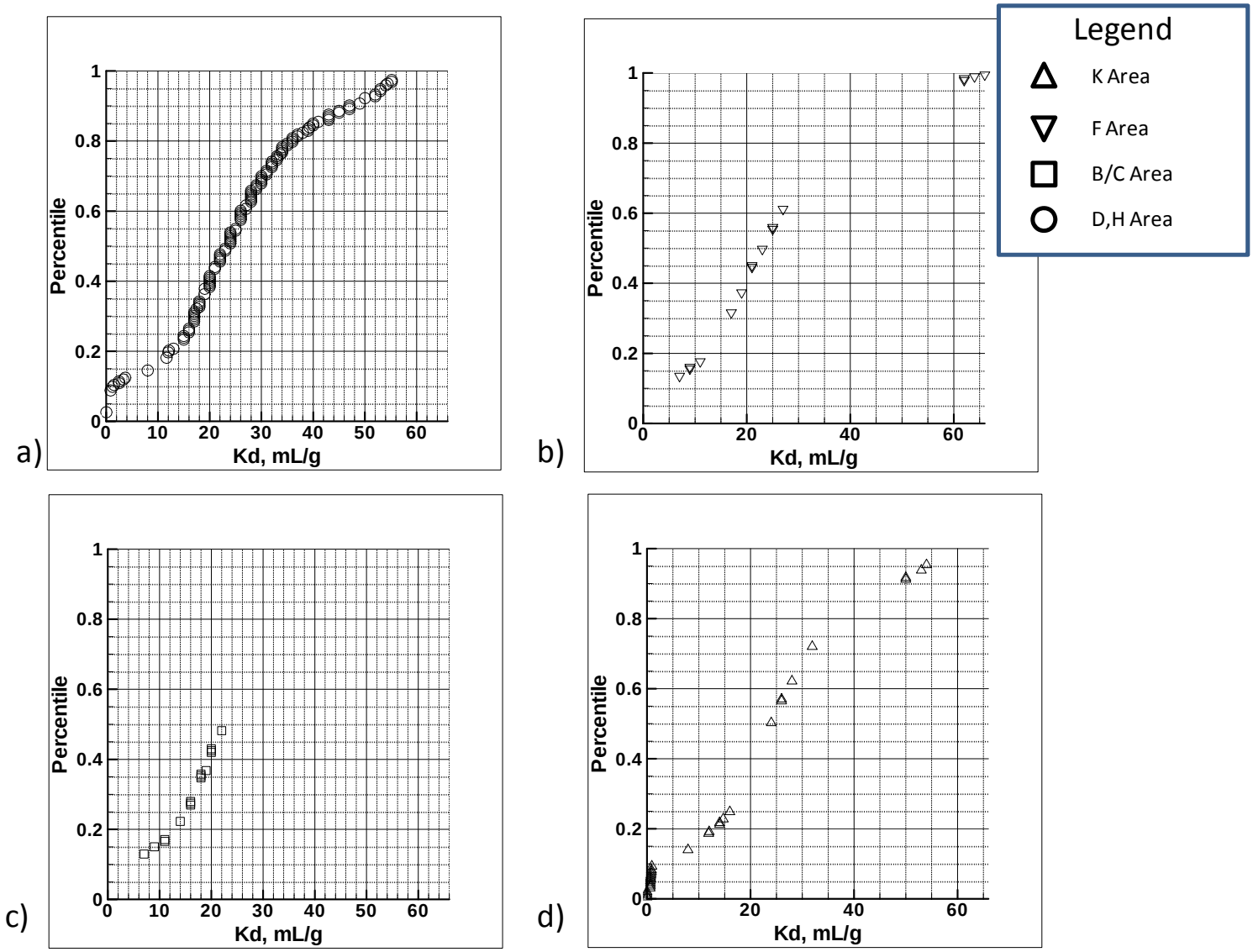


Figure 3 – Empirical cumulative distribution function for K_d estimates from leaching tests symbolized to indicate reactor area within the River Corridor.

