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Revision 0

Initial Concentration Conditions for Cr(VI) and NO3 at WMA S-SX for 2011

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

ch2m SM

P.O. Box 1600
Richland, Washington 99352

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C. Griffith
INTERA, Inc.

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By Julia Raymer at 3:05 pm, Feb 15, 2018

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ENVIRONMENTAL CALCULATION COVER PAGE

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Date: 08/15/2017

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Senior Reviewer:	JP McDonald/Sr Geologist		8/30/2017
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MS, Hydrogeology, The University of Texas at San Antonio, 2009

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Licenses: Professional Geoscientist (TX, IN, LA)

Daniel Lupton's professional experience ranges from geophysical well log analysis to evaluation of groundwater and surface water system interactions, and encompasses both field and numerical techniques. He has employed field techniques such as geophysical logging/correlation, water level sampling, and spring discharge surveys in conjunction with groundwater modeling to develop an improved understanding of complex flow systems. Much of Daniel's research experience has involved evaluations of groundwater basins to quantify local-, intermediate-, and regional-flow regimes. He co-developed a method for evaluating areas of recharge and discharge based on correlations of naturally occurring features. His project experience has centered on aquifer characterization techniques ranging from aquifer hydraulics to lithology/water quality. Additionally, Daniel has considerable experience in the evaluation and characterization of brackish water resources and the geologic units that contain these brackish resources. His current focus is on the analysis of geophysical logs in an attempt to evaluate water quality trends within groundwater basins. Much of this work involves the construction of geologic models using interpolation algorithms that are reflective of paleo-depositional environments. Daniel's work has afforded him the opportunity to extensively evaluate brackish groundwater resources in a number of aquifers within Texas, New Mexico, and Oklahoma.

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Terms

2-D	two-dimensional
3-D	three-dimensional
CHPRC	CH2M Hill Plateau Remediation Company
COC	contaminant of concern
Cr	chromium
CY	calendar year
ECF	environmental calculation file
EDA	Environmental Dashboard Application
EMMA	Environmental Model Management Archive
HEIS	Hanford Environmental Information System
HISI	Hanford Information System Inventory
NAVD88	North American Vertical Datum of 1988
NO_3	nitrate
OU	operable unit
WMA	waste management area

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1 Purpose

The purpose of this environmental calculation file (ECF) is to present the methodology, input data, and results used to delineate three-dimensional groundwater plumes for two contaminants of concern (COCs) – nitrate (NO_3) and chromium (Cr) – in the 200-UP-1 Operable Unit (OU) near and down-gradient of the Waste Management Area (WMA) S-SX tank farms. The three-dimensional interpolation was carried out in the Leapfrog-Geo®[1] geologic modeling platform, which includes an interpolation engine for analyzing and visualizing three-dimensional data.

Input data were derived from two-dimensional groundwater plumes developed in ECF-HANFORD-12-0075, *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2011 (CY2011) Hanford Site Groundwater Monitoring Report*, and from depth-discrete groundwater samples. Data from the two-dimensional plumes were placed at elevations corresponding to the March 2011 water table, and depth-discrete sample data were placed at the elevation of their collection depth. All interpolated plumes were reviewed by project scientists, and effort was made to incorporate site-specific expertise in the delineation of these plumes.

[1] Leapfrog Geo is a registered trademark of ARANZ Geo Limited of Christchurch, New Zealand.

2 Methodology

The three-dimensional interpolation was conducted following the general methodology described in the subsections below. All digital files discussed in the text are stored in the Environmental Model Management Archive (EMMA) indexed to this ECF.

2.1 Input Data Processing

1. An essential reference surface used in the development of the groundwater plumes is the March 2011 water table. This surface is in the form of a raster (numerical grid) at a resolution of 100 m, originating from DOE/RL-2011-118, *Hanford Site Groundwater Monitoring Report for 2011*. This raster is shown in the vicinity and down-gradient of the S-SX tank farm in Figure 1, and the file (*wt_2011.asc*) is included with this ECF as a digital file.

2. Depth-discrete groundwater sample data for nitrate and chromium in the vicinity and down-gradient of the S-SX tank farm were received in file *S-SX_CrNO3_DepthProfileSampleResults.xlsx*. Sample values, well coordinates, and surface elevations were retrieved from the Hanford Environmental Information System (HEIS) database via the Environmental Dashboard Application (EDA) available online at https://ehs.hanford.gov/eda/. These data were reviewed by John McDonald (INTERA, Incorporated) to retain highest-value sample results where duplicate analyses exist, to remove chromium sample results where reducing conditions are likely to exist, nitrate samples likely to have been affected by extraction wells, and nitrate samples collected too long ago to likely be representative of conditions in year 2011 (see Section 5 for details). Sample coordinates, elevations, and concentration values used for the three-dimensional interpolation are included in Appendix A for nitrate and Appendix B for chromium, and well locations with sample results for nitrate and chromium are respectively shown in Figure 2a and Figure 2b.

3. The two-dimensional representations of the nitrate plumes for 2011 developed in ECF-HANFORD-12-0075 were received as raster layer *200UP1_Nitrate_Ave_SSX_F9.asc*. The nitrate raster has a spatial resolution of 10 m, and concentrations are expressed in units of micrograms per liter (µg/L). This raster is shown in units of milligrams per liter (mg/L) in the S-SX tank farm area in Figure 2a.

4. The two-dimensional representation of the chromium plumes for 2011 developed in ECF-HANFORD-12-0075 were received as raster layers *200UP1_Chromium_Ave10REV.asc* and *200UP1_Chromium_AveREV_SSXF.asc*. The former raster has a spatial resolution of 40 m, and the latter has a resolution of 20 m. Numerical values directly from the grid are in transformed units (discussed below) and required back-transforming to obtain units of micrograms per liter (µg/L).

5. Geostatistical interpolation of the two-dimensional grid is described in Section 2 (Methodology) of ECF-HANFORD-12-0075, and input files used for kriging different data sets are given in Appendix C of the report. The input file used for *200UP1_Chromium_Ave10REV.asc* is *200UP1_Chromium_Ave_Matt.txt* given on page C-158 of the report, and the input file used for *200UP1_Chromium_AveREV_SSXF.asc* is *200UP1_Chromium_Ave_Matt_SSX.txt* given on page C-159. The header information in these input files indicates that the data were transformed using multiple-indicator kriging using the relations between output raster value and input concentration (same for both rasters) shown in Table 1.

