ECF-100BC5-16-0081
Revision 0

Hexavalent Source Term Estimates for 100-BC

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

P.O. Box 1600
Richland, Washington 99352

ECF-100BC5-16-0081
Revision 0

Hexavalent Source Term Estimates for 100-BC

Document Type: ENV Program/Project: EP&SP

G. Ruskauff
INTERA, Inc.

Date Published
October 2016

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

P.O. Box 1600
Richland, Washington 99352

APPROVED
By Lana Perry at 2:50 pm, Oct 19, 2016

Release Approval Date

TRADEMARK DISCLAIMER

ENVIRONMENTAL CALCULATION COVER PAGE

Section 1: Completed by the Responsible Manager

Project: 100-BC Remedial Investigation/Feasibility Study

Date: 05/03/2016

Calculation Title & Description: Hexavalent Chromium Source Term Estimates for 100-BC

RELEASE / ISSUE

DATE: Oct 19, 2016 HANFORD RELEASE

Section 2: Completed by Preparer

Calculation No.: ECF-100BC5-16-0081 **Revision No.:** 0

Revision History

Revision No.	Description	Date	Affected Pages
0	Initial issue	05/26/2016	All

Section 3: Completed by the Responsible Manager

Document Control:

Is the document intended to be controlled within the Document Management Control System (DMCS)? ☒ Yes ☐ No

Does document contain scientific and technical information intended for public use? ☒ Yes ☐ No

Does document contain controlled-use information? ☐ Yes ☒ No

Section 4: Document Review & Approval

Role	Name /Position	Signature	Date
Preparer:	G Ruskauff/Principal Hydrogeologist	[signature]	6/1/16
Checker:	TB Hammond/Hydrogeologist	[signature]	6/1/16
Senior Reviewer:	WE Nichols/Modeling Team Leader	[signature]	8 JUNE 2016
Responsible Manager:	AH Aly/Risk & Model Integr. Manager	[signature]	6/1/16

Section 5: Applicable if calculation is a risk assessment or uses an environmental model

PRIOR TO INITIATING MODELING:

Required training for modelers completed:

	Name /Position	Signature	Date
Integration Lead	NOT APPLICABLE – [initials]		

Safety Software Approved:

	Name /Position	Signature	Date
Integration Lead	NOT APPLICABLE – [initials]		

CALCULATION APPROVED:

	Name /Position	Signature	Date
Risk/Modeling Integration Manager:	AH Aly/Risk & Model Integr. Manager	[signature]	6/1/16

Contents

Figures

Terms

EMMA	Environmental Model Management Archive
PRZ	periodically rewetted zone
VZ	vadose zone

1 Purpose

This calculation was performed to generate the Cr(VI) mass loading for 100-BC Feasibility Study alternative 4 (50% Cr[VI] reduction from substrate injection at waste site 116-B-11 in summer 2019). No change in recharge or source (no further action) is implemented at 100-C-7:1.

2 Background

Column studies of chromium elution described in PNNL-17674, *Geochemical Characterization of Chromate Contamination in the 100 Area Vadose Zone at the Hanford Site*, were analyzed with a mass transfer approach as described in ECF-100BC5-0028, *Evaluation of Leaching Characteristics of Hexavalent Chromium from Contaminated 100-BC Sediments at Hanford Site to Estimate Time Dependent Mass Flux for Fate and Transport Modeling*. This approach was used to estimate Cr(VI) mass loading under recent conditions for transport model calibration as described in SGW-59365, *Model Package Report: 100-BC Scale-Appropriate fate and Transport Model*. The approach was modified to generate scenarios for the 100-BC Feasibility Study.

3 Methodology

Conceptualization of future mass loading from column analysis requires using empirically-estimated desorption parameters (Figure 1) to estimate a time-decaying leaching coefficient (Figure 2) as described in ECF-100BC5-0028. The curves cross in Figure 2 because the regression and confidence limits are poorly constrained past about 75 pore volumes.