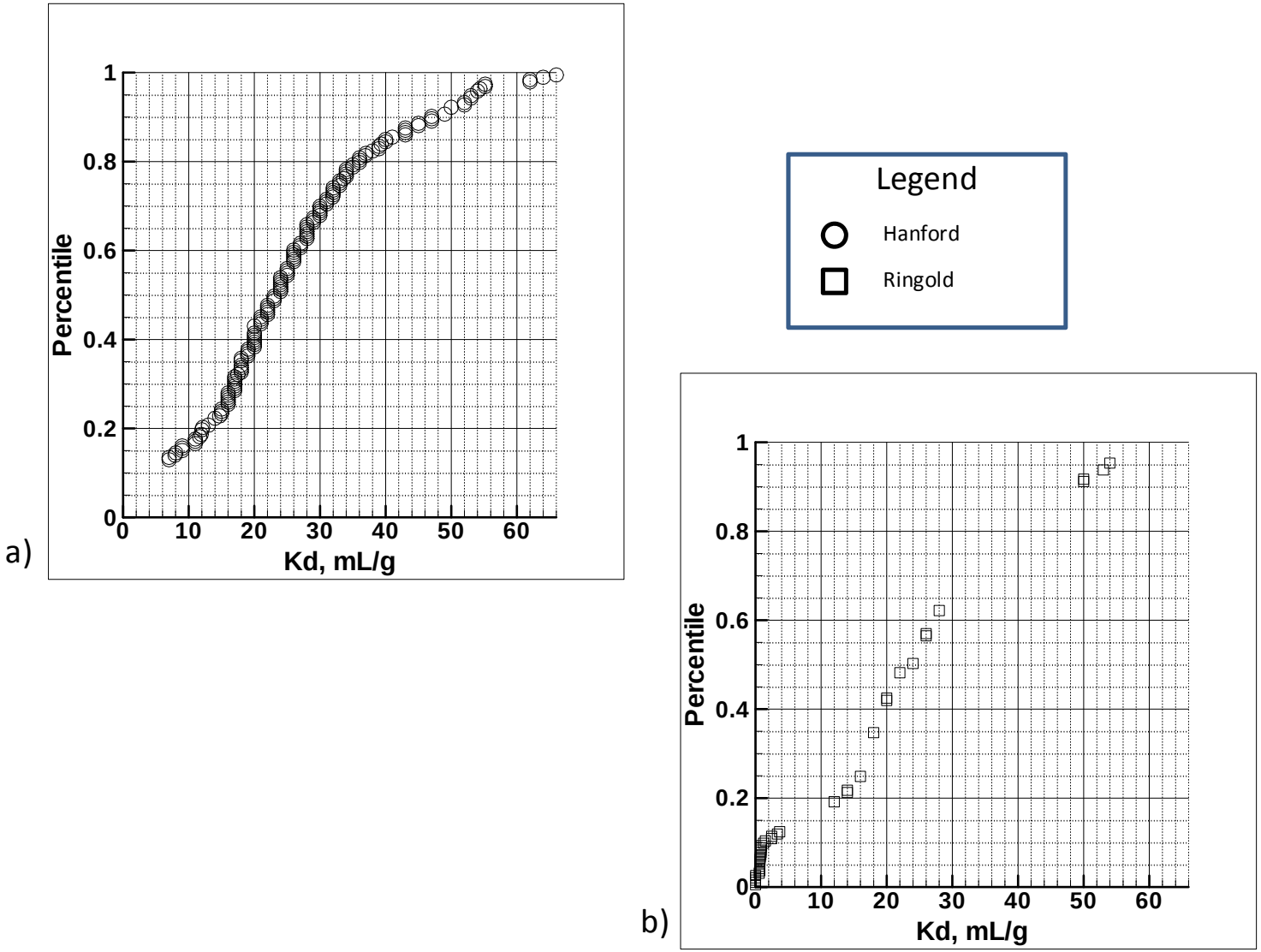


Figure 4 – Empirical cumulative distribution function for Kd estimates from leaching tests symbolized to indicate geologic formation of sediments.

