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Revision 1

Development of Source/Sink Mixing Package for the Feasibility Study in the 100-KR-4 Operable Unit

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

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Richland, Washington 99352

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Document Type: ENV Program/Project: EP&SP

H. Rashid
INTERA, Inc.

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ENVIRONMENTAL CALCULATION COVER PAGE

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Calculation Title and Description: Development of Source/Sink Mixing Package for the Feasibility Study in the 100-KR-4 Operable Unit	

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ENVIRONMENTAL CALCULATION COVER PAGE (Continued)

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SECTION 2 - Completed by Preparer

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1	Updated figures to account for renumbering of the alternatives and new simulations		All

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ENVIRONMENTAL CALCULATION COVER PAGE (Continued)

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Terms

100-K GWFTM	100-K Groundwater Fate and Transport Model
1D	one-dimensional
CHPRC	CH2M HILL Plateau Remediation Company
COPC	contaminant of potential concern
Cr(VI)	hexavalent chromium
DOE	U.S. Department of Energy
ECF	environmental calculation file
GWFTM	Groundwater Flow and Transport Model
HISI	Hanford Information System Inventory
HSU	hydro-stratigraphic unit
OU	Operable Unit
PNNL	Pacific Northwest National Laboratory
RI/FS	Remedial Investigation / Feasibility Study
SSM	source/sink mixing

1 Purpose

The objective of this environmental calculation file (ECF) is to document the process of developing source/sink mixing packages for all the Contaminants of Potential Concern (COPCs) under different flow conditions that would be used as a continuing source for the feasibility study of 100-KR-4 Operable Unit groundwater flow and transport model (100-K model) derived from vadose zone sources. The vadose zone calculation is performed with models implemented in the Subsurface Transport Over Multiple Phases (STOMP©[1]) fate and transport simulation software (PNNL-11216, *STOMP Subsurface Transport Over Multiple Phases: Application Guide*; PNNL-12030, *STOMP Subsurface Transport Over Multiple Phases: Theory Guide*; PNNL-15782, *STOMP Subsurface Transport Over Multiple Phases: Version 4.0: User's Guide*). Waste sites, contaminants associated with each waste site and source strength at each waste site for each COPC were identified as part of the remedial investigation study for 100-KR-4 Operable Unit and documented in the model package report for the 100-K Groundwater Flow and Transport Model (100-K GWFTM) (CP-61711, *Model Package Report: 100-K Scale-Appropriate Fate and Transport Model*). The STOMP 1-D model framework used in this analysis is identical to that used in CP-61711.

2 Methodology

Possible continuing source locations for each COPC were identified based on prior knowledge and observed groundwater concentrations between 2012 and 2016. The upper vadose zone of significant number of waste sites (56 percent of the waste sites, according to DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016*) at the 100-K area was excavated as part of the U.S. Department of Energy's (DOE's) remedial action goals. However, no soil remediation of the deep vadose zone was performed. Moreover, no characterization of the deep vadose zone is available for the waste sites within 100-K area. Scarcity of information on the areal extent, vertical distribution, and strength of the soil contamination made it difficult for a comprehensive vadose zone modeling for estimating the contribution to groundwater contamination from continuing sources at the potential source locations. Therefore, a simple one-dimensional soil column was used for estimating a characteristic release rate curve for each COPC at each potential source location using a unit source concentration uniformly distributed across the vadose zone. Increasing or decreasing of these release rate curves was performed within the transport calibration process on the observed groundwater concentration at or near the source locations. The detailed information on the transport calibration processes for developing continuing sources is documented in Section 3.5 of the model package report for the 100-K GWFTM (CP-61711).

2.1 Vadose Zone Modeling

The vadose zone calculation is performed with models implemented in the STOMP fate and transport simulation software (PNNL-11216; PNNL-12030; PNNL-15782). The STOMP one-dimensional (1-D) model framework used in this analysis is identical to that used in development of Source/Sink Mixing (SSM) packages for the MT3DMS (SERDP-99-1, *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*) modeling remedial investigation (RI) analysis for the 100-KR-4 Operable Unit (OU). However, a few changes were made to

[1] Battelle Memorial Institute (Battelle) retains copyright on all versions, revisions, and operational modes of the Subsurface Transport Over Multiple Phases (STOMP) software simulator, as permitted by the U.S. Department of Energy. STOMP is used here under a limited government use license.

the STOMP 1-D model framework to address the vadose zone remedial actions considered for the feasibility study (FS).

2.1.1 Identification of Vadose Zone Source Area

Figure 1 and Figure 2 show the potential continuing source locations for all the COPCs that were considered during transport calibration processes at KW and KE areas, respectively. Table 1 lists all the waste sites with their associated COPCs that were considered as the potential continuing sources for the RI analysis in the 100-KR-4 OU. The same waste sites and their associated COPCs were used to develop SSM packages for the FS in 100-KR-4 OU.

2.1.2 Identification of Representative Stratigraphic Column

Two lithologic units are present in the vadose zone in the 100-K source area. These are the gravel-dominated Hanford formation and the Ringold Formation Unit E. The Ringold E contains a slightly smaller percentage of coarse-grained sediments and a higher percentage of finer-grained sediments than the Hanford formation (SGW-40781, *100-HR-3 Remedial Process Optimization Modeling Data Package*; SGW-46279, *Conceptual Framework and Numerical Implementation of 100 Areas Groundwater Flow and Transport Model*). It is important to identify the thickness of the vadose zone and the location of the Hanford/Ringold E contact within the vadose zone for estimating a characteristic release rate curve for each COPC at each waste site. The 100 Area Geoframework Model (ECF-HANFORD-13-0020, *Process for Constructing a Three-dimensional Geological Framework Model of the Hanford Site,100 Area*) was evaluated at the selected waste site locations to get the representative vadose zone thickness and hydro-stratigraphic unit (HSU) contacts. Then, STOMP 1-D model grids were created for these representative columns. Figure 3 shows the representative stratigraphic columns at each source area. The water table elevations from 2014 annual groundwater monitoring report (DOE/RL-2015-07, *Hanford Site Groundwater Monitoring Report for 2014*) were used to define the saturated zone in the STOMP 1-D column. However, a fluctuating water table boundary condition was used to simulate the periodically rewetted zone. STOMP 1-D simulations were performed using these representative stratigraphic columns for all the scenarios considered in the RI and FS analysis.

2.1.3 Calculating Characteristic Release Rate Curve

STOMP is used to solve for water flow and contaminant transport in each of representative stratigraphic columns, under specified recharge scenario, for the appropriate initial uniform concentration of contaminant, for each COPC, for a pair of sequential simulations. The first simulation in this pair is of water flow only for historic recharge conditions, and was needed to obtain the soil moisture conditions throughout the model domain at the start time for the second simulation. The second simulation is of water flow and contaminant transport for future recharge scenarios, starting from the imposed initial contaminant distribution (same as CP-61711) and the initial soil moisture conditions provided by the first simulation. The second simulation set of the sequential pair provides information the solute mass entering the aquifer and exiting the downgradient boundary of the 1-D STOMP simulation.

2.2 Construction of Source/Sink Mixing Package

The contaminant flux releases from the vadose zone to the aquifer is applied to the transport model through the SSM package. The SSM package allows different ways to apply continuing source in the transport package. Continuing source can be applied as a source concentration or a mass-loading rate depending on the "ITYPE" flag selected in the SSM package. The mass-loading rate option was selected

