ECF-HANFORD-18-0030
Revision 0

DESCRIPTION OF GROUNDWATER CALCULATIONS AND ASSESSMENTS FOR THE CALENDAR YEAR 2017 (CY2017) 200 AREAS PUMP-AND-TREAT REPORT

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

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

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Contents

1 Purpose 1-1

2 Background 2-1

2.1 Groundwater Operable Units and Associated Remedies 2-2

2.1.1 200-ZP-1 Operable Unit 2-2

2.1.2 200-UP-1 Operable Unit — S-SX Tank Farms 2-2

2.1.3 200-UP-1 Operable Unit — Reduction-Oxidation Plant and U Plant 2-2

2.2 Use of Multiple Lines of Evidence 2-3

2.2.1 200-ZP-1 Operable Unit 2-3

2.2.2 200-UP-1 Operable Unit — S-SX Tank Farm and U-Plant 2-4

2.3 Groundwater Models 2-4

2.3.1 Model History 2-4

2.3.2 Current Version 2-6

3 Calculation Methods 3-1

3.1 Water Level Mapping 3-1

3.1.1 Universal Kriging with Analytic Elements 3-1

3.1.2 Particle Tracking 3-2

3.1.3 Interpolated Capture Frequency Map 3-2

3.2 Groundwater Modeling 3-2

3.2.1 Model Updates 3-2

3.2.2 Flow Modeling and Simulated Capture Frequency Map 3-5

3.2.3 Transport Modeling and Mass Recovery Calculations 3-5

3.3 Flow-Path Control 3-6

3.4 Transport Modeling and SGSIM plume maps depiction 3-6

4 Assumptions and Inputs 4-1

4.1 Assumptions 4-1

4.1.1 Water-Level Mapping and Interpolated Hydraulic Containment 4-1

4.1.2 Groundwater Flow Modeling and Simulated Hydraulic Containment 4-1

4.1.3 Transport Modeling and Mass Recovery Calculations 4-2

4.2 Input Data 4-2

4.2.1 Extraction and Injection Rates 4-3

4.2.2 Groundwater Elevations Measured at Monitoring Wells Used to Validate Simulated Groundwater Levels 4-9

4.2.3 Contaminant Transport Properties 4-13

4.2.4 Updated Initial Conditions for Contaminant Transport Simulations (Plumes) 4-13

4.2.5 200 West P&T System – Implementation of MT3D Contaminant Treatment System Package 4-27

5 Software Applications, Descriptions, Installation and Checkout, and Statements of Validity 5-1

5.1 Approved Software 5-1
5.2 Descriptions 5-1
5.2.1 MODFLOW (Controlled Calculation Software) 5-1
5.2.2 MT3DMS (Controlled Calculation Software) 5-1
5.2.3 MODPATH 5-2
5.2.4 KT3D_H2O 5-2
5.3 Support Software 5-2
5.3.1 MODFLOW Suite Support Software 5-2
5.3.2 R and Surfer® 5-2
5.4 Software Installation and Checkout 5-3
5.4.1 Statement of Valid Software Application 5-3

6 Calculations 6-1

6.1 200-ZP-1 Operable Unit 6-1
6.1.1 Water-Level Mapping and Particle Tracking 6-1
6.1.2 Groundwater Flow Modeling and Particle Tracking 6-2
6.1.3 Transport Modeling and Mass Recovery Calculations 6-3
6.1.4 Flow-Path Control Calculations 6-3
6.2 200-UP-1 Operable Unit — S-SX Tank Farms and U Plant 6-4
6.2.1 Water-Level Mapping and Particle Tracking 6-4
6.2.2 Transport Modeling and Mass Recovery Calculations 6-4

7 Results and Conclusions 7-1

7.1 200-ZP-1 Operable Unit 7-1
7.1.1 Hydraulic Containment 7-1
7.1.2 Flow-Path Control 7-7
7.1.3 Simulated and Observed Extraction Well Concentrations and Mass Removal 7-11
7.1.4 Projected Remedial System Mass Removal 7-28
7.2 200-UP-1 Operable Unit - S-SX Tank Farms 7-51
7.2.1 Hydraulic Containment and Flowpaths 7-51
7.3 200-UP-1 - U Plant 7-56
7.3.1 Hydraulic Containment and Flowpaths 7-56
7.3.2 Hydraulic Containment and Flow Path Control for Iodine-129 7-56
7.3.3 Simulated and Observed Extraction Well Concentrations 7-64
7.4 Summary 7-70
7.4.1 200-ZP-1 Operable Unit 7-70
7.4.2 200-UP-1 Operable Unit - S-SX Tank Farms 7-70
7.4.3 200-UP-1 Operable Unit - U Plant 7-70

8 References 8-1

Appendix

A Monthly Average Groundwater Elevations in Monitoring Wells…….…….A-i

B Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies…….… B-i

C Simulated Versus Observed Concentrations in Monitoring Wells……....C-i

Figures

Figure 2-1. Location of the Groundwater OUs on the Hanford Site.....2-1

Figure 2-2. Location of Major Facilities within the Groundwater OUs.....2-3

Figure 2-3. Groundwater Model Domain and Model Boundary Conditions 2-5

Figure 3-1. Calculated Inverse Sum of Square Residuals for Carbon Tetrachloride 3-9

Figure 3-2. Calculated Inverse Sum of Square Residuals for Nitrate 3-9

Figure 3-3. Calculated Weights for Carbon Tetrachloride.....3-10

Figure 3-4. Calculated Weights for Nitrate.....3-10

Figure 4-1. Pumping Rates in December 2017 for the 200 West P&T.....4-8

Figure 4-2. Selected Water-Level Hydrographs throughout the Study Area Illustrating the Correspondence between Simulated and Measured Groundwater Elevations (Page 1 of 3).....4-10

Figure 4-3. Maximum Footprint – CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Carbon Tetrachloride - Quantile Method.....4-17

Figure 4-4. CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Hexavalent Chromium 4-18

Figure 4-5. CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Iodine-129.....4-19

Figure 4-6. CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Nitrate 4-20

Figure 4-7. Maximum Footprint – CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Technetium-99 4-21

Figure 4-8. Maximum Footprint – CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Trichloroethene 4-22

Figure 4-9. Maximum Footprint – CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Tritium.....4-23

Figure 4-10. Maximum Footprint – CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Uranium.....4-24

Figure 4-11. Maximum Footprint – CY 2015 Weighted-Average SGSIM Initial Conditions Compared to CY 2012 Initial Conditions for Carbon Tetrachloride 4-25

Figure 4-12. Maximum Footprint – CY 2015 Weighted-Average SGSIM Initial Conditions Compared to CY 2012 Initial Conditions for Nitrate 4-26

Figure 4-13. COC Removal Efficiency....4-27
Figure 6-1. Example of AWLN Data Adjustment....6-1
Figure 6-2. Schematic of the Flow-Path Control Line-of-Control Used for Calculations in Chapter 7....6-5
Figure 7-1. Mapped Groundwater Levels, Extent of Carbon Tetrachloride and ICFM for 200-ZP-1 Above the RLM....7-2
Figure 7-2. Simulated Groundwater Levels, Extent of Carbon Tetrachloride and SCFM for 200-ZP-1 Above the RLM....7-2
Figure 7-3. Simulated Groundwater Levels, Extent of Carbon Tetrachloride and SCFM for 200-ZP-1 Below the RLM....7-3
Figure 7-4. Drawdown and Mounding (Mapping Method) Above the RLM: (a) Unadjusted and (b) Adjusted....7-4
Figure 7-5. Unadjusted Drawdown and Mounding (Modeling Method): (a) Above and (b) Below the RLM....7-5
Figure 7-6. Adjusted Drawdown and Mounding (Modeling Method): (a) Above and (b) Below the RLM....7-6
Figure 7-7. Mapped Gradient Changes Along Line of Control Above the RLM: (a) Baseline and (b) Current....7-8
Figure 7-8. Simulated Gradient Changes Along Line of Control Above the RLM: (a) Baseline and (b) Current....7-9
Figure 7-9. Simulated Gradient Changes Along Line of Control Below the RLM: (a) Baseline and (b) Current....7-10
Figure 7-10. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Carbon Tetrachloride (100-Year Half-Life)....7-13
Figure 7-11. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Carbon Tetrachloride (630-Year Half-Life)....7-14
Figure 7-12. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Hexavalent Chromium....7-15
Figure 7-13. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Iodine-129....7-16
Figure 7-14. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Nitrate....7-17
Figure 7-15. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Technetium-99....7-18
Figure 7-16. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Trichloroethene....7-19
Figure 7-17. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Tritium....7-20
Figure 7-18. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Uranium....7-21
Figure 7-19. Cumulative Mass Removal for Carbon Tetrachloride 100Y Half Life....7-22
Figure 7-20. Cumulative Mass Removal for Carbon Tetrachloride 630Y Half Life....7-22
Figure 7-21. Cumulative Mass Removal for Hexavalent Chromium....7-23
Figure 7-22. Cumulative Mass Removal for Iodine-129....7-24

Figure 7-23. Cumulative Mass Removal for Nitrate....7-23
Figure 7-24. Cumulative Mass Removal for Technetium-99....7-24
Figure 7-25. Cumulative Mass Removal for Trichloroethene....7-25
Figure 7-26. Cumulative Mass Removal for Tritium....7-25
Figure 7-27. Cumulative Mass Removal for Uranium....7-26
Figure 7-28. Cumulative Mass Removal for Carbon Tetrachloride 100Y Half Life - SGSIM Weighted Average Method....7-26
Figure 7-29. Cumulative Mass Removal for Carbon Tetrachloride 630Y Half Life - SGSIM Weighted Average Method....7-27
Figure 7-30. Cumulative Mass Removal for Nitrate – SGSIM Weighted Average Method....7-27
Figure 7-31. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Carbon Tetrachloride (Assuming 100-Year Half-Life) – Quantile Method....7-29
Figure 7-32. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Carbon Tetrachloride (Assuming 630-Year Half-Life) – Quantile Method....7-30
Figure 7-33. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Hexavalent Chromium....7-31
Figure 7-34. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Iodine-129....7-32
Figure 7-35. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Nitrate – Quantile Method....7-33
Figure 7-36. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Technetium-99....7-34
Figure 7-37. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Trichloroethene....7-35
Figure 7-38. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Tritium....7-36
Figure 7-39. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Uranium....7-37
Figure 7-40. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Carbon Tetrachloride (Assuming 100-Year Half-Life) – SGSIM Method....7-38
Figure 7-41. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Carbon Tetrachloride (Assuming 630-Year Half-Life) – SGSIM Method....7-39
Figure 7-42. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Nitrate – SGSIM Method....7-40
Figure 7-43. Projected Cumulative Mass Recovery as a Fraction of Initial Mass for Carbon Tetrachloride - 100 Year Half Life....7-41
Figure 7-44. Projected Cumulative Mass Recovery as a Fraction of Initial Mass for Carbon Tetrachloride - 630 Year Half Life....7-42
Figure 7-45. Projected Carbon Tetrachloride Plume Extent in CY2022....7-47

Figure 7-46. Projected Carbon Tetrachloride Plume Extent in CY2027 7-48
Figure 7-47. Projected Carbon Tetrachloride Plume Extent in CY2032 7-49
Figure 7-48. Projected Carbon Tetrachloride Plume Extent in CY2037 7-50
Figure 7-49. Groundwater Levels (Mapping Method) and Calculated Pathlines for 200-UP-1 OU — S-SX Tank Farms 7-52
Figure 7-50. Calculated Pathlines and Extent of Technetium-99 for 200-UP-1 OU — S-SX Tank Farms.....7-53
Figure 7-51. Calculated Pathlines and Extent of Chromium for 200-UP-1 OU — S-SX Tank Farms ...7-54
Figure 7-52. Calculated Pathlines and Extent of Nitrate for 200-UP-1 OU — S-SX Tank Farms.....7-55
Figure 7-53. Groundwater Levels (Mapping Method) and Calculated Pathlines for 200-UP-1 OU — U Plant.....7-57
Figure 7-54. Calculated Pathlines and Extent of Uranium for 200-UP-1 OU — U Plant 7-58
Figure 7-55. Calculated Pathlines and Extent of Technetium-99 for 200-UP-1 OU — U Plant 7-59
Figure 7-56. Calculated Pathlines and Extent of nitrate for 200-UP-1 OU — U Plant 7-60
Figure 7-57. Mapped Groundwater Elevations along Iodine-129 Injection Well Line of Control, December 2017 7-61
Figure 7-58. Mapped Gradient Changes Along Line of Control Above the RLM: (a) Baseline and (b) Current.....7-62
Figure 7-59. Simulated Gradient Changes Along Line of Control Above the RLM: (a) Baseline and (b) Current.....7-63
Figure 7-60. Comparison of Simulated and Observed Influent Concentrations at 200-UP-1 OU — S-SX Tank Farms and U Plant (Page 1 of 5) 7-65

Tables

Table 3-1. CPGWM Temporal Discretization 3-4
Table 4-1. Predicted Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies for Out-Year Simulations 4-4
Table 4-2. Residual Summary Statistics from CP Model Version 8.4.5 Validation, as Updated through December 2017.....4-9
Table 4-3. Contaminant Transport Properties Assumed for F&T Analyses Using the CP Model 4-14
Table 4-4. CTS Efficiency Percent Values Used for Transport Simulations (Percent) 4-28
Table 7-1. Mass Recovered, Fraction of Initial Mass Recovered for Carbon Tetrachloride at End of Active Pumping (2037) 7-43
Table 7-2. Mass Recovered, Fraction of Initial Mass Recovered, and Concentration Statistics (Median, Average, and 90th Percentile) for Each COC at End of Active Pumping (2037) 7-45

Terms

3D	three-dimensional
AWLN	automated water level network
CHPRC	CH2M HILL Plateau Remediation Company
CHD	constant head boundary conditions
COC	contaminant of concern
CPGWM	Central Plateau Groundwater Model
CTS	contaminant treatment system
CY	calendar year
ECF	environmental calculation file
F&T	fate and transport
FY	fiscal year
GHB	general head boundary conditions
gpm	gallons per minute
HISI	Hanford Information Systems Inventory
HSGF	hydrostratigraphic geological formation
HSU	hydrostratigraphic unit
ICFM	interpolated capture frequency map
MEUK	multi-event universal kriging
MNA	monitored natural attenuation
MNW2	Multi-Node Well Package
MODFLOW	Modular Ground-Water Flow Model
MODPATH	Particle-tracking post-processing program
MT3DMS	Modular 3-D Transport Multi-Species
OU	operable unit
PATH3D	Particle-tracking post-processing program
P&T	pump and treat
RAO	remedial action objective
RD/RAWP	Remedial Design/ Remedial Action Work Plan

REDOX	Reduction-Oxidation Plant
RK4	Runge-Kutta numerical integration scheme
RLM	Ringold lower mud
ROD	Record of decision
SCFM	simulated capture frequency map
SGSIM	sequential gaussian simulation program
SSP&A	S.S. Papadopulos and Associates, Inc.
UK	universal kriging
USGS	U.S. Geological Survey

1 Purpose

This environmental calculation file (ECF) describes calculations that were performed to assist in evaluating the performance of the groundwater pump and treat (P&T) remedies in place at the Hanford Site 200-ZP-1 and 200-UP-1 Groundwater Operable Units (OUs) as one basis for results presented in DOE/RL-2017-68, *Calendar Year 2017 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump and Treat Operations*. This ECF describes:

1. The use of groundwater elevation mapping and groundwater modeling to estimate the extent of hydraulic containment that is developed by both the 200-ZP-1 and the 200-UP-1 P&T remedies
2. The use of groundwater elevation mapping and groundwater modeling to evaluate the status of flowpath control in the downgradient areas of both the 200-ZP-1 and the 200-UP-1 P&T remedies
3. Calculations of actual mass recovered to-date by the 200-ZP-1 P&T system, comparisons of the actual and the simulated historical mass recovery, and projections of anticipated future mass recovery under assumed future extraction and injection rates

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2 Background

Groundwater P&T is an element of the selected final remedy for the 200-ZP-1 OU, the interim groundwater remedy for the S-SX Tank Farms (located in the 200-UP-1 OU), and the remedy for uranium associated with the U Plant (located in the 200-UP-1 OU) on the Hanford Site Central Plateau, located near Richland, Washington (Figure 2-1).

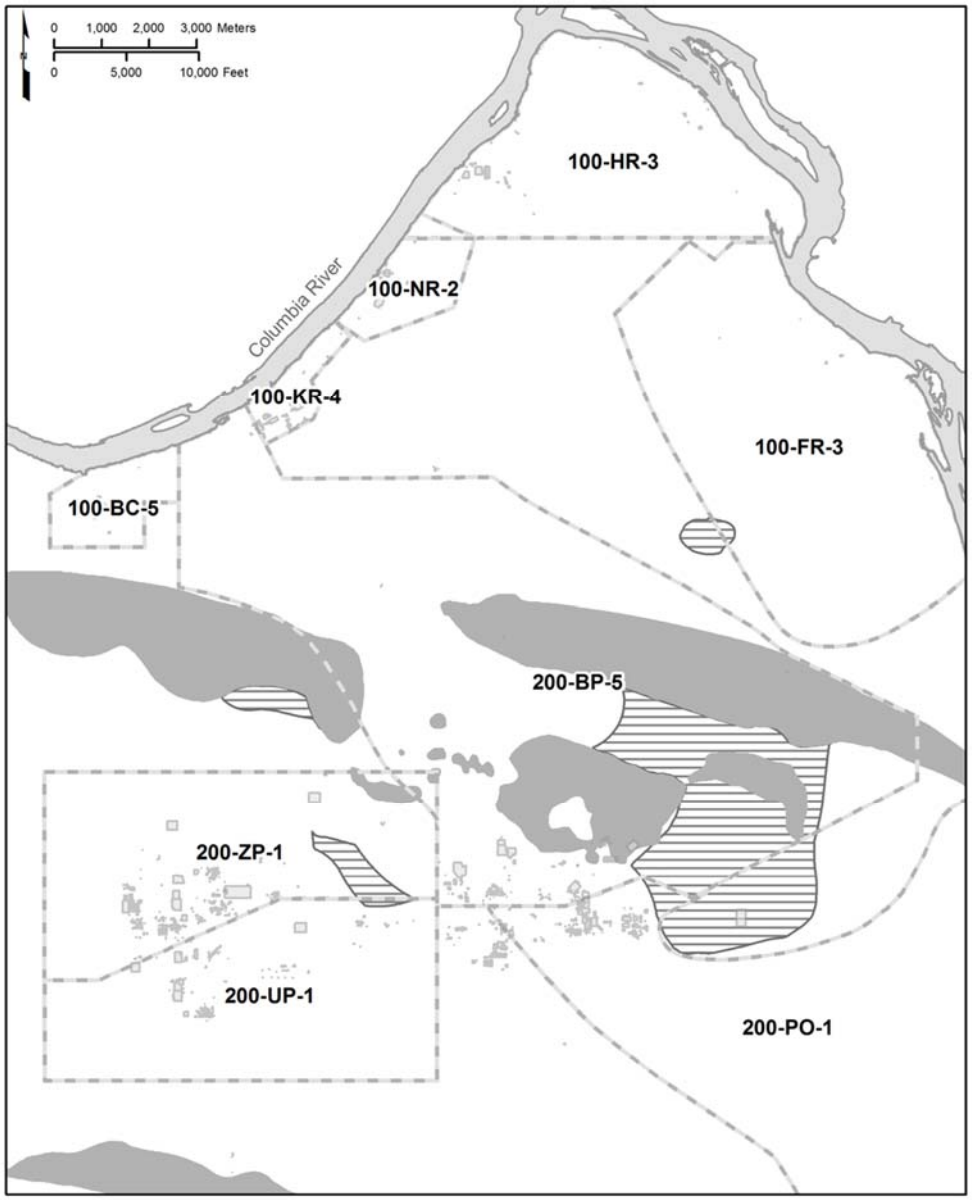

Figure 2-1. Location of the Groundwater OUs on the Hanford Site

2.1 Groundwater Operable Units and Associated Remedies

2.1.1 200-ZP-1 Operable Unit

For remediation of the 200-ZP-1 OU, DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*, and DOE/RL-2007-33, *Proposed Plan for Remediation of the 200-ZP-1 Groundwater Operable Unit*, describe groundwater P&T as an element of the final remedy, as set forth in the 200-ZP-1 OU Record of Decision (ROD; EPA et al., 2008, *Record of Decision, Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington*). The selected remedy combines P&T, monitored natural attenuation (MNA), flow-path control, and institutional controls with the goal of recovering 95 percent of the mass of each contaminant of concern (COC) within the 200-ZP-1 OU within 25 years (which corresponds with the year 2037; the active P&T remedy period commenced in 2012) as a measure of progress toward ultimately achieving remedial action objectives defined by published groundwater cleanup levels within a time frame of 125 years (which corresponds with the year 2137). Calculations of hydraulic containment, contaminant fate and transport (F&T), and mass recovery presented in previous 200-ZP-1 OU reports provide one basis for the calculations presented in this ECF.

2.1.2 200-UP-1 Operable Unit — S-SX Tank Farms

Groundwater in the 200-UP-1 OU is contaminated by releases that occurred near the S-SX Tank Farms, as well as other locations (Figure 2-2). A P&T interim remedial action has been implemented including three extraction wells located adjacent to the S-SX Tank Farms. The interim remedial action goal for contaminants for the S-SX Tank Farms P&T is to capture or contain technetium-99 contamination where it exceeds the maximum contaminant level by a factor of 10 or greater. The interim action is not intended to address any possible continuing sources (except to the extent that it contains groundwater contamination around the source area) until it can be determined if additional remedial actions are required under the final ROD.

2.1.3 200-UP-1 Operable Unit — Reduction-Oxidation Plant and U Plant

Uranium in groundwater near U Plant (Figure 2-2) originated from the 216-U-1 and 216-U-2 Cribs, which were also a source of technetium-99 and nitrate to groundwater. The uranium plume is interpreted to extend 1.5 km (0.9 mi) to the east of the cribs above the 30 µg/L cleanup level. The selected active remedy for plumes in the U Plant area is groundwater extraction and treatment (EPA et al., 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*). During 2015, construction of the uranium remedy was completed, including two extraction wells (299-W19-113 and 299-W19-114) and pipelines to convey extracted groundwater to the 200 West P&T radiological building for treatment. The U Plant P&T system began operating in September 2015. In calendar year (CY) 2017 one more extraction well was completed (299-W19-125) and began operating in September 2017.

The Reduction-Oxidation Plant (REDOX; Figure 2-2) cribs were the primary sources of iodine-129 that occurs in a region extending east from the southeastern 200 West Area. The selected remedy for this plume is hydraulic containment while other potential treatment technologies are evaluated (EPA et al., 2012). Hydraulic containment will be achieved by operating injection wells for the 200 West P&T located to the east of the iodine-129 plume to create a hydraulic barrier to further eastward migration. Three hydraulic control injection wells (299-E11-1, 299-E20-1, and 299-E20-2) were drilled during 2015 and began operating on October 28, 2015.

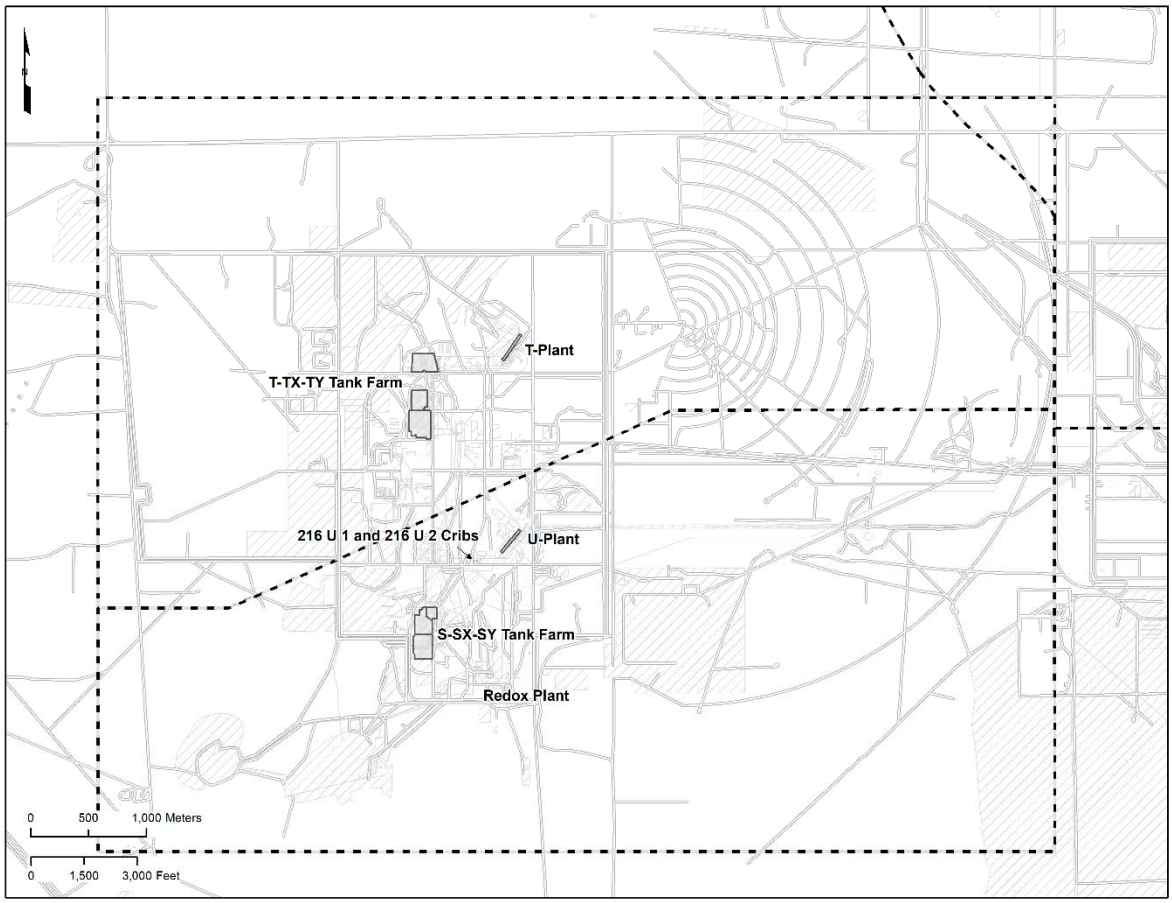

Figure 2-2. Location of Major Facilities within the Groundwater OUs

2.2 Use of Multiple Lines of Evidence

The variety of calculation methods used to support the CY 2017 annual P&T report (DOE/RL-2017-68) is summarized in the following subsections and are discussed in further detail in Chapter 3. These various calculations methods comprise the multiple-lines-of-evidence approach used to evaluate groundwater P&T remedy performance. Chapter 4 discusses the assumptions and inputs for each calculation, and Chapter 5 describes the software used to complete the calculations. Specific calculations are detailed in Chapter 6, and the results are presented in Chapter 7.

2.2.1 200-ZP-1 Operable Unit

To assess the current performance of the 200-ZP-1 P&T remedy and projected future performance in achieving the remedial action objectives (RAOs) set forth in the ROD, the following lines of evidence are used:

- Assessment of hydraulic containment and assessment of flow-path control:
  - Groundwater sample result interpolation (i.e., plume mapping)
  - Historical groundwater flow modeling and pathline calculation to estimate the modeled extent of hydraulic containment

  - Historical groundwater elevation mapping and pathline calculation to estimate the mapped extent of hydraulic containment

- Assessment of contaminant mass recovery:
  - Historical and projected groundwater flow and contaminant transport modeling
  - Calculation of historical and future (model-projected) P&T system influent concentrations and mass recovery

2.2.2 200-UP-1 Operable Unit — S-SX Tank Farm and U-Plant

To assess the current status of 200-UP-1 S-SX Tank Farm and U Plant P&T remedy performance in achieving the interim remedy objective of hydraulically containing or reducing the rate of migration of targeted constituents in groundwater, the following lines of evidence are used:

- Historical groundwater flow modeling pathline calculation to estimate the mapped extent of hydraulic containment, and identify areas of reduced or reversed hydraulic gradients
- Historical groundwater elevation mapping and pathline calculation to estimate the mapped extent of hydraulic containment, and identify areas of reduced or reversed hydraulic gradients

Historical modeled influent concentrations are also calculated for 200-UP-1 extraction wells simultaneously with the calculations made for the 200-ZP-1 wells. However, these calculations are not used at this time to infer the performance of the 200-UP-1 extraction wells.

2.3 Groundwater Models

2.3.1 Model History

The Central Plateau Groundwater Model (CPGWM) (CP-47631 Rev. 4, *Model Package Report: Central Plateau Groundwater Model, Version 8.4.5*) is the principal computational tool used to design and evaluate the performance of the 200-ZP-1 and 200-UP-1 groundwater remedies. The CPGWM is used to assess the performance of the P&T remedies and is supplemented by direct interpretations of water level and pumping data, as well as other lines of evidence. Figure 2-3 shows the groundwater model domain and model boundary conditions. The following narrative describes the development of the CPGWM.

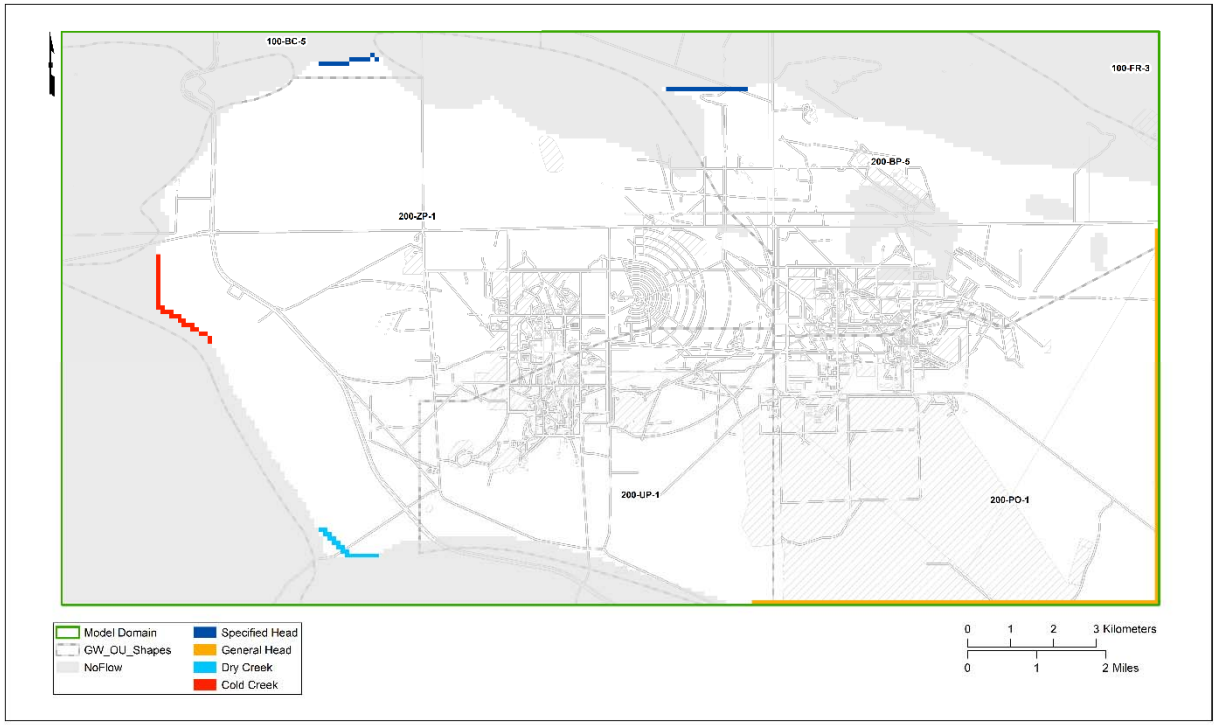

Figure 2-3. Groundwater Model Domain and Model Boundary Conditions

During 2008, a groundwater flow and contaminant transport model was developed to support 200-ZP-1 remedy decisions by estimating the extent of hydraulic containment developed by pumping and predicting influent concentrations and contaminant mass removal rates. The first version of the model is described in DOE/RL-2008-56, *200 West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses*, and in the 200-ZP-1 OU proposed plan (DOE/RL-2007-33). DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*, discusses the plan and schedule for the design, installation, and operation of the remedy set forth in the 200-ZP-1 OU ROD (EPA et al., 2008). DOE/RL-2009-38, *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan*, presents the results of simulations completed to support the remedy design presented in the remedial design/remedial action work plan. DOE/RL-2009-38 describes simulations performed to estimate concentrations over time at individual 200-ZP-1 OU extraction wells and for the combined treatment system for the eight COCs for the 200-ZP-1 OU: carbon tetrachloride, total chromium (trivalent and hexavalent), hexavalent chromium, nitrate, trichloroethene, iodine-129, technetium-99, and tritium (plus uranium). Uranium is not a COC identified in the 200-ZP-1 OU; rather, it is a COC for the 200-UP-1 OU that will be treated using the 200 West P&T.

During 2009 and 2010, the first version of the groundwater model discussed above underwent development and recalibration, and it was reissued via a series of model package reports as the CPGWM. During fiscal year (FY) 2010, Version 3.3 (CP-47631, Rev.0, *Model Package Report: Central Plateau Groundwater Model, Version 3.3*) of the CPGWM was used to evaluate the projected mass recovery of carbon tetrachloride across a range of pumping strategies, focusing on identifying the best placement for extraction and injection wells that had not yet been installed/completed. SGW-47651, *Final 200-ZP-1 Pump-and-Treat Remedy: Results of FY 2010 Groundwater Flow and Contaminant Transport Simulations*, describes the evaluation and concluded that operating the expanded P&T remedy at rates proposed in the 200-ZP-1 feasibility study (DOE/RL-2007-28) or the remedial design/remedial action

work plan (DOE/RL-2008-78) would likely not achieve the 95 percent mass recovery goal described in the 200-ZP-1 OU ROD (EPA et al., 2008). However, further evaluation of the results in SGW-50390, *FY 2011 Simulation-Optimization of the 200-ZP-1 Remedy Using the Central Plateau Model*, suggested that dynamic operation of the P&T remedy could increase mass recovery so it could approach (though not attain) the 95 percent mass recovery goal. It is also well established within the environmental remediation community that dynamic operation of P&T systems is advisable to meet RAOs under many circumstances (EPA et al., 2008). In 2014 Version 6.3.3 of the CPGWM was released as an extension of Version 3.3 for Build 6 of CH2M HILL Plateau Remediation Company (CHPRC) Modular Ground-Water Flow Model (MODFLOW). No changes were needed to apply Build 6**.** Part of this extension is an update of the simulation period to 2014, which entailed extending the temporal boundary conditions. To accommodate recent pumping in the 200 West Area, the simulation time periods were changed from yearly to monthly after 2007. The last "3" in 6.3.3 was introduced to refer to this change in boundary conditions.

Version 8.3.4 of the CPGWM was released in 2016 as an extension of Version 6.3.3 for Build 8 of CHPRC MODFLOW. Part of this extension is an update of the simulation period through August 2016, which entailed extending the temporal boundary conditions. The last "4" in 8.3.4 refers to the update completed on the boundary conditions of the model.

2.3.2 Current Version

The most recent model package report describing the CPGWM was released in 2017 as CP-47631_rev4, *Model Package Report: Central Plateau Groundwater Model Version 8.4.5*. CPGWM Version 8.4.5 was a major update of the model. The main feature was updating the method for grid generation and the definition of hydrostratigraphic units (HSUs) based on the hydrostratigraphic geological formation (HSGF) rather than by the surface data analyzed as part of the model development. The model used the same build of MODFLOW as Version 8.3.4. The calibration process used both to accommodate recent pumping in the 200 West Area, and the simulation time periods were changed from yearly to monthly after 2007. The last "4" in 8.3.4 refers to the update completed on the boundary conditions of the model.

The current version of the CPGWM (Version 8.4.5) simulates groundwater flow using the U.S. Geological Survey (USGS) three-dimensional groundwater flow model, MODFLOW, as discussed in the following documents:

- McDonald and Harbaugh, 1988, "A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model"
- Harbaugh and McDonald, 1996, *User's Documentation for MODFLOW-96, an Update to the U.S. Geological Survey Modular Finite-Difference Ground-Water Flow Model*
- Harbaugh et al., 2000, *MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process*
- Harbaugh, 2005, *MODFLOW-2005, The U.S. Geological Survey Modular Ground-Water Model – The Ground-Water Flow Process*

Contaminant transport is simulated using the code "MT3DMS" (Modular 3-D Transport Multi-Species) (Zheng and Wang, 1999, MT3DMS: *A Modular Three-Dimensional Multispecies Transport Model for Simulation of Advection, Dispersion and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide*; Zheng, 2006, *MT3DMS v5.2 Supplemental User's Guide*). MT3DMS is a three-dimensional, multi-species transport model developed specifically for use with MODFLOW to

simulate contaminant advection, dispersion, and chemical reactions in groundwater. MT3DMS was used to calculate the approximate directions and rates of migration of 200-ZP-1 and 200-UP-1 (S-SX Tank Farms and U Plant) COCs, as well as the approximate time-varying influent concentrations and masses of these contaminants at the extraction wells and at the combined system influent. The particle-tracking, post-processor MODPATH (Pollock, 1994, *User's Guide for MODPATH/MODPATH-PLOT, Version 3; A particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model*) is used to compute pathlines based upon results obtained from the CPGWM groundwater flow simulations.

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3 Calculation Methods

This chapter describes the calculation methods used for this ECF. Assumptions underlying the methods and inputs for the calculations are presented in Chapter 4.

3.1 Water Level Mapping

Groundwater elevation data are interpreted by evaluating hydrographs of measured water level data and by preparing maps of groundwater levels that depict patterns of groundwater flow and likely contaminant migration. Water-level data are interpreted prior to using the CPGWM in order to develop understanding of the patterns that can be directly inferred from the data.

3.1.1 Universal Kriging with Analytic Elements

Groundwater level mapping is used to estimate the extent of hydraulic containment through a step-wise process. The mapping technique is detailed in SGW-42305, *Collection and Mapping of Water Levels to Assist in the Evaluation of Groundwater Pump-and-Treat Remedy Performance*. To obtain a single estimate of the extent of hydraulic containment developed by a P&T remedy, the following steps are required:

1. Interpolate water-level data using universal kriging (UK) and analytical elements to describe the effect of extraction and injection wells and other hydrologic features.
2. Track particles on the mapped water level surface to estimate the extent of containment.

The UK technique enables a trend to be included in the mapping. Expressions that describe the water level response to these features are incorporated in the UK trend using superposition. The form of the underlying trend is the summation of these terms. The UK technique includes two processes: estimation and prediction. During the estimation process, the coefficients of the trend terms are estimated using generalized least squares. During the prediction process, groundwater levels are calculated on a regular grid using the estimated trend coefficients, and the resulting grid of water levels is then used to prepare contour maps for visualization.

To prepare groundwater elevation maps for the S-SX Tank Farms and U Plant areas, the UK trend incorporates the effect on the water levels of extraction and injection at wells; the Columbia River (because the river is a major hydrologic feature dictating regional patterns of flow); and basalt subcrops such as Gable Butte, Gable Mountain, and Rattlesnake Hills. Using superposition to sum the effects of these terms, the head (H) is estimated at any location (x,y), as shown in Equation 1:

$$H(x,y) = A + B\sum_{1}^{n} Q_i + C\sum_{1}^{m} L_j + D\sum_{1}^{p} R_k + \varepsilon(x,y) \qquad \text{(Equation 1)}$$

In Equation 1, A, B, C, and D are regression coefficients; n is the number of extraction and injection wells; m is the number of river segments; and p is the number of hydraulic barriers. Furthermore, Q_i describes the effect on heads by pumping at well i; L_j describes the effect on head by reach j of the Columbia River; and R_k describes the effect on heads of hydraulic barrier k. The final term, $\varepsilon(x,y)$, is the zero-mean residual error (i.e., the difference between the trend and the measured values at monitored locations), which is eventually described using a semivariogram. Because the Columbia River is the major discharge feature of the Hanford Site unconfined aquifer (and mountain front recharge and the location of basalt subcrops determine sitewide groundwater flow patterns), inclusion of the Q, L, and R terms enables approximate sitewide water level mapping, eliminating the need for the more commonly used linear (i.e., planar) trend term.

3.1.2 Particle Tracking

Particle tracking is used to estimate the extent of hydraulic containment that would develop under conditions represented by a groundwater level map, providing an instantaneous depiction of hydraulic containment corresponding to the water levels and pumping rates used to prepare the map. Particle tracking is accomplished using the fourth-order Runge-Kutta numerical integration scheme (RK4) (Press et al., 1996, *Numerical Recipes in Fortran-90*). Particle tracking using the RK4 approach indicates the approximate path of migrating groundwater and dissolved contaminants, as well as the relative timing of contaminant arrival at points of interest. The RK4 approach is based on that implemented in PATH3D (Particle-tracking post-processing program; Zheng, 1992, *PATH3D: A Groundwater Path and Travel-Time Simulator, Version 3.0*), which provides similar results to the USGS particle-tracking program, MODPATH (Pollock, 1994), which is used in combination with the CPGWM for similar purposes.

3.1.3 Interpolated Capture Frequency Map

If concurrent water level and pumping rate data are available, maps depicting water levels and capture can be produced on any frequency; however, discerning a best estimate of overall capture using numerous maps can be difficult, which can be solved by calculating an interpolated capture frequency map (ICFM). An ICFM depicts capture that is estimated on the basis of numerous water-level maps. An ICFM depicts the frequency that each particle terminates at an extraction well, calculated over all water-level maps. A frequency of 1.0 indicates that the particle is captured on every map, a frequency of zero indicates that a particle is not captured on any map, and intermediate frequencies indicate that the particle is captured using some maps and not on others. Frequencies below 1.0 may be due to:

- Variations in pumping rates
- Temporary well shut-off for scheduled and unscheduled maintenance
- Degree of adherence to, or violation of, assumptions that underlie the mapping method

An ICFM is most appropriately interpreted as a collective estimate for the monitoring period. Only frequencies of 0.5 and higher are depicted in figures presented in this ECF.

3.2 Groundwater Modeling

The CPGWM is used to aid in understanding performance of the in-place remedies and to project the likely future performance of the remedies under assumed operating conditions.

3.2.1 Model Updates

No changes were made to the fundamental structure – i.e., the model grid discretization, model layering, and the representation of the site hydro-stratigraphy – of the CPGWM Version 8.4.5 (CP-47631, Rev 4.) before performing the simulations described in this ECF. Limited changes that were made to the time discretization, boundary conditions and other inputs, are described in the following subsections.

3.2.1.1 Time Discretization

For the calculations summarized in this ECF, the time discretization was updated to simulate current and future P&T operations. Specifically, the time discretization of the CPGWM was updated to support a qualitative validation during recent years (particularly emphasizing startup in 2012 of the final 200-ZP-1 P&T remedy, the 200 West P&T) and to provide a suitable time discretization for simulating recent (2012 through 2017) operations of remedies for 200-ZP-1 and the 200-UP-1 S-SX Tank Farms and U Plant. Model time is discretized into stress periods and time steps, and changes in external forcing functions (e.g., recharge or pumping) typically occur by changing stress periods. Stress periods are further

divided into time steps, which allows for a more accurate discretization of the time derivative of the partial differential groundwater flow equation. The time discretization used for the applications described in this brief is as follows:

- Annual stress periods were used to simulate transient conditions during the period from 1944 through 2007.
- A refined discretization consisting of monthly stress periods was used for the years 2008 through 2012 to simulate the operations of the interim P&T remedy (enhanced with the addition of well 299-W15-225 in 2010) and to provide appropriate temporal resolution for model validation during the final P&T remedy startup in 2012.

For purposes of predictive simulations described in this ECF, two models were developed with different model start times and transport initial conditions. The purpose of making calculations with two time discretizations is to facilitate and document the transition from the previously prepared initial conditions (contaminant plumes, as discussed in ECF-200ZP1-13-0006, *Description of Groundwater Modeling Calculations for the Calendar Year 2012 (CY2012) 200 Areas Pump-and-Treat Report*) to more recently prepared initial conditions, as presented in the following discussion (preparation of the updated initial conditions [contaminant plumes] is discussed in detail in ECF-200W-16-0092 Rev. 1, *Calculation of Three-Dimensional Groundwater Concentration Plumes for 200-West for Calendar Year [CY] 2015*).

The time discretization for the model application that simulates the period from 2012 through 2137 using initial conditions (contaminant plumes) that approximately represent conditions during CY 2011 is summarized in Table 3-1 and is outlined below:

- The first 72 stress periods are monthly, representing the end of interim remedy operations and the startup of the final 200-ZP-1 P&T remedy.
- Stress period 73 is 9 months long and is used to simulate the connection of future wells to the P&T system, pumping at a rate of 7,400 L/min (1,955 gallons per minute [gpm]).
- Stress periods 74 through 78 represent the simulation of the final phase of the 200-ZP-1 P&T system operation, pumping at a rate of 8,043 L/min (2,125 gpm).
- Stress period 79 is 100 years long and is used to simulate the period during which MNA is the operating remedy.

The time discretization for the model application that simulates the period from 2015 through 2137 using initial conditions (contaminant plumes) representing approximate conditions in early CY 2015 is summarized in Table 3-1 and is outlined below:

- The first 36 stress periods are monthly, representing the end of interim remedy operations and the startup of the final 200-ZP-1 P&T remedy.
- Stress period 37 is 9 months long and is used to simulate the connection of future wells to the P&T system, pumping at a rate of 7,400 L/min (1,955 gpm).
- Stress periods 38 through 42 represent the simulation of the final phase of the 200-ZP-1 P&T system operation, pumping at a rate of 8,043 L/min (2,125 gpm) per stress period.
- Stress period 43 is 100 years long and is used to simulate the period during which MNA is the operating remedy.

Table 3-1. CPGWM Temporal Discretization

Historical Model		
Stress Period	**Duration**	**This Application**
1 through 64	1944 through 2007	Yearly stress periods
65 through 112	2008 through 2011	Monthly stress periods
Predictive Model Starting in 2012		
Stress Period	**Duration**	**This Application**
1 through 72	01/01/2012 to 12/31/2017	Monthly stress periods representing end of interim and startup of remedy (Phase II commences October 1, 2012)
73	01/01/2018 to 09/30/2018	Single stress period, continuing Phase II of remedy
74	10/01/2018 to 09/30/2019	Single stress period, continuing Phase III of remedy
75 through 77	10/01/2019 to 09/30/2034	5-year stress periods, continuing Phase III of remedy
78	10/01/2034 to 09/30/2037	Single stress period, continuing Phase III of remedy
79	10/01/2037 to 9/30/2137	100-year stress period
Predictive Model Starting in 2015		
Stress Period	**Duration**	**This Application**
1 through 36	01/01/2015 to 12/31/2017	Monthly stress periods representing Phase II of remedy
37	01/01/2018 to 09/30/2018	Single stress period, continuing Phase II of remedy
38	10/01/2018 to 09/30/2019	Single stress period, continuing Phase III of remedy
39 through 41	10/01/2019 to 09/30/2034	5-year stress periods, continuing Phase III of remedy
42	10/01/2034 to 09/30/2037	Single stress period, continuing Phase III of remedy
43	10/01/2037 to 9/30/2137	100-year stress period

CPGWM = Central Plateau Groundwater Model

3.2.1.2 Boundary Conditions and Other Inputs

The following updates were made to certain input files to the CPGWM to reflect recent data. Since these updates comprise inputs to the CPGWM, the details of these model inputs are described in Section 4.2:

- Updating well flow rates to actual rates recorded for extraction and injection wells through the end of CY 2017
- Updating the constant head (CHD), general head (GHB) and recharge boundary conditions for the CPGWM

Updating contaminant treatment system (CTS) package to reflect P&T system efficiencies through end of 2017.

In addition to the above, the CPGWM groundwater level calibration/validation data set was updated through the end of CY 2017, although no parameters were adjusted and calibration was not performed. Summary statistics for the validation/calibration residuals presented in Section 4.2.2 were similar to those presented for the calibrated model in CP-47631, which suggests that over the extended validation period (from 2009 through 2017), the model performs as well (in terms of statistical correspondence with measured water levels) as during the calibration period.

3.2.2 Flow Modeling and Simulated Capture Frequency Map

Groundwater simulations performed for CY 2017 assume transient-state (i.e., time-varying) conditions in the aquifer that reflect water level changes due to operation of the P&T extraction and injection wells. The stress periods correspond to calendar monthly average conditions. The approximate extent of hydraulic containment was calculated with the CPGWM using an approach similar to that described in Festger and Walter, 2002, "The Capture Efficiency Map: The Capture Zone Under Time-Varying Flow;" and Reilly and Pollock, 1996, "Sources of Water to Wells for Transient Cyclic Systems," focusing on the evaluation of the temporal variation in capture due to changing flow patterns and hydraulic gradients. This process is similar to the process used to calculate an ICFM and is implemented using the CPGWM as follows:

- Release particles near the end of each of the 12 monthly stress periods and simulate their migration using a very low effective porosity, approximating "instantaneous" particle travel.
- Record the instantaneous fate of each particle for each stress period.
- Calculate a capture zone for each stress period based on the "snapshot" of aquifer conditions at the time of the particle release, producing 12 instantaneous snapshots of the extent of capture.
- Construct a simulated capture frequency map (SCFM) by counting the number of times that a particle originating from a location was captured by a well, and then divide this count by the total number of releases (i.e., by 12).

3.2.3 Transport Modeling and Mass Recovery Calculations

Contaminant transport simulations were conducted to approximate the recent and likely future movement and fate of the 200-ZP-1 and 200-UP-1 COCs. For purposes of the 200-ZP-1 OU, the specific objectives of these simulations are as follows:

- Historical simulations:
  - Calculate influent concentrations and mass recovery at each extraction well and for the treatment system in its entirety since startup of the 200-ZP-1 P&T system.
  - Compare these values with recorded influent concentrations and mass recovery rates.
- Future projections:
  - Calculate influent concentrations and mass recovery at each extraction well for the remaining years of operation, providing an indication of the relative concentrations and mass recovery between different extraction wells over the life of the remedy.
  - Calculate the movement and fate of COCs in groundwater, and estimate the likely disposition and concentration of the COCs over the life of the remedy.

Inputs used for contaminant F&T simulations are detailed in Section 4.2.

3.3 Flow-Path Control

As stated in Section 4.3.3 of the 200-ZP-1 OU ROD (EPA et al., 2008):

> *Flow-path control is also required and shall be achieved by injecting the treated groundwater into the aquifer to the northeast and east of the groundwater contamination such that the treated injected water in these locations will slow the natural eastward flow of most of the groundwater and, as a result, keep COCs within the capture zone, as well as increase the time available for natural attenuation processes to reduce the contaminant concentrations not captured by the extraction wells.*

The locations and rates of the extraction and injection wells were designed to encompass and recover the majority of contaminant mass and to slow the migration of contaminants present at lower concentrations. As a result, evaluating the development of flow-path control relies upon post-processing and integrated assessment of (1) the extent of contamination (emphasizing carbon tetrachloride); (2) the extent of hydraulic containment determined using both water-level mapping and groundwater modeling methods (i.e., the ICFM and SCFM, respectively); and (3) the region over which hydraulic gradients are affected by the operation of the P&T system, as determined using both the water-level mapping and groundwater modeling methods. The control line for evaluating flow-path control has currently been established as a line that (1) is located a short distance upgradient of the eastern series of injection wells, (2) is generally perpendicular to the prevailing groundwater flow direction prior to when the 200 West P&T started operating, and (3) extends to the north and south of the eastern (downgradient) line of injection wells until such time as the perpendicular to the line of control extends outside the 100 µg/L carbon tetrachloride isoconcentration line. Details of the calculations are provided in this ECF.

3.4 Transport Modeling and SGSIM plume maps depiction

As detailed in ECF-200W-16-0092, application of the quantile kriging technique results in a single depiction of the three-dimensional (3D) extent of contamination, whereas the application of the sequential Gaussian simulation technique (ECF-200W-18-0028, *Evaluation of Three-Dimensional Extent of Carbon Tetrachloride and Nitrate in Groundwater for 200-West for Calendar Years (CYS) 2015 and 2017*) results in multiple "realizations" of the 3D extent of contamination – in this instance, providing 100 alternate realizations of the extent of carbon tetrachloride and of nitrate.

In support of the Remedial Design/ Remedial Action Work Plan (RD/RAWP) for 200-ZP-1, which was completed in 2008, 3D depictions of the extent of carbon tetrachloride and other COCs were prepared using sequential gaussian simulation (SGSIM) techniques (DOE/RL-2009-38; DOE/RL-2008-78). The estimated 3D extent and mass of contamination within groundwater generated using ensemble average (E-Type) of 100 SGSIM realizations was substantially larger than that generated using the ordinary kriging (quantile) technique and might over-state the mass of carbon tetrachloride present in groundwater due to the difficulty encountered in constraining the multiple realizations. To overcome constraining problems and improve estimated 3D extent and mass of contaminations, 100 transport model simulations were developed using initial concentration from each of 100 SGSIM realizations, then simulated mass recovery and simulated concentrations were compared with reported values and "weighted-average" plume was generated and compared to the plume generated using the ordinary kriging "Quantile" method.

The following procedures were completed to run each of 100 simulations and to generate "weighted-average" plume:

- Execute SGSIM postprocessor "postsim.exe" to extract SGSIM single realization in 1 percentile increment.

- Execute MakeIC_SGSIM.exe to generate realization initial plume concentrations file in format readable by MT3D.
- Execute transport simulation using MT3D for period from January 2015 through December 2017.
- Execute postprocessing scripts and calculate residuals between reported and simulated mass recovery for all extraction wells and calculate residuals between measured and simulated concentration for monitoring wells.
- For both mass and concentration, calculate the inverse of the sum of the squared residuals (1/SSQR) for each realization run:

$$1/\mathrm{SSQR}_{i=1}^{r} = \frac{1}{\sum_{k=1}^{n}(measured_k - simulated_k)^2}$$

- For both mass and concentration, calculate the sum (S) of 1/SSQR:

$$S = \sum_{i=1}^{r} 1/\mathrm{SSQR}_i$$

- Calculate the mass and concentration weights (*W*) for each individual realization by dividing (1/SSQR) with sum (S):

$$W_{i=1}^{r} = \frac{1/\mathrm{SSQR}_i}{S}$$

- Calculate the final weights (*Wf*) for each realization by averaging the mass and concentration weights:

$$Wf_{i=1}^{r} = Avearage\ (Wmass_i, Wconc_i)$$

- Calculate the final average weighted initial concentration (*AWC*) by multiplying the final realization weight by the realization initial plume concentrations:

$$AWC = \sum_{i=1}^{r} Wf_i * \mathrm{PlumeConc}_i$$

  - n = number of extraction wells for mass recovery residuals or number of monitoring wells for concentration residuals
  - r = number of realizations

Figures 3-1 and 3-2 depict the calculated individual realization inverse of sum of squared residuals (1/SSQR) compared to inverse of sum of squared residuals (1/SSQR) calculated using weighted-average, E-type and quantile initial plumes for carbon tetrachloride and nitrate. The following features appear evident from these figures:

- In both figures – the spread of the distribution (bar chart) depicted for the concentration percentiles is wider than that of the distribution depicted for the mass percentiles. This suggests that the sample data alone can be used to produce a wide range of plume geometries that are generally consistent with the data, but that only a relatively small number of these results in a

simulated mass recovery using the CPGWM that reasonably corresponds with measured historical mass recovery (as shown by the location of the narrower peak of the mass percentiles).

- In Figure 3-1, the peak of the mass percentile distribution is located to the right of the peak of the concentration percentile distribution. This appears to suggest that the "best" (in terms of correspondence with the sample data) plumes generated from the data, which lie around the 50th percentile, result in an underestimate of the historical mass recovery, and that the "best" (in terms of corresponce with historical mass recovery) plumes generated from the data lie at around the 57th percentile. This may suggest that contouring of the sample data to produce initial plumes would lead to slight underestimates of mass recovery either because (a) there is mass present in the subsurface that is not accounted for in the sample data, or (b) there are assumptions in the calculations made using the CPGWM that lead to systematic underestimates of the mass recovered. Such assumptions may include the transport parameters assumed for carbon tetrachloride, for example.
- In Figure 3-2, the peak of the mass percentile distribution is located to the left of the peak of the concentration percentile distribution. This appears to suggest that the "best" (in terms of correspondence with the sample data) plumes generated from the data, which lie around the 61st percentile, would result in an overestimate of the historical mass recovery, and that the "best" (in terms of corresponce with historical mass recovery) plumes generated from the data lie at around the 55th percentile. This may suggest that contouring of the sample data to produce initial plumes would lead to slight overestimates of mass recovery either because (a) the sample data slightly exaggerate the mass present in the subsurface, or (b) there are assumptions in the calculations made using the CPGWM that lead to systematic overestimates of the mass recovered. Such assumptions may include the transport parameters assumed for nitrate, for example.

These discrepancies may also suggest that the current monitoring network coverage is not in all places sufficient to accurately calculate the three-dimensional distribution and mass of contaminants.

Figures 3-3 and 3-4 depict the calculated mass, concentration and average weights used for final carbon tetrachloride and nitrate plume depictions.

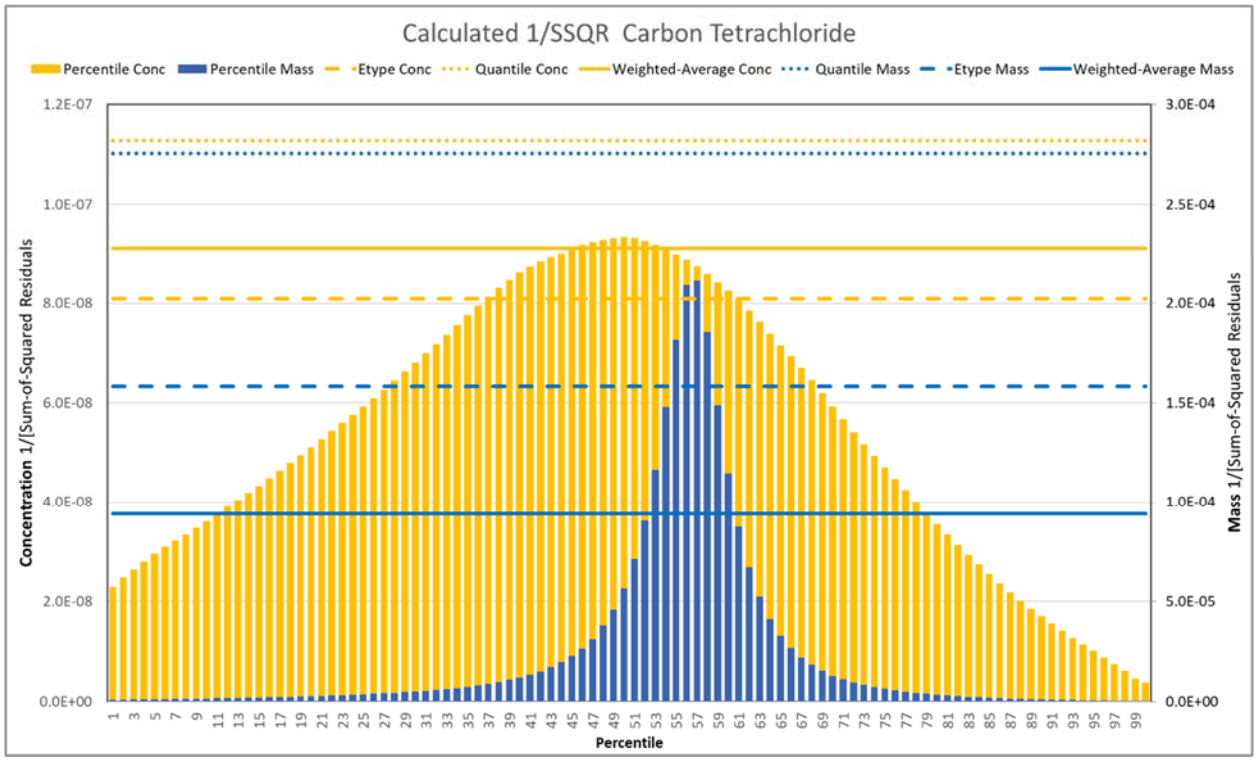


Figure 3-1. Calculated Inverse Sum of Square Residuals for Carbon Tetrachloride

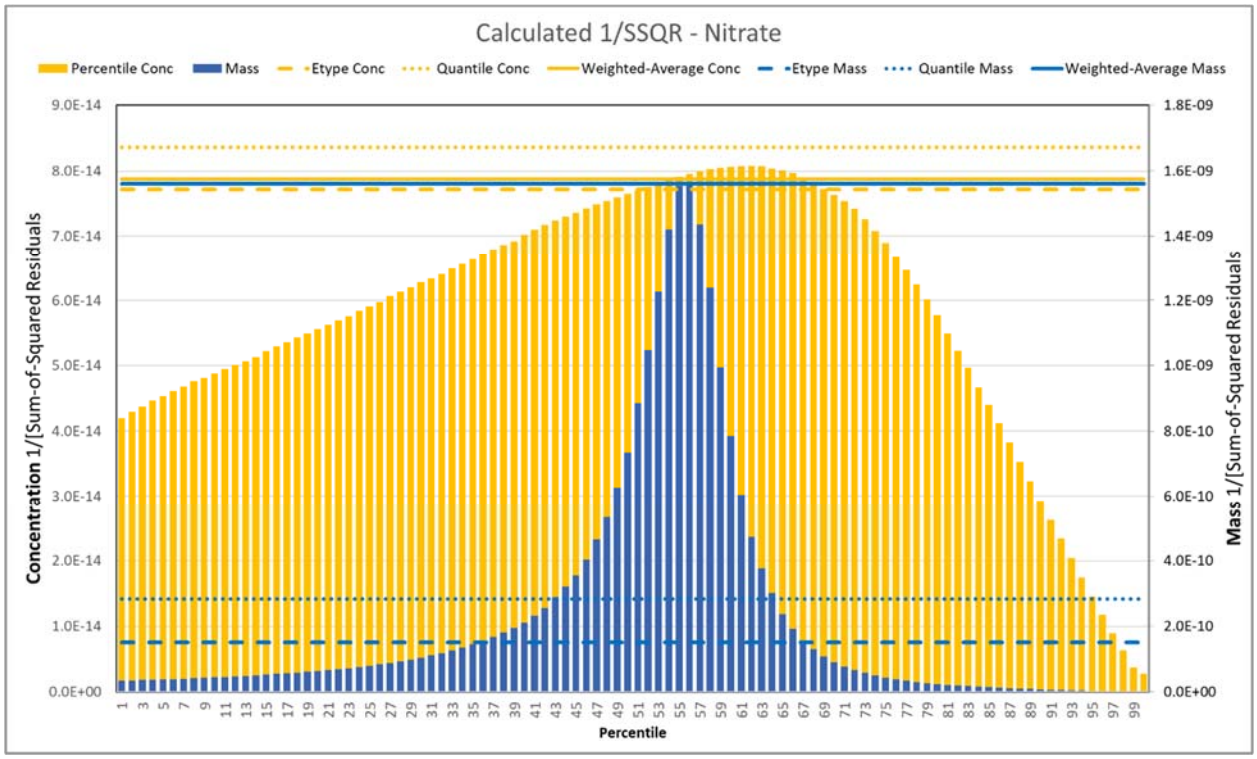


Figure 3-2. Calculated Inverse Sum of Square Residuals for Nitrate

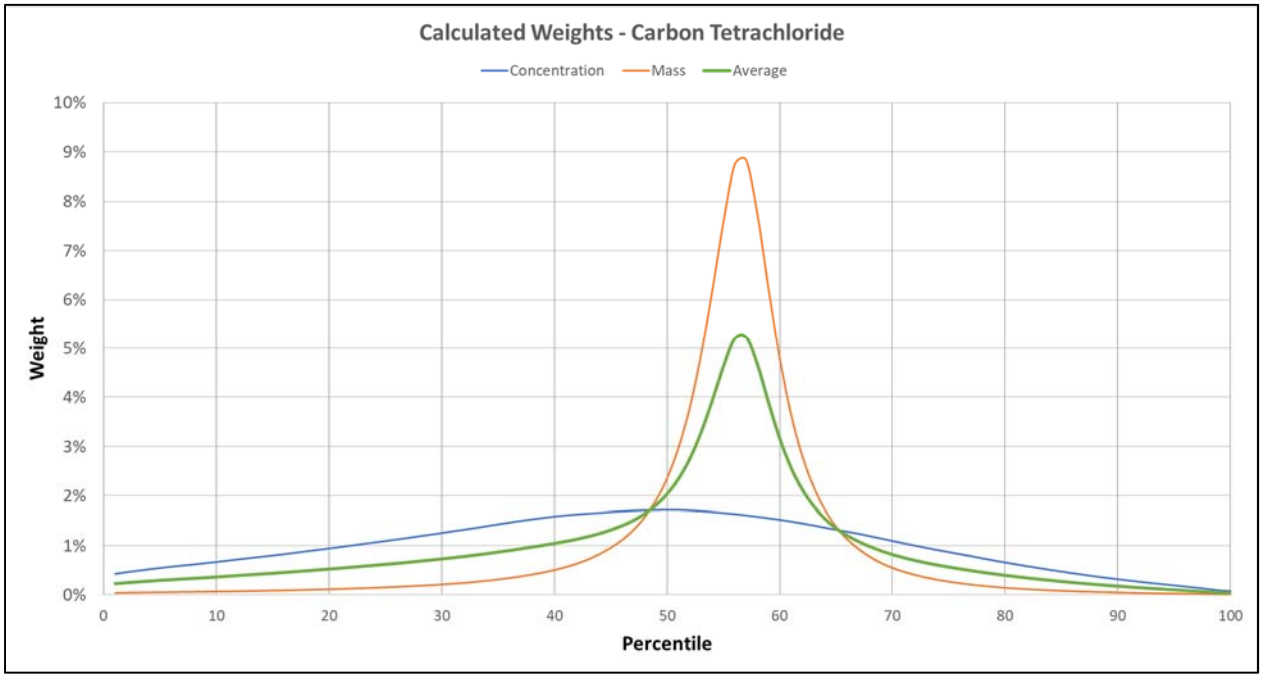


Figure 3-3. Calculated Weights for Carbon Tetrachloride

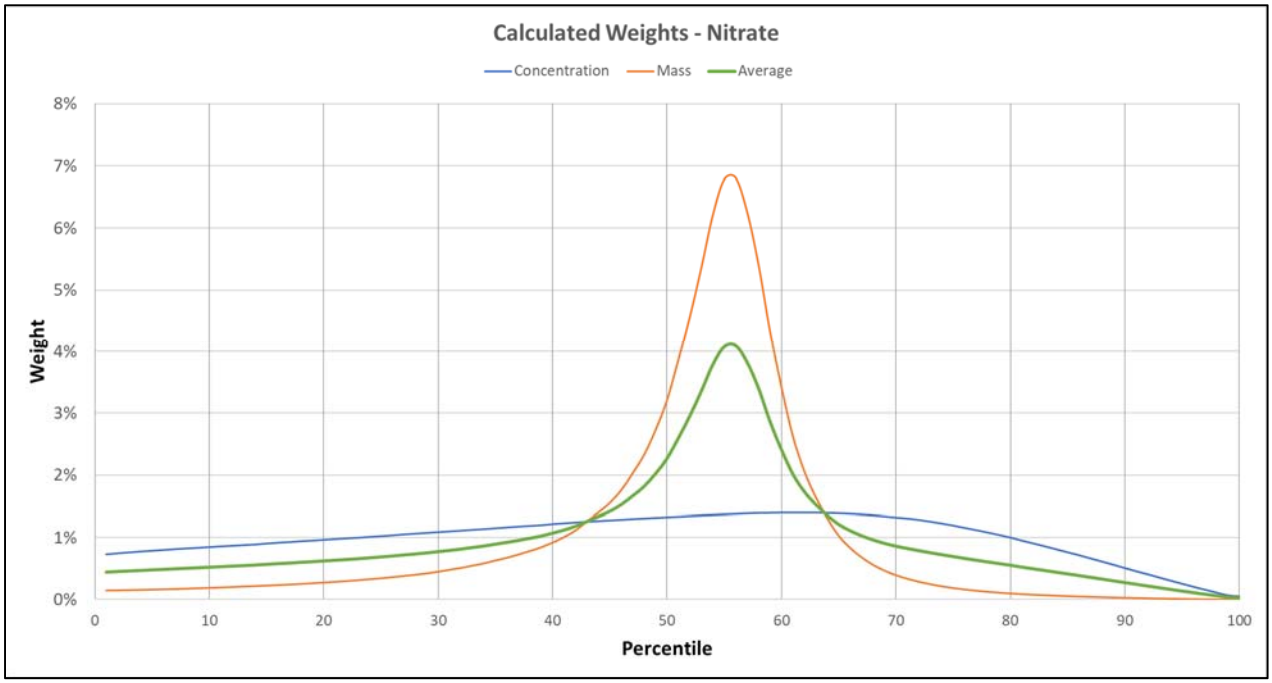


Figure 3-4. Calculated Weights for Nitrate

4 Assumptions and Inputs

This chapter outlines the assumptions and the inputs for the calculations in this ECF.

4.1 Assumptions

4.1.1 Water-Level Mapping and Interpolated Hydraulic Containment

Water-level contour maps are constructed using a technique that incorporates the effects of drawdown and mounding due to groundwater extraction and reinjection, respectively (SGW-42305). The resulting contour maps respect the values of water levels measured at each well and provide a plausible interpretation of groundwater levels and hydraulic gradients between measured locations. However, the accuracy of the contours is influenced by the following, as well as other factors:

- Degree of adherence to, or violation of, assumptions that underlie the mapping method (as outlined in SGW-42305):
  - The aquifer is homogeneous, isotropic, and of infinite areal extent.
  - The aquifer is confined so the transmissivity is uniform and unchanging. If the aquifer is unconfined, drawdowns should be a reasonably small fraction of the aquifer saturated thickness.
  - The pumping well penetrates and receives water from the entire saturated thickness of the aquifer (i.e., the well is not partially penetrating).
  - The drawdown and/or mounding has/have reached a (quasi-state) steady-state condition. If this is not the case, the rate of change in hydraulic gradients should approach zero.
- Accuracy of the measured (or recorded) water levels
- Number, distribution, and location of monitoring wells
- Relationship between the vertical open intervals of the monitoring wells and those of the extraction and injection wells
- Presence, continuity, and hydraulic properties of the Ringold lower mud (RLM) unit

These potential sources of error mean that the interpolated maps only approximate actual conditions. The water level and hydraulic containment maps are considered reasonable approximations that provide value when interpreting the likely directions and rates of groundwater movement and the likely extent of convergent hydraulic gradients that is consistent with the interpretation of hydraulic containment. When interpreting the results of this analysis, it should be noted that an ICFM typically provides a reasonable estimate of remedy-wide capture within the footprint of the measured data. However, distinguishing the capture zones of individual wells within a multi-well remedy can be prone to error because steady-state (or transient) balance of groundwater flows is not guaranteed using the water-level mapping method. In addition, the results presented on the basis of water-level mapping assume that vertical flow is negligible compared to horizontal flow, which is usually a reasonable assumption at some distance from pumping wells in regions of relatively low recharge.

4.1.2 Groundwater Flow Modeling and Simulated Hydraulic Containment

Simulated groundwater elevations are computed using the CPGWM, which is a calibrated and flow-conserved numerical simulator of groundwater in the Central Plateau. Since previous efforts were completed to calibrate the flow model parameters, the flow model outputs (i.e., heads) in general

correspond with measured water levels throughout the area. However, the accuracy of the simulated groundwater elevations (and of inferences from those elevations, such as the extent of hydraulic containment) is influenced by (1) the structural accuracy of the CPGWM (i.e., how well the model represents actual physical conditions), (2) the accuracy of the water-level data used for calibration, (3) the magnitude and distribution of validation/calibration residuals, and (4) other factors. These and other potential sources of error in the simulated groundwater contours, drawdown and mounding, and extent of hydraulic containment result in the simulated depictions only approximating actual conditions. As such, the simulated water level and hydraulic containment maps are interpreted as reasonable approximations that provide value when interpreting the likely directions and rates of groundwater movement, and the likely extents of convergent hydraulic gradients that are consistent with hydraulic containment. Comparison of the groundwater level maps and the extent of hydraulic containment (as simulated using the CPGWM with the depictions obtained using the water-level mapping technique described above) can provide confidence in the results obtained, as follows:

- In areas where the estimated extent of hydraulic containment is similar between the methods, confidence is relatively high that containment is being achieved (if both methods suggest containment is achieved) or is not being achieved (where both methods suggest containment is not achieved).
- In areas where the estimated extent of hydraulic containment differs substantially between the methods, confidence is lower in the interpretation of containment because one method suggests containment is being achieved, while the other suggests it is not achieved.

4.1.3 Transport Modeling and Mass Recovery Calculations

The contaminant transport modeling and projected fate calculations (including simulated recovery of contaminant mass at extraction wells) rely upon the accuracy of the outputs of the groundwater flow simulations, since the groundwater flow model forms the basis of the contaminant transport model and also the accuracy of the parameters and other assumptions and inputs to the contaminant transport model. The assumptions and limitations underlying the groundwater flow model were summarized above. The following are the key assumptions and limitations underlying the contaminant transport model, for purposes of the calculations presented in this ECF. These assumptions and limitations are fundamental to the use of contaminant F&T models at any site:

- The initial conditions (plume shells) are reasonable representations of the extent of contamination in groundwater under current conditions at the beginning of the simulations.
- The instantaneous equilibrium assumption that is used to partition dissolved contamination (plume shell concentrations) to the aquifer material provides a reasonable representation of the distribution of sorbed contamination at the commencement of the simulations.
- The transport parameters (i.e., porosity, dispersion, distribution coefficient, and degradation/decay rates) reasonably describe the processes that each COC undergoes in groundwater and on aquifer materials.

4.2 Input Data

This section summarizes the inputs that are specific to the calculations presented in this ECF. Features and inputs to the CPGWM that do not change for these calculations (e.g., the structure of the CPGWM) are not presented here. The principal inputs to the calculations completed for the CY 2017 annual groundwater P&T report (DOE/RL-2017-68) are as follows:

- Extraction and injection rates at wells
- Groundwater elevations measured at monitoring wells that are used to validate simulated groundwater levels
- Parameters for contaminant transport simulations
- Updated contaminant treatment system (CTS) package for transport simulations
- Updated initial conditions for contaminant transport simulations (i.e., plumes)

These inputs are described in the following subsections.

4.2.1 Extraction and Injection Rates

Historical groundwater extraction and injection flow rates for the 200 West P&T wells are provided in Table B-1 (for CY 2012/2013), Table B-2 (for CY 2014/2015) and Table B-3 (for CY 2016/2017) in Appendix B. Figure 4-1 depicts rates in December 2017 for the 200 West P&T treatment system, where negative rates indicate extraction and positive rates indicate injection.

During the CY 2017 extraction pumping rates for the 200 West P&T varied between 5,171 and 8,559 L/min (1,366 and 2,261 gpm). The system pumped a combined total average of 7,384 L/min (1,951 gpm).

To simulate P&T system downtime for well maintenance, a predictive run was simulated with 2,125 gpm (8,043 L/min) which represents an estimated 85% of 200 West P&T system full capacity of 2,500 gpm. Predicted groundwater extraction and injection flow rates are shown in Table 4-1.

Table 4-1. Predicted Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies for Out-Year Simulations

Model Stress Period		73	74	75	76	77	78	79
Well ID	**Well Name**	**1/1/2018-9/30/2018**	**10/1/2018-9/30/2019**	**10/01/2019-09/30/2024**	**10/01/2024-09/30/2029**	**10/01/2029-09/30/2034**	**10/01/2034-09/30/2037**	**10/01/2037-9/30/2137**
YE-01	299-W15-225	-85	-111	-111	-111	-111	-111	0
YE-02	299-W14-20	-85	-115	-115	-115	-115	-115	0
YE-03	299-W14-73	-102	-111	-111	-111	-111	-111	0
YE-04	299-W14-74	-94	-111	-111	-111	-111	-111	0
YE-05	299-W12-2	-85	-94	-94	-94	-94	-94	0
YE-06	299-W11-50	-85	-94	-94	-94	-94	-94	0
YE-07	299-W11-90	-94	-85	-85	-85	-85	-85	0
YE-08	299-W11-96	-94	-102	-102	-102	-102	-102	0
YE-09	299-W17-3	-85	-102	-102	-102	-102	-102	0
YE-10	299-W17-2	-77	-85	-85	-85	-85	-85	0
YE-11	299-W19-111	0	0	0	0	0	0	0
YE-12	299-W11-49	-111	-111	-111	-111	-111	-111	0
YE-13	299-W11-97	-94	-94	-94	-94	-94	-94	0
YE-14	299-W6-15	-77	-77	-77	-77	-77	-77	0
YE-15	299-W14-21	-77	-94	-94	-94	-94	-94	0
YE-16	299-W11-92	-85	-85	-85	-85	-85	-85	0
YE-17	299-W5-1	-81	-102	-102	-102	-102	-102	0
YE-18	299-W12-3	-77	-77	-77	-77	-77	-77	0
YE-19	299-W12-4	-111	-111	-111	-111	-111	-111	0

Table 4-1. Predicted Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies for Out-Year Simulations

Model Stress Period		73	74	75	76	77	78	79
Well ID	**Well Name**	**1/1/2018-9/30/2018**	**10/1/2018-9/30/2019**	**10/01/2019-09/30/2024**	**10/01/2024-09/30/2029**	**10/01/2029-09/30/2034**	**10/01/2034-09/30/2037**	**10/01/2037-9/30/2137**
YE-20	299-W14-22	-85	-94	-94	-94	-94	-94	0
YE-21	299-W22-90	-21	-21	-21	-21	-21	-21	0
YE-22	299-W22-91	-30	-30	-30	-30	-30	-30	0
YE-23	299-W22-92	-30	-30	-30	-30	-30	-30	0
YE-24	299-W19-125	-43	-43	-43	-43	-43	-43	0
YE-25	299-W19-113	-43	-43	-43	-43	-43	-43	0
YE-26	299-W19-114	-43	-43	-43	-43	-43	-43	0
YE-27	299-E33-268	0	0	0	0	0	0	0
YE-31	299-E33-360	-68	-68	-68	-68	-68	-68	0
YJ-01	299-W6-13	43	43	43	43	43	43	0
YJ-02	299-W6-14	145	123	123	123	123	123	0
YJ-03	299-W10-36	68	68	68	68	68	68	0
YJ-04	299-W10-35	102	102	102	102	102	102	0
YJ-05	299-W15-226	128	119	119	119	119	119	0
YJ-06	299-W15-227	128	119	119	119	119	119	0
YJ-07	299-W15-228	128	119	119	119	119	119	0
YJ-08	299-W18-41	111	111	111	111	111	111	0
YJ-09	699-49-69	21	21	21	21	21	21	0
YJ-10	699-45-67B	4	4	4	4	4	4	0

Table 4-1. Predicted Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies for Out-Year Simulations

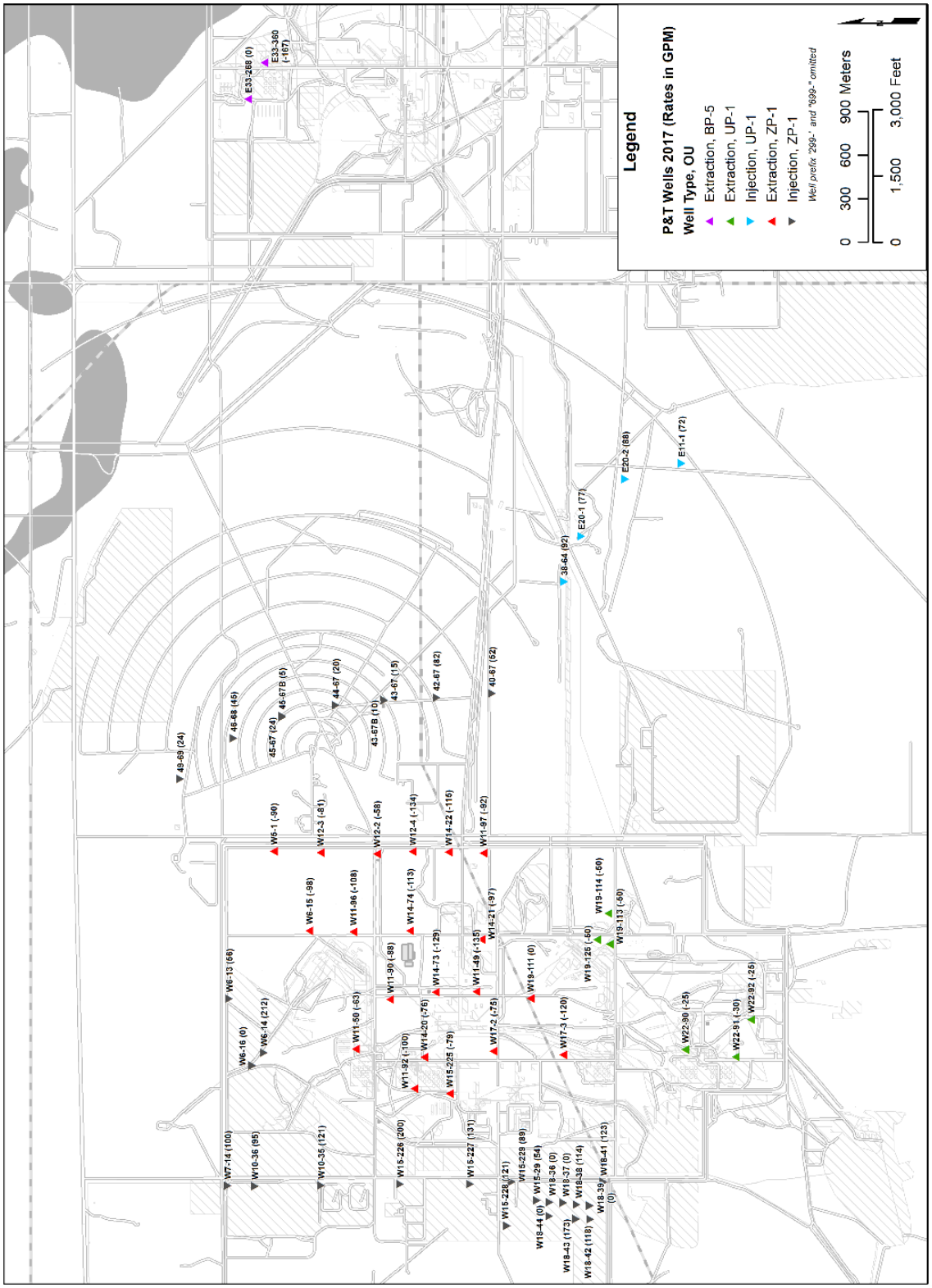
Model Stress Period		73	74	75	76	77	78	79
Well ID	**Well Name**	**1/1/2018-9/30/2018**	**10/1/2018-9/30/2019**	**10/01/2019-09/30/2024**	**10/01/2024-09/30/2029**	**10/01/2029-09/30/2034**	**10/01/2034-09/30/2037**	**10/01/2037-9/30/2137**
YJ-11	699-45-67	17	26	26	26	26	26	0
YJ-12	699-44-67	17	17	17	17	17	17	0
YJ-13	699-43-67	21	21	21	21	21	21	0
YJ-14	699-42-67	60	43	43	43	43	43	0
YJ-15	699-40-67	34	51	51	51	51	51	0
YJ-16	699-38-64	51	43	43	43	43	43	0
YJ-17	699-43-67B	30	34	34	34	34	34	0
YJ-18	299-W15-29	47	51	51	51	51	51	0
YJ-19	299-W18-36	55	60	60	60	60	60	0
YJ-20	299-W18-37	0	0	0	0	0	0	0
YJ-21	299-W18-38	85	85	85	85	85	85	0
YJ-22	299-W18-39	26	26	26	26	26	26	0
YJ-23	699-46-68	34	34	34	34	34	34	0
YJ-24	299-W15-229	85	85	85	85	85	85	0
YJ-25	299-W7-14	128	119	119	119	119	119	0
YJ-26	299-E20-1	51	43	43	43	43	43	0
YJ-27	299-E20-2	51	43	43	43	43	43	0
YJ-28	299-E11-1	51	43	43	43	43	43	0
YJ-29	299-W6-16	0	119	119	119	119	119	0

Table 4-1. Predicted Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies for Out-Year Simulations

Model Stress Period		73	74	75	76	77	78	79
Well ID	**Well Name**	**1/1/2018-9/30/2018**	**10/1/2018-9/30/2019**	**10/01/2019-09/30/2024**	**10/01/2024-09/30/2029**	**10/01/2029-09/30/2034**	**10/01/2034-09/30/2037**	**10/01/2037-9/30/2137**
YJ-30	299-W18-44	0	119	119	119	119	119	0
YJ-31	299-W18-43	119	119	119	119	119	119	0
YJ-32	299-W18-42	119	119	119	119	119	119	0

Note: Extraction and injection rates are shown in gallons per minute (gpm). Stress period of model commences in 2012.

ID = identification



Note: Negative rates indicate extraction; positive rates indicate injection.

Figure 4-1. Pumping Rates in December 2017 for the 200 West P&T

4.2.2 Groundwater Elevations Measured at Monitoring Wells Used to Validate Simulated Groundwater Levels

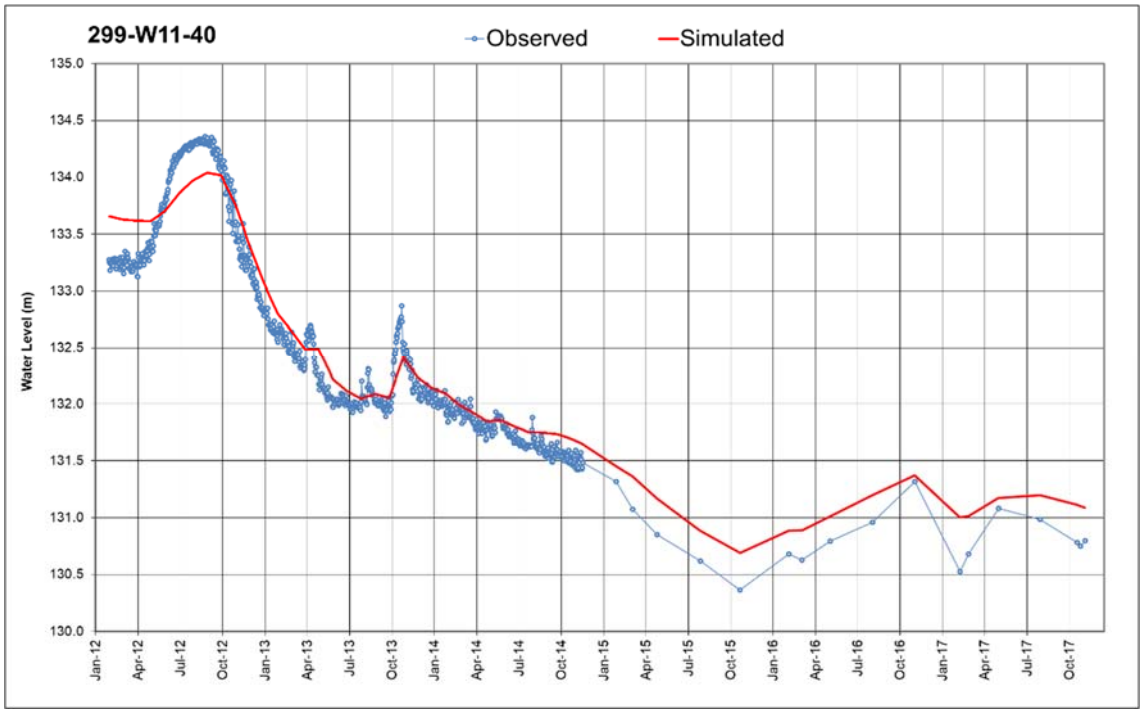
Groundwater level data obtained during CY 2017 included water levels obtained during or concurrent with synoptic water-level surveys, and water levels were obtained at various locations on a continuous basis from wells equipped with transducers and data loggers. The latter, collectively referred to as part of the Hanford Site automated water-level network (AWLN), comprises a smaller number of wells than is measured during synoptic surveys. The synoptic water-level event for the 200-ZP-1 OU occurred during March 2017 when water levels were obtained from over 200 monitoring wells. Throughout 2017, water levels were recorded using data loggers and transducers installed in approximately 20 monitoring wells throughout the 200-ZP-1 OU. In addition to the monitoring well data, water levels were recorded with data loggers in the extraction and injection wells that were actively operating during 2017; the number of wells monitored varied throughout the year. Figure 4-2 presents selected water-level hydrographs throughout the area illustrating the correspondence between simulated and measured groundwater elevations. When reviewing and interpreting water-level data, flow rates recorded at each extraction and injection well are also reviewed to provide an understanding of the probable causes for groundwater level changes.

Calibration targets for the CPGWM were updated with available continuous and manually measured water-level data through December 2017. Daily average water-level values were calculated and incorporated into the validation/calibration data set. Figure 4-2 provides comparisons of simulated and measured water levels at selected wells, including the extended simulation time frame in CY 2017. Since the flow parameters of the CPGWM were not recalibrated, this ECF does not present a rigorous evaluation of validation/calibration residuals; however, summary statistics for the validation/calibration residuals are provided in Table 4-2. The types of statistics listed are analogous to those presented in the previous CP Model Version 8.4.5 (CP-47631, Rev. 4), as updated through December 2017 using water-level data obtained both manually and from the AWLN. The values for these statistics are similar to those presented for the calibrated model in CP-47631, which suggests that over the extended validation period (from 2009 through 2017), the model performs as well (in terms of statistical correspondence with measured water levels) as during the calibration period. This is also supported by the correspondence between simulated and mapped water levels; between simulated and mapped drawdowns; and between simulated and mapped estimates of the extent of hydraulic containment, as presented in this ECF.

Table 4-2. Residual Summary Statistics from CP Model Version 8.4.5 Validation, as Updated through December 2017

Correlation	0.9843
Average Residual	0.42
Maximum Residual	5.22
Minimum Residual	-6.79
Sum of Squares for Errors	44,620
Mean Square Error	0.89
Root Mean Square Error	0.9443
Observation Range	20.990
Root Mean Square Error/Observation Range	0.0450
Coefficient of Determination (R^2)	0.97

CP = Central Plateau



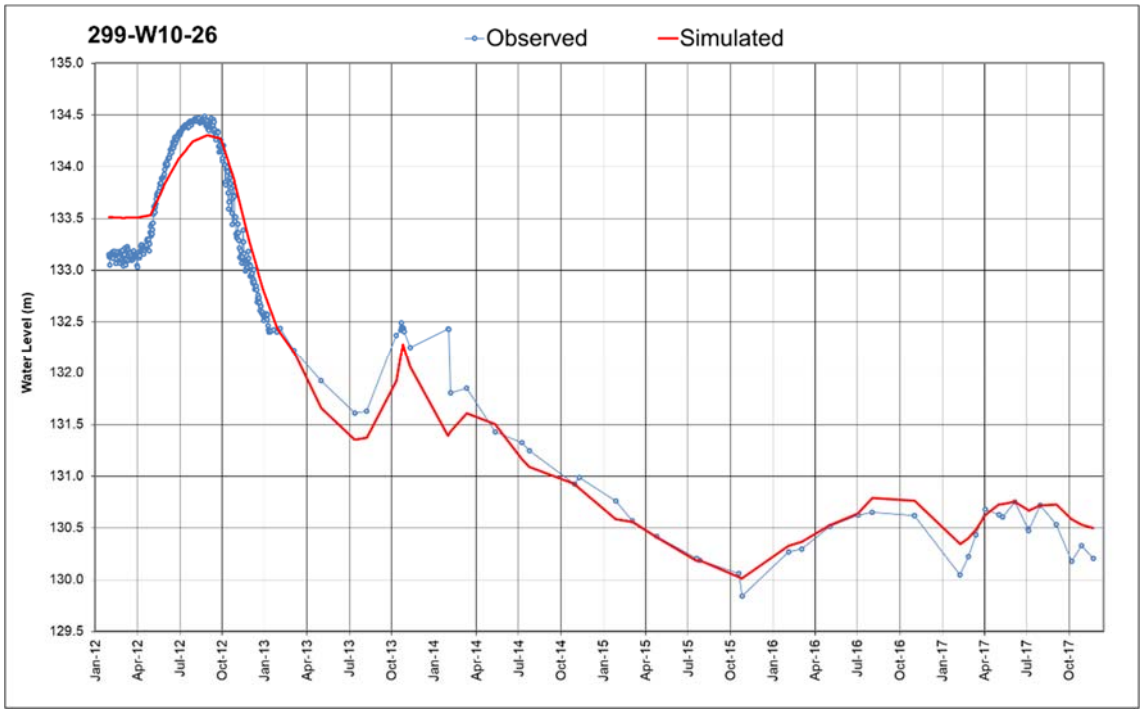
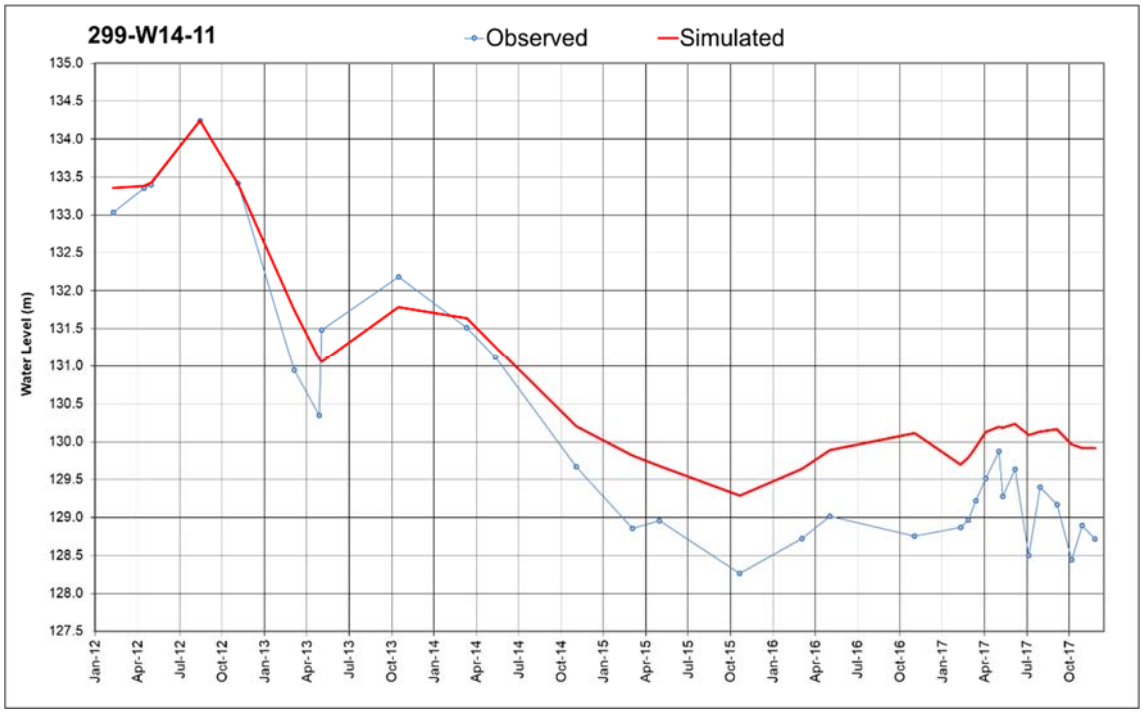


Figure 4-2. Selected Water-Level Hydrographs throughout the Study Area Illustrating the Correspondence between Simulated and Measured Groundwater Elevations (Page 1 of 3)



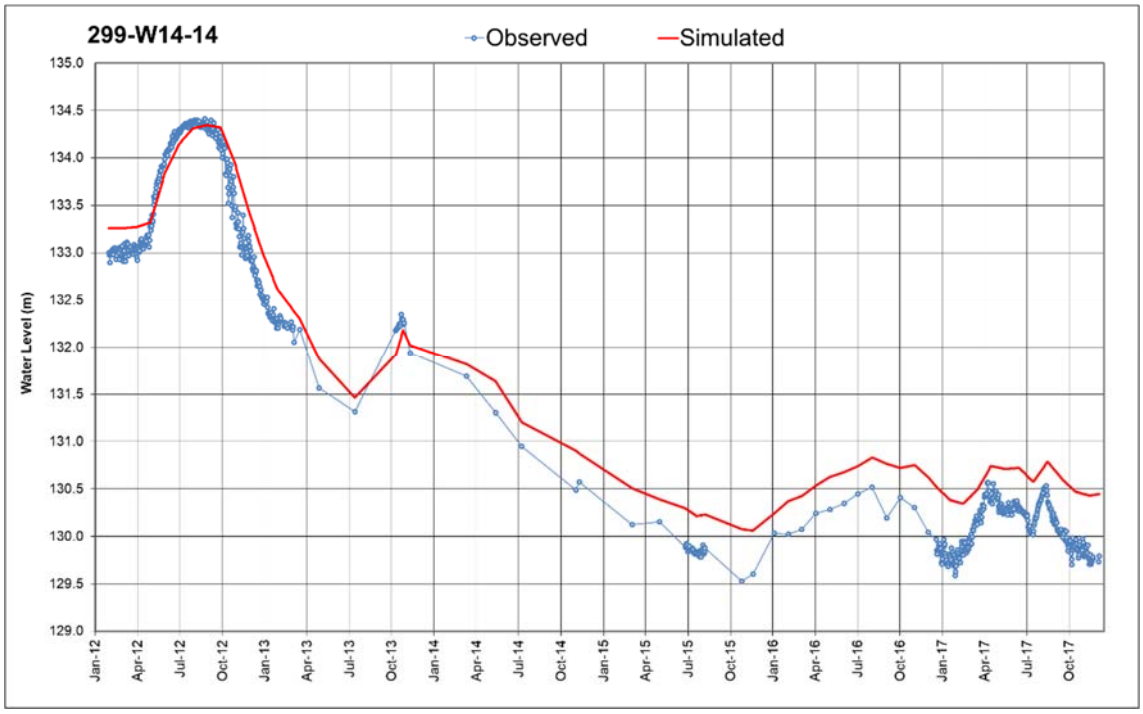
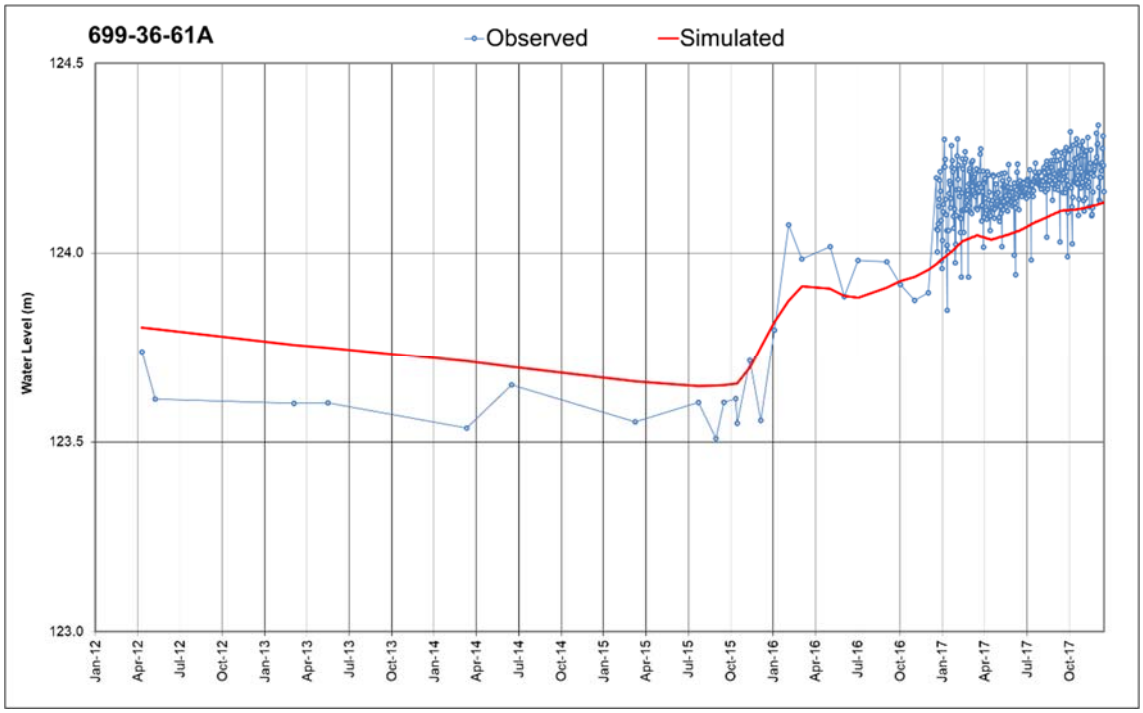


Figure 4-2. Selected Water-Level Hydrographs throughout the Study Area Illustrating the Correspondence between Simulated and Measured Groundwater Elevations (Page 2 of 3)



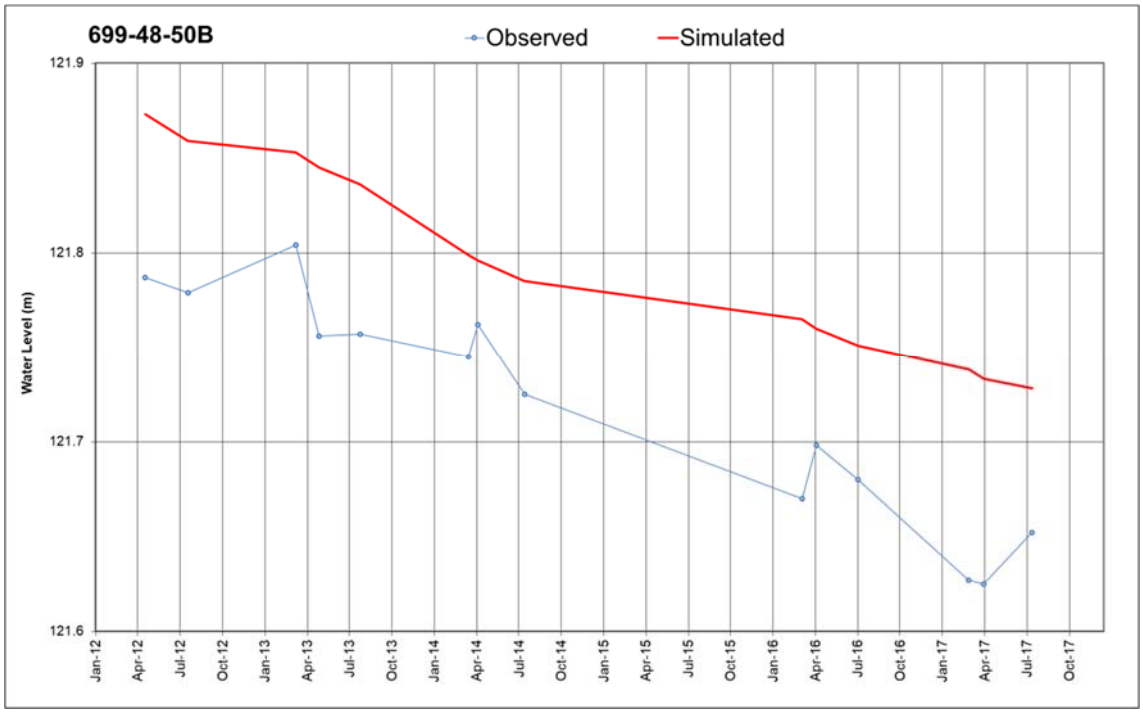


Figure 4-2. Selected Water-Level Hydrographs throughout the Study Area Illustrating the Correspondence between Simulated and Measured Groundwater Elevations (Page 3 of 3)

4.2.3 Contaminant Transport Properties

Contaminant transport parameters used in the calculations presented in this ECF are unchanged from those used in calculations for the CY 2012 annual P&T report, as documented in ECF-200ZP1-13-0006. However, since these transport parameters are fundamental to the calculations, these parameters are listed in Table 4-3 for completeness.