Table 1. Relation Between the Chromium Plume Raster Value and Concentration

Raster Value	Concentration (µg/L)
0.95	10
1.5	20
2.5	48
3.5	100
4.5	500
5.5	1,000
6.5	2,000
7.5	5,000

6. The original chromium rasters from ECF-HANFORD-12-0075 are in the converted raster values and were not directly converted back to concentration values (note that the nitrate rasters are useable as received). To accomplish the back-transformation of the chromium rasters to concentrations (in µg/L), the original rasters were first subset to the area near the S-SX tank farm and converted to point shapefiles. These points are located at the center of each raster cell, and spatial coordinates (Washington State Plane South, NAD83, 4602) were calculated for each point. The attribute table from these shapefiles were copied to Microsoft Excel®[2], and this spreadsheet was used as an input file for a short Python program that maps input raster values to a Lagrange interpolating polynomial derived from the original kriging parameters given above and two additional (raster value, concentration) pairs (0, 0) and (0.3, 3), which were added subjectively to prevent erratic oscillation in the range [0, 0.95). The Python program writes an output Excel file, which is then used to create point shapefiles with the interpolated chromium concentrations at each point. These points were then converted to the rasters shown in Figure 2b. Files used to develop these back-transformed rasters are named below and are included with this ECF as digital files. A graphical representation of the Lagrange polynomial used to back-transform the chromium concentrations written by the program is also given.

   a. Original rasters subset to the S-SX tank farm area:

      i. *Subset_01_Cr_Ave10REV.tif*

      ii. *Subset_01_Cr_AveREV_SSXF.tif*

   b. Converted raster values to points using the ArcGIS toolbox *Conversion Tools > From Raster > Raster to Point*, extracted XY coordinates, and flagged obviously problematic cells for disuse (i.e., cells with a "GRID_CODE" value of zero or less) in point shapefiles:

      i. *rastervals_cr_original_subset01_ave10rev_051017.shp*

      ii. *rastervals_cr_original_subset01_averev_ssxf_051017.shp*

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

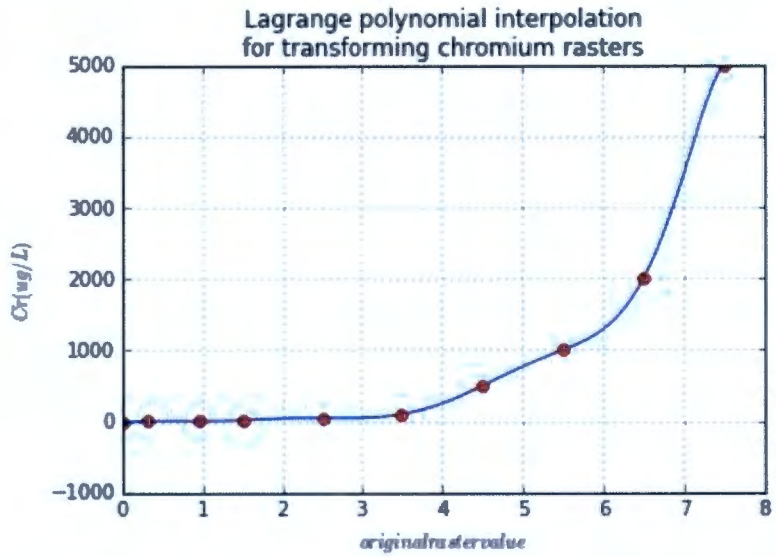
c. Copied attributes from these shapefiles to Excel spreadsheet *Cr_rastervals_for_interpolation_00_051017.xlsx*, which serves as the input file for the script in IPython Notebook:

   i. *chprc_Rel67_Cr_rasters_LagrangeInterpolation_051117.ipynb*.

      1. Uses Python 3.4; version used here installed using WinPython 64-bit distribution for Windows

      2. Requires modules numpy, matplotlib, and pandas

   ii. Plot of interpolating polynomial from within IPython Notebook:



   iii. Used script to map raster values from input file to the interpolating polynomial shown above, and output Excel file *Cr_interpolated_concentrations_051117.xlsx*, which contains separate tabs for the two different rasters.

d. Used the file *Cr_interpolated_concentrations_051117.xlsx* to create shapefiles of the interpolated chromium concentrations (μg/L). Within the shapefiles (not the Excel file), omitted all points with a "GRID_CODE" value less than 1.00 and at locations corresponding to the areas away from the plumes originating from the S-SX tank farm, as indicated on Figure 2a and Figure 2b.

   i. *2011_S-SX_Cr_interpolated_from_Ave10REV_01_051217.shp*

   ii. *2011_S-SX_Cr_interpolated_from_AveREV_SSXF_01_051217.shp*

e. Converted these point shapefiles to the following rasters using the ArcGIS toolbox *Conversion Tools > To Raster > Point to Raster*, specifying the original resolution of each raster (20 m for the AveREV_SSXF values and 40 m for the Ave10REV values):

   i. *2011_S-SX_Cr_interpolated_from_Ave10REV.tif*

   ii. *2011_S-SX_Cr_interpolated_from_AveREV_SSXF.tif*

   iii. These are the rasters shown in Figure 2b.

7. Extracted values from the March 2011 water table (Figure 1) to the following point shapefiles derived from the two-dimensional rasters of ECF-HANFORD-12-0075 (Figure 2a and Figure 2b). These points are shown symbolized by concentration in Figure 3a and Figure 3b.
   a. Nitrate point shapefile created from raster 200UP1_Nitrate_Ave_SSX_F9.asc using ArcGIS toolbox *Conversion Tools > From Raster > Raster to Point*:
      i. *2011_s-sx_no3_points_from_original_raster_050917.shp*
      ii. Original raster has no concentrations less than 30,000 µg/L (30 mg/L), so this is the minimum value for the point shapefile as well
      iii. Omitted points in locations disconnected and distant from S-SX tank farm plumes (e.g., see omitted areas on Figure 2a)
   b. Chromium point shapefiles created in the process described previously in step 5 of this subsection:
      i. *2011_S-SX_Cr_interpolated_from_Ave10REV_01_051217.shp*
      ii. *2011_S-SX_Cr_interpolated_from_AveREV_SSXF_01_051217.shp*
      iii. Omitted all points with a "GRID_CODE" (original raster) value less than 1.00 (corresponds to a concentration a little over 10 µg/L, based on the transform parameters noted in step 4 of this subsection) and omitted points corresponding to plumes disconnected and distant from S-SX tank farm plumes (e.g., see omitted area in Figure 2b)
8. The depth-discrete sample data and the two-dimensional raster concentration values plotted at elevations corresponding to the March 2011 water table were consolidated into the following input files for import into Leapfrog-Geo:
   a. *NO3_LeapfrogInput_02_051517.csv*
   b. *Cr_LeapfrogInput_02_051517.csv*