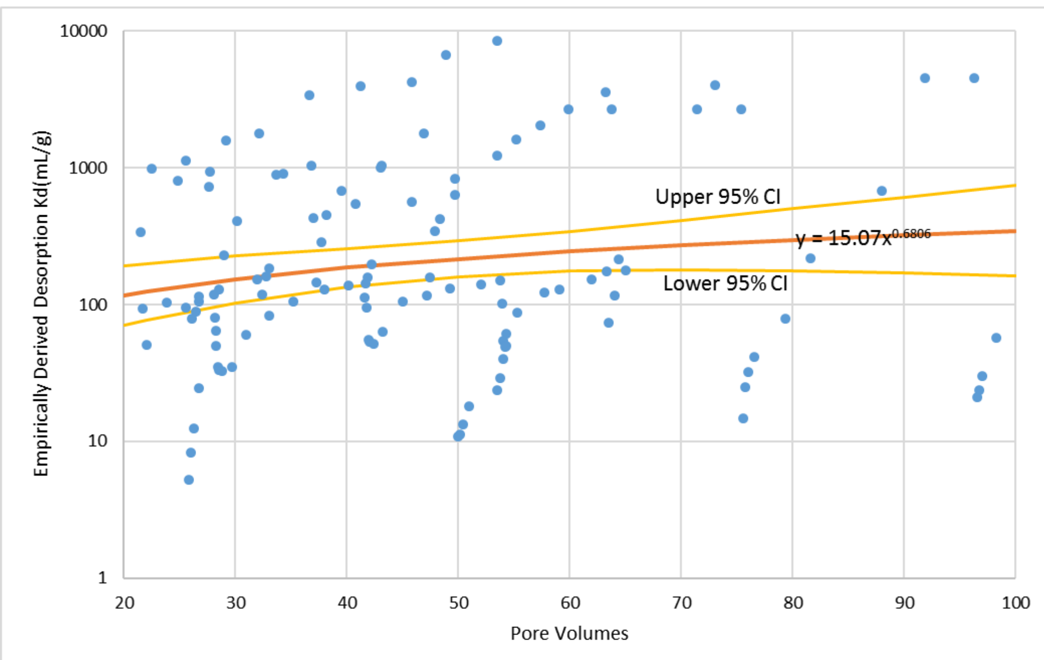

Figure 1. Empirically-Estimated Desorption Parameters and 95% Confidence Intervals