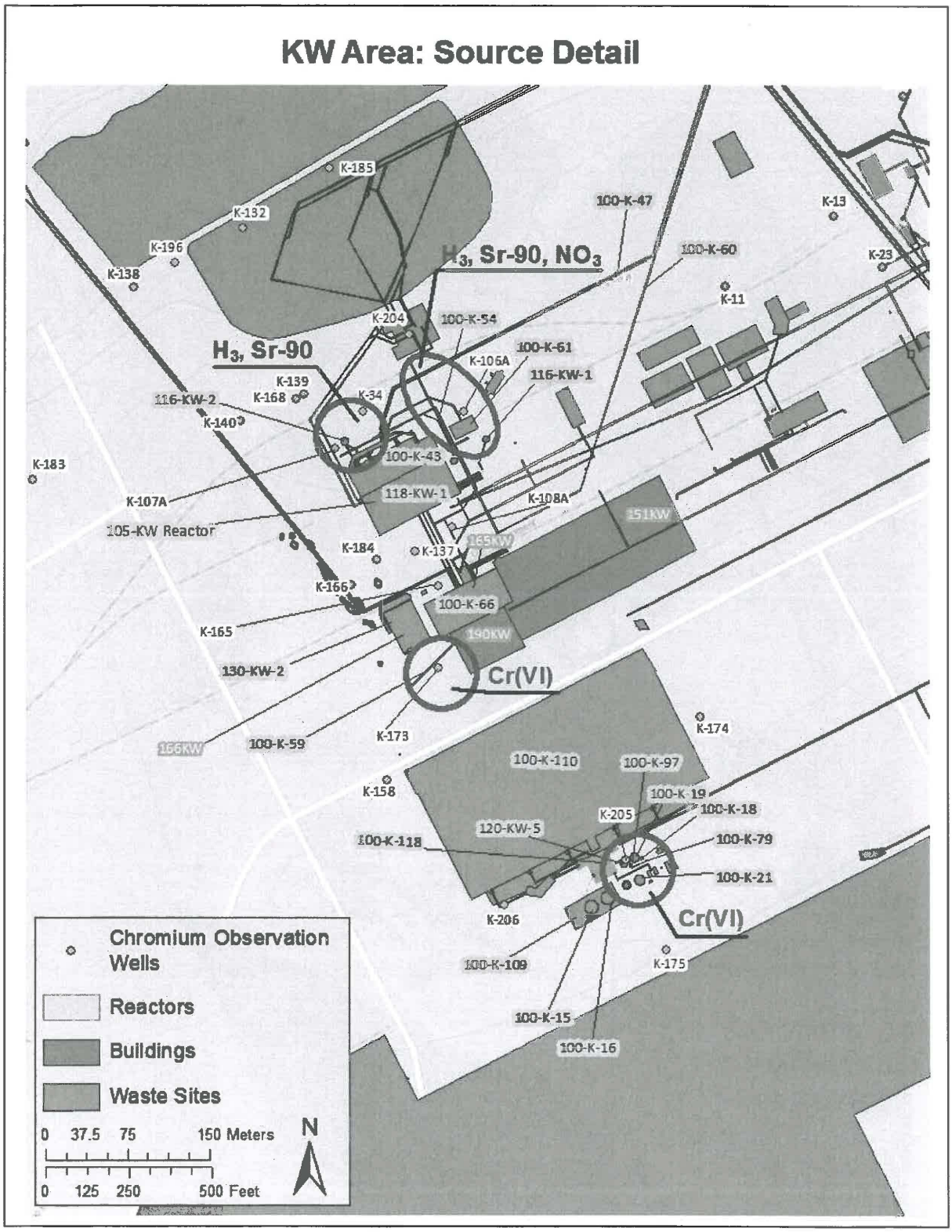

Figure 1. Potential Continuing Source Locations in the KW Area

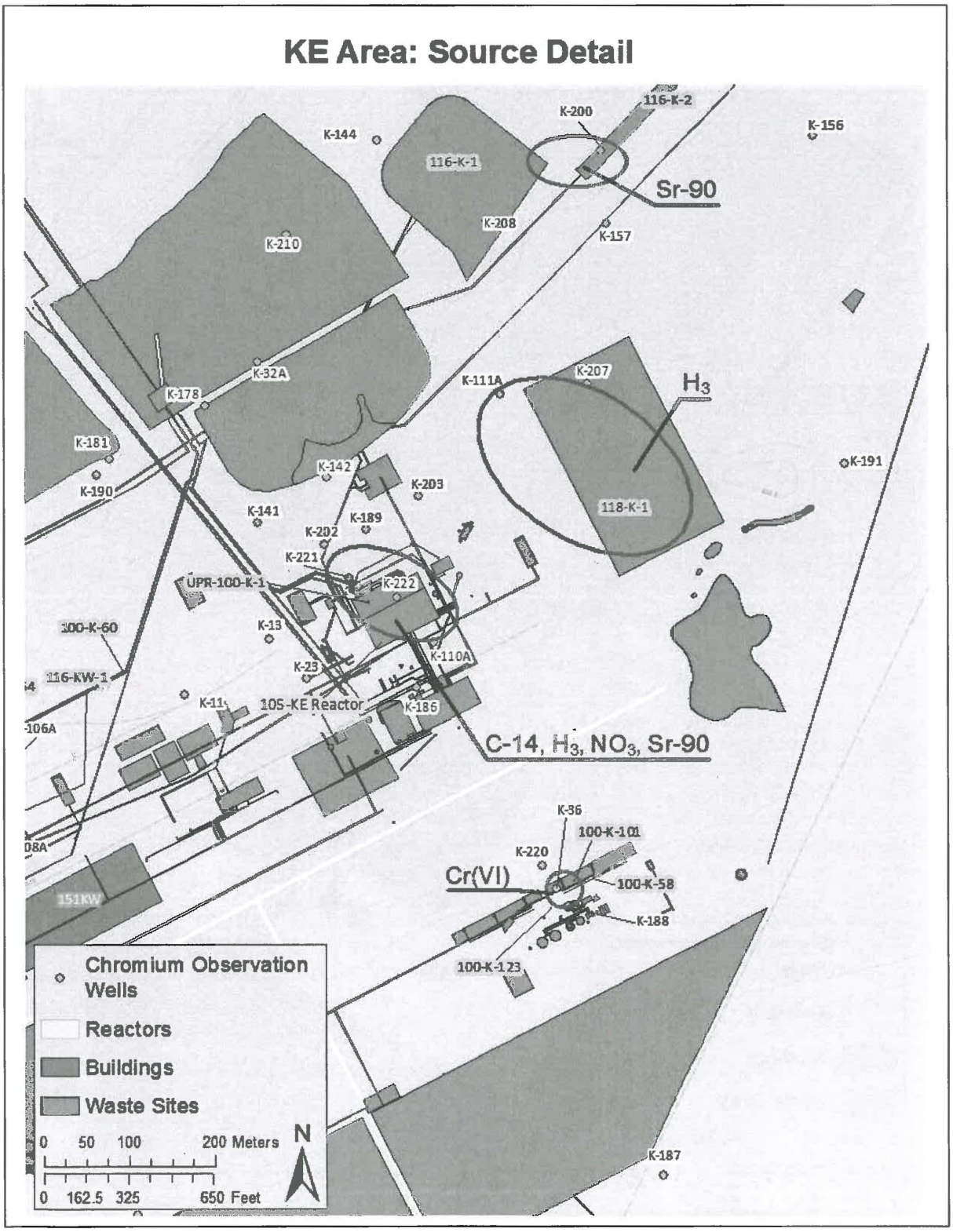

Figure 2. Potential Continuing Source Locations in the KE Area

Table 1. List of Waste Sites for Potential Continuing Sources to the Groundwater

Primary Waste Site	Nearby Related Waste Sites	Operational History	COPCs	Nearby wells	Cleanup Status
183.1KW Headhouse	120-KW-5, 100-K-18, 100-K-19, 100-K-21, 100-K-79, 100-K-97	Unplanned releases of the sodium dichromate dihydrate solution during transfer and material handling events along with some intentional releases to the ground during cleaning of tanks and conveyance lines	Cr(VI)	199-K-205	Contaminated soil was excavated up to 10.96 m from ground surface (DOE/RL-88-30)
183.1KE Headhouse	120-KE-6, 100-K-58, 100-K-79, 100-K-101, 100-K-123	Some sodium dichromate dihydrate solution remained in tank farm pipelines and was released during demolition of the headhouse	Cr(VI)	199-K-36, 199-K-188, 199-K-220	Site was not excavated
165-KW and 190-KW	100-K-59, 100-K-60, 100-K-66	Possible migration of sodium dichromate dihydrate solution from 183.1KW headhouse	Cr(VI)	199-K-173	Site was not excavated
116-KW-1 crib	100-K-47, 100-K-54, 100-K-61	Discharges of condensate generated by the reactor gas dryer system	C-14, nitrate, tritium	199-K-106A, 199-K-204	Contaminated soil was excavated up to 9.1 m from ground surface (DOE/RL-88-30)
116-KE-1 crib		Discharges of condensate generated by the reactor gas dryer system	C-14, nitrate, tritium	199-K-222	Contaminated soil was excavated up to 9.1 m from ground surface (DOE/RL-88-30)
105-KW FSB	116-KW-2 crib/reverse well, 100-K-43	Contamination of water in the FSB by fuel ruptures entered the FSB during reactor defueling operations	Strontium-90	199-K-107A, 199-K-34	Site was not excavated
105-KE FSB	100-K-42, UPR-100-K-1, 116-KW-2 crib	Same as 105-KW FSB but substantially more contaminated	Strontium-90, tritium	199-K-221, 199-K-222	Contaminated soil was excavated up to 8.5 m near well 199-K-221 and 4.5 m near well 199-K-222

Table 1. List of Waste Sites for Potential Continuing Sources to the Groundwater

Primary Waste Site	Nearby Related Waste Sites	Operational History	COPCs	Nearby wells	Cleanup Status
116-K-2 trench	116-K-1		Strontium-90	199-K-200	Contaminated soil was excavated up to 7.6 m from ground surface (116-K-2 CVP)
118-K-1 burial ground		Contaminated solid waste disposed at the burial ground	Tritium	199-K-111A, 199-K-207	Contaminated soil was excavated up to 12.2 m from ground surface (DOE/RL-88-30)

DOE/RL-88-30, *Hanford Site Waste Management Units Report.*
CVP-2006-00001, *Cleanup Verification Package for the 116-K-2 Effluent Trench.*

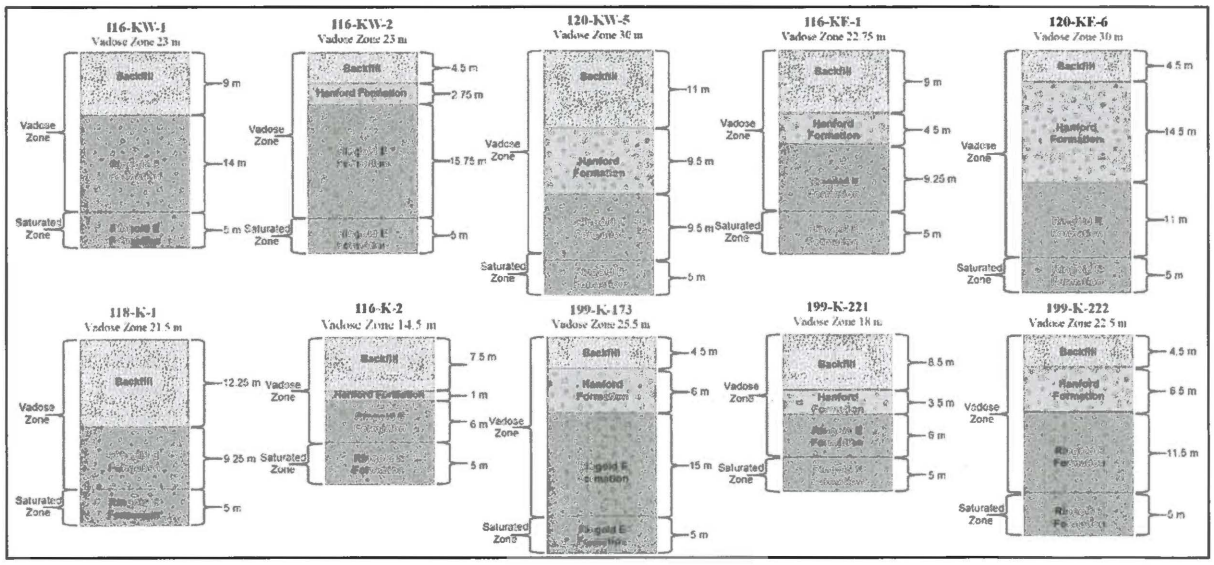

Figure 3. Representative Stratigraphic Columns for the Selected Waste Site Locations

to avoid any intermediate calculation and directly apply the STOMP output to the transport model. A Python®[2] script was used for constructing the SSM package using the characteristic release rate curve developed in STOMP, the calibrated number of cells at each waste site, and a calibrated multiplier file to scale release rates.

3 Assumptions and Inputs

All the features and processes of the 1-D STOMP model (e.g., hydraulic properties, saturation function parameters, boundary conditions, and initial conditions) were kept the same as STOMP simulations

[2] Python and is a registered trademark of the Python Software Foundation.

performed for the no further action scenario in the RI (CP-61711). However, flow boundary conditions such as time-varying upper boundary conditions (i.e., recharge), and prescribed (Dirichlet type) head boundary were changed due to the varying simulated hydraulic head for different pump-and-treat scenarios in the aquifer and assumed future soil flushing in the vadose zone.