2.2 Data Import into Leapfrog-Geo

1. The point data comprised of raster values and depth-discrete data (files NO3_LeapfrogInput_02_051517.csv and Cr_LeapfrogInput_02_051517.csv discussed above) were imported in to Leapfrog-Geo by right-clicking on the "Points" tab in the Project Tree and selecting "Import Points" (*Points > Import Points*).
   a. To improve visualization, increased the vertical exaggeration of the project by clicking on the "Z-Scale" icon in the lower-right portion of the screen and entering a value of 20 into the dialog box.
2. A clipping boundary was set by right-clicking the "Topographies" tab in the Project Tree (Topographies > Set Clipping Boundary…). Because the coordinates of the input data points are in Washington State Plane South (NAD83, 4602, meters), the coordinates for the Leapfrog project are implicitly in the same coordinate system, and all imported layers must already be in the same coordinate system to be consistent. The following limits were placed on the project area so that only data within these boundaries are displayed:
   a. X (East): Minimum = 565,000 m; Maximum = 569,000 m
   b. Y (North): Minimum = 132,500 m; Maximum = 136,000 m

3. The water table raster wt_2011.asc was imported into Leapfrog-Geo using the "Topographies" tab in the Project Tree (Topographies > New Topography > Import Elevation Grid). Setting this raster as the "Topography" enables it to be set as the upper boundary for the plume interpolation domain.

4. Shapefiles of roads, buildings, and the S-SX tanks were imported into Leapfrog-Geo using the "GIS Data, Maps, and Photos" tab in the Project Tree (*GIS Data, Maps, and Photos > Import Vector Data...*). These were brought in to drape over the Topography layer (here, the water table) for visual reference. Beneath Topography in the view menu, GIS Data is selected by pulldown menu. Individual shapefiles can be displayed.

2.3 3-D Interpolation in Leapfrog-Geo

1. Interpolation is carried out using the built-in interpolation utility in Leapfrog-Geo. The 3D interpolation is accomplished using the proprietary FastRBF™ algorithm (Carr et al., 2001). The interpolation properties/parameters (Boundary, Trend, Value Transform, etc.) are accessed and adjusted by double-clicking on the Interpolant item of interest from the Project Tree.

2. Interpolant items for nitrate and chromium were initially created by selecting the appropriate input data set and units and accepting default parameters. This is accessed by right-clicking on the "Interpolants" tab in the Project Tree (Interpolants > New Interpolant). Adjustments to the interpolant were made after the plume was created within Leapfrog.

3. Within the Boundaries tab of the interpolants for nitrate and chromium, the option to use the Topography (the year 2011 water table raster, in this case) as the upper boundary for the interpolation domain was selected. X and Y values reported below are in the Washington State Plane South (4602, meters, NAD83) projection.

4. Parameters used within the Value Transform, Trend, Interpolant, and Outputs tab are reported in Section 5, Calculation. Isopleth values used for the creation of plume volumes were chosen to be consistent with those used in the 2-D interpolation of ECF-HANFORD-12-0075, with the addition of one higher bin to show more detail and aid in selecting interpolation parameters to yield results more consistent with input data values.

3 Assumptions and Inputs

Assumptions for the three-dimensional interpolations include the following:

1. The water table is static and adequately represented by the March 2011 water table raster.
2. Two-dimensional plume rasters developed in ECF-HANFORD-12-0075 apply to the upper surface of the water table.
3. The extents of the contaminant plumes are within the saturated portion of the unconfined units above the Ringold lower mud.

Input data for nitrate are included in this report digitally as file *NO3_LeapfrogInput_02_051517.csv*, and input data for chromium are included in this report digitally as file *Cr_LeapfrogInput_02_051517.csv*. These consist of depth-discrete data placed at the elevation at which samples were collected and values converted from the 2D rasters developed in ECF-HANFORD-12-0075 placed at elevations corresponding to the year 2011 water table. Details on input data are provided in Section 2.1 above.

Depth-discrete data for nitrate are included in this ECF as Appendix A, and depth-discrete data for chromium are included as Appendix B. Data derived from 2D rasters are only included digitally due to their large number.

4 Software Applications

Leapfrog-Geo, Microsoft Excel, and ArcGIS software programs were used for this calculation. These are CH2M Hill Plateau Remediation Company (CHPRC) approved software, managed and used in compliance with the requirements of PRC-PRO-IRM-309, *Controlled Software Management*. Leapfrog-Geo is approved calculation software with the approval documented in CHPRC-01755. Microsoft Excel was used as spreadsheet software. ArcGIS was used to extract values from two-dimensional rasters onto points, to place and determine projected coordinates of control points, and to manipulate shapefiles and their attributes.

4.1 Approved Software

Required descriptions for approved calculation software used in this calculation are provided below.

4.1.1 Description

Leapfrog-Geo

- Software Title: Leapfrog-Geo
- Software Version: 3.0.0
- Hanford Information System Inventory (HISI) Identification Number: 3592 (Safety Software S3, graded to Level C)
- Authorized Workstation Type and Property Number: INTERA, Incorporated Workstation Computer, Property Tag INTERA-00710
- Authorized User: C. Griffith
- CHPRC Software Control Documents:
    - CHPRC-01753: *Leapfrog-Hydro and Leapfrog-Geo Software Management Plan*
    - CHPRC-01754: *Leapfrog-Hydro and Leapfrog-Geo Software Test Plan*
    - CHPRC-01755: *Leapfrog-Hydro and Leapfrog-Geo Acceptance Test Report: Leapfrog-Hydro Version 2.3.2 and Leapfrog-Geo Version 3.0.0*

4.1.2 Software Installation and Checkout

The Approved Safety Software package (Leapfrog-Geo) was installed using vendor-provided installation files as specified in CHPRC-01753. Installation tests identified in CHPRC-01754 were performed and successful installation confirmed, and Software Installation and Checkout Forms were completed and approved for installations used to perform model runs reported in this calculation. A copy of the Software Installation and Checkout Form is provided in Appendix C of this ECF.

4.1.3 Statement of Valid Software Application

The preparers of this calculation attest that the software identified above and used for the calculations described in this calculation is appropriate for the application and used within the range of intended uses for which it was tested and accepted by CHPRC. Because Leapfrog-Geo is graded as Level C, use of this software is logged in the HISI. Accordingly, this ECF has been logged by the software owner in the HISI under Identification Number 3592.

5 Calculation

Three-dimensional interpolation was carried out for the two COCs NO_3 and Cr. The overall approach was kept consistent with the steps described above in the Methodology section of this ECF. Interpolation parameters were selected to match existing two-dimensional contours (ECF-HANFORD-12-0075) at the water table, to have geometries consistent with the depth-discrete sample data, and to be consistent with site knowledge of project scientists. Table 2 shows the interpolation parameters used for the nitrate plumes, and Table 3 shows the interpolation parameters used for the chromium plumes.