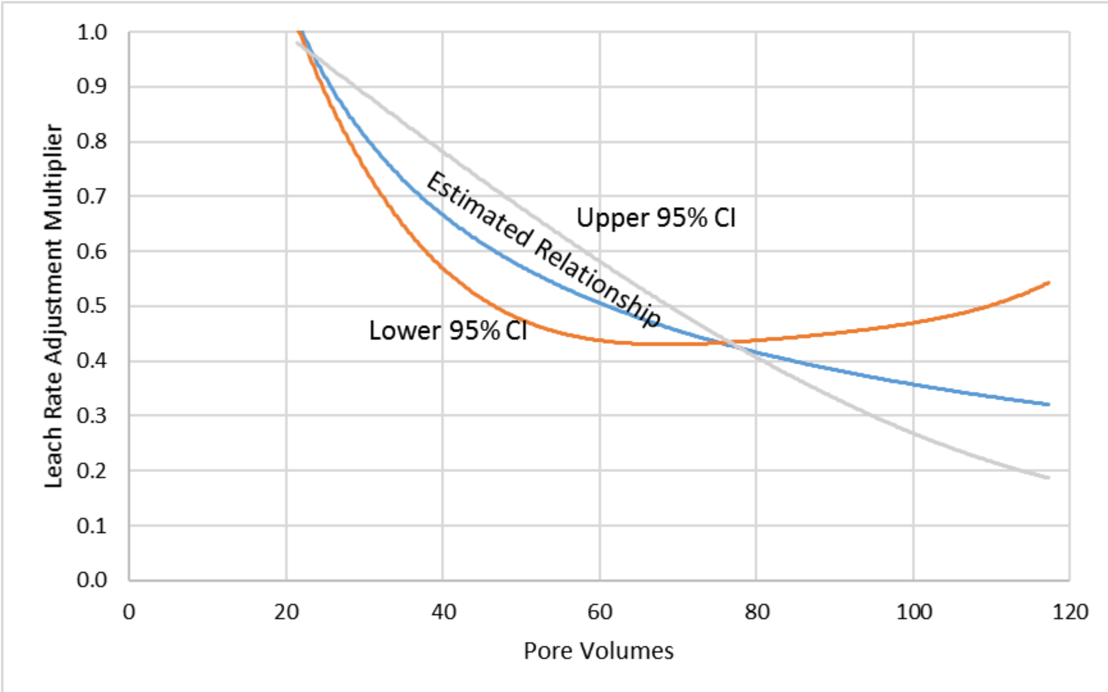

Figure 2. Leach Rate Adjustment Multiplier as a Function of Pore Volume

The source is conceptualized as existing in the periodically rewetted zone (PRZ) and vadose zone (VZ) for which the determining the flow rate is problematic because it depends on river-induced water table changes from year to year, as well as on potential site remediation activities. The minimum flow rate is recharge alone; this was selected as the basis for the computation. This assumption is conservative because the actual flow rate in the periodically rewetted zone (PRZ) is likely higher than recharge alone and therefore, because the leach rate multiplier is a function of pore volume, using a lower flow rate will result in leaching declining more slowly than for higher flow rates. This, in turn, will yield estimates with higher mass loading for longer times. The current recharge rate of 63 mm/yr (rate for areas with disturbed soil maintained vegetation free) was used to maintain consistency with the transport calibration. At waste site 116-B-11, the actual PRZ thickness in relation to the potential source is difficult to determine because the site is close to the river and water levels rise to within a meter of the bottom of the excavation as shown in Figure 3. The potential source can be attributed to 0.5 to 1 m of VZ. Additionally, the ISR process itself may change the source distribution.

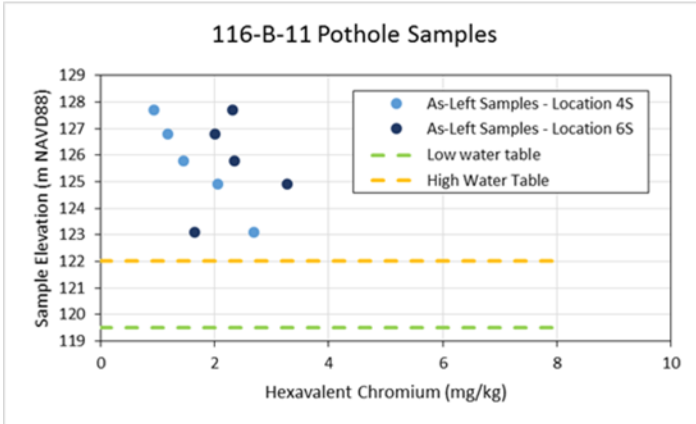

Figure 3. Diagram of Waste Site 116-B-11, Soil Concentrations, and Water Level

The time to flush one pore volume through 25 m^2 grid blocks (the model discretization where the chromium plume exists) with a 2 m thick VZ/PRZ and 63 mm/yr recharge rate is estimated at 2.5 years ($25\ m^2 \times 2\ m \times 0.08$)/ ([63 mm/yr/$m^2 \times 1$ yr/365.25 d$\times$1 m/1000 mm]$\times 25\ m^2$)/365.25, assuming a moisture content of 0.08. Similarly, 1 and 0.5 m thick VZ/PRZ give 1.3 and 0.63 years to flush one pore volume, respectively. This estimate yields the leach-rate multiplier curve shown in Figure 4. The 0.5 m curve ends just beyond 60 years because there is only about 105 pore volumes of experimental data. The variation in the leach-rate adjustment multiplier at 20 years averages about 20% relative to the 1 m PRZ curve and represents only the uncertainty attributable to the VZ/PRZ thickness.