3.1 Model Domain

The 1-D STOMP 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. The contamination that reaches the aquifer serves as a continuing source for the transport simulation in the 100-K GWFTM. All the cells within a source area for each waste site and their associated COPCs, developed through a calibration process during RI analysis as documented in CP-61711, were represented by a stratigraphic column for each waste site. The details on these representative columns can be found in the model package report of 100-K GWFTM (Section 3.5). These representative columns were used for 1-D STOMP simulation to derive a characteristic breakthrough curve.

3.2 Boundary and Initial Conditions

The initial conditions for the predictive simulations are the same as what were used for the no further action scenario in the RI analysis.

Four pump-and-treat alternative scenarios were developed as part of the FS. The details on these FS pump-and-treat scenarios are documented in ECF-100KR4-18-0044, *Modeling of Updated Design Alternatives for the 100-KR-4 Feasibility Study*. In addition, four dust suppression water simulations at the strontium-90 waste site locations were developed as part of the Technical Impracticability analysis. The details on the dust suppression water simulations are documented in ECF-100KR4-18-0063, *Model Simulations Supporting Technical Impracticability Documentation for Strontium-90, 100-KR-4 Groundwater Operable Unit.* The simulated hydraulic heads from these flow simulations were extracted and used as the boundary conditions to simulate the periodically rewetted zone for the continuing sources. The simulated hydraulic head files (*.HDS) were received from S.S. Papadopulos & Associates, Inc. and the file transfer process is documented in EMDT-RE-0029, *Flow Simulation Results for the Feasibility Study in the 100-KR-4 Operable Unit* (a copy of this electronic model data transmittal is provided in Attachment A).

3.3 Simulation Period

The 1-D STOMP model for the analysis documented in this ECF starts in 2018 and runs for 300 years. This simulation period is same as the simulation period used in the 100-K GWFTM for the FS scenarios.

4 Software Applications

STOMP was the primary software used for this calculation; as approved software, the information required is provided in this section. PEST utilities and Python scripts were used to extract time-varying hydraulic heads from each flow solution (binary files) and for post-processing the STOMP outputs to develop SSM package. The utilities/scripts related to developing SSM package were checked as part of the quality assurance process for CP-61711. These utilities/scripts are archived in the Environmental Model Management Archive (EMMA) indexed to the number and revision of this ECF.

4.1 Approved Software

The vadose zone fate and transport calculations are performed using CH2M HILL Plateau Remediation Company (CHPRC) Build 4 of the STOMP software, registered in the Hanford Information System Inventory (HISI) under identification number 2471. STOMP use by CHPRC is managed under the following software lifecycle documents: CHPRC-00222, STOMP *Functional Requirements Document*; CHPRC-00176, *STOMP Software Management Plan*; CHPRC-00211, *STOMP Software Test Plan*; CHPRC-00515, STOMP *Acceptance Test Report*; and CHPRC-00269, STOMP *Requirements Traceability Matrix*.

4.1.1 Description

The following required information for the STOMP software package used for this calculation is provided here:

- Software Title: STOMP
- Software Version: CHPRC Build 4
- HISI Identification Number: 2471
- Workstation type and property number (from which software is run): STOMP was executed on the INTERA Richland OLIVE Linux®[3] Cluster that is owned and managed by INTERA, Inc., a pre-selected subcontractor to CHPRC. The computer property tag for the front-end node is #825 at INTERA's office in Richland, Washington. This node is a Dell®[4] PowerEdge® R530 Server with 12 Intel®[5] Xeon E5-2680 v3 CPU (x2) Cores (48 processors) @ 2.5 GHz with 30 MB Cache and 128 GB of RAM. The workstation storage consists of 26 TB RAID-5 disk array. As given by the command "uname –a", the operating system details are

```
Linux olive 4.4.0-38-generic #57~14.04.1-Ubuntu SMP Tue Sep 6 17:20:43
UTC 2016 x86_64 x86_64 x86_64 GNU/Linux
```

4.1.2 Software Installation and Checkout

A copy of the *Software Installation and Checkout Form* for the STOMP installation used for this calculation is provided in Attachment B to this ECF.

4.1.3 Statement of Valid Software Application

DOE/RL-2011-50, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection*, 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 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 can simulate all the necessary features, events, and processes, and that STOMP meets all of the other required code selection criteria. Section 6.4.1 of DOE/RL-2011-50 addresses code selection criteria, including quality assurance documentation of verification studies for specific model attributes (e.g., unsaturated flow, solute

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

[4] Dell and PowerEdge are registered trademarks of Dell Corporation, Austin, Texas.

[5] Intel and Zeon are registered trademarks of Intel Corporation.

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) 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 the software test plan (CHPRC-00211).

5 Calculation

Input files for each waste site and their associated COPCs were created during the development of no further action scenario of RI analysis. These input files were modified by updating the boundary conditions to account for the changes in the simulated fluctuating water table boundary and source treatment by soil flushing for different alternative scenarios. Mass/activity exiting through the outflow boundary of the STOMP 1-D soil column is essentially what is entering the aquifer from the vadose zone. Characteristic release rate curves were generated using STOMP 1-D simulations for each representative column using the initial conditions described above and described with greater detail in CP-61711. The time series data comprising the characteristic release rate curves are the simulated mass/activity entering the aquifer over time for each COPC at each waste site. The only exceptions to the initial conditions used for generating the characteristic release rate curves were for strontium-90 near Well 199-K-221 and 199-K-222 which were simulated using depth discrete strontium-90 concentrations in the vadose zone (ECF-100KR2-16-0127, *Evaluation of Strontium-90 Leaching Characteristics from Borehole Sediment Samples Collected at UPR-100-K-1 and 116-KE-3 Crib within the 100-K Area of the Hanford Site*). The characteristic release rate curves for all the FS scenarios and for all the COPCs at the waste sites identified as continuing sources are shown in Figure 4 through Figure 15. Figure 12 through Figure 15 also include the characteristic release rate curves for all the Technical Impracticability scenarios at the strontium-90 waste sites locations. The characteristic release rate curves at a waste site for all the scenarios are quite similar unless a source treatment was applied to flush the vadose zone contaminant or to account for dust suppression water. For example, the characteristic release rate curve of Cr(VI) at KW Headhouse for FS scenario 5 (Figure 6) is significantly different from the other scenarios because soil flushing was not applied at KW Headhouse for scenario 5 whereas soil flushing was applied for other scenarios.

These characteristic release rate curves are then applied to all the 100-K GWFTM cells identified for each waste site and scaled using the calibrated multipliers.

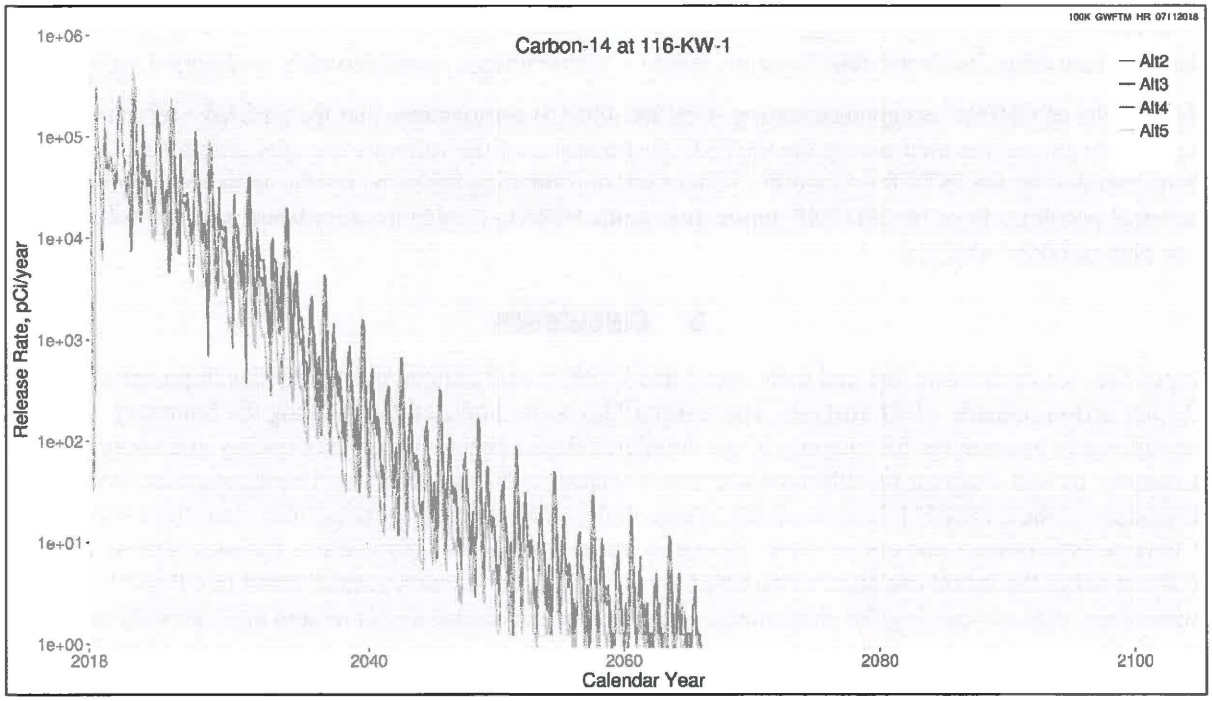

Figure 4. Characteristic Release Rate Curve for Carbon-14 at 116-KW-1 Gas Condensate Crib