4.2.4 Updated Initial Conditions for Contaminant Transport Simulations (Plumes)

Three dimensional depictions of the extent of contamination used for transport initial conditions presented in this ECF were prepared using data obtained through CY 2015 as described in ECF-200W-16-0092, Rev 1. Two-dimensional depictions of the maximum extent of the previously prepared CY 2012 initial conditions and the maximum extent of the recently updated CY 2015 initial conditions (ECF-200W-16-0092) are shown in Figures 4-3 through 4-10. Two-dimensional depictions of the maximum extent were calculated as the maximum concentration from all model layers at each model row-column location (i.e., the highest concentration, regardless of model layer) and then bilinearly interpolated from the model grid to the finer grid size for visualization and other calculations.

The simulation results obtained using the CY 2015 three-dimensional depictions for each COC are presented later in this ECF for comparison with measured quantities.

In addition to using the quantile kriging technique described in ECF-200W-16-0092, during CY2017 the SGSIM technique was used to assess the uncertainty in the extent and mass of carbon tetrachloride and nitrate. The calculations resulting in these updated 3D estimates are detailed in ECF-200W-18-0028 and in section 3.4 in this ECF. Two-dimensional depictions of the maximum extent of the SGSIM “weighted average” CY 2015 plume depictions are shown in Figures 4-11 and 4-12.

Table 4-3. Contaminant Transport Properties Assumed for F&T Analyses Using the CP Model

Constituent-Specific Parameter Values for the Central Plateau Model for the CY-2017 P&T Report						
COC	**K_d (mL/g)**	**Half-Life (yr)**	**Half-Life (day)**	**1st Oder Decay Rate (one/day)**	**Reference for K_d**	**Reference for Degradation Rate**
Nitrate	0	None assumed	None assumed	None assumed	PNNL-18564, Table 6.9, sandy-gravel sediment type	No Hanford Site relevant reference
Iodine-129	0.10	15,700,000	5,730,000,000	1.21×10^{-10}	—	—
Technetium-99	0	211,000	77,100,000	8.99×10^{-9}	—	—
Tritium	0	12.3	4,500.0	0.000154	—	—
Carbon Tetrachloride	0.011	100; 630[a]	36,500; 230,107	1.8977×10^{-5}; 3.012×10^{-6}	Compilation for Feasibility Study (DOE/RL-2007-28) and modeling undertake for Rev 0. of the RD/RAWP.	PNNL-22062
Trichloroethene	0.0250	None assumed	None assumed	None assumed	Empirical calculation[b]	No Hanford Site relevant reference
Chromium	0	None assumed	None assumed	None assumed	Same as for hexavalent chromium	—
Uranium	0.4000	4,470,000,000	1,630,000,000,000	4.25×10^{-13}	PNNL-18564, Table 6.9, sandy-gravel sediment type	—

Table 4-3. Contaminant Transport Properties Assumed for F&T Analyses Using the CP Model

Aquifer Dependent Transport Parameter Values for the Central Plateau Model for the CY-2017 P&T Report		
Property	**Value**	**Comments**
Effective Porosity	0.15	Approximate central value (Table D-2 of DOE/RL-2007-28)
Longitudinal Dispersivity	3.5 m	Introduced for stability of the transport calculations using recommendation from MT3DMS manual
Transverse Dispersivity	0.7 m	20 percent of longitudinal (consistent with the ratio specified in DOE/RL-2008-56)
Vertical Dispersivity	0.0 m	DOE/RL-2008-56
Molecular Diffusion Constant	0.0 m^2/day	Negligible term
Bulk Density, Coarse Hanford	1.93 g/cm^3	PNNL-18564, Table 6.2 (sitewide average values for this formation)
Bulk Density, Fine Hanford	1.93 g/cm^3	PNNL-18564, Table 6.2 (sitewide average values for this formation)
Bulk Density, Cold Creek	1.93 g/cm^3	PNNL-18564, Table 6.2 (sitewide average values for this formation)
Bulk Density, Ringold Unit E	1.90 g/cm^3	PNNL-18564, Table 6.2 (sitewide average values for this formation)
Bulk Density, Ringold Mud Unit	1.90 g/cm^3	PNNL-18564, Table 6.2 (sitewide average values for this formation)
Bulk Density, Ringold Unit A	1.90 g/cm^3	PNNL-18564, Table 6.2 (sitewide average values for this formation)
Particle Traking Parameters		
Effective Porosity	0.15	Approximate central value (Table D-2 of DOE/RL-2007-28)
Hydraulic Conductivity	5	Approximate Value for Ringold E

Table 4-3. Contaminant Transport Properties Assumed for F&T Analyses Using the CP Model

References: DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit.*

DOE/RL-2008-56, *200 West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses.*

PNNL-18564, *Selection and Traceability of Parameters to Support Hanford-Specific RESRAD Analyses: Fiscal Year 2008 Status Report.*

PNNL-22062, *Abiotic Degradation Rates for Carbon Tetrachloride and Chloroform: Final Report.*

a. The values used for carbon tetrachloride have been updated from the 2012 transport parameters half-life values of 41.3 and 100 years which were based upon studies completed by PNNL during the development of the Remedial Investigation and Feasibility Study (DOE/RL-2007-28 Rev. 0) in particular and analyses completed for Rev. 0 of the RD/RAWP. Subsequent analyses as reported in PNNL-22062 concluded that rates of hydrolysis at groundwater temperatures are significantly slower than predicted by extrapolations from high-temperature studies; and, that the half-life may also be strongly pH and temperature dependent. The PNNL report estimated a half-life of 630 years for hydrolysis for carbon tetrachloride for typical Hanford groundwater conditions (temperature of 16°C and pH of 7.75).

b. The empirical calculation is based on PNNL-13560, *Assessment of Carbon Tetrachloride Groundwater Transport in Support of the Hanford Carbon Tetrachloride Innovative Technology Demonstration Program* (Equations 1 and 2, p. C.16), assuming foc = 0.00027, solubility of PCE at 150 mg/L, and solubility of trichloroethene at 1,100 mg/L.

COC = contaminant of concern

CP = Central Plateau

CY = calendar year

K_d = distribution coefficient

MTD3MS = Modular 3D Transport Multi Species

P&T = pump and treat

RD/RAWP = Remedial Design/Remedial Action Work Plan

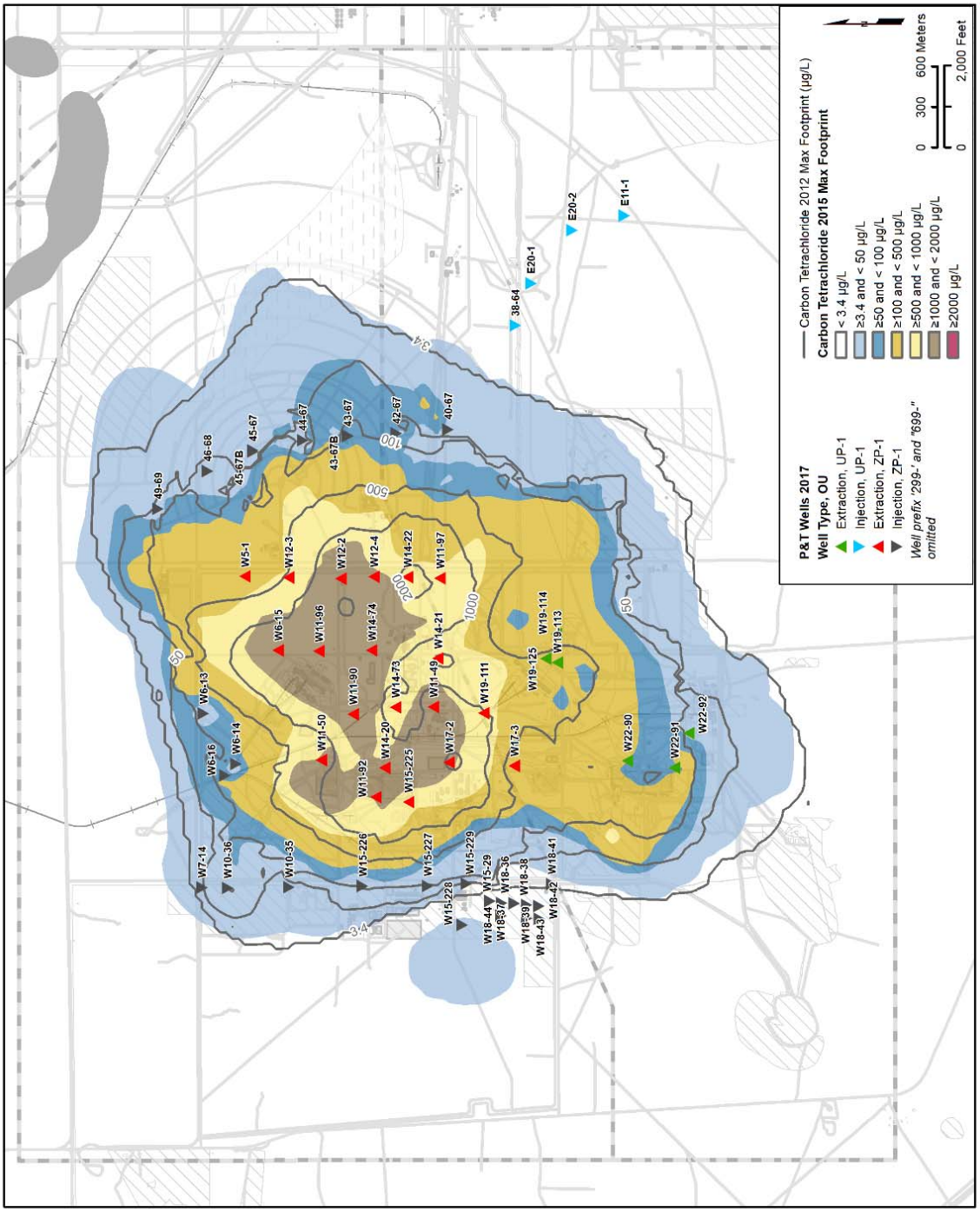


Figure 4-3. Maximum Footprint – CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Carbon Tetrachloride - Quantile Method

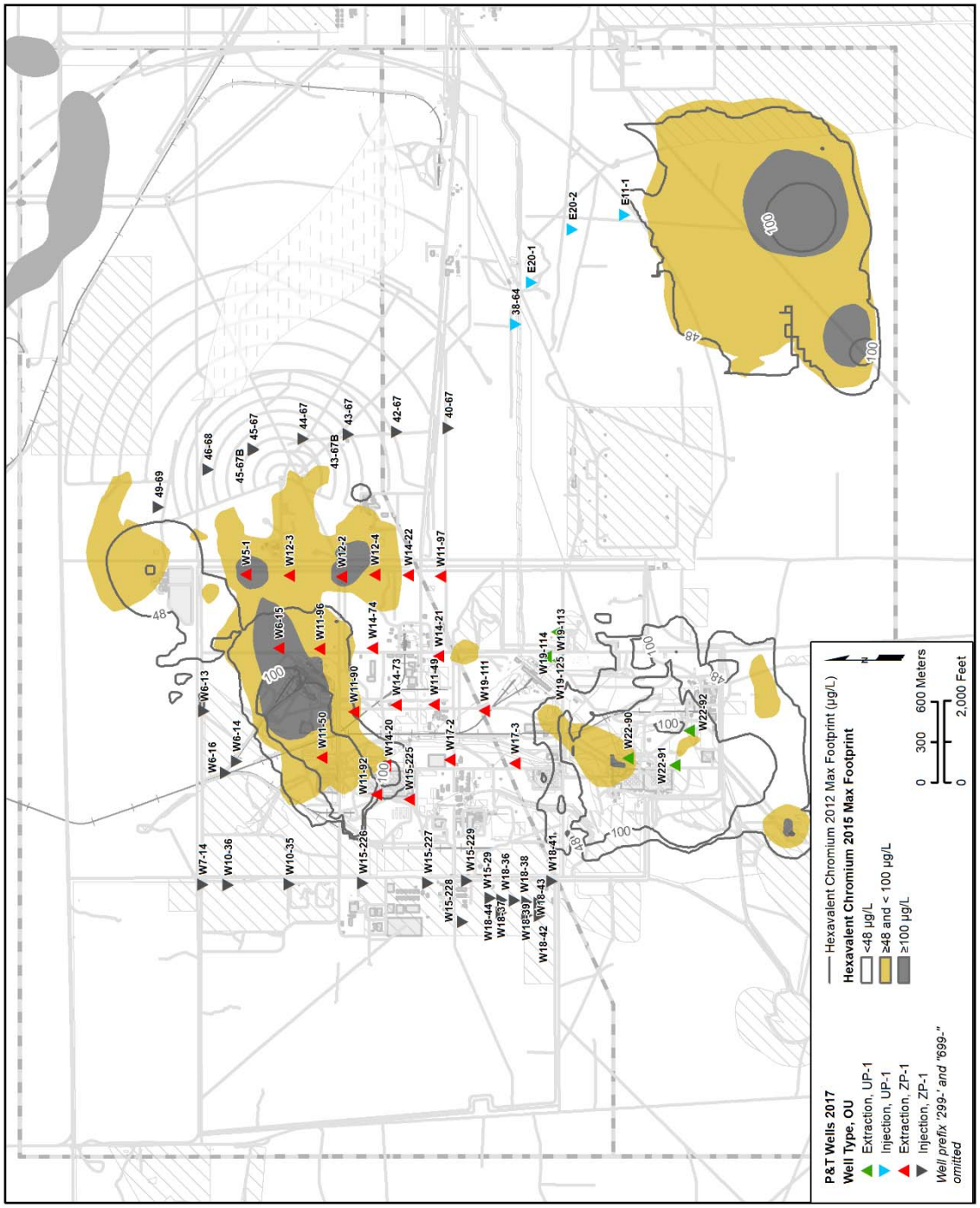


Figure 4-4. CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Hexavalent Chromium

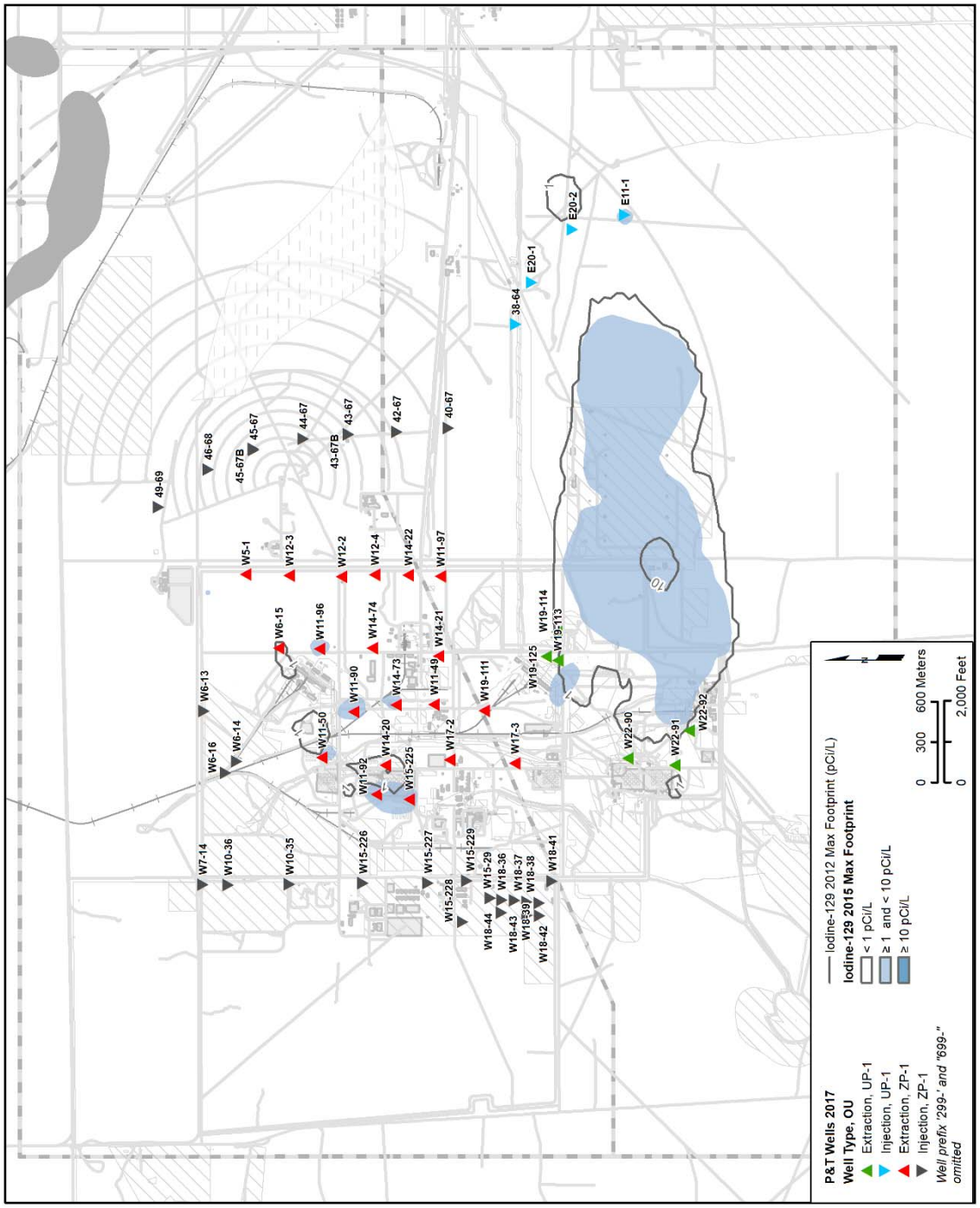


Figure 4-5. CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Iodine-129

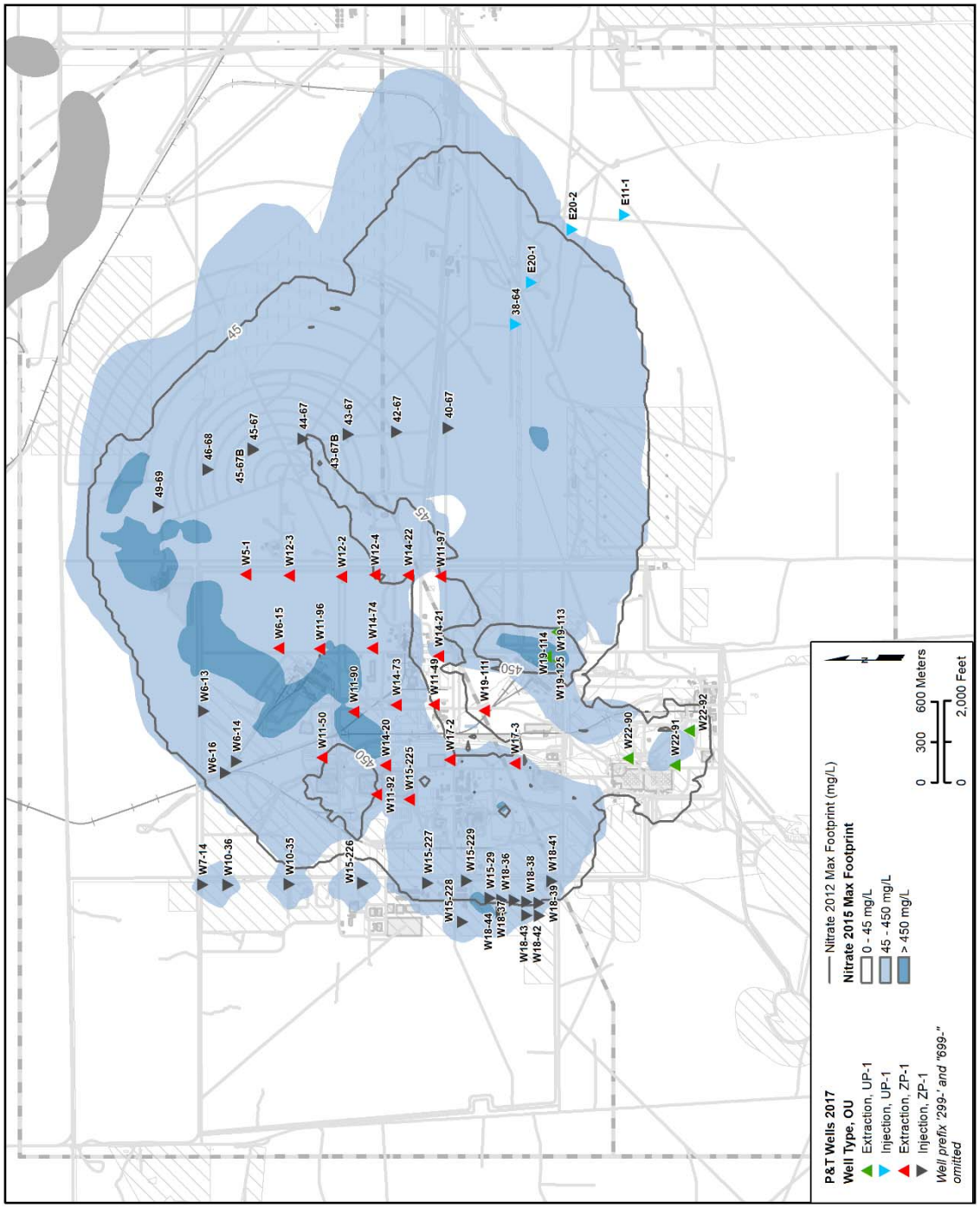


Figure 4-6. CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Nitrate

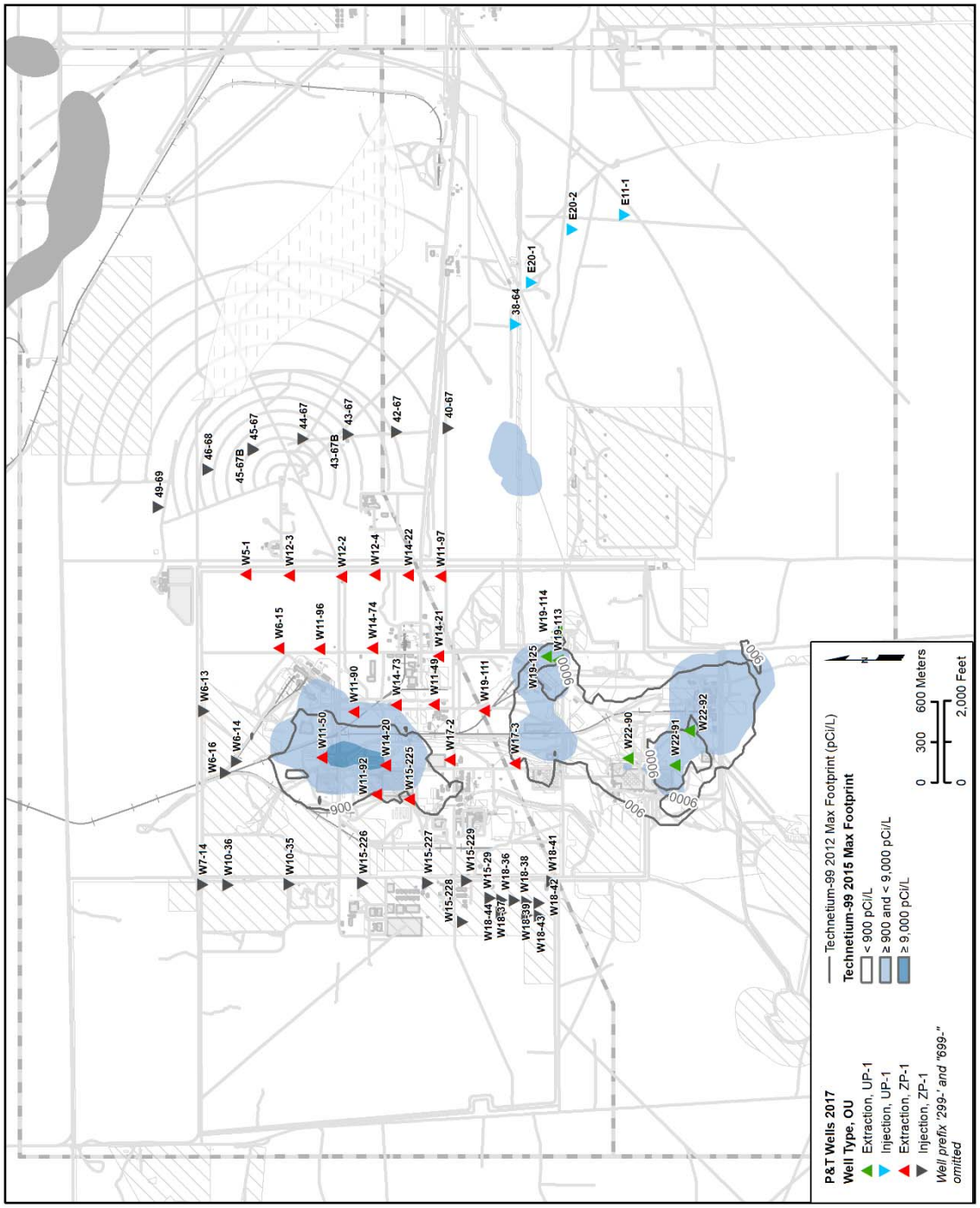


Figure 4-7. Maximum Footprint – CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Technetium-99

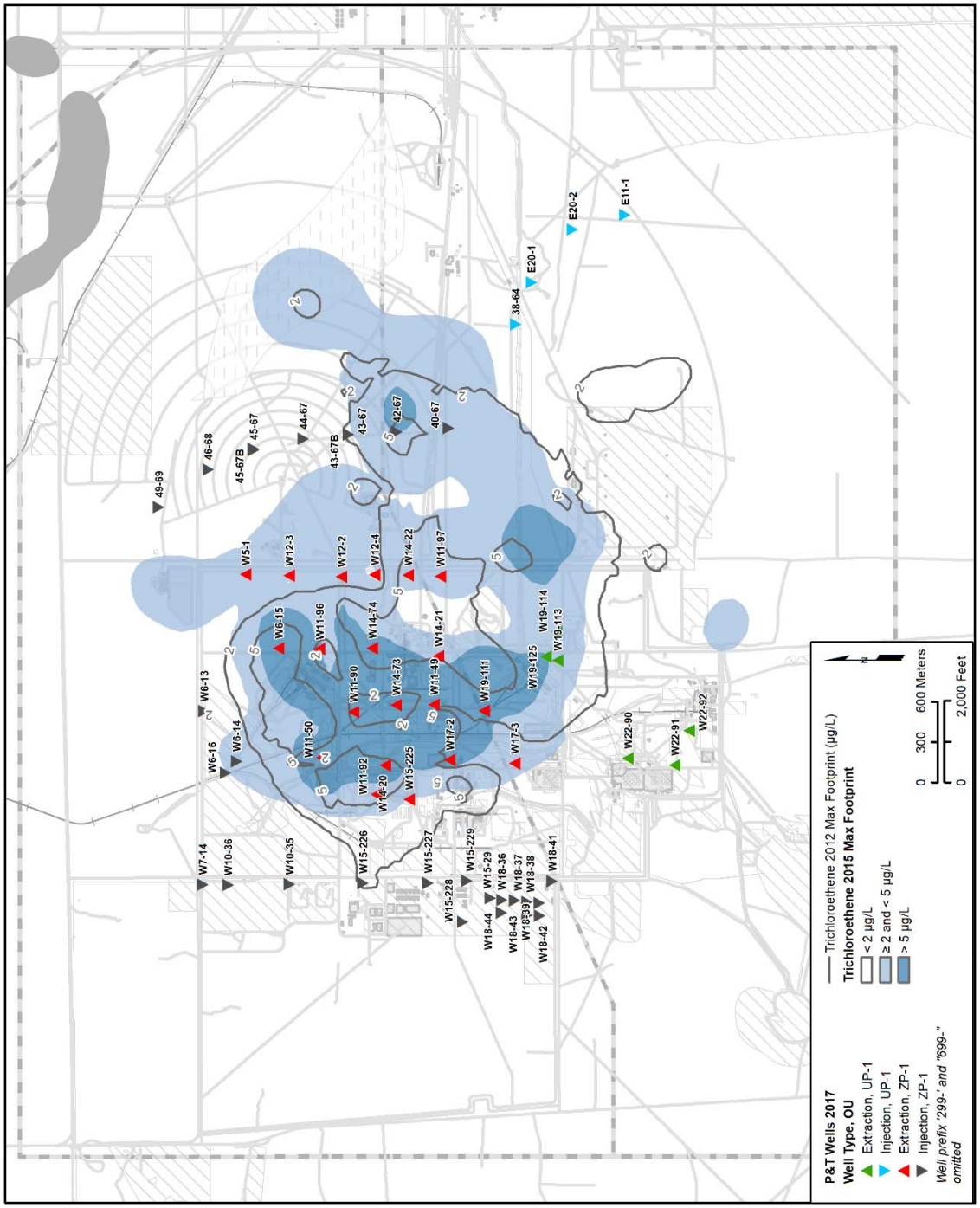


Figure 4-8. Maximum Footprint – CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Trichloroethene

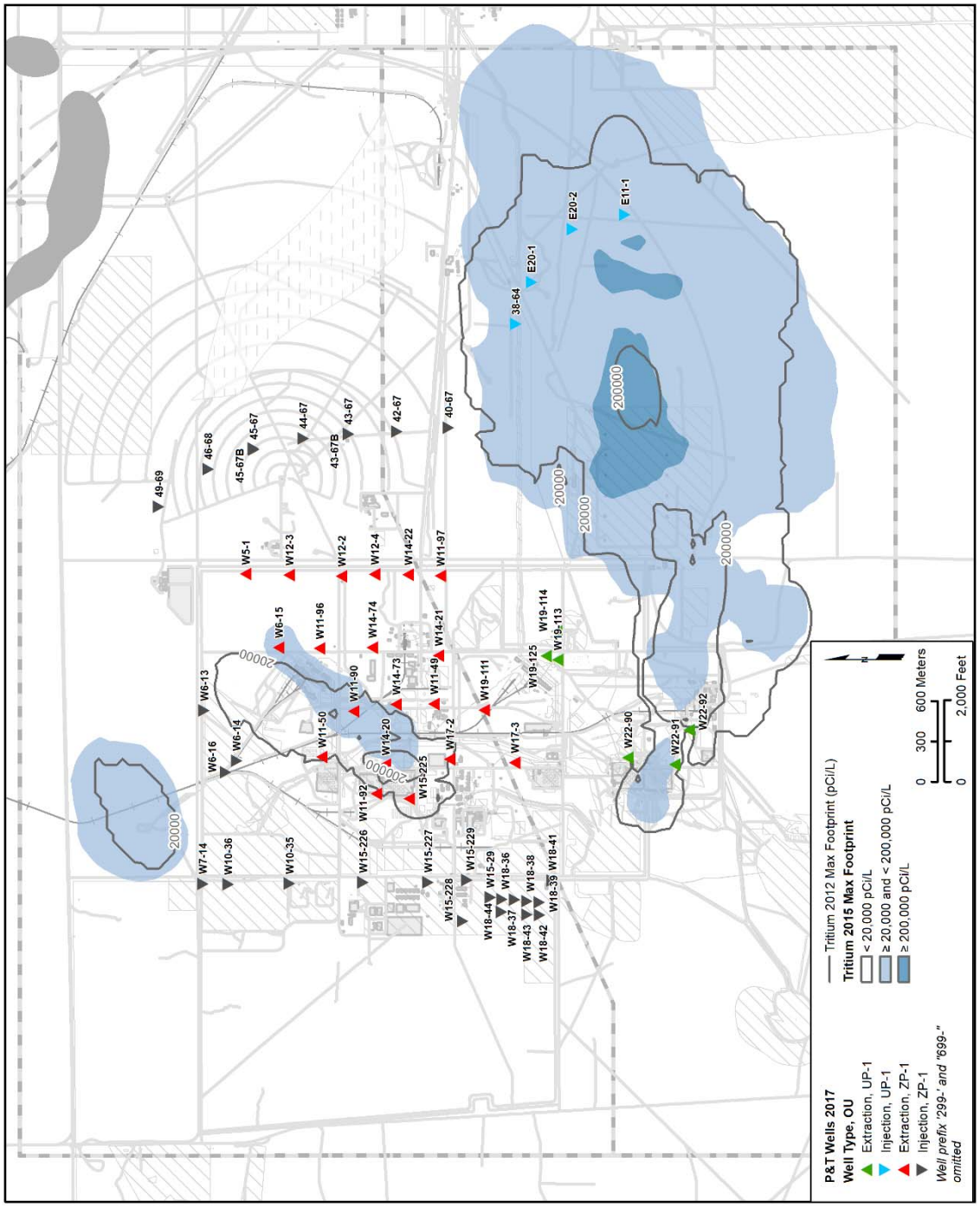


Figure 4-9. Maximum Footprint – CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Tritium

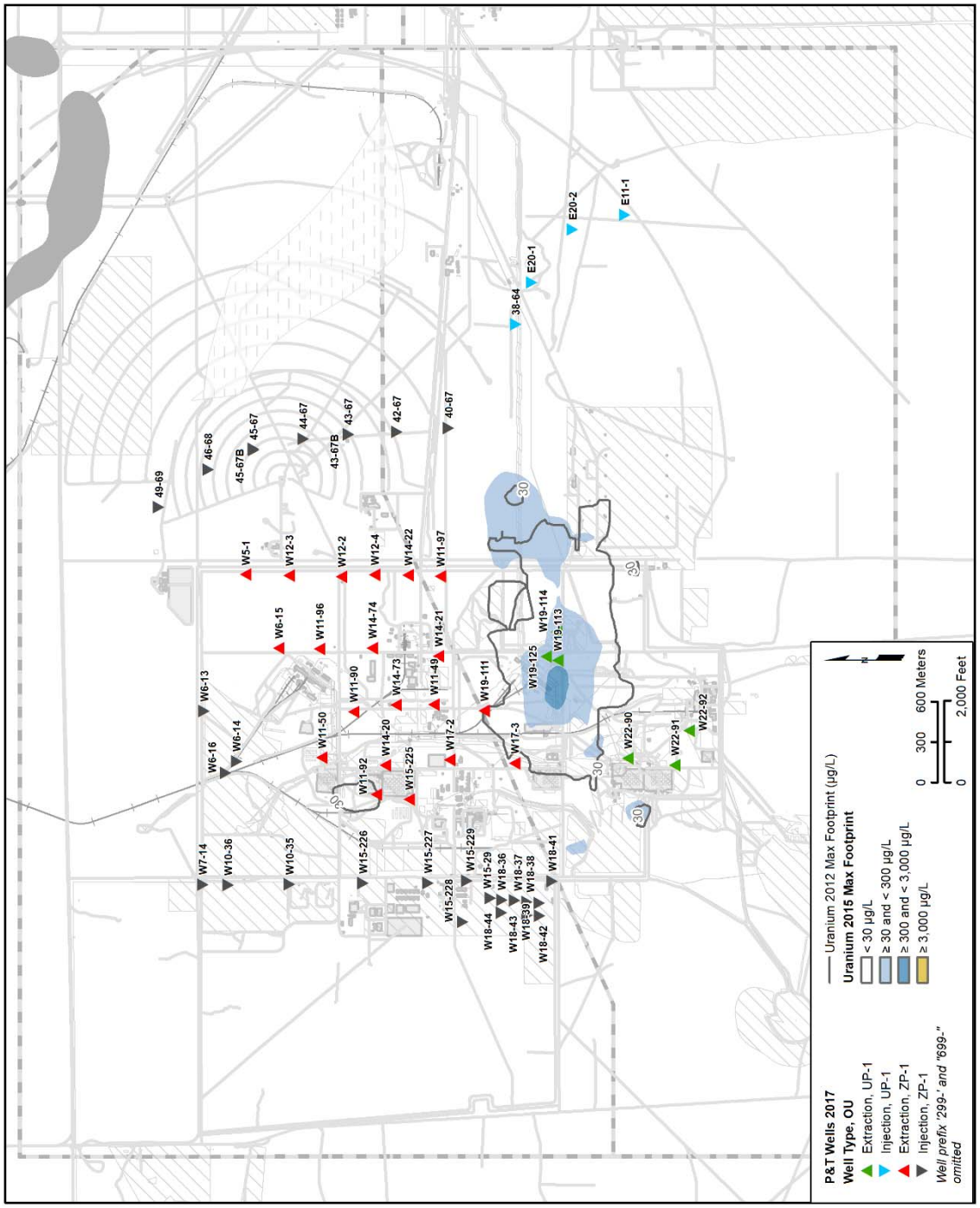


Figure 4-10. Maximum Footprint – CY 2015 Initial Conditions Compared to CY 2012 Initial Conditions for Uranium

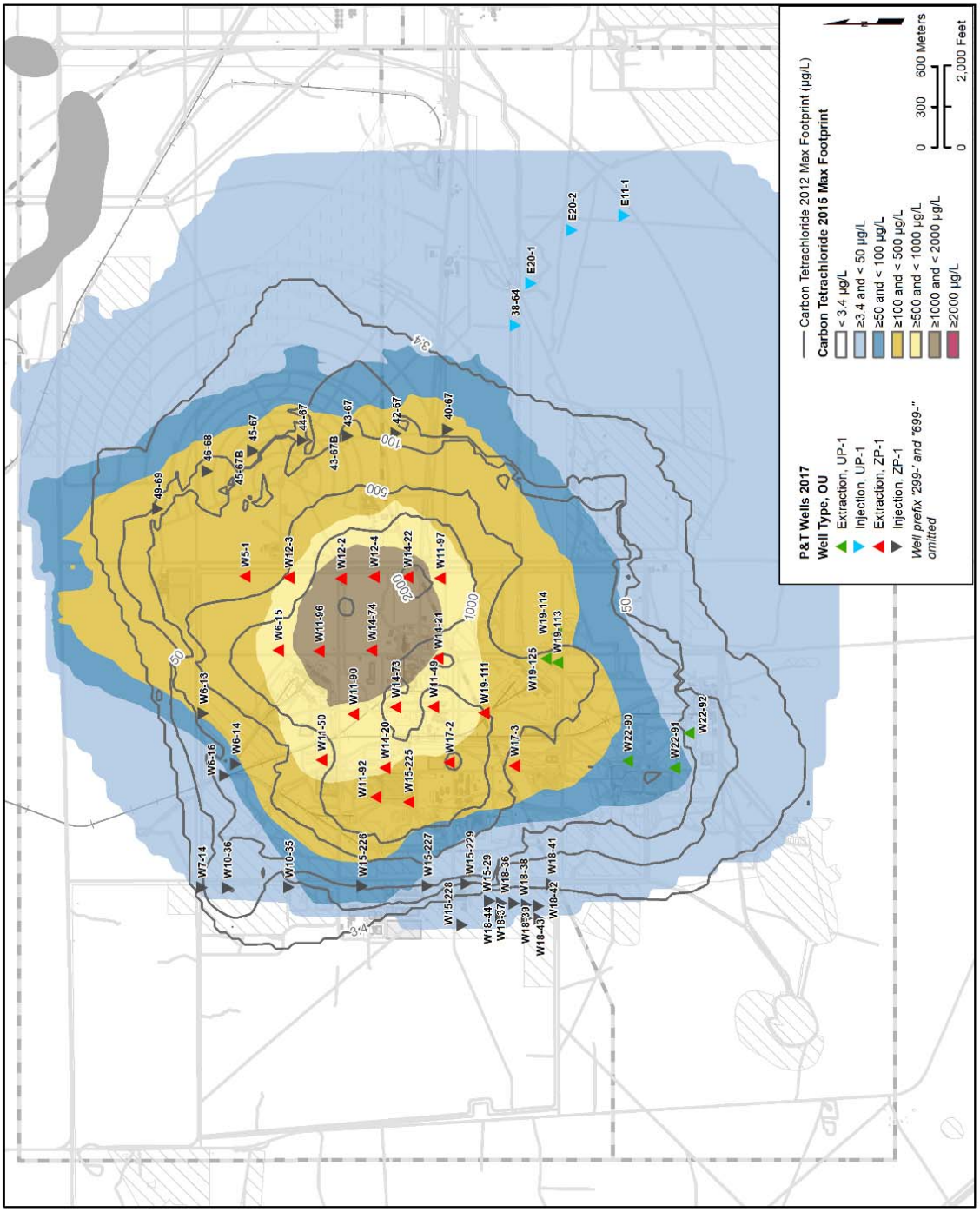


Figure 4-11. Maximum Footprint – CY 2015 Weighted-Average SGSIM Initial Conditions Compared to CY 2012 Initial Conditions for Carbon Tetrachloride

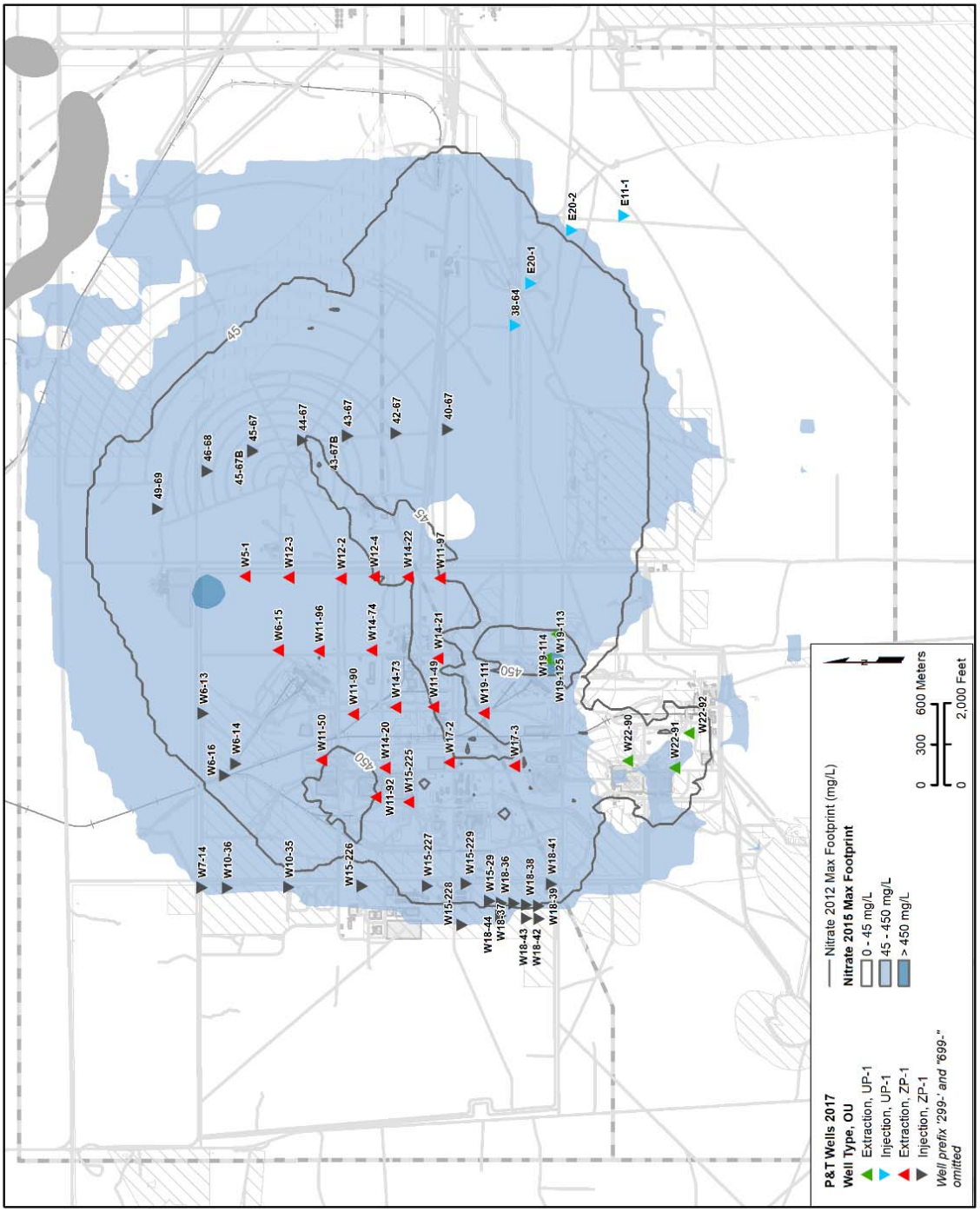


Figure 4-12. Maximum Footprint – CY 2015 Weighted-Average SGSIM Initial Conditions Compared to CY 2012 Initial Conditions for Nitrate

4.2.5 200 West P&T System – Implementation of MT3D Contaminant Treatment System Package

The 200 West P&T system exhibits varying COC-specific efficiencies in removing constituents from the extracted groundwater prior to reinjection. The effect of this varying treatment efficiency is simulated using the previously developed MT3DMS CTS package, which enables flow and transport simulations using the Hanford Site-specific versions of MODFLOW-MT3DMS to represent the removal of COCs from extracted water prior to reinjection. The CTS package specifically simulates the movement and removal of contaminant mass via a treatment system. The CTS package incorporates extraction wells, mixing, treatment, and injection wells as part of an integrated P&T system. Using the CTS package, the removal efficiency can be specified in a variety of ways, although the most suitable method is often deriving the efficiency empirically from treatment plant data. Use of the CTS package is particularly important where some contaminants (e.g., tritium) are essentially recirculated without treatment; where some contaminants (e.g., iodine-129) are greatly affected by mixing within the treatment system; and where some contaminants (e.g., nitrate), despite treatments to below applicable standards, are still reinjected at concentrations that represent a considerable mass.

Figure 4-13 illustrates the removal efficiency calculated on the basis of influent and effluent concentrations measured at the 200 West P&T. Based upon the efficiencies presented in Figure 4-13 and listed in Table 4-4, the CTS option to set the percentage of mass that is typically removed by the treatment system was implemented with the CPGWM simulations.

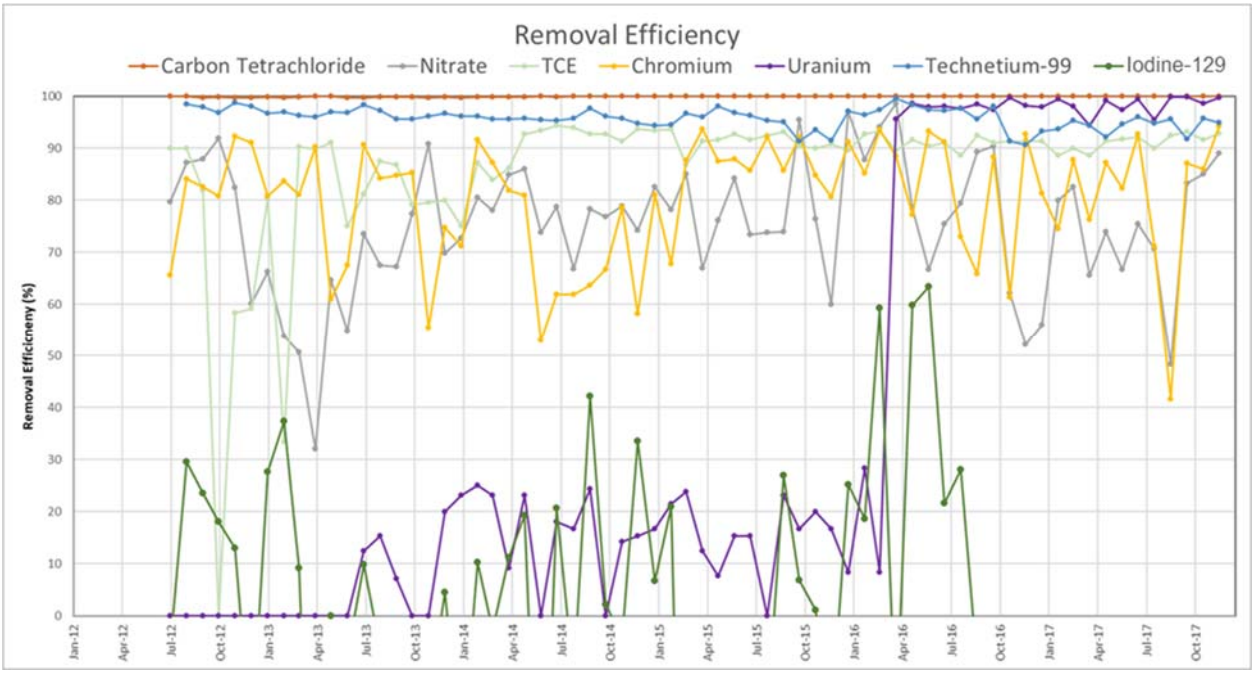


Figure 4-13. COC Removal Efficiency

Table 4-4. CTS Efficiency Percent Values Used for Transport Simulations (Percent)

Month/Year	Carbon Tetrachloride	Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Uranium	Tritium
Jan-12	100	77.9	0.0	79.6	98.5	90.0	69.0	0
Feb-12	100	77.9	0.0	79.6	98.5	90.0	69.0	0
Mar-12	100	77.9	0.0	79.6	98.5	90.0	69.0	0
Apr-12	100	77.9	0.0	79.6	98.5	90.0	69.0	0
May-12	100	77.9	0.0	79.6	98.5	90.0	69.0	0
Jun-12	100	77.9	0.0	79.6	98.5	90.0	69.0	0
Jul-12	100	77.9	0.0	79.6	98.5	90.0	69.0	0
Aug-12	100	87.1	29.6	87.2	98.5	90.0	69.0	0
Sep-12	100	86.3	23.5	87.9	97.9	81.8	69.0	0
Oct-12	100	85.4	18.1	91.9	96.8	0.0	69.0	0
Nov-12	100	93.9	13.0	82.4	98.8	58.3	69.0	0
Dec-12	100	91.7	0.0	60.1	98.0	59.2	69.0	0
Jan-13	100	81.1	27.6	66.3	96.7	80.4	37.7	0
Feb-13	100	82.2	37.3	53.8	96.9	33.3	37.7	0
Mar-13	100	73.3	9.1	50.6	96.3	90.2	37.7	0
Apr-13	100	75.8	0.0	32.0	95.9	89.8	37.7	0
May-13	100	67.7	0.0	64.7	96.9	91.1	37.7	0
Jun-13	100	70.8	0.0	54.9	96.8	75.0	37.7	0
Jul-13	100	88.1	9.8	73.5	98.3	81.1	37.7	0
Aug-13	100	80.9	0.0	67.4	97.2	87.5	37.7	0
Sep-13	100	84.5	0.0	67.3	95.6	86.8	37.7	0
Oct-13	100	81.3	0.0	77.4	95.6	79.2	37.7	0
Nov-13	100	66.7	0.0	90.8	96.1	79.6	37.7	0
Dec-13	100	80.9	4.5	69.8	96.6	80.0	37.7	0
Jan-14	100	69.2	0.0	72.7	96.2	75.0	33.9	0
Feb-14	100	79.9	10.2	80.5	96.1	87.2	33.9	0

Table 4-4. CTS Efficiency Percent Values Used for Transport Simulations (Percent)

Month/Year	Carbon Tetrachloride	Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Uranium	Tritium
Mar-14	100	86.7	0.0	78.1	95.5	83.9	33.9	0
Apr-14	100	77.5	11.2	85.0	95.6	86.1	33.9	0
May-14	100	77.9	19.3	86.0	95.7	92.6	33.9	0
Jun-14	100	69.0	0.0	73.8	95.5	93.4	33.9	0
Jul-14	100	75.0	20.7	78.7	95.3	94.3	33.9	0
Aug-14	100	75.3	0.0	66.8	95.7	93.9	33.9	0
Sep-14	100	75.4	42.2	78.3	97.6	92.6	33.9	0
Oct-14	100	73.5	2.2	76.8	96.2	92.6	33.9	0
Nov-14	100	77.2	0.0	78.9	95.7	91.4	33.9	0
Dec-14	100	71.3	33.6	74.2	94.8	93.6	33.9	0
Jan-15	100	82.6	6.6	82.6	94.3	93.4	15.4	0
Feb-15	100	77.3	20.9	78.2	94.5	93.6	0.0	0
Mar-15	100	89.7	0.0	85.1	96.6	86.8	23.1	0
Apr-15	100	93.3	0.0	66.9	96.0	91.4	16.7	0
May-15	100	86.3	0.0	76.2	98.1	91.7	20.0	0
Jun-15	100	87.8	0.0	84.2	96.8	92.6	16.7	0
Jul-15	100	83.3	0.0	73.4	96.3	91.7	8.3	0
Aug-15	100	93.7	0.0	73.8	95.3	92.4	28.3	0
Sep-15	100	85.9	27.0	74.0	95.0	93.1	8.3	0
Oct-15	100	89.2	6.9	95.5	91.3	90.4	95.6	0
Nov-15	100	82.1	1.1	76.3	93.5	90.0	98.6	0
Dec-15	100	75.7	0.0	60.0	91.4	90.7	97.9	0
Jan-16	100	91.9	25.2	97.0	97.0	89.6	98.0	0
Feb-16	100	84.7	18.6	87.8	96.4	92.6	97.7	0
Mar-16	100	93.4	59.3	94.0	97.4	93.2	98.4	0
Apr-16	100	87.2	0.0	98.6	99.5	89.6	97.4	0

Table 4-4. CTS Efficiency Percent Values Used for Transport Simulations (Percent)

Month/Year	Carbon Tetrachloride	Chromium	Iodine-129	Nitrate	Technetium-99	Trichloroethene	Uranium	Tritium
May-16	100	82.3	59.8	78.4	98.2	91.7	99.6	0
Jun-16	100	94.1	63.3	66.7	97.4	90.4	98.2	0
Jul-16	100	88.4	21.6	75.4	97.3	91.1	97.8	0
Aug-16	100	77.4	28.1	79.4	97.6	88.6	99.4	0
Sep-16	100	74.3	0.0	89.2	95.5	92.4	98.1	0
Oct-16	100	67.0	0.0	90.4	98.0	91.1	94.4	0
Nov-16	100	70.0	0.0	62.1	91.3	91.4	99.1	0
Dec-16	100	81.3	61.2	52.2	90.6	91.4	97.4	0
Jan-17	100	86.6	19.5	56.0	93.2	91.4	99.4	0
Feb-17	100	80.7	3.7	80.0	93.7	88.6	95.5	0
Mar-17	100	88.0	32.8	82.6	95.3	90.0	99.9	0
Apr-17	100	75.3	71.7	65.6	94.4	88.6	99.8	0
May-17	100	87.9	46.2	74.0	92.2	91.4	98.6	0
Jun-17	100	83.4	54.6	66.7	94.7	91.8	99.7	0
Jul-17	100	90.5	75.4	75.5	96.0	92.2	99.8	0
Aug-17	100	71.5	47.5	70.7	94.8	90.0	99.6	0
Sep-17	100	56.5	56.7	48.3	95.6	92.4	99.6	0
Oct-17	100	87.7	34.5	83.2	91.7	93.1	98.7	0
Nov-17	100	86.0	28.7	85.0	95.7	91.7	99.6	0
Dec-17	100	91.6	26.5	89.0	94.9	92.9	99.6	0
2018-2037	100	82.2	41.5	73.0	94.3	91.2	99.1	0

CTS = contaminant treatment system

5 Software Applications, Descriptions, Installation and Checkout, and Statements of Validity

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

5.1 Approved Software

The following software was used to perform calculations and was approved and compliant with PRC-PRO-IRM-309. The software is managed under the following documents consistent with the procedure:

- CHPRC-00257, Rev. 1, *MODFLOW and Related Codes Functional Requirements Document*
- CHPRC-00258, Rev. 4, *MODFLOW and Related Codes Software Management Plan*
- CHPRC-00259, Rev. 3, *MODFLOW and Related Codes Software Test Plan*
- CHPRC-00260, Rev. 8, *MODFLOW and Related Codes Requirements Traceability Matrix*
- CHPRC-00261, Rev. 8, *MODFLOW and Related Codes Acceptance Test Report*

CHPRC-00258 distinguishes between safety software and support software based on whether the software managed calculates reportable results or provides run support, visualization, or other similar functions. Brief descriptions of the software are provided in the following discussion.

5.2 Descriptions

5.2.1 MODFLOW (Controlled Calculation Software)

- **Software title:** MODFLOW-2000 (Harbaugh et al., 2000); solves transient groundwater flow equations using the finite-difference discretization technique.
- **Software version:** Version 1.19.01, modified by S.S. Papadopulos and Associates, Inc. (SSP&A) to address dry cell issues and to use the Orthomin solver (Vinsome, 1976, *Orthomin, an Iterative Method for Solving Sparse Sets of Simultaneous Linear Equations*); approved as CHPRC Build 8 using a version of the executable "mf2k-mst-chprc08dpv.exe" compiled to default double precision for real variables and optimized for speed.
- **Hanford Information Systems Inventory (HISI) identification number:** 2517 (safety software, graded Level C).
- **Workstation type and property number (from which software is run):** SSP&A, FE449.

5.2.2 MT3DMS (Controlled Calculation Software)

- **Software title:** MT3DMS (Zheng and Wang, 1999; Zheng, 2010, *MT3DMS v5.3 Supplemental User's Guide*).
- **Software version:** Version 5.3, modified by SSP&A to address dry cell issues; approved as CHPRC Build 8 using a version of the executable "mt3d-mst-chprc08dpv.exe" compiled to default double precision for real variables and optimized for speed.
- **HISI identification number:** 2518 (safety software, graded Level C).
- **Workstation type and property number (from which software is run):** SSP&A, FE449.

5.2.3 MODPATH

- **Software title:** MODPATH (Pollock, 1994). A particle-tracking, post-processor developed for use with the MODFLOW codes was used to evaluate the approximate directions and rates of groundwater flow and the approximate extent of hydraulic capture developed by proposed P&T well configurations.
- **Software version:** Version 5 modified by SSP&A to address dry cell issues; approved as CHPRC Build 6 using executable "modpath-chprc06.exe."
- **Workstation type and property number (from which software is run):** SSPA, FE449.

5.2.4 KT3D_H2O

KT3D_H2O was used to perform particle tracking to compute extent of hydraulic containment using mapped water levels. Use of this software at the Hanford Site is managed under an integrated software management plan (CHPRC-02839, *KT3D_H2O and MEUK Integrated Software Management Plan*):

- **Software title:** KT3D_H20 (SSP&A, 2011, *User's Guide to KT3D_H2O, Version 2*).
- **Software version**: CHPRC Build 2 (Version 3.5.1).
- **HISI identification number:** 2517 (safety software, graded Level C).
- **Workstation type and property number (from which software is run):** SSPA, FE449.

5.3 Support Software

The following programs are classified as support software.

5.3.1 MODFLOW Suite Support Software

- **Groundwater Vistas™:** Rumbaugh and Rumbaugh, 2015, *Groundwater Vistas Version 6*. Provided graphical tools used for model quality assurance and model input/output review.
- **ArcGIS®:** Mitchell, 1999, *The ESRI Guide to GIS Analysis, Volume 1: Geographic Patterns and Relationships*. Provided visualization tool for assessing simulated plume distributions, identifying extraction/injection well coordinates, and mapping auxiliary data.

5.3.2 R and Surfer®

- **R:** The R programming environment, a language and environment for statistical computing and graphics (The R Development Core Team, 2012, *The R Project for Statistical Computing*; Ihaka and Gentleman, 1996, "R: A Language for Data Analysis and Graphics"), was used to perform a variety of data processing including post-processing of model results and generating plots of aggregate data time series. The following R packages were also used as follows:
  - Package GSTAT provided the kriging engine for water levels.
  - Package SSPAMEUK provided functions for the generation of water-level kriging drifts.

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® ArcGIS is a registered trademark of Environmental Systems Research Institute, Inc., Redlands, California.

  - Package SSPATRACKER provided the interface to the Transient Tracker routine (a dynamic link library component of KT3D-H2O) for particle tracking.
  - Package raster for the generation of water-level ASCII grids and raster calculations.
- **Surfer®:** Data interpolation for visualization, model implementation, and quality assurance purposes.

5.4 Software Installation and Checkout

Safety software is checked out in accordance with procedures specified in CHPRC-00258. Executables are obtained from the CHPRC software owner, who maintains the configuration-managed copies in MKS Integrity, ensures that installation tests identified in CHPRC-00259 are performed and that successful installation is confirmed. Checkout forms are required and must be approved for installations used to perform model runs. Approved users for safety software are registered in HISI.

5.4.1 Statement of Valid Software Application

- The software identified in this ECF was used consistent with intended use for CHPRC (as identified in CHPRC-00257) and is a valid use of this software for this application.
- The software was used within its limitations, as identified in CHPRC-00257.
- The R programming environment has not been identified in CHPRC-00258 but is scheduled by the software owner to be included as support software in the next revision of that document. It is publicly available, open-source freeware.

® Surfer is a registered trademark of Golden Software, LLC, Golden, Colorado.

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6 Calculations

6.1 200-ZP-1 Operable Unit

6.1.1 Water-Level Mapping and Particle Tracking

This section discusses the procedure used to develop the necessary input files, perform the calculations, and post-process the outputs to develop the groundwater level maps using the multi-event universal kriging (MEUK) technique through the R environment.

The AWLN data were compared to manual measurements to test the reliability of transducer measurements. During this analysis, it was noted that several AWLN wells (299-W10-30, 299-W11-48, 299-W15-37, 299-W22-116, 299-W15-44, 299-W22-116, 299-W22-94, 699-36-61A, 699-45-69C, 699-48-71 and 299-W15-49) show relatively constant discrepancies between transducer data and manual measurements, in which case transducer data were adjusted to match manual measurements. Figure 6-1 shows adjustment applied to well 299-W15-37 for the period of December 2015 through December 2017.

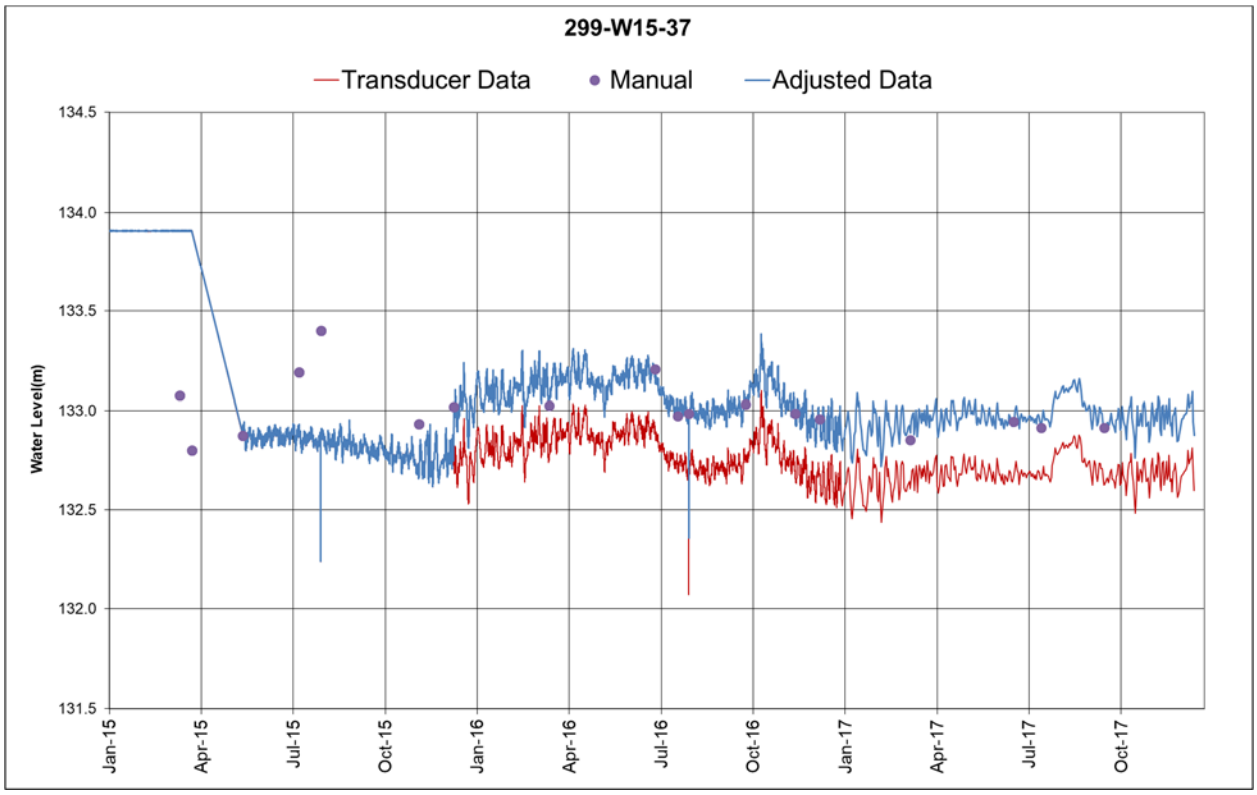


Figure 6-1. Example of AWLN Data Adjustment

At the conclusion of the AWLN adjustments, monthly averaged data were compiled into tables suitable for mapping, and then cross-validation analyses were performed to find the wells with the highest residual values. The water levels at these wells were considered suspect and subject to systematic error due to the wells deviating from vertical or error in manual measurements, or in some cases the wells were screened in deeper aquifers with different flow conditions. Based on the results from the cross-validation analysis, several wells were excluded from the mapping process, and the excluded water level is indicated in red in Appendix A, Table A-1.

The final monthly averaged data with excluded wells having the highest residual values were interpolated to a regular grid 20 m by 20 m (65.6 ft by 65.6 ft) using MEUK (Karanovic et al., 2009, "KT3D_H2O: A Program for Kriging Water Level Data Using Hydrologic Drift Terms"; Tonkin et al., 2016, "Multi-Event Universal Kriging (MEUK)") implemented in "Meuk_2017_200WVer2.R" and used to generate water-level maps.

The following steps were used to develop the necessary input files, perform the calculations, and post-process the outputs to develop the 200-ZP-1 ICFM using particle tracking for the mapped groundwater level surfaces:

1. The kriged results obtained through the process described above using "Meuk_2017_200WVer2.R" were imported in KT3D_H2O software, which includes the particle-tracking program "Transient Tracker." Transient Tracker implements the fourth-order RK4 (Press et al., 1996) numerical integration (particle-tracking) scheme, calculated upon hydraulic head surfaces. This particle-tracking approach is based upon the approach implemented in the MODFLOW-compatible particle-tracking code, PATH3D (Zheng, 1992), which has been demonstrated to provide very similar results to the USGS particle-tracking program, MODPATH (Pollock, 1994), to track particles from each cell center to generate the capture maps.

2. An ICFM was developed from the resulting 12 individual monthly capture maps by calculating the frequency with which each particle terminates at an extraction well, calculated over all water-level maps.

6.1.2 Groundwater Flow Modeling and Particle Tracking

The following steps were followed to develop the necessary input files, perform the calculations, and post-process the outputs to develop an SCFM using the CPGWM:

1. An input file for the MODFLOW Multi-Node Well (MNW2) Package was constructed to reflect the spatial and temporal configuration of the well operations. The historical (prior to CY2012) groundwater extraction rates used to generate this input file are reported in the EMMA data archive and accompanying documentation (EMDT-ST-004, *Historical Pumping Rates 200 West Area, Electronic Modeling Data Transmittal-Boundary Condition [Historical Pumping Rates]*). Historical groundwater extraction and injection flow rates for the 200 West P&T wells are provided in Appendix B, Table B-1 (for CY 2012/2013), Table B-2 (for CY 2014/2015) and Table B-3 (for CY 2016/2017).

2. The flow model was executed, and simulated hydraulic head distributions, as well as accessory outputs, were obtained.

3. Input files for the particle-tracking analyses were constructed, including particle starting locations encompassing an area equivalent to the plume footprint.

4. The particle tracking program MODPATH was executed, and the results were post-processed to identify particles that, if given sufficient time, would be captured by the extraction wells.

5. An SCFM was developed from the resulting 12 individual monthly capture maps by calculating the frequency with which each particle terminates at an extraction well, calculated over all water-level maps.

6.1.3 Transport Modeling and Mass Recovery Calculations

The following steps were followed to develop the necessary input files, perform the calculations, and post-process the outputs to develop the historical (recent time) and future (projected) contaminant F&T, as well as influent concentrations and mass recovery, using the CPGWM:

1. Each initial condition plume described earlier in section 4.2.4 was converted to the required MT3D initial concentration input file format.
2. Each contaminant transport model was executed to simulate contaminant concentrations and produce the required MT3D output concentration and mass files.
3. Post-processing scripts were executed to produce figures presented in this ECF, including the following:
    a. Concentration versus time for each individual extraction well for each COC presented in section 7.1.3 and 7.3.3 of this document.
    b. Concentration versus time for monitoring wells for each COC presented in Appendix C.
    c. Extracted mass versus time for each individual extraction well for each COC.
    d. Projected and cumulative mass recovery plots for the 200 Area P&T remedies.
    e. A table summary of transport results at year 2037.

6.1.4 Flow-Path Control Calculations

The locations and rates of extraction and injection wells were designed to encompass and recover the majority of the contaminant mass, and to slow the migration of contaminants present at lower concentrations. Flow-path control considers not only the extent of hydraulic containment but also the presence of reduced hydraulic gradients in key areas, principally to the northeast and southeast of the 200-ZP-1 OU. A line of control points for evaluating flow-path control has been established (Figure 6-2) that includes the approximate lateral extent of groundwater contaminated by carbon tetrachloride, as derived from three-dimensional interpolation completed in CY 2012 and more recently as depicted in ECF-Hanford-18-0013, *Calculation and Depiction of Groundwater Contamination for the Calendar Year 2017 Hanford Site Groundwater Monitoring Report.* The extent of hydraulic containment and the region over which hydraulic gradients are affected by the operation of the P&T system are determined using both the water-level mapping and groundwater modeling methods described in Chapter 3.

The following steps were followed to develop the necessary input files, perform the calculations, and post-process the outputs to develop figures to assist with the evaluation of Flow-Path Control:

1. Mapped and simulated water table grids which represent “Baseline” and “Current” conditions were obtained using methods described in Chapter 3. Baseline condition represent hydraulic conditions of the flow field in June 2012 and Current conditions represent hydraulic conditions of the flow field in December 2017.
2. Water table grids were imported in Surfer®. Using the Surfer® “Calculus” tool, new grids were calculated representing the hydraulic gradient direction and magnitude.
3. Grids representing the change in hydraulic gradient throughout the area were calculated by subtracting the Current and Baseline gradient magnitude grids.
4. Points representing the flow-path control line were then intersected with the flow gradient direction and magnitude grids, and point shapefiles were generated containing data fields representing the gradient direction and magnitude at the location of the flow-path control line.

These shapefiles were then used to create the hydraulic gradients arrows depicted in figures presented below.

The results of the flow-path control evaluation are summarized in Chapter 7.

6.2 200-UP-1 Operable Unit — S-SX Tank Farms and U Plant

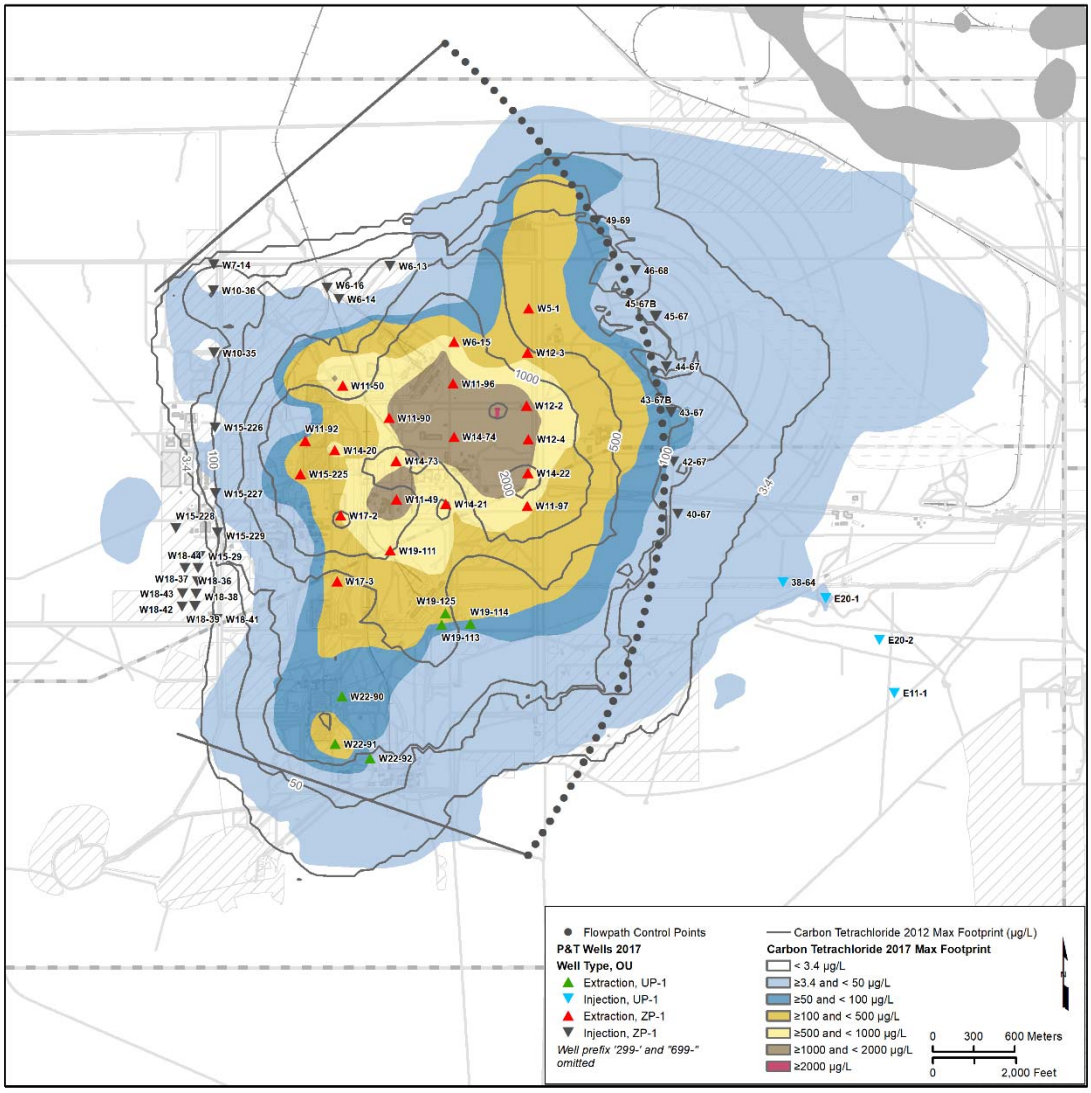
6.2.1 Water-Level Mapping and Particle Tracking

The following procedure was used to develop the necessary input files, perform the calculations, and post-process the outputs in order to develop the capture maps using the KT3D-H2O program:

The water levels and extraction data used to develop the 200-UP-1 OU water-level maps were the same as the maps used for the broader 200-ZP-1 OU (as presented in Section 6.1.1 and shown in Appendix A, Table A-1). Particles were then tracked on the groundwater elevation surfaces obtained for December 2017 using the Transient Tracker program (Zheng, 1992), which is part of the KT3D-H2O program. Capture analysis for the S-SX Tank Farms particles were tracked for the equivalent of 12 years assuming a mobile porosity of 0.15 and a hydraulic conductivity of 5 m/d (16.4 ft/d).

6.2.2 Transport Modeling and Mass Recovery Calculations

Since the 200-UP-1 S-SX Tank Farms and U Plant extraction wells are within the domain of the CPGWM and are adjacent to the larger 200-ZP-1 OU P&T system, simulated concentrations of COCs are obtained for the S-SX Tank Farms and U Plant wells when the CPGWM is executed (as described in Section 7.3.3). The simulated influent concentrations are presented in this ECF; however, the concentrations are not currently used to make any inferences about the performance of the S-SX Tank Farms remedy.



Note: The CY 2017 two-dimensional map of carbon tetrachloride (ECF-Hanford-18-0013, *Calculation and Depiction of Ground-Water Contamination for the Calendar Year 2017 Hanford Sitewide Groundwater Monitoring Report for 2017*) and the mapped extent of carbon tetrachloride are derived from three dimensions (ECF-200ZP1-13-0006, *Description of Groundwater Modeling Calculations for the Calendar Year 2012 (CY2012) 200 Areas Pump-and-Treat Report*).

Figure 6-2. Schematic of the Flow-Path Control Line-of-Control Used for Calculations in Chapter 7

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7 Results and Conclusions

7.1 200-ZP-1 Operable Unit

The figures and tables produced as output from the calculations described in this ECF for the 200-ZP-1 OU are provided in this chapter.

7.1.1 Hydraulic Containment

The results of the hydraulic containment calculations are presented in the following series of figures that depict groundwater level contours and the extent of hydraulic containment, as estimated using both the water-level mapping method and the groundwater modeling method:

- Figure 7-1 depicts the ICFM for the 200-ZP-1, as well as the approximate extent of carbon tetrachloride that is dissolved in groundwater above the RLM, as represented by the two-dimensional maximum extent derived from three-dimensional interpolation completed in CY 2017 and groundwater levels calculated using the water-level mapping method.
- Figure 7-2 depicts the SCFM for the 200-ZP-1, as well as the approximate extent of carbon tetrachloride that is dissolved in groundwater above the RLM, as represented by the two-dimensional maximum extent derived from three-dimensional interpolation completed in CY 2017 and groundwater levels calculated using the CPGWM.
- Figure 7-3 depicts the SCFM for the 200-ZP-1, as well as the approximate extent of carbon tetrachloride that is dissolved in groundwater below the RLM, as represented by the two-dimensional maximum extent derived from three-dimensional interpolation completed in CY 2017 and groundwater levels calculated using the CPGWM.

These figures depict groundwater levels and the extent of hydraulic containment using methods that integrate a series of quasi-steady-state calculations. In actuality, conditions in the Hanford Site Central Plateau vary over time due to P&T operations, and also as a result of historical activities. In particular, the water table in the Central Plateau is decreasing in many areas as a result of the cessation of historical operational discharges of water within ponds and other surface features that ultimately infiltrated to the subsurface; the current rate of decline is estimated to be on the order of 0.22 to 0.27 m/yr. To depict the approximate extent and magnitude of the drawdown and mounding resulting from operation of the P&T remedies, this underlying trend in water levels must be incorporated. The following figures present unadjusted and adjusted estimates of drawdown and mounding. The unadjusted estimates are based upon simply computing the difference between the June 2012 and December 2017 water-level contours. The adjusted estimates, however, are based upon computing the difference between the June 2012 and December 2016 water-level contours, and this difference is then added to the estimated area-wide head change of about 1.368 m (4.5 ft) from June 2012 to December 2017 due to the cessation of historical operational discharges.

The most pronounced difference between the simulated and mapped capture frequencies are visible on the eastern part of the maps where simulated capture frequencies above 0.5 extend close to the eastern line of injection wells but the mapped capture frequencies above 0.5 are of more limited extent. In this area, the groundwater level monitoring network has limited coverage (Figure 7-1) and it is possible that the mapped water levels may not accurately represent the region of reversed hydraulic gradients produced by injections wells.

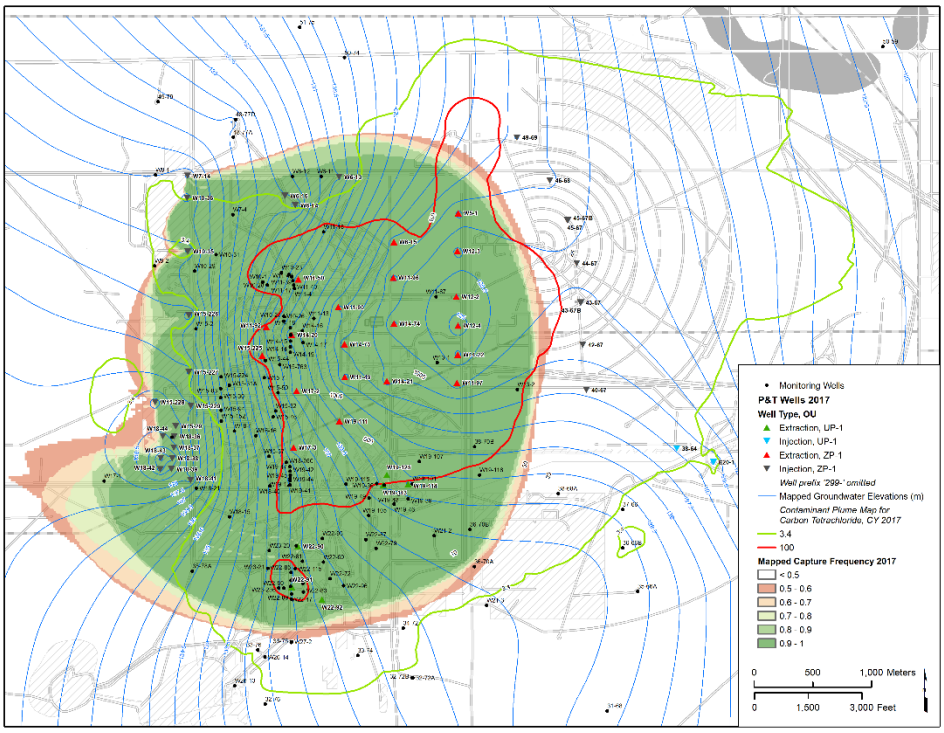


Figure 7-1. Mapped Groundwater Levels, Extent of Carbon Tetrachloride and ICFM for 200-ZP-1 Above the RLM

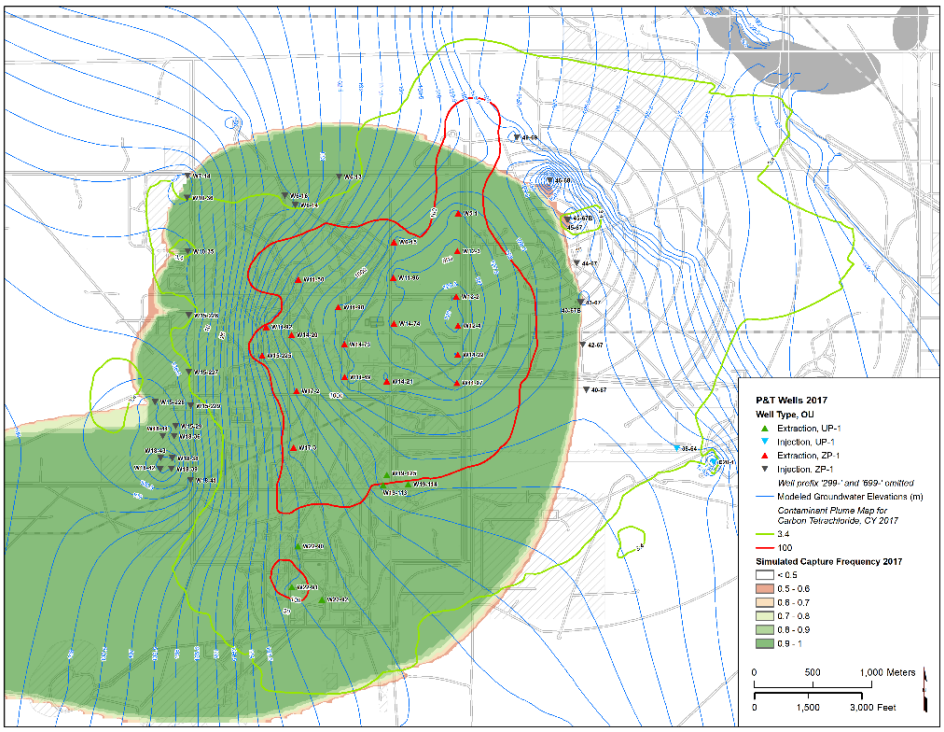


Figure 7-2. Simulated Groundwater Levels, Extent of Carbon Tetrachloride and SCFM for 200-ZP-1 Above the RLM

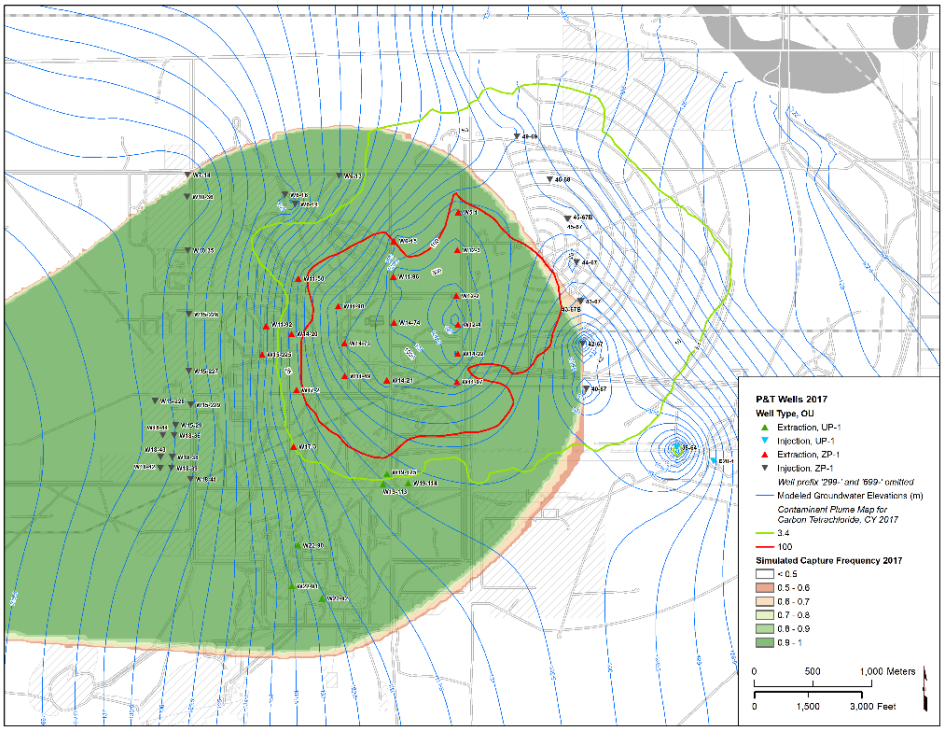


Figure 7-3. Simulated Groundwater Levels, Extent of Carbon Tetrachloride and SCFM for 200-ZP-1 Below the RLM

Figures 7-4 through 7-6 depict the estimated extent and magnitude of drawdown resulting from operation of the 200-ZP-1 and 200-UP-1 groundwater P&T systems:

- Figure 7-4 depicts the approximate extent of drawdown and mounding calculated using the water-level mapping method above the RLM. Two panels are shown:
  - Unadjusted (a): No correction is made for the background decline (recession) in water levels due to cessation of historical wastewater discharges to the subsurface.
  - Adjusted (b): A correction of 1.368 m is made for the background decline (recession) in water levels due to cessation of historical wastewater discharges to the subsurface.
- Figure 7-5 depicts the unadjusted approximate extent of drawdown and mounding calculated using the CPGWM. Two panels are shown:
  - (a) Above the RLM
  - (b) Below the RLM
- Figure 7-6 depicts the adjusted approximate extent of drawdown and mounding calculated using the CPGWM, incorporating a correction of 1.368 m for the background decline (recession) in water levels due to cessation of historical wastewater discharges to the subsurface. Two panels are shown:
  - (a) Above the RLM
  - (b) Below the RLM

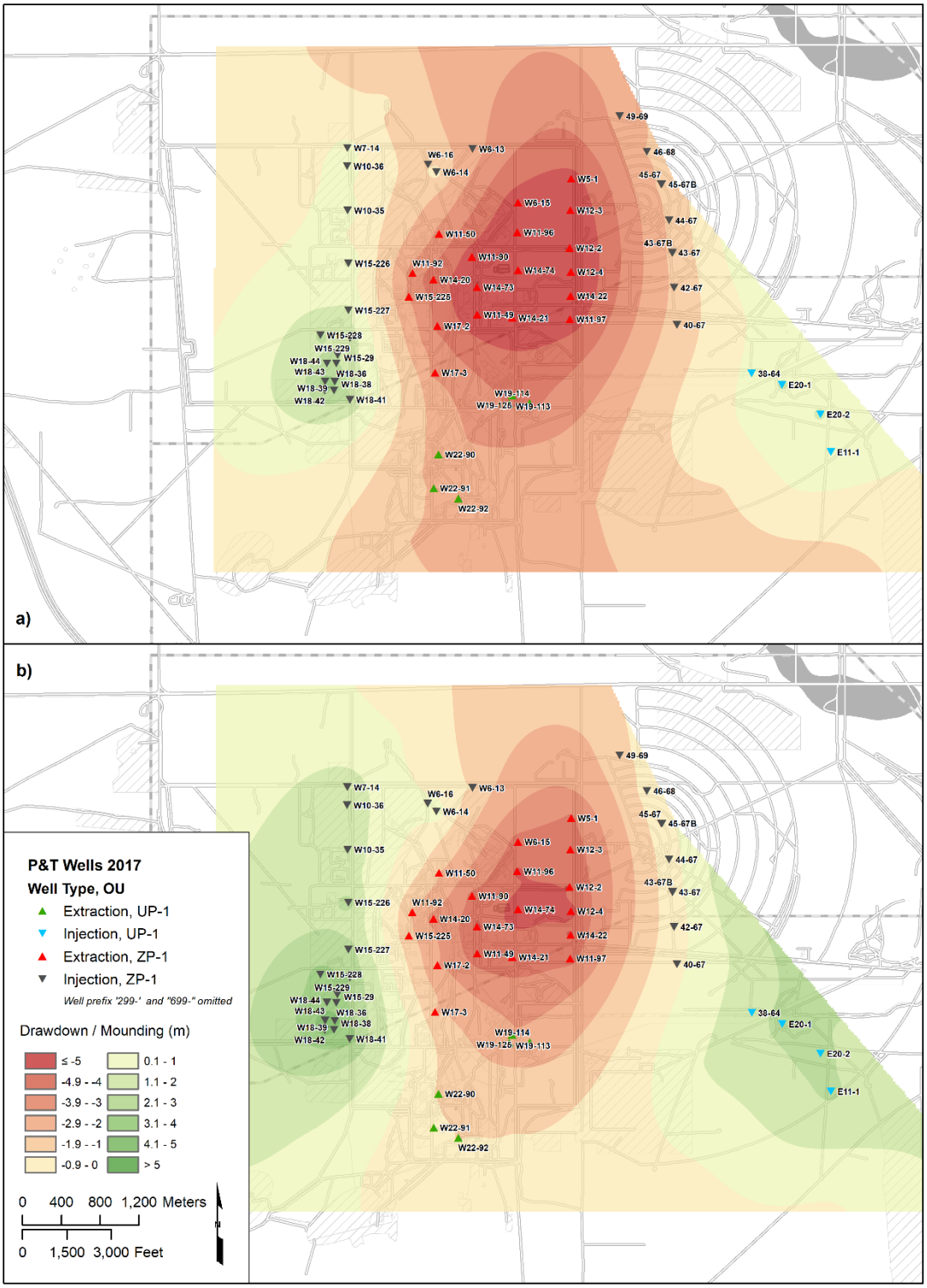


Figure 7-4. Drawdown and Mounding (Mapping Method) Above the RLM: (a) Unadjusted and (b) Adjusted

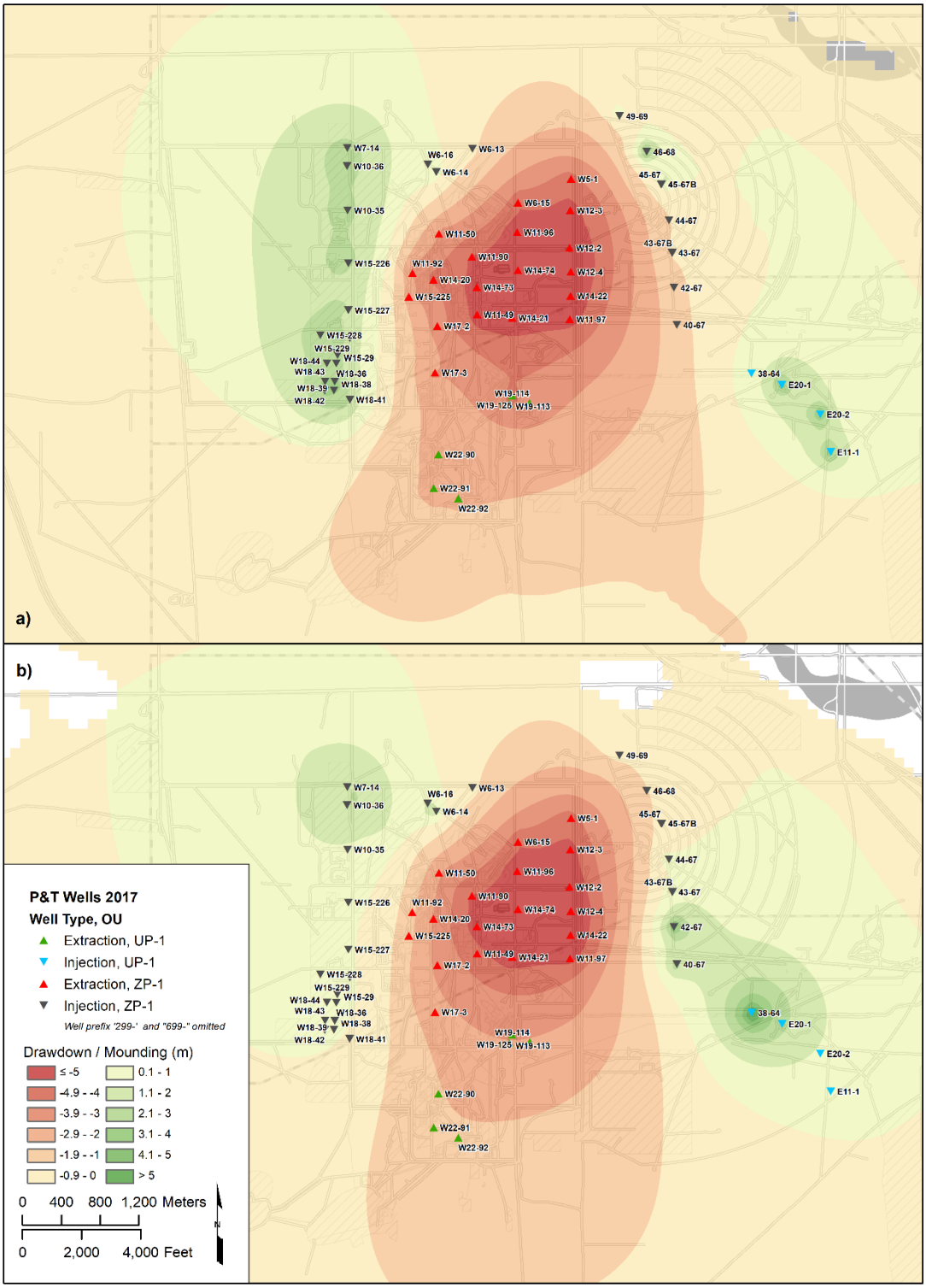


Figure 7-5. Unadjusted Drawdown and Mounding (Modeling Method): (a) Above and (b) Below the RLM

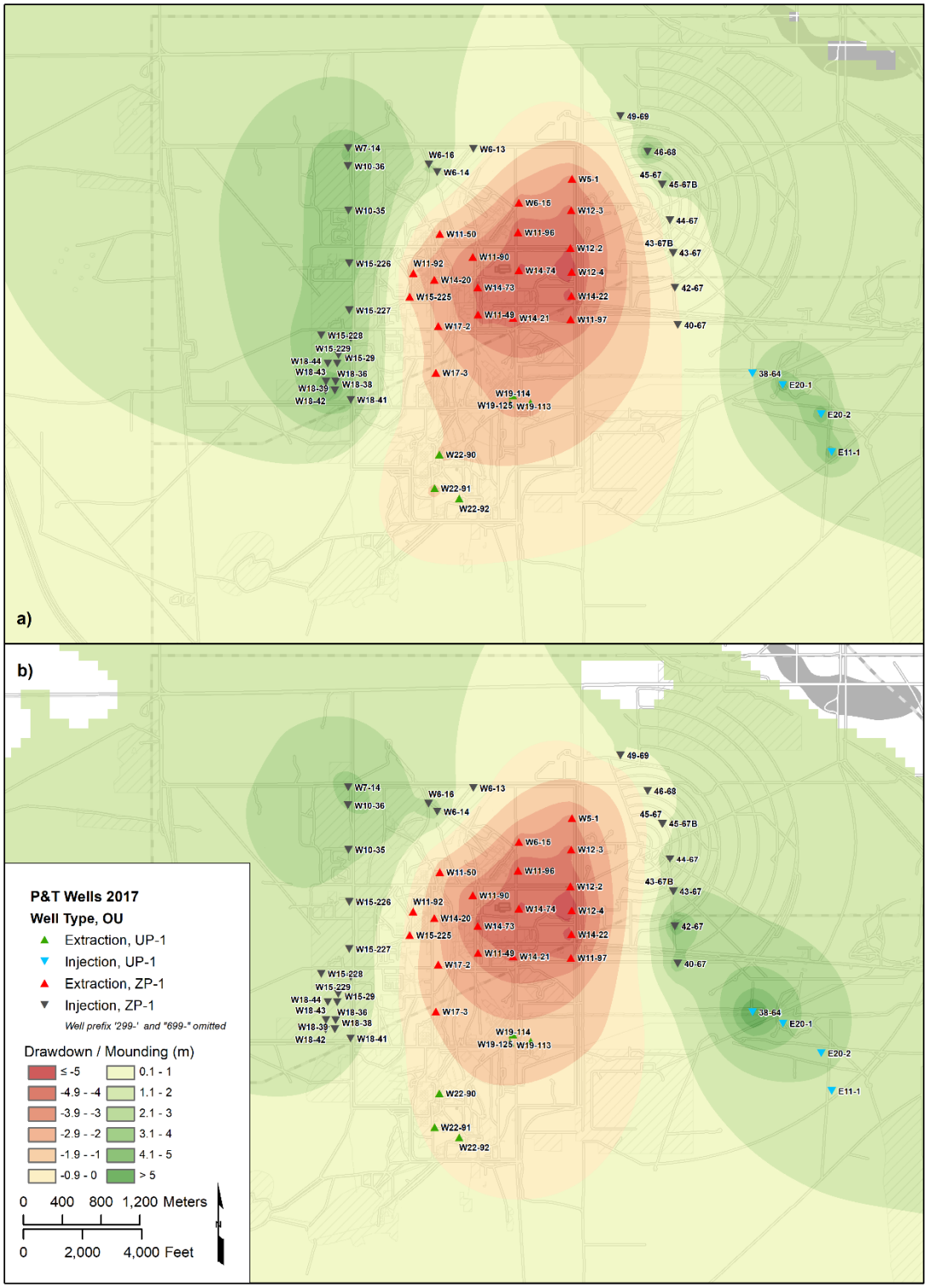


Figure 7-6. Adjusted Drawdown and Mounding (Modeling Method): (a) Above and (b) Below the RLM

7.1.2 Flow-Path Control

Results of the flow-path control assessment are presented in a series of figures, as described below.

Figures 7-7 to 7-9 depicts areas along the flow-path control line above the RLM, where hydraulic gradients are reduced or reversed by the combined operations of extraction and injection.

In each case, the direction and length of the arrows posted along the control line indicate the direction and relative magnitude of the hydraulic gradient at that location:

- Inset "a" depicts the "Baseline" hydraulic conditions of the flow field in June 2012. Posted arrows represent the flow direction and arrow length represents the hydraulic gradients.
- Inset "b" depicts "Current" hydraulic conditions of the flow field in December 2017. Posted arrows represent the flow direction and arrow length represent the hydraulic gradients. Colored map depicts the change in hydraulic gradients, which is calculated as the difference between hydraulic gradients in Current conditions in December 2017 and Baseline conditions in June 2012.

Figure 7-7 depicts areas along the control line above the RLM, where hydraulic gradients are reduced or reversed by the combined operation of extraction and injection, as calculated using the water-level mapping method.

Figure 7-8 depicts areas along the control line above the RLM, where hydraulic gradients are reduced or reversed by the combined operation of extraction and injection, as calculated using the CPGWM model.

Figure 7-9 depicts areas along the control line below the RLM, where hydraulic gradients are reduced or reversed by the combined operation of extraction and injection, as calculated using the CPGWM model.

Figures 7-7 to 7-9 depict reductions in hydraulic gradients (indicated by negative change in hydraulic gradient shaded in red color) near (between) the concentrated areas of extraction and injection wells to the northeast and southeast of the 200-ZP-1 OU. To the north and to the south of the eastern (downgradient) line of injection wells, the gradient change is smaller, which suggests a lesser impact of pumping on gradient in these areas. These results are consistent with expectations, as gradients have been reduced, and in some places reversed, in the region between the extraction and injection wells. Inset "b" in Figures 7-7 to 7-9 also depicts the approximate extent of groundwater contaminated by carbon tetrachloride represented by the most recent (CY 2017) two-dimensional extent as ECF-Hanford-18-0013.