Specific considerations for the interpolations are listed below:

1. When duplicate samples/analyses are available for nitrate or chromium, the highest-value result was retained.
2. Omitted nitrate depth profile result for 299-W22-94. These samples were collected during 2013 and near extraction well 299-W22-90 and may therefore not be representative of 2011 conditions.
3. Omitted nitrate depth profile result for 299-W22-50. These samples were collected 12 years before 2011, and data are available from nearby well 299-W22-91 drilled in 2011.
4. Only three depth-discrete chromium results were used for 299-W22-47. Chromium results for other depths in this well are believed to have been affected by reducing conditions.
5. Reducing conditions may have occurred at wells 299-W22-89 and 299-W22-96, but chromium depth-discrete results were retained since they agree with later groundwater sample results collected after the wells had been completed.
6. Interpolated plumes and data were compared to the top of the Ringold Lower Mud surface (*HS_011217_RLM_elgrd_20m.asc*) to determine if the surface needs to be applied as a lateral extent to constrain plume interpolation. For the plumes discussed in this ECF, the bottom of the plumes is well above the Ringold Lower Mud, so no steps needed to be taken to constrain them to this surface.

Table 2. Interpolation Parameters Used for the Nitrate Plumes in Leapfrog-Geo

Trend			
Directions		Ellipsoid Ratio	
Dip	0°	Maximum	5
Dip Azimuth	11.5°	Intermediate	5
Pitch	0°	Minimum	1
Value Transform			
Type	Log		
Pre-transform Clipping:		Pre-log Shift	-0.849
Lower Bound	0.85	Bin Count	50
Upper Bound	536		
Interpolant			
Type	Spheroidal	Alpha	3
Sill	3,000	Nugget	0
Range	500	Accuracy	0.7
Drift	None		
Outputs			
Evaluation limits			
Minimum	10	Exact Clipping	Yes
Maximum	NA	Enclose	Intervals
Default Resolution:	5 m		
Intervals:	30 mg/L, 45 mg/L, 100 mg/L, 200 mg/L		

Table 3. Interpolation Parameters Used for the Chromium Plumes in Leapfrog-Geo

Trend			
Directions		Ellipsoid Ratio	
Dip	0°	Maximum	5
Dip Azimuth	11.5°	Intermediate	5
Pitch	0°	Minimum	1
Value Transform			
Type	Log		
Pre-transform Clipping:		Pre-log Shift	-0.999
Lower Bound	1	Bin Count	50
Upper Bound	1,043		
Interpolant			
Type	Spheroidal	Alpha	3
Sill	3,000	Nugget	0
Range	500	Accuracy	0.007
Drift	None		
Outputs			
Evaluation limits			
Minimum	0	Exact Clipping	Yes
Maximum	NA	Enclose	Intervals
Default Resolution:	5 m		
Intervals:	13 µg/L, 48 µg/L, 100 µg/L, 200 µg/L, 480 µg/L		

6 Results / Conclusions

Figure 4 shows the three-dimensional plumes for nitrate, and Figure 5 shows the three-dimensional plumes for chromium in the 200 West Area near and down-gradient of the S-SX tank farm. These figures show the plumes as three-dimensional volumes and input data points with values at or above 30 mg/L for nitrate and 13 µg/L for chromium. The Leapfrog-Geo 3.0.0 project file for these plumes is stored on EMMA, indexed to this ECF. Leapfrog Viewer 4.6 files for the two plumes are also stored on EMMA. These files are opened with the free Leapfrog Viewer, which is available at http://www.leapfrog3d.com/products/leapfrog-viewer.

7 References

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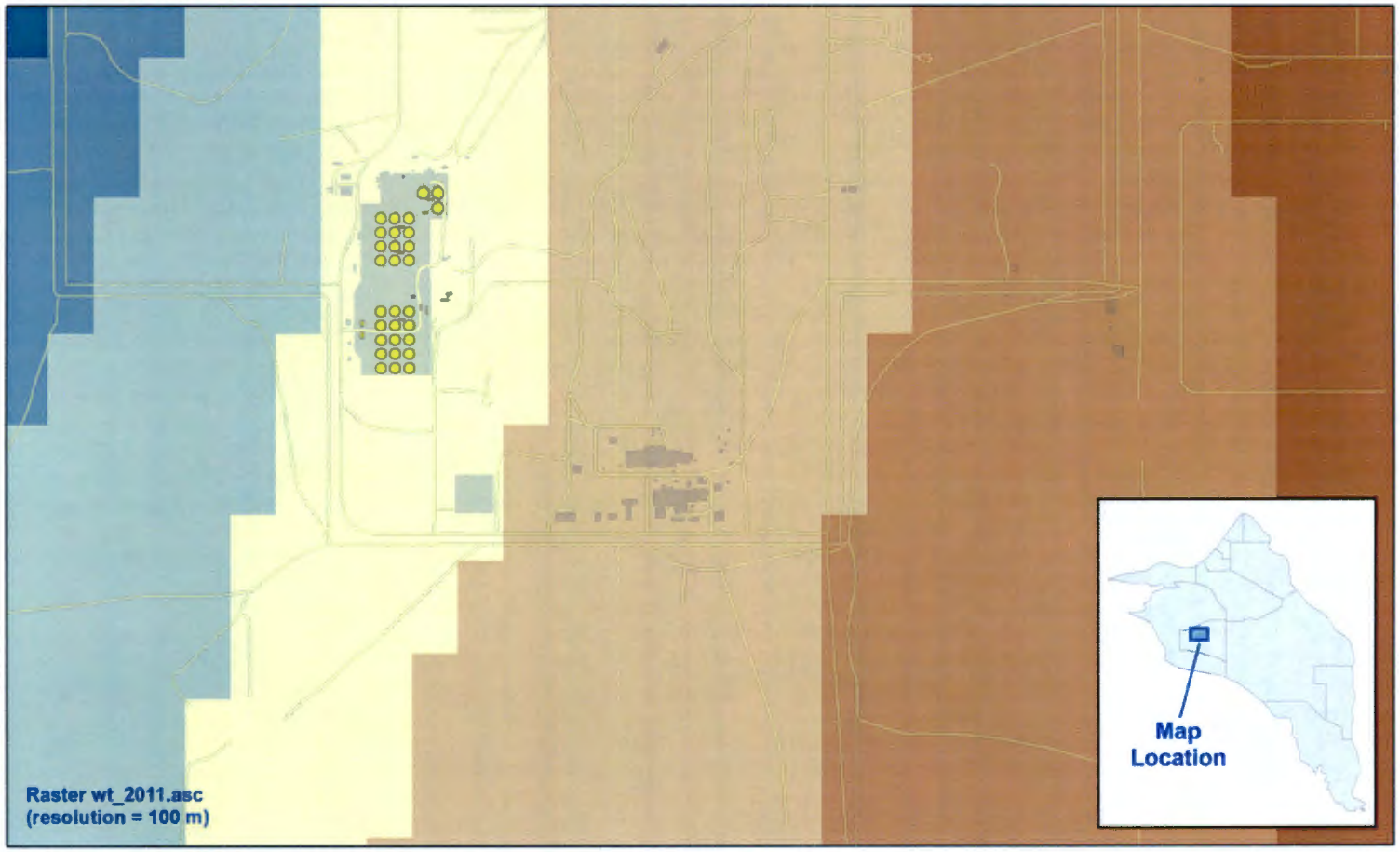