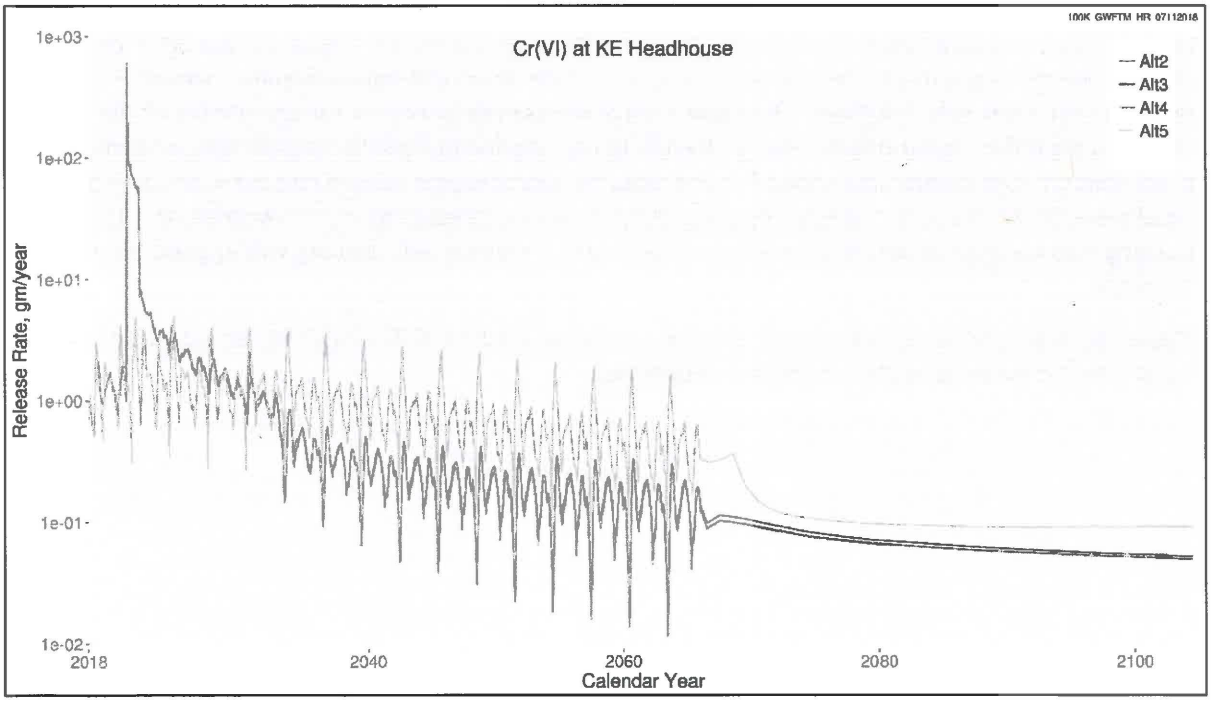

Figure 5. Characteristic Release Rate Curve for Hexavalent Chromium at KE Headhouse

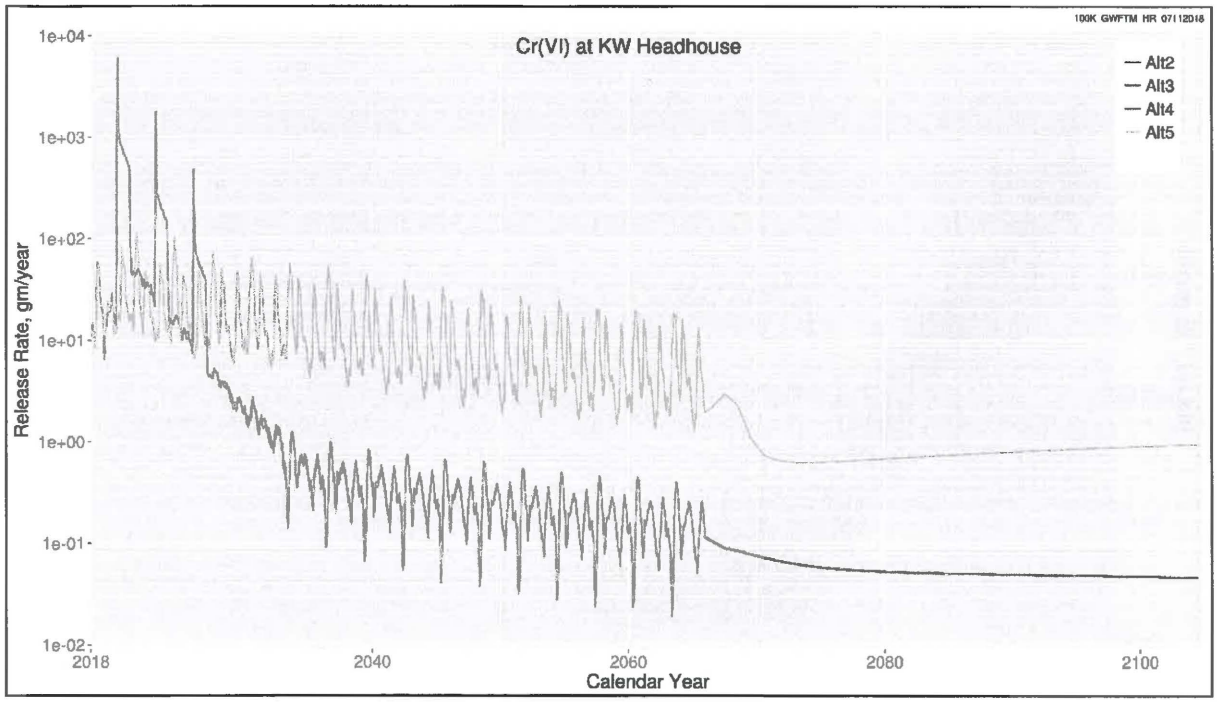

Figure 6. Characteristic Release Rate Curve for Hexavalent Chromium at KW Headhouse

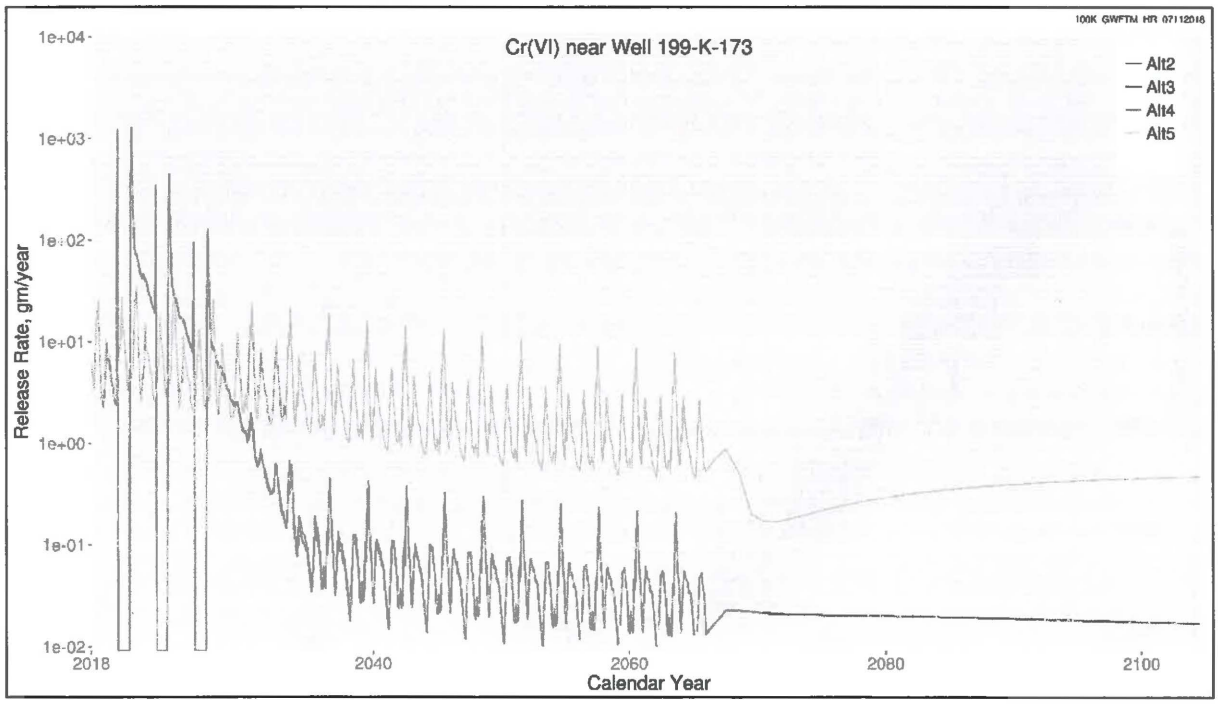

Figure 7. Characteristic Release Rate Curve for Hexavalent Chromium near Well 199-K-173

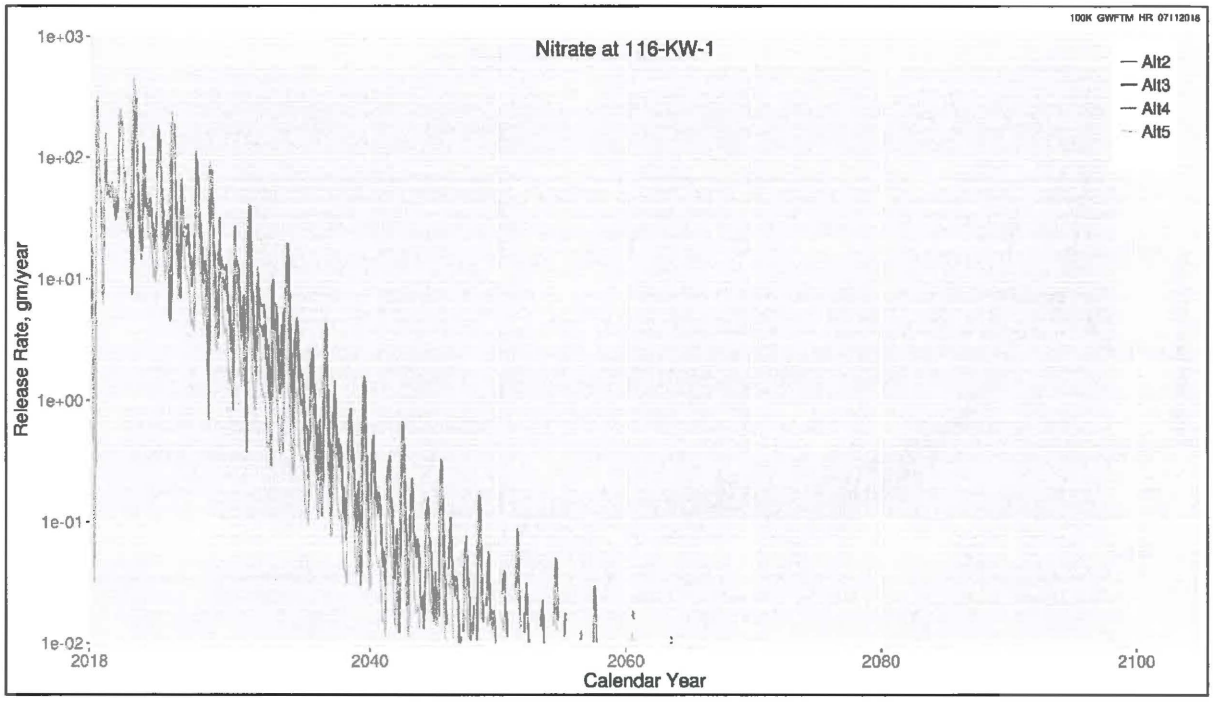

Figure 8. Characteristic Release Rate Curve for Nitrate at 116-KW-1 Gas Condensate Crib

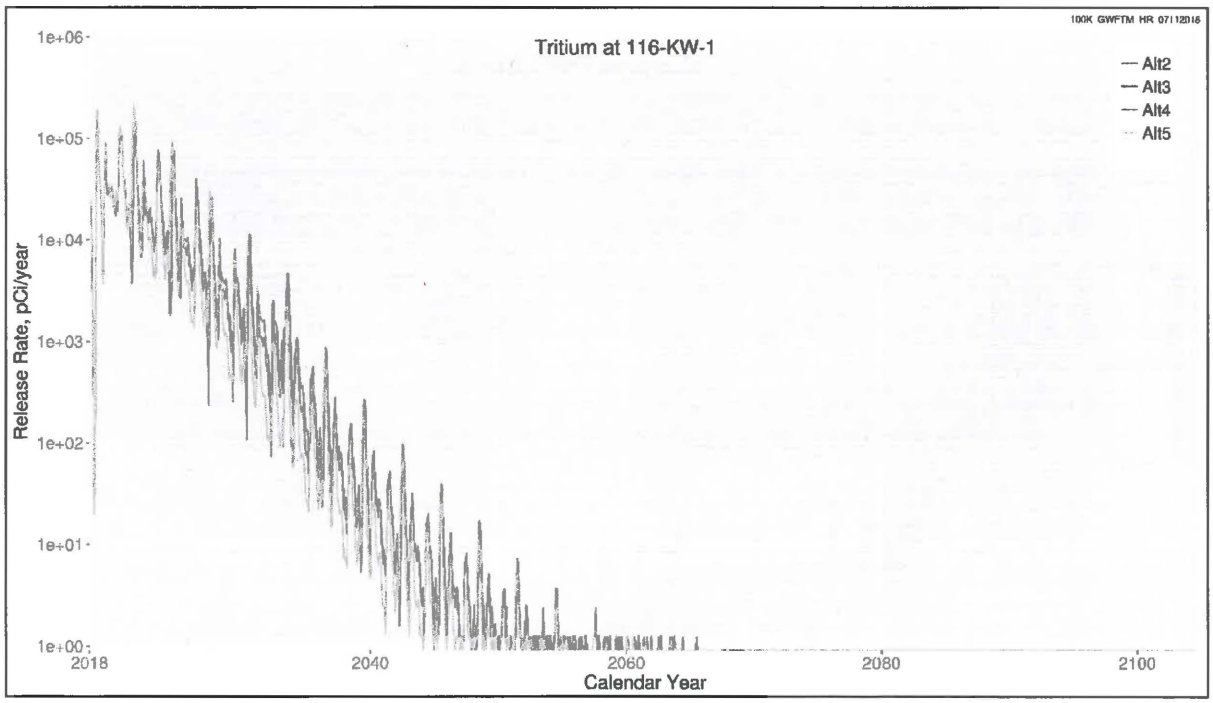

Figure 9. Characteristic Release Rate Curve for Tritium at Well 116-KW-1 Gas Condensate Crib

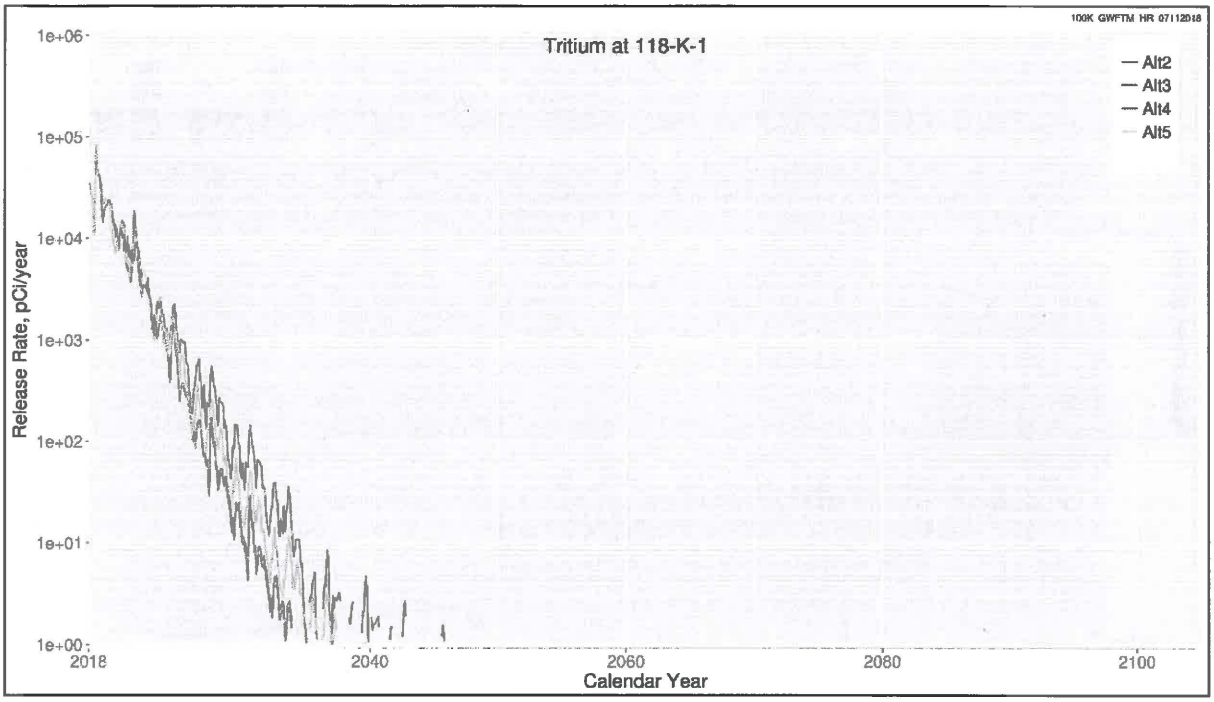

Figure 10. Characteristic Release Rate Curve for Tritium at Well 118-K-1 Burial Ground

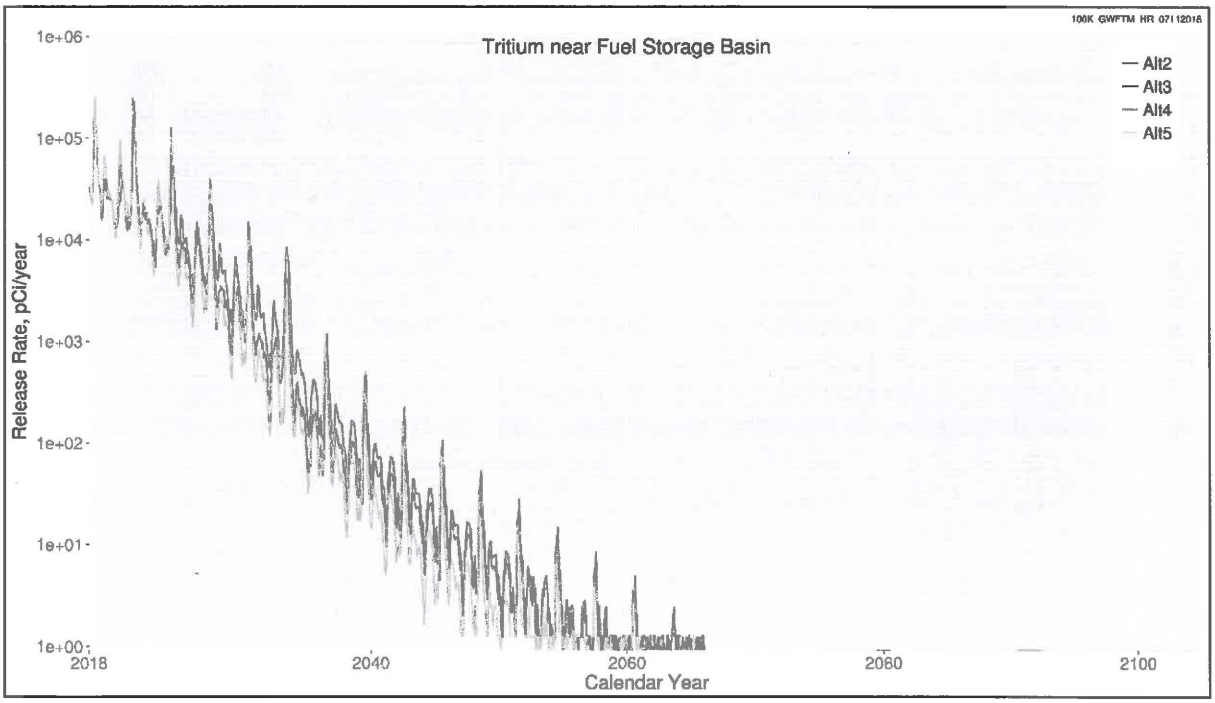

Figure 11. Characteristic Release Rate Curve for Tritium near Fuel Storage Basin

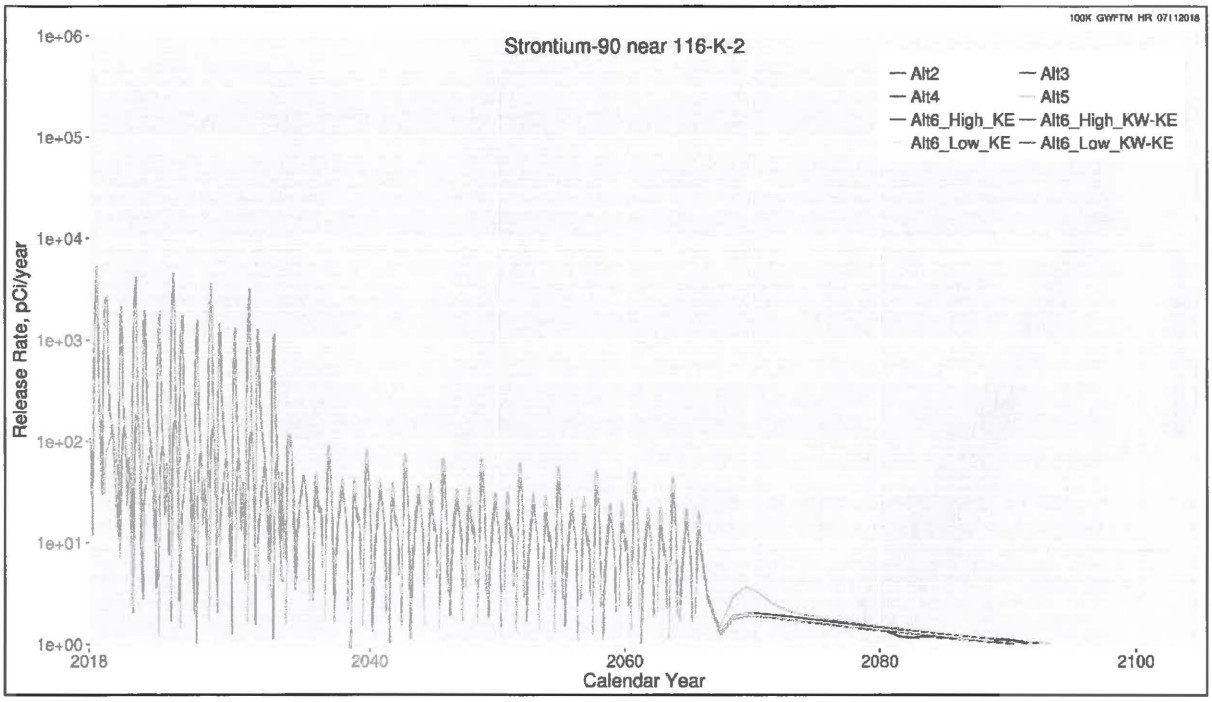

Figure 12. Characteristic Release Rate Curve for Strontium-90 near 116-K-2 Trench