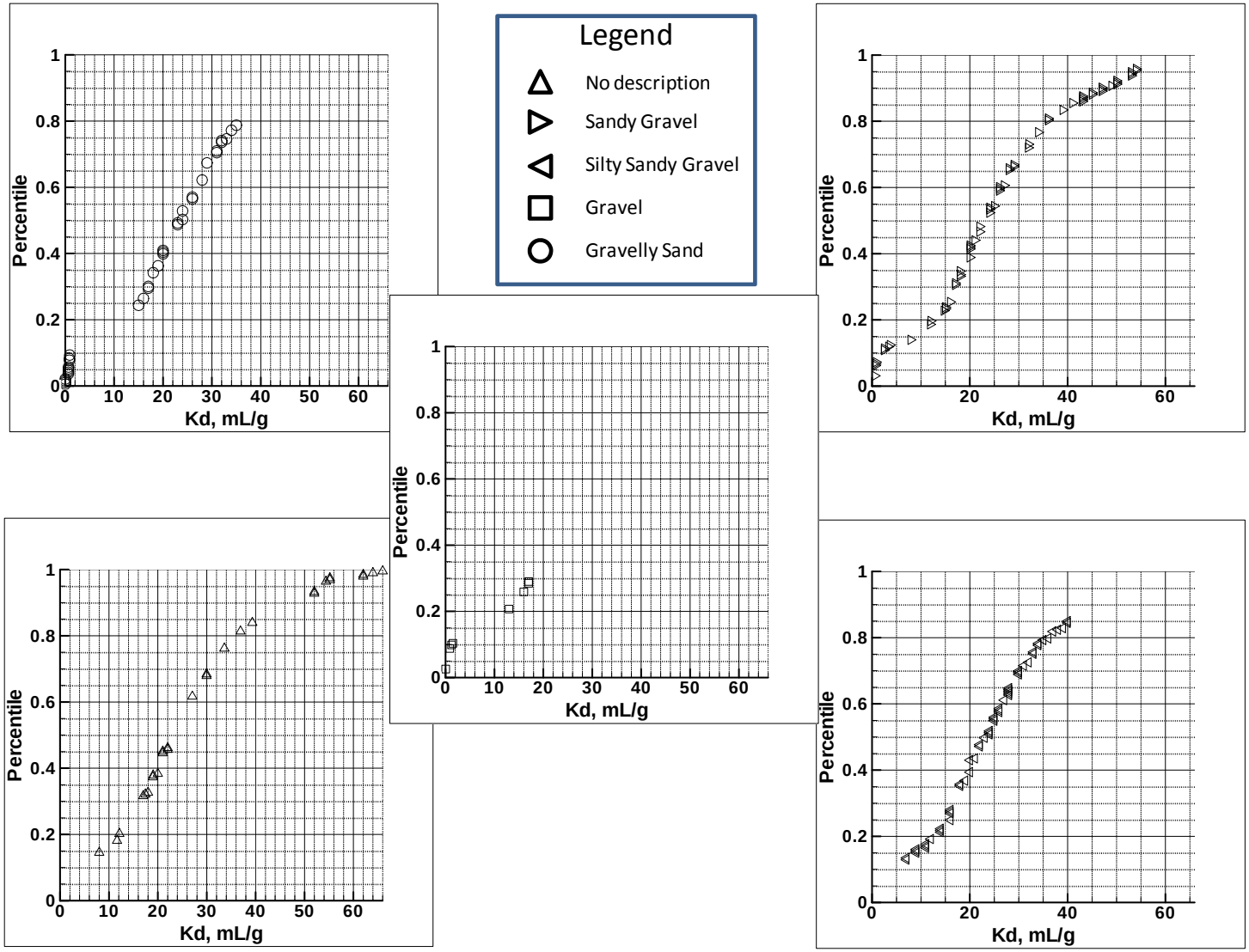


Figure 5 – Empirical cumulative distribution function for K_d estimates from leaching tests symbolized to indicate lithology of sediments.