Figure 1
Year 2011 water table raster in the vicinity of the S-SX tank farm

S-SX Tanks
Roads
Buildings

Groundwater Elevation (m msl)
131 to 132 m
132 to 133 m
133 to 134 m
134 to 135 m
135 to 136 m
136 to 137 m
137 to 138 m

N
0 250 500
Meters

Figure 1. Year 2011 Water Table Raster in the Vicinity of the S-SX Tank Farm

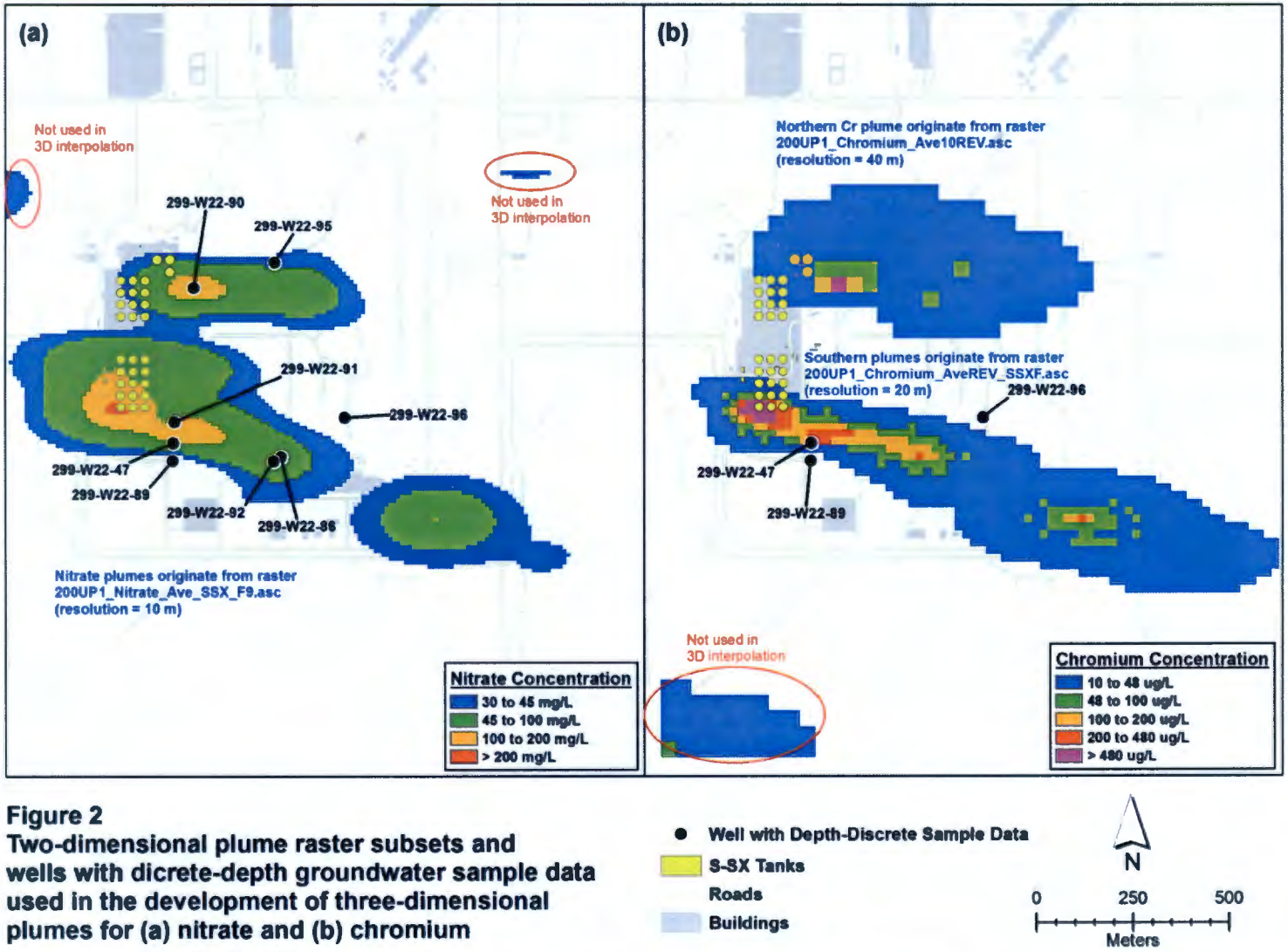


Figure 2
Two-dimensional plume raster subsets and wells with dicrete-depth groundwater sample data used in the development of three-dimensional plumes for (a) nitrate and (b) chromium

Figure 2. Two-dimensional Plume Raster Subsets and Wells with Discrete-depth Groundwater Sample Data used in the Development of Three-dimensional plumes for (a) Nitrate and (b) Chromium

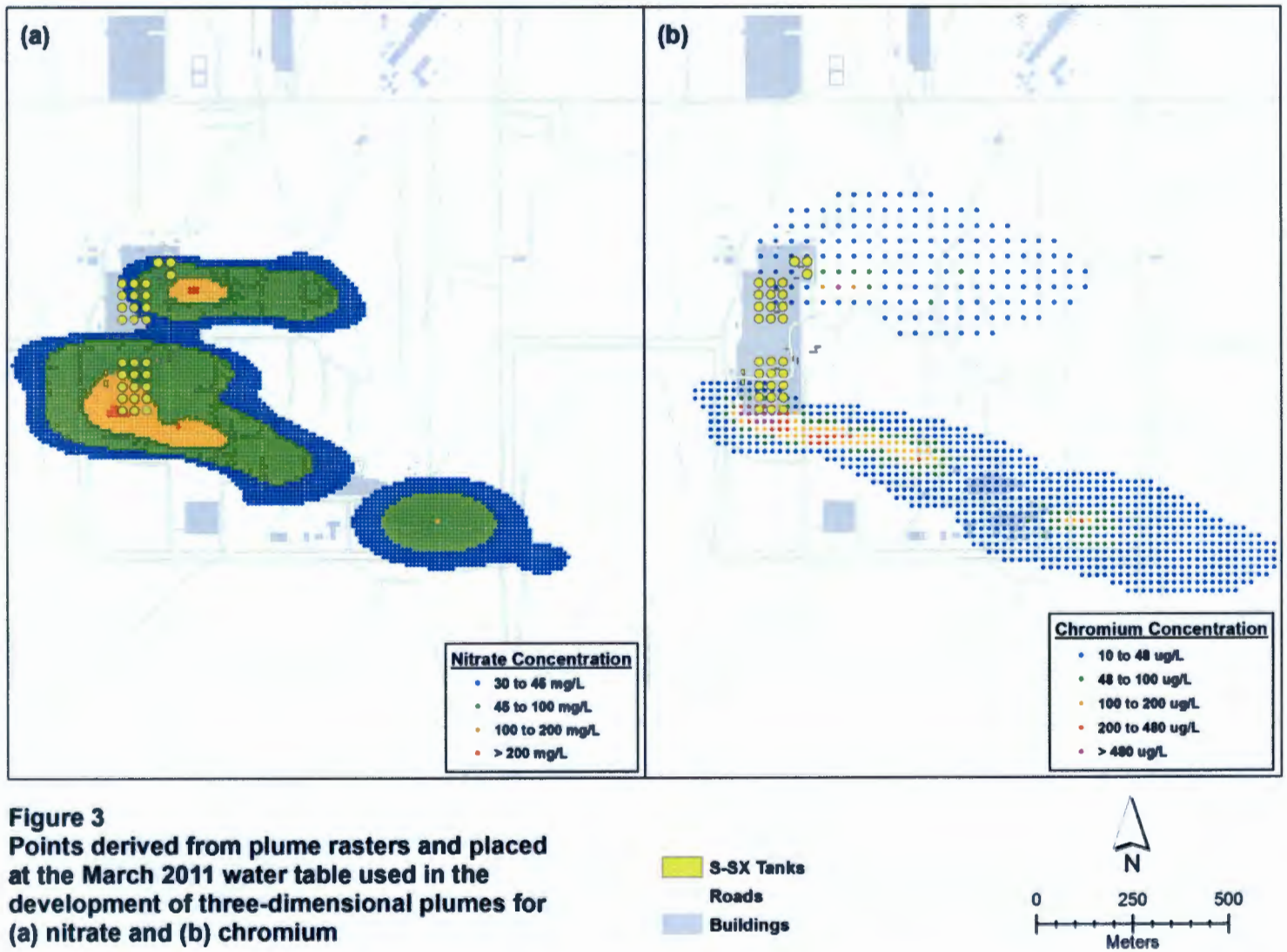
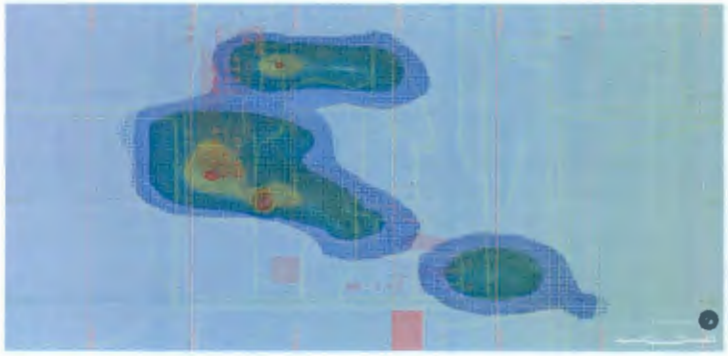


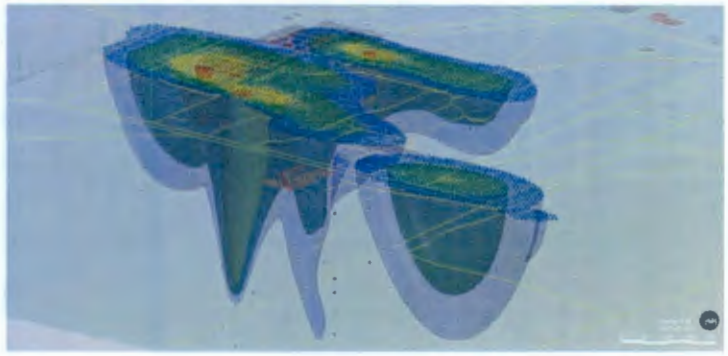
Figure 3
Points derived from plume rasters and placed at the March 2011 water table used in the development of three-dimensional plumes for (a) nitrate and (b) chromium

Figure 3. Points Derived from Plume Rasters and Placed at the March 2011 Water Table used in the Development of Three-dimensional Plumes for (a) Nitrate and (b) Chromium

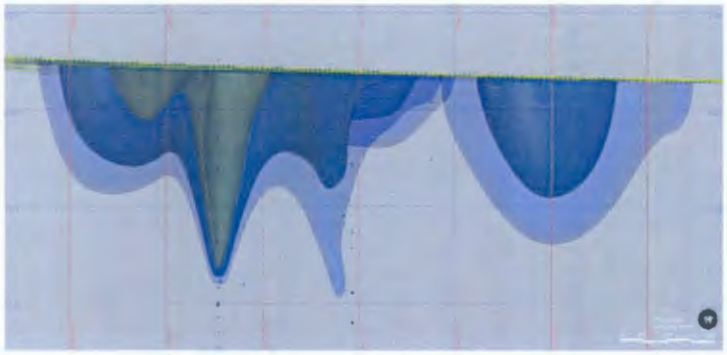
Map View



Oblique View from Southeast



Facing North



Facing West

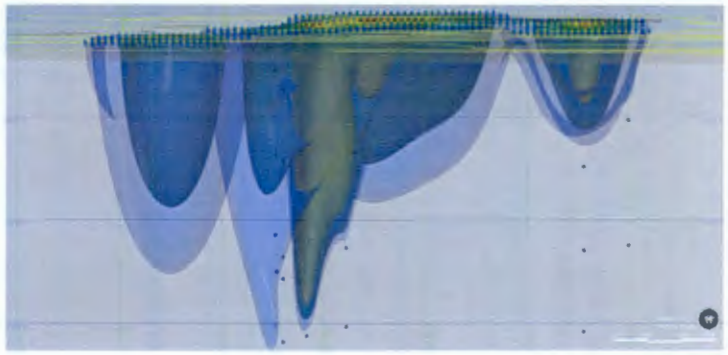


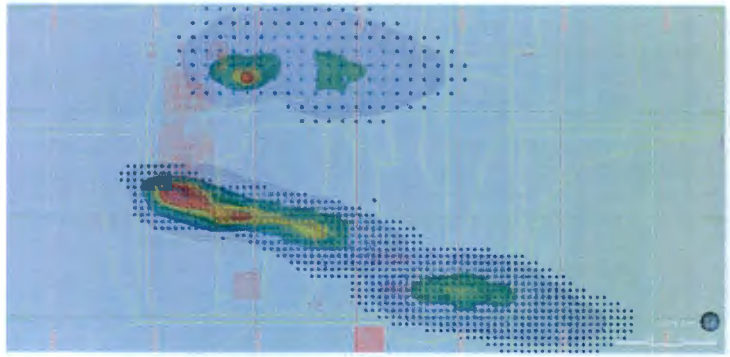
Figure 4
Interpolated nitrate plumes with concentrations of 30 mg/L or greater in the vicinity of the S-SX tank farm