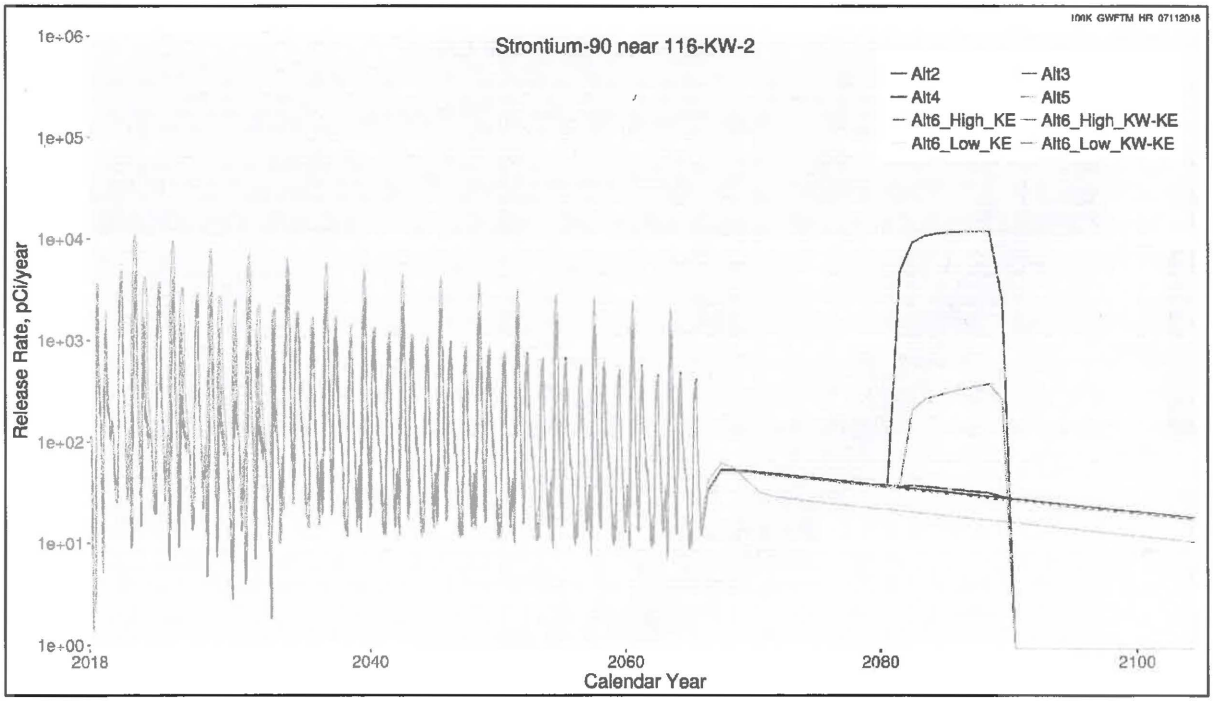

Figure 13. Characteristic Release Rate Curve for Strontium-90 near 116-KW-2

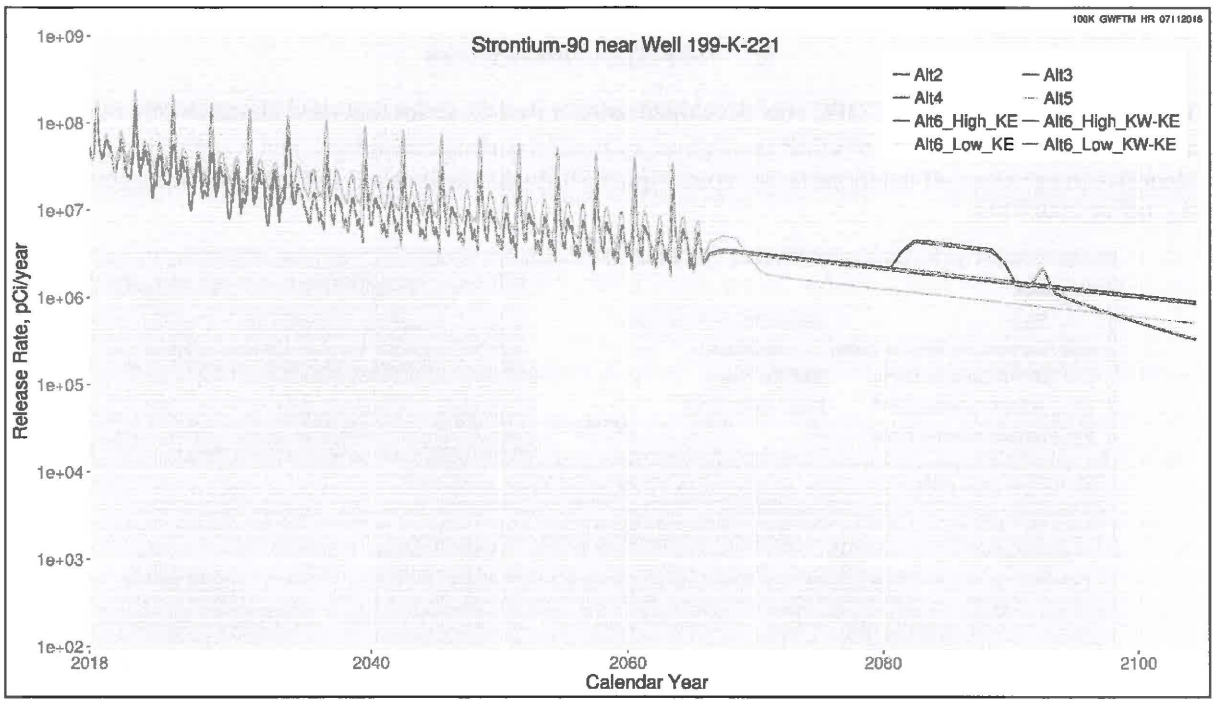

Figure 14. Characteristic Release Rate Curve for Strontium-90 near Well 199-K-221

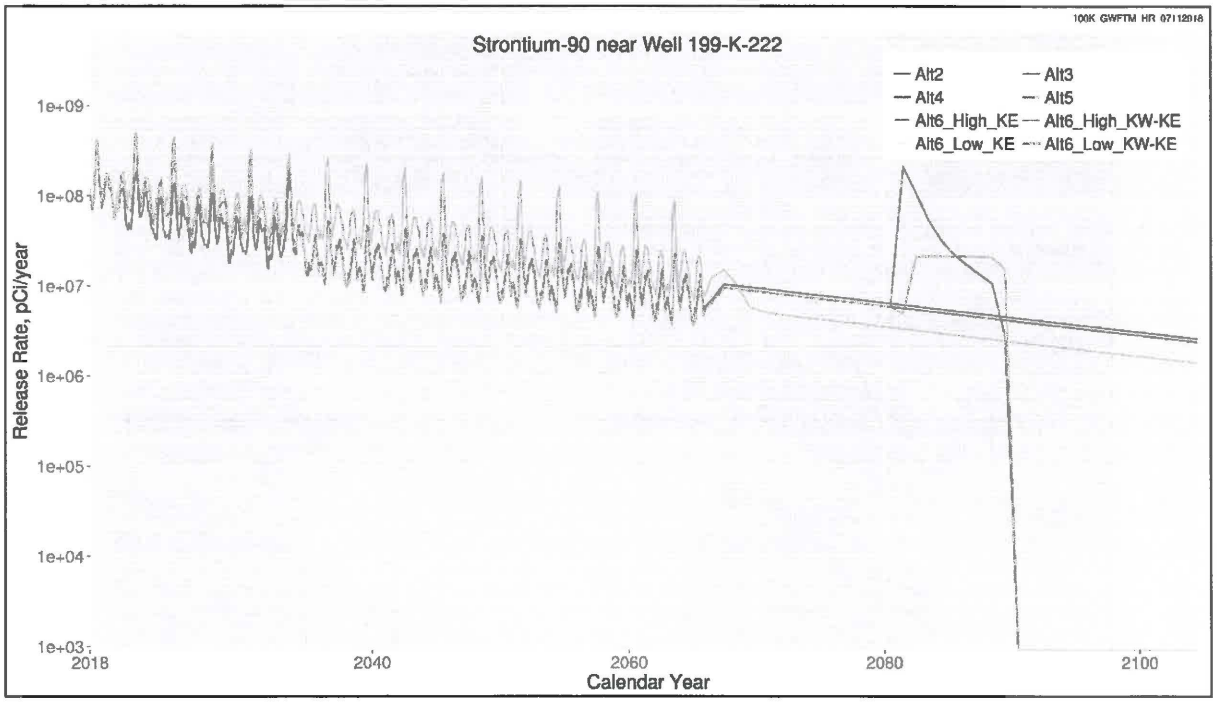

Figure 15. Characteristic Release Rate Curve for Strontium-90 near Well 199-K-222

6 Results/Conclusions

The SSM package for each COPC was developed using a Python script that used characteristic release rate curve derived from 1-D STOMP simulation, calibrated scaling multipliers, and a zone file that identifies the source cell locations as an input. Figure 16 shows the locations of the continuing sources in the 100-K GWFTM.