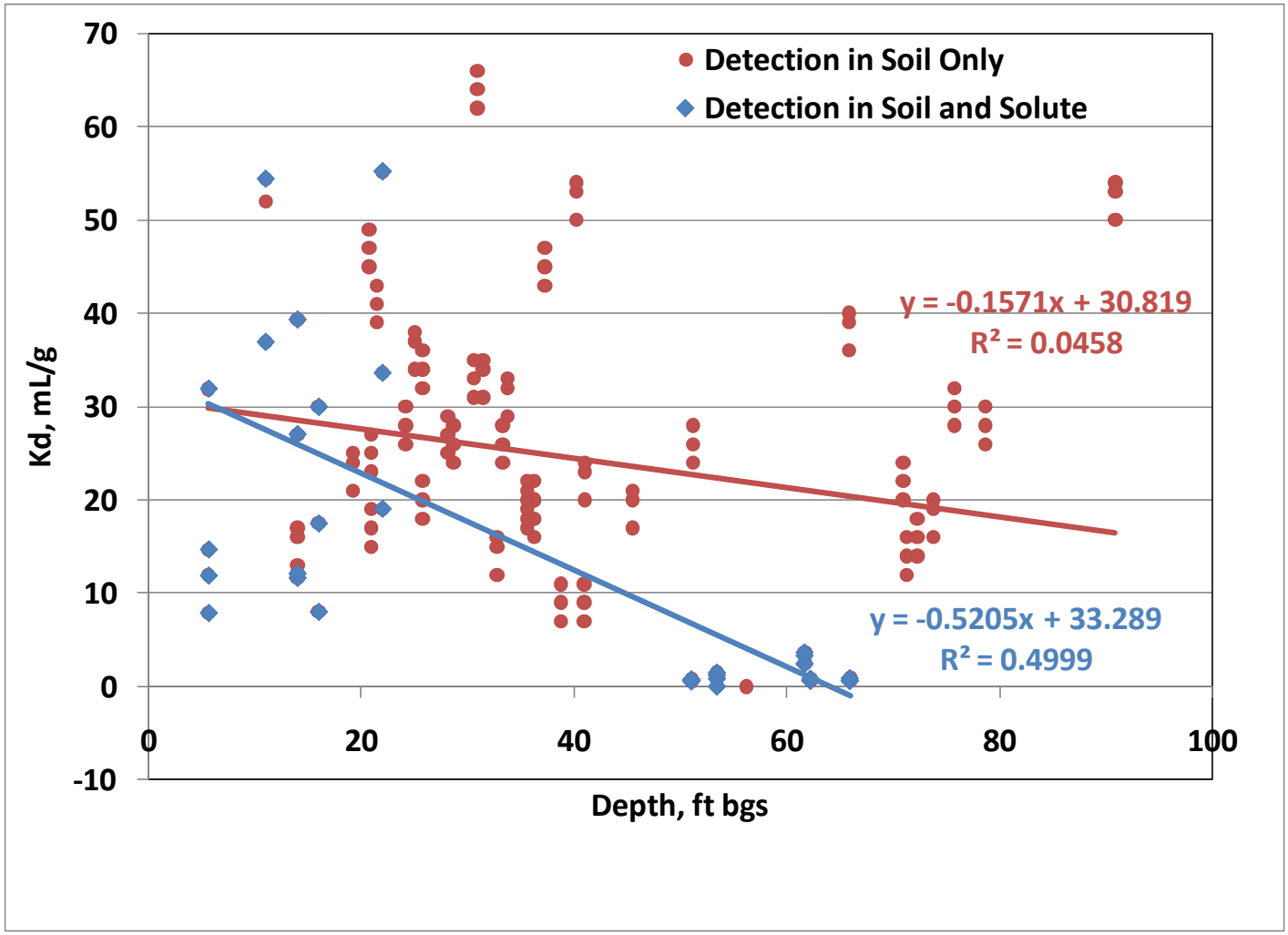
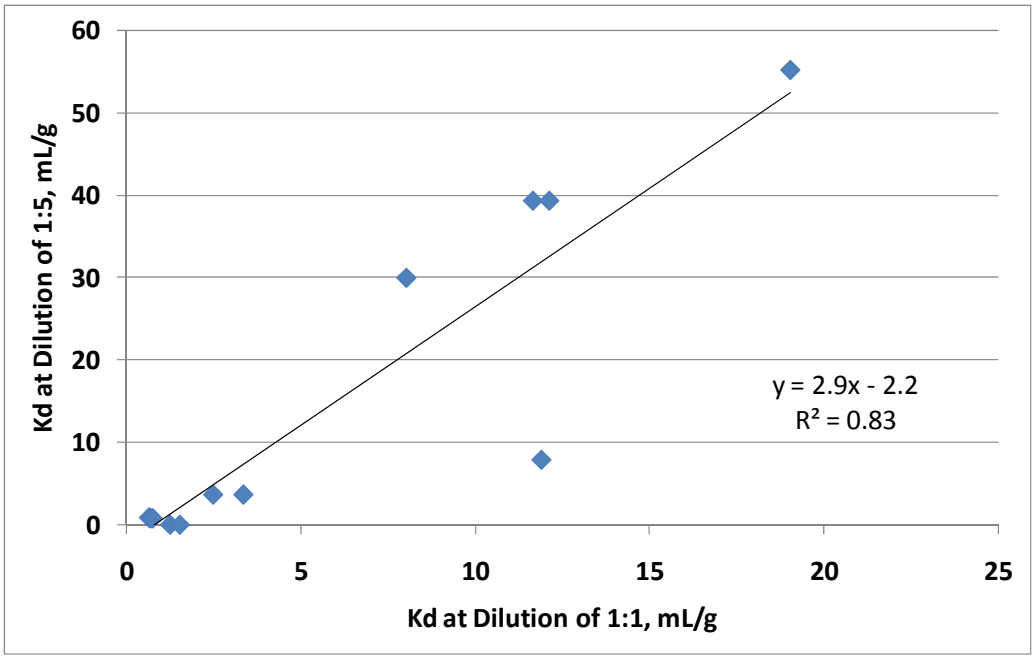
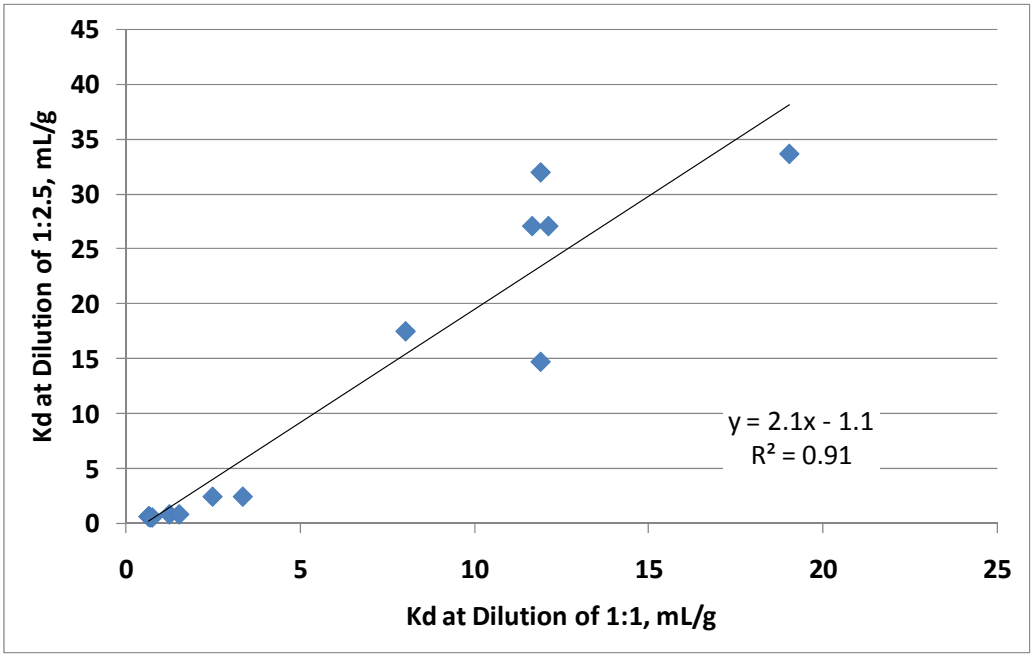


Figure 6 – Scatter plot of K_d versus depth with trend lines used to illustrate possible relationship between the two data.



a)



b)

Figure 7 – Scatter plot of K_d value based on dilution factor 1:1 versus dilution factor 1:5 (a) and 1:2.5 (b) with corresponding trendline

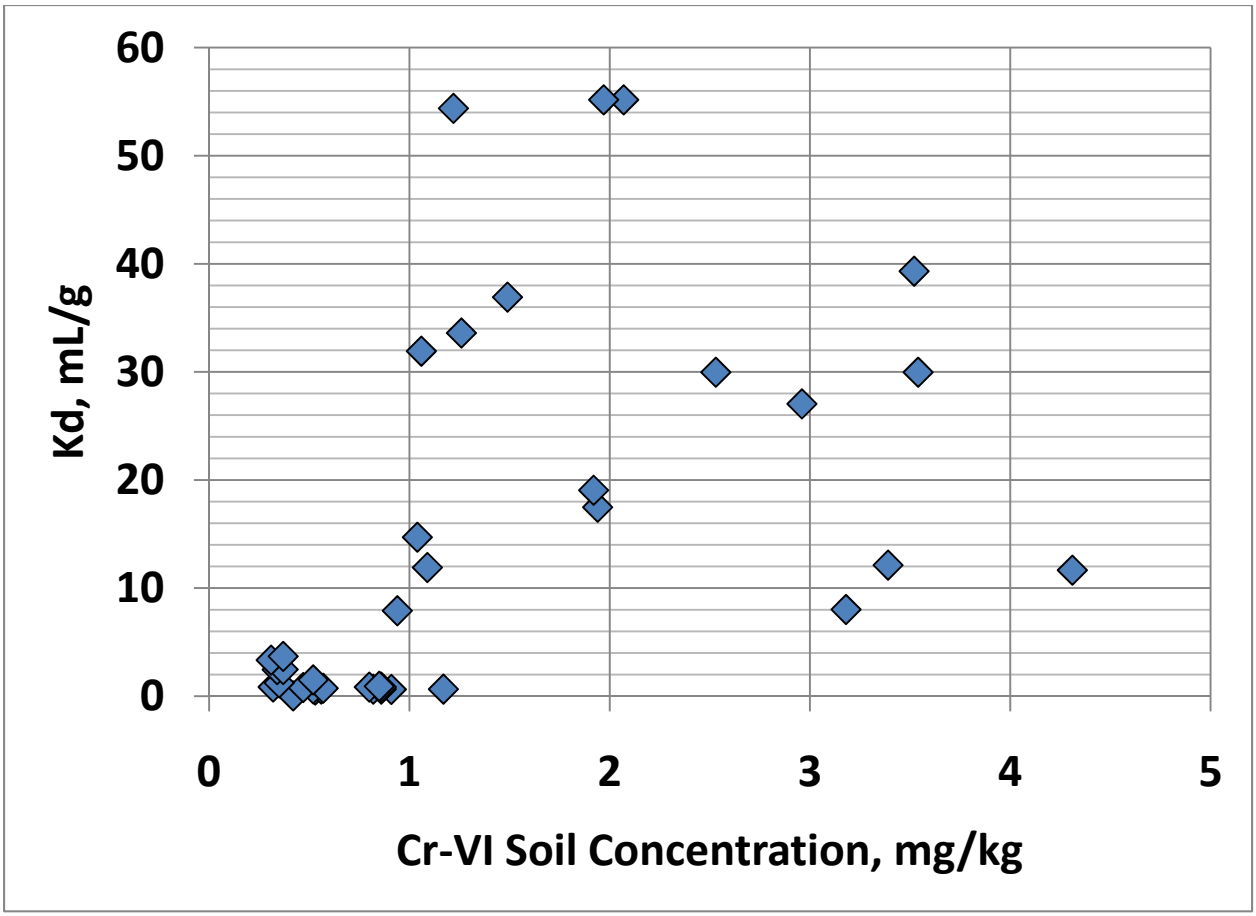


Figure 8 – Scatter plot of soil concentration versus estimated K_d for analyses where both soil and solute concentrations of Cr(VI) were detectable.

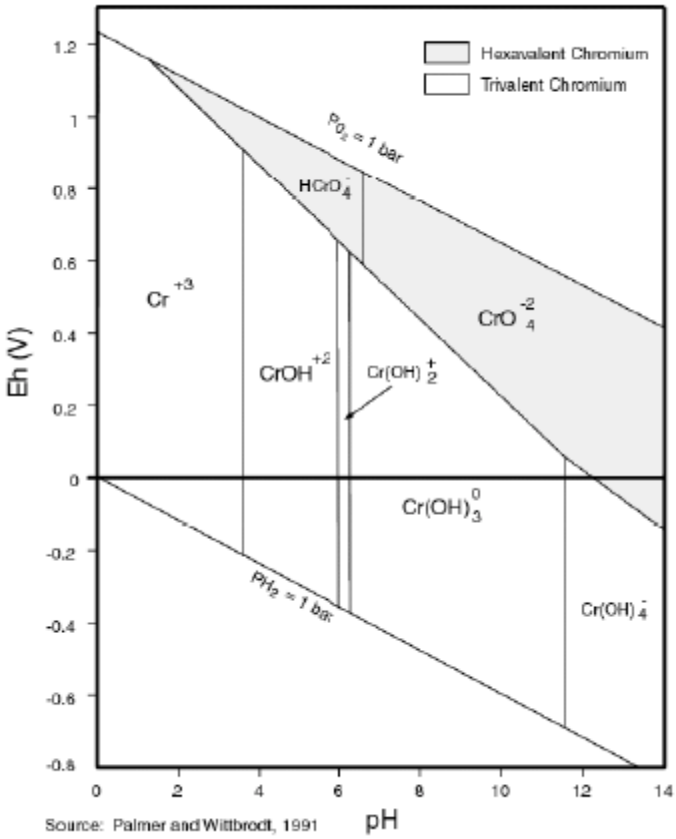


Figure 9 – Eh-pH diagram for Chromium

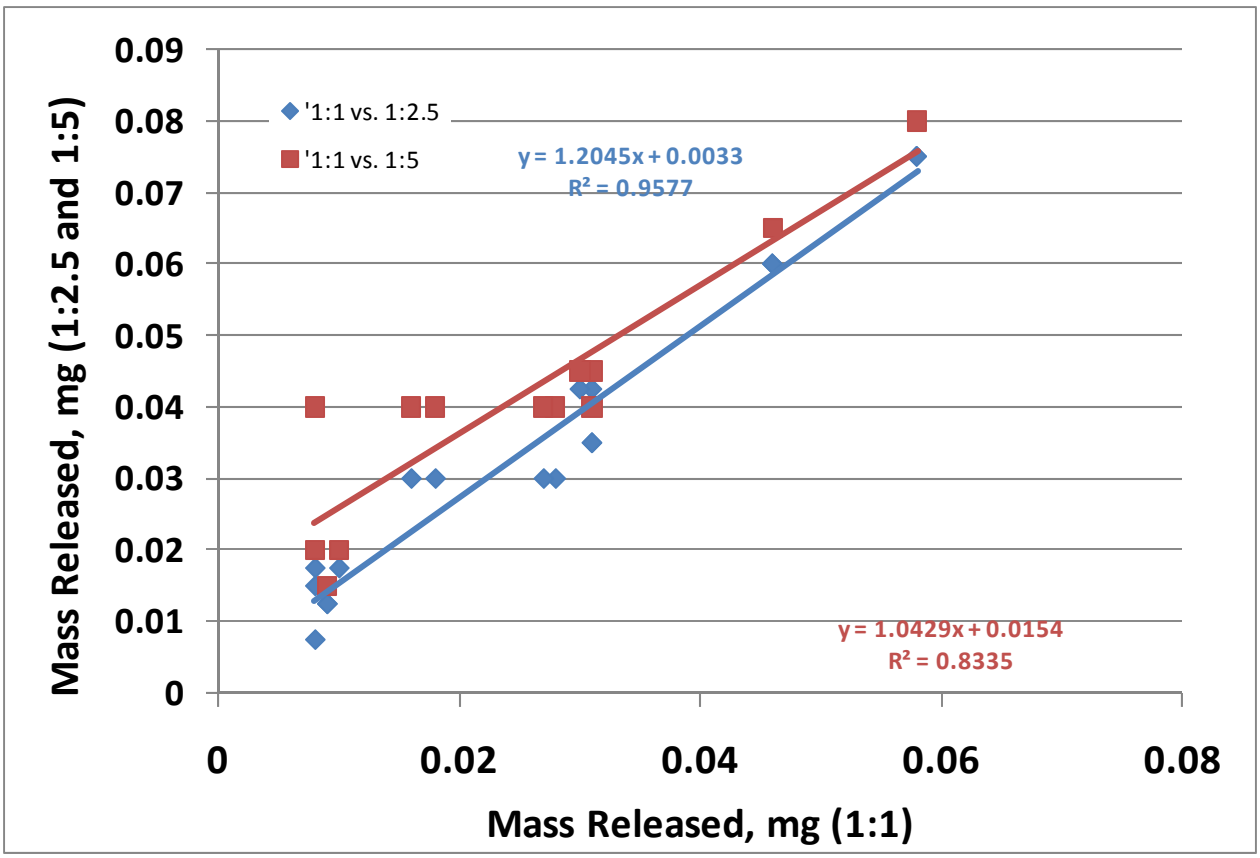


Figure 10 – Scatter plot of mass leached for dilution factor 1:1 versus mass leached for a dilution factor of 1:2.5 and 1:5.

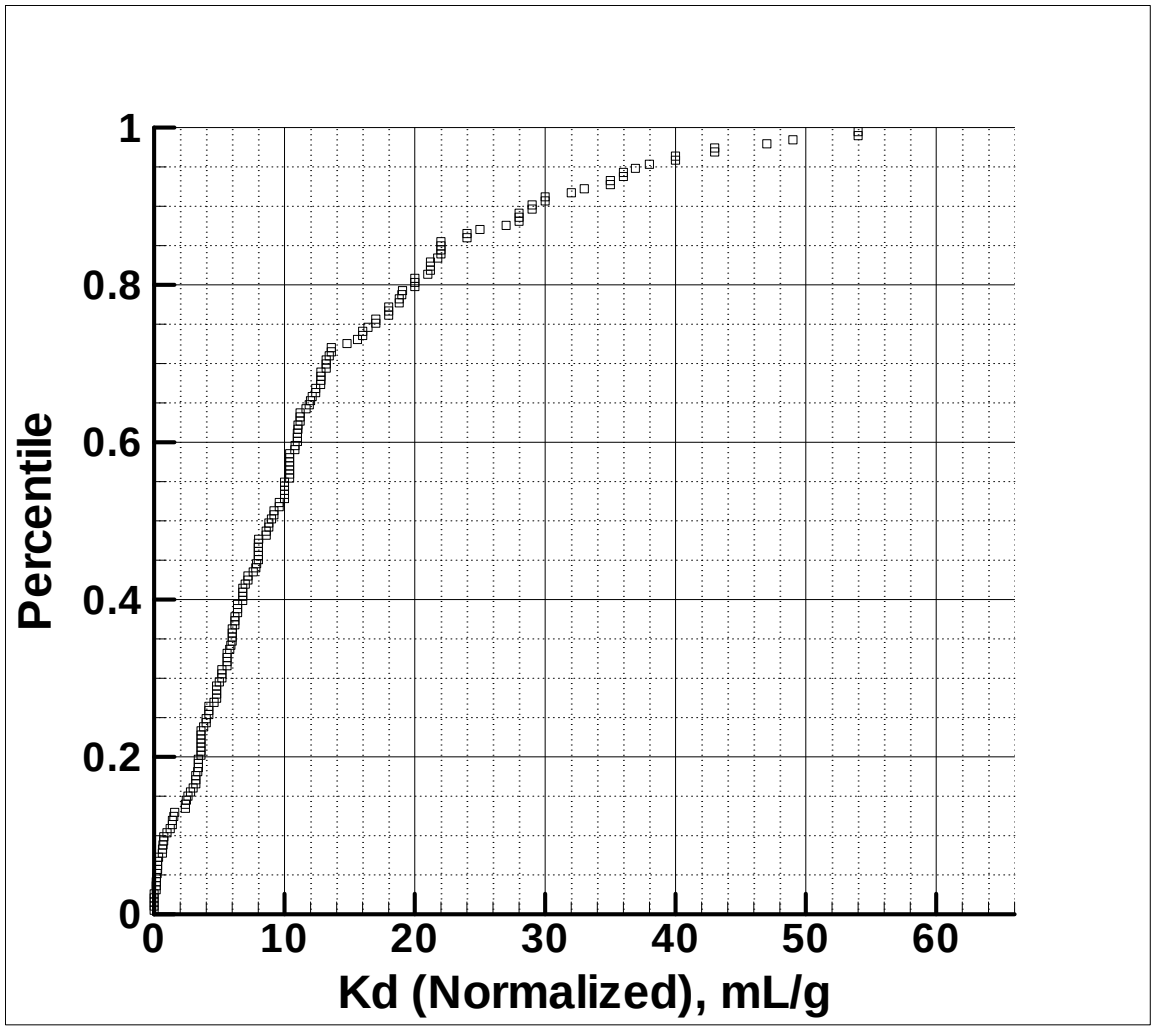


Figure 11 – Empirical cumulative distribution function for K_d estimates normalized based on the dilution factor used during leaching tests.