Colored volumes indicate concentration intervals:
Blue: 30 to 45 mg/L
Green: 45 to 100 mg/L
Orange: 100 to 200 mg/L
Red: > 200 mg/L

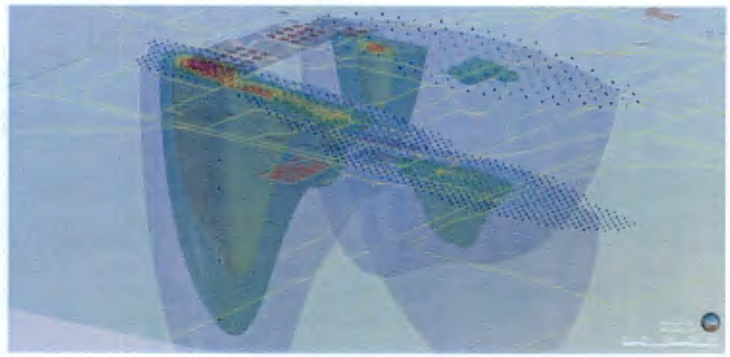
The upper surface of the plumes is the 2011 water table.
Vertical exaggeration = 20x.

Figure 4. Interpolated Nitrate Plumes with Concentrations of 30 mg/L or Greater in the Vicinity of the S-SX Tank Farm

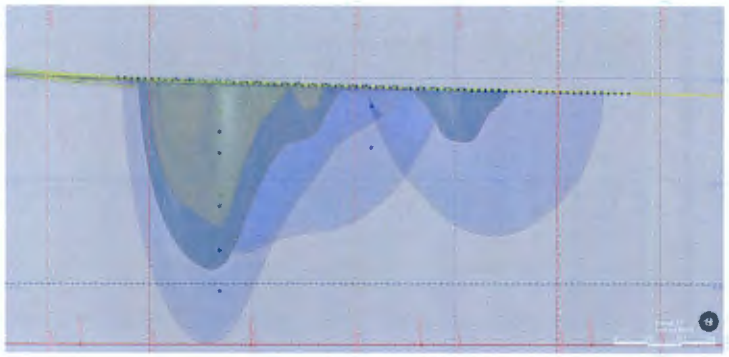
Map View



Oblique View from Southeast



Facing North



Facing West

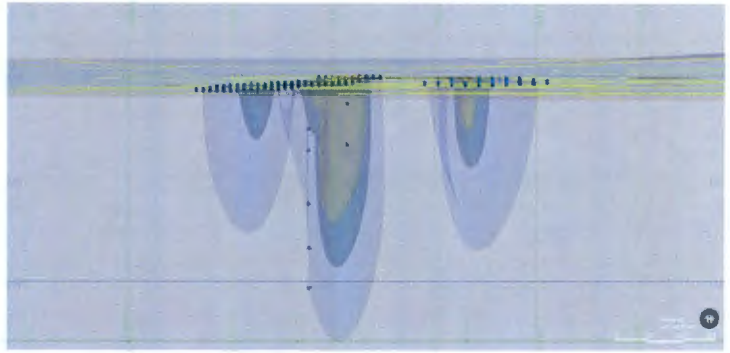


Figure 5
Interpolated chromium plumes with concentrations of 13 ug/L or greater in the vicinity of the S-SX tank farm

Colored volumes indicate concentration intervals:
Blue: 13 to 48 ug/L
Green: 48 to 100 ug/L
Orange: 100 to 200 ug/L
Red: 200 to 480 ug/L
Purple: > 480 ug/L

The upper surface of the plumes is the 2011 water table.
Vertical exaggeration = 20x.

Figure 5. Interpolated Chromium Plumes with Concentrations of 13 µg/L or Greater in the Vicinity of the S-SX Tank Farm

Appendix A

Depth-Discrete Data Used in the 3-D Plume Interpolation for Nitrate

Table A1. Depth-Discrete Data Used in the 3-D Plume Interpolation for Nitrate

Well Name	Land Surface Elev. (m msl)	Sample Depth (m bls)	Easting (X, m)	Northing (Y, m)	Sample Elevation (Z, m msl)	Nitrate (µg/L)	Nitrate (mg/L)
299-W22-47	205.533	70.41	566908.74	134076.28	135.123	176000	176
299-W22-47	205.533	71.63	566908.74	134076.28	133.903	456000	456
299-W22-47	205.533	73.15	566908.74	134076.28	132.383	469000	469
299-W22-47	205.533	74.07	566908.74	134076.28	131.463	536000	536
299-W22-47	205.533	75.59	566908.74	134076.28	129.943	478000	478
299-W22-47	205.533	77.11	566908.74	134076.28	128.423	491000	491
299-W22-47	205.533	78.64	566908.74	134076.28	126.893	487000	487
299-W22-47	205.533	80.16	566908.74	134076.28	125.373	478000	478
299-W22-47	205.533	81.99	566908.74	134076.28	123.543	483000	483
299-W22-47	205.533	83.21	566908.74	134076.28	122.323	327000	327
299-W22-47	205.533	84.73	566908.74	134076.28	120.803	352000	352
299-W22-47	205.533	86.26	566908.74	134076.28	119.273	400000	400
299-W22-47	205.533	87.78	566908.74	134076.28	117.753	362000	362
299-W22-47	205.533	89.31	566908.74	134076.28	116.223	216000	216
299-W22-47	205.533	90.83	566908.74	134076.28	114.703	338000	338
299-W22-47	205.533	92.35	566908.74	134076.28	113.183	63300	63.3
299-W22-47	205.533	93.88	566908.74	134076.28	111.653	17800	17.8
299-W22-47	205.533	95.4	566908.74	134076.28	110.133	29500	29.5
299-W22-47	205.533	96.93	566908.74	134076.28	108.603	19600	19.6
299-W22-47	205.533	98.45	566908.74	134076.28	107.083	10700	10.7
299-W22-47	205.533	99.97	566908.74	134076.28	105.563	36900	36.9

Table A1. Depth-Discrete Data Used in the 3-D Plume Interpolation for Nitrate

Well Name	Land Surface Elev. (m msl)	Sample Depth (m bls)	Easting (X, m)	Northing (Y, m)	Sample Elevation (Z, m msl)	Nitrate (µg/L)	Nitrate (mg/L)
299-W22-47	205.533	101.5	566908.74	134076.28	104.033	9690	9.69
299-W22-47	205.533	104.5	566908.74	134076.28	101.033	6020	6.02
299-W22-47	205.533	106.1	566908.74	134076.28	99.433	6510	6.51
299-W22-47	205.533	103	566908.74	134076.28	102.533	7750	7.75
299-W22-86	205.7	76.2	567186.74	134041.31	129.5	23000	23
299-W22-86	205.7	81.38	567186.74	134041.31	124.32	19000	19
299-W22-86	205.7	88.39	567186.74	134041.31	117.31	15000	15
299-W22-86	205.7	94.49	567186.74	134041.31	111.21	7000	7
299-W22-86	205.7	89.92	567186.74	134041.31	115.78	7000	7
299-W22-86	205.7	97.54	567186.74	134041.31	108.16	7000	7
299-W22-86	205.7	106.7	567186.74	134041.31	99	6000	6
299-W22-90	207.07	76.566	566961.39	134483.24	130.504	254000	254
299-W22-90	207.07	83.119	566961.39	134483.24	123.951	14600	14.6
299-W22-90	207.07	89.215	566961.39	134483.24	117.855	4430	4.43
299-W22-90	207.07	95.1	566961.39	134483.24	111.97	2170	2.17
299-W22-91	204.4	73.46	566911.76	134134.53	130.94	77000	77
299-W22-91	204.4	80.16	566911.76	134134.53	124.24	226000	226
299-W22-91	204.4	86.38	566911.76	134134.53	118.02	24300	24.3
299-W22-91	204.4	92.111	566911.76	134134.53	112.289	850	0.85
299-W22-92	205.558	74.646	567167.84	134029.77	130.912	54000	54
299-W22-92	205.558	80.833	567167.84	134029.77	124.725	69100	69.1

Table A1. Depth-Discrete Data Used in the 3-D Plume Interpolation for Nitrate

Well Name	Land Surface Elev. (m msl)	Sample Depth (m bls)	Easting (X, m)	Northing (Y, m)	Sample Elevation (Z, m msl)	Nitrate (µg/L)	Nitrate (mg/L)
299-W22-92	205.558	86.56	567167.84	134029.77	118.998	18200	18.2
299-W22-92	205.558	93.27	567167.84	134029.77	112.288	41300	41.3
299-W22-95	208.264	78.675	567170.54	134549.11	129.589	37500	37.5
299-W22-95	208.264	80.9092	567170.54	134549.11	127.3548	20100	20.1
299-W22-95	208.264	90.0471	567170.54	134549.11	118.2169	8370	8.37
299-W22-95	208.264	96.865	567170.54	134549.11	111.399	1130	1.13
299-W22-96	208.501	77.72	567351.93	134145.58	130.781	24700	24.7
299-W22-96	208.501	83.637	567351.93	134145.58	124.864	6060	6.06
299-W22-89	205.457	78.33	566906.77	134031.67	127.127	7920	7.92
299-W22-89	205.457	81.412	566906.77	134031.67	124.045	8190	8.19
299-W22-89	205.457	89.154	566906.77	134031.67	116.303	1450	1.45
299-W22-89	205.457	95.555	566906.77	134031.67	109.902	2900	2.9
299-W22-89	205.457	101.38	566906.77	134031.67	104.077	1570	1.57

bls = below land surface

msl = mean sea level

Appendix B

Depth-Discrete Data Used in the 3-D Plume Interpolation for Chromium

Table B1. Depth-Discrete Data Used in the 3-D Plume Interpolation for Chromium

Well Name	Land Surface Elev. (m msl)	Sample Depth (m bls)	Easting (X, m)	Northing (Y, m)	Sample Elevation (Z, m msl)	Chromium (µg/L)	Note
299-W22-47	205.533	75.59	566908.74	134076.28	129.943	196	--
299-W22-47	205.533	81.99	566908.74	134076.28	123.543	235	--
299-W22-47	205.533	87.78	566908.74	134076.28	117.753	142	--
299-W22-89	205.457	78.33	566906.77	134031.67	127.127	<13	Plotted at detection limit
299-W22-89	205.457	81.412	566906.77	134031.67	124.045	<13	Plotted at detection limit
299-W22-89	205.457	89.154	566906.77	134031.67	116.303	<13	Plotted at detection limit
299-W22-89	205.457	95.555	566906.77	134031.67	109.902	<13	Plotted at detection limit
299-W22-89	205.457	101.38	566906.77	134031.67	104.077	<13	Plotted at detection limit
299-W22-96	208.501	77.72	567351.93	134145.58	130.781	1.59	--
299-W22-96	208.501	83.637	567351.93	134145.58	124.864	<1	Plotted at detection limit

bls = below land surface

msl = mean sea level

Appendix C

Software Installation and Checkout

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: Leapfrog Geo — Software Version No.: 3.0.0

EXECUTABLE INFORMATION:

2. Executable Name (include path):

3. Executable Size (bytes): 5575 KB

COMPILATION INFORMATION:

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

   Vendor supplied

5. Operating System (include version number):

   Windows (Vendor supplied)

INSTALLATION AND CHECKOUT INFORMATION:

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

   INTERA-00710

7. Operating System (include version number):

   Windows 10 Pro - Version 1607

8. Open Problem Report? (●) No ( ) Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:

10. Procedure(s):

    per CHPRC-01754 Rev 0, Leapfrog Hydro Software Test Plan

11. Libraries:

    N/A

12. Input Files:

    per CHPRC-01754 Rev 0, Leapfrog Hydro Software Test Plan

13. Output Files:

    per CHPRC-01754 Rev 0, Leapfrog Hydro Software Test Plan

14. Test Cases:

    Vendor Installation Package, TC-1, TC-2,TC-3, TC-4

15. Test Case Results:

    Pass

16. Test Performed By: Clark Griffith (INTERA)

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

18. Disposition (include HISI update):

    Accepted; installation added to Hanford Off-Site user list

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: Leapfrog Geo — Software Version No.: 3.0.0

Prepared By:

19.	WE Nichols	
Software Owner (Signature)	Print	Date

20. Test Personnel:

Clark Griffith	Clark Griffith	11/18/2016
Sign	Print	Date
Sign	Print	Date
Sign	Print	Date

Approved By:

21.	N/R per SMP	
Software SME (Signature)	Print	Date

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