The flow-path control assessment indicates that during CY 2017, flow-path control had developed along much of the control line, through the reduction in hydraulic gradients by groundwater extraction and reinjection at the 200 West P&T.

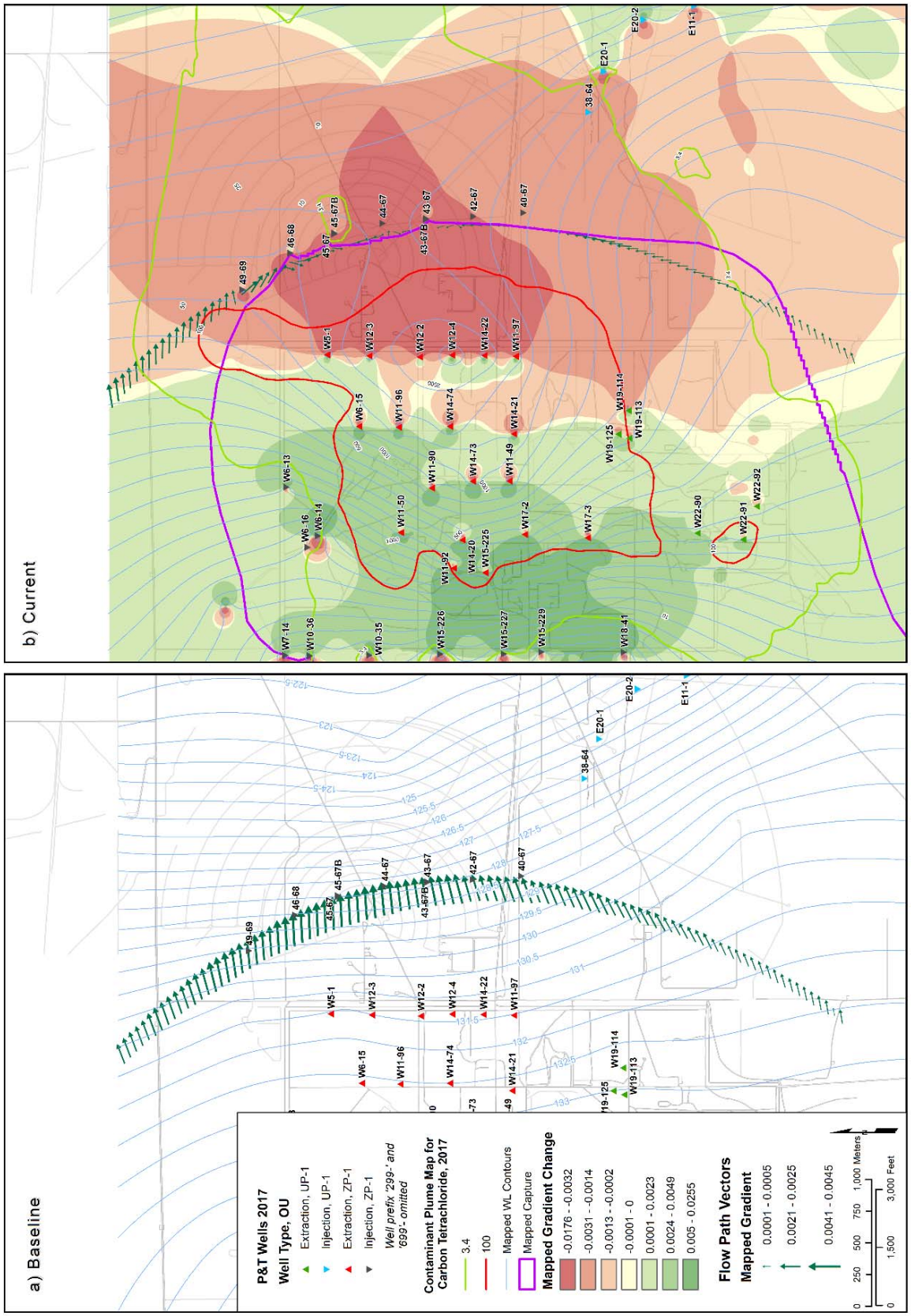


Figure 7-7. Mapped Gradient Changes Along Line of Control Above the RLM: (a) Baseline and (b) Current

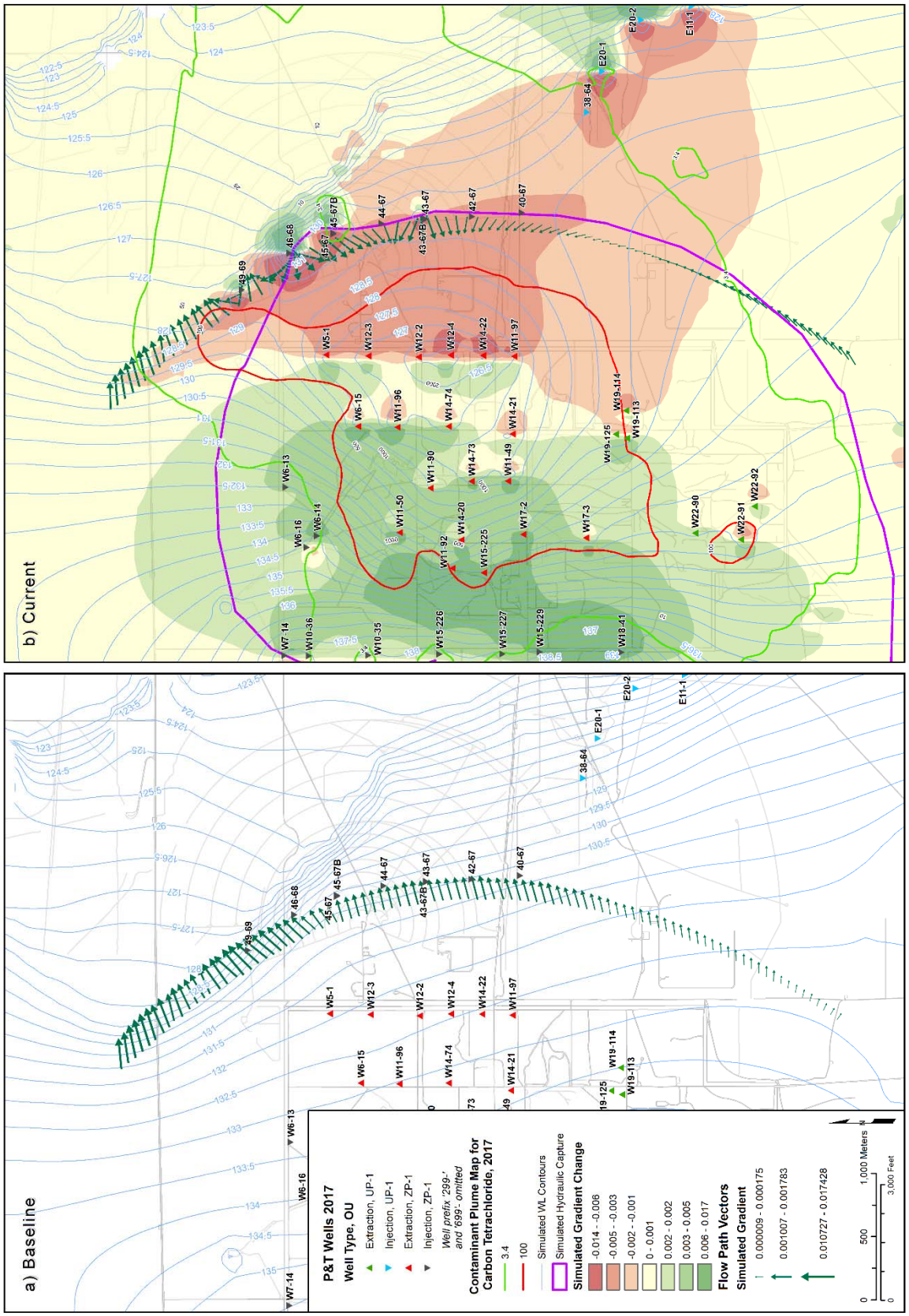


Figure 7-8. Simulated Gradient Changes Along Line of Control Above the RLM: (a) Baseline and (b) Current

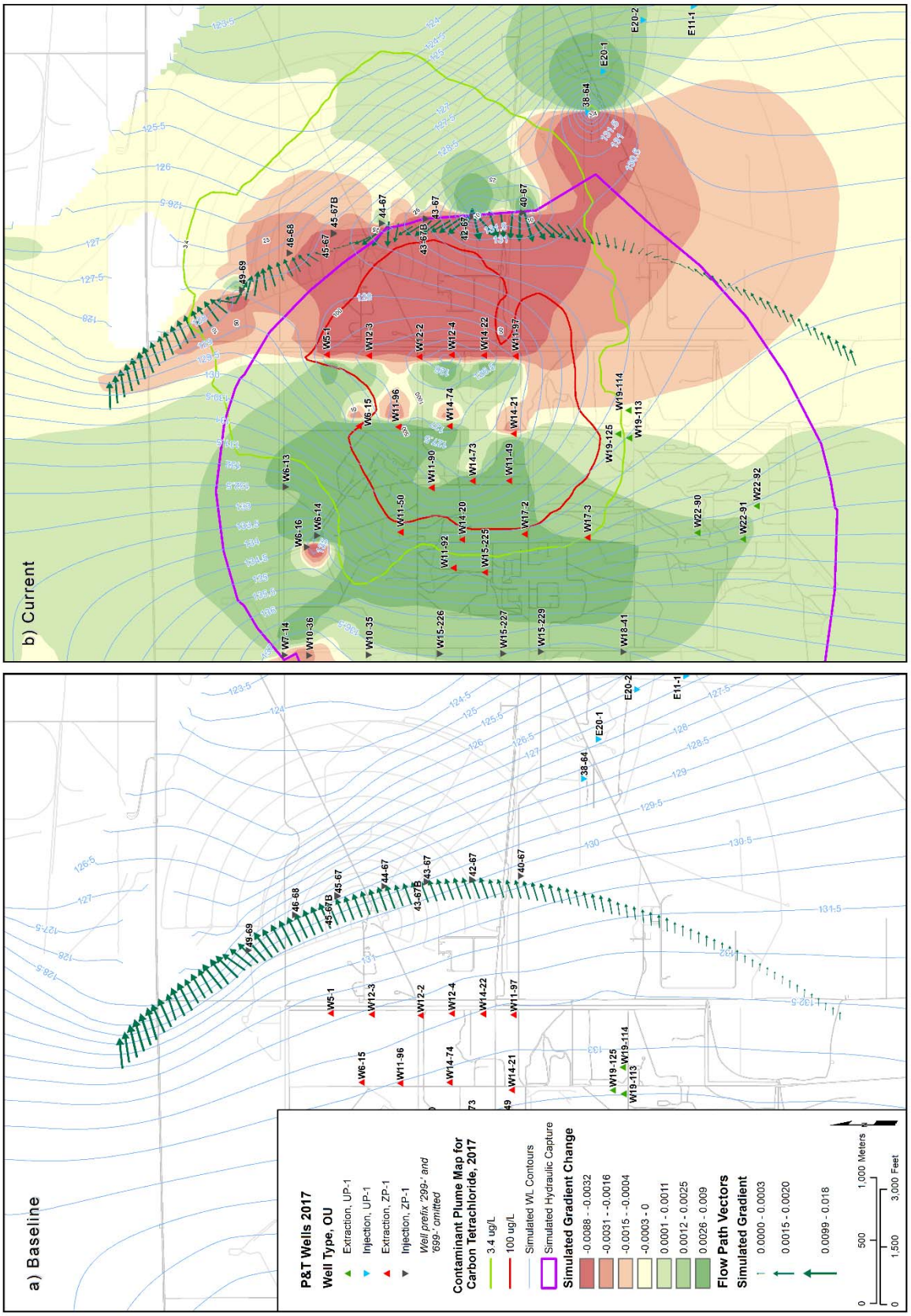


Figure 7-9. Simulated Gradient Changes Along Line of Control Below the RLM: (a) Baseline and (b) Current

7.1.3 Simulated and Observed Extraction Well Concentrations and Mass Removal

Figures 7-10 through 7-18 depict a comparison of the simulated and observed (measured) historical influent concentrations for each COC at the 200 West P&T extraction wells. These figures include extraction well concentrations information as follows:

- Figure 7-10: carbon tetrachloride (assuming a 100-year half-life)
- Figure 7-11: carbon tetrachloride (assuming a 630-year half-life)
- Figure 7-12: hexavalent chromium
- Figure 7-13: iodine-129
- Figure 7-14: nitrate
- Figure 7-15: technetium-99
- Figure 7-16: trichloroethene
- Figure 7-17: tritium
- Figure 7-18: uranium

Note: carbon tetrachloride and nitrate plots show two simulated results one with initial plume generated using SGSIM simulations and the second initial plume generated using the ordinary kriging "Quantile" method.

Figures 7-19 through 7-27 depict a comparison of the simulated and observed (measured) historical contaminant cumulative mass recovery for each COC at the 200 West P&T system extraction wells based upon the documented (and simulated) flow rates and the simulated and observed (measured) sample concentrations. These figures include extraction well and mass removal information for simulations using initial plumes generates by the ordinary kriging – quantile method:

- Figure 7-19: carbon tetrachloride (assuming a 100-year half-life)
- Figure 7-20: carbon tetrachloride (assuming a 630-year half-life)
- Figure 7-21: hexavalent chromium
- Figure 7-22: iodine-129
- Figure 7-23: nitrate
- Figure 7-24: technetium-99
- Figure 7-25: trichloroethene
- Figure 7-26: tritium
- Figure 7-27: uranium

Note: sudden increase in uranium mass recovery shown in Figure 7-27 was due to connecting U-Plant extraction wells to the P&T system.

Figures 7-28 through 7-30 depict a comparison of the simulated and observed (measured) historical contaminant cumulative mass recovery for carbon tetrachloride and nitrate for which initial plumes were generated using the SGSIM "weighted-average" method.

- Figure 7-28: carbon tetrachloride (assuming a 100-year half-life)
- Figure 7-29: carbon tetrachloride (assuming a 630-year half-life)
- Figure 7-30: nitrate

The terms that are depicted in these figures are defined as follows:

- **Simulated Extracted:** The cumulative mass recovery at pumping wells, as read directly from the standard transport model output file.
- **Simulated Injected:** The cumulative mass reinjected by injection wells due to partial (i.e., less than 100 percent) treatment efficiency for that constituent.
- **Total Removed:** The simulated cumulative mass removed calculated as a difference between extracted and injected simulated mass.
- **Reported:** The reported cumulative mass removed by the P&T system.

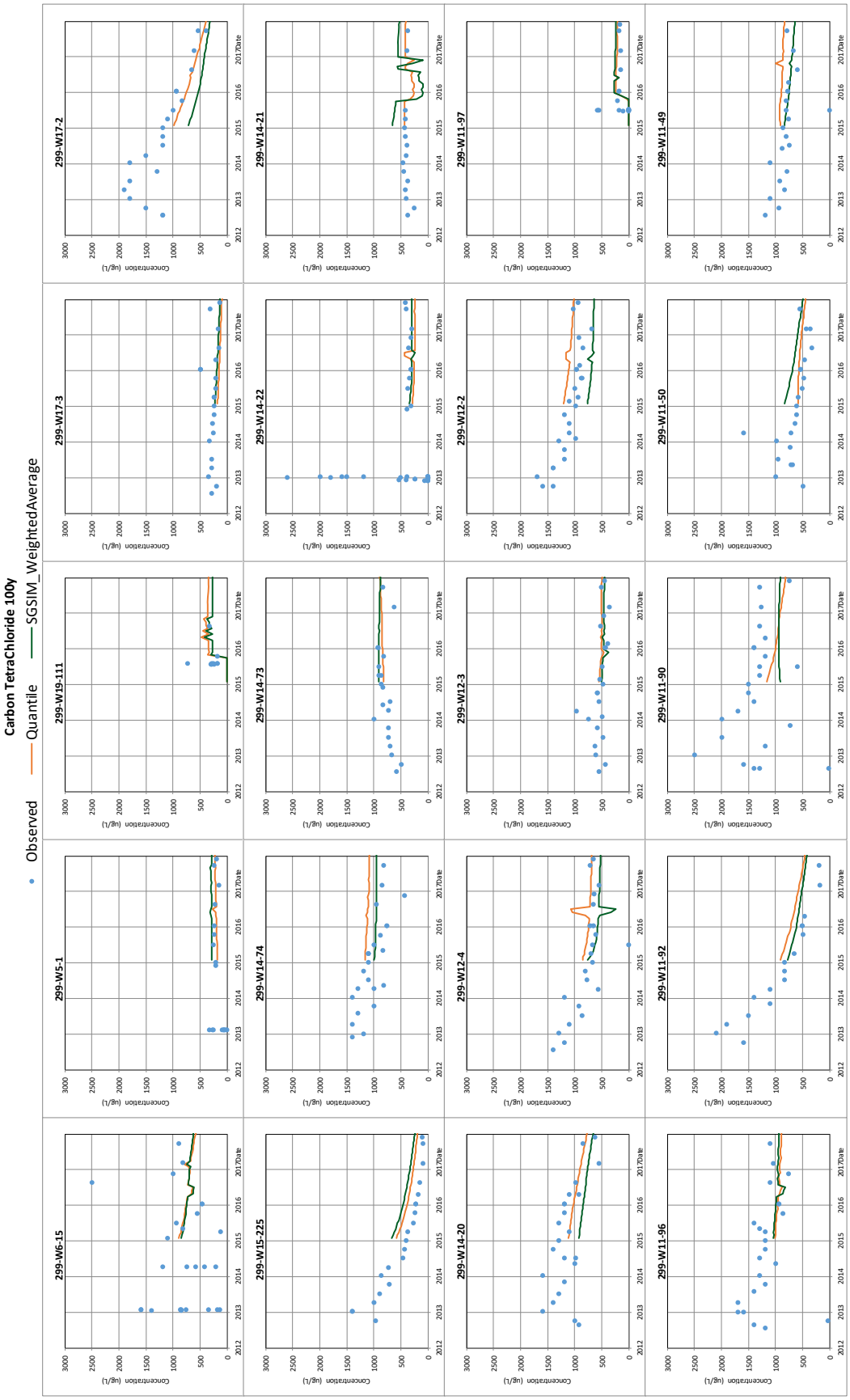


Figure 7-10. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Carbon Tetrachloride (100-Year Half-Life)

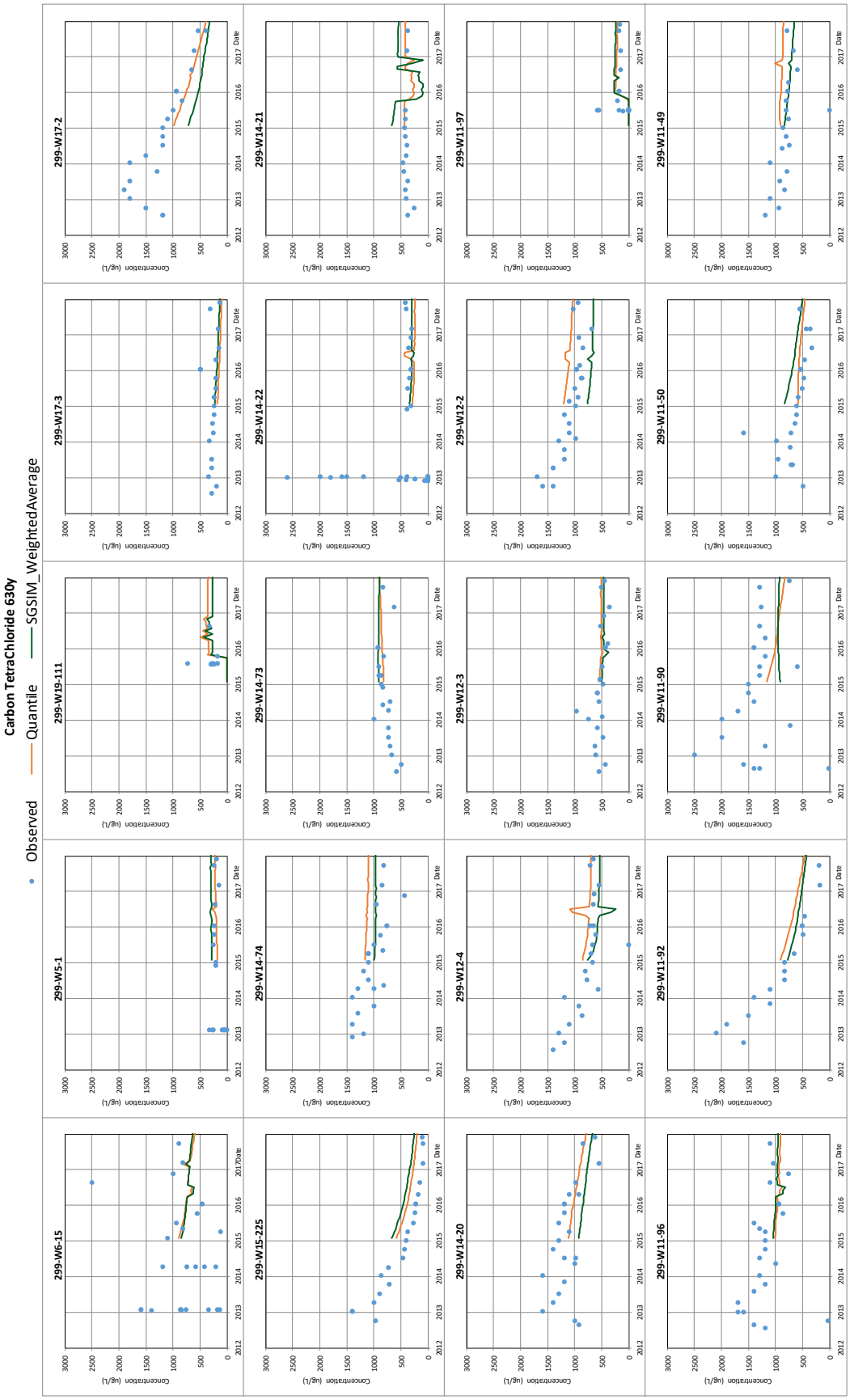


Figure 7-11. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Carbon Tetrachloride (630-Year Half-Life)

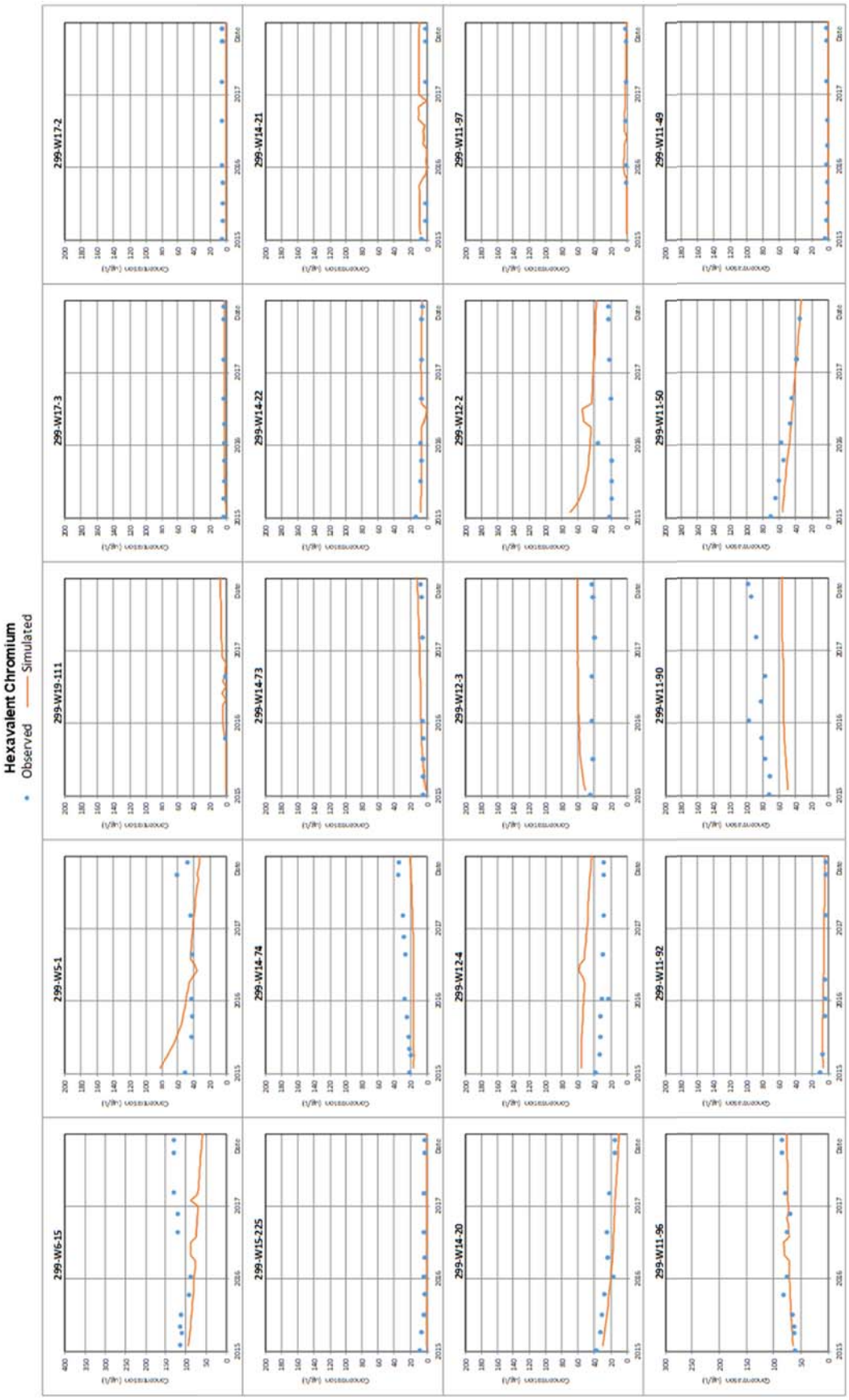


Figure 7-12. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Hexavalent Chromium

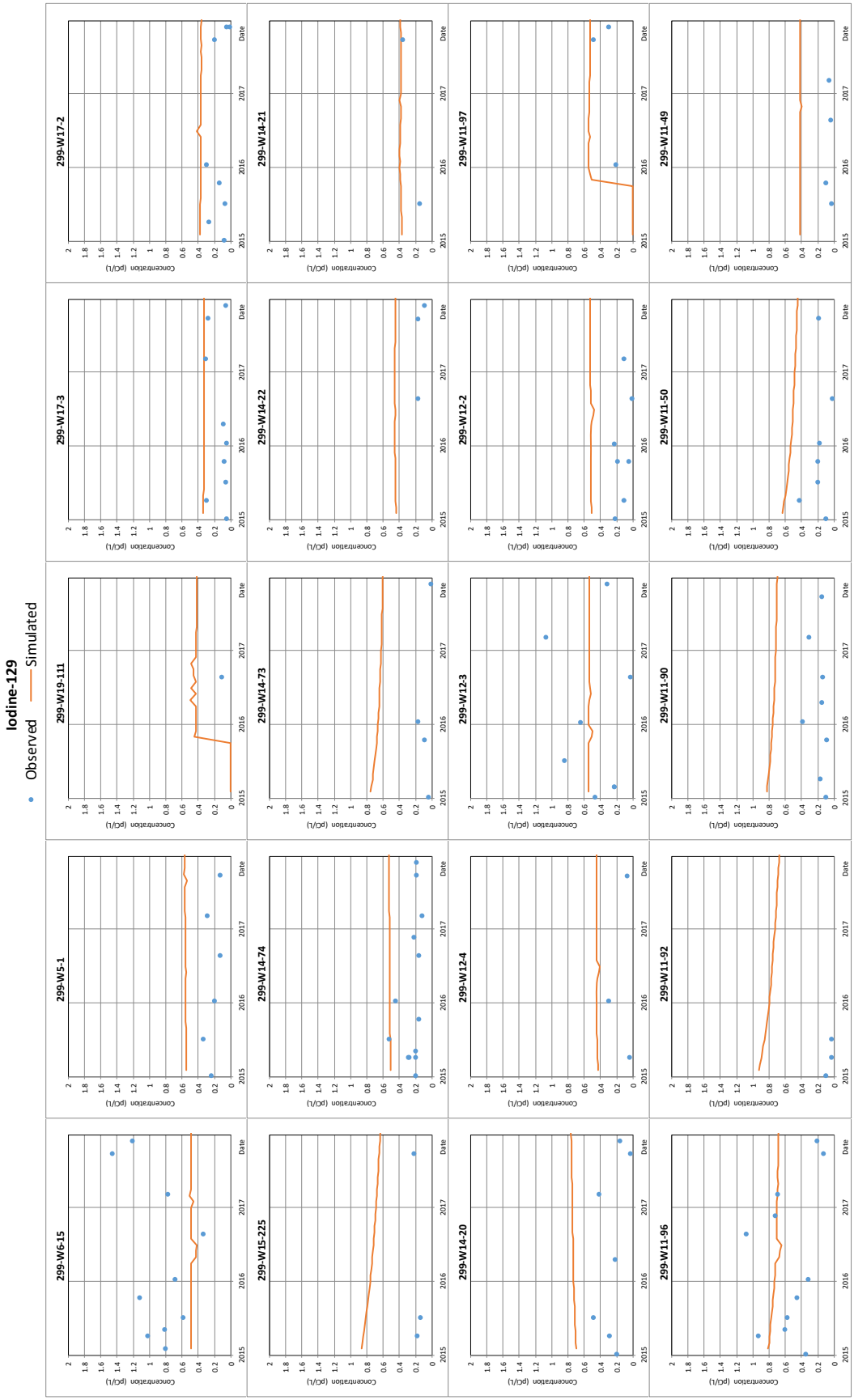


Figure 7-13. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Iodine-129

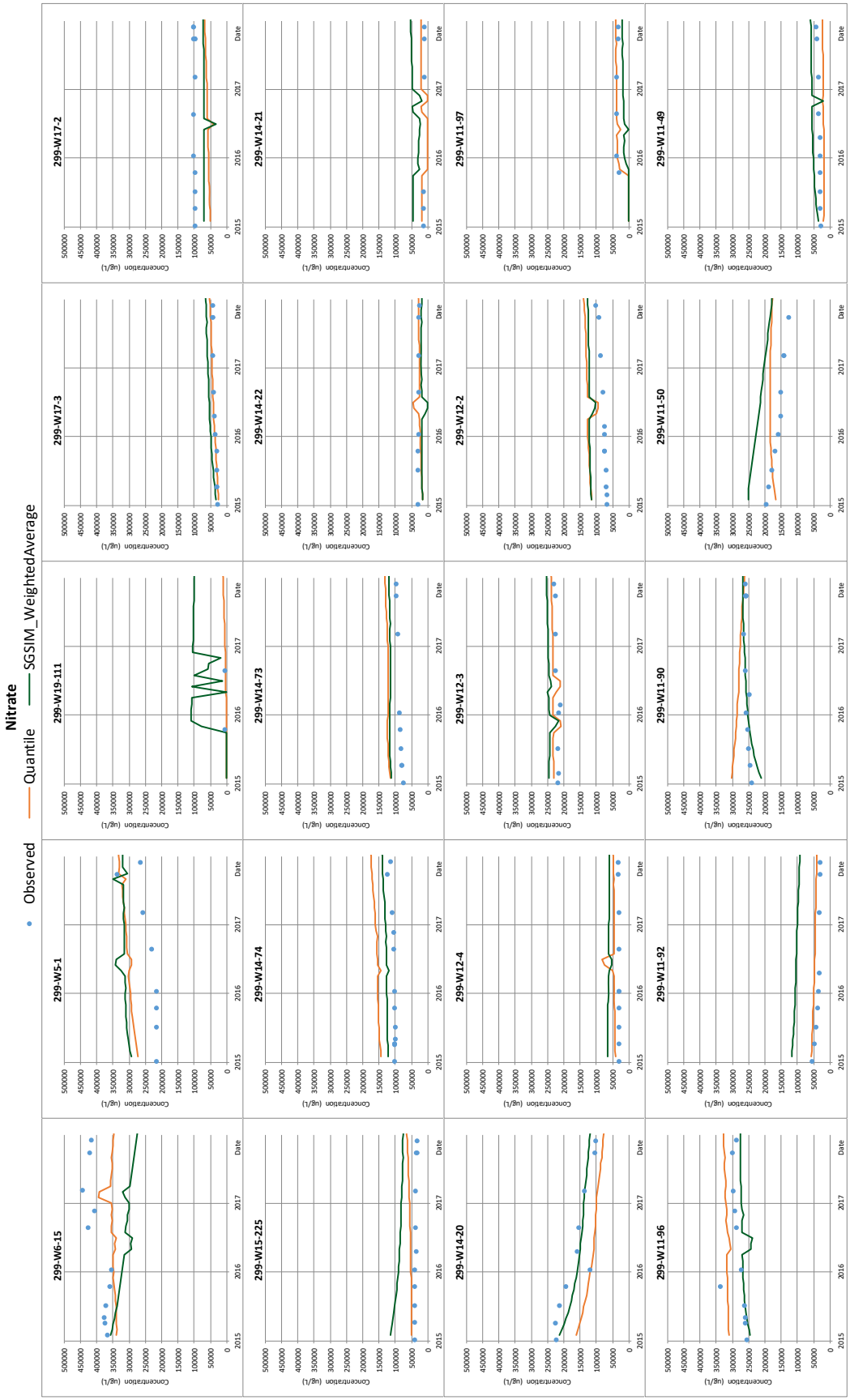


Figure 7-14. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Nitrate

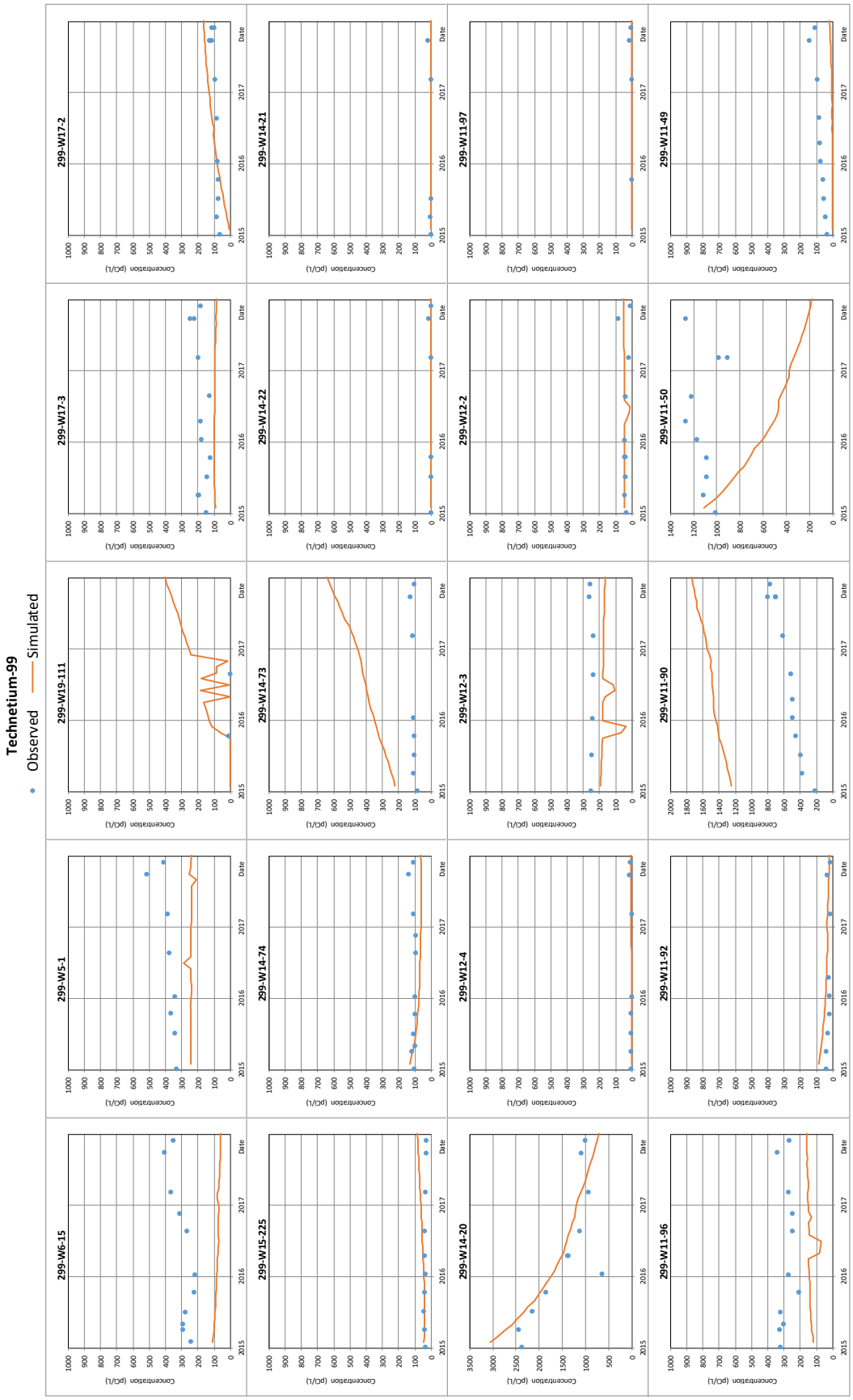


Figure 7-15. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Technetium-99

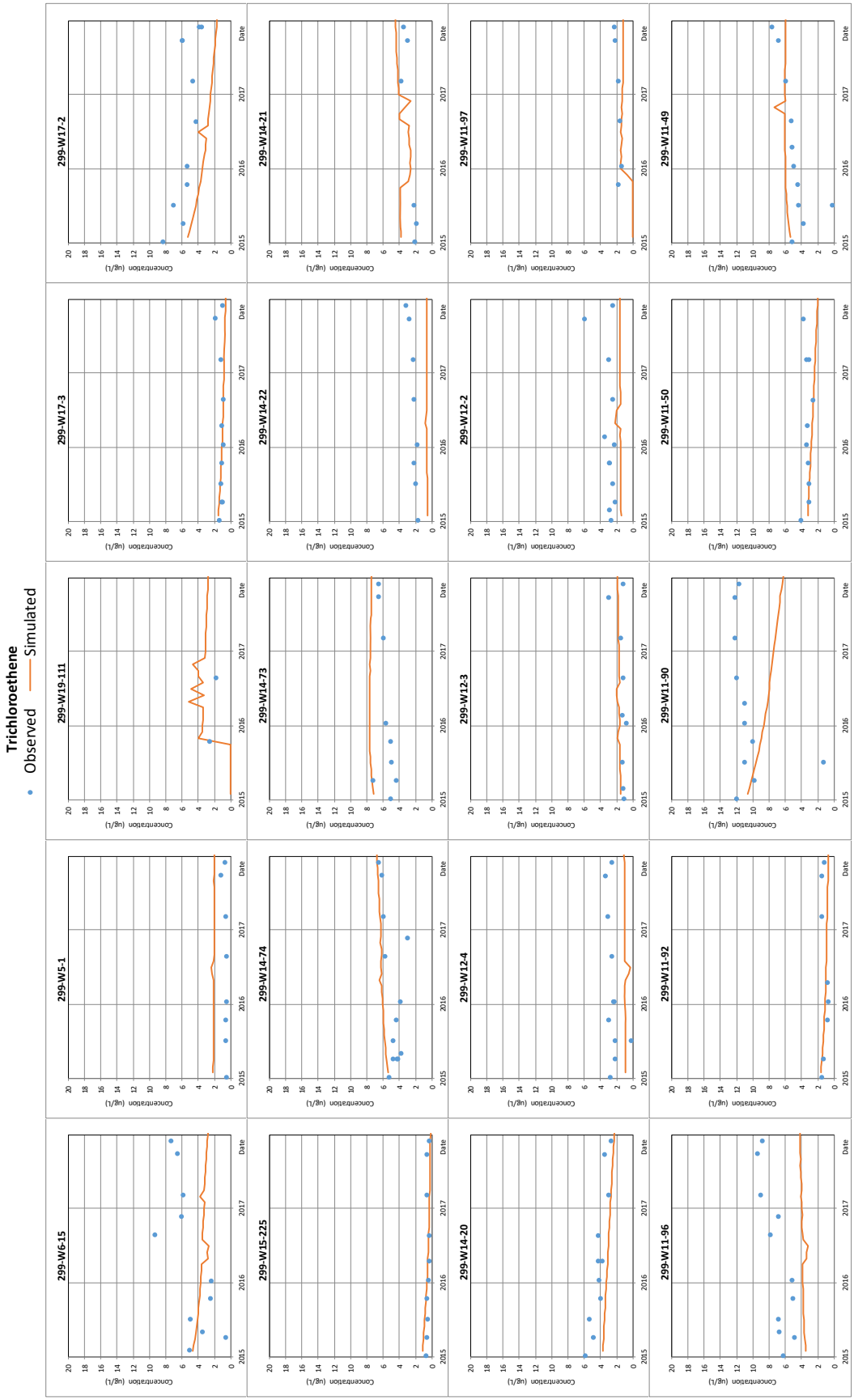


Figure 7-16. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Trichloroethene

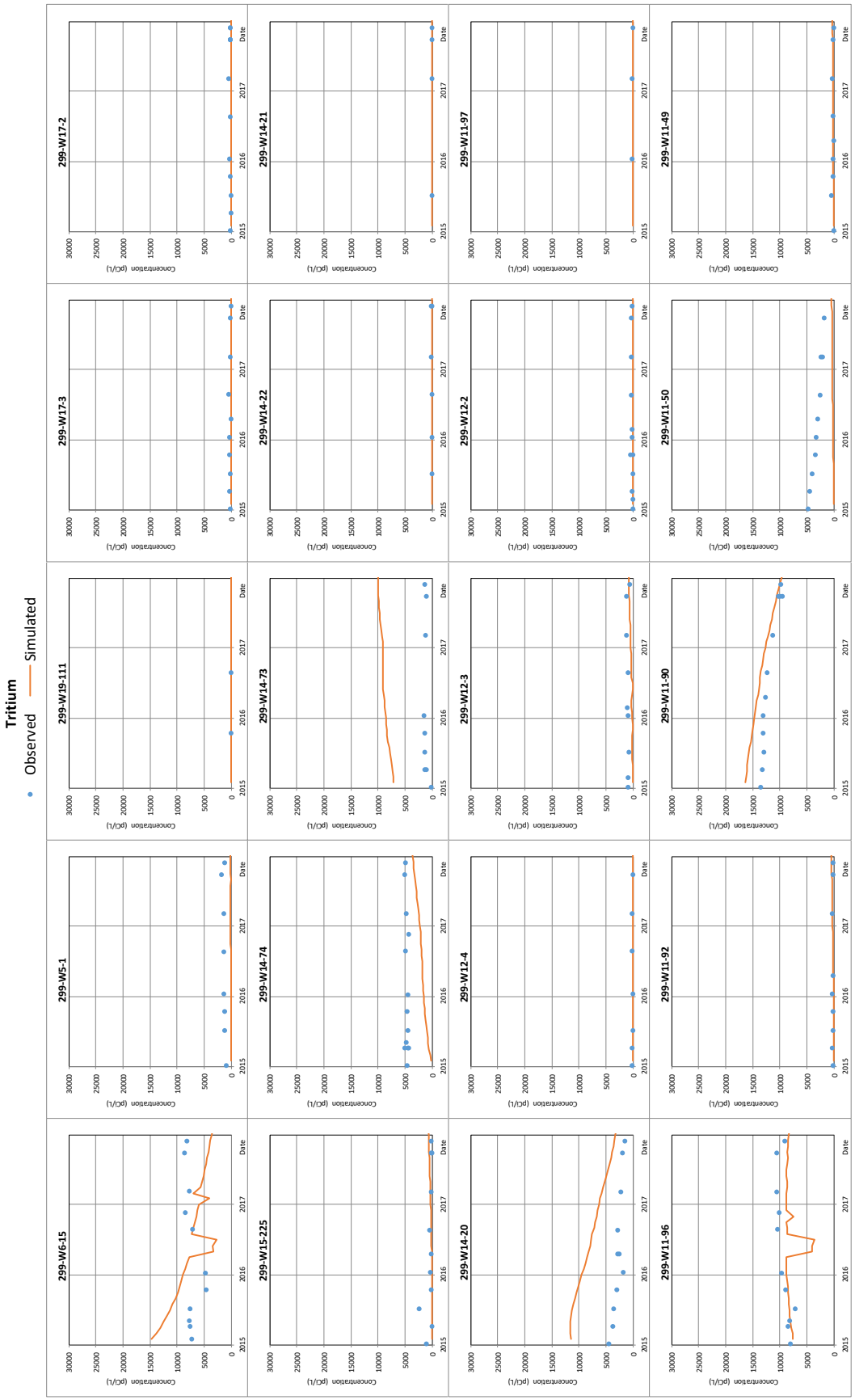


Figure 7-17. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Tritium

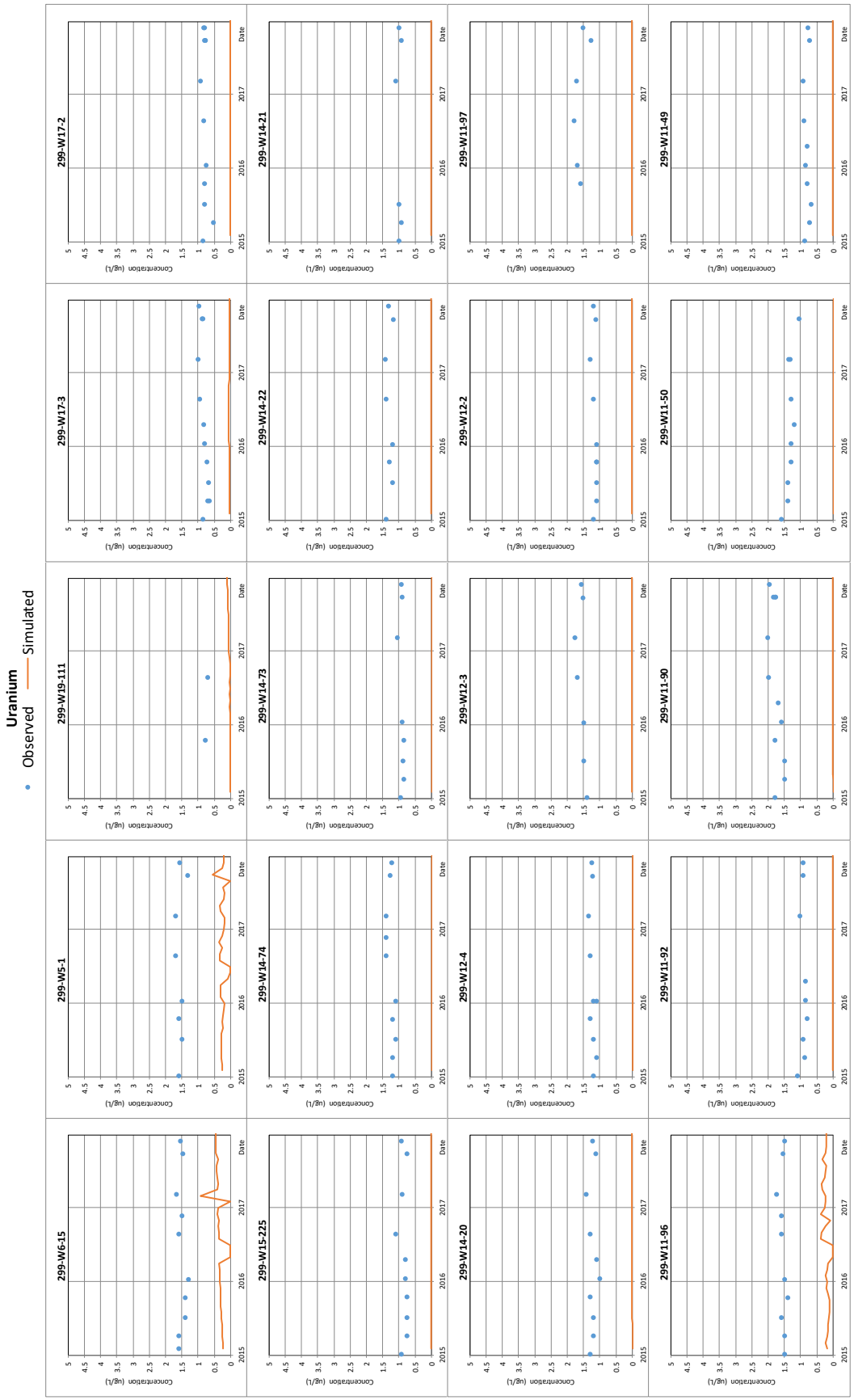


Figure 7-18. Comparison of Simulated and Observed Historical Influent Concentrations at 200-ZP-1 for Uranium

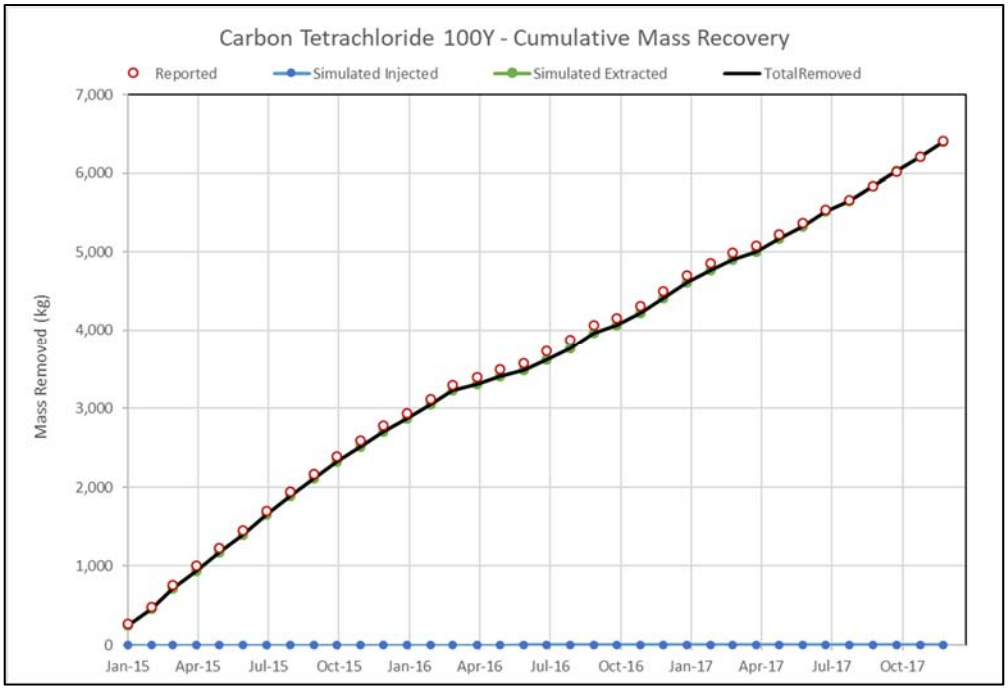


Figure 7-19. Cumulative Mass Removal for Carbon Tetrachloride 100Y Half Life

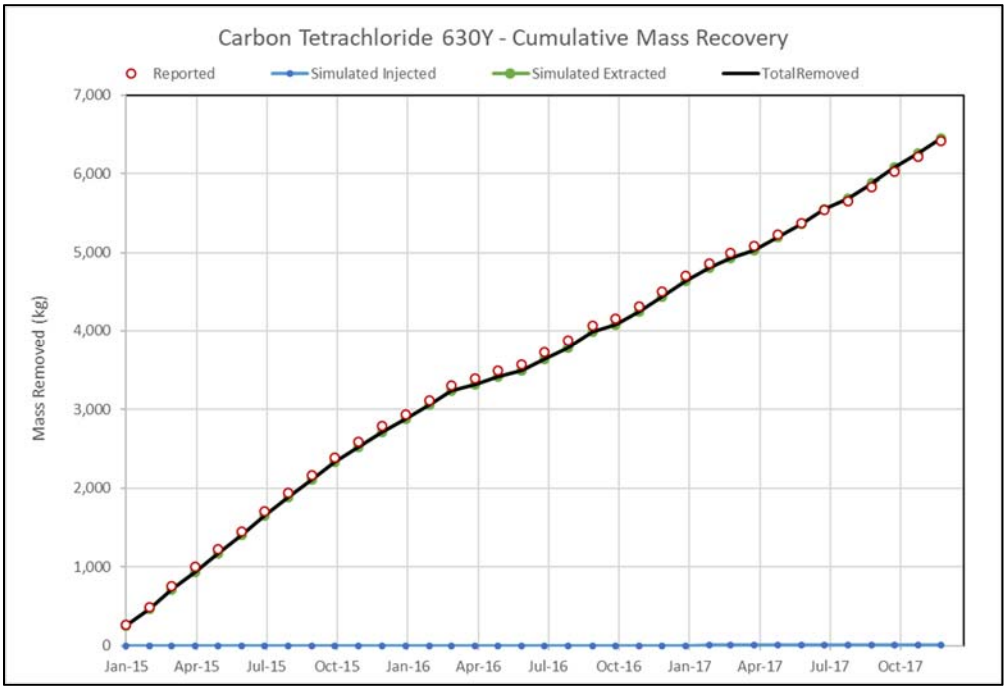


Figure 7-20. Cumulative Mass Removal for Carbon Tetrachloride 630Y Half Life

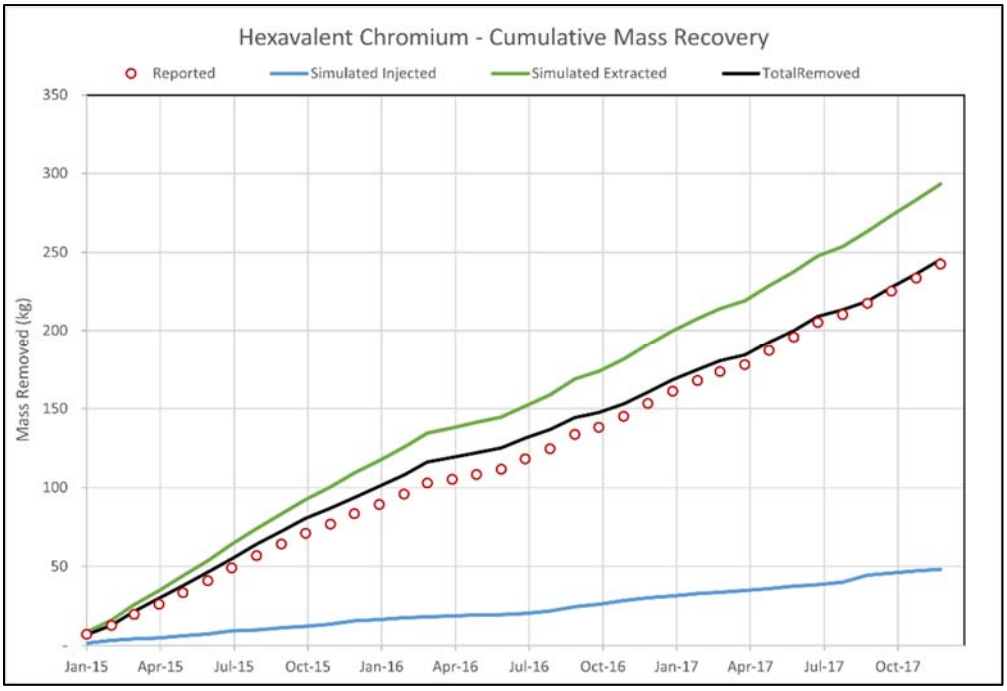


Figure 7-21. Cumulative Mass Removal for Hexavalent Chromium

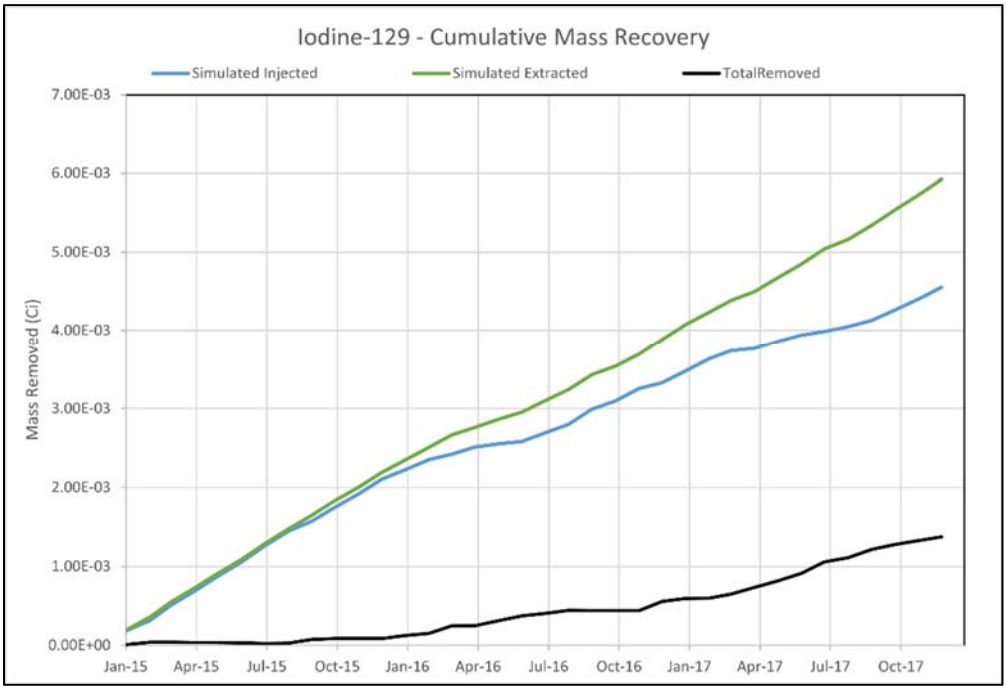


Figure 7-22. Cumulative Mass Removal for Iodine-129

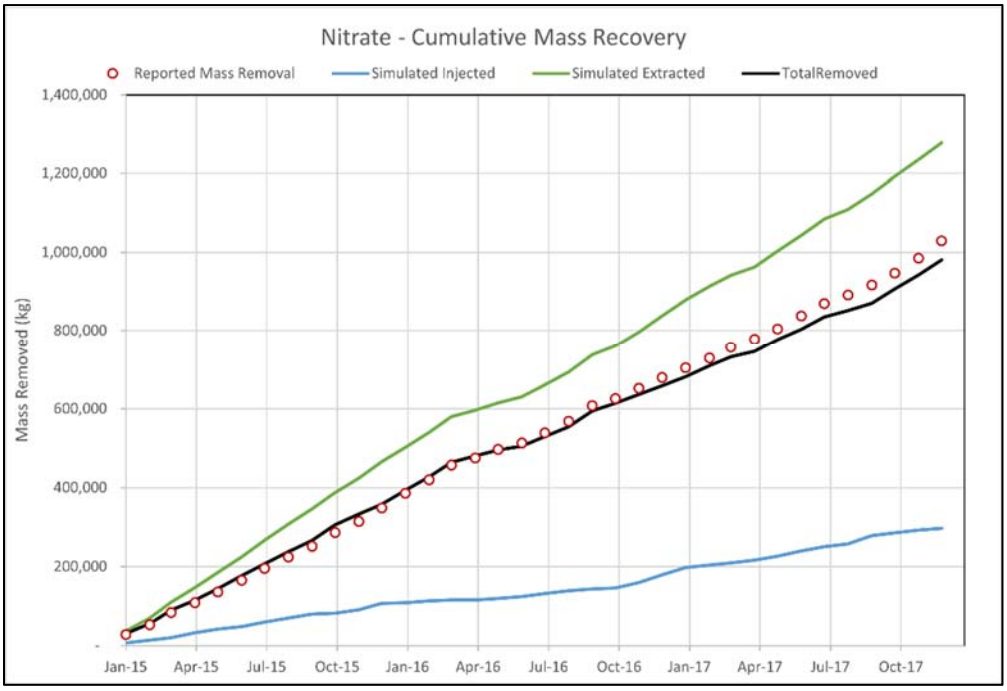


Figure 7-23. Cumulative Mass Removal for Nitrate

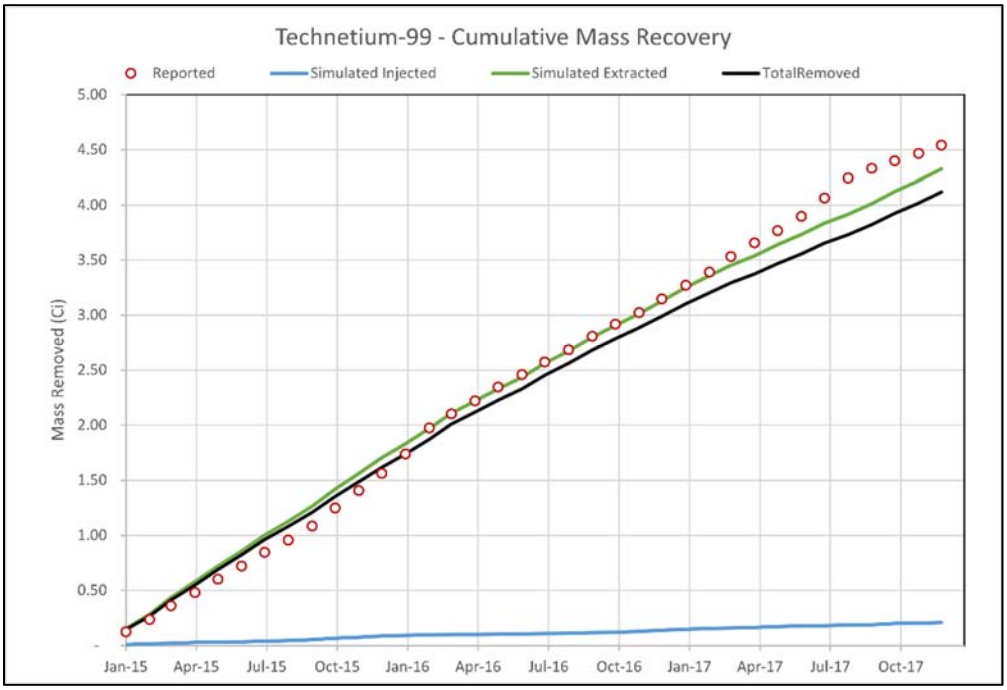


Figure 7-24. Cumulative Mass Removal for Technetium-99

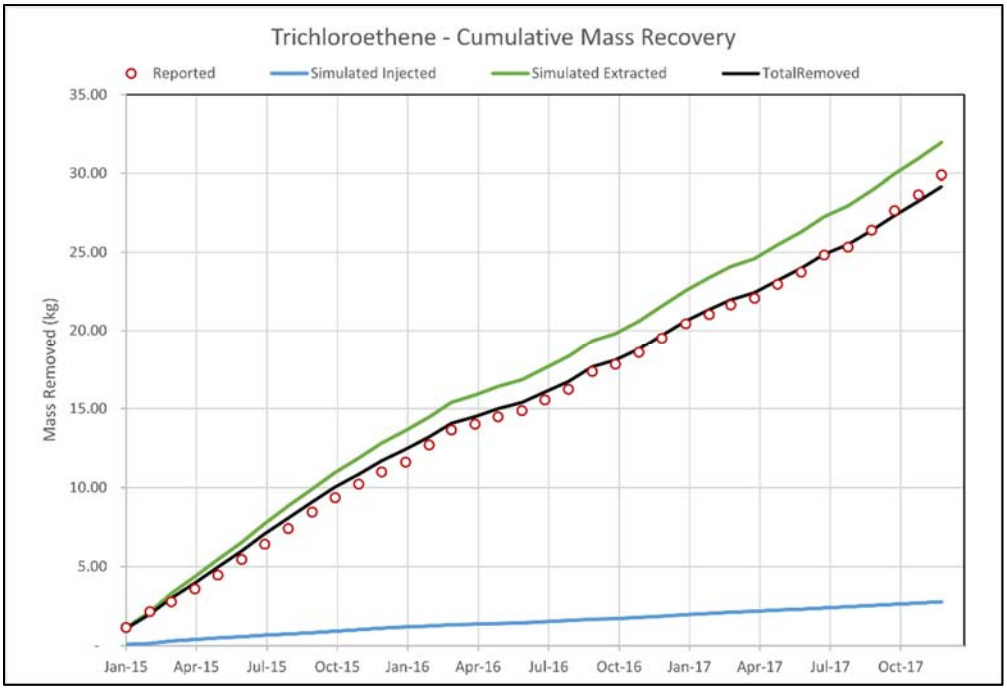


Figure 7-25. Cumulative Mass Removal for Trichloroethene

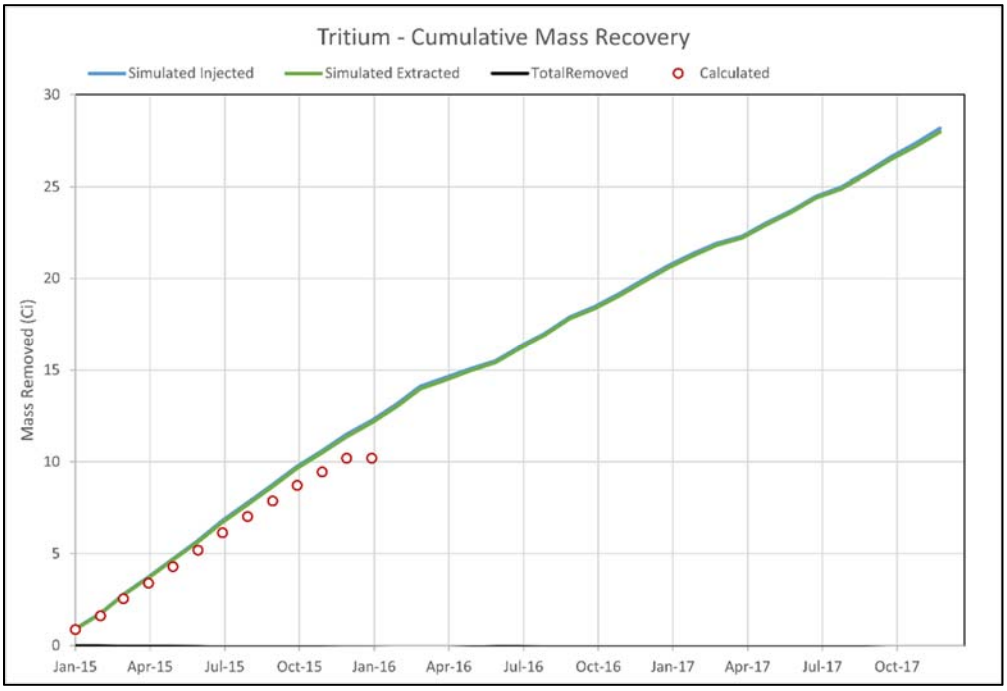


Figure 7-26. Cumulative Mass Removal for Tritium

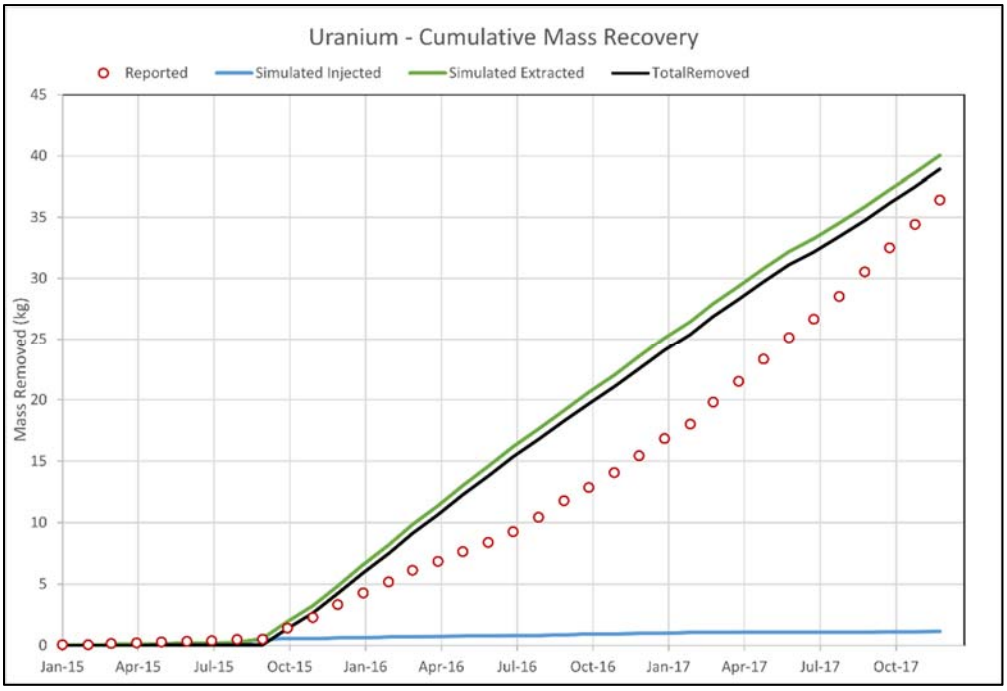


Figure 7-27. Cumulative Mass Removal for Uranium

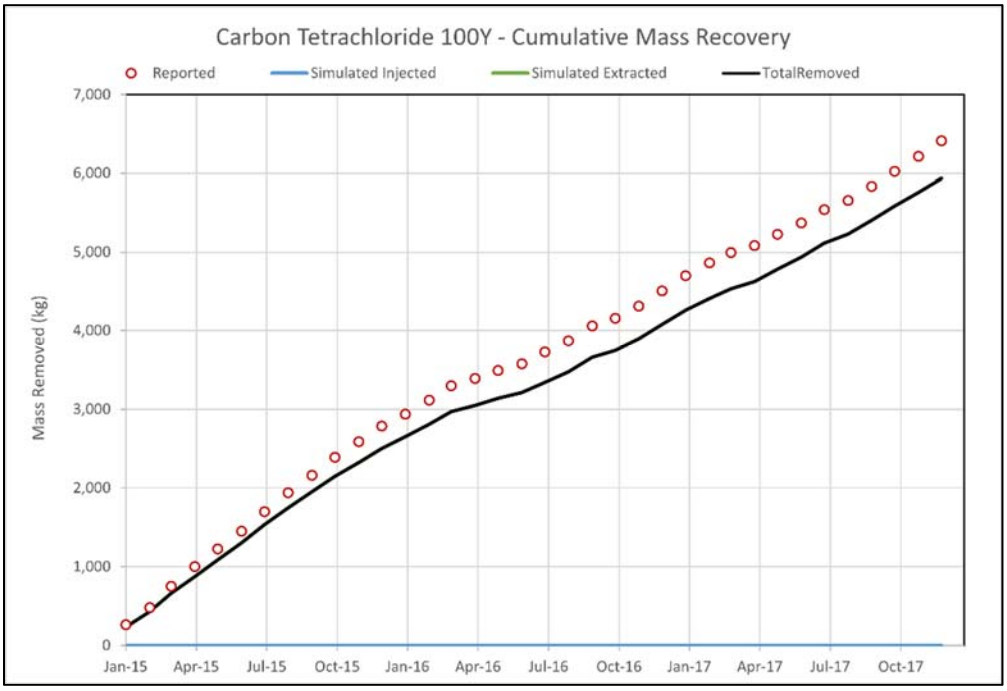


Figure 7-28. Cumulative Mass Removal for Carbon Tetrachloride 100Y Half Life - SGSIM Weighted Average Method

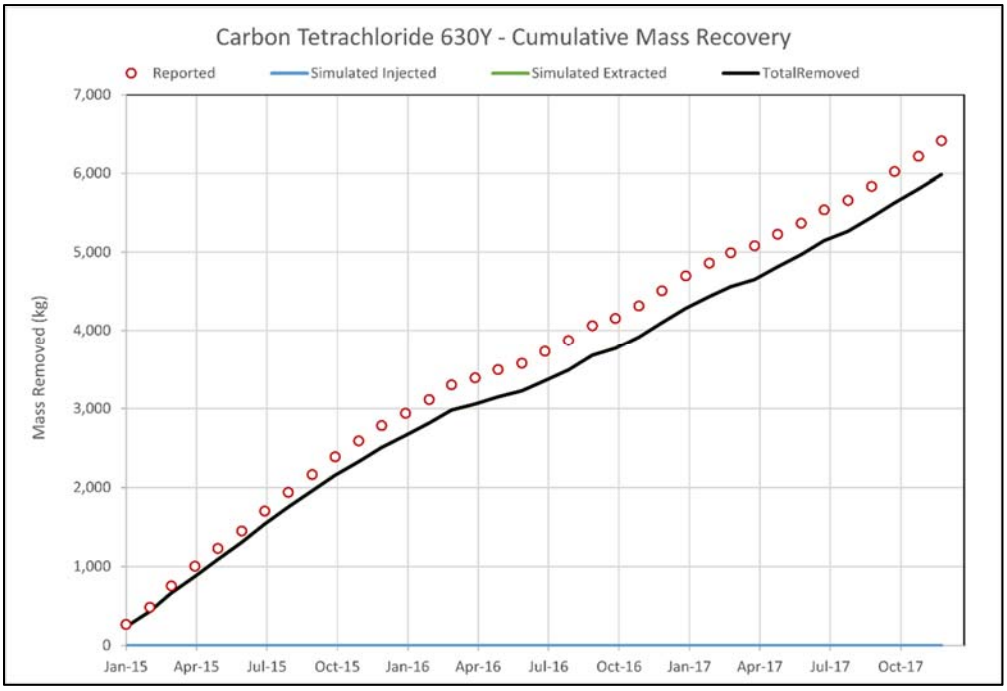


Figure 7-29. Cumulative Mass Removal for Carbon Tetrachloride 630Y Half Life - SGSIM Weighted Average Method

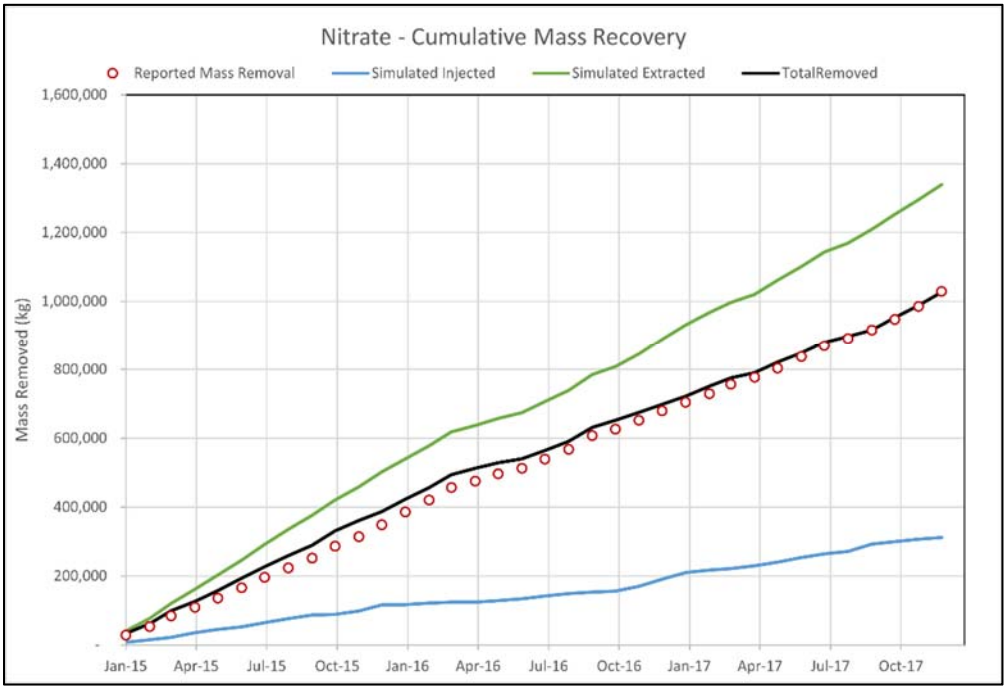


Figure 7-30. Cumulative Mass Removal for Nitrate – SGSIM Weighted Average Method

7.1.4 Projected Remedial System Mass Removal

The results of the predictive simulations of contaminant transport simulated using the CPGWM, based upon data obtained through CY 2015, are presented in Figures 7-31 through 7-42. The terms that are depicted in these figures are defined as follows:

- **Well:** The cumulative mass recovery at pumping wells, as read directly from the standard transport model output file.
- **Reactions:** The cumulative mass destruction via reactions (e.g., radioactive decay and degradation), as read directly from the standard transport model output file.
- **Simulated Mass Extracted + Decay:** The cumulative mass removed by wells and reactions.
- **Mass Remaining:** The initial mass less the cumulative mass removed by wells and reactions.
- **Actual Mass Removed:** The cumulative reported mass removed.

Figures 7-31 through 7-39 depict the projected cumulative mass recovery and the cumulative mass recovered as a fraction of initial mass (percentage) for simulations using initial plumes generated by ordinary kriging – quantile method as follows:

- Figure 7-31: carbon tetrachloride (assuming a 100-year half-life)
- Figure 7-32 carbon tetrachloride (assuming a 630-year half-life)
- Figure 7-33: hexavalent chromium
- Figure 7-34: iodine-129
- Figure 7-35: nitrate
- Figure 7-36: technetium-99
- Figure 7-37: trichloroethene
- Figure 7-38: tritium
- Figure 7-39: uranium

Figures 7-40 through 7-42 depict the projected cumulative mass recovery and the cumulative mass recovered as a fraction of initial mass (percentage) for carbon tetrachloride and nitrate which initial plumes were generated using SGSIM “weighted-average” method as follows:

- Figure 7-40: carbon tetrachloride (assuming a 100-year half-life)
- Figure 7-41 carbon tetrachloride (assuming a 630-year half-life)
- Figure 7-42: nitrate

Inflections in the “well” and “sinks” curves are seen to occur around 2037 and result from the simulated cessation of pumping at the 200-ZP-1 OU at that time.

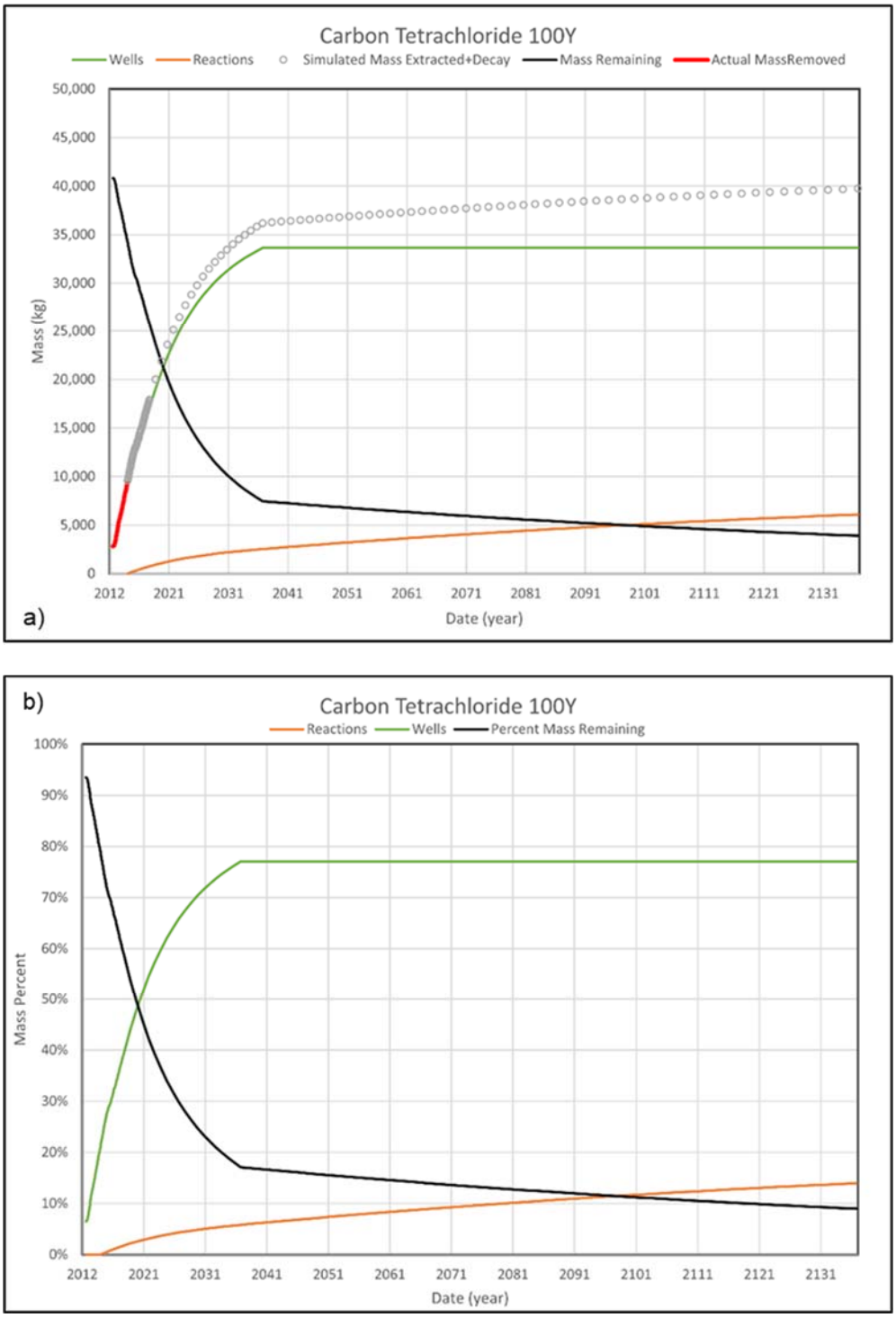


Figure 7-31. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Carbon Tetrachloride (Assuming 100-Year Half-Life) – Quantile Method

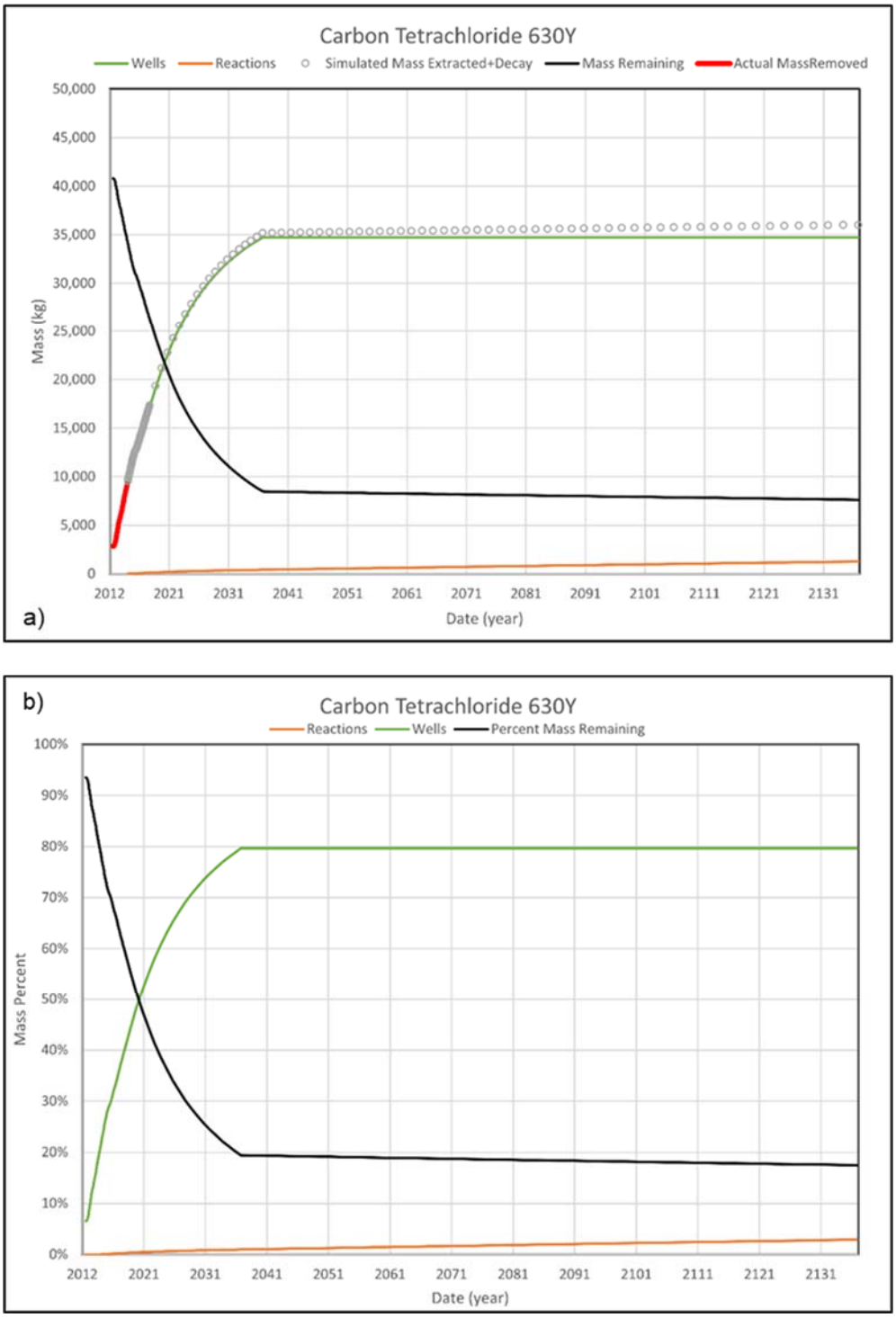


Figure 7-32. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Carbon Tetrachloride (Assuming 630-Year Half-Life) – Quantile Method

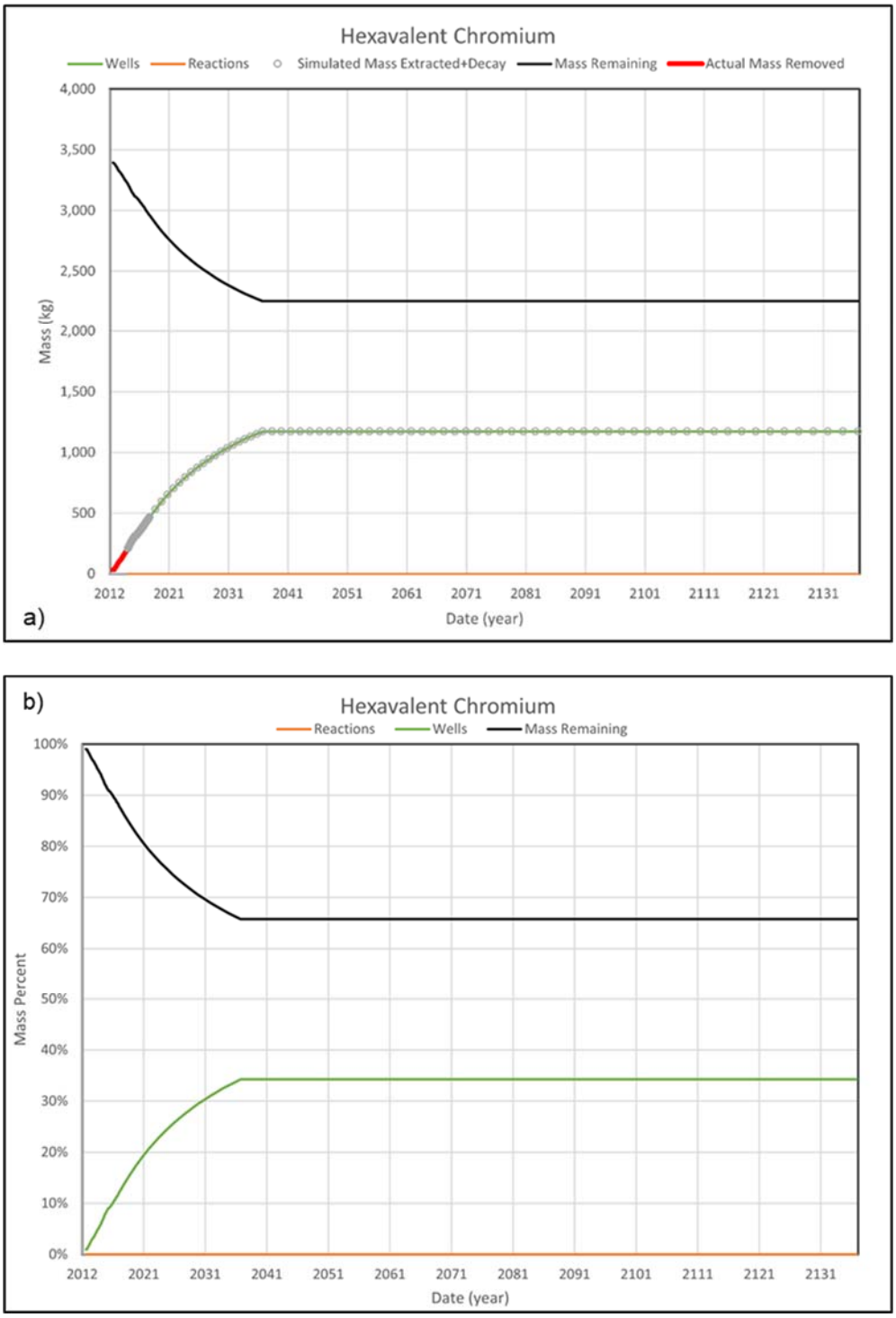


Figure 7-33. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Hexavalent Chromium

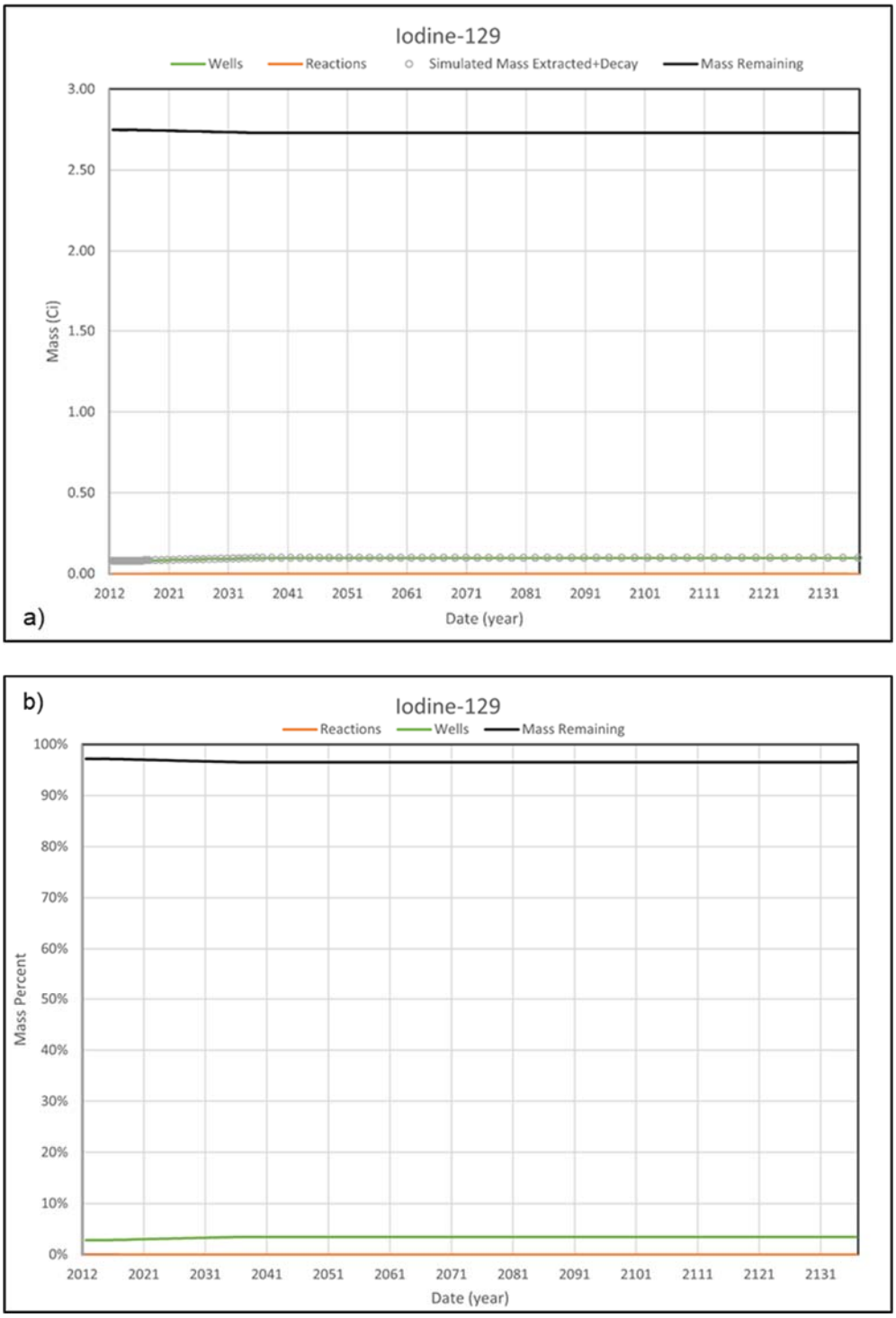


Figure 7-34. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Iodine-129

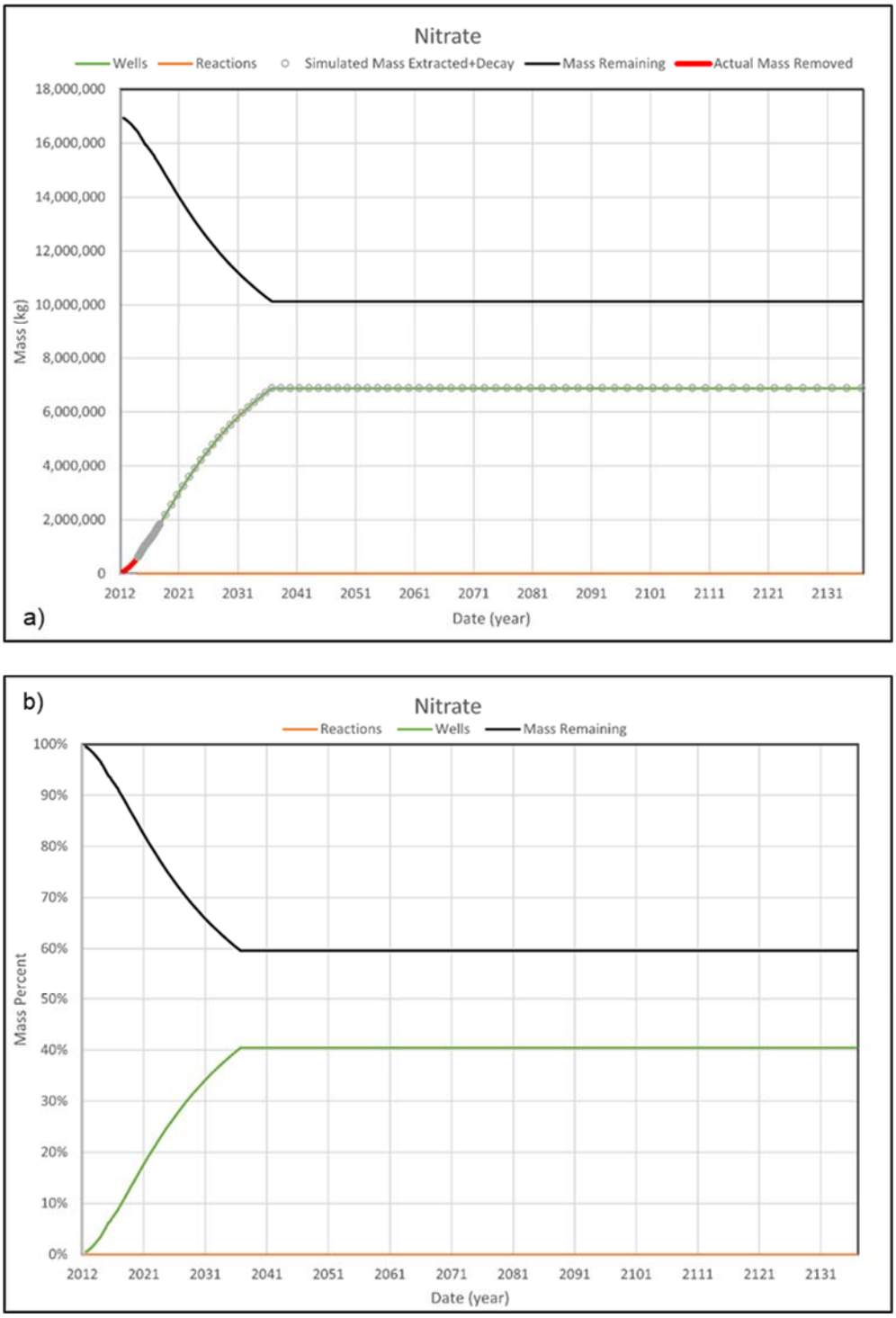


Figure 7-35. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Nitrate – Quantile Method