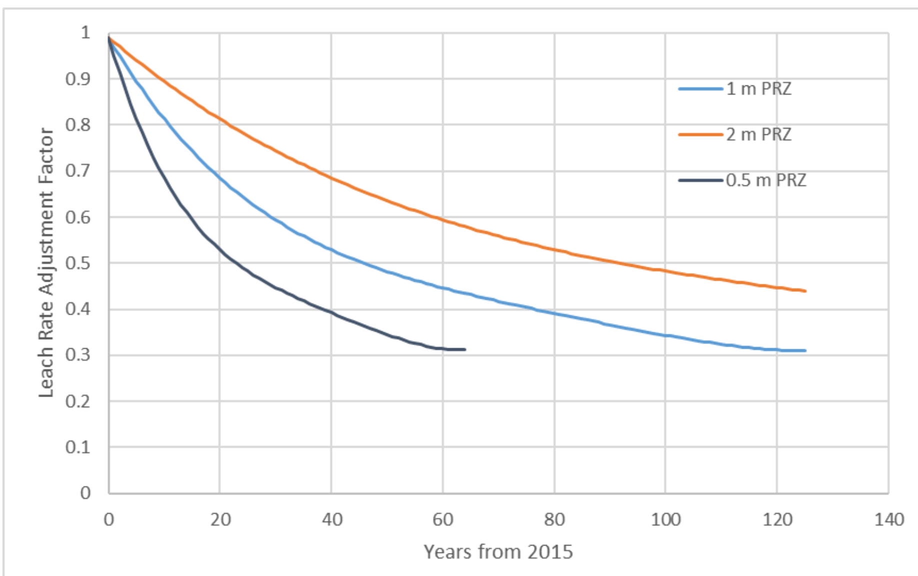

Figure 4. Leach Rate Adjustment Multiplier as a Function VZ/PRZ Thickness

The steps for the 116-B-11 leach-rate multiplier computation are as follows (an electronic version is committed to the Environmental Model Management Archive [EMMA] indexed to this ECF document, ECF-100BC5-16-0081 Rev. 0):

1. Using calibrated source parameters of total Cr soil concentration for the less than 2 mm size of 500 mg/kg, a Cr(VI) to total Cr ratio of 0.063, a 0.5 correction for soil fraction < 2 mm, and a leach rate of 2×10^{-4} compute the mass loading history for waste site 116-B-11.

2. Simulation year 1 is assumed as calendar year 2015, and therefore calendar year 2019, the year the remedy is applied, represents five years of elapsed time. To obtain the remaining mass at the end of 2019, divide by two, and recompute the mass loading.
3. Construct the model input file.

4 Assumptions and Inputs

The following assumptions were made:

- The Cr(VI) soil concentration, leaching coefficient, and bulk Cr(VI) soil concentration were assumed to be unchanged from the calibration period.
- Ambient recharge for current conditions (63 mm/yr; disturbed soil, maintained vegetation free) was assumed representative of the PRZ flow rate for purposes of converting pore volume into time.
- *In-situ* reduction was assumed to occur instantaneously resulting in the scenario-specified soil mass reduction.
- The reduction of leaching coefficient over pore volumes (time) given in ECF-100BC5-0028 was assumed to apply at the field scale.
- The mass at the end of calendar year 2019, not that in summer 2019, is sufficient for the 100-BC Feasibility Study comparative analysis (the computation is on an annual basis).

5 Software Applications

Software used to perform this calculation are approved, managed, and used in compliance with the CH2M Hill Plateau Remediation Company (CHPRC) requirements of PRC-PRO-IRM-309, *Controlled Software Management*.

5.1 Exempt Software

Microsoft Excel®[1] is site-licensed software used as spreadsheets that are wholly incorporated into this calculation and verified during the technical review of this report, and is therefore rated as exempt software (PRC-PRO-IRM-309, Section 1.3, Exemptions).

5.2 Statement of Valid Software Application

The preparer of this calculation attests that the software identified above, and used for the calculations described in this calculation, is appropriate for the application and used within its range of intended uses.

6 Calculation

The Cr(VI) source loading was initial calculated using the methodology presented in Section 3 and under the assumptions identified in Section 4. A suite of mass loading curves was considered reflecting VZ/PRZ thickness uncertainty (Figure 5). All curves correctly represent the expected sharp drop in mass loading coinciding with the removal of 50% of the soil Cr(VI) mass. The 0.5 m curve ends after about 70 years because the experimental data ends. A compromise approach was implemented by taking the 1 m PRZ

[1] Excel is a registered trademark of Microsoft Corporation in the United States and in other countries.

mass loading curve (the orange line) and displacing it to the computed 0.5 m PRZ curve so that mass loading is provided for the period considered by the FS.