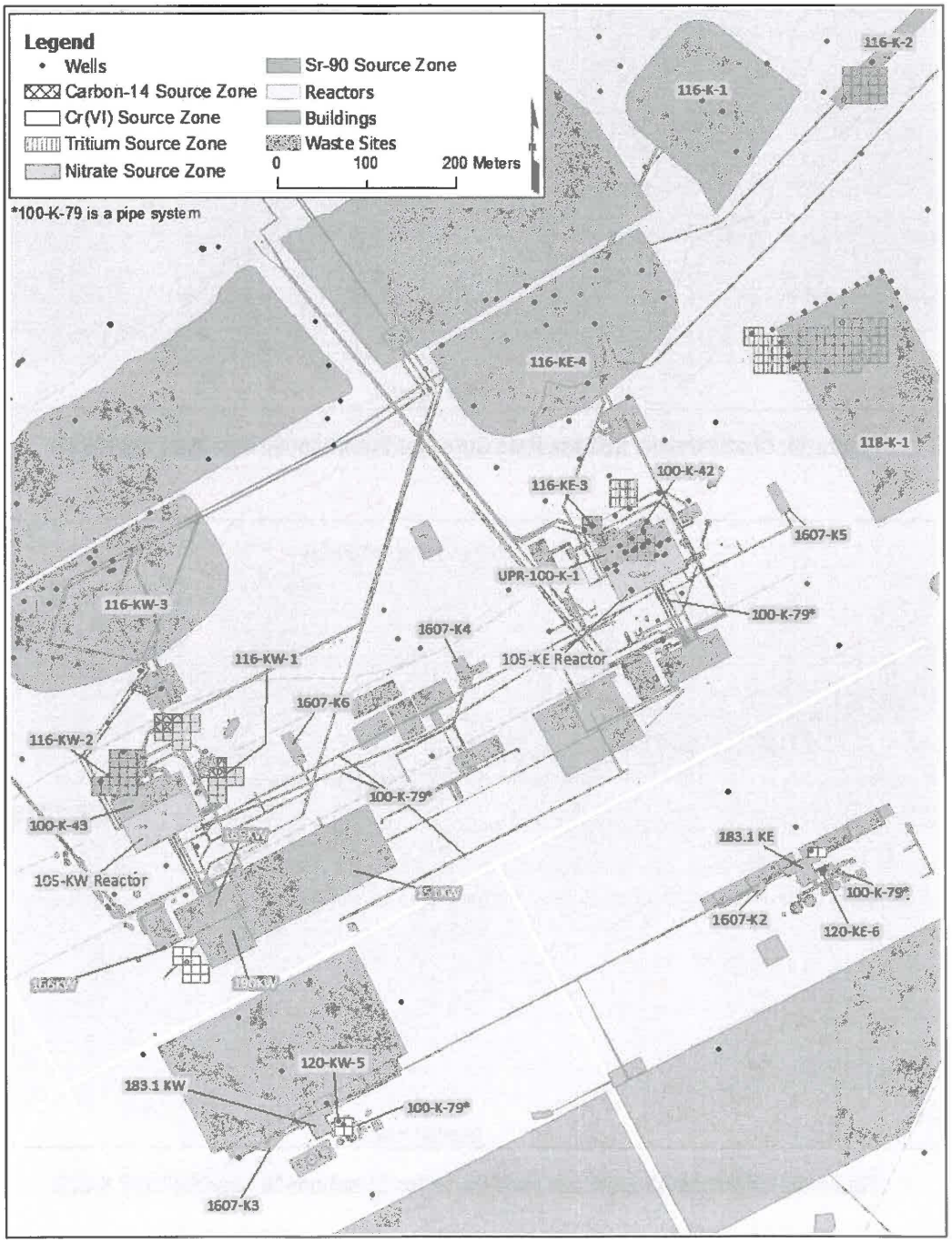

Figure 16. Continuing Source Locations in the 100-K GWFTM

Table 2. Number of Cells used as Continuing Source at each Waste Site Location

Primary Waste Site	Number of Cells with Continuing Sources				
	Hexavalent Chromium	Strontium-90	Tritium	Nitrate	Carbon-14
183.1KW Headhouse	4	None	None	None	None
183.1KE Headhouse	2	None	None	None	None
165-KW and 190-KW	11	None	None	None	None
116-KW-1 crib	None	None	6	28	11
116-KE-1 crib	None	None	None	None	None
105-KW FSB (116-KW-2)	None	22	None	None	None
105-KE FSB, UPR-100-K-1 (Near well 199-K-221 and 199-K-222)	None	13	9	None	None
116-K-2 trench	None	20	None	None	None
118-K-1 burial ground	None	None	76	None	None

7 References

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Attachment A

Electronic Model Data Transmittal EMDT-RE-0029 Rev. 1 "Flow Simulation Results for the Feasibility Study in the 100-KR-4 Operable Unit"

CH2MHILL

Environmental Modeling Data Transmittal Cover Page

No.: EMDT-RE-0029 **Revision No.:** 1

[Request EMDT number from Modeling Team Leader]

Title: ***Flow Simulation Results for the Feasibility Study in the 100-KR-4 Operable Unit*** **Date:** 08/13/2018

1. Data Description

Provide the description of data set or data type.

The simulated hydraulic head file (binary file with extension *.HDS) for the Feasibility Study scenarios using the 100-K Groundwater Flow and Transport Model.

2. Data Intended Use

Identify the data's intended use. Describe the rationale for its selection and how the data will be incorporated into a model, report, or database. Include discussion of the extent to which the data demonstrate the properties of interest.

Simulated hydraulic head at the selected model cells (i.e., waste sites) will be extracted to be used as fluctuating boundary conditions in 1-D STOMP simulations for calculating mass/activity release rates.

3. Data Sources

List databases, documents, etc. – provide sufficient detail to enable data to be located by independent reviewer

- ***Simulations for Feasibility Study using the 100-K Groundwater Flow and Transport Model were performed by S.S. Papadopulos & Associates, Inc.***
- ***Simulations for Technical Impracticability analysis using the 100-K Groundwater Flow and Transport Model were performed by S.S. Papadopulos & Associates, Inc.***
- ***The simulated hydraulic head files (*.HDS) were transferred through a file transfer site (WeTransfer)***
- ***The timestamp on the received final set of model output files were confirmed through email communication with S.S. Papadopulos & Associates, Inc.***
- ***Change in numbering of simulation scenarios (Alternatives) were confirmed through email communication with S.S. Papadopulos & Associates, Inc.***

4. Impact of Use or Nonuse of Data

Describe the importance of the data to the model, report, and/or conclusions which they support. Identify the value added and discuss the impacts of not using the data.

The simulated hydraulic head is a required input for the 1-D STOMP simulations

5. Prior Uses

Identify the data's prior uses. Describe whether the data have been used in similar applications by the scientific or regulatory community. Include the associated verification processes and prior reviews and review results.

None

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Environmental Modeling Data Transmittal Cover Page

No.: EMDT-RE-0029 **Revision No.:** 1

[Request EMDT number from Modeling Team Leader]

Title: ***Flow Simulation Results for the Feasibility Study in the 100-KR-4 Operable Unit*** **Date:** 08/13/2018

6. Data Acquisition Method(s)

Describe the data acquisition method and associated QA/QC, considering the following:

a. *Qualifications of personnel or organizations generating the data;*
b. *Technical adequacy of equipment and procedures used;*
c. *Environmental and programmatic conditions if germane to the data quality;*
d. *The extent to which acquisition processes reflect modeling requirements;*
e. *The quality and reliability of the measurement control program;*
f. *The degree to which independent audits of the process were conducted;*
g. *Extent and reliability of the associated documentation.*

ECF-100KR4-18-0044 (Modeling of Updated Design Alternatives for the 100-KR-4 Feasibility Study) and ECF-100KR4-18-0063 (Model Simulations Supporting Technical Impracticability Documentation for Strontium-90, 100-KR-4 Groundwater Operable Unit) document all the details on the model simulations and associated QA/QC procedures mentioned above

For databases, identify query language used to obtain data from database (SQL, etc.), briefly describe the query description and attach copy

7. Corroborating Data

Identify and discuss any corroborating datasets. Provide any documentation that confirms the corroborating data substantiate existing parameter values, distributions, or data quality.

Verification process was performed to confirm the latest version of the model simulations were used. The email confirmation is attached below

8. Data Quality Considerations

Discuss data quality considerations not identified in other sections. Include discussion of data quality indicators (i.e., accuracy, precision, representativeness, completeness, and comparability).

None

9. Assumptions and Limitations on Data Use

Document known uncertainties, assumptions, constraints or limits on data.

None

Data Configuration Item Submittal:

Data Provider Submittal	Alex Spiliotopoulos/Senior Hydrologist (S.S. Papadopulos & Associates, Inc.) NAME/POSITION	
	A. Spiliotopoulos SIGNATURE	8/13/2018 DATE

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Environmental Modeling Data Transmittal Cover Page

No.: EMDT-RE-0029 **Revision No.:** 1

[Request EMDT number from Modeling Team Leader]

Title: ***Flow Simulation Results for the Feasibility Study in the 100-KR-4 Operable Unit*** **Date:** 08/13/2018

Data Configuration Item Review and Verification:

10. Verification Process

Describe steps taken to verify that these data are appropriate for intended use, noting any limitations

None

11. Summary of Data Review

The review shall ensure that the report meets the listed criteria. Consideration includes ensuring that the data collection method employed was appropriate for the type of data being considered and confidence in the data acquisition and subsequent processing methodology is warranted.

Is documentation technically adequate, complete, and correct?	[ ] Yes	[ ] No
Are uncertainties and limitations on appropriate use of data discussed?	[ ] Yes	[ ] No
Are the assumptions, constraints, bounds, or limits on the data identified?	[ ] Yes	[ ] No

Data Reviewer Approval *Approval of Data Configuration Item*

H. Rashid/Hydrologist (Intera Inc.)
NAME/POSITION

S.M. Helalur Rashid 8/13/2018
SIGNATURE DATE

Email confirmation to verify the latest version of the simulation results were used in the 1-D STOMP simulations:

Helalur Rashid

From: Alex Spiliotopoulos <alexs@sspa.com>
Sent: Friday, May 25, 2018 10:46 AM
To: Helalur Rashid
Subject: RE: Documenting the FS SSMs to an ECF

All correct! Thanks Helal.

Alex Spiliotopoulos
Associate, Senior Hydrogeologist, PhD
S.S. Papadopulos & Associates, Inc.
7944 Wisconsin Avenue
Bethesda, MD 20814
Office: (301) 718-8900
Direct: (301) 500-2288
Cell: (301) 787-3506
Email: alex@sspa.com

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From: Helalur Rashid [mailto:hrashid@intera.com]
Sent: Thursday, May 24, 2018 5:40 PM
To: Alex Spiliotopoulos <alexs@sspa.com>
Subject: RE: Documenting the FS SSMs to an ECF

Okay, for some reason I thought TI waiver replaces ALT5. I have got the following alternative scenarios for which you should have SSM packages:

Scenario name	rar file name	Time stamp on HDS file
ALT2	Flow_Alt2_05092018_rev1.rar	5/9/2018
ALT3	K__RIFS_ALT3_02252018.rar	2/23/2018
ALT4	K__RIFS_ALT4_02252018.rar	2/23/2018
ALT5	K__RIFS_ALT5_02252018.rar	2/23/2018
TI waiver	TI_Waiver_Flow-Simulation_v1	3/20/2018

Please confirm whether the above table looks correct or not.

Thanks
Helal Rashid, P.E.
Hydrologist

INTERA Incorporated | 3240 Richardson Road, Suite 2 | Richland, WA 99354
hrashid@intera.com | Office: 509.946.9898

Email confirmation to verify the change in numbering for the Feasibility Study simulations:

Helalur Rashid

From: Alex Spiliotopoulos <alexs@sspa.com>
Sent: Monday, August 6, 2018 3:20 PM
To: Helalur Rashid
Subject: RE: Updating the ECF and EMDT for SSM package

Confirmed!

Alex Spiliotopoulos
Associate, Senior Hydrogeologist, PhD
S.S. Papadopulos & Associates, Inc.
7944 Wisconsin Avenue
Bethesda, MD 20814
Office: (301) 718-8900
Direct: (301) 500-2288
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From: Helalur Rashid <hrashid@intera.com>
Sent: Monday, August 6, 2018 5:48 PM
To: Alex Spiliotopoulos <alexs@sspa.com>
Subject: RE: Updating the ECF and EMDT for SSM package

Okay, I'll renumbered the alternatives to be consistent with your ECF. Please confirm the highlighted the texts below.

Thanks
Helal Rashid, P.E.
Hydrologist

INTERA Incorporated | 3240 Richardson Road, Suite 2 | Richland, WA 99354
hrashid@intera.com | Office: 509.946.9898

From: Alex Spiliotopoulos <alexs@sspa.com>
Sent: Monday, August 6, 2018 2:42 PM
To: Helalur Rashid <hrashid@intera.com>
Subject: RE: Updating the ECF and EMDT for SSM package

Exactly. Here is the revised numbering and description:

- Alternative 1: No Further Action; the interim remedy is suspended by 2019;
- Alternative 2 (Alt3 in EMDT-RE-00-29,Rev.0): Natural Attenuation and Institutional Controls (ICs), and Remove-Treat-Dispose (RTD) for Waste Sites; with Soil Flushing, MNA and ICs (KN, K-N Boundary, 100-N) and Pump-and-Treat (P&T) in KW and KE for Groundwater;
- Alternative 3 (Alt4 in EMDT-RE-00-29,Rev.0): Natural Attenuation and ICs, and RTD for Waste Sites; with Soil Flushing, MNA and ICs (K-N Boundary, 100-N) and P&T (KW, KE, KN) for Groundwater;
- Alternative 4 (Alt5 in EMDT-RE-00-29,Rev.0): Natural Attenuation and ICs, and RTD for Waste Sites; with Soil Flushing and P&T (all areas) for Groundwater;
- Alternative 5 (Alt2 in EMDT-RE-00-29,Rev.0): Natural Attenuation and ICs and RTD for Waste Sites; with MNA and ICs and River Protection P&T for Groundwater.

Alex Spiliotopoulos
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Email confirmation to verify the latest version of the Technical Impracticability simulation results were used in the 1-D STOMP simulations:

Helalur Rashid

From: Alex Spiliotopoulos <alexs@sspa.com>
Sent: Friday, August 10, 2018 4:36 PM
To: Helalur Rashid
Subject: Re: TI Waiver simulations

Confirmed!

Alex Spiliotopoulos
Associate, Senior Hydrogeologist, PhD
S.S. Papadopulos & Associates, Inc.
7944 Wisconsin Avenue
Bethesda, MD 20814
Office: (301) 718-8900
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Cell: (301) 787-3506
Email: alex@sspa.com

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From: Helalur Rashid <hrashid@intera.com>
Sent: Friday, August 10, 2018 6:33:35 PM
To: Alex Spiliotopoulos
Subject: TI Waiver simulations

Alex,

Please confirm the time stamp on the *.HDS files for the latest TI waiver simulations:

Scenario Name	rar file name	Time stamp on HDS file
High_KE	100K_ALT6-TI_High_KE_07302018_v1.rar	7/31/18 9:18 PM
High_KW-KE	100K_ALT6-TI_High_KW-KE_07302018_v1.rar	7/31/18 9:20 PM
Low_KE	100K_ALT6-TI_Low_KW-KE_07302018_v1.rar	7/31/18 9:00 PM
Low_KW-KE	100K_ALT6-TI_Low_KW-KE_07302018_v1.rar	7/31/18 9:16 PM

Thanks
Helal Rashid, P.E.
Hydrologist

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hrash@intera.com | Office. 509.946.9898

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Attachment B

Software Installation and Checkout Form for STOMP

CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM

Software Owner Instructions:
Complete Fields 1-13, then run test cases in Field 14. Compare test case results listed in Field 15 to corresponding Test Report outputs. If results are the same, sign and date Field 19. If not, resolve differences and repeat above steps.

Software Subject Matter Expert Instructions:
Assign test personnel. Approve the installation of the code by signing and dating Field 21, then maintain form as part of the software support documentation.

GENERAL INFORMATION:

1. Software Name: STOMP (Subsurface Transport Over Multiple Phases) Software Version No: Bld 4

EXECUTABLE INFORMATION:

2. Executable Name (include path):

MD5 File Signature	Executable File Name
6536b8e12d8c5b83dca76f2c947b6153	stomp-wae-bcg-chprc041.x
e0cdf04bc1a2f6c35c5a1b499939f663	stomp-wae-bcg-chprc041.x
6e72340bb39f6056e232fe5ff241c4d4	stomp-wae-bd-chprc041.x
3f837e0fb8d9f47dbcada606f542d7fc	stomp-wae-bd-chprc041.x
7c5b4cc36a8991b3d5a0ea2ed155ce47	stomp-wae-cgsq-chprc041.x
00a898c0c3ec06817485781adlc9cc46	stomp-wae-cgsq-chprc041.x
f18ff5ab5667065d8ab12657344fb6a0	stomp-wae-cgst-chprc041.x
061af86cf21ad8435b946d0efabe971b	stomp-wae-cgst-chprc041.x
3c8111a9855dc0e430bf3c8a7abcf37e	stomp-w-bcg-chprc041.x
20436d615a94955a2ce8eedb8cba546	stomp-w-bcg-chprc041.x
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066a269a75aedb933eb2536da5d7d1ff	stomp-w-bd-chprc041.x
c8e62ad7a0d9b6fca39d8a8952ef5d8e	stomp-w-cgsq-chprc041.x
28ad16806e1307aca51fd7bf89793e75	stomp-w-cgsq-chprc041.x
6c25051016db2fe1f883a7caaaable97	stomp-w-cgst-chprc041.x
ff9ff6f29b3469419ffaece87d7e772b	stomp-w-cgst-chprc041.x
0c3e3fba40f5b93e71bcf9586432fd27	stomp-w-r-bcg-chprc041.x
78492aee80a8c2d0a4e82aabf4a9c213	stomp-w-r-bcg-chprc041.x
84b129786aba3c4be884e15e45a67389	stomp-w-r-bd-chprc041.x
e990f1566c8099a8d54508de3da9cd88	stomp-w-r-bd-chprc041.x
18a589a2b55aab2db290efea19b39351	stomp-w-r-cgsq-chprc041.x
6569959476772a137df35ce874821889	stomp-w-r-cgsq-chprc041.x

3. Executable Size (bytes): MD5 signatures above uniquely identify each executable file

COMPILATION INFORMATION.

4. Hardware System (i.e., property number or ID):

Tellus Subsurface Modeling Platform

5. Operating System (include version number):

Linux tellusmgmt.rl.gov 2.6.18-308.4.1.el5 #1 SMP Tue Apr 17 17:08:00 EDT 2012 x86_64 x86_64 x86_64 GNU/Linux

INSTALLATION AND CHECKOUT INFORMATION:

6. Hardware System (i.e., property number or ID):

INTERA's Olive Linux System

7. Operating System (include version number):

Linux olive 3.19.0-25-generic #26~14.04.1-Ubuntu SMP Fri Jul 24 21:16:20 UTC 2015 x86_64 x86_64 x86_64 GNU/Linux

8. Open Problem Report? ◉ No ○ Yes PR/CR No.

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: STOMP (Subsurface Transport Over Multiple Phases) Software Version No.: Bld 4

TEST CASE INFORMATION:

9. Directory/Path:

[redacted]/bin

10. Procedure(s):

CHPRC-00211 Rev 1, STOMP Software Test Plan

11. Libraries:

N/A (static linking)

12. Input Files:

Input files for ITC-STOMP-1, ITC-STOMP-2, and ITC-STOMP-3
(Baseline for comparison are results files from ATC-STOMP-1, ATC-STOMP-2, and ATC-STOMP-3 prepared on Tellus during acceptance testing)

13. Output Files:

plot.* files produced by STOMP in testing

14. Test Cases:

ITC-STOMP-1, ITC-STOMP-2, and ITC-STOMP-3

15. Test Case Results:

Pass for all executable files listed above.

16. Test Performed By: WE Nichols

17. Test Results: (●) Satisfactory, Accepted for Use ( ) Unsatisfactory

18. Disposition (include HISI update):

Accepted; Installation noted in HISI for all approved users of OLIVE who have completed STOMP SMP and STP required reading assignments.

Prepared By:

19.	Software Owner (Signature)	WE Nichols Print	23 NOV 2015 Date

20. Test Personnel:

Sign	WE Nichols Print	23 NOV 2015 Date
Sign	Print	Date
Sign	Print	Date

Approved By:

21.	Software SME (Signature)	N/R (per CHPRC-00211 Rev 1) Print	Date

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