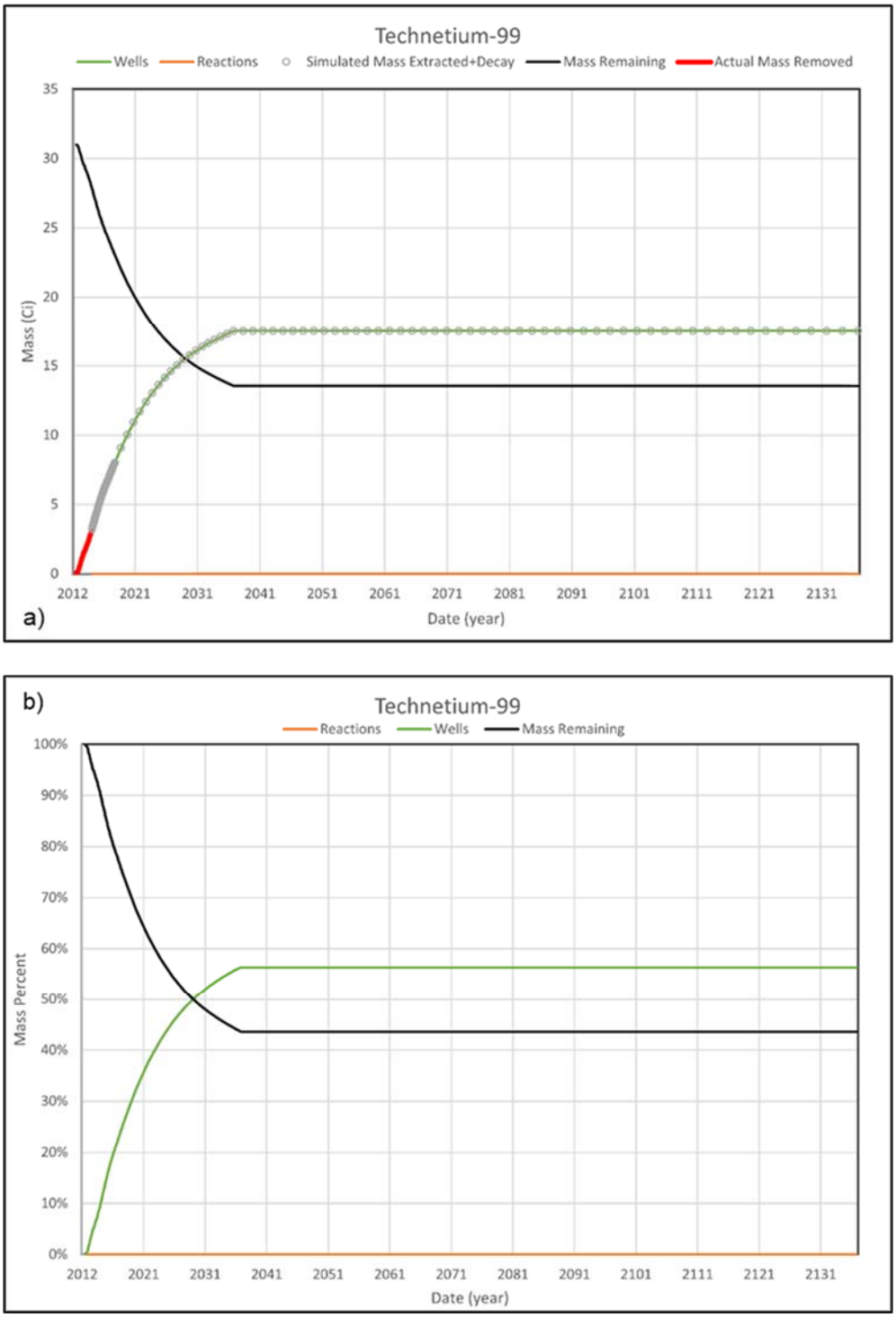


Figure 7-36. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Technetium-99

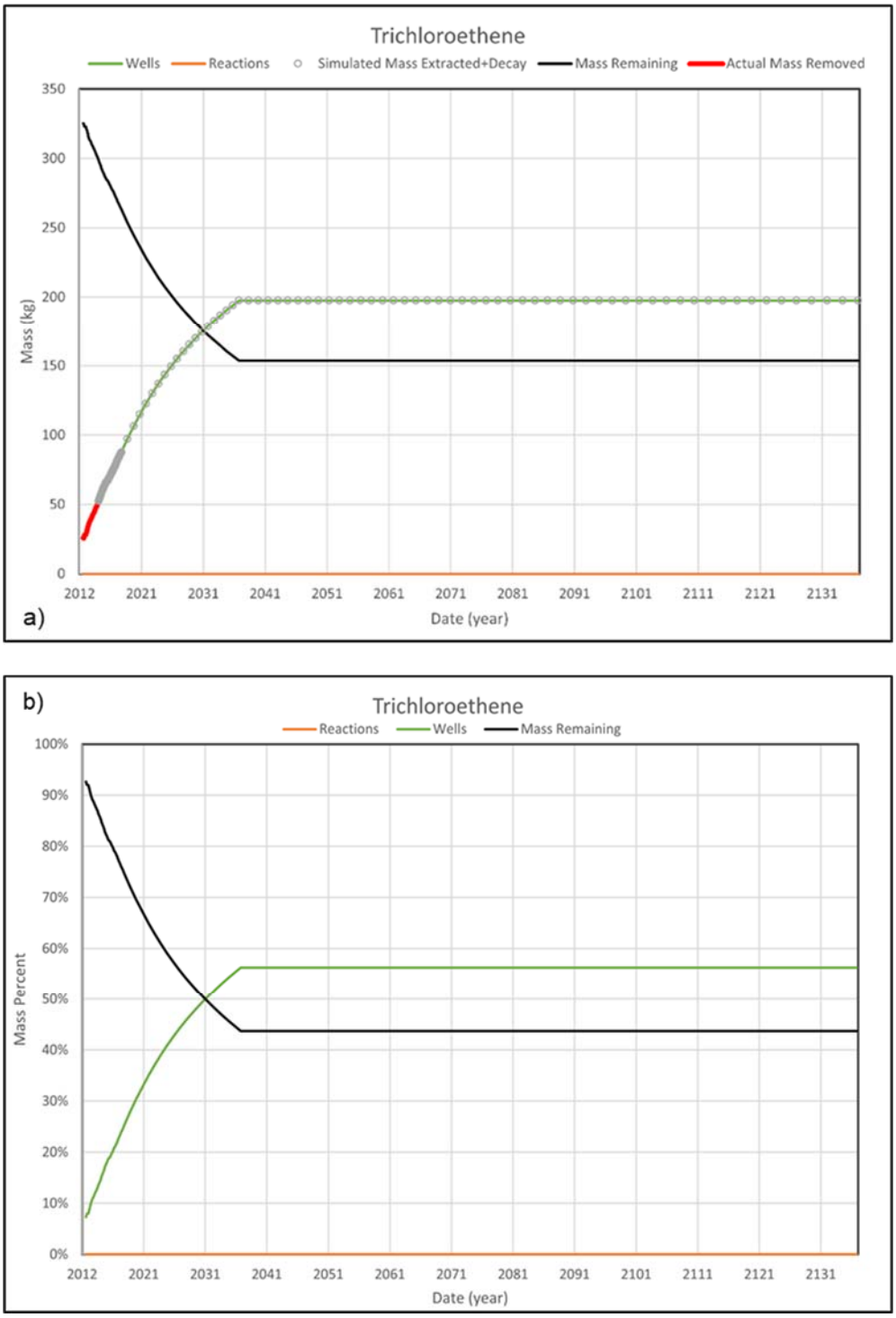


Figure 7-37. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Trichloroethene

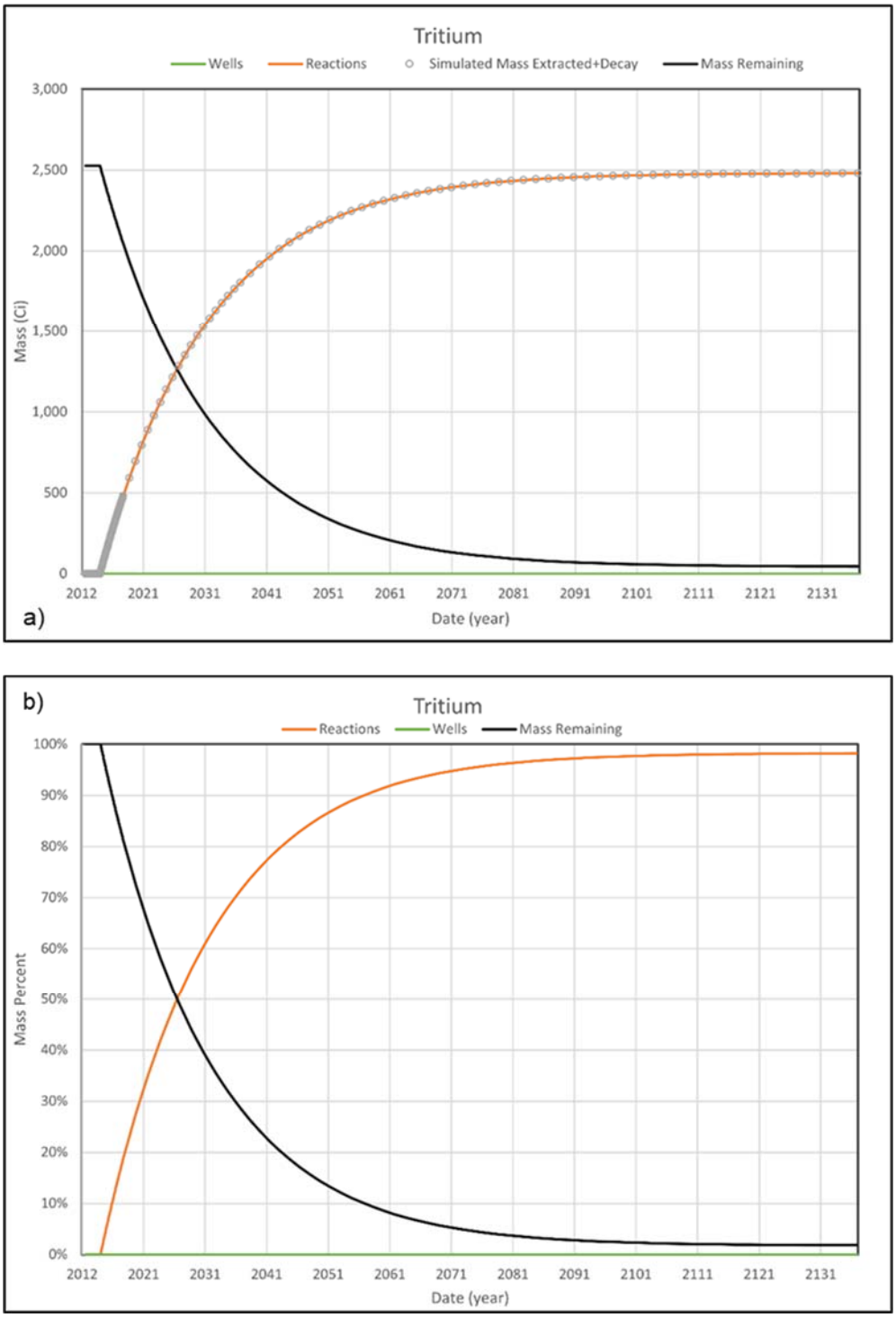


Figure 7-38. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Tritium

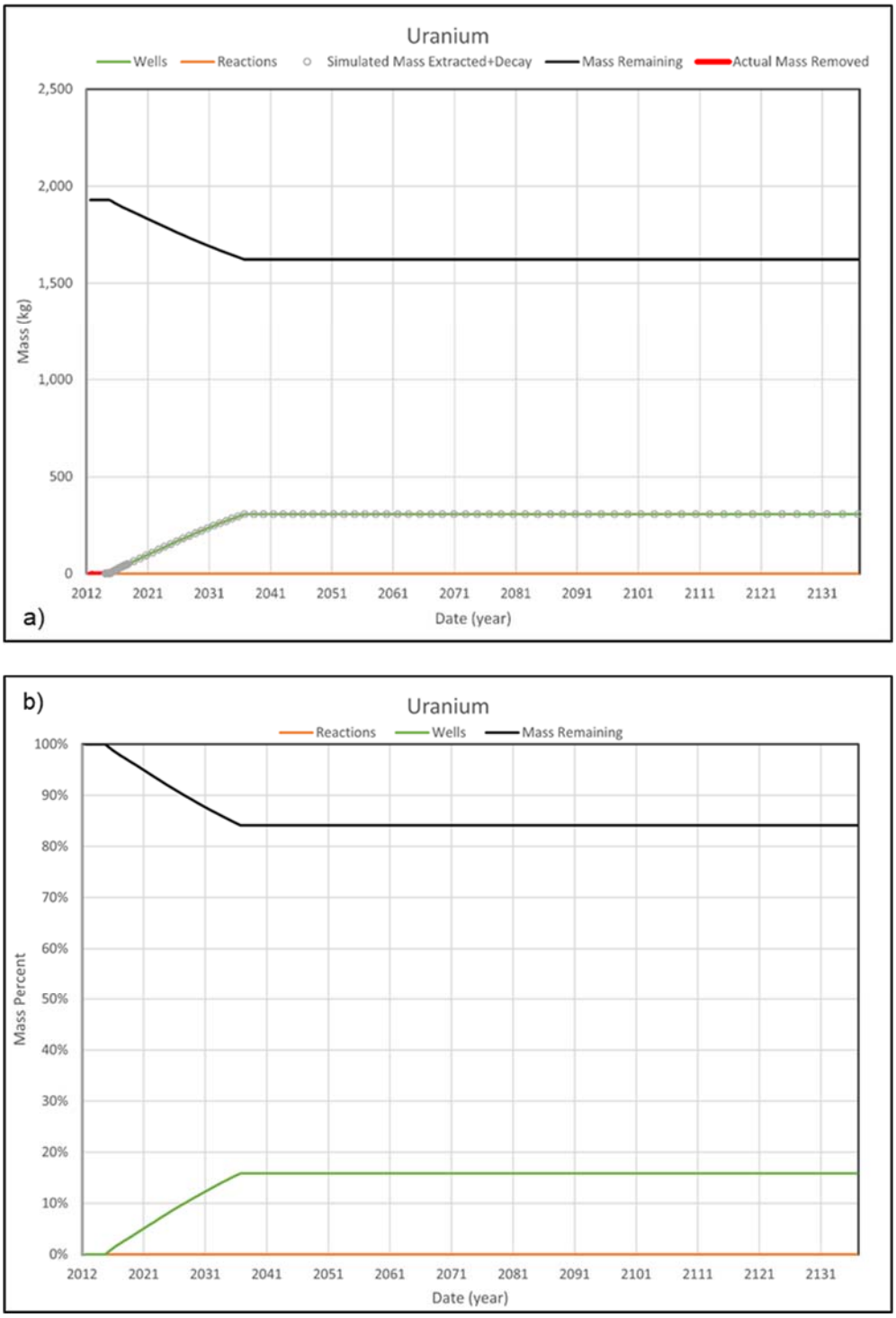


Figure 7-39. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Uranium

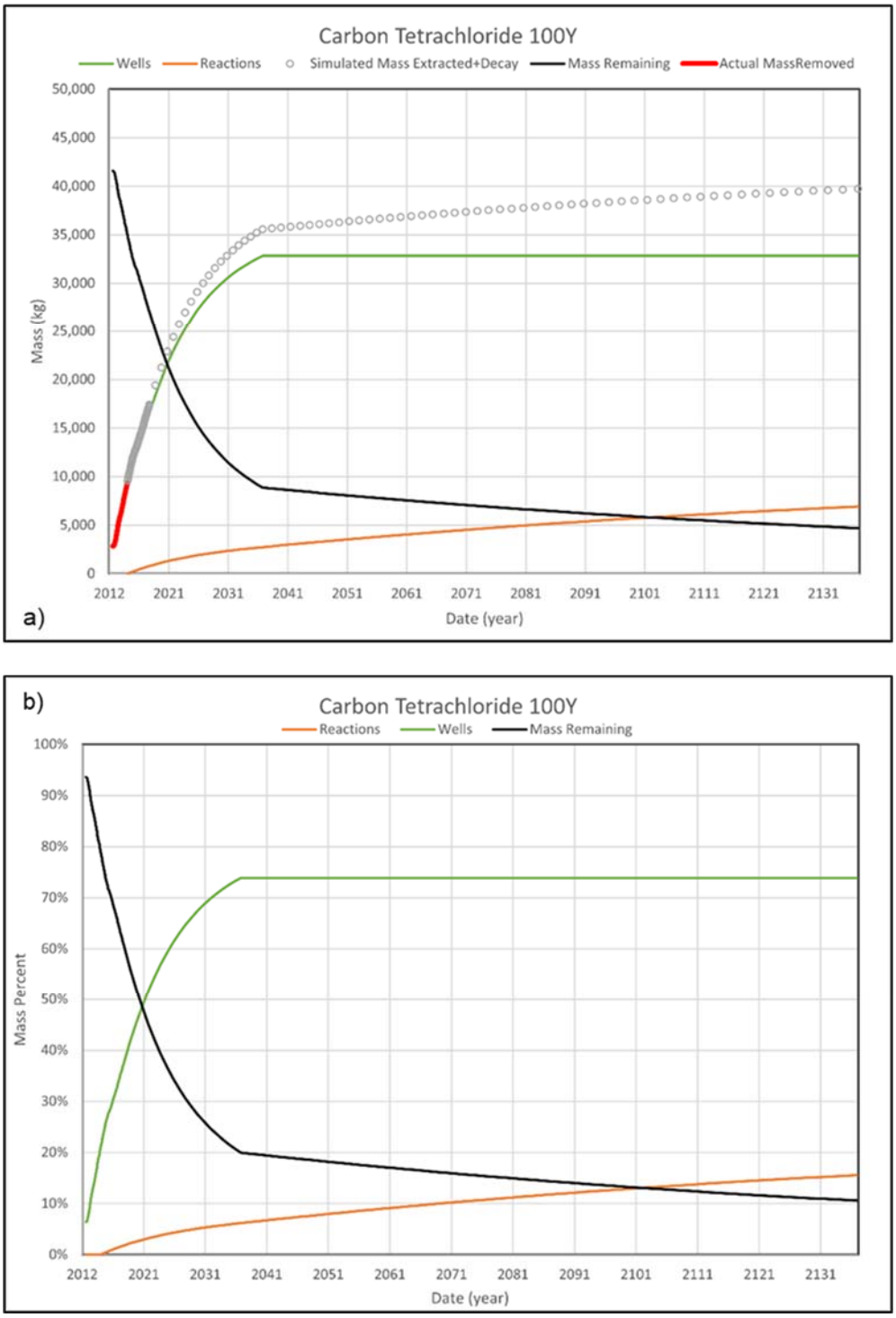


Figure 7-40. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Carbon Tetrachloride (Assuming 100-Year Half-Life) – SGSIM Method

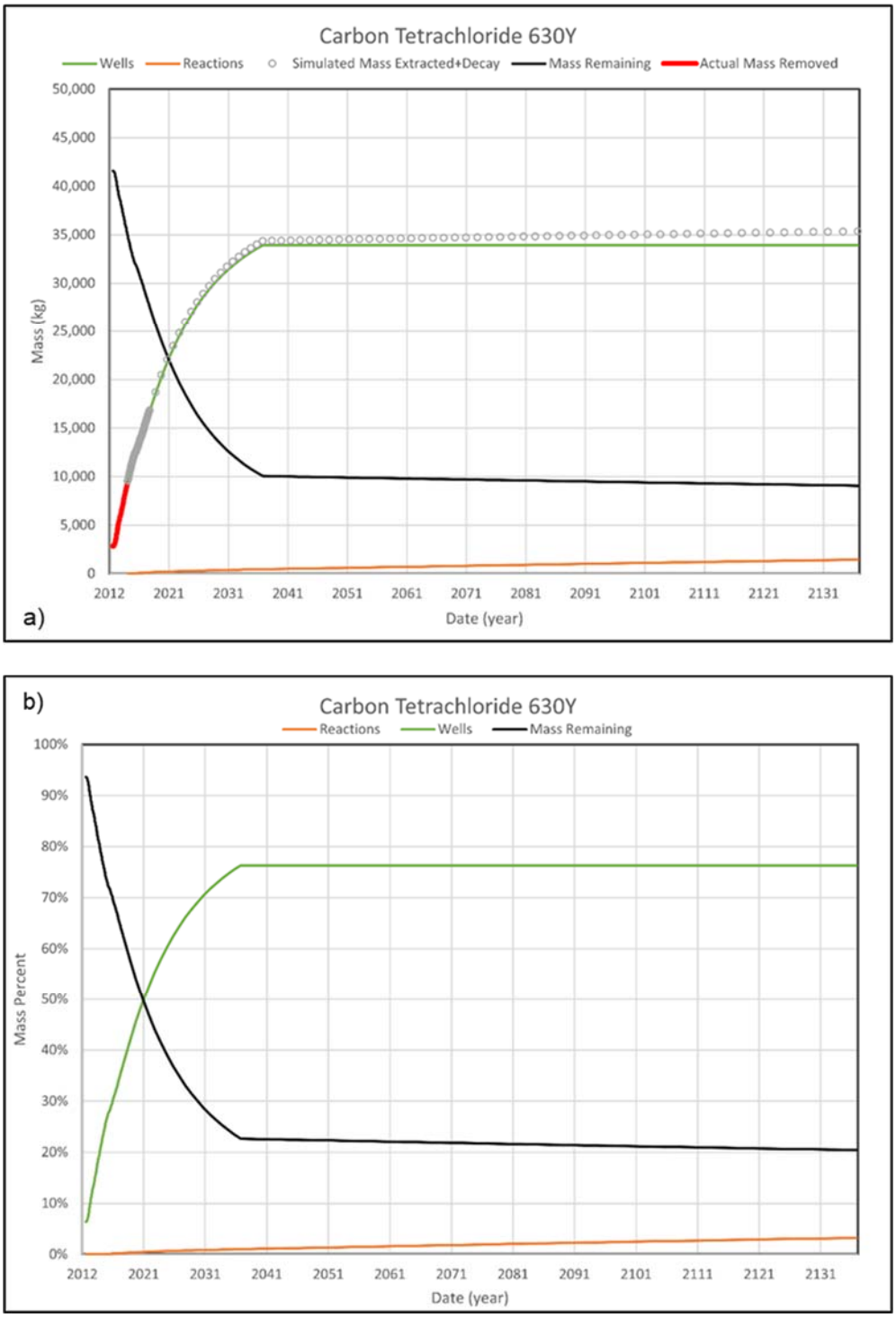


Figure 7-41. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Carbon Tetrachloride (Assuming 630-Year Half-Life) – SGSIM Method

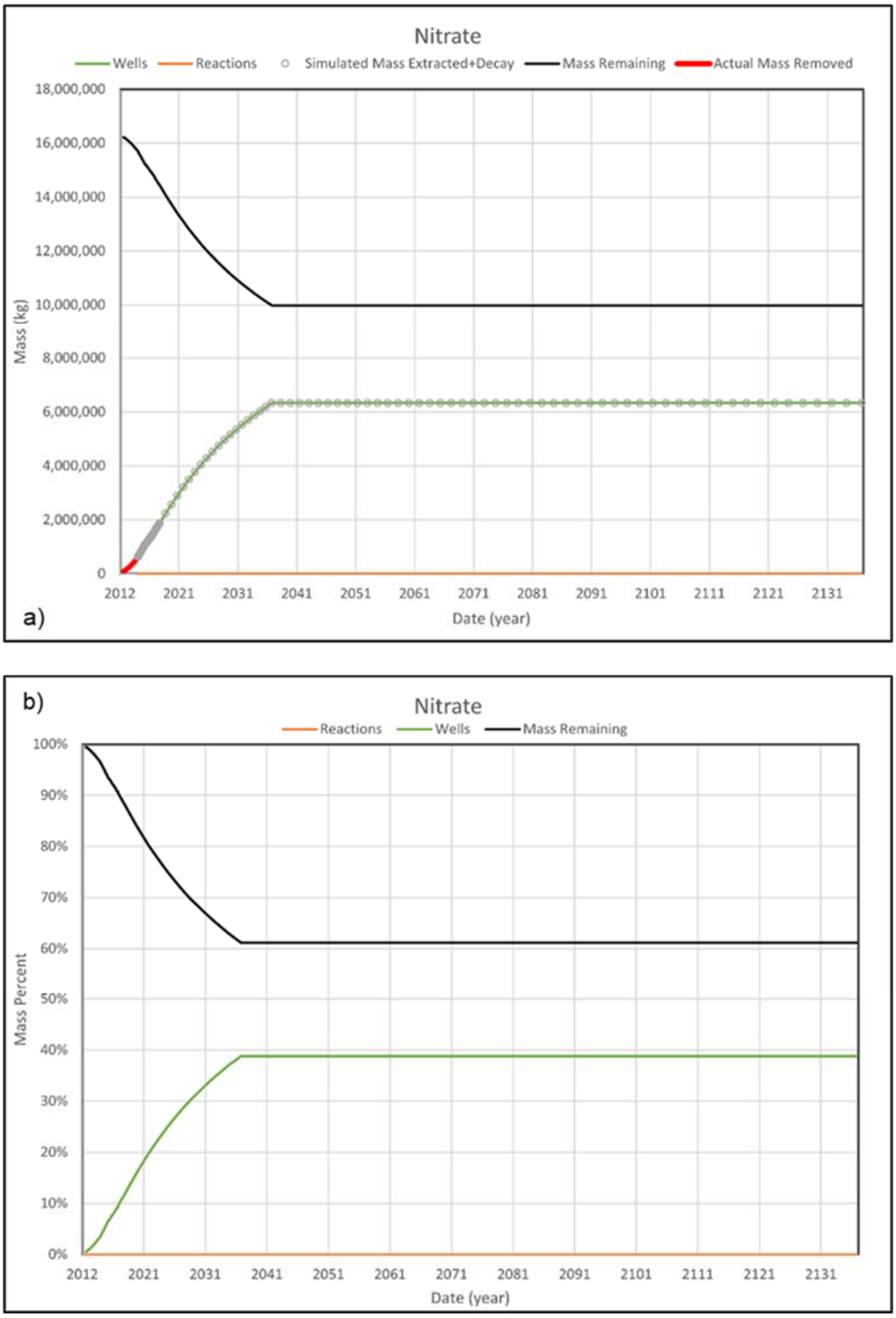


Figure 7-42. Projected (a) Cumulative Mass Recovery, and (b) Cumulative Mass Recovered as a Fraction of Initial Mass (%) for Nitrate – SGSIM Method

Figures 7-43 And 7-44 depict the projected cumulative carbon tetrachloride mass recovered as a fraction of initial mass (percentage) for different SGSIM realizations compared to the quantile-kriging and SGSIM weighted-average initial plumes as follow:

- Figure 7-43: carbon tetrachloride (assuming a 100-year half-life)
- Figure 7-44: carbon tetrachloride (assuming a 630-year half-life)

The estimated range from 52% to 95%, represents the range in uncertainty in the initial conditions. The projected mass removal using the either quantile or SGSIM "weighted average" plumes suggests that the 95% mass remediation goal will not be achieved with the current well field and operational parameters.

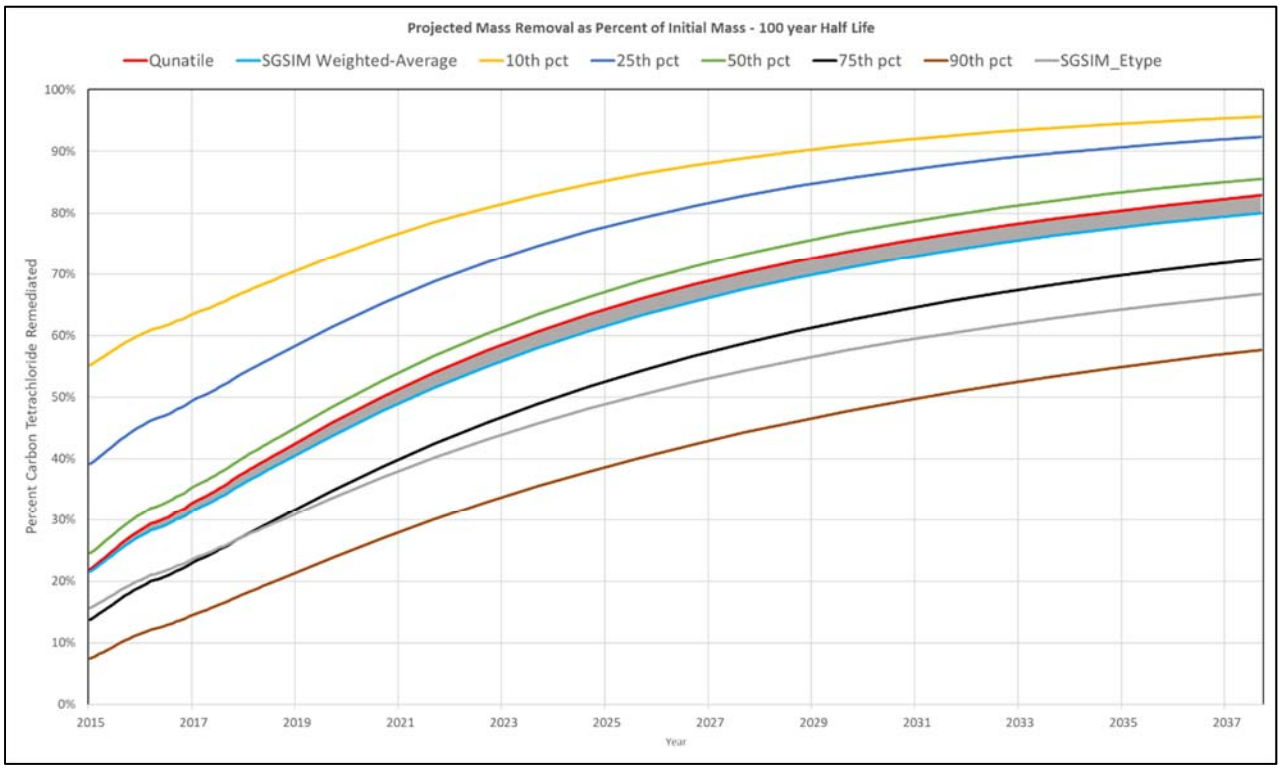


Figure 7-43. Projected Cumulative Mass Recovery as a Fraction of Initial Mass for Carbon Tetrachloride - 100 Year Half Life

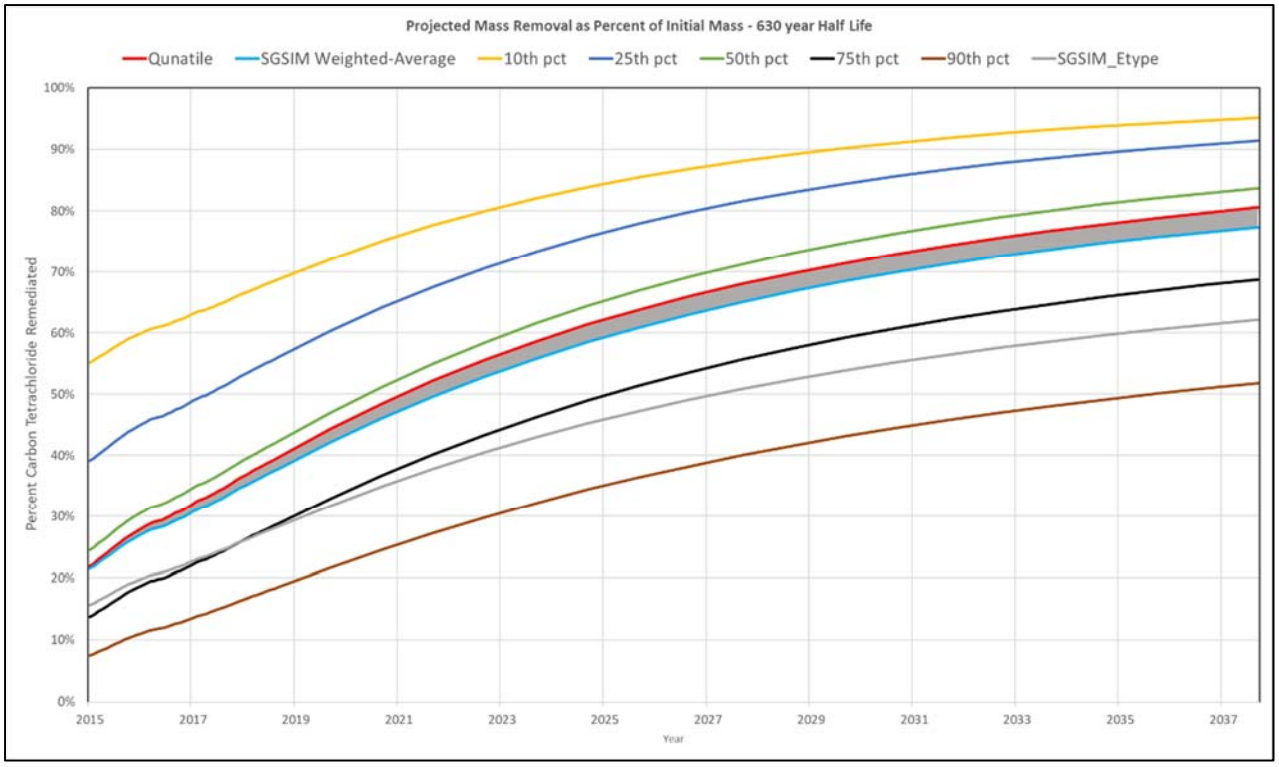


Figure 7-44. Projected Cumulative Mass Recovery as a Fraction of Initial Mass for Carbon Tetrachloride - 630 Year Half Life

Table 7-1 presents a summary of the projected carbon tetrachloride mass that will be recovered by the 200 West P&T remedy at the end of active pumping (CY 2037) and the fraction of the initial mass that this represents, for different SGSIM realizations compared to the quantile-kriging and SGSIM weighted-average.

Table 7-2 presents a summary of the projected contaminant mass that will be recovered by the 200 West P&T remedy, the fraction of the initial mass that this represents, and selected concentration statistics (i.e., the median, average, and 90th percentile) for each COC remaining in groundwater at the end of active pumping (CY 2037).

Figures 7-45 through 7-48 depict the projected cumulative carbon tetrachloride plume extents for years 2022, 2027, 2032, and 2037 compared to the initial mass in 2015 as generated using the quantile method.

Table 7-1. Mass Recovered, Fraction of Initial Mass Recovered for Carbon Tetrachloride at End of Active Pumping (2037)

Run	Initial Condition	Half Life (years)	K_d	Porosity	Calculated R*	Initial Mass 2015 (kg)			Mass Remediated by P&T (kg)	Mass Decayed (kg)	Total Mass Removed (kg)	Mass removed prior CY 2015	% Total Mass Remediated in 2037	% Dissolved Mass Remediated in 2037
						Dissolved	Sorbed	Total						
1	Quantile Kriging	100	0.011	0.15	1.1404	30,111	4,229	34,340	24,331	2,542	26,872	9,314	83%	89%
2	Stochastic Average Weighted	100	0.011	0.15	1.1404	30,789	4,324	35,112	23,504	2,741	26,244		80%	85%
3	Stochastic E-Type	100	0.011	0.15	1.1404	45,563	6,399	51,962	26,627	4,929	31,557		67%	69%
4	Stochastic 10th Percentile	100	0.011	0.15	1.1404	6,765	950	7,715	6,537	436	6,973		96%	103%
5	Stochastic 25th Percentile	100	0.011	0.15	1.1404	13,021	1,829	14,850	12,095	907	13,002		92%	100%
6	Stochastic 50th Percentile	100	0.011	0.15	1.1404	25,973	3,647	29,620	21,925	2,081	24,006		86%	92%
7	Stochastic 75th Percentile	100	0.011	0.15	1.1404	53,508	7,514	61,022	36,393	5,273	41,666		72%	78%
8	Stochastic 90th Percentile	100	0.011	0.15	1.1404	107,102	15,041	122,143	53,959	12,564	66,524		58%	62%
1	Quantile Kriging	630	0.011	0.15	1.1404	30,111	4,229	34,340	25,440	424	25,864	9,314	81%	86%
2	Stochastic Average Weighted	630	0.011	0.15	1.1404	30,789	4,324	35,112	24,594	458	25,052		77%	81%
3	Stochastic E-Type	630	0.011	0.15	1.1404	45,563	6,399	51,962	27,920	828	28,748		62%	63%
4	Stochastic 10th Percentile	630	0.011	0.15	1.1404	6,765	950	7,715	6,808	72	6,880		95%	102%

Table 7-1. Mass Recovered, Fraction of Initial Mass Recovered for Carbon Tetrachloride at End of Active Pumping (2037)

Run	Initial Condition	Half Life (years)	K_d	Porosity	Calculated R*	Initial Mass 2015 (kg)			Mass Remediated by P&T (kg)	Mass Decayed (kg)	Total Mass Removed (kg)	Mass removed prior CY 2015	% Total Mass Remediated in 2037	% Dissolved Mass Remediated in 2037
						Dissolved	Sorbed	Total						
5	Stochastic 25th Percentile	630	0.011	0.15	1.1404	13,021	1,829	14,850	12,615	150	12,766		91%	98%
6	Stochastic 50th Percentile	630	0.011	0.15	1.1404	25,973	3,647	29,620	22,920	346	23,266		84%	90%
7	Stochastic 75th Percentile	630	0.011	0.15	1.1404	53,508	7,514	61,022	38,152	883	39,035		69%	73%
8	Stochastic 90th Percentile	630	0.011	0.15	1.1404	107,102	15,041	122,143	56,719	2,113	58,833		52%	55%

* Retardation Factor

CY = calendar year

K_d = distribution coefficient

P&T = pump and treat

Table 7-2. Mass Recovered, Fraction of Initial Mass Recovered, and Concentration Statistics (Median, Average, and 90th Percentile) for Each COC at End of Active Pumping (2037)

Contaminant of Concern	Half Life (years)	K_d	Porosity	Calculated R	Initial Mass 2015 (kg)			Mass Remediated by P&T (kg)	Mass Decayed (kg)	Total Mass Removed (kg)	Reported Mass removed prior CY 2015	% Total Mass Remediated in 2037	% Dissolved Mass Remediated in 2037	Projected 2037 Concentrations[c]		
					Dissolved	Sorbed	Total							Median	Ave-rage	90th Percentile
Carbon Tetrachloride 100y Half life (kg | µg/L)	100	0.011	0.15	1.1404	30,111	4,229	34,340	24,331	2,542	26,872	9,314	83%	89%	5.6	28.2	58.3
Carbon Tetrachloride 630y Half life (kg | µg/L)	630	0.011	0.15	1.1404	30,111	4,229	34,340	25,440	424	25,864	9,314	81%	86%	6.2	31.8	65.4
Hexavalent Chromium (kg | µg/L)	NA	0	0.15	1.0000	3,226	-	3,226	973	-	973	200	34%	30%	12	21.6	55
Iodine-129 (Ci | pCi/L)	1.57E+07	0.1000	0.15	2.2767	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.454	0.439	0.454
Nitrate (kg | µg/L) [as NO3]	NA	0	0.15	1.0000	16,425,600	-	16,425,600	6,291,927	-	6,291,927	591,428	40%	38%	36600	59700	125000
Technetium (Ci | pCi/L)	211000	0	0.15	1.0000	28	-	28	14	-	14	3	56%	52%	163	329	668
Trichloroethene (kg | µg/L)	NA	0.025	0.15	1.3192	242	77	320	146	-	146	32	51%	60%	0.469	0.771	1.7
Uranium (kg | µg/L)	4.47E+09	0.40000	0.15	6.1067	316	1,612	1,927	306	0	306	2	16%	97%	6660	9660	20200
Tritium (Ci | pCi/L)	12.3	0	0.15	1.0000	NA	NA	NA	NA	NA	NA	NA	NA	NA	9.83	14	24

Table 7-2. Mass Recovered, Fraction of Initial Mass Recovered, and Concentration Statistics (Median, Average, and 90th Percentile) for Each COC at End of Active Pumping (2037)

Contaminant of Concern	Half Life (years)	K_d	Porosity	Calculated R	Initial Mass 2015 (kg)			Mass Remediated by P&T (kg)	Mass Decayed (kg)	Total Mass Removed (kg)	Reported Mass removed prior CY 2015	% Total Mass Remediated in 2037	% Dissolved Mass Remediated in 2037	Projected 2037 Concentrations[c]		
					Dissolved	Sorbed	Total							Median	Ave-rage	90th Percentile

COC = contaminant of concern
CY = calendar year
K_d = distribution coefficient
P&T = pump and treat

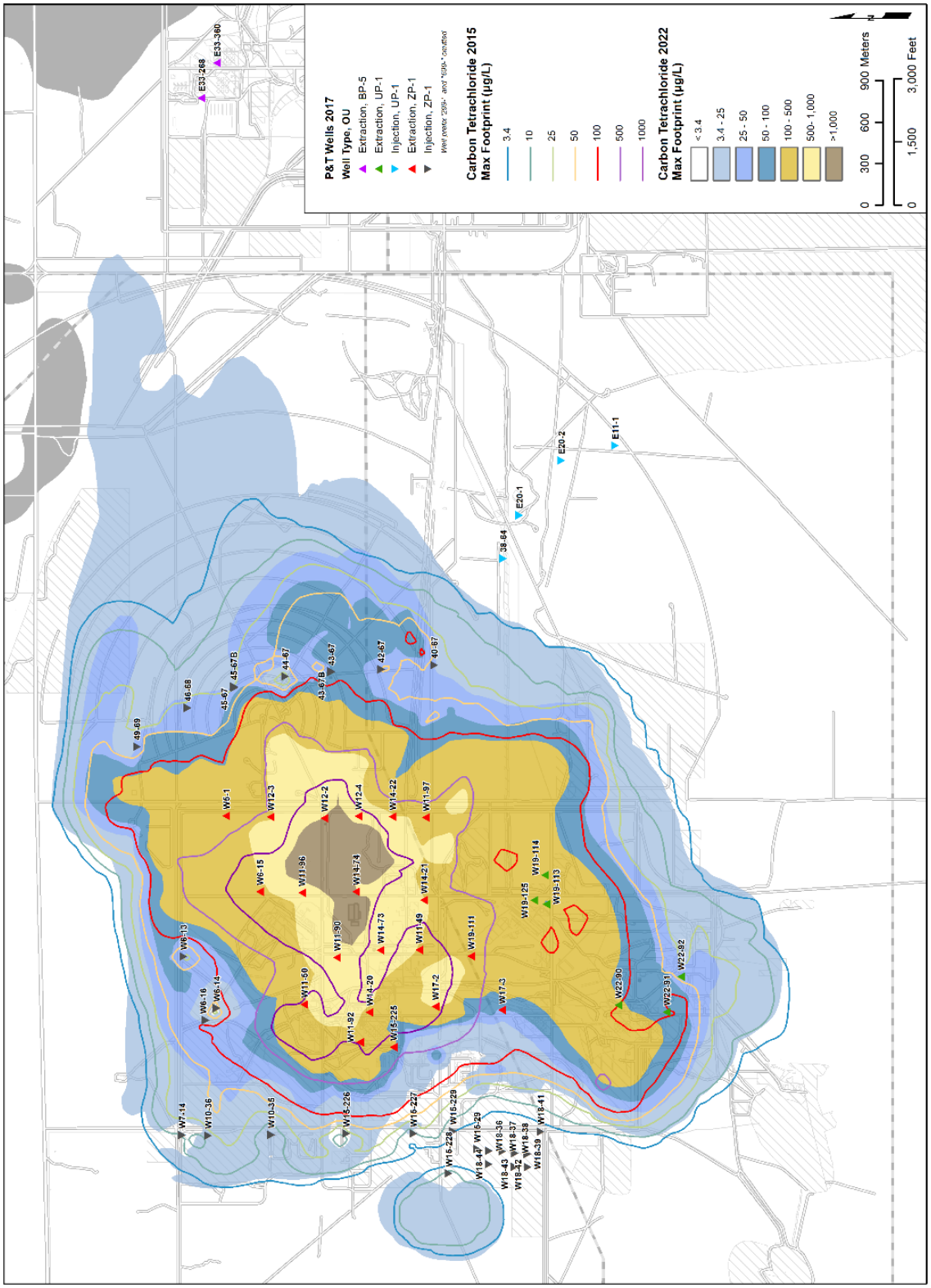


Figure 7-45. Projected Carbon Tetrachloride Plume Extent in CY2022

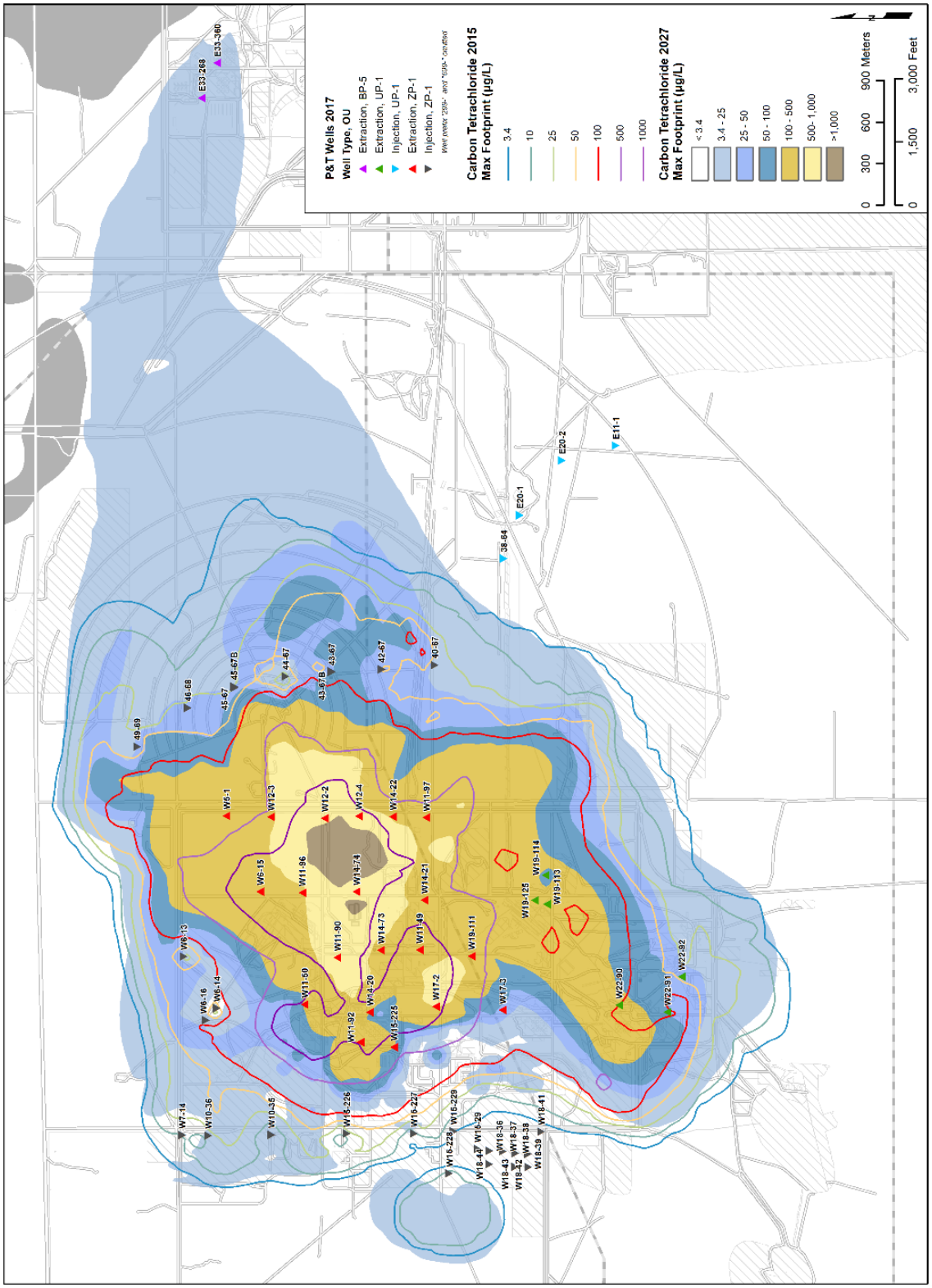


Figure 7-46. Projected Carbon Tetrachloride Plume Extent in CY2027

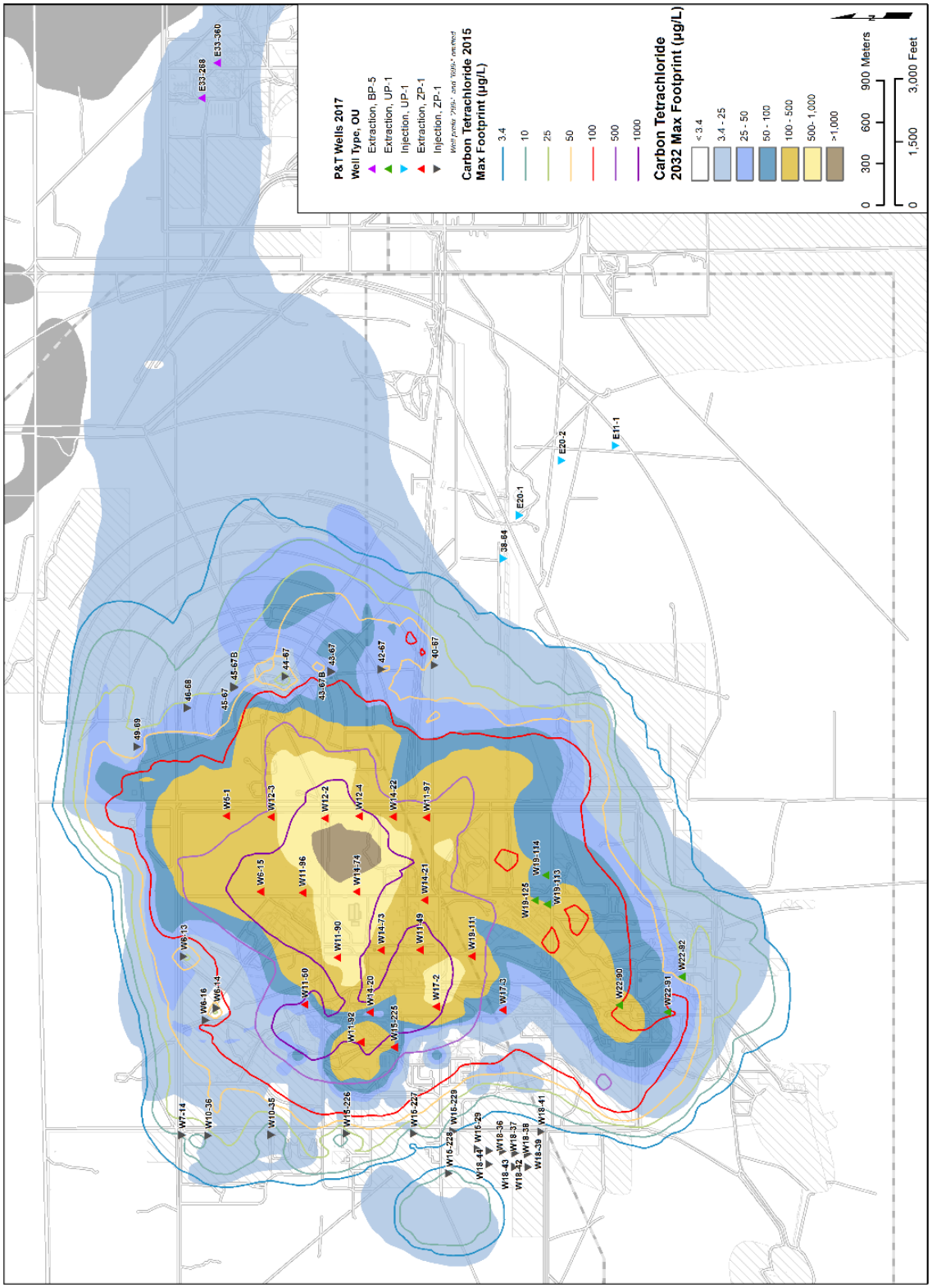


Figure 7-47. Projected Carbon Tetrachloride Plume Extent in CY2032

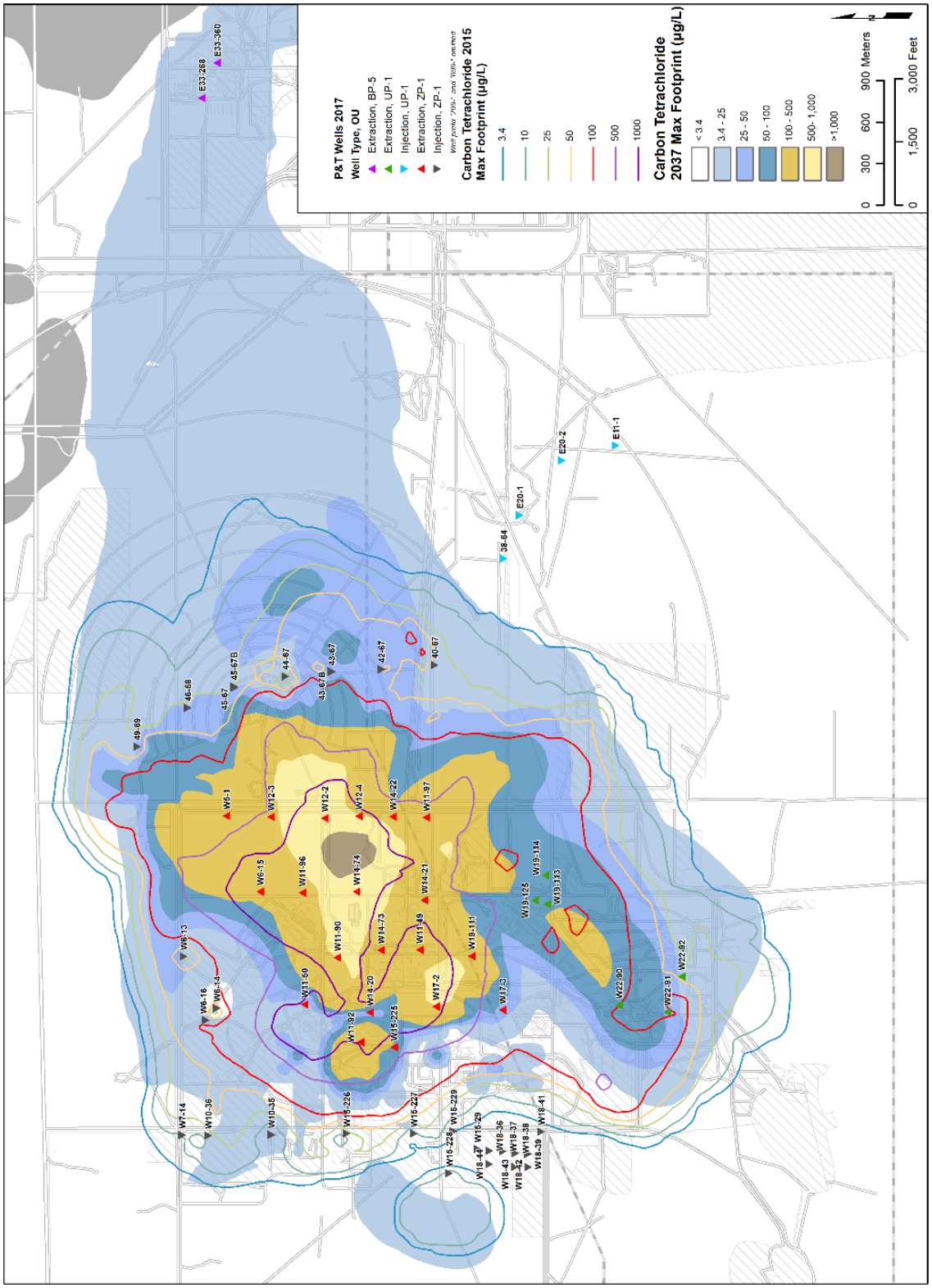


Figure 7-48. Projected Carbon Tetrachloride Plume Extent in CY2037

7.2 200-UP-1 Operable Unit - S-SX Tank Farms

This section presents figures and tables produced as output from the calculations contained in this ECF for the 200-UP-1 S-SX Tank Farms P&T remedy. These calculations and figures are produced as an accessory to the calculations undertaken to evaluate the performance of the 200-ZP-1 remedy, and are provided here to assist with inferring the performance of the 200-UP-1 remedies. Other calculations, analyses, and figures in addition to those presented here are produced and documented in ECF-200UP1-17-0094, *Fate and Transport Analysis for WMA S-SX Groundwater Plumes in the 200-UP-1 Operable Unit*, to support evaluations of the 200-UP-1 remedies.

7.2.1 Hydraulic Containment and Flowpaths

Figure 7-49 depicts mapped water levels together with estimated particle paths computed using reverse tracking from each extraction well. Annual time-stamps are depicted on the particle paths, which were estimated based upon the groundwater levels and hydraulic gradients, and the pumping rates during March 2017. Figures 7-50 through 7-52 depict the same water-level map and particle paths, as well as the mapped extent of technetium-99, chromium, and nitrate respectively as depicted in ECF-Hanford-18-0013. When operating, the hydraulic capture zones developed by the S-SX extraction wells effectively cover most of the technetium-99 plumes at concentrations above 9,000 pCi/L.

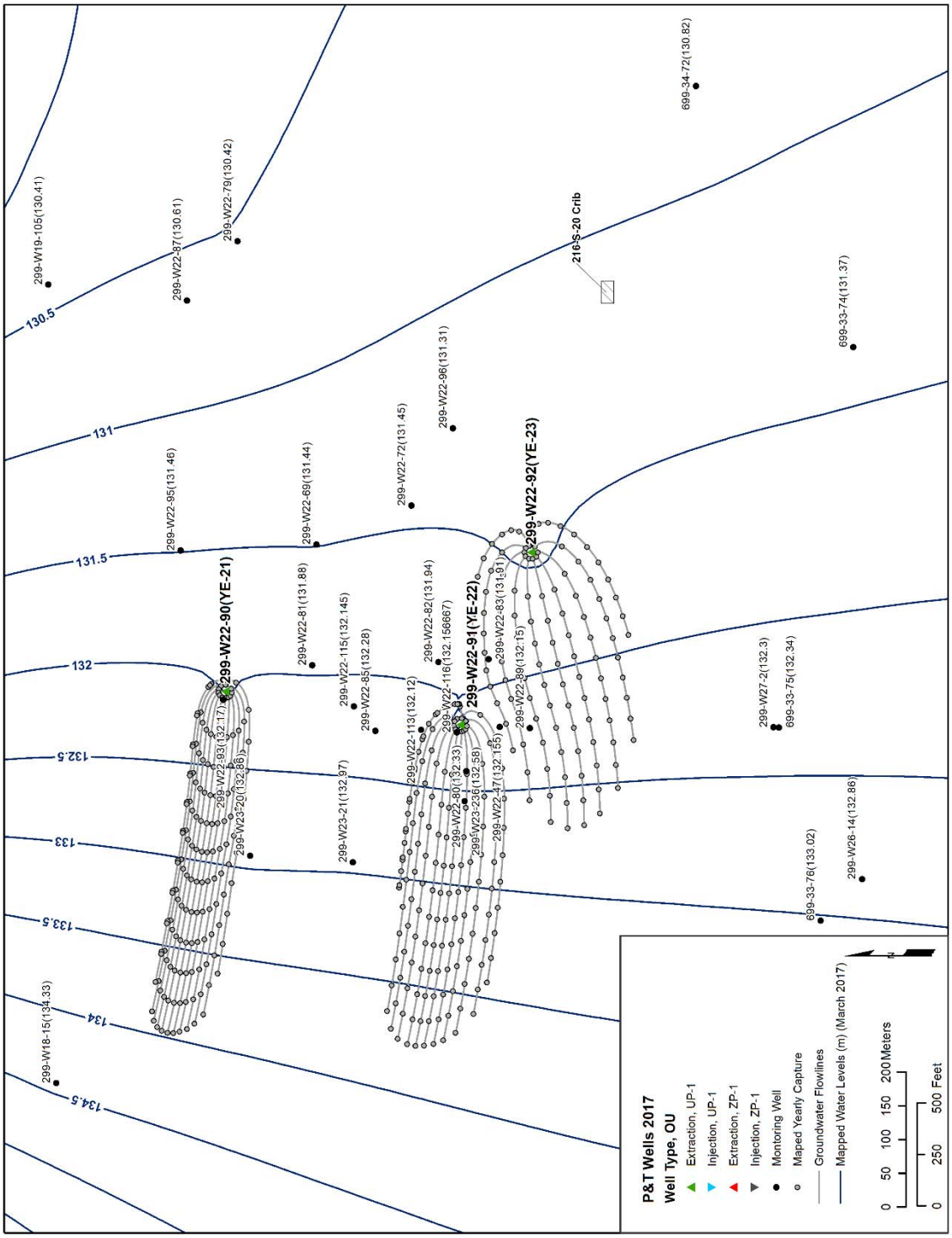


Figure 7-49. Groundwater Levels (Mapping Method) and Calculated Pathlines for 200-UP-1 OU — S-SX Tank Farms

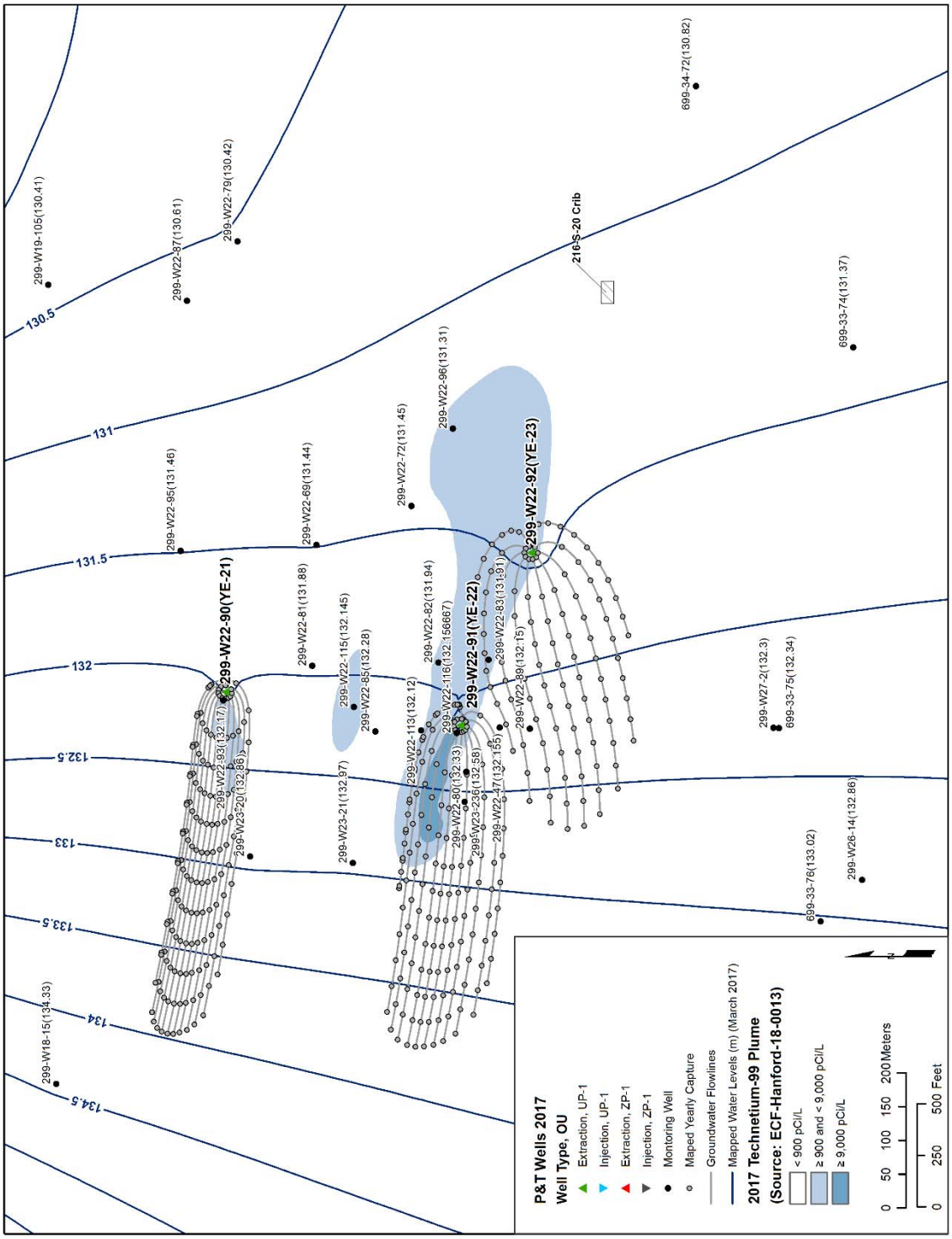


Figure 7-50. Calculated Pathlines and Extent of Technetium-99 for 200-UP-1 OU — S-SX Tank Farms

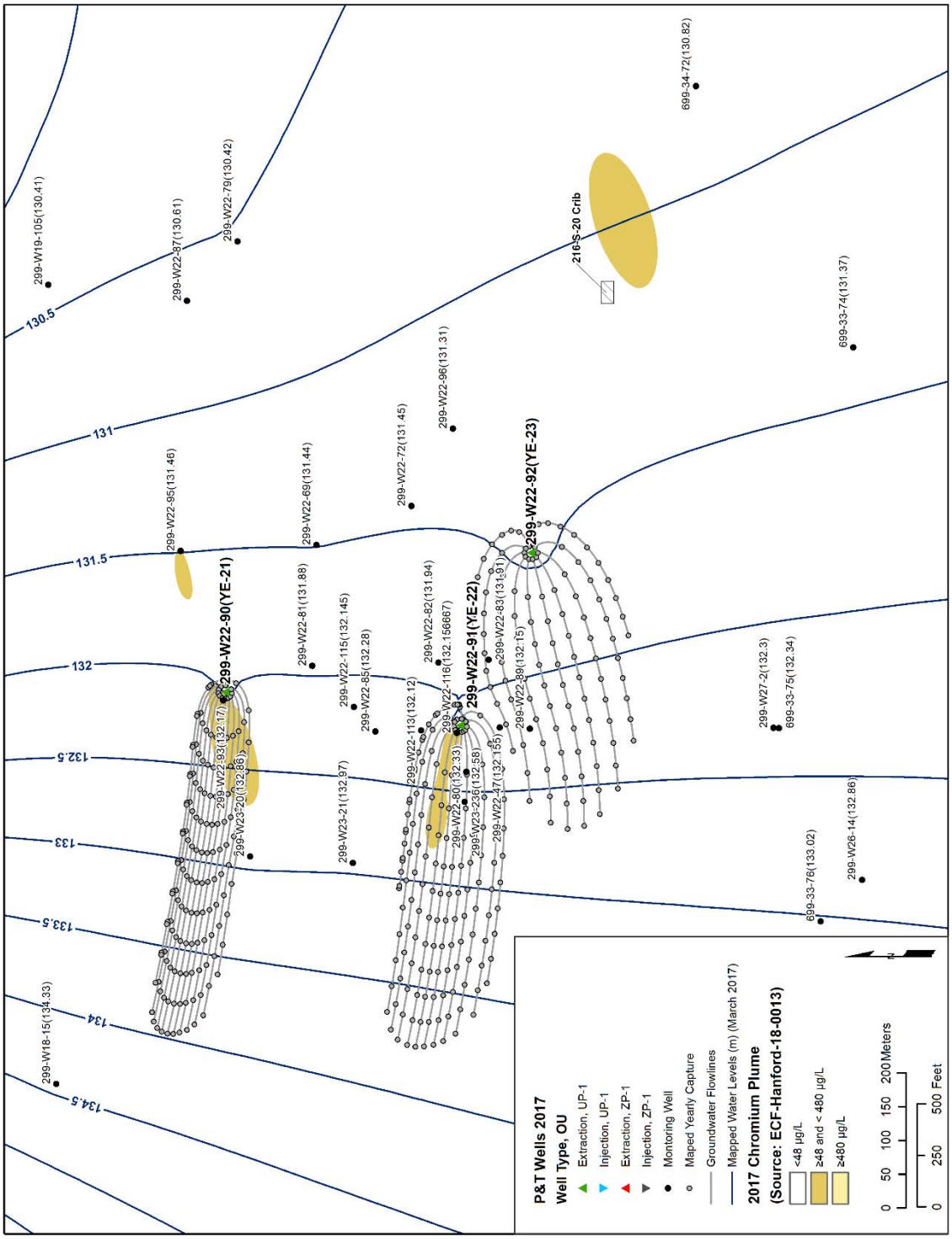


Figure 7-51. Calculated Pathlines and Extent of Chromium for 200-UP-1 OU — S-SX Tank Farms

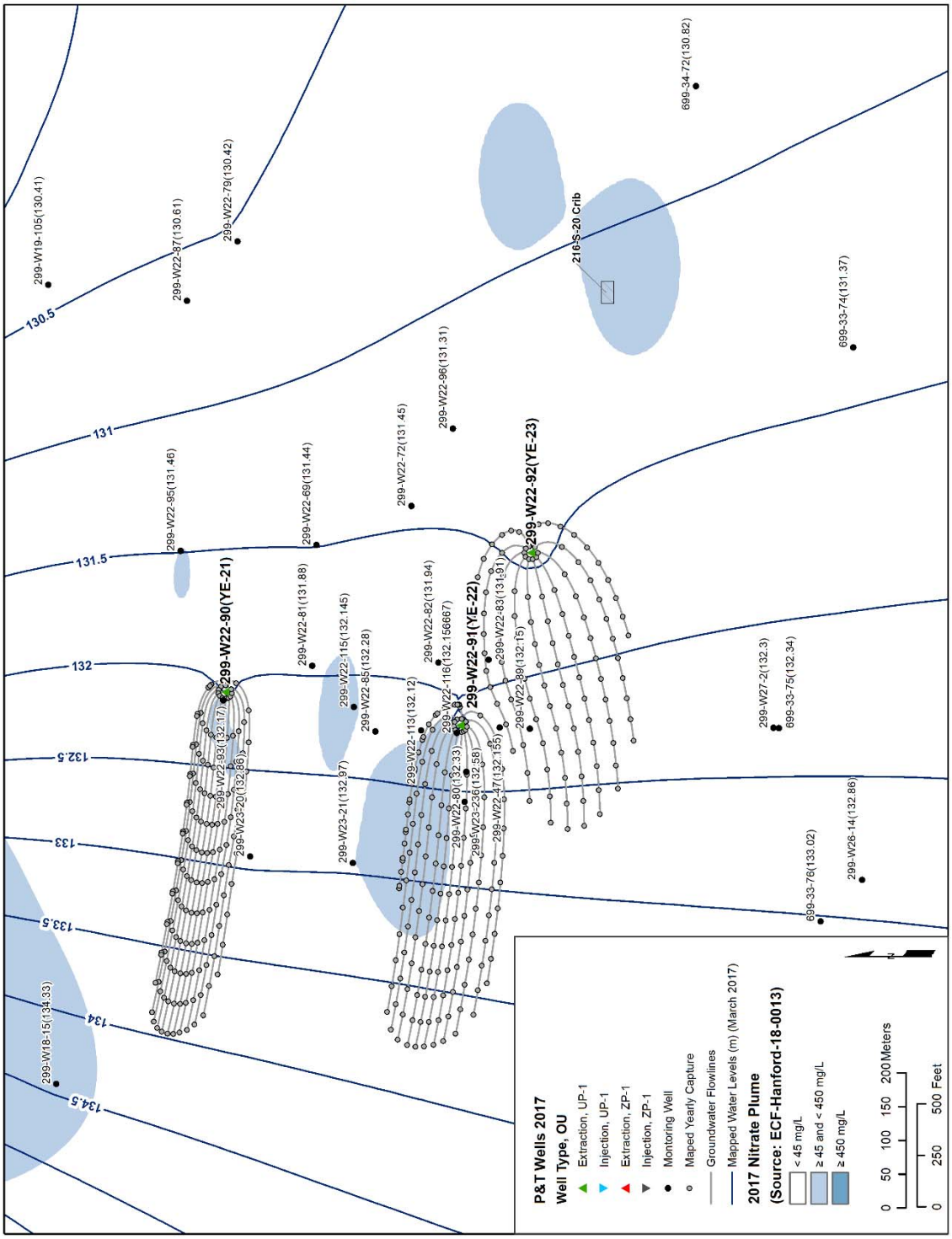


Figure 7-52. Calculated Pathlines and Extent of Nitrate for 200-UP-1 OU — S-SX Tank Farms

7.3 200-UP-1 - U Plant

This section presents figures and tables produced as output from the calculations described in this ECF for the 200-UP-1 OU U Plant extraction and injection remedy components. These calculations and figures are produced as an accessory to the calculations undertaken to evaluate the performance of the 200-ZP-1 remedy, and are provided here to assist with inferring the performance of the 200-UP-1 remedies. Other calculations, analyses and figures in addition to those presented here are produced and documented in ECF-200UP1-17-0093, *Fate and Transport Analysis for U Plant Groundwater Plumes in the 200-UP-1 Operable Unit*, and ECF-200UP1-18-0018, *200-UP-1 U Plant 2017 Uranium Plume Pump and Treat System Analysis*, to support evaluations of the 200-UP-1 remedies.

7.3.1 Hydraulic Containment and Flowpaths

Figure 7-53 depicts mapped water levels and estimated particle paths computed using reverse tracking from each extraction well. The figure also depicts approximate annual time stamps based upon groundwater levels, hydraulic gradients and pumping rates during December 2017. Figures 7-54 through 7-56 depict the same water-level map and particle paths, together with the mapped extent of uranium, technetium-99, and nitrate respectively as depicted in ECF-Hanford-18-0013.

Figure 7-54 indicates that the system is focused on capturing the central portion of the uranium plume, as designed. Based on the 2017 interpretation of plume geometry, the system is expected to capture about 76% of the areal extent of the uranium plume above 30 μg/L and about 89% of the plume above 300 μg/L.

Figures 7-55 and 7-56 show the December 2017 capture zones with the technetium-99 and nitrate plumes, respectively. The technetium-99 plume south of the U Plant is completely enveloped by the capture zones. For nitrate, all concentrations in the U Plant area are now below the high-concentration level (i.e., greater than 450 mg/L). The selected remedies for nitrate were P&T for the high-concentration area at U Plant and MNA for the remainder of the plume.

7.3.2 Hydraulic Containment and Flow Path Control for Iodine-129

Injection wells installed close to the leading edge of the iodine-129 plume on the east side of the 200-UP-1 OU are designed to slow the migration of the iodine-129 while attenuation processes take place to reduce concentrations in groundwater. Figures 7-57 depicts the mapped groundwater elevations for December 2017 near the injection well line of control established to contain and slow the migration of the iodine-129 plume. This figure illustrates the patterns of changing groundwater levels and gradients that result from the impact of the injection. Figures 7-58 and 7-59 depict outputs from the flow-path control assessment that was developed with specific application for 200-ZP-1, as applied to the injection wells of the 200-UP-1 iodine-129 remedy. These figures depict areas where hydraulic gradients are reduced or reversed by the injection. In each case, the direction and length of the arrows posted along a control line indicate the direction and relative magnitude of the hydraulic gradient at that location: inset “a” depicts the “Baseline” hydraulic conditions of the flow field under baseline conditions, whereas inset “b” depicts “Current” hydraulic conditions of the flow field. In each case, posted arrows represent the flow direction and arrow length represent the hydraulic gradients. The colored map depicts the change in hydraulic gradients, which is calculated as the difference between hydraulic gradients in Current conditions and Baseline conditions. Figure 7-58 depicts results as calculated using the water-level mapping method, whereas Figure 7-59 depicts results as calculated using the CPGWM model. Together, Figures 7-58 and 7-59 depict reductions in hydraulic gradients (indicated by negative change in hydraulic gradient shaded in red color): these results are consistent with expectations, as gradients have been reduced, and in some places reversed, in the region between the iodine-129 plume and injection wells.

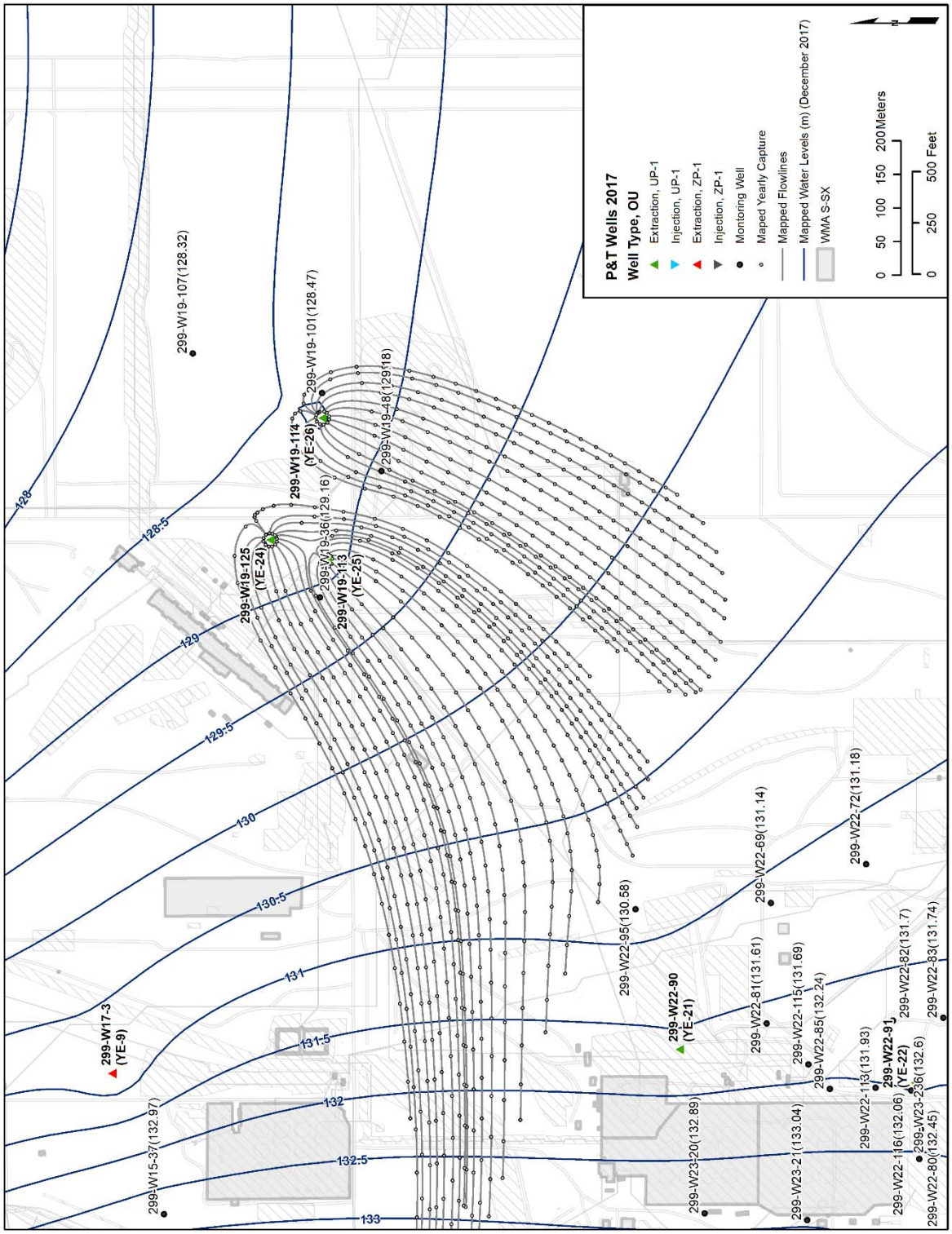


Figure 7-53. Groundwater Levels (Mapping Method) and Calculated Pathlines for 200-UP-1 OU — U Plant

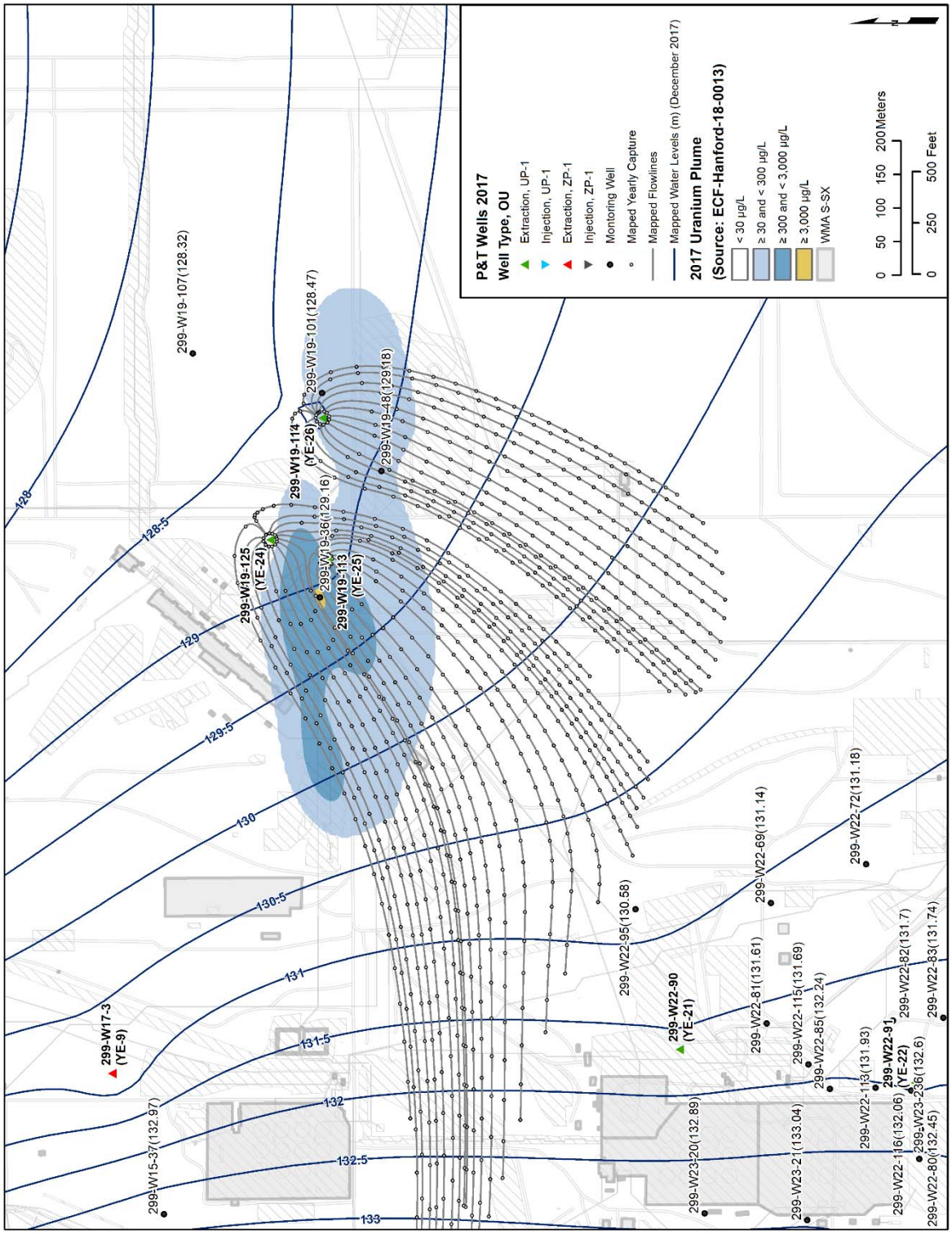


Figure 7-54. Calculated Pathlines and Extent of Uranium for 200-UP-1 OU — U Plant

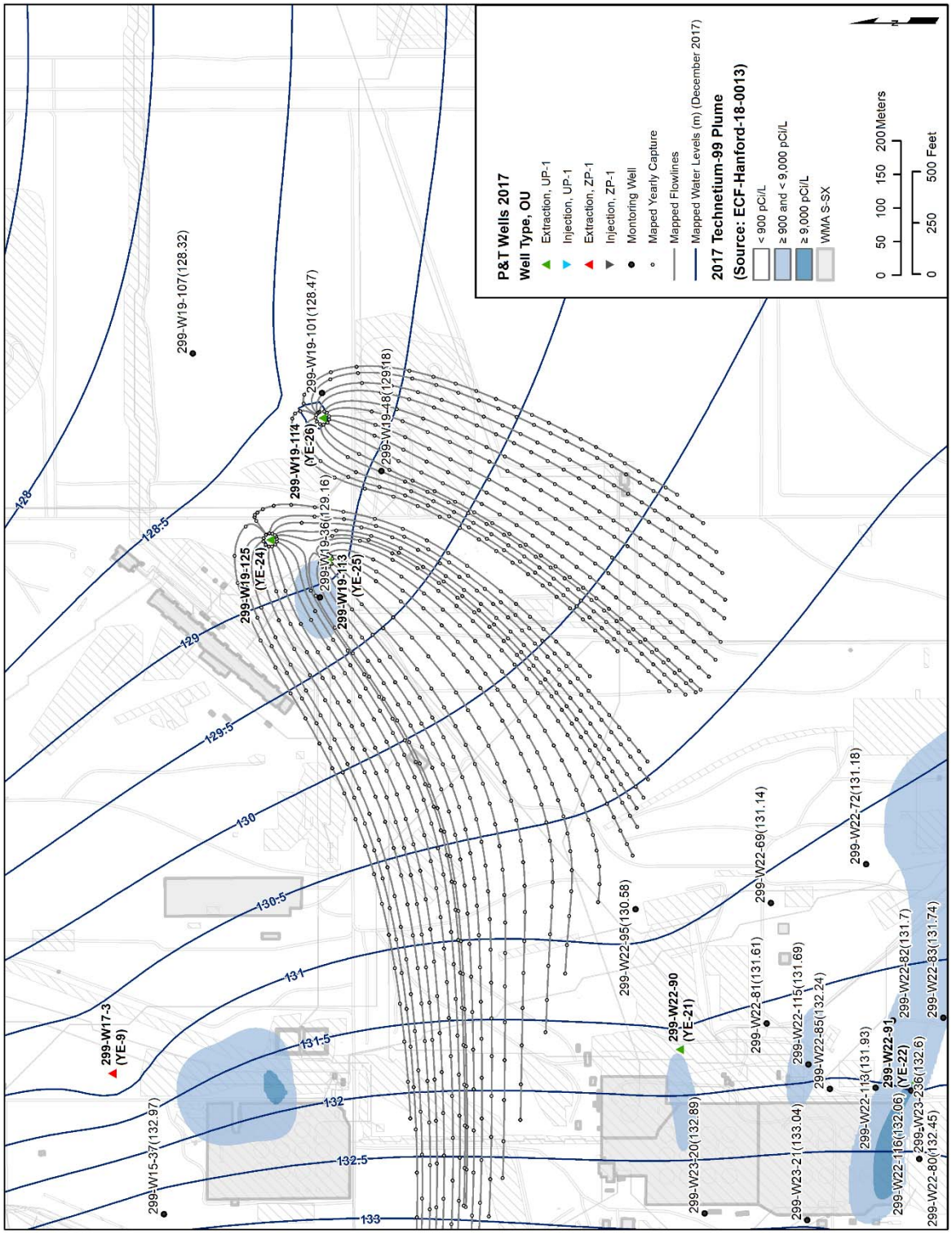


Figure 7-55. Calculated Pathlines and Extent of Technetium-99 for 200-UP-1 OU — U Plant

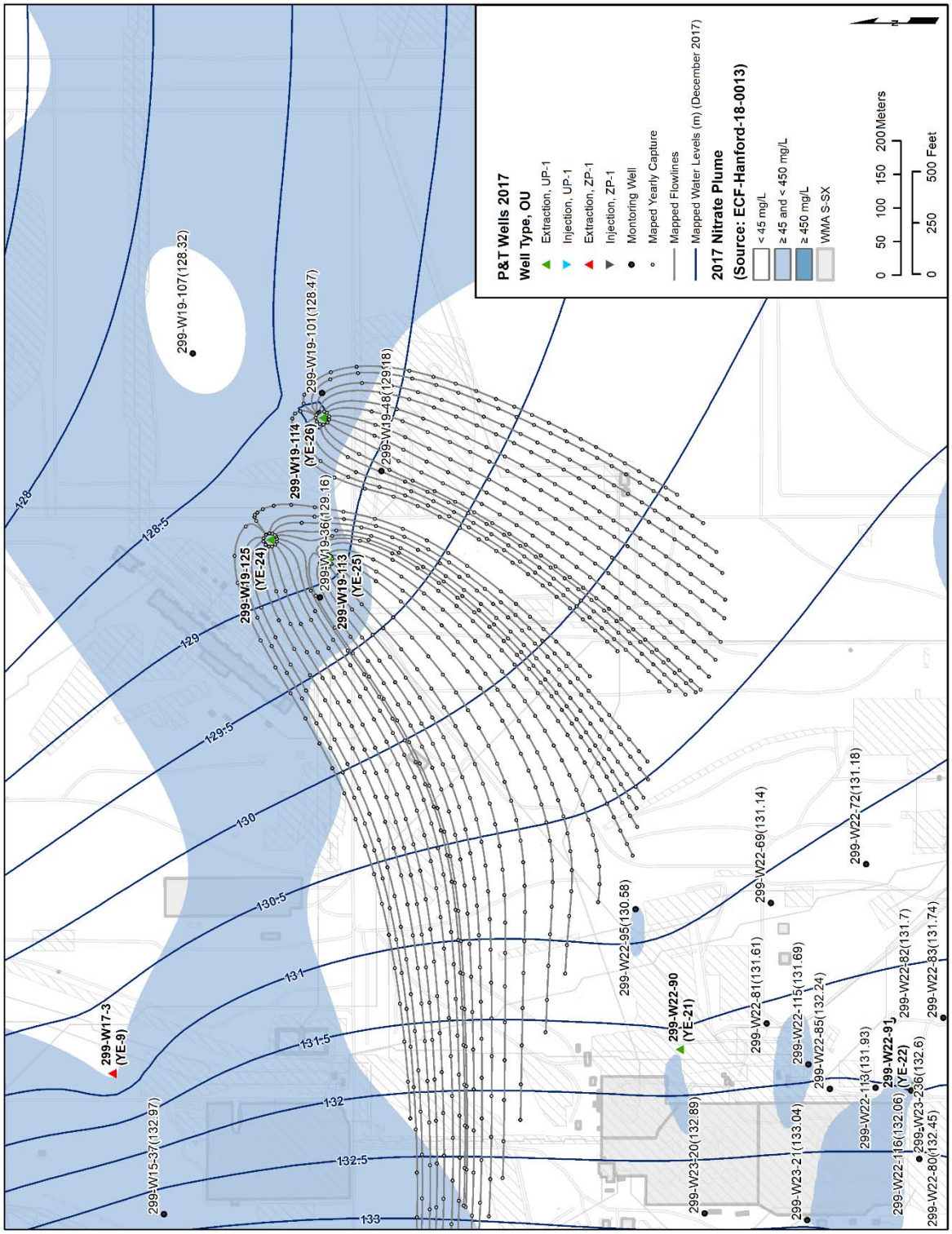


Figure 7-56. Calculated Pathlines and Extent of nitrate for 200-UP-1 OU — U Plant

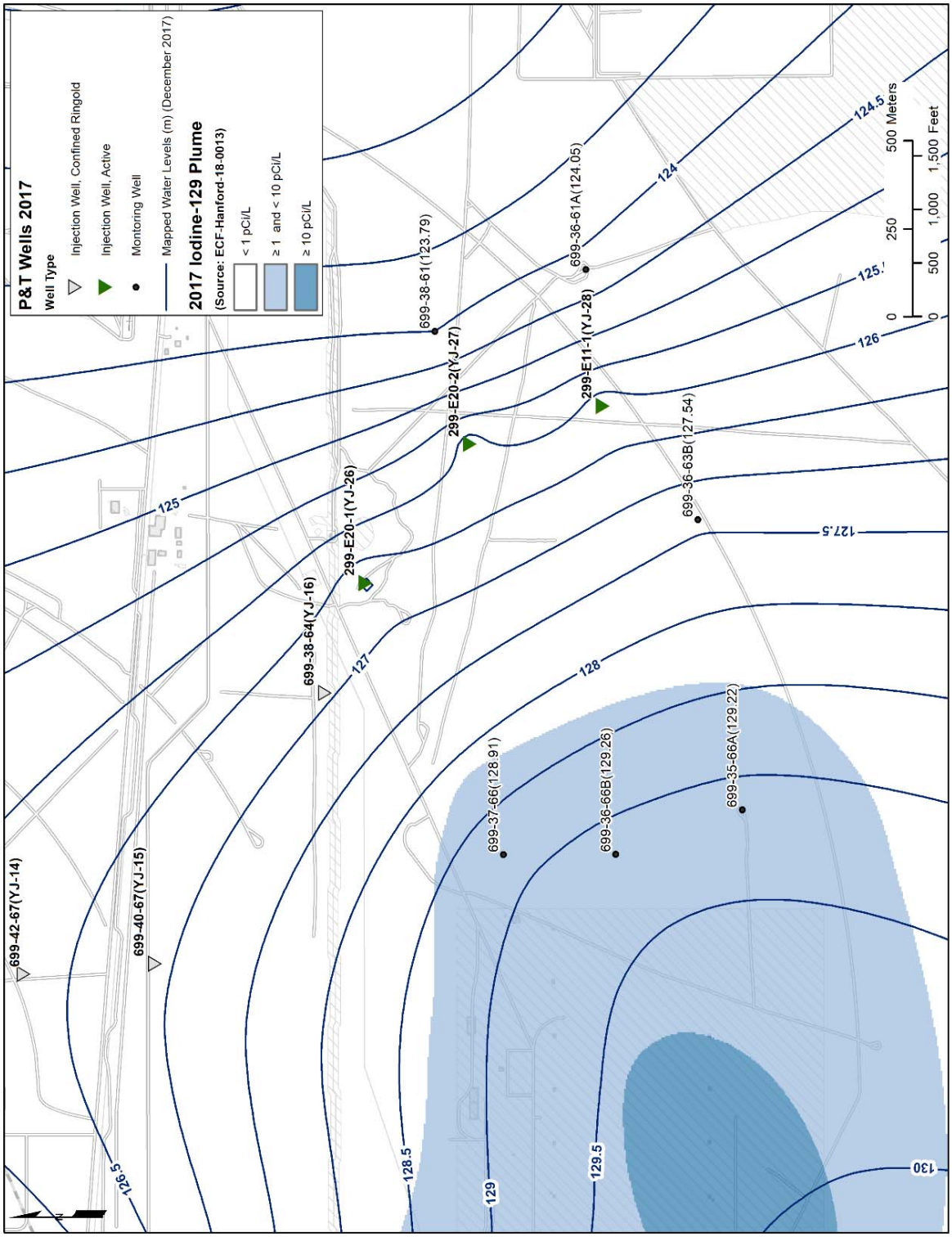


Figure 7-57. Mapped Groundwater Elevations along Iodine-129 Injection Well Line of Control, December 2017

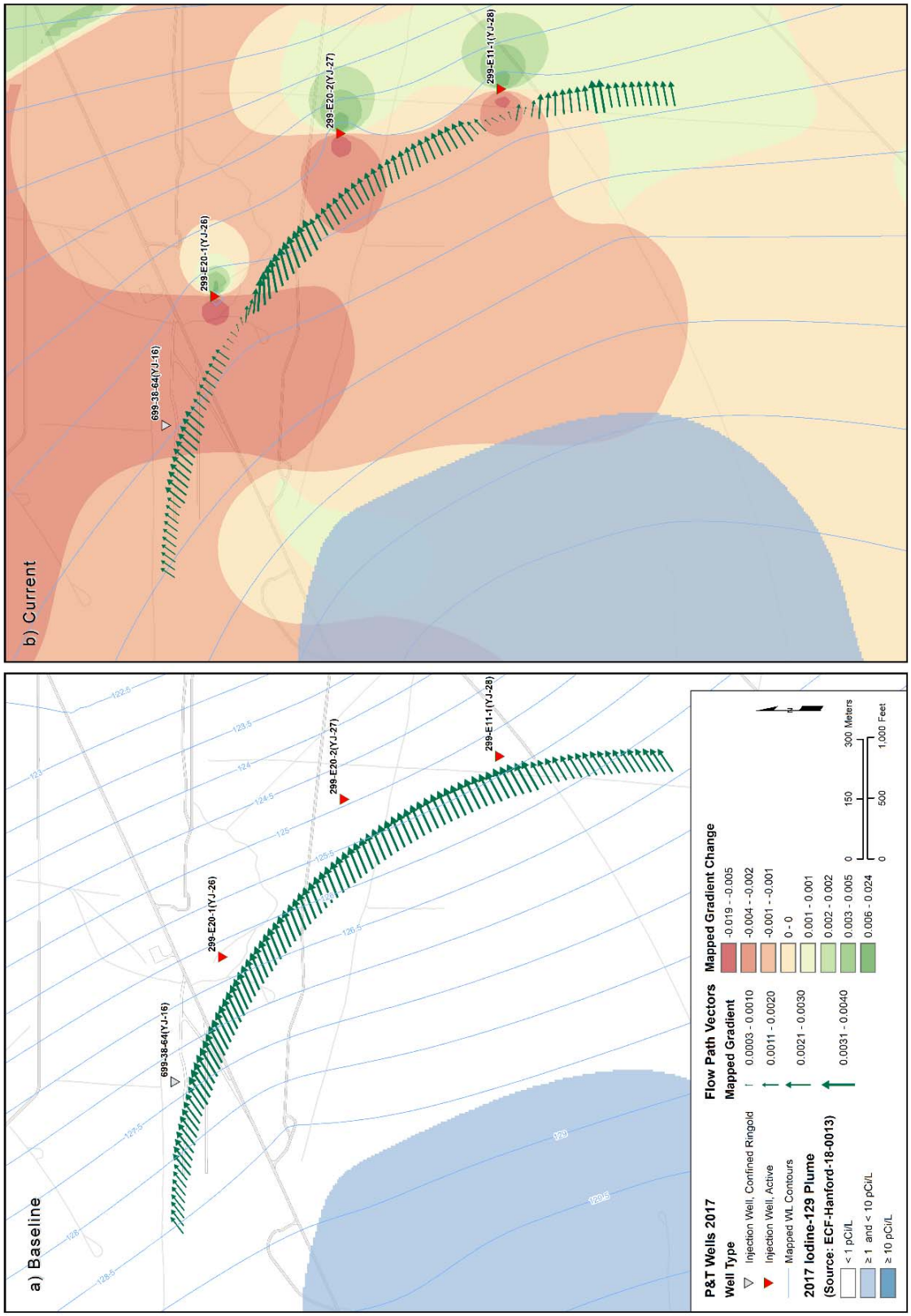


Figure 7-58. Mapped Gradient Changes Along Line of Control Above the RLM: (a) Baseline and (b) Current

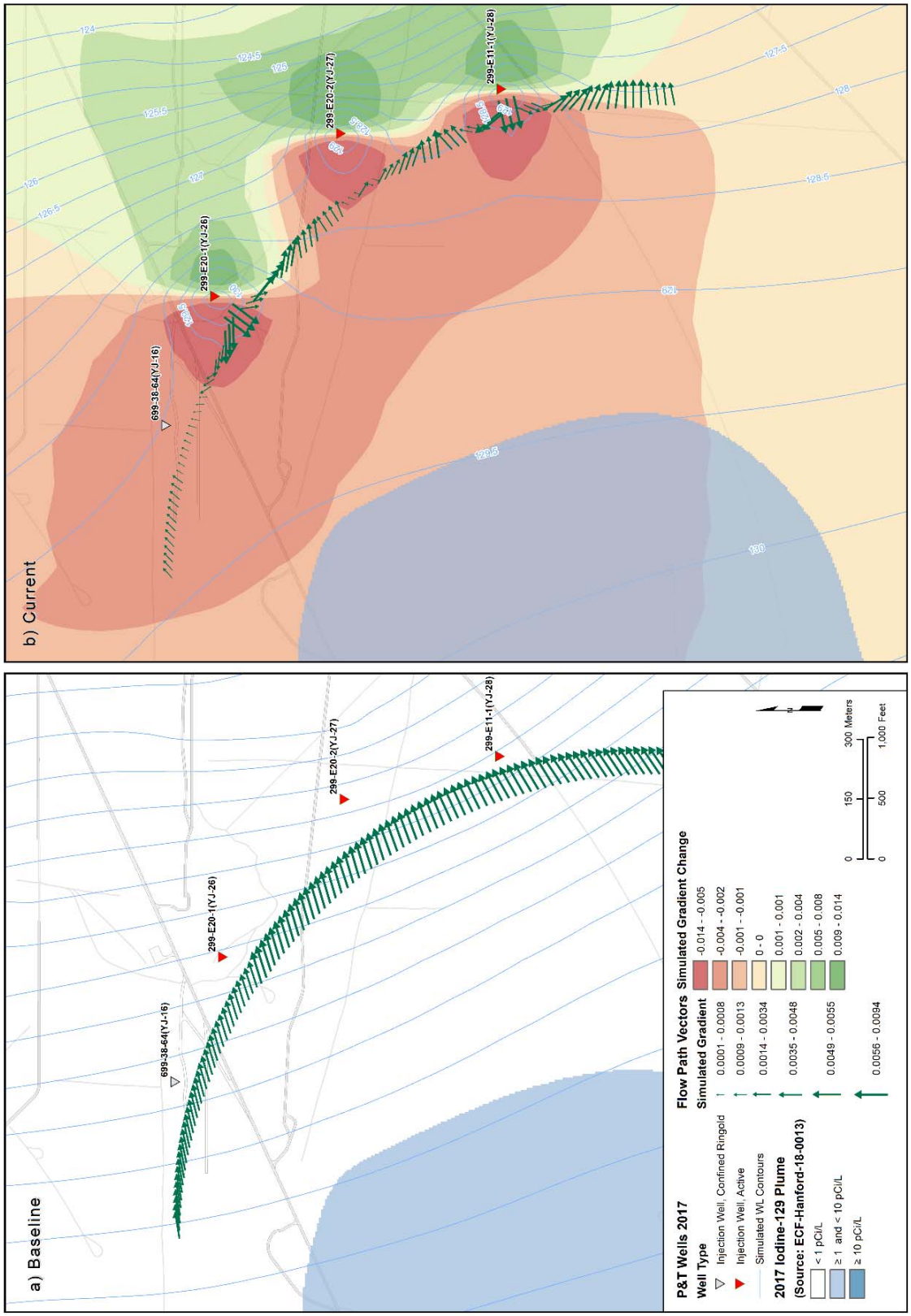
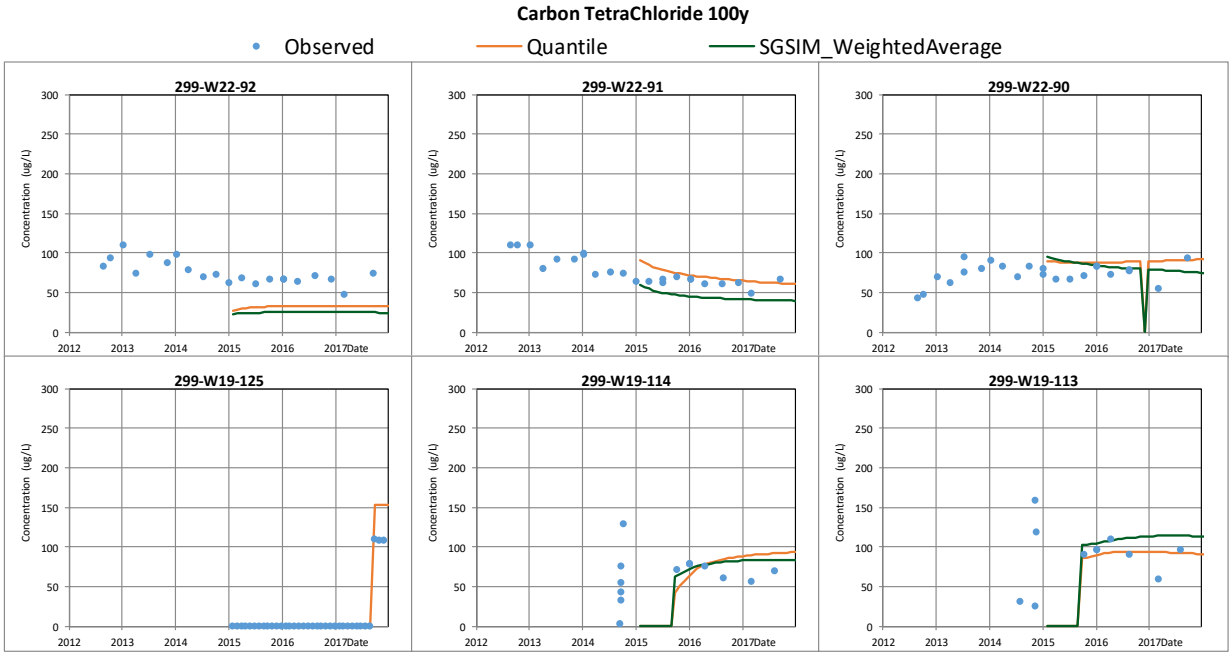


Figure 7-59. Simulated Gradient Changes Along Line of Control Above the RLM: (a) Baseline and (b) Current

7.3.3 Simulated and Observed Extraction Well Concentrations

Figure 7-60 depicts a comparison of the simulated and observed (measured) historical influent concentrations for the 200-UP-1 S-SX Tank Farms and U-Plant system extraction wells for each of the chemical constituents that was simulated using the CPGWM contaminant F&T model. Not all of these chemical constituents are COCs for the 200-UP-1 OU. However, since the water extracted at these wells is conveyed to the 200 West P&T above ground treatment system (as well as water extracted by the 200-ZP-1 P&T wells), all chemical constituents are plotted. Carbon tetrachloride and nitrate plots show two simulated results one with initial plume generated using SGSIM simulations and the second initial plume generated using the ordinary kriging “Quantile” method.



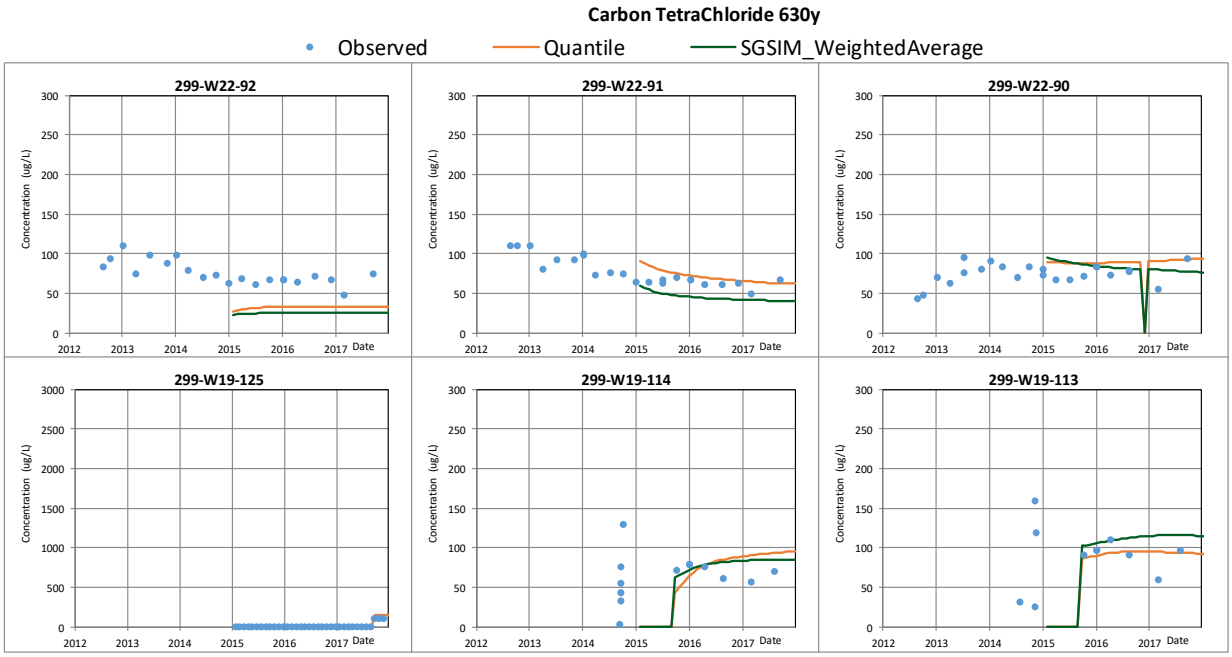


Figure 7-60. Comparison of Simulated and Observed Influent Concentrations at 200-UP-1 OU — S-SX Tank Farms and U Plant (Page 1 of 5)

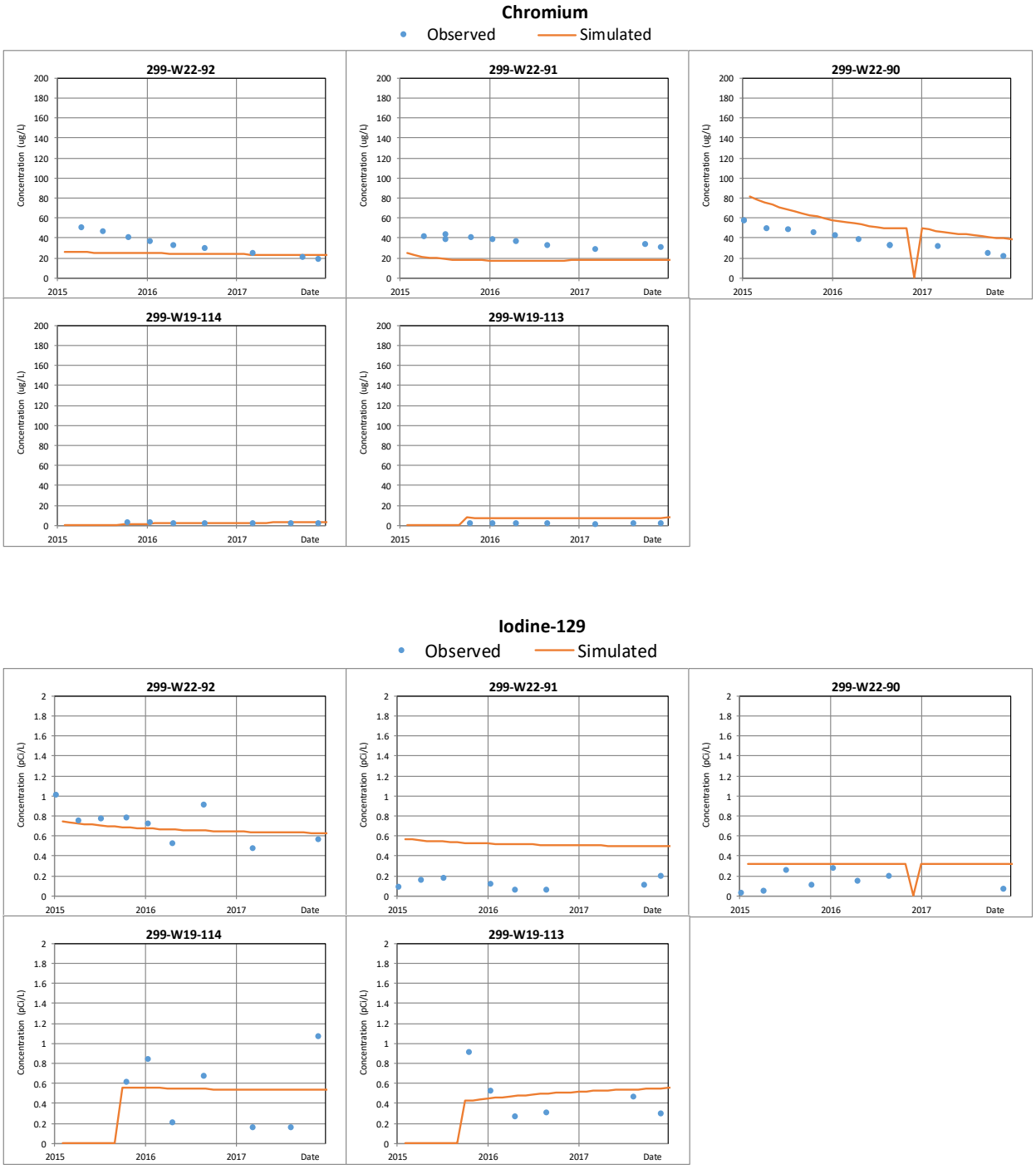
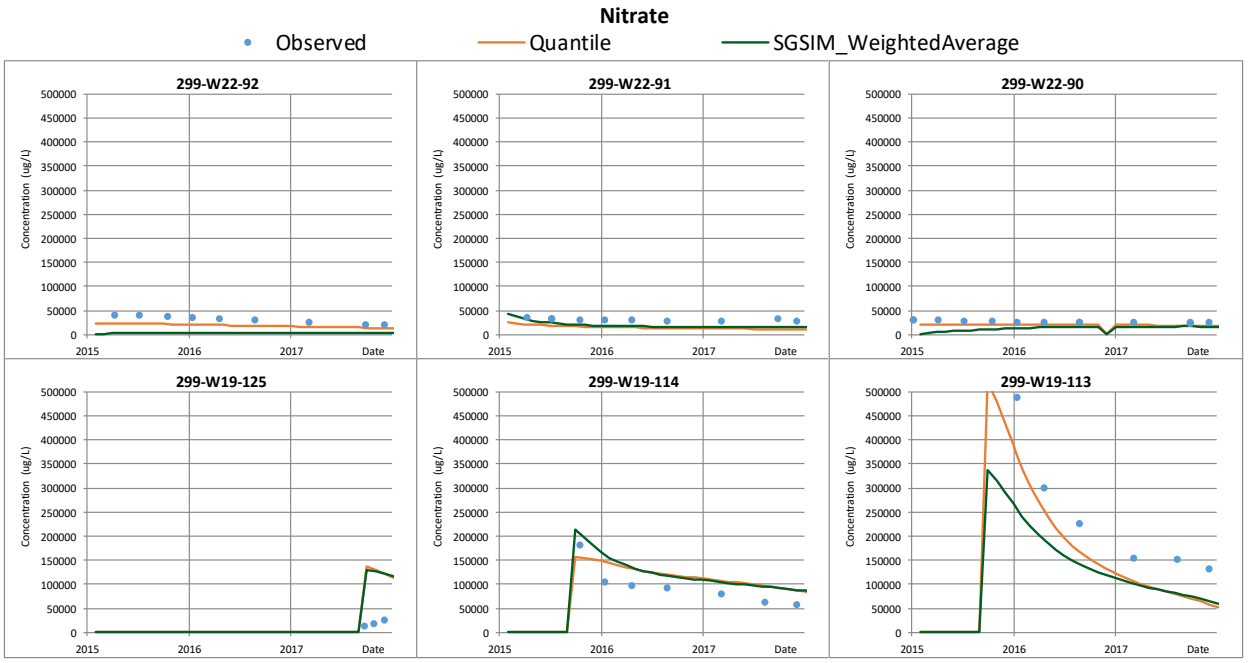


Figure 7-60. Comparison of Simulated and Observed Influent Concentrations at 200-UP-1 OU — S-SX Tank Farms and U Plant (Page 2 of 5)



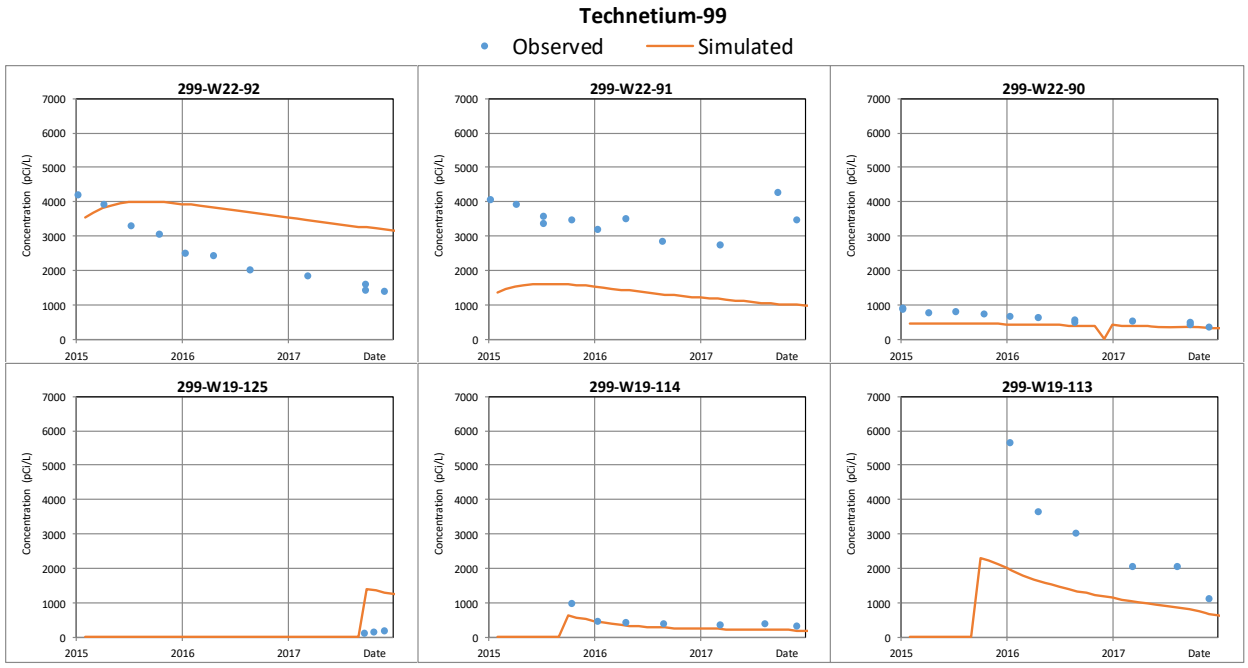
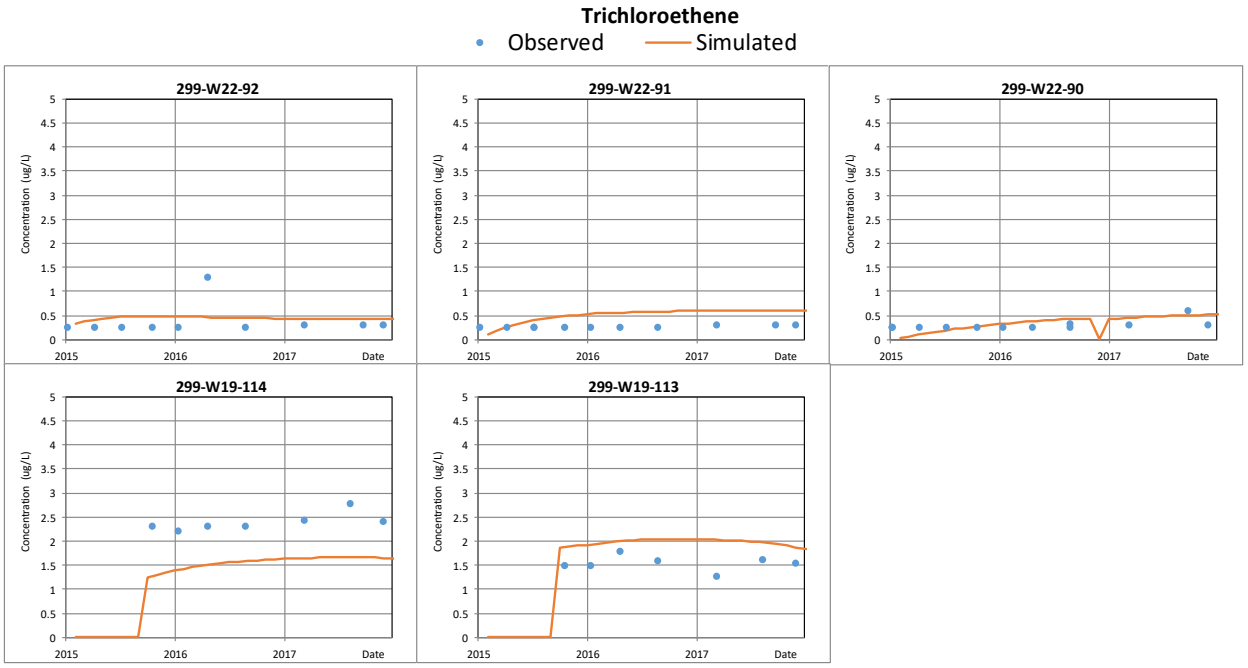


Figure 7-60. Comparison of Simulated and Observed Influent Concentrations at 200-UP-1 OU — S-SX Tank Farms and U Plant (Page 3 of 5)



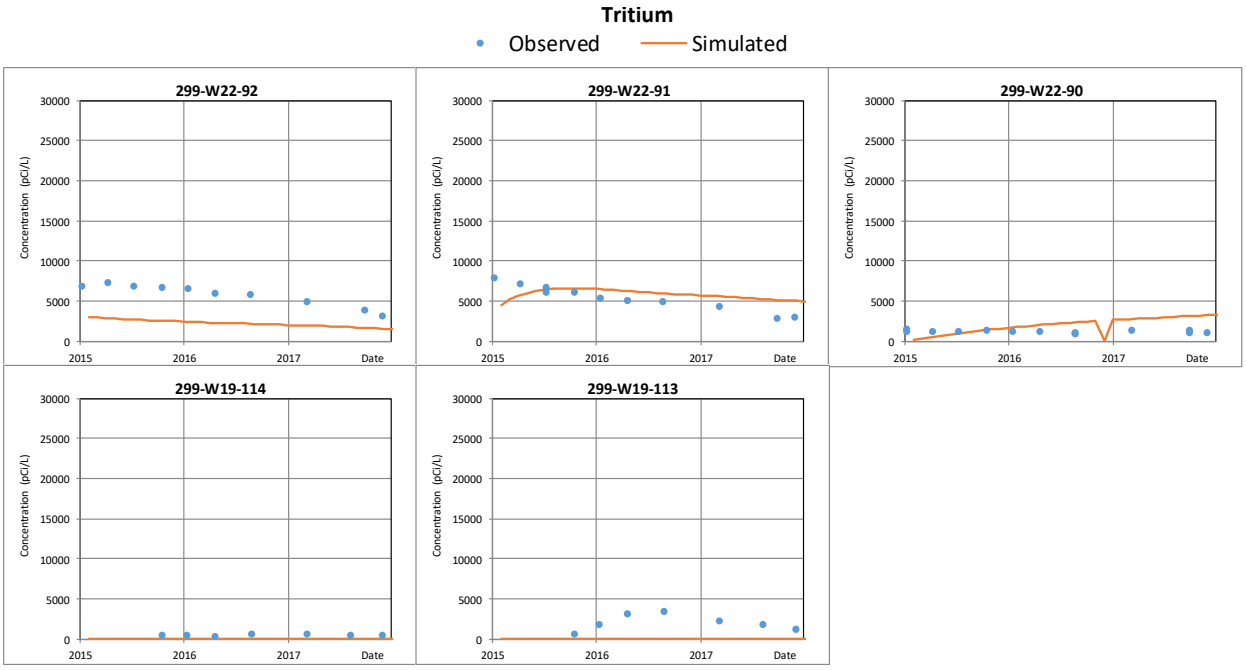


Figure 7-60. Comparison of Simulated and Observed Influent Concentrations at 200-UP-1 OU — S-SX Tank Farms and U Plant (Page 4 of 5)

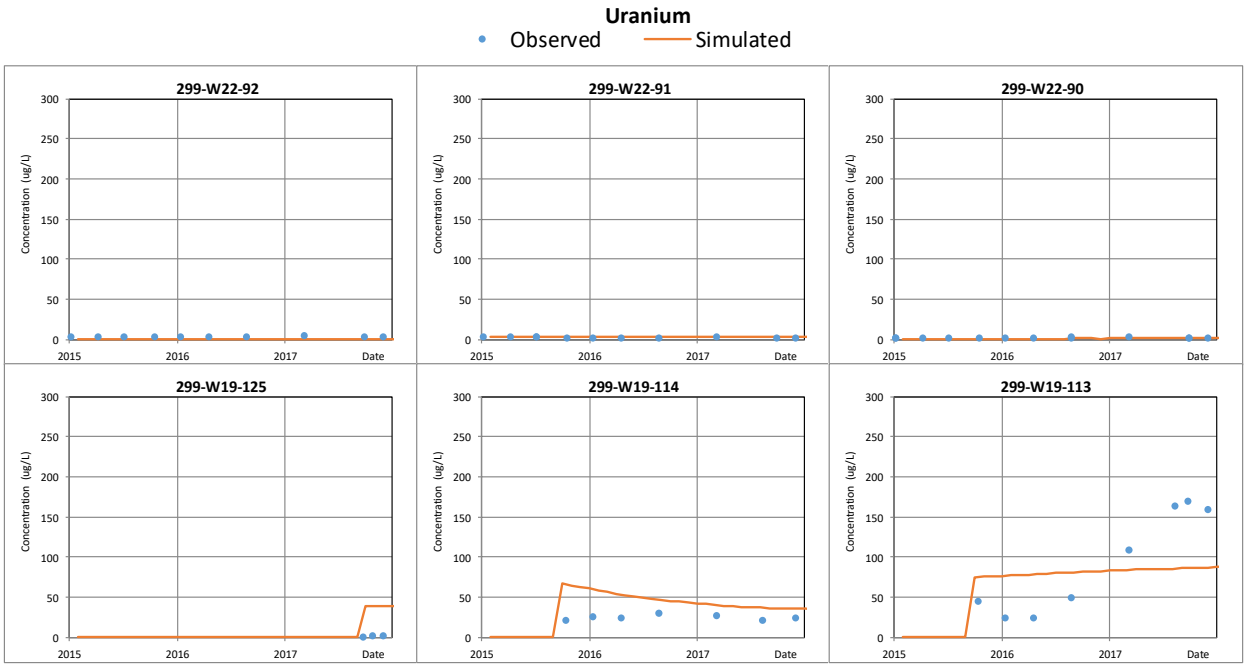


Figure 7-60. Comparison of Simulated and Observed Influent Concentrations at 200-UP-1 OU — S-SX Tank Farms and U Plant (Page 5 of 5)

7.4 Summary

7.4.1 200-ZP-1 Operable Unit

Figures of mapped capture and modeled hydraulic containment (ICFMs and SCFMs) presented in this ECF indicate that groundwater contaminated by carbon tetrachloride at concentrations greater than 100 µg/L is almost entirely hydraulically contained by the 200 West P&T system. The flow-path control assessment indicates that during CY 2017, flow-path control had developed along much of the control line, through the reduction in hydraulic gradients by groundwater extraction and reinjection at the 200 West P&T.

Section 7.1.4 provides the calculation methods based upon groundwater flow modeling and contaminant transport modeling in order to compare observed and predictive containment and mass removal and make future projections of the likely progress toward achieving the mass recovery goal. These calculation methods will be applied in future annual reports, when the 200 West P&T has been running at full capacity for a long enough period of time for hydraulic gradients to stabilize and for the parameters and assumptions of the contaminant transport model to be validated and revised, where necessary.

7.4.2 200-UP-1 Operable Unit - S-SX Tank Farms

The system at the 200-UP-1 OU for the S-SX Tank Farms is able to operate at its design capacity. When operating, the combined pumping rate from the three extraction wells is about 300 L/min (80 gpm) (note that the system may not operate 100 percent of the time due to scheduled and unscheduled periods of maintenance and shutdown). When operating, the hydraulic capture zones developed by the extraction wells effectively cover most of the technetium-99 plumes at concentrations above 9,000 pCi/L.

7.4.3 200-UP-1 Operable Unit - U Plant

The U Plant area groundwater extraction system came online in September 2015 with two extraction wells 299-W19-113 and 299-W19-114 and removes uranium, technetium-99, and nitrate from the groundwater downgradient from the 216-U-1 and 216-U-2 Cribs. 2017, a third extraction well, 299-W19-125, was added to the system. The extraction wells operated at a combined average rate of 562 L/min (148 gpm), which is 99% of the nominal design rate of 568 L/min (150 gpm).

The iodine-129 plume hydraulic containment injection wells were designed to operate at nominal flow rates of 189 to 379 L/min (50 to 100 gpm) per well. During 2017, 299-E20-1 operated at an average rate of 259 L/min (68.3 gpm), 299-E20-2 operated at an average rate of 249 L/min (65.9 gpm), and 299-E11-1 operated at an average rate of 263 L/min (69.6 gpm). Water-level data indicate the magnitude of the hydraulic gradient between the plume boundary and the injection wells has decreased, which has slowed the eastward migration of the plume.

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Appendix A

Monthly Average Groundwater Elevations in Monitoring Wells

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Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-E33-34	573104	137740	Jan-17	121.69	AWLN	299-W15-44	566685	136066	Jun-17	131.51	AWLN
299-W11-13	567099	136424	Jan-17	129.02	AWLN	299-W19-101	567939	135014	Jun-17	128.44	AWLN
299-W11-43	567270	136971	Jan-17	129.95	AWLN	299-W19-107	567998	135206	Jun-17	128.60	AWLN
299-W11-87	568141	136609	Jan-17	126.55	AWLN	299-W19-36	567635	135017	Jun-17	129.50	AWLN
299-W11-88	567875	137113	Jan-17	128.19	AWLN	299-W19-48	567823	134926	Jun-17	129.24	AWLN
299-W13-1	568149	136049	Jan-17	127.08	AWLN	299-W22-116	566901	134140	Jun-17	132.09	AWLN
299-W14-14	566898	136181	Jan-17	129.82	AWLN	299-W22-83	567009	134093	Jun-17	131.85	AWLN
299-W14-71	567733	135568	Jan-17	128.56	AWLN	299-W22-85	566903	134261	Jun-17	132.22	AWLN
299-W14-72	567328	135941	Jan-17	127.27	AWLN	699-35-78A	566064	134271	Jun-17	134.85	AWLN
299-W15-32	566773	135635	Jan-17	131.10	AWLN	699-36-61A	571395	134557	Jun-17	123.99	AWLN
299-W15-37	566716	135248	Jan-17	132.89	AWLN	699-38-61	571219	134997	Jun-17	123.69	AWLN
299-W15-44	566685	136066	Jan-17	130.81	AWLN	699-39-79	565891	135412	Jun-17	138.51	AWLN
299-W19-101	567939	135014	Jan-17	128.80	AWLN	699-45-69C	568947	137234	Jun-17	128.15	AWLN
299-W19-107	567998	135206	Jan-17	128.91	AWLN	299-W22-24P	567648	134411	Jun-17	130.57	Manual
299-W19-36	567635	135017	Jan-17	129.74	AWLN	299-W22-87	567542	134540	Jun-17	130.54	Manual
299-W19-48	567823	134926	Jan-17	129.45	AWLN	699-36-61A	571395	134557	Jun-17	124.00	Manual
299-W22-116	566901	134140	Jan-17	132.20	AWLN	699-36-63B	570684	134229	Jun-17	127.54	Manual
299-W22-83	567009	134093	Jan-17	131.96	AWLN	699-50-74	567360	138647	Jun-17	131.60	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W22-85	566903	134261	Jan-17	132.33	AWLN	699-51-63	570664	139148	Jun-17	122.51	Manual
699-35-78A	566064	134271	Jan-17	134.89	AWLN	299-W10-26	566843	136401	Jun-17	130.75	Manual
699-36-61A	571395	134557	Jan-17	123.94	AWLN	299-W10-27	566844	136442	Jun-17	130.75	Manual
699-38-61	571219	134997	Jan-17	123.66	AWLN	299-W11-41	566936	136678	Jun-17	130.99	Manual
699-39-79	565891	135412	Jan-17	138.83	AWLN	299-W14-11	566902	136288	Jun-17	129.63	Manual
699-45-69C	568947	137234	Jan-17	128.52	AWLN	299-W14-13	566902	136282	Jun-17	129.64	Manual
299-E28-26	572942	137024	Jan-17	121.68	Manual	299-W14-18	566897	136344	Jun-17	130.17	Manual
299-E28-28	572804	137108	Jan-17	121.65	Manual	299-W19-101	567939	135014	Jun-17	128.46	Manual
299-E32-3	572601	137384	Jan-17	121.67	Manual	299-W19-105	567565	134745	Jun-17	130.32	Manual
299-E33-266	572829	137468	Jan-17	121.55	Manual	299-W19-115	567372	135012	Jun-17	130.61	Manual
299-W18-15	566380	134733	Jan-17	134.30	Manual	299-W19-34A	567674	135012	Jun-17	128.26	Manual
299-W18-40	566723	134996	Jan-17	133.02	Manual	299-W19-39	567902	134887	Jun-17	129.43	Manual
299-W19-45	566898	135088	Jan-17	132.03	Manual	299-W19-43	567699	135004	Jun-17	128.03	Manual
299-W19-47	566895	135162	Jan-17	132.03	Manual	299-W19-46	567783	134842	Jun-17	129.81	Manual
299-W22-47	566909	134076	Jan-17	132.17	Manual	299-W19-48	567823	134926	Jun-17	129.27	Manual
299-W22-69	567180	134348	Jan-17	131.52	Manual	299-W19-49	567568	134894	Jun-17	130.09	Manual
299-W22-72	567237	134207	Jan-17	131.52	Manual	699-33-75	566908	133662	Jun-17	132.29	Manual
299-W22-81	567000	134354	Jan-17	131.94	Manual	699-34-61	571396	133810	Jun-17	125.92	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W22-82	567005	134167	Jan-17	131.99	Manual	699-34-72	567860	133785	Jun-17	130.75	Manual
299-W22-83	567009	134093	Jan-17	131.96	Manual	699-35-66A	569858	134099	Jun-17	130.22	Manual
299-W22-87	567542	134540	Jan-17	130.66	Manual	699-36-61A	571395	134557	Jun-17	123.94	Manual
299-W22-89	566907	134032	Jan-17	132.19	Manual	699-36-63B	570684	134229	Jun-17	127.48	Manual
299-W22-95	567171	134549	Jan-17	131.53	Manual	699-36-66B	569731	134469	Jun-17	129.08	Manual
299-W22-96	567352	134146	Jan-17	131.38	Manual	699-36-70B	568428	134626	Jun-17	129.94	Manual
699-33-75	566908	133662	Jan-17	132.38	Manual	699-37-66	569730	134797	Jun-17	128.87	Manual
699-51-63	570664	139148	Jan-17	122.43	Manual	699-38-61	571219	134997	Jun-17	123.65	Manual
699-52-55	573102	139443	Jan-17	121.75	Manual	699-38-65	570090	135040	Jun-17	128.46	Manual
299-W15-17	566307	135719	Jan-17	135.03	Manual	699-39-79	565891	135412	Jun-17	138.03	Manual
299-W15-30	566305	135749	Jan-17	135.08	Manual	699-40-62	571164	135764	Jun-17	122.54	Manual
299-W15-83	566305	135826	Jan-17	134.97	Manual	699-48-77C	566469	138087	Jun-17	134.33	Manual
299-W15-94	566308	135640	Jan-17	134.86	Manual	699-48-77D	566433	138119	Jun-17	134.46	Manual
299-W17-1	565311	135039	Jan-17	136.66	Manual	299-W15-37	566716	135248	Jun-17	132.95	Manual
299-W18-21	566098	134979	Jan-17	136.65	Manual	299-W18-260	566863	135197	Jun-17	132.13	Manual
299-W18-22	566089	134990	Jan-17	135.91	Manual	299-W18-40	566723	134996	Jun-17	133.06	Manual
299-W19-105	567565	134745	Jan-17	130.48	Manual	299-W19-12	566897	135059	Jun-17	131.78	Manual
299-W19-116	568510	135090	Jan-17	129.62	Manual	299-W19-41	566897	135005	Jun-17	132.15	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W19-34A	567674	135012	Jan-17	128.61	Manual	299-W19-42	566897	135123	Jun-17	132.11	Manual
299-W19-34B	567663	135011	Jan-17	129.73	Manual	299-W19-44	566897	135042	Jun-17	132.06	Manual
299-W19-36	567635	135017	Jan-17	129.65	Manual	299-W19-45	566898	135088	Jun-17	132.08	Manual
299-W19-39	567902	134887	Jan-17	129.61	Manual	299-W19-47	566895	135162	Jun-17	132.12	Manual
299-W19-43	567699	135004	Jan-17	128.24	Manual	299-W22-114	567726	134048	Jun-17	130.94	Manual
299-W19-44	566897	135042	Jan-17	131.99	Manual	699-30-57	572394	132771	Jun-17	124.14	Manual
299-W19-46	567783	134842	Jan-17	129.98	Manual	699-32-59	571800	133400	Jun-17	124.51	Manual
299-W19-48	567823	134926	Jan-17	129.42	Manual	699-38-65	570090	135040	Jun-17	128.57	Manual
299-W19-49	567568	134894	Jan-17	130.27	Manual	299-E28-9	573096	136587	Jun-17	121.78	Manual
299-W22-113	566905	134193	Jan-17	132.13	Manual	299-E28-21	573038	136830	Jun-17	121.57	Manual
299-W22-115	566939	134292	Jan-17	132.14	Manual	299-W18-15	566380	134733	Jun-17	134.34	Manual
299-W22-116	566901	134140	Jan-17	132.15	Manual	299-W22-47	566909	134076	Jun-17	132.09	Manual
299-W22-85	566903	134261	Jan-17	132.26	Manual	299-W22-69	567180	134348	Jun-17	131.44	Manual
299-W22-93	566949	134486	Jan-17	131.67	Manual	299-W22-72	567237	134207	Jun-17	131.44	Manual
299-W23-20	566718	134446	Jan-17	132.84	Manual	299-W22-81	567000	134354	Jun-17	131.86	Manual
299-W23-21	566708	134294	Jan-17	132.96	Manual	299-W22-82	567005	134167	Jun-17	131.93	Manual
699-48-77A	566413	137969	Jan-17	134.87	Manual	299-W22-83	567009	134093	Jun-17	131.90	Manual
699-48-77C	566469	138087	Jan-17	134.23	Manual	299-W22-87	567542	134540	Jun-17	130.57	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-48-77D	566433	138119	Jan-17	134.37	Manual	299-W22-89	566907	134032	Jun-17	132.15	Manual
299-E28-18	573104	136768	Jan-17	121.68	Manual	299-W22-95	567171	134549	Jun-17	131.46	Manual
299-E32-5	572600	137285	Jan-17	121.67	Manual	299-W22-96	567352	134146	Jun-17	131.31	Manual
299-E32-6	572600	137515	Jan-17	121.67	Manual	699-51-63	570664	139148	Jun-17	122.50	Manual
299-E32-8	572663	137741	Jan-17	122.58	Manual	699-52-55	573102	139443	Jun-17	121.74	Manual
299-E33-34	573104	137740	Jan-17	121.67	Manual	299-W19-116	568510	135090	Jun-17	129.40	Manual
299-W15-224	566308	135926	Jan-17	134.94	Manual	299-W22-113	566905	134193	Jun-17	132.05	Manual
699-34-61	571396	133810	Jan-17	125.84	Manual	299-W22-115	566939	134292	Jun-17	132.04	Manual
699-35-66A	569858	134099	Jan-17	129.22	Manual	299-W22-116	566901	134140	Jun-17	132.05	Manual
699-36-61A	571395	134557	Jan-17	123.85	Manual	299-W22-80	566843	134126	Jun-17	132.27	Manual
699-36-66B	569731	134469	Jan-17	129.13	Manual	299-W22-85	566903	134261	Jun-17	132.18	Manual
699-37-66	569730	134797	Jan-17	128.87	Manual	299-W22-93	566949	134486	Jun-17	131.57	Manual
699-38-61	571219	134997	Jan-17	123.61	Manual	299-W23-20	566718	134446	Jun-17	132.77	Manual
699-38-65	570090	135040	Jan-17	128.17	Manual	299-W23-21	566708	134294	Jun-17	132.90	Manual
699-40-62	571164	135764	Jan-17	122.54	Manual	299-W23-236	566799	134128	Jun-17	132.51	Manual
699-49-55A	573146	138352	Jan-17	121.68	Manual	699-49-55A	573146	138352	Jun-17	121.69	Manual
699-49-57A	572544	138389	Jan-17	121.68	Manual	699-50-56	572748	138842	Jun-17	121.74	Manual
699-50-56	572748	138842	Jan-17	121.70	Manual	299-E33-34	573104	137740	Jun-17	121.67	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-E33-30	572924	137468	Jan-17	121.68	Manual	299-W19-34B	567663	135011	Jun-17	115.87	Manual
299-E33-34	573104	137740	Jan-17	121.67	Manual	299-W19-36	567635	135017	Jun-17	129.48	Manual
299-E32-10	572951	137742	Jan-17	121.65	Manual	299-W19-44	566897	135042	Jul-17	132.05	Manual
299-E32-2	572648	137468	Jan-17	121.64	Manual	299-W19-45	566898	135088	Jul-17	132.06	Manual
299-E32-4	572604	137187	Jan-17	121.64	Manual	299-W19-47	566895	135162	Jul-17	132.10	Manual
299-E32-5	572600	137285	Jan-17	121.67	Manual	299-E32-2	572648	137468	Jul-17	120.63	Manual
299-E32-6	572600	137515	Jan-17	121.68	Manual	299-W15-152	566309	135550	Jul-17	134.90	Manual
299-E32-7	572600	137647	Jan-17	121.66	Manual	299-W15-17	566307	135719	Jul-17	135.22	Manual
299-E32-8	572663	137741	Jan-17	121.63	Manual	299-W15-30	566305	135749	Jul-17	135.26	Manual
299-E32-9	572795	137742	Jan-17	121.66	Manual	299-W15-94	566308	135640	Jul-17	135.01	Manual
299-W6-11	567163	137635	Jan-17	132.59	Manual	299-W17-1	565311	135039	Jul-17	116.79	Manual
299-W6-12	566916	137635	Jan-17	133.48	Manual	299-W18-21	566098	134979	Jul-17	136.73	Manual
299-W6-6	567319	137639	Jan-17	132.82	Manual	299-W18-40	566723	134996	Jul-17	133.05	Manual
299-W7-3	566292	137639	Jan-17	134.97	Manual	299-W15-83	566305	135826	Jul-17	135.19	Manual
299-W8-1	565749	137647	Jan-17	136.32	Manual	699-29-66	570054	132337	Jul-17	129.60	Manual
699-48-77C	566469	138087	Feb-17	134.26	Manual	699-30-57	572394	132771	Jul-17	124.00	Manual
699-48-77D	566433	138119	Feb-17	134.38	Manual	699-30-63	570717	132675	Jul-17	128.48	Manual
699-51-75	566978	138906	Feb-17	132.21	Manual	699-31-68	569598	133081	Jul-17	129.81	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-51-75P	566978	138906	Feb-17	132.27	Manual	699-32-59	571800	133400	Jul-17	123.84	Manual
299-W13-1	568149	136049	Feb-17	126.92	Manual	299-E28-13	573084	136485	Jul-17	121.53	Manual
299-W14-72	567328	135941	Feb-17	127.51	Manual	299-E28-18	573104	136768	Jul-17	121.48	Manual
299-W10-33	566773	136610	Feb-17	131.78	Manual	299-W15-17	566307	135719	Jul-17	135.22	Manual
299-W11-18	567182	137161	Feb-17	131.51	Manual	299-W18-22	566089	134990	Jul-17	136.07	Manual
299-W11-43	567270	136971	Feb-17	129.75	Manual	299-W18-40	566723	134996	Jul-17	133.08	Manual
299-E33-34	573104	137740	Feb-17	121.69	AWLN	299-E28-26	572942	137024	Jul-17	121.48	Manual
299-W11-13	567099	136424	Feb-17	128.93	AWLN	299-E28-28	572804	137108	Jul-17	121.65	Manual
299-W11-43	567270	136971	Feb-17	129.86	AWLN	299-E32-10	572951	137742	Jul-17	121.66	Manual
299-W11-87	568141	136609	Feb-17	126.40	AWLN	299-E32-9	572795	137742	Jul-17	121.66	Manual
299-W11-88	567875	137113	Feb-17	128.08	AWLN	299-E33-265	572866	137468	Jul-17	121.58	Manual
299-W13-1	568149	136049	Feb-17	126.93	AWLN	299-E33-266	572829	137468	Jul-17	121.55	Manual
299-W14-14	566898	136181	Feb-17	129.78	AWLN	699-32-64	570451	133304	Jul-17	128.60	Manual
299-W14-71	567733	135568	Feb-17	128.41	AWLN	299-E33-34	573104	137740	Jul-17	121.69	AWLN
299-W14-72	567328	135941	Feb-17	127.48	AWLN	299-W11-13	567099	136424	Jul-17	129.27	AWLN
299-W15-32	566773	135635	Feb-17	130.95	AWLN	299-W11-43	567270	136971	Jul-17	129.83	AWLN
299-W15-37	566716	135248	Feb-17	132.92	AWLN	299-W11-87	568141	136609	Jul-17	125.94	AWLN
299-W15-44	566685	136066	Feb-17	130.83	AWLN	299-W11-88	567875	137113	Jul-17	127.18	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W19-101	567939	135014	Feb-17	128.73	AWLN	299-W13-1	568149	136049	Jul-17	126.58	AWLN
299-W19-107	567998	135206	Feb-17	128.83	AWLN	299-W14-14	566898	136181	Jul-17	130.18	AWLN
299-W19-36	567635	135017	Feb-17	129.67	AWLN	299-W14-71	567733	135568	Jul-17	128.19	AWLN
299-W19-48	567823	134926	Feb-17	129.41	AWLN	299-W14-72	567328	135941	Jul-17	127.32	AWLN
299-W22-116	566901	134140	Feb-17	132.19	AWLN	299-W15-32	566773	135635	Jul-17	131.37	AWLN
299-W22-83	567009	134093	Feb-17	131.95	AWLN	299-W15-37	566716	135248	Jul-17	132.96	AWLN
299-W22-85	566903	134261	Feb-17	132.32	AWLN	299-W15-44	566685	136066	Jul-17	131.47	AWLN
699-35-78A	566064	134271	Feb-17	134.94	AWLN	299-W19-101	567939	135014	Jul-17	128.58	AWLN
699-36-61A	571395	134557	Feb-17	123.98	AWLN	299-W19-107	567998	135206	Jul-17	128.61	AWLN
699-38-61	571219	134997	Feb-17	123.70	AWLN	299-W19-36	567635	135017	Jul-17	129.59	AWLN
699-39-79	565891	135412	Feb-17	138.82	AWLN	299-W19-48	567823	134926	Jul-17	129.33	AWLN
699-45-69C	568947	137234	Feb-17	128.47	AWLN	299-W22-116	566901	134140	Jul-17	132.13	AWLN
299-W15-11	566412	136001	Feb-17	134.38	Manual	299-W22-83	567009	134093	Jul-17	131.86	AWLN
299-W15-33	566433	135967	Feb-17	134.13	Manual	299-W22-85	566903	134261	Jul-17	132.23	AWLN
299-W19-6	567133	134694	Feb-17	131.78	Manual	699-35-78A	566064	134271	Jul-17	134.88	AWLN
299-W10-27	566844	136442	Feb-17	130.18	Manual	699-36-61A	571395	134557	Jul-17	124.00	AWLN
299-W11-40	566927	136710	Feb-17	130.53	Manual	699-38-61	571219	134997	Jul-17	123.70	AWLN
299-W11-41	566936	136678	Feb-17	130.39	Manual	699-39-79	565891	135412	Jul-17	138.78	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W11-42	566920	136746	Feb-17	130.77	Manual	699-45-69C	568947	137234	Jul-17	127.98	AWLN
299-W10-26	566843	136401	Feb-17	130.05	Manual	299-E32-3	572601	137384	Jul-17	121.65	Manual
299-W14-13	566902	136282	Feb-17	128.77	Manual	299-W10-26	566843	136401	Jul-17	130.49	Manual
299-W14-15	566900	136231	Feb-17	129.43	Manual	299-W14-14	566898	136181	Jul-17	130.10	Manual
299-W14-18	566897	136344	Feb-17	129.38	Manual	299-W10-14	566017	136609	Jul-17	137.24	Manual
299-W18-15	566380	134733	Feb-17	134.28	Manual	299-W10-26	566843	136401	Jul-17	130.47	Manual
299-W19-34A	567674	135012	Feb-17	128.52	Manual	299-W10-27	566844	136442	Jul-17	130.56	Manual
299-W19-34B	567663	135011	Feb-17	129.67	Manual	299-W11-41	566936	136678	Jul-17	130.75	Manual
299-W11-47	566934	136681	Feb-17	131.31	Manual	299-W14-11	566902	136288	Jul-17	128.50	Manual
299-W11-87	568141	136609	Feb-17	126.23	Manual	299-W14-13	566902	136282	Jul-17	128.90	Manual
299-W14-11	566902	136288	Feb-17	128.87	Manual	299-W14-18	566897	136344	Jul-17	129.76	Manual
299-W19-43	567699	135004	Feb-17	128.17	Manual	299-W15-37	566716	135248	Jul-17	132.92	Manual
299-W19-34B	567663	135011	Feb-17	129.70	Manual	299-W18-15	566380	134733	Jul-17	134.37	Manual
299-W19-36	567635	135017	Feb-17	129.61	Manual	299-W18-21	566098	134979	Jul-17	136.80	Manual
299-W22-47	566909	134076	Feb-17	132.14	Manual	299-W18-22	566089	134990	Jul-17	136.08	Manual
299-W22-69	567180	134348	Feb-17	131.48	Manual	299-W19-101	567939	135014	Jul-17	129.01	Manual
299-W22-72	567237	134207	Feb-17	131.48	Manual	299-W19-105	567565	134745	Jul-17	130.34	Manual
299-W22-81	567000	134354	Feb-17	131.91	Manual	299-W19-115	567372	135012	Jul-17	130.60	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W22-82	567005	134167	Feb-17	131.97	Manual	299-W19-34A	567674	135012	Jul-17	129.69	Manual
299-W22-83	567009	134093	Feb-17	131.93	Manual	299-W19-34B	567663	135011	Jul-17	129.84	Manual
299-W22-87	567542	134540	Feb-17	130.63	Manual	299-W19-36	567635	135017	Jul-17	129.73	Manual
299-W22-89	566907	134032	Feb-17	132.17	Manual	299-W19-39	567902	134887	Jul-17	129.63	Manual
299-W22-95	567171	134549	Feb-17	131.50	Manual	299-W19-43	567699	135004	Jul-17	129.17	Manual
299-W22-96	567352	134146	Feb-17	131.33	Manual	299-W19-46	567783	134842	Jul-17	129.95	Manual
699-25-70	568545	131172	Feb-17	130.61	Manual	299-W19-48	567823	134926	Jul-17	129.58	Manual
699-33-75	566908	133662	Feb-17	132.36	Manual	299-W19-49	567568	134894	Jul-17	130.34	Manual
699-34-61	571396	133810	Feb-17	125.93	Manual	699-33-75	566908	133662	Jul-17	132.29	Manual
699-34-72	567860	133785	Feb-17	130.83	Manual	699-34-72	567860	133785	Jul-17	130.75	Manual
699-35-66A	569858	134099	Feb-17	129.28	Manual	699-36-70B	568428	134626	Jul-17	129.93	Manual
699-36-61A	571395	134557	Feb-17	123.94	Manual	699-39-79	565891	135412	Jul-17	138.85	Manual
699-36-66B	569731	134469	Feb-17	129.33	Manual	299-E13-18	573119	134216	Jul-17	121.73	Manual
699-36-70B	568428	134626	Feb-17	130.05	Manual	299-E32-4	572604	137187	Jul-17	121.63	Manual
699-37-66	569730	134797	Feb-17	128.91	Manual	299-E32-5	572600	137285	Jul-17	121.69	Manual
699-38-61	571219	134997	Feb-17	123.65	Manual	299-E32-6	572600	137515	Jul-17	121.70	Manual
699-38-65	570090	135040	Feb-17	128.25	Manual	299-E32-7	572600	137647	Jul-17	121.68	Manual
699-40-62	571164	135764	Feb-17	125.57	Manual	299-E32-8	572663	137741	Jul-17	121.70	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-48-77A	566413	137969	Feb-17	134.88	Manual	299-E33-30	572924	137468	Jul-17	121.71	Manual
699-48-77C	566469	138087	Feb-17	134.27	Manual	299-E33-34	573104	137740	Jul-17	121.70	Manual
699-48-77D	566433	138119	Feb-17	134.43	Manual	699-36-63B	570684	134229	Jul-17	127.56	Manual
299-E28-18	573104	136768	Feb-17	121.67	Manual	699-34-61	571396	133810	Jul-17	125.96	Manual
299-E32-5	572600	137285	Feb-17	121.67	Manual	699-36-61A	571395	134557	Jul-17	123.98	Manual
299-E32-6	572600	137515	Feb-17	121.67	Manual	699-38-61	571219	134997	Jul-17	123.68	Manual
299-E32-8	572663	137741	Feb-17	122.57	Manual	699-38-65	570090	135040	Jul-17	128.56	Manual
299-W18-15	566380	134733	Feb-17	134.34	Manual	699-40-62	571164	135764	Jul-17	122.53	Manual
299-W19-101	567939	135014	Feb-17	128.67	Manual	699-51-63	570664	139148	Jul-17	122.50	Manual
299-W19-105	567565	134745	Feb-17	130.45	Manual	699-52-55	573102	139443	Jul-17	121.74	Manual
299-W19-115	567372	135012	Feb-17	130.74	Manual	299-E28-26	572942	137024	Jul-17	121.68	Manual
299-W19-116	568510	135090	Feb-17	129.54	Manual	299-E32-10	572951	137742	Jul-17	119.66	Manual
299-W19-34A	567674	135012	Feb-17	128.61	Manual	299-E32-4	572604	137187	Jul-17	121.63	Manual
299-W19-39	567902	134887	Feb-17	129.57	Manual	299-E32-9	572795	137742	Jul-17	121.67	Manual
299-W19-43	567699	135004	Feb-17	128.23	Manual	299-E33-30	572924	137468	Jul-17	121.68	Manual
299-W19-46	567783	134842	Feb-17	129.96	Manual	299-W15-152	566309	135550	Jul-17	134.99	Manual
299-W19-49	567568	134894	Feb-17	130.25	Manual	299-W15-17	566307	135719	Jul-17	135.27	Manual
299-W22-113	566905	134193	Feb-17	132.15	Manual	299-W15-224	566308	135926	Jul-17	135.23	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W22-115	566939	134292	Feb-17	132.15	Manual	299-W15-30	566305	135749	Jul-17	135.21	Manual
299-W22-116	566901	134140	Feb-17	132.16	Manual	299-W15-83	566305	135826	Jul-17	135.24	Manual
299-W22-80	566843	134126	Feb-17	132.37	Manual	299-W15-94	566308	135640	Jul-17	135.08	Manual
299-W22-85	566903	134261	Feb-17	132.25	Manual	299-W17-1	565311	135039	Jul-17	136.86	Manual
299-W22-93	566949	134486	Feb-17	131.69	Manual	299-W18-21	566098	134979	Jul-17	136.89	Manual
299-W23-20	566718	134446	Feb-17	132.87	Manual	299-W18-22	566089	134990	Jul-17	136.22	Manual
299-W23-21	566708	134294	Feb-17	133.01	Manual	299-W18-40	566723	134996	Jul-17	133.08	Manual
299-W23-236	566799	134128	Feb-17	132.62	Manual	699-47-60	571474	137969	Jul-17	121.82	Manual
699-49-55A	573146	138352	Feb-17	121.68	Manual	699-48-77A	566413	137969	Jul-17	134.86	Manual
699-49-57A	572544	138389	Feb-17	121.67	Manual	699-48-77C	566469	138087	Jul-17	134.37	Manual
699-50-56	572748	138842	Feb-17	121.70	Manual	699-48-77D	566433	138119	Jul-17	134.53	Manual
699-51-63	570664	139148	Feb-17	123.22	Manual	699-49-57B	572536	138381	Jul-17	121.74	Manual
699-52-55	573102	139443	Feb-17	121.72	Manual	699-50-59	571947	138742	Jul-17	121.76	Manual
299-E33-34	573104	137740	Feb-17	121.68	Manual	699-55-57	572445	140120	Jul-17	121.74	Manual
299-W19-105	567565	134745	Feb-17	130.54	Manual	299-W19-116	568510	135090	Jul-17	129.36	Manual
299-W19-116	568510	135090	Feb-17	129.70	Manual	299-W22-113	566905	134193	Jul-17	132.22	Manual
299-W19-36	567635	135017	Feb-17	129.73	Manual	299-W22-115	566939	134292	Jul-17	132.13	Manual
299-W19-48	567823	134926	Feb-17	129.49	Manual	299-W22-116	566901	134140	Jul-17	132.24	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W23-4	566628	134392	Feb-17	133.44	Manual	299-W22-69	567180	134348	Jul-17	131.43	Manual
699-33-56	572923	133627	Feb-17	121.97	Manual	299-W22-80	566843	134126	Jul-17	132.41	Manual
699-40-62	571164	135764	Feb-17	122.57	Manual	299-W22-81	567000	134354	Jul-17	131.87	Manual
299-W19-107	567998	135206	Feb-17	128.75	Manual	299-W22-85	566903	134261	Jul-17	132.28	Manual
699-49-79	565771	138271	Feb-17	135.03	Manual	299-W22-93	566949	134486	Jul-17	131.71	Manual
299-W11-88	567875	137113	Feb-17	128.05	Manual	299-W23-20	566718	134446	Jul-17	132.85	Manual
299-W19-115	567372	135012	Mar-17	130.68	Manual	299-W23-21	566708	134294	Jul-17	132.98	Manual
299-W10-14	566017	136609	Mar-17	136.98	Manual	299-W23-236	566799	134128	Jul-17	132.62	Manual
299-W11-13	567099	136424	Mar-17	128.95	Manual	299-E28-18	573104	136768	Aug-17	121.70	Manual
299-W11-18	567182	137161	Mar-17	131.43	Manual	299-E32-5	572600	137285	Aug-17	121.70	Manual
299-W11-43	567270	136971	Mar-17	129.71	Manual	299-E32-6	572600	137515	Aug-17	121.70	Manual
299-W11-45	566993	136776	Mar-17	127.35	Manual	299-E32-8	572663	137741	Aug-17	121.70	Manual
299-W11-87	568141	136609	Mar-17	126.27	Manual	299-E33-34	573104	137740	Aug-17	121.69	Manual
299-W11-88	567875	137113	Mar-17	128.07	Manual	299-W15-31A	566377	135856	Aug-17	134.77	Manual
299-W13-1	568149	136049	Mar-17	125.78	Manual	299-W18-1	566422	135465	Aug-17	134.61	Manual
299-W14-71	567733	135568	Mar-17	128.29	Manual	299-W22-72	567237	134207	Aug-17	131.47	Manual
299-W14-72	567328	135941	Mar-17	127.35	Manual	299-W22-87	567542	134540	Aug-17	130.58	Manual
299-W15-2	566094	136336	Mar-17	136.71	Manual	299-W22-95	567171	134549	Aug-17	131.23	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W15-30	566305	135749	Mar-17	134.97	Manual	299-W22-96	567352	134146	Aug-17	131.32	Manual
299-W15-31A	566377	135856	Mar-17	134.54	Manual	699-49-55A	573146	138352	Aug-17	122.72	Manual
299-W15-46	566752	135587	Mar-17	132.15	Manual	699-49-57A	572544	138389	Aug-17	121.73	Manual
299-W15-50	566793	135791	Mar-17	131.23	Manual	699-50-56	572748	138842	Aug-17	121.79	Manual
299-W15-7	566676	135920	Mar-17	131.97	Manual	299-W14-71	567733	135568	Aug-17	128.18	Manual
299-W17-1	565311	135039	Mar-17	136.76	Manual	299-W19-101	567939	135014	Aug-17	128.58	Manual
299-W18-16	566605	135426	Mar-17	133.65	Manual	299-W19-39	567902	134887	Aug-17	129.54	Manual
299-W19-107	567998	135206	Mar-17	128.57	Manual	299-W19-4	567950	135351	Aug-17	128.80	Manual
299-W19-4	567950	135351	Mar-17	128.92	Manual	299-W19-43	567699	135004	Aug-17	128.30	Manual
299-W19-6	567133	134694	Mar-17	131.50	Manual	299-W19-46	567783	134842	Aug-17	129.93	Manual
299-W21-2	568124	134574	Mar-17	130.26	Manual	299-W19-48	567823	134926	Aug-17	129.39	Manual
299-W22-24P	567648	134411	Mar-17	130.62	Manual	299-W19-49	567568	134894	Aug-17	130.18	Manual
299-W22-24Q	567648	134411	Mar-17	130.56	Manual	299-W19-115	567372	135012	Aug-17	131.65	Manual
299-W22-24R	567648	134411	Mar-17	132.35	Manual	299-W17-1	565311	135039	Aug-17	136.81	Manual
299-W22-24S	567648	134411	Mar-17	130.71	Manual	299-W22-47	566909	134076	Aug-17	132.25	Manual
299-W22-24T	567648	134411	Mar-17	130.84	Manual	299-W22-82	567005	134167	Aug-17	132.03	Manual
299-W22-79	567630	134465	Mar-17	130.42	Manual	299-W22-83	567009	134093	Aug-17	131.99	Manual
299-W6-3	567118	137299	Mar-17	131.95	Manual	299-W22-89	566907	134032	Aug-17	132.25	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-35-78A	566064	134271	Mar-17	134.87	Manual	699-35-66A	569858	134099	Aug-17	129.25	Manual
699-38-61	571219	134997	Mar-17	123.65	Manual	699-36-63B	570684	134229	Aug-17	127.55	Manual
699-38-68A	569180	134932	Mar-17	129.76	Manual	699-36-66B	569731	134469	Aug-17	129.29	Manual
699-39-79	565891	135412	Mar-17	139.78	Manual	699-37-66	569730	134797	Aug-17	128.92	Manual
699-45-69C	568947	137234	Mar-17	128.38	Manual	699-50-85	564130	138669	Aug-17	135.21	Manual
699-49-79	565771	138271	Mar-17	134.99	Manual	299-W11-40	566927	136710	Aug-17	130.98	Manual
699-50-74	567360	138647	Mar-17	131.90	Manual	299-W11-41	566936	136678	Aug-17	130.85	Manual
699-50-85	564130	138669	Mar-17	135.17	Manual	299-W11-42	566920	136746	Aug-17	131.21	Manual
699-51-63	570664	139148	Mar-17	122.51	Manual	299-W11-47	566934	136681	Aug-17	130.81	Manual
699-51-75	566978	138906	Mar-17	132.22	Manual	299-W14-11	566902	136288	Aug-17	129.40	Manual
699-51-75P	566978	138906	Mar-17	132.23	Manual	299-W14-13	566902	136282	Aug-17	129.39	Manual
299-W10-14	566017	136609	Mar-17	136.98	Manual	299-E33-34	573104	137740	Aug-17	121.72	AWLN
299-W10-29	566083	136829	Mar-17	136.49	Manual	299-W10-26	566843	136401	Aug-17	130.72	Manual
299-W10-31	566266	136968	Mar-17	135.98	Manual	299-W10-27	566844	136442	Aug-17	130.76	Manual
299-W15-152	566309	135550	Mar-17	134.81	Manual	299-W11-13	567099	136424	Aug-17	129.32	AWLN
299-W15-17	566307	135719	Mar-17	135.08	Manual	299-W11-43	567270	136971	Aug-17	129.79	AWLN
299-W15-224	566308	135926	Mar-17	135.00	Manual	299-W11-87	568141	136609	Aug-17	126.31	AWLN
299-W15-50	566793	135791	Mar-17	131.32	Manual	299-W11-88	567875	137113	Aug-17	127.83	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W15-83	566305	135826	Mar-17	135.02	Manual	299-W13-1	568149	136049	Aug-17	126.99	AWLN
299-W15-94	566308	135640	Mar-17	134.91	Manual	299-W14-14	566898	136181	Aug-17	130.36	AWLN
299-W18-1	566422	135465	Mar-17	134.45	Manual	299-W14-15	566900	136231	Aug-17	130.10	Manual
299-W18-16	566605	135426	Mar-17	133.33	Manual	299-W14-18	566897	136344	Aug-17	130.07	Manual
299-W18-21	566098	134979	Mar-17	136.70	Manual	299-W14-71	567733	135568	Aug-17	128.50	AWLN
299-W18-22	566089	134990	Mar-17	135.98	Manual	299-W14-72	567328	135941	Aug-17	127.66	AWLN
299-W21-3	568571	133980	Mar-17	130.47	Manual	299-W15-32	566773	135635	Aug-17	131.64	AWLN
299-W26-13	566424	133294	Mar-17	133.48	Manual	299-W15-37	566716	135248	Aug-17	133.10	AWLN
299-W26-14	566683	133539	Mar-17	132.86	Manual	299-W15-44	566685	136066	Aug-17	131.83	AWLN
299-W27-2	566908	133670	Mar-17	132.30	Manual	299-W19-101	567939	135014	Aug-17	128.44	AWLN
299-W6-11	567163	137635	Mar-17	132.48	Manual	299-W19-107	567998	135206	Aug-17	128.57	AWLN
299-W6-12	566916	137635	Mar-17	133.36	Manual	299-W19-116	568510	135090	Aug-17	129.39	Manual
299-W6-3	567118	137299	Mar-17	131.91	Manual	299-W19-36	567635	135017	Aug-17	129.56	AWLN
299-W6-6	567319	137639	Mar-17	132.52	Manual	299-W19-36	567635	135017	Aug-17	129.53	Manual
299-W7-3	566292	137639	Mar-17	134.92	Manual	299-W19-48	567823	134926	Aug-17	129.25	AWLN
299-W7-4	566409	137308	Mar-17	134.99	Manual	299-W22-116	566901	134140	Aug-17	132.27	AWLN
299-W8-1	565749	137647	Mar-17	136.33	Manual	299-W22-83	567009	134093	Aug-17	131.95	AWLN
299-W9-2	565742	136873	Mar-17	136.74	Manual	299-W22-85	566903	134261	Aug-17	132.32	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-32-76	566684	133138	Mar-17	132.62	Manual	699-35-78A	566064	134271	Aug-17	134.84	AWLN
699-33-76	566621	133600	Mar-17	133.02	Manual	699-36-61A	571395	134557	Aug-17	124.03	AWLN
699-35-66A	569858	134099	Mar-17	129.29	Manual	699-38-61	571219	134997	Aug-17	123.66	AWLN
699-36-66B	569731	134469	Mar-17	129.33	Manual	699-39-79	565891	135412	Aug-17	137.11	AWLN
699-36-70A	568467	134309	Mar-17	130.32	Manual	699-45-69C	568947	137234	Aug-17	128.12	AWLN
699-37-66	569730	134797	Mar-17	128.91	Manual	699-48-77C	566469	138087	Aug-17	134.33	Manual
699-49-57A	572544	138389	Mar-17	121.68	Manual	699-48-77D	566433	138119	Aug-17	134.50	Manual
699-49-57B	572536	138381	Mar-17	121.70	Manual	699-51-63	570664	139148	Aug-17	122.50	Manual
299-W10-1	566663	136735	Mar-17	132.59	Manual	699-52-55	573102	139443	Aug-17	121.74	Manual
299-W10-23	566824	136815	Mar-17	131.45	Manual	299-E28-18	573104	136768	Aug-17	121.73	Manual
299-W10-24	566885	136799	Mar-17	131.12	Manual	299-E32-5	572600	137285	Aug-17	121.73	Manual
299-W10-26	566843	136401	Mar-17	130.22	Manual	299-E32-6	572600	137515	Aug-17	121.73	Manual
299-W10-27	566844	136442	Mar-17	130.27	Manual	299-E32-8	572663	137741	Aug-17	121.74	Manual
299-W10-28	566702	136710	Mar-17	131.86	Manual	299-E33-34	573104	137740	Aug-17	121.73	Manual
299-W11-39	566908	136780	Mar-17	130.92	Manual	699-49-55A	573146	138352	Aug-17	121.74	Manual
299-W11-40	566927	136710	Mar-17	130.68	Manual	699-49-57A	572544	138389	Aug-17	121.74	Manual
299-W11-41	566936	136678	Mar-17	130.53	Manual	699-50-56	572748	138842	Aug-17	121.82	Manual
299-W11-42	566920	136746	Mar-17	130.89	Manual	299-W19-116	568510	135090	Aug-17	129.40	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W11-47	566934	136681	Mar-17	130.49	Manual	299-W19-34B	567663	135011	Aug-17	129.66	Manual
299-W13-2	568833	135819	Mar-17	128.20	Manual	299-W19-36	567635	135017	Aug-17	129.52	Manual
299-W14-11	566902	136288	Mar-17	128.97	Manual	299-W22-113	566905	134193	Aug-17	132.29	Manual
299-W14-13	566902	136282	Mar-17	129.00	Manual	299-W22-115	566939	134292	Aug-17	132.20	Manual
299-W14-14	566898	136181	Mar-17	129.86	Manual	299-W22-116	566901	134140	Aug-17	132.30	Manual
299-W14-15	566900	136231	Mar-17	129.60	Manual	299-W22-47	566909	134076	Aug-17	132.27	Manual
299-W14-16	567001	136318	Mar-17	129.44	Manual	299-W22-69	567180	134348	Aug-17	131.51	Manual
299-W14-17	567007	136218	Mar-17	129.38	Manual	299-W22-72	567237	134207	Aug-17	131.49	Manual
299-W14-18	566897	136344	Mar-17	129.58	Manual	299-W22-80	566843	134126	Aug-17	132.46	Manual
299-W14-19	566899	136135	Mar-17	129.79	Manual	299-W22-81	567000	134354	Aug-17	131.96	Manual
299-W15-37	566716	135248	Mar-17	132.85	Manual	299-W22-82	567005	134167	Aug-17	132.06	Manual
299-W15-763	566809	136029	Mar-17	130.85	Manual	299-W22-83	567009	134093	Aug-17	132.02	Manual
299-W18-15	566380	134733	Mar-17	134.33	Manual	299-W22-85	566903	134261	Aug-17	132.35	Manual
299-W18-260	566863	135197	Mar-17	132.03	Manual	299-W22-87	567542	134540	Aug-17	130.57	Manual
299-W18-40	566723	134996	Mar-17	133.32	Manual	299-W22-89	566907	134032	Aug-17	132.28	Manual
299-W19-101	567939	135014	Mar-17	128.58	Manual	299-W22-93	566949	134486	Aug-17	131.79	Manual
299-W19-105	567565	134745	Mar-17	130.41	Manual	299-W22-95	567171	134549	Aug-17	131.53	Manual
299-W19-115	567372	135012	Mar-17	130.69	Manual	299-W22-96	567352	134146	Aug-17	131.33	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W19-116	568510	135090	Mar-17	129.51	Manual	299-W23-20	566718	134446	Aug-17	132.89	Manual
299-W19-12	566897	135059	Mar-17	131.99	Manual	299-W23-21	566708	134294	Aug-17	133.02	Manual
299-W19-34A	567674	135012	Mar-17	128.52	Manual	299-W23-236	566799	134128	Aug-17	132.68	Manual
299-W19-39	567902	134887	Mar-17	129.53	Manual	699-48-77C	566469	138087	Aug-17	134.36	Manual
299-W19-41	566897	135005	Mar-17	132.08	Manual	699-48-77D	566433	138119	Aug-17	134.53	Manual
299-W19-42	566897	135123	Mar-17	132.03	Manual	299-W18-15	566380	134733	Aug-17	134.27	Manual
299-W19-43	567699	135004	Mar-17	128.14	Manual	299-W19-101	567939	135014	Aug-17	128.48	Manual
299-W19-44	566897	135042	Mar-17	132.00	Manual	299-W19-105	567565	134745	Aug-17	130.37	Manual
299-W19-45	566898	135088	Mar-17	132.00	Manual	299-W19-115	567372	135012	Aug-17	130.72	Manual
299-W19-46	567783	134842	Mar-17	129.90	Manual	299-W19-34A	567674	135012	Aug-17	129.54	Manual
299-W19-47	566895	135162	Mar-17	132.03	Manual	299-W19-39	567902	134887	Aug-17	129.48	Manual
299-W19-48	567823	134926	Mar-17	129.35	Manual	299-W19-43	567699	135004	Aug-17	128.73	Manual
299-W19-49	567568	134894	Mar-17	130.19	Manual	299-W19-46	567783	134842	Aug-17	129.88	Manual
299-W21-3	568571	133980	Mar-17	130.43	Manual	299-W19-48	567823	134926	Aug-17	129.34	Manual
299-W22-113	566905	134193	Mar-17	132.12	Manual	299-W19-49	567568	134894	Aug-17	130.18	Manual
299-W22-115	566939	134292	Mar-17	132.11	Manual	699-33-75	566908	133662	Aug-17	132.38	Manual
299-W22-116	566901	134140	Mar-17	132.12	Manual	699-34-61	571396	133810	Aug-17	126.03	Manual
299-W22-47	566909	134076	Mar-17	132.13	Manual	699-34-72	567860	133785	Aug-17	130.80	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W22-69	567180	134348	Mar-17	131.44	Manual	699-35-66A	569858	134099	Aug-17	129.29	Manual
299-W22-72	567237	134207	Mar-17	131.45	Manual	699-36-61A	571395	134557	Aug-17	124.04	Manual
299-W22-80	566843	134126	Mar-17	132.33	Manual	699-36-66B	569731	134469	Aug-17	129.33	Manual
299-W22-81	567000	134354	Mar-17	131.88	Manual	699-36-70B	568428	134626	Aug-17	129.99	Manual
299-W22-82	567005	134167	Mar-17	131.94	Manual	699-37-66	569730	134797	Aug-17	128.60	Manual
299-W22-83	567009	134093	Mar-17	131.91	Manual	699-38-61	571219	134997	Aug-17	123.75	Manual
299-W22-87	567542	134540	Mar-17	130.61	Manual	699-38-65	570090	135040	Aug-17	230.72	Manual
299-W22-89	566907	134032	Mar-17	132.15	Manual	699-40-62	571164	135764	Aug-17	122.56	Manual
299-W22-93	566949	134486	Mar-17	132.60	Manual	299-W10-14	566017	136609	Sep-17	136.40	Manual
299-W22-95	567171	134549	Mar-17	131.46	Manual	299-W10-29	566083	136829	Sep-17	136.43	Manual
299-W22-96	567352	134146	Mar-17	131.31	Manual	299-W10-31	566266	136968	Sep-17	135.93	Manual
299-W23-20	566718	134446	Mar-17	132.86	Manual	299-W9-2	565742	136873	Sep-17	136.79	Manual
299-W23-21	566708	134294	Mar-17	132.97	Manual	299-W21-3	568571	133980	Sep-17	130.36	Manual
299-W23-236	566799	134128	Mar-17	132.58	Manual	299-W22-47	566909	134076	Sep-17	132.24	Manual
699-19-58	572133	129299	Mar-17	126.54	Manual	299-W22-93	566949	134486	Sep-17	131.73	Manual
699-22-70P	568798	130166	Mar-17	130.00	Manual	299-E33-34	573104	137740	Sep-17	121.75	AWLN
699-22-70Q	568798	130166	Mar-17	130.10	Manual	299-W11-13	567099	136424	Sep-17	129.13	AWLN
699-25-70	568545	131172	Mar-17	130.60	Manual	299-W11-43	567270	136971	Sep-17	129.68	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-26-83BQ	564635	131319	Mar-17	122.65	Manual	299-W11-87	568141	136609	Sep-17	125.91	AWLN
699-26-83BR	564635	131319	Mar-17	121.34	Manual	299-W11-88	567875	137113	Sep-17	127.28	AWLN
699-29-66	570054	132337	Mar-17	129.61	Manual	299-W13-1	568149	136049	Sep-17	126.58	AWLN
699-29-70AP	568465	132162	Mar-17	131.42	Manual	299-W14-14	566898	136181	Sep-17	130.17	AWLN
699-29-70AQ	568465	132162	Mar-17	130.61	Manual	299-W14-71	567733	135568	Sep-17	128.41	AWLN
699-29-70CP	568494	132247	Mar-17	122.39	Manual	299-W14-72	567328	135941	Sep-17	126.95	AWLN
699-29-70CQ	568494	132247	Mar-17	121.36	Manual	299-W15-32	566773	135635	Sep-17	131.42	AWLN
699-29-70CR	568494	132247	Mar-17	121.95	Manual	299-W15-37	566716	135248	Sep-17	132.97	AWLN
699-29-70CS	568494	132247	Mar-17	121.25	Manual	299-W15-44	566685	136066	Sep-17	131.47	AWLN
699-29-70CT	568494	132247	Mar-17	121.04	Manual	299-W19-101	567939	135014	Sep-17	128.46	AWLN
699-29-70CU	568494	132247	Mar-17	120.73	Manual	299-W19-107	567998	135206	Sep-17	128.52	AWLN
699-29-70DP	568532	132221	Mar-17	127.94	Manual	299-W19-34B	567663	135011	Sep-17	129.53	Manual
699-29-78	566212	132414	Mar-17	133.50	Manual	299-W19-36	567635	135017	Sep-17	129.49	AWLN
699-30-66	569991	132739	Mar-17	129.56	Manual	299-W19-36	567635	135017	Sep-17	129.43	Manual
699-31-68	569598	133081	Mar-17	129.82	Manual	299-W19-48	567823	134926	Sep-17	129.24	AWLN
699-32-62	571010	133216	Mar-17	127.66	Manual	299-W22-116	566901	134140	Sep-17	132.25	AWLN
699-32-70B	568462	133242	Mar-17	130.81	Manual	299-W22-83	567009	134093	Sep-17	131.94	AWLN
699-32-72A	567943	133363	Mar-17	130.97	Manual	299-W22-85	566903	134261	Sep-17	132.30	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-32-72B	567935	133362	Mar-17	131.01	Manual	699-25-55	573089	131212	Sep-17	124.19	Manual
699-33-74	567473	133552	Mar-17	131.37	Manual	699-25-70	568545	131172	Sep-17	130.52	Manual
699-33-75	566908	133662	Mar-17	132.34	Manual	699-35-78A	566064	134271	Sep-17	134.84	AWLN
699-34-61	571396	133810	Mar-17	125.94	Manual	699-36-61A	571395	134557	Sep-17	124.04	AWLN
699-34-72	567860	133785	Mar-17	130.82	Manual	699-38-61	571219	134997	Sep-17	123.74	AWLN
699-36-61A	571395	134557	Mar-17	123.94	Manual	699-39-79	565891	135412	Sep-17	138.64	AWLN
699-36-70A	568467	134309	Mar-17	130.29	Manual	699-45-69C	568947	137234	Sep-17	128.10	AWLN
699-36-70B	568428	134626	Mar-17	130.04	Manual	699-48-77C	566469	138087	Sep-17	134.32	Manual
699-38-65	570090	135040	Mar-17	128.25	Manual	699-48-77D	566433	138119	Sep-17	134.49	Manual
699-38-70B	568469	135331	Mar-17	128.88	Manual	699-36-63B	570684	134229	Sep-17	127.61	Manual
699-38-70C	569084	135326	Mar-17	129.57	Manual	299-W10-26	566843	136401	Sep-17	130.53	Manual
699-39-84CP	564338	135566	Mar-17	123.02	Manual	299-W10-27	566844	136442	Sep-17	130.58	Manual
699-39-84CQ	564338	135566	Mar-17	111.36	Manual	299-W11-41	566936	136678	Sep-17	130.77	Manual
699-39-84CR	564338	135566	Mar-17	118.41	Manual	299-W14-13	566902	136282	Sep-17	129.22	Manual
699-39-84CS	564338	135566	Mar-17	107.55	Manual	299-W14-18	566897	136344	Sep-17	129.88	Manual
699-39-84CT	564338	135566	Mar-17	123.37	Manual	299-W14-11	566902	136288	Sep-17	129.17	Manual
699-39-84CU	564338	135566	Mar-17	125.08	Manual	299-W22-114	567726	134048	Sep-17	130.98	Manual
699-40-62	571164	135764	Mar-17	122.57	Manual	299-W22-115	566939	134292	Sep-17	132.21	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-44-64	570391	136897	Mar-17	123.07	Manual	299-W15-37	566716	135248	Sep-17	132.92	Manual
699-47-60	571474	137969	Mar-17	121.78	Manual	299-W18-260	566863	135197	Sep-17	132.08	Manual
699-47-80AP	565562	137693	Mar-17	129.86	Manual	299-W18-40	566723	134996	Sep-17	133.04	Manual
699-47-80AQ	565562	137693	Mar-17	134.02	Manual	299-W19-101	567939	135014	Sep-17	128.53	Manual
699-47-80DP	565494	137779	Mar-17	126.78	Manual	299-W19-105	567565	134745	Sep-17	130.28	Manual
699-48-77A	566413	137969	Mar-17	134.87	Manual	299-W19-115	567372	135012	Sep-17	130.59	Manual
699-48-77C	566469	138087	Mar-17	134.25	Manual	299-W19-116	568510	135090	Sep-17	129.31	Manual
699-48-77D	566433	138119	Mar-17	134.41	Manual	299-W19-12	566897	135059	Sep-17	132.05	Manual
699-49-55B	573139	138351	Mar-17	121.74	Manual	299-W19-34A	567674	135012	Sep-17	128.40	Manual
699-49-57B	572536	138381	Mar-17	121.70	Manual	299-W19-39	567902	134887	Sep-17	129.45	Manual
699-50-59	571947	138742	Mar-17	121.69	Manual	299-W19-41	566897	135005	Sep-17	132.11	Manual
699-52-55	573102	139443	Mar-17	121.74	Manual	299-W19-42	566897	135123	Sep-17	132.09	Manual
699-52-55B	573102	139441	Mar-17	121.73	Manual	299-W19-43	567699	135004	Sep-17	127.99	Manual
699-54-57	572619	140030	Mar-17	121.69	Manual	299-W19-44	566897	135042	Sep-17	132.04	Manual
699-55-57	572445	140120	Mar-17	121.66	Manual	299-W19-45	566898	135088	Sep-17	132.05	Manual
699-26-83BP	564635	131319	Mar-17	122.43	Manual	299-W19-46	567783	134842	Sep-17	129.81	Manual
299-E33-34	573104	137740	Mar-17	121.68	AWLN	299-W19-47	566895	135162	Sep-17	132.09	Manual
299-W11-13	567099	136424	Mar-17	129.14	AWLN	299-W19-48	567823	134926	Sep-17	129.33	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W11-43	567270	136971	Mar-17	129.78	AWLN	299-W19-49	567568	134894	Sep-17	130.06	Manual
299-W11-87	568141	136609	Mar-17	126.52	AWLN	299-W22-113	566905	134193	Sep-17	132.21	Manual
299-W11-88	567875	137113	Mar-17	127.99	AWLN	299-W22-115	566939	134292	Sep-17	132.12	Manual
299-W13-1	568149	136049	Mar-17	126.92	AWLN	299-W22-116	566901	134140	Sep-17	132.22	Manual
299-W14-14	566898	136181	Mar-17	129.99	AWLN	299-W22-80	566843	134126	Sep-17	132.39	Manual
299-W14-71	567733	135568	Mar-17	128.34	AWLN	299-W22-85	566903	134261	Sep-17	132.27	Manual
299-W14-72	567328	135941	Mar-17	127.75	AWLN	299-W22-93	566949	134486	Sep-17	131.69	Manual
299-W15-32	566773	135635	Mar-17	131.20	AWLN	299-W23-20	566718	134446	Sep-17	132.83	Manual
299-W15-37	566716	135248	Mar-17	132.94	AWLN	299-W23-21	566708	134294	Sep-17	132.95	Manual
299-W15-44	566685	136066	Mar-17	130.95	AWLN	299-W23-236	566799	134128	Sep-17	132.60	Manual
299-W19-101	567939	135014	Mar-17	128.60	AWLN	299-W22-47	566909	134076	Sep-17	132.22	Manual
299-W19-107	567998	135206	Mar-17	128.72	AWLN	299-W22-69	567180	134348	Sep-17	131.42	Manual
299-W19-36	567635	135017	Mar-17	129.59	AWLN	299-W22-72	567237	134207	Sep-17	131.40	Manual
299-W19-48	567823	134926	Mar-17	129.33	AWLN	299-W22-81	567000	134354	Sep-17	131.87	Manual
299-W22-116	566901	134140	Mar-17	132.15	AWLN	299-W22-82	567005	134167	Sep-17	131.98	Manual
299-W22-83	567009	134093	Mar-17	131.91	AWLN	299-W22-83	567009	134093	Sep-17	131.95	Manual
299-W22-85	566903	134261	Mar-17	132.28	AWLN	299-W22-87	567542	134540	Sep-17	130.48	Manual
699-35-78A	566064	134271	Mar-17	134.91	AWLN	299-W22-89	566907	134032	Sep-17	132.21	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-36-61A	571395	134557	Mar-17	124.00	AWLN	299-W22-96	567352	134146	Sep-17	131.23	Manual
699-38-61	571219	134997	Mar-17	123.72	AWLN	699-39-79	565891	135412	Sep-17	138.81	Manual
699-39-79	565891	135412	Mar-17	138.70	AWLN	699-34-61	571396	133810	Sep-17	126.00	Manual
699-45-69C	568947	137234	Mar-17	128.38	AWLN	699-35-66A	569858	134099	Sep-17	129.19	Manual
699-34-61	571396	133810	Mar-17	125.99	Manual	699-36-61A	571395	134557	Sep-17	124.03	Manual
299-E13-10	573195	134253	Mar-17	121.68	Manual	699-36-63B	570684	134229	Sep-17	127.60	Manual
299-E13-14	573087	134474	Mar-17	121.73	Manual	699-36-66B	569731	134469	Sep-17	129.23	Manual
299-E28-18	573104	136768	Mar-17	121.66	Manual	699-36-70A	568467	134309	Sep-17	130.11	Manual
299-E32-5	572600	137285	Mar-17	121.65	Manual	699-37-66	569730	134797	Sep-17	128.90	Manual
299-E32-6	572600	137515	Mar-17	121.65	Manual	699-38-61	571219	134997	Sep-17	123.71	Manual
299-E32-8	572663	137741	Mar-17	121.66	Manual	699-38-65	570090	135040	Sep-17	128.61	Manual
299-E33-34	573104	137740	Mar-17	121.66	Manual	699-40-62	571164	135764	Sep-17	122.57	Manual
299-W19-34B	567663	135011	Mar-17	129.62	Manual	699-51-63	570664	139148	Sep-17	122.52	Manual
299-W19-36	567635	135017	Mar-17	129.50	Manual	699-52-55	573102	139443	Sep-17	121.79	Manual
699-25-55	573089	131212	Mar-17	124.18	Manual	299-E32-5	572600	137285	Sep-17	121.75	Manual
699-30-57	572394	132771	Mar-17	124.12	Manual	299-E32-6	572600	137515	Sep-17	121.75	Manual
699-33-56	572923	133627	Mar-17	121.74	Manual	299-E32-8	572663	137741	Sep-17	121.75	Manual
699-49-55A	573146	138352	Mar-17	121.68	Manual	699-49-55A	573146	138352	Sep-17	121.72	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-49-57A	572544	138389	Mar-17	121.67	Manual	699-49-57A	572544	138389	Sep-17	121.77	Manual
699-50-56	572748	138842	Mar-17	121.69	Manual	699-50-56	572748	138842	Sep-17	121.82	Manual
699-53-55C	573115	139624	Mar-17	121.71	Manual	299-E33-34	573104	137740	Oct-17	121.74	Manual
299-W10-29	566083	136829	Mar-17	136.57	Manual	299-W22-95	567171	134549	Oct-17	131.41	Manual
299-W10-31	566266	136968	Mar-17	136.06	Manual	699-33-75	566908	133662	Oct-17	132.32	Manual
299-W9-2	565742	136873	Mar-17	136.83	Manual	699-34-72	567860	133785	Oct-17	130.73	Manual
299-W22-116	566901	134140	Mar-17	132.20	Manual	699-36-70B	568428	134626	Oct-17	129.89	Manual
299-W22-47	566909	134076	Mar-17	132.18	Manual	699-51-63	570664	139148	Oct-17	122.53	Manual
299-W22-93	566949	134486	Mar-17	131.74	Manual	699-52-55	573102	139443	Oct-17	121.81	Manual
699-29-66	570054	132337	Mar-17	129.76	Manual	299-W19-116	568510	135090	Oct-17	129.29	Manual
699-30-57	572394	132771	Mar-17	124.65	Manual	299-W22-113	566905	134193	Oct-17	132.14	Manual
699-31-68	569598	133081	Mar-17	129.98	Manual	299-W22-115	566939	134292	Oct-17	132.08	Manual
699-35-66A	569858	134099	Mar-17	129.40	Manual	299-W22-116	566901	134140	Oct-17	132.18	Manual
699-36-66B	569731	134469	Mar-17	129.45	Manual	299-W22-85	566903	134261	Oct-17	132.23	Manual
699-37-66	569730	134797	Mar-17	129.03	Manual	299-W22-93	566949	134486	Oct-17	131.59	Manual
299-E28-30	573140	136551	Mar-17	121.51	Manual	299-W23-20	566718	134446	Oct-17	132.83	Manual
299-W22-115	566939	134292	Mar-17	132.18	Manual	299-W23-21	566708	134294	Oct-17	132.96	Manual
699-38-68A	569180	134932	Mar-17	129.81	Manual	699-29-66	570054	132337	Oct-17	129.51	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-47-80AQ	565562	137693	Mar-17	133.99	Manual	699-30-57	572394	132771	Oct-17	124.15	Manual
299-W10-26	566843	136401	Mar-17	130.43	Manual	699-30-63	570717	132675	Oct-17	128.61	Manual
299-W10-27	566844	136442	Mar-17	130.48	Manual	699-33-75	566908	133662	Oct-17	132.30	Manual
299-W14-11	566902	136288	Mar-17	129.22	Manual	699-34-61	571396	133810	Oct-17	125.96	Manual
299-W14-13	566902	136282	Mar-17	129.23	Manual	699-34-72	567860	133785	Oct-17	130.71	Manual
299-W14-18	566897	136344	Mar-17	129.84	Manual	699-36-61A	571395	134557	Oct-17	123.99	Manual
299-W11-41	566936	136678	Mar-17	130.73	Manual	699-36-63B	570684	134229	Oct-17	127.55	Manual
699-13-64	570416	127309	Mar-17	132.23	Manual	699-36-70B	568428	134626	Oct-17	129.87	Manual
699-32-62	571010	133216	Apr-17	127.78	Manual	699-38-61	571219	134997	Oct-17	123.72	Manual
699-32-72A	567943	133363	Apr-17	131.09	Manual	699-38-65	570090	135040	Oct-17	128.66	Manual
699-36-70B	568428	134626	Apr-17	130.13	Manual	699-40-62	571164	135764	Oct-17	122.57	Manual
299-E13-14	573087	134474	Apr-17	121.77	Manual	299-E33-34	573104	137740	Oct-17	121.77	AWLN
699-49-55A	573146	138352	Apr-17	121.70	Manual	299-E33-34	573104	137740	Oct-17	121.76	Manual
299-W18-260	566863	135197	Apr-17	132.32	Manual	299-W11-13	567099	136424	Oct-17	128.94	AWLN
299-W19-12	566897	135059	Apr-17	132.26	Manual	299-W11-43	567270	136971	Oct-17	129.53	AWLN
299-W19-34A	567674	135012	Apr-17	128.70	Manual	299-W11-87	568141	136609	Oct-17	125.62	AWLN
299-W19-34B	567663	135011	Apr-17	129.88	Manual	299-W11-88	567875	137113	Oct-17	127.01	AWLN
299-W19-36	567635	135017	Apr-17	129.72	Manual	299-W13-1	568149	136049	Oct-17	126.23	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W19-39	567902	134887	Apr-17	129.66	Manual	299-W14-14	566898	136181	Oct-17	129.93	AWLN
299-W19-41	566897	135005	Apr-17	132.34	Manual	299-W14-71	567733	135568	Oct-17	128.28	AWLN
299-W19-42	566897	135123	Apr-17	132.24	Manual	299-W14-72	567328	135941	Oct-17	126.65	AWLN
299-W19-43	567699	135004	Apr-17	128.30	Manual	299-W15-32	566773	135635	Oct-17	131.28	AWLN
299-W19-46	567783	134842	Apr-17	130.09	Manual	299-W15-37	566716	135248	Oct-17	132.95	AWLN
299-W19-48	567823	134926	Apr-17	129.52	Manual	299-W15-44	566685	136066	Oct-17	131.30	AWLN
299-W19-49	567568	134894	Apr-17	130.34	Manual	299-W18-260	566863	135197	Oct-17	132.06	Manual
699-48-77A	566413	137969	Apr-17	134.86	Manual	299-W18-40	566723	134996	Oct-17	133.07	Manual
699-48-77C	566469	138087	Apr-17	134.31	Manual	299-W19-101	567939	135014	Oct-17	128.61	AWLN
699-48-77D	566433	138119	Apr-17	134.45	Manual	299-W19-101	567939	135014	Oct-17	128.56	Manual
699-51-63	570664	139148	Apr-17	122.51	Manual	299-W19-105	567565	134745	Oct-17	130.23	Manual
699-52-55	573102	139443	Apr-17	121.74	Manual	299-W19-107	567998	135206	Oct-17	128.48	AWLN
699-32-70B	568462	133242	Apr-17	130.90	Manual	299-W19-115	567372	135012	Oct-17	130.54	Manual
699-45-69C	568947	137234	Apr-17	128.48	Manual	299-W19-12	566897	135059	Oct-17	131.99	Manual
699-47-60	571474	137969	Apr-17	121.79	Manual	299-W19-34A	567674	135012	Oct-17	128.29	Manual
699-33-75	566908	133662	Apr-17	132.43	Manual	299-W19-34B	567663	135011	Oct-17	129.32	Manual
699-34-61	571396	133810	Apr-17	126.02	Manual	299-W19-36	567635	135017	Oct-17	129.32	AWLN
699-34-72	567860	133785	Apr-17	130.90	Manual	299-W19-36	567635	135017	Oct-17	129.29	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-35-66A	569858	134099	Apr-17	129.37	Manual	299-W19-39	567902	134887	Oct-17	129.46	Manual
699-36-61A	571395	134557	Apr-17	124.02	Manual	299-W19-41	566897	135005	Oct-17	132.07	Manual
699-36-66B	569731	134469	Apr-17	129.42	Manual	299-W19-42	566897	135123	Oct-17	132.03	Manual
699-36-70B	568428	134626	Apr-17	130.12	Manual	299-W19-43	567699	135004	Oct-17	127.86	Manual
699-37-66	569730	134797	Apr-17	129.00	Manual	299-W19-44	566897	135042	Oct-17	131.98	Manual
699-38-61	571219	134997	Apr-17	123.72	Manual	299-W19-46	567783	134842	Oct-17	129.65	Manual
699-38-65	570090	135040	Apr-17	128.26	Manual	299-W19-47	566895	135162	Oct-17	132.04	Manual
699-40-62	571164	135764	Apr-17	122.55	Manual	299-W19-48	567823	134926	Oct-17	129.28	AWLN
699-48-77C	566469	138087	Apr-17	134.22	Manual	299-W19-48	567823	134926	Oct-17	129.31	Manual
699-48-77D	566433	138119	Apr-17	135.38	Manual	299-W19-49	567568	134894	Oct-17	129.98	Manual
699-30-63	570717	132675	Apr-17	128.62	Manual	299-W22-116	566901	134140	Oct-17	132.13	AWLN
699-32-59	571800	133400	Apr-17	124.25	Manual	299-W22-47	566909	134076	Oct-17	132.11	Manual
699-36-63B	570684	134229	Apr-17	127.48	Manual	299-W22-69	567180	134348	Oct-17	131.38	Manual
699-50-56	572748	138842	Apr-17	121.69	Manual	299-W22-72	567237	134207	Oct-17	132.01	Manual
299-E33-34	573104	137740	Apr-17	121.68	AWLN	299-W22-81	567000	134354	Oct-17	131.82	Manual
299-W11-13	567099	136424	Apr-17	129.47	AWLN	299-W22-82	567005	134167	Oct-17	131.91	Manual
299-W11-43	567270	136971	Apr-17	129.96	AWLN	299-W22-83	567009	134093	Oct-17	131.86	AWLN
299-W11-87	568141	136609	Apr-17	127.19	AWLN	299-W22-83	567009	134093	Oct-17	131.88	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W11-88	567875	137113	Apr-17	128.45	AWLN	299-W22-85	566903	134261	Oct-17	132.24	AWLN
299-W13-1	568149	136049	Apr-17	127.35	AWLN	299-W22-87	567542	134540	Oct-17	130.45	Manual
299-W14-14	566898	136181	Apr-17	130.34	AWLN	299-W22-89	566907	134032	Oct-17	132.13	Manual
299-W14-71	567733	135568	Apr-17	128.47	AWLN	299-W22-96	567352	134146	Oct-17	131.20	Manual
299-W14-72	567328	135941	Apr-17	128.31	AWLN	699-35-78A	566064	134271	Oct-17	134.96	AWLN
299-W15-32	566773	135635	Apr-17	131.46	AWLN	699-36-61A	571395	134557	Oct-17	124.03	AWLN
299-W15-37	566716	135248	Apr-17	132.97	AWLN	699-38-61	571219	134997	Oct-17	123.76	AWLN
299-W15-44	566685	136066	Apr-17	131.27	AWLN	699-39-79	565891	135412	Oct-17	138.87	AWLN
299-W19-101	567939	135014	Apr-17	128.53	AWLN	699-45-69C	568947	137234	Oct-17	128.00	AWLN
299-W19-107	567998	135206	Apr-17	128.68	AWLN	699-49-55A	573146	138352	Oct-17	121.77	Manual
299-W19-36	567635	135017	Apr-17	129.55	AWLN	699-49-57A	572544	138389	Oct-17	121.78	Manual
299-W19-48	567823	134926	Apr-17	129.30	AWLN	699-50-56	572748	138842	Oct-17	121.84	Manual
299-W22-116	566901	134140	Apr-17	132.14	AWLN	299-W19-45	566898	135088	Oct-17	132.08	Manual
299-W22-83	567009	134093	Apr-17	131.89	AWLN	699-31-68	569598	133081	Oct-17	129.89	Manual
299-W22-85	566903	134261	Apr-17	132.26	AWLN	299-W17-1	565311	135039	Oct-17	137.26	Manual
699-35-78A	566064	134271	Apr-17	134.84	AWLN	699-32-64	570451	133304	Oct-17	128.66	Manual
699-36-61A	571395	134557	Apr-17	123.98	AWLN	699-48-77C	566469	138087	Oct-17	134.34	Manual
699-38-61	571219	134997	Apr-17	123.70	AWLN	699-48-77D	566433	138119	Oct-17	134.53	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-39-79	565891	135412	Apr-17	137.56	AWLN	299-E28-18	573104	136768	Oct-17	121.83	Manual
699-45-69C	568947	137234	Apr-17	128.42	AWLN	299-E32-5	572600	137285	Oct-17	121.75	Manual
299-W14-13	566902	136282	Apr-17	129.48	Manual	299-E32-6	572600	137515	Oct-17	121.75	Manual
299-W14-18	566897	136344	Apr-17	130.11	Manual	299-E32-8	572663	137741	Oct-17	121.76	Manual
299-W18-15	566380	134733	Apr-17	134.28	Manual	299-W10-26	566843	136401	Oct-17	130.18	Manual
299-W19-101	567939	135014	Apr-17	128.55	Manual	299-W10-27	566844	136442	Oct-17	130.28	Manual
299-W19-105	567565	134745	Apr-17	130.43	Manual	299-W11-41	566936	136678	Oct-17	130.57	Manual
299-W19-115	567372	135012	Apr-17	130.75	Manual	299-W14-11	566902	136288	Oct-17	128.44	Manual
299-W19-116	568510	135090	Apr-17	129.58	Manual	299-W14-13	566902	136282	Oct-17	128.73	Manual
299-W22-113	566905	134193	Apr-17	132.20	Manual	299-W14-18	566897	136344	Oct-17	129.46	Manual
299-W22-115	566939	134292	Apr-17	132.16	Manual	699-32-59	571800	133400	Oct-17	124.18	Manual
299-W22-116	566901	134140	Apr-17	132.19	Manual	699-35-66A	569858	134099	Oct-17	129.30	Manual
299-W22-47	566909	134076	Apr-17	132.15	Manual	699-36-66B	569731	134469	Oct-17	129.34	Manual
299-W22-69	567180	134348	Apr-17	131.50	Manual	699-37-66	569730	134797	Oct-17	129.00	Manual
299-W22-72	567237	134207	Apr-17	131.49	Manual	699-48-77C	566469	138087	Oct-17	135.39	Manual
299-W22-80	566843	134126	Apr-17	132.40	Manual	699-48-77D	566433	138119	Oct-17	134.54	Manual
299-W22-81	567000	134354	Apr-17	131.92	Manual	699-30-66	569991	132739	Oct-17	129.45	Manual
299-W22-82	567005	134167	Apr-17	131.99	Manual	699-44-64	570391	136897	Oct-17	123.06	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W22-83	567009	134093	Apr-17	131.96	Manual	299-W19-115	567372	135012	Oct-17	130.58	Manual
299-W22-85	566903	134261	Apr-17	132.29	Manual	299-W19-116	568510	135090	Oct-17	129.36	Manual
299-W22-87	567542	134540	Apr-17	130.63	Manual	299-W22-87	567542	134540	Oct-17	130.49	Manual
299-W22-89	566907	134032	Apr-17	132.22	Manual	299-W14-19	566899	136135	Nov-17	129.74	Manual
299-W22-93	566949	134486	Apr-17	131.81	Manual	299-W26-13	566424	133294	Nov-17	133.61	Manual
299-W22-95	567171	134549	Apr-17	131.52	Manual	299-W26-14	566683	133539	Nov-17	132.96	Manual
299-W22-96	567352	134146	Apr-17	131.36	Manual	699-32-76	566684	133138	Nov-17	132.61	Manual
299-W23-20	566718	134446	Apr-17	132.87	Manual	699-33-75	566908	133662	Nov-17	132.42	Manual
299-W23-21	566708	134294	Apr-17	133.03	Manual	699-33-76	566621	133600	Nov-17	133.13	Manual
299-W23-236	566799	134128	Apr-17	132.64	Manual	299-W10-23	566824	136815	Nov-17	131.61	Manual
699-52-55	573102	139443	Apr-17	121.73	Manual	299-W10-24	566885	136799	Nov-17	131.28	Manual
699-52-55B	573102	139441	Apr-17	121.74	Manual	299-W10-28	566702	136710	Nov-17	131.98	Manual
299-E28-18	573104	136768	Apr-17	121.65	Manual	299-W11-47	566934	136681	Nov-17	130.65	Manual
299-E32-5	572600	137285	Apr-17	121.65	Manual	299-W11-39	566908	136780	Nov-17	131.02	Manual
299-E32-6	572600	137515	Apr-17	121.66	Manual	299-W11-40	566927	136710	Nov-17	130.78	Manual
299-E32-8	572663	137741	Apr-17	121.66	Manual	299-W11-42	566920	136746	Nov-17	130.99	Manual
299-E33-34	573104	137740	Apr-17	121.65	Manual	299-W10-1	566663	136735	Nov-17	132.62	Manual
299-W10-26	566843	136401	Apr-17	130.68	Manual	299-W11-41	566936	136678	Nov-17	130.56	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W10-27	566844	136442	Apr-17	130.70	Manual	699-51-63	570664	139148	Nov-17	122.52	Manual
299-W11-41	566936	136678	Apr-17	130.80	Manual	699-52-55	573102	139443	Nov-17	121.78	Manual
299-W14-11	566902	136288	Apr-17	129.52	Manual	299-W11-45	566993	136776	Nov-17	130.45	Manual
699-49-55A	573146	138352	Apr-17	121.68	Manual	299-W18-15	566380	134733	Nov-17	134.59	Manual
699-49-57A	572544	138389	Apr-17	121.67	Manual	299-W19-101	567939	135014	Nov-17	128.57	Manual
699-50-56	572748	138842	Apr-17	121.70	Manual	299-W19-105	567565	134745	Nov-17	130.24	Manual
699-50-59	571947	138742	Apr-17	121.69	Manual	299-W19-115	567372	135012	Nov-17	130.59	Manual
299-W22-114	567726	134048	Apr-17	130.78	Manual	299-W19-34A	567674	135012	Nov-17	128.36	Manual
699-53-55B	573111	139625	Apr-17	121.62	Manual	299-W19-36	567635	135017	Nov-17	129.32	Manual
699-53-55C	573115	139624	Apr-17	121.71	Manual	299-W19-39	567902	134887	Nov-17	129.51	Manual
699-55-57	572445	140120	Apr-17	121.67	Manual	299-W19-43	567699	135004	Nov-17	127.87	Manual
299-W26-13	566424	133294	May-17	133.50	Manual	299-W19-46	567783	134842	Nov-17	129.85	Manual
299-W26-14	566683	133539	May-17	132.87	Manual	299-W19-48	567823	134926	Nov-17	129.39	Manual
299-W27-2	566908	133670	May-17	132.30	Manual	299-W19-49	567568	134894	Nov-17	129.98	Manual
699-32-76	566684	133138	May-17	129.61	Manual	299-W22-47	566909	134076	Nov-17	132.16	Manual
699-33-74	567473	133552	May-17	131.35	Manual	299-W22-69	567180	134348	Nov-17	131.46	Manual
699-33-75	566908	133662	May-17	132.34	Manual	299-W22-72	567237	134207	Nov-17	131.46	Manual
699-33-76	566621	133600	May-17	133.03	Manual	299-W22-81	567000	134354	Nov-17	131.89	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W19-115	567372	135012	May-17	130.70	Manual	299-W22-82	567005	134167	Nov-17	132.00	Manual
699-38-70B	568469	135331	May-17	128.89	Manual	299-W22-87	567542	134540	Nov-17	130.51	Manual
699-38-70C	569084	135326	May-17	129.54	Manual	299-W22-89	566907	134032	Nov-17	132.23	Manual
299-W7-3	566292	137639	May-17	133.96	Manual	299-W22-95	567171	134549	Nov-17	131.46	Manual
699-51-75	566978	138906	May-17	132.22	Manual	299-W22-96	567352	134146	Nov-17	131.32	Manual
299-E33-34	573104	137740	May-17	121.68	AWLN	699-48-77C	566469	138087	Nov-17	134.37	Manual
299-W11-13	567099	136424	May-17	129.48	AWLN	699-48-77D	566433	138119	Nov-17	134.54	Manual
299-W11-43	567270	136971	May-17	129.97	AWLN	299-W11-39	566908	136780	Nov-17	131.00	Manual
299-W11-45	566993	136776	May-17	130.73	Manual	299-W11-40	566927	136710	Nov-17	130.75	Manual
299-W11-47	566934	136681	May-17	130.84	Manual	299-W11-42	566920	136746	Nov-17	130.98	Manual
299-W11-87	568141	136609	May-17	126.69	AWLN	299-W10-26	566843	136401	Nov-17	130.33	Manual
299-W11-88	567875	137113	May-17	127.72	AWLN	299-W10-27	566844	136442	Nov-17	130.39	Manual
299-W13-1	568149	136049	May-17	127.13	AWLN	299-W14-14	566898	136181	Nov-17	129.86	Manual
299-W14-14	566898	136181	May-17	130.36	AWLN	299-W14-11	566902	136288	Nov-17	128.89	Manual
299-W14-72	567328	135941	May-17	128.04	AWLN	299-W14-17	567007	136218	Nov-17	129.25	Manual
299-W15-32	566773	135635	May-17	131.53	AWLN	299-E33-34	573104	137740	Nov-17	121.77	AWLN
299-W15-37	566716	135248	May-17	132.99	AWLN	299-W11-13	567099	136424	Nov-17	128.86	AWLN
299-W15-44	566685	136066	May-17	131.37	AWLN	299-W11-43	567270	136971	Nov-17	129.41	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W19-101	567939	135014	May-17	128.50	AWLN	299-W11-87	568141	136609	Nov-17	125.40	AWLN
299-W19-107	567998	135206	May-17	128.66	AWLN	299-W11-88	567875	137113	Nov-17	126.76	AWLN
299-W19-116	568510	135090	May-17	129.53	Manual	299-W13-1	568149	136049	Nov-17	126.00	AWLN
299-W19-36	567635	135017	May-17	129.54	AWLN	299-W14-13	566902	136282	Nov-17	129.13	Manual
299-W19-48	567823	134926	May-17	129.28	AWLN	299-W14-14	566898	136181	Nov-17	129.85	AWLN
299-W22-116	566901	134140	May-17	132.12	AWLN	299-W14-72	567328	135941	Nov-17	126.48	AWLN
299-W22-83	567009	134093	May-17	131.88	AWLN	299-W15-32	566773	135635	Nov-17	131.09	AWLN
299-W22-85	566903	134261	May-17	132.25	AWLN	299-W15-37	566716	135248	Nov-17	132.96	AWLN
699-35-78A	566064	134271	May-17	134.84	AWLN	299-W15-44	566685	136066	Nov-17	131.26	AWLN
699-36-61A	571395	134557	May-17	123.97	AWLN	299-W15-44	566685	136066	Nov-17	131.33	Manual
699-38-61	571219	134997	May-17	123.68	AWLN	299-W15-763	566809	136029	Nov-17	130.76	Manual
699-39-79	565891	135412	May-17	138.24	AWLN	299-W15-765	566697	136373	Nov-17	130.81	Manual
699-45-69C	568947	137234	May-17	128.36	AWLN	299-W19-101	567939	135014	Nov-17	128.52	AWLN
299-W11-40	566927	136710	May-17	131.08	Manual	299-W19-107	567998	135206	Nov-17	128.41	AWLN
299-W11-41	566936	136678	May-17	130.96	Manual	299-W19-36	567635	135017	Nov-17	129.22	AWLN
299-W11-42	566920	136746	May-17	131.28	Manual	299-W19-48	567823	134926	Nov-17	129.23	AWLN
299-W10-26	566843	136401	May-17	130.63	Manual	299-W22-116	566901	134140	Nov-17	132.15	AWLN
299-W10-27	566844	136442	May-17	130.68	Manual	299-W22-83	567009	134093	Nov-17	131.89	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W14-11	566902	136288	May-17	129.87	Manual	299-W22-85	566903	134261	Nov-17	132.25	AWLN
299-W14-13	566902	136282	May-17	129.34	Manual	699-35-78A	566064	134271	Nov-17	135.05	AWLN
299-W14-15	566900	136231	May-17	130.10	Manual	699-36-61A	571395	134557	Nov-17	124.04	AWLN
299-W14-18	566897	136344	May-17	130.02	Manual	699-38-61	571219	134997	Nov-17	123.78	AWLN
299-W14-14	566898	136181	May-17	130.25	Manual	699-39-79	565891	135412	Nov-17	138.37	AWLN
299-W14-19	566899	136135	May-17	130.37	Manual	699-45-69C	568947	137234	Nov-17	127.89	AWLN
299-W15-44	566685	136066	May-17	131.54	Manual	299-W14-15	566900	136231	Nov-17	128.27	Manual
299-W15-763	566809	136029	May-17	131.20	Manual	299-W14-16	567001	136318	Nov-17	129.50	Manual
299-W15-765	566697	136373	May-17	130.91	Manual	299-W14-18	566897	136344	Nov-17	128.25	Manual
299-W19-116	568510	135090	May-17	129.47	Manual	299-W19-116	568510	135090	Nov-17	129.34	Manual
299-W19-34B	567663	135011	May-17	129.68	Manual	299-W19-34B	567663	135011	Nov-17	129.36	Manual
299-W19-36	567635	135017	May-17	129.53	Manual	299-W22-113	566905	134193	Nov-17	132.24	Manual
299-W22-113	566905	134193	May-17	132.11	Manual	299-W22-115	566939	134292	Nov-17	132.18	Manual
299-W22-115	566939	134292	May-17	132.10	Manual	299-W22-116	566901	134140	Nov-17	132.21	Manual
299-W22-116	566901	134140	May-17	132.10	Manual	299-W22-85	566903	134261	Nov-17	132.32	Manual
299-W22-80	566843	134126	May-17	132.32	Manual	299-W23-20	566718	134446	Nov-17	132.93	Manual
299-W22-85	566903	134261	May-17	132.23	Manual	299-W23-21	566708	134294	Nov-17	133.08	Manual
299-W22-93	566949	134486	May-17	131.64	Manual	699-34-61	571396	133810	Nov-17	126.02	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W23-20	566718	134446	May-17	133.82	Manual	699-35-66A	569858	134099	Nov-17	129.29	Manual
299-W23-21	566708	134294	May-17	132.97	Manual	699-36-66B	569731	134469	Nov-17	129.34	Manual
299-W23-236	566799	134128	May-17	132.58	Manual	699-37-66	569730	134797	Nov-17	128.98	Manual
699-36-63B	570684	134229	May-17	127.53	Manual	699-38-61	571219	134997	Nov-17	123.79	Manual
699-48-77C	566469	138087	May-17	134.26	Manual	699-38-65	570090	135040	Nov-17	128.79	Manual
699-48-77D	566433	138119	May-17	134.38	Manual	699-40-62	571164	135764	Nov-17	122.61	Manual
299-W22-47	566909	134076	May-17	131.52	Manual	699-50-85	564130	138669	Nov-17	135.28	Manual
299-W22-69	567180	134348	May-17	132.51	Manual	299-W10-23	566824	136815	Nov-17	131.49	Manual
299-W22-72	567237	134207	May-17	131.50	Manual	299-W10-24	566885	136799	Nov-17	131.13	Manual
299-W22-81	567000	134354	May-17	131.94	Manual	299-W10-28	566702	136710	Nov-17	132.18	Manual
299-W22-82	567005	134167	May-17	132.00	Manual	299-W11-39	566908	136780	Nov-17	130.92	Manual
299-W22-87	567542	134540	May-17	130.64	Manual	299-W11-42	566920	136746	Nov-17	130.89	Manual
299-W22-89	566907	134032	May-17	132.24	Manual	299-W11-45	566993	136776	Nov-17	130.37	Manual
299-W22-95	567171	134549	May-17	131.55	Manual	299-E28-18	573104	136768	Nov-17	118.56	Manual
299-W22-96	567352	134146	May-17	131.37	Manual	299-E32-5	572600	137285	Nov-17	121.75	Manual
699-33-75	566908	133662	May-17	132.42	Manual	299-E32-6	572600	137515	Nov-17	121.75	Manual
699-34-61	571396	133810	May-17	126.01	Manual	299-E32-8	572663	137741	Nov-17	121.76	Manual
699-34-72	567860	133785	May-17	130.86	Manual	299-E33-34	573104	137740	Nov-17	121.76	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-36-61A	571395	134557	May-17	124.02	Manual	299-W10-1	566663	136735	Nov-17	132.75	Manual
699-36-66B	569731	134469	May-17	129.38	Manual	299-W11-40	566927	136710	Nov-17	130.80	Manual
699-36-70B	568428	134626	May-17	130.05	Manual	299-W11-41	566936	136678	Nov-17	130.65	Manual
699-37-66	569730	134797	May-17	128.97	Manual	299-W11-47	566934	136681	Nov-17	130.62	Manual
699-38-61	571219	134997	May-17	123.71	Manual	699-49-55A	573146	138352	Nov-17	121.77	Manual
699-38-65	570090	135040	May-17	128.41	Manual	699-49-57A	572544	138389	Nov-17	121.77	Manual
699-40-62	571164	135764	May-17	122.54	Manual	699-50-56	572748	138842	Nov-17	121.81	Manual
299-W18-15	566380	134733	May-17	134.34	Manual	299-W21-3	568571	133980	Dec-17	130.11	Manual
299-W19-101	567939	135014	May-17	128.49	Manual	699-36-63B	570684	134229	Dec-17	127.54	Manual
299-W19-105	567565	134745	May-17	130.42	Manual	299-W22-114	567726	134048	Dec-17	130.73	Manual
299-W19-115	567372	135012	May-17	130.72	Manual	299-W10-26	566843	136401	Dec-17	130.21	Manual
299-W19-34A	567674	135012	May-17	128.51	Manual	299-W10-27	566844	136442	Dec-17	130.29	Manual
299-W19-39	567902	134887	May-17	129.51	Manual	299-W11-41	566936	136678	Dec-17	130.56	Manual
299-W19-43	567699	135004	May-17	128.10	Manual	299-W14-13	566902	136282	Dec-17	128.85	Manual
299-W19-46	567783	134842	May-17	129.91	Manual	299-W14-18	566897	136344	Dec-17	129.51	Manual
299-W19-48	567823	134926	May-17	129.36	Manual	299-W14-11	566902	136288	Dec-17	128.72	Manual
299-W19-49	567568	134894	May-17	130.20	Manual	299-W22-47	566909	134076	Dec-17	131.91	Manual
699-51-63	570664	139148	May-17	122.51	Manual	299-W22-69	567180	134348	Dec-17	131.14	Manual

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
699-52-55	573102	139443	May-17	121.73	Manual	299-W22-72	567237	134207	Dec-17	131.18	Manual
299-W14-11	566902	136288	May-17	129.28	Manual	299-W22-81	567000	134354	Dec-17	131.61	Manual
299-W10-26	566843	136401	May-17	130.61	Manual	299-W22-82	567005	134167	Dec-17	131.70	Manual
299-W10-27	566844	136442	May-17	130.66	Manual	299-W22-115	566939	134292	Dec-17	131.69	Manual
299-W14-13	566902	136282	May-17	129.28	Manual	299-W22-83	567009	134093	Dec-17	131.68	Manual
299-W14-18	566897	136344	May-17	129.97	Manual	299-W22-85	566903	134261	Dec-17	132.26	Manual
299-E28-18	573104	136768	May-17	121.68	Manual	299-W22-89	566907	134032	Dec-17	131.96	Manual
299-E32-5	572600	137285	May-17	121.68	Manual	299-W22-93	566949	134486	Dec-17	133.32	Manual
299-E32-6	572600	137515	May-17	121.68	Manual	299-W22-95	567171	134549	Dec-17	130.58	Manual
299-E32-8	572663	137741	May-17	121.68	Manual	299-W23-20	566718	134446	Dec-17	132.89	Manual
299-E33-34	573104	137740	May-17	121.68	Manual	699-35-66A	569858	134099	Dec-17	129.22	Manual
699-49-55A	573146	138352	May-17	121.70	Manual	699-36-66B	569731	134469	Dec-17	129.26	Manual
699-50-56	572748	138842	May-17	121.73	Manual	699-37-66	569730	134797	Dec-17	128.91	Manual
299-W22-47	566909	134076	Jun-17	132.14	Manual	699-48-77C	566469	138087	Dec-17	131.04	Manual
299-W22-69	567180	134348	Jun-17	131.48	Manual	699-48-77D	566433	138119	Dec-17	133.91	Manual
299-W22-72	567237	134207	Jun-17	131.47	Manual	299-W22-113	566905	134193	Dec-17	131.93	Manual
299-W22-81	567000	134354	Jun-17	131.91	Manual	299-W22-116	566901	134140	Dec-17	131.99	Manual
299-W22-83	567009	134093	Jun-17	131.96	Manual	299-E33-34	573104	137740	Dec-17	121.75	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W21-2	568124	134574	Jun-17	130.21	Manual	299-W11-13	567099	136424	Dec-17	128.77	AWLN
299-W21-3	568571	133980	Jun-17	130.47	Manual	299-W11-43	567270	136971	Dec-17	129.36	AWLN
299-W22-89	566907	134032	Jun-17	132.14	Manual	299-W11-87	568141	136609	Dec-17	125.33	AWLN
299-W22-95	567171	134549	Jun-17	131.45	Manual	299-W11-88	567875	137113	Dec-17	126.62	AWLN
299-W23-236	566799	134128	Jun-17	132.56	Manual	299-W13-1	568149	136049	Dec-17	125.84	AWLN
299-W22-82	567005	134167	Jun-17	131.93	Manual	299-W14-14	566898	136181	Dec-17	129.76	AWLN
299-W23-20	566718	134446	Jun-17	132.85	Manual	299-W14-72	567328	135941	Dec-17	126.39	AWLN
699-29-66	570054	132337	Jun-17	129.44	Manual	299-W15-32	566773	135635	Dec-17	131.31	AWLN
699-30-63	570717	132675	Jun-17	128.72	Manual	299-W15-37	566716	135248	Dec-17	132.97	AWLN
699-31-68	569598	133081	Jun-17	129.87	Manual	299-W15-44	566685	136066	Dec-17	131.30	AWLN
699-32-64	570451	133304	Jun-17	128.66	Manual	299-W19-101	567939	135014	Dec-17	128.47	AWLN
299-W22-115	566939	134292	Jun-17	132.09	Manual	299-W19-107	567998	135206	Dec-17	128.32	AWLN
299-W22-93	566949	134486	Jun-17	131.62	Manual	299-W19-36	567635	135017	Dec-17	129.16	AWLN
299-W23-21	566708	134294	Jun-17	132.95	Manual	299-W19-48	567823	134926	Dec-17	129.18	AWLN
299-W22-10	567013	134215	Jun-17	131.87	Manual	299-W22-116	566901	134140	Dec-17	132.13	AWLN
299-W22-113	566905	134193	Jun-17	132.06	Manual	299-W22-80	566843	134126	Dec-17	132.45	Manual
299-W22-116	566901	134140	Jun-17	132.07	Manual	299-W22-83	567009	134093	Dec-17	131.80	AWLN
299-W22-80	566843	134126	Jun-17	132.29	Manual	299-W22-85	566903	134261	Dec-17	132.22	AWLN

Table A-1. Monthly Average Water-Level Data Used for Water-Level Mapping

Name	Easting	Northing	Month	Average Water Level (m)	Type	Name	Easting	Northing	Month	Average Water Level (m)	Type
299-W22-85	566903	134261	Jun-17	132.21	Manual	699-35-78A	566064	134271	Dec-17	135.09	AWLN
299-W22-96	567352	134146	Jun-17	131.28	Manual	699-36-61A	571395	134557	Dec-17	124.05	AWLN
299-E33-34	573104	137740	Jun-17	121.68	AWLN	699-38-61	571219	134997	Dec-17	123.79	AWLN
299-W11-13	567099	136424	Jun-17	129.45	AWLN	699-39-79	565891	135412	Dec-17	138.39	AWLN
299-W11-43	567270	136971	Jun-17	129.92	AWLN	699-45-69C	568947	137234	Dec-17	127.76	AWLN
299-W11-87	568141	136609	Jun-17	126.29	AWLN	299-E32-2	572648	137468	Dec-17	121.70	Manual
299-W11-88	567875	137113	Jun-17	127.38	AWLN	299-E32-4	572604	137187	Dec-17	121.72	Manual
299-W13-1	568149	136049	Jun-17	126.83	AWLN	299-E32-5	572600	137285	Dec-17	121.51	Manual
299-W14-14	566898	136181	Jun-17	130.30	AWLN	299-E32-6	572600	137515	Dec-17	121.74	Manual
299-W14-71	567733	135568	Jun-17	128.32	AWLN	299-E32-7	572600	137647	Dec-17	121.73	Manual
299-W14-72	567328	135941	Jun-17	127.77	AWLN	299-W23-21	566708	134294	Dec-17	133.04	Manual
299-W15-32	566773	135635	Jun-17	131.40	AWLN	299-W23-236	566799	134128	Dec-17	132.60	Manual
299-W15-37	566716	135248	Jun-17	132.96	AWLN						

Note: Water levels shown in **red** font represent outliers and were not used in water-level mapping.

AWLN = automated water level network

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Appendix B

Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies

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Tables

Table B-1. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2012 and CY 2013 ..... B-1

Table B-2. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2014 and CY 2015 ..... B-5

Table B-3. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2016 and 2017 ..... B-8

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Table B-1. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2012 and CY 2013

Stress Period of Model Commences in 2012		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Well ID	Well Name	Jan. 2012	Feb. 2012	Mar. 2012	Apr. 2012	May 2012	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	June 2013	July 2013	Aug. 2013	Sept. 13	Oct. 2013	Nov. 2013	Dec. 2013
YE-01	299-W15-225	-249	-250	-247	-242	-11	0	0	0	-3	-28	-50	-69	-68	-68	-68	-83	-99	-94	-84	-68	-91	-86	-79	-81
YE-02	299-W14-20	0	0	0	0	0	0	0	-5	-14	-54	-87	-96	-101	-91	-96	-119	-111	-109	-107	-97	-87	0	-100	-103
YE-03	299-W14-73	0	0	0	0	0	0	-2	-23	-12	-46	-55	-67	-79	-75	-77	-104	-133	-113	-99	-73	-1	-69	-80	-81
YE-04	299-W14-74	0	0	0	0	0	0	0	0	0	0	-55	-91	-95	-90	-83	-110	-110	-104	-94	-97	-110	-111	-86	-95
YE-05	299-W12-2	0	0	0	0	0	0	0	-18	-8	-52	-65	-81	-97	-94	-97	-117	-137	-95	-63	-57	-23	-80	-88	-86
YE-06	299-W11-50	0	0	0	0	0	0	0	0	-12	-50	-83	-96	-101	-91	-97	-45	-112	-109	-108	-85	-105	-43	-103	-90
YE-07	299-W11-90	0	0	0	0	0	0	0	-4	-15	-56	-89	-95	-98	-92	-98	-132	-113	-111	-109	-97	-114	-56	-103	-110
YE-08	299-W11-96	0	0	0	0	0	0	0	-7	-22	-41	-58	-68	-95	-90	-82	-109	-128	-95	-62	-57	-64	-109	-83	-81
YE-09	299-W17-3	0	0	0	0	0	0	-3	-20	-10	-45	-68	-78	-83	-75	-78	-102	-124	-112	-97	-87	-96	-44	-75	-80
YE-10	299-W17-2	0	0	0	0	0	0	-2	-17	-9	-38	-57	-66	-84	-77	-79	-91	-93	-91	-87	-51	0	-63	-81	-81
YE-11	299-W19-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YE-12	299-W11-49	0	0	0	0	0	0	-4	-23	-11	-48	-67	-77	-81	-75	-77	-101	-127	-111	-95	-95	-96	-87	-79	-79
YE-13	299-W11-97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YE-14	299-W6-15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YE-15	299-W14-21	0	0	0	0	0	0	-3	-20	-10	-44	-60	-62	-82	-74	-78	-101	-108	-102	-95	-89	-95	-34	-79	-100
YE-16	299-W11-92	0	0	0	0	0	0	0	-2	-9	-53	-81	-94	-102	-93	-101	-126	-113	-110	-109	-101	-90	0	-102	-129
YE-17	299-W5-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YE-18	299-W12-3	0	0	0	0	0	0	-3	-21	-8	-44	-60	-92	-98	-94	-97	-119	-135	-95	-72	-64	-100	-109	-87	-85
YE-19	299-W12-4	0	0	0	0	0	0	-4	-23	-8	-49	-69	-94	-99	-95	-97	-112	-131	-95	-61	-102	-88	-79	-87	-124
YE-20	299-W14-22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YE-21	299-W22-90	0	0	0	0	0	0	0	-1	-3	-10	-17	-23	-22	-23	-23	-22	-23	-23	-23	-22	-14	-3	-23	-23

Table B-1. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2012 and CY 2013

Stress Period of Model Commences in 2012		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Well ID	Well Name	Jan. 2012	Feb. 2012	Mar. 2012	Apr. 2012	May 2012	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	June 2013	July 2013	Aug. 2013	Sept. 13	Oct. 2013	Nov. 2013	Dec. 2013
YE-22	299-W22-91	0	0	0	0	0	0	0	-1	-3	-11	-20	-23	-33	-20	-27	-34	-35	-35	-35	-34	-21	-3	-25	-24
YE-23	299-W22-92	0	0	0	0	0	0	0	-1	-3	-10	-19	-14	-23	-23	-24	-23	-24	-24	-24	-23	-14	-3	-24	-24
YE-25	299-W19-113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YE-26	299-W19-114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YE-27	299-E33-268	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	82
YJ-01	299-W6-13	0	0	0	0	0	0	5	25	7	82	125	118	133	120	127	221	296	277	49	90	119	51	97	173
YJ-02	299-W6-14	0	0	0	0	0	0	4	18	6	55	88	89	97	90	93	143	178	177	147	82	145	111	163	127
YJ-03	299-W10-36	0	0	0	0	0	0	4	16	5	49	79	82	89	83	86	126	160	158	135	74	84	90	148	128
YJ-04	299-W10-35	0	0	0	0	0	0	4	19	6	56	92	92	101	93	97	152	196	205	169	148	56	135	138	159
YJ-05	299-W15-226	0	0	0	0	0	0	5	19	7	69	105	102	114	104	109	176	228	234	201	186	72	85	282	221
YJ-06	299-W15-227	0	0	0	0	0	0	4	15	4	50	80	83	90	84	87	127	158	158	130	135	141	84	211	0
YJ-07	299-W15-228	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-08	299-W18-41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-09	699-49-69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
YJ-10	699-45-67B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	145
YJ-11	699-45-67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49
YJ-12	699-44-67	0	0	0	0	0	0	0	5	51	80	71	113	147	144	153	122	109	20	75	78	107	79	60	0
YJ-13	699-43-67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
YJ-14	699-42-67	0	0	0	0	0	0	0	8	51	87	69	114	150	144	138	111	112	21	101	109	115	81	74	0
YJ-15	699-40-67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-16	699-38-64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23

Table B-1. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2012 and CY 2013

Stress Period of Model Commences in 2012		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Well ID	Well Name	Jan. 2012	Feb. 2012	Mar. 2012	Apr. 2012	May 2012	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	June 2013	July 2013	Aug. 2013	Sept. 13	Oct. 2013	Nov. 2013	Dec. 2013
YJ-17	699-43-67B	0	0	0	0	0	0	0	11	50	93	72	117	145	139	138	118	85	14	72	67	52	47	56	1
YJ-18	299-W15-29	135	129	118	91	4	0	0	0	0	1	12	131	77	75	78	108	133	122	135	136	140	78	23	80
YJ-19	299-W18-36	84	81	76	64	3	0	0	0	0	21	69	72	77	75	77	86	92	103	93	87	85	70	36	74
YJ-20	299-W18-37	1	1	1	1	0	0	0	0	0	16	67	71	75	45	74	66	70	80	72	66	54	31	54	91
YJ-21	299-W18-38	68	66	62	53	3	0	0	0	0	13	59	65	71	76	62	29	38	66	43	21	8	24	64	68
YJ-22	299-W18-39	69	67	63	54	4	0	0	0	0	6	56	63	69	72	64	49	62	66	46	35	10	17	49	0
YJ-23	699-46-68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-24	299-W15-229	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-25	299-W7-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-26	299-E20-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-27	299-E20-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-28	299-E11-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W11-45	-6	-8	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W11-46	-9	-13	-18	-18	-15	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-1	-10	-11	-9	-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-11	-10	-10	-10	-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-34	-11	-11	-10	-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-35	-13	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B-1. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2012 and CY 2013

Stress Period of Model Commences in 2012		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Well ID	Well Name	Jan. 2012	Feb. 2012	Mar. 2012	Apr. 2012	May 2012	June 2012	July 2012	Aug. 2012	Sept. 2012	Oct. 2012	Nov. 2012	Dec. 2012	Jan. 2013	Feb. 2013	Mar. 2013	Apr. 2013	May 2013	June 2013	July 2013	Aug. 2013	Sept. 13	Oct. 2013	Nov. 2013	Dec. 2013
	299-W15-37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-43	-12	-12	-12	-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-45	-14	-14	-14	-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-46	-43	-43	-26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-7	-5	-5	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W15-765	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W18-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W18-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W19-23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W19-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W19-25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W19-36E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W19-36I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W19-39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	299-W19-43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: Extraction and injection rates are shown in gallons per minute (gpm).

ID = identification

Table B-2. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2014 and CY 2015

Stress Period of Model Commences in 2012		25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Stress Period of Model Commences in 2015														1	2	3	4	5	6	7	8	9	10	11	12
Well ID	Well Name	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	June 2014	July 2014	Aug. 2014	Sept. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	June 2015	July 2015	Aug. 2015	Sept. 2015	Oct. 2015	Nov. 2015	Dec. 2015
YE-01	299-W15-225	-81	-80	-87	-90	-90	-93	-98	-90	-80	-99	-99	-97	-98	-96	-98	-97	-95	-96	-98	-86	-94	-96	-96	-96
YE-02	299-W14-20	-104	0	0	0	-65	-99	-119	-112	-110	-111	-109	-107	-110	-105	-113	-108	-110	-110	-115	-99	-111	-116	-114	-100
YE-03	299-W14-73	-80	-79	-86	-90	-84	-93	-89	-82	-79	-127	-144	-138	-147	-130	-125	-117	-118	-116	-130	-127	-129	-127	-123	-108
YE-04	299-W14-74	-90	-79	-107	-127	-99	-111	-94	-93	-76	-123	-129	-130	-139	-107	-143	-123	-121	-135	-144	-140	-140	-128	-106	-91
YE-05	299-W12-2	-79	-85	-93	-112	-93	-100	-102	-93	-5	-129	-118	-106	-113	-105	-115	-106	-105	-106	-112	-110	-96	-98	-97	-89
YE-06	299-W11-50	-81	-115	-116	-119	-108	-115	-119	-112	-110	-112	-110	-110	-110	-106	-113	-109	-109	-110	-114	-99	-110	-113	-112	-94
YE-07	299-W11-90	-111	-138	-137	-149	-109	-111	-100	-99	-95	-105	-106	-103	-110	-102	-113	-107	-109	-113	-115	-99	-113	-119	-109	-94
YE-08	299-W11-96	-78	-70	-88	-101	-84	-91	-96	-38	0	-100	-101	-86	-98	-78	-92	-90	-92	-105	-111	-110	-112	-90	-75	-92
YE-09	299-W17-3	-77	-96	-90	-96	-92	-82	-100	-86	-71	-109	-114	-117	-124	-117	-125	-122	-117	-123	-131	-128	-119	-130	-121	-109
YE-10	299-W17-2	-80	-79	-86	-90	-85	-91	-99	-89	-78	-95	-95	-93	-95	-92	-85	-85	-86	-86	-91	-88	-89	-85	-73	-91
YE-11	299-W19-111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YE-12	299-W11-49	-78	-79	-86	-89	-105	-111	-126	-106	-78	-117	-117	-122	-133	-121	-131	-126	-120	-128	-131	-125	-127	-131	-117	-109
YE-13	299-W11-97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-48
YE-14	299-W6-15	0	0	0	0	0	0	0	0	0	0	0	0	-7	-56	-59	-57	-52	-64	-58	-59	-55	-46	-16	-60
YE-15	299-W14-21	-109	-107	-107	-109	-96	-97	-99	-89	-79	-99	-100	-104	-108	-107	-109	-108	-104	-106	-108	-102	-75	0	0	0
YE-16	299-W11-92	-137	-137	-137	-139	-116	-112	-100	-92	-88	-109	-110	-107	-120	-93	-108	-113	-111	-112	-117	-108	-108	-117	-120	-101
YE-17	299-W5-1	0	0	0	0	0	0	0	0	0	-1	-41	-58	-57	-58	-65	-58	-62	-55	-65	-68	-65	-72	-84	-84
YE-18	299-W12-3	-79	-80	-95	-98	-88	-89	-86	-86	-57	-103	-93	-83	-84	-76	-84	-80	-86	-85	-104	-101	-29	0	0	-64
YE-19	299-W12-4	-136	-86	-120	-135	-97	-121	-114	-103	-97	-144	-123	-108	-126	-109	-127	-118	-114	-117	-125	-121	-125	-121	-108	-98
YE-20	299-W14-22	0	0	0	0	0	0	0	0	0	-1	-41	-58	-63	-66	-82	-61	-71	-80	-88	-85	-84	-94	-96	-90

Table B-2. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2014 and CY 2015

Stress Period of Model Commences in 2012		25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Stress Period of Model Commences in 2015														1	2	3	4	5	6	7	8	9	10	11	12
Well ID	Well Name	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	June 2014	July 2014	Aug. 2014	Sept. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	June 2015	July 2015	Aug. 2015	Sept. 2015	Oct. 2015	Nov. 2015	Dec. 2015
YE-21	299-W22-90	-22	-23	-22	-23	-24	-20	-17	-16	-16	-17	-17	-17	-19	-24	-25	-25	-25	-24	-25	-21	-23	-24	-24	-24
YE-22	299-W22-91	-35	-35	-35	-35	-35	-36	-35	-33	-33	-35	-35	-33	-35	-35	-35	-35	-35	-34	-35	-30	-33	-35	-35	-35
YE-23	299-W22-92	-24	-24	-24	-24	-24	-29	-35	-33	-33	-35	-35	-33	-35	-35	-35	-35	-35	-34	-34	-30	-33	-34	-34	-34
YE-25	299-W19-113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-9	-34	-34	-44
YE-26	299-W19-114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-16	-81	-81	-97
YE-27	299-E33-268	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-44	-94	-95
YJ-01	299-W6-13	46	102	102	99	73	103	111	87	94	63	10	47	87	31	82	81	53	58	51	64	50	33	35	46
YJ-02	299-W6-14	207	204	131	182	243	241	276	211	103	318	298	250	276	218	210	129	178	187	183	175	182	179	220	215
YJ-03	299-W10-36	150	90	87	204	124	117	121	102	116	110	116	108	85	117	106	76	94	76	104	96	104	90	85	76
YJ-04	299-W10-35	146	138	169	187	177	159	96	140	122	133	156	164	160	120	99	104	110	100	120	114	116	96	63	74
YJ-05	299-W15-226	176	172	186	123	197	216	223	217	191	220	238	231	239	192	234	282	229	248	217	226	251	260	171	163
YJ-06	299-W15-227	262	251	255	239	155	167	136	103	90	105	107	57	102	76	108	92	115	125	123	117	109	71	75	119
YJ-07	299-W15-228	0	0	0	0	0	0	0	0	0	0	0	0	144	174	176	178	128	135	138	99	137	120	121	123
YJ-08	299-W18-41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42	97	94	94	75	91	85	83
YJ-09	699-49-69	0	0	0	0	0	0	0	0	26	81	83	93	103	62	89	67	49	28	50	32	17	53	58	66
YJ-10	699-45-67B	50	20	16	36	21	0	35	8	0	3	8	5	2	2	4	1	0	3	0	0	0	0	0	0
YJ-11	699-45-67	110	85	99	116	113	84	80	94	57	120	107	90	72	109	102	81	57	80	90	81	81	66	48	50
YJ-12	699-44-67	33	27	43	59	43	43	84	61	47	36	45	45	28	18	46	41	43	30	43	32	13	17	14	15
YJ-13	699-43-67	0	0	0	0	0	0	0	0	0	0	0	0	0	70	83	94	101	93	85	55	52	63	48	67
YJ-14	699-42-67	42	16	105	80	96	95	90	128	116	107	117	120	114	106	120	104	110	83	121	115	79	81	106	105

Table B-2. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2014 and CY 2015

Stress Period of Model Commences in 2012		25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Stress Period of Model Commences in 2015														1	2	3	4	5	6	7	8	9	10	11	12
Well ID	Well Name	Jan. 2014	Feb. 2014	Mar. 2014	Apr. 2014	May 2014	June 2014	July 2014	Aug. 2014	Sept. 2014	Oct. 2014	Nov. 2014	Dec. 2014	Jan. 2015	Feb. 2015	Mar. 2015	Apr. 2015	May 2015	June 2015	July 2015	Aug. 2015	Sept. 2015	Oct. 2015	Nov. 2015	Dec. 2015
YJ-15	699-40-67	0	0	0	0	0	0	0	0	0	101	134	131	131	117	110	102	110	109	107	70	90	90	58	29
YJ-16	699-38-64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	69	136	133	126	77	70
YJ-17	699-43-67B	3	48	50	53	41	59	54	47	42	4	40	31	10	47	55	63	67	62	57	37	35	42	32	44
YJ-18	299-W15-29	49	42	57	33	40	60	55	44	42	45	46	45	30	43	43	31	38	16	28	13	26	55	53	52
YJ-19	299-W18-36	88	94	96	100	65	90	101	89	79	81	88	85	70	56	67	42	60	72	60	69	70	66	68	68
YJ-20	299-W18-37	42	17	22	0	20	28	30	22	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-21	299-W18-38	97	100	98	73	60	87	84	69	55	58	57	54	59	58	57	58	36	45	42	51	45	39	40	41
YJ-22	299-W18-39	73	66	48	64	51	77	73	62	38	56	55	53	25	4	34	29	13	39	30	39	41	38	9	5
YJ-23	699-46-68	0	0	0	0	0	0	0	0	0	117	136	138	101	97	30	83	103	114	152	75	91	118	63	87
YJ-24	299-W15-229	0	0	0	0	0	0	0	0	0	0	17	98	145	112	152	166	158	158	158	143	83	159	157	149
YJ-25	299-W7-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-26	299-E20-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	58	79
YJ-27	299-E20-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	53	59
YJ-28	299-E11-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	75	87

Note: Extraction and injection rates are shown in gallons per minute (gpm).

ID = identification

Table B-3. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2016 and 2017

Stress Period of Model Commences in 2012		49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Stress Period of Model Commences in 2015		13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Well ID	Well Name	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	July 2016	Aug. 2016	Sept. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	June 2017	July 2017	Aug. 2017	Sept. 2017	Oct. 2017	Nov. 2017	Dec. 2017
YE-01	299-W15-225	-86	-49	-33	-60	-74	-96	-55	-76	-79	-73	-92	-99	-99	-92	-90	-45	-84	-83	-86	-11	-92	-87	-88	-79
YE-02	299-W14-20	-82	-116	-116	-106	-108	-110	-114	-76	-120	-101	-99	-100	-100	-98	-76	-73	-79	-67	-84	-71	-70	-81	-71	-76
YE-03	299-W14-73	-87	-89	-95	-63	-47	-29	-99	-91	-97	-69	-105	-118	-113	-102	-69	-48	-90	-94	-108	-54	-119	-116	-120	-129
YE-04	299-W14-74	-83	-97	-102	-5	-68	-24	-82	-85	-119	-10	-72	-104	-109	-104	-58	-17	-87	-88	-103	-113	-114	-114	-113	-113
YE-05	299-W12-2	-77	-87	-71	-1	0	0	-52	-55	-110	-59	-88	-93	-99	-95	-52	-50	-82	-89	-101	-79	-107	-93	-80	-58
YE-06	299-W11-50	-80	-87	-82	-77	-80	-81	-92	-74	-75	-45	-38	-98	-100	-96	-75	-71	-77	-66	-81	-70	-69	-60	-61	-63
YE-07	299-W11-90	-80	-127	-133	-80	-81	-82	-117	-95	-119	-100	-95	-85	-100	-98	-76	-72	-78	-66	-95	-106	-104	-99	-87	-88
YE-08	299-W11-96	-75	-93	-107	0	0	0	-59	-67	-109	-2	-48	-99	-108	-97	-51	-19	-94	-96	-99	-20	-106	-105	-106	-108
YE-09	299-W17-3	-87	-86	-78	-67	-32	-8	-89	-84	-82	-21	-103	-128	-118	-101	-89	-74	-86	-93	-99	-10	-97	-102	-108	-120
YE-10	299-W17-2	-84	-88	-86	-28	-54	0	-59	-91	-96	-66	-99	-110	-108	-99	-68	-48	-91	-94	-104	-88	-110	-109	-109	-75
YE-11	299-W19-111	0	0	0	0	0	0	0	-2	-17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YE-12	299-W11-49	-85	-89	-95	-94	-101	-93	-35	-80	-92	0	-79	-121	-117	-91	-85	-71	-85	-92	-113	-96	-131	-135	-136	-135
YE-13	299-W11-97	-85	-42	-13	-29	0	-5	-55	-36	-80	-24	-79	-99	-95	-86	-78	-74	-88	-93	-91	-9	-77	-93	-91	-92
YE-14	299-W6-15	-66	-63	-59	0	0	0	-16	-49	-92	-30	-88	-26	0	0	-23	-22	-95	-97	-95	-18	-97	-95	-97	-98
YE-15	299-W14-21	0	0	0	0	0	0	0	-22	-74	0	0	-33	-91	-77	-82	-73	-74	-76	-95	-81	-98	-94	-88	-97
YE-16	299-W11-92	-87	-86	-78	-83	-98	-99	-63	-67	-93	-51	-99	-119	-113	-100	-88	-75	-83	-91	-101	-69	-97	-92	-97	-100
YE-17	299-W5-1	-42	-53	-43	-1	0	0	-39	-47	-94	-59	-81	-96	-99	-92	-44	-45	-97	-98	-56	0	0	-56	-81	-90
YE-18	299-W12-3	-72	-69	-56	-1	0	0	-46	-52	-91	-11	-88	-104	-96	-86	-56	-19	-97	-98	-99	-54	-99	-105	-104	-81
YE-19	299-W12-4	-72	-85	-64	-1	0	0	-52	-54	-93	-62	-91	-112	-80	-81	-62	-55	-79	-85	-118	-66	-136	-134	-135	-134
YE-20	299-W14-22	-43	-56	-44	-1	0	0	-39	-46	-82	-45	-83	-100	-89	-78	-59	-53	-78	-88	-97	-16	-97	-97	-109	-115
YE-21	299-W22-90	-25	-25	-22	-24	-25	-25	-24	-18	-9	-5	0	-8	-25	-25	-25	-25	-24	-24	-23	-20	-20	-25	-25	-25
YE-22	299-W22-91	-35	-35	-31	-34	-35	-35	-35	-34	-30	-31	-32	-34	-35	-35	-35	-35	-34	-35	-29	-20	-21	-30	-30	-30
YE-23	299-W22-92	-34	-34	-30	-33	-34	-33	-34	-33	-33	-33	-32	-30	-34	-33	-33	-32	-32	-32	-26	-20	-20	-25	-13	-25
YE-24	299-W19-125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-18	-49	-50	-50
YE-25	299-W19-113	-54	-54	-54	-53	-54	-55	-55	-46	-55	-53	-55	-55	-55	-55	-55	-55	-54	-54	-39	-46	-50	-49	-50	-50
YE-26	299-W19-114	-99	-99	-99	-97	-99	-100	-99	-95	-100	-96	-86	-100	-100	-99	-100	-99	-97	-96	-73	-93	-82	-50	-50	-50

Table B-3. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2016 and 2017

Stress Period of Model Commences in 2012		49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Stress Period of Model Commences in 2015		13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Well ID	Well Name	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	July 2016	Aug. 2016	Sept. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	June 2017	July 2017	Aug. 2017	Sept. 2017	Oct. 2017	Nov. 2017	Dec. 2017
YE-27	299-E33-268	-79	-81	-78	-66	-79	-80	-90	-95	-108	-7	0	-23	0	-26	-89	-86	-77	-24	0	0	0	0	0	0
YE-31	299-E33-360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-8	-30	-35	-110	-141	-139	-141	-82	-162	-167
YJ-01	299-W6-13	57	55	35	51	54	54	10	16	66	20	52	50	50	45	12	12	72	62	67	47	47	7	45	56
YJ-02	299-W6-14	163	194	105	78	124	101	154	128	190	74	152	193	208	193	54	140	201	205	210	94	182	182	189	212
YJ-03	299-W10-36	72	62	80	83	62	68	67	38	55	43	54	58	57	40	78	62	62	91	64	69	72	58	82	95
YJ-04	299-W10-35	73	85	107	61	22	27	110	78	110	40	74	126	146	132	95	91	134	142	142	58	105	102	105	121
YJ-05	299-W15-226	159	175	134	184	239	205	177	124	176	71	109	185	193	197	175	49	189	195	203	170	93	180	185	200
YJ-06	299-W15-227	91	108	145	90	53	70	123	102	145	52	116	147	150	145	124	83	112	148	162	142	96	125	139	131
YJ-07	299-W15-228	124	119	122	110	0	0	81	151	156	73	154	182	179	172	174	163	178	151	186	39	176	171	186	121
YJ-08	299-W18-41	77	97	96	43	0	1	35	71	110	44	102	120	122	114	80	42	130	105	157	30	134	130	134	123
YJ-09	699-49-69	56	40	45	0	8	26	43	35	43	22	21	12	8	27	22	10	9	34	28	26	33	24	24	24
YJ-10	699-45-67B	0	3	2	0	0	0	2	1	0	0	0	0	0	0	1	0	1	2	6	5	1	10	8	5
YJ-11	699-45-67	34	56	41	11	29	24	41	32	8	10	32	13	8	3	0	5	9	3	22	29	18	21	27	24
YJ-12	699-44-67	11	8	14	1	3	0	0	0	0	0	2	31	11	10	3	2	3	2	2	6	3	25	24	20
YJ-13	699-43-67	60	37	31	10	23	20	34	30	39	25	12	25	24	23	19	17	15	0	33	30	32	26	21	15
YJ-14	699-42-67	59	49	108	39	90	78	110	90	93	69	72	89	78	76	72	64	75	65	57	83	82	57	83	82
YJ-15	699-40-67	30	49	40	9	14	23	51	35	54	32	26	16	61	41	19	17	19	15	30	21	21	36	22	52
YJ-16	699-38-64	53	53	47	14	21	22	57	46	78	41	51	45	1	61	47	43	68	56	77	41	82	99	86	92
YJ-17	699-43-67B	40	25	20	7	15	14	22	20	26	17	8	17	16	15	13	11	10	0	22	20	21	18	14	10
YJ-18	299-W15-29	51	57	56	41	20	17	20	41	56	25	58	65	67	69	63	54	73	71	64	12	25	64	64	54
YJ-19	299-W18-36	68	71	70	54	61	34	63	65	77	33	76	85	87	84	78	27	61	74	80	10	86	48	0	0
YJ-20	299-W18-37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-21	299-W18-38	44	42	27	29	69	44	45	55	57	29	57	67	65	63	64	59	15	65	94	10	103	97	159	114
YJ-22	299-W18-39	1	1	12	19	20	12	20	21	21	11	19	20	20	20	21	11	17	12	0	0	0	0	0	0
YJ-23	699-46-68	66	69	53	17	41	15	63	51	56	42	42	25	0	1	2	1	11	39	45	23	25	46	45	45
YJ-24	299-W15-229	140	148	119	18	0	0	36	114	148	55	102	110	114	48	55	78	111	81	71	24	126	61	119	89

Table B-3. Historical Groundwater Extraction and Injection Rates for 200-ZP-1 and 200-UP-1 P&T Remedies during CY 2016 and 2017

Stress Period of Model Commences in 2012		49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
Stress Period of Model Commences in 2015		13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Well ID	Well Name	Jan. 2016	Feb. 2016	Mar. 2016	Apr. 2016	May 2016	June 2016	July 2016	Aug. 2016	Sept. 2016	Oct. 2016	Nov. 2016	Dec. 2016	Jan. 2017	Feb. 2017	Mar. 2017	Apr. 2017	May 2017	June 2017	July 2017	Aug. 2017	Sept. 2017	Oct. 2017	Nov. 2017	Dec. 2017
YJ-25	299-W7-14	0	0	0	0	0	0	0	133	205	114	184	223	189	137	166	162	185	211	136	157	175	160	157	100
YJ-26	299-E20-1	63	70	59	3	7	9	12	66	91	43	61	66	70	78	66	47	71	61	74	69	56	78	74	77
YJ-27	299-E20-2	48	51	42	3	1	3	44	6	44	30	76	63	64	70	59	40	61	54	64	60	64	82	85	88
YJ-28	299-E11-1	73	77	65	13	36	29	62	52	74	48	42	73	75	83	60	34	77	70	81	79	82	54	66	72
YJ-29	299-W6-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-30	299-W18-44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
YJ-31	299-W18-43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	165	175	106	173
YJ-32	299-W18-42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	113	138	77	118

Note: Extraction and injection rates are shown in gallons per minute (gpm).

ID = identification

Appendix C

Simulated Versus Observed Concentrations in Monitoring Wells

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Appendix C

Simulated Versus Observed Concentrations in Monitoring Wells

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Figures

Figure C-1. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 100 years Half Life (Page 1 of 6) C-1
Figure C-2. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 630 years Half Life (Page 1 of 6) C-7
Figure C-3. Comparison of Simulated and Observed Concentrations for Hexavalent Chromium (Page 1 of 7) C-13
Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 1 of 10) C-20
Figure C-5. Comparison of Simulated and Observed Concentrations for Iodine-129 (Page 1 of 8) C-30
Figure C-6. Comparison of Simulated and Observed Concentrations for Technetium-99 (Page 1 of 9) C-38
Figure C-7. Comparison of Simulated and Observed Concentrations for Trichloroethene (Page 1 of 8) C-47
Figure C-8. Comparison of Simulated and Observed Concentrations for Tritium (Page 1 of 9) C-55
Figure C-9. Comparison of Simulated and Observed Concentrations for Uranium (Page 1 of 9) C-64

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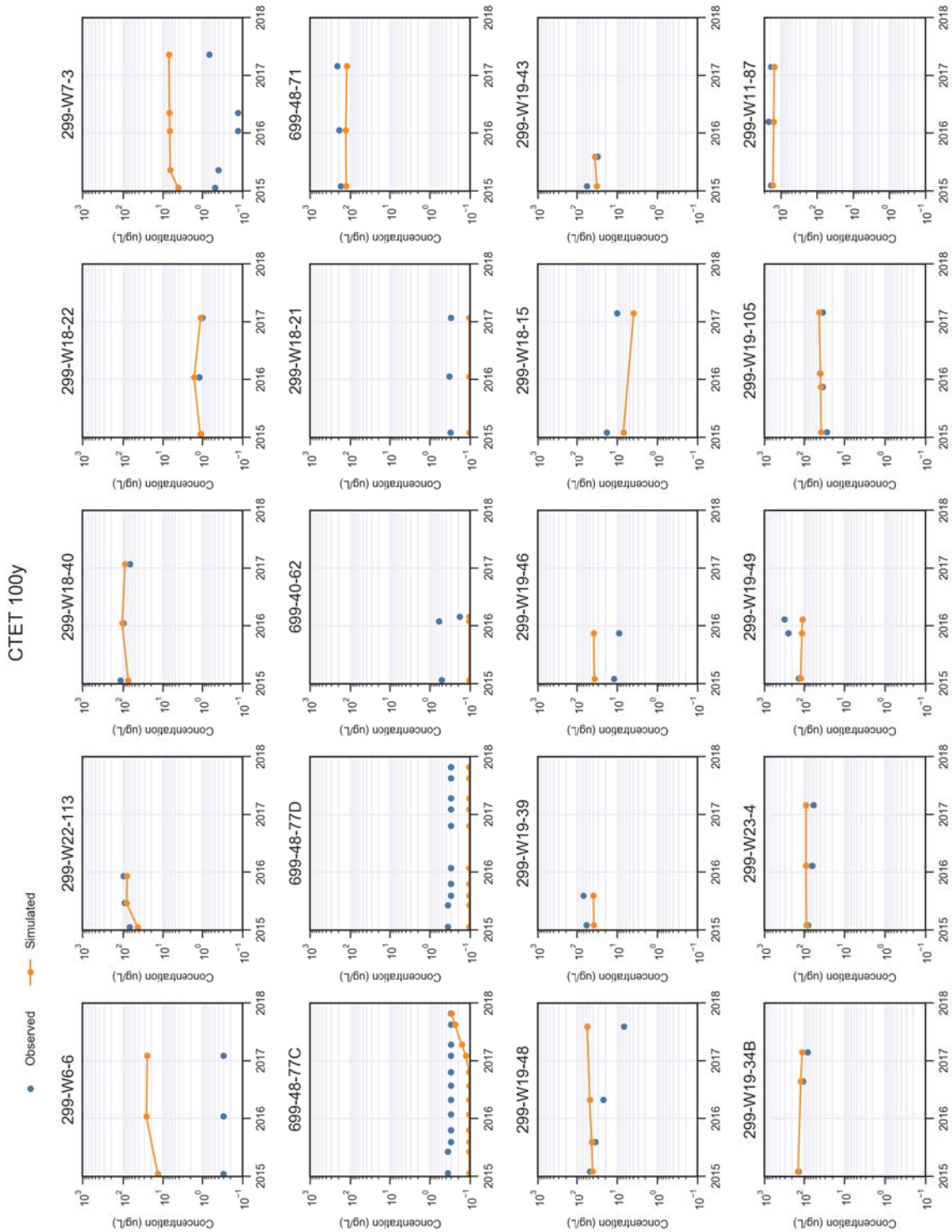

Figure C-1. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 100 years Half Life (Page 1 of 6)

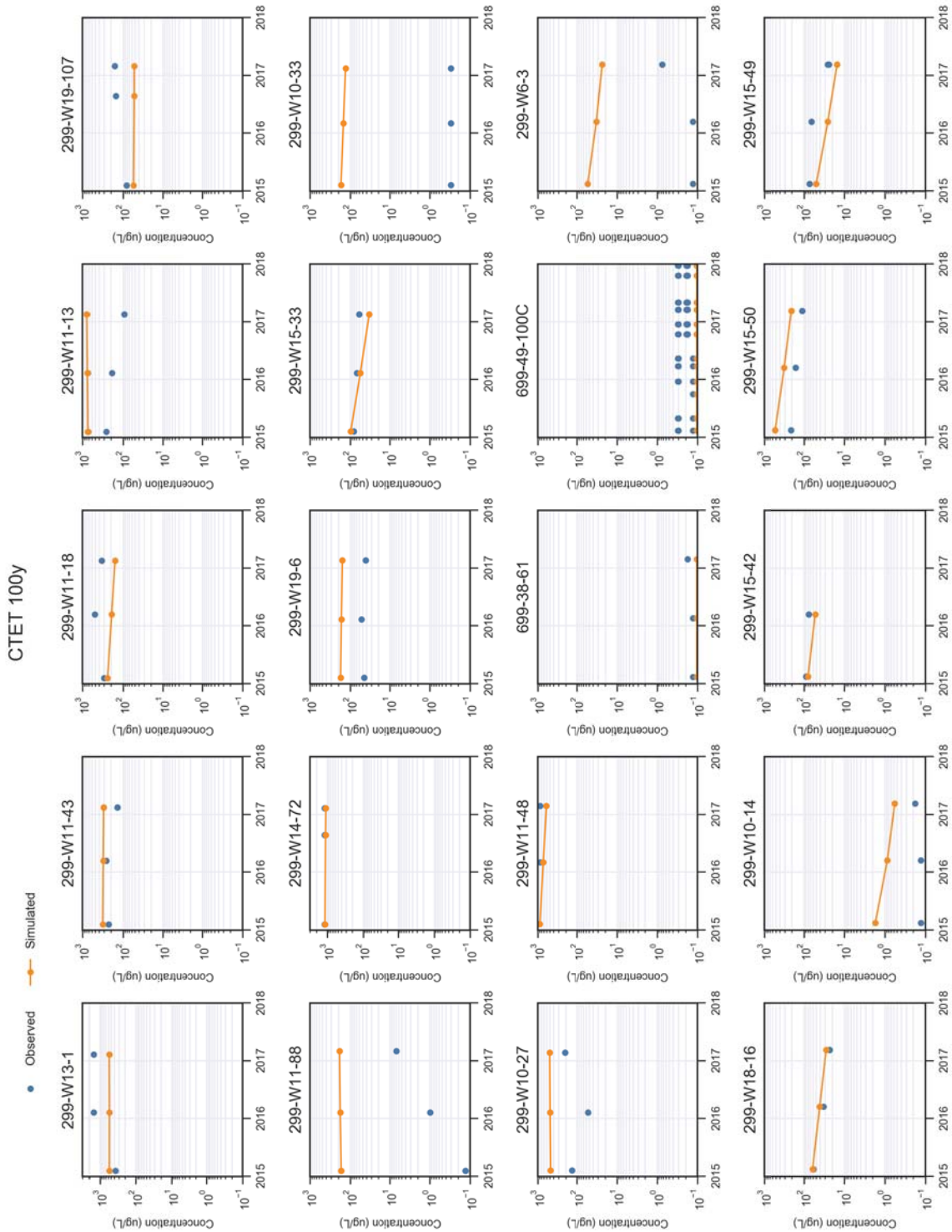

Figure C-1. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 100 years Half Life (Page 2 of 6)

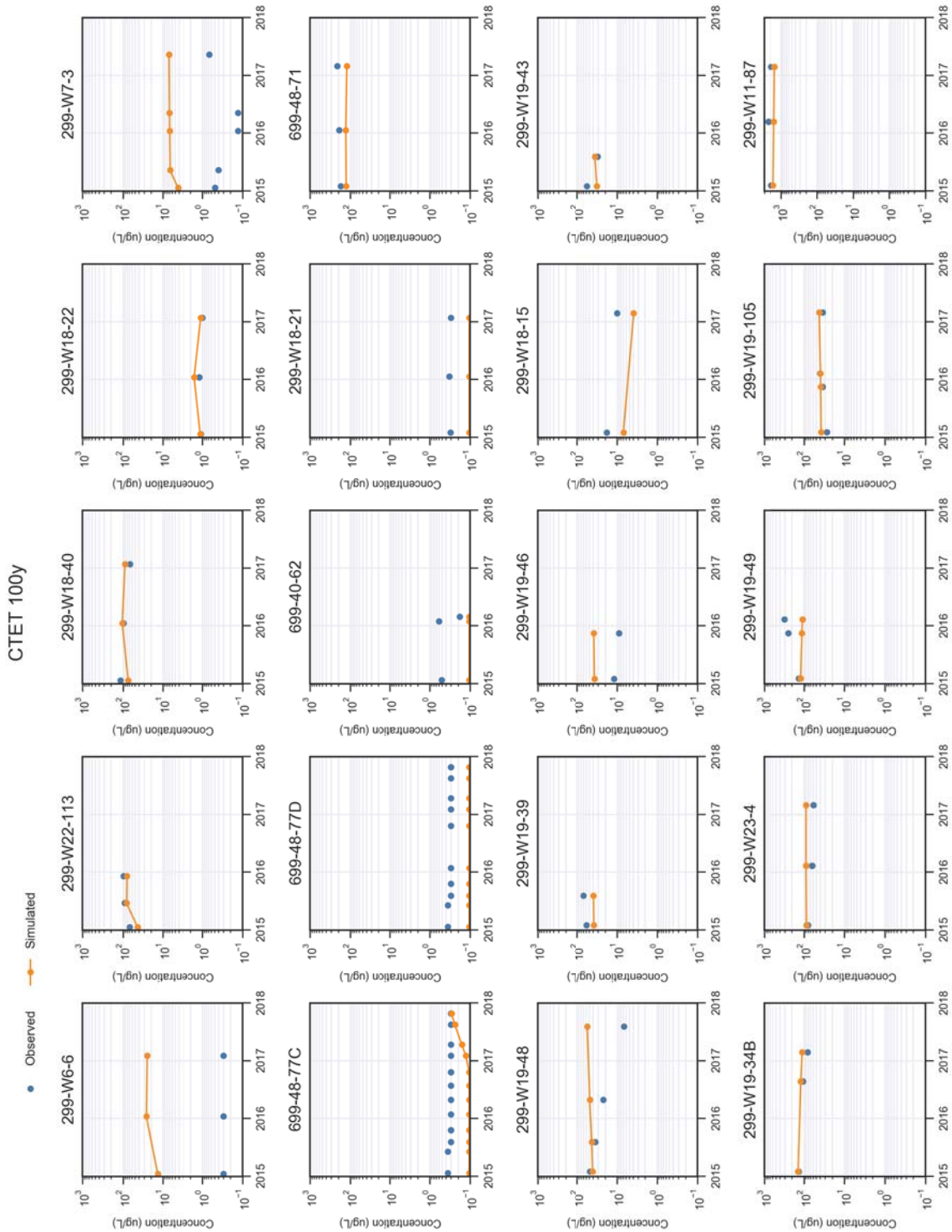

Figure C-1. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 100 years Half Life (Page 3 of 6)

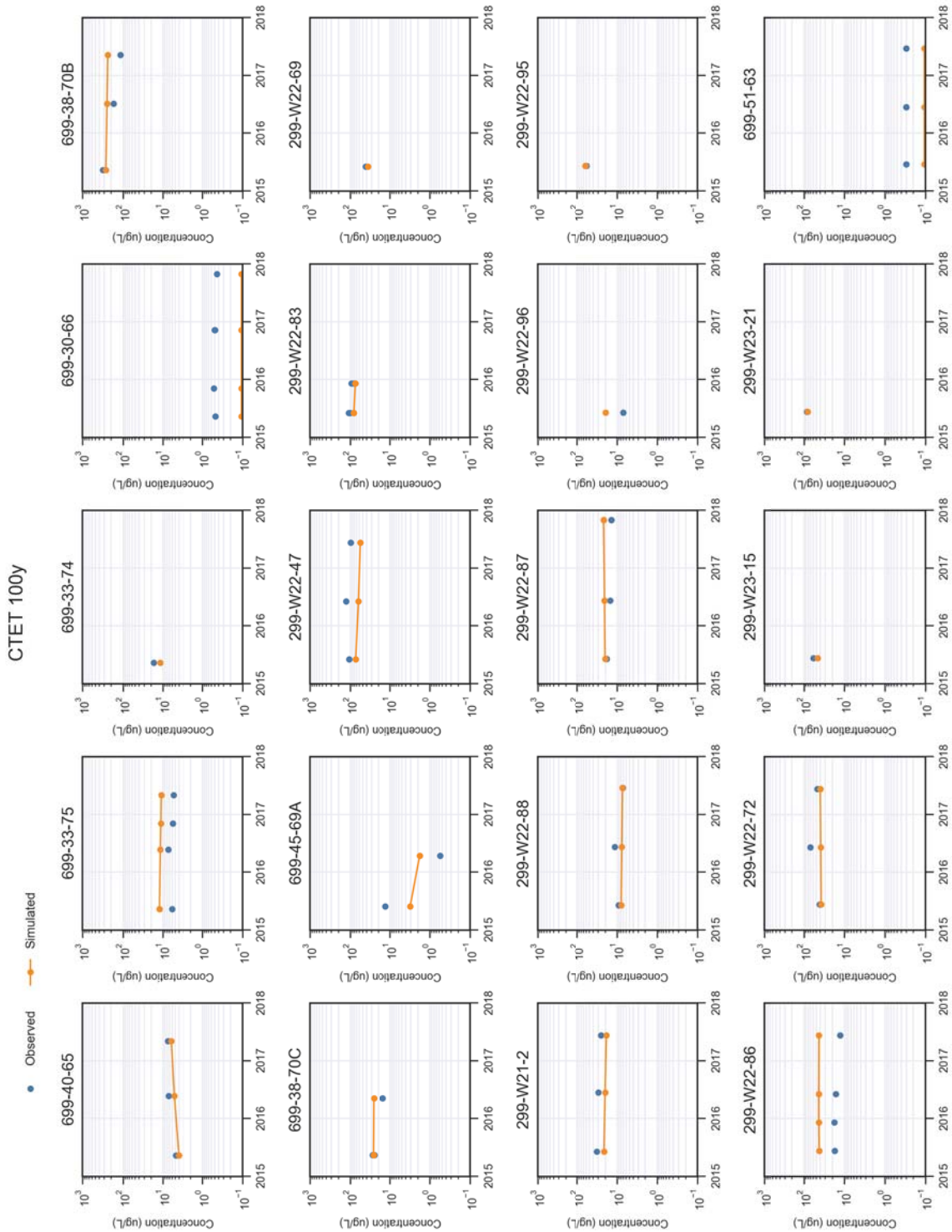

Figure C-1. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 100 years Half Life (Page 4 of 6)

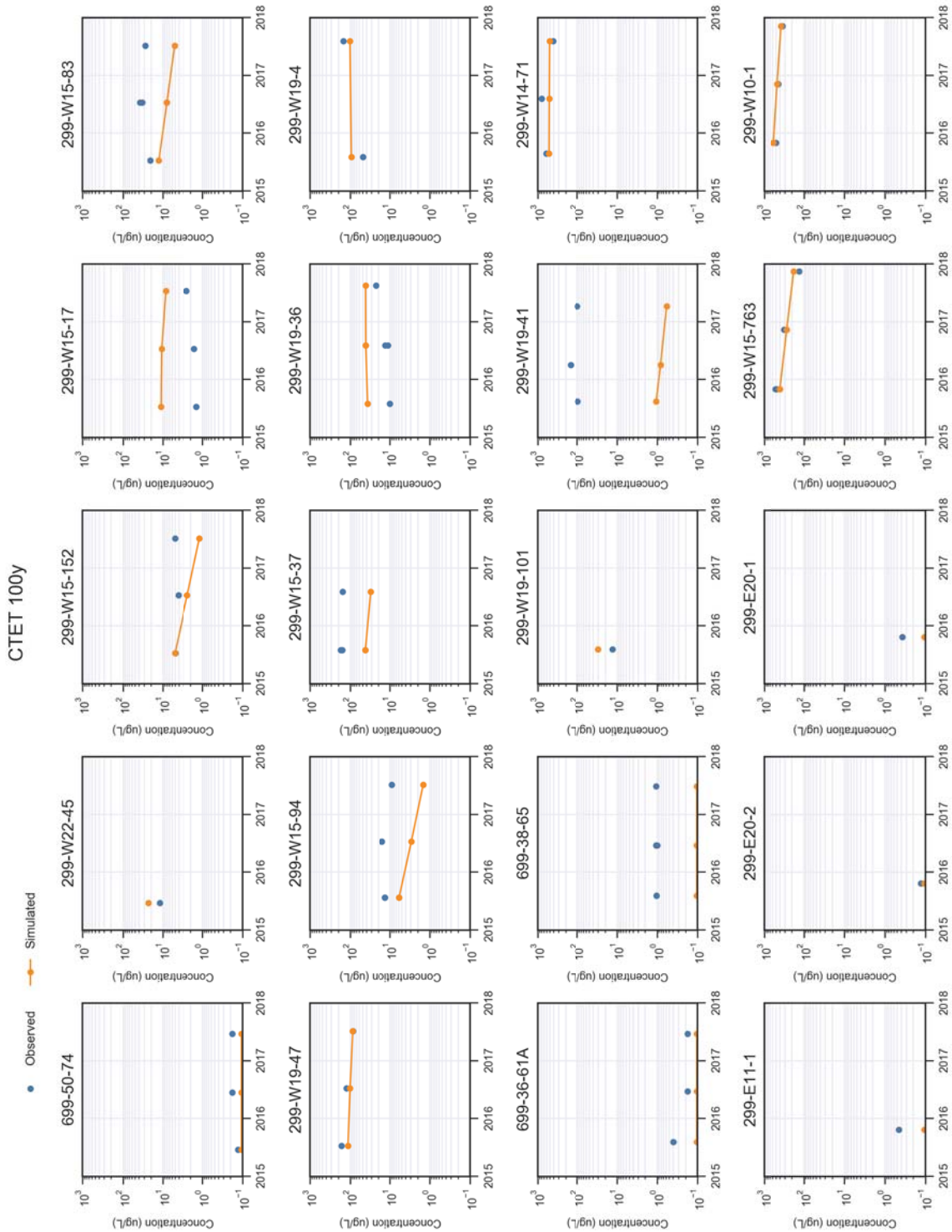

Figure C-1. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 100 years Half Life (Page 5 of 6)

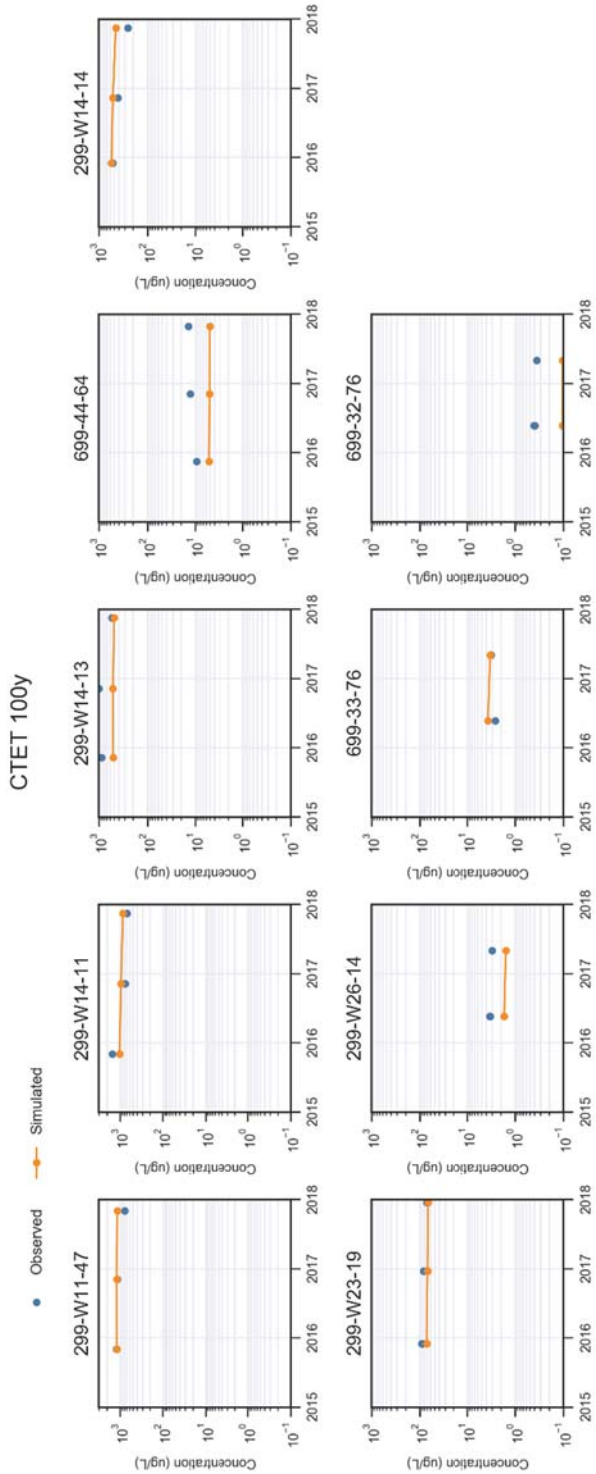

Figure C-1. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 100 years Half Life (Page 6 of 6)

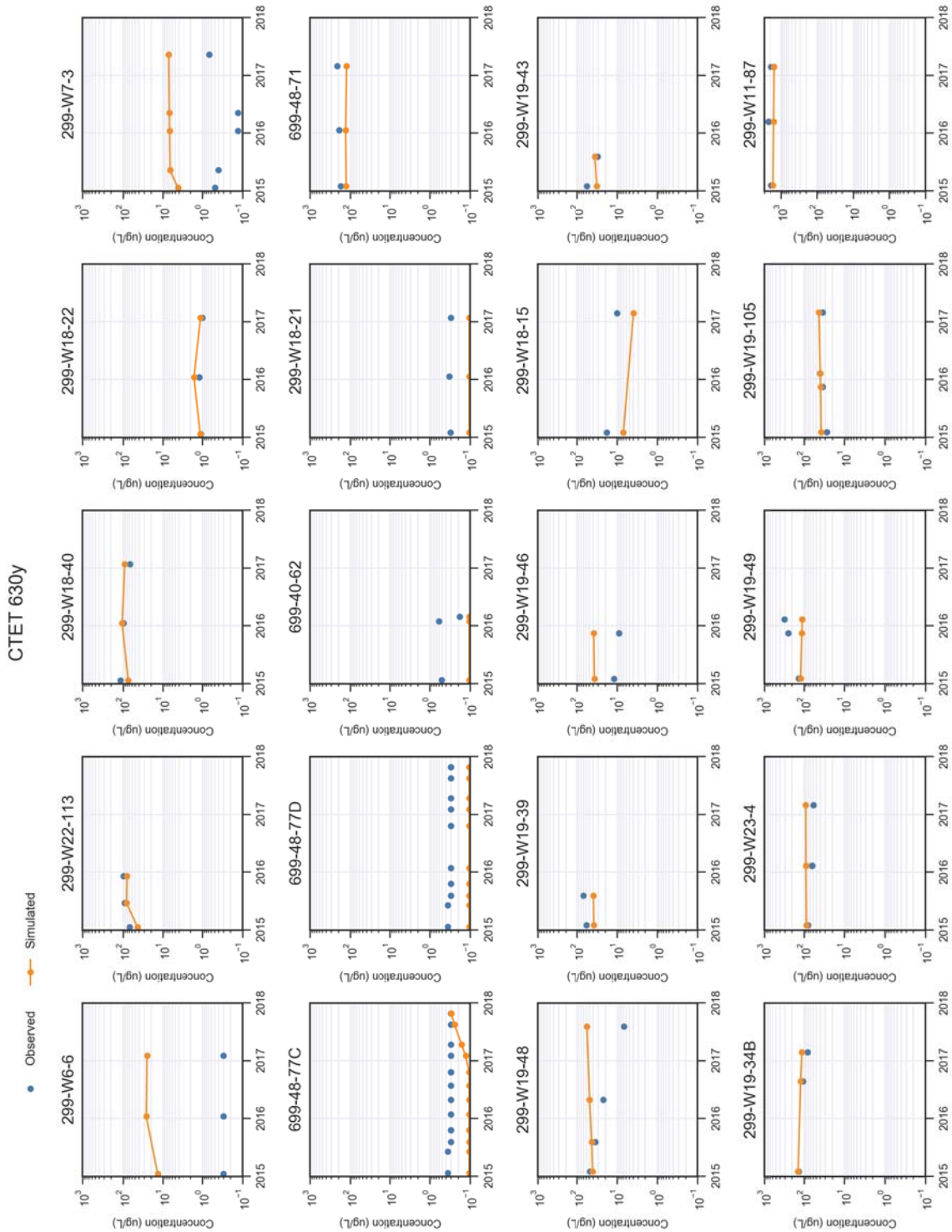

Figure C-2. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 630 years Half Life (Page 1 of 6)

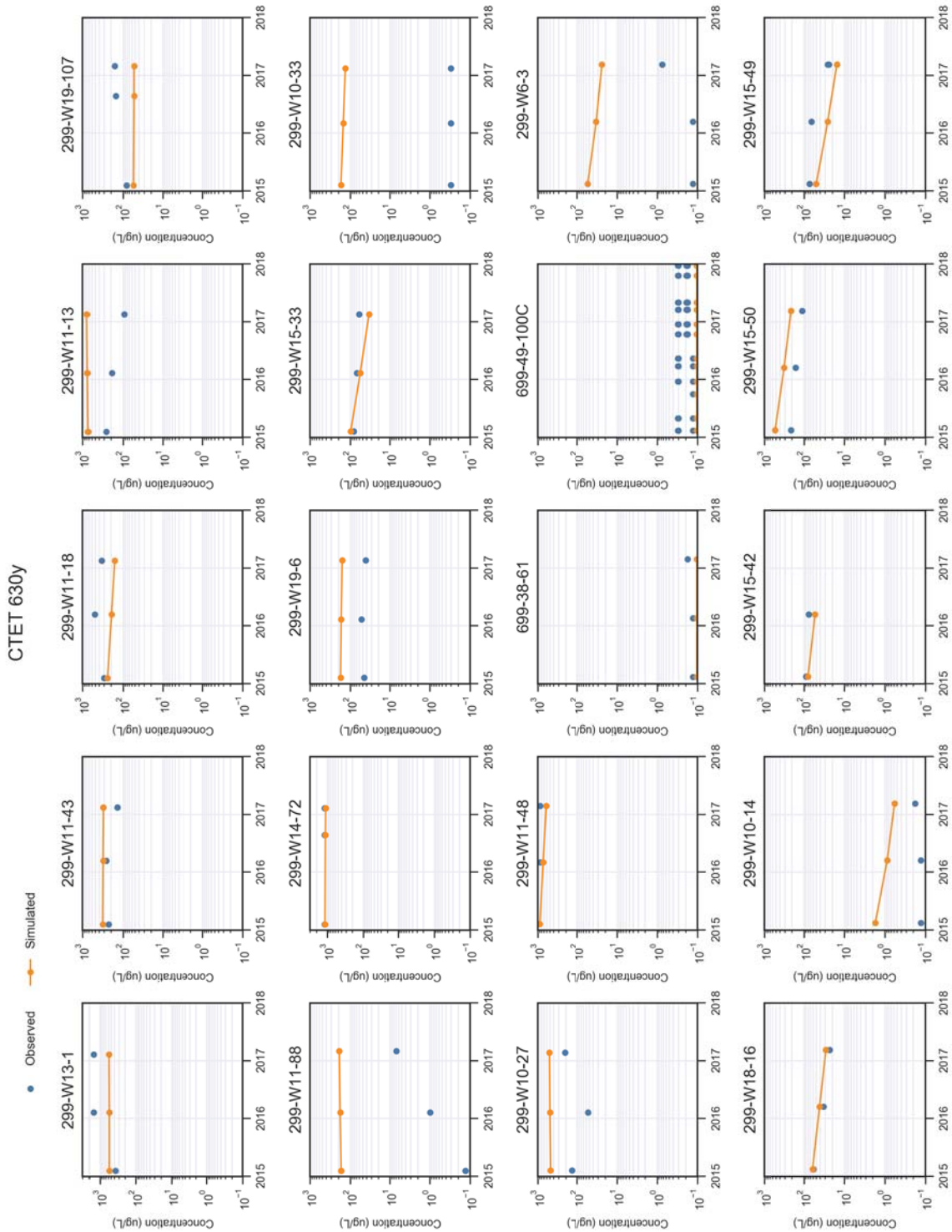

Figure C-2. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 630 years Half Life (Page 2 of 6)

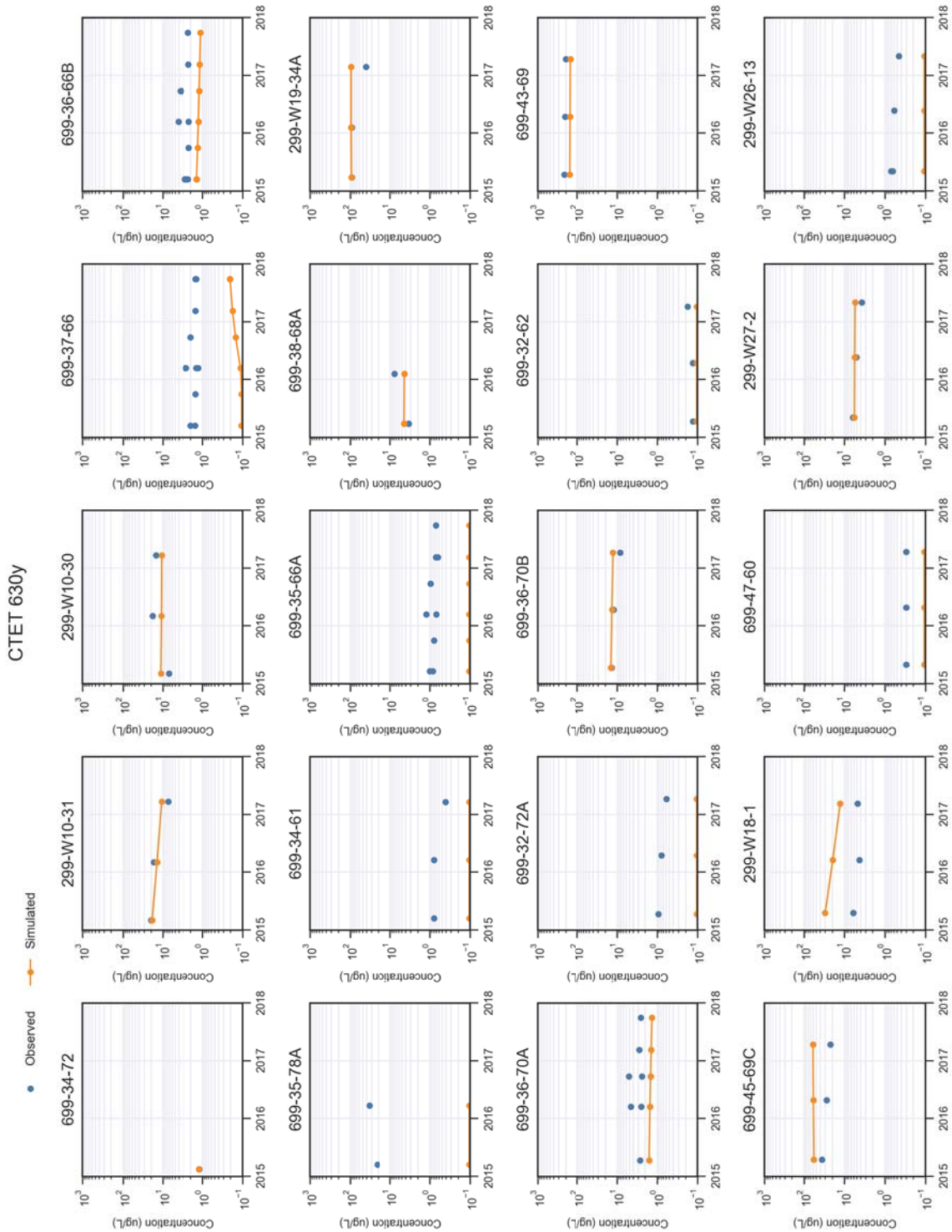

Figure C-2. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 630 years Half Life (Page 3 of 6)

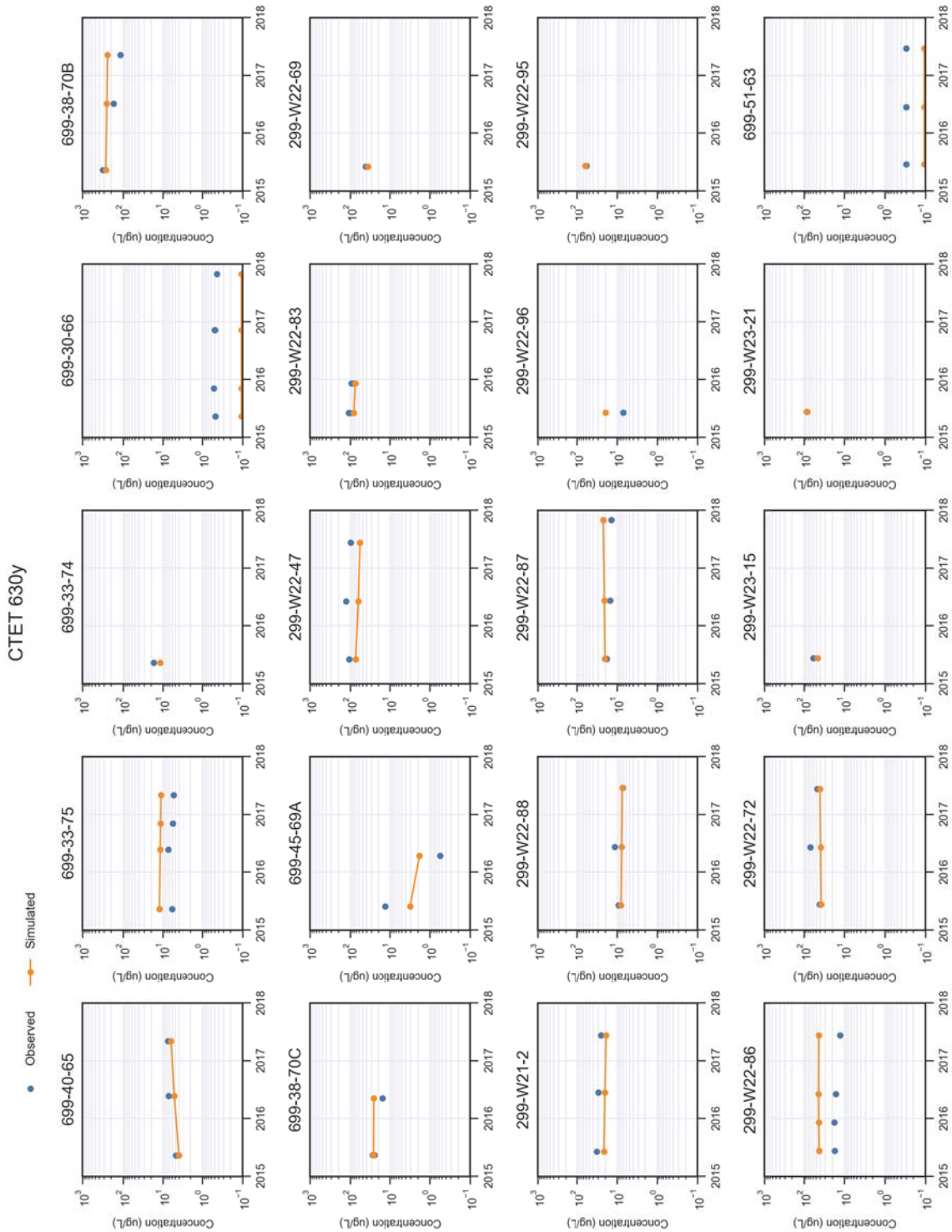

Figure C-2. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 630 years Half Life (Page 4 of 6)

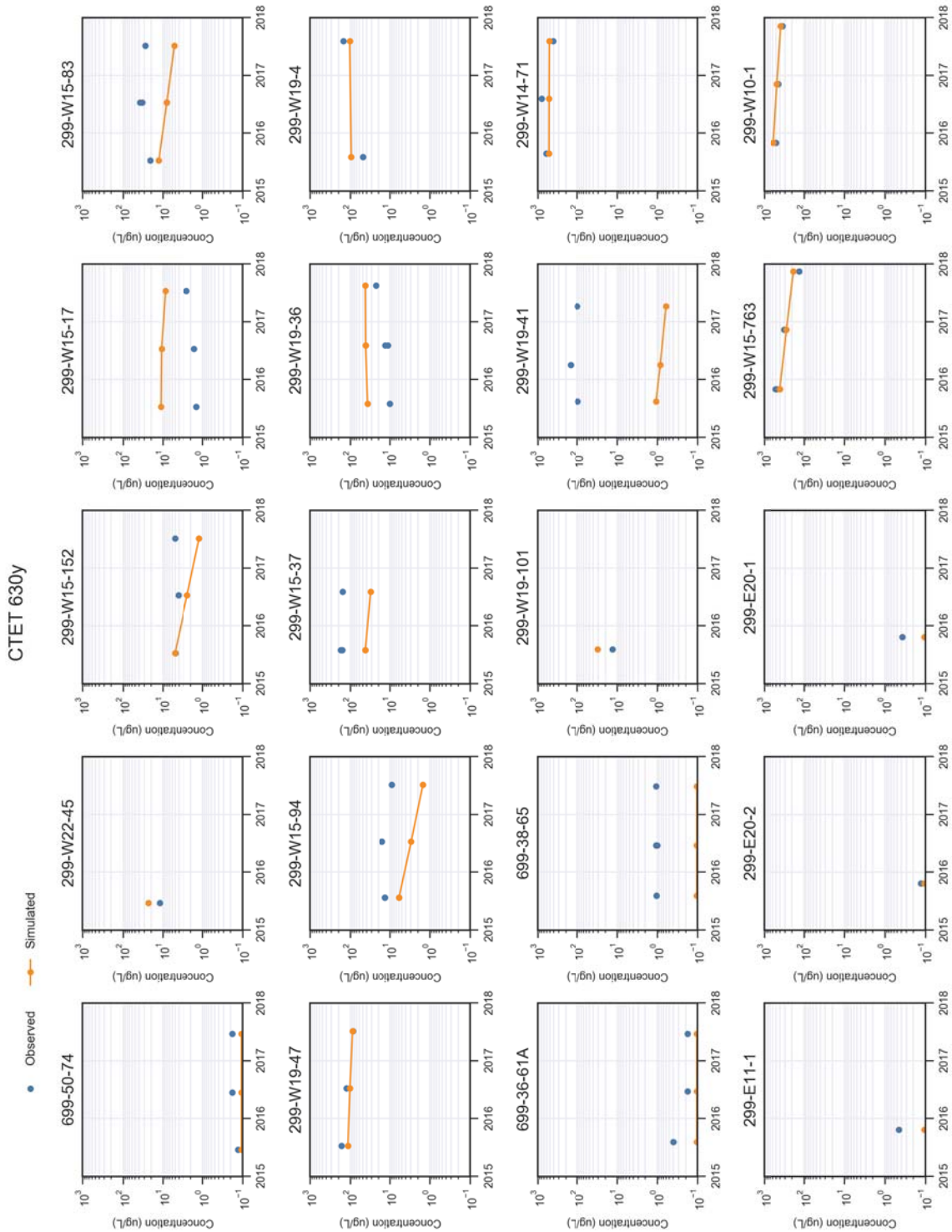

Figure C-2. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 630 years Half Life (Page 5 of 6)

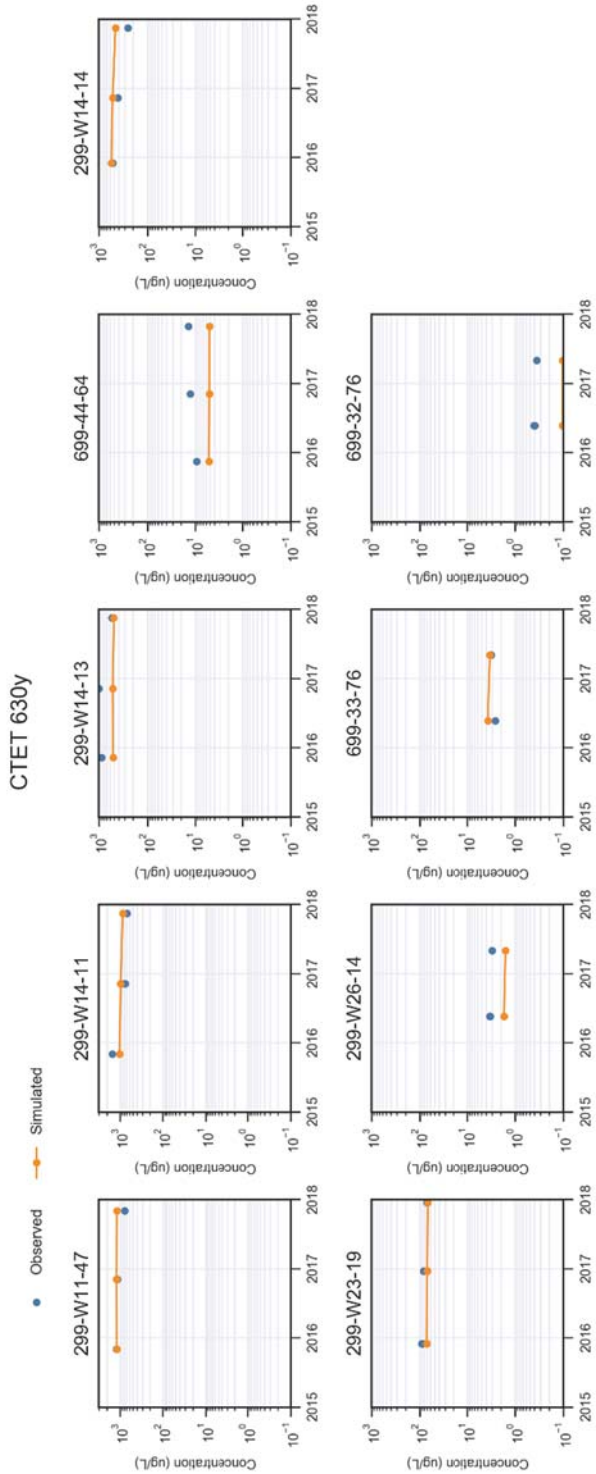

Figure C-2. Comparison of Simulated and Observed Concentrations for Carbon Tetrachloride 630 years Half Life (Page 6 of 6)

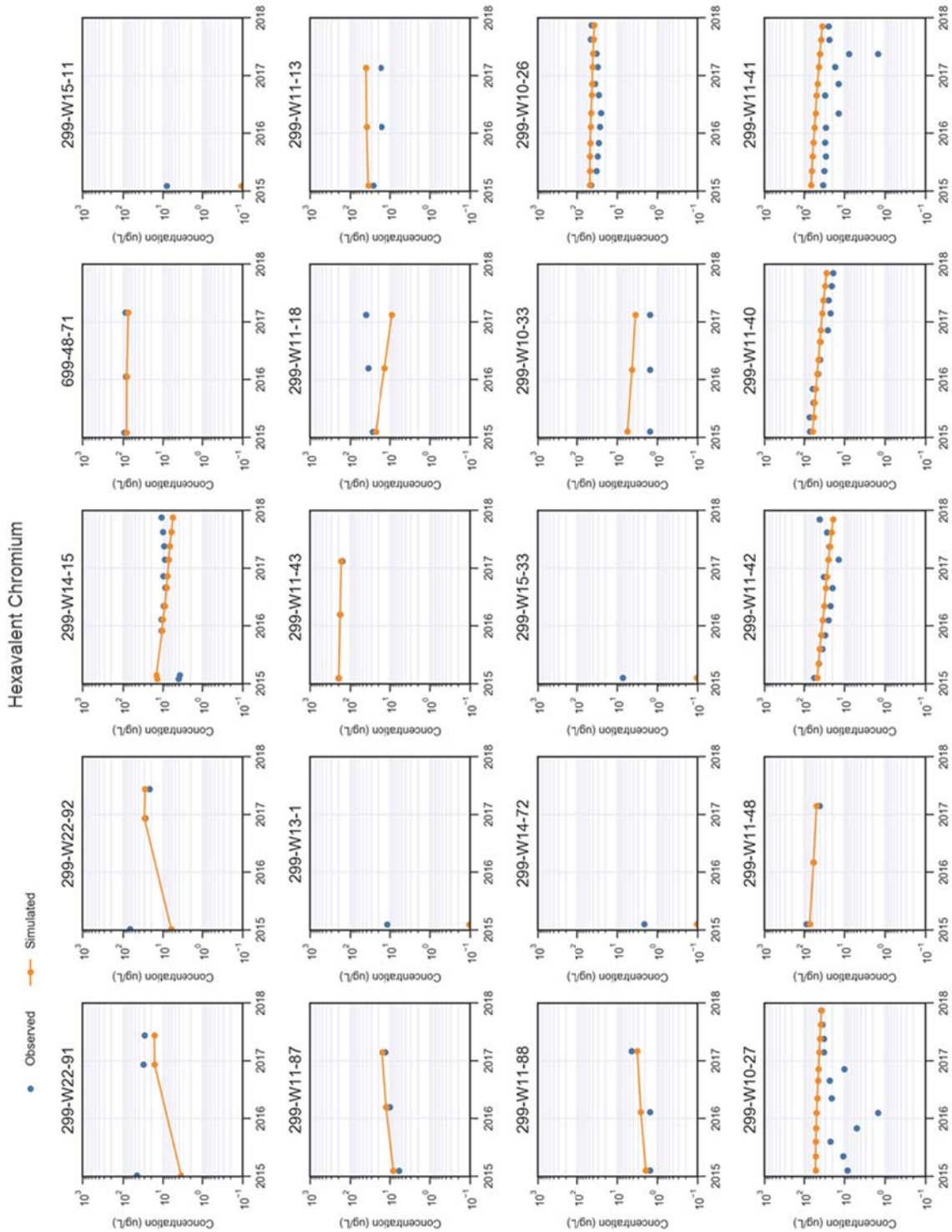

Figure C-3. Comparison of Simulated and Observed Concentrations for Hexavalent Chromium (Page 1 of 7)

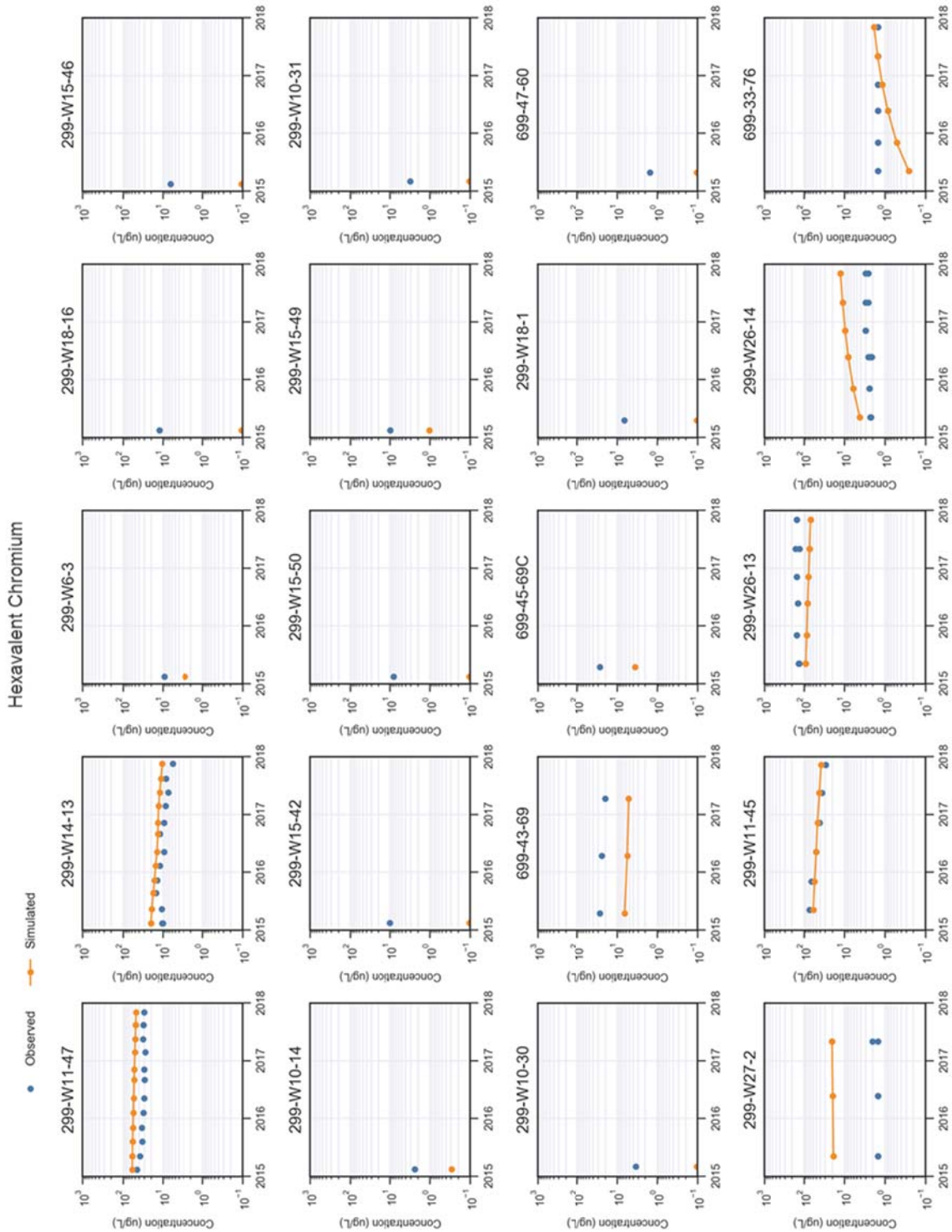

Figure C-3. Comparison of Simulated and Observed Concentrations for Hexavalent Chromium (Page 2 of 7)

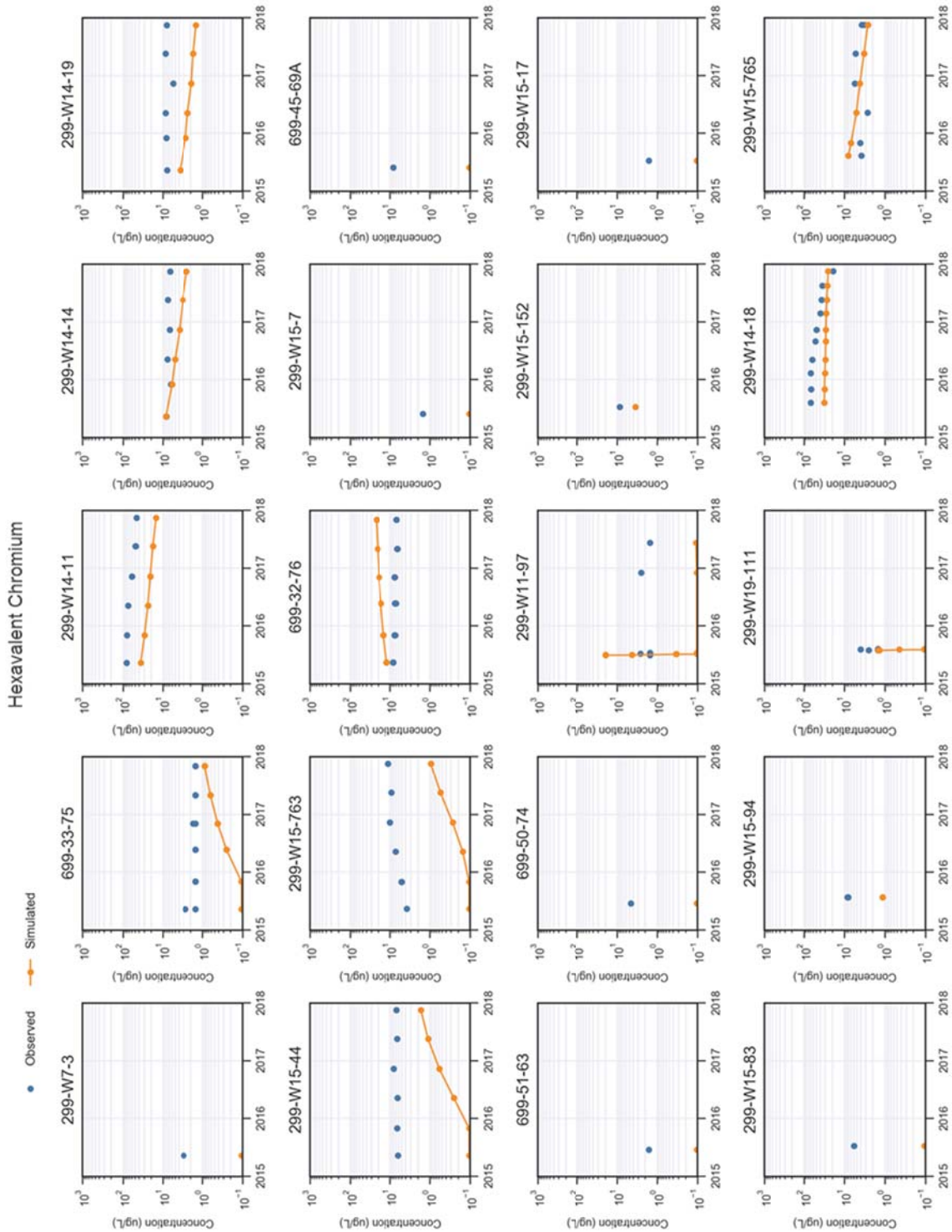

Figure C-3. Comparison of Simulated and Observed Concentrations for Hexavalent Chromium (Page 3 of 7)

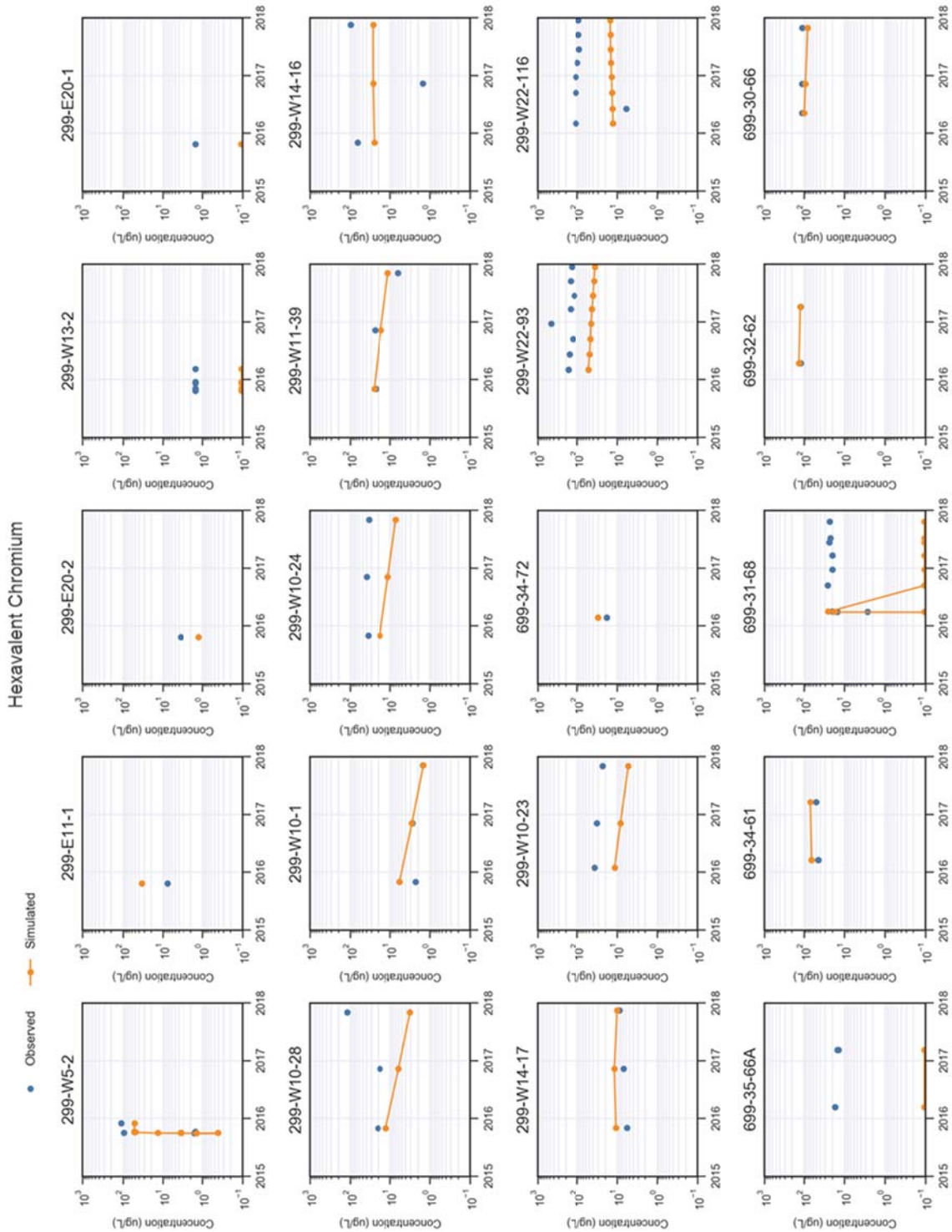

Figure C-3. Comparison of Simulated and Observed Concentrations for Hexavalent Chromium (Page 4 of 7)

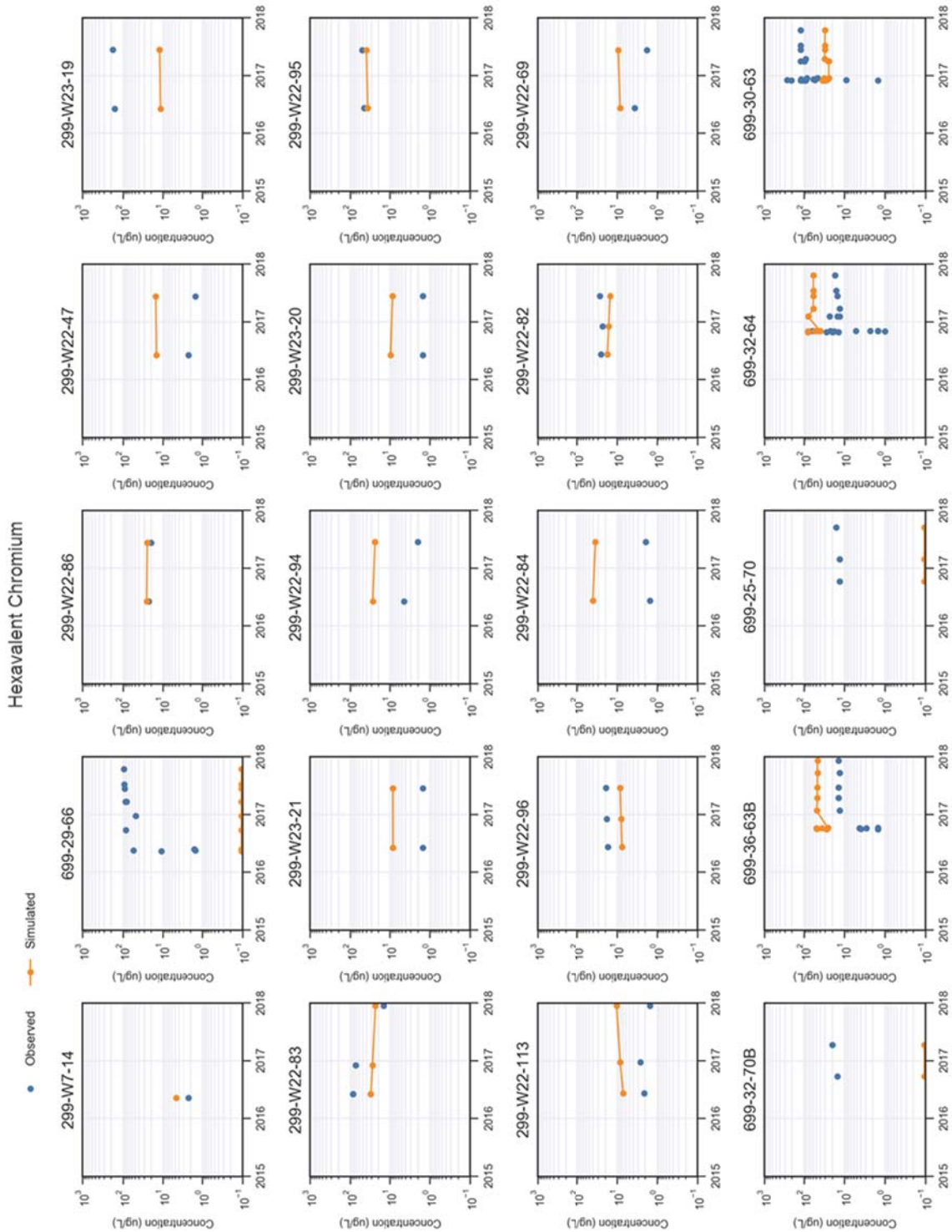

Figure C-3. Comparison of Simulated and Observed Concentrations for Hexavalent Chromium (Page 5 of 7)

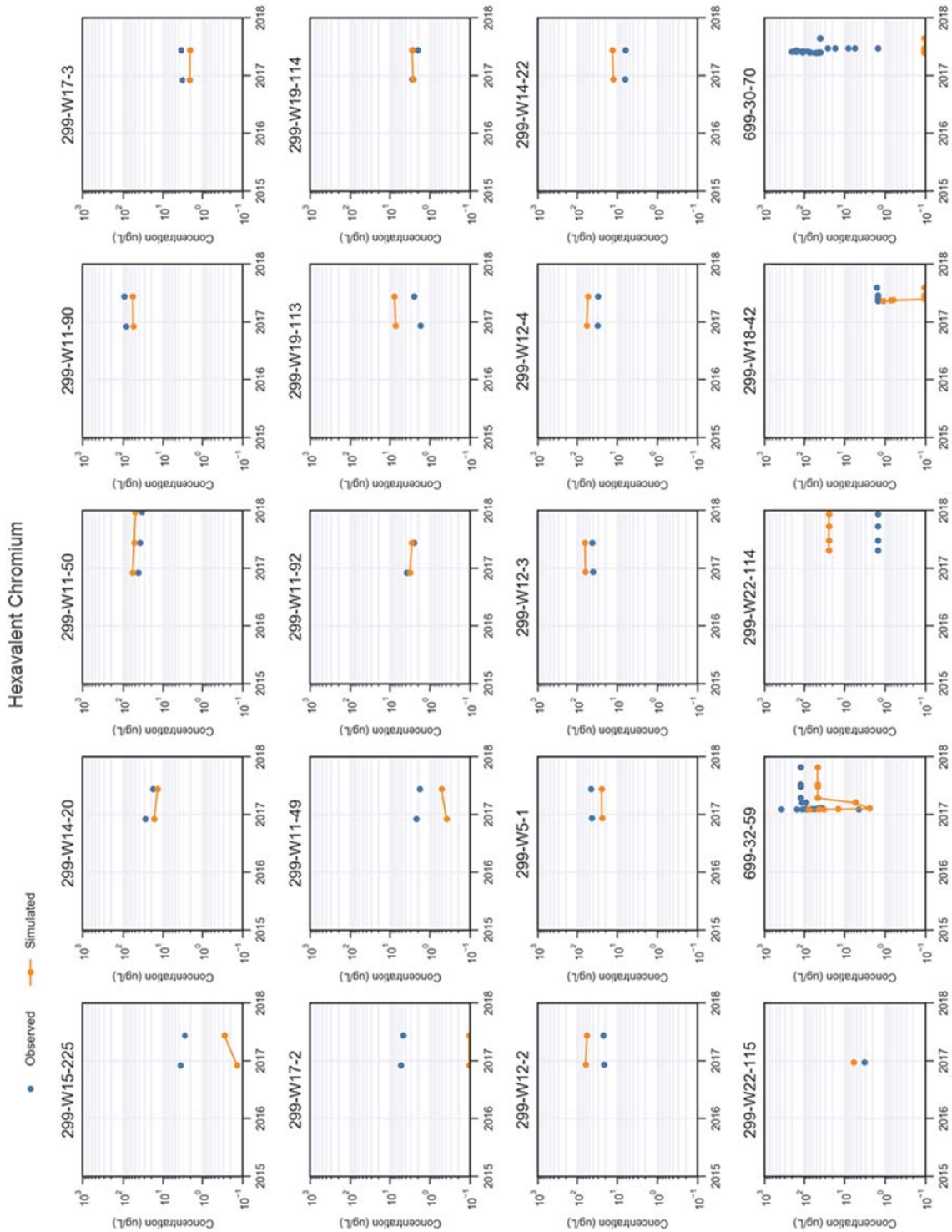

Figure C-3. Comparison of Simulated and Observed Concentrations for Hexavalent Chromium (Page 6 of 7)

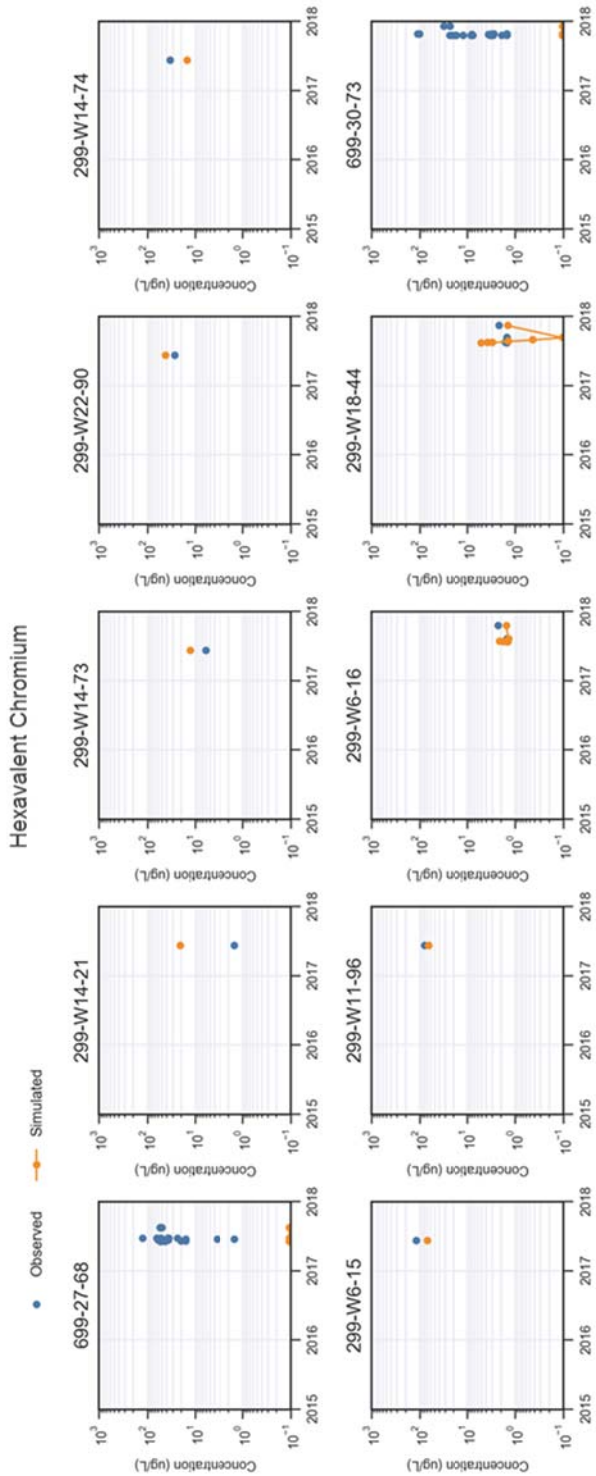

Figure C-3. Comparison of Simulated and Observed Concentrations for Hexavalent Chromium (Page 7 of 7)

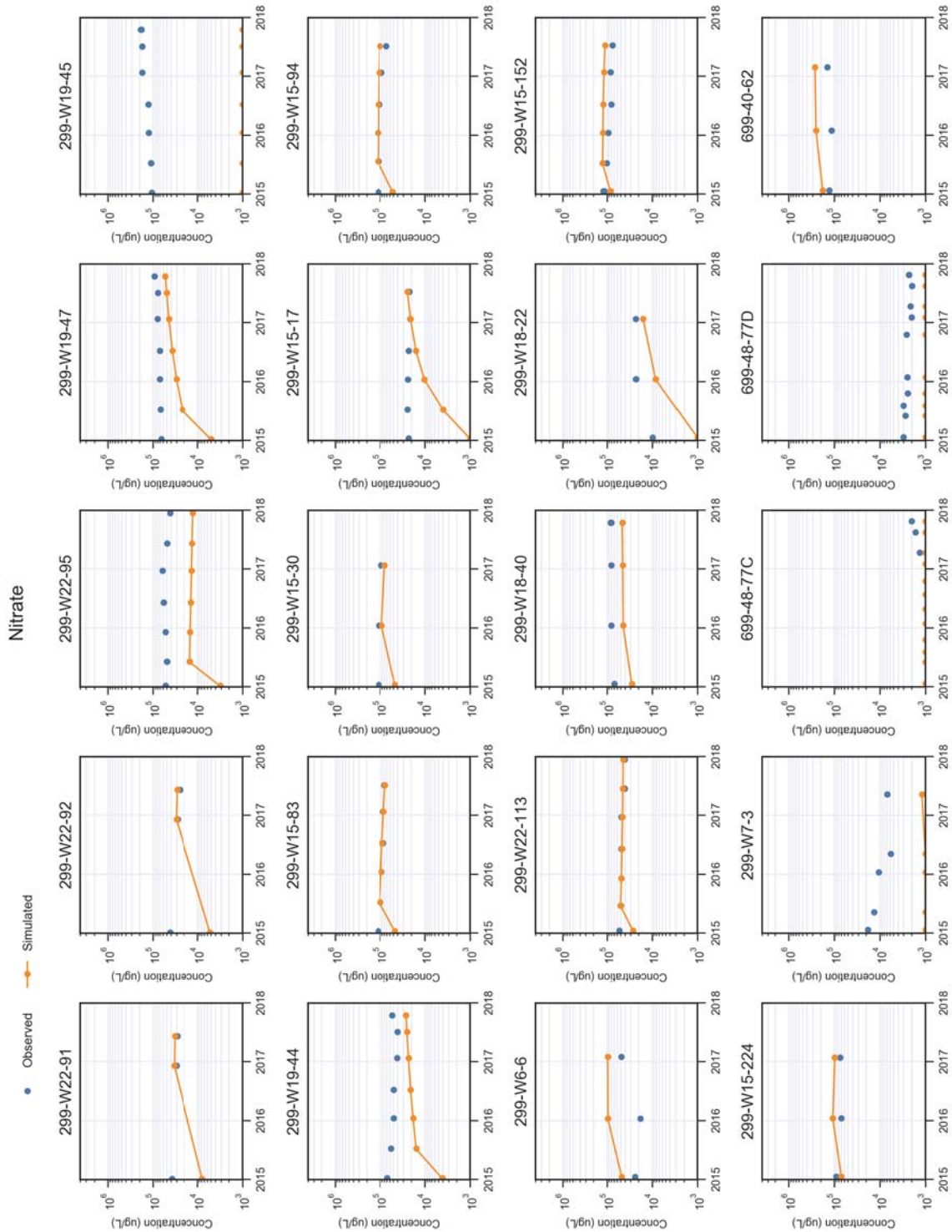

Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 1 of 10)

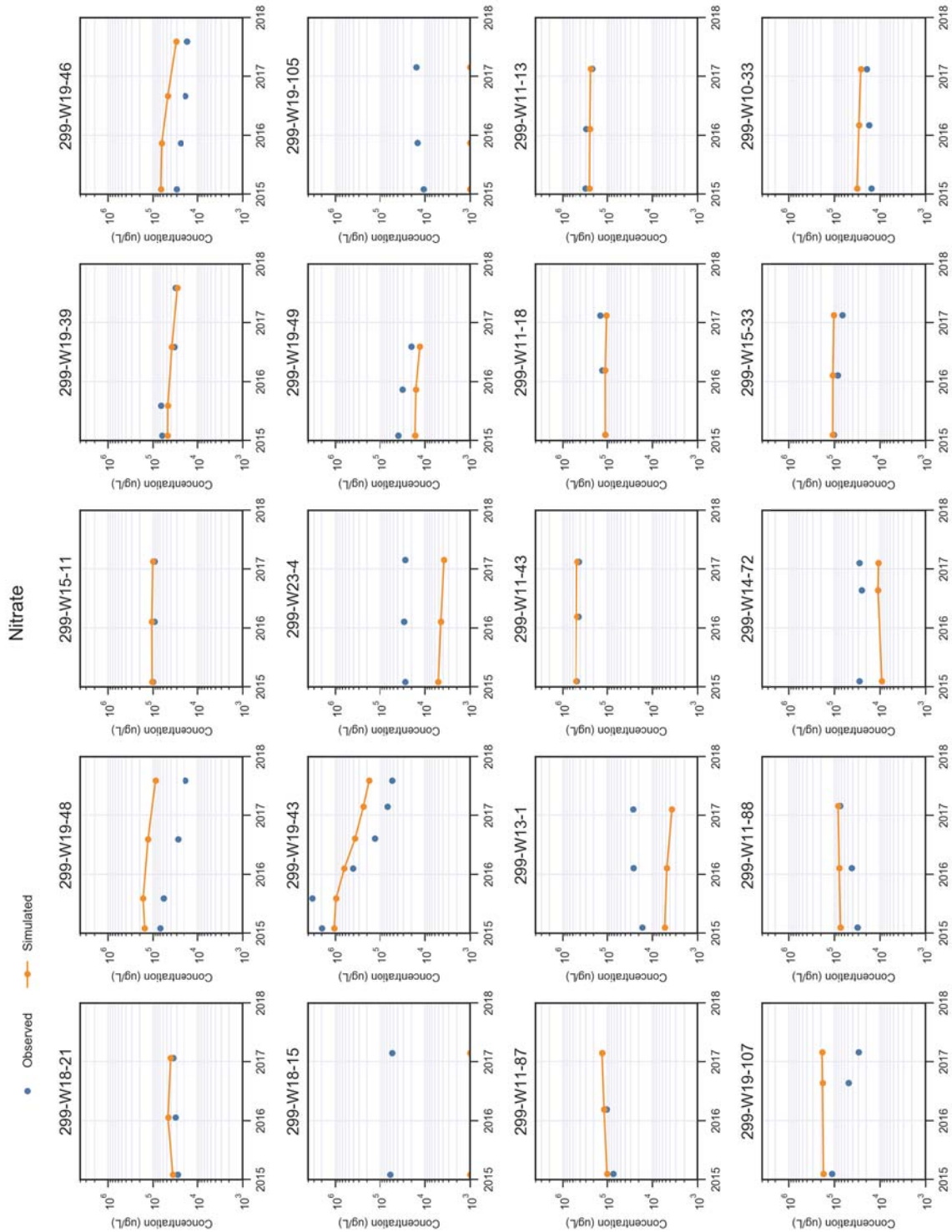

Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 2 of 10)

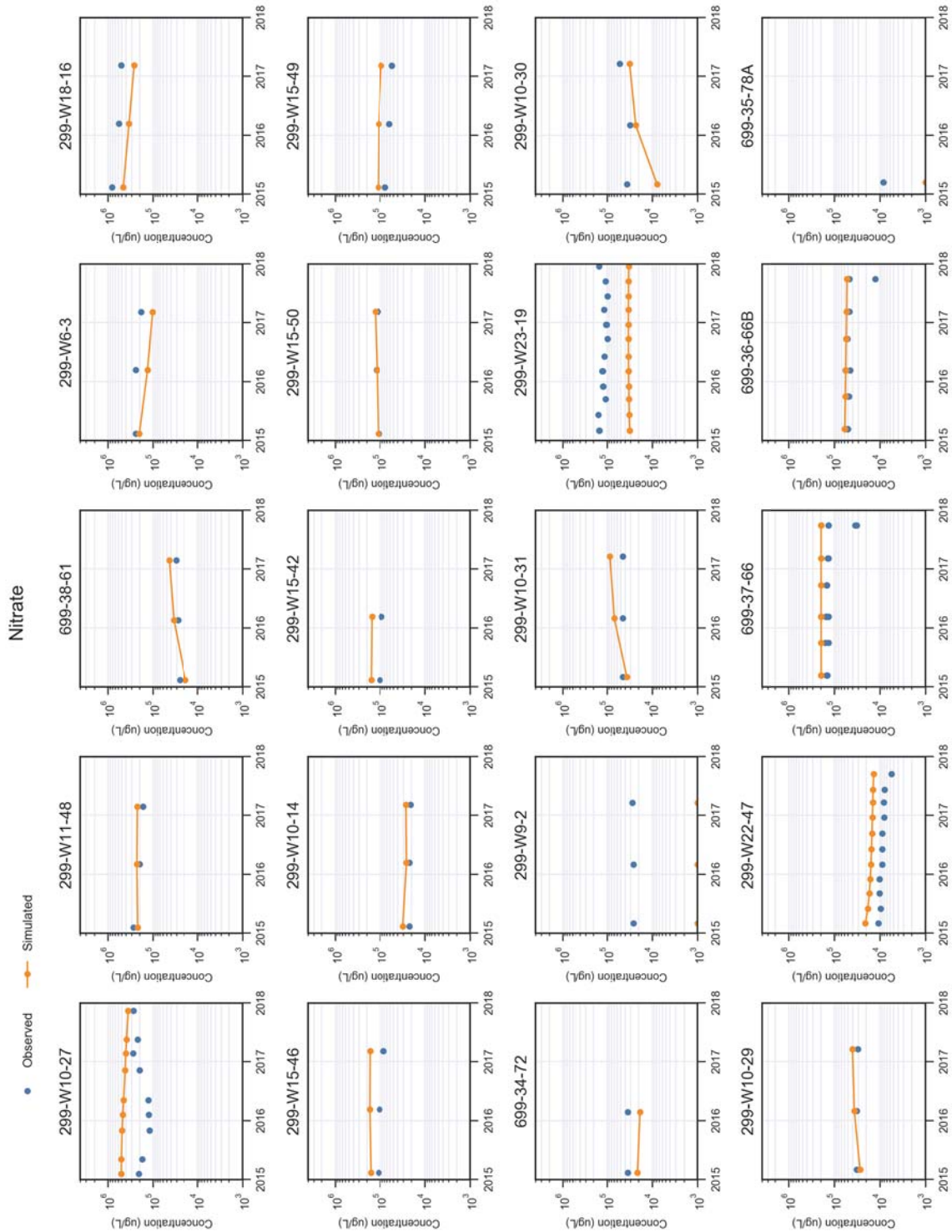

Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 3 of 10)

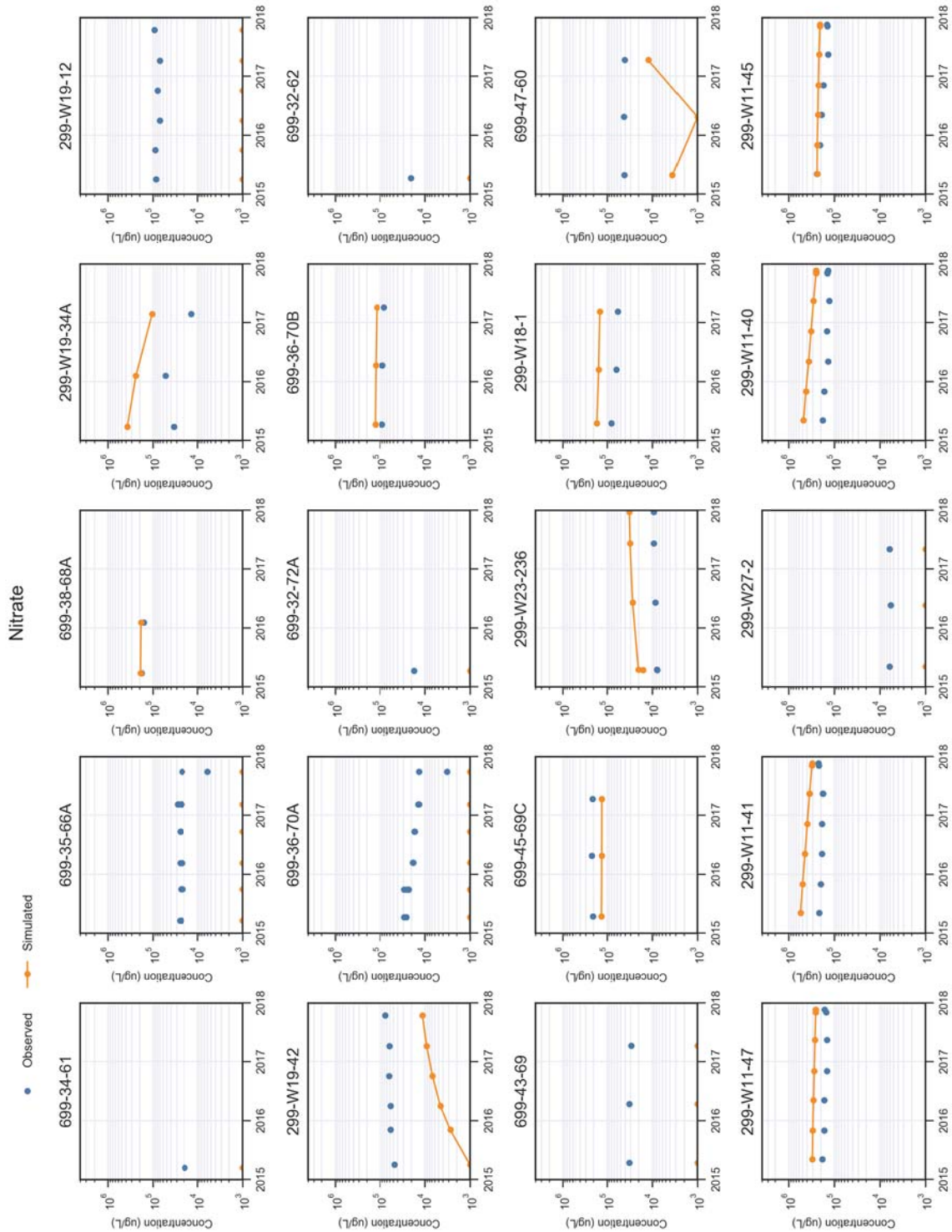

Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 4 of 10)

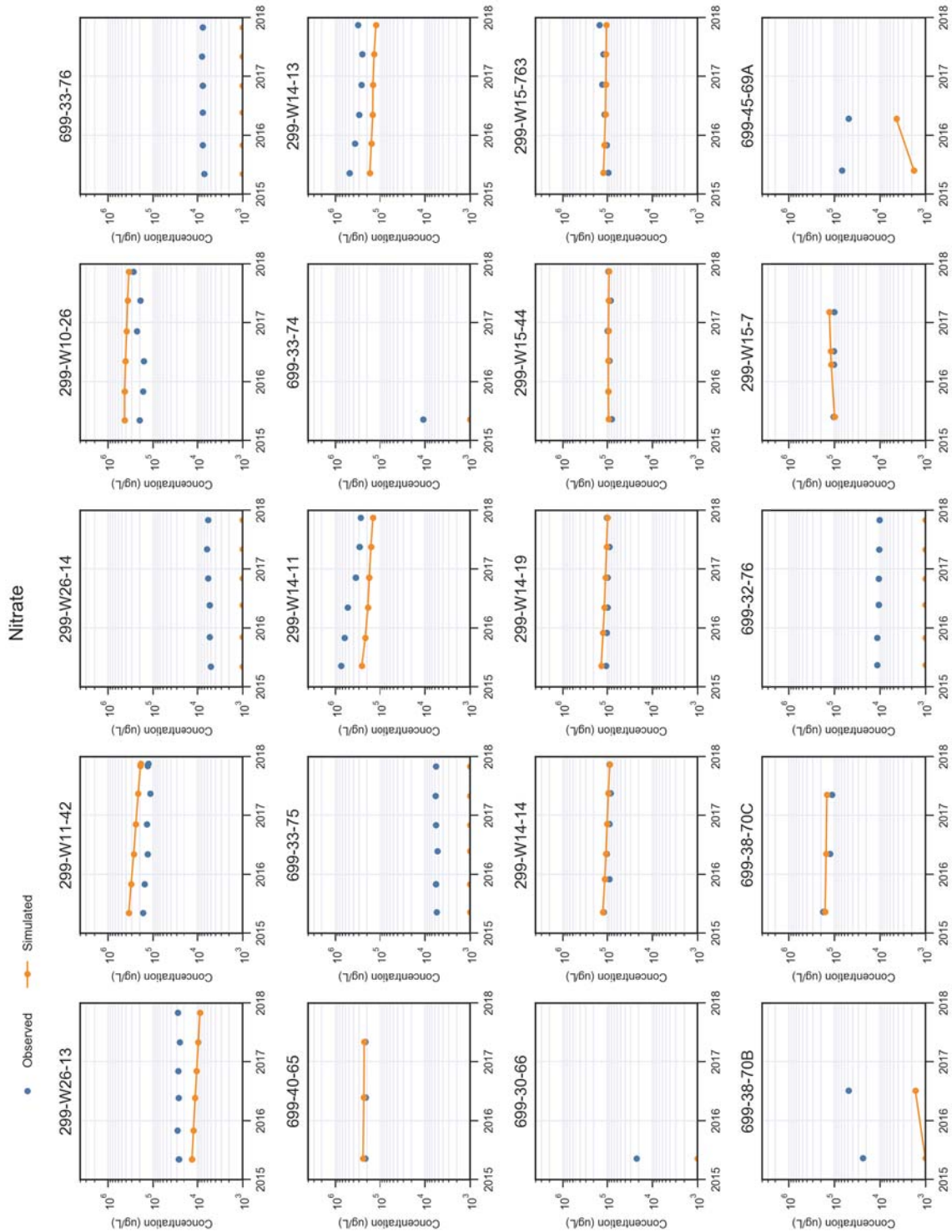

Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 5 of 10)

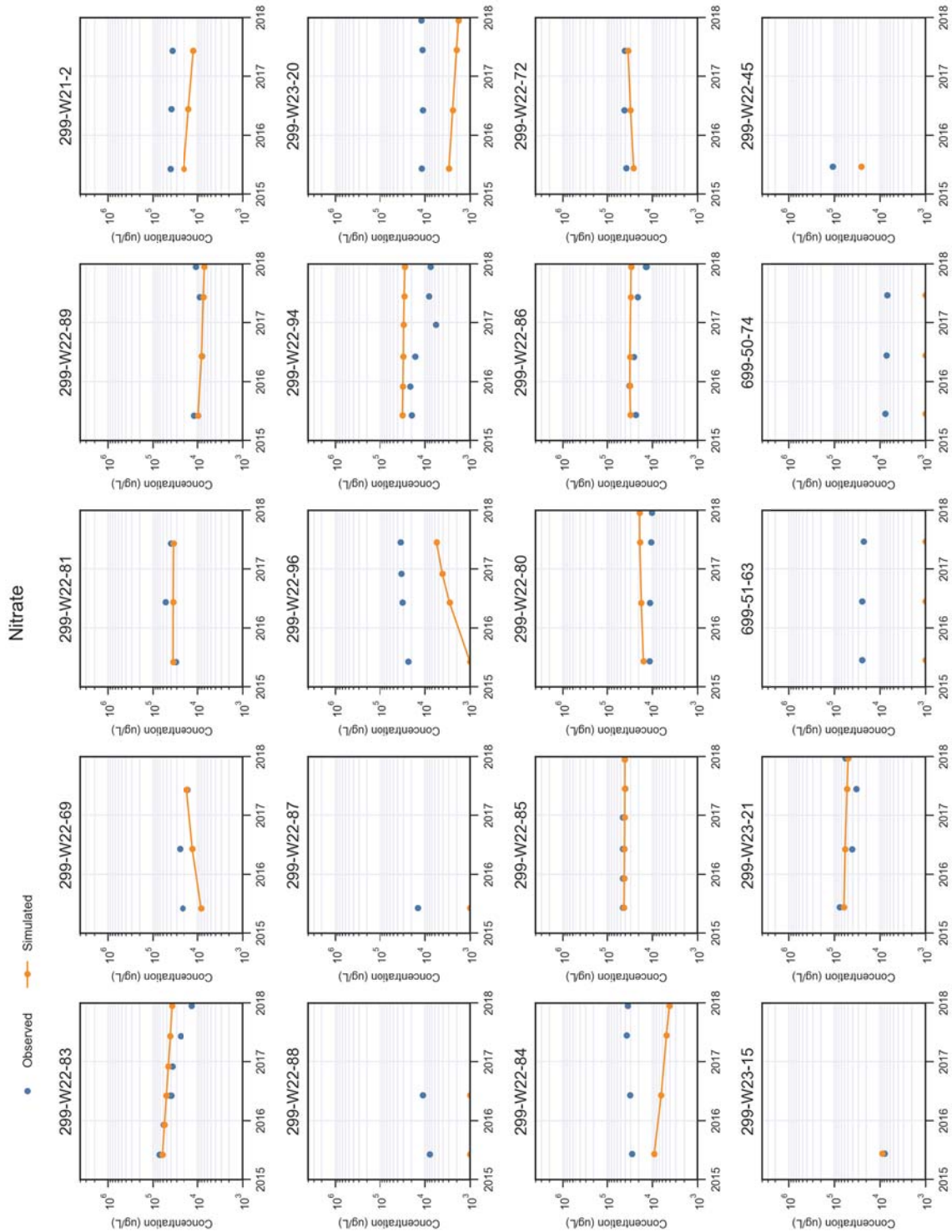

Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 6 of 10)

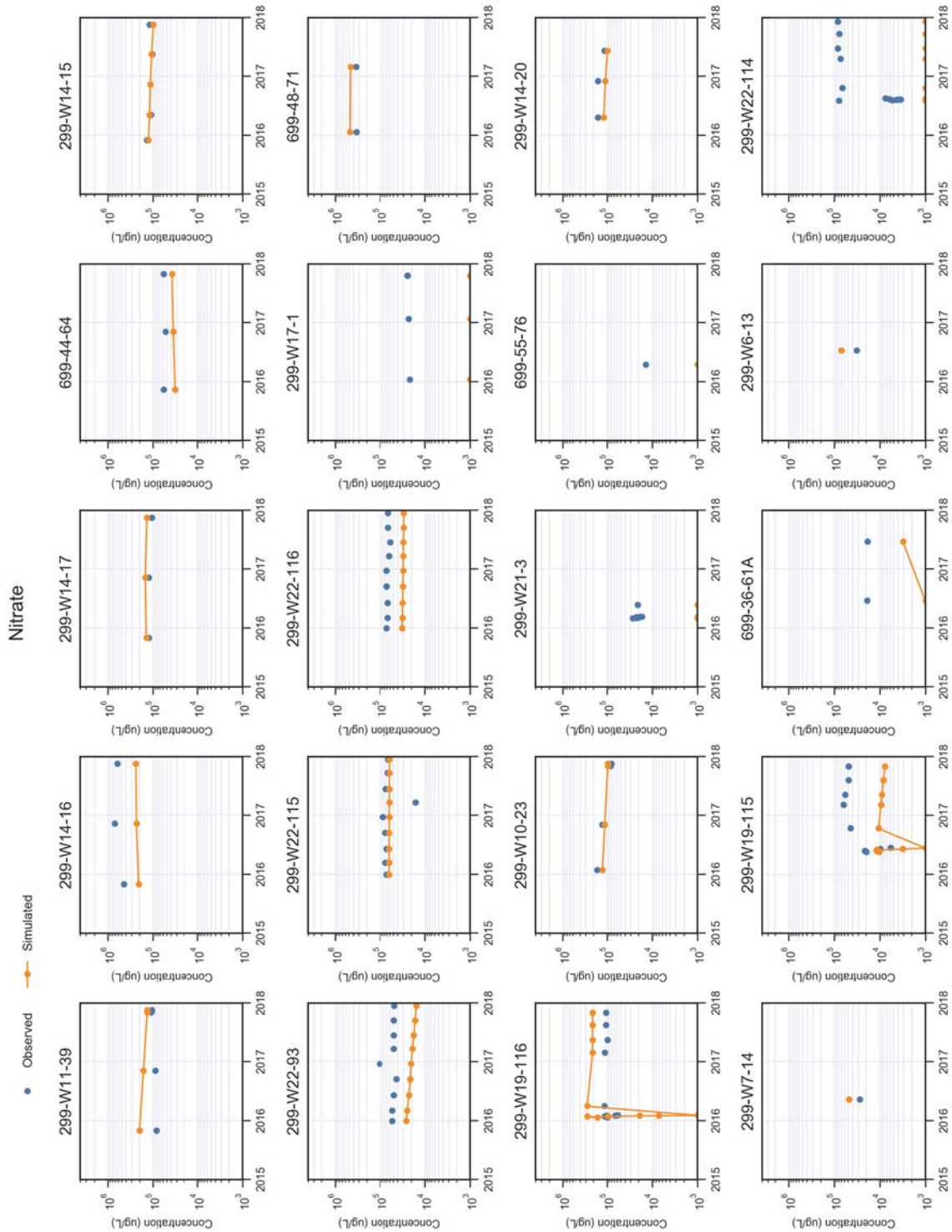

Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 7 of 10)

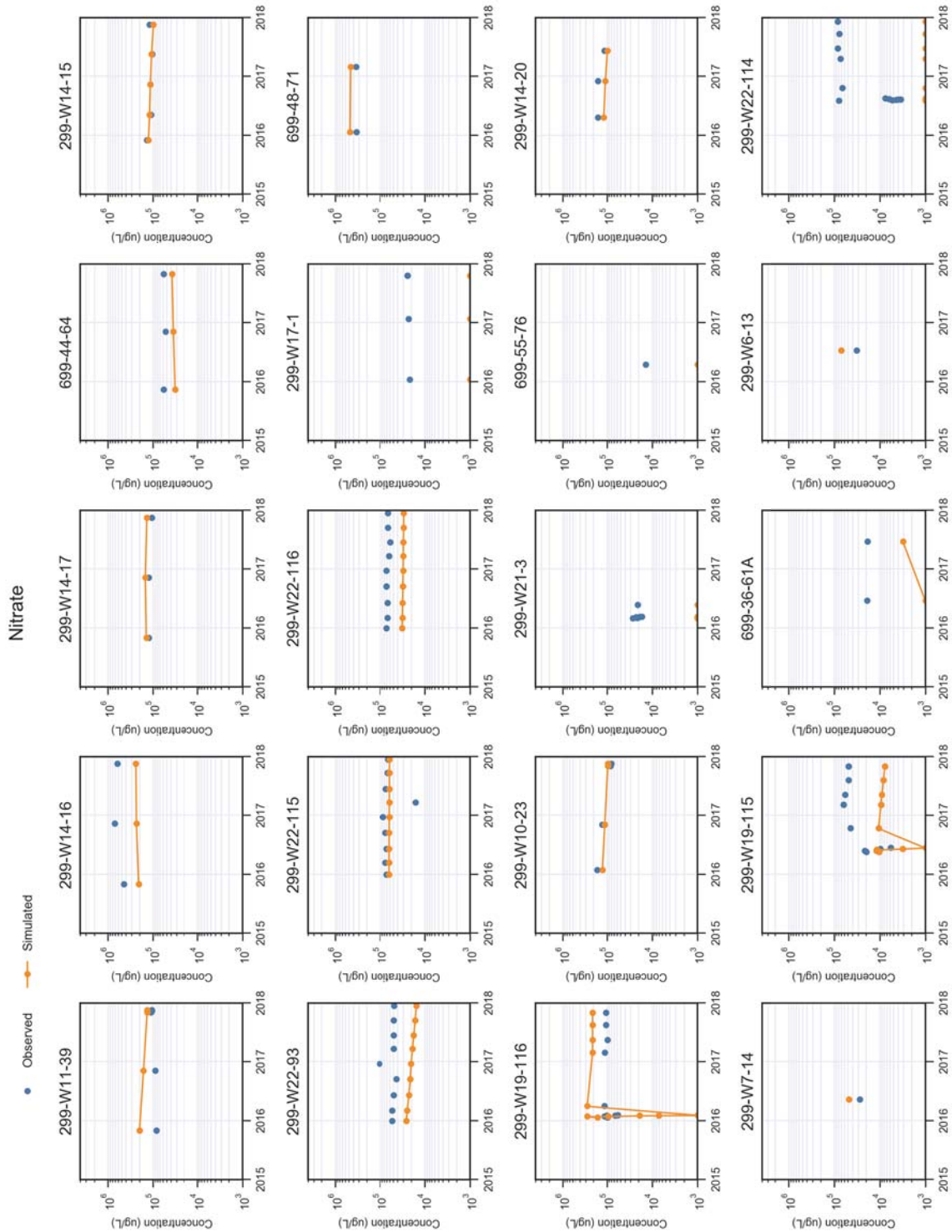

Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 8 of 10)

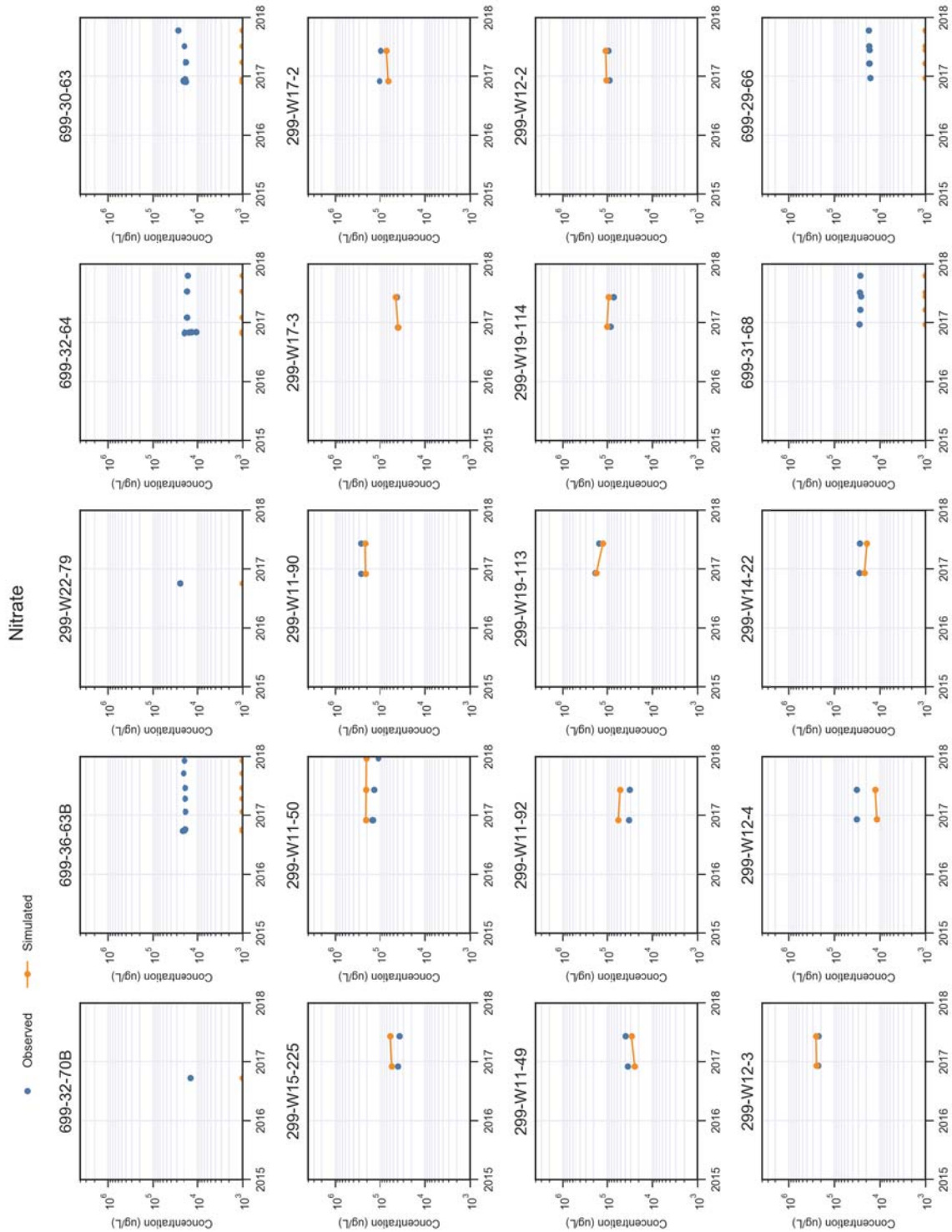

Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 9 of 10)

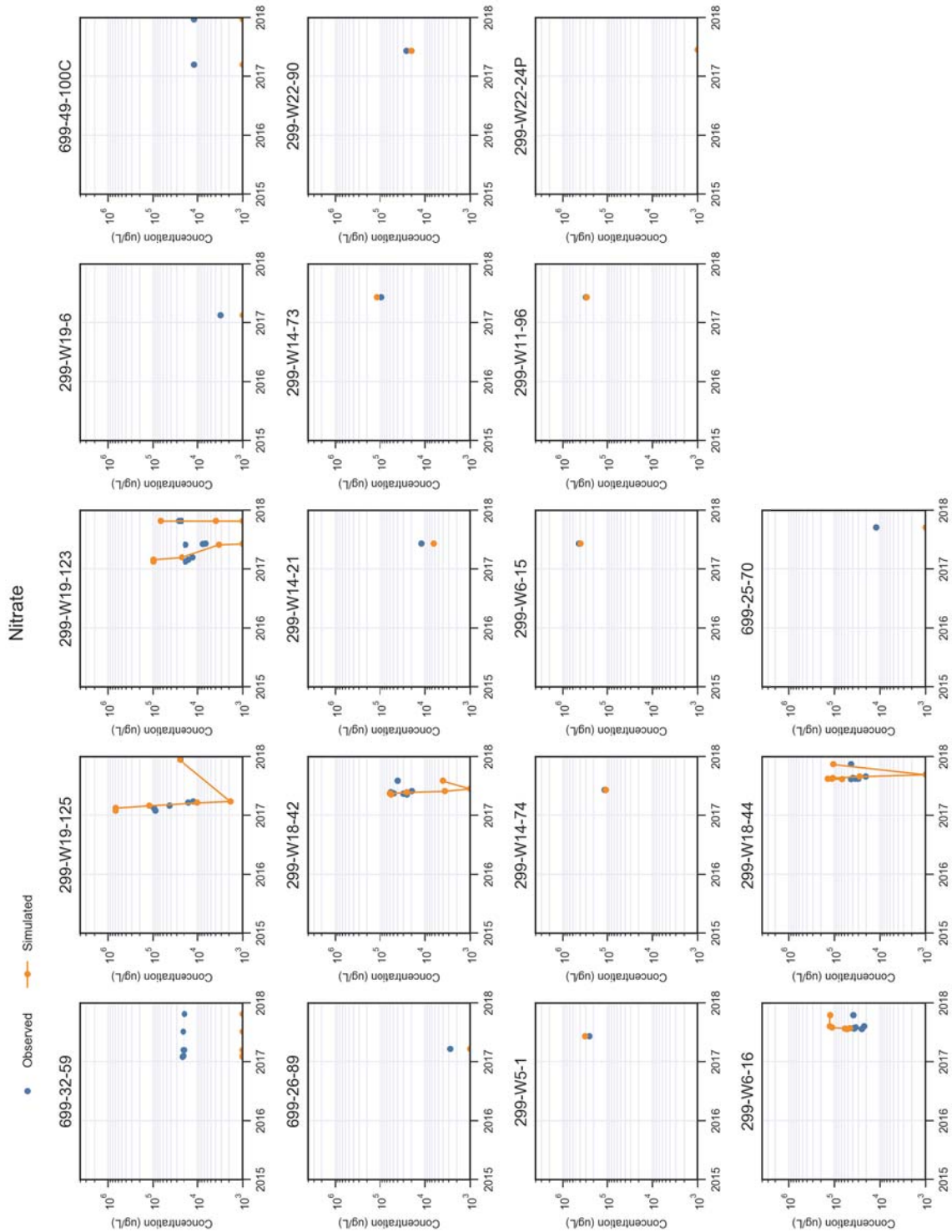

Figure C-4. Comparison of Simulated and Observed Concentrations for Nitrate (Page 10 of 10)

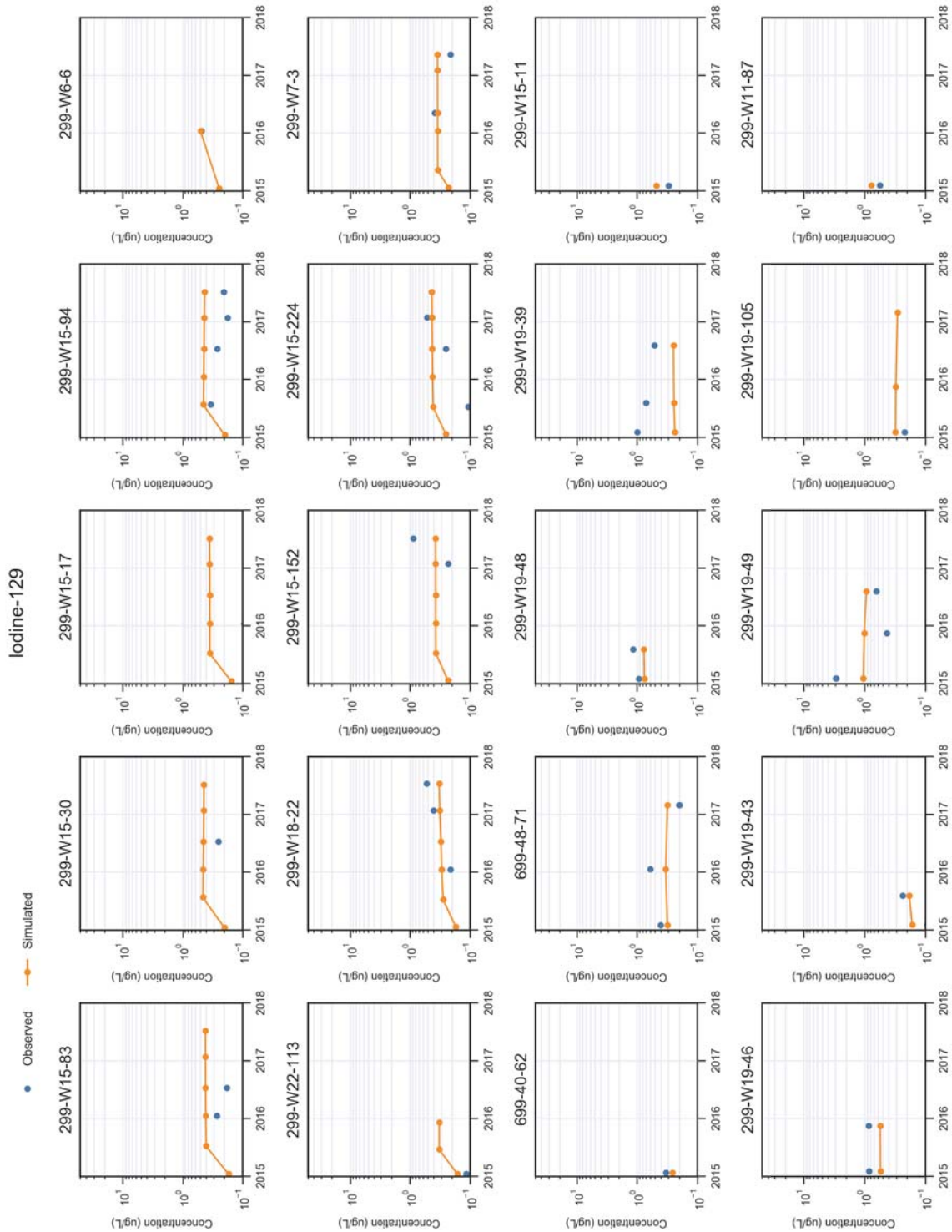

Figure C-5. Comparison of Simulated and Observed Concentrations for Iodine-129 (Page 1 of 8)

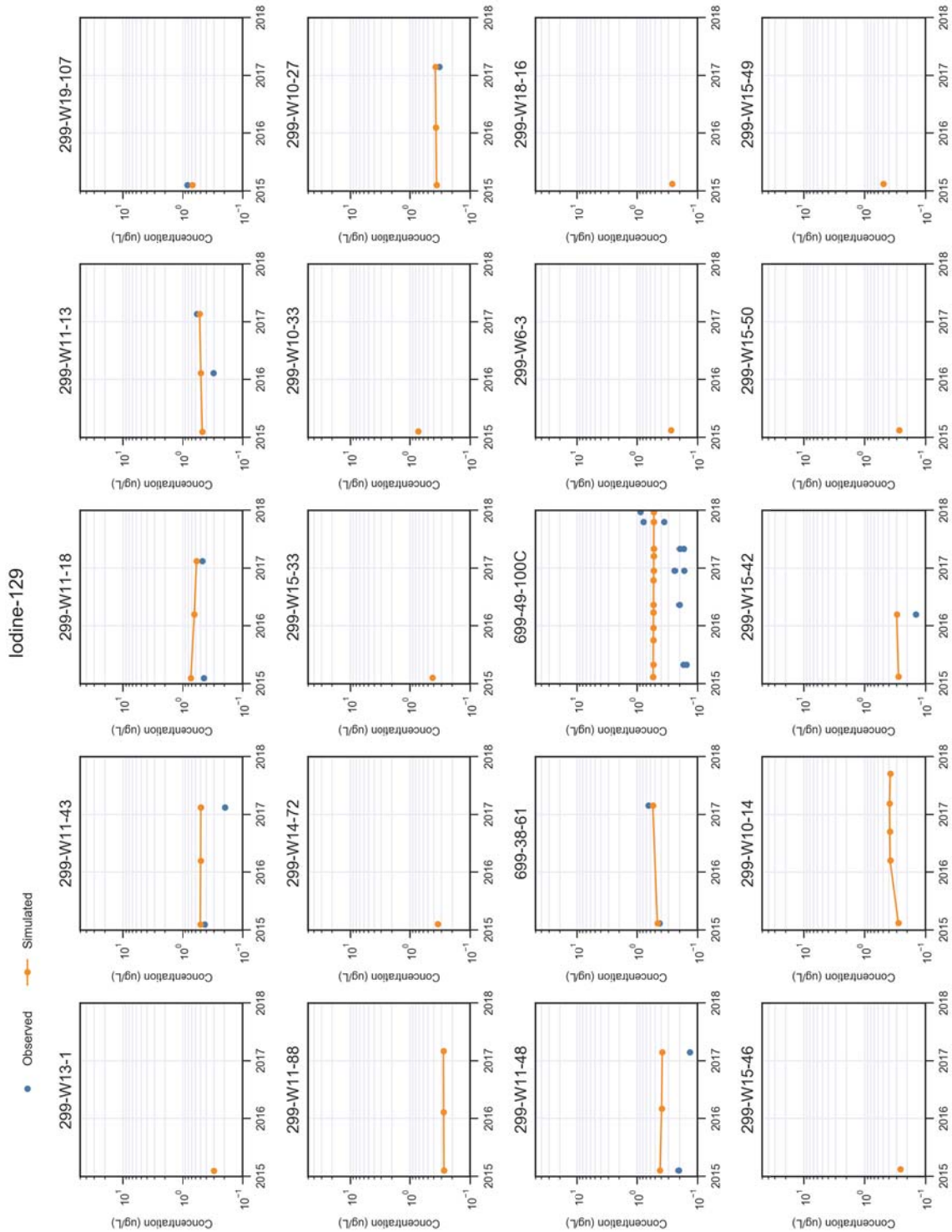

Figure C-5. Comparison of Simulated and Observed Concentrations for Iodine-129 (Page 2 of 8)

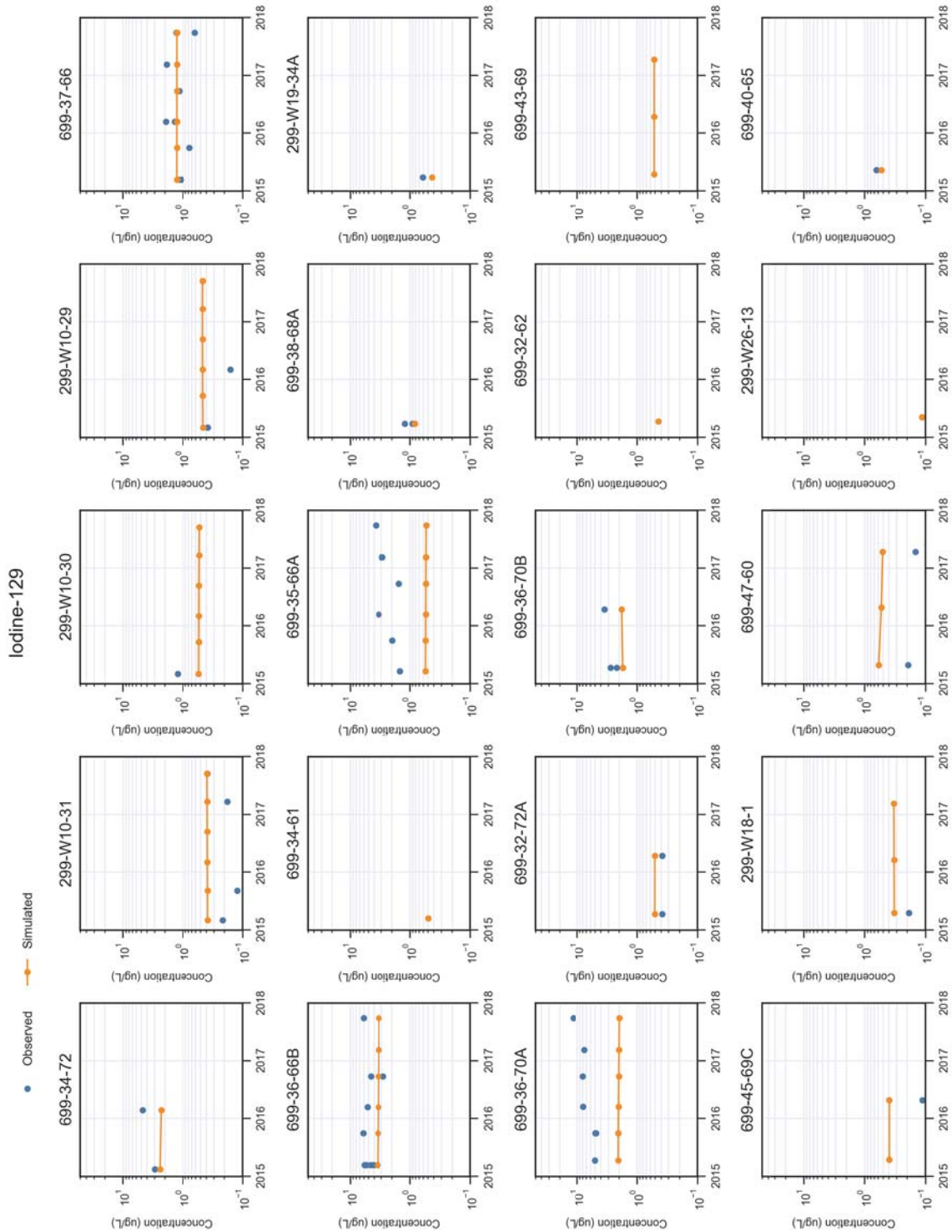

Figure C-5. Comparison of Simulated and Observed Concentrations for Iodine-129 (Page 3 of 8)

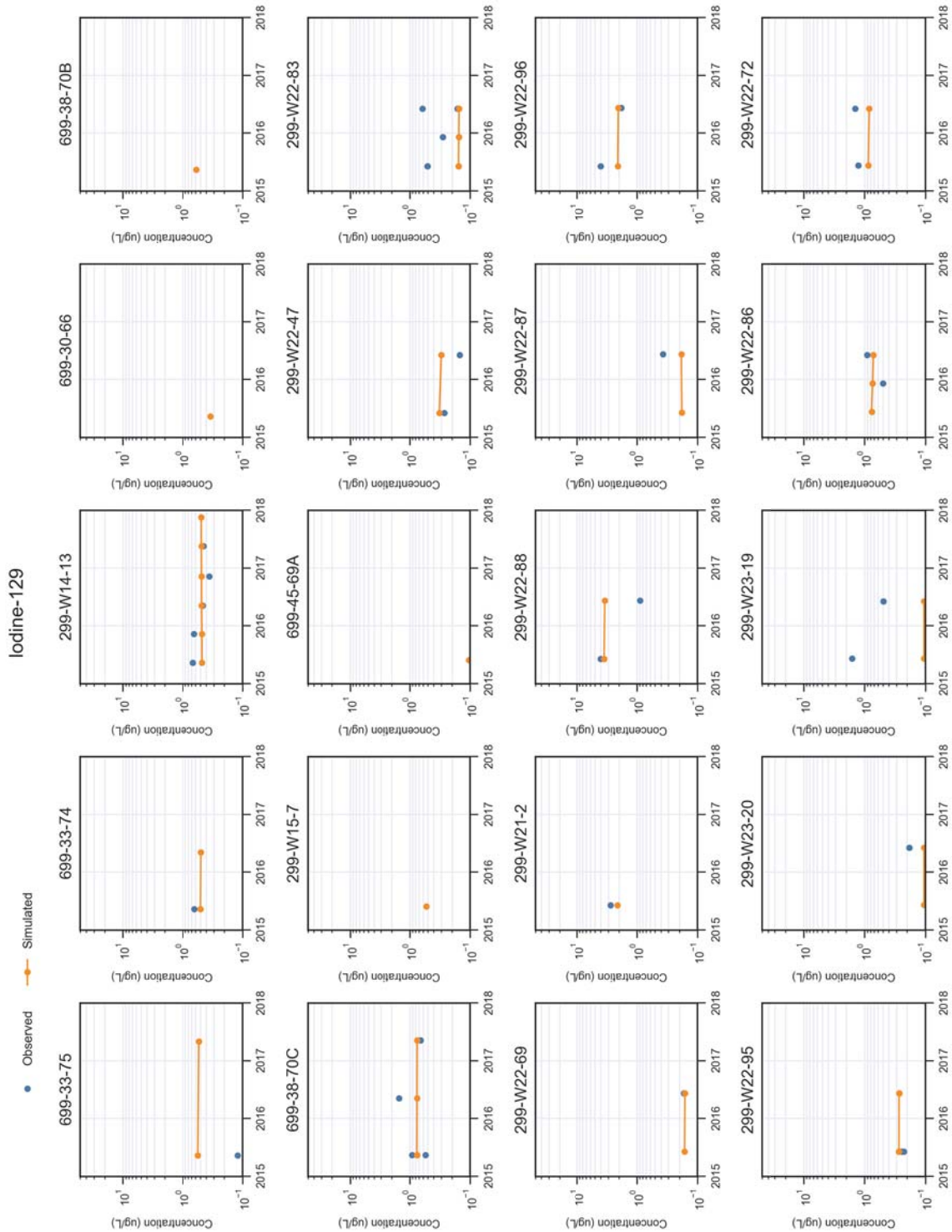

Figure C-5. Comparison of Simulated and Observed Concentrations for Iodine-129 (Page 4 of 8)

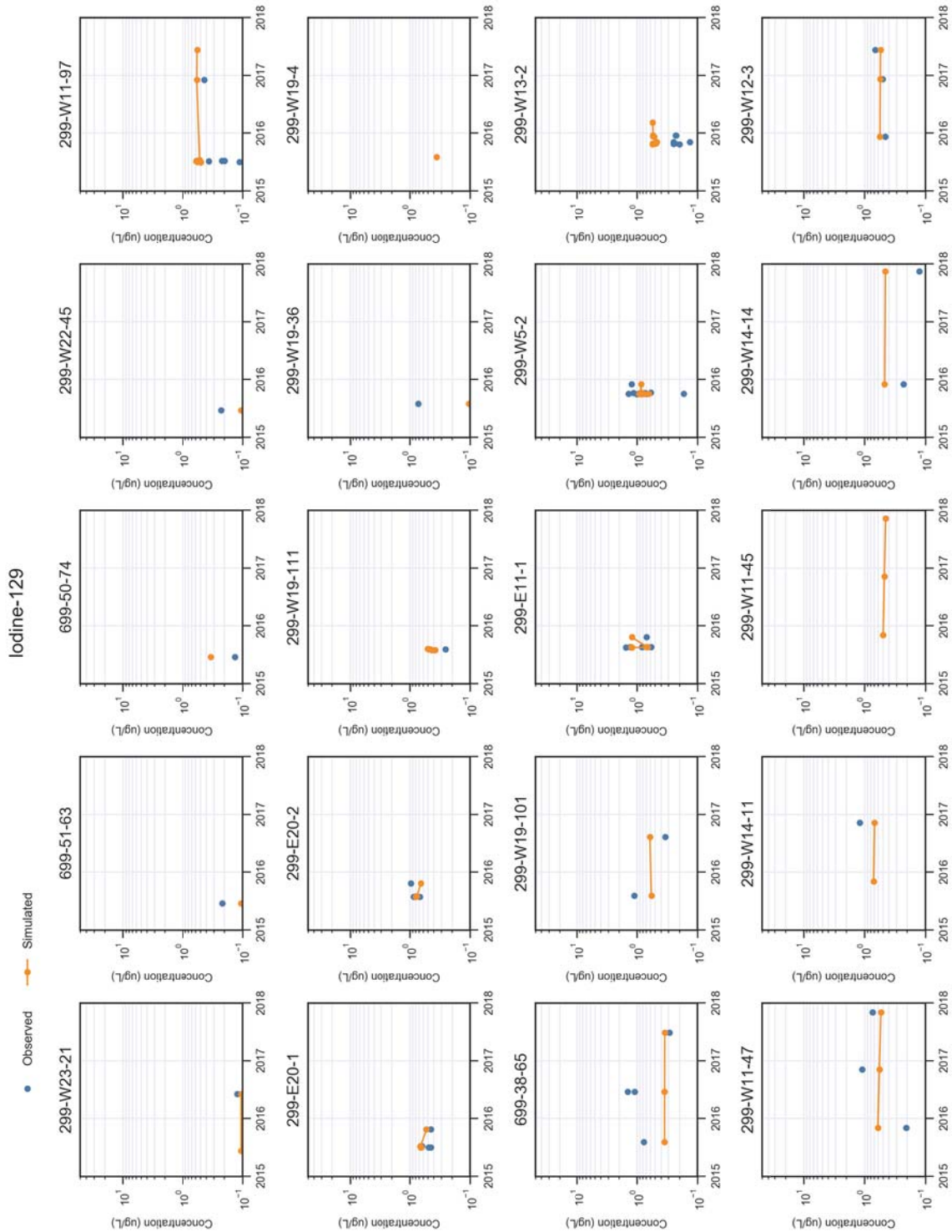

Figure C-5. Comparison of Simulated and Observed Concentrations for Iodine-129 (Page 5 of 8)

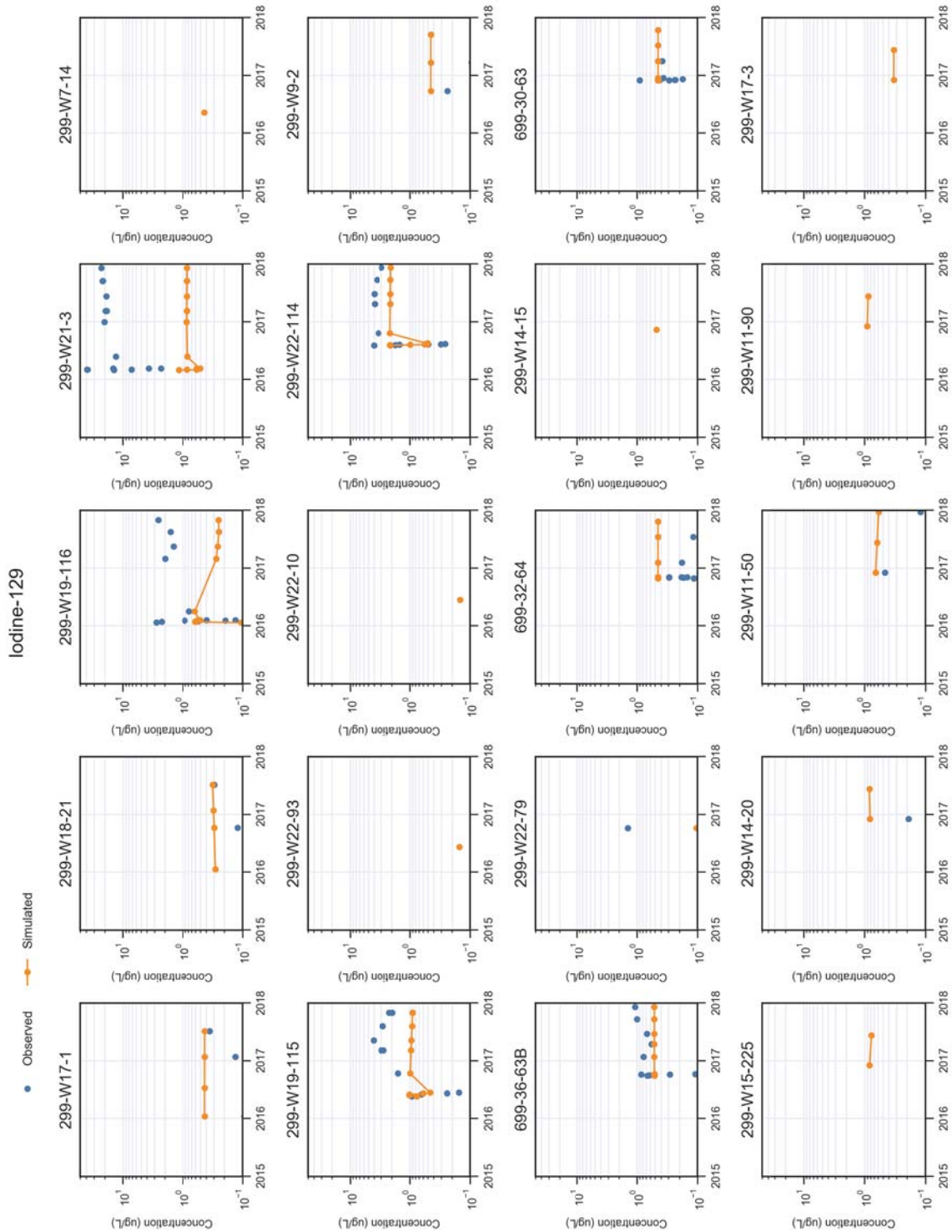

Figure C-5. Comparison of Simulated and Observed Concentrations for Iodine-129 (Page 6 of 8)

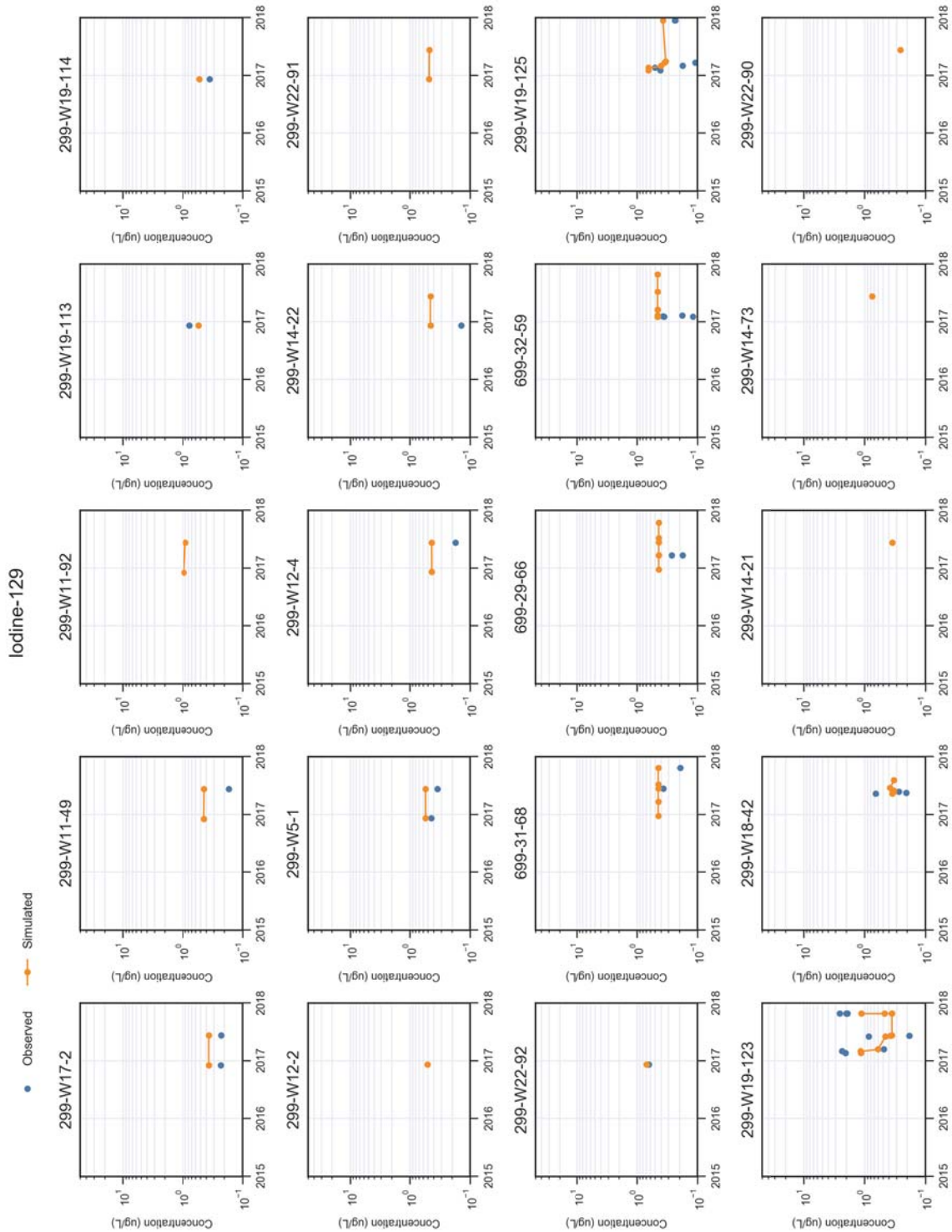

Figure C-5. Comparison of Simulated and Observed Concentrations for Iodine-129 (Page 7 of 8)

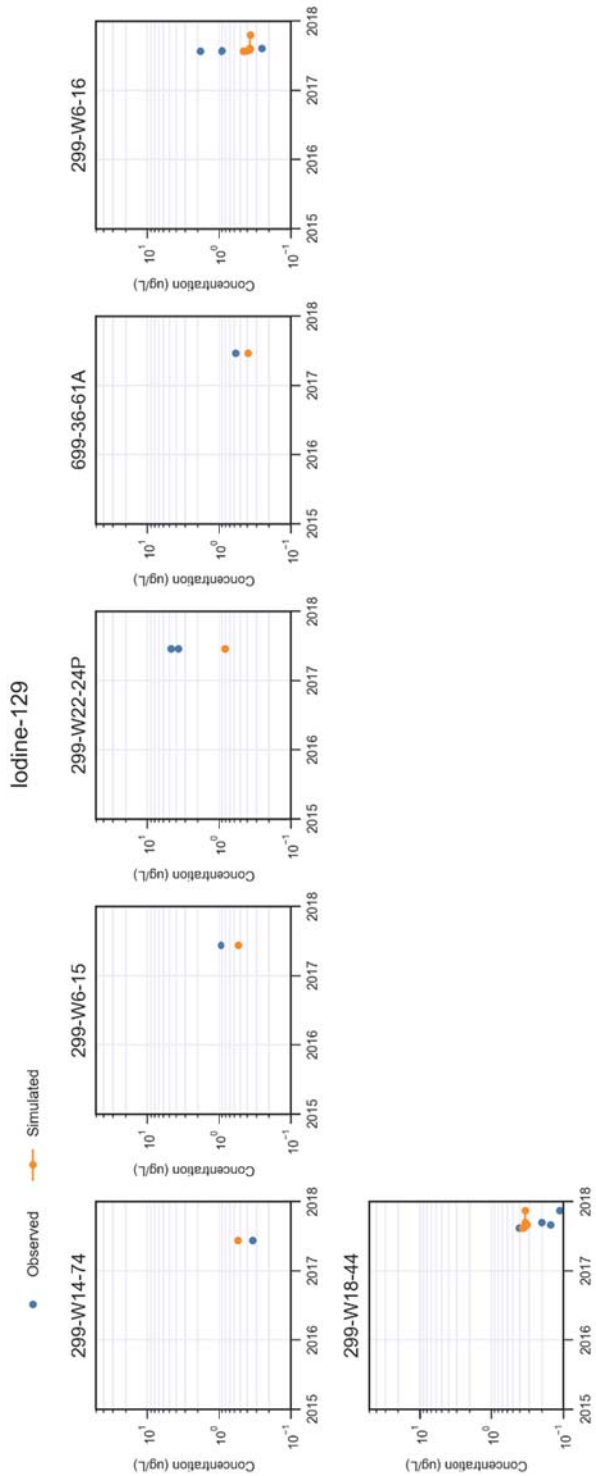

Figure C-5. Comparison of Simulated and Observed Concentrations for Iodine-129 (Page 8 of 8)

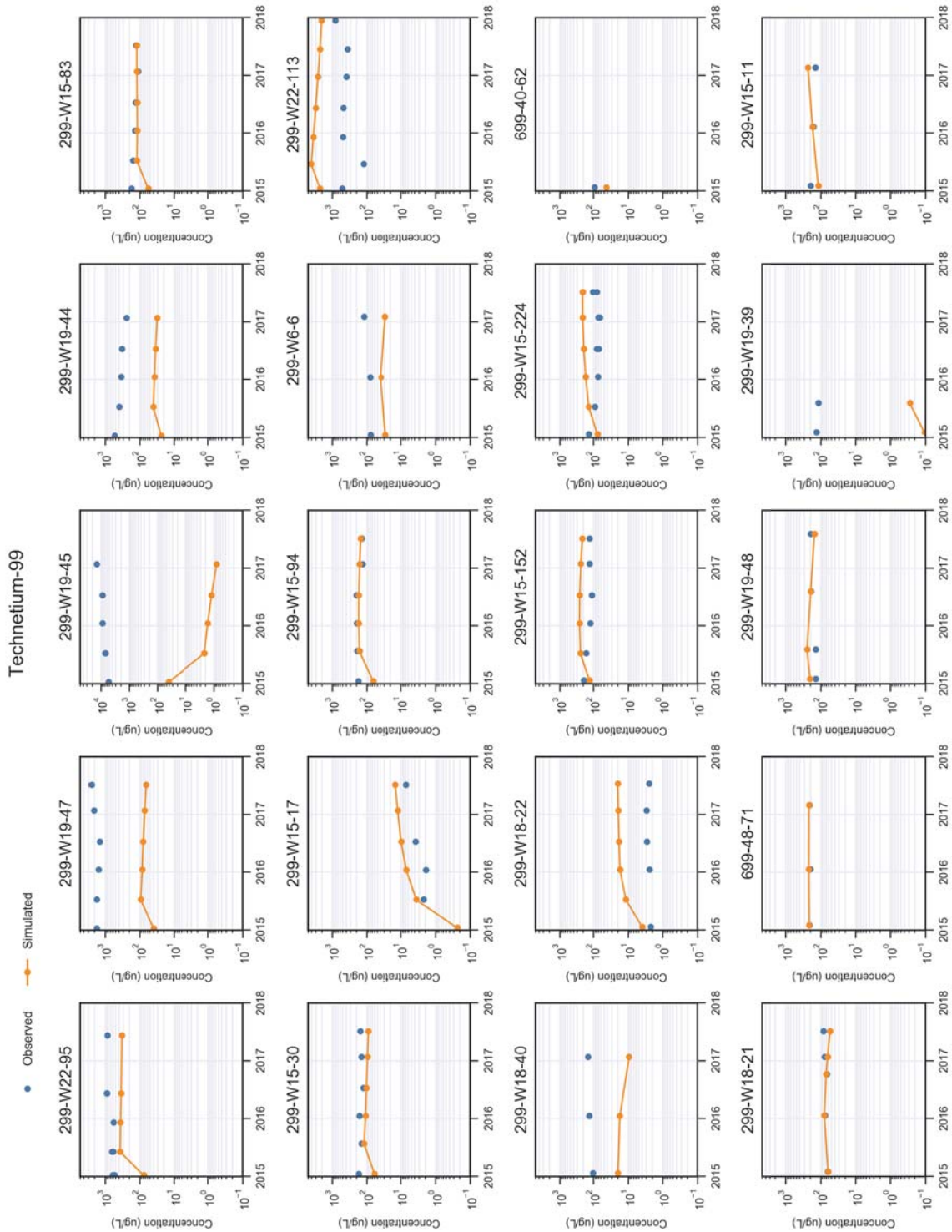

Figure C-6. Comparison of Simulated and Observed Concentrations for Technetium-99 (Page 1 of 9)

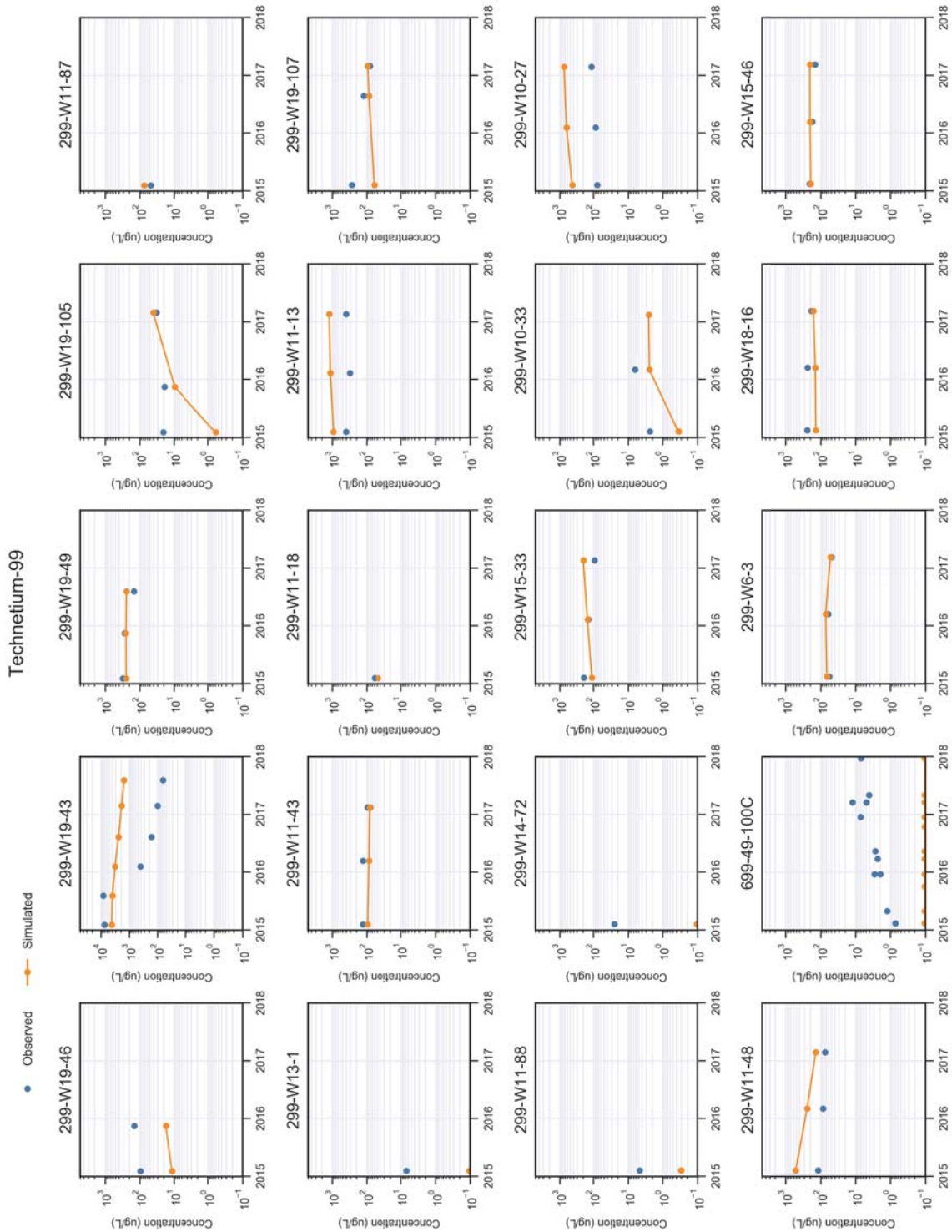

Figure C-6. Comparison of Simulated and Observed Concentrations for Technetium-99 (Page 2 of 9)

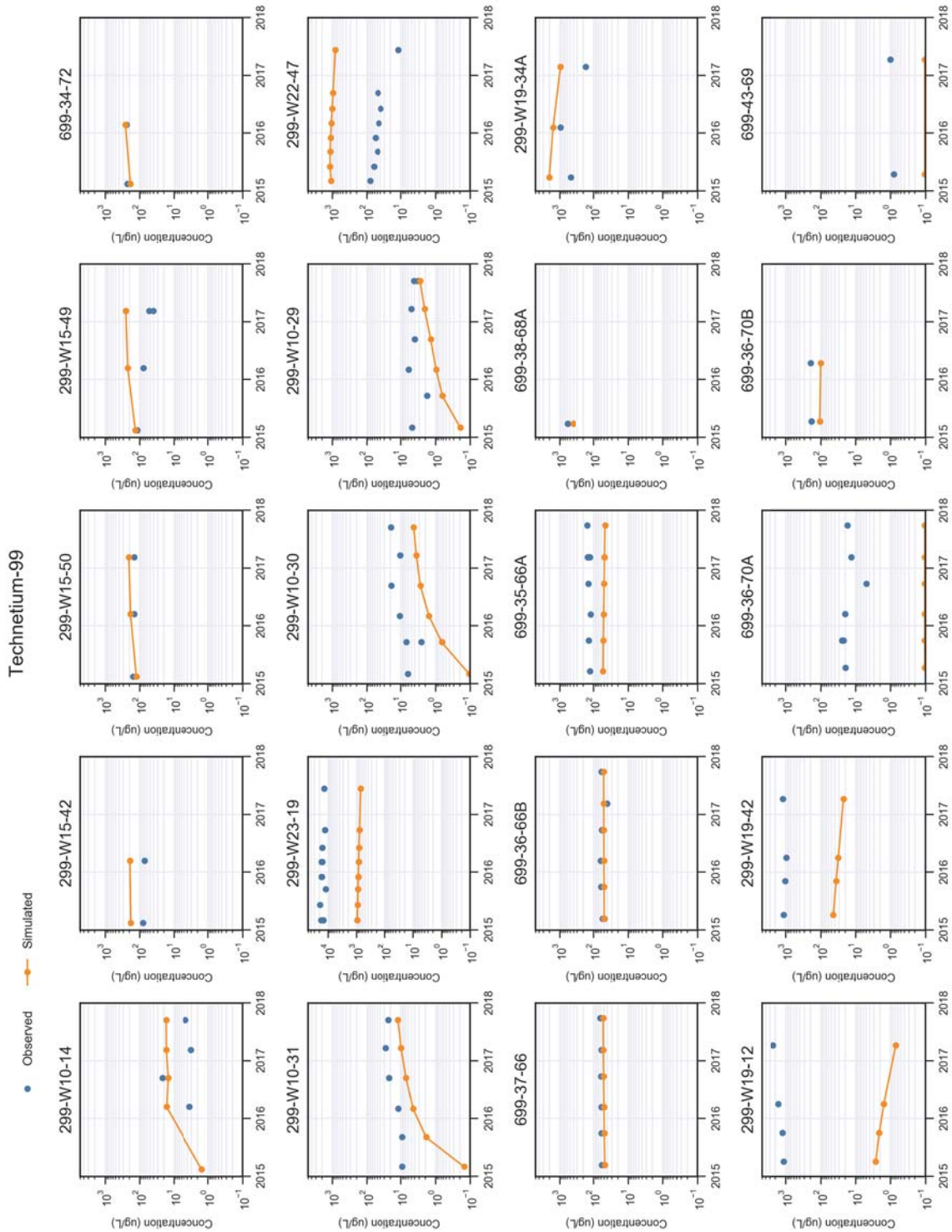

Figure C-6. Comparison of Simulated and Observed Concentrations for Technetium-99 (Page 3 of 9)

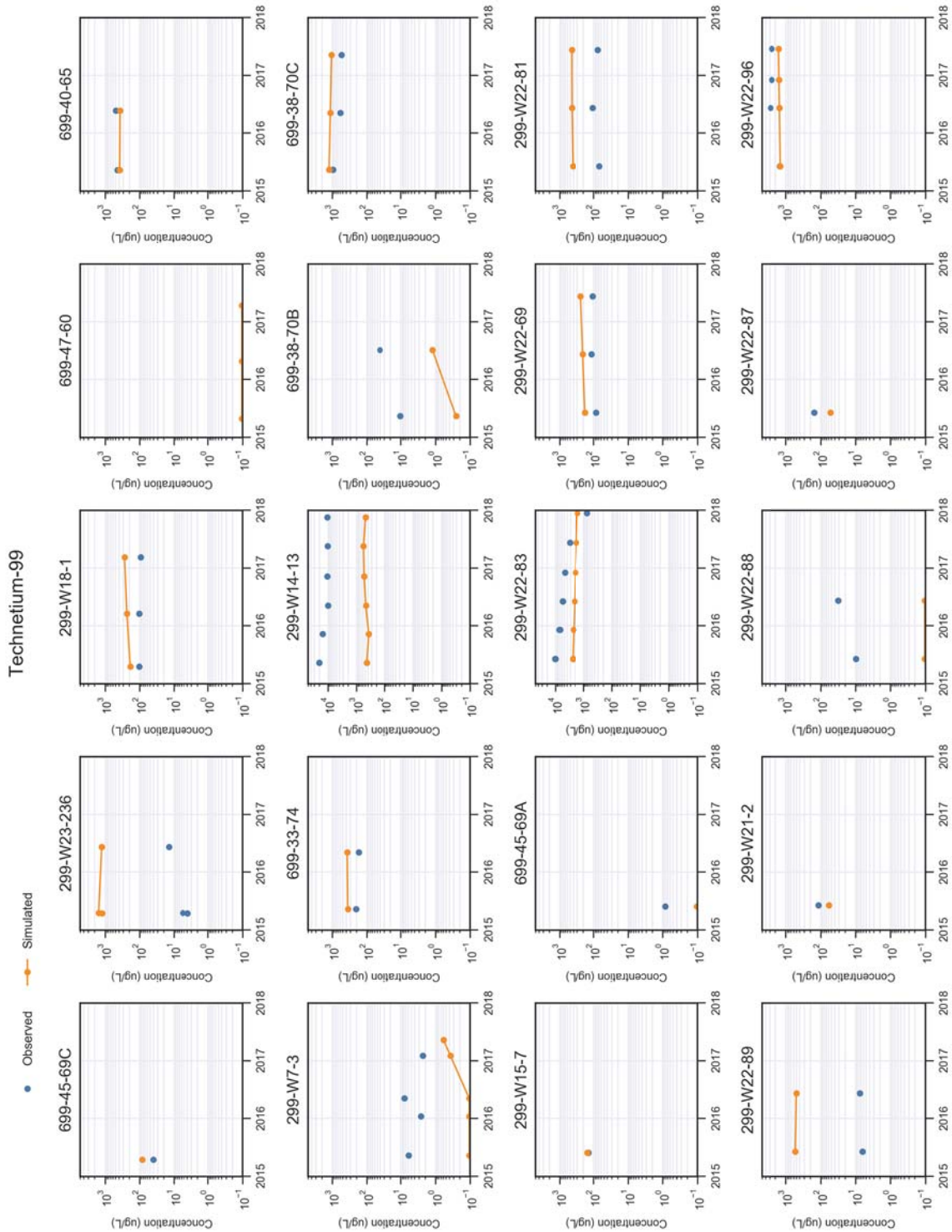

Figure C-6. Comparison of Simulated and Observed Concentrations for Technetium-99 (Page 4 of 9)

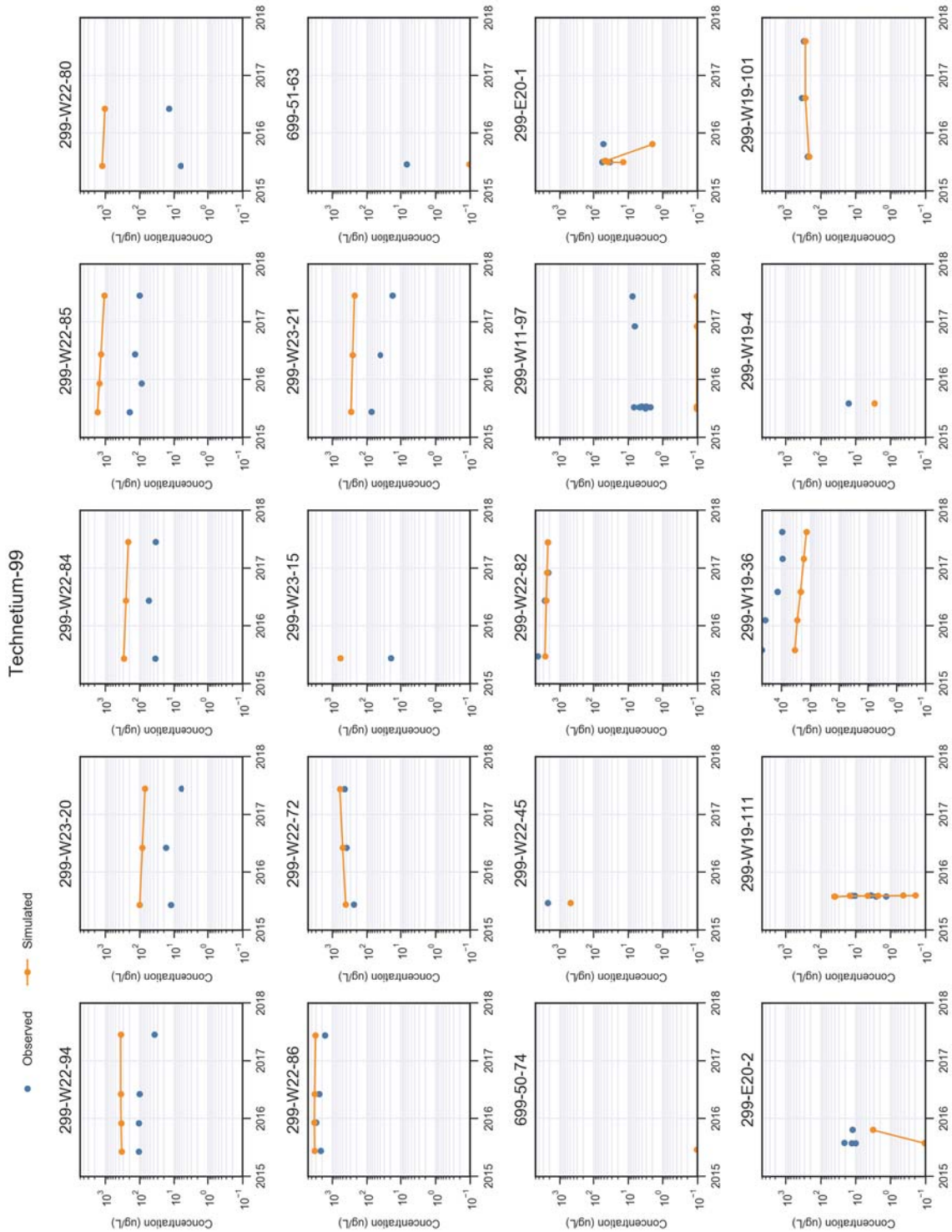

Figure C-6. Comparison of Simulated and Observed Concentrations for Technetium-99 (Page 5 of 9)

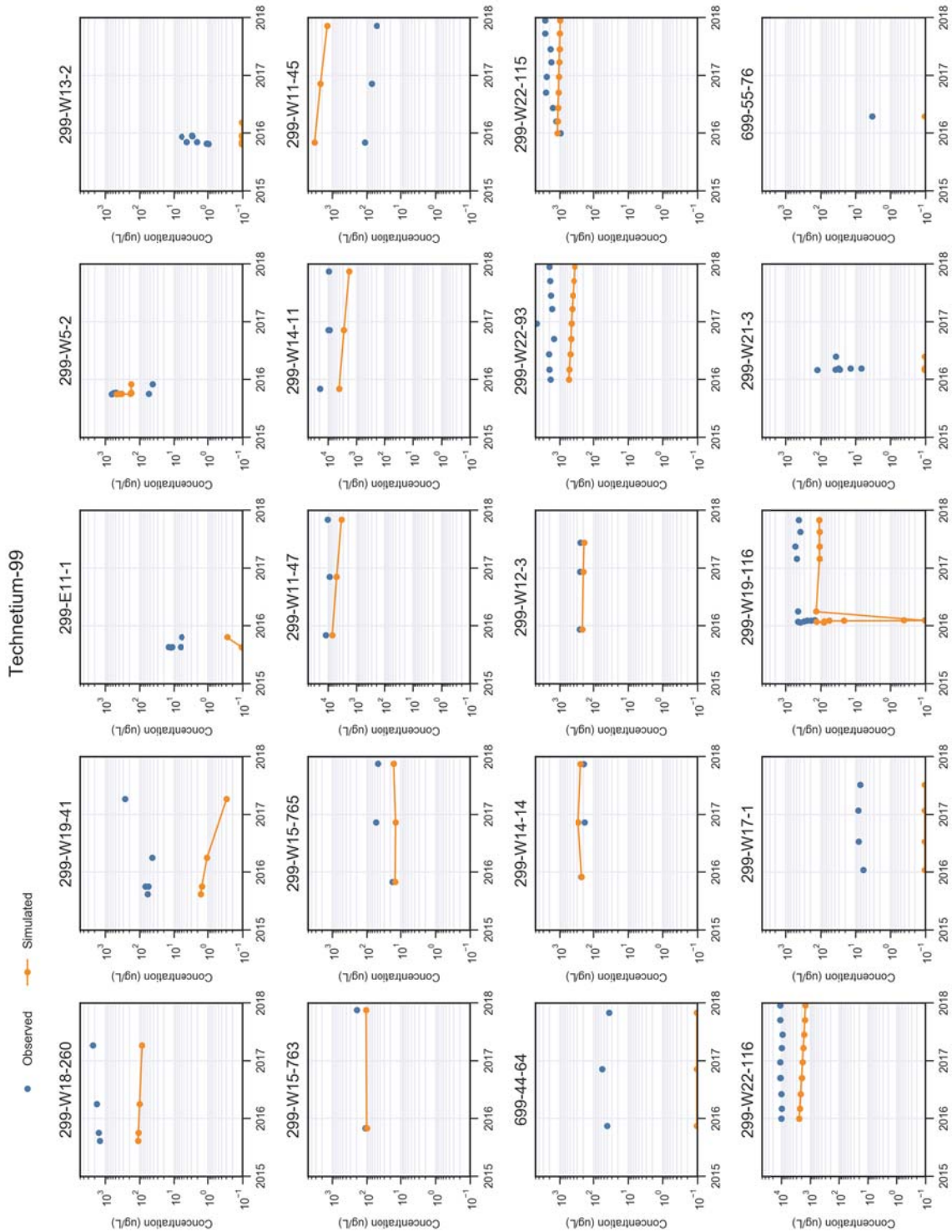

Figure C-6. Comparison of Simulated and Observed Concentrations for Technetium-99 (Page 6 of 9)

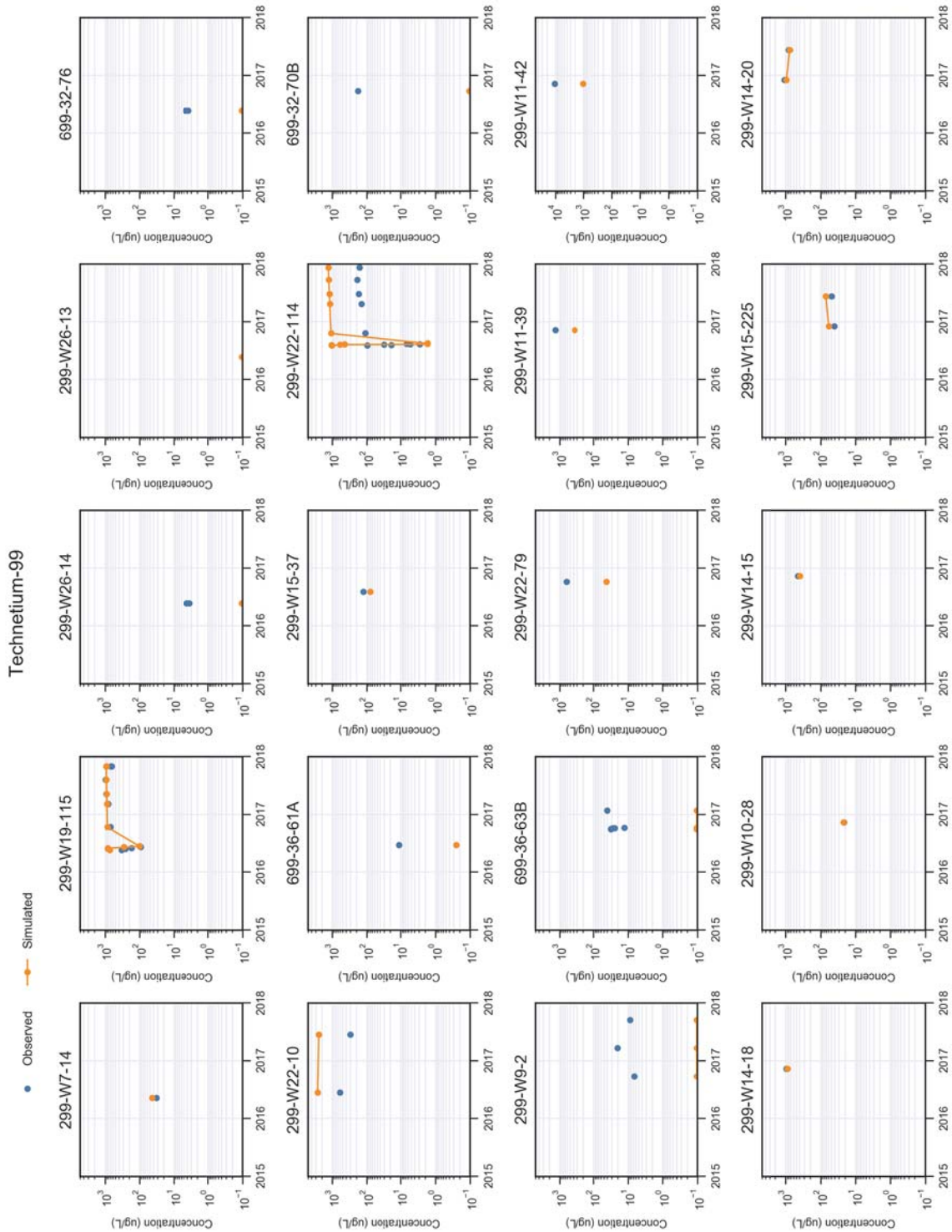

Figure C-6. Comparison of Simulated and Observed Concentrations for Technetium-99 (Page 7 of 9)

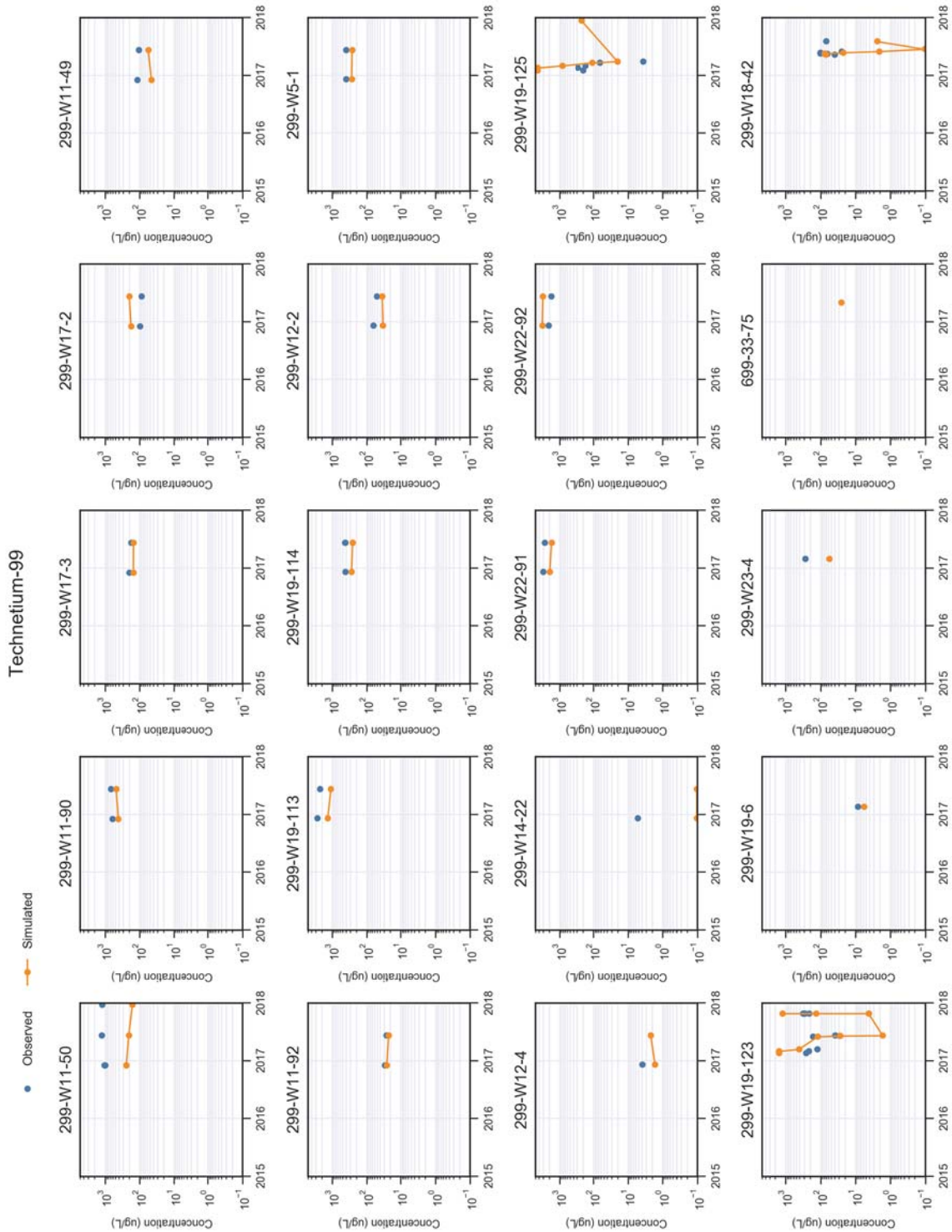

Figure C-6. Comparison of Simulated and Observed Concentrations for Technetium-99 (Page 8 of 9)