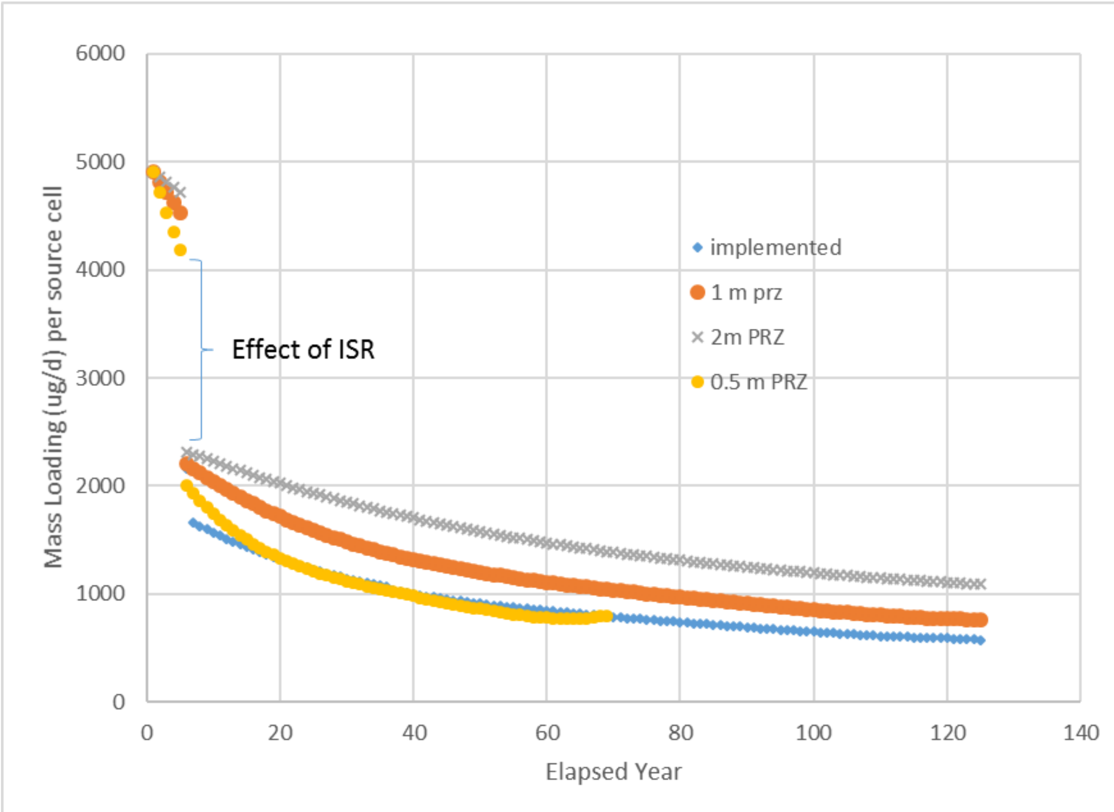

Figure 5. Cr(VI) Source Loading Curves

The range of mass loading shown in Figure 5 only considers the VZ/PRZ thickness. Additional variation will result from including the uncertainty in the leaching rate adjustment multiplier (Figure 2) that is about the same order of magnitude as the variation from VZ/PRZ. Thus, considering the range of uncertainty, all of the curves in Figure 5 are equivalent. The actual soil concentrations at the source areas are unknown, and significant irreducible uncertainties are present in this calculation as described in Section 7. Therefore, the calculation is considered an adequate approximation to represent source loading of Cr(VI) for the intended purpose of supporting transport simulations for the feasibility study.

7 Results/Conclusions

Conservative estimates of pore flushing based on recharge were generated for evaluating the impact of ISR on waste site 116-B-11. Several sources of uncertainty affect this calculation:

1. The actual distribution and concentration of soil contamination;
2. The leaching coefficient was estimated from core-scale data, and is applied at the field scale. This uncertainty is judged irreducible.
3. The data supporting leaching coefficient decay is very noisy (Figure 1) although the general behavior of less Cr(VI) leaching over time is observed. This uncertainty is judged irreducible. Site-specific monitoring and evaluation will be required to evaluate the true behavior.

4. The PRZ flow rate was assumed equivalent to current recharge of 63 mm/yr. Given the water table fluctuations that create the PRZ this is a lower flow rate than actual, which causes the leaching rate to reduce more slowly, and is a conservative assumption because chromium mass loading will remain higher longer than if a higher flow rate is used.

The two chromium leaching-related parameters judged to have irreducible uncertainty have ranges over orders of magnitude. Additional long-term monitoring may provide more insight into proper relative magnitudes. However, for the purposes of comparative analysis for the feasibility study, the mass loading estimates given here are within the potential range of uncertainty of the VZ/PRZ thickness and leaching rate adjustment multiplier, and broadly illustrate the potential that soil remediation to reduce the soil concentration can affect site conditions.

8 References

ECF-100BC5-16-0028, 2016, *Evaluation of Leaching Characteristics of Hexavalent Chromium from Contaminated 100-BC Sediments at Hanford Site to Estimate Time Dependent Mass Flux for Fate and Transport Modeling*, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington.

PNNL-17674, 2008, *Geochemical Characterization of Chromate Contamination in the 100 Area Vadose Zone at the Hanford Site*, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-17674.pdf.

SGW-59365, 2016, *Model Package Report: 100-BC Scale-Appropriate fate and Transport Model*, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington.