ECF-Hanford-13-0030
Revision 0

Initial Groundwater Plume Development to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units

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

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Initial Groundwater Plume Development to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units

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T. B. Hammond
INTERA, Inc.

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P.O. Box 1600
Richland, Washington 99352

APPROVED
By Ashley R Jenkins at 7:40 am, Jul 13, 2015

Release Approval Date

ENVIRONMENTAL CALCULATION COVER PAGE

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Terms

COPC	Contaminant of Potential Concern
CCU	Cold Creek unit
Hf	Hanford Formation (undifferentiated)
K_H	Horizontal Hydraulic Conductivity
Ringold E	Ringold Formation unit E
Ringold A	Ringold Formation unit A
Rlm	Ringold Formation lower mud unit
Rtf	Member of Taylor Flats of the Ringold Formation
TOB	Top of Basalt

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1 Purpose

Operations at the Hanford site have resulted in multiple contaminants of potential concern (COPC's) within the highly transmissive water bearing units of the suprabasalt aquifer. The purpose of this environmental calculation file (ECF) is to explain the steps involved in the creation of files that contain fate and transport model grid cells representative of groundwater contaminant plumes located in the supra-basalt sediment aquifers beneath the 200 BP-5 (BP-5) and 200 PO-1 (PO-1) operable units at the Hanford site. Objectively the goal of this ECF was to construct the plume fate and transport modeling grids as to utilize the most recent contaminant concentration data available for tritium, iodine-129, uranium-238, chromium(VI), cyanide, technetium-99, nitrate and strontium-90.

2 Background

Three dimensional (3D) COPC groundwater plumes have previously been constructed for use in fate and transport modeling for 200-UP-1 (UP-1) operable unit using the Leapfrog Hydro geologic modeling software (ECF-200UP1-14-0019) with depth-discrete plume information. Due to the much greater expanse of the plumes in the 200 East area, less depth-discrete plume information is available for this purpose and a more bounding approach for defining plume vertical extents is required. It was proposed to represent the vertical extent of the plumes for BP-5 and PO-1 by projecting these vertically downward, with uniform concentration, to a specified-depth boundary. This specified-depth boundary would be represented by a geological unit of lower horizontal hydraulic conductivity (K_H). A meeting was held with BP-5 and PO-1 project groundwater scientists on May 05, 2014, in which the proposed approach was reviewed and adopted. Subsequently, limited depth-discrete data were utilized (where available) to locally refine the general vertical plume definition.

In order to perform fate and transport modeling of COPC's within the highly transmissive upper hydrostratigraphic units of the suprabasalt aquifer, estimates of COPC concentrations were needed. This ECF provides an interpolation of point data to be used as part of numerical fate and transport modeling for the suprabasalt aquifer beneath the BP-5 and PO-1 operable units. The estimates will be used to establish the initial concentration values for the numerical model. Initial concentration is a term used in modeling to denote the estimated concentration at the start of the transient numerical model simulation.

3 Methodology

COPC plumes were created to represent average and maximum concentration initial conditions. Plume development for BP-5 and PO-1 involved nine major steps. These included: 1) data compilation, 2) creation of two dimensional plume extent raster grids, 3) determination of aquifer units containing the plumes and plume depth boundaries, 4) creation of a plume depth boundary surface, 5) assignment of plumes to a fate and transport model grid, 6) extraction of UP-1 3D plumes from Leapfrog Hydro, 7) combining 3D plumes (stitching) of the same constituents that are common to both the 200 UP-1 and BP-5 areas, 8) Insertion of depth-discrete data into the plumes and 9) plume checking. The ninth step was checking the model grid containing the plumes for errors. Upon completion of this final step the plumes were then ready to be used in COPC fate and transport runs. Evaluations of the results from the initial fate and transport runs provided additional checks upon plume construction quality and accuracy.

3.1 Data compilation

a. COPC concentration data were taken from Hanford Environmental Information System (HEIS) ranging from the most recent back to 2011. Depth-discrete data were taken from HEIS ranging from most recent back to 2009. Depth discrete data is derived from analyses of groundwater samples taken at different depths during drilling of boreholes.

b. The locations, screen depths and elevations of wells corresponding to COPC data were taken from HEIS.

3.2 Creation of two dimensional plume extent raster grids

a. All COPC plume extent and concentration ASCII files (plume grids) were obtained from the S.S. Papadopolus and Associates (SSP&A) FTP server with their express permission. The plume grids were developed by interpolating point sample data (from HEIS) obtained from monitoring wells, injection wells, inactive extraction wells, and aquifer tubes to a fine grid using Ordinary Kriging (OK) in two dimensions (2D; ECF-HANFORD-13-0012, REV. 0).

b. These files were then brought into GIS and converted to raster formats using the ArcMap 10.2.1 ArcToolbox Conversion tools →To Raster →ASCII to Raster functions.

3.3 Determination of aquifer units containing the plumes and plume depth boundaries

a. Polylines representing the horizontal extents of each plume were generated from the raster files created in step 2b above in GIS by using the ArcToolbox Conversion tools → From Raster → Raster to Polyline functions.

b. The polylines were then imported into Leapfrog Hydro and displayed at the elevation of the water table in the most up-to-date version of the Hanford South Geologic Solids Model (Central Plateau to river, ECF in progress).

c. Supra-basalt aquifer units below the water table, but above lower K_H units ("lower" refers to magnitude of K_H) and within the plume horizontal extents, were determined to contain the plumes. The lower K_H units are geologic units beneath higher K_H plume hosting units and serve as lower plume boundaries. This assumption was further confirmed by making sure that wells in the COPC dataset had screened open intervals within the plume hosting units. These plume hosting units included:

    i. Undifferentiated Hanford Formation (Hf)

    ii. Cold Creek unit of the Ringold formation (CCU)

    iii. Ringold Formation Unit E (Ringold E), only hosts plumes in areas where it is above the water table (see explanation below in step 3e)

d. Lower K_H units contacting higher plume hosting units were determined to serve as the plume depth boundaries. These units included:

    i. Top of Basalt (TOB)

    ii. Ringold Formation Unit E (Ringold E)

    iii. Ringold Formation Lower mud (RLM)

e. Lower K_H units extend above the water table in certain plume regions. To deal with this issue, a surface interpolated from the bottom-of-well-screen elevations was created using

Leapfrog Hydro. This surface was then exported from Leapfrog Hydro and then imported into ArcMap where it was integrated into a composite surface representing the lower boundary elevations for all COPC plumes.

3.4 Creation of a plume depth boundary surface

a. Previously generated ASCII files of the Hanford South Geologic Framework Model unit surfaces were imported into ArcMap and converted to raster files using the ArcMap 10.2.1 ArcToolbox Conversion tools →To Raster →ASCII to Raster functions. Rasters were created for the following units:

   i. Hf

   ii. CCU

   iii. Member of Taylor Flats of the Ringold Formation (Rtf)

   iv. Ringold E

   v. Rlm

   vi. Ringold Formation Unit A (Ringold A)

   vii. Top of basalt (TOB, most current version)

b. A base shape file was then created using ArcMap Geoprocessing→Union functions. The files combined using this function included all the geologic unit rasters listed above and the bottom-of-screen elevations surface. The output of these functions is a polygon feature shape file that is a mosaic of the input files that will serve as one single surface containing all of the total plume depth elevations (Figure 1). A column was added containing the lower plume bounding unit information for each polygon in the attribute table (Table 1). This column will represent the criteria for dissolving the fields for determining the final lower boundary areas for all plumes.

Table 1. Example of ArcMap Lower Plume Boundary Raster File Attributes

FID[a]	Shape	HSU[b]
8	Polygon	RWIE
9	Polygon	RLM
10	Polygon	RLM
11	Polygon	SCR
12	Polygon	TOB

a. Field I.D.

b. Hydrostratigraphic unit forming plume lower boundaries.

c. Refine the lower plume boundary areas in the base shape file created in step b by using ArcMap Geoprocessing→Dissolve. Be sure to check only “HSU” in the “Dissolve_Field(s)” option and click “create multipart features” at the bottom. The output file will be a shape file but the polygons represent the lower plume bounding units Ringold E (RWIE in Table 1), RLM, TOB or Bottom-of-screen (SCR in Table 1; Figure 1).

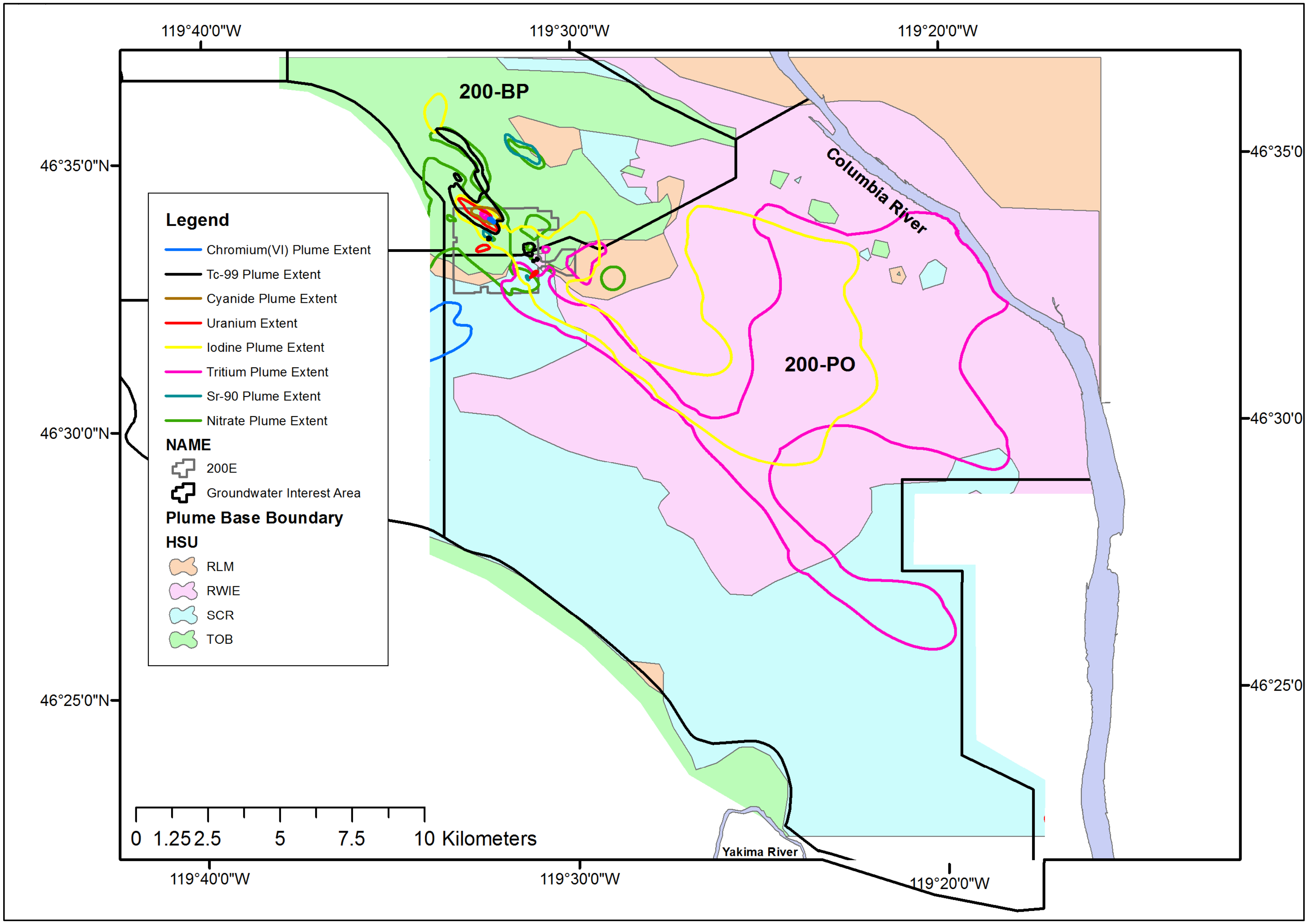

Figure 1. 2013 Plume Extents and Lower Boundary Surfaces

3.5 Assignment of plumes to fate and transport model grid

a. Since the plume raster cell size is 10 m by 10 m and the model cell size is 200 m by 200 m, it is necessary to assign a concentration value derived from all of the concentrations of the 10 m plume cells (interpolated in the 2D plumes from SSP&A) comprising each 200 m model cell. This was done using ArcMap ArcToolbox → Spatial Analyst Tool → Zonal → Zonal Statistics as Table. This tool was used to populate each 200 m model cell by taking the maximum value from all of the 10 m plume cells comprising the 200 m model cell.

b. The zonal statistics table was joined with the model grid shape file attribute table in ArcMap. The model grid shape file was then reformatted to a data file (.ref) which can be read by MODFLOW. These steps were done for each COPC.

c. An R script was then used to insert the concentration values into each cell for each of the seven model layers (see Attachment A). The script uses concentration data reference files (.ref), zone information files (.inf), ibound (indicating active or inactive cells) for MODFLOW (inf) and bottom elevation of each layer (.ref) to generate the plume for each layer.

3.6 Extraction of UP-1 3D plumes from Leapfrog Hydro

a. In Leapfrog Hydro, plume COPC concentrations were extracted from the desired plume interpolant in one meter intervals for each cell within the interpolated plume. Leapfrog Hydro plume cells forming the outer edge of the plumes vary in size. Therefore the number of extractions could vary from the peripheral plume cells between the more uniformly sized interior plume cells. This was done only for iodine-129, technetium-99, nitrate and uranium-238 as these were the only 3D plumes developed for UP-1.

b. Then the concentrations were tabulated in Excel and the average and maximum concentrations were calculated for each 200 m fate and transport model cell volume (see Table 2). Since the fate and transport model cells vary in thickness, the number of extractions could vary from cell to cell.

Table 2. Example of Excel Table Containing Extracted 3D Plume Concentrations

X	Y	Z[a]	I[a]	J[a]	TYPE[b]	U_2013	Extent[c]
567500	135500	81	39	18	1	0.44638	0
567400	135400	82	39	18	2	0.40692	1
567500	135500	82	39	18	1	0.44939	0
567400	135400	83	39	18	2	0.41202	1
567500	135500	83	39	18	1	0.45223	0

a. Z, I and J are grid spacing coordinates (m) within each 200 m 3D plume cell. 2D plume grids are 10 m resolution.

b. Type is the model layer

c. Extent refers to the plume from which the concentration (U_2013 column) is from. A value of 0 refers indicates concentrations from the BP-5 plume portion and a value of 1 indicates concentrations from the PO-1 plume portion.

c. Fate and transport model grid files were then created for average and maximum conditions for each of the seven, fate and transport model layers. These files were then reformatted as .ref files that could be stitched with the .ref plume files (BP-5 and PO-1) created in step 5.

3.7 Combining 3D plumes (stitching) of the same constituents that are common to both the UP-1 and BP-5 areas

a. An R script was used to stitch together the nitrate, uranium-238, iodine-129 and technetium-99 plumes (see Attachment B) by assigning concentrations from the region to be stitched from the either the .ref file from BP-5/PO-1 or UP-1. The script did this by using an .inf file that designated the locations of concentrations from either .ref file. This process was performed for all seven model layers (Figure 2).

3.8 Insertion of Depth-Discrete Data

a. Depth-discrete concentration data for BP-5 from analyses of samples collected in late 2009 and 2010 were used to replace interpreted values in model layers corresponding to the depth-discrete sampling elevations. Interpreted data refers to that assigned to the initial plumes in section 3.5 above. Replacement of initial interpreted values with depth-discrete data values was done by using a

"select-replacement" method in which the higher concentration of the interpreted and depth-discrete data values was assigned to the model grid cell. For example, if an interpreted value of 6.5 pCi/L versus a depth discrete value of 6.0 pCi/L existed for the same model cell location, the interpreted value would be assigned to the model grid cell as it is the higher of the two. The select-replacement method works as follows:

ii. Depth-discrete X, Y and Z (sample elevation) information for each COPC sampling location was converted to model grid row-column-line format.

iii. Pre-existing interpreted data at the depth-discrete sampling location was then replaced with depth-discrete COPC concentration data values if depth-discrete COPC concentration data values were greater.

iv. For average concentration initial conditions, depth-discrete data was averaged with pre-existing interpreted data and these averages replaced pre-existing interpreted data for those model grid cells.

3.9 Plume checking

a. Initial checking was done by examining the plume outlines set to the elevation of the water table in Leapfrog Hydro to check for proper plume placement with respect to their corresponding aquifer hosting geologic units.

b. All plumes were then imported into ArcMap and examined over the depth boundary surface (section 3.4) for their correct geographic placement (See Figures 1 and 2). This was done for all seven model layers for each plume. Attachment A contains maps of all plumes for all model layers.

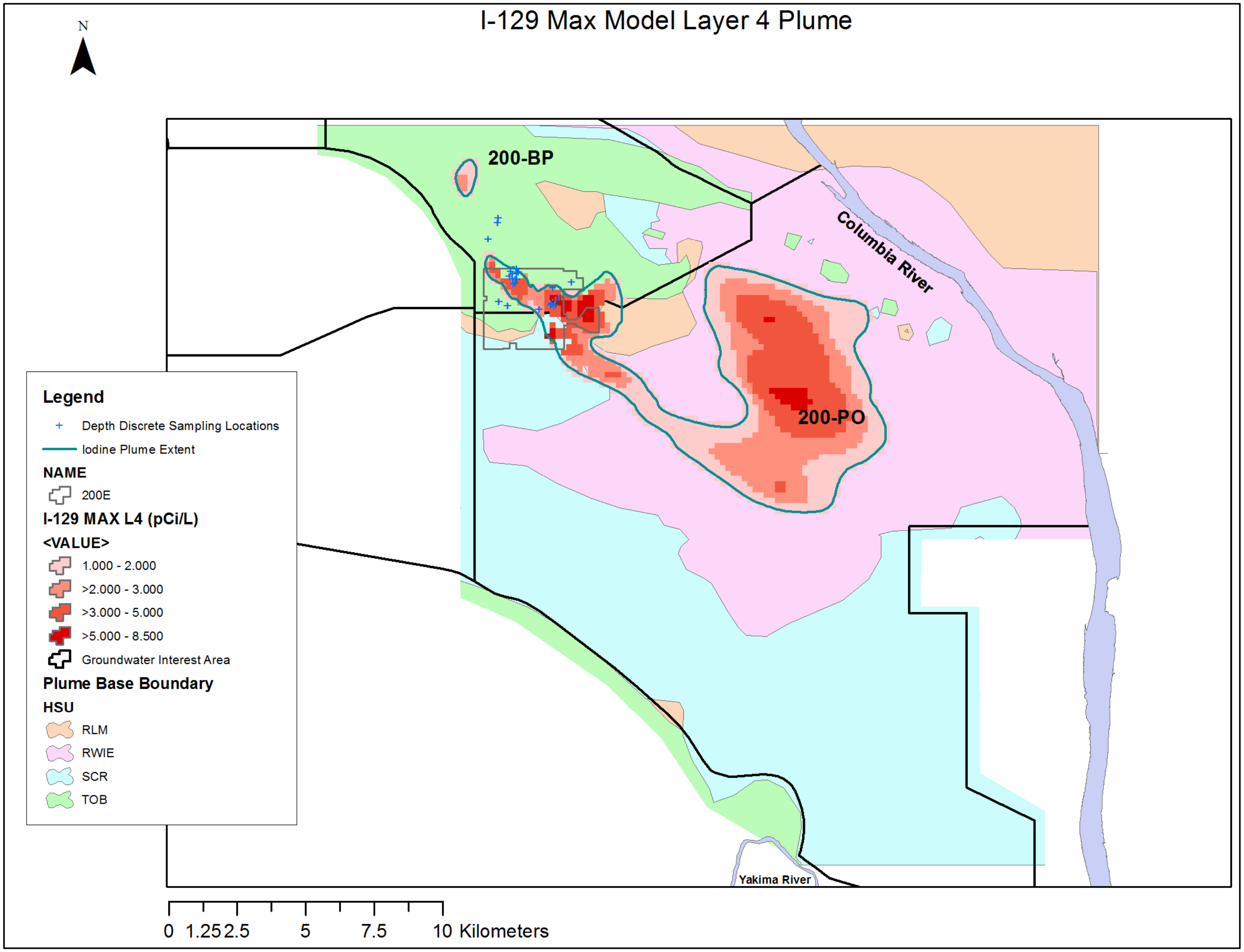

Figure 2. Example of a Stitched Plume (iodine-129 model layer 4)

4 Assumptions and Inputs

4.1 Assumptions

Two groups of assumptions exist that are involved with the gradient calculations discussed here in. Data assumptions include:

- All COPC concentration data obtained from HEIS and plume grids from SSP&A used were correct and are the results of quality analyses.
- All well location data (x, y and z) and well screen information used are correct.

Conceptual assumptions include:

- Plume lateral boundaries are limited by their 2D extents and plumes extend vertically directly downward from the water table to the top of a lower K_H aquifer unit. The top of the lower K_H aquifer unit serves as the lower plume boundary.
- In plume areas defined by wells screened across the water table and where the water table is below the top of a lower K_H aquifer unit, an interpolated surface based on the bottoms of well screen elevations serves as the lower plume boundary. This in effect preserves a more reasonable plume thickness in these areas in comparison with extending to the top of the lower-K_H unit. For example, saturated Ringold E is very thick in some areas where the top is above the water table and if the plume were to extend down to the top of the next unit (i.e., Rlm) it would contain extra COPC mass in exceedance of what is estimated to be present based on COPC concentration data.

4.2 Inputs

Inputs for the 2D plumes that were precursors to the 3D plumes included COPC concentration data ranging from the most recent back to 2011 and the corresponding well location and screen information. These data were queried from the HEIS. Inputs for 3D plume generation include 2D plume files from SSP&A (generated from the HEIS queried data) and UP-1 area 3D plumes previously created in Leapfrog Hydro. Surfaces generated by the Hanford South geologic framework model (ECF-HANFORD-13-0029, DRAFT A) served as inputs for the creation of the lower plume depth boundary surface.

5 Software Applications

Software used for this calculation is applicable in accordance with PRC-PRO-IRM-309, *Controlled Software Management.*

5.1 Approved Software

The following software was used to perform the calculations and was approved and compliant with PRC-PRO-IRM-309. This software is managed under the following documents consistent with the procedure: Leapfrog-Hydro is approved calculation software with the approval documented in CHPRC-01755, Rev. 1. Microsoft Excel® and Access and ArcGIS®3 software programs were used for this calculation as spreadsheet software.

5.2 Descriptions

Required software descriptions are approved in the subsections that follow.

5.2.1 Microsoft Excel® 2010

- Software title: Microsoft Excel® 2010
- Software Version: 2010
- Site licensed software managed by the IRM service provider, and hence exempt as a software tool, although the application of this software is reviewed as part of this calculation.
- Workstation type and property number (from which software is run): Dell Laptop (non-HLAN), Dell Service Tag #BX9MMQ1

5.2.2 Leapfrog Hydro®

- Software Title: Leapfrog Hydro®
- Software Version 2.1.1
- Hanford Information Systems Inventory (HISI) Identification Number: 2874 (Safety Software,graded Level C)
- Workstation type and property number (from which software is run): Dell Laptop (non-HLAN),Dell Service Tag #14610748609 and Dell Laptop (non-HLAN),Dell Service Tag #BX9MMQ1

5.2.3 ArcMap®

ArcMap® was used for grid math and interpolations using the spatial analyst tool and 3D analyst tools. The Zonal Statistics tool was used to adapt the 10 m plume cells to the 200 m model grid.

- Software Title: ArcMap®
- Software Version: Version 10.2.1
- Hanford Information Systems Inventory (HISI) Identification Number: (unregistered)
- Workstation type and property number (from which software is run): Dell Laptop (non-HLAN),Dell Service Tag #14610748609 and Dell Laptop (non-HLAN),Dell Service Tag #BX9MMQ1

5.3 Statement of Valid Software Application

- Microsoft Excel® 2010 was used for calculating the average and maximum COPC concentrations from the information extracted from the 3D plumes previously created for UP-1.
- Leapfrog Hydro® software identified was used consistent with intended use for CHPRC as identified in CHPRC-01753 and is a valid use of this software for the problem addressed in this application. This software was used within the limitations defined in CHPRC-01753 for CHPRC applications and was deemed suitable for use on the workstation mentioned in section 5.2.3 by software testing described in CHPRC-01754 Rev. 0. A copy of the Software Installation and Checkout form for this software is provided in Attachment A.
- ArcMap was used to support the assignment of COPC concentrations to the plumes and for generating a lower plume boundary surface for all plumes.

6 Calculation

Only basic average (mean) calculations were performed for this ECF. These calculations followed the simple formula for arithmetic mean:

$$\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

where $\overline{x}$ = mean concentration, x_i = each concentration value and n = the number of concentration values averaged.

7 Results/Conclusions

Sixteen contaminant plumes to be used in fate and transport modeling were created as a result of this ECF. Each of the eight COPC's had plumes constructed representing contamination under average conditions and maximum conditions. Under average conditions, the 200 m model grid cells contained the mean concentration of all of the 10 m plume grid cells comprising it. Under maximum conditions, the 200 m model grid cells contained the maximum concentration of all of the 10 m plume grid cells comprising it. Each of these plumes was defined, where appropriate, for each of the seven model layers.

Four of the plumes were stitched together from newly created plumes for BP-5/PO-1 and previously created 3D plumes for UP-1. The stitched plumes included those for iodine-129, nitrate, technetium-99 and uranium-238. The four remaining plumes (tritium, cyanide, chromium(VI) and strontium-90) were not stitched. The final plumes were formatted as reference (.ref) files that can be read by MODFLOW. All final plume files have been submitted for fate and transport modeling. Attachment C contains plume maps for all each COPC for each model layer. Attachment D contains tables listing the mean, maximum, 90th percentile and standard deviation values for average and maximum conditions for each plume model layer.

Uncertainties associated with COPC plumes creation include the potential for error in sample analysis resulting in concentration data errors, errors in well location information and calculation and utility software malfunctions. However, the magnitude of the above mentioned uncertainties is small due to laboratory quality control measures, well survey quality control measures and software testing.

7.1 Chromium(VI)

The chromium(VI) plume exists in two sections. A small section is located in BP-5 and a large section is located on the western margin of PO-1 (Figures C-1 through C-8). The highest mean concentration under average conditions occurred in layer 1 with concentration gradually decreasing down to layer 4 at which point a large decrease occurred. Maximum concentrations under both average and maximum conditions were consistent for all four layers.

7.2 Cyanide

The cyanide plume is present only in BP-5 and is the smallest plume in area (Figures C-9 through C-22). The highest mean and maximum concentrations under average conditions occurred in layers 1 and 2 (Table D-2). Under maximum conditions, the highest mean was in layer 2 and the highest maximum concentration occurred in layers 1 through 4.

7.3 Tritium

The tritium plume is extensive and is present in multiple parts in ZP-1, UP-1, BP-5, 300-FF-5 and PO-1 but most significantly in PO-1 (Figures C-23 through C-36). The highest mean concentration under average conditions were seen in layer 1 decreasing slightly down to layer 4 at which point a sharp decrease in concentration occurred (Table D-3). This trend was identical for mean concentration under maximum conditions. The maximum concentration under average conditions, were consistent down to layer 5 at which point a sharp decrease occurred. Under maximum conditions, maximum concentrations were generally the same (~647,624 pCi/L) for all layers except layers 4 and 6 where concentrations dropped by an order of magnitude.

7.4 Iodine-129

The iodine plume is extensive and is present in multiple parts in ZP-1, UP-1, BP-5 and PO-1 but most significantly in PO-1 (Figures C-37 through C-50). Mean concentrations under average and maximum conditions increased slightly to their highest in layer 4 at which point concentrations dropped sharply (Table D-4). Maximum concentrations under average and maximum conditions increased gradually down to layer 4 to their highest values and then sharply decreased.

7.5 Nitrate

The nitrate plume is present in ZP-1, UP-1, BP-5 and PO-1 with a small sub-plume in 300-FF-5 (Figures C-51 through C-64). The largest portion exists in BP-5. Mean concentrations under average and maximum conditions were highest in layer 2 at which point concentrations decreased (Table D-5). Maximum concentrations under average conditions gradually decreased from their highest values in layers 1 and 2 to the lowest values in layers 6 and 7. Maximum concentrations under maximum conditions are highest in layer 2 and then decreased below layer 4.

7.6 Strontium-90

The strontium-90 plume is present in BP-5 and PO-1 with the largest portion in BP-5 (Figures C-65 through C-78). Maximum concentrations under average and maximum conditions are the same for all layers (Table D-6). Mean concentrations under average and maximum conditions are highest in layer 1 and gradually decrease to their lowest values in layers 6 and 7.

7.7 Technetium-99

The technetium-99 plume present in multiple parts in ZP-1, UP-1, BP-5 and PO-1 with the largest portion in BP-5 (Figures C-79 through C-92). Mean concentrations under average and maximum conditions are highest in layers 4 and 2 respectively and decrease down to layer 7 (Table D-7). Maximum concentrations under average conditions are highest in layers 1 and 2 and gradually decrease down to layer 7. Maximum concentrations under maximum conditions are consistent down to layer 4 at which point concentrations increase and then decrease down to layers 5, 6 and 7.

7.8 Uranium-238

The uranium-238 plume is present in multiple parts in UP-1, BP-5 and PO-1 with the largest portion of the plume in BP-5 (Figures C-93 through C-106). Mean concentration under average conditions is highest in layer 2 and gradually decreases down to layers 6 and 7 (Table D-8). Maximum concentrations under average conditions are also highest in layer 2 but decrease sharply down to layers 3 through 7. Maximum concentrations under average conditions decrease gradually from their highest values in layers 2 and 3 down to their lowest values in layers 6 and 7. Maximum concentrations under maximum conditions are constant down to layer 4 at which point there is a sharp decrease in concentration for layers 5 through 7.

8 References

CHPRC-01753 Rev. 0, Leapfrog-Hydro Software Management Plan, CH2M Hill Plateau Remediation Company, Richland, Washington.

CHPRC-01754 Rev. 0, Leapfrog-Hydro Software Test Plan, CH2M Hill Plateau Remediation Company, Richland, Washington.

CHPRC-01755 Rev. 1, Leapfrog-Hydro Acceptance Test Report: Version 2.1, CH2M Hill Plateau Remediation Company, Richland, Washington.

ECF-HANFORD-13-0012, Rev.0, Calculation and Depiction of Groundwater Contamination for the Calendar Year 2012 (CY2012) Hanford Site Groundwater Monitoring Report, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-HANFORD-13-0029, DRAFT A. (In Review), Development of the Hanford South Geologic Framework Model, Hanford Site Washington, CH2M HILL Plateau Remediation Company, Richland, Washington.

ECF-200UP1-14-0019, 2014, Initial Groundwater Plume Development (Uranium, Technetium-99, Nitrate, and Iodine-129) to Support Fate and Transport Modeling for Remedial Design in the 200-UP-1Groundwater Operable Unit, CH2M-HILL Plateau Remediation Company, Richland, Washington.

PRC-PRO-IRM-309, 2009, Controlled Software Management, Rev. 3, CH2M HILL Plateau Remediation Company, Richland, Washington.

Attachment A

R Script Used for Model Layer Concentration Value Population

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```
nr=135
nc=155
nl=7

format_num=10
conc2d<-array(1,dim=c(nr,nc))
base<-array(1,dim=c(nr,nc))
zone<-array(1,dim=c(nl,nr,nc))
bote<-array(1,dim=c(nl,nr,nc))
tope<-array(1,dim=c(nl,nr,nc))
ibnd<-array(1,dim=c(nl,nr,nc))
scre<-array(1,dim=c(nr,nc))
conc<-array(1,dim=c(nl,nr,nc))

for (ilay in 1:nl) {
  for (irow in 1:nr) {
    for (icol in 1:nc) {
      tope[ilay,irow,icol] = 500
      bote[ilay,irow,icol] = 0
      zone[ilay,irow,icol] = 0
      conc[ilay,irow,icol] = 0
      ibnd[ilay,irow,icol] = 0
      conc2d[irow,icol] = 0
      base[irow,icol] = 0
      scre[irow,icol] = 90
    }
  }
}

zone_list<-read.table("zone_table.txt",header=TRUE,sep=",")
```

```
tmp<-read.delim("H3_temp.ref",header=FALSE,sep="")
for (irow in 1:nr) {
  for (icol in 1:nc) {
    tmpMod = icol%%format_num
    if (tmpMod == 0) {
      tmpMod = format_num
    }
    conc2d[irow,icol] = as.numeric(tmp[((irow-1)*ceiling(nc/format_num))+ceiling(icol/format_num) ,
tmpMod])
  }
}

tmp<-read.delim("screen_layer.ref",header=FALSE,sep="")
for (irow in 1:nr) {
  for (icol in 1:nc) {
    tmpMod = icol%%format_num
    if (tmpMod == 0) {
      tmpMod = format_num
    }
    scre[irow,icol] = as.numeric(tmp[((irow-1)*ceiling(nc/format_num))+ceiling(icol/format_num) ,
tmpMod])
  }
}

tmp<-read.delim("Plume_D_HSU.inf",header=FALSE,sep="")
for (irow in 1:nr) {
  for (icol in 1:nc) {
    tmpMod = icol%%format_num
```

```
    if (tmpMod == 0) {
      tmpMod = format_num
    }
    base[irow,icol] = as.numeric(tmp[((irow-1)*ceiling(nc/format_num))+ceiling(icol/format_num) ,
tmpMod])
  }
}

for (ilay in 1:nl) {
  tmp<-read.delim(paste("bot",ilay,".ref",sep=""),header=FALSE,sep="")
  for (irow in 1:nr) {
    for (icol in 1:nc) {
    tmpMod = icol%%format_num
    if (tmpMod == 0) {
      tmpMod = format_num
    }
      bote[ilay,irow,icol] = as.numeric(tmp[((irow-1)*ceiling(nc/format_num))+ceiling(icol/format_num) ,
tmpMod])
      if (ilay != nl) {
        tope[ilay+1,irow,icol] = bote[ilay,irow,icol]
      }
    }
  }
}

format_num = 50

for (ilay in 1:nl) {
  tmp<-read.delim(paste("k_zone_",ilay,"e.inf",sep=""),header=FALSE,sep="")
  for (irow in 1:nr) {
    for (icol in 1:nc) {
```

```
    tmpMod = icol%%format_num
    if (tmpMod == 0) {
      tmpMod = format_num
    }
      zone[ilay,irow,icol] = as.numeric(tmp[((irow-1)*ceiling(nc/format_num))+ceiling(icol/format_num) ,
tmpMod])
    }
  }
}

format_num = 25

for (ilay in 1:nl) {
  tmp<-read.delim(paste("ibnd",ilay,".inf",sep=""),header=FALSE,sep="")
  for (irow in 1:nr) {
    for (icol in 1:nc) {
    tmpMod = icol%%format_num
    if (tmpMod == 0) {
      tmpMod = format_num
    }
      ibnd[ilay,irow,icol] = as.numeric(tmp[((irow-1)*ceiling(nc/format_num))+ceiling(icol/format_num) ,
tmpMod])
    }
  }
}

format_num = 10
mud_id = 8
for (irow in 1:nr) {
  for (icol in 1:nc) {
    tmp_HSU = zone_list$ZONE_ID[which(zone_list$BASE_ID == base[irow,icol])]
```

```
#If based on HSU go through the zone list
HSU_FOUND = 0

if (tmp_HSU == 10) {
  for (ilay in 1:nl) {
    if (ibnd[ilay,irow,icol]>0) {
      if (scre[irow,icol]<=tope[ilay,irow,icol] ) {
        #  Use the elevation but don't go below mud
        if (HSU_FOUND == 0 && zone[ilay,irow,icol] != mud_id ) {
          conc[ilay,irow,icol] = conc2d[irow,icol]
        } else {
          conc[ilay,irow,icol] = 0
          HSU_FOUND = 1
        }
      }
    }
  }
} else {
#else it is based on elevation
  for (ilay in 1:nl) {
    if (ibnd[ilay,irow,icol] != 0) {
      if (HSU_FOUND == 0 && zone[ilay,irow,icol] != tmp_HSU ) {
        conc[ilay,irow,icol] = conc2d[irow,icol]
      } else {
        conc[ilay,irow,icol] = 0
        HSU_FOUND = 1
      }
    }
  }
```

```
    }
  }
}


for (ilay in 1:nl) {
  cat(file=paste("out_conc",ilay,".ref",sep=""),"",append=FALSE)
  for (irow in 1:nr) {
    for (icol in 1:nc) {
      tmpVal = sprintf(" %13.6e",conc[ilay,irow,icol])
      tmpStr = paste(tmpStr,tmpVal,sep="")
      if (icol == nc) {
        cat(file=paste("out_conc",ilay,".ref",sep=""),paste(tmpStr,"\n",sep=""),append=TRUE)
        tmpStr = ""
      } else if  ((icol %% format_num) == 0) {
        cat(file=paste("out_conc",ilay,".ref",sep=""),paste(tmpStr,"\n",sep=""),append=TRUE)
        tmpStr = ""
      }
    }
  }
}


#  cat(file=paste("out_conc",".ref",sep=""),"",append=FALSE)
#  for (irow in 1:nr) {
#    for (icol in 1:nc) {
#      tmpVal = sprintf(" %13.6e",conc2d[irow,icol])
#      tmpStr = paste(tmpStr,tmpVal,sep="")
#      if (icol == nc) {
```

```
#        cat(file="out_conc.ref",paste(tmpStr,"\n",sep=""),append=TRUE)
#        tmpStr = ""
#      } else if ((icol %% format_num) == 0) {
#        cat(file="out_conc.ref",paste(tmpStr,"\n",sep=""),append=TRUE)
#        tmpStr = ""
#      }
#    }
#  }
```

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Attachment B

R Script Used for Plume Stitching

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```
nr=135
nc=155
nl=7
tmpStr = ""
tmpVal = 0
format_num=10
bp_5<-array(1,dim=c(nl,nr,nc))
up_1<-array(1,dim=c(nl,nr,nc))
finl<-array(1,dim=c(nl,nr,nc))
stch<-array(1,dim=c(nr,nc))

for (ilay in 1:nl) {
  for (irow in 1:nr) {
    for (icol in 1:nc) {
      bp_5[ilay,irow,icol] = 0
      up_1[ilay,irow,icol] = 0
      finl[ilay,irow,icol] = 0
      stch[irow,icol] = 0
    }
  }
}

tmp<-read.delim("stitch.inf",header=FALSE,sep="")
for (irow in 1:nr) {
  for (icol in 1:nc) {
    tmpMod = icol%%format_num
    if (tmpMod == 0) {
      tmpMod = format_num
    }
    stch[irow,icol] = as.numeric(tmp[((irow-1)*ceiling(nc/format_num))+ceiling(icol/format_num) ,
tmpMod])
  }
}

for (ilay in 1:nl) {
  tmp<-read.delim(paste("./IC/out_conc",ilay,".ref",sep=""),header=FALSE,sep="")
  for (irow in 1:nr) {
    for (icol in 1:nc) {
      tmpMod = icol%%format_num
      if (tmpMod == 0) {
        tmpMod = format_num
      }
      bp_5[ilay,irow,icol] = as.numeric(tmp[((irow-1)*ceiling(nc/format_num))+ceiling(icol/format_num) ,
tmpMod])
    }
  }
}


for (ilay in 1:nl) {
  tmp<-read.delim(paste("./UP1/U_cnc2avg",ilay,".ref",sep=""),header=FALSE,sep="")
```

```
  for (irow in 1:nr) {
    for (icol in 1:nc) {
      tmpMod = icol%%format_num
      if (tmpMod == 0) {
        tmpMod = format_num
      }
      up_1[ilay,irow,icol] = as.numeric(tmp[((irow-1)*ceiling(nc/format_num))+ceiling(icol/format_num) ,
tmpMod])
    }
  }
}

format_num = 10
mud_id = 8
for (ilay in 1:nl) {
  for (irow in 1:nr) {
    for (icol in 1:nc) {
      if (stch[irow,icol] == 1) {
        finl[ilay,irow,icol] = up_1[ilay,irow,icol]
      } else {
        finl[ilay,irow,icol] = bp_5[ilay,irow,icol]
      }
    }
  }
}


for (ilay in 1:nl) {
  cat(file=paste("fin_plm",ilay,".ref",sep=""),"",append=FALSE)
  for (irow in 1:nr) {
    for (icol in 1:nc) {
      tmpVal = sprintf(" %13.6e",finl[ilay,irow,icol])
      tmpStr = paste(tmpStr,tmpVal,sep="")
      if (icol == nc) {
        cat(file=paste("fin_plm",ilay,".ref",sep=""),paste(tmpStr,"\n",sep=""),append=TRUE)
        tmpStr = ""
      } else if  ((icol %% format_num) == 0) {
        cat(file=paste("fin_plm",ilay,".ref",sep=""),paste(tmpStr,"\n",sep=""),append=TRUE)
        tmpStr = ""
      }
    }
  }
}



#  cat(file=paste("out_conc",".ref",sep=""),"",append=FALSE)
#  for (irow in 1:nr) {
#    for (icol in 1:nc) {
#      tmpVal = sprintf(" %13.6e",conc2d[irow,icol])
#      tmpStr = paste(tmpStr,tmpVal,sep="")
```

```
#      if (icol == nc) {
#        cat(file="out_conc.ref",paste(tmpStr,"\n",sep=""),append=TRUE)
#        tmpStr = ""
#      } else if ((icol %% format_num) == 0) {
#        cat(file="out_conc.ref",paste(tmpStr,"\n",sep=""),append=TRUE)
#        tmpStr = ""
#      }
#    }
#  }
```

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Attachment C

Plume Maps

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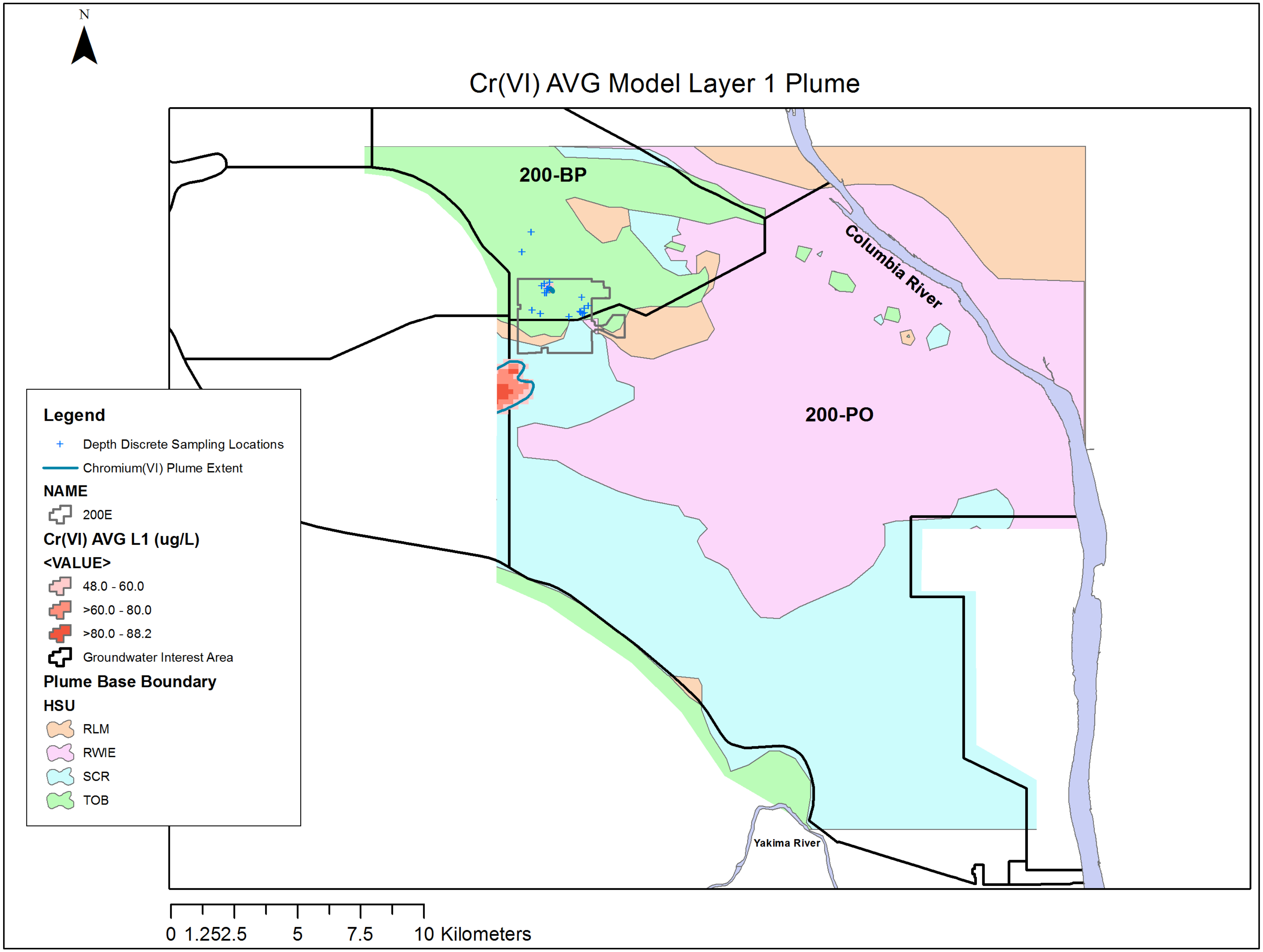


Figure C-1. Chromium(VI) Plume in Layer 1, Average Basis

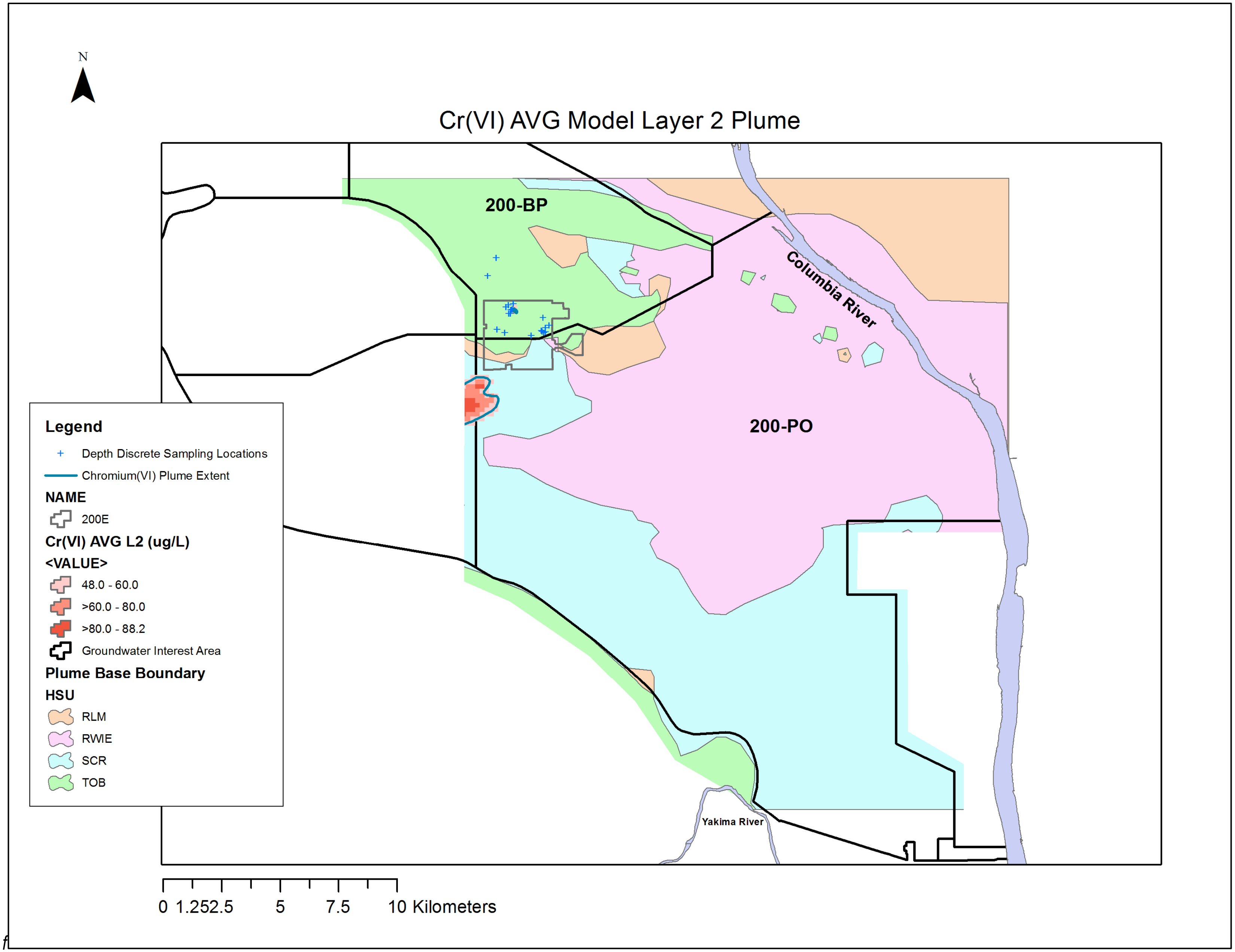


Figure C-2. Chromium(VI) Plume in Layer 2, Average Basis

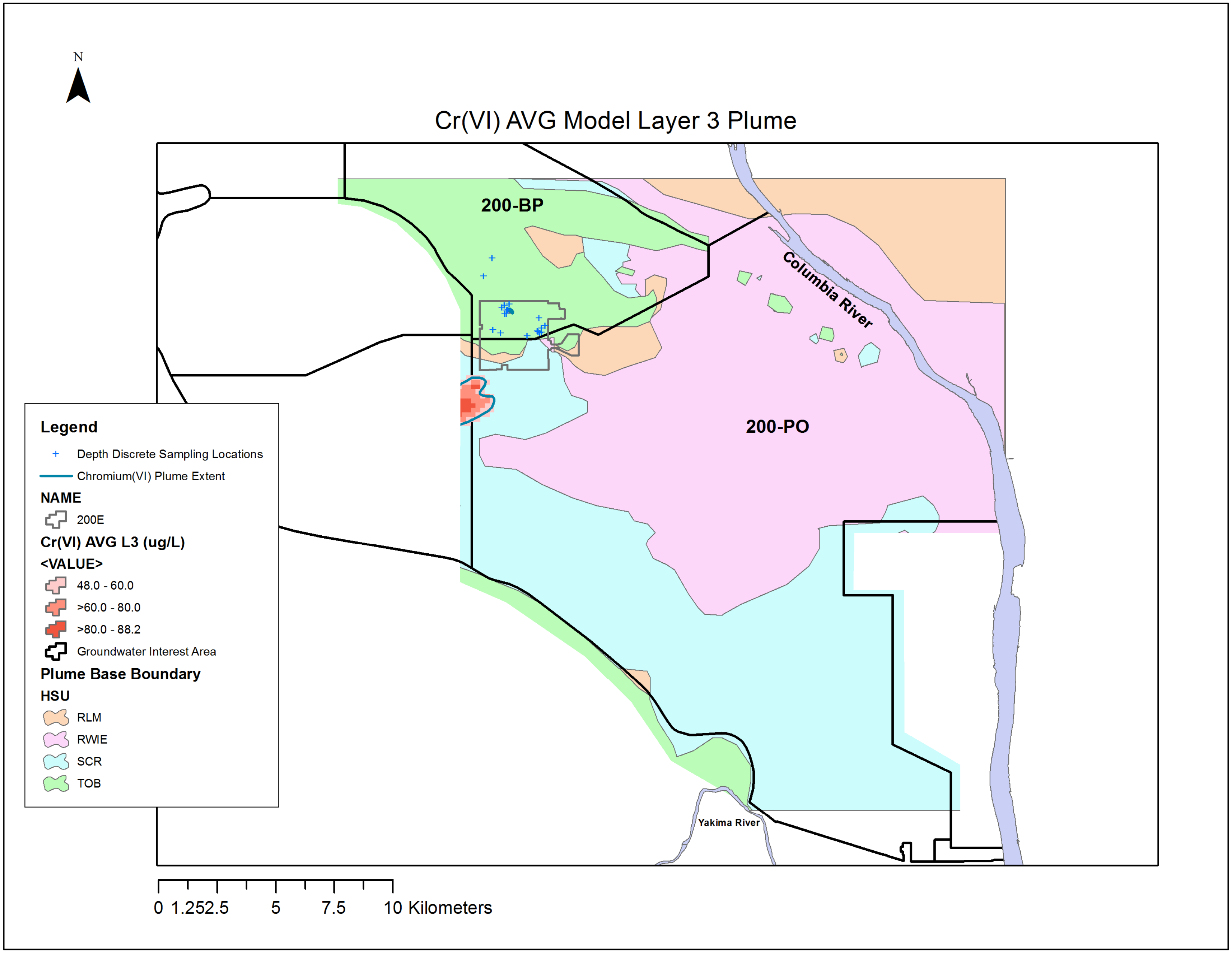


Figure C-3. Chromium(VI) Plume in Layer 3, Average Basis

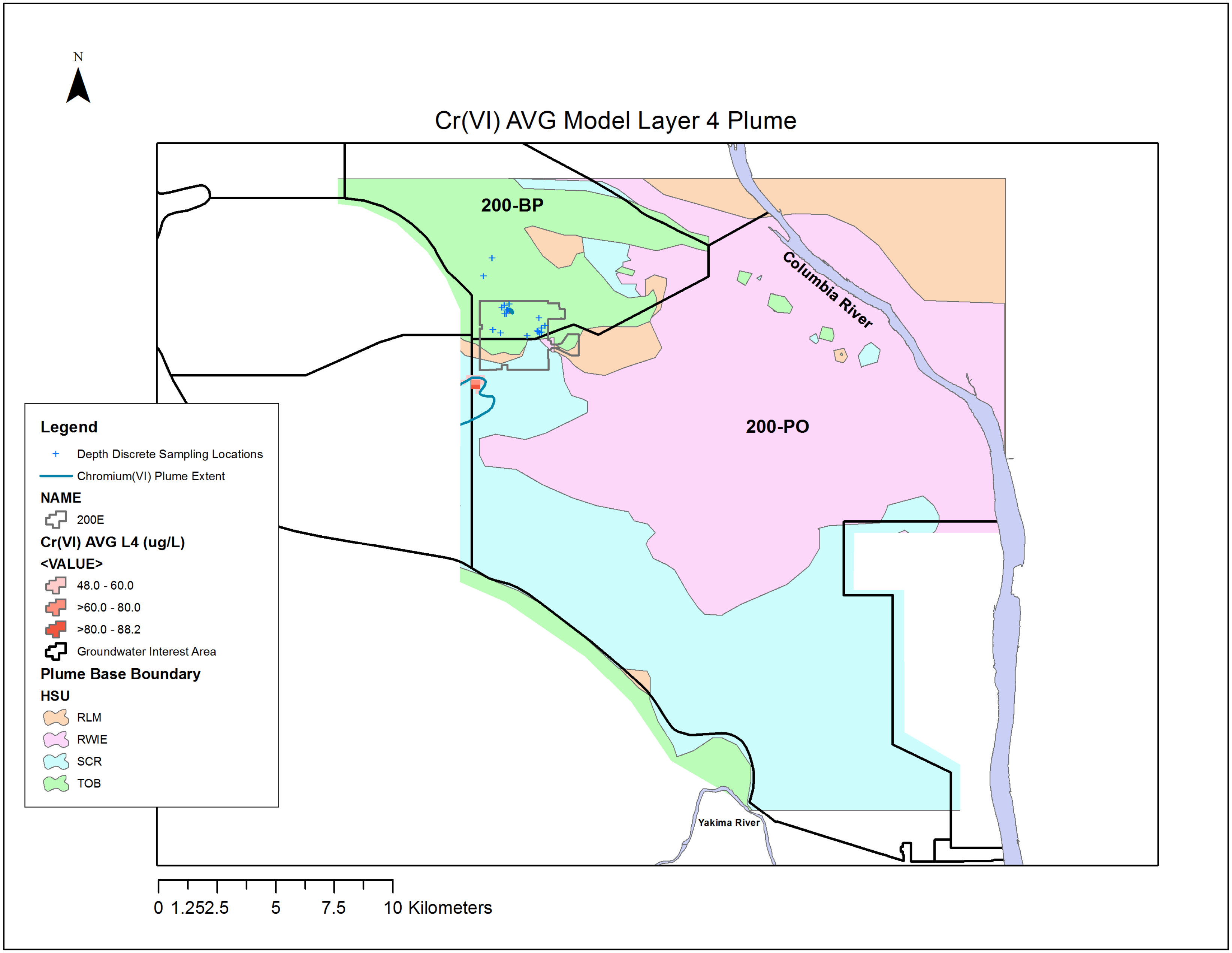


Figure C-4. Chromium(VI) Plume in Layer 4, Average Basis

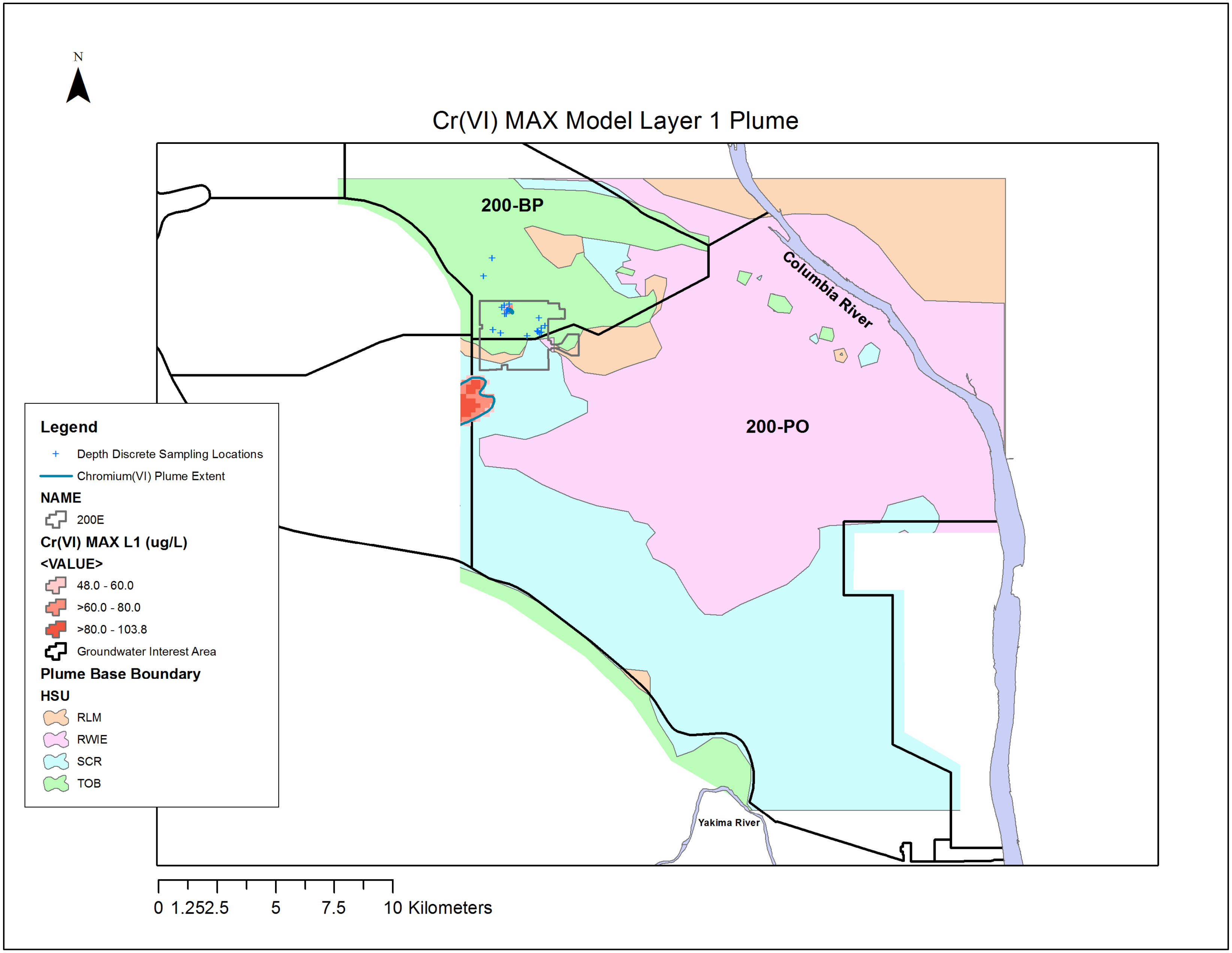


Figure C-5. Chromium(VI) Plume in Layer 1, Maximum Basis

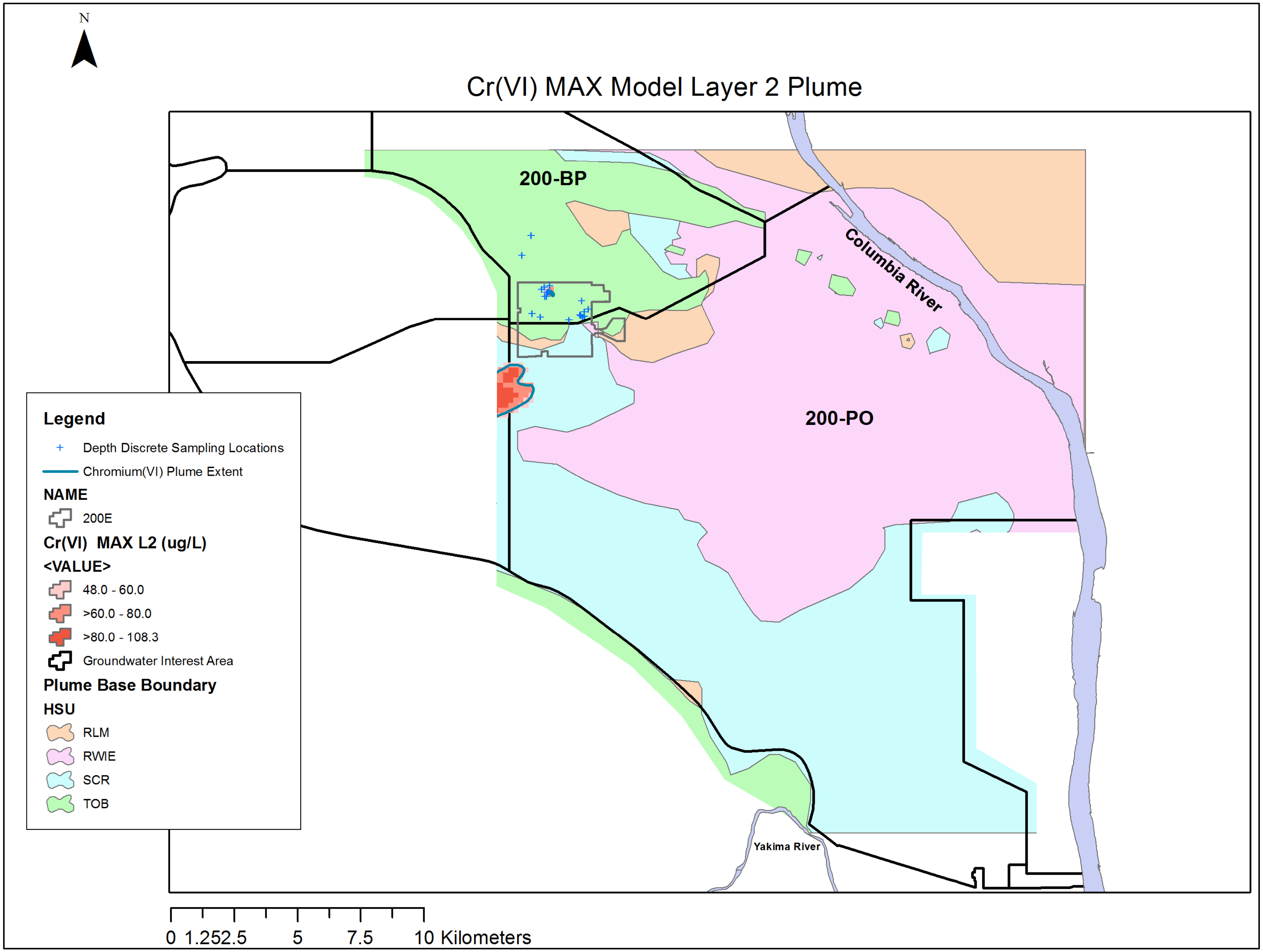


Figure C-6. Chromium(VI) Plume in Layer 2, Maximum Basis

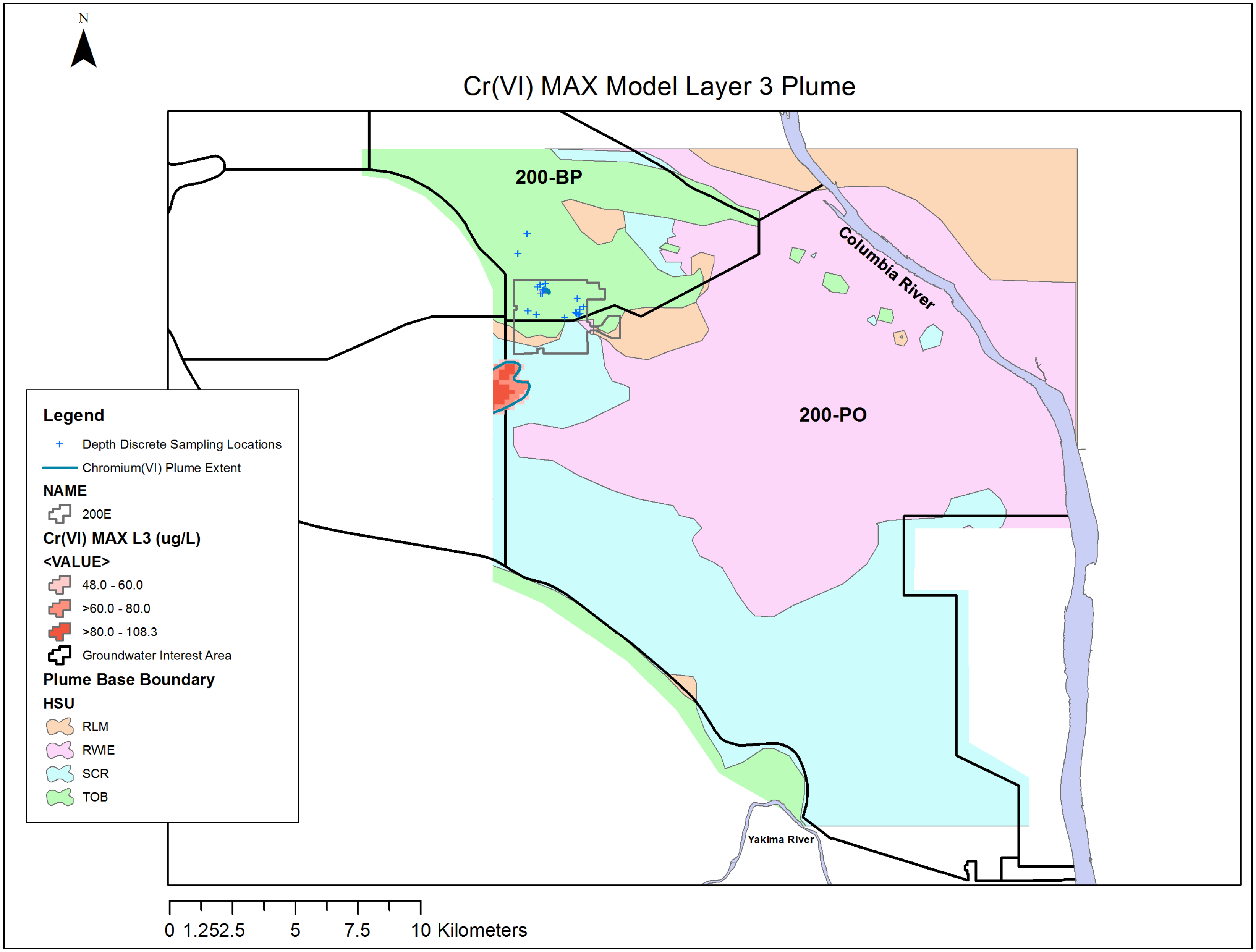


Figure C-7. Chromium(VI) Plume in Layer 3, Maximum Basis

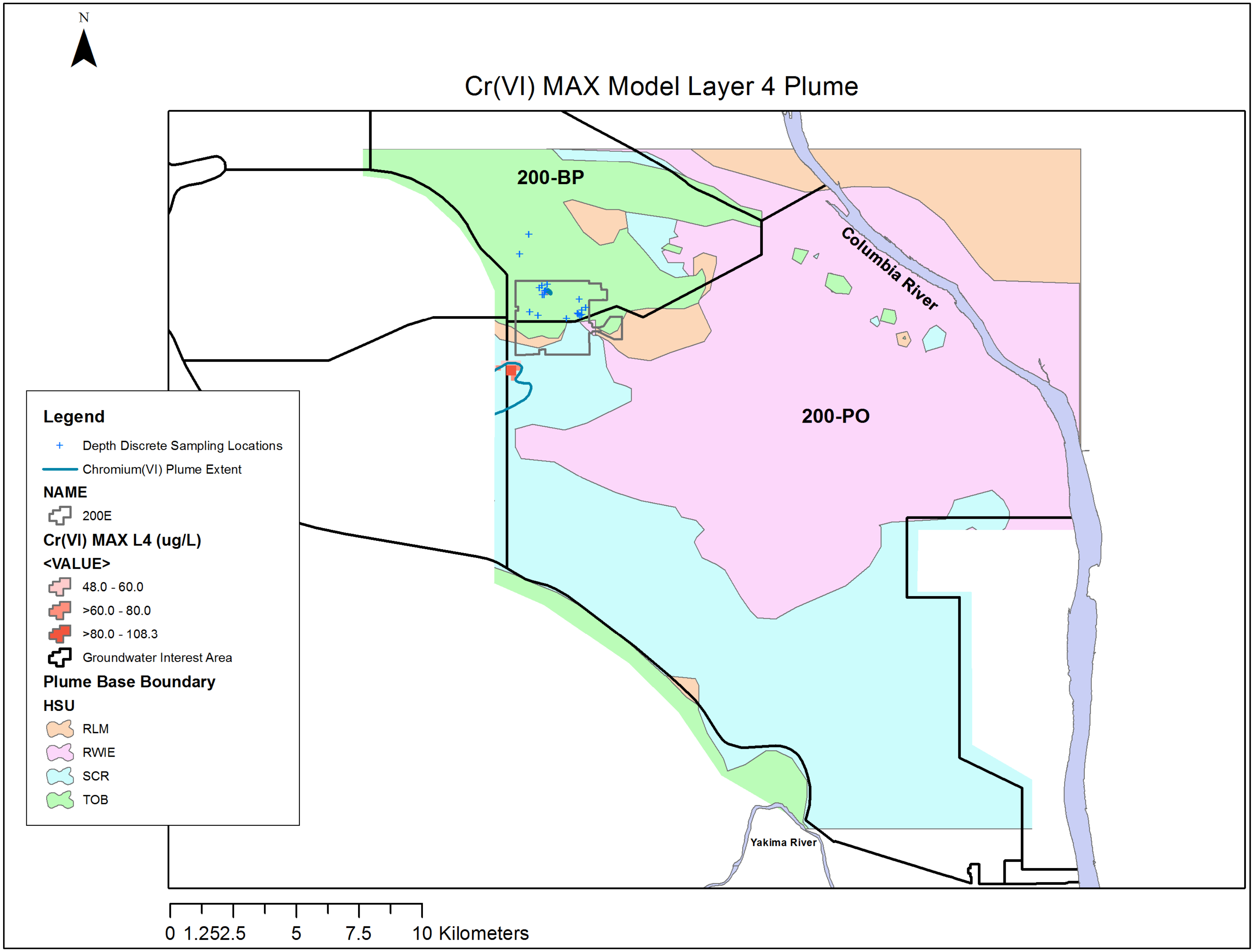


Figure C-8. Chromium(VI) Plume in Layer 4, Maximum Basis

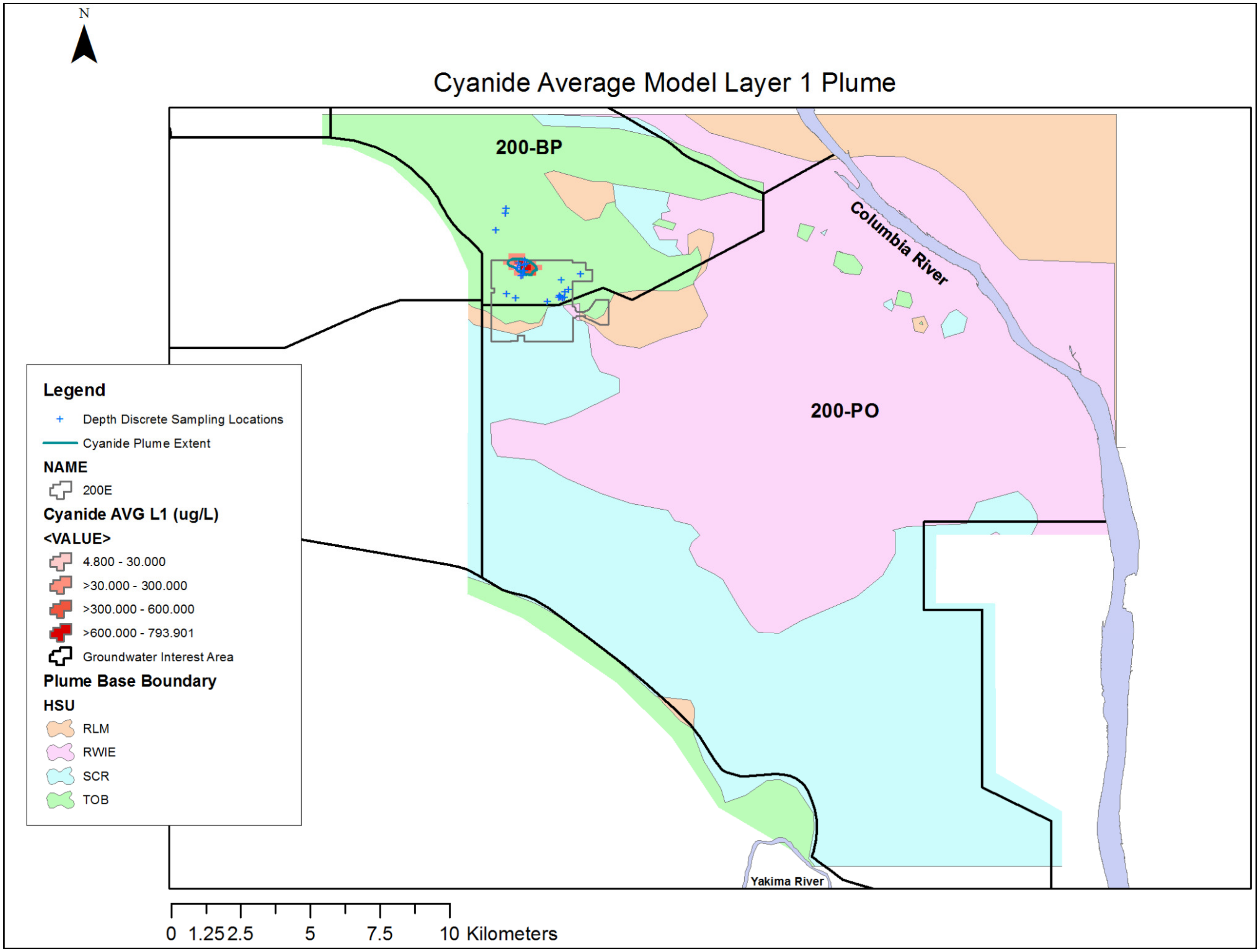


Figure C-9. Cyanide Plume in Layer 1, Average Basis

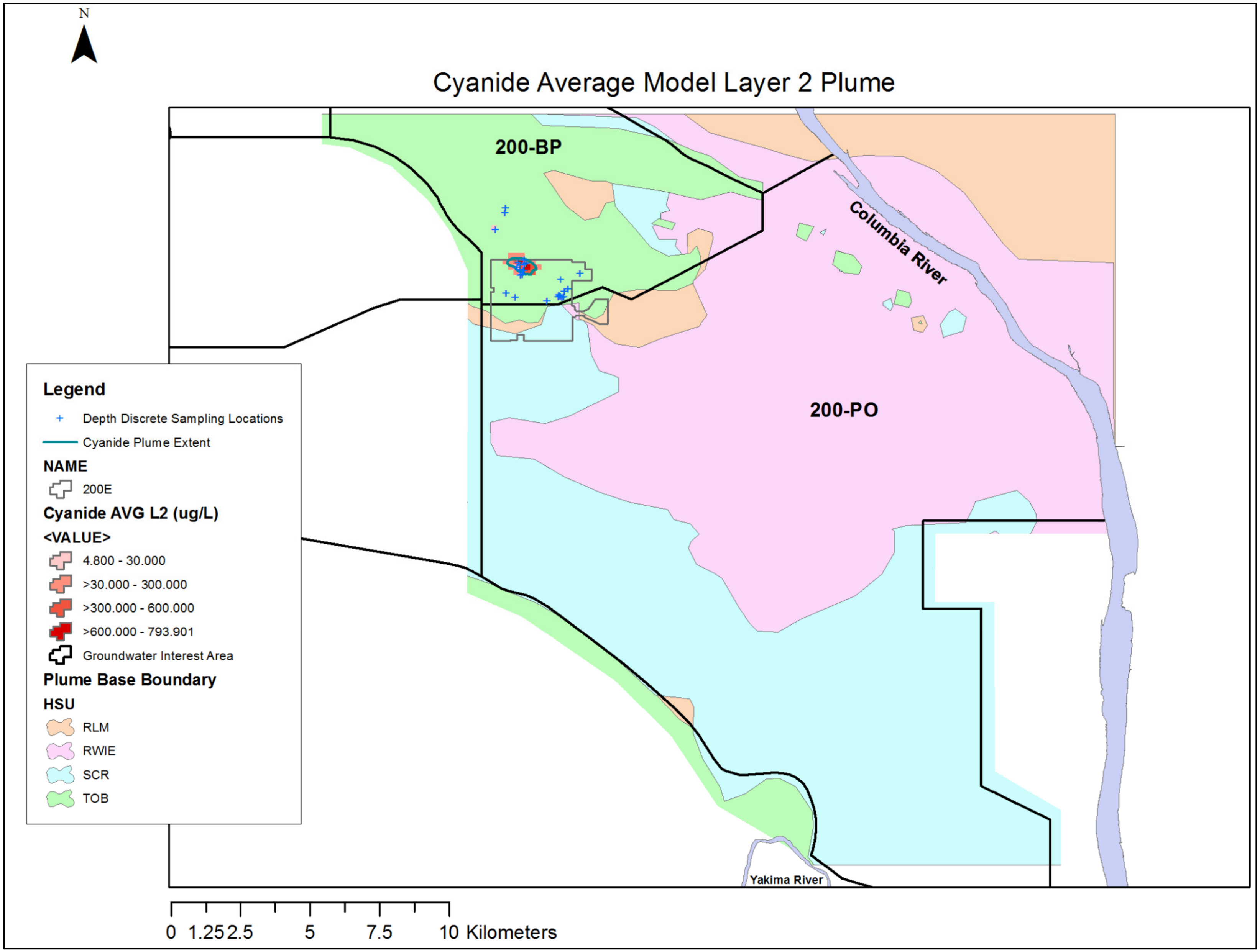


Figure C-10. Cyanide Plume in Layer 2, Average Basis

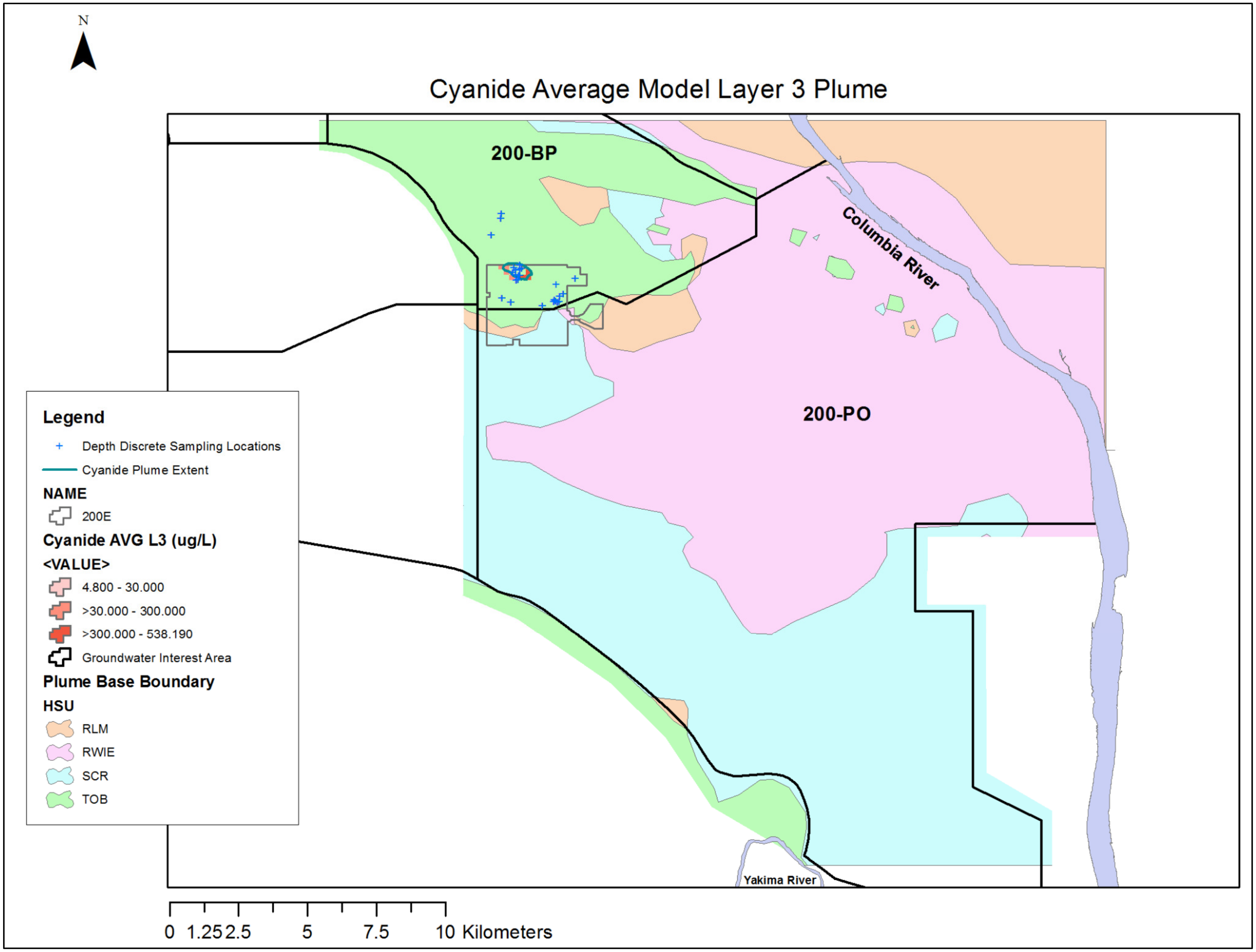


Figure C-11. Cyanide Plume in Layer 3, Average Basis

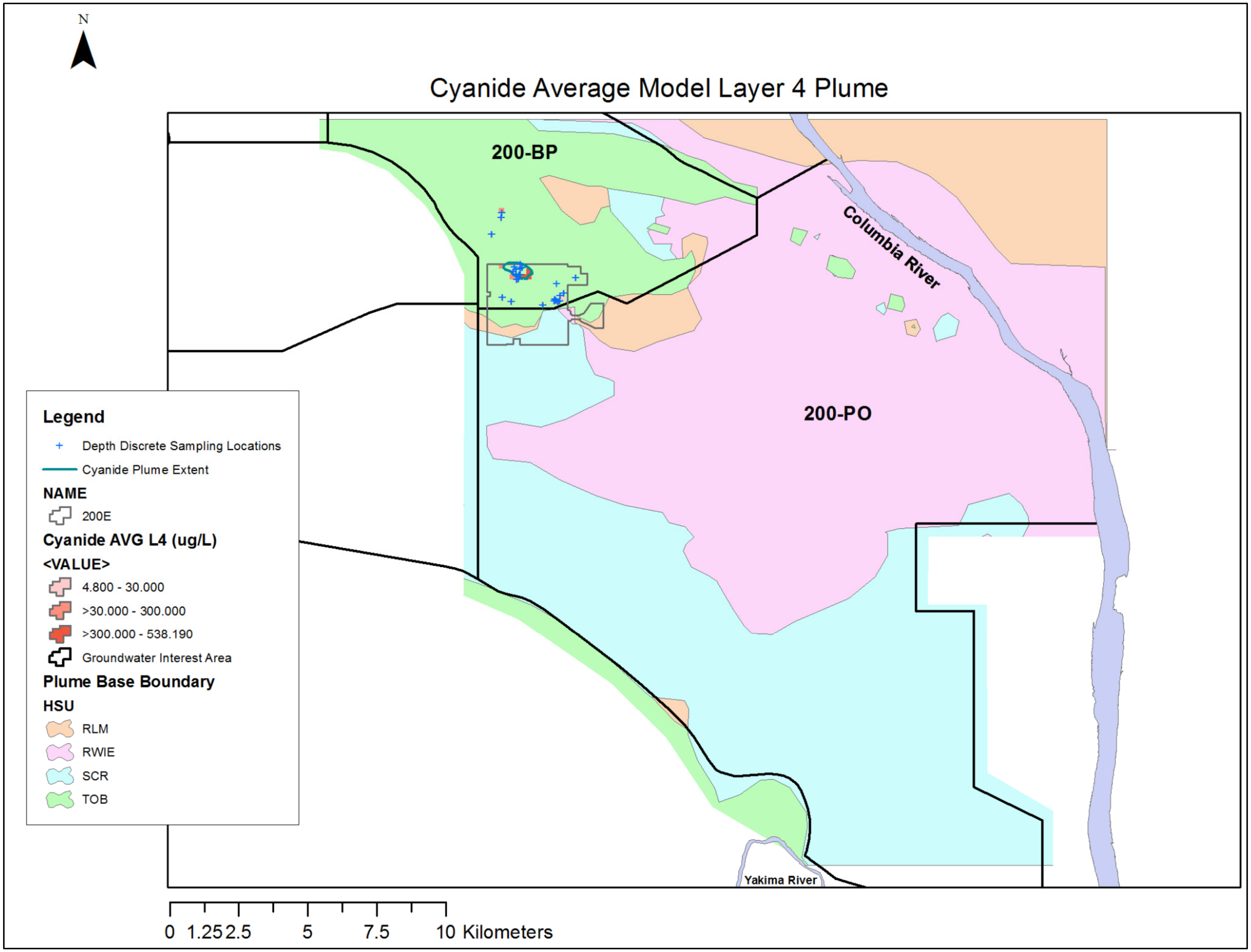


Figure C-12. Cyanide Plume in Layer 4, Average Basis

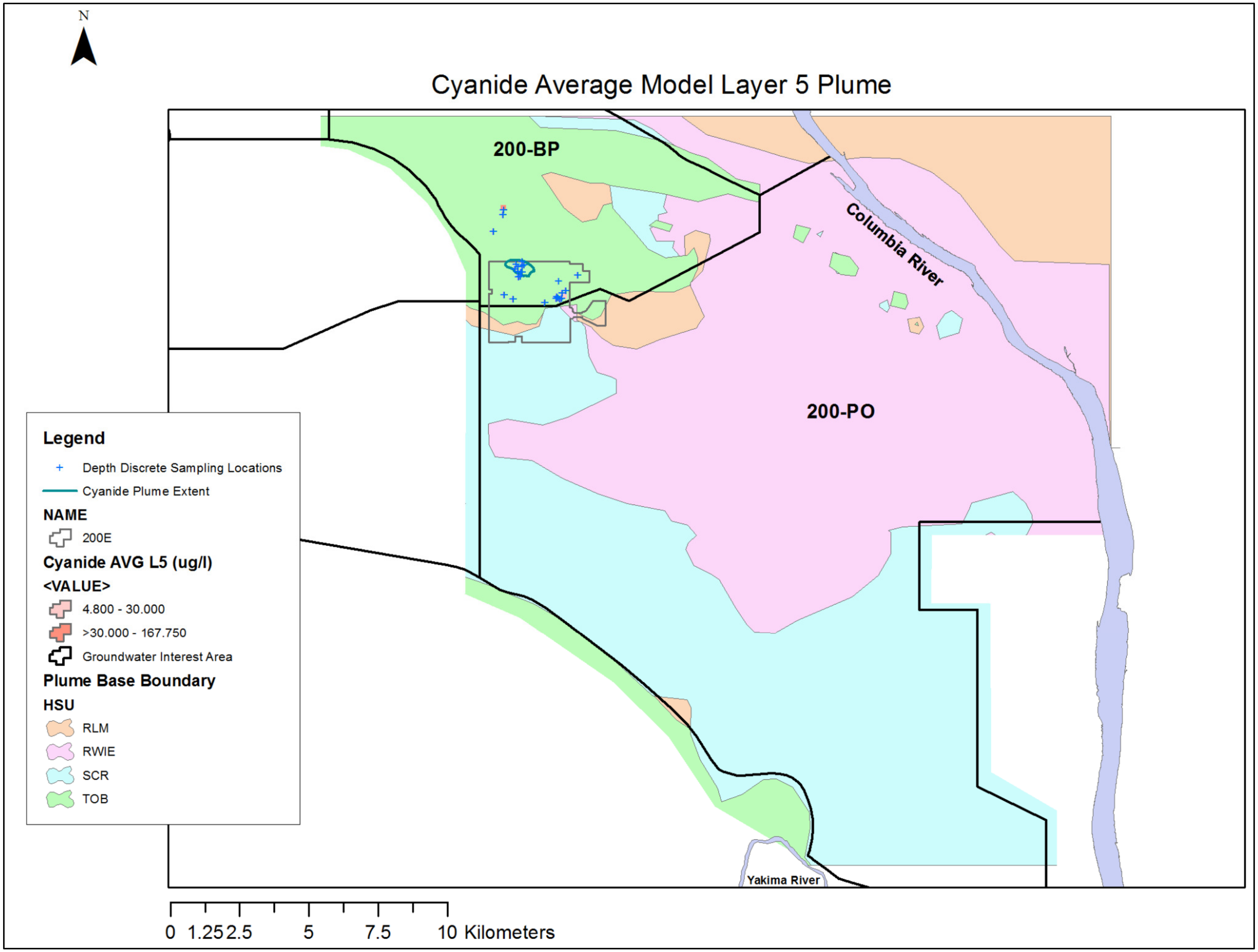


Figure C-13. Cyanide Plume in Layer 5, Average Basis

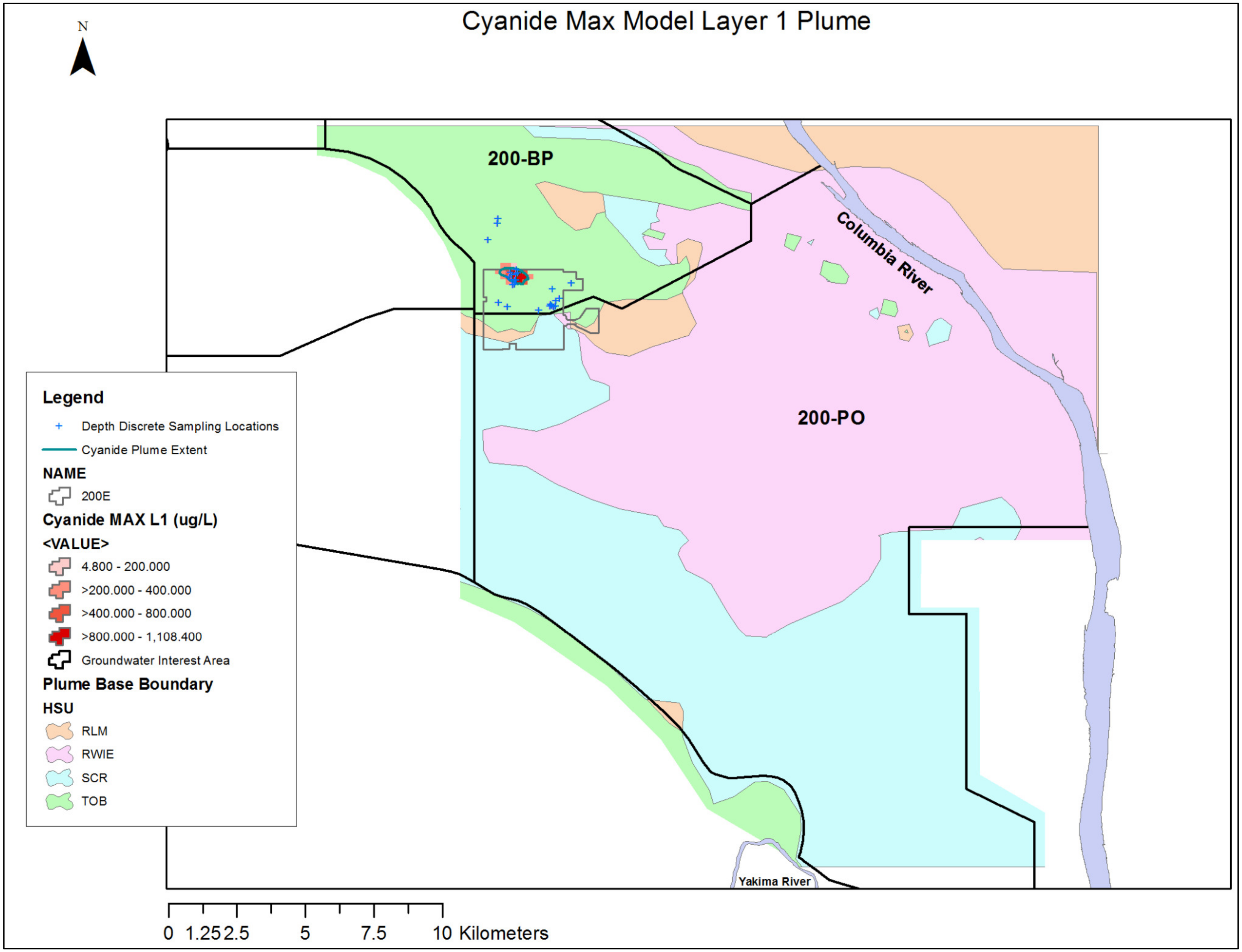


Figure C-14. Cyanide Plume in Layer 1, Maximum Basis

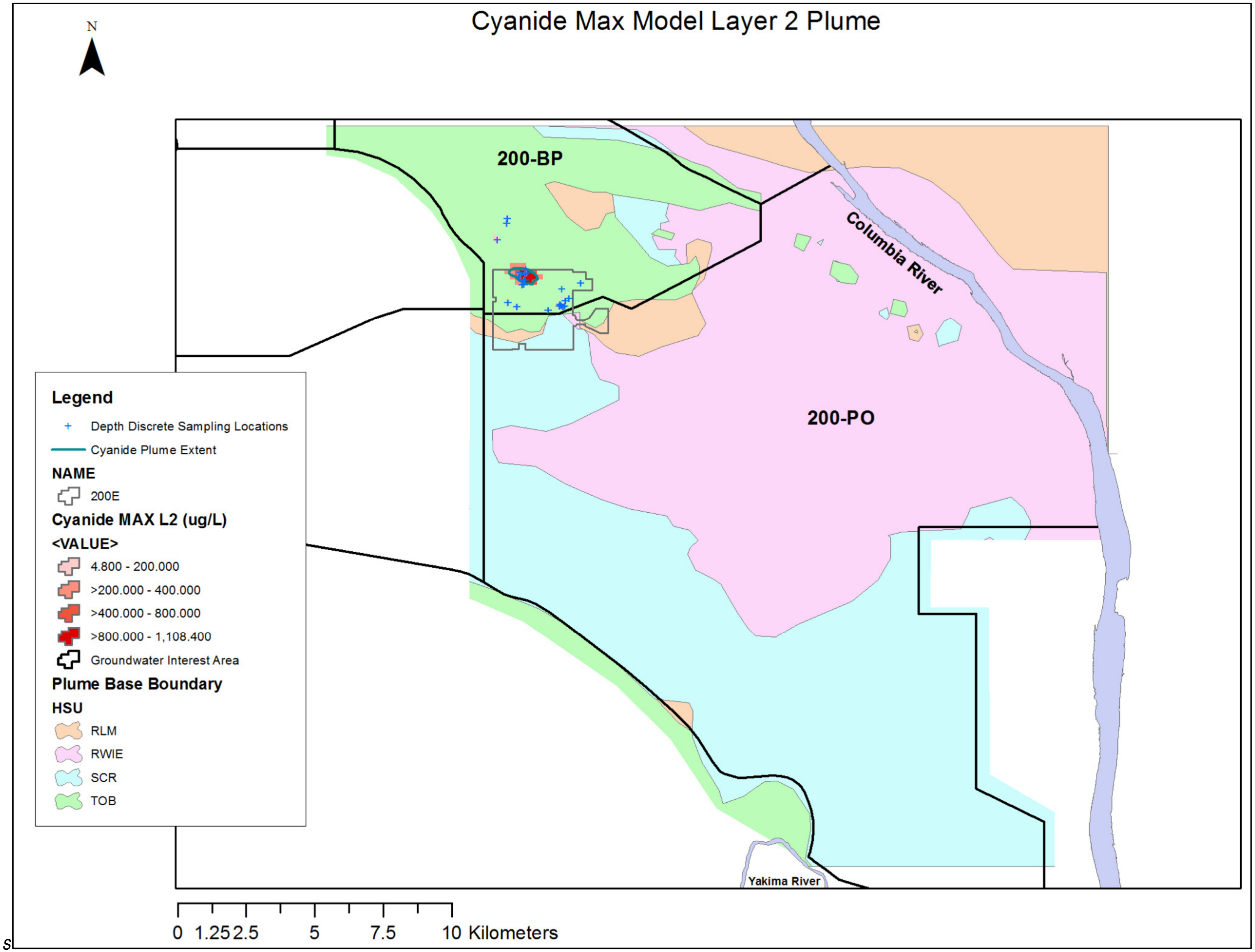


Figure C-15. Cyanide Plume in Layer 2, Maximum Basis

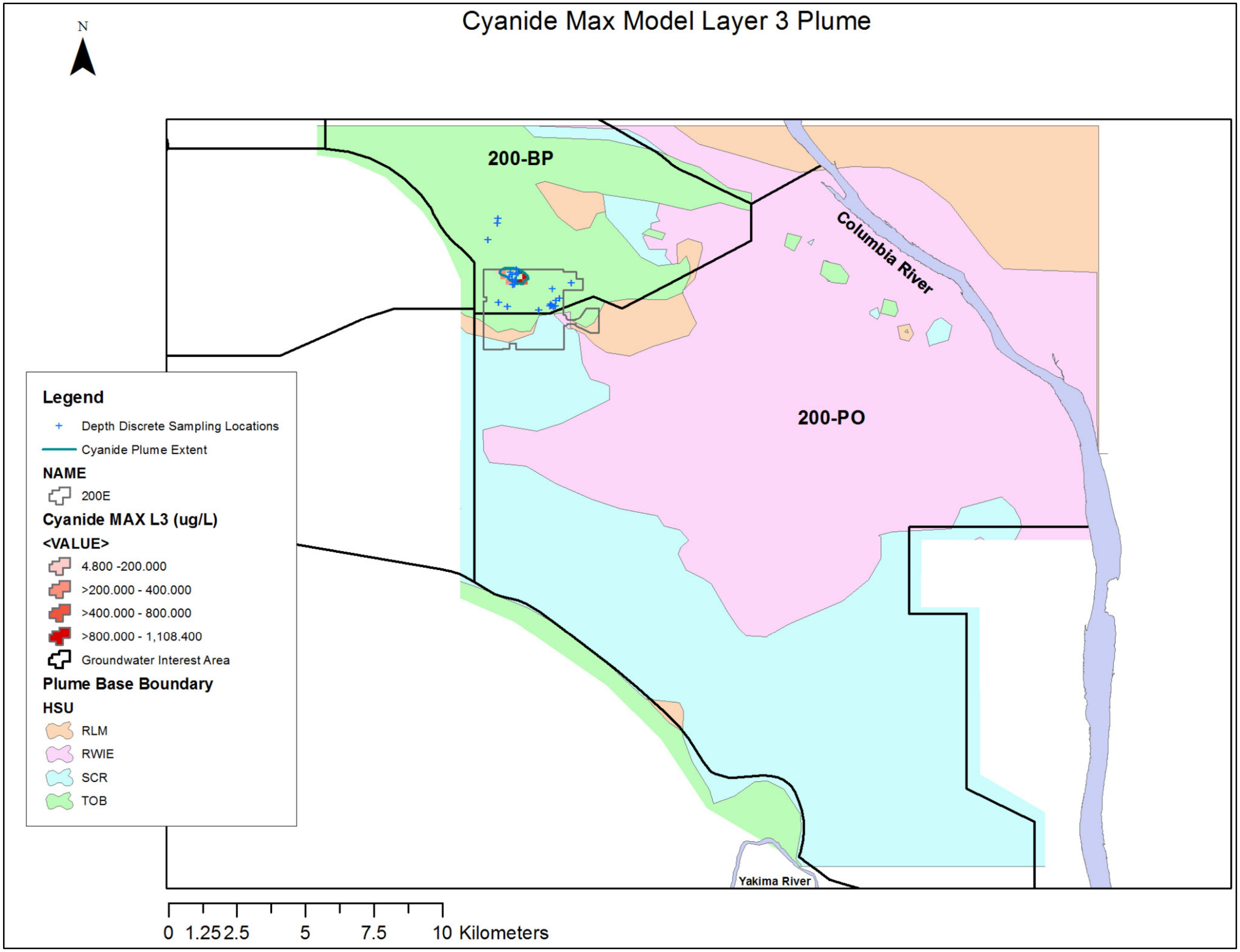


Figure C-16. Cyanide Plume in Layer 3, Maximum Basis

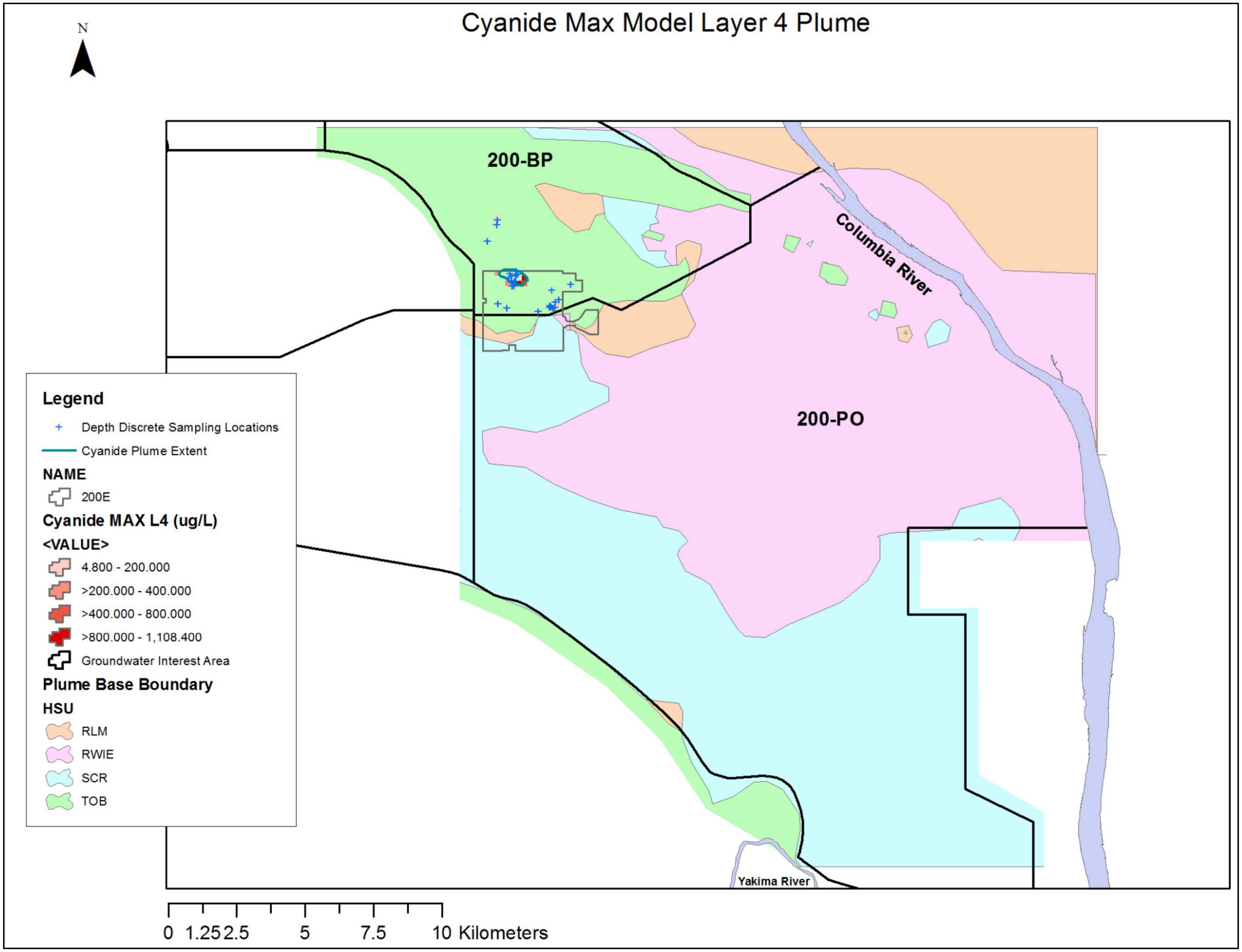


Figure C-17. Cyanide Plume in Layer 4, Maximum Basis

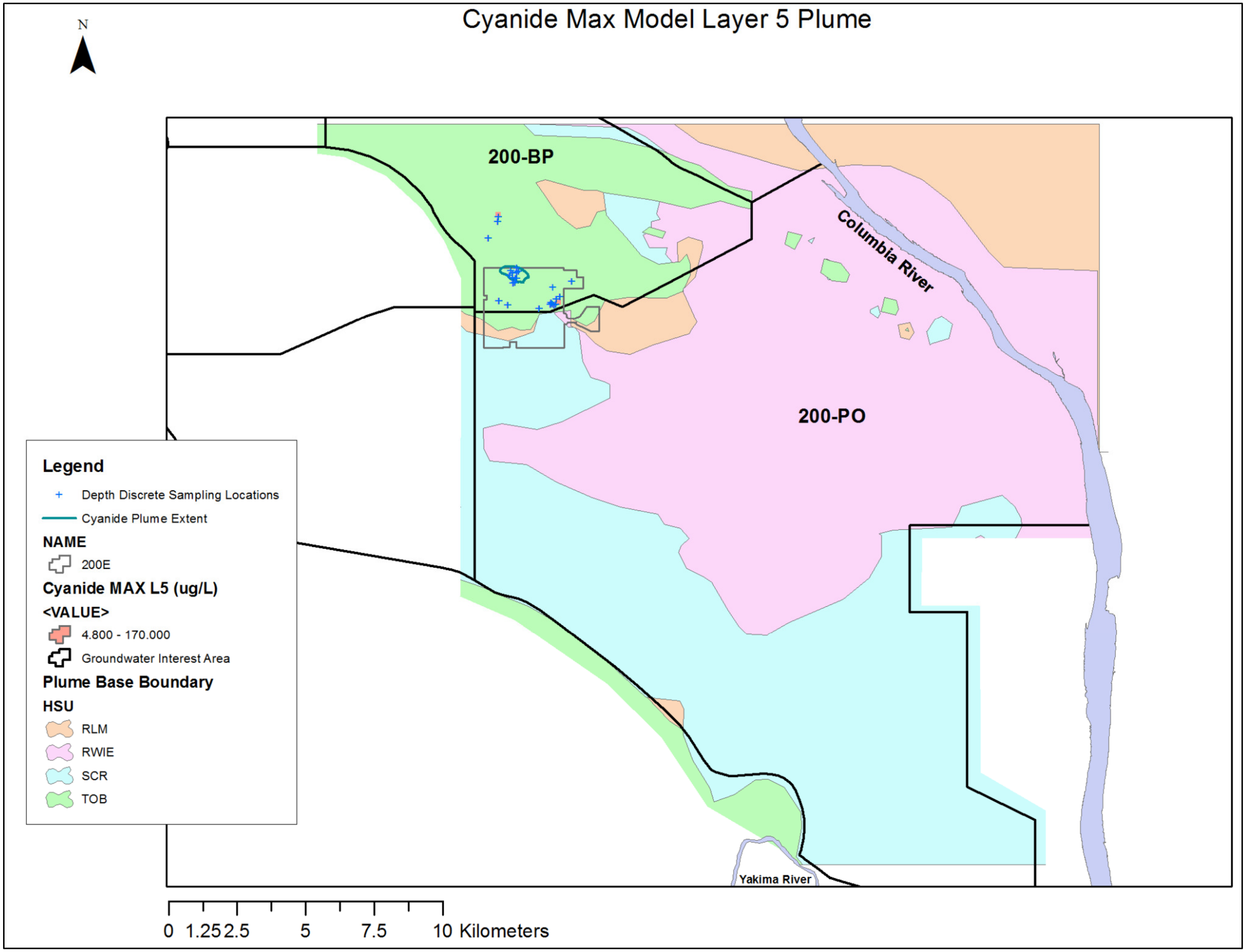


Figure C-18. Cyanide Plume in Layer 5, Maximum Basis

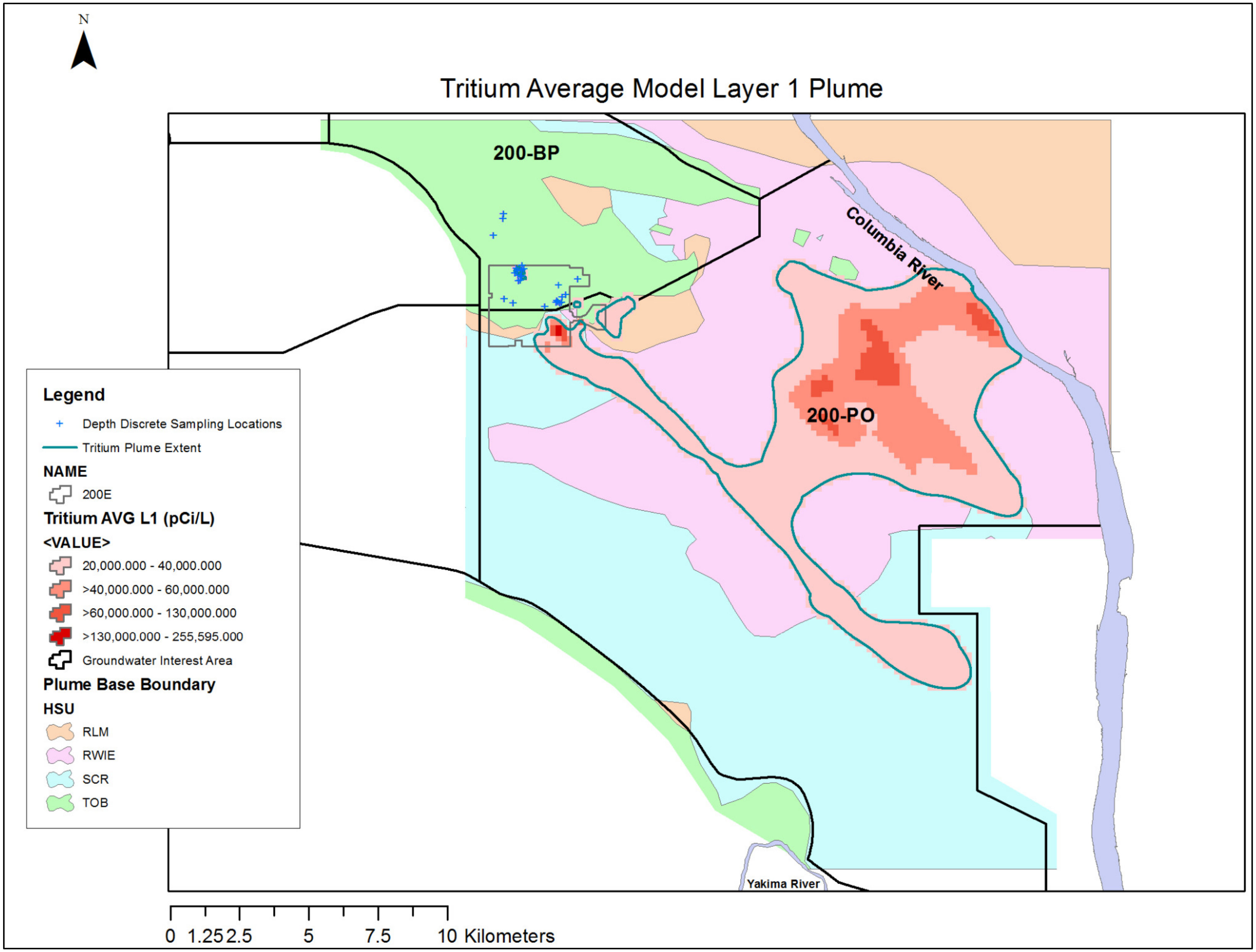


Figure C-19. Tritium Plume in Layer 1, Average Basis

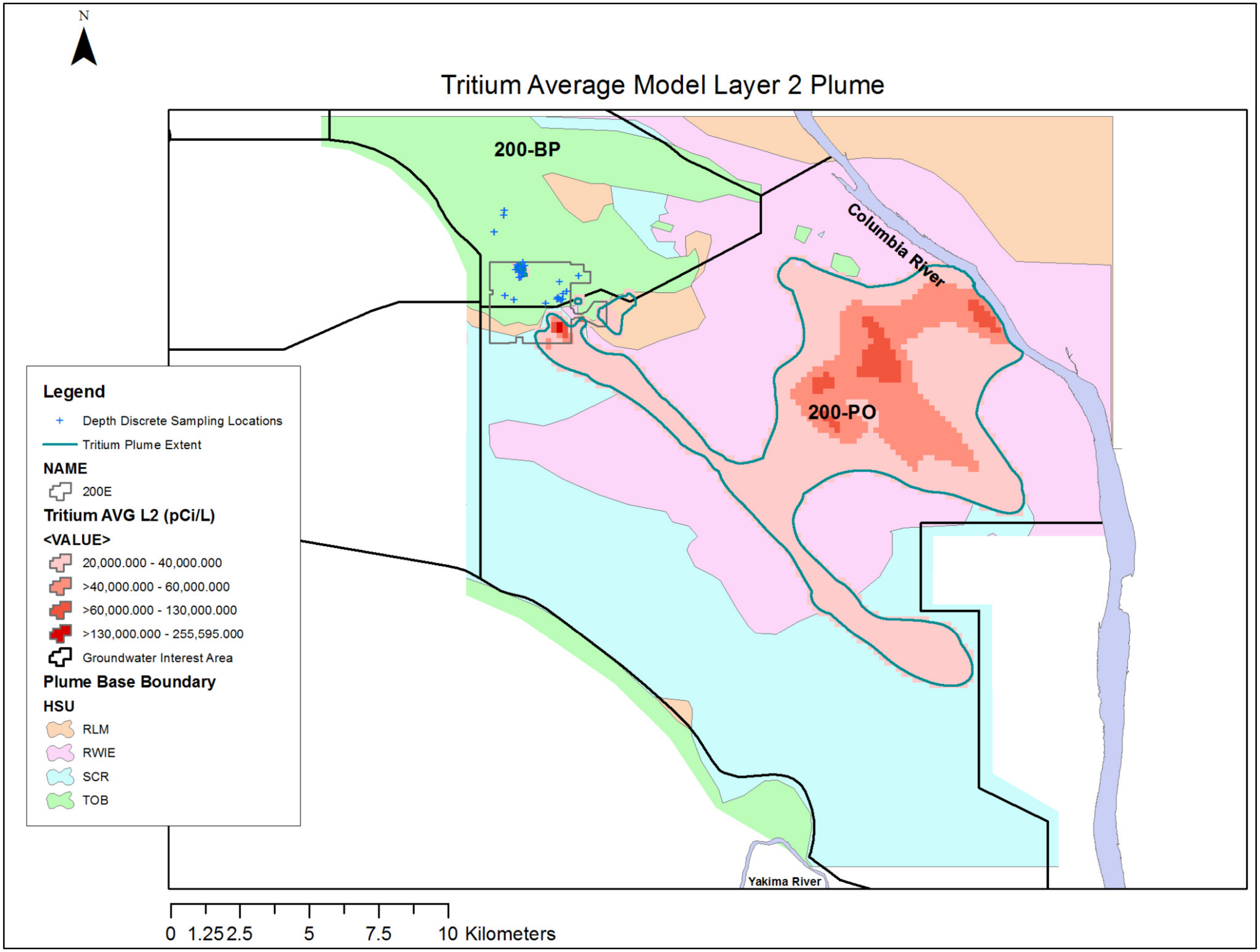


Figure C-20. Tritium Plume in Layer 2, Average Basis

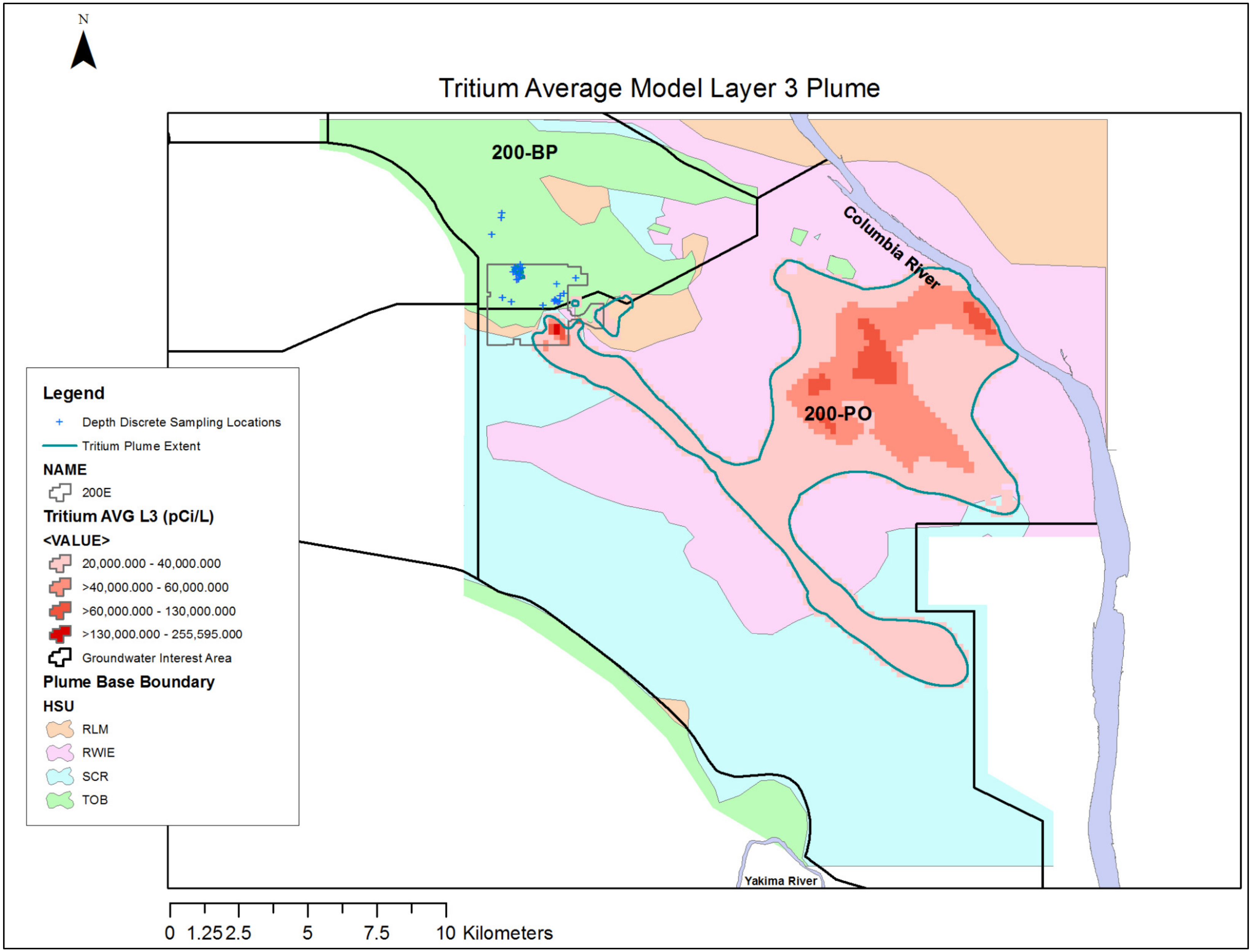


Figure C-21. Tritium Plume in Layer 3, Average Basis

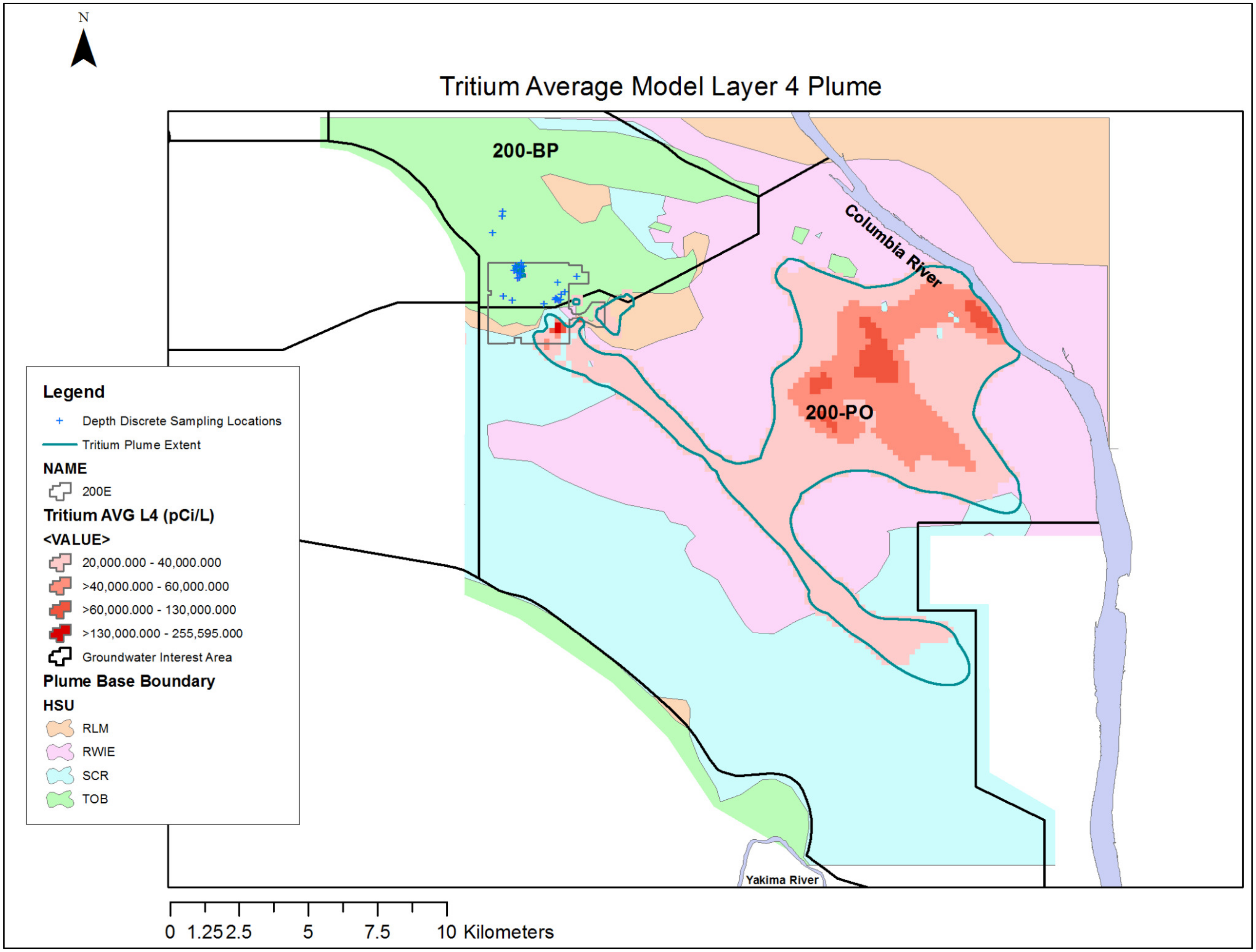


Figure C-22. Tritium Plume in Layer 4, Average Basis

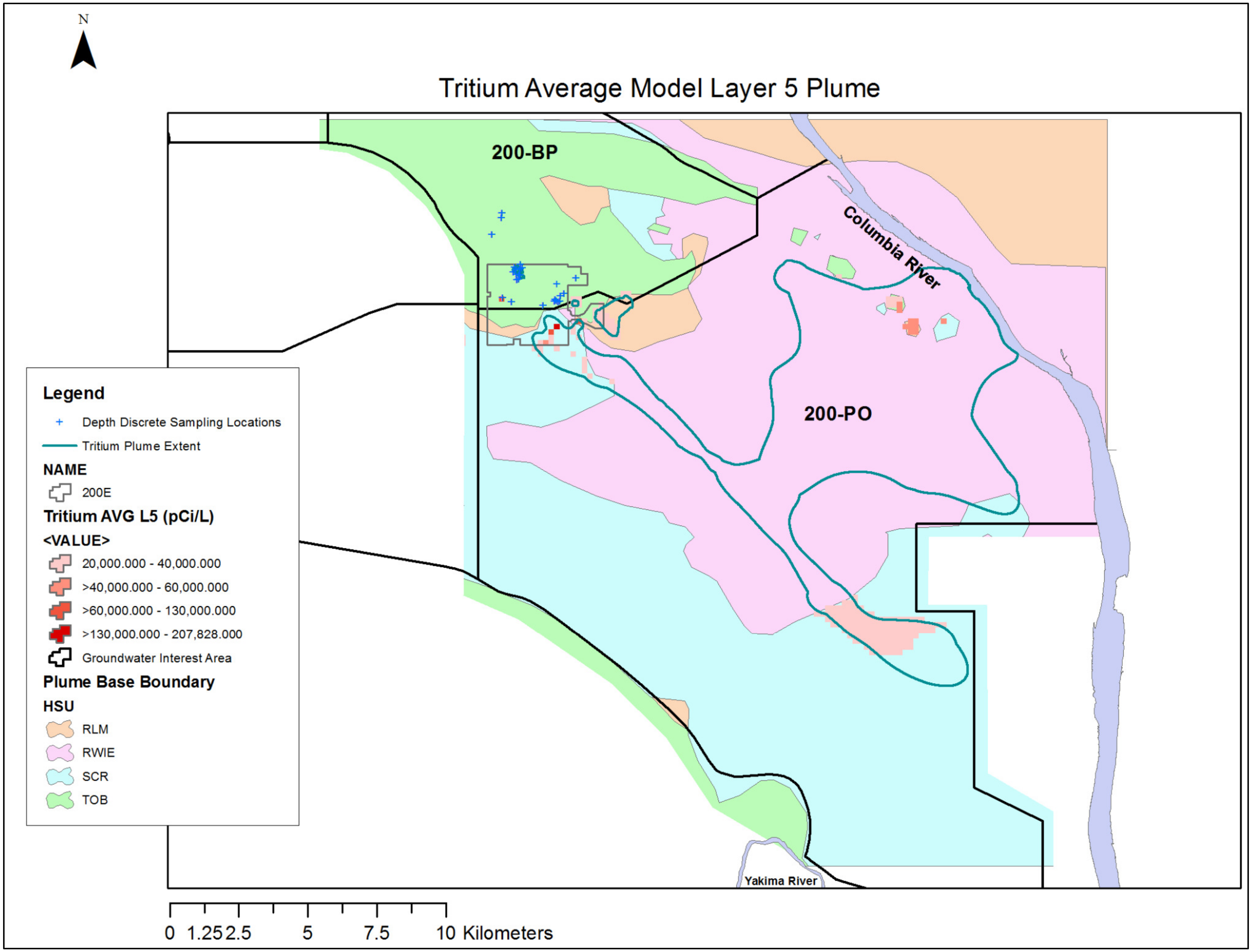


Figure C-23. Tritium Plume in Layer 5, Average Basis

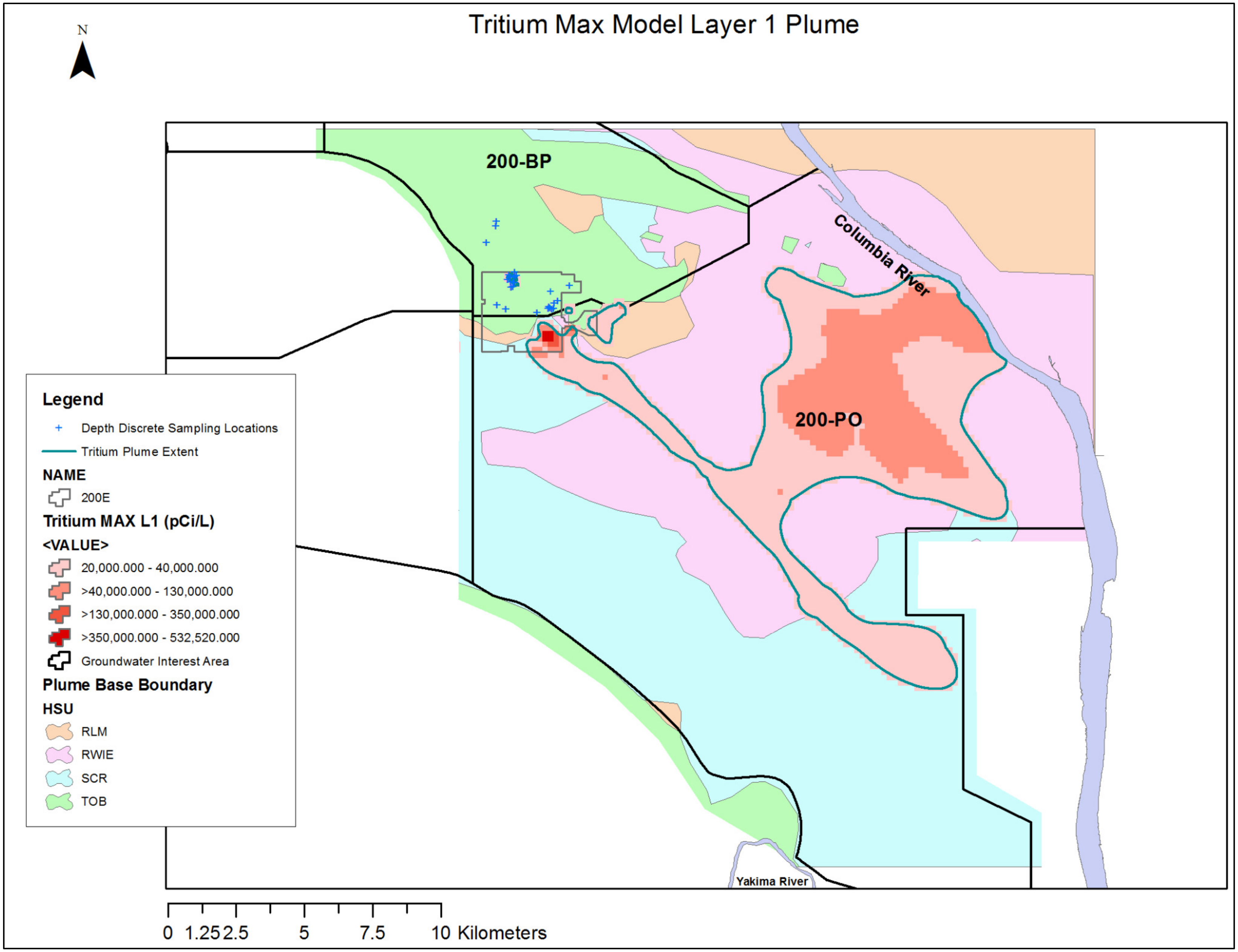


Figure C-24. Tritium Plume in Layer 1, Maximum Basis

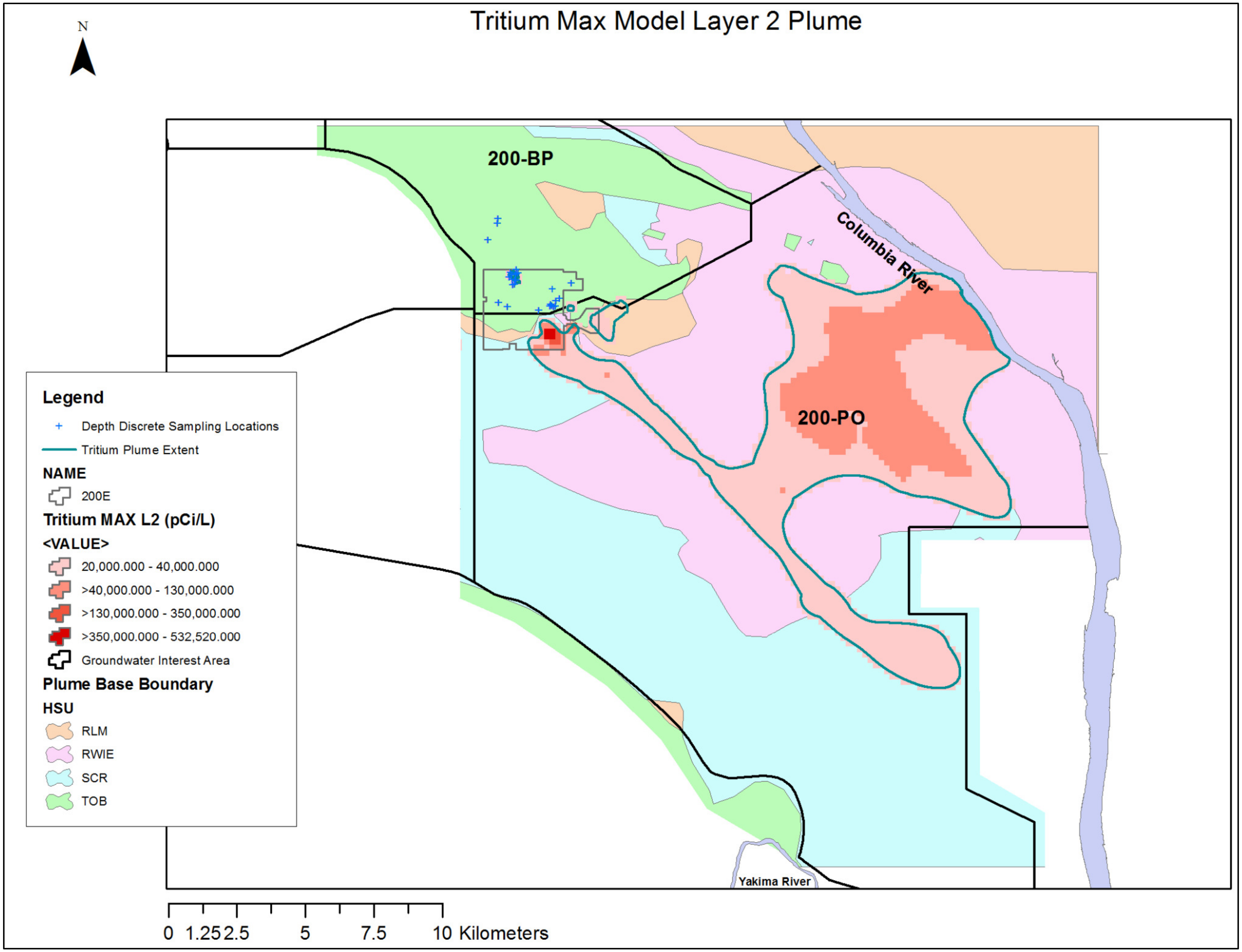


Figure C-25. Tritium Plume in Layer 2, Maximum Basis

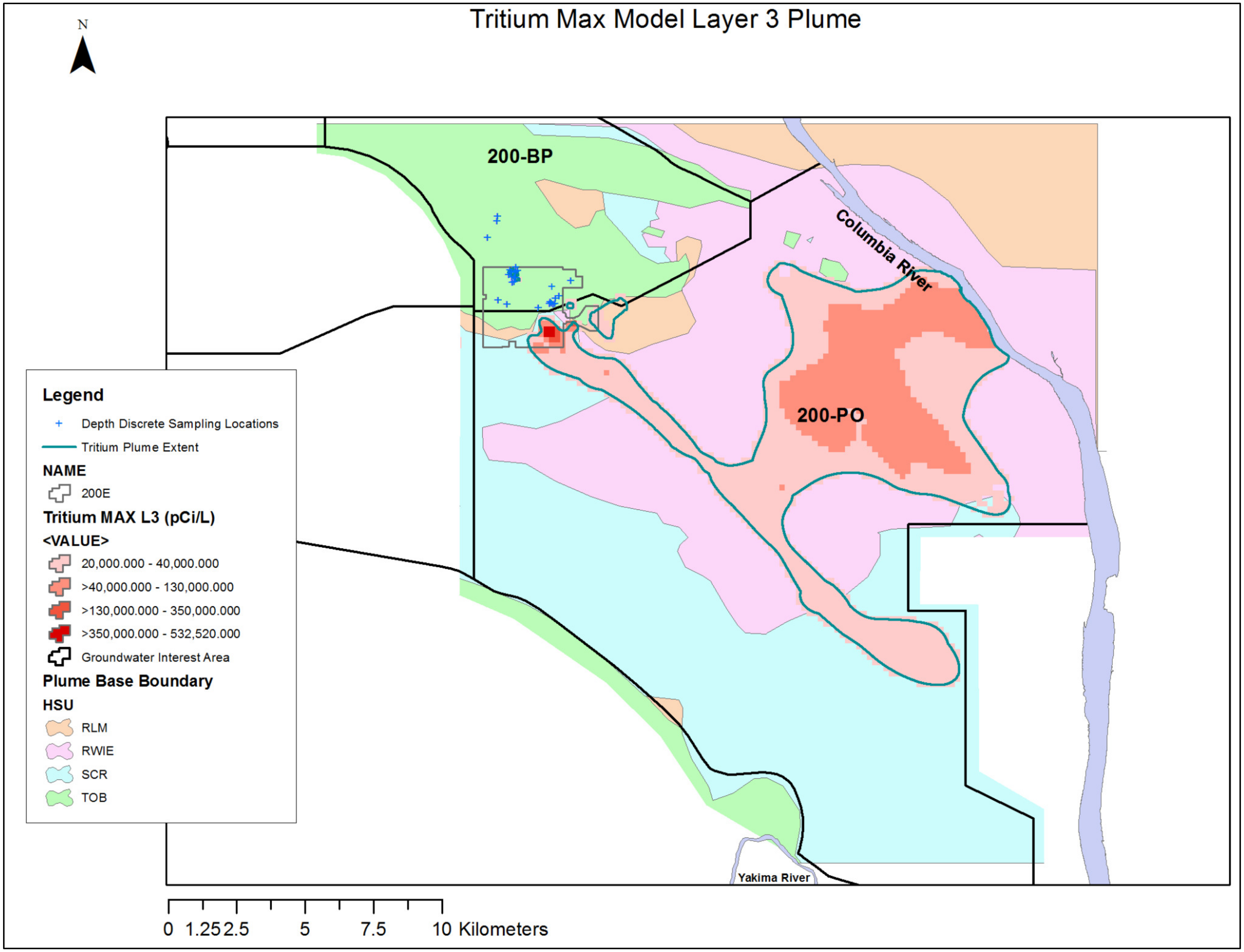


Figure C-26. Tritium Plume in Layer 3, Maximum Basis

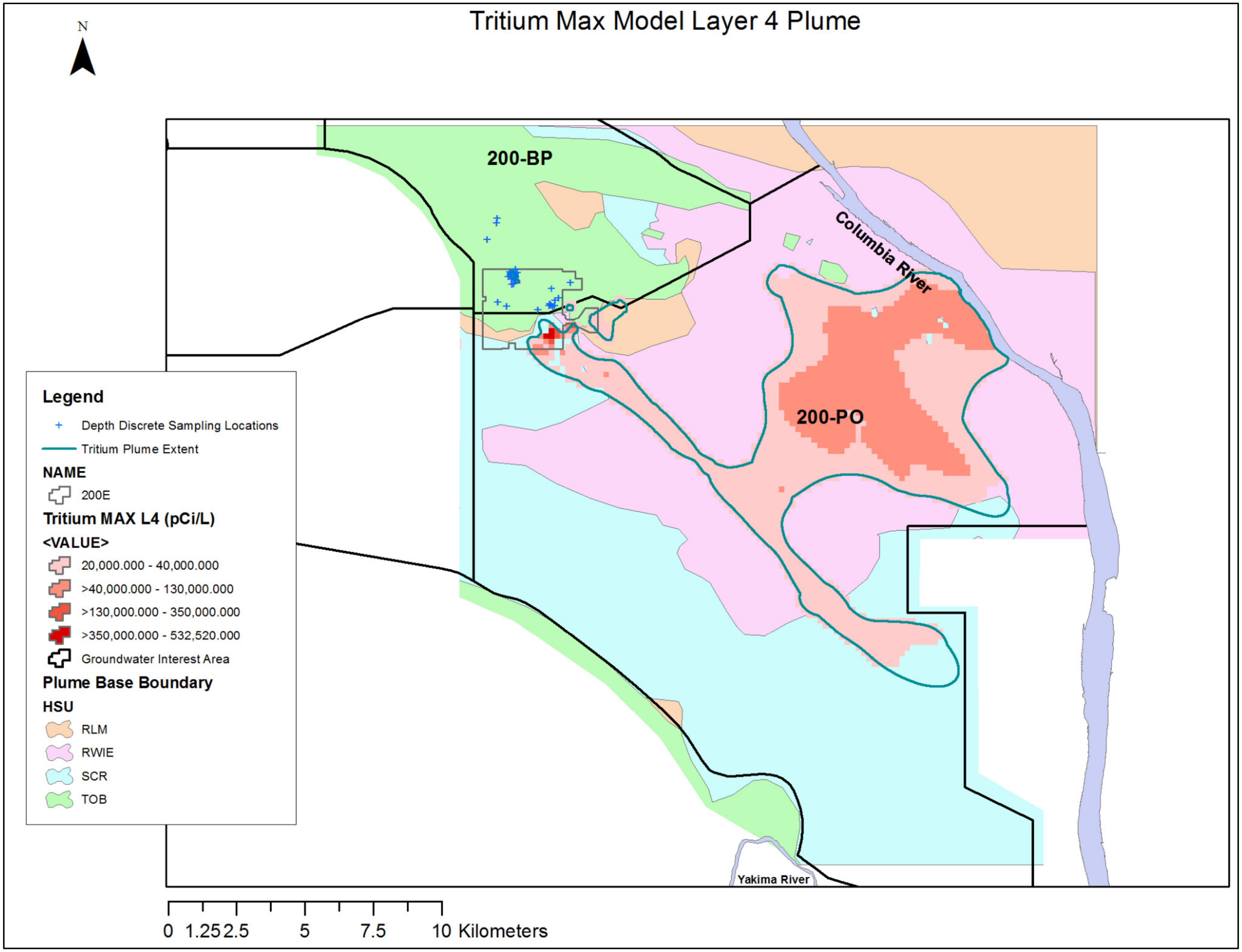


Figure C-27. Tritium Plume in Layer 4, Maximum Basis

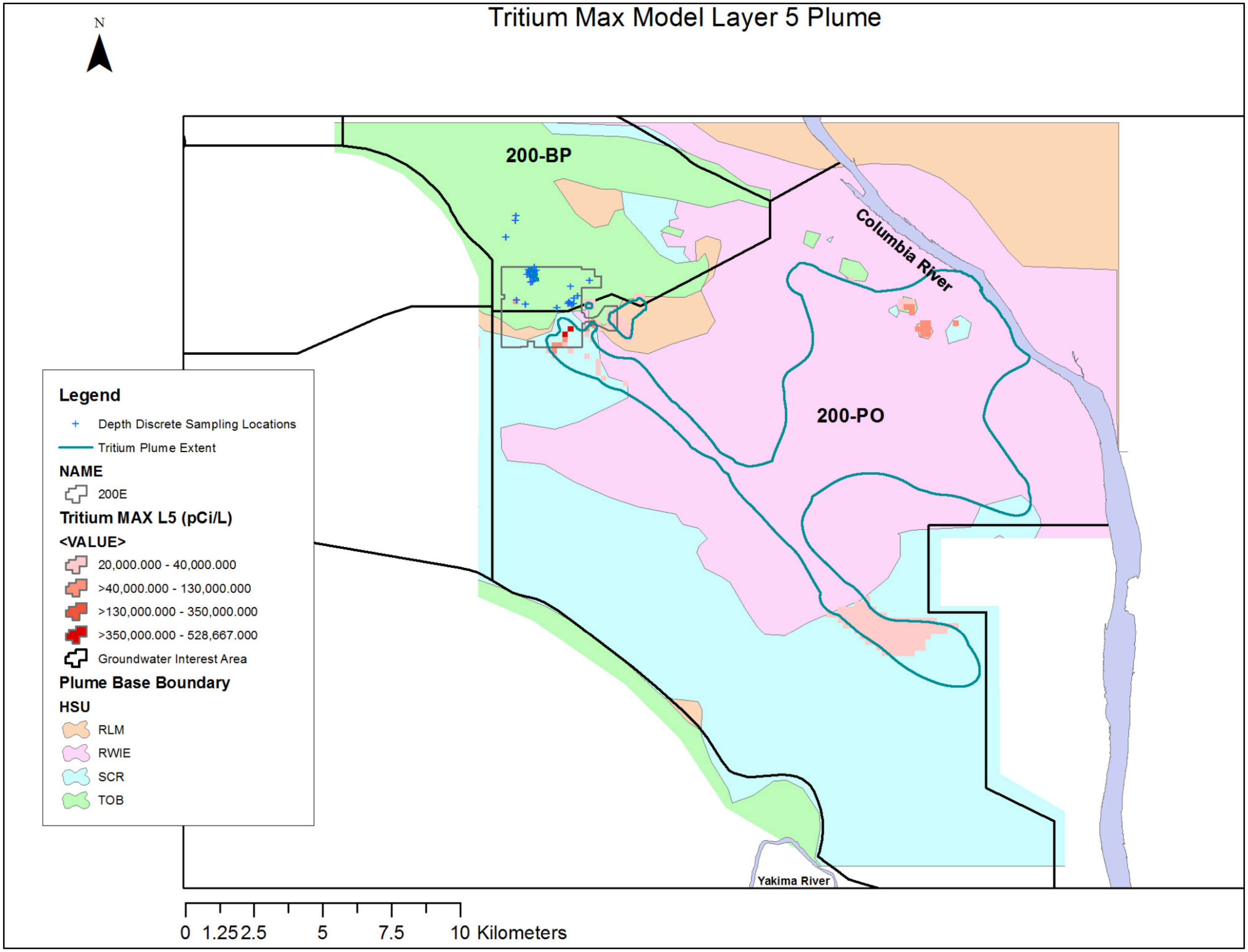


Figure C-28. Tritium Plume in Layer 5, Maximum Basis

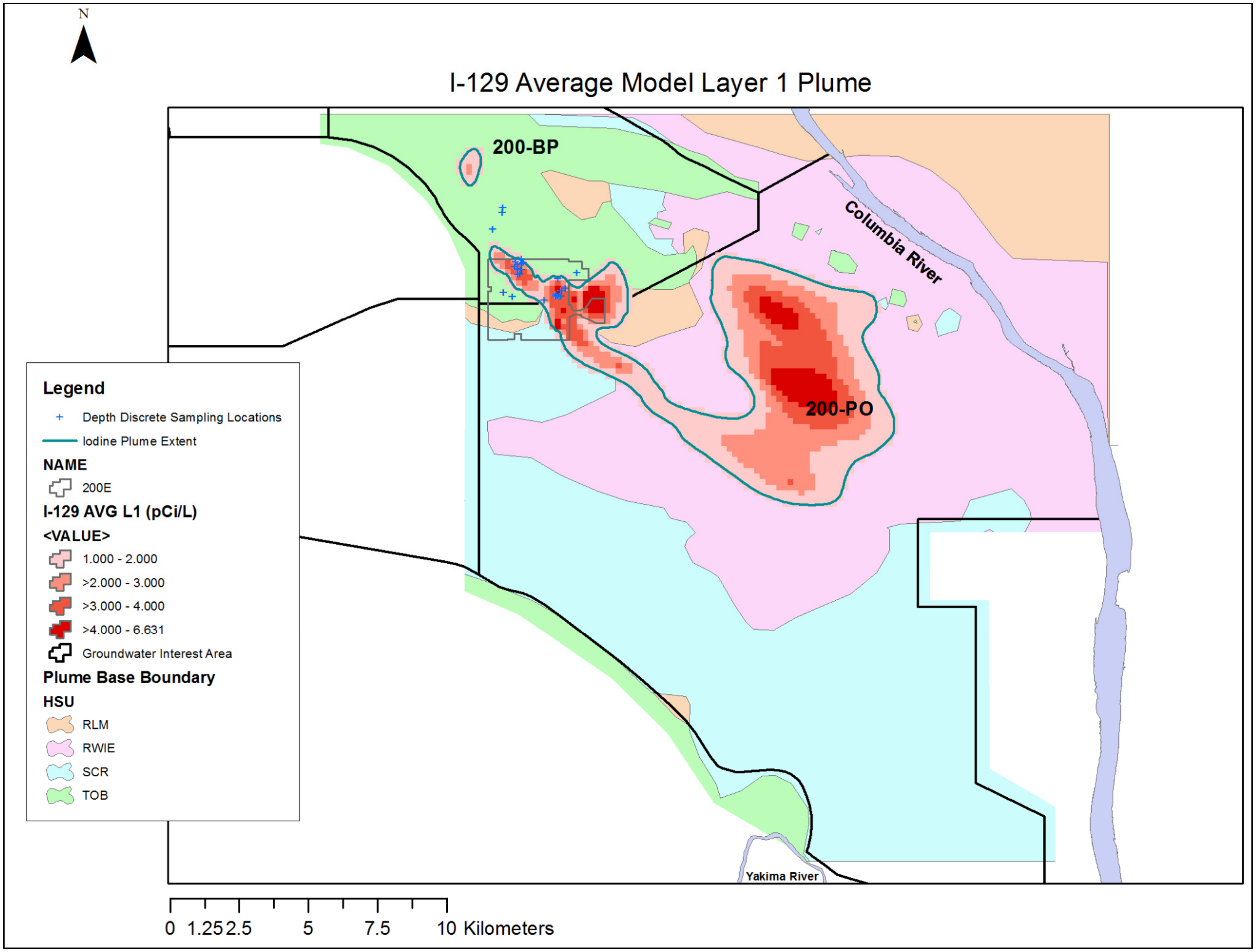


Figure C-29. Iodine-129 Plume in Layer 1, Average Basis

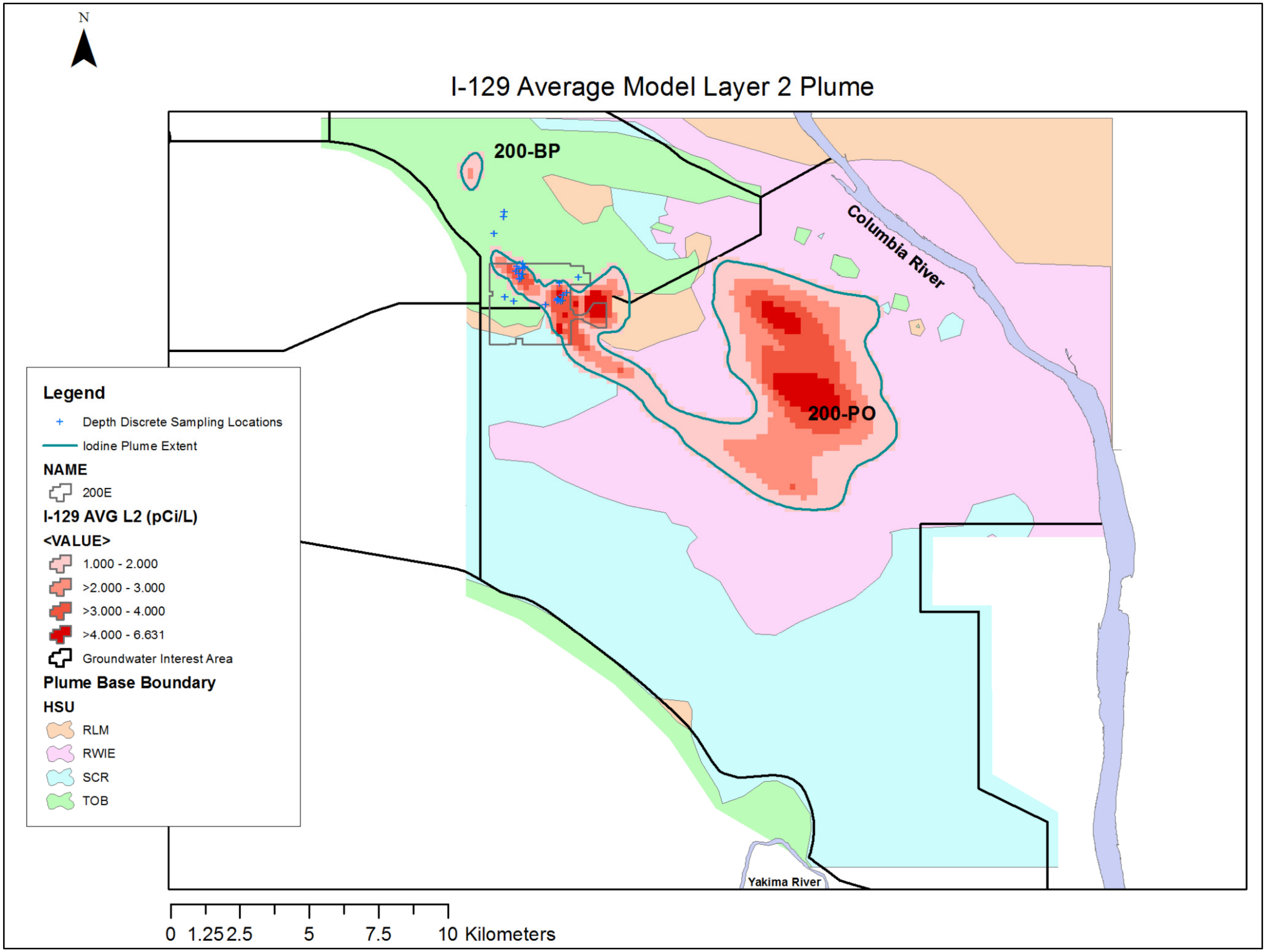


Figure C-30. Iodine-129 Plume in Layer 2, Average Basis

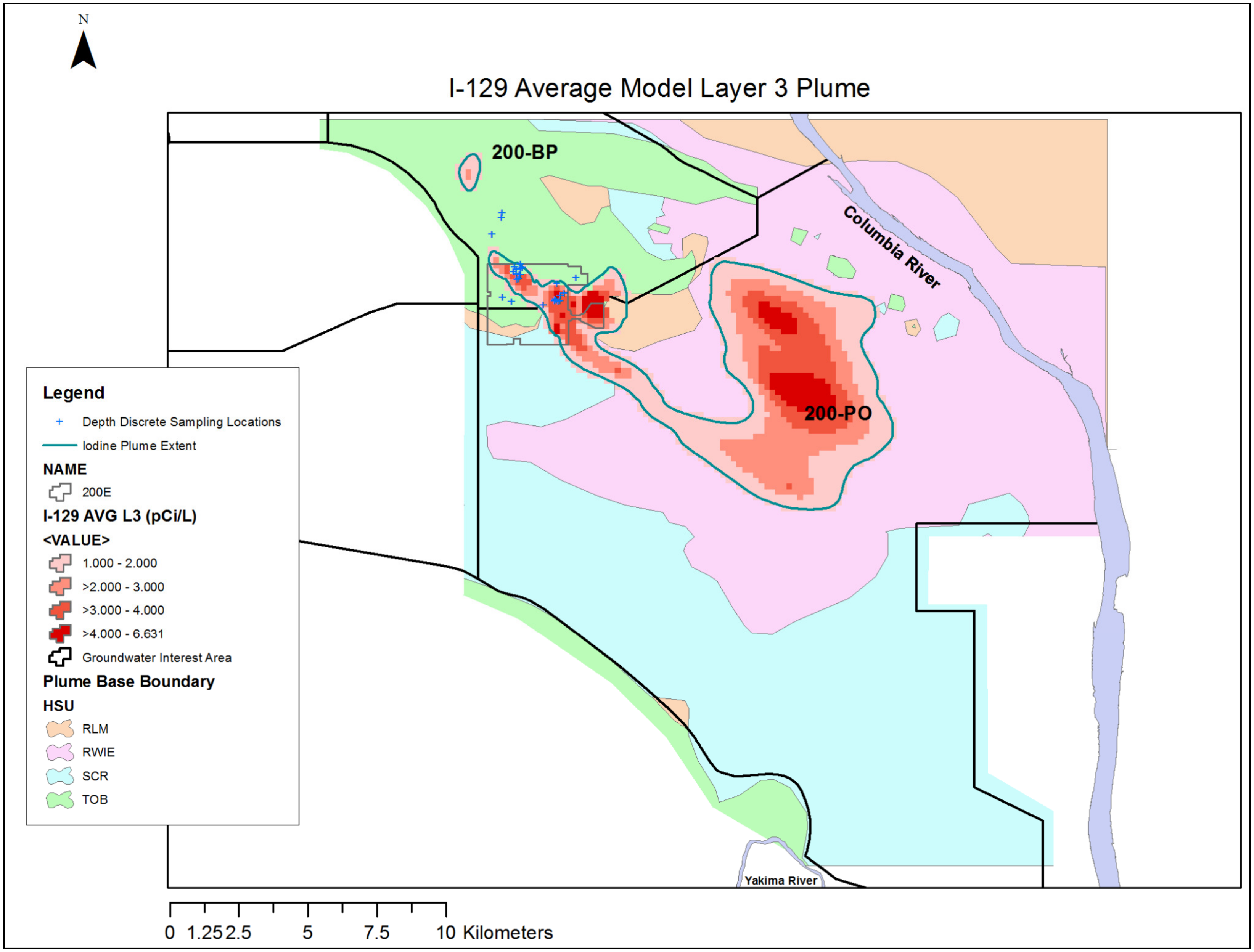


Figure C-31. Iodine-129 Plume in Layer 3, Average Basis

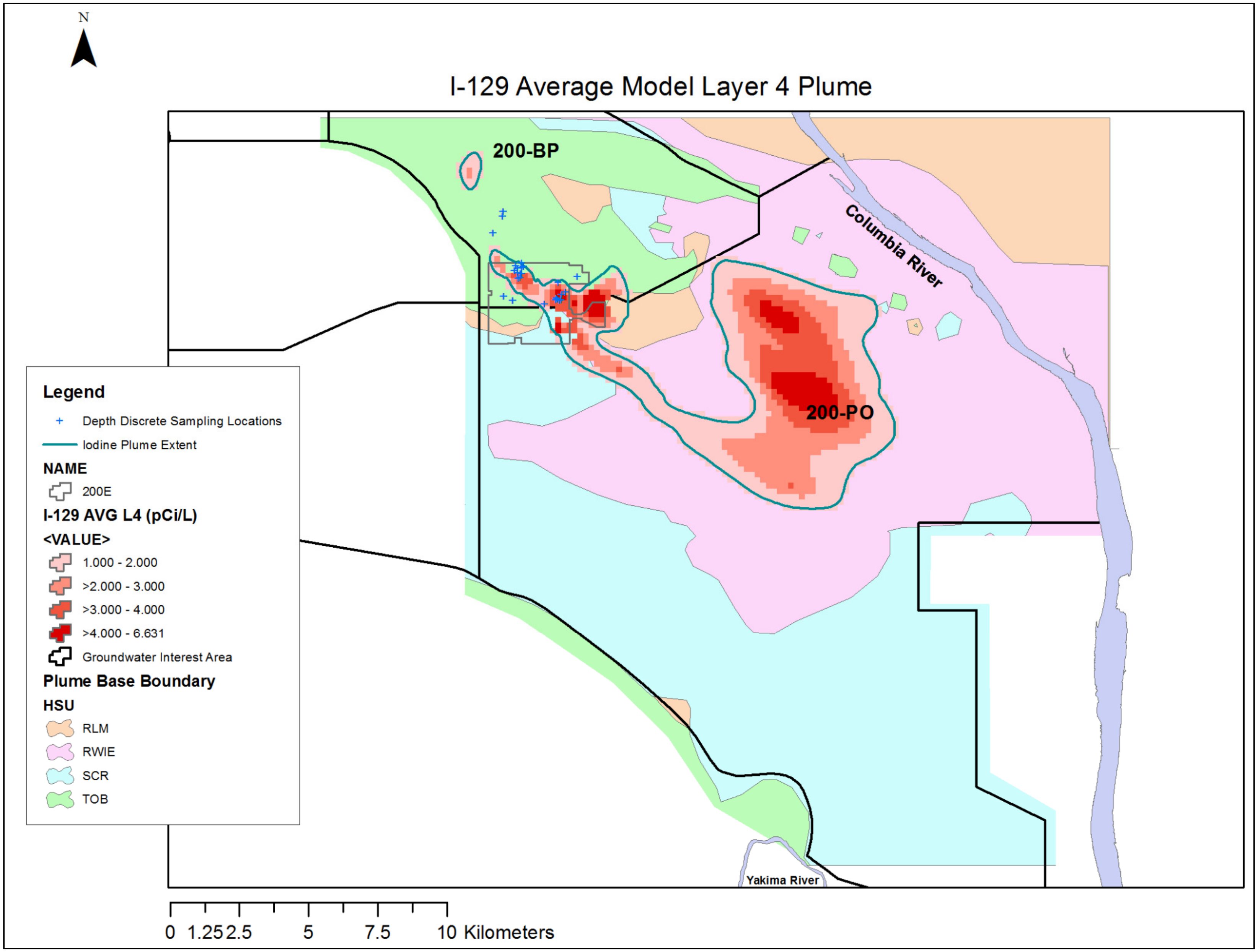


Figure C-32. Iodine-129 Plume in Layer 4, Average Basis

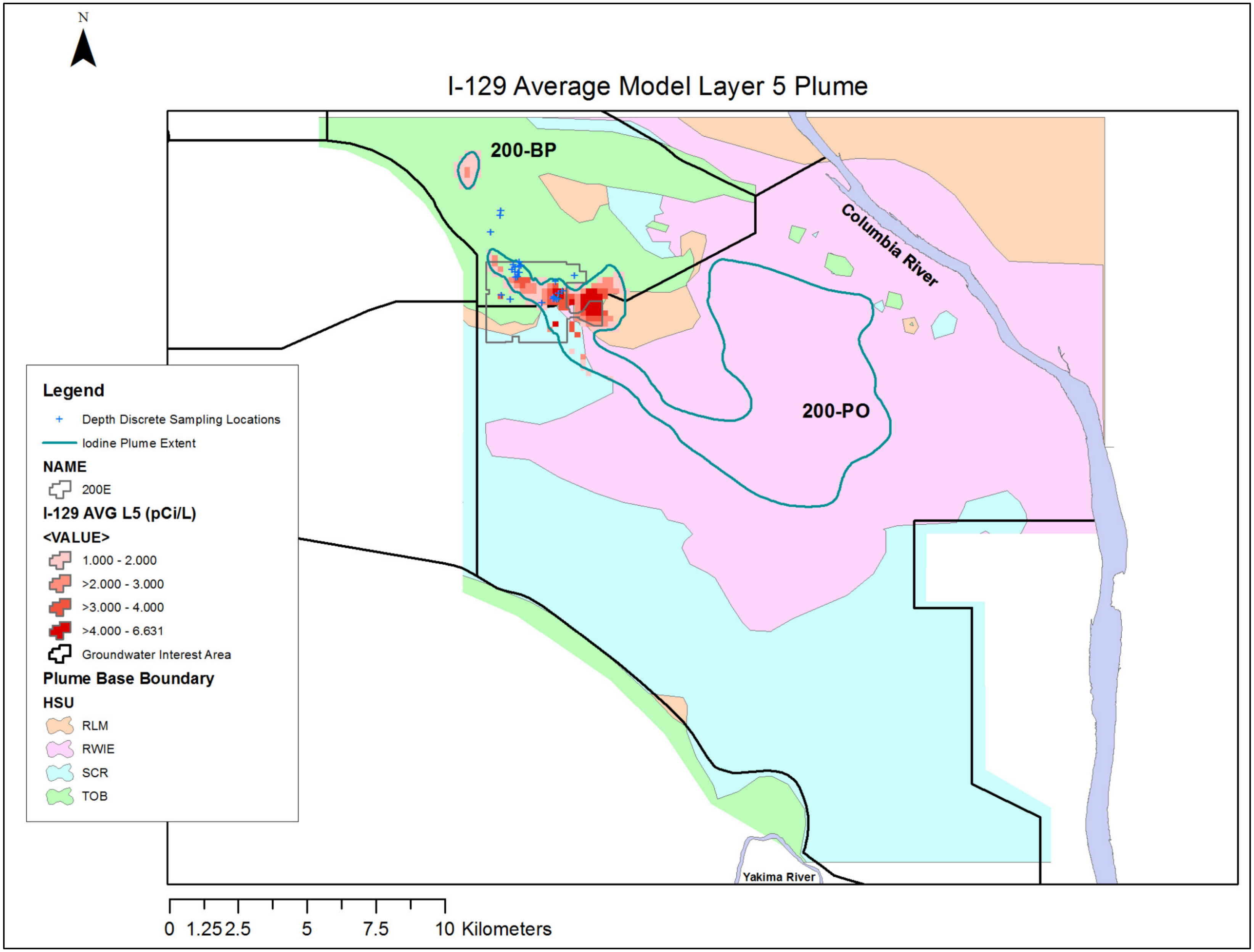


Figure C-33. Iodine-129 Plume in Layer 5, Average Basis

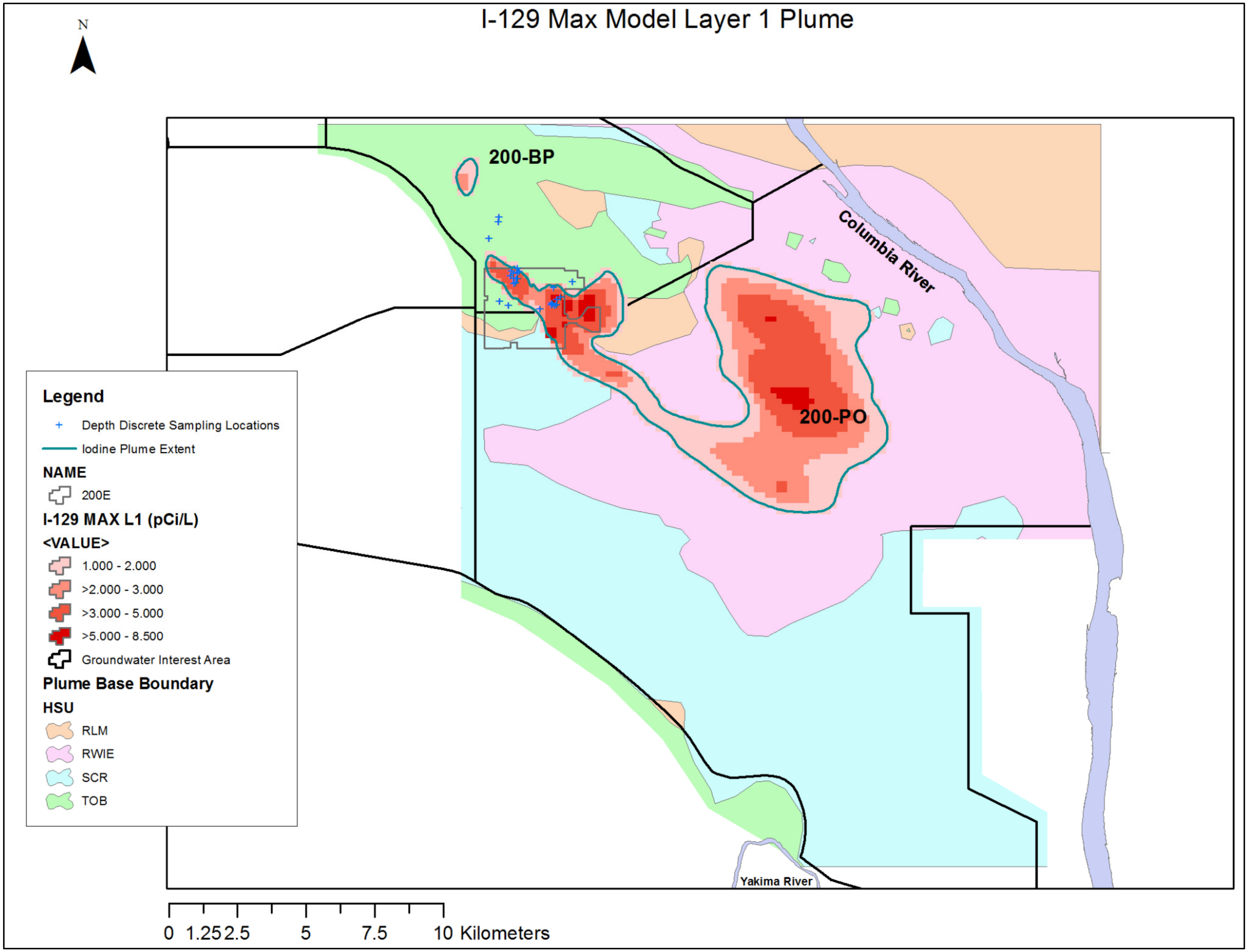


Figure C-34. Iodine-129 Plume in Layer 1, Maximum Basis

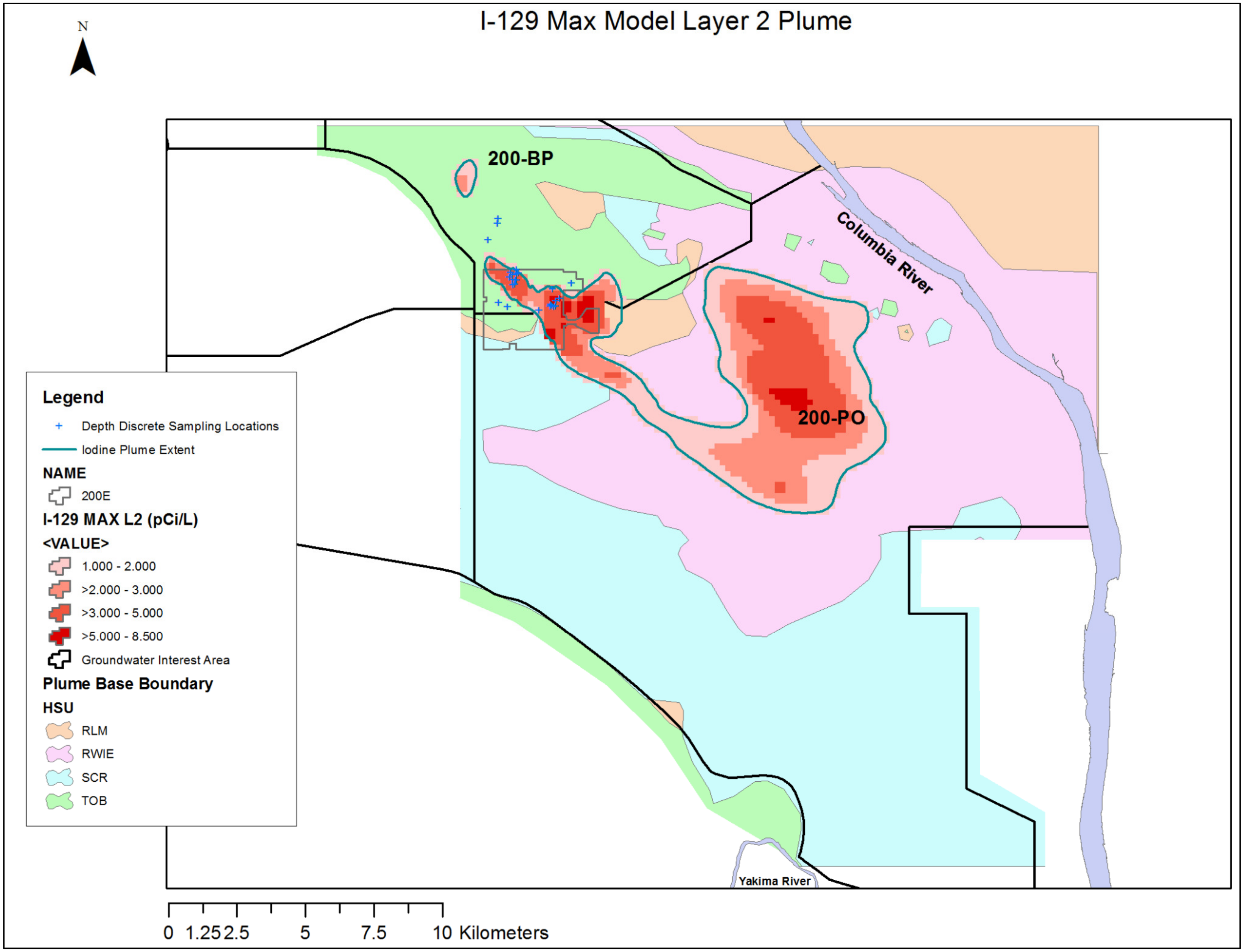


Figure C-35. Iodine-129 Plume in Layer 2, Maximum Basis

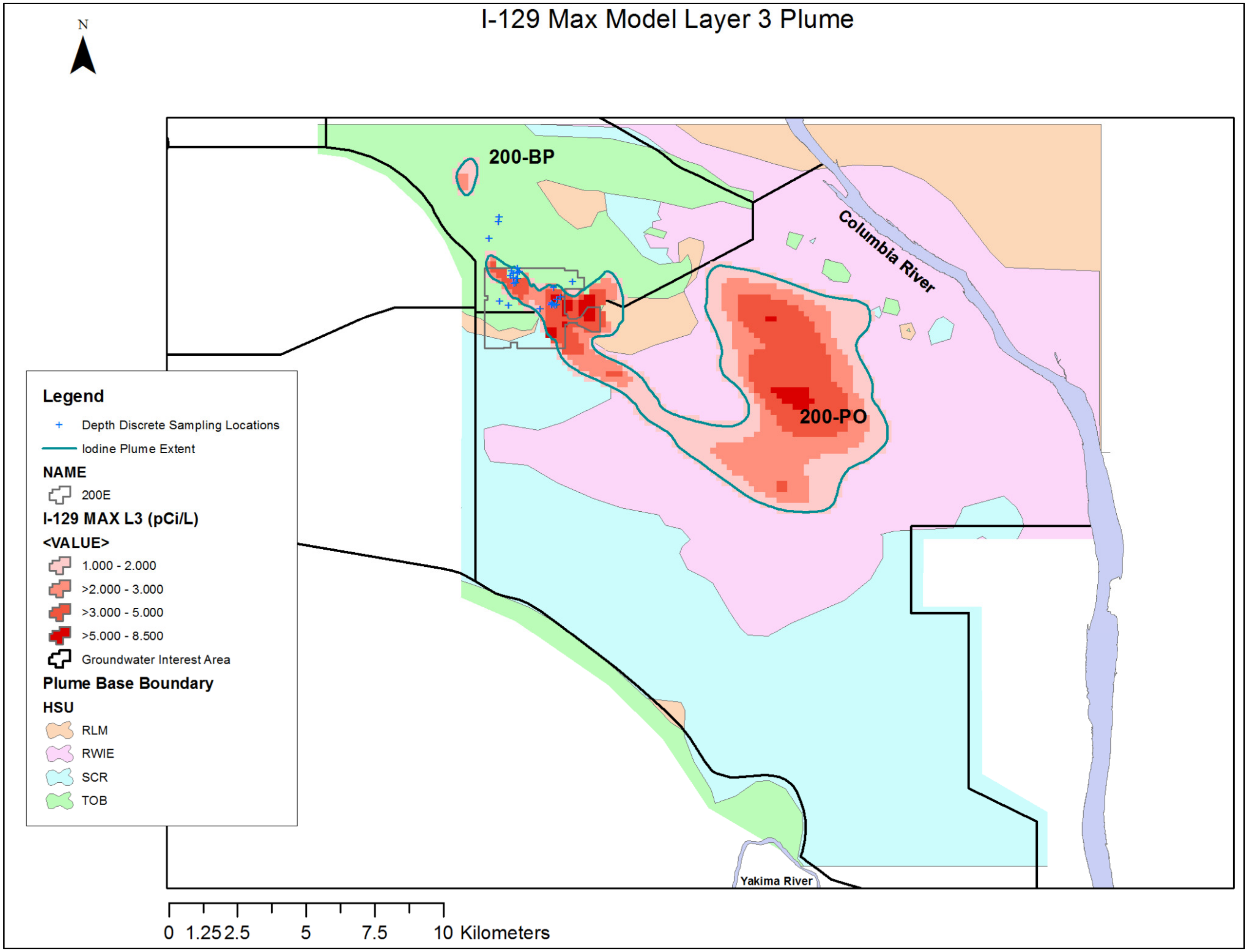


Figure C-36. Iodine-129 Plume in Layer 3, Maximum Basis

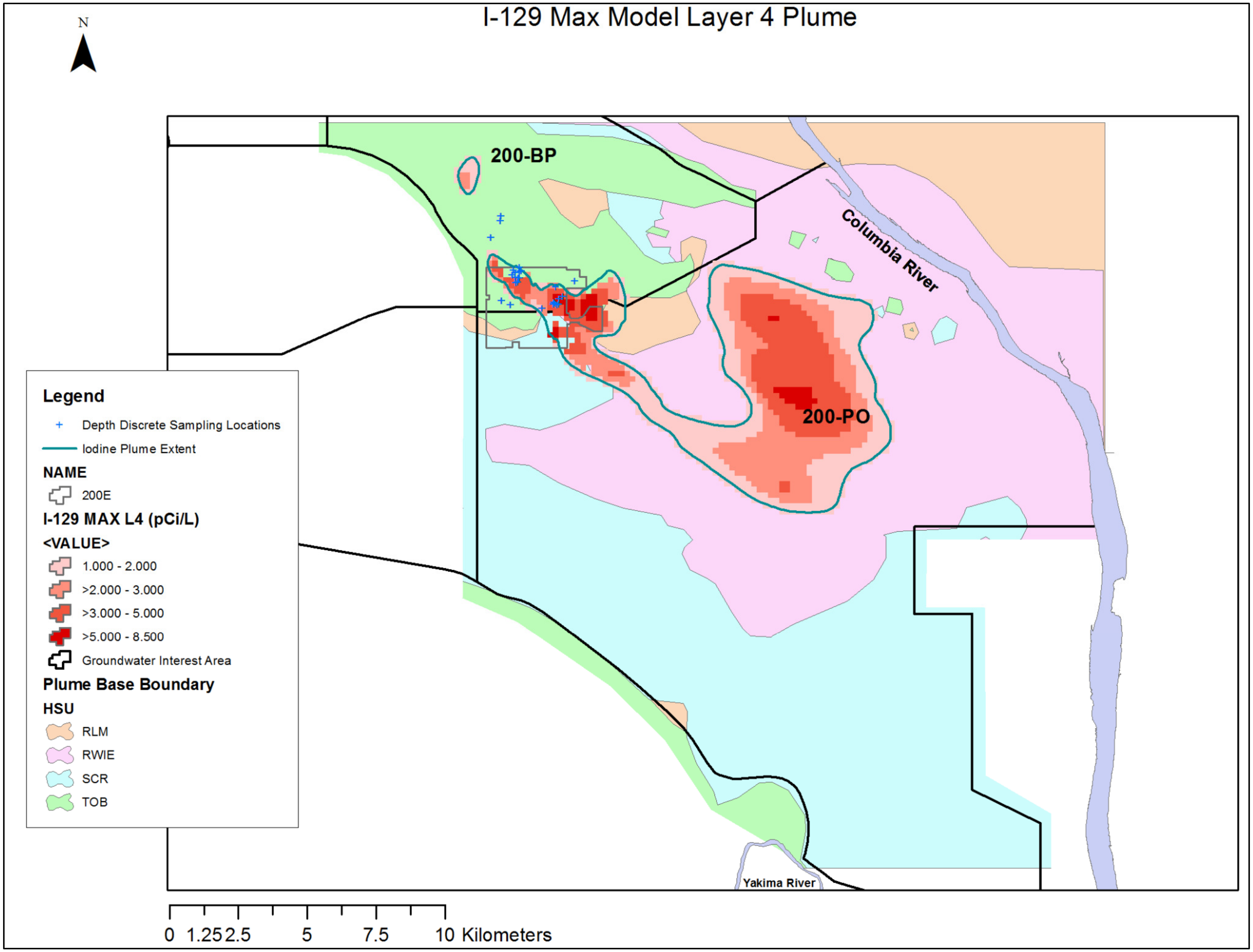


Figure C-37. Iodine-129 Plume in Layer 4, Maximum Basis

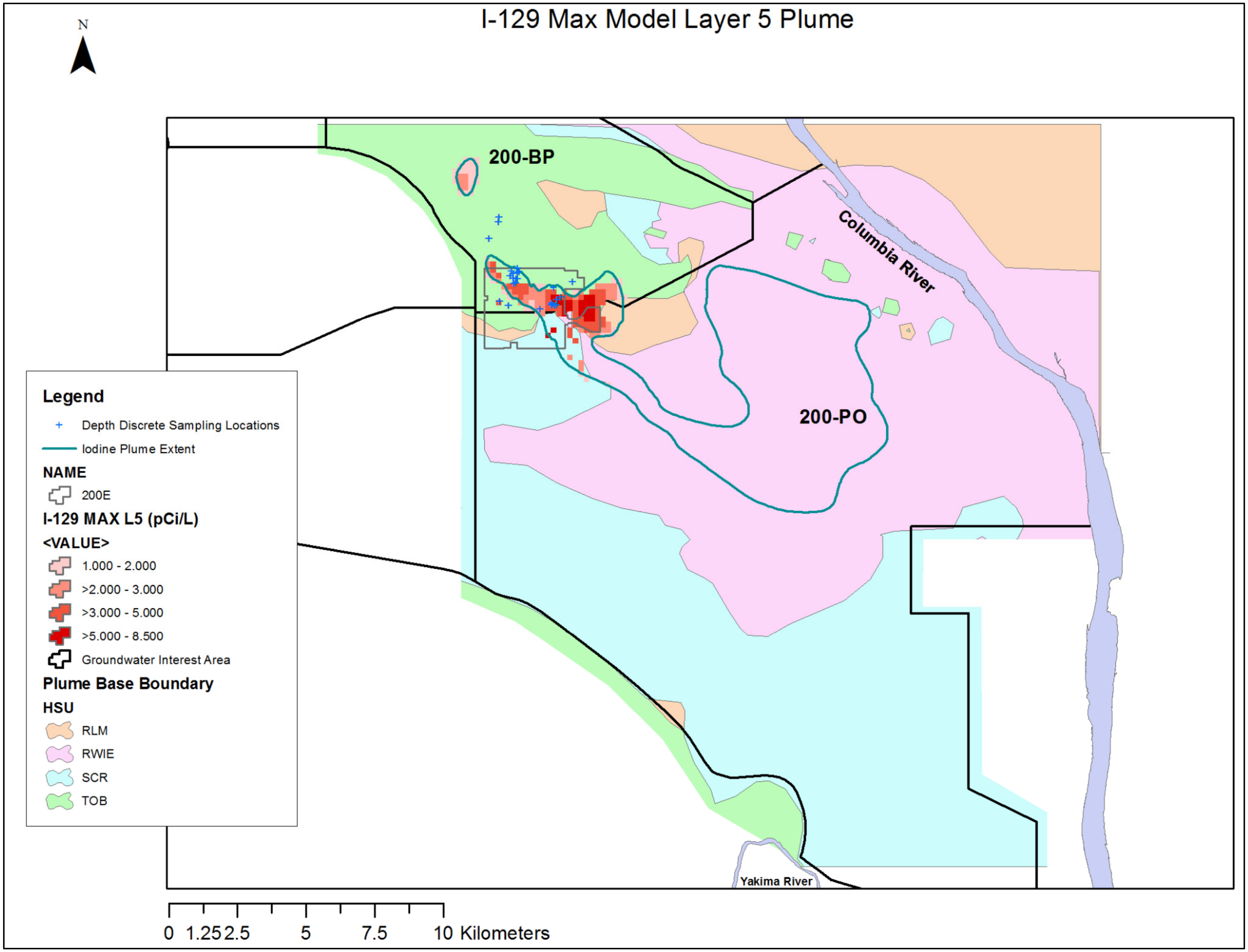


Figure C-38. Iodine-129 Plume in Layer 5, Maximum Basis

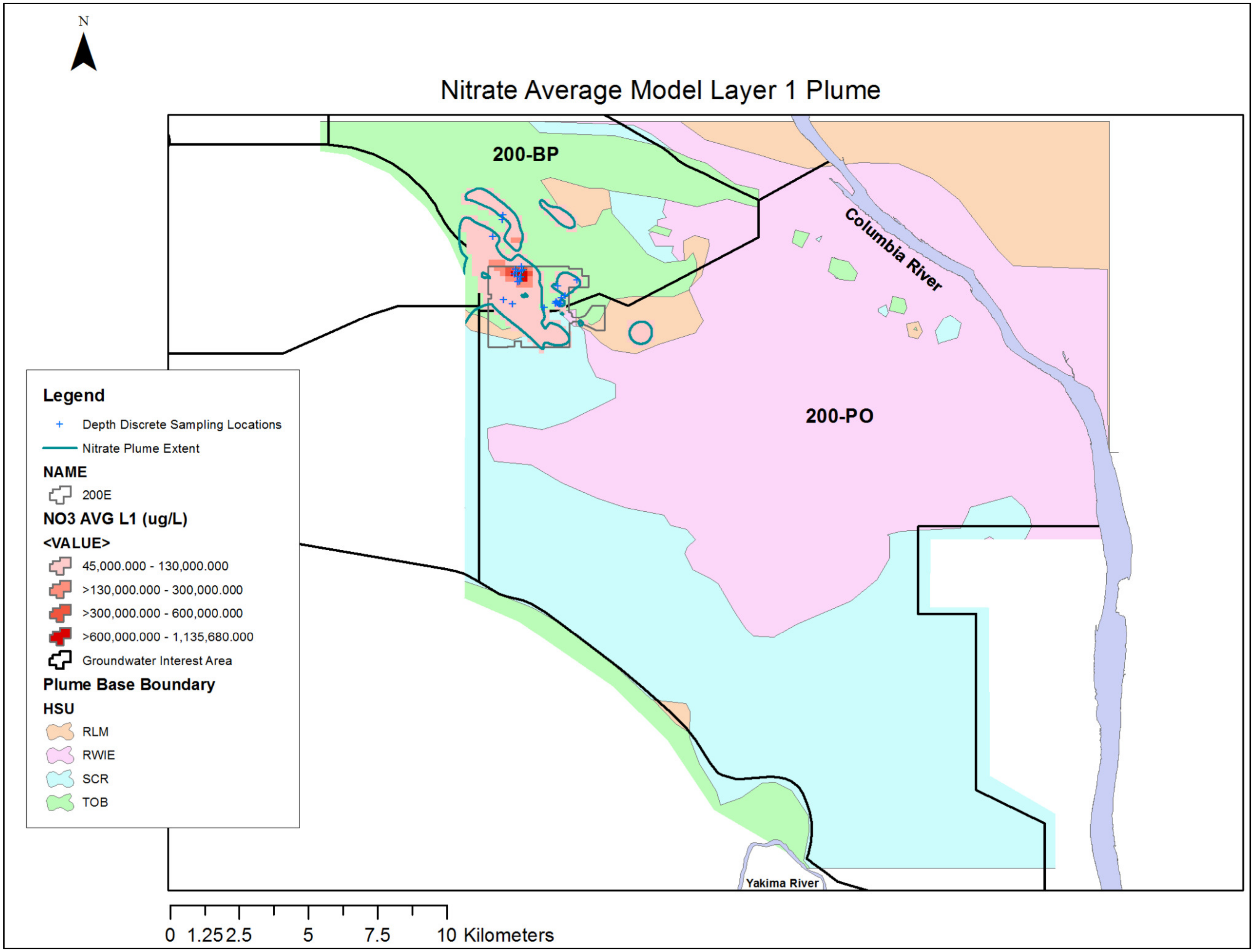


Figure C-39. Nitrate Plume in Layer 1, Average Basis

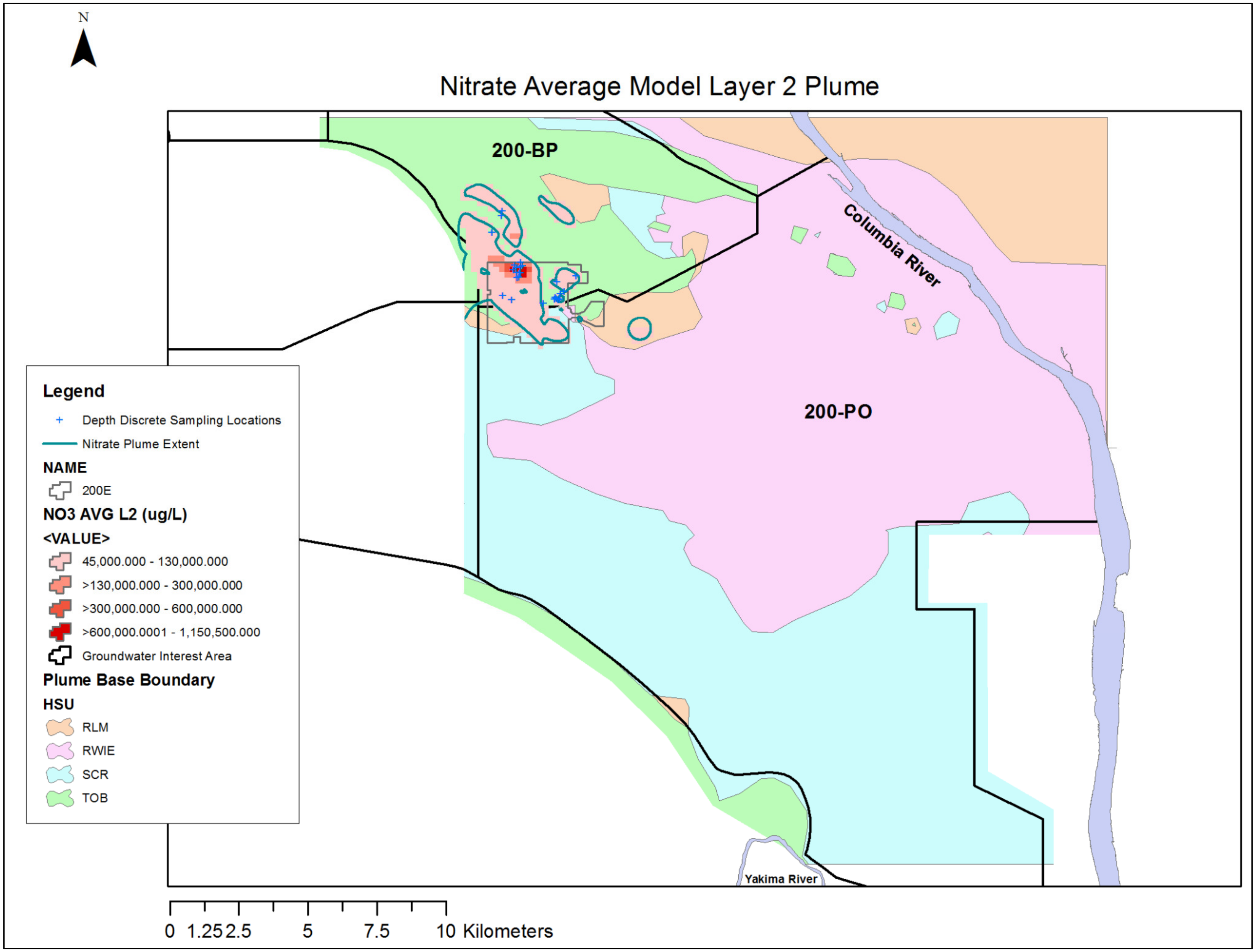
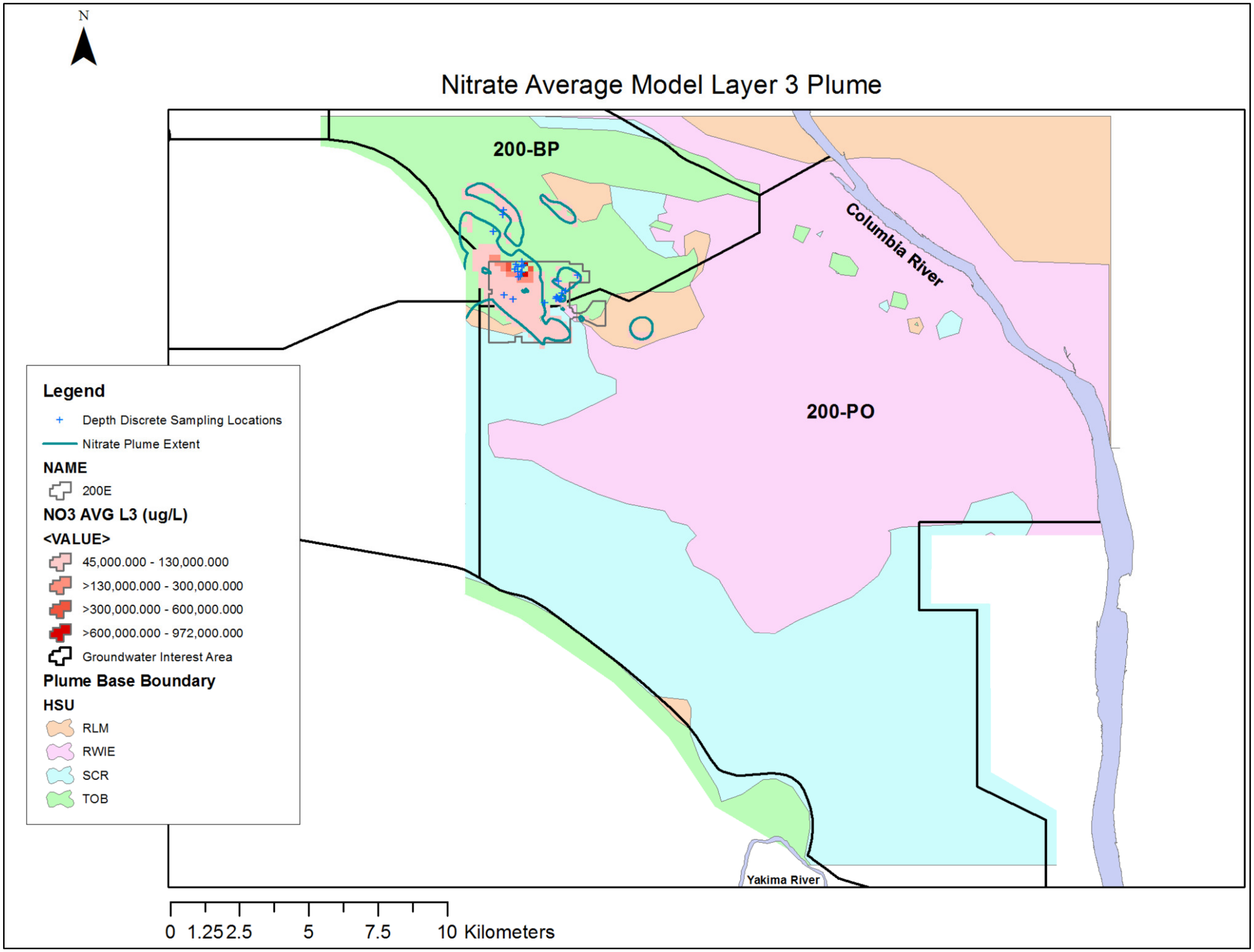


Figure C-40. Nitrate Plume in Layer 2, Average Basis



N
Nitrate Average Model Layer 3 Plume
200-BP
Columbia River
200-PO
Yakima River
Legend
Depth Discrete Sampling Locations
Nitrate Plume Extent
NAME
200E
NO3 AVG L3 (ug/L)
<VALUE>
45,000.000 - 130,000.000
>130,000.000 - 300,000.000
>300,000.000 - 600,000.000
>600,000.000 - 972,000.000
Groundwater Interest Area
Plume Base Boundary
HSU
RLM
RWIE
SCR
TOB
0 1.25 2.5 5 7.5 10 Kilometers

Figure C-41. Nitrate Plume in Layer 3, Average Basis

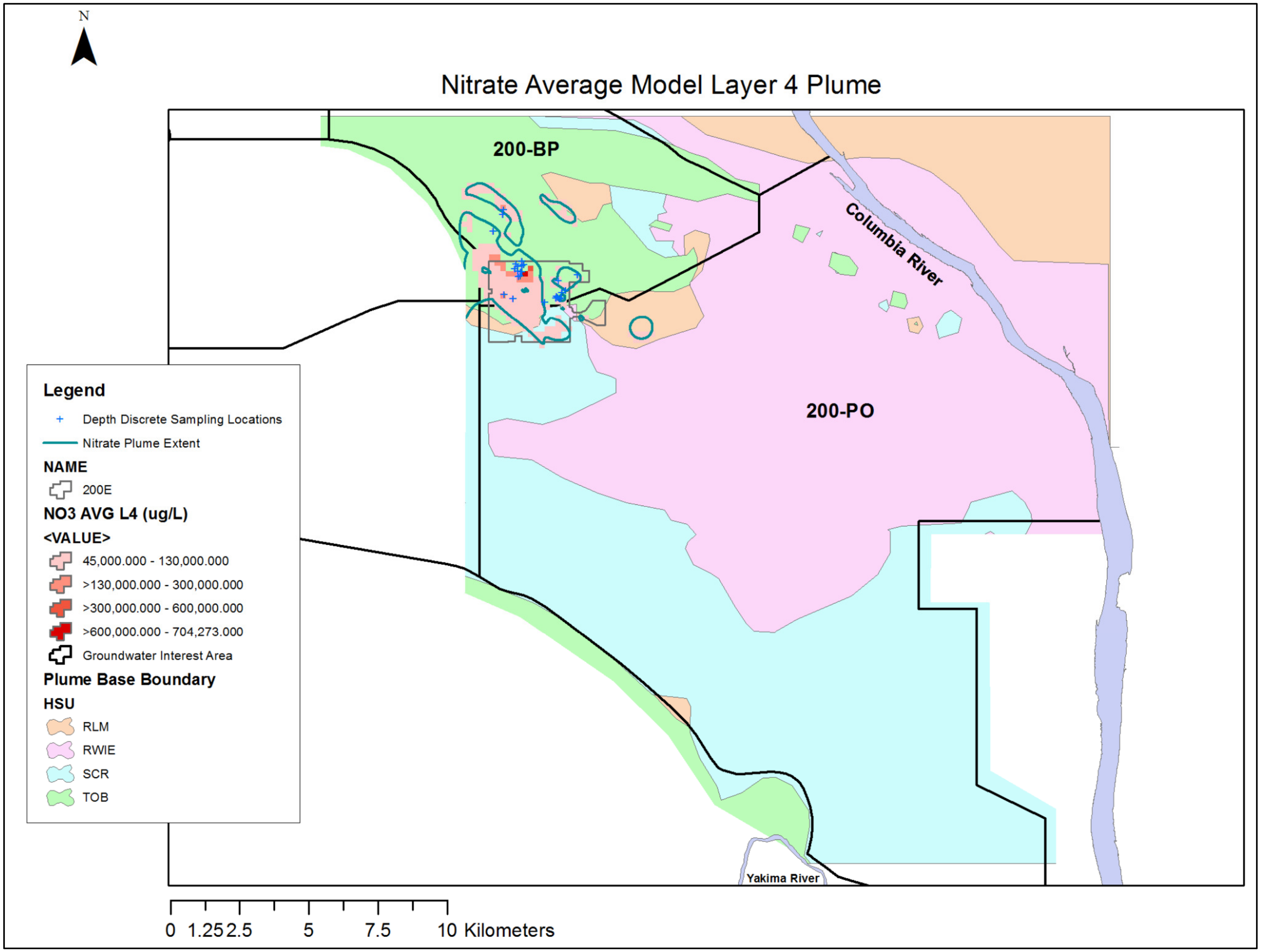


Figure C-42. Nitrate Plume in Layer 4, Average Basis

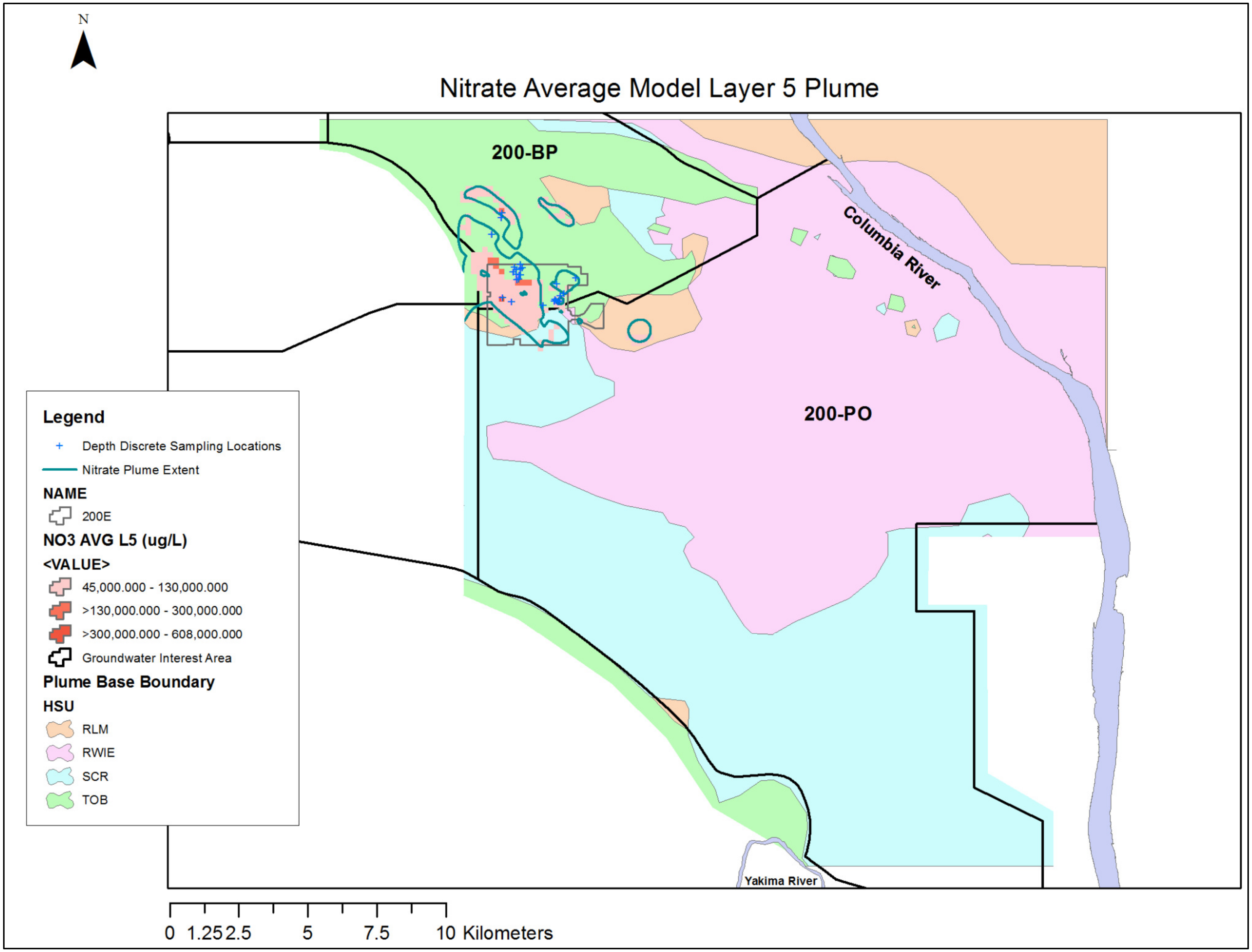


Figure C-43. Nitrate Plume in Layer 5, Average Basis

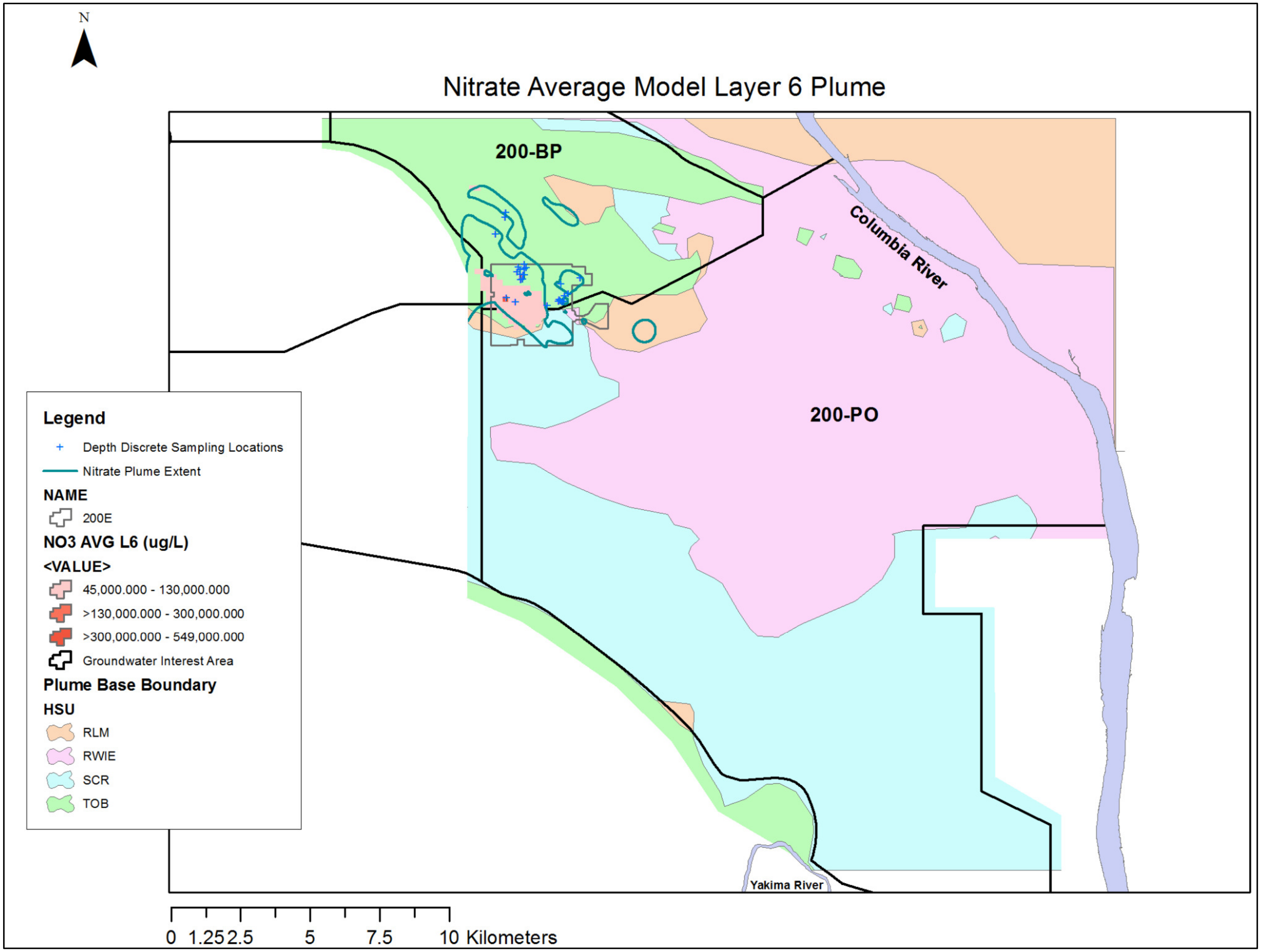


Figure C-44. Nitrate Plume in Layer 6, Average Basis

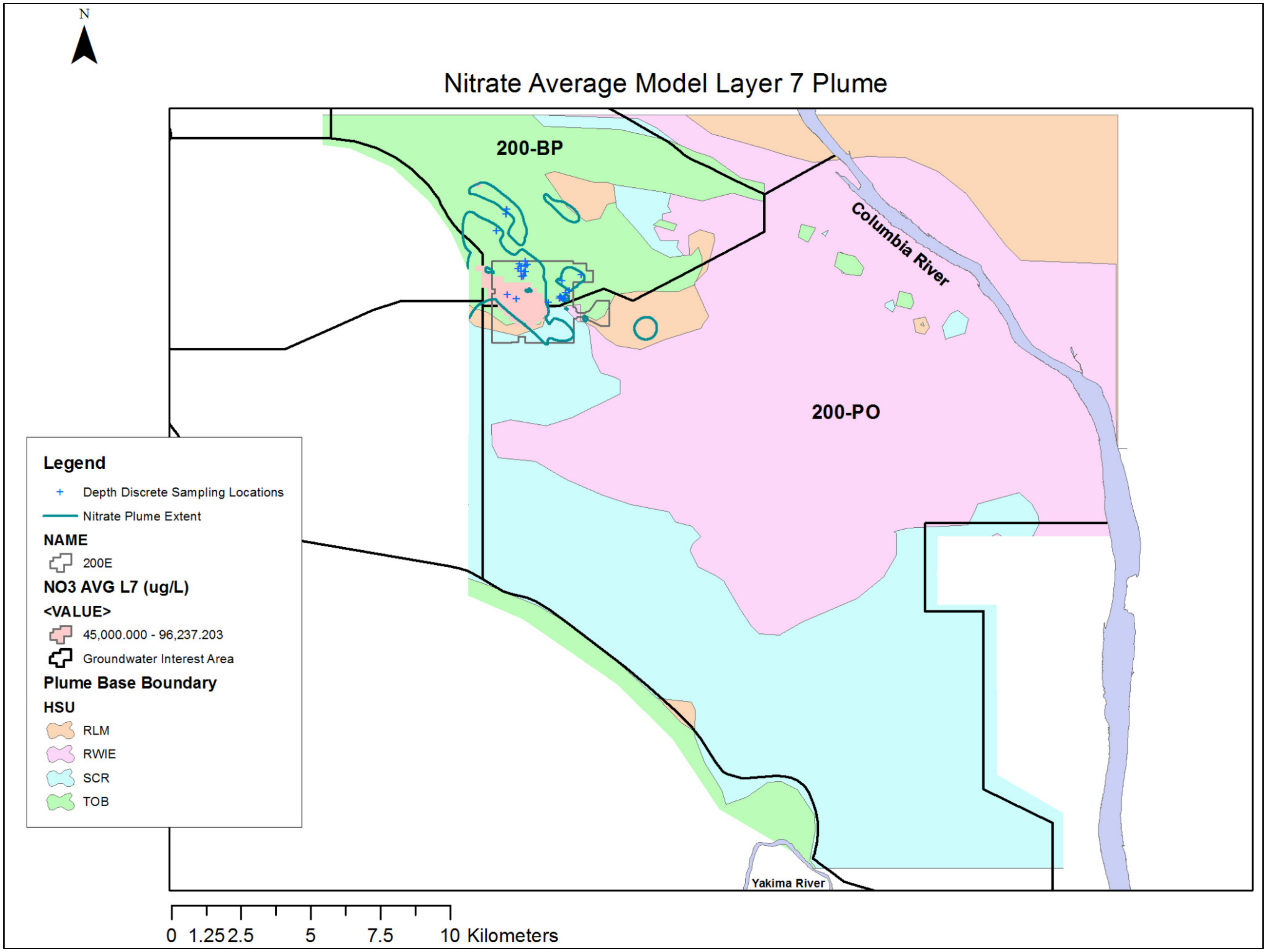


Figure C-45. Nitrate Plume in Layer 7, Average Basis

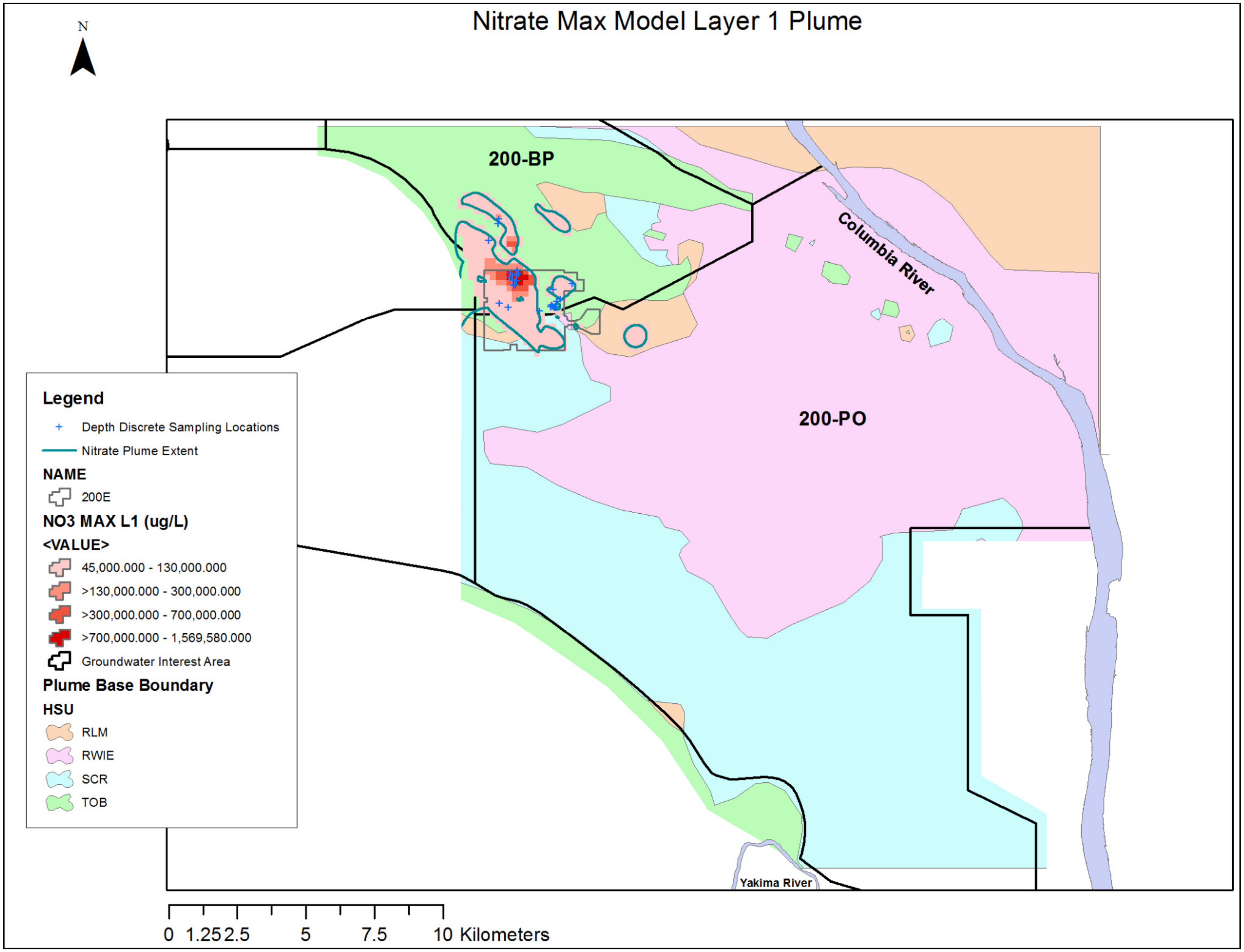


Figure C-46. Nitrate Plume in Layer 1, Maximum Basis

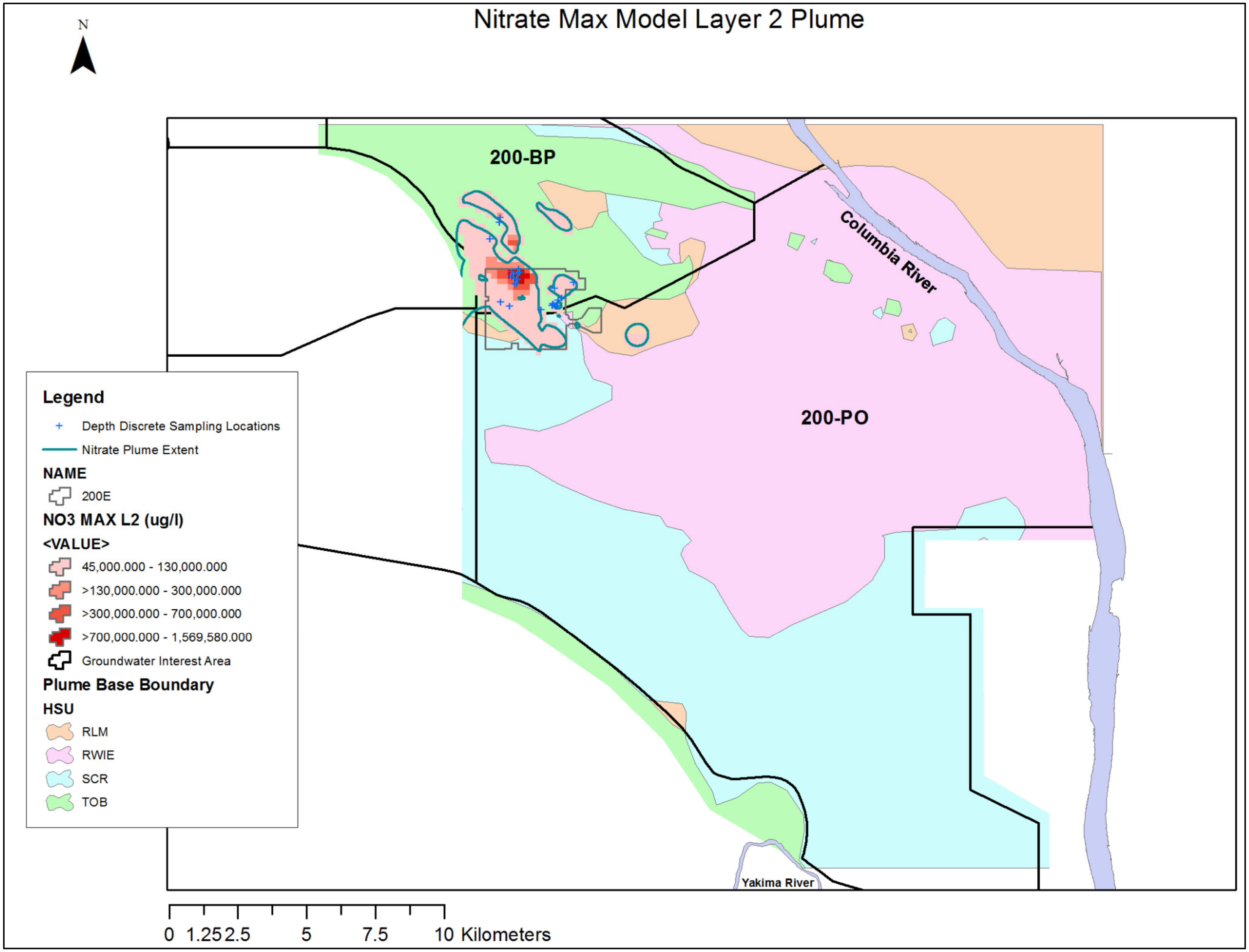


Figure C-47. Nitrate Plume in Layer 2, Maximum Basis

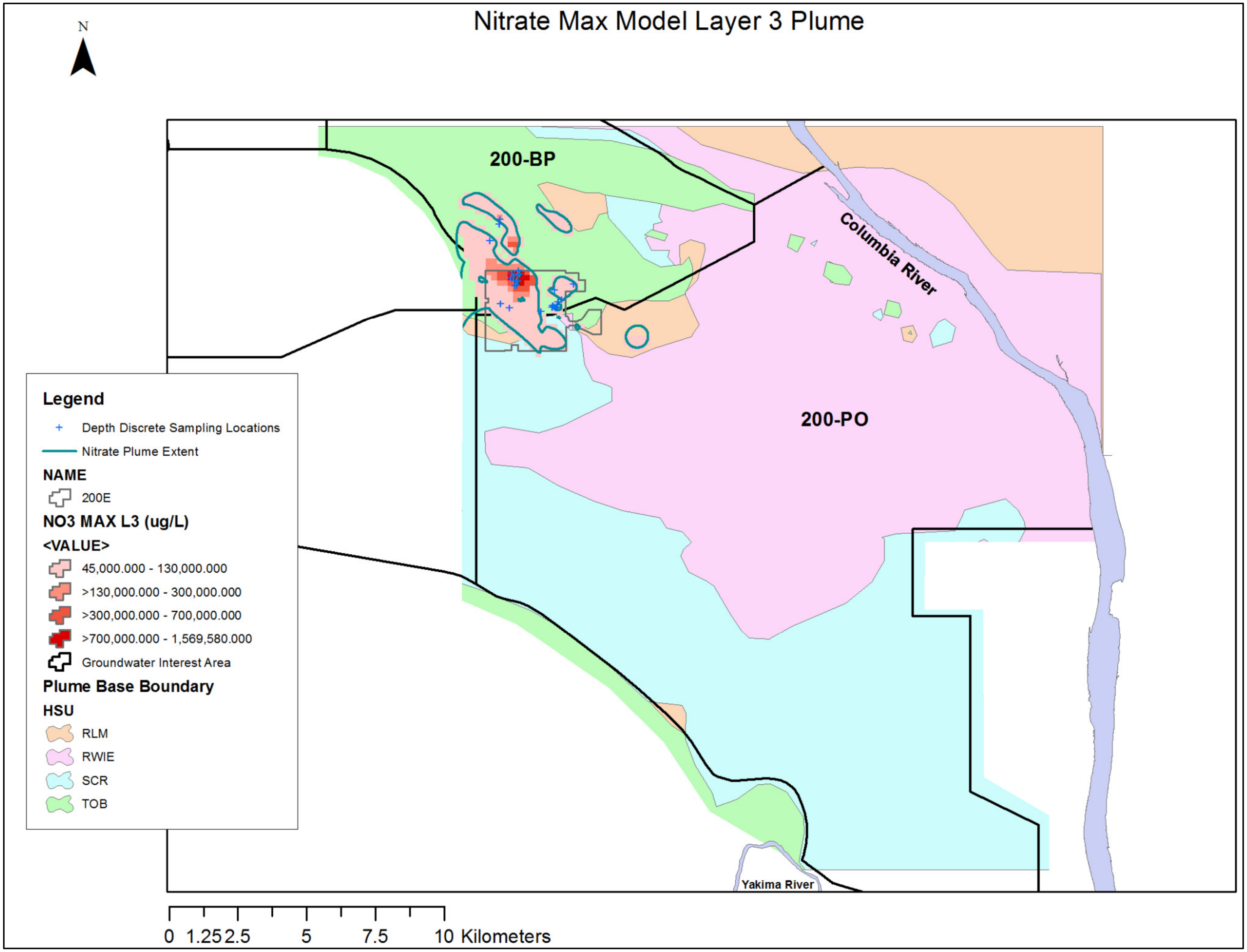


Figure C-48. Nitrate Plume in Layer 3, Maximum Basis

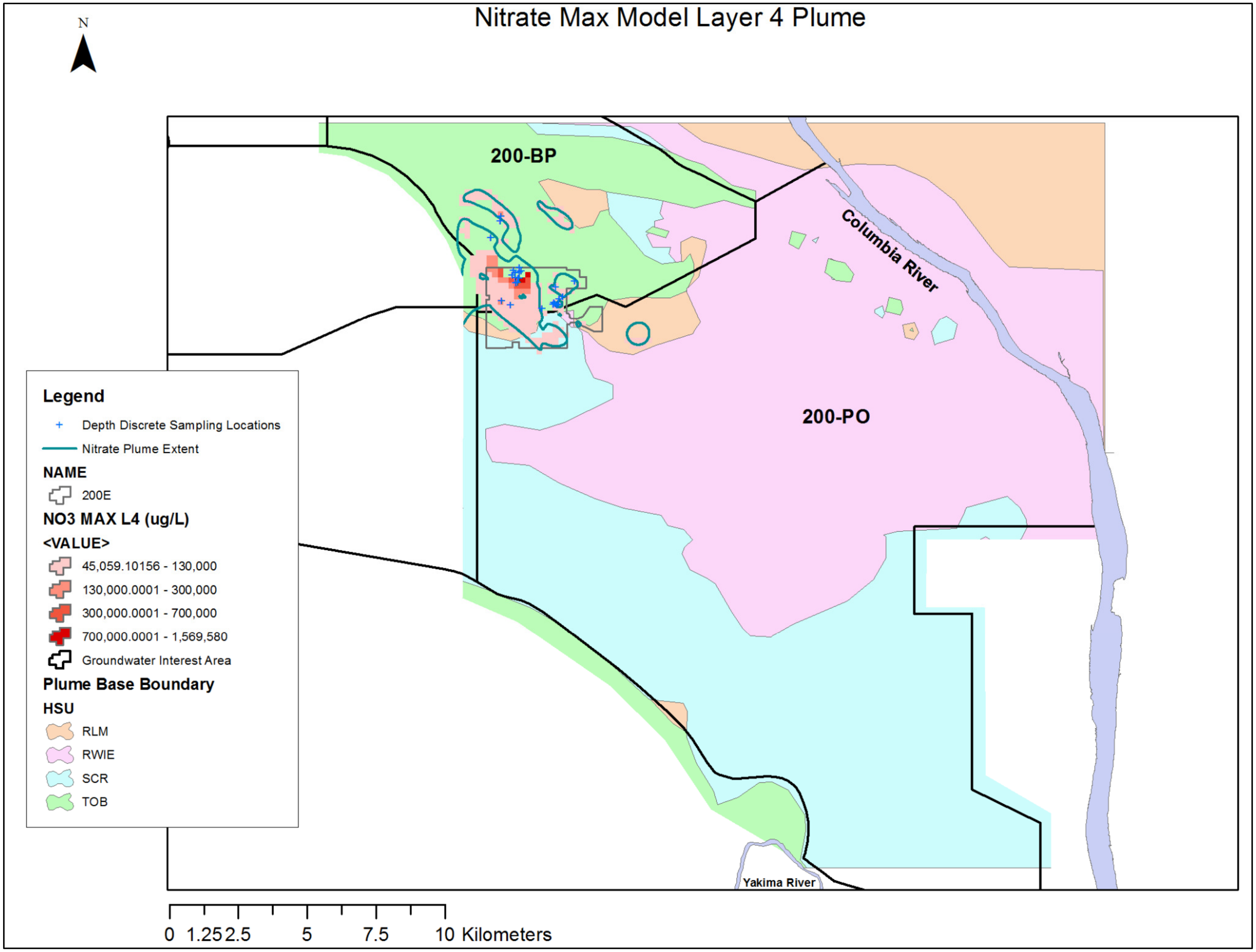


Figure C-49. Nitrate Plume in Layer 4, Maximum Basis

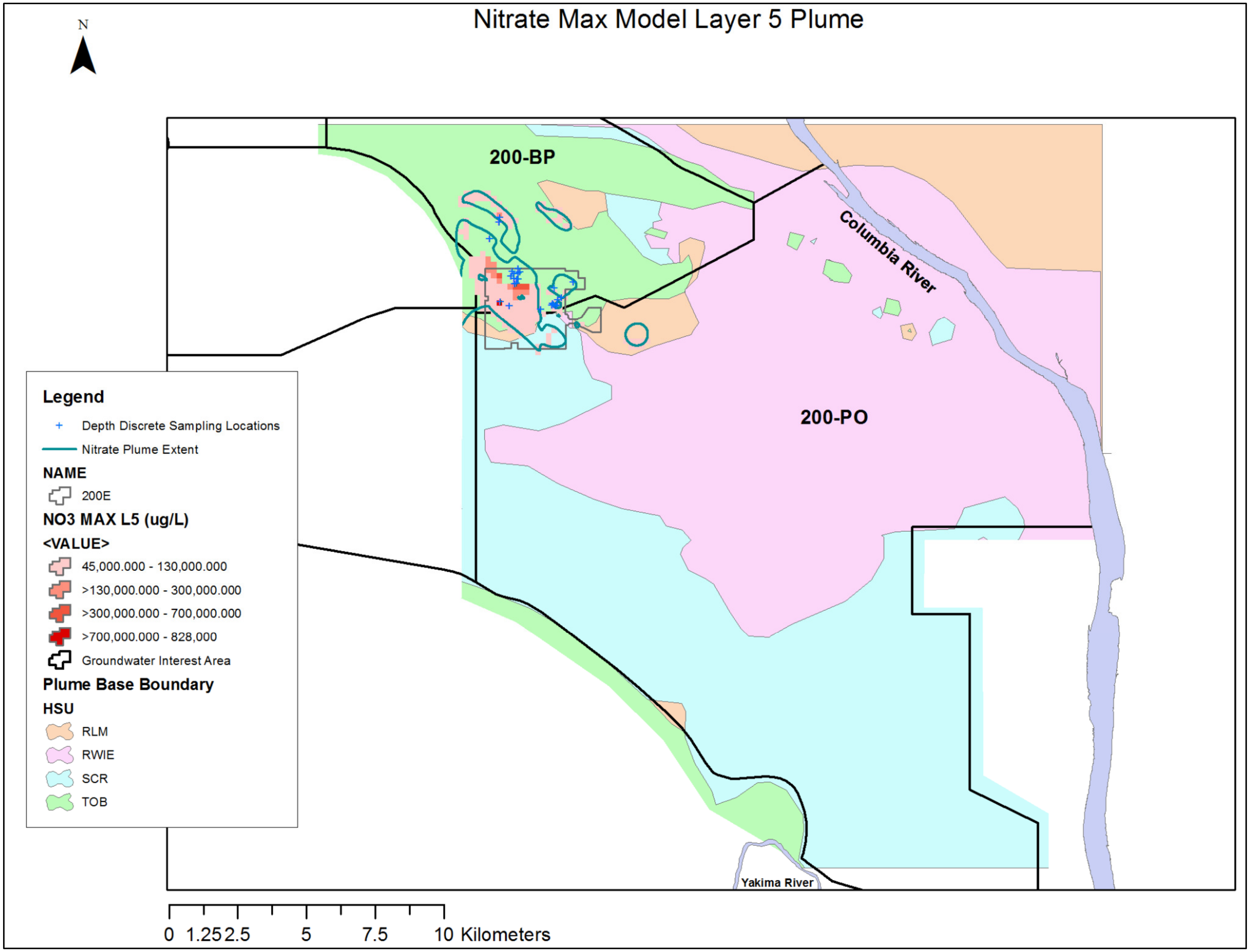


Figure C-50. Nitrate Plume in Layer 5, Maximum Basis

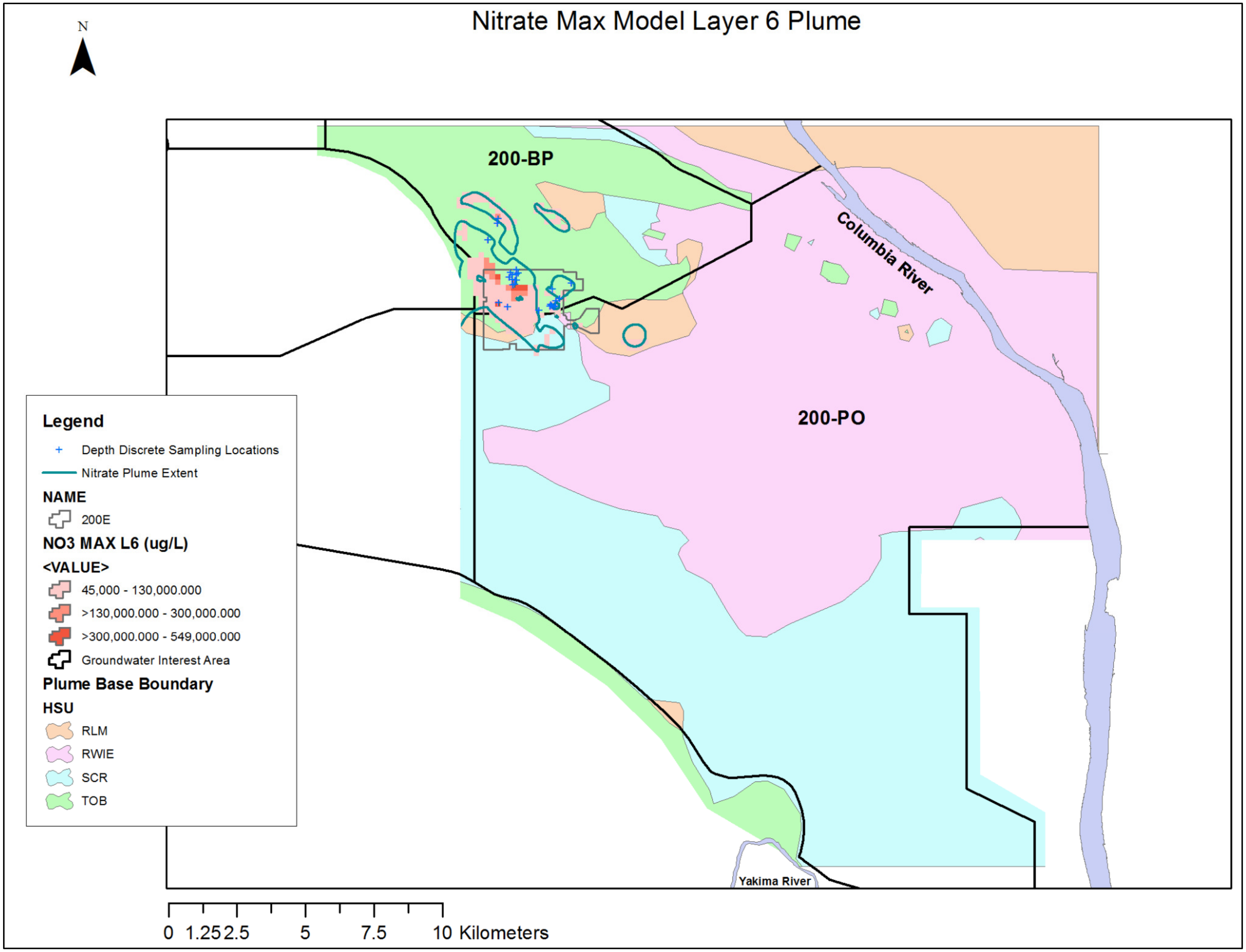


Figure C-51. Nitrate Plume in Layer 6, Maximum Basis

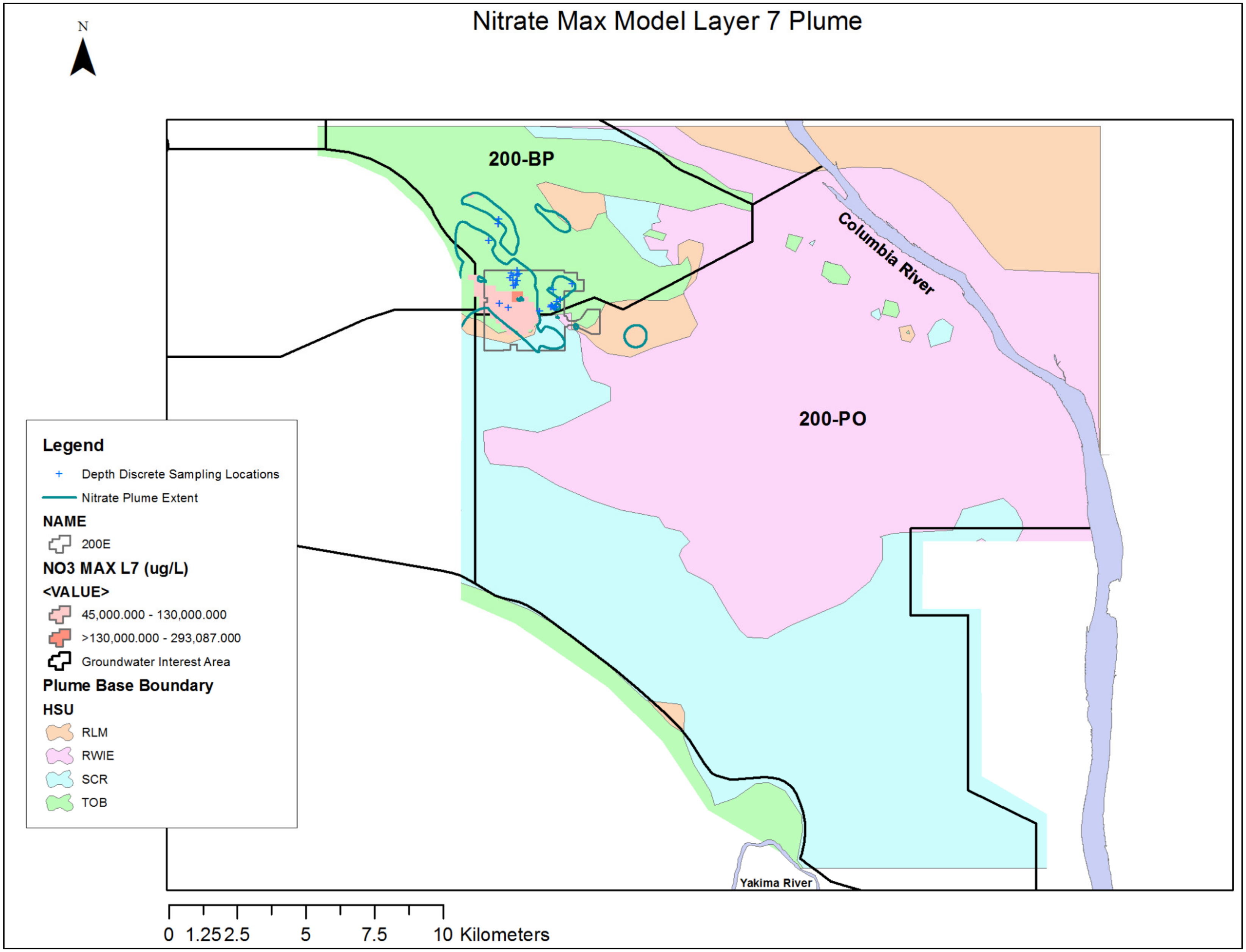


Figure C-52. Nitrate Plume in Layer 7, Maximum Basis

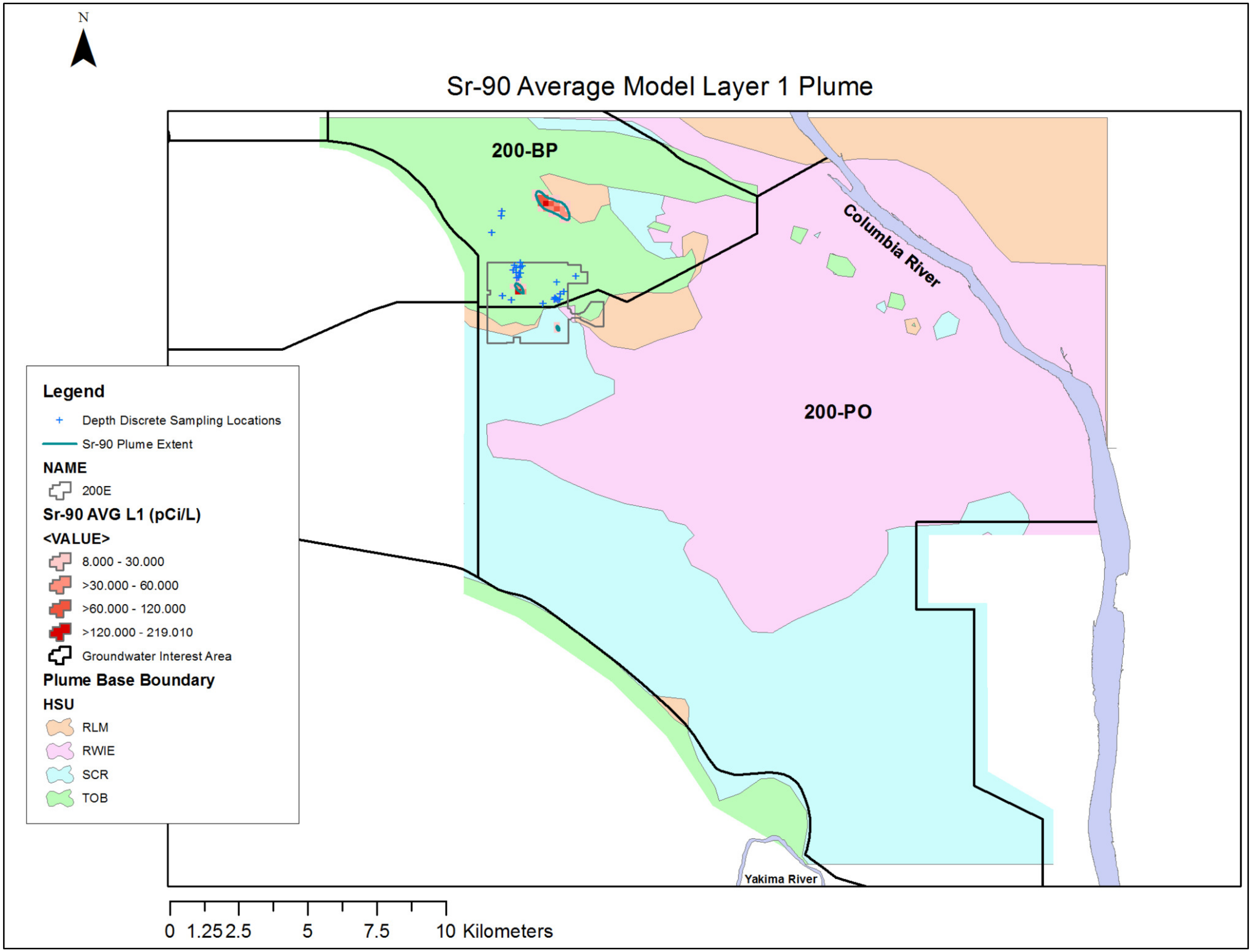


Figure C-53. Strontium-90 Plume in Layer 1, Average Basis

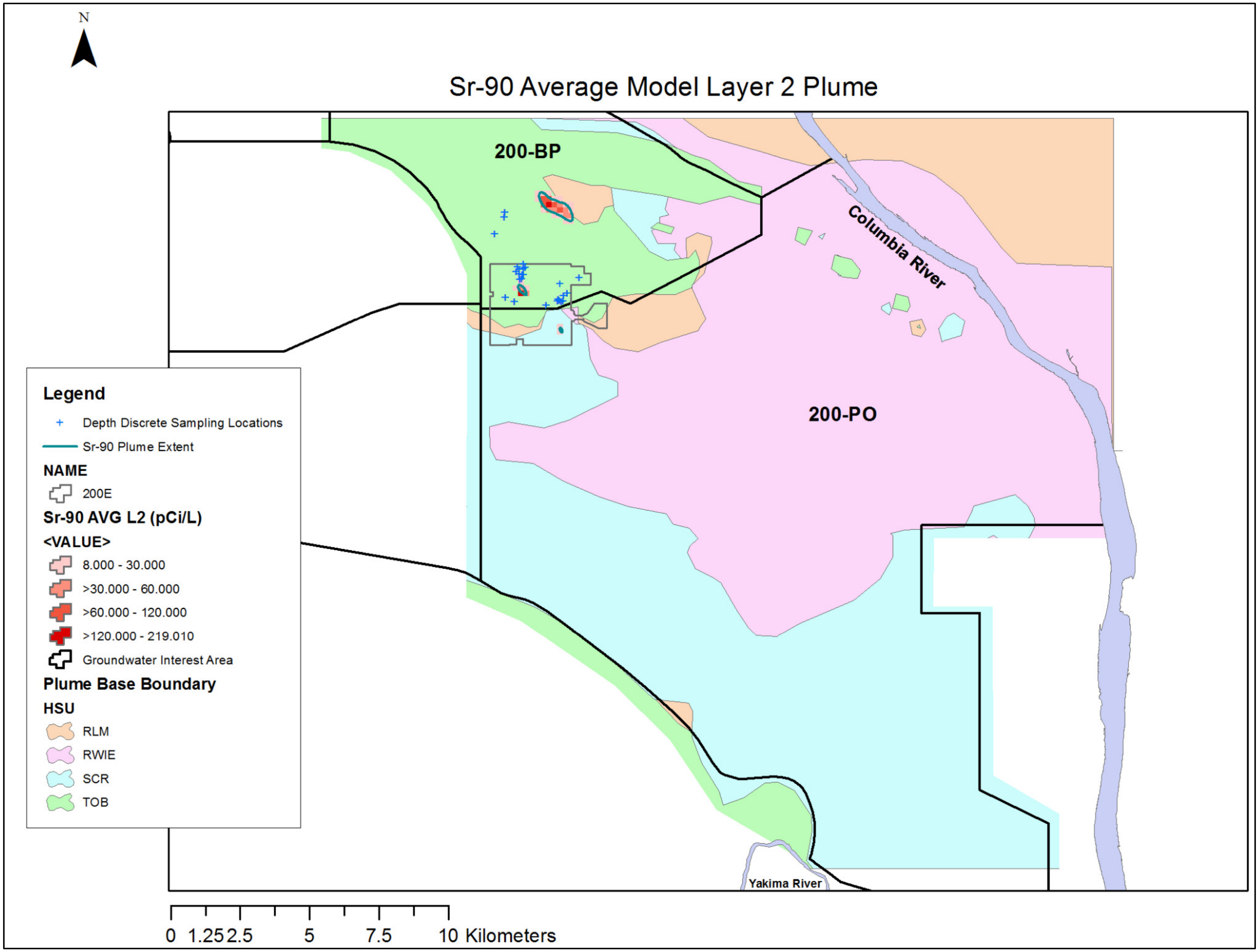


Figure C-54. Strontium-90 Plume in Layer 2, Average Basis

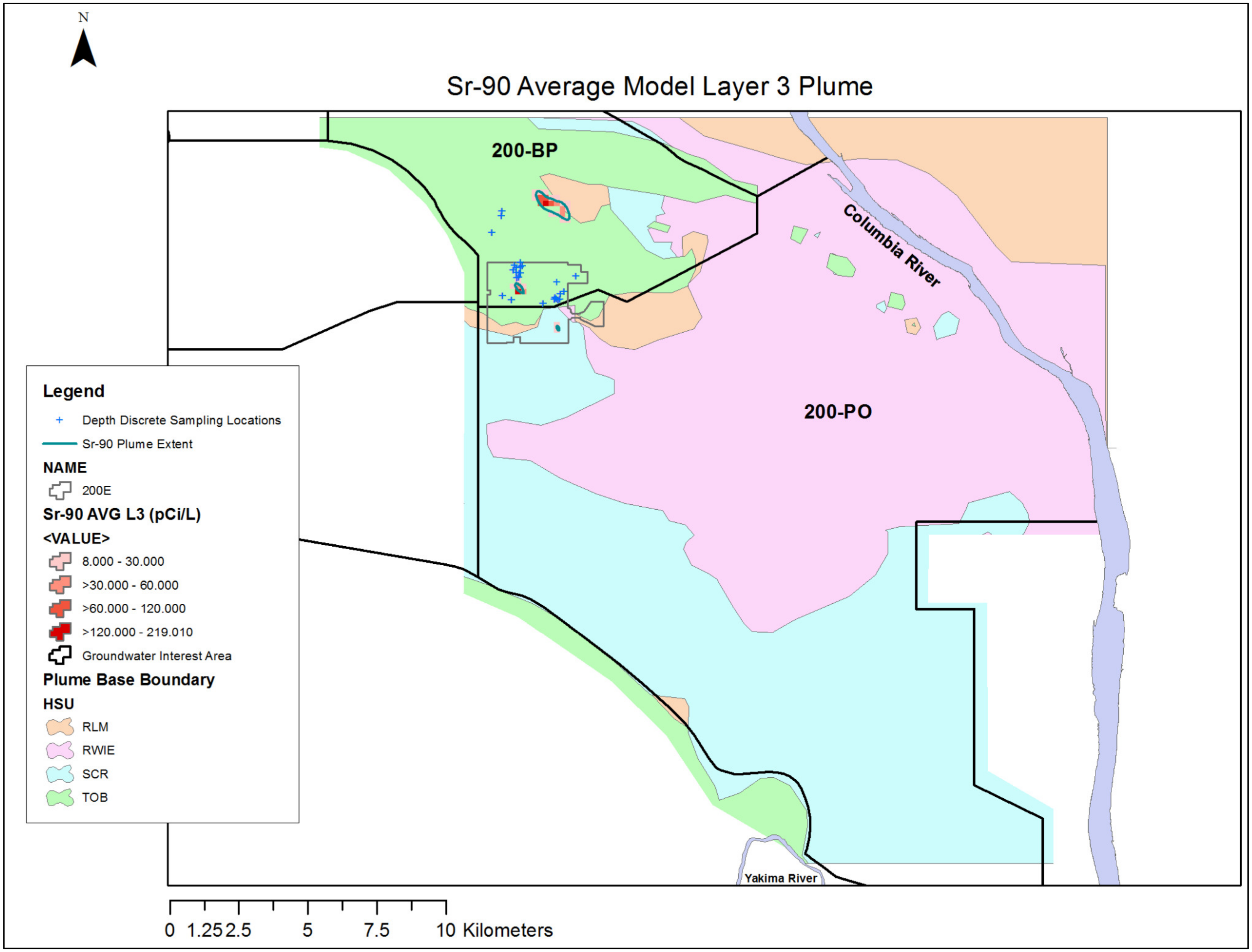


Figure C-55. Strontium-90 Plume in Layer 3, Average Basis

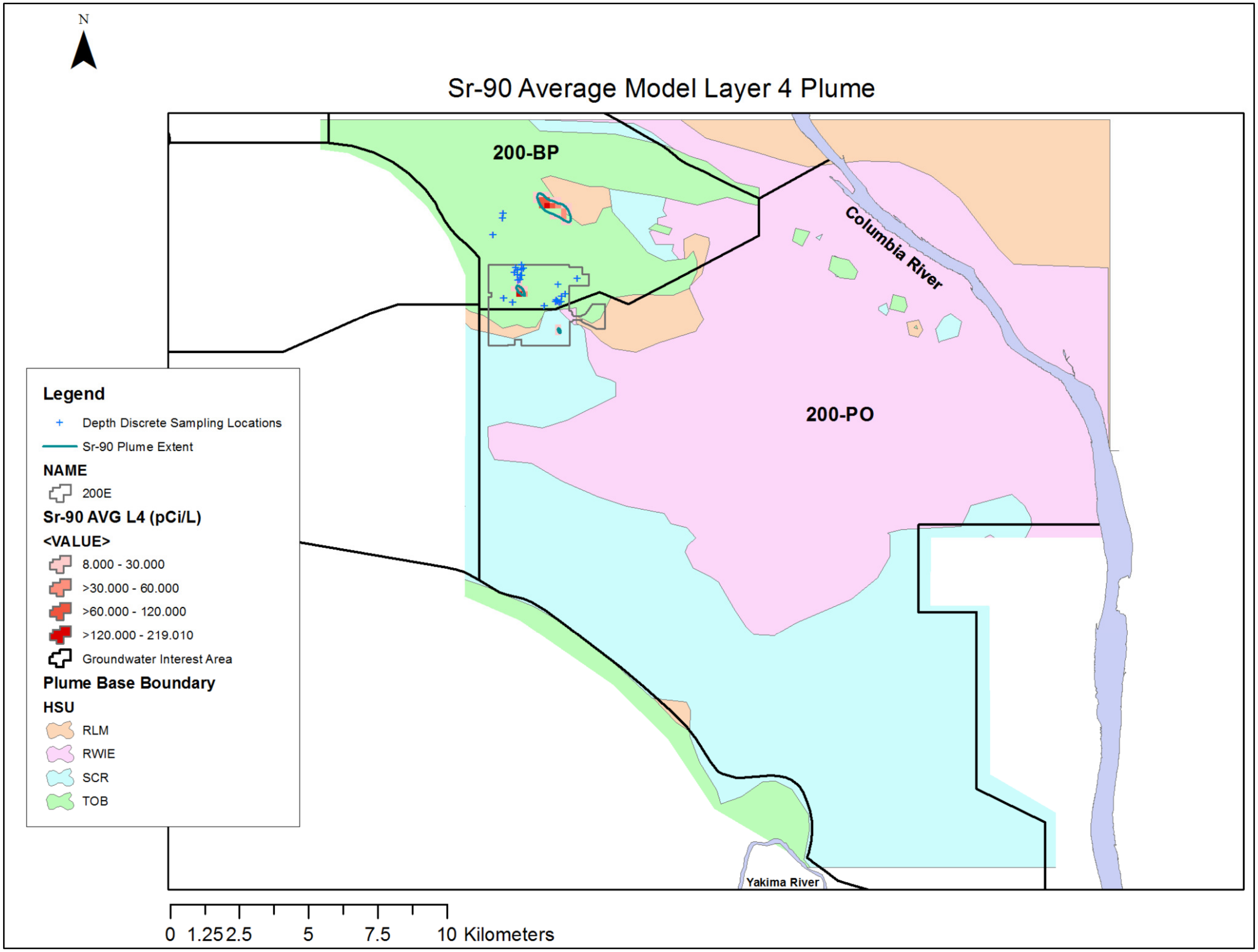


Figure C-56. Strontium-90 Plume in Layer 4, Average Basis

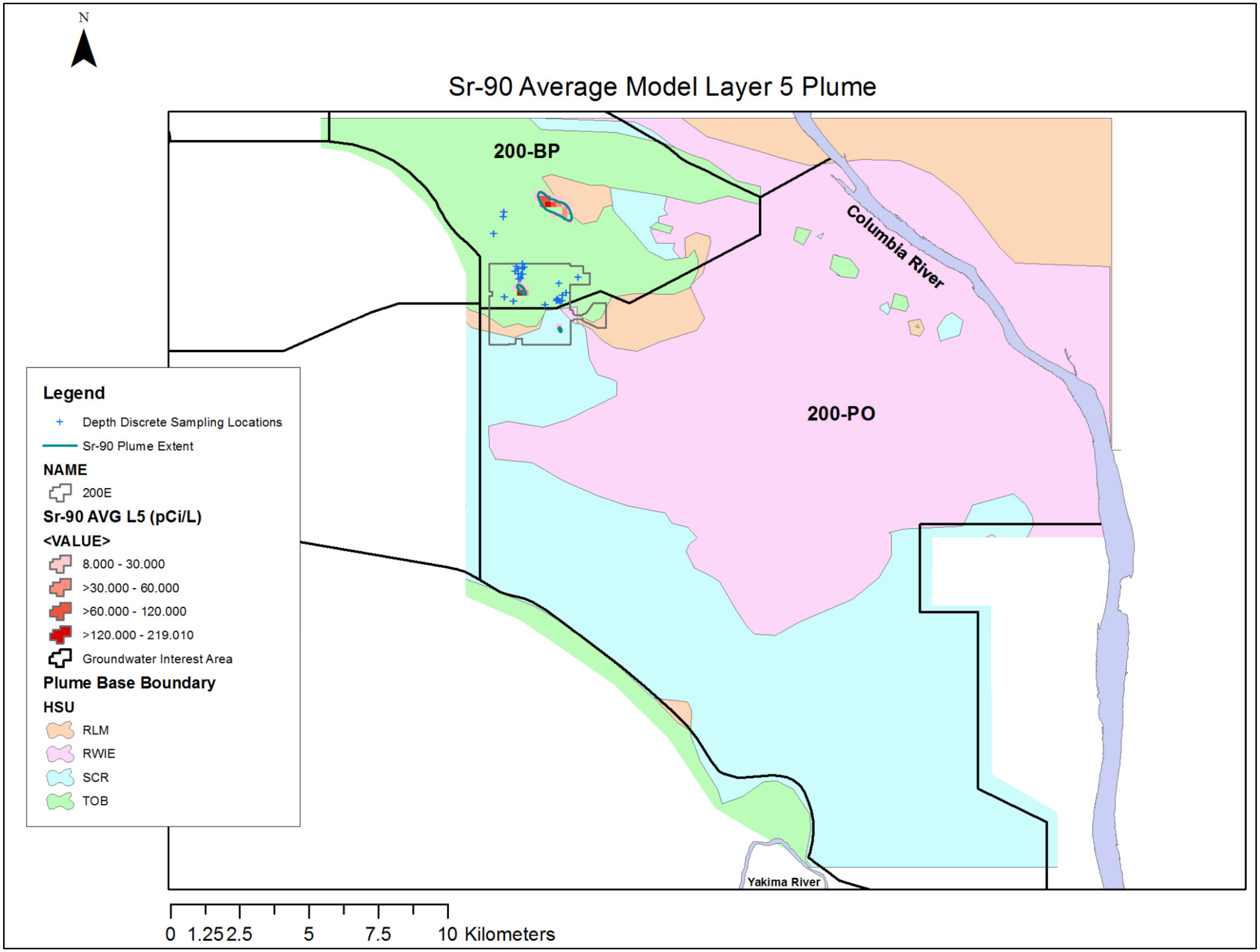


Figure C-57. Strontium-90 Plume in Layer 5, Average Basis

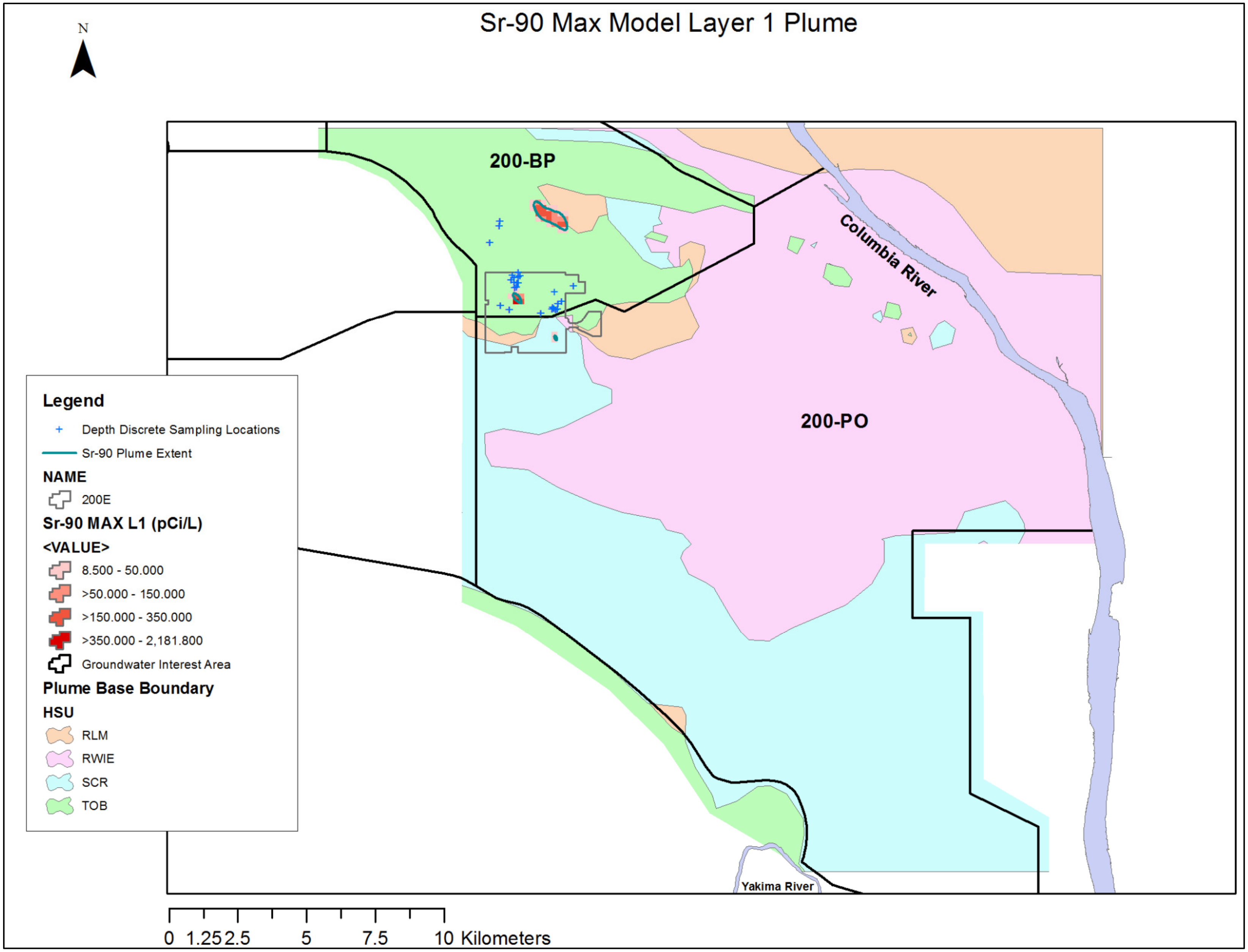


Figure C-58. Strontium-90 Plume in Layer 1, Maximum Basis

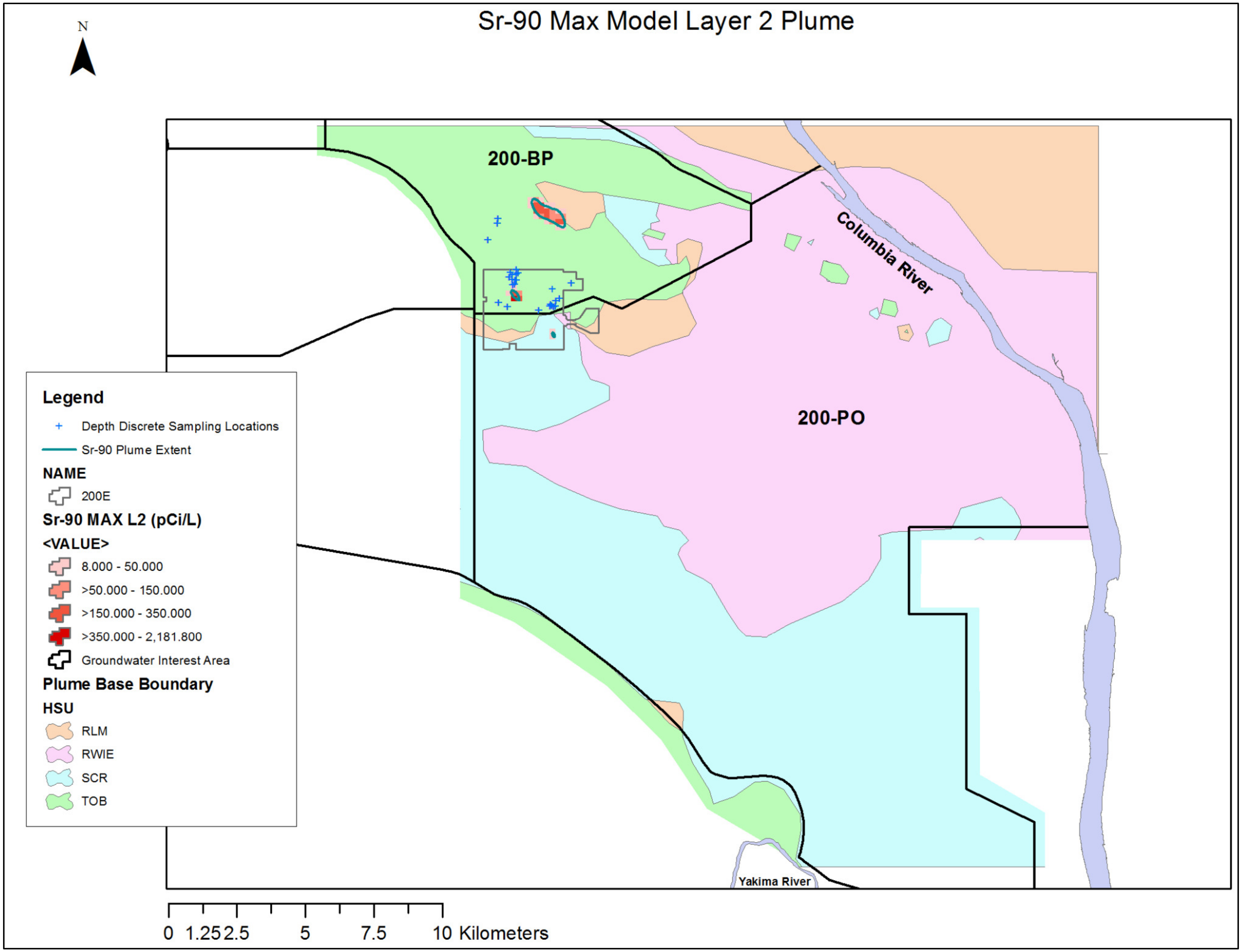


Figure C-59. Strontium-90 Plume in Layer 2, Maximum Basis

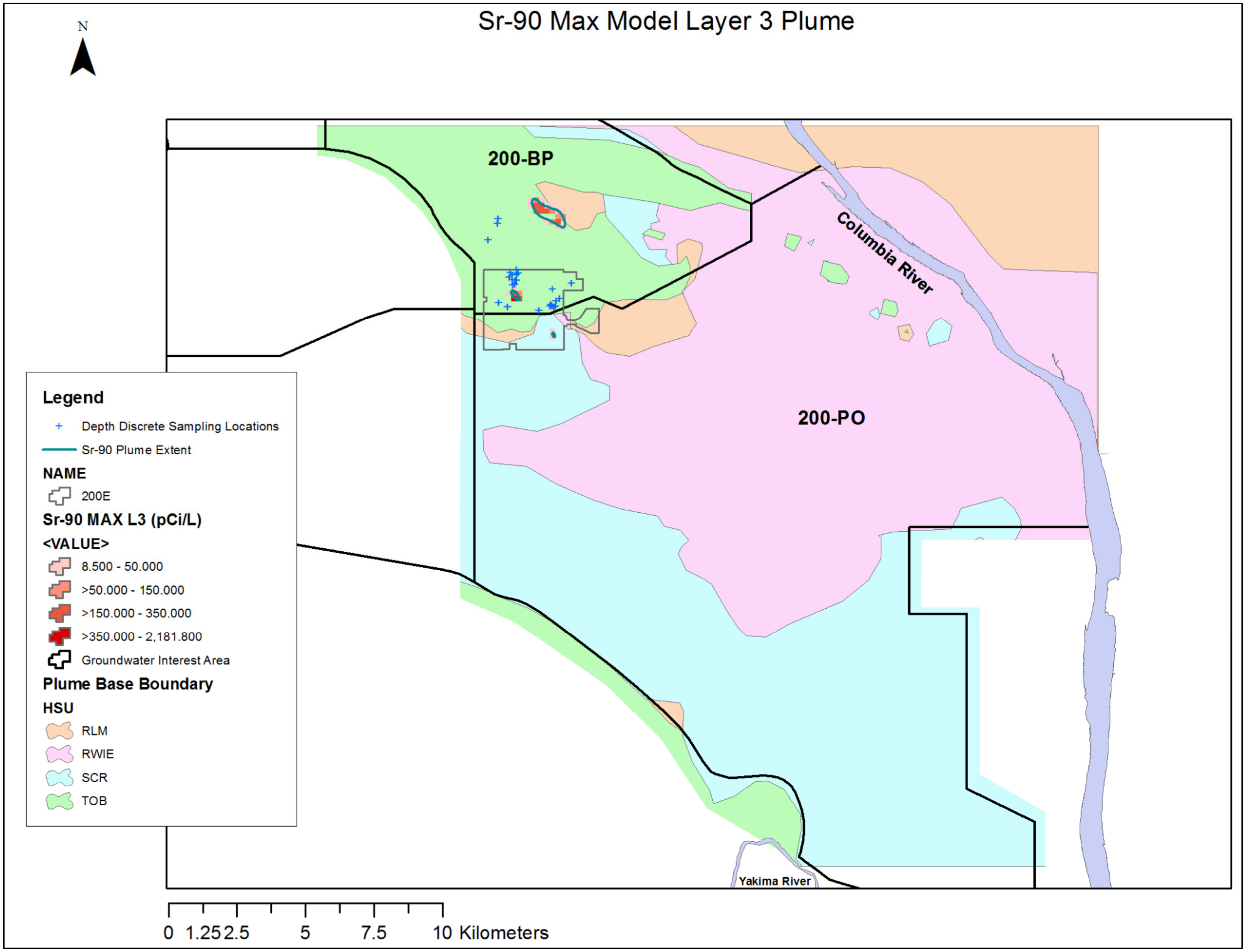


Figure C-60. Strontium-90 Plume in Layer 3, Maximum Basis

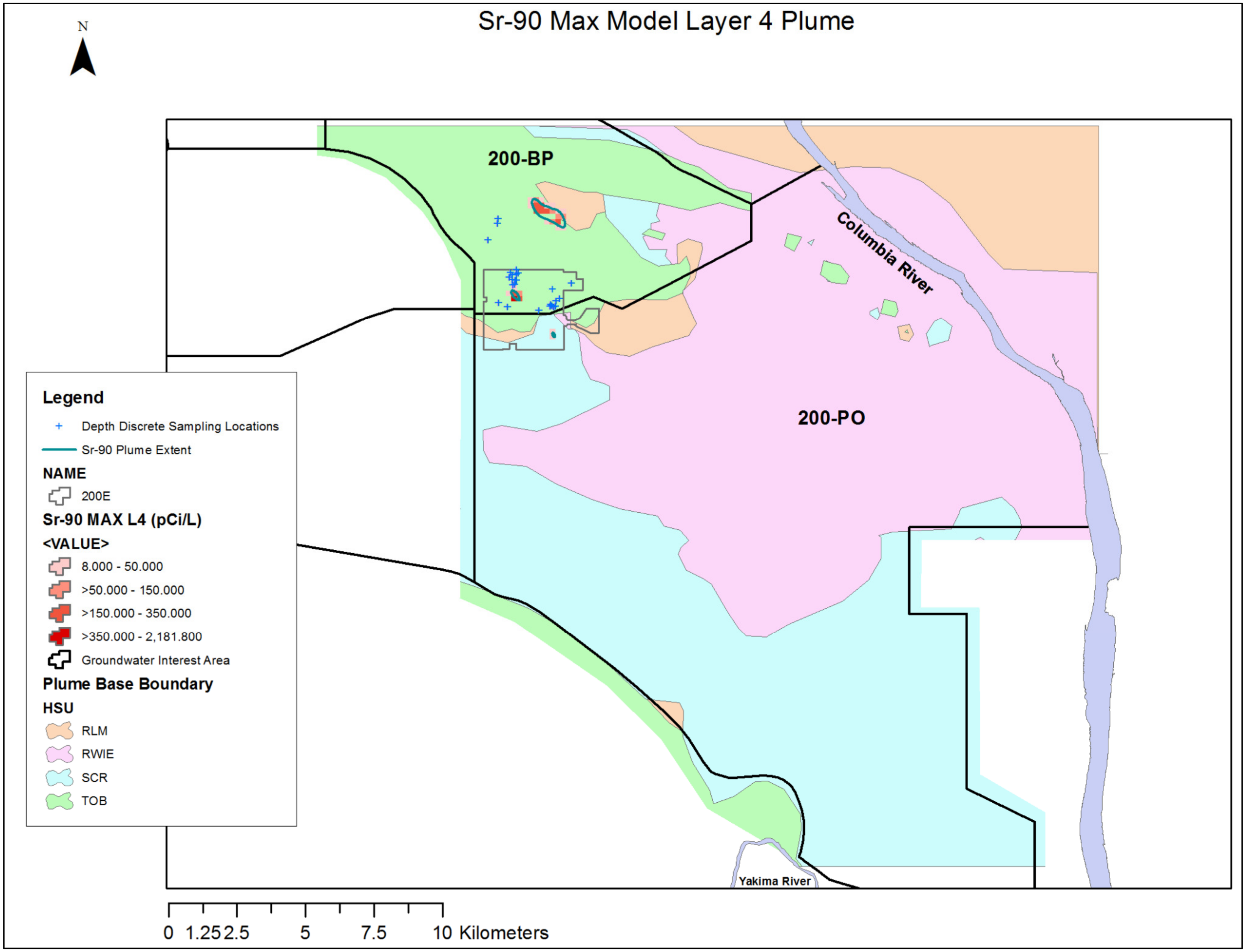


Figure C-61. Strontium-90 Plume in Layer 4, Maximum Basis

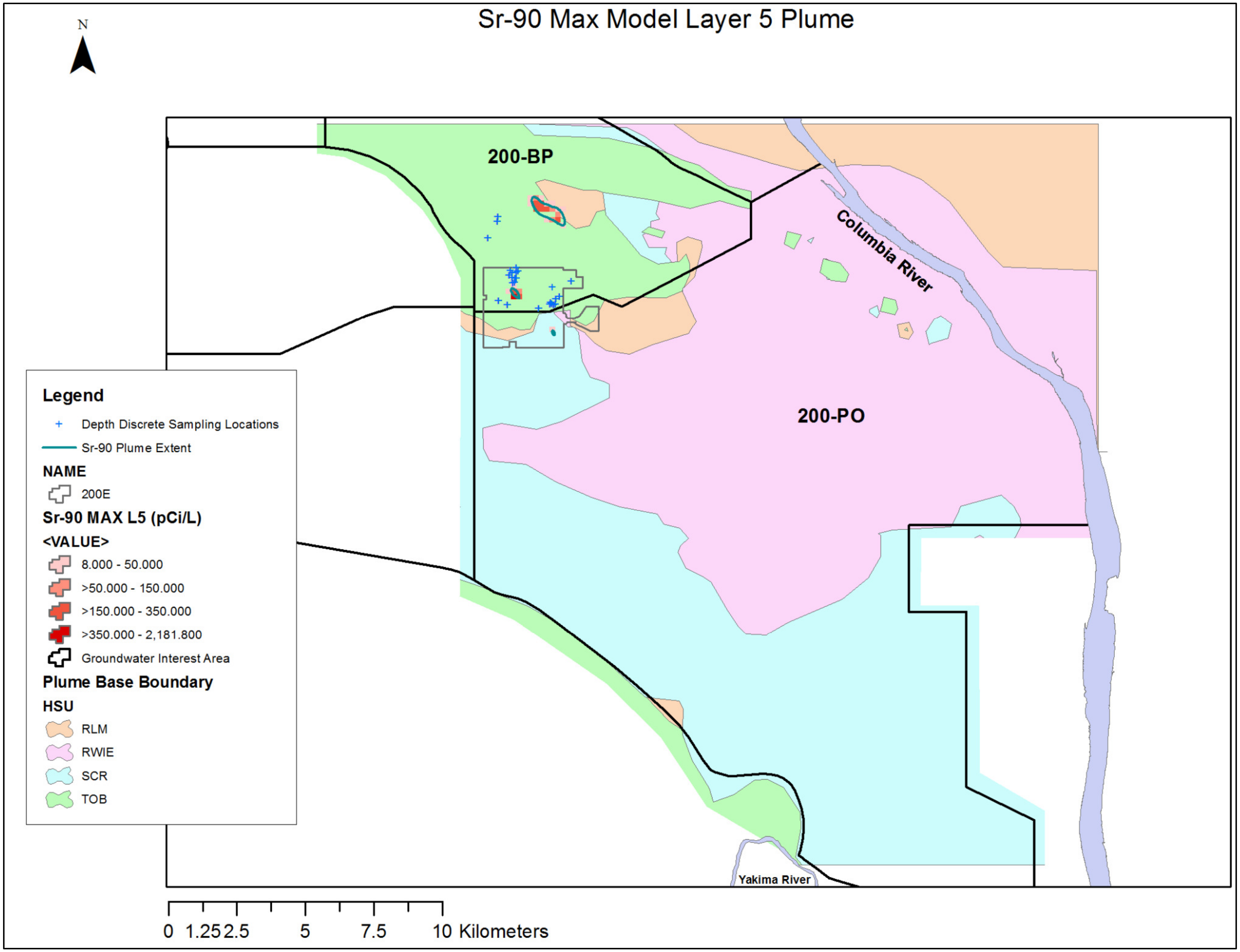


Figure C-62. Strontium-90 Plume in Layer 5, Maximum Basis

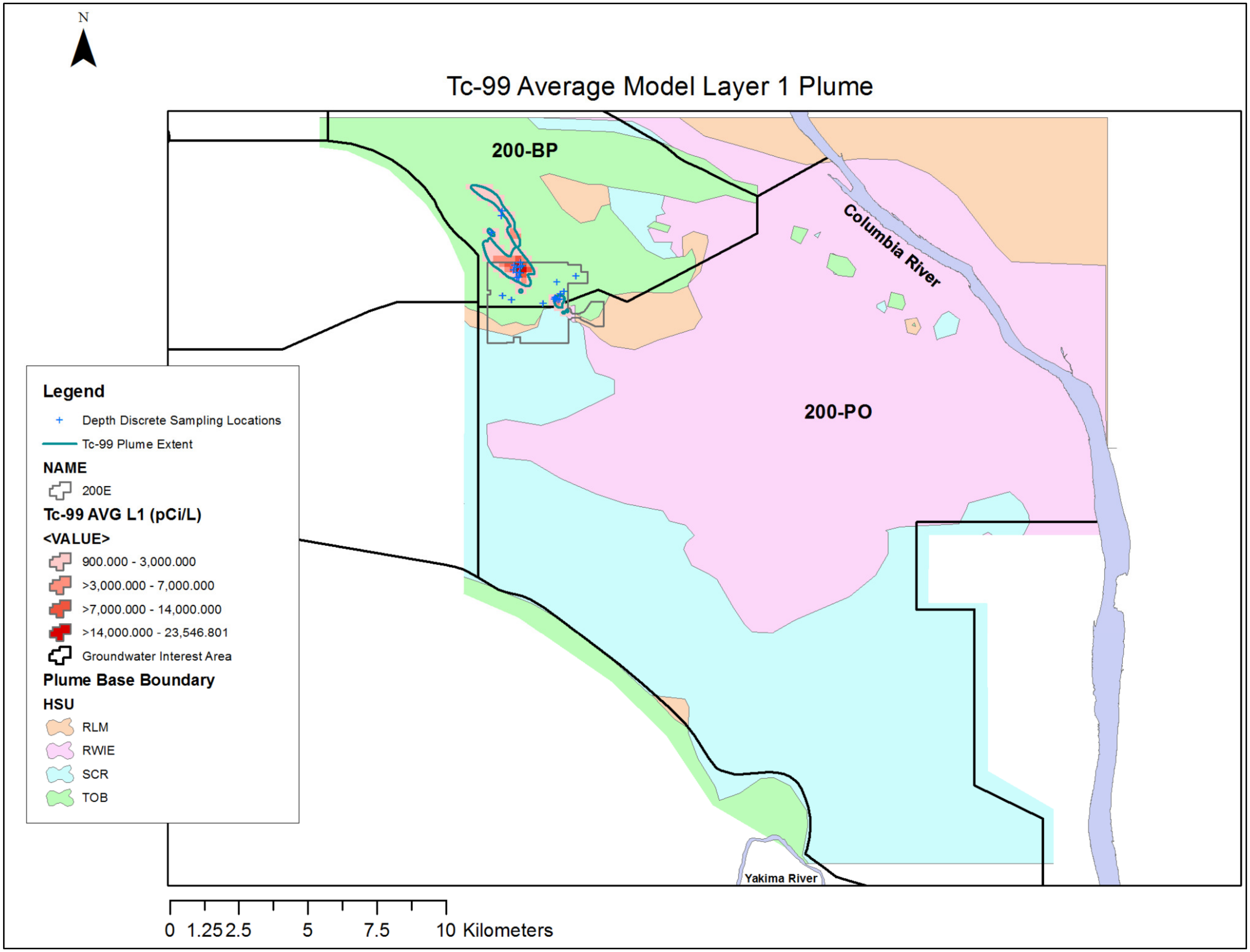


Figure C-63. Technetium-99 Plume in Layer 1, Average Basis

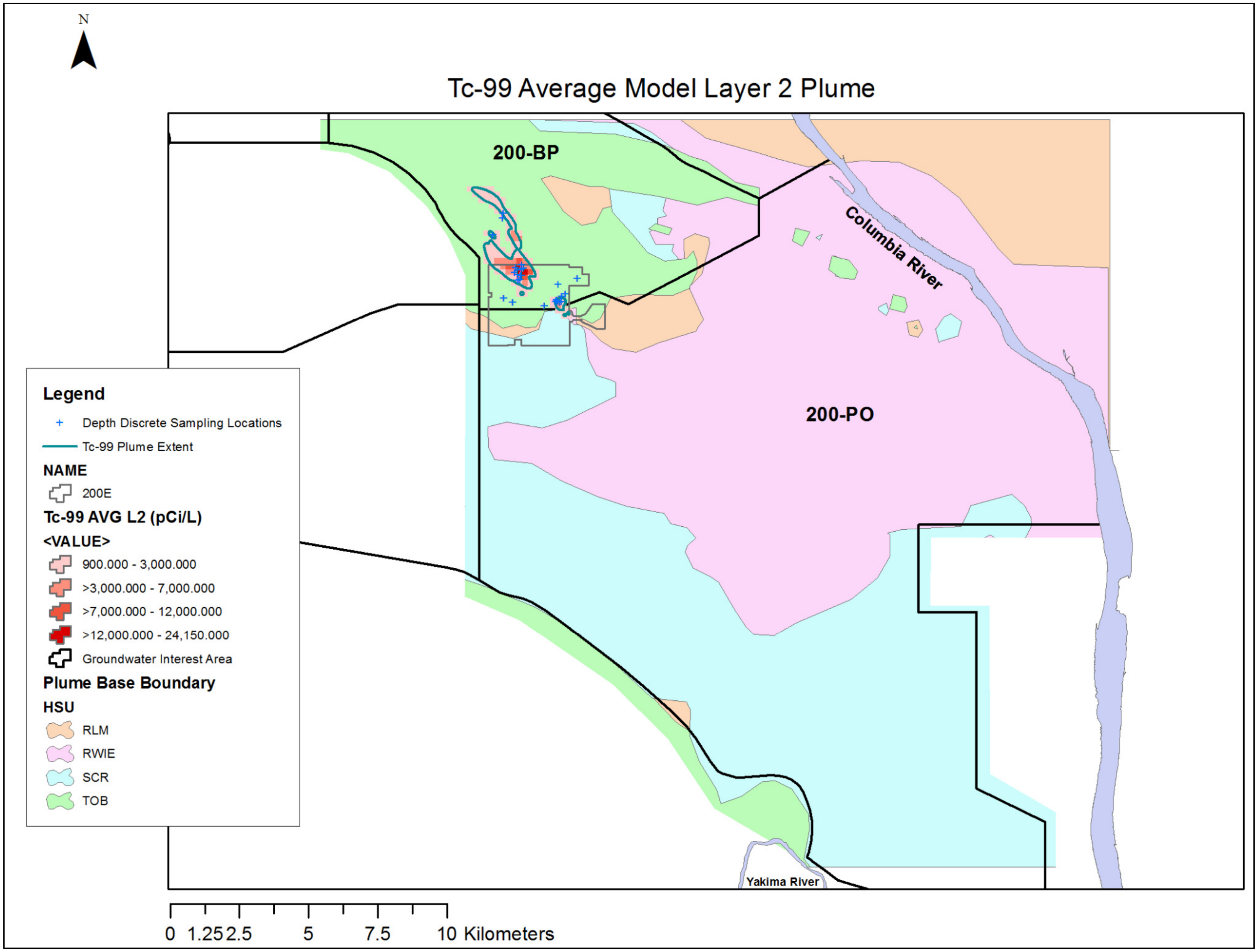


Figure C-64. Technetium-99 Plume in Layer 2, Average Basis

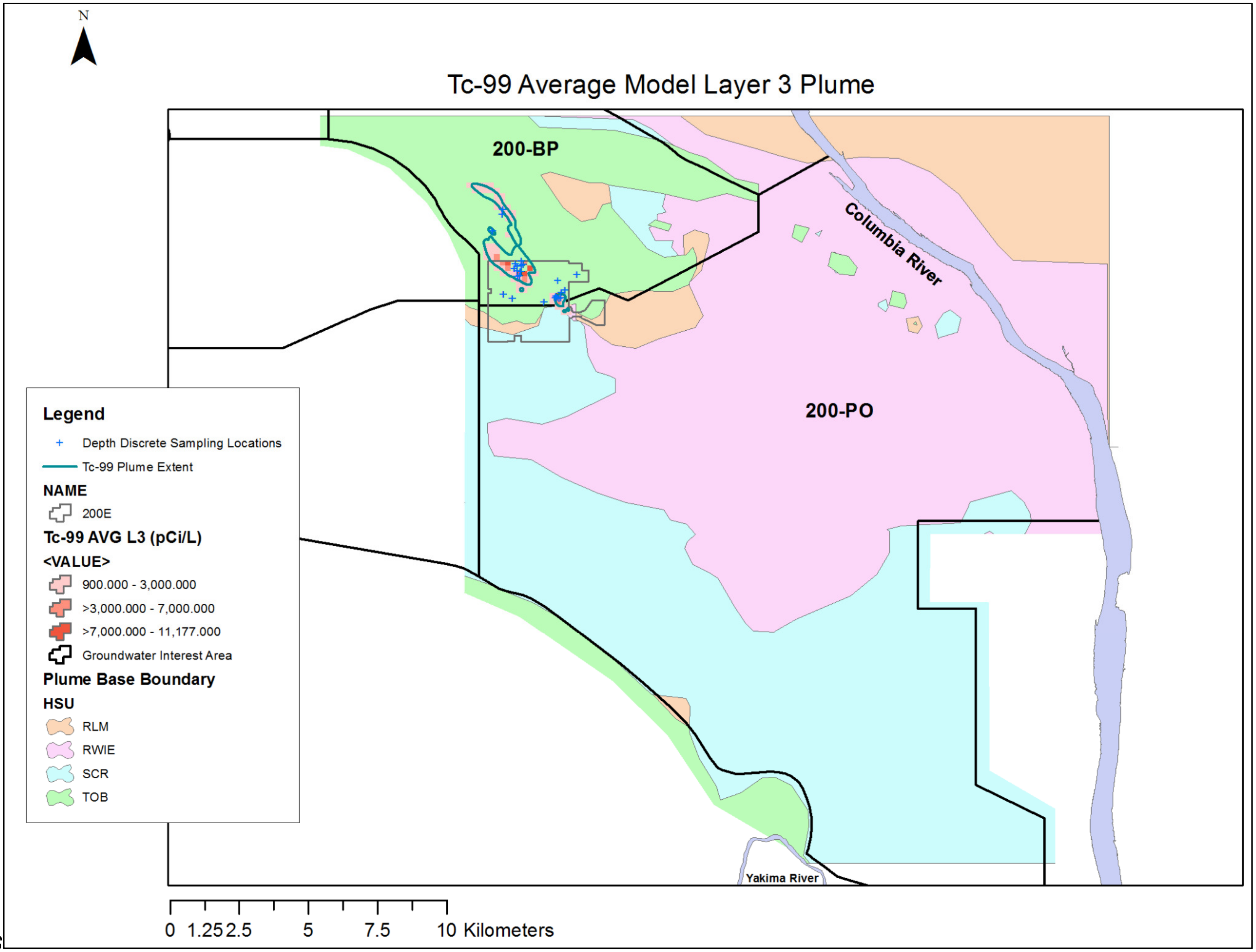


Figure C-65. Technetium-99 Plume in Layer 3, Average Basis

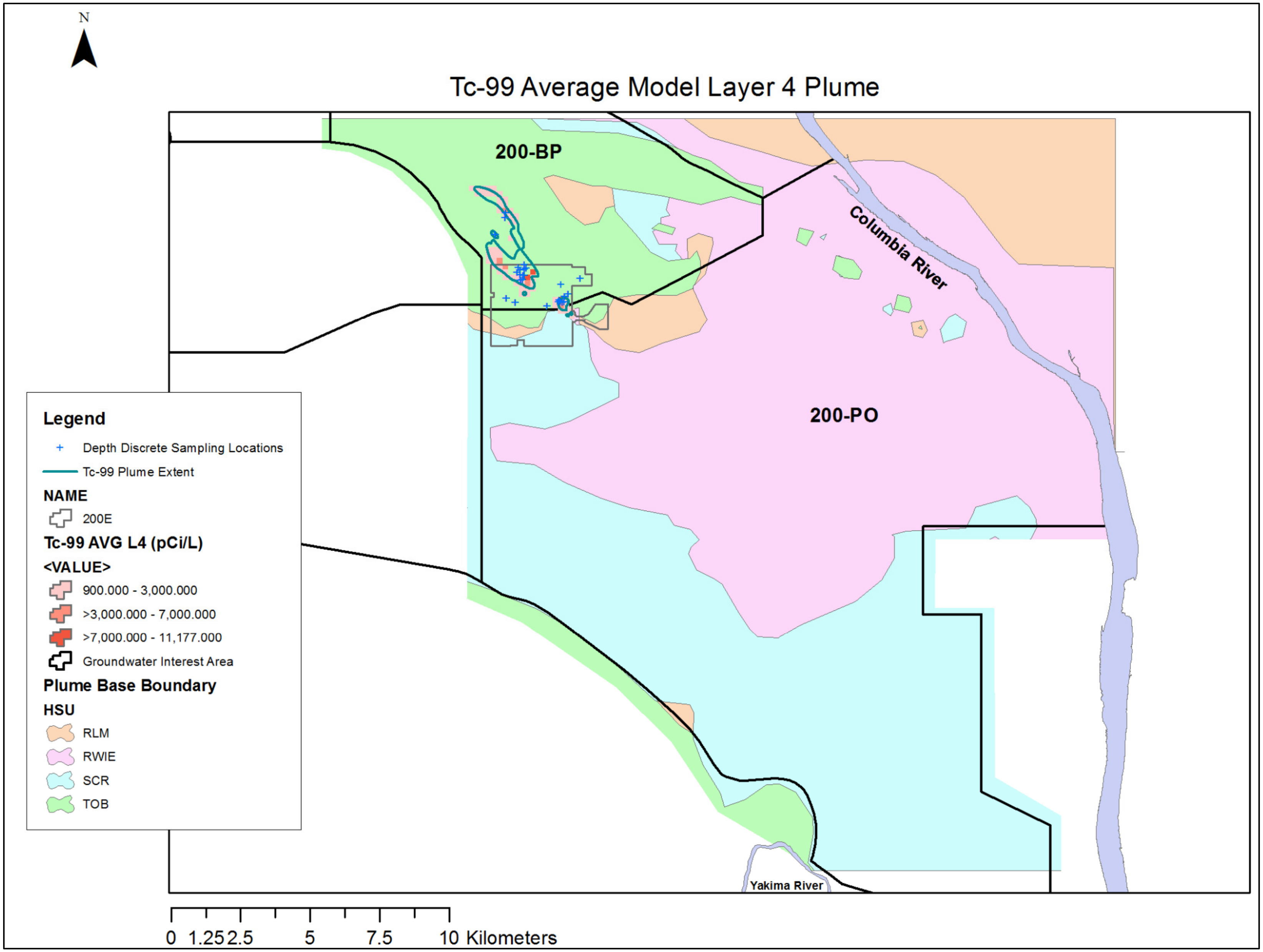


Figure C-66. Technetium-99 Plume in Layer 4, Average Basis

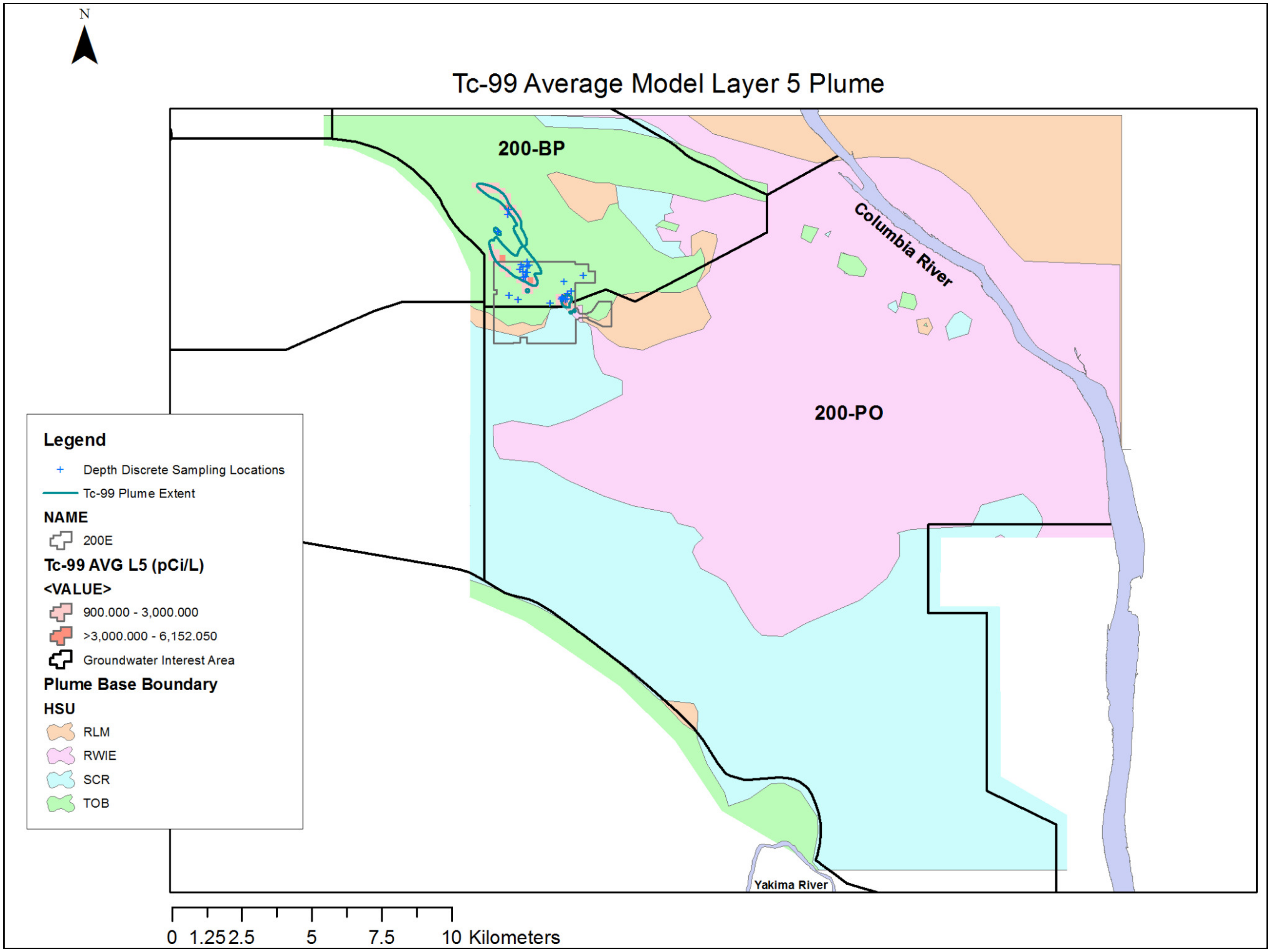


Figure C-67. Technetium-99 Plume in Layer 5, Average Basis

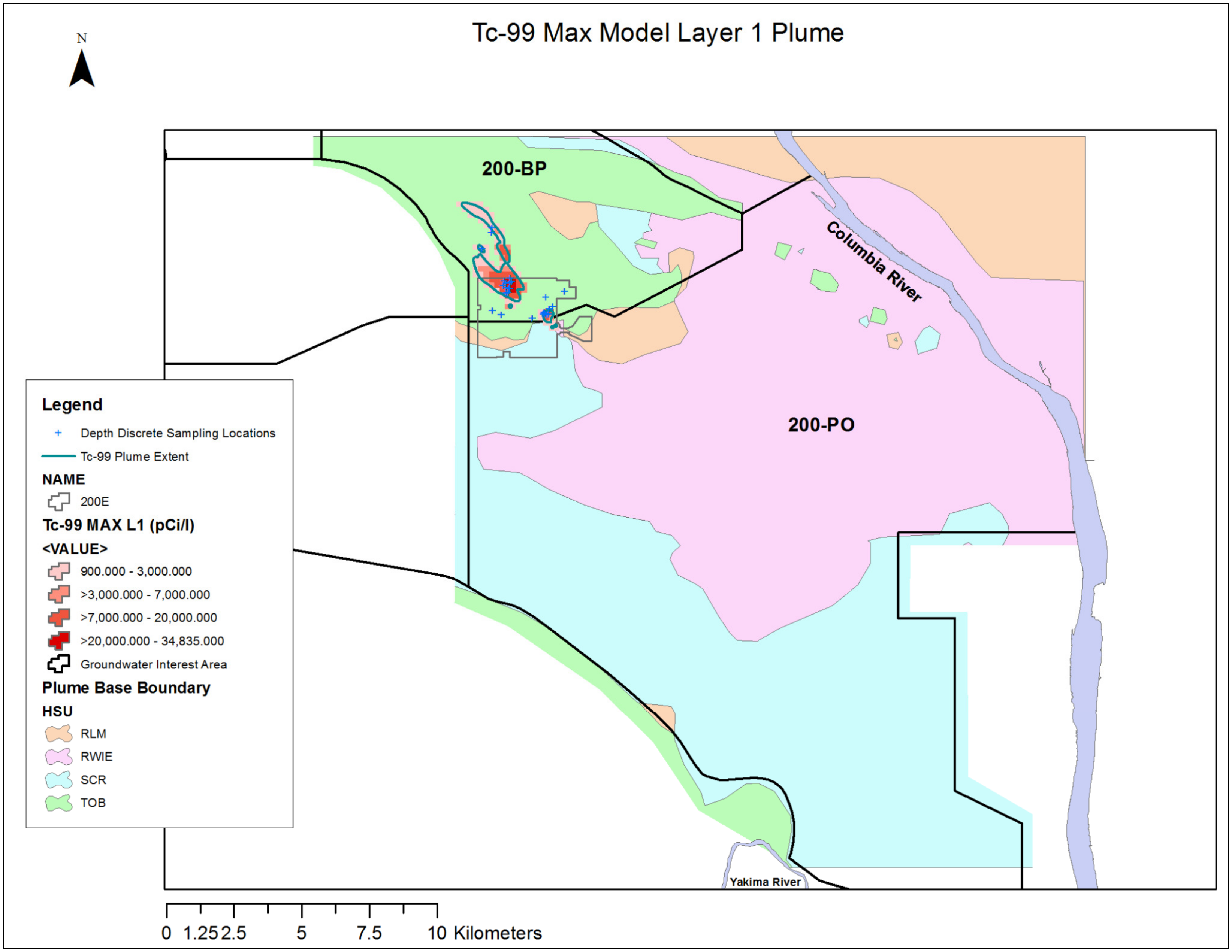


Figure C-68. Technetium-99 Plume in Layer 1, Maximum Basis

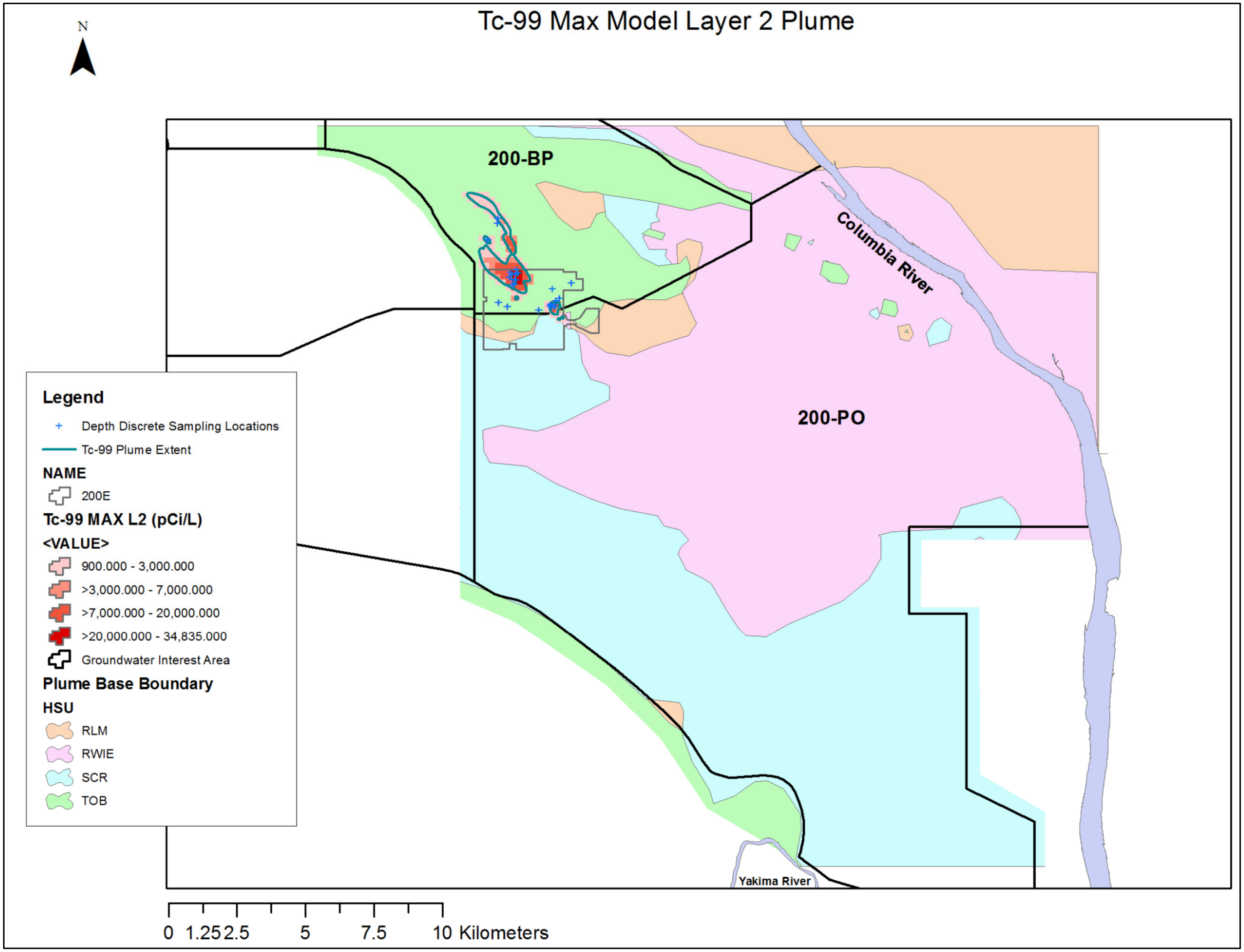


Figure C-69. Technetium-99 Plume in Layer 2, Maximum Basis

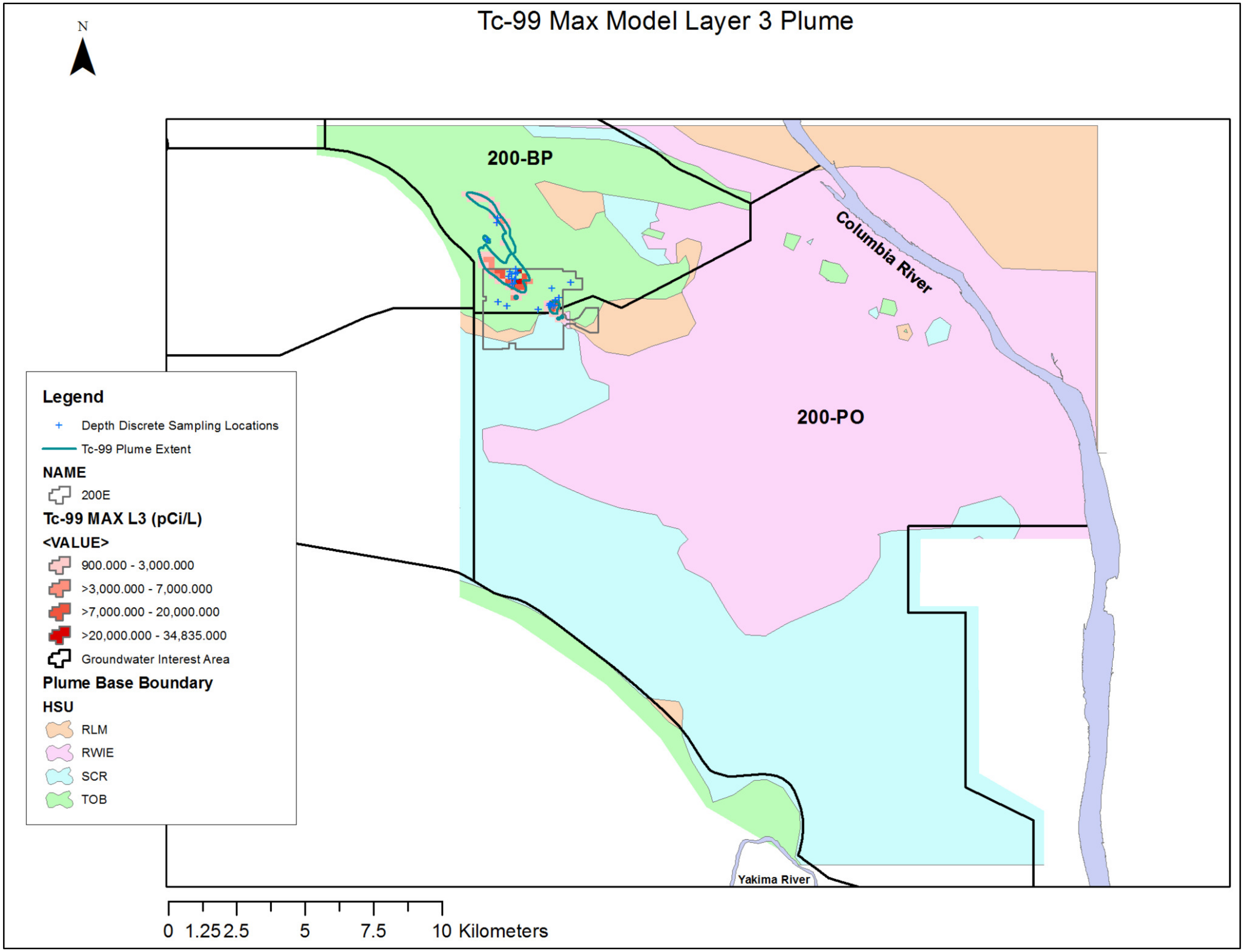


Figure C-70. Technetium-99 Plume in Layer 3, Maximum Basis

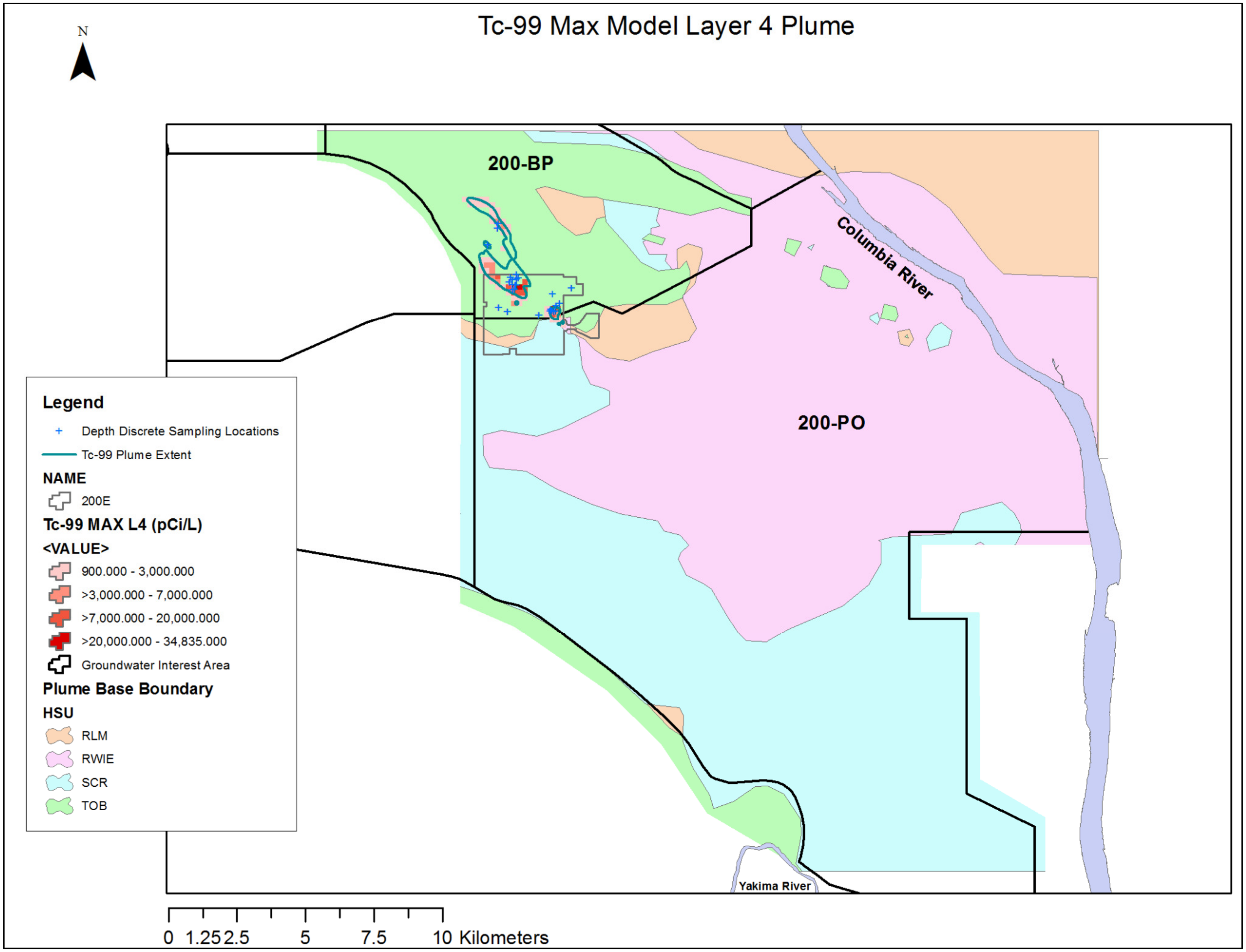


Figure C-71. Technetium-99 Plume in Layer 4, Maximum Basis

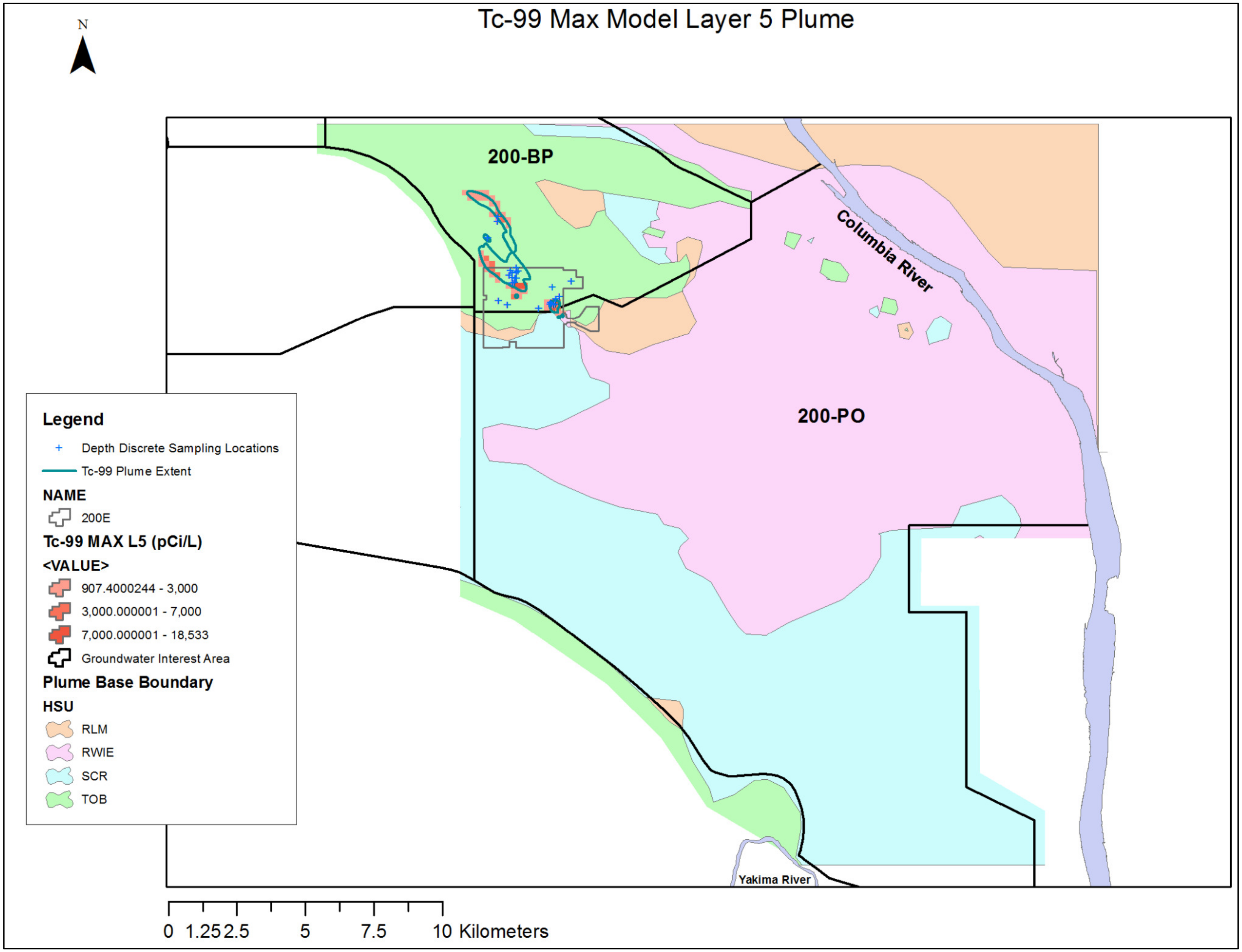


Figure C-72. Technetium-99 Plume in Layer 5, Maximum Basis

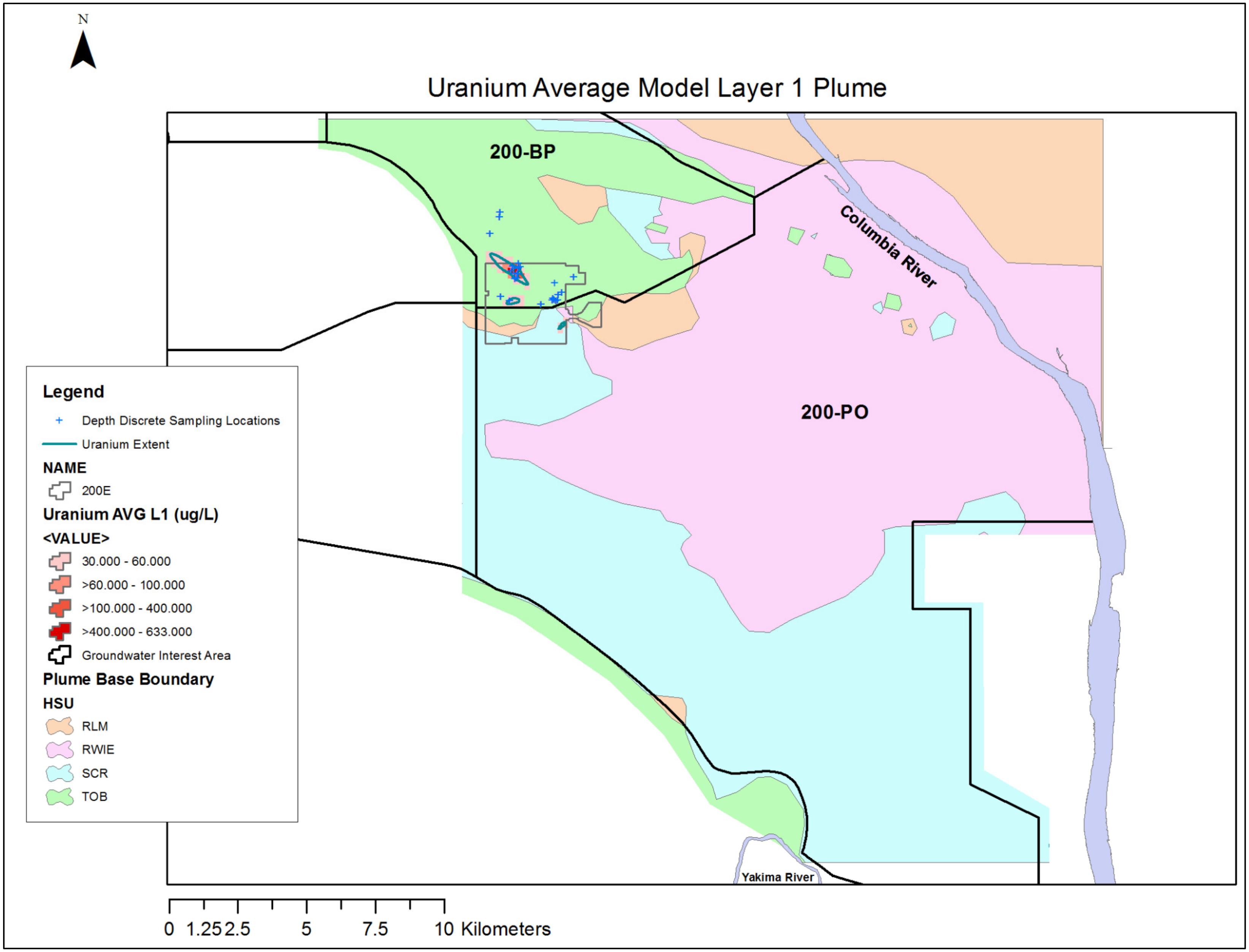


Figure C-73. Uranium Plume in Layer 1, Average Basis

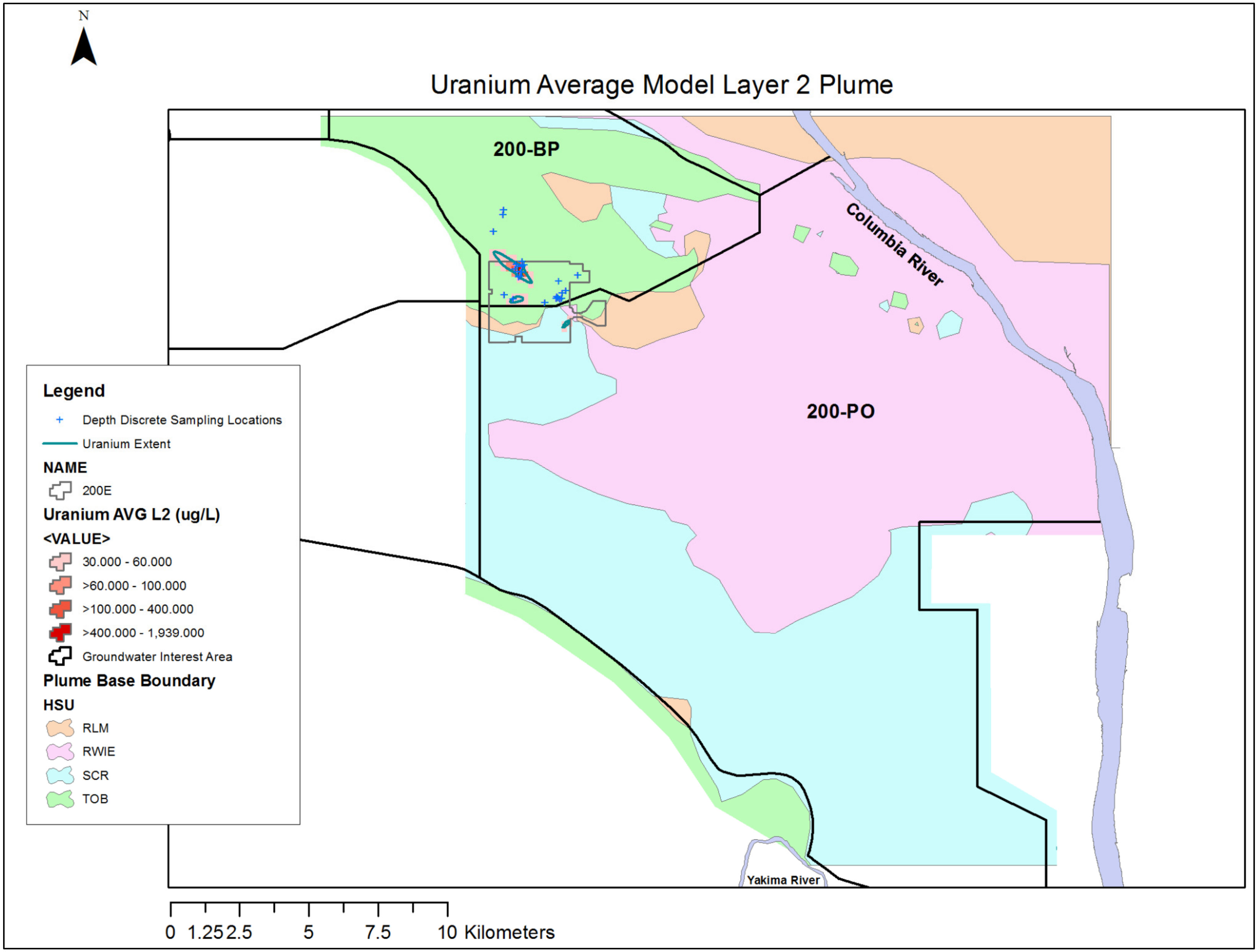


Figure C-74. Uranium Plume in Layer 2, Average Basis

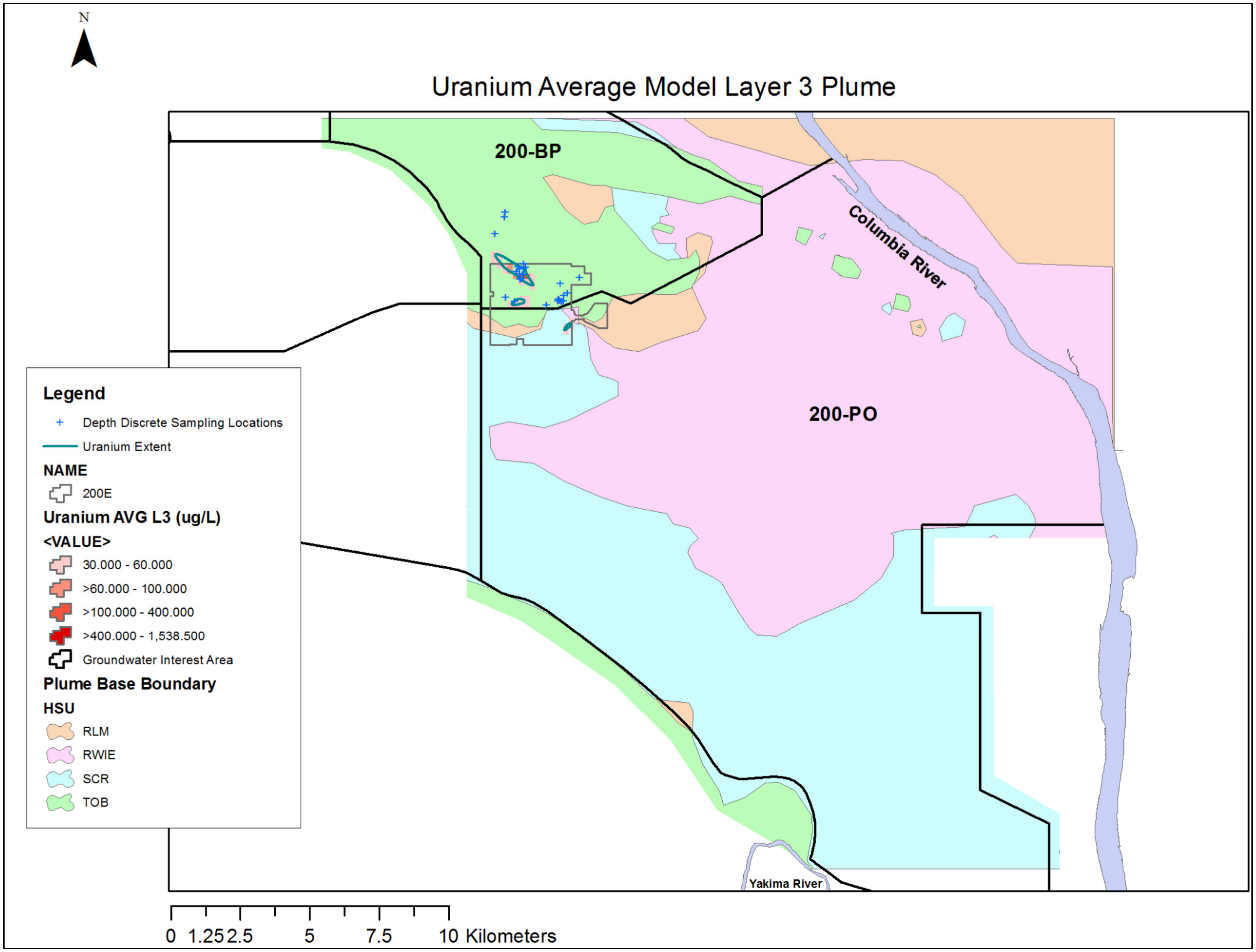


Figure C-75. Uranium Plume in Layer 3, Average Basis

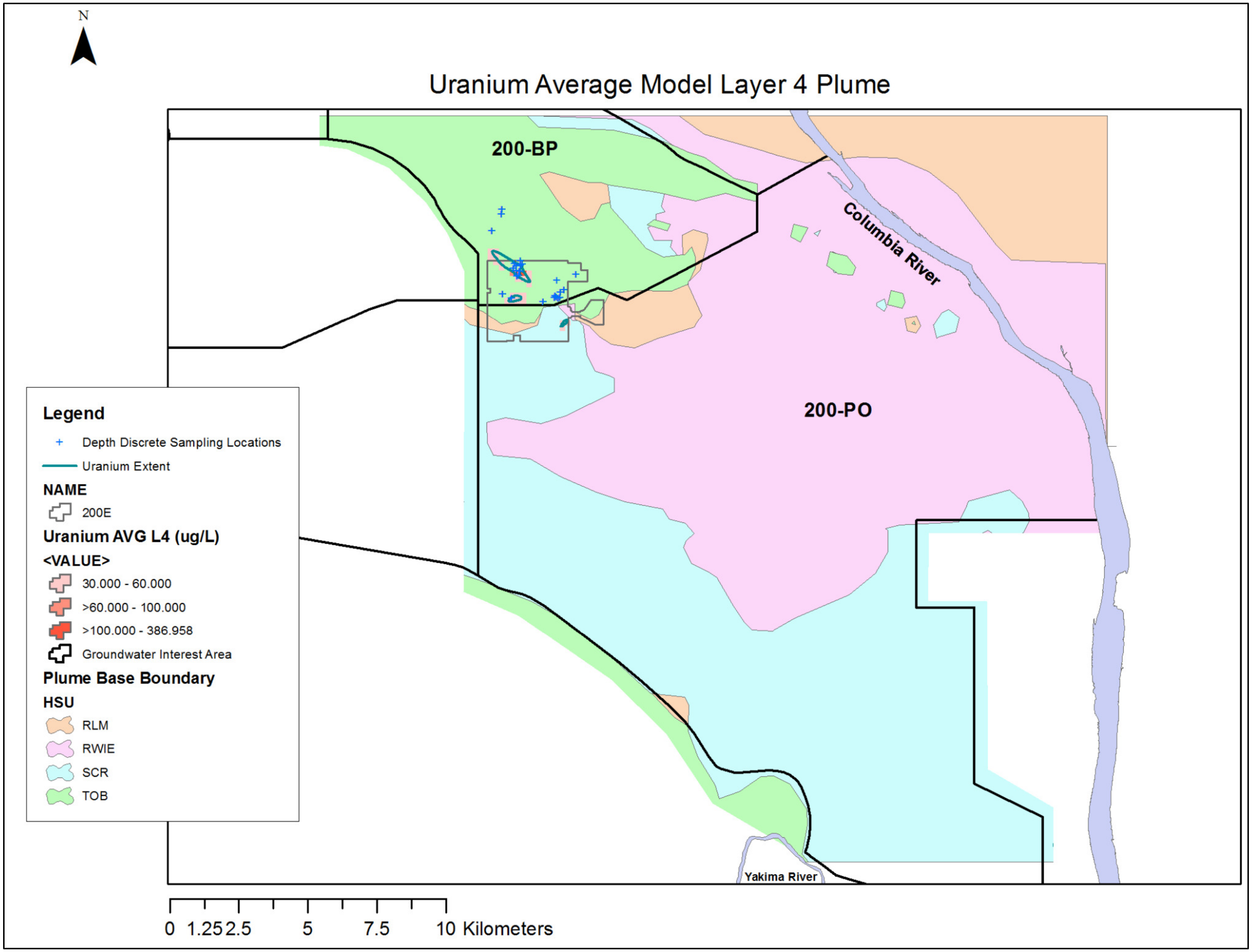


Figure C-76. Uranium Plume in Layer 4, Average Basis

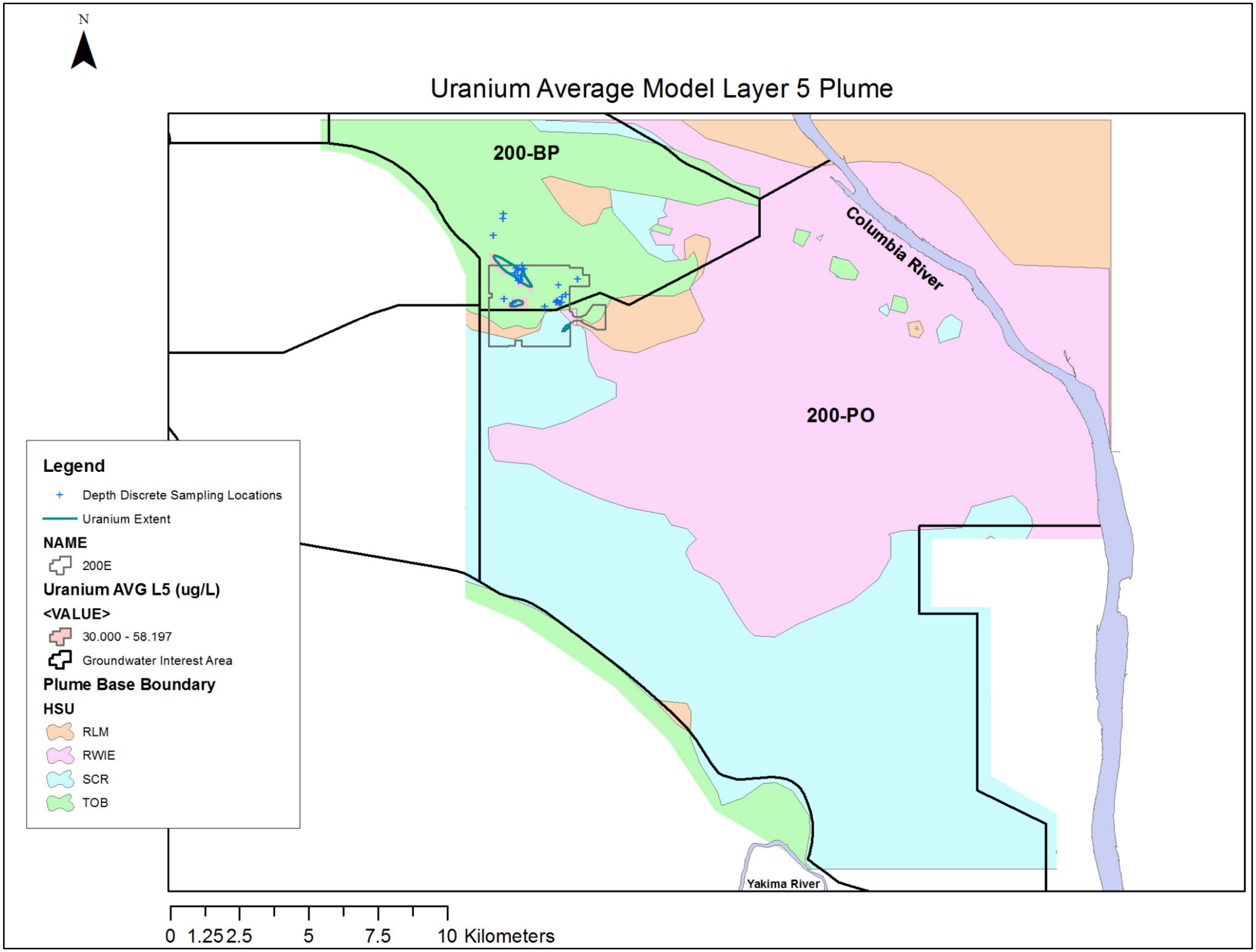


Figure C-77. Uranium Plume in Layer 5, Average Basis

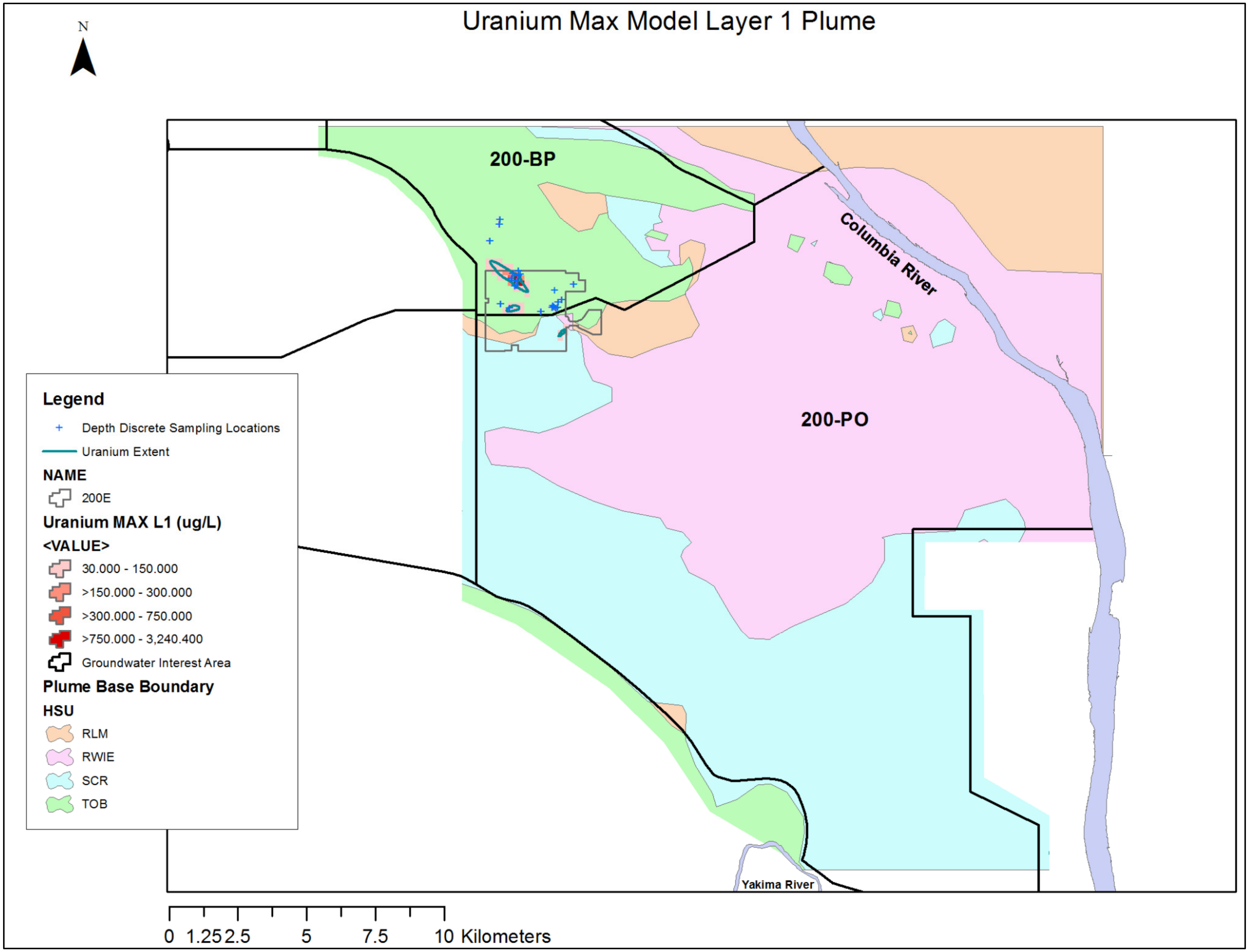


Figure C-78. Uranium Plume in Layer 1, Maximum Basis

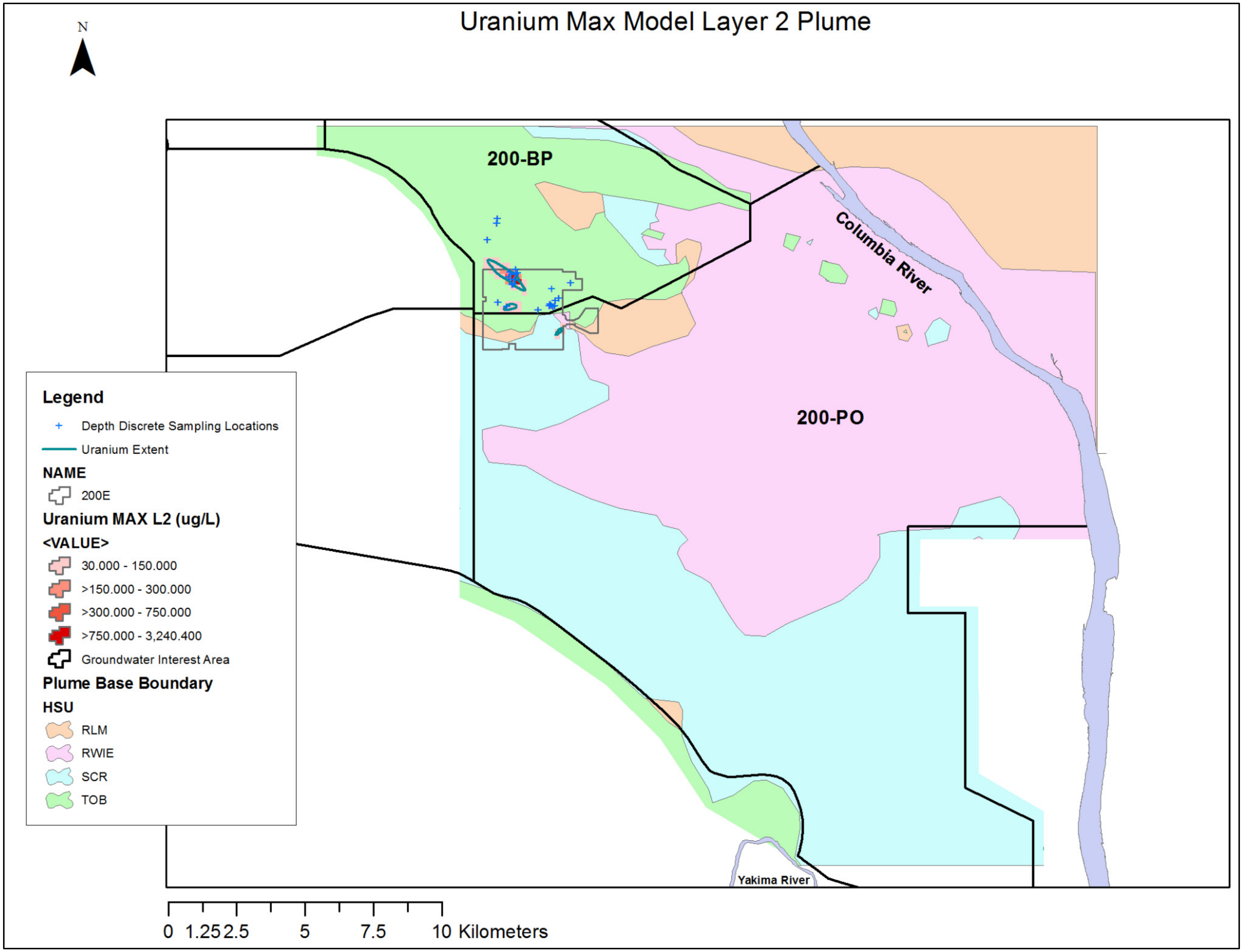


Figure C-79. Uranium Plume in Layer 2, Maximum Basis

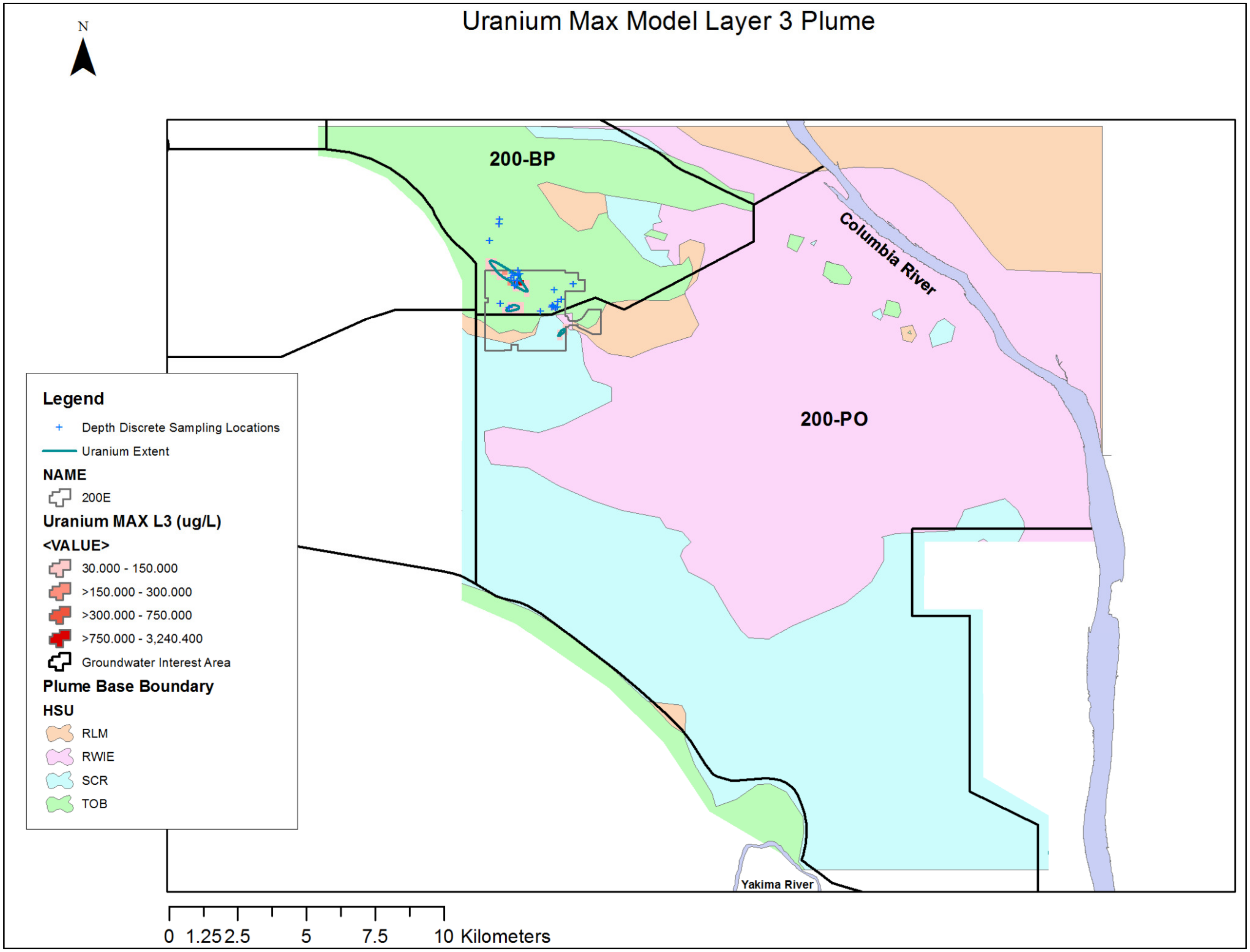


Figure C-80 Uranium Plume in Layer 3, Maximum Basis

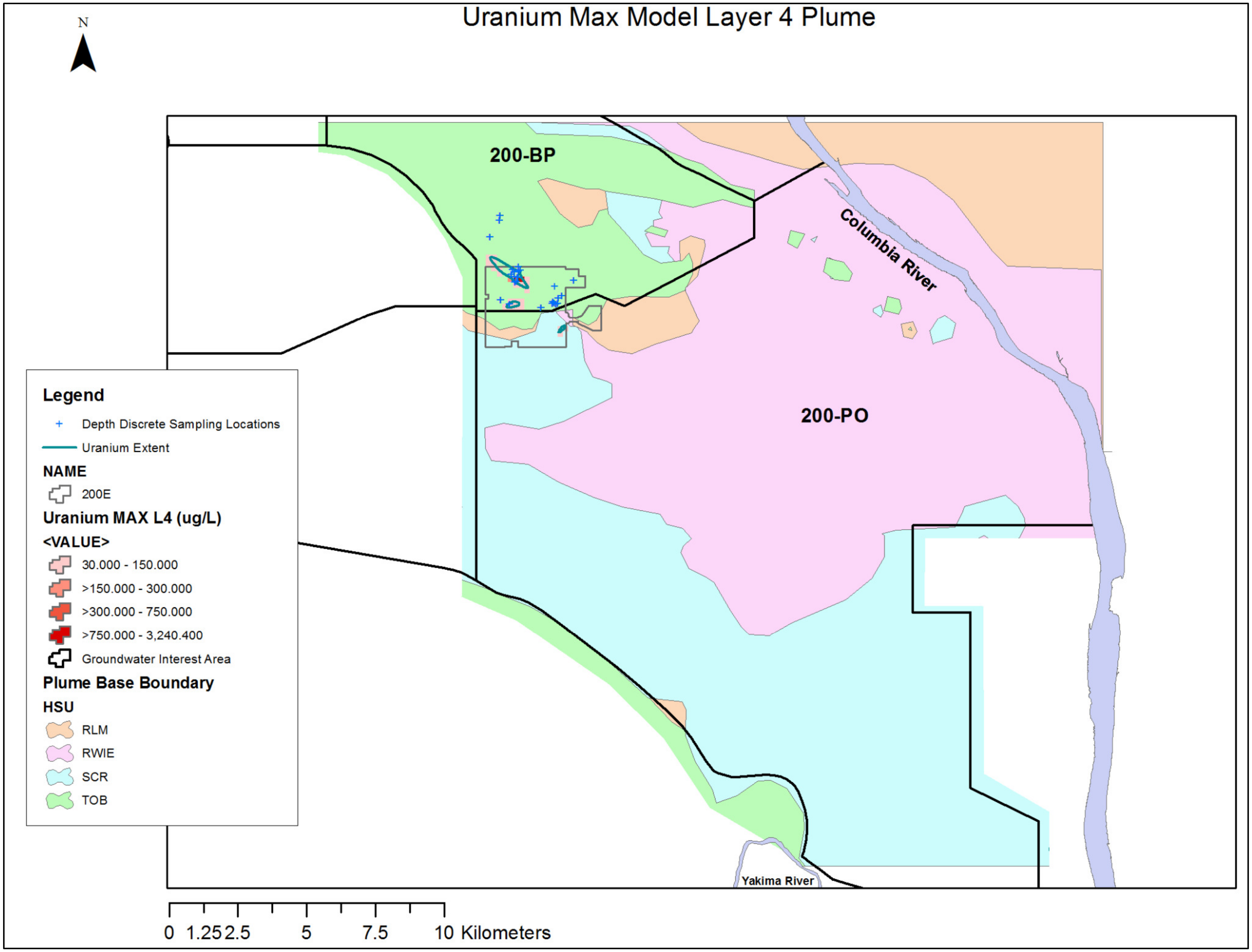


Figure C-81. Uranium Plume in Layer 4, Maximum Basis

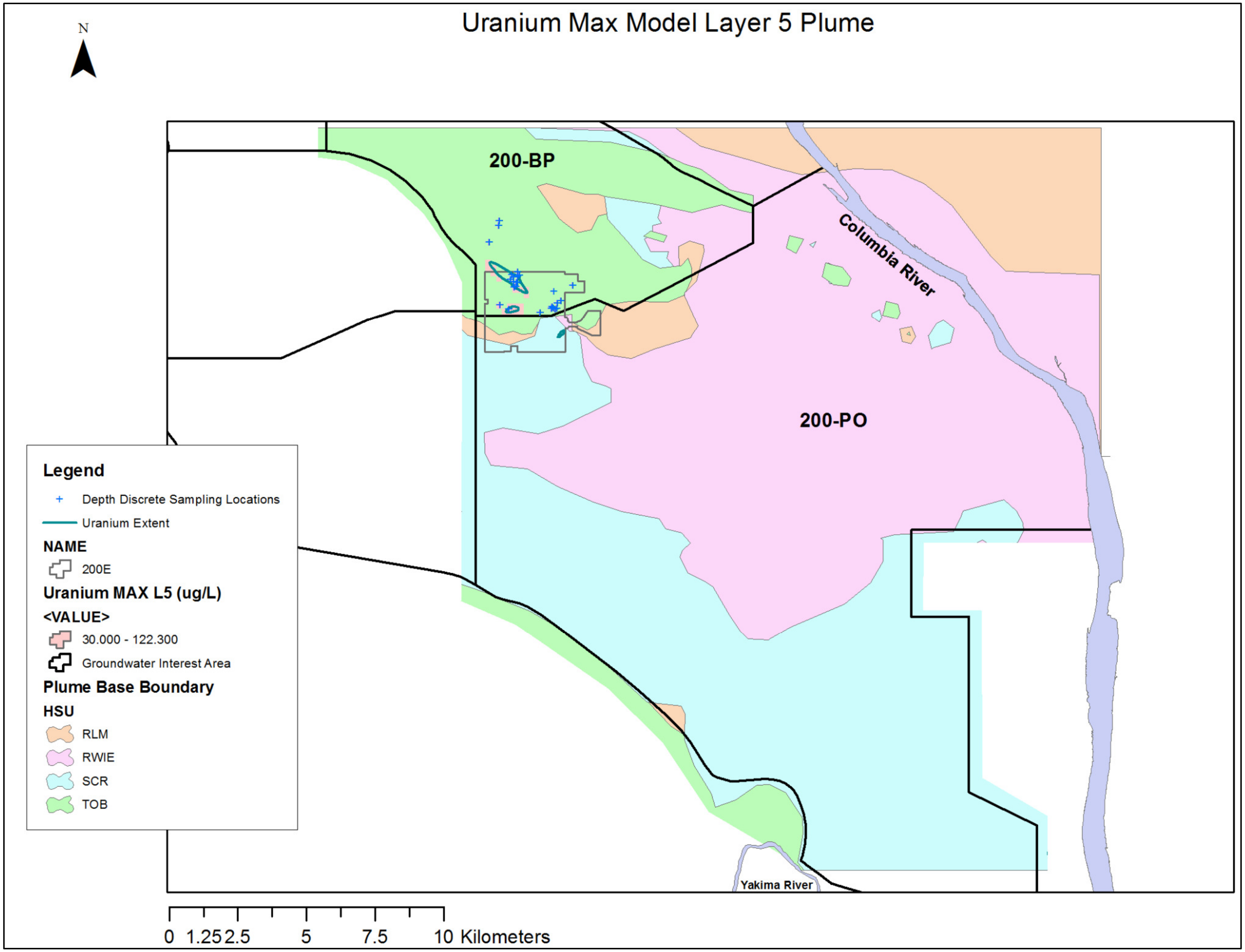


Figure C-82. Uranium Plume in Layer 5, Maximum Basis

Attachment D

Plume Summary Tables

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Table D-1. Chromium(VI) Plume Model (200 m) Layer Summary Statistics

	Layer 1				Layer 2				Layer3				Layer 4			
Conditions	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.
Mean	0	0	NA	0	59.2	65.5	64.3	8.92	65.5	65.5	65.5	0	65.5	65.5	65.5	0
Max	0	0	NA	0	62.8	79.2	75.5	12.9	65.5	79.2	76.5	19.4	65.5	79.2	76.5	19.4

Note: Values listed in this table are µg/L.

Table D-2. Cyanide Plume Model (200 m) Layer Summary Statistics

	Layer 1				Layer 2				Layer 3				Layer 4				Layer 5			
Conditions	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.
Mean	0	0	NA	0	312	794	620	245	227	538	420	176	201	538	474	194	39	168	107	72.1
Max	0	0	NA	0	569	1110	1000	383	429	1110	871	348	345	1110	851	392	39.5	170	108	73.1

Note: Values listed in this table are µg/L.

Table D-3. Tritium Plume Model (200 m) Layer Summary Statistics

	Layer 1				Layer 2				Layer 3				Layer 4				Layer 5			
Conditions	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.
Mean	42,100	67,700	57,200	14,300	30,900	256,000	55,400	15,900	31,000	256,000	55,100	15,800	31,500	25,600	55,500	16,000	24,700	20,800	35,000	17,600
Max	45,800	68,600	62,600	14,400	34,000	533,000	58,100	26,400	34,000	53,300	58,000	26,000	34,400	53,300	58,200	24,800	30,800	52,900	45,000	53,300

Note: Values listed in this table are pCi/L.

Table D-4. Iodine-129 Plume Model (200 m) Layer Summary Statistics

	Layer 1				Layer 2				Layer 3				Layer 4				Layer 5			
Conditions	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.
Mean	1.37	3.27	1.70	0.400	2.25	6.63	3.77	1.07	2.25	6.63	3.79	1.08	2.25	6.63	3.78	1.07	2.41	6.63	4.20	1.28
Max	1.55	4.00	1.85	0.524	2.53	8.50	4.17	1.19	2.53	8.50	4.20	1.20	2.52	8.50	4.20	1.19	3.12	8.50	5.52	1.61

Note: Values listed in this table are pCi/L.

Table D-5A. Nitrate Plume Model (200 m) Layer Summary Statistics

	Layer 1				Layer 2				Layer 3				Layer 4			
Conditions	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.
Mean	4.61E+04	4.69E+04	4.66E+04	9.75E+02	8.44E+04	1.15E+06	1.01E+05	1.34E+05	6.91E+04	7.04E+05	9.10E+04	6.08E+04	7.03E+04	7.04E+05	9.52E+04	6.52E+04
Max	4.76E+04	4.92E+04	4.88E+04	2.26E+03	1.22E+05	1.57E+06	1.87E+05	2.19E+05	4.76E+04	4.92E+04	4.88E+04	2.26E+03	1.04E+05	1.57E+06	1.55E+05	1.66E+05

Note: Values listed in this table are µg/L.

Table D-5B. Nitrate Plume Model (200 m) Layer Summary Statistics

	Layer 5				Layer 6				Layer 7			
Conditions	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.
Mean	6.62E+04	6.08E+05	9.16E+04	5.09E+04	6.62E+04	6.08E+05	9.16E+04	5.09E+04	6.62E+04	6.08E+05	9.16E+04	5.09E+04
Max	8.55E+04	8.28E+05	1.32E+05	8.40E+04	8.55E+04	8.28E+05	1.32E+05	8.40E+04	8.55E+04	8.28E+05	1.32E+05	8.40E+04

Note: Values listed in this table are µg/L.

Table D-6. Sr-90 Plume Model (200 m) Layer Summary Statistics

	Layer 1				Layer 2				Layer 3				Layer 4				Layer 5			
Conditions	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.
Mean	0	0	NA	0	49	219	110	55	48	219	108	54	46	219	104	52	48	219	108	54
Max	0	0	NA	0	193	2180	204	464	199	2180	265	453	186	2180	252	436	199	2180	265	454

Note: Values listed in this table are pCi/L.

Table D-7A. Tc-99 Plume Model (200 m) Layer Summary Statistics

	Layer 1				Layer 2				Layer 3				Layer 4			
Conditions	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.
Mean	0	0	NA	0	3.08E+03	2.42E+04	6.38E+03	4.03E+03	2.16E+03	1.12E+04	4.13E+03	2.09E+03	2.06E+03	1.12E+04	3.43E+03	1.98E+03
Max	0	0	NA	0	5.81E+03	3.48E+04	1.60E+04	7.59E+03	4.50E+03	3.48E+04	9.21E+03	6.13E+03	4.70E+03	3.48E+04	9.24E+03	6.40E+03

Note: Values listed in this table are in pCi/L.

Table D-7B. Tc-99 Plume Model (200 m) Layer Summary Statistics

	Layer 5			
Conditions	Avg	Max	90th Percentile	S.D.
Mean	1.69E+03	6.15E+03	3.16E+03	1.05E+03
Max	3.46E+03	1.85E+04	8.81E+03	3.81E+03

Note: Values listed in this table are in pCi/L.

Table D-8. Uranium Plume Model (200 m) Layer Summary Statistics

	Layer 1				Layer 2				Layer 3				Layer 4				Layer 5			
Conditions	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.	Avg	Max	90th Percentile	S.D.
Mean	0	0	NA	0	131	1940	250	347	106	1539	79.1	295	59	387	68.2	80	36	58.2	42.3	7.8
Max	0	0	NA	0	380	3240	621	889	281	3240	194	794	283	3240	184	810	47	122	67.2	24.0

Note: Values listed in this table are µg/L.

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Attachment E

Software Installation and Checkout Form for Leapfrog Hydro®

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 Hydro — Software Version No.: 2.1.1

EXECUTABLE INFORMATION:

2. Executable Name (include path):
[redacted]\Hydro.exe
3. Executable Size (bytes):

COMPILATION INFORMATION:

4. Hardware System (i.e., property number or ID):
Vendor Supplied
5. Operating System (include version number):
Vendor Supplied

INSTALLATION AND CHECKOUT INFORMATION:

6. Hardware System (i.e., property number or ID):
Intera 0474
7. Operating System (include version number):
Windows 7 Professional
8. Open Problem Report? (●) No ( ) Yes PR/CR No.

TEST CASE INFORMATION:

9. Directory/Path:
[redacted]h\LeapfrogTests
10. Procedure(s):
CHPRC-01754 Rev. 0, Leapfrog Hydro Software Test Plan
11. Libraries:
N/A
12. Input Files:
Per CHPRC-01754
13. Output Files:
Per CHPRC-01754
14. Test Cases:
Vendor Installation Package, TC1, TC2, TC3, TC4, TC5
15. Test Case Results:
All Pass
16. Test Performed By:
17. Test Results: (●) Satisfactory, Accepted for Use ( ) Unsatisfactory
18. Disposition (include HISI update):
Accepted ADDED TO HISI —

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CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: Leapfrog Hydro		Software Version No.: 2.1.1
Prepared By:		
19. [signature] Software Owner (Signature)	William E. Nichols Print	22 MAY 2014 Date
20. Test Personnel:		
[signature] Sign	Travis Hammond Print	22 May 2014 Date
Sign	Print	Date
Sign	Print	Date
Approved By:		
21. N/R Software SME (Signature)	(PER SOFTWARE MANAGEMENT PLAN) Print	Date

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