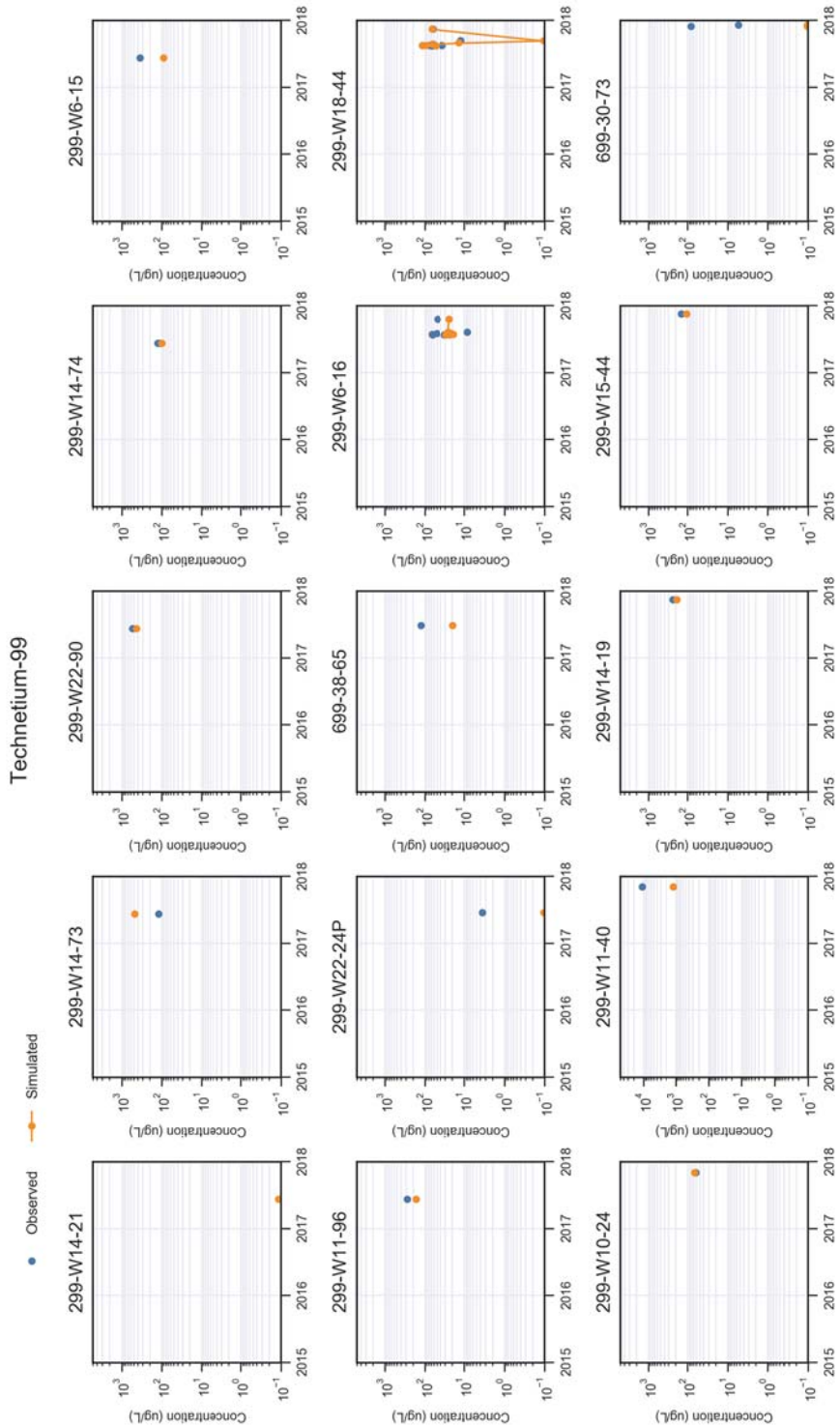

Figure C-6. Comparison of Simulated and Observed Concentrations for Technetium-99 (Page 9 of 9)

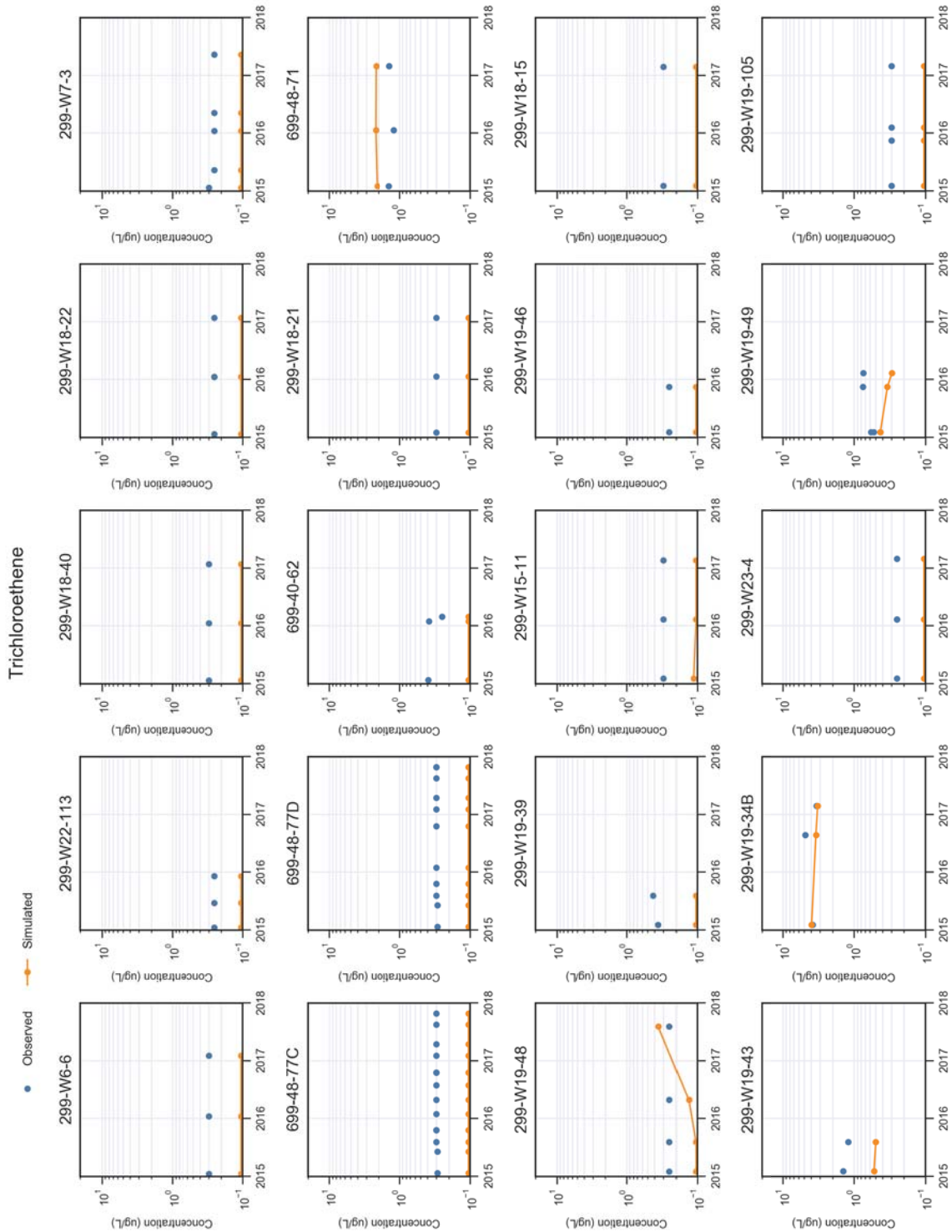

Figure C-7. Comparison of Simulated and Observed Concentrations for Trichloroethene (Page 1 of 8)

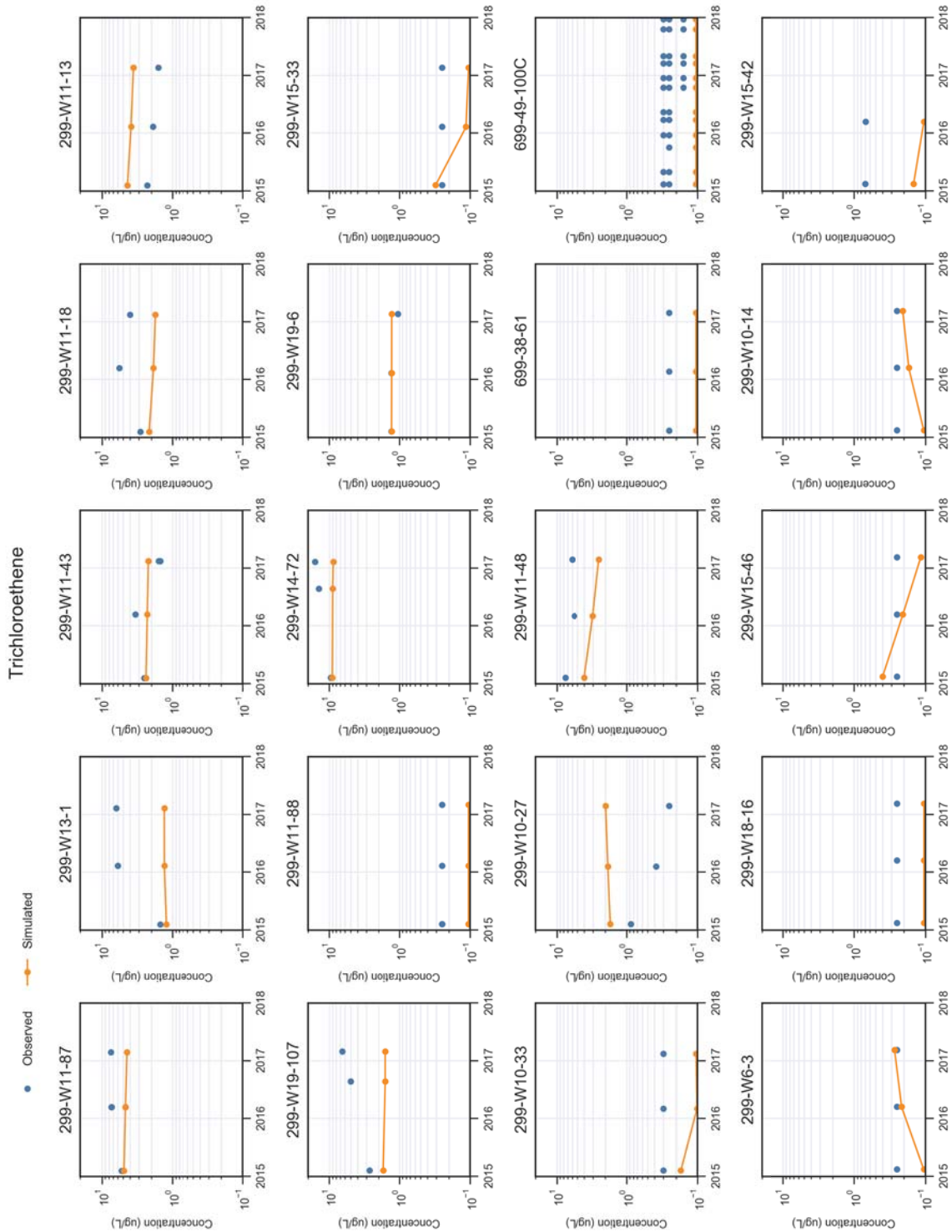

Figure C-7. Comparison of Simulated and Observed Concentrations for Trichloroethene (Page 2 of 8)

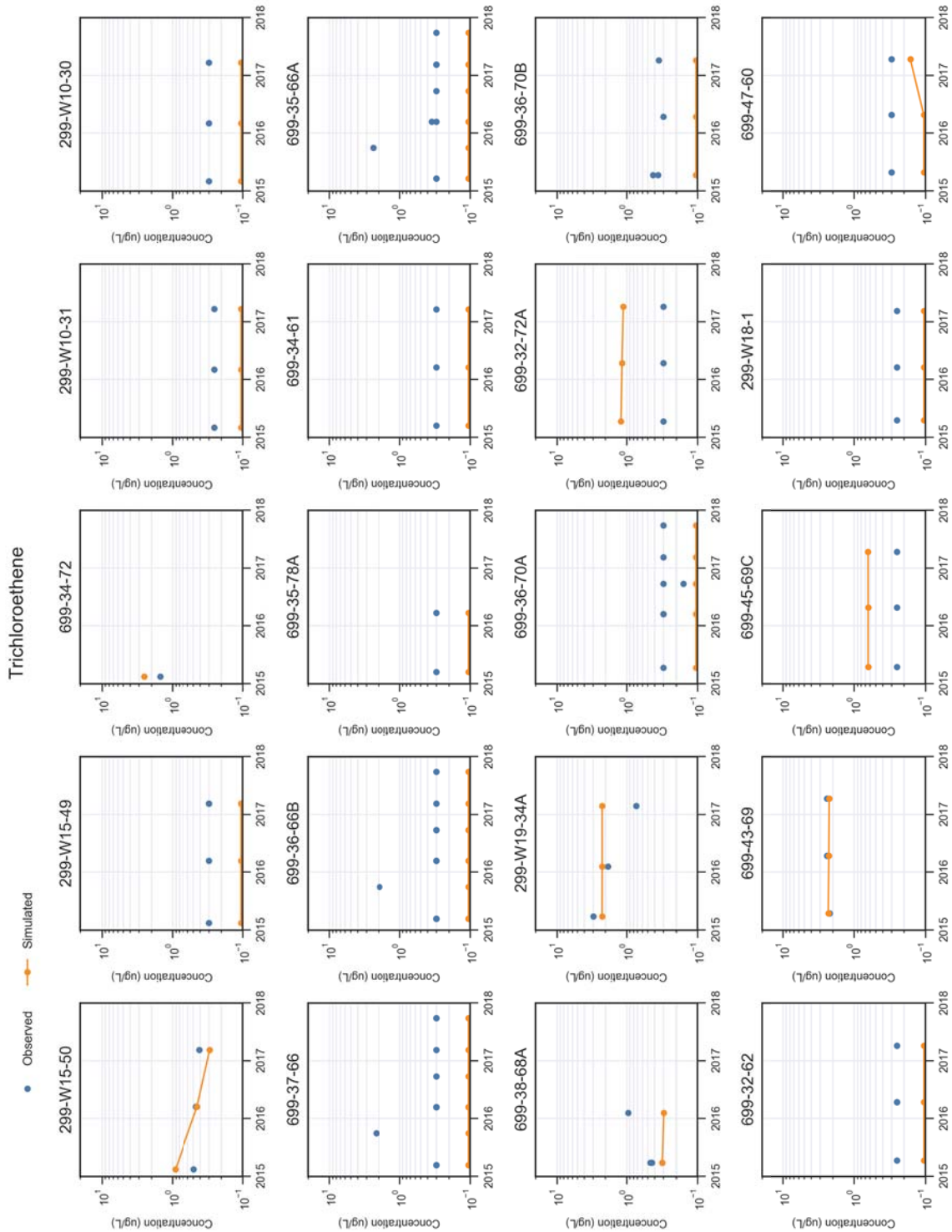

Figure C-7. Comparison of Simulated and Observed Concentrations for Trichloroethene (Page 3 of 8)

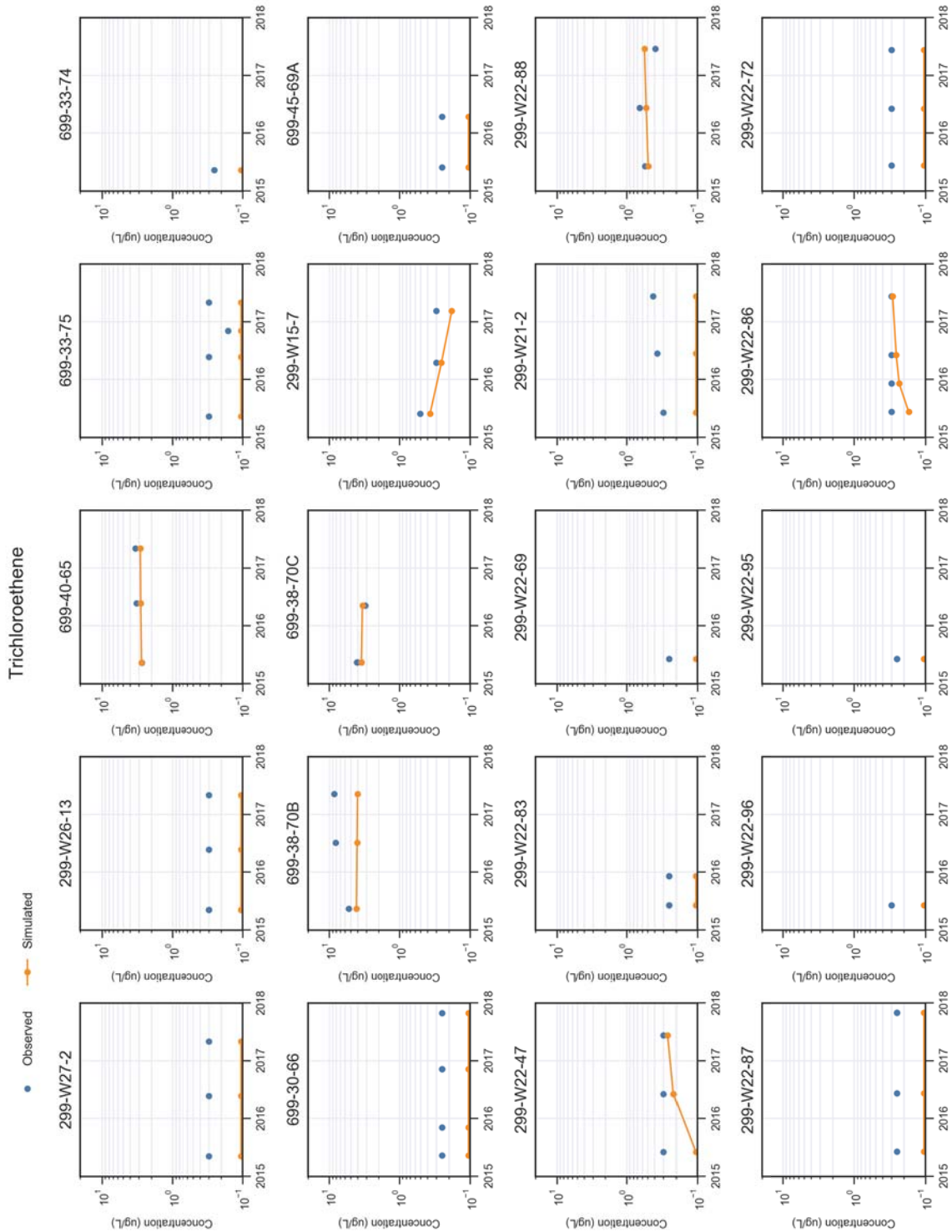

Figure C-7. Comparison of Simulated and Observed Concentrations for Trichloroethene (Page 4 of 8)

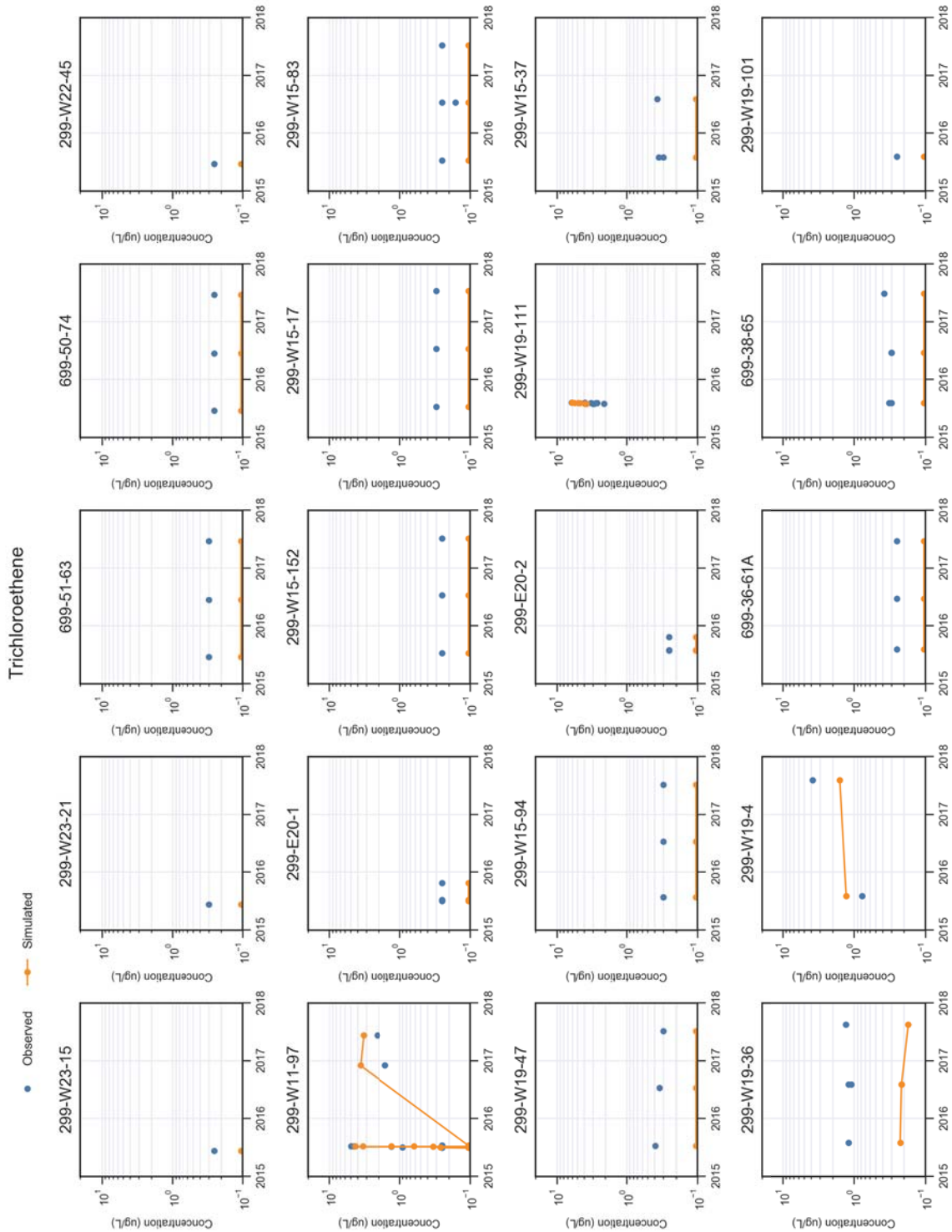

Figure C-7. Comparison of Simulated and Observed Concentrations for Trichloroethene (Page 5 of 8)

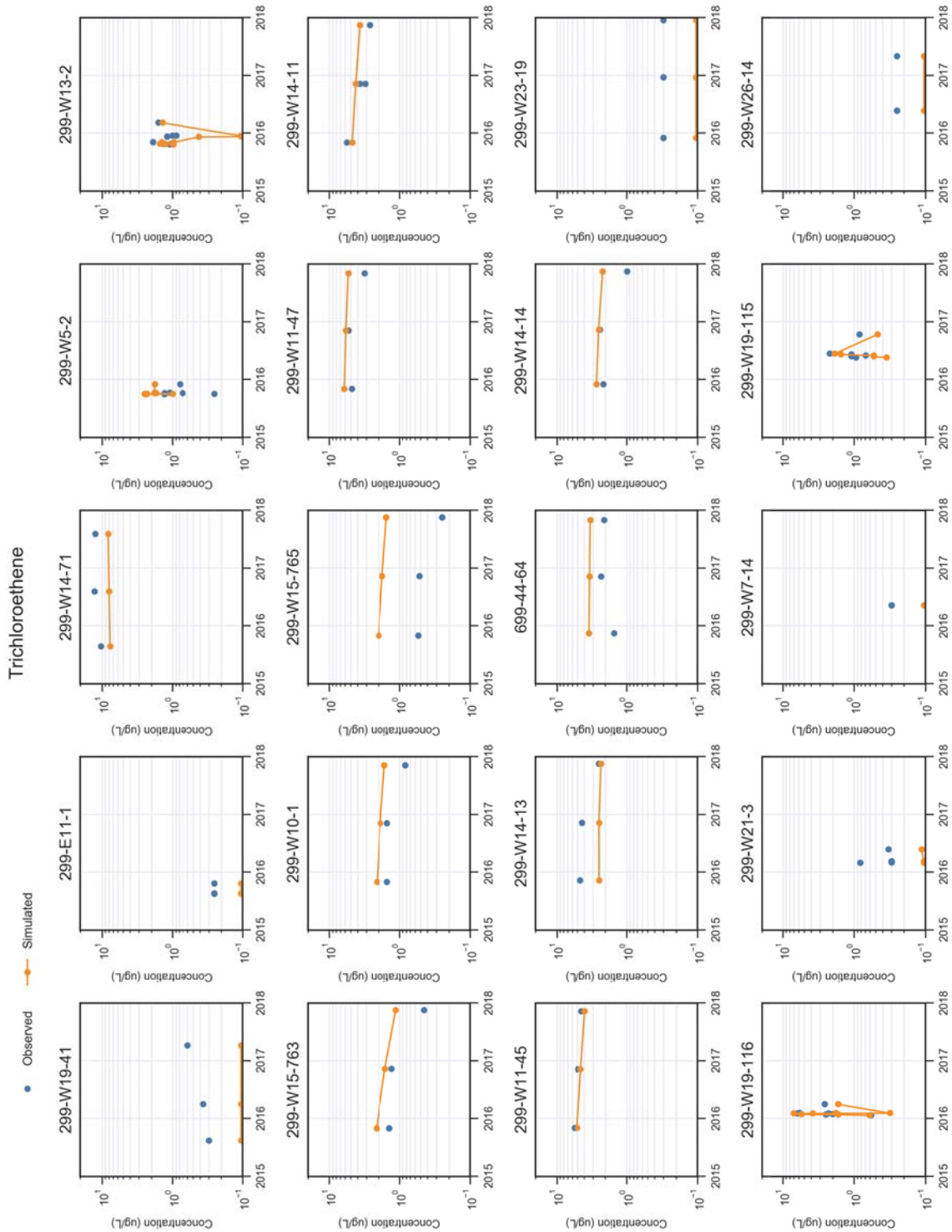

Figure C-7. Comparison of Simulated and Observed Concentrations for Trichloroethene (Page 6 of 8)

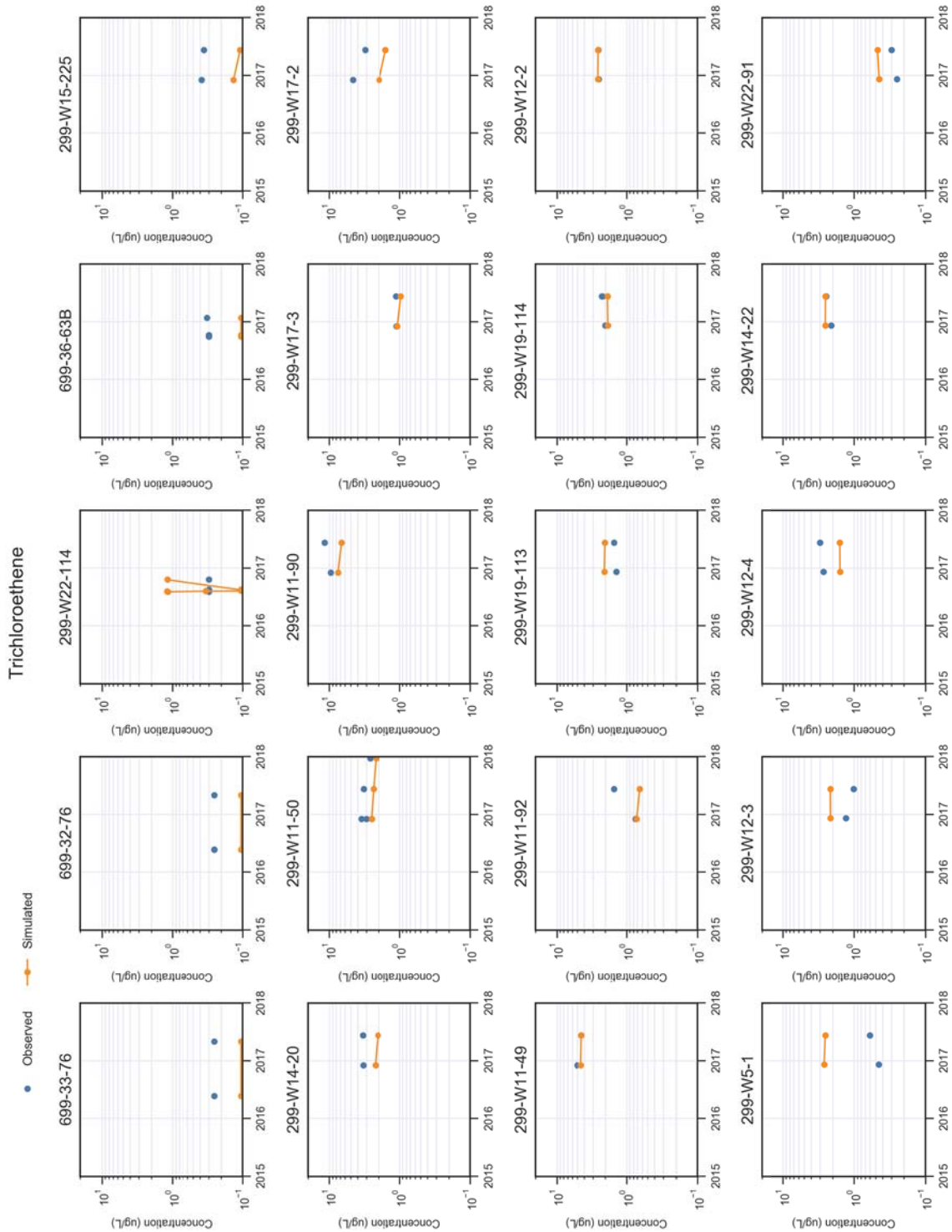

Figure C-7. Comparison of Simulated and Observed Concentrations for Trichloroethene (Page 7 of 8)

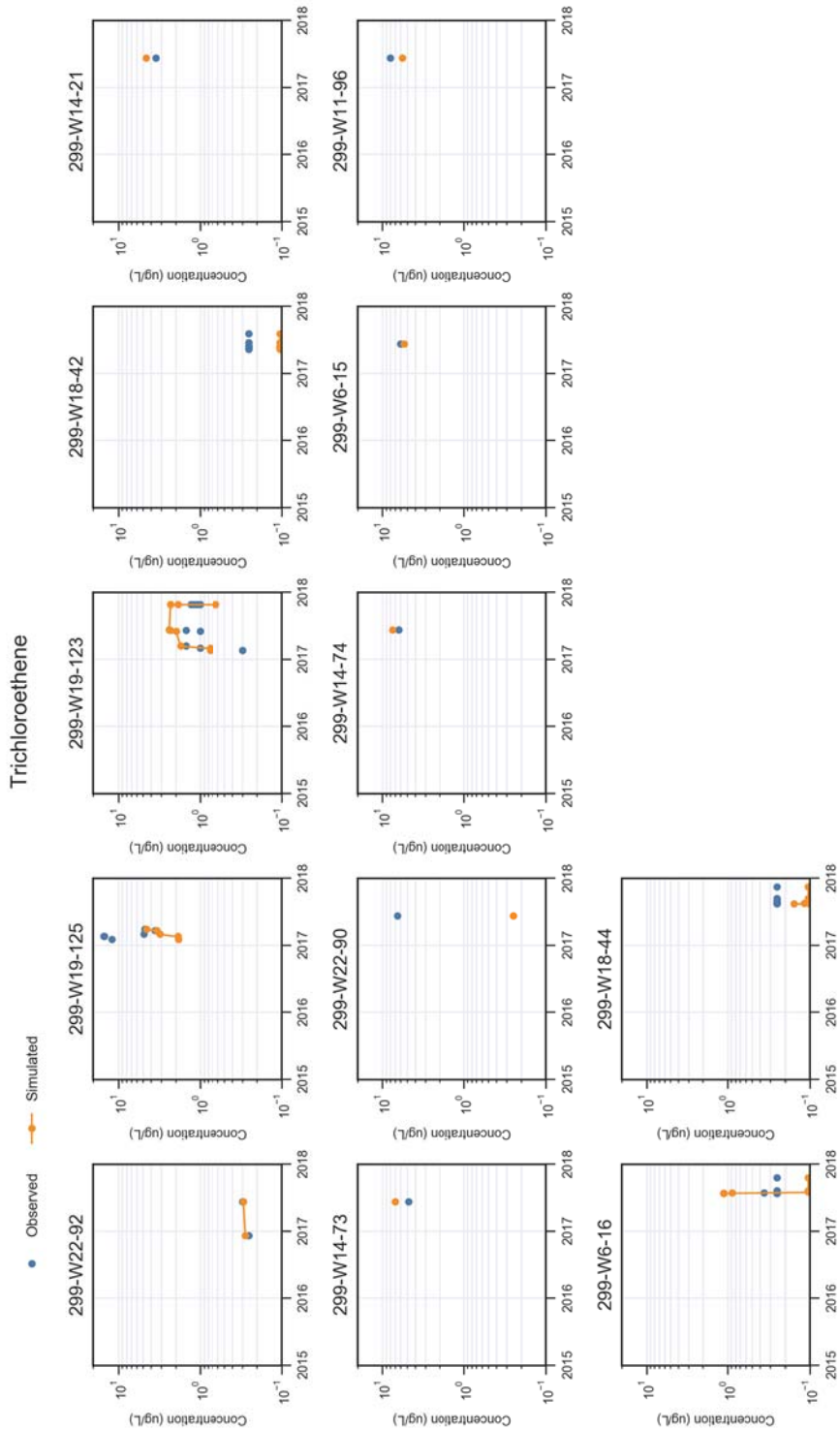

Figure C-7. Comparison of Simulated and Observed Concentrations for Trichloroethene (Page 8 of 8)

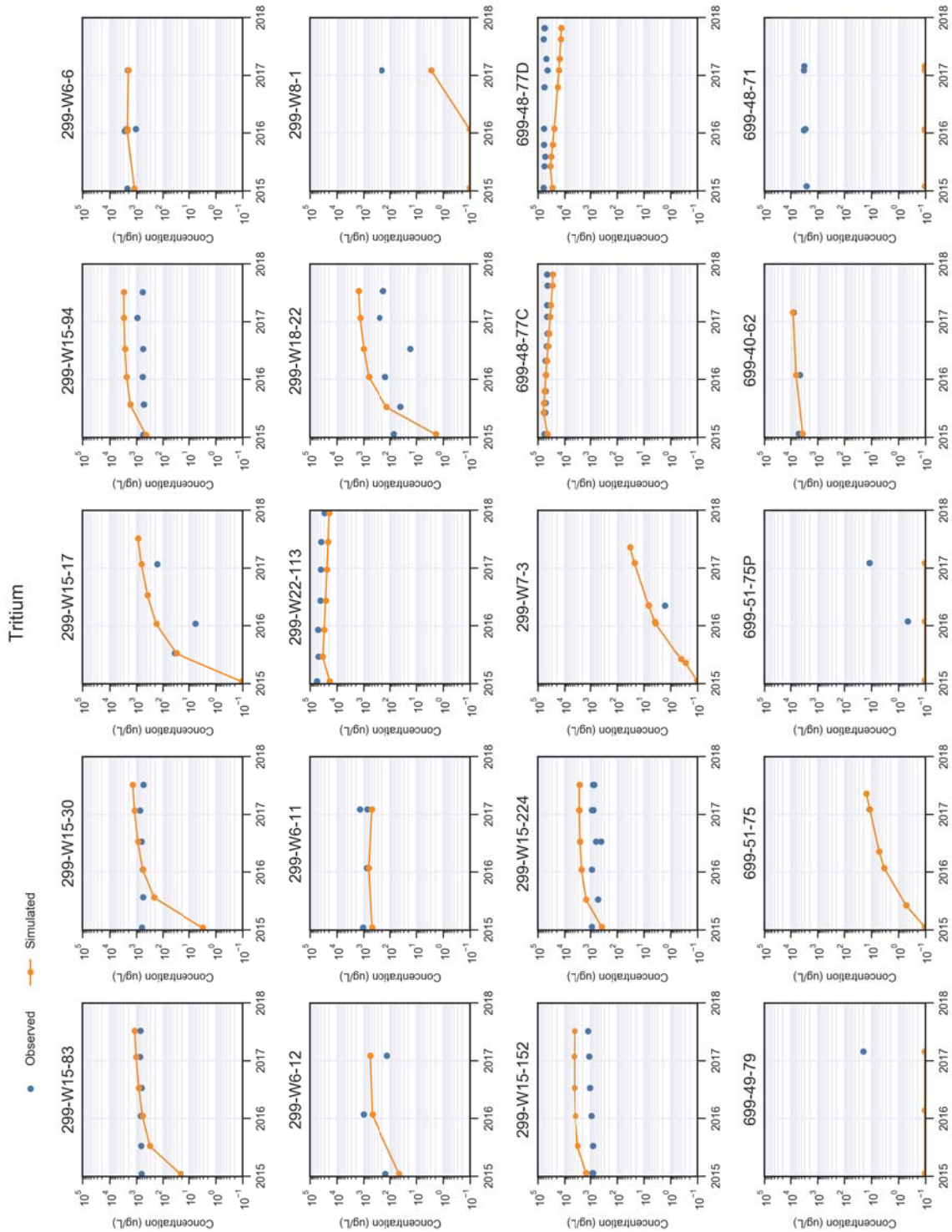

Figure C-8. Comparison of Simulated and Observed Concentrations for Tritium (Page 1 of 9)

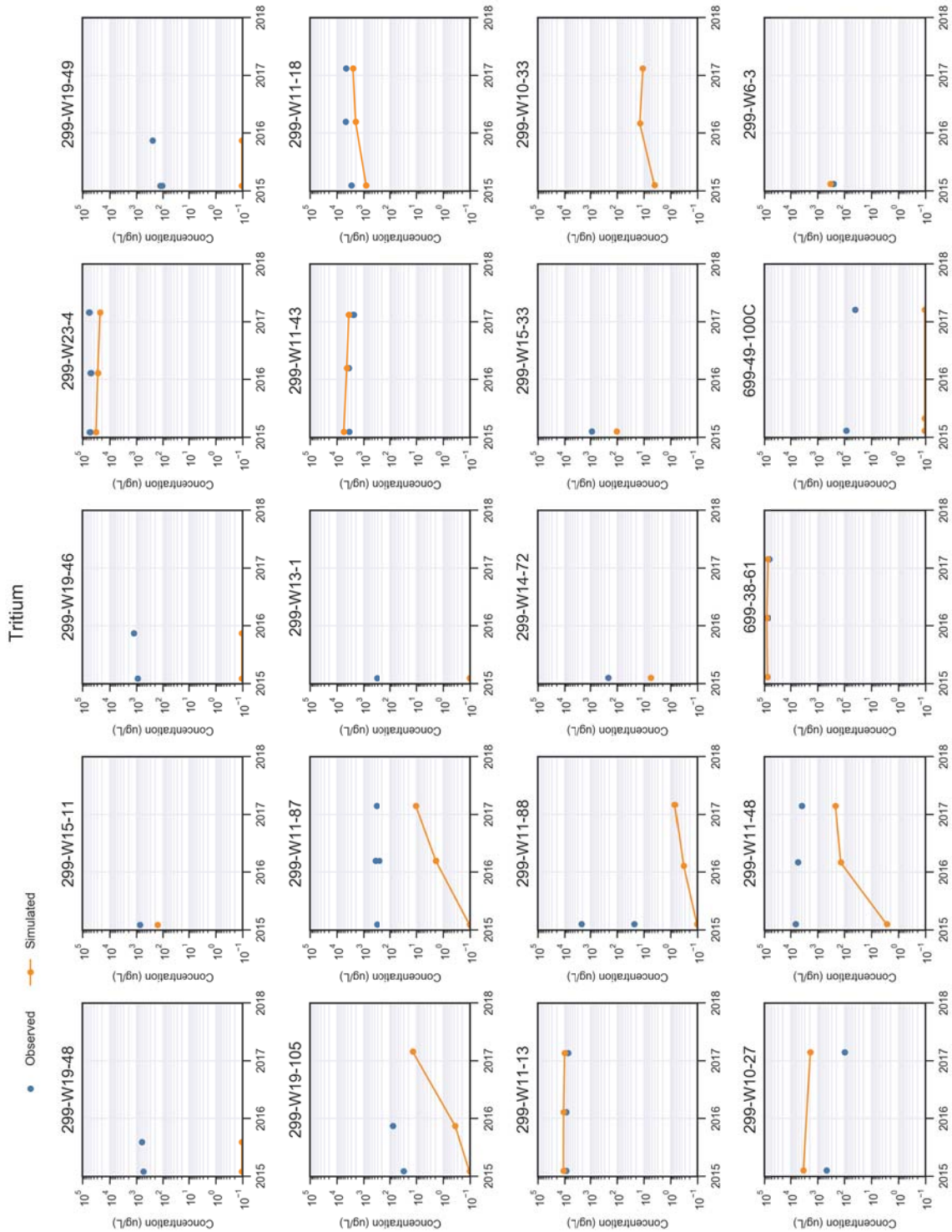

Figure C-8. Comparison of Simulated and Observed Concentrations for Tritium (Page 2 of 9)

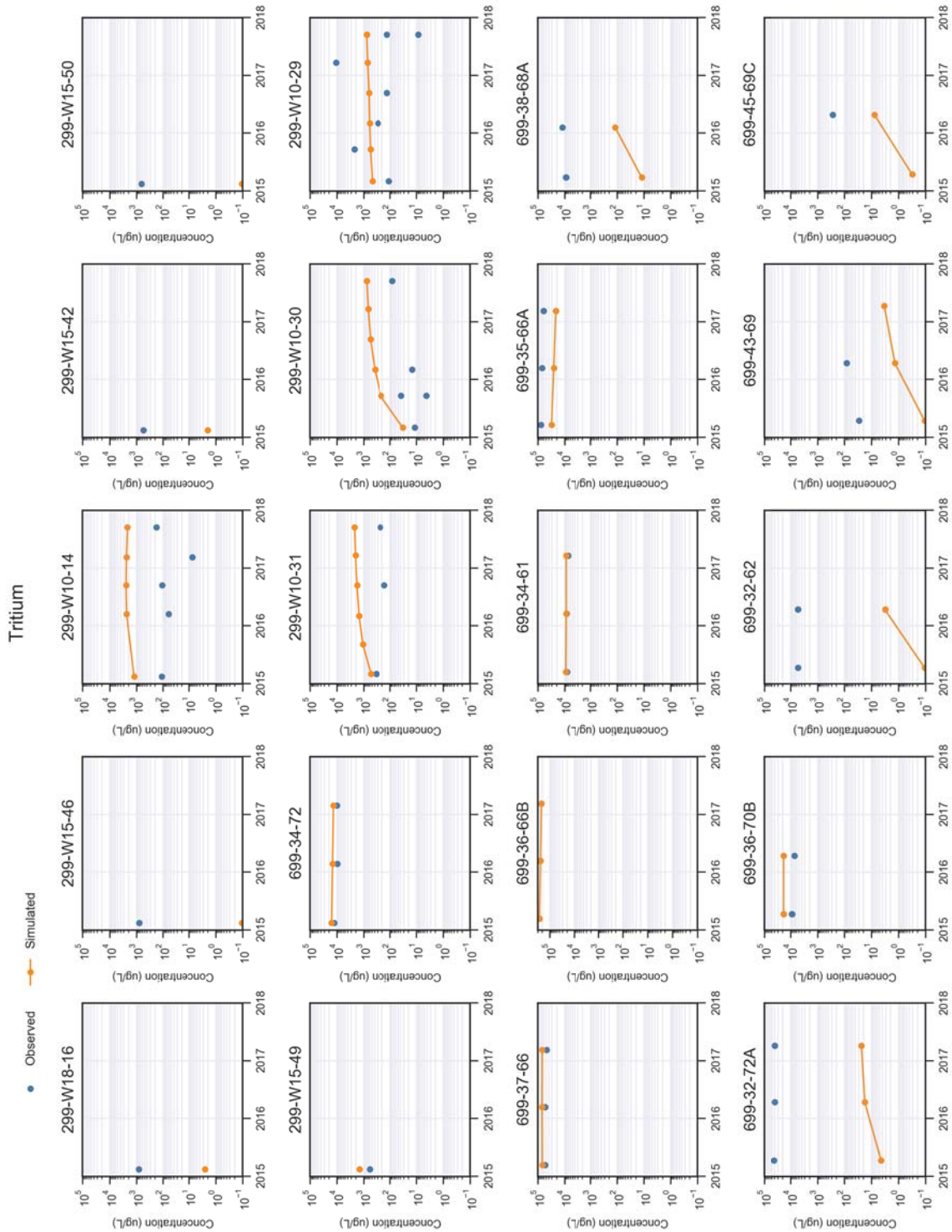

Figure C-8. Comparison of Simulated and Observed Concentrations for Tritium (Page 3 of 9)

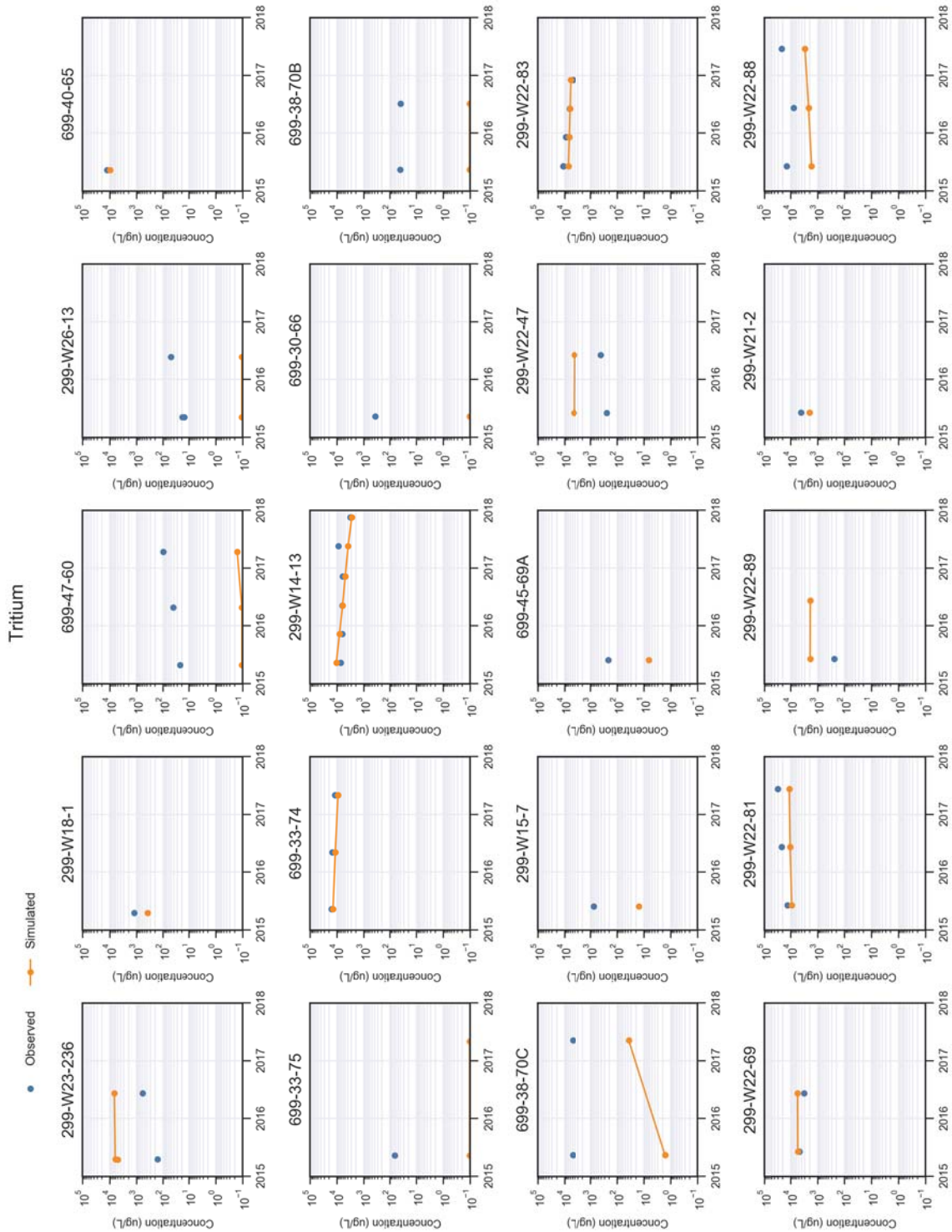

Figure C-8. Comparison of Simulated and Observed Concentrations for Tritium (Page 4 of 9)

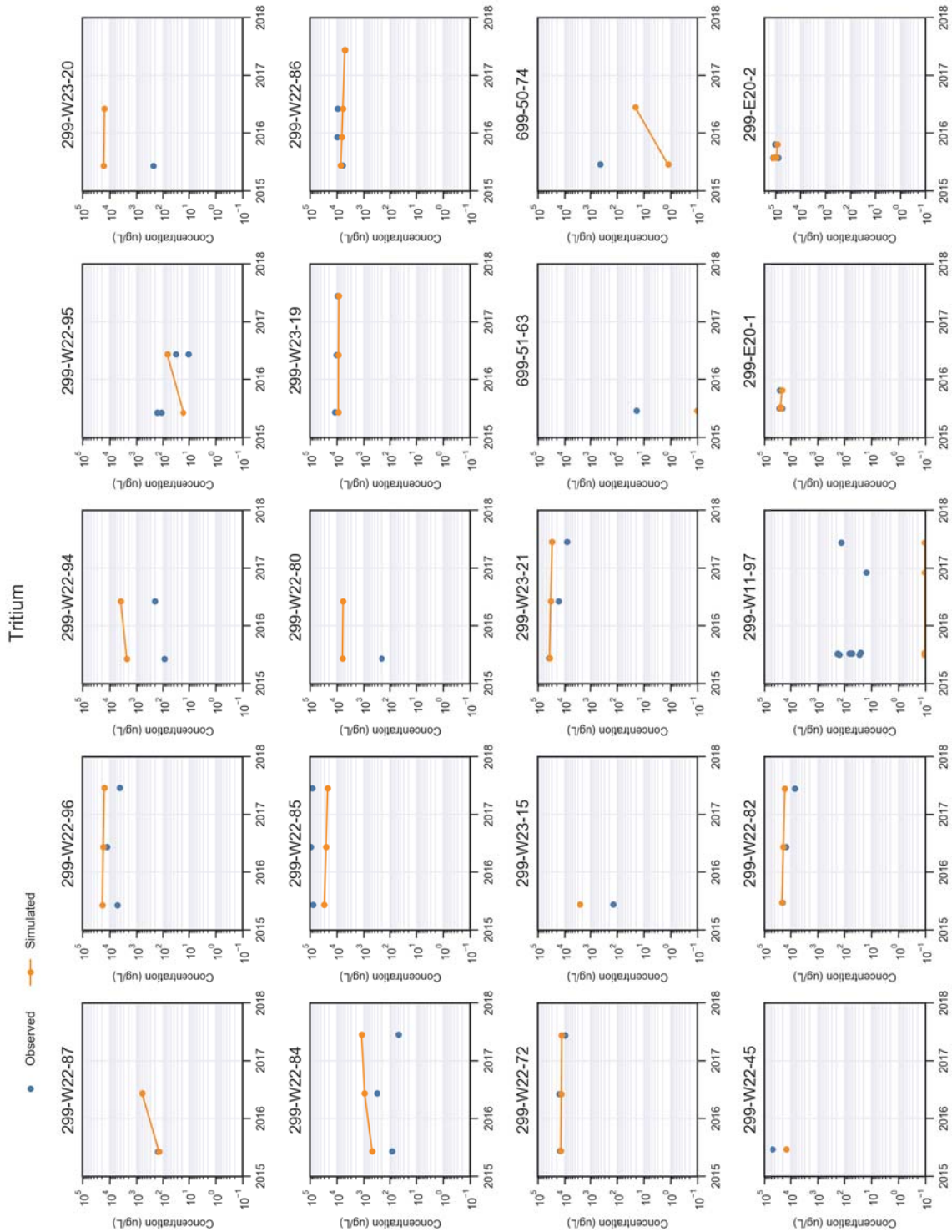

Figure C-8. Comparison of Simulated and Observed Concentrations for Tritium (Page 5 of 9)

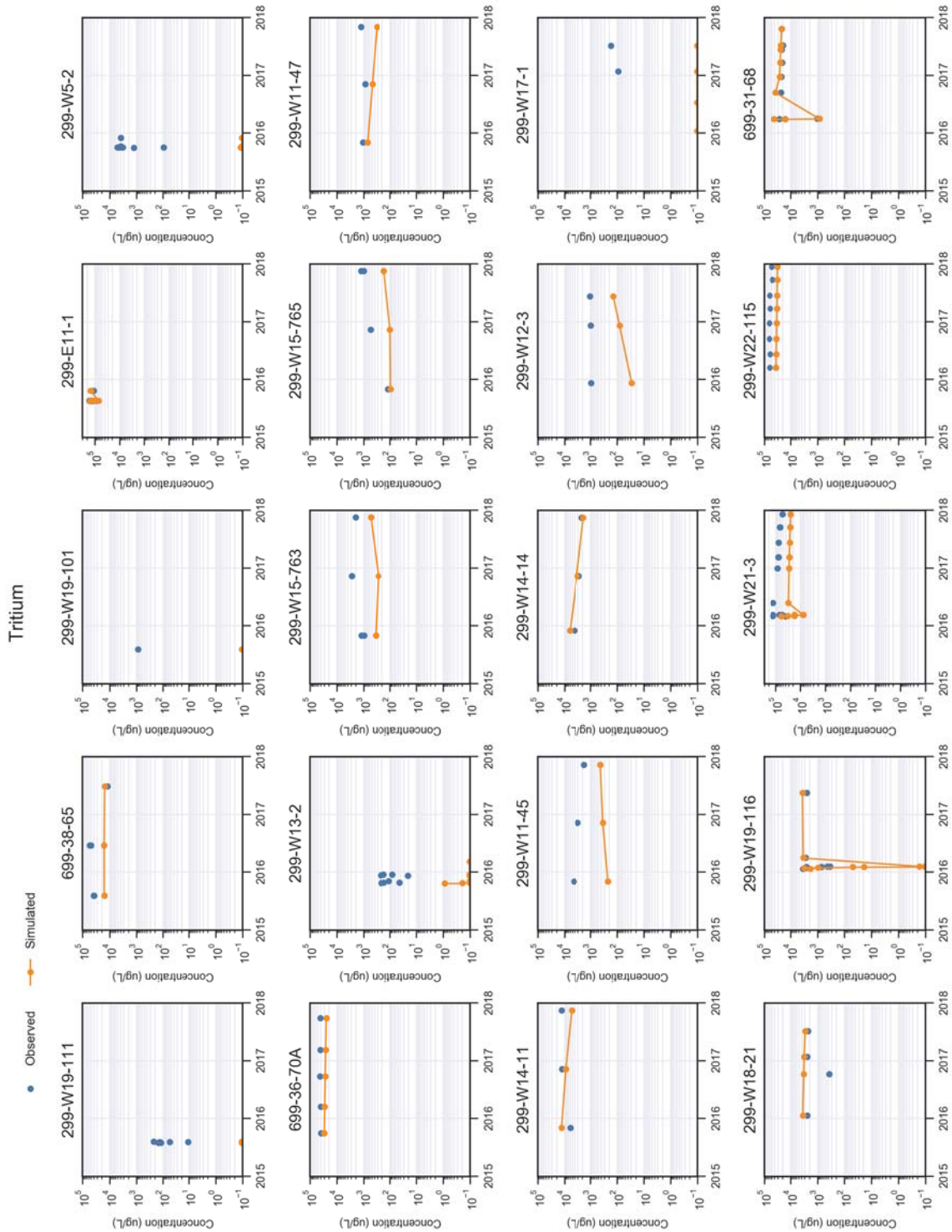

Figure C-8. Comparison of Simulated and Observed Concentrations for Tritium (Page 6 of 9)

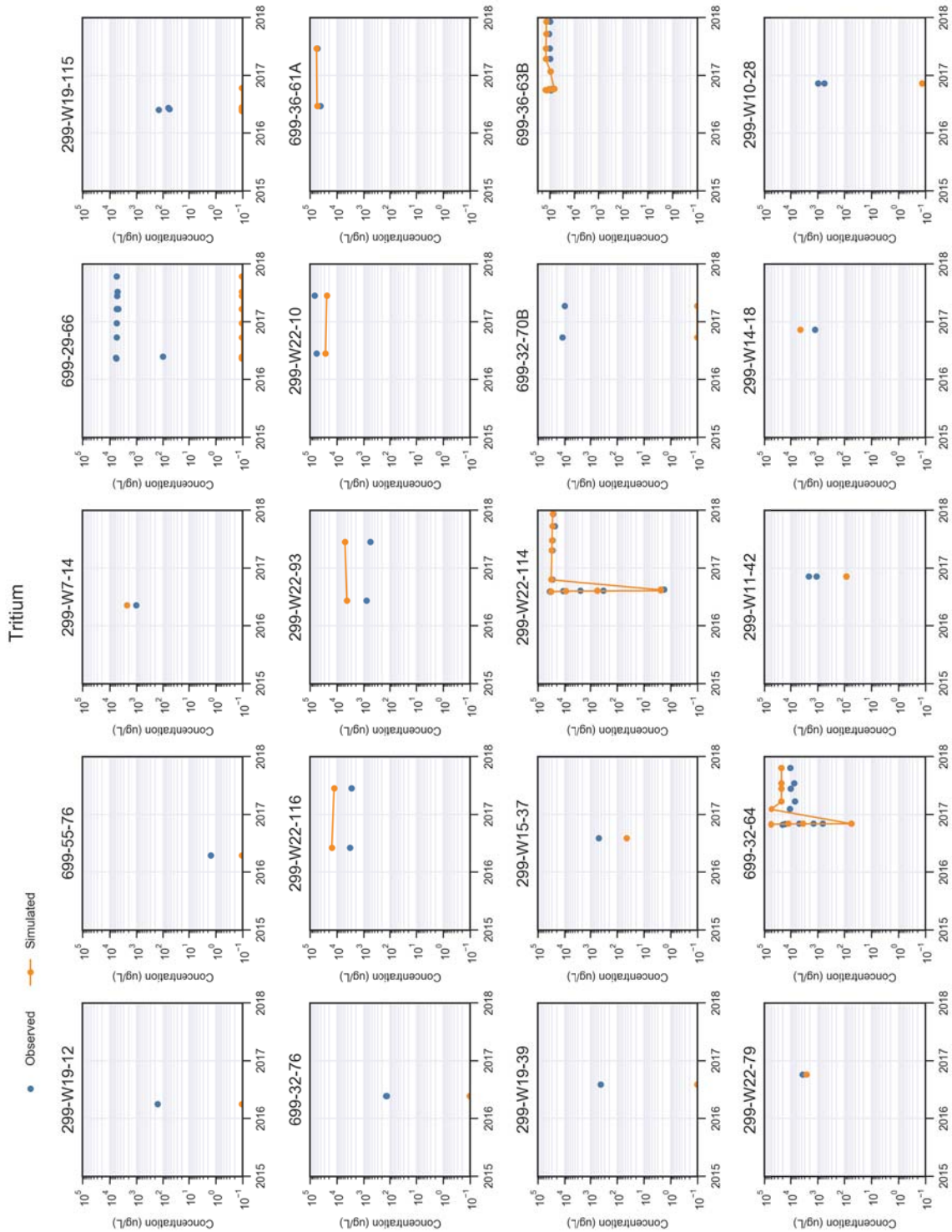

Figure C-8. Comparison of Simulated and Observed Concentrations for Tritium (Page 7 of 9)

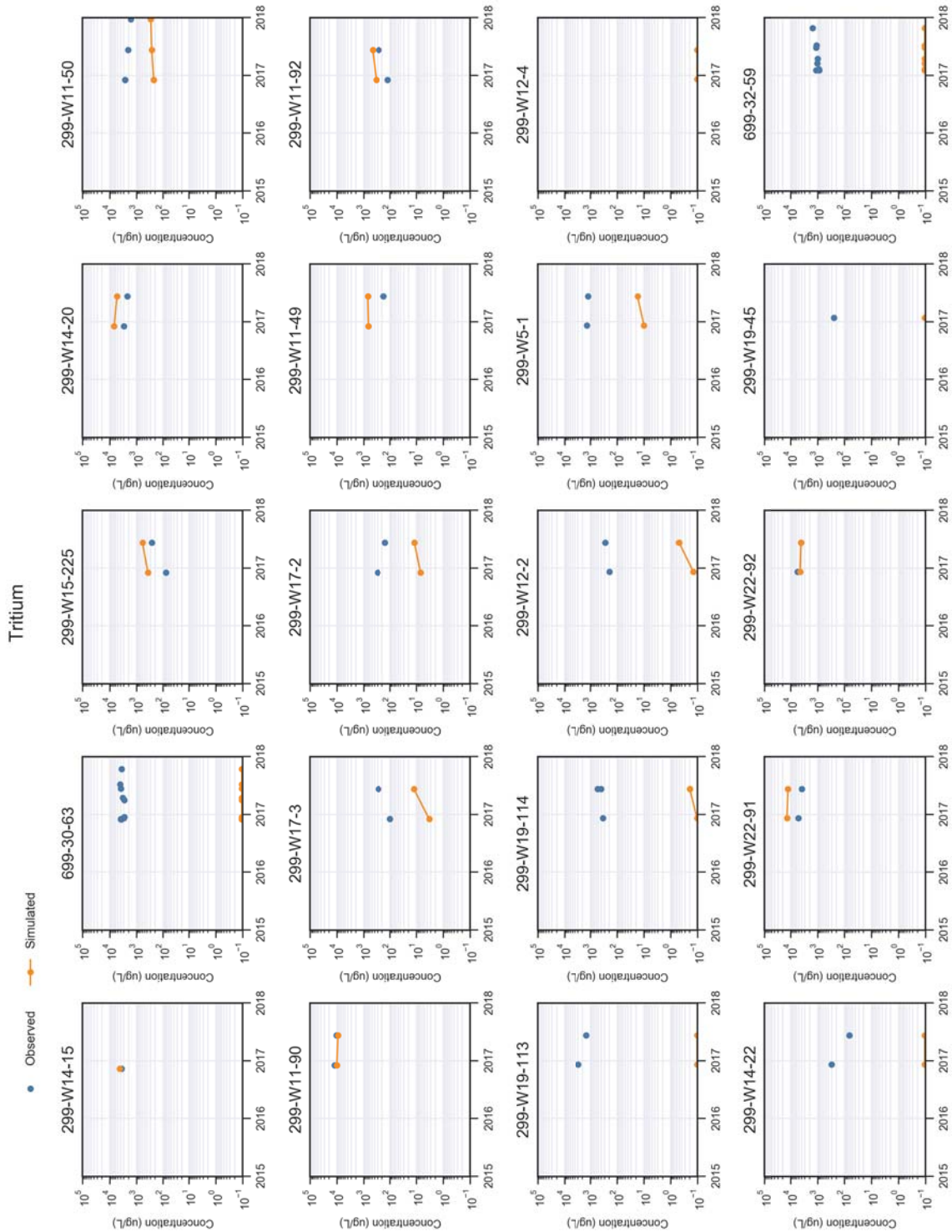

Figure C-8. Comparison of Simulated and Observed Concentrations for Tritium (Page 8 of 9)

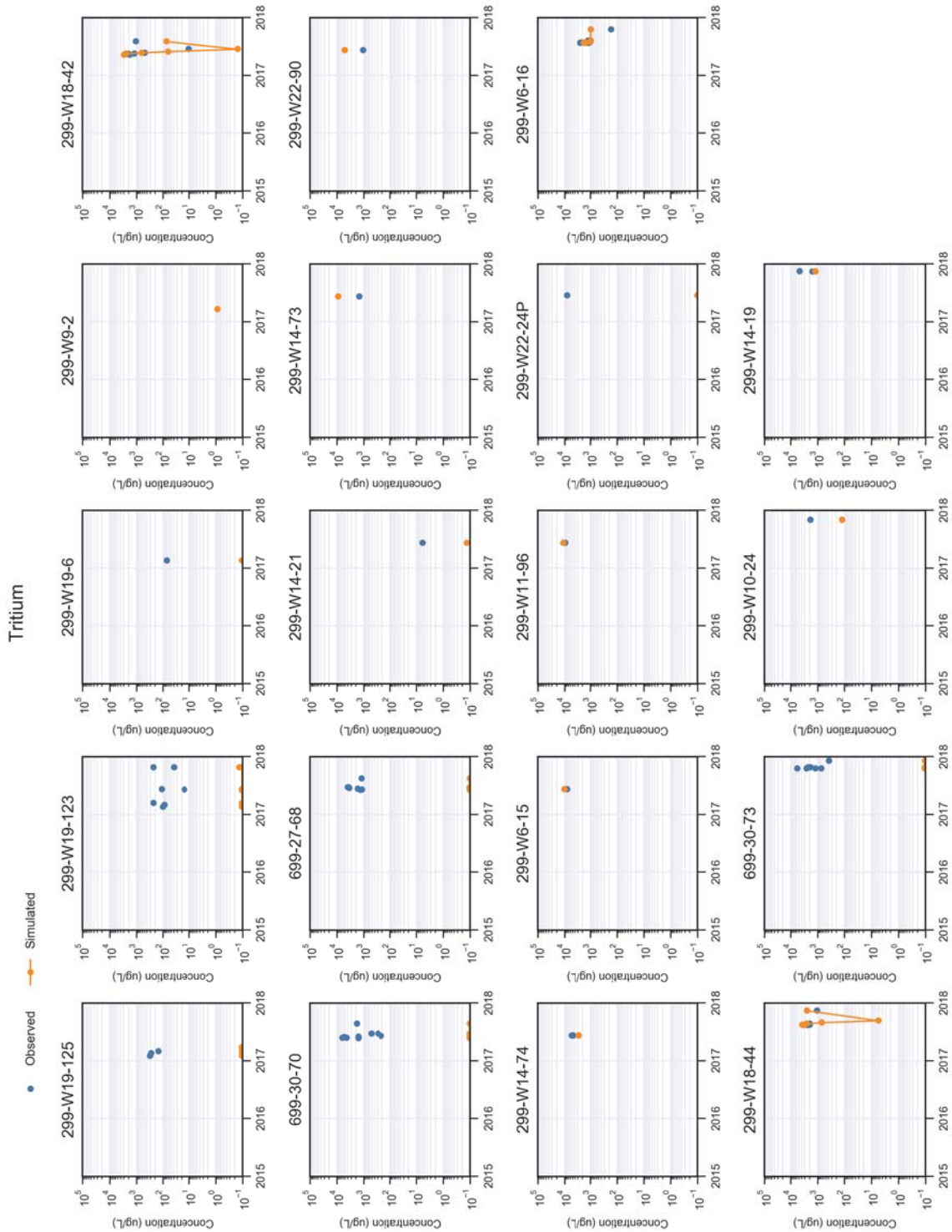

Figure C-8. Comparison of Simulated and Observed Concentrations for Tritium (Page 9 of 9)

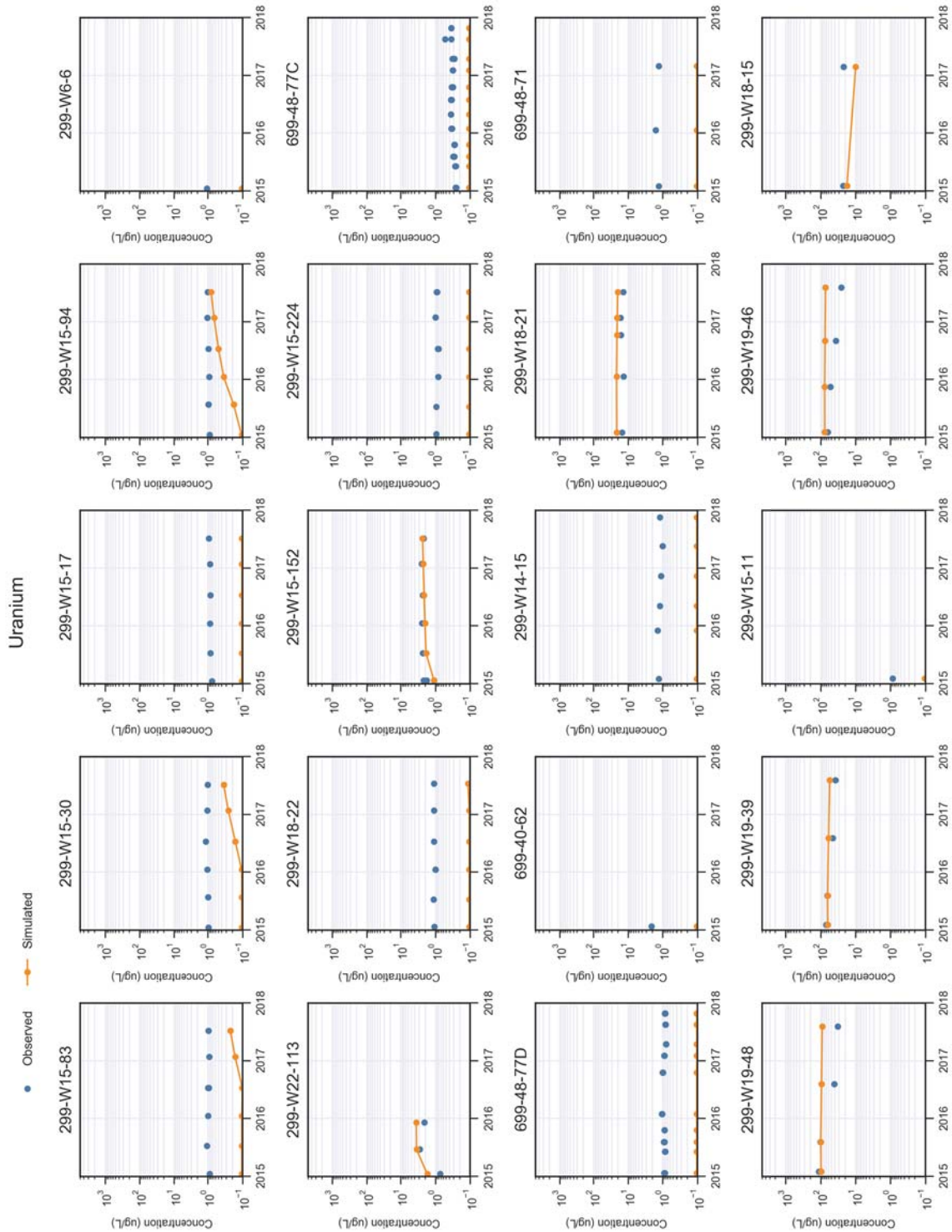

Figure C-9. Comparison of Simulated and Observed Concentrations for Uranium (Page 1 of 9)

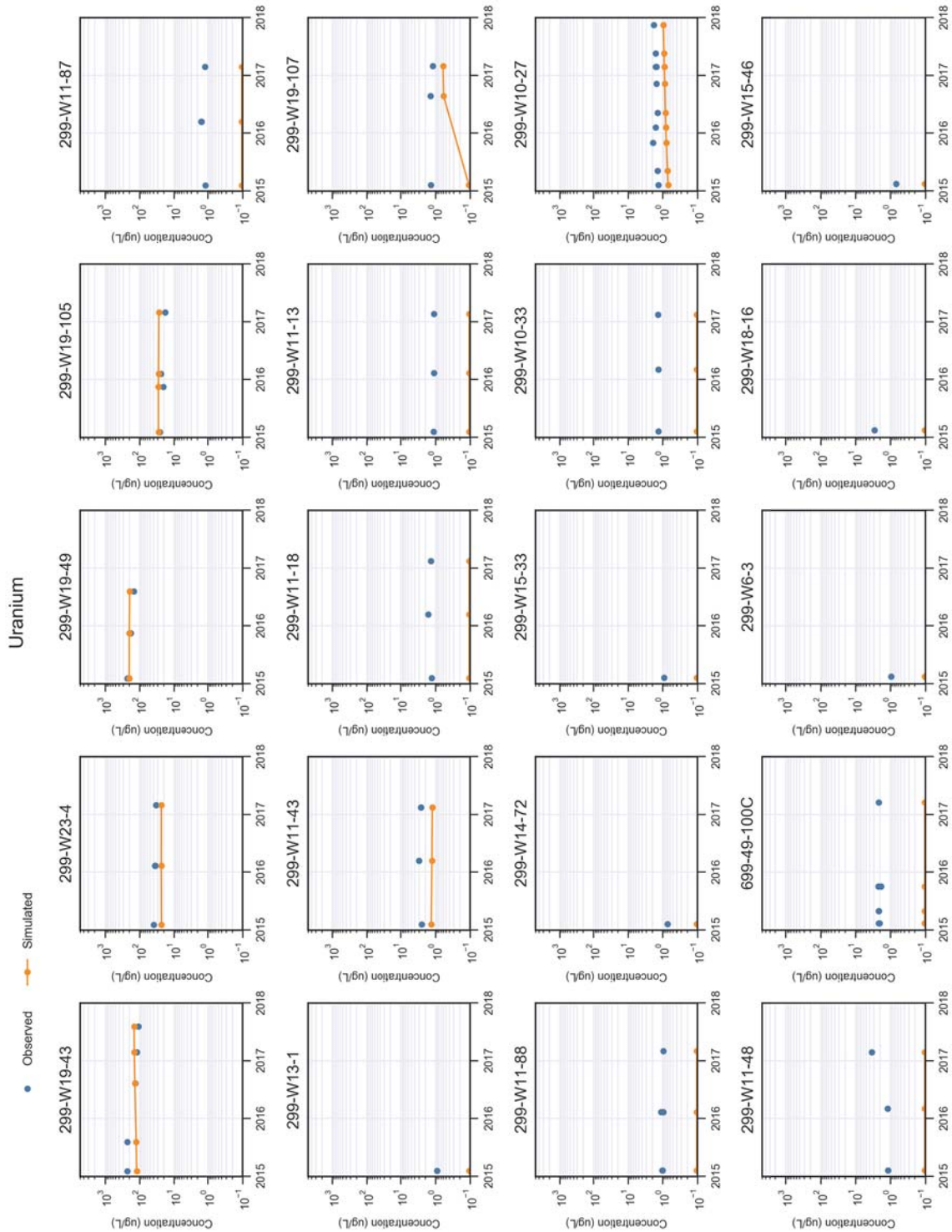

Figure C-9. Comparison of Simulated and Observed Concentrations for Uranium (Page 2 of 9)

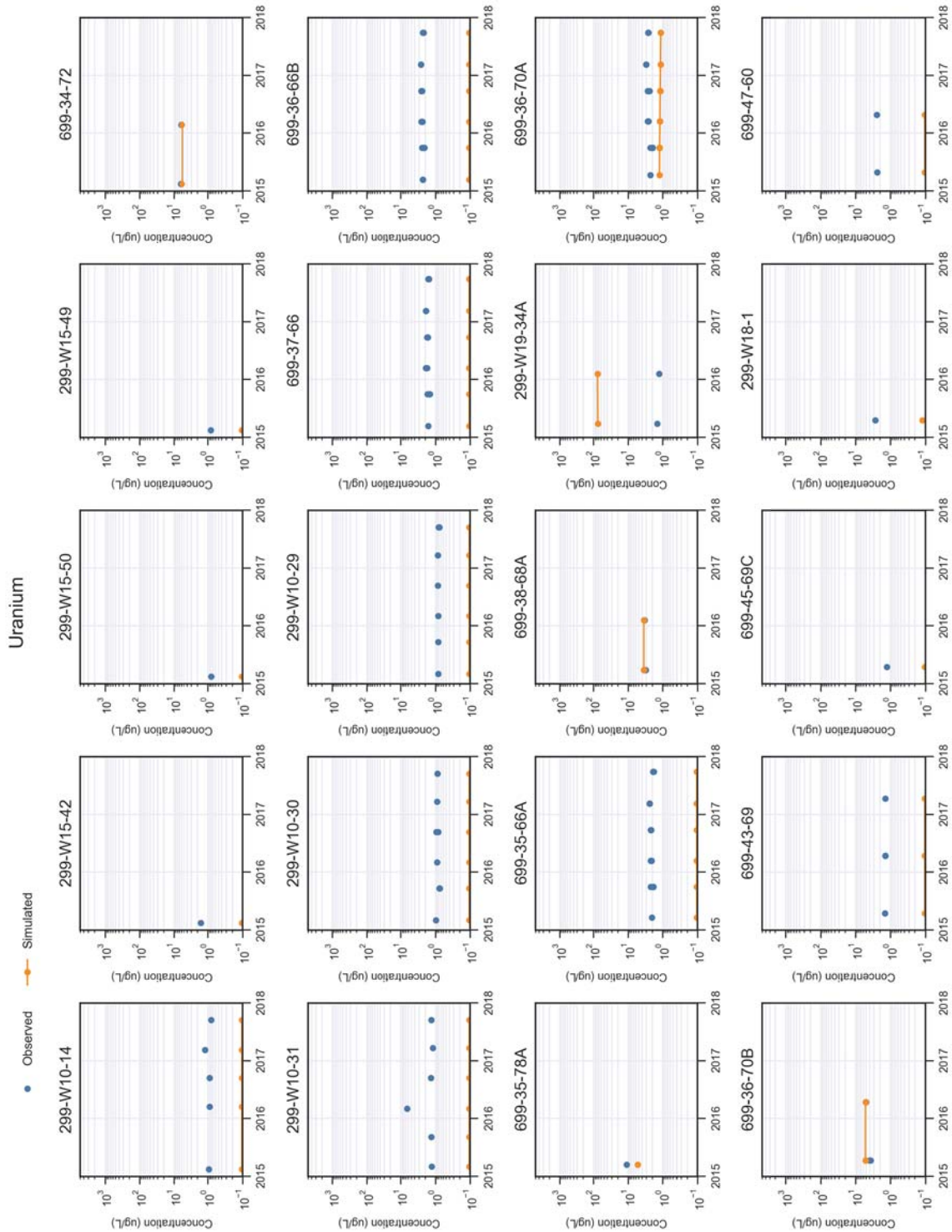

Figure C-9. Comparison of Simulated and Observed Concentrations for Uranium (Page 3 of 9)

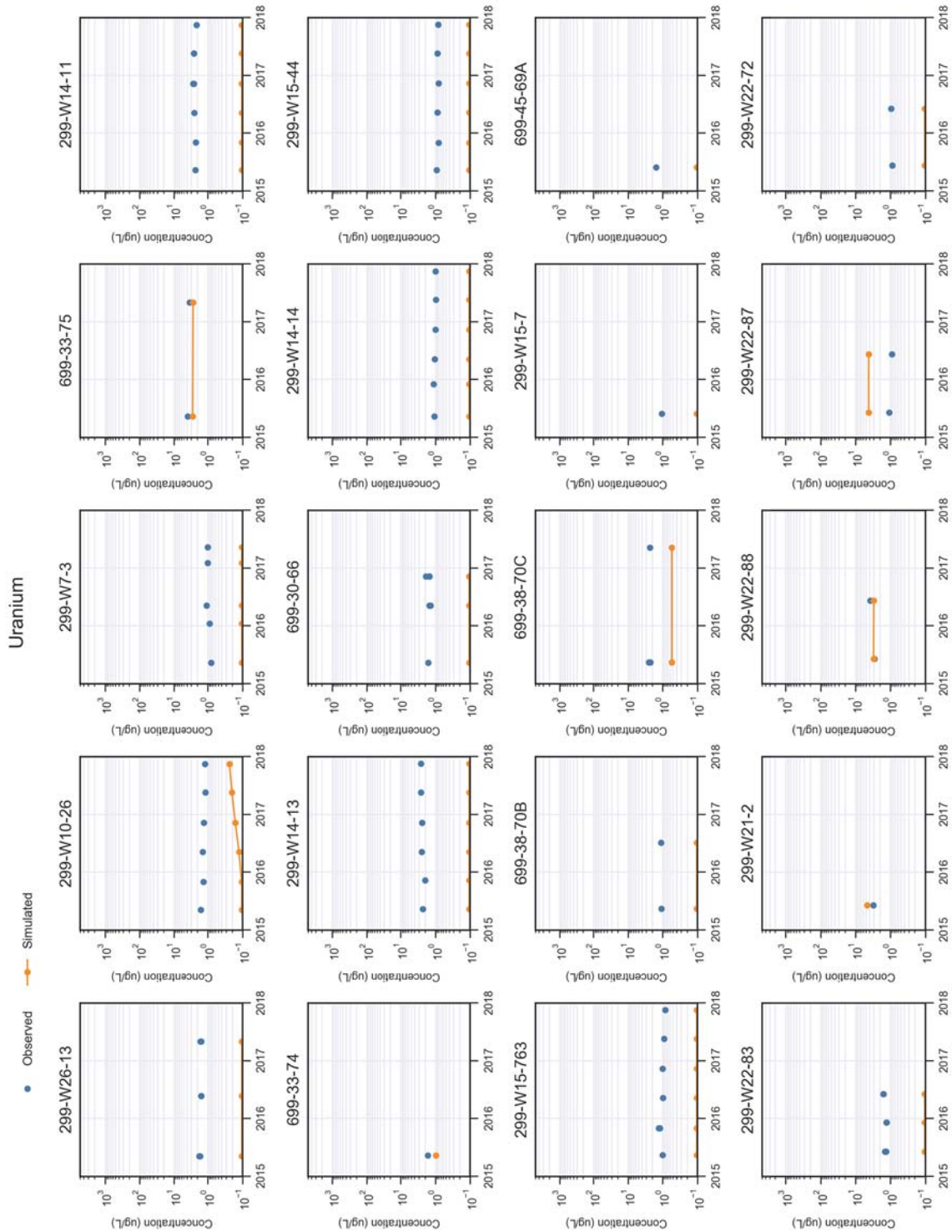

Figure C-9. Comparison of Simulated and Observed Concentrations for Uranium (Page 4 of 9)

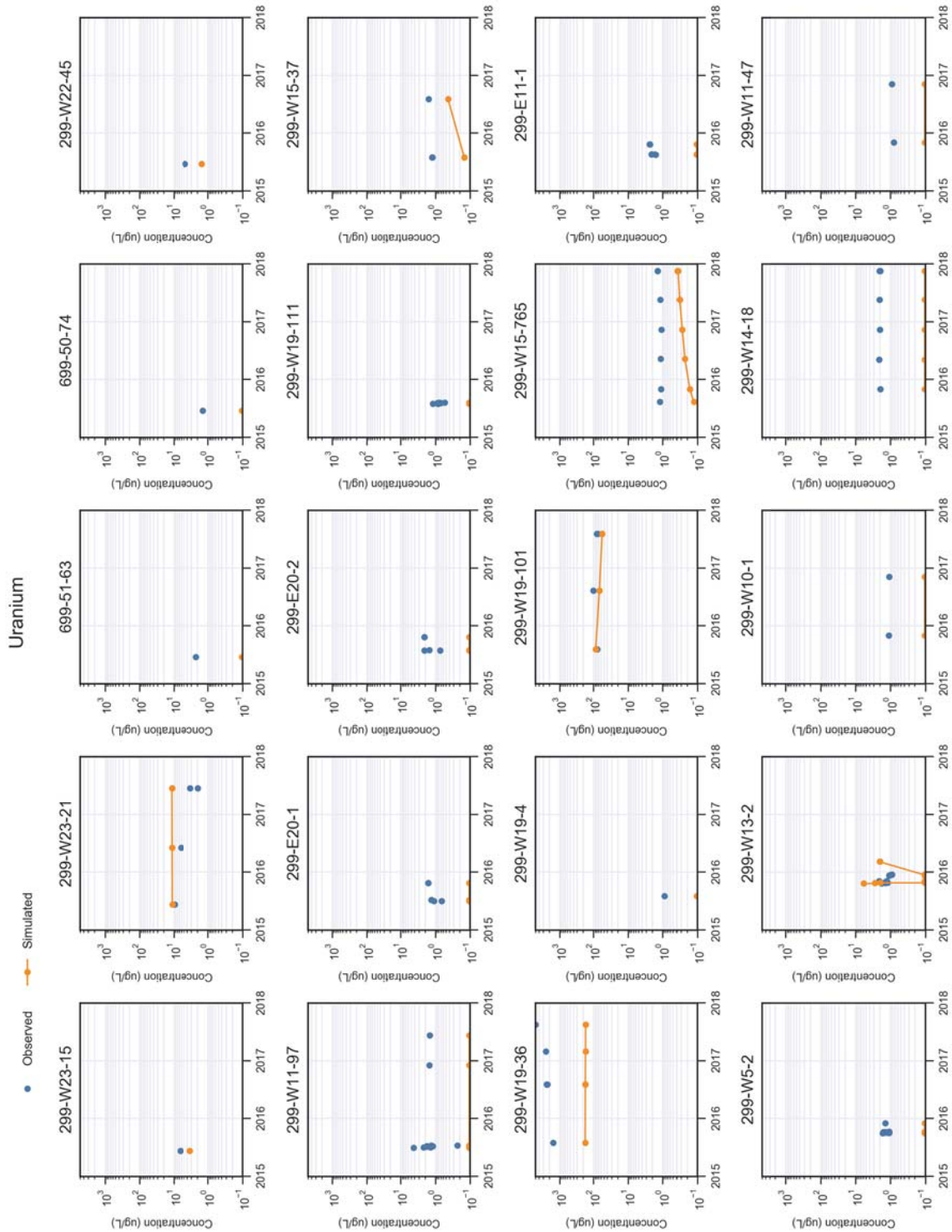

Figure C-9. Comparison of Simulated and Observed Concentrations for Uranium (Page 5 of 9)

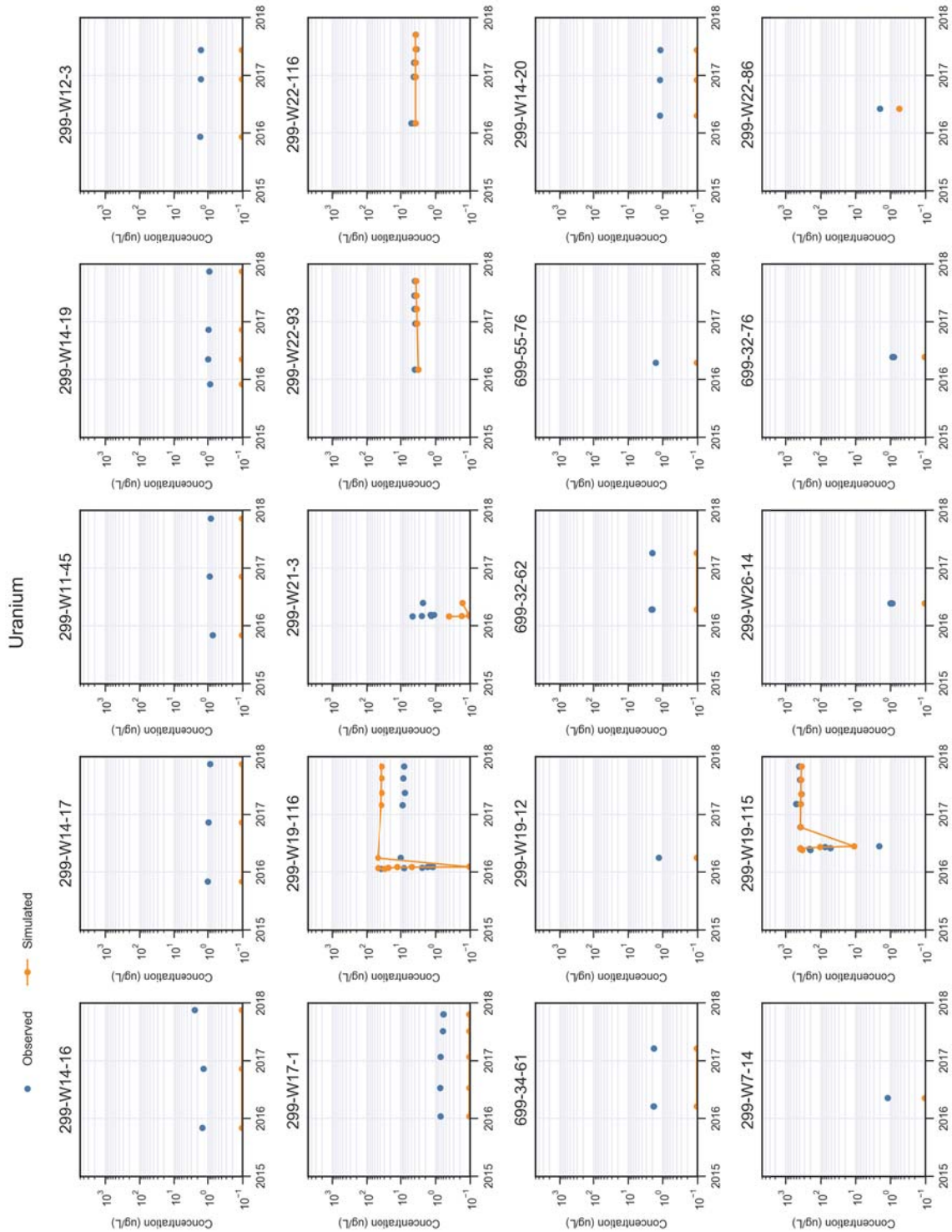

Figure C-9. Comparison of Simulated and Observed Concentrations for Uranium (Page 6 of 9)

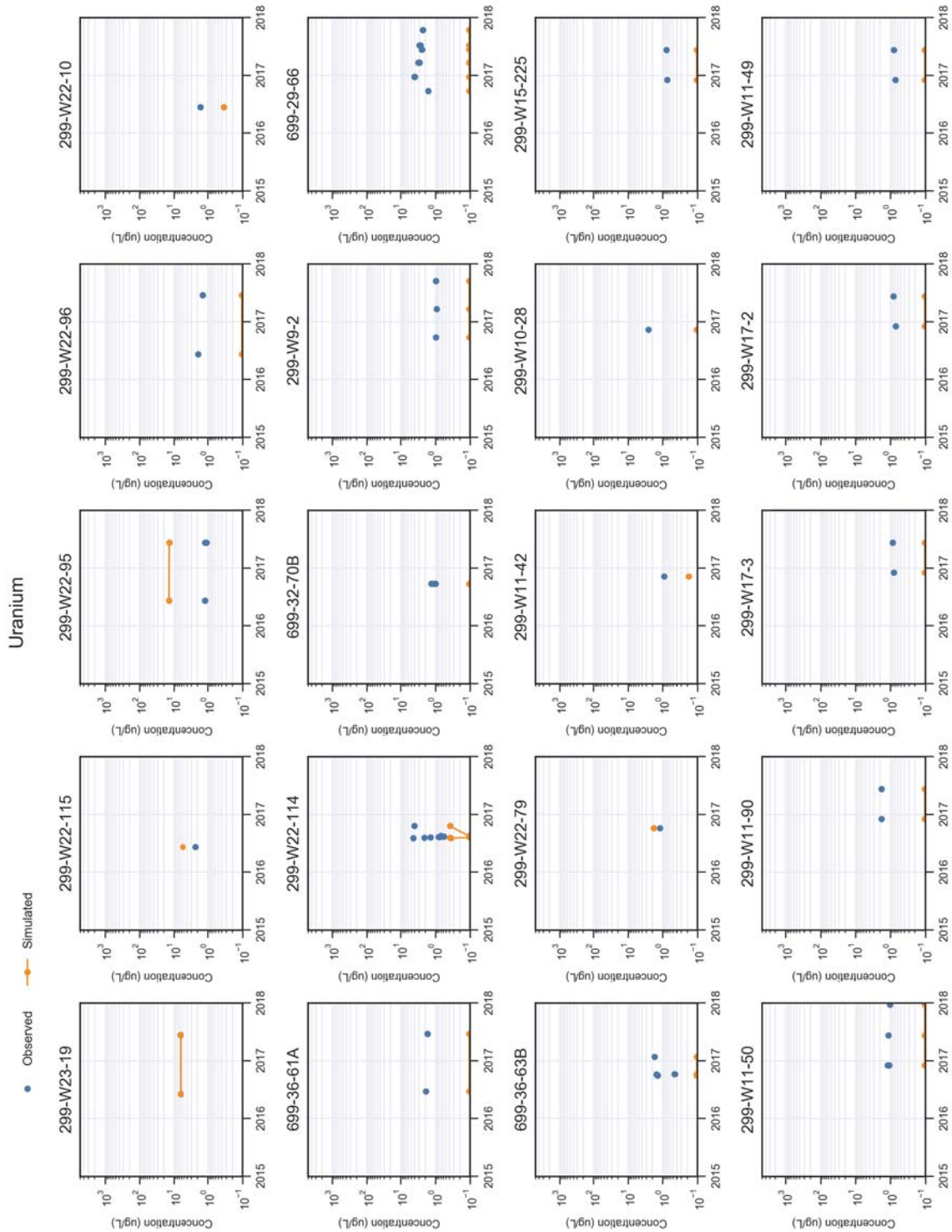

Figure C-9. Comparison of Simulated and Observed Concentrations for Uranium (Page 7 of 9)

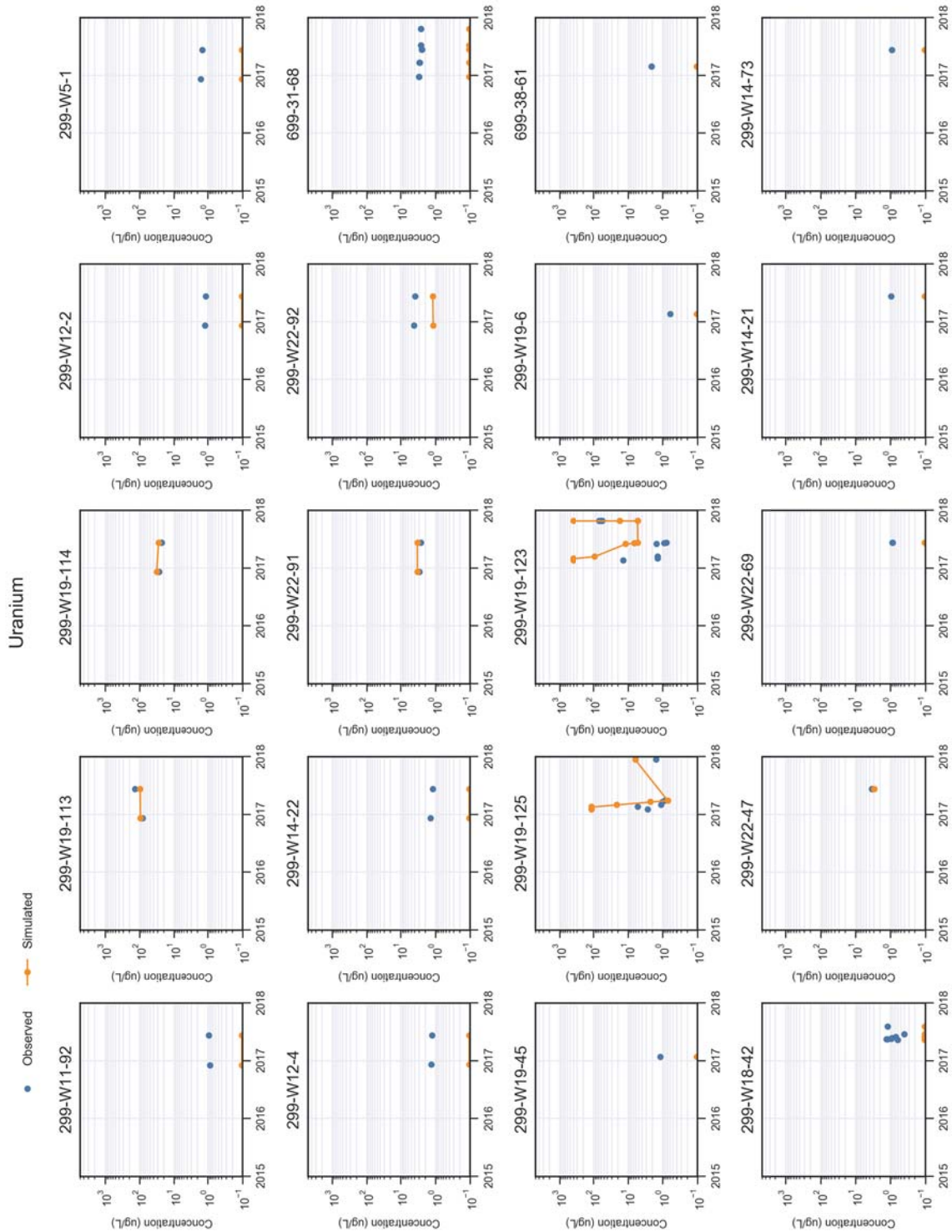

Figure C-9. Comparison of Simulated and Observed Concentrations for Uranium (Page 8 of 9)

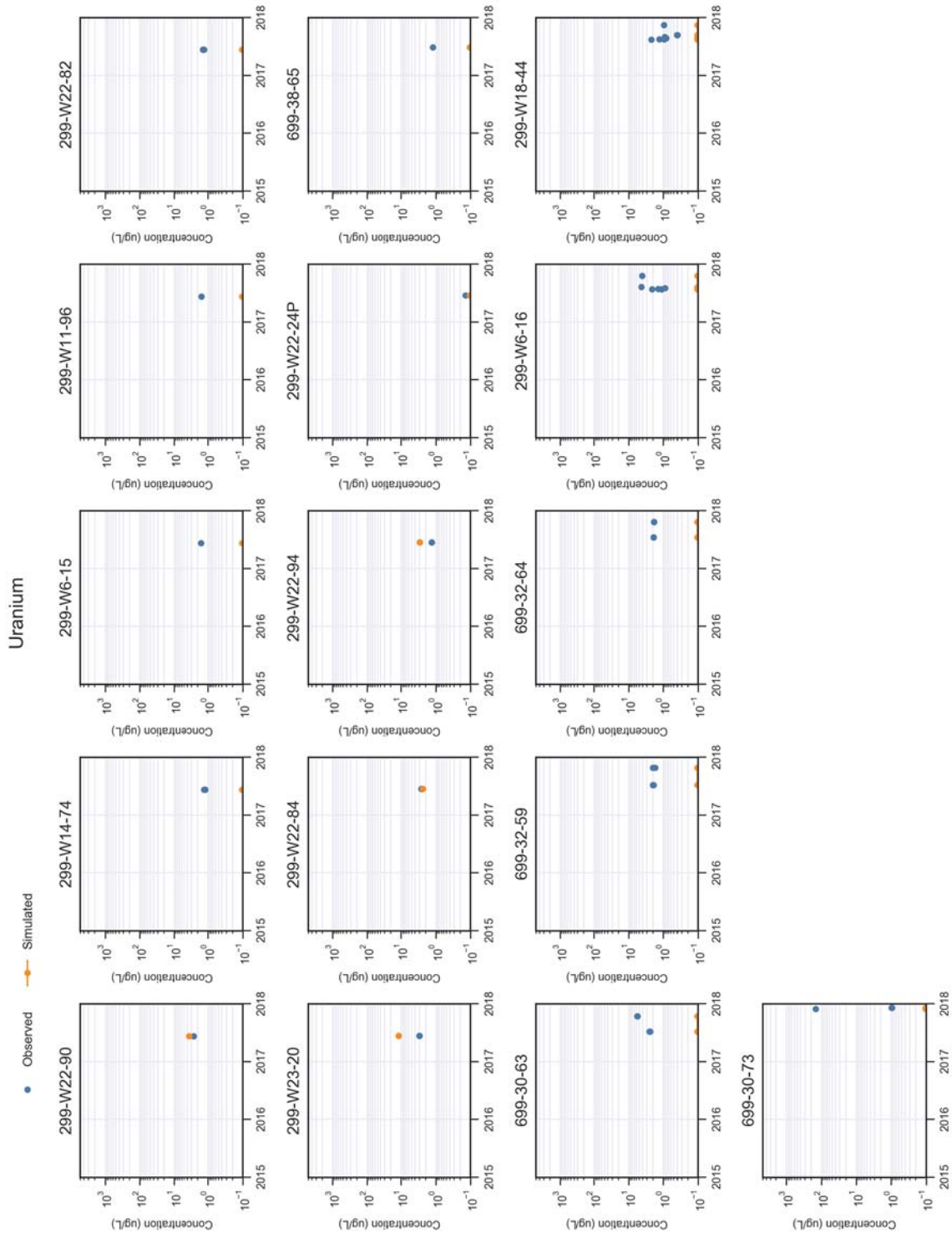

Figure C-9. Comparison of Simulated and Observed Concentrations for Uranium (Page 9 of 9)